REPORT

Boston Alternative Energy Facility – Environmental Statement

Chapter 15 Marine Water and Sediment Quality

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Executive Summary

This chapter of the Environmental Statement (ES) considers marine sediment and water quality. A description of the baseline is provided using site information, desk-based studies and the information provided in **Chapter 16 Estuarine Processes**. Data used to inform the baseline and the impact assessment was collected within the last three years. The potential impacts associated with construction, operation and decommissioning of the Boston Alternative Energy Facility (the Facility) are identified and an assessment made on the severity of each impact using the methodology detailed in **Chapter 6 Approach to Environmental Impact Assessment**. It is considered that release of sediment during the capital dredge for the wharf represents the worst case activity associated with Facility. The assessment also considers cumulative impacts where the Facility is considered alongside the predicted impacts of other relevant plans and projects within the study area.

The outcome of the assessment is that all effects are predicted to temporary and be **minor adverse** on water and sediment quality for both the construction and operational phase.

No impacts during decommissioning are anticipated with relation to marine water and sediment quality, as the wharf will be left *in situ* as a permanent structure.

In relation to cumulative effects, the only project identified to have the potential to interact with the works to construct the Facility is the Boston Tidal Barrier. This is in relation to the sediment plumes created during simultaneous dredging campaigns (capital or maintenance). Overall, it is concluded that the cumulative impact of suspended sediment concentrations from the plume of the two projects being dredged at the same time is **minor adverse**. Furthermore, this represents the worst case position because it is likely that the construction of the Boston Barrier will be completed before any construction starts on the Facility.

15 Marine Water and Sediment Quality

15.1 Introduction

15.1.1 This chapter of the Environmental Statement (ES) describes the existing environment in relation to marine sediment and water quality and details the assessment of the potential impacts during the construction, operational and decommissioning phases of the Facility.

15.1.2 This chapter has been informed by **Chapter 16 Estuarine Processes**.

15.2 Legislation, Policy and Guidance

International Legislation

15.2.1 The principal European and International policy and legislation used to inform the assessment of potential impacts on marine water and sediment quality for this project includes:

- Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy (the Water Framework Directive (WFD));
- Directive 2008/105/EC Priority Substances establishing Environmental Quality Standards for contaminants in water; and
- The International Convention for the Prevention of Marine Pollution by Ships (MARPOL Convention) 73/78.

National Legislation

15.2.2 The key European Directives are transposed into UK law through several regulations which are discussed below.

<u>Water Environment (Water Framework Directive) (England and Wales) Regulations 2017</u>

15.2.3 The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 (HMSO, 2017) replaced the Water Environment (Water Framework Directive) (England and Wales) Regulations 2003 (HMSO, 2003a). The Regulations transpose the WFD into national law and provide for its implementation, including the designation of all surface waters (rivers, lakes, transitional (estuarine) waters, coastal waters and ground waters) as water bodies, and the requirement to achieve GES or GEP. The Regulations and associated Directions remain in force in England and Wales through the provisions of the European Union (Withdrawal) Act 2018.

Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015

15.2.4 The WFD (Standards and Classification) Directions (England and Wales) 2015 (HMSO, 2015) provide the standards used to determine the ecological or chemical status of a water body. These include:

- The thresholds for determining the biological, hydromorphological and physico-chemical status of surface water bodies; and
- The thresholds for determining the quantitative and chemical status of groundwater bodies.

National Planning Policy Framework

15.2.5 Paragraph 170(e) of the updated National Planning Policy Framework (February 2019) states the following in relation to water and sediment quality:

> Planning policies and decisions should contribute to and enhance the natural and local environment by *"…preventing new and existing development from contributing to, being put at unacceptable risk from, or being adversely affected by, unacceptable levels of soil, air, water or noise pollution or land instability. Development should, wherever possible, help to improve local environmental conditions such as air and water quality, taking in to account relevant information such as river basin management plans."*

15.2.6 **Appendix 13.1 Water Framework Directive Compliance Assessment** takes into account river basin management plans.

National Planning Policy

15.2.7 The assessment of potential impacts on marine water and sediment quality has been made with specific reference to the relevant National Policy Statement (NPS). These are the principal decision-making documents for Nationally Significant Infrastructure Projects (NSIPs). Those relevant to the project are:

- Overarching NPS for Energy (EN-1) (Department for Energy and Climate Change (DECC), 2011a); and
- NPS for Renewable Energy Infrastructures (EN-3) (DECC 2011b).

15.2.8 The specific assessment requirements for marine water and sediment quality are provided in **Table 15-1.**

Table 15-1 NPS Requirements for the Marine Sediment and Water Quality Chapter

NPS requirement	NPS reference	ES reference
Infrastructure development can have adverse effects on the water environment, including transitional waters and coastal waters. During the construction, operation and decommissioning phases, discharges would occur. There may also be an increased risk of spills and leaks of pollutants to the water environment. These effects could lead to adverse impacts on health or on protected species and habitats and could, in particular result in surface waters, ground waters of protected areas failing to meet environmental objectives established under the Water Framework Directive (WFD).	EN-1 Paragraph 5.15.1	Potential impacts of the project on water quality are assessed in **Section 15.7** of this ES chapter. Impacts to habitats and species are assessed in **Chapter 17 Marine and Coastal Ecology**. A WFD Compliance Assessment is provided in **Chapter 13 Appendix 13.1 Water Framework Directive Compliance Assessment**.
Where the project is likely to have adverse effects on the water environment, the application should undertake an assessment of the existing status of, and impacts of the proposed project, on water quality, water resources and physical characteristics of the water environment as part of the Environmental Statement or equivalent.	EN-1 Paragraph 5.15.2	Potential impacts of the project on water quality are assessed in **Section 15.7** of this ES chapter. Impacts to habitats and species are assessed in **Chapter 17 Marine and Coastal Ecology**. A WFD Compliance Assessment is provided in **Chapter 13 Appendix 13.1 Water Framework Directive Compliance Assessment**.
Where the project is likely to have effects on water quality or resources the applicant should undertake an assessment as required in EN-1, Section 5.15.	EN-3 Paragraph 2.5.85	Potential impacts of the project on water quality are assessed in **Section 15.7** of this ES chapter. A WFD Compliance Assessment is provided in **Chapter 13 Appendix 13.1 Water Framework Directive Compliance Assessment.**

15.2.9 Other UK policies and plans of relevance to this chapter are the Marine Policy Statement (MPS) (HM Government, 2011). This document guides decision making with regard to marine developments and signposts the relevant legislation to be followed.

15.2.10 The MPS provides the high-level approach to marine planning and general principles for decision making. It also sets out the framework for environmental, social and economic considerations that need to be considered in marine planning. Section 2.6.4 of the MPS states that:

"*Developments and other activities at the coast and at sea can have adverse effects on transitional waters, coastal waters and marine waters. During the construction, operation and decommissioning phases of developments, there can be increased demand for water, discharges to water and adverse ecological effects resulting from physical modifications to the water environment. There may also be an increased risk of spills and leaks of pollutants into the water environment and the likelihood of transmission of invasive non-native species, for example through construction equipment, and their impacts on ecological water quality need to be considered*."

