Lower Thames Crossing

6.1 Environmental Statement Chapter 14 – Road Drainage and the Water Environment

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Lower Thames Crossing

6.1 Environmental Statement
Chapter 14 Road Drainage and the Water Environment

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14 Road Drainage and the Water Environment

14.1 Introduction

14.1.1 This chapter presents the assessment of the likely significant effects of the proposed A122 Lower Thames Crossing ('the Project') on road drainage and the water environment during construction and operation. The assessment considers likely significant effects on local and catchment-wide water quality, surface water and groundwater resources, land drainage and flood risk.

14.1.2 The assessment follows the methodology set out in Design Manual for Roads and Bridges (DMRB) LA 113 Road Drainage and the Water Environment (Highways England, 2020a), and relevant guidance including Environment Agency (EA) and Planning Inspectorate publications.

14.1.3 This chapter is supported by Figures 14.1 to 14.7 (Application Document 6.2), and additional information contained in the following appendices (Application Document 6.3):

a. Appendix 14.1: Assessment Criteria Tables

b. Appendix 14.2: Water Features Survey Factual Report

c. Appendix 14.3: Operational Surface Water Drainage Pollution Risk Assessment

d. Appendix 14.4: Hydromorphology Assessment

e. Appendix 14.5: Hydrogeological Risk Assessment

f. Appendix 14.6: Flood Risk Assessment (FRA)

g. Appendix 14.7: Water Framework Directive (WFD) Assessment

h. Appendix 14.8: Road Drainage and the Water Environment Legislation and Policy

14.2 Legislative and policy framework

14.2.1 This assessment has been undertaken in accordance with relevant legislation and having regard to national and local plans and policies. Appendix 14.8 sets out how the Applicant has considered and addressed those policies in the NPSs which relate to the assessment of effects considered in this chapter of the Environmental Statement. Policies in the NPSs which relate to decision making in relation to matters of relevance to this topic of the ES are addressed in the Planning Statement (Application Document 7.2).

Legislative requirements

14.2.2 Relevant water environment, flood risk and drainage legislation that has been considered during the assessment is presented in Appendix 14.8: Road Drainage and the Water Environment Legislation and Policy.

National policy

14.2.3 Nationally Significant Infrastructure Projects (NSIPs) are determined in accordance with the decision-making framework in the Planning Act 2008 and relevant National Policy Statements (NPSs), as well as any other matters that are both important and relevant (which may include the National Planning Policy Framework (NPPF) (Ministry of Housing, Communities and Local Government, 2021).

14.2.4 The National Policy Statement for National Networks (NPSNN) (Department for Transport, 2014) sets out the Government's policies to deliver NSIPs on the national road and rail networks in England. Modifications to nationally significant energy infrastructure are required as part of the Project. Four utilities diversions constitute NSIPs in their own right, and therefore the Project will also be assessed against the following energy policy statements:

a. Overarching National Policy Statement for Energy (EN-1) (Department of Energy and Climate Change, 2011a)

b. National Policy Statement for Gas Supply Infrastructure and Gas and Oil Pipelines (EN-4) (Department of Energy and Climate Change, 2011b)

c. National Policy Statement for Electricity Networks Infrastructure (EN-5) (Department of Energy and Climate Change, 2011c).

14.2.5 However, the NPSNN forms the 'case-making' basis for the Project, and the need for nationally significant utilities diversions arises solely from the need for the road element of the Project.

14.2.6 National Highways has taken these policy requirements into account during the development and design of the Project and the preparation of this Environmental Statement (ES).

14.2.7 The NPPF sets out the Government's planning policies. It provides a framework within which locally prepared plans for housing and other development can be produced.

14.2.8 The NPPF does not contain specific policies for NSIPs. However, the NPPF advises that local authorities' planning policies should take into account NSIPs which are located within their local areas. Paragraph 1.17 of the NPSNN states that the NPS and NPPF are consistent and paragraph 1.18 explains that the NPPF is an important and relevant consideration, '*but only to the extent relevant to* [the] *project*.'

14.2.9 Appendix 14.8: Road Drainage and the Water Environment Legislation and Policy, (Application Document 6.3), lists the planning policies at a national level and the Project response

14.2.10 Further information on how the application has responded to national planning policies is available in the Planning Statement (Application Document 7.2).

Local policy framework

14.2.11 Consideration has been given to county policies within Kent and Essex, the updated London Plan (Greater London Authority, 2021) and local policies relating to the water environment within the following host local authorities: Maidstone, Tonbridge and Malling, Medway, Gravesham, Thurrock, Havering and Brentwood. These are outlined in Appendix 14.8: Road Drainage and the Water Environment Legislation and Policy (Application Document 6.3) and are considered further within the Planning Statement (Application Document 7.2).

14.2.12 Further details on policies specifically linked to local and regional flood risk management are provided in Part 2 of Appendix 14.6: Flood Risk Assessment (Application Document 6.3).

14.2.13 Some of the flood risk management documents considered include the Kent Local Flood Risk Management Strategy 2017-2023 (Kent County Council, 2017) and the Local Flood Risk Management Strategy (Essex County Council, 2018), which consider strategies for reducing the impact of flooding from man-made drainage systems, small watercourses and rainfall runoff from the land, and the Thames Estuary 2100 (TE2100) Plan (EA, 2021) that sets out how the EA is planning to manage tidal flood risk in the Thames Estuary until the year 2100.

14.2.14 The Thames River Basin Management Plan (RBMP) (Department for Environment, Food and Rural Affairs (Defra) and EA, 2016) provides a framework for protecting and enhancing the benefits provided by the water environment. To achieve this, and because water and land resources are closely linked, it also informs decisions on land-use planning. The 2021 consultation draft update to the Thames RBMP has also been considered.

14.3 Assessment methodology

Standards and guidance

14.3.1 The following standards and guidance documents have been used in devising the methodology for data collection and assessment of road drainage and the water environment impacts:

a. DMRB LA 113 Road Drainage and the Water Environment (Highways England, 2020a)

b. Flood Risk and Coastal Change Planning Practice Guidance (Department for Levelling Up, Housing and Communities, 2022)

c. Advice Note Eighteen: The Water Framework Directive (Planning Inspectorate, 2017a)

d. Practical Methodology for Determining the Significance of Impacts on the Water Environment (Mustow et al., 2005)

e. The Environment Agency’s approach to groundwater protection (EA, 2018c)

f. Guidance on the identification and risk assessment of groundwater dependent terrestrial ecosystems, version 5 (Water Framework Directive UK Technical Advisory Group (WFD-UKTAG), 2014a)

14.3.2 A wide suite of guidance documents relevant to flood risk and drainage were also used and are summarised in Appendix 14.6: Flood Risk Assessment - Part 2 (Application Document 6.3).

Scope of the assessment

14.3.3 The scope of the assessment included reviewing existing data sources, collecting data from site surveys and investigations, and carrying out surface and groundwater modelling studies so that baseline features of the water environment could be established, and the effects of the Project could be understood.

14.3.4 The following aspects have been scoped into the assessment of impacts on the water environment as a result of the Project:

a. Effects on the water quality attributes of surface and groundwater bodies during construction and operation (principally water quality impacts from routine runoff and spillage). Saline intrusion into local aquifers is also considered.

b. Assessment of effects on surface water and groundwater flows and levels, and dependent water uses (e.g. abstractions and discharges), during construction and operation.

c. Construction and operational effects on Groundwater Dependent Terrestrial Ecosystems (GWDTEs).

d. Construction and operational effects on the hydromorphology of watercourses.

e. Construction and operational effects on flood risk and existing land drainage regimes.

14.3.5 It has been agreed in consultation with the EA and Marine Management Organisation (MMO) that no modelling or sampling is needed to assess any impacts on the hydrodynamics and sediment transport regimes of the River Thames. This aspect is scoped out because in-river works associated with the Project would be limited in extent, scale and duration. Taking account of the mitigation and monitoring measures detailed in Sections 14.5 and 14.8 of this chapter, the likelihood of significant effects on these aspects is very low. It has also been agreed with these statutory bodies that modelling assessments of construction phase discharges do not need to be carried out, as these discharges would be treated to meet applicable standards before discharge. The discharge regime would also be controlled by the requirements of a Deemed Marine Licence in addition to an Environmental Permit.

14.3.6 This chapter has interrelations with the following ES chapters: Chapter 6: Cultural Heritage, Chapter 7: Landscape and Visual, Chapter 8: Terrestrial

Biodiversity, Chapter 9: Marine Biodiversity, Chapter 10: Geology and Soils, Chapter 13: Population and Human Health, and Chapter 15: Climate.

14.3.7 Chapter 10: Geology and Soils includes an assessment of potential effects on the water environment from landfill and other potentially contaminated land.

Temporal scope

14.3.8 The environmental assessment uses defined temporal scopes to characterise the duration of potential effects. The temporal scope refers to the time periods over which impacts may be experienced by receptors.

14.3.9 Temporary (short and medium-term) effects are typically those associated with demolition and construction works, and permanent (long-term) effects are typically those associated with the completed and operational development. Therefore:

a. Short-term is defined as having a duration of one year or less.

b. Medium-term is defined as having a duration of between one and three years

c. Long-term is defined as lasting more than three years.

14.3.10 This approach was discussed and agreed with the EA during scoping of the Appendix 14.7: Water Framework Directive Assessment (Application Document 6.3) and has been applied as an overarching principle.

Limits of deviation and Rochdale Envelope

14.3.11 The Project's application of the Rochdale Envelope is summarised in Chapter 2: Project Description. The Limits of Deviation (LOD) for the project (defined in the Draft Development Consent Order (Application Document 3.1)) represent an 'envelope' within which the Project would be constructed and have informed the reasonable worst case approach to assessment for the purposes of this chapter. For example, the LOD for the main tunnel vertical alignment, and its associated structures and the A122 Lower Thames Crossing/M25 junction cutting, have been accounted for in the groundwater modelling assessments. Also, where necessary, reasonable worst case assumptions have been applied to the assessment of the effects of below ground utilities works regarding designs and construction techniques for these works.

14.3.12 For the assessment of flood risk a reasonable worst-case approach has also been adopted. The flood models have included several conservative assumptions, for example, representing the Bowaters Sluice (a key flood defence asset) as fully blocked, and incorporating generous freeboard allowances to the soffits of watercourse crossing structures (over and above the modelled floodwater levels). Climate change over the lifetime of the Project has been accounted for. The viaduct crossing of the Mardyke and its tributaries has a design height set to provide for clearance to allow machinery to work beneath the structure to undertake maintenance of the watercourses.

Use of the River Thames

14.3.13 Vessel movements on the River Thames are not relevant to this assessment, and use of the river is therefore excluded from the scope of this chapter. Chapter 9: Marine Biodiversity provides a qualitative assessment of the effects of the vessel movements associated with construction of the Project and relevant attributes of the river.

Scoping Opinion

14.3.14 A Scoping Report (Highways England, 2017) was submitted to the Planning Inspectorate on 2 November 2017, setting out the proposed approach to this Environmental Impact Assessment (EIA). A Scoping Opinion was received from the Secretary of State on 13 December 2017, which included comments on the scope of assessment from the Planning Inspectorate and statutory environmental bodies. These comments have been taken into account in the preparation of the chapter, and the Project response is set out in Appendix 4.1: The Inspectorate's Scoping Opinion and National Highways Response (Application Document 6.3).

Consultation

Project consultation

14.3.15 Statutory Consultation under Section 42 of the Planning Act 2008 was undertaken on the Project from 10 October 2018 to 20 December 2018. This provided an opportunity for consultees to comment on the Preliminary Environmental Information Report (PEIR) (Highways England, 2018). A summary of the responses can be found in the Consultation Report (Application Document 5.1). Consultees comprised prescribed bodies, local authorities, people with an interest in land affected by the Project, and local communities.

14.3.16 The Project design continued to be developed, which resulted in changes to the Project. These formed the basis for the Supplementary Consultation, which was undertaken from 29 January 2020 to 2 April 2020. A further Design Refinement Consultation was undertaken from 14 July 2020 to 12 August 2020.

14.3.17 A Community Impacts Consultation was undertaken from 14 July 2021 to 8 September 2021. This sought feedback on the impacts of the Project at a local ward level, as well as the mitigation proposed for those impacts. Changes to the Project since the Design Refinement Consultation were also presented, along with a summary of how feedback to earlier consultation had shaped the development of the Project.

14.3.18 Prior to the submission of this DCO application, a Local Refinement Consultation was held between 12 May 2022 and 20 June 2022. This provided local communities with the opportunity to comment on proposed refinements to the Project.

14.3.19 These consultations all included information about the environmental impacts associated with the refinements presented for consultation. A summary of the responses to these consultation stages can also be found in the Consultation Report (Application Document 5.1).

Stakeholder engagement

14.3.20 A summary of the stakeholder engagement specific to the water environment during the EIA process is provided in Table 14.1. Details of the Project's engagement with the MMO are provided in Chapter 9: Marine Biodiversity.

Table 14.1 Stakeholder engagement

Stakeholder	Date of meeting / communication	Summary of discussions
Environment Agency (EA)	25 May 2017	Meeting to discuss the relationship between the Project and TE2100 policies, and to decide which policies apply in the study area. The relationship between the Project and local flood risk management policies, including TE2100, is detailed in Appendix 14.6: Flood Risk Assessment - Part 2 (Application Document 6.3).
EA	7 June 2017	Meeting to present proposed methodologies for assessing flood risk. The required scope of hydraulic modelling of watercourses was agreed. Details of the agreed scope are provided in Appendix 14.6: Flood Risk Assessment - Part 4 and Flood Risk Assessment - Part 5 (Application Document 6.3).
EA	8 November 2017	Meeting to discuss hydraulic modelling methodologies. Key modelling parameters were agreed. These are documented in Appendix 14.6: Flood Risk Assessment - Part 4 and Flood Risk Assessment - Part 5 (Application Document 6.3).
EA	22 March 2018	Meeting to discuss the approach to watercourse crossings and diversions and to agree key principles linked to provision of compensatory flood storage. The agreed principles are detailed in Section 14.5.
EA	11 November 2018	Meeting to present progress on the hydraulic modelling of the Mardyke and West Tilbury Main watercourses.
EA	12 February 2019	Accompanied site visit to Thurrock.
EA	27 February 2019	Meeting to introduce the ground investigation (GI) strategy.
EA	16 May 2019	Meeting to agree flood modelling climate change scenarios to be applied, and to discuss strategies for managing residual flood risks. Details of agreed climate change allowances and strategies for managing residual flood risk are provided Appendix 14.6: Flood Risk Assessment - Part 6 (Application Document 6.3).
EA	12 July 2019	Meeting to provide an update regarding the water features survey. A survey boundary to the north of the River Thames was agreed. Details of the survey methodology and results are provided in Appendix 14.2: Water Features Survey Factual Report (Application Document 6.3).

Stakeholder	Date of meeting / communication	Summary of discussions
EA	17 July 2019	Meeting to present the approach to hydrogeological modelling. The scope of the Hydrogeological Risk Assessment was agreed. The scope and findings of the assessment are presented in Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3).
EA	22 July 2019	Meeting to provide the EA with a flood modelling progress update.
EA	7 August 2019	Meeting to discuss progress of GI and provide updated survey plans.
EA	16 September 2019	Issue of the North Portal Stage 1 Numerical Model technical note. This note was reviewed and accepted by the EA, and is provided as Annex K of Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3).
EA	23 September 2019	Meeting to discuss Stages 1 and 2 of Appendix 14.7: Water Framework Directive Assessment (Application Document 6.3) and to scope any assessments needed concerning construction phase discharges to the River Thames. Zones of Influence and water bodies to be scoped into the WFD assessment were agreed, and it was also agreed that modelling assessments of construction phase discharges to the River Thames were not required.
EA	11 November 2019	Progress update on the Stage 2 groundwater modelling for the North Portal and Ramsar site. Preliminary findings were presented and the next steps for the assessment were agreed.
EA	16 December 2019	Workshop to discuss design options for crossing the West Tilbury Main watercourse and to present a preferred option, which is a 65m culvert. It was agreed this represents the least-worse option.
EA	13 January 2020	Meeting to discuss Stage 3 of the WFD Assessment. Project activities/works to be scoped in and taken forward to Stage 4 of the assessment were agreed.
EA	26 February 2020	Meeting to provide an update on progress to date on the FRA.
EA	20 February 2020	Interim Stage 4 WFD Assessment report issued, and comments on the report were received 27 March 2020. Details of the comments received and how they have been addressed are provided Appendix 14.7: Water Framework Directive Assessment (Application Document 6.3).

Stakeholder	Date of meeting / communication	Summary of discussions
EA and Natural England	12 March 2020	Meeting to discuss the South Portal and Thames Estuary and Marshes Ramsar site pumping tests and findings of a Project-wide cuttings and embankments assessment. The approach to assessing potential for effects on GWDTEs was agreed.
EA	8 April 2020	Progress update on Project GIs.
EA	29 April 2020	Meeting to provide an update on groundwater modelling assessments at the A122 Lower Thames Crossing/M25 junction and on the pollution potential of the proposed highway drainage infiltration basins to the south of the River Thames. The meeting was followed by issue of technical notes detailing these assessments, which were reviewed and accepted by the EA.
EA	18 May 2020	A progress update on the Mardyke and West Tilbury Main flood models, including the breach modelling at Tilbury, was presented.
EA	1 June 2020	Meeting to discuss progress of Project GIs to the south of the River Thames.
EA	10 and 14 July 2020	Meetings to provide a summary of the findings of the Mardyke and West Tilbury Main fluvial flood risk modelling and the River Thames defences breach modelling at Tilbury and Purfleet. Comments were provided by the EA which have subsequently been addressed in Appendix 14.6: Flood Risk Assessment (Application Document 6.3).
EA	16 September 2020	Initial enhanced pre-application advice meeting regarding requirements for the North Portal discharge. It was agreed that this discharge would be subject to an environmental permit.
EA	8 October 2020	EA meeting to discuss the potential withdrawal of maintenance of the existing defences at Coalhouse Point. At this meeting concerns were raised regarding the suitability of this land for use in providing new freshwater habitat. It was agreed that alternative options to deliver this mitigation would be investigated.
EA	13 October 2020	Meeting to discuss EA's feedback on their review of the FRA. Comments have been addressed within the finalised flood models and Appendix 14.6: Flood Risk Assessment (Application Document 6.3).
EA	16 October 2020	Meeting to discuss the FRA with EA Area Manager and agree a way forward for Development Consent Order (DCO) submission.
EA	2 November 2020	Follow up meeting – enhanced pre-application advice regarding the requirements for the North Portal discharge. Indicative discharge quality parameters were discussed.

Stakeholder	Date of meeting / communication	Summary of discussions
EA	3 November 2020	Initial pre-application advice meeting regarding requirements for the South Portal discharge. It was agreed at this meeting that the discharge would be subject to an environmental permit.
EA	16 December 2020	Follow-up meeting to discuss the potential withdrawal of EA maintenance of the existing flood defences at Coalhouse Point. The Project provided an update on the alternative options under consideration to deliver freshwater habitat reprovision, including land in the Mardyke catchment.
EA	4 February 2021	Meeting to discuss EA feedback on their sense check of the Mardyke flood model. This feedback has been incorporated into the final Mardyke flood model.
EA	5 March 2021	Meeting to discuss mitigation in the Mardyke catchment for freshwater habitat creation (replacing the Coalhouse Point site). It was agreed that the Project would investigate the potential for this to deliver multiple functions, including water vole habitat creation and floodplain compensation storage.
EA	18 March 2021	Meeting to discuss the West Tilbury Main and Mardyke flood modelling, including breach modelling. The next steps for model reviews and sign-off were agreed.
EA	29 June 2021	Modelling meeting with EA to provide design updates including proposed flood storage areas and culverts in the West Tilbury Main catchment, and to provide an update on the proposed freshwater habitat creation area in the Mardyke.
EA	6 July 2021	Meeting to present the M25 detailed groundwater modelling assessment. This assessment and its conclusions were accepted by the EA.
EA	5 August 2021	Meeting to provide an update on the proposed water vole mitigation and freshwater habitat creation in the Mardyke catchment. The EA agreed on the suitability of this site for providing the required mitigation.
EA	26 August 2021	Meeting to discuss Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3) and to brief new EA specialists on works carried out to date.
EA	07 September 2021	Meeting to receive EA feedback on Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3). Minor comments were received and have been addressed in the final version of the report.
EA	01 March 2022	Meeting to provide an update on the water and contamination assessments, including contaminant transport modelling of the East Tilbury Landfill, the Hydrogeological Risk Assessment, the FRA, and potential enhancements to the West Tilbury Main.

Stakeholder	Date of meeting / communication	Summary of discussions
EA	04 April 2022	Meeting to discuss the FRA report and to brief EA specialists on new works carried out since the last review of the report.
EA	14 June 2022	Meeting to discuss the Hydrogeological Risk Assessment report and to brief EA specialists on new works carried out since the last review of the report.
EA	27 June 2022	Meeting to discuss design changes affecting the West Tilbury Main watercourse and the enhancements proposed. EA commented that the Applicant's efforts to limit impacts and provide for compensation by improving other reaches of the watercourse are welcomed.
EA	30 August 2022	Received EA comments on Appendix 14.7: Water Framework Directive Assessment (Application Document 6.3). Comments reviewed and addressed in the final version of the report.
EA and Natural England	9 April 2020	Joint meeting to discuss the water balance sustaining the Thames Estuary and Marshes Ramsar site and the potential for ecological effects due to Project-induced changes in the groundwater regime. EA comments on the Stage 4 WFD Interim Report were also discussed.
EA and Natural England	1 June 2020	Meeting to discuss Project proposals for WFD marine habitat compensation. It was agreed, in principle, that providing marine compensatory habitat via a third-party delivery organisation would be acceptable.
EA and Natural England	8 June 2020	Meeting to discuss options for the disposal of surface water runoff from the southern tunnel entrance compound. It was agreed in principle that the Project's preferred option of discharging runoff to the River Thames via the Thames Estuary and Marshes Ramsar ditch network is a viable option subject to appropriate controls.
EA and Natural England	9 June 2020	Hydrogeological update south of the River Thames, providing the results of updated groundwater modelling studies of the ground protection tunnel and main tunnels, water balance of the Thames Estuary and Marshes Ramsar site, as well as an infiltration drainage pollution risk assessment.
EA and Natural England	9 June 2020	Meeting to discuss EA comments and Project responses on the Stage 4 WFD Assessment. Project responses were agreed, as detailed in Appendix 14.7: Water Framework Directive Assessment (Application Document 6.3).
EA and Natural England	2 July 2020	Meeting to discuss Project proposals for disposal of process water and runoff from the northern tunnel entrance compound, and for use of an existing jetty.

Stakeholder	Date of meeting / communication	Summary of discussions
EA and Natural England	14 July 2020	Hydrogeological update north of the River Thames, providing the results of updated groundwater modelling studies of the North Portal.
EA and Natural England	15 July 2020	Meeting to provide an update on the proposals to create freshwater habitat (for water vole mitigation and WFD compensation) at Coalhouse Fort.
EA and Natural England	03 March 2021	Meeting to discuss securing mechanisms within the Control Plan and for the South Portal discharge. Update provided on the Hydrogeological Risk Assessment.
Natural England	6 November 2019	Discussion on the approach to hydrogeological modelling at the North and South Portals and to provide an update on preliminary findings. The next steps for the assessment were agreed.
Kent County Council, London Borough of Havering, Gravesham Borough Council and Thurrock Council	July 2017	Meetings to present and agree the approach to assessing flood risk and key operational drainage principles within the administrative areas of the stakeholders. The outcomes of the meetings are documented in Appendix 14.6: Flood Risk Assessment - Part 7 (Application Document 6.3).
	21 April 2020 and 22 April 2020	Workshops to present preliminary information on the environmental effects of the Project and mitigation proposals.
London Borough of Havering	19 September 2019	Meeting to discuss operational drainage attenuation ponds on the M25. Design principles were agreed. Details are provided in Appendix 14.6: Flood Risk Assessment - Part 7 (Application Document 6.3).
Essex County Council	11 April 2019	Meeting to present the approach to assessing flood risk and to discuss consenting requirements regarding ordinary watercourse crossings and diversions. Overarching principles were agreed.
Essex County Council	4 September 2019	Meeting to discuss operational drainage retention basins and infiltration basins. Design principles were agreed. Details are provided in Appendix 14.6: Flood Risk Assessment - Part 7 (Application Document 6.3).
Essex County Council and Thurrock Council	23 June 2021	Meeting to further discuss the operational drainage design and compliance with the design and the principles set out in the Essex SuDS Design Guide (Essex County Council, 2020). Details are provided in Appendix 14.6: Flood Risk Assessment - Part 7 (Application Document 6.3).

Stakeholder	Date of meeting / communication	Summary of discussions
EA, Natural England, Kent County Council, London Borough of Havering, Gravesham Borough Council and Thurrock Council	25 January 2022	Meeting to discuss the proposed Tilbury Fields re-design
North Kent Marshes Internal Drainage Board	14 July 2020	Meeting to provide an overview of the Project's drainage strategy to the south of the River Thames. The strategy was agreed as being acceptable in principle.
Southern Water Services	11 April 2019	Meeting to discuss and agree principles for disposal of foul water arising from the Project to the sewer network, and regarding a clean water supply strategy in the Kent area. Discussions culminated in preparation of a feasibility study for diversions and temporary site compound connections.
Anglian Water Services	14 November 2017 21 June 2018 8 August 2018 21 January 2019 19 August 2019 10 October 2019	Meetings to discuss and agree principles for disposal of foul water arising from the Project in the Essex area to the sewer network. Discussions culminated in preparation of a feasibility study for diversions and temporary site compound connections.
Essex and Suffolk Water		Meetings regarding a clean water supply strategy. Discussions culminated in preparation of developer services applications, submitted in December 2019.

Study area

Construction

14.3.21 The study areas for the water environment are illustrated in Figure 14.1: Surface Water Receptors and Resources, and Figure 14.2: Groundwater Receptors and Resources (Application Document 6.2).

14.3.22 Study areas for field surveys, modelling and desk-based assessments were defined to reflect the surrounding water environment and after considering the distance over which significant effects can reasonably have the potential to occur. This approach was in line with DMRB LA 113 (Highways England, 2020a) and was agreed in consultation with the EA.

14.3.23 Desk studies collected data for water features within the Order Limits, as well as downstream reaches of the River Thames and the Mardyke and any other surface water body within 500m of the Order Limits. The groundwater desk study area included any receptor or resource within 3km of the Order Limits.

14.3.24 As part of the water features survey, surface water features (open bodies of water, surface water abstractions and discharges) within 500m of the Order Limits and groundwater features (including wells, boreholes and springs) within 1km of the Order Limits were visited. The study areas covered by the water features survey are presented in the figures provided in Appendix 14.2: Water Features Survey Factual Report (Application Document 6.3).

14.3.25 Flood modelling studies were carried out to define baseline information to inform the design and to quantify the flood risk impacts of the Project. Each model used a bespoke study area that was set in consultation with the EA. The watercourses modelled, and the extent of the model domains, are discussed and illustrated in Appendix 14.6: Flood Risk Assessment - Part 4 and Flood Risk Assessment - Part 5 (Application Document 6.3).

14.3.26 Groundwater modelling studies were carried out to assess the potential for changes to groundwater levels and flows near the Thames Estuary and Marshes Ramsar site (south of the River Thames and local to the North Portal), as well as local to the proposed cutting where the Project interfaces with the M25. The groundwater modelling assessment study areas are described in Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3).

14.3.27 The impacts of utilities diversions on groundwater levels and flows and groundwater quality (saline intrusion), have been assessed for all below-ground works, especially utilities corridors. The assessment does not include overhead electricity corridors, other than reference to pylon foundations. Further details are provided in Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3).

Operation

14.3.28 The study areas described for the construction phase assessments were also used for the operational phase assessments on flood risk and water environment resources and receptors.

14.3.29 The operational drainage pollution risk assessment study area was defined with reference to the user guidance accompanying the Highways England Water Risk Assessment Tool (HEWRAT; note National Highways was formerly known as Highways England) (Highways England, 2019a). Pollution risks to receiving watercourses and groundwater bodies have been assessed for drainage outfalls both individually and cumulatively, in accordance with the HEWRAT user guidance.

Impact assessment methodology

14.3.30 The assessment follows the general approach described in Chapter 4: EIA Methodology. This section provides topic-specific information regarding the methodology used for establishing the baseline conditions, and the methods used for the construction and operational phase assessments.

Method of establishing baseline conditions

Existing baseline

14.3.31 The existing baseline in relation to the water environment was established based on data collection, consultation, modelling studies and site surveys to gather data to characterise the existing qualities of the water environment.