Local Planning Policy

15.2.11 The South-East Lincolnshire Local Plan was adopted in March 2019 and replaces all policies in the previous Boston Borough Local Plan. *Policy 30: Pollution* is relevant to water and sediment quality, where it is stated that development proposals will not be permitted where they would lead to unacceptable adverse impacts upon surface water quality.

15.2.12 *Policy 28: The Natural Environment* of the South-East Lincolnshire Local Plan also includes elements which are indirectly related to water and sediment quality, where development proposals that would cause harm to the assets of internationally designated sites will not be permitted, except in exceptional circumstances, where imperative reasons of overriding public interest exist, and the loss will be compensated by the creation of sites of equal or greater nature conservation value.

Guidance

15.2.13 This chapter refers to two sets of guidance in relation to assessing sediment quality as follows. The first is the Centre for Environment, Fisheries and Aquaculture Science (Cefas) Action Levels (Marine Management Organisation (MMO), 2018) (see **Table 15-2**). These levels are used to indicate general contaminant levels in the sediments. If overall levels do not generally exceed the lower threshold values of these guideline standards, then contamination levels are not considered to be of significant concern and are low risk in terms of potential effects on the marine environment. Most of the material assessed against these standards arises from dredging activities but they are considered an acceptable way of indicating the risks to the environment from other marine activities as part of the Environmental Impact Assessment (EIA) process.

Table 15-2 Selected Cefas Action Levels (MMO, 2018)

Contaminant	Action Level 1 (mg/kg)	Action Level 2 (mg/kg)
Arsenic	20	100
Cadmium	0.4	5
Chromium	40	400
Copper	40	400
Nickel	20	200
Mercury	0.3	3
Lead	50	500
Zinc	130	800
Organotins (Tributyltin (TBT) and Dibutyltin (DBT))	0.1	1
Polychlorinated Biphenyls (sum of ICES 7)	0.01	None
PCBs (sum of 25 congeners)	0.02	0.2
Polycyclic aromatic Hydrocarbons (PAH)	0.1 (exception dibenz[a,h]anthracene which is 0.01)	None
Total Hydrocarbons (THC)	100	None

15.2.14 The MMO (using the Cefas Action levels) states that, in general, contaminant levels below Action Level 1 are not considered to be of concern. Material with persistent contaminant levels above Action Level 2 is generally considered to pose an unacceptable risk to the marine environment (and therefore material is unlikely to be considered suitable for disposal to sea). For material with persistent contaminant levels between Action Levels 1 and 2, further consideration of additional evidence may be required before the risk can be quantified. Therefore, for EIA, in the same way, if contaminant levels in the sediments under consideration persistently exceed Action Level 1, additional assessment is required. This might be the application of additional sediment quality guidelines or undertaking more detailed water quality modelling for example.

15.2.15 Given that there are no Action Level 2 concentrations for some parameters, it is more difficult to make a definitive assessment regarding the potential risk of the sediment to the marine environment where exceedances of Action Level 1 are recorded.

15.2.16 This is particularly the case for individual Polycyclic aromatic hydrocarbons (PAHs). However, an indication can be provided by applying the second set of guidelines, the Canadian Interim Sediment Quality Guidelines (ISQG), which do have a second threshold effect level. The ISQGs were developed by the Canadian Council of Ministers of the Environment for evaluating the potential for adverse biological effects in aquatic systems (CCME, 1999). They were derived from available toxicological information, reflecting the relationships between sediment concentrations of chemicals and any adverse biological effects resulting from exposure to these chemicals. They are not statutory standards and should be used with caution as they were designed specifically for Canada and are based on the protection of pristine environments. However, in the absence of suitable alternatives, these guidelines can provide additional information.

15.2.17 ISQGs comprise two assessment levels. The lower level is referred to as the Threshold Effects Level (TEL) and represents a concentration below which adverse biological effects are expected to occur only rarely (for example in some sensitive species). The higher level, the Probable Effect Level (PEL), defines a concentration above which adverse effects may be expected in a wider range of organisms. The three ranges of chemical concentrations (<TEL, between TEL and PEL, and >PEL) indicate those concentrations that are rarely, occasionally and frequently associated with adverse biological effects, respectively. **Table 15-3** summaries the Canadian ISQG for available PAHs.

Table 15-3 Selected PAH ISQGs TELs and PELs (dry weights) (from CCME, 1999)

PAH	TEL	PEL
	mg/kg	
Acenaphthene	0.0067	0.0889
Acenaphthylene	0.00587	0.128
Anthracene	0.0469	0.245
Benzo(a)pyrene, Benzo(b) fluoranthene	0.0888	0.763
Benz(a)anthracene	0.0748	0.693
Chrysene	0.108	0.846
Dibenz(a,h)anthracene	0.006	0.135
Fluoranthene	0.113	1.494
Fluorene	0.002	0.144
Napthalene	0.0346	0.391
Phenanthrene	0.0867	0.544
Pyrene	0.153	1.398

Environmental Quality Standards

15.2.18 Under the WFD, chemical status of a surface water body is assessed by compliance with environmental standards for the priority chemicals that are listed in the EC Environmental Quality Standards Directive (2008/105/EC), as amended by Directive 2013/39/EU (implemented by the WFD (Standards and Classification) Directions (England and Wales) 2015) which increased the list of priority chemicals to 45. Chemical status under the WFD is recorded as 'good' or 'fail' and is determined by the worst scoring chemical.

15.2.19 Certain substances that are regarded as the most polluting were identified in 2001 as Priority Hazardous Substances by a Decision of the European Parliament and the Council of Ministers (Decision 2455/2001/EC). This first list of substances became Annex X of the WFD. This was replaced by Annex II of the Directive on Environmental Quality Standards (Directive 2008/105/EC) (EQSD), also known as the Priority Substances Directive, and this was further updated in 2013 by Directive 2013/39/EU. For these substances, Environmental Quality Standards (EQS) are determined at the European level and these apply to all Member States.

15.2.20 For other substances, standards are derived by each Member State. This list of compounds or Specific Pollutants is defined as substances that can have a harmful effect on biological quality, and which may be identified by Member States as being discharged to water in "significant quantities".