Desk-based studies

14.3.32 A desk-based review of the following data sources was undertaken to determine baseline conditions across the Project study areas and to inform conceptual and numerical models of the water environment:

a. Information describing water management in the Shorne Marshes Royal Society for the Protection of Birds (RSPB) reserve, the Thames Estuary and Marshes Ramsar, and the South Thames Estuary and Marshes Site of Special Scientific Interest (SSSI), which includes plans illustrating key flow routes, directions and the locations of outfalls and water level management infrastructure (September 2017 and May 2018)

b. Water quality monitoring data records for the Mardyke, ditches at East Tilbury and the River Thames at Gravesend (EA, 2022)

c. ‘Catchment data explorer’ database of Cycle 2 and 3 WFD information (EA, 2020b)

d. EA groundwater level monitoring data records from observation boreholes (December 2017, June 2018, March 2020)

e. EA records of licensed surface and groundwater abstractions and consented discharges to surface water and ground (September 2017, January 2018, April 2020 and June 2022)

f. Bedrock and superficial aquifer designations, aquifer vulnerability to pollution and groundwater source protection zone (SPZ) mapping (EA, 2019c)

g. Bedrock and superficial aquifer designations, aquifer vulnerability to pollution and groundwater SPZ mapping from the Magic Map Application (Defra, 2022)

h. Shapefiles of groundwater SPZs (EA, 2020c)

i. EA historical rainfall and evaporation dataset from climatological stations near the Project (March 2020)

j. Abstraction rate data, well construction information and water quality data from the Linford public water supply well, operated by Essex and Suffolk Water (Northumbrian Water Limited, 2018)

k. EA flood data, including hydraulic models, and flood defence asset data (various dates 2018 and 2019)

l. Responses to water features survey questionnaires issued to landowners and tenants with a water interest (e.g. abstraction well, borehole, spring, consented discharge, pond or other water feature) (July and October 2019)

m. Groundwater flood maps from GeoSmart (2019), GW5

n. Information on the construction and management of the Thames and Medway Canal, provided by the Thames and Medway Canal Association (various dates 2018/2019)

o. EA Abstraction Licensing Strategies for Medway (EA, 2013a), and Roding, Beam, Ingrebourne and Mardyke (EA, 2019a)

p. EA Essex Groundwater Investigation Final Report: South Essex Catchments (Amec, 2016)

q. EA Report on Phase 2 (numerical modelling) of the North Kent Groundwater Modelling Project (Water Management Consultants, 2006)

r. Drainage Data Management System (DDMS) and as-built records for the A2, A13 and M25 characterising existing road drainage arrangements (September 2017)

Fieldwork

14.3.33 A water features survey was undertaken with the aim of identifying the presence, usage and existing characteristics of surface and groundwater resources. The field survey involved photographing features and making field notes and measurements of their physical qualities and water quality.

14.3.34 The survey collected data that was used to verify desk study information and inform the Environmental Permit applications for the GI works. Questionnaire responses from landowners were also collected to enhance the understanding of the water environment baseline. Further details of the survey are provided in Appendix 14.2: Water Features Survey Factual Report (Application Document 6.3).

14.3.35 A site walkover focusing on the River Thames southern frontage, the Thames and Medway Canal, and the ditch network on Filborough and Shorne Marshes, part of the Thames Estuary and Marshes Ramsar site, was undertaken in March 2019. The aim of the walkover was to collect information to aid in the understanding of factors that may affect the groundwater and surface water flow regimes at the designated site. The information collected included photographs and field notes describing features such as the tidal flap valve at the Denton New Cut outfall to the River Thames and sources of inflows and outflows to and from the Thames and Medway Canal. The outputs of the survey have been used to inform a conceptual site model (CSM) of the water balance of the designated site, as detailed in Section 14.4.

14.3.36 Water samples from a ditch bordering the Thames Estuary and Marshes Ramsar site, referred to as the western ditch, were collected and analysed to collect data to characterise its baseline water quality. Surveys were undertaken between November 2021 and June 2022 and the parameters measured were agreed with the EA and Natural England. The data is presented in Appendix 14.2: Water Features Survey Factual Report (Application Document 6.3).

14.3.37 A monthly visit has been undertaken to Manor Farm and its surrounds in North Ockendon from October 2021 to May 2022. During each visit observations of flow conditions in the ponds and ditch network that serve a landowner's irrigation system have been documented, together with a photographic record. Further information on the survey findings is provided in Appendix 14.2.

14.3.38 A programme of intrusive GI works was carried out in two phases to help develop the reference design, and where data has been available, support the core assessments of the effects of the Project on the water environment. Phase 1 completed between September 2017 and February 2018, and between September 2018 and January 2019, was focused on the alignment of the crossing and the areas surrounding the proposed North and South Portals.

14.3.39 Phase 2 of the GI was carried out between April 2019 and June 2020 and included investigations along the whole Project route, as well as further works in the North and South Portal areas. The Phase 2 GI works were split into the following packages:

a. Package A – covers the area of the Project route south of the River Thames. This includes the M2 at junction 1, the South Portal, and land north of the South Portal to the River Thames.

b. Package B – covers the area of the Project route immediately north of the River Thames, around the North Portal and north up to the Tilbury Loop railway line.

c. Package C – covers the area of the Project route from the Tilbury Loop railway line, northwards to the A13/A1089/A122 Lower Thames Crossing junction in Orsett Heath.

d. Package D – covers the area of the Project route from the A13/A1089/A122 Lower Thames Crossing junction in Orsett Heath to the M25, north of junction 29 in Great Warley.

e. Package E – covers the area of the Project route under the Gravesend Reach of the River Thames, between Tilbury and Gravesend. The Project route would be entirely in tunnel in this section.

14.3.40 The GI included borehole drilling, in situ hydraulic testing and groundwater level and quality monitoring. Constant-rate pumping tests were conducted in the Chalk aquifer near the South Portal (30-day duration) and in the Ramsar site (five-day duration), while water quality was monitored for the surface water bodies receiving pumping test discharges. Also, the end of the Phase 2 GI included a 30-day pumping test at the North Portal in May and June 2020.

14.3.41 Phase 3 of the GI, carried out between May 2020 and January 2021, was split into packages similar in geographical extent to those of the Phase 2 GI. The main purpose of the GI was to obtain further geotechnical information along the Project route.

14.3.42 To provide a robust understanding of the groundwater environment at the A122 Lower Thames Crossing/M25 junction, the Phase 2 GI data was supplemented by additional Phase 3 GI data, including supplementary exploratory holes; and groundwater monitoring standpipes were used to develop the detailed groundwater models and assessment of the A122 Lower Thames Crossing/M25 junction. Further detail is shown in Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3).

14.3.43 Whilst further field data included an additional pumping test completed at the North Portal as part of Phase 3 works, and a separate pumping test at the end of the Phase 2 GI, these were not used to further develop the North Portal groundwater model. The groundwater model prepared using the Phase 1 and Phase 2 GI data, comprising detailed geological logging, *in situ* permeability testing (packer tests) and continuous groundwater level monitoring at the North Portal, were sufficient to develop robust conclusions on the potential impacts to groundwater flows, levels and quality. The South Portal groundwater model, based on Phase 2 GI, including two pumping tests but importantly also the extensive logging and monitoring, is sufficient to develop robust conclusions on the potential impacts [18]unctiater flows, levels and quality.

14.3.44 Emerging GI data has been used to verify key modelling assumptions. Further details are provided in Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3).

14.3.45 Intrusive GI works will continue to progress beyond the submission of the DCO application. The data obtained will be used to support the development of the detailed design of the groundwater mitigation measures discussed in Section 14.5.

14.3.46 Topographical channel surveys of reaches of the Mardyke, Orsett Fen Sewer, Golden Bridge Sewer, Stringcock Sewer, Mardyke West Tributary and the West Tilbury Main watercourses were completed in November and December 2018 by Storm Geomatics, in accordance with the EA Standard Technical Specifications Version 3.2 (EA, 2013b). The data was used to develop flood models of the watercourses.

14.3.47 Visual inspections of existing EA assets were undertaken in 2019, including the Bowaters Sluice. Other flood defences on the Project route have been carried out to scope an asset condition monitoring programme. The monitoring will collect a robust pre-construction baseline dataset against which any impacts from the Project's construction phase can be monitored.

Modelling

Flood modelling

14.3.48 The flood flow regimes of key main river watercourses were modelled with the aims of:

a. generating data, for example flood levels and extents, to inform the design of the Project and ensure it is resilient to flooding

b. quantifying the impacts of the Project on flood risk to neighbouring land

c. informing the specification of flood risk mitigation measures such as compensatory floodplain storage provision

14.3.49 Models were developed of the West Tilbury Main, the Mardyke and the lower reaches of its tributaries, namely the Orsett Fen Sewer, Golden Bridge Sewer, Stringcock Sewer and Mardyke West Tributary. The findings of the topographical surveys of the channels described above, and key hydraulic structures, were used in the models' development. The data was used to build the flood models using the latest versions of Flood Modeller (1D) and TUFLOW (2D) software. Further details are provided in Appendix 14.6: Flood Risk Assessment - Part 4 and Flood Risk Assessment - Part 5 (Application Document 6.3).

14.3.50 Flood risk in the event of a breach or failure of the defences on the River Thames was also assessed by modelling. A hydrodynamic model was supplied by the EA, which was developed to inform the TE2100 Plan, as detailed in Appendix 14.6: Flood Risk Assessment - Part 5 (Application Document 6.3).

Hydrogeological modelling

14.3.51 Using results of the desk-based study and Gis, records of groundwater levels and interpretation of the pumping tests, the baseline hydrogeological conditions have been established in order to conduct subsequent modelling of drawdown potentially caused by the construction and operational phases, as well as the potential for increased saline intrusion.

14.3.52 A staged approach to modelling groundwater was adopted. Stage 1 used published data, and data obtained via the Phase 1 GI results. During Stage 2, the models were updated using additional available GI data. The Stage 3 models were refined using all available data from the Phase 2 GI. Further details are provided in Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3).

14.3.53 Groundwater modelling was also undertaken of the proposed North Portal using a Modflow finite difference, three-dimensional, numerical model. Baseline groundwater levels, flow pathways and saline intrusion were modelled.

14.3.54 Modflow was also used to assess the baseline groundwater conditions at the A122 Lower Thames Crossing/M25 junction. The model was developed using available GI and groundwater data to determine hydrogeological boundaries, spatial variation of superficial aquifer units and estimates of groundwater levels and groundwater flows.

14.3.55 Assessment of the potential mobilisation of contaminants from landfills, including the East Tilbury landfill, during the construction dewatering of the North Portal, is described in Chapter 10: Geology and Soils (Application Document 6.1).

Water quality

14.3.56 Published data from EA water quality monitoring sites and the Thames RBMP (Defra and EA, 2018), as well as data collected during the Project GI, water features survey and ecology surveys were used to characterise the baseline water quality of surface waters within the study area. The baseline data subsequently informed pollution risk assessments for routine operational road drainage and accidental spillages. These assessments were completed using the HEWRAT and the Metal Bioavailability Assessment Tool (M-BAT) (WFD-UKTAG, 2014b) to quantify the effects on receiving surface water bodies. To the south of the River Thames and north of the Thames at the A13 junction, where infiltration drainage solutions are proposed, ConSim modelling (Golder Associates, 2018) was used to assess baseline groundwater quality near proposed highway drainage infiltration basins.

Future baseline ('Without Scheme' scenario)

14.3.57 Existing environmental conditions are expected to be subject to change in future years. Future baseline conditions with regard to water quality and flood risk in the absence of the Project, relevant to the opening year, have been forecast by taking into consideration legislative and policy drivers and environmental trends, including the predicted effects of climate change.

14.3.58 Groundwater level estimates are expected to be subject to change in future years and this is assessed in Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3). Factors such as the predicted effects of climate change, where relevant, changing regional groundwater abstraction volumes, changing recharge patterns, groundwater level rebound after significant historical abstractions and River Thames water level rise have been considered.

Method of assessment – construction

14.3.59 Construction activities could cause adverse water quality impacts from release of potential contaminants, such as runoff containing silt, cements and hydrocarbons. Construction could also disturb and mobilise ground contaminants, alter existing catchment hydrology/hydromorphology, and impact flood risk, groundwater level and flow regimes, and GWDTE. Watercourses and other water sources (rainfall, groundwater) could also cause a risk of flooding to construction compounds, haul routes and worksites.

14.3.60 For an impact on a receptor to occur, both a source and a pathway need to be present. DMRB LA 113 (Highways England, 2020a) provides methods for the simple and more detailed assessment of the effects of construction of road schemes, considering five principal topics. DMRB LA 113 also advocates following the guidance within CIRIA report C648 (CIRIA, 2006) for the assessment of construction impacts. Table 14.2 summarises the methods adopted from DMRB LA 113 and where the results of the assessments are reported.

14.3.61 The potential for mobilisation of landfill contaminants is assessed in Chapter 10 Geology and Soils.

Method of assessment – operation

14.3.62 Assessment of the operational phase of the Project requires consideration of the potential for impacts to surface water and groundwater quality, water levels and flows, hydrology and hydraulics. Table 14.2 summarises the DMRB LA 113 (Highways England, 2020a) methods adopted in the operational assessment.

Table 14.2 Summary of assessment methodologies

Potential impact	DMRB LA 113 level of assessment	Project phase and assessment description	Cross-reference
Groundwater levels and flows	Simple/ detailed	Construction and operation: Simple, spreadsheet, risk assessment for proposed highway cuttings and embankments and below-ground utilities works. Simple (semi-quantitative) CSM and water balance study of the Thames Estuary and Marshes Ramsar site and South Thames Estuary and Marshes SSSI, within the Order Limits. Detailed assessment by groundwater flow modelling, of proposed ground protection tunnel and main tunnels to assess any potential impacts to the Thames Estuary and Marshes Ramsar site and South Thames Estuary and Marshes SSSI, within the Order Limits. Conceptual and detailed numerical groundwater modelling local to the North Portal of the tunnel. Conceptual and detailed numerical groundwater modelling local to the A122 Lower Thames Crossing/M25 junction.	Section 14.6 and Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3)
Groundwater quality	Simple	<u>Construction:</u> Utilities <u>Operation:</u> Pollution risk assessment (routine runoff and spillage risk) of infiltration basins (soakaways) using HEWRAT Utilities	Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3) Section 14.6 and Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3) Appendix 14.5: Hydrogeological Risk Assessment
Groundwater quality	Detailed	Construction and operation: Modelling of the potential movement of the saline/ freshwater boundary in the Chalk aquifer connected to the River Thames. Operation:	Section 14.6 and Appendix 14.5: Hydrogeological Risk Assessment

Potential impact	DMRB LA 113 level of assessment	Project phase and assessment description	Cross-reference
		Infiltration basin pollution risk assessments using ConSim v2.5 (Golder Associates, 2018).	(Application Document 6.3)
		Construction: CSMs of credible sources of contamination migration local to the North Portal. Potential mobilisation (particle tracking – Modpath) of contaminants from the western boundary of the East Tilbury Landfill during dewatering activities local to the North Portal.	Chapter 10: Geology and Soils and Appendix 10.6: Preliminary Risk Assessment Report (Application Document 6.1 and 6.3 respectively)
		Qualitative assessment of contamination risks linked to the Ockendon Landfill site.	
GWDTEs	Simple/ detailed	Construction and operation: Simple assessment referencing DMRB LA 113 Appendix B (Highways England, 2020a), informed by ecology surveys (Phase 1 habitat and National Vegetation Classification (NVC) surveys), where relevant, groundwater CSMs and groundwater numerical modelling (A122 Lower Thames Crossing/M25 junction).	Section 14.6 and Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3)
Surface water quality	Simple/ detailed	Operation: Pollution risk assessments (routine runoff and spillage risk) using HEWRAT and M-BAT.	Section 14.6 and Appendix 14.3: Operational Surface Water Drainage Pollution Risk (Application Document 6.3)
Hydromorph-ology	Simple	Operation: Desk study guided by Appendix E of DMRB LA 113 (Highways England, 2020a).	Section 14.6 and Appendix 14.4: Hydromorphology Assessment (Application Document 6.3)

Potential impact	DMRB LA 113 level of assessment	Project phase and assessment description	Cross-reference
Flood impacts to and resulting from the Project	Detailed	Construction and operation: Hydraulic and hydrological modelling of the West Tilbury Main, Mardyke and tributaries, and Thames defence breach.	Section 14.6 and Appendix 14.6: Flood Risk Assessment (Application Document 6.3)

14.3.63 Transport modelling data, specifically annual average daily traffic and Heavy Goods Vehicles data for the design year of the Project, has been used to inform the assessment of operational drainage discharges on receiving surface and groundwater quality. This information, in the form of number of vehicles per 24 hours along relevant links, has been extracted from the operational traffic model (simulation reference ID: LR_CS67 2045, dated May 2022) which is representative of predicted traffic flows in the year 2045, when the Project would be operational. Further information can be found in Appendix 14.3: Operational Surface Water Drainage Pollution Risk Assessment and Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3).

14.3.64 A WFD assessment has also been carried out and is presented in Appendix 14.7: Water Framework Directive Assessment (Application Document 6.3). Its objective is to establish the nature and anticipated magnitude of the impacts of the Project on the WFD quality elements of relevant surface water and groundwater bodies, and any dependent designated sites. For surface water bodies, it has assessed biological, hydromorphological and physicochemical quality elements. For groundwater bodies, quantitative and chemical quality elements have been considered. The assessment presents conclusions regarding the potential for deterioration of current water body status and the prevention of achieving water body status objectives, and the results have informed the assessments and conclusions presented in Section 14.6 and Section 14.9 of this chapter.

Determining significance of effects

14.3.65 As described in Chapter 4: EIA Methodology the significance of environmental effects was determined by considering the value (sensitivity) of the receptor and the magnitude of impact.

14.3.66 As set out in Table 3.69 in DMRB LA 113 (Highways England, 2020a), assessments of the potential effects of road projects should consider, where present, watercourses, floodplains, estuaries, groundwater, lakes/ponds and canals. The functions of these features to support water supplies, dilute and remove waste effluents, convey and store water, support biodiversity and recreational activities, and add value to the economy, should all be considered.

14.3.67 The following paragraphs set out the value (sensitivity) and impact magnitude criteria used in this assessment, based on guidance provided in DMRB LA 113 (Highways England, 2020a). Significance of effect was then determined using the matrix approach shown in Table 4.3 of Chapter 4: EIA Methodology (Application Document 6.1).

14.3.68 The assessment of significance undertaken in this chapter is used as the basis for identifying effects which are considered significant in the context of the EIA Regulations.

Defining the value/sensitivity of resources and/or receptors

14.3.69 The value (sensitivity) of the identified receptors/resources was determined using the criteria shown in Table 1.1 in Appendix 14.1: Assessment Criteria Tables (Application Document 6.3), which reproduces Table 3.70 of DMRB LA 113 (Highways England, 2020a), with the addition of criteria for hydromorphology drawn from published literature (Northern Ireland Environment Agency, 2014).

Defining impact magnitude

14.3.70 The magnitude of impacts on receptors/resources was determined using the criteria outlined in Table 1.2 in Appendix 14.1: Assessment Criteria Tables (Application Document 6.3), which reproduces Table 3.71 of DMRB LA 113 (Highways England, 2020a), with the addition of criteria for hydromorphology drawn from published literature (Northern Ireland Environment Agency, 2014).

Determining significance

14.3.71 Significance of effect was then determined using a matrix approach. For all water environment receptors other than GWDTEs, the matrix shown in Table 4.3 of Chapter 4: EIA Methodology (Application Document 6.1) has been applied. Effects can be either beneficial or adverse. Where an impact magnitude is no change, its overall significance of effect is classified as neutral, no matter the sensitivity of the receptor.

14.3.72 A separate risk matrix, applied to the assessment of effects on GWDTEs only, is provided in Table B.4 of DMRB LA 113 (Highways England, 2020a), which is reproduced as Table 14.3.This risk matrix is used, as detailed in Section B6 of DMRB LA 113 (Highways England, 2020a), to determine if a more detailed assessment and characterisation of a GWDTE is necessary to develop more appropriate and robust mitigation measures.

14.3.73 Professional judgement has been used when assigning overall significance where there is a choice, with adherence to the precautionary principle. Overall effects of moderate, large and very large significance are considered to be significant in the context of the EIA Regulations.

Table 14.3 Risk matrix for effects on GWDTEs

		Magnitude of impact			
		Negligible	**Minor**	**Moderate**	**Major**
Importance	**High**	Negligible risk	Moderate risk	Significant risk	Significant risk
	Moderate	Negligible risk	Moderate risk	Moderate risk	Significant risk
	Low	Negligible risk	Negligible risk	Negligible risk	Moderate risk

Assumptions and limitations

14.3.74 General assumptions used throughout the Environmental Statement, and limitations affecting the assessments are set out in Chapter 4: EIA Methodology. Relevant assumptions and any other limitations encountered during the water environment assessments are as described below. Acknowledging the assumptions and limitations identified below and in Chapter 4: EIA Methodology, the Environmental Statement is considered robust and in line with relevant legislation, policy and guidance.

14.3.75 Data to characterise existing water features within the study areas has been collected from desk-based sources, including EA and British Geological Survey (BGS) datasets, and using responses from landowner questionnaires. Where land access was available, water features have also been surveyed in the field, resulting in a robust baseline understanding.

14.3.76 The assessment of the effects of the Project on groundwater flow and level regimes has used data from a range of sources, including available Project GI data, historical data and GI reports, EA groundwater modelling reports and Project bespoke groundwater modelling. In the groundwater models developed to assess the Project, key model parameters have been tested within realistic ranges to gauge the sensitivity of the model's impact predictions. Design scenarios have also been assessed to account for a reasonable worst case for dewatering requirements. For example, at the North Portal the maximum excavation footprint, within the LOD, was represented within the groundwater numerical models. Further details are provided in the technical annexes that support Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3). Intrusive GI works will continue to progress beyond the submission of the DCO application. The data obtained will be used to support the development of the detailed design of the Project and verify modelling assumptions used in the worst-case scenario.

14.3.77 The FRA has assumed an operational life of 100 years, with climate change allowances in line with EA guidelines, published in July 2021, (EA, 2021) applied for this time horizon.

14.3.78 To ensure the Project is safe from flooding over its design life, flood protection measures have been designed to the following standards:

a. Highways: 1 in 200-year tidal event plus a climate change allowance over 100 years in addition to a freeboard of 600mm.

b. Tunnel and tunnel portal: 1 in 1,000-year event plus a climate change allowance over 100 years in addition to a freeboard of 1,000mm.

c. Highway drainage design: In accordance with DMRB standard CG 501 (Highways England, 2020d), the drainage design includes an uplift allowance of 20% on peak rainfall intensity during a 1 in 100-year storm event for carriageway drainage, with sensitivity checks on retention and infiltration basin designs undertaken for a 1 in 100-year plus 40% storm event.

d. Highway drainage design: In accordance with DMRB standard CG 501 (Highways England, 2020d), the drainage design will prevent any flooding beyond the highway boundary during flood events up to and including the 1 in 100-year storm event, including an allowance for climate change.

14.3.79 Where existing culverts would be affected by the Project, for example on the Chadwell St Mary link, the DDMS has been reviewed to collect information about their structural form and condition. It has been assumed the Project would replace affected culverts using culverts of suitable form and capacity, as secured by commitment Road Drainage and the Water Environment (RDWE013 in the Register of Environmental Actions and Commitments (REAC) that forms part of Appendix 2.2: Code of Construction Practice, First iteration of Environmental Management Plan (Application Document 6.3). The Code of Construction Practice is abbreviated as the CoCP.

14.3.80 The DCO application has been developed on the basis of a 2030 opening year. This assumes consent is granted in 2024. Following the DCO Grant there would be preparatory works, referred to in the draft DCO as preliminary works taking place in 2024. The main construction period for the Lower Thames Crossing would start in early 2025, with the road being open for traffic in late 2030. Construction may take approximately six years, but as with all large projects there is a level of uncertainty over the construction programme, which will be refined once contractors are appointed and as the detailed design is developed. The 2030 opening year has been selected as the basis for the assessments and is representative of the reasonable worst-case scenario. This has been used consistently across the environmental assessments, transport assessments and the economic appraisal of the Project.

Nitrogen deposition compensation sites

14.3.81 The DCO Application Documents identify the locations of habitat creation sites proposed to provide compensation for the effects of nitrogen deposition. The design and management regimes for these locations will be developed as part of the detailed design, in accordance with control plan documents that include the Outline Landscape and Ecology Management Plan (oLEMP) (Application Document 6.7), Design Principles (Application Document 7.5) and ES Figure 2.4: Environmental Masterplan (Application Document 6.2).

14.3.82 The environmental assessment of these habitat creation areas has reflected a reasonable worst case, for both construction and operational phases. This is described in Chapter 2: Project Description. The following assumptions have been made in the assessment of water environment effects associated with the nitrogen compensation areas:

a. Existing watercourses flowing through or bordering these habitat creation areas would not be physically disturbed during construction or operational phases of the Project, and their current riparian corridors would be retained.

b. Any ponds, other waterbodies or areas of wetland vegetation within the habitat creation sites would also be retained.

c. During the management of vegetation and landform, the Project would reduce release of diffuse (rural) sources of pollution such as nitrate (fertilisers) and pesticides (including herbicides), to prevent groundwater pollution as set out in the Environment Agency's approach to groundwater protection (EA, 2018c) and to avoid surface water pollution. Further, for any habitat creation site that coincides wholly or partly with a SPZ1, the Contractor would agree any necessary measures with the EA to ensure that no site activities within the SPZ1 would present a hazard to drinking water sources.

14.4 Baseline conditions

Existing baseline

14.4.1 The baseline conditions for the water environment study areas are described from south to north.

Surface water features

14.4.2 The study area and surface water features in this area are illustrated in Figure 14.1: Surface Water Receptors and Resources (Application Document 6.2).

14.4.3 To the south of the River Thames, in the section of the Project between the A2 and the South Portal, and at the habitat creation area at Westfield Sole, there are few surface water features. Some ponds and a stream flow through Shorne Woods and there are also dry valleys in this location.

14.4.4 Moving north, the Project crosses beneath the South Thames Estuary and Marshes SSSI, Shorne Marshes RSPB reserve and the Thames Estuary and Marshes Ramsar site. These areas are drained by a network of main rivers and ordinary watercourses, which ultimately discharge to the River Thames via the Denton New Cut which has a flapped outfall to the Thames.

14.4.5 From site observation, the watercourses draining through the designated sites, which have a flat topography, range between 2m and 4m in width. They have vegetated banks (grass, reeds), a silty bed load, and a water level/flow regime that is managed. Further baseline information is provided in Appendix 14.2: Water Features Survey Factual Report (Application Document 6.3).

14.4.6 The Thames and Medway Canal is located in this area. The canal, originally built in the 1800s, is partially infilled and now runs from Gravesend to Higham. Its tow path is used by pedestrians and cyclists.

14.4.7 The Project road would cross beneath the River Thames, which is tidally dominated. Approximately 7.5km upstream of the proposed tunnel location, a reach of the river is designated in the Swanscombe Marine Conservation Zone, illustrated in Figure 9.1 (Application Document 6.2), which aims to protect a geographically restricted but important population of tentacled lagoon-worm *Alkmaria romijni*. The zone stretches from the Queen Elizabeth II Bridge to Columbia Wharf in Grays. Salinity conditions are such that the water becomes increasing saline downstream of Gravesend, and within the study area the river constitutes a major shipping route for commercial and leisure craft.

14.4.8 To the north of the River Thames there are several hydrological catchments. Local to the North Portal, the West Tilbury Main and numerous ordinary watercourses drain the West and East Tilbury Marshes, both of which lie within the defended River Thames floodplain. During site walkover surveys conducted in September 2017, July 2018 and May 2022, several of these drains were observed to be dry (Appendix 14.2: Water Features Survey Factual Report, Application Document 6.3). There is a groundwater-fed pond which is understood to be used by the landowner to provide a storage reservoir for groundwater used in spray irrigation. The other surface water catchment is drained by the Gobions Sewer, a watercourse that rises to the west of Linford. The watercourse is designated as a main river from just upstream of its crossing of East Tilbury Road to its point of discharge to the Thames Estuary.

14.4.9 Further north, the primary surface water features are the Mardyke and its tributaries including the Orsett Fen Sewer, Golden Bridge Sewer, Stringcock Sewer and Mardyke West. The Mardyke drains a total catchment area of 90km^2, rising in Holden’s Wood between Great Warley and Little Warley and flowing approximately 18km to discharge into the River Thames via a flapped outfall at Purfleet. A very small part of the study area, near the M25 in North Ockendon, is located within the headwaters of the River Ingrebourne. In this location, there are also a number of recreational lakes located at the Stubbers Adventure Centre, and a reservoir that serves an agricultural irrigation system.

Groundwater features

14.4.10 The study area and groundwater features are illustrated in Figure 14.2: Groundwater Receptors and Resources (Application Document 6.2). The distribution of geological units is mapped and their lithologies described in Chapter 10: Geology and Soils. The extent of hydrogeological units (outcrop or sub-outcrop of superficial and bedrock aquifers respectively) is shown in Figure 14.3 and Figure 14.4 (Application Document 6.2). Further details about all hydrogeological units, aquifer designations and properties are presented in Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3).

14.4.11 The Chalk is the dominant groundwater-bearing stratum south of the River Thames and crops out on the North Downs, the chalk hills that lie south of London (herein referred to as the chalk hills within the study area). A wide, patchy outcrop of Palaeogene sands and clays mantle the top of the North Downs but are expected to be largely under-drained and may have perched water levels.

14.4.12 South of the River Thames, the Chalk is an important aquifer due to significant abstraction for public water supplies. Wetlands of the Kent marshes that fringe the River Thames, including the Medway Estuary and Marshes Ramsar site, are influenced by freshwater flows and may be vulnerable to groundwater abstraction (EA, 2013a). Fracture flow is the dominant groundwater flow mechanism. The Chalk aquifer is unconfined on the North Downs. It is widely accepted that the most productive fractures are found in the upper sections of the aquifer. Most groundwater flow tends to be concentrated in a few, large, solution-enhanced fractures. These are typically associated with current or geologically past (periglacial) water table elevations or layering (bedding) within the Chalk (BGS, 2008). Chalk rock enhanced fissure flow is associated with specific stratigraphical horizons in southern England. These include the Belle Tout Beds. Structure (faults and discontinuities) may also be important.

14.4.13 Dry valleys form the characteristic landscape of the North Downs. The valley network within the North Downs appears to be controlled by structure, and along the valley floors, transmissivity and storage can be high (BGS and EA, 1997).

14.4.14 North of the River Thames, the Chalk aquifer is covered by superficial deposits and/or other bedrock. Where confined, the Chalk aquifer typically has a lower transmissivity due to fewer fractures and less circulation of groundwater in the geological past.

14.4.15 Other hydrogeological units occur in the study area and are summarised in Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3). The main superficial aquifer, north of the River Thames, comprises the Essex Gravels (various River Terrace Deposits).

Water quality

Surface water quality

14.4.16 Surface water quality has been defined using available data records supplied by the EA, in addition to field sampling of pH, temperature and electrical conductivity, carried out in September 2017, July 2018 and July 2019 during the water features survey and during ecology surveys of watercourses on Tilbury Marshes in spring 2022. Additional water quality data was also collected during the Project's GI and during a focused survey of key ditches within the Thames Estuary and Marshes Ramsar that commenced in November 2021 and collected data monthly to June 2022. Requests for water quality data records specific to the watercourses flowing through the Shorne Marshes RSPB reserve and the Thames Estuary and Marshes Ramsar site were also made to the RSPB and Natural England. The information collected is presented in Appendix 14.2: Water Features Survey Factual Report (Application Document 6.3).

South of the River Thames

14.4.17 No data records were available from the EA, RSPB or Natural England for watercourses south of the River Thames, and none of these are defined WFD water bodies within the Thames RBMP.

14.4.18 The field data recorded pH ranging from 7 to 9 and temperatures from 3°C to 28°C, from samples of water in the ditch network draining the designated sites. Electrical conductivity was recorded generally in the range of 455µS/cm to 2,713µS/cm. However at some sites, for example, on the western ditch downstream of the Thames Medway Canal, higher values were recorded, indicative of increased salinity. The field data has been included in full in Appendix 14.2: Water Features Survey Factual Report (Application Document 6.3).

The River Thames

14.4.19 The River Thames salinity, based on published EA data from a monitoring site at Gravesend recorded monthly between April 2018 and January 2019, varies between 7.0 parts per thousand (ppt) and a maximum of 23.4ppt. This is equivalent to brackish to saline water. The salinity recorded ranged between 20% and 67% of the salinity of sea water. This is equivalent to a calculated chloride concentration of approximately 3,900mg/l to 12,950mg/l. Salinity concentrations appear to vary seasonally, with the EA data showing generally higher salinity values during summer months. This is discussed in more detail, in relation to potential saline intrusion of groundwater, in Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3).

14.4.20 The River Thames is designated as a number of water bodies within the Thames RBMP. The Thames Middle water body flows through the study area and achieves a chemical status of Fail, attributed to exceedance of target concentrations of several priority hazardous substances, including mercury and its compounds, benzo(g-h-i)perylene, benzo(k)fluoranthene, polybrominated diphenyl ethers and tributyltin compounds. Further baseline water quality for the River Thames is provided in Chapter 9: Marine Biodiversity.

North of the River Thames

14.4.21 Available EA data for monitoring sites to the north of the River Thames is summarised in Table 14.4. The monitoring points are illustrated in Figure 14.1: Surface Water Receptors and Resources (Application Document 6.2).

Table 14.4 Existing surface water quality – EA monitoring records

<table>
<tr><th>Water body and sampling location</th><th>Period of record</th><th>Parameters sampled</th></tr>
<tr><td>Mardyke West upstream of Upminster Sewage Treatment Works*</td><td>2000–2011</td><td>Temperature, conductivity, Biological Oxygen Demand, Chemical Oxygen Demand, ammoniacal nitrogen, nitrogen (total oxidised), nitrate, nitrite, suspended solids, silica, chloride, orthophosphate, dissolved oxygen</td></tr>
<tr><td>Mardyke West at Fen Lane</td><td>2000–2022</td><td rowspan="2">pH, temperature, ammoniacal nitrogen, nitrogen (Total N), nitrite, nitrate, ammonia, orthophosphate, dissolved oxygen</td></tr>
<tr><td>Mardyke East at Harrow Inn</td><td>2000–2020</td></tr>
<tr><td>Mardyke at Grange Farm Access Road*</td><td>2000–2004</td><td>pH, conductivity, turbidity, temperature, Biological Oxygen Demand, nitrate, nitrite, ammoniacal nitrogen, nitrogen (Total N), chloride, orthophosphate, dissolved oxygen</td></tr>
<tr><td>Mardyke at Stifford Bridge</td><td>2000–2022</td><td>Full suite of WFD priority substances.</td></tr>
<tr><td>West Tilbury Main system at three locations*</td><td>2000–2006</td><td>pH, temperature, conductivity, ammoniacal nitrogen, nitrate, nitrite, nitrogen (Total N),</td></tr>
</table>

Water body and sampling location	Period of record	Parameters sampled
Mucking Marshes at Railway Culvert*	2000–2008	suspended solids, orthophosphate, polychlorinated biphenyls, metals (copper, zinc, nickel, iron), Dissolved Organic Carbon, dissolved oxygen
**water monitoring station now closed*		

14.4.22 Available data for the Mardyke indicates that the watercourse can experience low dissolved oxygen concentrations, elevated Biological Oxygen Demand and high nutrient, in particular phosphate, concentrations. WFD-specific pollutants are recorded in concentrations that are indicative of no or very limited deviation from ‘natural’ conditions, and there are no known discharges of WFD priority substances to the watercourse, as evidenced by the data records at the Stifford Bridge monitoring site. However, the most recent data indicates issues with concentrations of three WFD priority hazardous substances, detailed below.

14.4.23 EA data for the West Tilbury Main system indicates the presence of several contaminants such as ammoniacal nitrogen, boron, chromium, mercury, zinc, vanadium and orthophosphate.

14.4.24 The Mardyke, and its east and west branches are all designated WFD surface water bodies, and their current status is detailed in Appendix 14.7: Water Framework Directive Assessment (Application Document 6.3) and illustrated in Figure 14.5 (Application Document 6.2). As shown, all these water bodies achieve moderate overall status and are designated as heavily modified. The overall status of the Mardyke, Mardyke East Tributary and Mardyke West Tributary have improved from poor in cycle 1 (2009). However, all three water bodies have experienced a deterioration in chemical status. The data from 2019 indicates failures based on exceedances of concentrations of three priority hazardous substances, namely mercury, perfluorooctane sulphonate and polybrominated diphenyl ethers. The latter two are used as fabric protectors and fire retardants and may be released into the environment via landfill sites. The reasons for not achieving good status are reported in the RBMP as point sources of pollution (sewage discharges) and land drainage.

14.4.25 The overarching objective for these watercourses described in the RBMP is for no deterioration of their cycle 2 status. No measures are in place, or proposed in the current RBMP cycle, to contribute to improving water body status. However, the South Essex Catchment Partnership has a master plan for restoration of the Lower Mardyke. Proposals are to improve 1km of the Mardyke by creating new berms to form a narrower river channel with faster flow, exposing river gravels and creating new breaches/channels to enhance and restore 20 hectares of riparian habitat.

14.4.26 The drains flowing through the west and east Tilbury Marshes were sampled during field surveys, most recently in spring 2022, and recorded pH ranging from 7.2 to 8.5, with a typical temperature between 10°C and 14°C. In most samples, electrical conductivity was recorded in the range of 2,020µS/cm to 4,555µS/cm. However, several samples recorded electrical conductivity values exceeding 10,000µS/cm, potentially indicating influence/interaction between some of the drains and the tidal River Thames or interaction with landfill leachate.

14.4.27 Data collected from the Mardyke and its tributaries indicated a range of pH of 7 to 8 and temperature range of 13°C to 15°C. Recorded electrical conductivity values ranged between 728µS/cm and 1,095µS/cm. The full set of field data for surface water quality has been provided in Appendix 14.2: Water Features Survey Factual Report (Application Document 6.3), and further discussion of water quality local to the North Portal is provided in Chapter 10: Geology and Soils. Further information on freshwater ecology is provided in Appendix 8.4: Freshwater Ecology (Application Document 6.3).

Groundwater quality

Aquifer vulnerability

14.4.28 The vulnerability to aquifer pollution from point contaminative sources (petrol filling stations, landfills and historical contaminative land uses) is discussed in Chapter 10: Geology and Soils. Regional contamination issues, including from widespread agricultural practices (usually above-ground, diffuse surface sources) and salinity (seawater ingress at coastal or tidal river margins), are discussed in this chapter.

14.4.29 Within the Order Limits, Principal aquifers of highest vulnerability comprise the unconfined Chalk aquifer where there is permeable soil or no cover. A shallow water table increases vulnerability, as do fractures, since pollution can potentially enter the water table more rapidly.

Saline intrusion

14.4.30 Saline intrusion of the Chalk aquifer has historically been caused by water from the tidal River Thames entering the aquifer. Low groundwater levels, lowered by man-made abstraction, relative to river water levels, increased the phenomenon around the river in the last century (EA, 2018a).

14.4.31 Restrictions to licensed abstraction are required in some areas of the North Kent Medway Chalk due to the potential for saline intrusion (EA, 2013a).

14.4.32 Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3) shows the historical chloride contours for the Chalk aquifer (Institute of Geological Sciences, 1968). Saline intrusion on the south side of the River Thames is shown as being close to the Thames boundary. Historical concentrations in the Thames Estuary and Marshes Ramsar site, within the Order Limits, are 100mg/l to 25mg/l of chloride, reducing southwards. East of the Order Limits, the historical mapping shows higher concentrations, of greater than 500mg/l of chloride.

14.4.33 North of the River Thames, historical chloride contours within the Order Limits are 1,000mg/l to 50mg/l of chloride, reducing northwards (Institute of Geological Sciences,1968).

14.4.34 Baseline groundwater quality monitoring data was assessed across several locations during Phase 1 and 2 Gis. A full description of the locations and the findings of the monitoring is presented in Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3).

14.4.35 Phase 1 and 2 GI monitoring completed to the south of the River Thames shows fresh to brackish Chalk aquifer groundwater beneath the Thames Estuary and Marshes Ramsar site. Concentrations vary spatially and with time. All groundwater samples have a lower chloride concentration than the calculated chloride content of the River Thames (using salinity data from water quality monitoring data records (EA, 2020b)). In addition, the maximum and average chloride concentrations are greater than the 1968 historical Chalk aquifer values presented in Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3), beneath the areas of the Thames Estuary and Marshes Ramsar site that fall within the Order Limits. Uphill of the Ramsar site, consistently lower chloride concentrations of approximately 50mg/l or less have been monitored in the Chalk aquifer.

14.4.36 Groundwater quality monitoring completed to the north of the River Thames, in the Tilbury Marsh area, shows that all Chalk aquifer groundwater has a lower chloride concentration than that calculated for the River Thames. In addition, data shows generally higher chloride concentrations than the 1968 historical chloride contours. The cause may be related to increased saline intrusion and/or influence from local landfills. Landfills are discussed in Chapter 10: Geology and Soils.

Groundwater quality types

14.4.37 South of the River Thames, two distinct water types are evident. In the unconfined Chalk aquifer, calcium bicarbonate water is present, typical of recently recharged water. The confined Chalk aquifer water, beneath the Alluvium at the Thames Estuary and Marshes Ramsar site, is sodium chloride water, likely to be reflecting saline intrusion effects from the River Thames.

14.4.38 North of the River Thames, in the Tilbury Marsh area, the Project GI data shows a sodium chloride water type. This reflects saline intrusion of the confined Chalk aquifer. Man-made influence, including landfill leachate migration, may be a factor too (Chapter 10: Geology and Soils). A different water type is shown at the Linford public water supply well, located 2km further north, as this is a calcium bicarbonate type, typical of freshly recharged water (assessed using water data from Northumbrian Water Limited (2018)).

WFD groundwater bodies

14.4.39 The WFD designated groundwater bodies and their water quality status (defined using the most recently published 2019 dataset) are shown in Figure 14.6 (Application Document 6.2) and summarised in Table 14.5. Further details are provided in Appendix 14.7: Water Framework Directive Assessment (Application Document 6.3).

Table 14.5 WFD groundwater status

Water body (WFD ID)	Cycle 2 (2019) water body classification
North Kent Medway Chalk (GB40602G401000)	Overall status: Poor Quantitative: Poor Chemical: Poor
Essex Gravels (GB40503G000400)	Overall status: Poor Quantitative: Good

Water body (WFD ID)	Cycle 2 (2019) water body classification
	Chemical: Poor
Essex South Lower London Tertiaries (GB40602G401000)	Overall status: Good Quantitative: Good Chemical: Good
South Essex Thurrock Chalk (GB40601G401100)	Overall status: Poor Quantitative: Poor Chemical: Poor

14.4.40 The North Kent Medway Chalk is an unconfined aquifer and is vulnerable to man-made pollution (aquifer vulnerability is discussed above). Past widespread agricultural application of fertilisers has contributed to high nitrate concentrations in groundwater (BGS and EA, 2003). Nitrate vulnerable zones (NVZs) have been established by the EA on the North Downs and are shown on Figure 14.6: Water Framework Directive - Groundwater Bodies and Current Status (Application Document 6.2). Those within the study area are the North Kent groundwater NVZ.

14.4.41 Baseline nitrate concentrations in the Chalk aquifer, south of the River Thames, including near the Thames Estuary and Marshes Ramsar site, are shown in Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3). This is based on Phase 1 and Phase 2 GI data and shows some elevated nitrate concentrations above 50mgNO_3/l.

14.4.42 The Essex Gravels water body is confirmed as having Poor overall status. Land use pressures and permeable soils have resulted in agricultural nitrate leaching to the groundwater. This has resulted in a Poor chemical status. Measures proposed by the EA are to ensure there is no deterioration from the current status and for protected area compliance only. The EA recommendation is that improvement is not cost beneficial (Defra and EA, 2018).

14.4.43 The South Essex Thurrock Chalk water body was previously of Good overall status (Cycle 2, 2016). However, it is now reported as having a Poor overall status, which relates to the quantitative water balance and the general chemical test (EA 2020c).

Water levels, flows and utilisation

Surface water levels and flows

14.4.44 Water levels and flows in the system of ditches in the designated sites to the south of the River Thames are subject to seasonal management. During winter and spring, it is reported by the RSPB that water levels in the ditch network serving the Shorne Marshes RSPB reserve are controlled using an active pumping system to maintain them at a maximum of 2m above ordnance datum. The ditch network routes flow to the Denton New Cut, a larger drainage ditch that drains to the River Thames, via a tidal flapped outfall. Water is licensed for abstraction from this watercourse to allow the RSPB to manage water within the reserve.

14.4.45 Filborough Marshes, immediately to the south, are similarly drained by a ditch network. Water drains north into the Denton New Cut, with some water level management possible through manual adjustment of a stopper board on the opening of a culvert that provides connectivity to the Denton New Cut. The Denton New Cut provides the route of drainage to the River Thames.

14.4.46 A study to understand the baseline water balance of the Thames Estuary and Marshes Ramsar site is presented in Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3). The study concluded that rainfall is the main input, with a smaller and less certain input from leakage from the Thames and Medway Canal. Transpiration (the exhalation of water vapour from plants) and evaporation represent the major outflows from the water balance. Further details are reported in Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3).

14.4.47 Water levels in the Thames and Medway Canal are maintained using water that is abstracted from an extraction pool on the Denton New Cut.

14.4.48 To the north of the River Thames, the water levels and flow regimes of the network of watercourses on the East and West Tilbury Marshes are subject to the influence of tide locking. These systems drain to the River Thames via the Bowaters Sluice and Star Dam, illustrated in Figure 14.1: Surface Water Receptors and Resources (Application Document 6.2).

14.4.49 Both assets have flapped outfalls. During each tidal cycle the flaps close, and for a period the watercourses are unable to discharge by gravity. The flat topography also influences water levels and flows in these watercourses, with very little fall in the system to drive flow or encourage large variations in water level. The West Tilbury Main, one of the key drainage systems in this area, and designated a main river, has been calculated to have a mean flow of $0.01m^3/s$ and a flow that is equalled or exceeded 95% of the time (Q95) of $0.004m^3/s$. Its flood flow regime has also been analysed as part of Appendix 14.6: Flood Risk Assessment (Application Document 6.3). At the outlet of the catchment, a flood with a 50% annual chance of occurrence has an approximate peak flow of $0.77m^3/s$, and a rarer event, with a 1% annual chance, peaks at $3.5m^3/s$.

14.4.50 The Mardyke has a flow regime that is also influenced by tidal conditions as it also discharges to the River Thames via a flapped outfall. Using data recorded at the EA flow gauging station in the lower catchment, at Stifford Bridge, the Mardyke has a mean flow of $0.71m^3/s$ and a typical summer low flow (Q95) of $0.04m^3/s$. Its flood flow regime has also been analysed as part of the FRA. A flood with a 50% annual chance of occurrence has a peak flow of $9.6m^3/s$, and a rarer event, with a 1% annual chance, peaks at $22.9m^3/s$.

Surface water utilisation

14.4.51 The EA has supplied records of licensed abstractions and consented discharges to surface water sources in the study area, shown in Figure 14.1: Surface Water Receptors and Resources (Application Document 6.2).

14.4.52 With regard to abstractions, to the south of the River Thames several ditches flowing through the Shorne Marshes RSPB reserve support abstraction to supply ‘top-up water’ for wetland support.

14.4.53 On the River Thames, water intake pipes supplied water for non-evaporative cooling to the former Tilbury Power Station.

14.4.54 To the north of the River Thames, the Mardyke and its tributaries, including the Orsett Fen Sewer and Stringcock Sewer, support several abstractions of water for agricultural use (spray irrigation), with a cluster of abstractions at Orsett Fen and North Ockendon. Full details are provided in Appendix 14.2: Water Features Survey Factual Report (Application Document 6.3). Another feature of note is a storage reservoir for abstracted groundwater, which is situated near Low Street. The reservoir stores the groundwater that supplies an agricultural irrigation system.

14.4.55 Information regarding the presence and usage of unlicensed water supplies supported by surface water has been collected through consultation with local authorities and landowners. The information collected is provided in Appendix 14.2: Water Features Survey Factual Report (Application Document 6.3).

14.4.56 EA records show that there are numerous consented discharges to surface waters within the study area, in particular to the north of the River Thames, as illustrated in Figure 14.1: Surface Water Receptors and Resources (Application Document 6.2). Discharges include effluents from wastewater treatment works, domestic properties and trade effluent. Discharges are received by the River Thames, the Mardyke and many tributaries of the Mardyke. Full details are provided in Appendix 14.2: Water Features Survey Factual Report (Application Document 6.3).

Groundwater levels and flows

14.4.57 Groundwater levels within the study area are influenced by geology, topography, natural recharge, seepage to baseflow and springs, and man-made groundwater abstractions (present and historical).

Chalk aquifer

14.4.58 The February 2014 Chalk aquifer water level contours for the whole study area are presented in Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3) together with hydrographs of EA monitoring boreholes. Contours have been estimated using this monitoring data. February 2014 represents a high groundwater level period associated with prolonged winter rainfall.

14.4.59 In the North Downs, groundwater flow direction is generally towards the north-east, although modified by eight public water supply wells in the study area. Groundwater levels are tens of metres deep, becoming shallower near the North Kent Marshes. At the Ramsar site, water levels are similar to the mean tide level of the River Thames, and water levels in the deep aquifers, including the Chalk aquifer, show tidal fluctuation.

14.4.60 Diffuse leakage (depending on groundwater levels and overlying superficial geology) may occur along the southern edge of the North Kent Marshes. In the Ramsar site, within the Order Limits, no springs have been observed during site walkovers. The water balance of these wetlands is likely to be dominated by rainfall, runoff and local man-made controls on surface water (Soley *et al*., 2012).

14.4.61 Partial gravel and Chalk outcrop beneath the River Thames (Phase 2 GI), indicates a direct hydraulic link between the Chalk aquifer and the river water within the Order Limits, as at other locations such as Greenwich to Woolwich

(EA, 2018a). The link supports the hypothesis that the River Thames acts as a discharge feature to the Chalk aquifer and hence separates the Chalk aquifer south and north of the river.

14.4.62 North of the River Thames there is a gentle groundwater gradient generally towards the river but also altered by the influence of Linford (when operating) and Stifford public water supply wells (Amec, 2016). At Tilbury Marsh, water levels in the deep aquifers, including the Chalk aquifer, show tidal variation. Inland, following the pause in public supply from 2011 onwards, rebound effects are noted near the Linford public water supply well. At the A13/A1089/A122 Lower Thames Crossing junction area, baseline Chalk aquifer water levels are locally higher. North, near the M25 and further west, the effects of ceased chalk quarry dewatering at Thurrock (Scott Wilson, 2010), as well as cessation of 1900s industrial pumping in London (EA, 2018a) and other unknown historical abstractions, are also evident. Further information is given in Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3).

Perched groundwater

14.4.63 Local perched groundwater can occur where there are layered sands and clays, and perched water may be locally important for baseflow to small streams or ponds. Perched water levels may exist in the shallow layered sands and clays beside the A2 and may be locally important in the Lower London Tertiaries at the Chadwell St Mary link and the A13 and in the Essex Gravels near the A122 Lower Thames Crossing/M25 junction. At the A13/A1089/A122 Lower Thames Crossing junction area, baseline groundwater levels in the Lower London Tertiaries are locally higher, although the overlying River Terrace Deposits appear generally dry. Local streams, possible springs and water-filled former gravel pits (including recreational lakes) may be associated with the complex perched groundwater regime near the A122 Lower Thames Crossing/M25 junction.

Groundwater utilisation

EA data

14.4.64 The EA has supplied records of licensed abstractions and consented discharges to groundwater in the study area, shown in Figure 14.2: Groundwater Receptors and Resources (Application Document 6.2). A full list of abstraction licences and discharges is presented in Appendix 14.2: Water Features Survey Factual Report (Application Document 6.3) and discussed in Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3). Abstractions support public water supply and industrial and agricultural uses.

Chalk aquifer abstractions

14.4.65 Groundwater, mostly from the Chalk aquifer of the North Downs, provides 80% of Kent’s public water supply, industry and agriculture (BGS and EA, 2003). More than 50% of an average year’s effective rainfall is abstracted for public water supply and other uses (BGS, 2008).

14.4.66 The Medway abstraction licensing strategy (EA, 2013a) states a ‘presumption against’ the granting of licences for abstraction from the Chalk for unconstrained consumptive use. Any new or varied licence will be likely to have a

'Groundwater Level Condition'. Southern Water Services Limited (Southern Water) uses groundwater resources from the North Kent Medway Chalk aquifer.

14.4.67 North of the River Thames, there is less utilisation of groundwater for public water supply. Only around 3% of public water supply comes from groundwater (Chalk aquifer) (Scott Wilson, 2010). The Essex and Suffolk Water Company (part of Northumbrian Water Limited) uses groundwater resources from the South Essex Thurrock Chalk aquifer in the study area, at Linford and Stifford public supply wells.

Published SPZs (public supply wells)

14.4.68 Public water supply wells (potable water) have published SPZs. Their locations, in relation to the Project road and Order Limits, are shown on Figure 14.2: Groundwater Receptors and Resources (Application Document 6.2). The SPZs are discussed below in relation to features of the Project that cross the SPZs, including the road, highway drainage and utilities. The drawing showing the location of the proposed highway drainage infiltration basins is in Part 9 of Appendix 14.6: Flood Risk Assessment (Application Document 6.3). The same infiltration features are also shown in relation to the nearby SPZs in Plate 7.1 of Annex M of Appendix 14.5 (Application Document 6.3) and in Plate 5.1 of Annex N of Appendix 14.5 (Application Document 6.3). The locations of the utility works are shown in Figure 2.2 (Application Document 6.2).

14.4.69 South of the River Thames, the Project route does not cross the inner protection zone (SPZ1) of any of the public water supply wells. A nitrogen deposition compensation site is proposed in part of the SPZ1 of the Three Crutches Pumping Station (PS), Shorne.

14.4.70 The Project includes a new route for use by walkers, cyclists and horse riders, and a highway drainage infiltration basin is proposed at the outer edge of an SPZ2 of the Southern Water public water supply near Shorne.

14.4.71 Reuse of an existing highway drainage infiltration basin, at the location of the M2/A2/Lower Thames Crossing junction, is proposed within the combined catchment area (SPZ3) of multiple public water supply sources.

14.4.72 Further west along the A2, the Project road and highway drainage infiltration basins would be located in part of the combined catchment area (SPZ3) of multiple public water supply sources.

14.4.73 Utility works are not proposed within SPZ1s, south of the River Thames, although a multi-utility route lies just outside the outer edge of an SPZ1 and is parallel to the A2 at the western end of the Order Limits. Two multi-utility corridors would cross a SPZ2 and gas and multi-utility corridors would cross the merged SPZ3. However, none of the utility works would impact the Chalk aquifer to which the source protection zones relate, since the Chalk aquifer water table is generally tens of metres deeper than the proposed works.

14.4.74 North of the River Thames, the Project route does not cross a SPZ1 of any of the public water supply wells. Only a temporary access road, part of a lined pond, a planted landscaped area and some utilities (described below) cross the SPZ1 near Linford public supply well.

14.4.75 The Project route passes through parts of the SPZ2 of the Linford public water supply well, continuing northwards in the combined SPZ3 of the Linford and

Stifford sources, including Chadwell St Mary link and parts of the A13/A1089/A122 Lower Thames Crossing junction.

14.4.76 Utility works are not proposed within SPZ1s, north of the River Thames, except for mostly overhead electricity works (one new temporary pylon, one new permanent pylon plus two new pylons of footprint overlapping that of existing pylons) within the Linford SPZ1, a temporary water pipeline for the Lower Thames Crossing tunnel boring machinery supply and two multiple utility corridors. A small number of the underground utility corridors would be in a SPZ2, mostly beside Muckingford Road at Linford. Further away, in the combined SPZ3, there would multi-utility corridors, temporary multi-utility corridors, gas pipelines and overhead electricity works including pylons. These would be located from the North Portal to north of junction 29, although the majority would be in the Chadwell St Mary link area and around the A13/A1089/A122 Lower Thames Crossing junction.

Private groundwater abstractions

14.4.77 Local authorities keep records of drinking water consumption of unlicensed groundwater supply. The local authorities have stated that they hold no records for unlicensed supplies within the study area.

14.4.78 South of the River Thames, licensed groundwater abstractions, which are not for public supply, comprise industrial use abstractions at Nuralite Industrial Centre, and general use abstractions at Gravesend Waste Water Treatment Works, all from the Chalk aquifer. Next to the south bank of the River Thames, there are wells that serve abstractions for mineral washing.

14.4.79 North of the River Thames, licensed groundwater abstractions, which are not for public supply, comprise mostly agricultural or mixed use. Mineral washing is the most common industrial use. Near Low Street, there are three groundwater abstractions for agricultural use and general use including for drinking, but the licence holder has communicated that these abstraction wells have not been used since 2013 (Perfect Circle, 2020). An abstraction from a Chalk well is located at Orsett Golf Course, in the Chadwell St Mary link area. Near Orsett Fen, in the Ockendon link area, there are three general farm and domestic abstractions, two of which are located in the Order Limits, and all have a default SPZ1 (50m radius) within the Order Limits. Phase 2 GI suggests these abstract from sandy strata beneath the London Clay Formation (Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3)). Near the A122 Lower Thames Crossing/M25 junction, spring water flow is reported to be utilised downstream for surface water abstraction for spray irrigation storage.

14.4.80 The water features survey recorded one unlicensed groundwater abstraction. This is located at the Southern Valley Golf Club course on the chalk hills within the study area. A full list of abstractions (licensed and unlicensed) is presented in Appendix 14.2: Water Features Survey Factual Report (Application Document 6.3).

Groundwater – surface water interactions

14.4.81 South of the River Thames, several ponds are located in Shorne Woods Country Park. These overlay Palaeogene strata, and perched water from sandy layers may feed these ponds, in addition to rainfall. Diffuse seepage (depending on groundwater levels) may occur along the southern edge of the Ramsar site, at least during higher water level periods, but flow rates are small due to the shallow groundwater gradient. Discrete springs have not been observed here. The water balance of the Ramsar site (Application Document 6.3, Appendix 14.5: Hydrogeological Risk Assessment) is dominated by rainfall, evapotranspiration, and surface water and local man-made controls of surface water including drainage ditches, pumping, a weir and dams.

14.4.82 North of the River Thames, groundwater appears to be the main inflow to the irrigation reservoir at Low Street. This is used for licensed agricultural water supply. Baseflow may occur at Gobions Sewer, varying with seasonal groundwater levels and abstraction (Linford).

14.4.83 Springs are reported near North Ockendon, associated with River Terrace Deposits, and are shown on Figure 14.2. One of the possible springs is located beside St Mary Magdalene Church and is said to feed three connected ponds at Hall Farm which are relics of an old moat (part of the Hall Farm moat, paddock and St Mary Magdalene Churchyard Site of Importance for Nature Conservation (SINC). Here, a brick well house appears to show no spring flow. The second feature described as a spring is located in fields east of St Mary Magdalene Church. Here, the landowner asserts that a 16 foot (5m) deep Victorian drainage system (named as the North Ockendon catchment in Appendix 14.5) exists beneath the fields and is the source of water that flows into ditches at the bottom of the hill. The outlets from the above described ponds and the North Ockendon catchment are said to be the water source that feeds a downstream surface water abstraction used for agricultural irrigation. However, the July 2021 walkover observed the culvert connecting the same ditch system to the west of the M25, towards the irrigation reservoir, to be dry. Similar observations were recorded in monthly walkovers between October 2021 and May 2022. This suggests that ditch flow towards the irrigation reservoir from the east side to the west side of the M25 may be absent or unreliable. Further details and photographs are provided in Appendix 14.2: Water Features Survey Factual Report (Application Document 6.3) and Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3).