15.3 Consultation

15.3.1 Consultation undertaken throughout the pre-application phase has informed the approach and the information provided in this chapter. A summary of the consultation of relevance to marine sediment and water quality is detailed in **Table 15-4.**

Table 15-4 Consultation and Responses

Consultee and Date	Response	Chapter Section Where Consultation Comment is Addressed
Scoping Response - The Planning Inspectorate, July 2018	The inspectorate advises that an assessment of the potential land contamination and hydrogeological effects that may arise from the construction of the wharf including the disturbance of sediment within the River Witham should be included within the ES. The ES should include a full assessment of the potentially significant environmental effects that may arise from the construction and operation of the wharf and fully describe any required mitigation.	Disturbance of sediment associated with the construction of the wharf is assessed in **Section 15.7**

Consultee and Date	Response	Chapter Section Where Consultation Comment is Addressed
	Regarding scoping out environmental effect to The Wash Inner WFD water body on the basis that the distance from the proposed development and the embedded migration measures will avert a likely significant effect. Require more information on embedded mitigation measures – therefore any likely significant environmental effects on The Wash must be assessed in the ES with appropriate cross reference to the ecology assessment.	The main potential effect to The Wash is associated with sediment plumes during construction – the potential impacts associated with sediment plumes are assessed in **Section 15.7.** Specific consideration of the Inner Wash WFD water body is provided in the WFD Compliance Assessment in **Chapter 13 Appendix 13.1 Water Framework Directive Compliance Assessment**.
	Consider the potential effects of surface water run off on the marine environment.	Details regarding the management of surface water on land to prevent runoff to the marine environment are detailed in **Chapter 5 Project Description** and considered in **Chapter 13 Surface Water, Flood Risk and Drainage Strategy**.
	No approach is provided for the assessment of some of the potential construction and operational effects identified in the Scoping Report -for example release of contaminants from dredging and spread of invasive species. In addition, it is not clear what information will be gathered to inform the assessments outlined. The ES should clearly set out the information on which the assessments have been based, including detailed information on the construction activities and operation of the proposed development. Details of the methodologies applied and any limitations to the assessments should be provided in the ES.	The approach to the assessment of release of contaminants is provided in **Section 15.4**. The information used to assess the baseline is provided in **Section 15.6**. Spread of invasive species is covered in **Chapter 17 Marine and Coastal Ecology** and is also included in the WFD Compliance Assessment found in **Chapter 13 Appendix 13.1 Water Framework Directive Compliance Assessment**.
Scoping Response - MMO, July 2018	Should a new offshore disposal site need to be designated, further impacts at the disposal site (such as increased suspended sediment, changes to sediment properties and their effects on biological receptors) would need to be considered.	A new offshore disposal site is not required. None of the capital or maintenance-dredged material will be disposed

Consultee and Date	Response	Chapter Section Where Consultation Comment is Addressed
	Should there be an identified need for maintenance dredging, the impacts should also be identified in section 6.9.11 (operational impacts).	at sea. All will be managed on land in accordance with the waste hierarchy. There will be no discharges to the marine environment once landed as the stockpile area will include arrangements for any process water to be transferred to collection tanks and used in the aggregate facility. Given the above, no further consideration is necessary within this chapter.
Scoping Response - Port of Boston, 5th July 2018	Various comments regarding the requirement for sea disposal.	See response above.
Section 42 Consultation Response – Boston Borough Council (BBC), 6th August 2019	The proposal must not undermine the Wash nature conservation designation.	Noted. Potential effects on the Wash are included within **Appendix 17.1** Habitats Regulations Assessment (HRA).
Section 42 Consultation Response – Environment Agency, 6th August 2019	Chapter 15 Marine Water and Sediment Quality. Section 15.6.10 onwards (and Chapter 16) refers to sediment sampling sites using site codes SC12-SC23 but no map figure is provided to show where these sites are. There is reference made to a Figure 16.6 but this doesn't appear to be included. There are also additional particle size data from samples taken at these sites in 2018 that could be included.	Sample locations used in this chapter to inform the baseline and impact assessment have been added to **Figure 15.1**. All particle size analysis data is presented in **Chapter 16 Estuarine Processes and Appendix 16.1 Supplementary Information to Estuarine Processes**.
	Chapter 15 Marine Water and Sediment Quality. Section 15.6.19 "In terms of chemical contaminants, the waterbody is at 'good' status, thus indicating no significant exceedances of EQS." This is a default 'good' status as there were no chemical monitoring data available for the classification period. This, therefore, is not indicative of no significant exceedances of EQS. The 2019 WFD classifications are expected to be released on the Catchment Data Explorer in early	Noted. Text altered.

Consultee and Date	Response	Chapter Section Where Consultation Comment is Addressed
	2020, these will not include any additional chemicals data for the Witham so that status will again default to 'good', but the overall status may be improved.	
Section 42 Consultation Response – MMO, 6th August 2019	Whilst the applicant has used previous sampling regimes, only one set of raw data has been provided. The applicant should provide the raw results of all sampling regimes, including locations (either coordinates or as a map) to allow a robust review to be undertaken. Figure 15.1 does not appear show all sediment samples and does not appear to relate to the results provided in Chapter 15.	**Figure 15.1** has been updated to show all sample locations. Only the most recent data is presented in raw form as it is considered to be the most relevant, and this is the data that the impact assessment is based on. Older data is summarised, and comments made regarding whether the recent data is in line with historical data.
Section 42 Consultation Response – Natural England, 6th August 2019	We acknowledge that issues relating to the freeing up of sediment from the dredging process both during construction and ongoing maintenance around the wharf have been assessed including the impacts associated with suspended sediments, increased turbidity, and potential mobilisation of heavy metals / contaminants including hydrocarbons.	Noted.
	The non-technical summary and HRA quote increase of 624 vessels but Chapter 15 and 16 state 560.	Noted. The proposed increase in vessel numbers was 624 in the Preliminary Environmental Information Report (PEIR). This is reduced to 580 following consultation and subsequent scheme changes.
	Same text as used for Chapter 16 - so same errors have occurred.	Noted and updated where relevant.
	Natural England defers mainly to comments of CEFAS and EA on water quality issues.	Noted.
	Whilst contaminant level do not reach level 2 there are still a lot of contaminates. What can be done to reduce them? Natural England would value a discussion with CEFAS and EA on this matter. Is there any risk to shellfisheries in the Wash or prey availability for designated site features? This is not considered here.	The consideration of shellfish water as Protected Areas under the WFD is considered in the WFD Compliance Assessment found in **Chapter 13 Appendix 13.1 Water Framework Directive Compliance Assessment**.

Consultee and Date	Response	Chapter Section Where Consultation Comment is Addressed
		Noted regarding suggestion for a discussion with Cefas and EA regarding contaminant levels.
	Survey data from 2011 are 8 years old and therefore may not be true representatives of present day.	The most recent survey data which was collated in 2017 has been used to inform the baseline and the impact assessment relating to marine water and sediment quality.
	Just because the site is classed as bad doesn't necessarily mean that adding more is okay. This needs to be discussed more.	This comment has been noted and the water body is allocated a higher sensitivity value as a result of the bad classification (i.e. moving towards being unable to accept additional pressures).

15.4 Assessment Methodology

Impact Assessment Methodology

15.4.1 Two main phases of development are considered, in conjunction with the present-day baseline, over the life cycle of the Facility (at least 25 years). These are:

- construction phase; and
- operational phase;

15.4.2 The method for assessment follows that presented in **Chapter 6 Approach to EIA** with topic specific definitions for sensitivity and magnitude as outlined below.

15.4.3 The sensitivity of a receptor, in this case marine water quality, is dependent upon its:

- Tolerance to an effect (i.e. the extent to which the receptor is adversely affected by a particular effect);
- Adaptability (i.e. the ability of the receptor to avoid adverse impacts that would otherwise arise from a particular effect); and
- Recoverability (i.e. a measure of a receptor's ability to return to a state at, or close to, that which existed before the effect caused a change).