14.4.84 No interaction between the confined Chalk aquifer and surface water occurs north of the Eocene margin (the geological boundary, north of which the London Clay Formation, deposited in the Eocene epoch, overlies and confines the Chalk aquifer).

Groundwater Dependent Terrestrial Ecosystems (GWDTEs)

14.4.85 In accordance with best practice to assess compliance of the Project with the WFD, GWDTEs have been assessed. GWDTEs are wetlands which critically depend on groundwater flows and/or chemistries (European Communities (2011), shown in WFD-UKTAG (2014a)). A river system or permanent lake fed by a spring would not be considered as a GWDTE but an aquatic ecosystem (European Communities, 2011).

14.4.86 In compliance with the methodology set out in DMRB LA 113 Appendix B (Highways England, 2020a), data from NVC surveys and Phase 1 habitat survey data (discussed in Chapter 8: Terrestrial Biodiversity) was screened to confirm whether any of the plant communities recorded within 50m of the Order Limits are indictive of groundwater dependency (Appendix 8.2: Plants and

Habitats (Application Document 6.3)) and therefore indicate the presence of a potential GWDTE. In addition, published EA mapping of GWDTEs (SSSIs) was referenced. Additional published information was obtained about London Borough of Havering SINCs using an ecological data search of information held by Greenspace Information for Greater London CIC and reported by eCountability Limited (2020). Further details are given in Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3), and areas identified as potential GWDTEs are shown in Figure 14.2: Groundwater Receptors and Resources (Application Document 6.2).

14.4.87 EA mapping, which covers only SSSIs (EA, 2021a) shows that within most of the Project study area there are no GWDTEs. The exception is the Ingrebourne Marshes SSSI, the most eastern 180m of which is located within the 3km radius of the Project. Information noted from the site's citation indicates that the eastern part of the SSSI supports Fen (marsh and swamp) and is in unfavourable, declining condition due to the build-up of Himalayan balsam. The South Thames Estuary and Marshes SSSI and Mucking Flats SSSI are not assessed as being GWDTEs by the EA.

14.4.88 A desk study review of London Borough of Havering SINC citations (eCountability Limited, 2020) identified habitats indicative of groundwater dependency at six SINC sites located north of the River Thames, near the M25. These sites are illustrated in Figure 14.2: Groundwater Receptors and Resources (Application Document 6.2) and are described in the paragraphs below.

14.4.89 Project vegetation mapping was used to identify potential GWDTEs, where possible. North of the River Thames, due to land access restrictions, Phase 1 habitat survey was carried out from Public Rights of Way at Cranham Marsh Local Nature Reserve (LNR), with the exception of Bonus Wood where there is no public access.

14.4.90 Project NVC surveys identified plant communities indicative of a potential GWDTE in the following locations, illustrated in Figure 14.2: Groundwater Receptors and Resources (Application Document 6.2):

a. Ditches and marsh at Goshems Farm Landfill and Low Street Pit Local Wildlife Sites (LWSs), scoring moderate groundwater dependency.

b. North Ockendon Pit SINC, comprising part historical landfill beside the Ockendon link, scoring low groundwater dependency, and noted as generally species-poor throughout.

14.4.91 Low groundwater dependency vegetation was identified in marginal vegetation beside ditch networks, in the Filborough and Shorne Marshes (part of the Ramsar site). Aquatic vegetation showed no groundwater dependency. Detailed assessment of the Ramsar site included a water balance study of a 350,000m^2 area of Filborough Marshes that lies within and borders the Order Limits. Shorne Marshes, at greater distance, receives pumped surface water (RSPB, 2018). The studies and surface water management demonstrate that Filborough and Shorne Marshes are not GWDTEs. This is supported by the EA GWDTE mapping. Detailed assessment of potential impacts at these areas is presented in Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3) and summarised below in the ‘statutory designated sites’ section.

14.4.92 The Project would cause the direct physical loss of part of Goshems Farm Landfill and Low Street Pit LWSs. This impact is assessed in Chapter 8: Terrestrial Biodiversity and is not discussed further in this chapter.

14.4.93 NVC surveys also identified small and discrete areas of vegetation with low groundwater dependency at Hall Farm moat, paddock and St Mary Magdalene Churchyard SINC, and Thames Chase Forest Centre SINC. Fen (swamp and mire) marginal habitat was recorded, however both sites were species-poor and because they are surface water bodies, they are not GWDTEs.

14.4.94 Habitats typical of wetlands were used to identify potential GWDTEs where NVC data was unavailable. Project Phase 1 habitat type data was used to identify equivalent habitats. Three Natura 2000 habitats were identified and comprised wet grassland, swamp and wet woodland. Groundwater dependency scores are not attributed to these habitats.

14.4.95 Wet grassland habitats identified include those at the main river on the western edge of the Thames Estuary and Marshes Ramsar site at Filborough Marshes, Low Street Pit LWS, North Ockendon Pit SINC, Puddle Dock Angling Centre SINC, Franks Wood and Cranham Brickfields SINC, Tomkyns East Pastures SINC, Carter’s Brook and Paine’s Brook SINC and several M25 motorway drainage basins. The first three show correlation with sites identified using NVC data, listed above. Puddle Dock SINC is beside the Mardyke West tributary and includes much open water. Franks Wood and Cranham Brickfields SINC, Tomkyns East Pastures SINC and Carter’s Brook and Paine’s Brook SINCs include a variety of habitats of which wet grassland is one. The Filborough Marsh has been discounted as a GWDTE, as discussed above. Attenuation basins were constructed, and are necessary, for the function of highway drainage and therefore are not included in the assessment of impacts or discussed further in this chapter.

14.4.96 Swamp habitats identified include those at Mucking Flats SSSI, the main river at Tilbury Fort LWS, the main river of Gobions Sewer and a pond near Linford (the Project would cause the partial loss of this feature), and various isolated ditches and ponds such as at Jeskyns Community Woodland car park pond, Cooper Shaw Road ditches and three small locations in the Thames Chase area. It is noted that swamp habitat is indicative of low groundwater dependency (EA, 2014).

14.4.97 Wet woodland habitat has been identified by desk study of the published citation for the Redlands Angling Centre SINC (eCountability Limited, 2020). The citation, last edited in 2005, describes a small area of willow woodland in the south-east corner of the 2.43ha site.

14.4.98 Low groundwater dependency vegetation (swamp habitat) was identified at Mucking Flats SSSI, located immediately beside the River Thames and likely to be influenced by river water. These facts suggest that Mucking Flats SSSI is not a GWDTE. This is supported by the EA GWDTE mapping.

14.4.99 South of the River Thames, Jeskyns Community Woodland car park pond was identified as a potential GWDTE. North of the River Thames, Cranham Marsh LNR, Cooper Shaw Road ditches, North Ockendon Pit SINC, three small locations in the Thames Chase area, and the other above-listed SINC sites were identified as potential GWDTEs. Low or low to moderate importance was assessed at most sites (Annex P of Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3)), with the possible exception of Cranham Marsh LNR and the distant Ingrebourne Marshes SSSI. None of the habitats recorded appear to be critically dependent upon groundwater flows and/or chemistries.

14.4.100 At Cranham Marsh much of the LNR has a vegetation cover of broadleaved woodland which is not groundwater dependent. One small area of low groundwater dependency (EA, 2014) swamp habitat was recorded. The Project survey recorded three discrete areas of fen (valley mire). This habitat is likely to be of high groundwater dependency (EA, 2014). Further details are presented in Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3).

14.4.101 Sites scoped out of the assessment comprised main rivers, locations at which the Project would cause physical loss (discussed in Chapter 8: Terrestrial Biodiversity), highway drainage basins and sites that were determined not to be GWDTEs.

Statutory designated sites

14.4.102 Due to their statutory designated status as a Ramsar site, Special Protection Area and SSSI, further investigations have been undertaken to develop an understanding of the baseline water resource and quality of the marshes along the southern edge of the River Thames and above the proposed tunnel, illustrated in Figure 14.7: Water Framework Directive – Protected Areas (Application Document 6.2). The EA states that these designations are influenced by freshwater flows and may be vulnerable to groundwater abstraction (EA, 2013a).

14.4.103 The marshes sit on a low-lying floodplain on the south bank of the River Thames. This area is underlain by a variable thickness of Alluvium, River Terrace Deposits and Chalk. The South Portal would be located approximately 1,000m south of the Thames Estuary and Marshes Ramsar site in what can be described as a Chalk terrain. The north-dipping slope comprises occasional Head deposits overlying Chalk. A series of dry valley features with an approximate south-to-north orientation are indicative of the local structural geology (e.g. discontinuities) of the Chalk.

14.4.104 A CSM of the ground and groundwater profile in this area has been developed and is presented in Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3). Rainfall is considered to be the principal source of recharge to the surface and shallow groundwater in the area of the Thames Estuary and Marshes Ramsar site. A water balance study of the shallow water system concluded that rainfall contributes the largest proportion of inflow and that the system is separated from the deeper confined Chalk aquifer due to the predominantly silty clay Alluvium soils that overlie the Chalk aquifer. Evidence for this is given from the Phase 1 pumping test water level responses and Phase 1 and 2 exploratory boreholes.

14.4.105 Other less significant potential sources of inflow include seepage from the Thames and Medway Canal and return flow from licensed abstractions.

Outflows originate from surface water losses to the River Thames, licensed surface water abstractions and evapotranspiration. The balance between these inflows and outflows results in variations in the natural storage in the ditch network.

14.4.106 Baseline surface water and groundwater quality, shown as electrical conductivity values in the ditches on Filborough and Shorne Marshes, is provided in Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3). Data was collected during the Phase 1 GI and during the water features survey. This, together with chloride concentrations, shows that generally fresh water is present in the ditches of Filborough Marshes located within the Order Limits. The surface water becomes more saline north of the Thames Estuary and Marshes Ramsar site.

14.4.107 Baseline nitrate groundwater concentrations in the Chalk aquifer, flowing towards the Thames Estuary and Marshes Ramsar site, are high as demonstrated by the fact that many samples exceed Drinking Water Standards (50mgNO_3/l). As discussed above, the Ramsar shallow system is largely separated from the Chalk aquifer and so the direct influence of deep groundwater is limited.

Hydromorphology

14.4.108 The baseline hydromorphological features of watercourses within the study area were characterised using both desk study research and field observations. The two watercourses that are designated as WFD surface water bodies (the Mardyke and Mardyke West tributary) both have a hydromorphological designation of Heavily Modified (by human activity) and both waterbodies achieve Moderate overall status.

14.4.109 A review of historical mapping was undertaken and concluded that the watercourses in the study area 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.

14.4.110 Field observations noted that many of the watercourses have channels that have been extensively modified for land drainage or flood defence purposes. Several have low-energy, tide-locked flow regimes, and in general the watercourses exhibit limited hydromorphological diversity. Further baseline information is provided in Appendix 14.4: Hydromorphology Assessment (Application Document 6.3).

Flood risk

14.4.111 Fluvial and tidal flood risk zones and flood defence assets are illustrated in Appendix 14.6: Flood Risk Assessment (Application Document 6.3).

14.4.112 To the south of the River Thames, the Project route traverses undulating ground that generally falls towards the Thames Estuary, with the Thames floodplain extending approximately 1.4km south of the shoreline. The floodplain is classified as Flood Zone 3 but benefits from the protection of the Thames tidal flood defences.

14.4.113 These defences comprise raised embankments and walls that are managed and maintained by the EA. The defences provide protection against tidal flooding from the River Thames during storm events with a 0.1% chance of happening each year (to the year 2030) as reported in the London Regional Flood Risk Appraisal (Greater London Authority, 2018). South of the River Thames, the Project would cross the North Kent Marshes TE2100 policy unit (Lower Estuary Marshes – action zone 6). In this rural area, the recommended flood risk management policy for this area is P3, to maintain defence standards at the current level, rather than to improve/raise them to keep pace with the predicted effects of climate change (EA, 2012). Those parts of Gravesend that are urban fall under Policy P4, to take further action to keep up with climate and land use change so that flood risk does not increase.

14.4.114 Immediately to the north of the River Thames, the Project route traverses land that has a low-lying, floodplain topography, which gives way to undulating ground that generally rises as the Order Limits extend northwards. The Project route crosses the River Thames tidal floodplain in one location and the fluvial floodplain of the Mardyke in two locations. These areas are defined as Flood Zone 3 and, in some locations, are protected by flood defences.

14.4.115 Defences comprise raised river walls and embankments alongside the River Thames frontage. There are several flood management assets on the Tilbury Marshes. These include the Bowaters Sluice at the outfall of the West Tilbury Main, the Star Dam, and the Tilbury Flood Storage Area. Defences protect against tidal flooding from the Thames during storm events with a 0.1% chance of happening each year, reported in the London Regional Flood Risk Appraisal (Greater London Authority, 2018). The Project would straddle Purfleet, Grays and Tilbury policy unit (Middle Estuary – action zone 5), where the recommended policy is P4, to take further action to keep pace with climate and land use change such that flood risk does not increase in the future (EA, 2012).

14.4.116 Regarding other sources of flood risk, lands behind the River Thames defences are at risk of rapid inundation in the unlikely scenario of defence overtopping or breach. There is localised risk of flooding from surface water, with overland flow routes and areas vulnerable to surface water ponding shown on the Long-Term Flood Risk Information Map (EA, 2018b).

14.4.117 Groundwater flooding is the result of water rising from an underlying aquifer. Assessment of baseline groundwater flooding for the Project study area has referenced Lead Local Flood Authorities' (LLFA's) Strategic FRAs and a bespoke digital mapping product by GeoSmart (2019). Full details are included in Appendix 14.6: Flood Risk Assessment (Application Document 6.3), which presents GeoSmart (2019) mapping of groundwater flood risk.

14.4.118 Kent County Council observed that groundwater flooding may occur in areas susceptible to surface water flooding (Kent County Council, 2011) and has the potential to occur after prolonged periods of unusually high rainfall (Kent County Council, 2014), having caused groundwater flooding in January 2014 (location not specified). No groundwater flood events in the study area are listed by the council. GeoSmart (2019) mapping shows virtually no risk of flooding on high ground of the North Downs, although GI shows potential for perched groundwater in layered Palaeogene and superficial strata near the A2. Areas of low to moderate risk are shown at the lower slopes of the North Downs near Lower Higham Road, with one small area of high risk.

14.4.119 North of the River Thames, Thurrock Council (2018) identifies susceptibility to groundwater flood risk outside of the study area and states no reported incidents of groundwater flooding. GeoSmart (2019) mapping shows areas of low and moderate risk associated with the boundary between the Chalk and the Thanet Formation, and a small area identified as being high risk, which is coincident with a groundwater-fed irrigation reservoir (Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3)). Northwards, Phase 2 GI shows evidence of perched groundwater within the Thanet Formation and topographical low areas, such that the pond and Gobions Sewer may receive baseflow. Throughout much of the Chadwell St Mary link area, groundwater level in the Chalk aquifer is controlled by pumping from the Linford public water supply well, as evidenced by EA monitoring borehole hydrographs (Appendix 14.5: Hydrogeological Risk Assessment).

14.4.120 At the A13/A1089/A122 Lower Thames Crossing junction, there are no recorded incidents of groundwater flooding in the area (Thurrock Council, 2018). GeoSmart (2019) mapping shows the junction to be in an area entirely of negligible risk from groundwater flooding. Recent exploratory holes (Phase 2 GI) suggest that the River Terrace Gravels are dry. There may be locations of perched water in the deposits that overlay less permeable strata. Phase 2 GI long-term monitoring shows that maximum perched water levels may be 0.9m higher than the deepest cutting along less than 100m distance of the proposed A13 westbound to Project road southbound link road.

14.4.121 At the Ockendon link, there is no recorded evidence of groundwater flooding (Thurrock Council, 2018). GeoSmart (2019) mapping shows low and moderate risk in the Mardyke floodplain and negligible risk elsewhere. Phase 2 GI indicates primarily silty clay superficial deposits suggesting absence of significant shallow, permeable strata. While the Chalk aquifer (beneath London Clay) was historically artesian beneath topographical low areas, the thickness of the London Clay Formation in this area is assumed to prevent any emergence of Chalk groundwater.

14.4.122 At the A122 Lower Thames Crossing/M25 junction and beyond northwards, the Strategic Flood Risk Assessment (London Borough of Havering, 2017) indicates groundwater flooding from superficial deposits may represent a 75% risk to most of the 1km squares mapped for the area from Orsett Fen to just south of the A127. Groundwater flood incidents at Great Warley Hall (east of M25 junction 29, south of the A127) in September 2005 and near Heron Way, Cranham (January 2005), are recorded. The Preliminary Sources Study Report Addendum (Highways England, 2019b) records a verbal communication that groundwater flooding occurred around Stubbers Adventure Centre.

Drainage

14.4.123 Within the study area, land to the south of the River Thames is mainly in agricultural use and the Project route also crosses through the Southern Valley Golf Club course. Most rainfall runoff drains to the underlying permeable Chalk geology, with the rest flowing into the marsh areas fringing the Thames. Existing development to the south of the Thames is served by foul sewer networks, and runoff from roads drains to ground via soakaways.

14.4.124 National Highways manages the drainage assets serving the strategic road network and records their status in DDMS. Priority assets recorded include soakaways, outfalls and culverts and are classified A to D based on perceived risk to water quality and flooding, or Category X where risk is very low or has already been mitigated.

14.4.125 Information on the existing highway drainage arrangements of the A2 was collected from the DDMS in August 2020. The road is served by kerbs and gullies or combined kerb and drain connected to pipe networks that outfall into several infiltration basins (soakaways to ground), which are illustrated in Figure 14.1: Surface Water Receptors and Resources (Application Document 6.2). As no data regarding the baseline status of these soakaways is available from the DDMS, a priority soakaway assessment (Highways Agency, 2012) was carried out to verify risk to the water environment from drainage through these existing features. Hazard ranking scores are all below 175 and the routine runoff risk category of each soakaway is D (low risk).

14.4.126 There are no priority outfalls or culverts along the A2/M2. The DDMS details a flooding hotspot at the Park Pale Interchange (M2 junction 1). However, the DDMS Hotspot Action Status record indicates that the flood risk at the interchange has been mitigated (Category X). One other flooding hotspot is recorded on the A2 westbound carriageway which has a baseline risk level assigned as Category C (moderate risk).

14.4.127 To the north of the River Thames, land is mainly in agricultural use and rainfall runoff mostly drains to field drainage systems and to watercourses. Areas of built development are served by the public surface water and combined sewer network, maintained by Thames Water, and existing highway drainage systems.

14.4.128 Information on the existing drainage arrangements of the A13 and M25 was collected from the DDMS and as-built records held by National Highways' maintaining agent for the M25 and Thurrock Council.

14.4.129 Records have been obtained from Thurrock Council showing an existing drainage system on the A13 of kerbs with gullies and collector drains. Although there is a low point in the road at the Orsett Cock roundabout, runoff is discharged to a watercourse approximately 1.5km to the east of the current roundabout (close to the junction between the A13 and A1014). There are no flooding hotspots and the DDMS records just one historic flooding incident, dating to 2011.

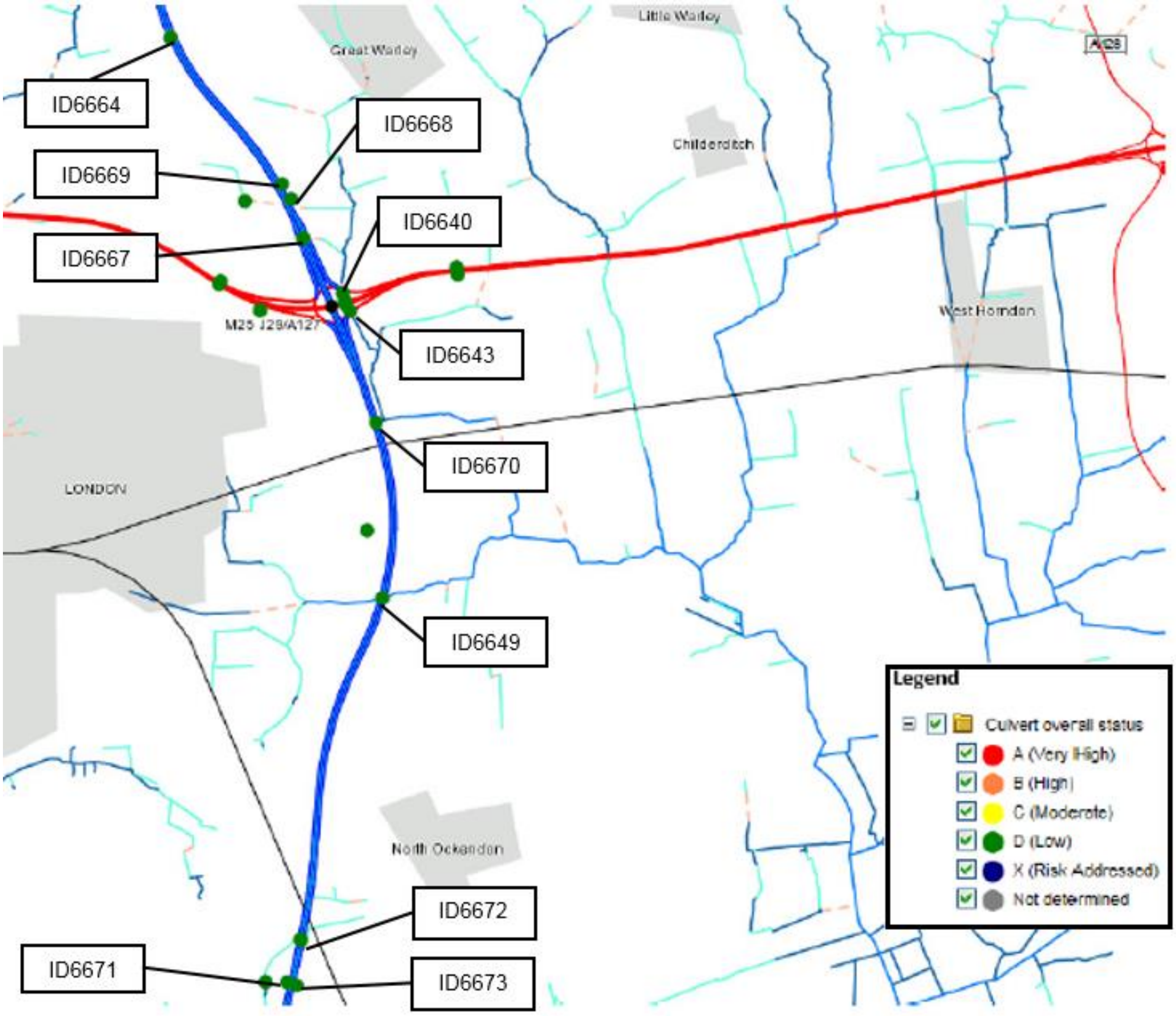
14.4.130 There are no existing soakaways serving the A13. The DDMS has been reviewed to identify existing outfalls and culverts, and no existing outfalls or culverts have been identified.

14.4.131 The M25 carriageway drains via a series of outfalls and discharges into the Mardyke, Mardyke West Tributary and several smaller streams. Several of the drainage catchments discharge into drainage basins before reaching the receiving watercourse. These features are dry, grassed basins that provide a range of storage volumes. At the M25 junction 29, there are no attenuation measures; instead, simple gravity pipe networks with no restrictions or flow controls provide the existing drainage solution. The DDMS records show there are no flooding hotspots, nor any priority soakaways.

14.4.132 The DDMS has been reviewed to identify existing outfalls and culverts, and where no baseline status is recorded these have been verified using Highways Agency (2010) guidelines. A total of 14 outfalls within the study area discharge to the Mardyke West Tributary, the Upminster Tributary of the Mardyke and the Puddledock Sewer (another tributary of the Mardyke), none of which have a baseline status. The risks posed by these outfalls to the receiving watercourses have been verified using HEWRAT (Highways England, 2019a). The results categorise three of the outfalls as posing a minimal risk (Category X). The remaining outfalls are verified as Category B (high risk), due to failures for sediment and acute soluble pollution. As described in Section 14.5, and in further detail in Appendix 14.6: Flood Risk Assessment - Part 7(Application Document 6.3), the Project would modify existing, or provide new, treatment systems for runoff discharging via all of the outfalls that are retained in the design.

14.4.133 A total of 11 culverts have been identified, all of which have been classified with an overall risk category D (low risk), as shown in Plate 14.1. Details of where the Project would modify any of these culverts are provided in Appendix 14.6: Flood Risk Assessment - Part 10 (Application Document 6.3).

Plate 14.1 DDMS priority culvert overall status mapping (not to scale) – M25 – junction 29



Summary of receptors and their value

14.4.134 Table 14.6 and Table 14.7 provide a summary of the surface and groundwater receptors within the road drainage and water environment study areas, their key attributes and the values assigned to their importance (sensitivity) with reference to Table 3.70 in DMRB LA 113 (Highways England, 2020a).

Table 14.6 Summary of receptor importance – surface water

Receptor	Attribute*	Value (sensitivity)	Rationale
Ditch networks at Filborough and Shorne Marshes, including the Denton New Cut (part of the Thames Estuary and Marshes Ramsar site)	Flow storage and conveyance	Medium	Tide-locked flow regime but providing important function of storage locally and a route of discharge to the River Thames.
	Hydromorphology	Low	Low-energy watercourses with channels extensively modified for land drainage. Exhibit limited hydromorphological diversity.
	Water quality	High	Watercourses not having a WFD classification showing in an RBMP and with a Q95 flow of ≤0.001m^3/s but maintaining flora and fauna of high conservation value.
	Water supply	Medium	Network supplies licensed abstractions for ‘top-up’ water to the Thames and Medway Canal and for water management within the Shorne Marshes RSPB reserve.
Thames and Medway Canal	Flow storage and conveyance	Medium	Canal is partially infilled; stores rather than conveys water.
River Thames	Flow storage and conveyance	Very high	Regional scale flow route. Large floodplain benefiting from flood defences, posing significant residual flood risk to vulnerable development and essential infrastructure.
	Hydromorphology	High	Assessed in Chapter 9: Marine Biodiversity.
	Water quality	High	Also assessed in Chapter 9: Marine Biodiversity.
	Water supply	Low	No active abstraction consents within the study area.
	Dilution and transport of wastewater	High	Receives numerous consented discharges of treated sewage and trade discharges.
West Tilbury Main	Flow storage and conveyance	Medium	Primary drainage route for a local catchment of just over 6km^2. Subject to tide locking. Watercourse channel extensively modified.
	Hydromorphology	Low	Serves as a land drainage/flood defence. Exhibits limited hydromorphological diversity.
	Water quality	Medium	Watercourse not having a WFD classification shown in an RBMP and with a Q95 flow of >0.001m^3/s.
Reservoir at Low Street	Water storage and supply	Medium	Supports an irrigation system that sustains an agricultural business.

Receptor	Attribute*	Value (sensitivity)	Rationale
Gobions Sewer	Flow storage and conveyance	Medium	Primary drainage route for a local catchment of just over $11km^2$.
	Hydromorphology	Medium	Watercourse with a natural flow regime, with a channel exhibiting limited, but some, hydromorphological diversity.
	Water quality	Medium	Watercourse not having a WFD classification shown in an RBMP and with a Q95 flow of >$0.001m^3/s$.
Mardyke	Flow storage and conveyance	High	Primary drainage route for catchment of over $80km^2$. Subject to tide locking, with high-risk flood zones (Flood Zone 3) located in the study area.
	Hydromorphology	Medium	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.
	Water quality	High	Watercourse having a WFD classification shown in a RBMP and with a Q95 flow of <$1m^3/s$.
	Water supply	Medium	Supplies several licensed abstractions for general and agricultural water use.
	Dilution and transport of wastewater	Medium	Receives several consented discharges of sewerage and trade effluents.
Orsett Fen Sewer, Golden Bridge Sewer and Stringcock Sewer	Flow storage and conveyance	Medium	Draining catchments of between approximately $6km^2$ and $10km^2$. These watercourses have high risk flood zones (Flood Zone 3) located in the study area, but which are limited in scale and extent.
	Hydromorphology	Low	Watercourses with impacted natural flow regimes, low energy, no morphological features and very limited hydromorphological diversity.
	Water quality	Medium	Watercourses not having a WFD classification shown in an RBMP and with a Q95 flow of >$0.001m^3/s$.
	Water supply	Medium	Watercourses supply several licensed abstractions for general and agricultural water use.
	Dilution and transport of wastewater	Medium	Watercourses receive several consented discharges of sewerage and trade effluents.

Receptor	Attribute*	Value (sensitivity)	Rationale
Mardyke West Tributary	Flow storage and conveyance	High	Draining a catchment of approximately 30km^2. This watercourse has a high-risk flood zone (Flood Zone 3) located in the study area but which is fairly limited in scale and extent.
	Hydromorphology	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.
	Water quality	High	Watercourse has a WFD classification shown in an RBMP and with a Q95 flow of <1m^3/s.
	Dilution and transport of wastewater	Medium	Receives several consented discharges of sewerage and trade effluents.
	Water supply	Medium/low	Supplies one licensed abstraction for aquaculture (fish farm).
Unnamed ordinary watercourses, ponds and recreational lakes at Stubbers Adventure Centre	Flow storage and conveyance	Medium/low	Features that store and/or convey water at the local scale, generally not posing significant flood risk to vulnerable development.
	Hydromorphology	Low	Typically, do not support a permanent flow system, channels typically exhibit no natural features or processes.
	Water quality	Medium/low	Watercourses not having a WFD classification showing in an RBMP and with a Q95 flow of ≤0.001m^3/s.