15.4.4 The sensitivity is assessed using expert judgement and described with a standard semantic scale. Definitions for each term are provided in **Table 15-5**.

Table 15-5 Definitions for Assessing the Sensitivity for Marine Sediment and Water Quality

Sensitivity	Definition
High	The water quality of the receptor supports or contributes towards the designation of an internationally or nationally important feature and/or has a very low capacity to accommodate any change to current water quality status, compared to baseline conditions.
Medium	The water quality of the receptor supports high biodiversity and/or has low capacity to accommodate change to water quality status.
Low	The water quality of the receptor has a high capacity to accommodate change to water quality status due, for example, to large relative size of the receiving water and capacity for dilution and flushing. Background concentrations of certain parameters already exist.
Negligible	Specific water quality conditions of the receptor are likely to be able to tolerate proposed change with very little or no impact upon the baseline conditions detectable.

15.4.5 Prediction of the magnitude of potential effects has been based on the consequences that the Facility might have upon the marine water and sediment quality status. These descriptions of magnitude are specific to the assessment of marine water and sediment quality impacts and are considered in addition to the generic descriptors of impact magnitude that are presented in the EIA. Potential impacts have been considered in terms of permanent or temporary, and adverse or beneficial effects. The magnitude of an effect is dependent upon its:

- Scale (i.e. size, extent or intensity);
- Duration;
- Frequency of occurrence; and
- Reversibility (i.e. the capability of the environment to return to a condition equivalent to the baseline after the effect ceases).

15.4.6 The magnitude of effect is assessed using the terms in **Table 15-6**.

Table 15-6 Definitions for Assessing the Magnitude of Effect for Marine Sediment and Water Quality

Magnitude	Definition
High	Large scale change to key characteristics of the water quality status of the receiving water feature. Water quality status degraded to the extent that a permanent or long-term change occurs. Inability to meet (for example) Environmental Quality Standard (EQS) is likely.
Medium	Medium scale changes to key characteristics of the water quality status taking account of the receptor volume, mixing capacity, flow rate, etc. Water quality status likely to take considerable time to recover to baseline conditions.
Low	Noticeable but not considered to be substantial changes to the water quality status taking account of the receiving water features. Activity not likely to alter local status to the extent that water quality characteristics change considerably or EQSs are compromised.
Negligible	Although there may be some impact upon water quality status, activities are predicted to occur over a short period. Any change to water quality status would be quickly reversed once the activity ceases.

15.4.7 Where the potential for an accidental spill or leak is concerned, the focus will be on control measures that would be employed to reduce accidental releases to the marine environment. An **Outline Code of Construction Practice (OCoCP)** (document reference 7.1) has been prepared to set out principles, controls and management measures to be implemented during the construction phase to manage potential significant effects, including measures for controlling and managing accidental spills and leaks, therefore this has not been considered further in this section.

Cumulative Impact Assessment

15.4.8 Cumulative impacts are assessed through consideration of the extent of influence of changes or effects upon marine sediment and water quality arising from the Facility alone; and those arising from the proposed project cumulatively or in combination with other developments and other nearby estuary activities. It is considered likely that only the Boston Tidal Barrier project is relevant to the Facility to act cumulatively with regards to impacts associated with marine water quality. Information to support the Cumulative Impact Assessment has been drawn from findings of the Boston Tidal Barrier Environmental Statement (Environment Agency 2016).

Transboundary Impact Assessment

15.4.9 Transboundary impacts are assessed through consideration of the extent of influence of changes or effects and their potential to impact upon marine and sediment quality receptor groups that are located within other EU member states. Given the distance of the Facility from international boundaries in the North Sea, it is concluded that transboundary impacts on marine sediment and water quality would not occur.

15.5 Scope

Study Area

15.5.1 This chapter reflects the study area presented in **Chapter 16 Estuarine Processes** given that marine sediment and water quality effects will reflect the extent of any sediment plume created during dredging. The study area therefore addresses the potential effects on marine sediment and water quality along The Haven and into The Wash embayment (**Chapter 16 Estuarine Processes**, **Figure 16.1**).

Data Sources

15.5.2 The assessment was undertaken with reference to several sources, as detailed in **Table 15-7**.

Table 15-7 Key Information Sources

Data Source	Reference
Geology: six boreholes at a site about 900 m to the south of the Facility	Lincs Laboratory (2011)
Geology: four boreholes at a site about 500 m to the south of the Facility	T.L.P. Ground Investigations (2012)
Estuary-bed sediment: six samples collected in the Haven in 2010	Halcrow Jacobs Alliance (2011)
16 grab samples collected for Particle Size Distribution (PSD) and chemical analysis. 12 of these sampling locations also collected deeper core samples (vibrocores). Recovered for the Boston Tidal Barrier 2017 for the Environment Agency.	Newton (2017). Boston Barrier Project: 2017 Water Quality and Sediment Quality Report. *Report: EA02/17NEAS*. Estuarine & Coastal Monitoring & Assessment Service (ECMAS), Environment Agency.
Locations in The Haven were sampled for water quality throughout the water column and sent for chemical analysis. Collected for the Boston Tidal Barrier in 2017 for the Environment Agency.	
Water Quality in Water Framework Directive water bodies	Environment Agency Data Catchment Explorer. https://environment.data.gov.uk/catchment-planning/ [Accessed, 2020]

Assumptions and Limitations

15.5.3 As agreed with the MMO, the available vibrocore data (Estuarine and Coastal Monitoring and Assessment Service (ECMAS) data, Newton (2017)) was considered representative of the Facility's wharf location, as one sample was within the proposed Application Site, and another two were in close proximity of the Order limits.

15.6 Existing Environment

15.6.1 This section provides an overview of the key information for marine sediment and water quality. It is separated into two sections sediment quality (including sediment physical characteristics) and water quality.

Sediment Quality

Particle Size Distribution

15.6.2 Particle Size Distribution (PSD) data are relevant to this chapter because sediment grain size is a significant factor that controls the capacity for both suspended and bed sediments to concentrate and retain metals and organic pollutants (Horowitz, 1987). Finer sediments (clay and silt fractions) have a greater adsorbing capacity and, therefore retain higher concentrations of contaminants.

15.6.3 PSD data is described in detail in **Chapter 16 Estuarine Processes**. To summarise, 16 grab samples were collected between 11-15th August 2017, and 12 vibrocores (up to four at each location) were recovered between 30th August to 3rd September 2017 (Newton, 2017). These sample locations are shown in **Figure 15.1**. Older estuary bed sampling campaigns from 2000, 2005 and 2010 along The Haven are described in **Appendix 16.1 Supplementary Information to Estuarine Processes**.

15.6.4 The PSD results show slightly different characteristics for samples located upstream, opposite and downstream of the Facility. Upstream of the Facility the sediments are finer with a higher proportion of mud to sand. The bed samples opposite the Facility show roughly 50:50 sand and mud proportion. Downstream, the bed sediments are slightly coarser.

15.6.5 Previous sampling by Mott MacDonald (2015) also showed that the Holocene deposits upstream of the Facility are predominantly clayey silt to silty very fine sand. Discontinuous peat layers were also recognised between 0.1 m and 0.7 m thick.

15.6.6 Historical datasets from August 2000, August 2005 and April 2010 show that at two locations in The Haven (one upstream of the Facility and one downstream) the median particle sizes equated to very fine sand with between 19% and 32% mud for the subtidal samples, and very fine silt for the intertidal samples.

15.6.7 Overall, therefore it is anticipated that the material to be dredged will consist of very fine sand with a relatively large percentage of silt.

Contaminants

15.6.8 All sediment samples taken in 2017 were sent for chemical analysis. The results have been compared to the Cefas Action Levels (see **Table 15-8** for the grab data, and **Table 15-9** for the vibrocore data). Note that location SC23 was within the Application Site's Order limits and SC22 and SC24 were in close proximity to the Order limits (see **Figure 15.1**).

15.6.9 Almost all of the trace metal concentrations in the grab samples were below Cefas Action Level 1 concentrations. Only the following exceedances of the Cefas Action Level 1 values were recorded:

- Chromium (SC12, SC19); and
- Nickel (SC12 - SC21 inclusive).

15.6.10 With regards to the vibrocores, most of the trace metal levels were below Cefas Action Level 1 concentrations. However, some trace metals exceeded the respective Cefas Action Level 1 values, as listed below.

- Arsenic (SC17, 2 m);
- Chromium (SC13, 0.5 m; SC21, 1 m);
- Nickel (SC12, 0.5 m, 2 m; SC13, 0.5 m; SC14, 1 m; SC17, 0.5 m, 2 m; SC19, 1m; SC21, 0.5 m, 1 m; SC22, 0.5 m); and
- Zinc (SC13, 0.5 m).

15.6.11 The exceedances of trace metals in both the grab and the vibrocore samples were recorded as being close to the Action Level 1 concentration and therefore are considered marginal exceedances. There were no exceedances of Action Level 2 concentrations. As a result, sediment concentrations associated with metals within The Haven sediments are not considered to be significantly elevated.

15.6.12 In terms of PAHs, there are several exceedances of Cefas Action Level 1 both in the grab samples (surface sediment) and vibrocores (note there are no Action Level 2 concentrations). PAHs are a diverse group of aromatic compounds containing two or more fused arenes structures and are formed by the incomplete/inefficient combustion of organic material, diagenesis and biosynthesis (UK MPA, 2019). PAHs are ubiquitous in the environment, with natural background levels resulting from natural processes. However, a significant fraction of PAHs resulting in the environment are due to anthropogenic sources (e.g. burning of fuel, internal combustion engines etc.) (CCME 1992). **Table 15-10** summarises the common sources of the PAHs with the highest concentrations found within The Haven sediment samples.

15.6.13 Historical data collected in 2010-2011 support the findings of the 2017 data in that metal concentrations were found to be relatively low with levels of PAHs elevated.

Table 15-8 2017 Surface (Grab) sample data for The Haven compared to the Cefas Action Levels (yellow indicates exceedance of Action Level 1, no Action Level 2 exceedances were recorded (note there are no Action Level 2 concentrations for PAHs))

Contaminant	Unit	SC12	SC13	SC14	SC15	SC16	SC17	SC18	SC19	SC20	SC21	SC22	SC23	SC24	SC25	SC26	SC27
Arsenic	mg/kg	15.4	13.7	15.3	14.6	13	15.3	14.8	15.8	16.2	14.5	12	9.12	12.9	10.6	11	9.75
Cadmium		0.321	0.265	0.305	0.285	0.249	0.3	0.296	0.311	0.318	0.276	0.229	0.148	0.241	0.186	0.21	0.175
Chromium		40.4	34.2	38	38.2	33.1	38.2	36.8	40.5	42.4	36.3	26.3	18.2	30.7	23.2	25.1	20.2
Copper		22	17.9	20.5	19.8	17.6	20.7	20.4	21.1	22.7	18.7	13.2	8.62	15.6	11.6	12.6	9.41
Lead		36.7	31	34.7	33.3	29.6	34.4	33.4	36.5	38.1	33	24.2	16.8	28.5	21.1	22.6	17.9
Mercury		0.166	0.131	0.154	0.145	0.115	0.144	0.14	0.138	0.16	0.132	<0.1	<0.1	0.115	<0.1	<0.1	<0.1
Nickel		24.9	21.6	23.4	23.5	20.5	23.5	22.9	24.7	25.9	22.6	17	11.8	19.6	14.9	16.4	13.1
Zinc		123	103	114	114	101	116	114	119	127	107	81.5	54.2	92.2	70.4	78.4	60.6
PAHs																	
Acenaphthene	µg/kg	34.6	30	32.6	29.8	29.4	32.6	31.9	37.5	37.4	26.8	20.6	19	27.8	20.6	15.4	13.9
Acenaphthylene		12.6	15.4	12.5	12	11.6	11.8	12.5	13.1	12.3	10.3	9.45	8.4	10.1	9.36	6.45	6.23
Anthracene		63.3	70.3	58.6	51.7	55.6	61.4	61.4	81.7	66.2	49.6	53.2	37.4	50	39.1	24.8	26.4
Benzo(a)Anthracene		164	156	149	140	134	160	147	190	166	133	121	94.2	131	101	71.6	68.2
Benzo(a)Pyrene		181	174	165	165	153	176	158	210	187	154	135	104	152	110	89.7	75.3
Chrysene		192	219	216	142	162	225	173	262	240	155	178	130	192	143	112	101
Dibenzo(a,h)Anthracene		37.2	32.7	32.4	32.4	30.9	33.6	29.4	42.9	43	34.8	24.4	18.3	28.4	19.7	19	14.6
Fluoranthene		473	445	442	371	378	462	428	518	472	359	336	226	360	276	207	189
Fluorene		74.7	65.5	75.5	66.1	64.8	76.3	70.1	76.2	78.8	62.7	50.1	36.3	62	48.4	36.7	32.8
Naphthalene		239	220	257	235	205	251	229	240	249	206	181	114	227	203	150	133
Phenanthrene		392	364	391	326	335	389	382	410	400	318	295	189	321	266	173	178
Pyrene		402	387	384	336	330	389	364	452	405	319	298	197	322	241	183	167

Table 15-9 2017 Vibrocore sample data for The Haven compared to the Cefas Action Levels (yellow indicates exceedance of Action Level 1, no Action Level 2 exceedances were recorded (note there are no Action Level 2 concentrations for PAHs))