**Note: Only those attributes that are applicable to a water body have been included and assigned an importance score. Attributes have been defined with reference to Table 3.69 of DMRB LA 113 (Highways England, 2020a). Other attributes of these watercourses are assessed in other chapters of this Environmental Statement, for example biodiversity attributes are assessed in Chapter 8: Terrestrial Biodiversity and Chapter 9: Marine Biodiversity. Attributes linked to recreation are addressed in Chapter 13: Population and Human Health.*

Table 14.7 Summary of receptor importance – groundwater

Receptor	Attribute quality [1]	Importance	Rationale
Chalk aquifer (North Kent Medway Chalk water body)	17,700 megalitres per annum (ML/a) licensed volume for public supply Presumption against new consumptive abstractions	Very high	Used for public water supply and possible, albeit limited, contribution to fresh water in North Kent Marshes including Thames and Medway Marshes Ramsar site.
Public water supply wells and SPZ1s (North Kent)	73% of public supply in Kent is from groundwater (mostly Chalk)	Very high	Used for public water supply.
Chalk aquifer (South Essex and Thurrock Chalk water body)	3,728ML/a total licensed public water supply Presumption against new licences in confined aquifer and restricted during low-flow periods for unconfined Chalk	Very high	Used for public water supply although only 3% of total. Thurrock Council area public supply (Scott Wilson, 2010)
Public water supply well (Linford) and SPZ1	One of two public supply wells in south Essex.	Very high	Currently offline for public supply but assumption is that it will be used again for public supply (including drinking water).
Lower London Tertiaries water body	High nitrates (>50mg/l) sometimes recorded in Phase 2 GI	Medium	Not used for groundwater abstractions Baseflow to local stream Leakage to underlying South Essex and Thurrock Chalk water body
Essex Gravels water body	Poor overall WFD status due to high nitrates	Medium	Agricultural water supplies Baseflow to local surface water bodies
Private supply wells, including agricultural, industrial and golf course uses	5,889ML/a (South Essex)	Medium	Local water use that may sustain an agricultural or other business.

Note: Only those attributes that are applicable to a groundwater body have been included and assigned an importance score.

Future baseline (‘Without Scheme’ scenario)

14.4.135 The future baseline identifies anticipated changes to the existing baseline over time in the absence of the Project and is used as a basis against which to predict the potential impacts of the Project. A description of how the future baseline has been considered within the assessment is provided in Chapter 4: EIA methodology.

14.4.136 While it is unknown whether the overall future trend would be for water quality improvement or degradation, legislative drivers, for example the Floods and Water (Amendment etc.) (EU Exit) Regulations 2019, would encourage future water quality improvements.

14.4.137 Future investment in the regional sewer network would likely contribute to improving the current status of the Mardyke catchment, where point-source pollution from wastewater treatment works is stated as a current pressure in the RBMP.

14.4.138 The UK Government forecasts that it is likely that Flood Zones 2 and 3 would increase in area coverage in the future baseline scenario, therefore introducing flood risk to areas previously unaffected. However, this may be counteracted by implementation of some of the flood risk management policies set out in TE2100, including, for example, a new Thames barrage. Climate change allowances have been selected in consultation with the EA, as appropriate, to define future baseline flood risk to the Project. Further details are provided in Appendix 14.6: Flood Risk Assessment (Application Document 6.3).

14.4.139 Climate change is likely to cause changes to future baseline groundwater levels and flows in the UK. There are no UK Government published climate change allowances for groundwater, and the understanding of how groundwater will respond to changes in coupled climate and human stresses is limited, with insufficient research undertaken to date (Jackson *et al*., 2013). There is some consensus about changes in mean annual recharge in the UK, with most confidence in predictive effects on Chalk catchments in southern England, where the length of the recharge season is likely to shorten. Further details are provided in Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3).

14.4.140 Sea level rise is expected to impact coastal and estuarine areas leading to increased groundwater salinities. Inland groundwater abstractions have the potential to worsen the situation if aquifers are overused. However, the presumption against new abstraction licences (EA, 2013a) of the North Kent Medway Chalk is expected to continue.

14.5 Project design and mitigation

14.5.1 Environmental considerations have influenced the Project throughout the design development process, from early route options assessment through to refinement of the Project design. An iterative process has facilitated design updates and improvements, informed by environmental assessment and input from the Project engineering teams, stakeholders and public consultation.

14.5.2 Through this design evolution process, changes have been made to avoid negative effects on water environment receptors as follows:

a. Selection of a route that avoids an SPZ1 of public water supply wells, safeguarding potable groundwater quality.

b. Relocation of the South Portal further south and upgradient, compared to the design presented at the Section 42 Statutory Consultation. As a result, at the portal the excavation depth would be above the mean and maximum recorded groundwater level (Figure 3 in Appendix 14.5: Hydrogeological

Risk Assessment (Application Document 6.3)). Pumping of groundwater to dewater the portal excavation is not anticipated, removing the risk of temporary groundwater lowering and the potential for impacts on downgradient designated wetlands of the Thames Estuary and Marshes Ramsar and South Thames Estuary and Marshes SSSI.

c. To the south of the River Thames, where there is a lack of suitable watercourses to receive operational drainage from the Project, new wide, shallow infiltration basins have been sited to avoid SPZ1s. Their locations have targeted dry valleys and provide for sufficient height of ground above the water table (even when compared to the high groundwater level condition of February 2014). Basin locations avoid large-scale development downgradient and would be as far as practicable from the Thames Estuary and Marshes Ramsar site. These design features and basin locations would reduce the potential for groundwater flooding and for sink holes to develop. Basin design has also accommodated the constraints posed by existing electricity pylons.

d. Selecting viaduct crossings of the Mardyke and its main river tributaries (the Orsett Fen Sewer and Golden Bridge Sewer) to avoid physical channel bed and bank disturbance, protecting existing hydromorphological regimes, as well as preventing ecological barrier effects and reducing losses of riparian habitats. This method of crossing offers the best solution in terms of maintaining floodplain connectivity and reducing floodplain storage losses.

14.5.3 Further detail is provided in Chapter 3: Assessment of Reasonable Alternatives (Application Document 6.1).

14.5.4 The Project includes a range of environmental commitments as part of its DCO application. Commitments of relevance to road drainage and the water environment are set out in this section under the following categories:

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

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, taking into account the embedded and good practice mitigation.

14.5.5 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 below, each with an alpha-numerical reference code e.g. (SX.X or LSP.XX). Good practice and essential mitigation are included in the REAC. The REAC forms part of Appendix 2.2: Code of Construction Practice, First iteration of Environmental Management Plan (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 to safeguard the water environment are provided below and commitments to other measures that would safeguard controlled waters are reported in Section 10.5 of Chapter 10: Geology and Soils.

14.5.6 The Design Principles, Environmental Masterplan, CoCP and REAC all form part of the Project control plan. The control plan is the framework for mitigating, monitoring and controlling the effects of the Project. It is made up of a series of control documents, which present the mitigation measures identified in the application that must be implemented during design, construction and operation to reduce the adverse effects of the Project. Further explanation of the control plan and the documents which it comprises is provided in the Introduction to the Application (Application Document 1.3).

14.5.7 Enhancement measures have been directly incorporated into the Project as part of the application of 'good design' principles. Enhancements are measures that are considered to be over and above any measures to avoid, reduce or remediate adverse impacts of the Project. Relevant beneficial effects arising as a consequence of this good design process are described below.

Embedded mitigation

Construction phase

14.5.8 No construction phase embedded mitigation is presented for road drainage and the water environment.

Operational phase

14.5.9 Operational phase embedded mitigation of relevance to road drainage and the water environment is as follows:

a. Where the Project crosses the statutory main rivers Mardyke, Orsett Fen Sewer and Golden Bridge Sewer, to protect riverbanks and facilitate access by the EA to these watercourses to undertake maintenance activities, the Design Principles (Application Document 7.5) commit to a bankside access track being incorporated into the design of the crossings, the width of which would be subject to consultation with the EA (S12.05).

b. The drainage design incorporates Sustainable Drainage Systems (SuDS) and reduces the risk of causing flooding elsewhere by using attenuation features as presented on Figure 2.4: Environmental Masterplan (Application Document 6.2). Drainage of operational areas on greenfield sites would be designed to ensure that post-development surface water runoff rates do not exceed existing rates (LSP.16). Where this attenuation is provided via ponds, the ponds would be designed to appear as naturalistic elements within the wider setting, with planting provided to soften edges where this is appropriate (LSP.17). Conveyance of runoff would be by means of drainage ditches and pipes, and drainage ditches would be used wherever practicable (LSP. 28). This strategy would protect receiving watercourse flow regimes as well as preventing increased scour near drainage outfalls and changes to sediment deposition/accretion in downstream reaches.

c. Drainage design would include treatment systems for highway runoff designed in accordance with DMRB CG 501 (Highways England, 2020d) and DMRB CD 532 (Highways England, 2020g), to meet the requirements specified for each outfall to surface watercourses identified in Appendix 14.3: Operational Surface Water Drainage Pollution Risk Assessment (Application Document 6.3). Further survey and sampling to define the flow regime and water quality of receiving watercourses would be carried out at proposed points of discharge to inform the detailed design of treatment measures (RDWE025).

d. Incorporation of measures to prevent increases in flood risk elsewhere (RDWE037, RDWE039 and RDWE040). These include provision of compensation storage for any permanent losses of floodplain storage volume associated with the West Tilbury Main, Mardyke and Mardyke West Tributary. As presented on Figure 2.4: Environmental Masterplan (Application Document 6.2), the existing topography would be lowered to create depressions that are hydraulically connected to the neighbouring floodplain, allowing their inundation during flood events. Other measures include provision of a flood bund at Orsett Fen and a flow control structure on the West Tilbury Main.

e. Freshwater and wetland habitat would be created to compensate for reaches of open watercourse channels lost to culverting or infilling beneath the Project footprint. These include culverting on the West Tilbury Main and several ordinary watercourses along the Project route to the north of the River Thames. These areas are presented on Figure 2.4: Environmental Masterplan (Application Document 6.2). As illustrated, a floodplain compensation storage area next to the Mardyke West Tributary would be planted as marshy grassland. Also, in the Mardyke catchment, wetland restoration in the form of creating ditches and open water bodies, and wet woodland planting is proposed on land next to the Mardyke Viaduct, combining habitat improvement in this area with the provision of floodplain compensation storage, as presented on Figure 2.4: Environmental Masterplan (Application Document 6.2) (S12.06). At Coalhouse Point, land will be used to create a series of shallow scrapes and ditches to create habitat suitable for use by birds and aquatic invertebrates which are designated interests of the SPA/Ramsar (S9.13).

f. At nitrogen deposition compensation sites (LSP. 27) any existing watercourses, inclusive of their riparian corridors, that flow through or adjacent to the sites would not be physically disturbed. Any ponds or other waterbodies would be retained.

g. At nitrogen deposition compensation sites (LSP. 27), to ensure no detriment to surface or groundwater quality, during the planting and management of vegetation and landform the Project would reduce release of diffuse (rural) sources of pollution such as nitrate (fertilisers) and pesticides (including herbicides), to prevent groundwater pollution as set out in the Environment Agency's approach to groundwater protection (EA, 2018c) and to avoid surface water pollution.

h. Where a natural pond would be removed as part of the construction, this would be replaced. These newly created ponds would be of a similar area, depth and habitat characteristic to the removed ponds and would be provided as part of the proposed landscape mitigation illustrated in Figure 2.4: Environmental Masterplan (Application Document 6.2). Further details are provided in Chapter 8: Terrestrial Biodiversity.

i. Realigned channels would be constructed to reflect the size and form of existing channels to accommodate baseline flow and sediment regimes. The Design Principle S9.10 (Application Document 7.5, Design Principles) commits to, where practicable, constructing realigned channels that are more naturalised in form and that follow historic ditch patterns, promoting morphological and habitat diversity.

j. As detailed in the S9.10 Design Principle (Application Document 7.5, Design Principles), on watercourses that may be used by commuting or foraging mammals, new culverts have been designed to allow mammal passage. The locations and design of mammal ledges and underpasses would be as detailed in the Flood Risk Assessment - Part 10 (ES Appendix 14.6, Application Document 6.3) (RDWE044).

k. The A122 Lower Thames Crossing/M25 junction design would include measures to reduce groundwater drawdown and draining of the Secondary A superficial aquifer (Essex Gravels) (RDWE038).

Good practice

Construction phase

14.5.10 Construction phase good practice related to road drainage and the water environment is set out in CIRIA publication C648 (CIRIA, 2006). Some of the noteworthy measures applicable to the Project are as follows:

a. Securing and carrying out construction works in accordance with relevant environmental permits and consents. The consents required are detailed in the Consents and Agreements Position Statement (Application Document 3.3).

b. The contractor shall prepare a construction phase FRA in accordance with the National Planning Policy Framework (Department of Levelling Up Housing and Communities, 2021). The scope of the construction phase FRA shall consider all construction phase activities and temporary works necessary to deliver the Project. The construction phase FRA shall consider on-site and off-site flood risk and include climate change allowances up to 2030 in accordance with Flood risk assessments: climate change allowances (Environment Agency, 2022) (RDWE001).

c. Worksite drainage systems would be inspected and maintained to ensure they continue to operate to their design standard, safeguarding surface and groundwater quality (RDWE002).

d. Water use efficiency and leakage reduction measures would be adopted during the construction phase, such as use of water-efficient fittings (taps, toilets) in site offices and welfare facilities, use of misting/atomising systems for dust suppression, drive-on recirculating systems for wheel washing, and sub-metering to help in detecting leaks where reasonably practicable. (RDWE004).

e. Wastewater generated from the compound welfare facilities would be discharged to sewer, subject to the agreements with the utility providers or in locations where a sewer connection is not reasonably practicable, collected and taken off site by tanker for disposal at a licensed treatment facility (RDWE005). Details of the discussions with these providers is included in Table 14.1 in Section 14.3.

f. The Contractor shall develop a construction phase drainage plan. The plan shall demonstrate how the Contractor would manage surface water runoff across the worksite, including details of how offsite impacts would be prevented. The surface water drainage design for temporary works shall include climate change allowances up to 2030 in accordance with Flood risk assessments: climate change allowances (Environment Agency, 2022). Work site drainage systems would incorporate pollution control systems designed in line with Control of Water Pollution from Construction Sites C532 (CIRIA, 2001) or as agreed with the Secretary of State. Surface watercourses and waterbodies (as identified in Table 14.6 of ES Chapter 14 (Application Document 6.1)) near work sites would be regularly inspected for signs of siltation or other forms of pollution in line with CIRIA C741 guidance (CIRIA, 2015) and pumped groundwater, process effluents and construction site runoff would be tested to ensure compliance with discharge consent requirements. Rainfall runoff from areas where there is a risk of contamination would be managed using temporary drainage systems and would be subject to treatment prior to discharge. Rainfall runoff from areas of low contamination risk would be captured and reused where reasonably practicably to reduce consumptive water use (e.g to supply wheel wash facilities or for dust suppression).The Contractor shall consult with the EA on any proposed work site discharge to ground in Source Protection Zone 1 and Source Protection Zone 2 (RDWE006).

g. The potential for an impact on the integrity of the River Thames flood defences due to ground movement during tunnelling would be reduced by adopting good tunnelling practice, such as continuous working, erecting linings immediately after excavation, grouting, management of the tunnel face pressures and the measurement of excavated material quantities. In line with the requirements of the EA, flood defences would be monitored to establish a pre-construction baseline, and for a period of at least two years after completion of the works to construct the tunnel, to enable detection of any effects on the structural integrity/condition of the assets during construction of the Project. The monitoring methodology would be agreed with the EA and would continue until the annual rate of settlement is less than a rate agreed with the EA (RDWE007).

h. Where below-ground utilities diversions are required, watercourses would be crossed using trenchless techniques, in order to avoid disturbance to channel form, flow regimes and riparian habitats and species, unless other techniques are agreed with the EA or LLFA, where relevant (RDWE008).

i. A series of commitments have been made to protect groundwater levels and flows at locations of underground utilities works (REAC Refs RDWE051 to RDWE058). The good practice measures described in the commitments, which are specific to individual utilities corridors, would reduce ingress of groundwater into shafts and tunnels and deeper trenches and avoid the potential for significant draining of perched or shallow groundwater, and the associated effects on groundwater dependent receptors.

j. 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).

k. 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).

l. As detailed in Appendix 2.2: Code of Construction Practice, First iteration of Environmental Management Plan (Application Document 6.3), equipment such as spill kits and absorption mats would be made easily accessible on-site and personnel would be trained in using them. Clear protocols and communication channels would be provided to ensure that any spillages are dealt with as soon as they are identified (GS005). This would prevent large areas of soil potentially becoming contaminated and in turn protect surface water quality.

m. Construction site compounds where chemical, waste oils or fuel storage and refuelling activities take place would be managed in line with the following measures:

   i. Within construction compounds specific areas would be designated for the storage of chemicals, waste oils and fuel, and refuelling activities.

   ii. These designated areas shall not be located within SPZ1 (both published SPZ1 or default SPZ1 where a potable water supply abstraction is identified

   iii. These designated areas would be bunded to provide capacity for at least 110% of the largest container and placed on hardstanding to prevent downward migration of contaminants.

   iv. These designated areas would be designed with drainage to include measures for isolating spillages.

   v. Any transfer of fuel or other potentially contaminated liquids would only take place within a designated transfer area.

   vi. Drip trays would be provided to reduce the risk of spillages (GS004).

n. Chapter 10: Geology and Soils includes commitments for the protection of the health of construction workers, as well as to measures to reduce the risk of contamination migrating and entering controlled waters, causing chronic pollution.

o. In order not to compromise their function, existing drainage attenuation features (ponds and infiltration basins) on the A2/M2 and M25 highways affected by the Project, as illustrated on Figure 2.4: Environmental Masterplan (Application Document 6.2), would not be used to receive construction worksite runoff over and above runoff. The contractor would renovate any retention pond used for construction phase drainage that is to form part of the operational drainage system (silt removal). Infiltration basins to form part of the operational drainage system shall only be used to receive runoff from completed sections of highway; general site runoff shall not be discharged to these infiltration basins. Pollution control measures shall be in place before any retention pond or infiltration is brought into service. This applies both to temporary storage facilities and the storage provided for the operational phase of the Project (RDWE043).

p. For protection of potable groundwater sources, no fuel storage or fuel filling shall be allowed within a published or bespoke (in agreement with the Environment Agency) source protection zone 1 (SPZ1) or within the 50m default source protection zone radius of a private water supply well or spring (GS004 and GS005).

Operational phase

14.5.11 Operational phase good practice of relevance to road drainage and the water environment is as follows:

a. 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 (Highways England, 2020b) (RDWE011).

b. Drainage infrastructure and treatment systems would be maintained in accordance with National Highways' DMRB GS 801 Asset Delivery Asset Inspection Requirements (Highways England, 2020f) and DMRB GM 701 Asset Delivery Asset Maintenance Requirements (ADAMr) (Highways England, 2020e), as applicable, to ensure they continue to operate to their design standard to safeguard surface and groundwater quality (RDWE012).

c. Where culverting cannot be avoided, new culverts would be sized to maintain the current land drainage regime and to convey flood flows, inclusive of allowance for climate change, as detailed in Part 10 of the FRA and as shown on Drawing 10081 (ES Appendix 14.6, Application Document 6.3) (RDWE013).

d. Culverts would be inspected and maintained, in accordance with National Highways' DMRB CS 450, DMRB GS 801 Asset Delivery Asset Inspection Requirements and DMRB GM 701 Asset Delivery Asset Maintenance Requirements (ADAMr), as applicable (RDWE014). Where there are any additional, specific inspection or maintenance requirements, these would be documented in the Maintenance and Repair Statement.

Essential mitigation

14.5.12 An iterative appraisal of the Project design taking into account the Design Principles and good practice was undertaken to identify any potentially significant effects that would require essential mitigation. Effects on the water environment that could be significant and therefore required further consideration for essential mitigation were identified as follows:

a. Changes to the groundwater regime due to abstraction for supply to tunnel boring machinery during construction.

b. Temporary intertidal habitat loss and the potential for scour and changes to the hydrodynamics and water quality of the River Thames due to construction of the tunnels, water supply to the Coalhouse Point wetland mitigation area, and receipt of construction compound discharges and operational tunnel drainage.

c. Drawdown and contamination of aquifers local to the North Portal and ramps and changes to groundwater levels/flows and quality during construction of the ground protection tunnel, main tunnels and cross-passages.

d. Detriment to supply systems that support agricultural irrigation during construction and operation.

e. Pollution and impacts on the hydromorphology of surface water receptors that receive construction worksite drainage.

f. Groundwater drawdown at the A122 Lower Thames Crossing/M25 junction, affecting the water balance at a small number of SINCs

g. Increases in flood risk caused by the Project, due to temporary and permanent loss of floodplain storage and embankments impeding floodplain flow conveyance, and flood risk to the Project during construction at construction compounds located within defended Flood Zone 3.

h. Barriers to fish and eel migration due to culverting.

i. Changes to groundwater levels and flows due to deeper below-ground utilities works at specific locations.

14.5.13 Project-specific essential mitigation measures needed to avoid, reduce or offset potential impacts that could otherwise result in effects considered significant in the context of the EIA Regulations were identified for the construction and operational phases.

Construction phase

14.5.14 Construction phase essential mitigation of relevance to road drainage and the water environment is as follows:

a. Water supplied to the tunnel boring machinery may be groundwater abstracted from a Northumbrian Water borehole at Linford. If this is the case, then extraction rates would be agreed with Northumbrian Water prior to commencement of main tunnelling works and would not be exceeded (RDWE003).

b. Construction of the North Portal and ramps to include a deep barrier around the excavations to reduce groundwater ingress. The depth of the barrier walls would be informed by the results of modelling and consultation with the EA and Thurrock Council prior to the commencement of excavation works. The need for any supplementary mitigation measures and any necessary monitoring would also be informed by the results of modelling and consultation with the EA prior to the commencement of excavation works. Technical solutions would be developed by the Contractor following further investigation and assessment. Potential solutions could include:

c. Ground treatment such as grouting to form a low permeability plug below the depth of excavation to reduce the risk of water inflow.

d. Ground improvements (for example an impermeable barrier) to decrease the permeability of the ground to lessen the risk of contaminant mobilisation.

e. Potential to reduce the footprint of the structure by optimising the tunnel bore spacing and layout of the tunnel boring machinery launch structure (GS021).

f. An existing well and reservoir at Low Street that is used by a landowner to pump and store groundwater to feed irrigation systems would be crossed by the Project. Prior to works for the construction of the viaduct crossing that may impact this well and reservoir, this water supply system would be reconfigured, as agreed with the landowner, to maintain continuity of supply during construction and operation of the Project (RDWE015).

g. An existing ditch network in North Ockendon, illustrated in Appendix 14.2: Water Features Survey Factual Report (Application Document 6.3), that is reported by the landowner to form part of an irrigation supply system, would be disconnected by the alignment of the Project road. A new supply route across the Project road would be provided unless otherwise agreed with the landowner (RDWE016).

h. The Contractor could stabilise the ground to reduce ground movement (e.g. to protect Network Rail assets), facilitate operation of tunnel boring machinery and maintenance of the cutter head using a ground protection tunnel or suitable methods accepted by National Highways that would avoid the need for surface excavations/penetrations within areas designated for protection of wildlife (RDWE017).

i. The ground protection tunnel and shafts, if used under RDWE017, would be constructed using methods to control groundwater pumping and ingress, such as:

    i. Wet excavation and grout plug placement to form the shafts

    ii. Use of mud pressure balancing tunnel boring machinery to form a lined tunnel with a specified maximum leakage rate compliant with the Lower Thames Crossing tunnelling specification. Water and flow monitoring within the tunnel would be undertaken for the periods that the ground protection tunnel is being used for construction purposes, in consultation with the EA, to verify compliance with the tunnel’s design specification regarding maximum permissible rates of water ingress (RDWE018a).

j. The ground protection tunnel and shafts, if used under RDWE017, would be decommissioned by backfilling with suitable materials to ensure the ground protection tunnel and shafts are completely filled. No temporary works would be left in the upper 2m of ground. Shaft sites would be returned to their current land use (RDWE018b).

k. Chemicals and materials, such as cement, grout and lubricants used during construction activities in proximity to any groundwater SPZ would be stored, transported and used in a suitable manner to safeguard potable water supply (RDWE019).

l. Construction of cross-passages between the main tunnels would use groundwater control techniques, such as grouting or ground freezing, to reduce dewatering requirements and therefore local groundwater drawdown (RDWE020).

m. Bankside vegetation reinstatement and planting at the entrance to the West Tilbury Main culvert (reference X-EFR-2-01) identified in Part 10 of ES Appendix 14.6: Flood Risk Assessment (Application Document 6.3) 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 would include Alder. Root barriers would be installed to protect structural integrity of the bank as appropriate (RDWE021).

n. Water discharged into the western ditch from the southern tunnel entrance compound would be treated to the standard specified within the discharge consent granted by the EA and released at greenfield runoff rates. The runoff collection and management system would be operated until full reinstatement of the compound area is complete. The water quality standards for the discharge into the western ditch will include (but not be limited to) the following parameters and would not exceed these values unless otherwise agreed by the EA as part of its discharge consents (such agreement not to be unreasonably withheld or delayed) which would be set following consultation with Natural England: Discharge rate of no more than the 1 in 2 year greenfield rate or 2ls-1; whichever is greater; pH, biochemical oxygen demand, dissolved oxygen, total ammonia, unionised ammonia, suspended solids, total phosphorus, turbidity, salinity, cover of filamentous green algae Enteromorpha, water levels (depth), with standards no greater than that recorded during the pre-construction survey (RDWE033).

o. Compensatory flood storage areas (CFSAs) would be formed to offset any loss of storage attributable to the Project. The form of CFSAs used for the Project would comprise areas that allow flood water to freely flow in and out of them, and areas where floodwater is temporarily retained in upstream catchments. All CFSAs would be designed to accommodate a 1 in 100 year fluvial event with climate change allowances up to 2130, and would be as described in Part 6 of Appendix 14.6: Flood Risk Assessment (Application Document 6.3) and as shown in Drawings 1080, 1081 and 1082. (RDWE037). Their preliminary design and modelled efficacy has been reviewed and approved by the EA.

p. In line with RDWE001 and in accordance with the requirements of the National Planning Policy Framework regarding development and flood risk, the northern tunnel entrance compound and Station Road compound to the north of the River Thames and the southern tunnel entrance compound and Milton compound to the south of the River Thames, which are partially sited within Flood Zones 2 and 3, would be laid out in accordance with a site-specific flood risk assessment, where facilities at highest vulnerability to flooding, e.g. sleeping accommodation, medical and welfare and principal office facilities, are located in the lowest flood risk zone (Zone 1). Only low vulnerability and water compatible uses would be situated in the high-risk Flood Zone 3. (RDWE022).

q. To mitigate potential effects on water quality and hydrodynamics within the River Thames, the discharge arrangement described in RDWE028 would be constructed and operational in advance of the excavation of the North Portal and tunnelling works and would be used for the discharge of treated construction phase effluents. All effluents would receive treatment prior to discharge into the River Thames to ensure compliance the Environmental Permitting (England and Wales) Regulations 2016 (RDWE023).

r. Potential effects arising from the maintenance, use and decommissioning of marine structures would be controlled by the measures agreed with the MMO as detailed in the Deemed Marine Licence (RDWE024). Further details are provided in Chapter 9: Marine Biodiversity.

s. Drainage from the northern tunnel entrance compound is proposed to outfall from the north side of the River Thames. The design of the discharge pipeline and outfall to the Thames would provide for a subtidal, mid-water discharge for effective dilution and dispersal, and to reduce disturbance to the intertidal zone. The discharge infrastructure would be designed in accordance with measures agreed with the MMO as detailed in the Deemed Marine Licence (Schedule 15 of the Draft Development Consent Order, Application Document 3.1) (RDWE028). Further details are provided in Chapter 9: Marine Biodiversity.

t. The West Tilbury Main culvert under the Project road (reference EFR-2-01), identified in Appendix 14.6: Flood Risk Assessment - Part 10 (Application Document 6.3) 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).

u. The West Tilbury Main culvert (reference EFR-2-01), identified in Appendix 14.6: Flood Risk Assessment - Part 10 (Application Document 6.3) would be partially 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 0.30m (RDWE031).

v. Findings from the groundwater modelling of the A122 Lower Thames Crossing/M25 junction cutting shows that without mitigation, there could be up to 0.7m groundwater drawdown at St Cedd's Holy Well, at the Hall Farm moat, and up to 1.1m groundwater drawdown at Hobbs Hole and southern edge of Thames Chase Forest Centre. These features are illustrated in Annex L of Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3). Therefore, during detailed design, having regard for ground investigation (GI) data and monitoring (groundwater levels, surface water levels and, where feasible, flows), the need for measures to reduce groundwater drawdown beyond the M25 cutting, for example through the implementation of seepage control, would be confirmed in consultation with the EA and London Borough of Havering, and, if confirmed to be necessary, the detail of such measures would be agreed by the Secretary of State following consultation with the EA and the London Borough of Havering (RDWE038).

w. The main tunnels would be constructed so that the crown of the tunnel is at sufficient depth below the bed of the River Thames to avoid the need for any works within the river to provide tunnel scour protection (RDWE041).

x. There is a requirement to replace an approximately 100-metre section of existing water pipeline on Lower Higham Road. This utility diversion, work number MU26, would be approximately 10m distance south of the South Thames Estuary and Marshes SSSI and Thames Estuary and Marshes Ramsar. Any pumped water removal and subsequent disposal of water from the utility works shall be subject to approval from the EA and comply with EA Permitting Regulations to protect the adjacent areas of nature conservation RDWE053).

y. The temporary water pipeline for the Lower Thames Crossing tunnel boring machinery supply (Work Number MUT6) would cross Gobions Sewer, within the SPZ1 area of the Linford groundwater source. Should the crossing be below ground, such as by means of a trenchless methodology, the design, implementation and subsequent removal of the underground sections of the utility corridor within the SPZ1 shall be conducted in consultation with Northumbrian Water and the EA (Appendix 14.6: Flood Risk Assessment (Application Document 6.3)) (RDWE058).