Contaminant	Unit	Sample site and depth (m)																								
		SC12			SC13		SC14		SC15		SC16		SC17		SC18		SC19		SC20		SC21	SC22		SC23		
		0.5	1	2	0.5	1	0.5	1	2	0.5	0.5	1	2	0.5	1	0.5	1	2	0.5	1	2	0.5	1	0.5	1	1.5
Arsenic	mg/kg	15.4	-	18.8	16.9	16.2	12.3	n/a	n/a	12.8	13.6	11.9	24.8	12.2	12.5	-	n/a	n/a	14.7	15.7	14.8	12	12.9	12.8	10.3	9.06
Cadmium		0.221		0.208	0.287	0.246	0.195			0.195	0.242	0.185	0.358	0.202	0.146			0.263	0.278	0.321	0.231	0.212	0.181	0.143	0.115	0.221
Chromium		38.9	-	32.1	41.5	35.8	32.8	-	-	32.4	38.1	25.4	27.1	29.4	33	-	-	-	40.6	42.2	35.6	37.4	32.5	28	21.9	21.2
Copper		34.3	23.7	17.7	23.2	19.5	18	19.5	10.9	17.5	20.1	14.2	11.5	14.4	17.4	-	18.8	17.7	21.2	19.9	21	19.4	16.5	12.7	10.2	8.33
Lead		-	-	9.17	33.4	33.6	29.9	-	-	28.4	34	27.6	14.7	24.9	9.48	-	-	-	35.3	40.1	41.7	34.2	29.1	33.8	26.9	19.5
Mercury		0.143	-	<0.1	0.143	0.133	0.114	-	-	<0.1	0.139	<0.1	<0.1	<0.1	<0.1	-	-	-	0.14	0.154	0.207	0.137	<0.1	0.111	<0.1	<0.1
Nickel		24.2	-	28	27	21.8	20	-	-	20	21.4	15.9	24.2	17.1	25.5	-	-	-	23.5	22.6	19.9	21	19.1	18	13.9	13.9
Zinc		117	-	62.4	135	108	101	-	-	99.1	109	66.7	54.1	81.2	61.8	-	-	-	114	110	105	103	88.1	72.1	55.1	49.3
PAHs																										
Acenaphthene	µg/kg	28.6	-	<4	25.1	23.3	30.4	-	-	22.8	42	20	<4	15.1	<4	34.5	-	-	-	41.2	69.3	33	23.5	21.9	25.4	7.06
Acenaphthylene		8.99	-	<4	10.5	8.86	8.61	-	-	8.57	11.6	9.8	<4	6.82	<4	10.8	-	-	-	13.7	16.4	9.18	8.43	7.82	5.62	4.36
Anthracene		50.5	-	<4	50.3	46.6	43.1	-	-	45.6	49.1	56.2	5.99	35.1	<4	51.4	-	-	-	67.6	146	57.4	36.7	55.6	42.1	18
Benzo(a)Anthracene		143	-	11.6	180	141	138	-	-	122	200	202	24	95.7	4.12	178	-	-	-	202	410	151	122	215	218	82.4
Benzo(a)Pyrene		141	-	11.1	201	154	138	-	-	115	167	181	27.4	69.9	<4	166	-	-	-	166	316	157	98.2	165	164	58.4
Chrysene		187	-	15.9	251	195	165	-	-	156	232	215	37.2	121	6.27	244	-	-	-	266	388	184	161	255	217	99.5
Dibenzo(a,h)Anthracene		31	-	<4	41	31.5	25	-	-	22.3	29.8	30.4	6.43	18.9	<4	33	-	-	-	33.8	72.1	32.3	25.8	26.9	27.9	13
Fluoranthene		331	-	28.8	429	313	315	-	-	302	436	662	64.8	217	14.1	463	-	-	-	489	1140	375	277	584	490	180
Fluorene		62.7	-	6.71	56.4	56.9	68.8	-	-	53.6	84.8	45.1	9.51	43.4	<4	77.7	-	-	-	110	144	72.8	51.1	51.2	40.8	20.8
Naphthalene		192	-	16.7	178	203	194	-	-	119	255	83.3	34.1	144	4.5	245	-	-	-	331	342	196	194	75.9	66.2	43.8

Contaminant	Unit	Sample site and depth (m)																								
		SC12			SC13		SC14		SC15		SC16		SC17		SC18		SC19		SC20		SC21	SC22		SC23		
		0.5	1	2	0.5	1	0.5	1	2	0.5	0.5	1	2	0.5	1	0.5	1	2	0.5	1	2	0.5	1	0.5	1	1.5
Phenanthrene		303	-	26.3	295	300	264	-	-	265	333	225	68.3	199	<9	351	-	-	-	440	542	289	288	248	282	138
Pyrene		287	-	32.5	377	279	278	-	-	253	382	518	59.4	191	17.5	397	-	-	-	429	915	322	238	463	459	155

Table 15-10 List of Main PAHs Found Around the Proposed Dredge Area Sediments

Contaminant	Source
Chrysene	Coal tar and tobacco smoke.
Fluoranthene	Isomer of pyrene, coal tar pitch, used as an intermediate for dyes (fluorescent), pharmaceuticals and agrochemicals.
Fluorene	Coal tar. Insoluble in water and soluble in many organic solvents.
Phenanthrene	Coal tar and petroleum
Pyrene	Coal tar, produced in a wide range of combustion conditions (created when products like coal, oil, gas, and rubbish are burnt but the burning process is incomplete). Used commercially to make dyes, plastics and pesticides. Oil spills, storm water runoff, vehicle exhausts are all sources.

15.6.14 The data was compared to the Canadian Sediment Quality guidelines to provide further information on the PAH contaminant levels. This assessment is presented in **Table 15-11** (surface samples) and **Table 15-12** (vibrocore samples). Similar to the Cefas action levels, most samples exceed the lower TEL threshold. However, only one sample (vibrocore) at SC21 (2m) recorded a concentration at the PEL for fluorene. All other samples recorded values considerably lower than the PEL.

Table 15-11 2017 surface sample data compared to Canadian Sediment Quality guidelines for PAHs (light blue indicates TEL exceedance, there were no PEL exceedances)

Contaminant	Unit	SC12	SC13	SC14	SC15	SC16	SC17	SC18	SC19	SC20	SC21	SC22	SC23	SC24	SC25	SC26	SC27
Acenaphthene	µg/kg	34.6	30	32.6	29.8	29.4	32.6	31.9	37.5	37.4	26.8	20.6	19	27.8	20.6	15.4	13.9
Acenaphthylene		12.6	15.4	12.5	12	11.6	11.8	12.5	13.1	12.3	10.3	9.45	8.4	10.1	9.36	6.45	6.23
Anthracene		63.3	70.3	58.6	51.7	55.6	61.4	61.4	81.7	66.2	49.6	53.2	37.4	50	39.1	24.8	26.4
Benzo(a)Anthracene		164	156	149	140	134	160	147	190	166	133	121	94.2	131	101	71.6	68.2
Benzo(a)Pyrene		181	174	165	165	153	176	158	210	187	154	135	104	152	110	89.7	75.3
Chrysene		192	219	216	142	162	225	173	262	240	155	178	130	192	143	112	101
Dibenzo(a,h)Anthracene		37.2	32.7	32.4	32.4	30.9	33.6	29.4	42.9	43	34.8	24.4	18.3	28.4	19.7	19	14.6
Fluoranthene		473	445	442	371	378	462	428	518	472	359	336	226	360	276	207	189
Fluorene		74.7	65.5	75.5	66.1	64.8	76.3	70.1	76.2	78.8	62.7	50.1	36.3	62	48.4	36.7	32.8
Naphthalene		239	220	257	235	205	251	229	240	249	206	181	114	227	203	150	133
Phenanthrene		392	364	391	326	335	389	382	410	400	318	295	189	321	266	173	178
Pyrene		402	387	384	336	330	389	364	452	405	319	298	197	322	241	183	167

Table 15-12 2017 vibrocore data compared to the Canadian Sediment Quality Guidelines (light blue indicates TEL exceedance. Dark blue indicates PEL exceedances)

Contaminant	Unit	Sample site and depth (m)																								
		SC12			SC13		SC14		SC15		SC16		SC17		SC18		SC19		SC20		SC21		SC22		SC23	
		0.5	1	2	0.5	1	0.5	1	2	0.5	0.5	1	2	0.5	1	0.5	1	2	0.5	1	2	0.5	1	0.5	1	1.5
Acenaphthene	µg/kg	28.6	-	<4	25.1	23.3	30.4	-	-	22.8	42	20	<4	15.1	<4	34.5	-	-	-	41.2	69.3	33	23.5	21.9	25.4	7.06
Acenaphthylene		8.99	-	<4	10.5	8.86	8.61	-	-	8.57	11.6	9.8	<4	6.82	<4	10.8	-	-	-	13.7	16.4	9.18	8.43	7.82	5.62	4.36
Anthracene		50.5	-	<4	50.3	46.6	43.1	-	-	45.6	49.1	56.2	5.99	35.1	<4	51.4	-	-	-	67.6	146	57.4	36.7	55.6	42.1	18
Benzo(a)Anthracene		143	-	11.6	180	141	138	-	-	122	200	202	24	95.7	4.12	178	-	-	-	202	410	151	122	215	218	82.4
Benzo(a)Pyrene		141	-	11.1	201	154	138	-	-	115	167	181	27.4	69.9	<4	166	-	-	-	166	316	157	98.2	165	164	58.4
Chrysene		187	-	15.9	251	195	165	-	-	156	232	215	37.2	121	6.27	244	-	-	-	266	388	184	161	255	217	99.5
Dibenzo(a,h)Anthracene		31	-	<4	41	31.5	25	-	-	22.3	29.8	30.4	6.43	18.9	<4	33	-	-	-	33.8	72.1	32.3	25.8	26.9	27.9	13
Fluoranthene		331	-	28.8	429	313	315	-	-	302	436	662	64.8	217	14.1	463	-	-	-	489	1140	375	277	584	490	180
Fluorene		62.7	-	6.71	56.4	56.9	68.8	-	-	53.6	84.8	45.1	9.51	43.4	<4	77.7	-	-	-	110	144	72.8	51.1	51.2	40.8	20.8
Naphthalene		192	-	16.7	178	203	194	-	-	119	255	83.3	34.1	144	4.5	245	-	-	-	331	342	196	194	75.9	66.2	43.8
Phenanthrene		303	-	26.3	295	300	264	-	-	265	333	225	68.3	199	<9	351	-	-	-	440	542	289	288	248	282	138
Pyrene		287	-	32.5	377	279	278	-	-	253	382	518	59.4	191	17.5	397	-	-	-	429	915	322	238	463	459	155

15.6.15 Given the historical industrialisation of the estuary, these concentrations are expected in an estuary with a working dock and associated industrialised history (Halcrow Jacobs Alliance, 2011) and all pre-construction surveys for the Boston Barrier, including the 2017 grab and vibrocore samples noted elevated levels of PAHs at differing degrees.

15.6.16 One sample was collected within the Order limits and two others are in close proximity of the Order limits (as can be seen in **Figure 15.1**). As such, it is anticipated that sediment quality is likely to be of a similar nature and reflect generalised sediment conditions in the estuary given that there are no specific pollution sources to the dredge area that could give rise to variances. As a result, the sediments are likely to exhibit marginally elevated levels of metals with concentrations of PAHs above lower sediment quality guidelines.

Water Quality

15.6.17 The proposed works are shown in **Figure 15.2** against the WFD water bodies in the study area. Note that WFD compliance is not specifically considered here – an assessment focussing on all WFD compliance parameters, including water quality, can be found in **Appendix 13.1 Water Framework Directive Compliance Assessment**. Water quality information available for the WFD water body in which the Facility is located is presented here to provide context to the water quality baseline only.

15.6.18 The WFD water body in which the Facility is located is the Witham transitional water body (GB530503000100). This water body is a 'heavily modified' water body due to 'flood protection' and 'ports, harbours and navigation' and is currently classified to have an overall status of 'bad'. In terms of water quality, the water body fails chemical status for Polybrominated diphenyl ethers (PBDE) and mercury and its compounds. Dissolved inorganic nitrogen (DIN) is also considered to be at moderate status.

15.6.19 Water quality samples were undertaken within The Haven during the 2017 sampling campaign by the Environment Agency (Newton, 2017) (**Figure 15.3**). Samples WS01 to WS06 were tested for heavy metals as well as for pH, dissolved oxygen and turbidity. Samples taken from WS07 to WS11 were tested for pH, dissolved oxygen and turbidity. Stations WS06 and WS07 are the closest to the Facility location as they are located within 50 m of the Order limits.

15.6.20 There were exceedances of the annual average EQS' for heavy metals in some of the samples, as can be seen in the yellow highlighted cells in **Table 15-13**. The exceedances were recorded for the following metals:

- Chromium (at all sampling locations);
- Copper (WS01 at 1m above bed; WS03 at 1m above bed; WS04 at 3m and 1m above bed; and WS06 at 3m and 1m above bed);
- Iron (WS03 at 4m and 1m above bed; WS05 and WS06 throughout the water column);
- Lead (at all sampling locations); and
- Zinc (WS03 at 1m above bed; WS04, WS05 and WS06 throughout the water column).

15.6.21 Benzo(g,h,i)perylene was detected in concentrations above the maximum allowable concentration EQS at all sampling locations and depths (**Table 15-14**). This compound occurs naturally in crude oils and is present in products of incomplete combustion and in coal tar (EPA, 1987). It has been identified in cigarette smoke, charcoal-broiled steaks, and edible oils (IARC, 1983) and in soils, groundwater, and surface waters at hazardous waste sites (ATSDR, 1990). It can typically end up in the water when it is released from vehicle exhausts.

Table 15-13 Water Quality Data for The Haven (2017 samples) indicative to the EQS (yellow indicates exceedance of annual average, no exceedances of maximum allowable concentrations were recorded).