Operational phase

14.5.15 Operational phase essential mitigation of relevance to road drainage and the water environment is as follows:

a. To ensure continued functionality of the West Tilbury Main, an existing blockage of the culvert where Station Road crosses the West Tilbury Main would be cleared and the section of West Tilbury Main running northward from Station Road would be re-established as a flowing watercourse. The culvert and watercourse maintenance would be as described in the Flood Risk Assessment - Part 10 and illustrated on Drawing 00180 (Appendix 14.6, Application Document 6.3) (RDWE047).

b. The Project road would intercept an overland flow path running east to west across East Tilbury marshes. To offset the loss of this flow path, three existing culverts would be removed, and one enlarged replacement culvert would be constructed. A flow control structure (ref S-EFR-2-01) would be constructed in West Tilbury Main to manage flood levels in the marshes, as described in Flood Risk Assessment - Part 10 and illustrated on Drawing 00180 (Appendix 14.6, Application Document 6.3) (RDWE046).

c. The tunnel drainage system would include provision for the capture and isolation of contaminated waters to prevent pollution of the receiving watercourse. Discharges would be restricted to high tide conditions to maximise available dilution and mixing and to prevent scour/erosion of the intertidal zone (RDWE026).

d. Infiltration basins shall be provided at the locations identified on Figure 2.4: Environmental Masterplan (Application Document 6.2). These would be designed as vegetated drainage systems in accordance with the relevant provisions of DMRB CD 532. Pollution control measures for infiltration basins shall comprise the treatment systems identified in Part 7 of the FRA and pollution control measures on existing infiltration basins shall be decommissioned and replaced with equivalent alternatives. Where included, infiltration basins would incorporate a lined sediment forebay with sufficient capacity to accommodate the first flush. Where sediment forebays cannot be accommodated, a vortex grit separator shall be installed upstream of the basin inlet. Infiltration basins would accommodate runoff from the Project road for all events up to and including the 1 in 100 year rainfall event with climate change and overland flow paths shall be established to manage exceedance flows from infiltration basins during extreme events (RDWE034).

e. The proposed road drainage attenuation and treatment pond located at Chadwell St Mary, as indicated on Figure 2.4: Environmental Masterplan (Application Document 6.2) is situated within a groundwater SPZ1. The entire pond would include an impermeable lining in order to prevent seepage of drainage discharges into the ground to safeguard potable groundwater quality (RDWE032).

f. Retention ponds shall be provided at the locations shown on Figure 2.4: Environmental Masterplan (Application Document 6.2). New retention ponds shall be designed as vegetated drainage systems in accordance with the provisions of DMRB CD 532 and will be sized to ensure no increase in flood risk outside the highway boundary by providing for discharge that is attenuated to the 1 in 1 year greenfield runoff rate (or 1 litre per second whichever is higher) for all events up to and including the 1 in 100 year rainfall event with climate change. Attenuation would be by means of vortex controls, orifice plates or a combination thereof. Overland follow paths shall be established to manage exceedance flows from retention ponds. Discharge rates from existing retention ponds would be reduced by a least 50% on current discharge rates. Pollution control measures shall comprise the treatment systems identified in Appendix 14.6: Flood Risk Assessment - Part 7 (Application Document 6.3). Retention ponds would incorporate a lined sediment forebay with sufficient capacity to accommodate the first flush. (RDWE035).

g. A detention basin shall be provided at the location identified on Figure 2.4 Environmental Masterplan (Application Document 6.2). The basin shall be designed as a vegetated drainage system in accordance with the relevant provisions of DMRB CD 532. The basin will be sized to ensure no increase in flood risk outside of the highway boundary by providing for discharge that is attenuated to the 1 in 1-year greenfield runoff rate (or 1 litre per second, whichever is higher) for all events up to and including the 1 in 100 year rainfall event with climate change. Attenuation would be by means of vortex controls, orifice plates or a combination thereof. Overland flow paths shall be established to manage exceedance flows from the detention basin. Pollution control measures shall comprise the treatment systems identified in Appendix 14.6: Flood Risk Assessment - Part 7 (Application Document 6.3). The detention basin would incorporate a lined sediment forebay with sufficient capacity to accommodate the first flush. (RDWE048).

h. Water infiltration into the tunnel bores and cross-passages during operation would be reduced by measures including gaskets (for segmentally lined tunnels) and membranes (for sprayed concrete lined tunnels), compliant with the Lower Thames Crossing tunnelling specification (RDWE027).

i. Flood protection would be provided around the North Portal to reduce the risk of inundation of the tunnel. The flood protection will comprise flood walls, bunds and targeted earthworks. The portal protection would be designed to accommodate a 1 in 1000 year River Thames extreme tide level with climate change allowances up to 2130 and a freeboard (to allow for residual uncertainties) of 1000mm. The portal protection would be as described in ES Appendix 14.6: Flood Risk Assessment – Part 6 (Application Document 6.3) (RDWE029).

j. A drainage channel would be provided between the Mardyke and the viaduct abutment immediately to the west of the river. The channel would be designed to manage intercepted floodplain flows for a 1 in 100-year storm event with climate change allowances to 2130. (RDWE040).

k. A raised bund would be constructed to prevent formation of the new flow path from Golden Bridge Sewer to the Mardyke in Orsett Fen. The bund would be designed to provide the intended function during storm events up to the 1 in 1000-year with climate change allowance to 2130 and incorporate a freeboard allowance of 60mm. The bund would be as described in Flood Risk Assessment - Part 6 (and as shown on Drawing 00181) of Appendix 14.6 (Application Document 6.3) (RDWE039).

l. Water level control structures (weirs) shall be provided to facilitate operation of the wetland areas, all as detailed in ES Appendix 14.6: Flood Risk Assessment – Part 10 (Application Document 6.3). One level control structure shall be constructed at the northern end of the watercourse running south to north through Coalhouse Point Wetland (see Drawing No. 00180 of ES Appendix 14.6: Flood Risk Assessment, Application Document 6.3). Two level control structures shall be constructed where the Mardyke is connected to the watercourses in the proposed Mardyke Wetland (see Drawing No. 00181 of ES Appendix 14.6, Flood Risk Assessment, Application Document 6.3) (RDWE050).

m. The medium-pressure gas pipeline (Work No. G1b) is proposed to cross beneath the A122 Lower Thames Crossing by construction of deep shafts and a microbore tunnel. The works are above the Chalk aquifer water table. However, shallower Lower London Tertiary aquifers (Thanet Formation) may be present at shaft locations for Work No. G1b. Should perched groundwater be encountered then the shafts shall be sealed after construction to prevent ingress of groundwater and potential permanent draining of any perched groundwater (RDWE051).

n. Multi-utilities corridors and gas pipelines are proposed close to New Fish Pond beside the Inn on the Lake, Shorne. It is not known whether the pond is lined and there is potential hydraulic connection between the pond and the Lambeth Group aquifer and the Harwich Formation aquifer. Perched groundwater could be present. There is a potential for utility trenches to act as a permanent drain where the base of a trench slopes downwards away from the pond. In addition, crossings of utility corridors may require locally deeper trenches which could increase the draining effect if extended down slope. If New Fish Pond is confirmed to be unlined, then where within 50m distance of the pond, gas pipeline Work No. G1b (western section), underground multi-utility Work No. MU12 and temporary underground multi-utility Work No. MUT2 shall be constructed to reduce the potential draining effects away from the pond area (RDWE052).

o. The Low Street irrigation reservoir (located at Easting 567,023 and Northing 177,780) is groundwater fed. Utility corridors are proposed to the east, west and north of the reservoir (Work No. MU28 and Work No. MU33) and have the potential to form a barrier to groundwater flow, cause draining of groundwater that would otherwise flow towards the unlined reservoir or cause direct drainage from the reservoir. The spatial arrangement of the utility corridors and the below-ground materials shall be designed to prevent drainage from the reservoir, or barrier effects reducing groundwater flow to the reservoir (RDWE054).

p. Shallow groundwater conditions are expected at land in the small valley feature near where Hoford Road would cross the A122 Lower Thames Crossing and at the continuation of the valley feature where Brentwood Road would cross the A122 Lower Thames Crossing, near Brook Farm. Underground multi-utility Work No. MU37, Work No. MU38 and Work No. MU40 would be aligned perpendicular to the valley and could cause a barrier to groundwater flow. The design of the utility corridors, shall consider the depth to formation level and below-ground materials to reduce barrier effects to groundwater flow (RDWE055).

q. Complex layered superficial geology at the proposed A122 Lower Thames Crossing/M25 junction area is water bearing and may contribute baseflow to unlined surface water bodies such as Hobbs Hole, part of the Thames Chase Forest Centre SINC. Underground multi-utility corridor Work No. MU72 is a proposed trenchless installation of a multi-utility corridor beneath the London, Tilbury, and Southend railway. The utility diversion would require works beneath groundwater. Temporary groundwater level lowering outside of the Order Limits shall be reduced by total or partial temporary exclusion of water flow into the shafts. On completion of placing the utility diversion, the shaft walls shall be removed, and the shafts shall be backfilled with soil arisings in the same order as excavated in order to reduce change of the layered geology. Any groundwater removal during the works shall be subject to Environmental Permitting Regulations (RDWE056).

r. Complex layered superficial geology at the proposed A122 Lower Thames Crossing/M25 junction is water bearing and may contribute baseflow to unlined surface water bodies such as the moat at Hall Farm moat, paddock and St Mary Magdalene Churchyard SINC, and Fields south of Cranham Marsh SINC. Work No. MU73 is a proposed trenchless installation of a multi-utility corridor from west of the London, Tilbury and Southend railway, under the proposed cutting of the A122 Lower Thames Crossing, to east of the M25. The construction method shall reduce the depths of the temporary launch pit and reception pit so that the pits are above the groundwater level and the trenchless equipment is launched from above groundwater. After completion of the utility works, the pits shall be backfilled with soil arisings in the same order as excavated in order to reduce change of the layered geology. Should the temporary launch pit and reception pit be required to be excavated to below groundwater level then temporary groundwater level lowering outside of the Order Limits shall be reduced by temporary total or partial exclusion of water flow into the pits. On completion of placing the utility diversion, the pit water exclusion measures shall be removed, and the pits shall be backfilled with soil arisings in the same order as excavated. Any groundwater removal during the works shall be subject to Environment Permitting Regulations (Appendix 14.6: Flood Risk Assessment (Application Document 6.3)) (RDWE057).

s. A new structure in the existing tidal flood defence fronting the Coalhouse Point HRA mitigation area, shown on the Environmental Masterplan (ES Figure 2.4, Application Document 6.2) may be constructed to facilitate passage of water from the River Thames as a source of water supply to the mitigation area, consistent with the commitment in HR010. The structure would be self-regulating and allow for water ingress to be prevented when the desired water level within the created ditches and scrapes is achieved consistent with the commitment in HR010 (RDWE049)

t. The irrigation reservoir at Low Street is groundwater fed. Utility corridors are proposed to the east, west and north of the reservoir (Work numbers MU28 and MU33) and have the potential to form a barrier to groundwater flow, cause draining of groundwater that would otherwise flow towards the unlined reservoir or cause direct drainage from the reservoir. The spatial arrangement of the utility corridors and the below ground materials shall be designed to prevent drainage from the reservoir or barrier effects reducing groundwater flow to the reservoir (RDWE054)

Enhancement

14.5.16 Beneficial effects arising from enhancements to the Project of relevance to the water environment are as follows:

a. Discharge rates from existing retention ponds retained by the Project shall be reduced by at least 50% by providing additional storage volumes, benefiting the flood regime of receiving watercourses in the Mardyke and West Mardyke Tributary catchments (RDWE035).

b. Baseline flood risk in the Mardyke catchment would be further reduced through the proposed wetland restoration in Orsett Fen, which would hold back and slow down the flow of water, thereby reducing flood risk on a catchment scale (S12.06).

c. A net gain in open watercourse channel would be achieved, through creation of new channels, watercourse diversions and breaking out culverted watercourses, as detailed in Appendix 14.6: Flood Risk Assessment - Part 10 (Application Document 6.3).

14.6 Assessment of likely significant effects

14.6.1 This section presents the assessment of likely significant effects on road drainage and the water environment resulting from the construction and operational phases of the Project. This is based on the design of the Project and takes into account the mitigation as presented in Section 14.5 of this chapter.

14.6.2 As documented in Table 14.2, a range of assessments has been undertaken at a simple and detailed level following DMRB LA 113 (Highways England, 2020a). The detailed findings of these assessments are provided in Appendices 14.3 to 14.6 (Application Document 6.3) and are summarised below.

14.6.3 The assessment considers the value/sensitivity and impact magnitude criteria drawn from DMRB LA 113, and the significance of effects has been determined in accordance with the matrix provided in Table 4.3 of Chapter 4: EIA Methodology (Application Document 6.1) and through the use of professional judgement.

Construction phase

Groundwater levels and flows

South of the River Thames

14.6.4 The proposed ground protection tunnel, main tunnels and cross-passages have the potential to cause partial draining of the North Kent Medway Chalk aquifer and resulting groundwater drawdown during construction. Following the implementation of the essential and good practice mitigation measures described in Section 14.5, such as lining the tunnels so that a specified maximum leakage rate is achieved, the impacts of the construction of the ground protection tunnel and shafts and the main tunnels are assessed as having a negligible magnitude impact on the North Kent Medway Chalk aquifer, which is assigned very high importance. Therefore, the effects of these works are assessed as temporary slight adverse, which is **not significant**.

14.6.5 The proposed ground protection tunnel, main tunnels and cross-passages also have the potential to cause groundwater lowering of the shallow water system at the Thames Estuary and Marshes Ramsar site, which is assigned very high importance. As discussed in Section 14.4, a water balance study of the shallow water system concluded that rainfall contributes the largest proportion of inflow to the Thames Estuary and Marshes Ramsar site, within the Order Limits. The Project would cause no change to the rainfall regime. Assessments have concluded that the shallow water system is largely separated from the deeper confined Chalk aquifer. As a result and following the implementation of the essential and good practice mitigation measures described in Section 14.5, such as use of groundwater control techniques, including grouting or ground freezing to reduce local groundwater drawdown, the magnitude of impact is assessed as negligible. Therefore, the effect of these works on the shallow groundwater component of the water balance of the Thames Estuary and Marshes Ramsar site, which is assigned very high importance, are assessed to be temporary slight adverse, which is **not significant**.

14.6.6 The location of the South Portal means that excavation would be above the water table, and therefore groundwater control or groundwater pumping would not be required. Consequently, changes to groundwater levels and flows in the underlying North Kent Medway Chalk aquifer, which is assigned very high importance, would be avoided. The impacts of the South Portal construction are assessed as having a magnitude of no change. Therefore, the effect of the South Portal construction on the North Kent Medway Chalk aquifer, which has very high importance, is assessed as neutral, which is **not significant**.

14.6.7 The three NSIP utilities that are underground gas pipelines are located south of the River Thames. Other below-ground utilities works, south of the Thames, would comprise multiple utilities (MU) corridors, other gas pipelines and pylon foundations. The majority of the MU corridors and gas pipelines would be open cut trenches at shallow depth (within 3m depth), locally deeper (6m) for gas pipeline connections. A magnitude of impact of no change to groundwater levels and flows of the North Kent Medway Chalk aquifer, which has very high importance, has been assessed associated with shallow utilities works, resulting in a neutral effect, which is **not significant**.

14.6.8 Deep utility corridor sections are required for new gas pipelines, including two of the NSIP utilities works, with shafts circa 12 to 20m deep. However, the assessed impact to the Chalk aquifer groundwater levels is no change, as the water table is approximately 25m lower than the base of the deepest shaft and dewatering of the North Kent Medway Chalk would be avoided. Therefore, the effect of the gas pipelines construction on the North Kent Medway Chalk aquifer, which has very high importance, is assessed as neutral, which is **not significant.**

North of the River Thames

14.6.9 Construction of the North Portal and approach ramps would take place below the water table and groundwater control would be required. Without suitable mitigation, dewatering (pumping) would induce widespread drawdown of groundwater levels in the underlying South Essex and Thurrock Chalk aquifer and adversely affect the Linford public water supply well. Implementation of the mitigation measures described in Section 14.5, and secured by REAC ref GS021, such as construction of deep barrier walls and basal grouting, would reduce groundwater ingress. The proposed structures are parallel to the groundwater flow and therefore would not create a barrier effect during the construction phase. As a result, the magnitude of impact of any residual groundwater control on groundwater levels and flows would be negligible. Considering the very high importance of the aquifer and public water supply well, as well as the negligible magnitude of impact, the effect of these works is assessed as temporary slight adverse, which is **not significant**.

14.6.10 Ground improvement in the form of soil mixing is likely to be necessary to support the construction activities of the tunnel approach ramp, North Portal and tunnel. When the ground improvement is included in the North Portal groundwater model, inclusive of the mitigation measures described in Section 14.5, and secured by REAC ref GS021, the results show that the drawdown remains constrained to an area very near to the Project alignment. The magnitude of impact on groundwater levels and flows is assessed as negligible. Considering the very high importance of the aquifer and public water supply well, as well as the negligible magnitude of impact, the effect of the soil mixing is assessed as temporary slight adverse, which is **not significant**.

14.6.11 The temporary water pipeline for the Lower Thames Crossing tunnel boring machinery supply and two sections of multi-utility corridors are proposed within the Linford SPZ1. The majority of these works would be carried out using open cut trench methods and excavations would therefore be shallow (within 3m depth, with most of the trenches being 1-1.5m deep). A short, shallow trenchless section (RDWE058) may also be required beneath Gobions Sewer, within the SPZ1, for the temporary water pipeline. In addition, new pylons for overhead electricity works would include pad foundations within the SPZ1. All works would be within superficial deposits or the upper levels of the Thanet Formation and therefore would avoid the South Essex and Thurrock Chalk water body. An impact on groundwater levels and flows of no change is therefore assessed, which combined with the very high importance of the Chalk aquifer and SPZ1, results in an overall effect of temporary neutral, which is **not significant**.

14.6.12 Construction of the Project's viaduct over the Tilbury Loop railway line has the potential to compromise an existing source of water that is pumped from a well and stored in a reservoir at Low Street, to feed an irrigation system. These receptors are assigned medium importance, as described in Table 14.6 and Table 14.7. As described in Section 14.5, and secured by REAC Ref RDWE015, the Applicant commits to reconfigure this system to ensure that the water source and means of water supply storage and distribution are not compromised. Following implementation of this mitigation measure, the magnitude of impact on these medium importance receptors is assessed as negligible with an overall effect of permanent neutral (since the water source would be maintained), which is **not significant**.

14.6.13 The potential for groundwater seepage is inferred at the deepest cutting at the A13/A1089/A122 Lower Thames Crossing junction (A13 westbound to Project road southbound/A1089 link road 3), which could partially drain the Essex South Lower London Tertiaries, causing the groundwater level to lower. The aquifer is assigned medium value and the magnitude of impact has been assigned as negligible adverse, due to the expected small flows of groundwater into the cutting. The assessed environmental effects are temporary slight adverse, which is **not significant**.

14.6.14 All cuttings are above the Chalk aquifer. However, groundwater control during construction of the deepest cutting in the Lower London Tertiaries at the A13/A1089/A122 Lower Thames Crossing junction could cause short-term, locally reduced recharge to the underlying Chalk aquifer. The aquifer is assigned very high value and the magnitude of impact has been assigned negligible adverse, due to the expected small flows of groundwater into the cutting. The assessed environmental effects are temporary slight adverse, which is **not significant**.

14.6.15 The proposed cutting at the A122 Lower Thames Crossing/M25 junction has the potential to partially drain the local Essex Gravels aquifer, causing groundwater level lowering. The aquifer is assigned medium value and the impact has been assigned minor magnitude, informed by the results of a groundwater modelling study (further detailed in Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3)) and considering the mitigation proposed to reduce effects. Mitigation, secured by REAC Ref RDWE038, includes retaining walls or other seepage control systems to limit groundwater ingress into the cutting. The assessed environmental effects are permanent slight adverse, which is **not significant**.

14.6.16 Without suitable mitigation, construction of the cutting at the A122 Lower Thames Crossing/M25 junction has also been assessed as potentially impacting an existing surface water abstraction for irrigation. The existing abstraction is said by the landowner to be fed by groundwater flows collected in historical deep drains (North Ockendon catchment) and a spring (part of the Hall Farm moat, paddock and St Mary Magdalene Churchyard SINC) 75m east and 40m south-west respectively, from St Mary Magdalen Church. As described in Section 14.5, the Applicant commits to measures to reduce groundwater drawdown beyond the M25 (REAC Ref RDWE038), during construction, reducing the magnitude of impact to negligible. As a result, the residual effect of the cutting on this receptor is assessed as slight adverse, which is **not significant**.

14.6.17 Related to the above, the construction of the cutting at the A122 Lower Thames Crossing/M25 junction has the potential to cause groundwater lowering. This may result in reduced baseflow to ponds and ditches, without mitigation, at the Hall Farm moat, paddock and St Mary Magdalene Churchyard SINC; and southern edge of Thames Chase Forest Centre SINC (including the Hobbs Hole pond). Ecology surveys show these to have low importance, as described in Section 14.4. As described in Section 14.5, the Applicant commits to measures to reduce groundwater drawdown beyond the M25 during construction, reducing the magnitude of impact to negligible. As a result, the residual effect of the cutting on these receptors is assessed as slight adverse, which is **not significant**.

14.6.18 The proposed cutting at the A122 Lower Thames Crossing/M25 junction has been assessed as not causing groundwater drawdown that could impact water levels in recreational lakes at Stubbers Adventure Centre, which have been assigned a medium value. In addition, the lakes are founded on clay bedrock geology and have been confirmed by the site operators to be mostly clay lined. Therefore, the magnitude of impact is classified as no change. The effect of these works is assessed as being permanent neutral, which is **not significant**.

14.6.19 North of the River Thames the deepest utility works would be mostly gas pipelines at locations where roads are crossed beneath the A13/A1089/A122 Lower Thames Crossing junction area. Groundwater bodies in these areas comprise mostly Lower London Tertiaries (medium value) or low permeability Head Deposits (negligible value) on top of unproductive bedrock (London Clay Formation). There would be a magnitude of impact of negligible and overall, an effect assessed as neutral, which is **not significant**. Elsewhere at the deep sections of utilities corridors near Brentwood Road and at the A13 crossings, the magnitude of impact on groundwater levels is also assessed as negligible. This is because strata at the depths proposed for these utility works are dry, based on available GI. In addition, should perched water be encountered, any construction phase dewatering would be limited due to short duration of construction and the moderately shallow excavations. Overall, the effect is assessed as neutral, which is **not significant**.

14.6.20 A multiple utility (ref MU72) has a deep section at the proposed crossing beneath the London, Tilbury and Southend railway line and multiple utility MU73 has a deep section at the proposed crossing beneath the same railway and continuing beneath the A122 Lower Thames Crossing/M25 junction cutting and the existing M25. Long-term groundwater monitoring undertaken as part of the GI confirms that the excavations would be beneath the water table. Applying the precautionary principle, Project commitments are secured in the REAC (RDWE056 and RDWE057) to ensure any potential impact on the medium-value designated groundwater body and nearby medium-value SINCs are reduced to one of negligible magnitude. Overall, an effect of neutral is assessed, which is **not significant**.

Groundwater quality

South of the River Thames

14.6.21 Saline intrusion of groundwater can occur where groundwater levels are lowered to levels less than adjacent sea or estuary water levels. Construction of the ground protection tunnel and associated shafts and the main tunnels and cross-passages has the potential to cause saline intrusion of the Chalk aquifer, due to groundwater drawdown near the River Thames. South of the Thames, saline intrusion would have the potential to impact the North Kent Medway Chalk water body, which has very high importance as an aquifer that supports regional public water supply abstractions. Measures such as the detailing of gaskets and waterproofing tunnel lining membranes to achieve specified leakage rates and ground treatment (e.g. grouting or ground freezing), would reduce groundwater pumping and drawdown, such that the magnitude of impact is assessed as negligible. The overall effect on groundwater quality south of the River Thames (of very high importance) due to saline intrusion (which with mitigation is assessed to be negligible) is assessed as temporary slight adverse, which is **not significant**.

14.6.22 It has been demonstrated that the Thames Estuary and Marshes Ramsar site (of very high importance) is not supported by the deep Chalk aquifer and is therefore not at risk of impact from saline intrusion, as a result of Project construction activities. A magnitude of impact of no change is assessed, which would result in an overall effect of neutral, which is **not significant**.

14.6.23 No saline intrusion would be caused by the proposed deep utility works since no deep utilities are proposed close to the tidal River Thames and no significant dewatering is proposed. A magnitude of impact on groundwater quality of no change is therefore assessed, resulting in a temporary neutral effect (regardless of receptor value), which is **not significant**.

North of the River Thames

14.6.24 North of the River Thames, saline intrusion would have the potential to impact the South Essex and Thurrock Chalk water body and the inland Linford public water supply well. Both these receptors are assigned very high value. The essential mitigation identified for the North Portal and ramps construction, presented in Section 14.5 and secured by REAC Ref GS021, that includes deep barrier walls and other ground improvement measures, would limit groundwater ingress to the excavation sites and reduce groundwater drawdown. These mitigation measures would reduce the magnitude of impact on the Chalk aquifer to negligible. The significance of effect has therefore been assessed to be temporary slight adverse, which is **not significant**.

14.6.25 At the northern tunnel entrance construction compound, no changes in groundwater salinity are predicted as a consequence of the soil mixing required to facilitate construction. A magnitude of impact on groundwater quality of no change is therefore assessed, resulting in a neutral effect (regardless of receptor value), which is **not significant**.

14.6.26 No saline intrusion would be caused by the proposed deep utility works since no deep utilities are proposed close to the tidal River Thames and no significant dewatering is proposed. A magnitude of impact on groundwater quality of no change is therefore assessed, resulting in a temporary neutral effect (regardless of receptor value), which is **not significant**.

GWDTEs

14.6.27 GWDTEs have the potential to be detrimentally affected if groundwater levels or flows are reduced due to the draining effect of a road cutting where hydraulically connected groundwater is shallow. GWDTEs also have the potential to be affected should discharges to ground elsewhere increase the nutrient loading (e.g. nitrates) of water that feeds the GWDTE, or otherwise cause detriment to supporting groundwater quality. Table 14.3 is used to assess the impact to the following GWDTEs.

South of the River Thames

14.6.28 One small pond at the Jeskyns Community Woodland car park has been assessed as a potential GWDTE as discussed in Section 14.4. No utility diversion works are proposed in proximity. Using the GWDTE risk matrix shown in Table 14.3, the low importance of the feature (a car park pond of low ecological value) and the negligible impact on groundwater levels and groundwater quality means that the overall significance of effect is assessed to be temporary negligible adverse, which is **not significant**.

North of the River Thames

14.6.29 Cranham Marsh LNR, near the A122 Lower Thames Crossing/M25 junction, has been assessed as having a variety of habitats, the majority not being dependent on groundwater. Discrete areas of fen (valley mire) habitat recorded in the Middle Wood and Spring Wood parts of the LNR are each assigned moderate value as a GWDTE. At a minimum distance of approximately 800m from the cutting, the groundwater modelling study (further detailed in Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3)) shows that no groundwater drawdown at the LNR would be caused. Therefore, the magnitude of impact on the groundwater regime and groundwater dependent habitats within the LNR would be assessed as negligible. Therefore, there would be an effect of temporary negligible adverse significance, which is **not significant**.

14.6.30 The Ingrebourne Marshes SSSI is mapped as a GWDTE by the EA and has high value. However, the SSSI is situated over 2km further south-west of Cranham Marsh LNR, and almost 3km from the Order Limits. A negligible impact magnitude is assessed for this GWDTE, with an overall effect of negligible, which is **not significant**.

14.6.31 North Ockendon Pit SINC, an area near Ockendon link, has been assessed using information from Project habitat surveying, as a potential GWDTE (Section 14.4). The importance of the area has been assessed as low as a GWDTE due to a low ecological value and low groundwater dependency score. Construction of the proposed cutting at the A122 Lower Thames Crossing/M25 junction would potentially cause drawdown of groundwater levels in the aquifer (the Essex Gravels) that has connectivity to this site. Considering the mitigation proposed to limit groundwater ingress into the cutting, which is secured by REAC Ref RDWE038, a negligible adverse impact magnitude is assessed. The overall significance of effect would be temporary negligible adverse, which is **not significant**.

14.6.32 Various small areas associated with ditches and ponds have been assessed as potential GWDTEs (Section 14.4). Golf course pond margins north of Thames Chase and ditches beside Cooper Shaw Road, Tilbury, have been identified. They are assessed as of low importance, based on ecological value. The assessed negligible magnitude of impact to groundwater level and groundwater quality means that the overall significance of effect would be temporary negligible adverse, which is **not significant**.

14.6.33 A desk study review of London Borough of Havering SINC citations (eCountability Limited, 2020) has identified some sites that have plant communities that are indicative of a potential GWDTE. These are located near the M25, as described in Section 14.4, near the A122 Lower Thames Crossing/M25 junction and northwards near M25 junction 28. The various sites are assessed as of low to moderate importance with respect to GWDTE importance. Other sites such as Hobbs Hole pond in Thames Chase Forest Centre SINC, and the ponds at Hall Farm moat, paddock and St Mary Magdalene Churchyard SINC are not GWDTEs due to them being open water bodies, therefore they are discussed in the groundwater levels and flows section of this assessment. Following consideration of the mitigation measures secured by REAC ref RDWE038, and those related to utilities works number MU72 and MU73 (RDWE056 and RDWE057), the assessed negligible magnitude of impact on these GWDTE sites is due to the evaluated insignificant changes to groundwater levels and groundwater quality due to the Project, including proposed utilities works. The overall significance of effect would be temporary negligible adverse, which is **not significant**.

Surface water quality

South of the River Thames

14.6.34 Rainfall runoff from the southern tunnel entrance compound would be discharged to a ditch, referred to as the western ditch, in Filborough Marshes. The ditch, and wider interconnected network of watercourses, would convey the runoff to the River Thames via an existing outfall. Impacts on baseline water quality would be prevented through provision of a treatment system at the compound that would, for example, remove suspended sediments and chalk fines. As secured by REAC Ref RDWE033, measures would also be taken to manage runoff from large areas of chalk stockpiles at the compound. The quality of the discharge would be governed by the conditions of an EA discharge consent. The water quality attribute of the ditch network is assigned high importance, and a negligible magnitude of impact is assessed, due to the provision of treatment measures as described above. The overall significance of effect is classified as temporary slight adverse, which is **not significant**.

River Thames

14.6.35 It is proposed that groundwater pumped from the North Portal excavation during construction, as well as effluent generated from the tunnel boring machinery slurry treatment plant, would be discharged to the River Thames via one outfall, located to the west of Diver Shoal Groyne 4, illustrated on Port of London Authority Chart 337. Discharges are expected over a total period of approximately 46 months. Effluents would be tested and receive treatment at the northern tunnel entrance compound, to meet the required standards to achieve compliance with limits specified by the EA discharge consent. With these safeguards in place, it is considered that the discharge would result in a negligible magnitude of impact on the water quality attributes of the River Thames, which have a high importance. The overall significance of effect is classified as temporary slight adverse, which is **not significant**.

14.6.36 It is proposed to construct a new self-regulating tide gate or equivalent structure on the north bank of the River Thames at Coalhouse Point to supply water to a proposed area of wetland that 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 works would be undertaken using good practice measures and in accordance with conditions set out in the Deemed Marine Licence. With these safeguards in place, it is considered that the construction works would result in a negligible magnitude of impact on the water quality attributes of the River Thames, which have a high importance. The overall significance of effect is classified as temporary slight adverse, which is **not significant**.

North of the River Thames

14.6.37 To the north of the River Thames, as secured by REAC Ref RDWE002, drainage from worksites would be managed in accordance with the measures set out in Section 14.5, which include provision of site drainage systems that incorporate pollution control systems designed in line with Control of Water Pollution from Construction Sites (C532) (CIRIA, 2001), and set up of construction compounds to include designated areas for higher risk activities such as refuelling, storage and stockpiling. Surface waters with the potential to receive worksite runoff include the West Tilbury Main, Gobions Sewer, the Mardyke and its tributaries (the Golden Bridge Sewer, Orsett Fen Sewer and Stringcock Sewer), the Mardyke West Tributary, as well as ordinary watercourses within these catchments. The water quality attributes of these receptors have been assigned values ranging from high (Mardyke and Mardyke West Tributary) to medium (West Tilbury Main, Gobions Sewer, Golden Bridge Sewer, Orsett Fen Sewer and Stringcock Sewer and ordinary watercourses). There would be an impact magnitude of no change to the water quality attributes of receiving watercourses. The overall significance of effect is therefore assessed as temporary neutral, which is **not significant**.

14.6.38 In the event of an accidental spillage or a pollution incident caused by extreme weather conditions, as detailed in Appendix 2.2: Code of Construction Practice, First iteration of Environmental Management Plan (Application Document 6.3), protocols would be in place to allow containment and rapid clean up. The potential for a spillage event to cause pollution of the water environment would therefore be reduced such that an impact of no greater magnitude than minor adverse would occur. The water quality of the watercourses listed in the paragraph above, which ranges from high to medium value, has the potential to be impacted by an accidental spillage. Overall, the significance of effect on those receptors of high value (the Mardyke and Mardyke West Tributary) is classified as slight adverse due to the localised and temporary nature of any effect, which is **not significant**. A minor adverse impact on other watercourses of medium value would also result in a significance of slight adverse, which is **not significant**.

14.6.39 Safeguarding the quality of surface watercourses would also protect the integrity of existing surface water abstractions for water supply. Existing abstractions are supported by the Mardyke, the Mardyke West Tributary, Golden Bridge Sewer, Orsett Fen Sewer and Stringcock Sewer, all of which are assigned medium importance for this attribute. An impact magnitude of no change is predicted on existing regimes. Therefore, the overall significance of effect is classified as temporary neutral, which is **not significant**.

14.6.40 The ability of watercourses to assimilate/dilute existing consented discharges has also been considered. The existing flow regimes of the watercourses that receive such discharges, namely the River Thames, the Mardyke, the Mardyke

West Tributary, Golden Bridge Sewer, Orsett Fen Sewer and Stringcock Sewer, would not be affected as construction activities are not predicted to reduce supporting baseflows, and any additional discharges to these watercourses arising from construction of the Project would be attenuated and treated to appropriate rates and water quality standards. No reduction in the dilution of existing consented discharges is therefore anticipated, and there is assessed to be a negligible magnitude of impact on this attribute. The wastewater dilution/transport function of surface water resources ranges from high (River Thames) to medium (all other watercourses listed above) importance. Therefore, the overall significance of effect is classified as temporary slight adverse to neutral, which is **not significant**.

14.6.41 At nitrogen deposition compensation sites, in accordance with Design Principle LSP. 27, any existing watercourses, inclusive of their riparian corridors, would not be physically disturbed by the habitat creation works. This would reduce the risk of receipt of sediment-laden runoff and subsequent temporary degradation of water quality. These receptors (which are all ordinary watercourses) are assigned medium value for their water quality attributes and combined with an impact magnitude of no change, an overall effect of temporary neutral is assessed, which is **not significant**.

Hydromorphology

South of the River Thames

14.6.42 During the construction phase, it is proposed to discharge treated rainfall runoff from the southern tunnel entrance compound to a ditch that is in Filborough Marshes. The ditch, and wider interconnected network of watercourses, would convey the runoff to the River Thames via an existing outfall. The outfall structure would cause a very localised and temporary effect on the ditch while being installed. However, discharges would be limited to the 1 in 2-year greenfield runoff rate or 1l/s (whichever is greater) to prevent scour/erosion or changes to the hydrological regime (RDWE033). The hydromorphology attribute of the ditch is assigned low importance and the impact magnitude is assessed as minor. Therefore, the overall significance of effect is classified as temporary slight adverse, which is **not significant**.

North of the River Thames

14.6.43 Residual impacts on the hydromorphology of the River Thames are associated with construction of an outfall to discharge process water and drainage from the northern tunnel entrance compound, and a self-regulating tide gate or equivalent structure to supply water to the Coalhouse Point wetland mitigation site. The Thames is assigned high importance for its hydromorphology attributes. The magnitude of impact is assessed as negligible. The construction footprint of the self-regulating tidal gate construction is very small, and the mitigation measures described in Section 14.5 and secured by REAC Ref RDWE028, include an outfall design that provides for a subtidal mid-water discharge to reduce disturbance to the intertidal zone. In addition, all works would be undertaken in compliance with a Deemed Marine Licence, further detail of which is provided in Chapter 9: Marine Biodiversity. Overall, the significance of effects on the hydromorphology of the River Thames is assessed as temporary slight adverse, which is **not significant**.

14.6.44 As detailed in Appendix 14.4: Hydromorphology Assessment (Application Document 6.3), during construction of the Project several temporary watercourse crossings would be required to facilitate the movements of construction plant and materials. In addition, watercourses would need to be crossed to facilitate utilities diversions and several ponds would be lost.

14.6.45 Watercourses requiring temporary crossings are smaller ordinary watercourses and drainage ditches which are assigned low to medium value for their baseline hydromorphological characteristics. The ponds that would be lost are also assigned low to medium value due to their lack of hydromorphological diversity and interest.

14.6.46 Temporary crossings for access would comprise simple, open-span bridges, the design of which would accord with EA Standard Rules SR2015 No 28 guidance (EA, 2016), limiting effects on channel form and in-channel processes, and the spatial extent of any impacts would be localised, not exceeding the reach scale. Crossings for utilities diversions would be undertaken using trenchless techniques, in order to avoid disturbance to channel form, flow regimes and riparian habitats and species, unless other techniques are agreed with the EA or LLFA, where relevant. Access and utilities crossings would also be subject to secondary consents, as detailed in the Consents and Agreements Position Statement (Application Document 3.3). As detailed in Section 14.5, ponds would be replaced by newly created ponds of a similar area, depth and habitat characteristic. The mitigation measures described would reduce the impact on the hydromorphology of these receptors to a minor-to-negligible magnitude.

14.6.47 Overall, construction of the Project is assessed as having an effect of temporary neutral to slight adverse on the low to medium value watercourses as result of minor to negligible levels of impact, which is **not significant**.

Flood impacts (to and from the Project)

14.6.48 A detailed Flood Risk Assessment (Application Document 6.3, Appendix 14.6) has been prepared that has assessed flood risk to the Project, and any impacts of the Project, during its construction and operation.

South of the River Thames

14.6.49 Construction compounds at the A226 Gravesend Road and Milton would be located in the defended floodplain of the River Thames. All other aspects of construction, including proposed utilities works, would be located in Flood Zone 1, at low risk of flooding from rivers and the sea. The greatest source of flood risk to the Project to the south of the River Thames is surface water. Rainfall runoff from construction compounds and worksites would be collected and managed in accordance with the good practice measures described in Section 14.5. Runoff from the southern tunnel entrance compound would be encouraged to soakaway to ground, to replicate the existing regime or, where needing treatment, would be discharged to the receiving watercourse at greenfield rates and in accordance with an EA environmental permit. This would both reduce the risk of flooding to the Project and mitigate the potential for increases in surface water flood risk to other areas of land. The impact on the land drainage regime (medium importance) is assessed as negligible. The overall significance of construction phase flood risk to the Project and arising from the Project is assessed as temporary neutral to slight adverse, which is **not significant**.

North of the River Thames

14.6.50 The Project would require construction work to be carried out in Flood Zones 2 and 3, areas at medium to high risk of flooding from rivers and/or the sea. These zones are located inland of the north bank of the River Thames in the catchment of the West Tilbury Main, where the North Portal of the Project would be constructed and utilities works would take place, as well as further north, where the Project crosses the floodplain of the Mardyke in Ockendon and the Mardyke West Tributary, near the M25, with utilities works also required in both these catchments.

14.6.51 Existing flood defences would be relied upon for protection against tidal inundation during the construction phase of the Project. These defences would be monitored during construction to detect any effects on their condition or integrity, with remedial actions put in place if any impact were to be identified.

14.6.52 As detailed in commitment RDWE022, the Contractor would prepare site-specific flood risk assessments and emergency response measures for construction activities in the floodplain and to demonstrate that site compounds within Flood Zone 3 are set up and temporary works comply with the requirements of the NPPF. Within compounds, it is expected that facilities located in Flood Zones 2 and 3 would be limited to water-compatible uses and flood repairable facilities, such as storage yards for precast concrete materials. This approach, as well as establishing flood warning and evacuation procedures, would mitigate the residual risk of flooding to construction workers, as well as safeguarding construction plant and materials.

14.6.53 To ensure that the construction activities of the Project do not cause impacts on flood risk elsewhere, compensatory flood storage would be provided to offset any loss of flood storage volume due to temporary earthworks, stockpiles and construction compounds. In addition, rainfall runoff from construction compounds and worksites would be managed in accordance with the good practice measures described in Section 14.5. The magnitude of impact on the flood flow and storage attributes of the West Tilbury Main (medium importance), the Mardyke (high importance) and the Mardyke West Tributary (high importance) is assessed as negligible. The overall significance of construction phase flood risk to the Project therefore ranges from temporary neutral (West Tilbury Main) to slight adverse (Mardyke and Mardyke West Tributary), which is **not significant**.

Operational phase

Groundwater levels and flows

14.6.54 Detailed assessments of the impacts of the Project on groundwater levels and flows have been undertaken in accordance with the methodologies described in Table 14.2. The findings of these studies have informed the impact assessment reported below and in more detail in Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3).

South of the River Thames

14.6.55 During operation, the effects of the below-ground utilities works on groundwater levels and flows south of the River Thames would be as described for construction. A magnitude of impact on the North Kent Medway Chalk (very high value) of no change has been assessed, associated with both shallow and deeper utilities works, resulting in a permanent, neutral effect which is **not significant**.

14.6.56 Ponds, especially New Fish Pond beside the Inn on the Lake, at Shorne, are located near proposed open-cut trench utility corridors (multiple utility and gas pipelines). The potential for hydraulic interaction between perched groundwater and New Fish Pond, is uncertain. Therefore, as described in Section 14.5, the Project commits (REAC Ref RDWE052) to reducing the potential permanent draining effect of utility trenches away from the pond area. Considering the described mitigation, the effect of these works on the ponds, which is assigned a value of medium importance, are assessed to be permanent neutral, which is **not significant**.

14.6.57 The Lower London Tertiaries (Thanet Formation) where present at the A2/A122 Lower Thames Crossing junction, have the potential to hold perched water. Should perched water be present, a permanent draining effect on the medium-value groundwater body (Thanet Formation) could be caused by groundwater ingress into shafts of the deep microtunnel section of one gas pipeline (G1b). Mitigation measures outlined in REAC Ref RDWE051, would result in an impact magnitude of no change to groundwater levels and flows in the Thanet Formation aquifer, with an overall effect that is permanent neutral and **not significant**.

14.6.58 Highway drainage soakaways located near the South Portal have the potential to cause rapid flow through fissures and subsequent sudden formation of sink holes. In addition, soakaways have the potential to cause groundwater mounding and therefore local groundwater flooding further downhill. The North Kent Medway Chalk aquifer has a very high value. The mitigation described in Section 14.5, which includes infiltration basins in accordance with DMRB CG 501 (National Highways, 2022) and CD 530 (National Highways, 2021), results in an assessed negligible magnitude of impact on groundwater levels and flows in this very high value aquifer. Therefore, the overall significance of effect is assessed as permanent slight adverse, which is **not significant**.

14.6.59 The operation of the main tunnels and cross-passages has the potential to cause a draining effect due to tunnel leakage, resulting in groundwater drawdown. However, the embedded mitigation measures, described in Section 14.5 and which include tunnel design to achieve compliance with specified maximum daily leakage rates, would reduce this. A negligible magnitude of impact on groundwater levels and flows in the North Kent Medway Chalk aquifer (very high value) is assessed. Therefore, the effect of these structures on the aquifer is classified as permanent slight adverse, which is **not significant**.

14.6.60 The permanent ground improvements beneath the Thames Estuary and Marshes Ramsar site (for example, grout blocks for the excavation of cross-passages and for tunnel boring machinery interventions, as well as mitigation for potential settlement of Network Rail assets), and backfilling of the ground protection tunnel, have the potential to create a barrier effect and consequential impact to the groundwater levels and flows in the North Kent and Medway Chalk and overlying River Terrace Deposits. The importance of these aquifers is very high and medium, respectively. A negligible magnitude of impact is assessed due to the small dimensions and wide spacing of the concrete blocks and the fact that the ground protection tunnel would mainly be in the Alluvium and also aligned parallel to the groundwater flow direction. Therefore, the overall significance of effect on the North Kent and Medway Chalk and overlying River Terrace Deposits is assessed as permanent slight adverse, which is **not significant**.

North of the River Thames

14.6.61 During operation, the effects of the below-ground utilities works on groundwater levels and flows north of the River Thames would be as described for construction, with the exception of Low Street irrigation reservoir and selected parts of Chadwell St Mary link as described below. A magnitude of impact of no change has been assessed because the encountered strata, which are assigned medium value, would either be dry, or should there be perched water then there would be no overall draining effect, as any water seeping into a trench would seep back into the same Lower London Tertiaries strata at the deeper sections. Therefore, the overall effect is assessed as permanent neutral, which is **not significant**.

14.6.62 Potential for permanent local draining effects or barrier effects in shallow groundwater near the Low Street irrigation reservoir and in the vicinity of Chadwell St Mary link area (Hoford Road and Brentwood Road) (assigned medium value) caused by open cut trenches for utilities works, has been identified. Applying the precautionary principle, Project commitments are secured in the REAC, reference RDWE054 and RDWE055, to reduce effects on these receptors by adopting designs and construction techniques that reduce groundwater draining or barrier effects. The residual magnitude of impact is assessed as negligible, with an overall effect of permanent neutral, which is **not significant**.

14.6.63 The operation of the main tunnels and North Portal have the potential to impede groundwater flows in the North Kent Medway Chalk aquifer. In addition, the proposed excavations have the potential to lower groundwater levels due to leakage. The aquifer is of very high value. The alignment of the proposed structures would be parallel to the groundwater flow and so would not create a barrier effect during the operational phase. In addition, given the mitigation measures described in Section 14.5, which include specified maximum daily tunnel leakage rates, the magnitude of impact would be negligible. Therefore, the overall effect is assessed as permanent slight adverse, which is **not significant**.

14.6.64 The operation of the Project's viaduct over the Tilbury Loop railway line has the potential to compromise an existing source of water that is drawn from a well and stored in a reservoir at Low Street, to feed an irrigation system. These receptors are assigned medium importance, as described in Table 14.6 and Table 14.7. As described in Section 14.5, the Applicant commits to reconfigure this system to ensure that the water source and means of water supply storage and distribution is not compromised. Following implementation of this mitigation measure, the magnitudes of impact on these receptors is assessed as negligible, with an overall effect of permanent neutral (since the water source would be maintained), which is **not significant**.

14.6.65 The proposed cuttings in the Chadwell St Mary link of the Project have the potential to act as a drain and lower the groundwater table. This has the potential to affect local abstractions, including the Linford public water supply well, Orsett Golf Club well and local reaches of the Gobions Sewer, which may receive baseflow from groundwater. The Project would fall within an SPZ2 in this location. A simple assessment, using the method set out in DMRB LA 113 (Highways England, 2020a), shows that GI groundwater levels are below the proposed cuttings, and therefore would not cause draining of the aquifer. The environmental value of the potential receptors ranges from medium (Gobions Sewer, Orsett Golf Club well) to very high (Linford public supply well and the South Essex and Thurrock Chalk aquifer). Combined with an impact magnitude of no change, the overall significance of effect on all these receptors is classified as permanent neutral, which is **not significant**.

14.6.66 The proposed embankments included within the Project design have the potential to reduce rainfall recharge received by aquifers and cause compaction of the underlying aquifer, further reducing the aquifers' ability to recharge. Potential groundwater lowering could affect unconfined and semi-confined aquifers and impact groundwater abstractions and watercourses, south of the Eocene margin, as described above. A simple assessment, in line with DMRB LA 113 (Highways England, 2020a) is presented in Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3). This shows that the percentage reduction of recharge area is small and that consolidation effects of aquifers would be negligible. The environmental importance of the potential receptors is medium to very high, as described above. The assessed impact is negligible. Therefore, the overall significance of effect is classified as permanent neutral or slight adverse, which is **not significant**.

14.6.67 The proposed embankments, including ground improvements, between viaducts over the Mardyke floodplain area could cause a barrier effect to shallow aquifers (e.g. Alluvium) and detrimentally interact with the aquifer source for the local private wells at Orsett Fen. However, available GI indicates that no aquifers are present at shallow depth (encountered soils are generally clayey) and that the likely aquifer used by the nearby Orsett Fen wells is the Harwich Formation, deep below the low-permeability London Clay Formation. The assessed importance of the wells is medium, and the potential magnitude of impact is assessed as no change to negligible since ground improvements would be much shallower. Therefore, the assessed level of significance is permanent neutral to slight adverse, which is **not significant**.

14.6.68 The proposed A13 soakaways have the potential to cause groundwater mounding and therefore local groundwater flooding. The Essex Gravels aquifer and underlying Lower London Tertiaries aquifer have a medium value. The proposed drainage design would result in a negligible magnitude of impact on groundwater levels and flows in these aquifers. Therefore, an overall significance of effect of permanent neutral or slight adverse is assessed, which is **not significant**.

14.6.69 The potential for groundwater seepage is inferred at the deepest cutting at the A13/A1089/A122 Lower Thames Crossing junction (A13 westbound to Project road southbound/A1089 link road 3), which has the potential to partially drain the Essex South Lower London Tertiaries, causing the groundwater level to lower. The aquifer is assigned medium value and the magnitude of impact has been assigned as negligible adverse, due to the expected small flows of groundwater into the cutting. Overall, the significance of effect is assessed as permanent slight adverse, which is **not significant**.

14.6.70 All cuttings are above the Chalk aquifer, north of the River Thames. However, the deepest cutting at the proposed A13/A1089/A122 Lower Thames Crossing junction may reduce the long-term recharge from the overlying Thanet Formation, which in this area is separated from the Chalk aquifer by the low permeability Pegwell Member (basal unit of the Thanet Formation). However, the recharge reduction is assessed as negligible. The assessed importance of the Chalk aquifer is very high, and therefore the overall significance of effect is assessed as permanent slight, which is **not significant**.

14.6.71 The proposed deep cutting at the A122 Lower Thames Crossing/M25 junction has the potential to partly drain the local Essex Gravels aquifer, causing permanent groundwater lowering (drawdown). The aquifer is assigned medium value, and the magnitude of impact would be permanent minor adverse, based on the results of the groundwater modelling study (further detailed in Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3)) and considering the mitigation proposed to reduce effects. Mitigation, secured by REAC Ref RDWE038, includes retaining walls or other seepage control systems to limit groundwater ingress into the cutting. The assessed environmental effects would be permanent slight adverse, which is **not significant**.

14.6.72 Without suitable mitigation, operation of the cutting at the A122 Lower Thames Crossing/M25 junction has also been assessed as potentially impacting an existing surface water abstraction for irrigation. The existing abstraction is said by the landowner to be fed by groundwater flows collected in historical deep drains (North Ockendon catchment) and a spring (part of the Hall Farm moat, paddock and St Mary Magdalene Churchyard SINC) 75m east and 40m south-west, respectively, from St Mary Magdalen Church. As described in Section 14.5, the Applicant commits to measures to reduce groundwater drawdown beyond the M25, by implementing essential mitigation such as retaining walls or other seepage control systems, reducing the magnitude of impact to negligible. As a result, the residual effect of the cutting on these receptors is assessed as permanent slight adverse, which is **not significant**.

14.6.73 Related to the above, the operation of the cutting at the A122 Lower Thames Crossing/M25 junction has the potential to cause groundwater lowering. Without mitigation, this may result in reduced baseflow to ponds and ditches at the Hall Farm moat, paddock and St Mary Magdalene Churchyard SINC, and the southern edge of Thames Chase Forest Centre SINC (including Hobbs Hole pond). The ponds and watercourses are not GWDTEs (Annex P) and as surface water receptors, are assigned a medium value. In addition, in Section 14.5, the Applicant commits to measures to reduce groundwater drawdown beyond the M25, by implementing essential mitigation such as retaining walls or other seepage control systems, reducing the magnitude of impact to negligible. As a result, the residual effect of the cutting on these receptors is assessed as permanent slight adverse, which is **not significant**.

14.6.74 Operation of the proposed cutting at the A122 Lower Thames Crossing/M25 junction has been assessed as not causing groundwater drawdown that could impact water levels in the recreational lakes at Stubbers Adventure Centre, which have been assigned a medium value. The lakes are founded on clay geology and it has been confirmed by the site operators that they are generally clay lined. Therefore, the magnitude of impact is considered to be no change. The effect of these works are assessed as permanent neutral, which is **not significant**.

Groundwater quality

14.6.75 The potential for effects of saline intrusion on groundwater quality has been assessed. Pollution risks to groundwater bodies that would receive discharges of highway drainage from the Project have been assessed. Routine runoff and the risk of pollution being caused by an accidental spillage incident have been appraised, and the detailed results are presented in Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3).

South of the River Thames

14.6.76 During operation, the effects of the below-ground utilities works on groundwater quality south of the River Thames would be as described for construction. A magnitude of impact on groundwater quality of no change is therefore assessed, resulting in a permanent neutral effect (regardless of receptor value), which is **not significant**.

14.6.77 The operation of the main tunnels has the potential to cause groundwater drawdown due to leakage and therefore saline intrusion of the North Kent Medway Chalk aquifer. Mitigation comprising adherence to best practice water tightness of the tunnel liner system (including gaskets for segmentally lined tunnels and membranes for sprayed concrete lined cross passages), detailed in Section 14.5, would ensure that groundwater drawdown effects would be negligible during operation. Considering the very high importance of the underlying North Kent Medway Chalk water body and the negligible magnitude of impact, the overall significance of effect is classified as permanent slight adverse, which is **not significant**.

14.6.78 Pollution risk to groundwater bodies that would receive discharges of highway drainage, via soakaways, has been assessed. Infiltration basins would comprise wide, shallow basins (Section 14.5). All infiltration basins and swales have been tested for the risk of pollution during an accidental spillage using HEWRAT (Highways England, 2019a) methodology (Section 14.3), and all these soakaways pass with the proposed mitigation in place. For the proposed M2, A2 and Gravesend link soakaways, the importance of the underlying North Kent Medway Chalk water body is very high. Therefore, considering the negligible magnitude of impact to groundwater quality, an overall effect of permanent slight adverse has been assessed, which is **not significant**.

14.6.79 Pollution risk to groundwater bodies, including downstream receptors at SPZ1s and beneath the Thames Estuary and Marshes Ramsar site, from routine discharges of highway drainage via soakaways, has also been assessed. The combined impact of all infiltration basins, and swales local to infiltration basins, has been tested for risk of pollution from routine runoff, including intermittent road salting, using detailed assessment in Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3), and all these receptors pass with the proposed mitigation in place. For the proposed M2, A2 and Gravesend link soakaways, the importance of the underlying North Kent Medway Chalk water body, SPZ1s and Ramsar site is very high. Therefore, by considering the negligible magnitude of impact from routine runoff, an overall effect of permanent slight adverse has been assessed, which is **not significant**.

North of the River Thames

14.6.80 The effects of below-ground utilities works on groundwater quality during operation would be as described for construction. A magnitude of impact on groundwater quality of no change is therefore assessed, resulting in a permanent neutral effect (regardless of receptor value), which is **not significant**.

14.6.81 The operation of the main tunnels has the potential to cause groundwater drawdown due to leakage, potentially causing increased saline intrusion and mobilisation of landfill contaminants. The results of the groundwater numerical modelling, presented in Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3), show that, by implementing mitigation measures as listed in Section 14.5 and adhering to industry standards for water tightness of the tunnel liner system, the impact on groundwater drawdown on the South Essex and Thurrock Chalk and inland Linford public water supply well would be negligible during operation of the Project road tunnels. The South Essex and Thurrock Chalk and inland Linford public water supply well are assessed as being of very high importance. Therefore, the overall significance of effect is classified as permanent slight adverse, which is **not significant**.

14.6.82 For the operation of highway drainage, the proposed A13 soakaways include pollution control measures, as detailed in Section 14.5, for example incorporating a vortex grit separator. The importance of the underlying Lower London Tertiaries water body is medium. Therefore, considering the assessed negligible impact on groundwater quality, an overall effect of permanent slight adverse significance has been assessed, which is **not significant**.

GWDTEs

South of the River Thames

14.6.83 One small pond at the Jeskyns Community Woodland car park has been assessed as a potential GWDTE (Section 14.4). The pond has a low ecological value, and the magnitude of the change to local groundwater levels and quality is assessed as negligible. An overall significance of effect of permanent negligible significance has been assessed, which is **not significant**.

North of the River Thames

14.6.84 Cranham Marsh LNR, near the A122 Lower Thames Crossing/M25 junction, has been assessed as having a variety of habitats, the majority not being dependent on groundwater. Discrete areas of fen (valley mire) habitat, recorded in the Middle Wood and Spring Woods part of the LNR, are assigned moderate value with respect to GWDTEs. At a minimum distance of approximately 800m from the proposed cutting, the groundwater modelling study (detailed in Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3) shows that no groundwater drawdown would be caused at the LNR. The magnitude of impact on the groundwater regime and groundwater-dependent habitats within the LNR are assessed as negligible. Therefore, there would be an effect of permanent negligible adverse significance, which is **not significant**.

14.6.85 North Ockendon Pit SINC, an area near the Ockendon link, has been assessed as a potential GWDTE as discussed in Section 14.4. The importance of the area as a GWDTE has been assessed as low, due to a low ecological value and low groundwater dependency score. The proposed cutting at the A122 Lower Thames Crossing/M25 junction could cause permanent drawdown of groundwater levels in the aquifer (the Essex Gravels) that has connectivity to the site. Considering the mitigation proposed to limit groundwater ingress into the cutting, a negligible adverse impact is assessed. The overall significance of effect is permanent negligible, which is **not significant**.

14.6.86 Various other small areas associated with ditches and ponds have been identified as potential GWDTEs (Section 14.4). These include golf course pond margins north of Thames Chase and ditches beside Cooper Shaw Road, Tilbury. These areas are assessed to be of low importance as GWDTEs, based on their ecological value. The magnitude of impacts on groundwater levels and groundwater quality local to them would be negligible. Therefore, the overall significance of effect would be permanent negligible, which is **not significant**.

14.6.87 A desk study review of London Borough of Havering SINC citations (eCountability Ltd, 2020) has identified some that have plant communities that are indicative of a potential GWDTE. These are located near the M25 (Section 14.4), near the A122 Lower Thames Crossing/M25 junction and northwards near M25 junction 28. The various sites are assessed as of low to moderate importance with respect to GWDTE importance, as detailed in Appendix 14.5: Hydrogeological Risk Assessment (Application Document 6.3). The assessed magnitude of impact on these sites is no change, due to the evaluated insignificant changes to groundwater levels and groundwater quality due to the Project. The overall significance of effect would be permanent negligible, which is **not significant**.

Surface water quality

14.6.88 Pollution risks to surface water bodies that would receive discharges of highway drainage from the Project have been assessed. Routine runoff and the risk of pollution being caused by an accidental spillage incident have been appraised, and the detailed results are presented in Appendix 14.3: Operational Surface Water Drainage Pollution Risk Assessment (Application Document 6.3). In line with guidance set out in DMRB LA 113 (Highways England, 2020a), the routine runoff method focuses on acute impacts from soluble pollutants (represented by dissolved copper and zinc) and chronic impacts from sediment-bound pollutants.

South of the River Thames

14.6.89 To the south of the River Thames, there would be no discharges to surface watercourses during operation of the Project.

North of the River Thames

14.6.90 To the north of the Thames, the Project would drain via surface water outfalls discharging to the Gobions Sewer, the West Tilbury Main, the Mardyke, the Mardyke West and several unnamed tributaries of the Mardyke. The baseline water quality characteristics of these watercourses are such that they are assigned importance for water quality ranging from high to medium. The Mardyke and Mardyke West Tributary qualify for high importance as they have a WFD classification in the Thames RBMP (Defra and EA, 2018), achieving moderate overall status, and have summer low flows (Q95) of less than $1m^3/s$. The Gobions Sewer, West Tilbury Main and smaller Mardyke tributaries are assigned medium importance as they do not have a WFD classification in the Thames RBMP and their flow regimes are such that they have summer low flows (Q95) of around $0.002m^3/s$ to $0.004m^3/s$. Their biological water quality attributes range in importance from high to medium, with the Mardyke recording a variety of coarse fish species, albeit in low densities, and typical communities of macroinvertebrates, and the West Tilbury Main considered to provide habitat for eels and minor coarse fish species, but exhibiting depressed scores for freshwater macroinvertebrates, likely due to saline influence.

14.6.91 Magnitudes of impact have been qualified using the HEWRAT and M-BAT (WFD-UKTAG, 2014b), with each drainage outfall assessed individually and cumulative assessments carried out as necessary in accordance with the guidance (Highways England, 2019a).

14.6.92 Once the proposed treatment measures are factored into the assessment, with one exception described in the paragraph below, the outfalls individually achieve a pass for both acute impacts and Environmental Quality Standard compliance for soluble and sediment-bound pollutants. On this basis, discharges of highway runoff from these outfalls would result in a negligible magnitude of impact on the water quality attributes of receiving watercourses, which range in importance from high to medium. Overall, there is assessed to be a permanent slight adverse to neutral effect, which is **not significant**.

14.6.93 A large road drainage catchment discharging to a small tributary of the Mardyke fails the HEWRAT assessment in terms of acute impacts for copper. In line with DMRB LA 113 (Highways England, 2020a), this failure constitutes a magnitude impact of minor adverse, which when combined with the medium value of the receiving watercourse, results in an overall permanent slight adverse significance of effect, which is **not significant**.

14.6.94 In line with the guidelines provided in DMRB LA 113 (Highways England, 2020a), sensitivity tests were carried out using the HEWRAT to further investigate this failure.

14.6.95 Detailed results from the HEWRAT show that the Runoff Specific Threshold 24 hour (RST24) for dissolved copper would be exceeded 3.2 times per year, only marginally above the allowable two failures per year. A solubles treatment efficiency of 74% at the outfall is required to achieve acute impact compliance. This is a small increase from the 70% treatment that the guidance suggests the proposed treatment train can deliver. As detailed in REAC Ref. RDWE025, during detailed design, the treatment measures for the catchment draining to this outfall would be configured to ensure the required retention times and through-flow rates to achieve these degrees of treatment. This would result in a negligible magnitude of impact on the medium-value water quality attributes of the two receiving watercourses. Overall, the significance of effect would be permanent slight adverse, which is **not significant**.

14.6.96 When the outfalls are assessed cumulatively, a combined discharge from two outfalls would cause a 900m reach of a tributary of the Mardyke to be affected by acute copper impacts. Runoff requires 75% treatment for solubles to avoid acute impacts. As detailed above, there is a commitment to achieving the required treatment efficiency. There is therefore assessed to be a minor adverse impact on a watercourse of medium value, having a permanent slight adverse effect overall, which is **not significant**.

14.6.97 Accidental spillage risk assessment concludes that the calculated percentages of a spillage causing a serious pollution incident are below the set thresholds, except for two drainage catchments: one discharging to the Mardyke West Tributary and one to an unnamed tributary of the Mardyke, both having medium value for water quality. When risk reduction factors are taken into account, to reflect the proposed drainage design, the two catchments achieve compliance with the assessment criteria and the magnitude of impact is therefore assigned as no change. The risk of pollution associated with an accident is therefore assessed as having a permanent neutral overall effect, which is **not significant**.

14.6.98 The assessments conclude that the objectives of the WFD would not be compromised by discharge of runoff during operation of the Project.

14.6.99 Safeguarding the quality of surface watercourses during the long-term operation of the Project would also protect the integrity of existing surface water abstractions for water supply. An impact magnitude of no change is predicted on existing regimes. The water supply attributes of surface water resources range from high to medium importance. Therefore, the overall significance of effect is classified as permanent neutral, which is **not significant**.

14.6.100 The ability of watercourses to assimilate/dilute existing consented discharges has also been considered. The existing flow regimes of watercourses would not be affected, as operational discharges would be attenuated so as not to impact on receiving watercourse flow regimes. No reduction in the dilution of existing consented discharges is therefore anticipated, and there is assessed to be a negligible magnitude of impact on this attribute. The wastewater dilution/transport function of surface water resources ranges from high to medium importance. Therefore, the overall significance of effect is classified as permanent neutral to slight adverse, which is **not significant**.

Hydromorphology

South of the River Thames

14.6.101 To the South of the River Thames, as detailed in Appendix 14.4: Hydromorphology Assessment (Application Document 6.3), the Project would not directly or indirectly affect any surface water features during the operational phase. Watercourses to the south of the River Thames were screened out from further assessment of the potential for hydromorphological change.

14.6.102 At nitrogen deposition compensation sites, in accordance with Design Principle LSP.27, any existing watercourses, inclusive of their riparian corridors and bodies of water would not be physically disturbed by the habitat creation. These receptors are assigned low to medium value for their hydromorphological quality, and combined with an impact magnitude of no change, an overall effect of permanent neutral is assessed, which is **not significant**.

North of the River Thames

14.6.103 Once operational, the footprint of the proposed self-regulating tidal gate or equivalent structure would not extend beyond the footprint of an existing flood bund and therefore the structure would have no permanent impact on the existing hydrodynamics or hydromorphology of the river.

14.6.104 As detailed in Section 14.5, the Project design avoids long-term impacts on the hydromorphology of the Mardyke and its first-order tributaries the Orsett Fen and Golden Bridge sewers, as well as one ordinary watercourse, by spanning these watercourses using viaducts. 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. Channels would be undisturbed, and a bankside corridor would also be retained, limiting disturbance of existing riparian vegetation and habitats.

14.6.105 Where culverting and watercourse realignment cannot be avoided, the suite of measures described in Section 14.5 would reduce hydromorphology impacts. Geomorphological inputs into the detailed design would ensure the construction of any realignment or culvert is suitable and would not result in instability, bank or bed erosion, or scour.

14.6.106 The hydromorphological desk study, presented in Appendix 14.4: Hydromorphology Assessment (Application Document 6.3), assigned low to medium importance to the baseline hydromorphological characteristics of the watercourses with the potential to be permanently impacted by the Project, due to the heavy modifications they have already been subject to. Watercourses not supporting a permanent flowing system, with a channel width of less than 1m, exhibiting no natural features or processes were screened out of the assessment.

14.6.107 The spatial extent of the directly impacted reaches of watercourses represents a very small percentage of these water bodies, at a maximum of less than 2% on the West Tilbury Main. Effects are therefore considered to be limited to the reach scale and are assessed as having a magnitude ranging from moderate adverse for the West Tilbury Main (low importance), to minor adverse for the Gobions Sewer (medium importance), to negligible for the remaining watercourses (low importance). Overall, the significance of the effects of the Project on baseline hydromorphology is therefore classified in the range of permanent slight adverse (West Tilbury Main) to neutral (Gobions Sewer), which is **not significant**.

14.6.108 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 within the study area. On the West Tilbury Main, an existing 700mm diameter culvert would be replaced by a large box culvert (2.8m high, 4m wide), and on this watercourse a further three culverts would be removed and approximately 125m of open channel watercourse would be re-established by unblocking an existing culvert north of Station Road. The watercourse would also be subject to a localised diversion that would remove two near 90-degree bends. All these proposed works would therefore result in a more natural watercourse alignment and form along localised reaches.

14.6.109 Additionally, subject to securing landowner agreements and Ordinary Watercourse Consent from the LLFA, an ordinary watercourse in the Mardyke catchment, having low importance, would be broken out of culvert, providing for a net increase in the open channel reach on this watercourse of approximately 500m. This would provide potential improvements in hydromorphological diversity, as well creating habitat for macroinvertebrates, macrophytes and fish, with a magnitude of impact assessed as moderate beneficial. Overall, there would be a localised effect of permanent slight beneficial significance, which is **not significant**.

14.6.110 At nitrogen deposition compensation sites north of the River Thames, in accordance with Design Principle LSP.27, any existing watercourses, inclusive of their riparian corridors and bodies of water would not be physically disturbed by the habitat creation. These receptors are assigned low to medium value for their hydromorphological quality, and combined with an impact magnitude of no change, an overall effect of permanent neutral is assessed, which is **not significant**.

Flood impacts (to and from the Project)

14.6.111 A detailed Flood Risk Assessment has been prepared, presented in Appendix 14.6 (Application Document 6.3), which has appraised risks of flooding to the Project, as well as any effects the Project could cause.

14.6.112 Appendix 14.6: Flood Risk Assessment - Part 7 (Application Document 6.3) includes a surface water drainage strategy that details how rainfall runoff generated from the highway would be managed to prevent surface water flooding of the Project during its operational phase. The strategy also describes how impacts on the watercourses and groundwater bodies receiving discharges of highway drainage would be mitigated to ensure no increases in flood risk elsewhere.

14.6.113 The degree of flood risk to the Project varies geographically.

South of the River Thames

14.6.114 To the south of the River Thames, the FRA concludes that the Project is not at significant risk of flooding from rivers, tides, sewers, water mains or reservoirs.

14.6.115 Isolated areas along the existing A2/M2 corridor have a history of surface water flooding. Junction reconfiguration and new drainage provisions provided by the Project would eliminate existing surface water flood risk in these localised areas. An impact of minor beneficial magnitude is therefore predicted in terms of reducing existing surface water flood risk locally. Combined with an attribute importance of medium, the Project south of the River Thames is assessed as having an overall significance of effect on surface water flood risk elsewhere, of permanent neutral to slight beneficial, which is **not significant**.

14.6.116 There would be no change in baseline flood risk from other sources of flooding.

14.6.117 The operational drainage design would ensure no increases in rainfall runoff rates or volumes, with rainfall encouraged to infiltrate to ground. The magnitude of impact on the existing land drainage regime to the south of the River Thames is assessed as no change and therefore the overall significance of effect is permanent neutral, which is **not significant**.

North of the River Thames

14.6.118 To the north of the River Thames, between the North Portal and Chadwell St Mary, some parts of the Project would be in Flood Zone 3, at residual risk of tidal flooding should defences, including walls and sluice gates, along the Thames overtop or breach. Fluvial flooding is also a risk, linked to flow through West Tilbury Main exceeding its capacity. This watercourse has been modelled, as detailed in Appendix 14.6: Flood Risk Assessment - Part 5 (Application Document 6.3), to generate data used to inform the choice of flood protection measures needed.

14.6.119 To ensure the Project is safe over its lifetime, protection of the North Portal from river and tidal floods is integrated into the design. The drainage system would protect the new highway from surface water flooding, and there is assessed to be no significant risk to the Project from other forms of flooding.

14.6.120 The mitigation measures described in Section 14.5, and further detailed in Appendix 14.6: Flood Risk Assessment - Part 6 (Application Document 6.3), would make the Project safe over its lifetime without increasing flood risk elsewhere. The magnitude of impact on the flood flow and storage attributes of the River Thames, the West Tilbury Main and Gobions Sewer is classified as no change. Combined with an attribute importance of very high (River Thames) and medium (West Tilbury Main and Gobions Sewer), the Project is assessed as having an overall permanent neutral significance of effect on flood risk within the catchments of these watercourses, which is **not significant**.

14.6.121 At the A13/A1089/A122 Lower Thames Crossing junction, the Project would be located entirely within Flood Zone 1, remote from any surface water bodies and at low risk of flooding from rivers and the sea. The risk of flooding from all other sources has also been assessed as low. Over and above the drainage system, there is no requirement to provide flood protection measures to ensure that the Project remains safe over its lifetime.

14.6.122 The Project's drainage systems would prevent changes to the land drainage regime and increases in surface and groundwater flood risk to land within and beyond the Order Limits. The local land drainage regime is assigned high sensitivity, combined with a magnitude of impact of no change, resulting in an effect on flood risk with an overall significance of permanent neutral, which is **not significant**.

14.6.123 Along the Ockendon link, the Project would cross three main rivers and their floodplains (the Mardyke, Golden Bridge Sewer and Orsett Fen Sewer). The risks of flooding from these sources have been assessed by hydraulic modelling (see Appendix 14.6: Flood Risk Assessment - Part 4 (Application Document 6.3)). The Project, where it crosses Flood Zone 3, has been designed to safeguard it from flooding during the 0.5% annual exceedance probability storm, inclusive of an allowance for climate change in addition to a freeboard allowance, with a higher standard of flood protection provided in the design of the North Portal. The drainage system would protect the new highway from surface water flooding. No significant risks to the Project from other sources of flood risk have been identified.

14.6.124 The Project would contribute to reducing baseline flood risk in the Mardyke catchment through the proposed wetland restoration in Orsett Fen, which would hold back and slow down the flow of water, thereby reducing flood risk on a catchment scale. The catchment is assigned high importance with regard to flood storage and conveyance, and the impact magnitude is assessed as minor beneficial. The Project is assessed as having an overall significance of effect on flood risk elsewhere, of permanent slight beneficial, due to the relatively small spatial area of wetland restoration, which is **not significant**.

14.6.125 In the northernmost section, the Project would cross one main river, the Mardyke West Tributary, which is assigned high sensitivity for its flood flow and storage attributes. Mitigation detailed in Section 14.5 and in Appendix 14.6: Flood Risk Assessment - Part 6 (Application Document 6.3), is proposed to ensure that the Project is not at risk of flooding from this source. No significant risks to the Project from other sources of flooding have been identified.

14.6.126 In the Mardyke West catchment, the Project would contribute to a beneficial impact by reducing baseline flood risk in the Mardyke catchment through the proposed reduction in discharge rates from existing M25 drainage catchments. A reduction of existing rates by a minimum of 50%, in line with Essex County Council policy (Essex County Council, 2012), would be achieved, which is assessed as a moderate beneficial magnitude of impact. Combined with an attribute importance of high, the Project is assessed as having an overall significance of effect on flood risk in this catchment of permanent moderate beneficial, which is **significant**.

14.6.127 At nitrogen deposition compensation sites, in accordance with Design Principle LSP.27, any existing watercourses, inclusive of their riparian corridors and bodies of water would not be physically disturbed by the habitat creation. These receptors are assigned low to medium value for their flood flow storage and conveyance attributes, and combined with an impact magnitude of no change, an overall effect of permanent neutral is assessed, which is **not significant**.

14.7 Cumulative effects

Intra-project effects

14.7.1 Cumulative effects of the Project can occur as a result of interrelationships between different environmental topics, which are referred to as 'intra-project effects'. For road drainage and the water environment, interrelationships are identified with air quality (Chapter 5), cultural heritage (Chapter 6), terrestrial biodiversity (Chapter 8), marine biodiversity (Chapter 9) and geology and soils (Chapter 10) and are summarised below:

a. Air quality - potential for dust from construction traffic and nitrogen from operational traffic to be deposited, causing detriment to water environment quality.

b. Cultural heritage - alteration of watercourses affecting historic landscape features.

c. Cultural heritage - dewatering from tunnelling and other Project activities resulting in groundwater alteration that, in turn, could affect hydrologically sensitive heritage assets, affecting the preservation of archaeological remains.

d. Terrestrial biodiversity - potential for the Project to cause pollution or to alter existing land drainage and watercourse flow regimes, resulting in degradation of aquatic habitats and likely resultant effects on aquatic species that occupy those habitats.

e. Terrestrial biodiversity - dewatering from tunnelling and other Project activities resulting in groundwater alteration that, in turn, could affect hydrologically sensitive habitats, such as marshy grassland, and the species they support, including some that form qualifying features of designated sites.

f. Marine biodiversity – potential for the Project to cause pollution of the tidal River Thames, resulting in degradation of marine habitats and likely resultant effects on marine species that occupy those habitats

g. Geology and soils – potential for excavation of soils and earthworks to impact on the rainfall runoff and land drainage regime. Links between land contamination and pollution of the water environment, with construction activities having potential to cause the mobilisation of contaminants into the water environment (groundwater and surface water).

14.7.2 The above interrelationships have been considered as part of the assessment reported in this chapter, and the relevant topic chapters identified above.

Inter-project effects

14.7.3 In addition to intra-project effects, cumulative effects can also occur due to the Project in combination with other existing and/or proposed development. These are known as 'inter-project' effects and are considered separately in Chapter 16: Cumulative Effects Assessment.

14.7.4 It should be noted that the traffic data used in the assessment of the water environment already accounts for traffic generated by other planned or near certain or more than likely developments. In accordance with the Planning Inspectorate's (2019) Advice Note 17: Cumulative Effects Assessment, no additional cumulative assessment of these aspects is required.

14.7.5 Flood risk effects have been considered as part of the assessment of inter-project effects on residential receptors reported in Chapter 16: Cumulative Effects Assessment.

14.8 Monitoring

14.8.1 Monitoring is required where significant effects are identified following the inclusion of the design and mitigation measures. While no significant adverse effects have been identified relating to the water environment, the following monitoring is an integral part of implementing the mitigation outlined in Section 14.5.

14.8.2 The REAC, which forms part of Appendix 2.2: Code of Construction Practice, First iteration of Environmental Management Plan (Application Document 6.3), documents the monitoring that would be required during the construction phase.

14.8.3 Monitoring of the following aspects of the water environment is proposed, with details of monitoring programmes to be agreed with the relevant environmental regulator:

a. The ground protection tunnel, if constructed under REAC reference RDWE017, would include water and flow monitoring for the periods that the ground protection tunnel is being used for construction purposes, in consultation with the EA, to verify compliance with the tunnel's design specification regarding maximum permissible rates of water ingress (RDWE018a).

b. As detailed in REAC commitment GS021, a groundwater monitoring programme around the North Portal (GS021) would be agreed with the EA prior to the commencement of excavation works to construct the North Portal box structure.

c. Groundwater monitoring would be undertaken to confirm the effectiveness of the mitigation detailed in RDWE038. The monitoring regime would be developed in consultation with the EA and to validate the Contractor's final design solution (RDWE045).

d. In line with the requirements of the EA as set out in the Scoping Opinion and detailed in the Consultation Report (Application Document 5.1), it is expected that asset condition monitoring for River Thames flood defences would be necessary to establish a pre-construction baseline and monitor for any effects on the structural integrity/condition of the assets during construction of the Project (RDWE007).

14.9 Summary

14.9.1 The assessment of effects on the water environment considered the construction and operational effects on surface and groundwater quality, flows, levels, GWDTEs and flood risk. Assessments were carried out in accordance with DMRB LA 113 (Highways England, 2020a), informed by desk study, field surveys, GI and a range of numerical modelling studies.

14.9.2 Receptors considered as part of the water environment include superficial and bedrock aquifers, public water supply and other licensed groundwater abstractions, watercourses and their floodplains, other water bodies and surface water abstractions and discharges.

14.9.3 Potential effects include pollution of the water environment, both acute and chronic, detriment to hydromorphology, changes to groundwater levels and flows and subsequent effects on receptors supported by these waters, increases in flood risk and changes to the land drainage regime.

14.9.4 Mitigation has been proposed, and would be secured via commitments within the Project Design Principles, REAC and DCO requirements, including a sustainable highway drainage design providing runoff treatment and attenuation, compensation floodplain storage and measures to reduce groundwater ingress into excavations (e.g. cuttings).

14.9.5 Table 14.8 provides a summary of all predicted impacts in the chapter, taking into account the Project design and mitigation set out in Section 14.5. The assessments conclude that there would be no likely significant adverse effects on water environment receptors. One likely significant beneficial effect has been assessed. This effect is associated with a reduction in baseline flood risk within the Mardyke West Tributary catchment due to reducing existing highway runoff discharges into receiving watercourses by a minimum of 50%. Other, more minor and not significant, beneficial effects include provision of flood risk benefits through wetland restoration in the Mardyke catchment, and a net gain in open watercourse channels within the study area.

Table 14.8 Road drainage and the water environment impact summary table

Impact description	Importance	Impact magnitude	Effect	Residual significance
Construction				
Impacts on groundwater levels and flows due to tunnelling, cuttings, and excavations	Very high (North Kent Medway Chalk)	Negligible	Slight adverse	Not significant
	Very high (Thames Estuary and Marshes Ramsar)	Negligible	Slight adverse	Not significant
	Very high (South Essex Thurrock Chalk)	Negligible	Slight adverse	Not significant
	Medium (Essex South Lower London Tertiaries)	Negligible adverse	Slight adverse	Not significant
	Medium (Essex Gravels)	Minor adverse	Slight adverse	Not significant
Impacts on groundwater levels and flows due to buried utilities corridors	Very high (North Kent Medway Chalk)	No change	Neutral	Not significant
	Very high (Thames Estuary and Marshes Ramsar)	No change	Neutral	Not significant
	Very high (South Essex Thurrock Chalk)	No change	Neutral	Not significant
	Medium (Essex South Lower London Tertiaries)	Negligible	Neutral	Not significant
	Medium (Essex Gravels)	Negligible	Neutral	Not significant
Deterioration of groundwater quality due to saline intrusion or pollution by construction site runoff	Very high (North Kent Medway Chalk and South Essex Thurrock Chalk)	Negligible	Slight adverse	Not significant
Deterioration of groundwater quality due to utilities works	Very high (North Kent Medway Chalk and South Essex Thurrock Chalk)	No change	Neutral	Not significant
	Very high (Thames Estuary and Marshes Ramsar)	No change	Neutral	Not significant

Impact description	Importance	Impact magnitude	Effect	Residual significance
Deterioration of surface water quality due to accidental spills and receipt of worksite runoff	High (Filborough Marshes Ditches, River Thames, Mardyke and Mardyke West Tributary)	Minor adverse to negligible	Slight adverse to neutral	Not significant
	Medium (West Tilbury Main, Gobions Sewer, Mardyke tributaries and ordinary watercourses)	No change	Neutral	Not significant
Detriment to existing abstractions and water supply systems	Very high (public groundwater supplies)	Negligible	Slight adverse	Not significant
	Medium (private groundwater supplies for agriculture/golf course)	Negligible	Slight adverse to neutral	Not significant
	Medium (surface water abstractions)	No change	Neutral	Not significant
Detriment to surface water bodies that may receive baseflow due to changes in groundwater levels or flows	Medium (Hall Farm moat, paddock and St Mary Magdalene Churchyard SINC)	Negligible	Slight adverse	Not significant
	Medium (Hobbs Hole and southern edge of Thames Chase Forest Centre SINC)	Negligible	Slight adverse	Not significant
	Medium (Low Street Reservoir)	Negligible	Neutral	Not significant
Detriment to GWDTEs due to changes in groundwater quantity or quality	High (Ingrebourne Marshes SSSI)	Negligible	Negligible	Not significant
	Moderate (Cranham Marsh LNR)	Negligible	Negligible	Not significant
	Low (other GWDTEs)	Negligible	Negligible	Not significant
Impacts on hydromorphology due to tunnelling, utilities works, a new hydraulic structure and drainage outfall construction	High (River Thames)	Negligible	Slight adverse	Not significant
	Medium to low (other watercourses)	Minor adverse to negligible	Slight adverse to neutral	Not significant
Increases in flood risk due to changes in the land drainage regime	High (north of River Thames)	Negligible	Neutral to slight adverse	Not significant
	Medium (south of River Thames)	Negligible	Neutral to slight adverse	Not significant

Impact description	Importance	Impact magnitude	Effect	Residual significance
Impacts on watercourse attributes (water quality, hydromorphology) due to habitat creation at nitrogen deposition compensation sites	Medium to low (unnamed ordinary watercourses)	No change	Neutral	Not significant
Operation				
Deterioration of groundwater quality due to saline intrusion, receipt of road drainage	Very high (North Kent Medway Chalk and Thames Estuary and Marshes Ramsar)	Negligible	Neutral or Slight adverse	Not significant
	Medium (Lower London Tertiaries)	Negligible	Neutral or slight adverse	Not significant
Deterioration of groundwater quality due to utilities works corridors below the water table	Very high (North Kent Medway Chalk, South Essex Thurrock Chalk and Linford public water supply)	No change	Neutral	Not significant
	Medium (Lower London Tertiaries, Essex Gravels)	No change	Neutral	Not significant
Deterioration of surface water quality due to receipt of road drainage or accidental spills	High (Mardyke and Mardyke West Tributary)	Negligible	Slight adverse	Not significant
	Medium (Gobions Sewer, West Tilbury Main and six tributaries of the Mardyke)	Minor adverse to negligible	Neutral or slight adverse	Not significant
Effects on groundwater levels and flows due to tunnel leakage, grout blocks and infiltration drainage	Very high (North Kent Medway Chalk, South Essex Thurrock Chalk and Linford public water supply)	Negligible	Slight adverse	Not significant
	Medium (Essex Gravels)	Negligible	Neutral or slight adverse	Not significant
Effects on groundwater levels and flows at cuttings and embankments	Very high (South Essex Thurrock Chalk and Linford public water supply)	No change	Neutral	Not significant
	Medium (Essex Gravel, private water supplies and Gobions Sewer)	Negligible	Slight adverse	Not significant

Impact description	Importance	Impact magnitude	Effect	Residual significance
Effects on groundwater levels and flows along underground utilities corridors	Very high (North Kent Medway Chalk, South Essex Thurrock Chalk and Linford public water supply)	No change	Neutral	Not significant
	Medium (Essex Gravel, Lower London Tertiaries, private water supplies)	No change	Neutral	Not significant
Detriment to surface water bodies that may receive baseflow due to changes in groundwater levels or flows	Medium (Hall Farm moat, paddock and St Mary Magdalene Churchyard SINC)	Negligible	Slight adverse	Not significant
	Medium (pond at Hobbs Hole and southern edge of Thames Chase Forest Centre SINC)	Negligible	Slight adverse	Not significant
	Low Street Reservoir	Medium	Neutral	Not significant
Detriment to GWDTEs due to changes in groundwater quantity or quality	High (Ingrebourne Marshes SSSI)	Negligible	Negligible	Not significant
	Moderate (Cranham Marsh LNR)	Negligible	Negligible	Not significant
	Low (other GWDTEs)	Negligible	Negligible	Not significant
Impacts on hydromorphology due to culverting	Medium (Gobions Sewer)	Minor adverse	Slight adverse	Not significant
	Low (West Tilbury Main)	Moderate adverse	Slight adverse	Not significant
	Low (ordinary watercourses)	Negligible	Neutral	Not significant
Changes to the land drainage regime	High (catchments north of the River Thames)	No change	Neutral	Not significant
	Medium (catchments south of the River Thames)	No change	Neutral	Not significant

Impact description	Importance	Impact magnitude	Effect	Residual significance
Changes to baseline flood risk	Very high (River Thames)	No change	Neutral	Not significant
	Medium (West Tilbury Main and Gobions Sewer)	No change	Neutral	Not significant
	High (Mardyke West Tributary catchment)	Moderate beneficial	Moderate beneficial	Significant
	High (Mardyke at Orsett Fen)	Minor beneficial	Slight beneficial	Not significant
	Medium (south of River Thames)	Minor beneficial	Neutral to slight beneficial	Not significant
Impacts on watercourses attributes (water quality, hydromorphology) due to maintenance of habitats created at nitrogen deposition compensation sites	Medium to low (unnamed ordinary watercourses)	No change	Neutral	Not significant

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