Unit		Antimony	Arsenic	Cadmium	Chromium	Copper	Iron	Lead	Manganese	Mercury	Nickel	Selenium	Zinc	Dissolved Oxygen	Turbidity	pH	Salinity
	Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	mg/l	NTU		ppt
ug/l	***EQS (annual average)***	*100*	*25*	*0.2*	*0.6*	*3.76*	*1000*	*1.3*	-	-	-	-	*7.9*	-	-	-	-
ug/l	***EQS (maximum allowable concentration)***	-	-	-	*32*	-	-	*14*	-	*0.07*	*34*	-	-	-	-	-	-
WS01	Surface	<10	2.79	<0.03	1.26	2.02	923	2.08	48.4	<0.01	3.8	<1	6.33	6.5	53.1	7.99	2.99
	3m above bed	<10	2.35	<0.03	1.15	1.51	685	1.73	49	<0.01	2.25	<1	5.04	6.54	36.4	7.96	15.54
	1m above bed	<10	5.73	<0.2	8.45	5.49	5720	12.1	358	0.0226	6.96	<1	28.1	6.39	41.7	7.94	17.88
WS02	Surface	-	2.73	<0.03	1.29	1.45	-	1.85	-	<0.01	2.51	-	5.76	9.45	29.1	7.94	4.73
	4m above bed	-	2.33	<0.03	1.19	1.4	-	1.76	-	<0.01	2.1	-	5.51		36.9	7.93	16.93
	1m above bed	-	4.34	<0.03	4.65	2.32	-	6.51	-	0.015	2.86	-	11.1		80.8	7.95	19.4
WS03	Surface	<10	2.47	<0.03	1.37	1.52	861	2.06	54.8	<0.01	2.37	<1	5.34	6.44	49.5	7.95	7.51
	4m above bed	<10	2.58	<0.03	1.49	1.54	1070	2.31	58.5	<0.01	2.27	<1	5.64	6.69	41.1	7.94	17.04
	1m above bed	<10	7.62	<0.2	9.18	5.84	6650	13.8	412	0.0327	7.23	<1	28.8	6.51	355.8	7.94	19.36
WS04	Surface	-	2.58	<0.03	1.39	2.39	-	2.51	-	<0.01	3.71	-	7.95	6.37	27.4	7.98	9.64
	3m above bed	-	2.4	<0.03	1.46	7.25	-	2.81	-	<0.01	3.17	-	8.47		55.2	7.94	16.86
	1m above bed	-	4.34	0.0467	4.53	4.05	-	8.18	-	0.0149	5.29	-	19		357.5	7.95	18.85
WS05	Surface	<10	2.65	<0.03	1.64	2.35	1200	2.84	72.2	<0.01	3.49	<1	8.89	6.53	51.2	7.93	12.06
	2m above bed	<10	2.8	<0.03	-	3.29	1080	3.02	74.8	<0.01	3.41	<1	9.87	6.63	52.7	7.94	15.49
	1m above bed	<10	2.9	<0.03	2.48	2.69	1940	4.37	97.8	<0.01	3.73	<1	11.1		56.5	7.93	17.39
WS06	Surface	<10	2.97	<0.03	2.15	2.51	1650	3.8	92.3	<0.01	3.54	<1	10.1	6.55	69.2	7.95	16.42
	3 m above bed	<10	3.65	0.0454	4.02	4	2850	7.41	183	0.0122	5.15	<1	20	6.52	72.1	7.96	16.75
	1 m above bed	<10	5.02	0.0422	4.92	4.43	3590	9.24	220	0.0103	6.08	<1	21	6.51	131.7	7.97	17.42
WS07	Surface	Not measured												6.63	43.5	7.9	20.33
	3 m above bed													6.62	53.1	7.9	20.72

Unit		Antimony	Arsenic	Cadmium	Chromium	Copper	Iron	Lead	Manganese	Mercury	Nickel	Selenium	Zinc	Dissolved Oxygen	Turbidity	pH	Salinity
	1 m above bed	Not measured												6.63	81.5	7.9	20.63
WS08	Surface													6.72	43.5	7.9	20.51
	3 m above bed													6.69	45.8	7.9	20.98
	1 m above bed													6.7	56.2	7.9	20.97
WS09	Surface													6.82	47.5	7.9	20.73
	3 m above bed													6.72	43.8	7.9	21.02
	1 m above bed													6.77	68.1	7.9	20.92
WS10	Surface													6.66	41.4	7.9	20.47
	2 m above bed													6.67	57.2	7.9	20.89
	1 m above bed													6.69	63.3	7.9	20.93
WS11	Surface													6.77	56.7	7.89	20.03
	3 m above bed													6.7	53.1	7.89	20.35
	1 m above bed													6.69	69.9	7.89	20.3

Table 15-14 Water Quality (Priority Substances) Data for The Haven (2017 samples) indicative to the EQS (yellow indicates exceedance of annual average standard, red indicates exceedance of the maximum allowable standard).

Unit		Anthracene	Benzo(a)Pyrene	Benzo(b)Fluoranthene	Benzo(k)Fluoranthene	Benzo(g,h,i)Perylene	Fluoranthene	Naphthalene
	Units	µg/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
ug/l	***EQS (annual average)***	*0.1*	*-*	*-*	*-*	*-*	*0.0063*	*2*
ug/l	***EQS (maximum allowable concentration)***	*0.1*	*0.027*	*0.017*	*0.017*	*0.00082*	*0.12*	*130*
WS01	Surface	<0.01	0.00139	0.00126	0.00063	0.00169	0.00266	<0.1
	3m above bed	<0.01	0.00172	0.00176	0.00091	0.00178	0.00357	<0.1
	1m above bed	<0.01	0.00337	0.00324	0.00179	0.00356	0.00502	<0.1
WS02	Surface	<0.01	0.00167	0.00145	0.00076	0.00188	0.00374	<0.01
	4m above bed	<0.01	0.00129	0.00113	0.0006	0.00142	0.00284	<0.01

Unit		Anthracene	Benzo(a)Pyrene	Benzo(b)Fluoranthene	Benzo(k)Fluoranthene	Benzo(g,h,i)Perylene	Fluoranthene	Naphthalene
	1m above bed	<0.01	0.00201	0.00188	0.00104	0.00199	0.00389	<0.01
WS03	Surface	<0.01	0.00189	0.00193	0.001	0.00206	0.00495	<0.1
	4m above bed	<0.01	0.00203	0.00198	0.00107	0.00227	0.00383	<0.1
	1m above bed	<0.01	0.00449	0.0042	0.00237	0.0044	0.00533	<0.1
WS04	Surface	<0.01	0.00158	0.00146	0.00072	0.0019	0.00395	<0.01
	3m above bed	<0.01	0.0023	0.00219	0.00124	0.00232	0.00446	<0.01
	1m above bed	<0.01	0.011	0.0101	0.00579	0.0103	0.0109	<0.01
WS05	Surface	<0.01	0.00338	0.00322	0.00178	0.00341	0.00729	<0.1
	2m above bed	<0.01	0.00191	0.00169	0.00086	0.00211	0.00338	<0.1
	1m above bed	<0.01	0.00171	0.00183	0.00093	0.00195	0.00345	<0.1
WS06	Surface	<0.01	0.00246	0.00236	0.00128	0.00249	0.00533	<0.1
	3 m above bed	<0.01	0.00187	0.00188	0.001	0.00207	0.00321	<0.1
	1 m above bed	<0.01	0.00374	0.00365	0.002	0.00411	0.00546	<0.1

15.6.22 Turbidity values ranged from approximately 27 NTU (Nephelometric Turbidity Units) at the surface of site WS04 to 357 NTU located at 1 m above bed at WS04, with most values between 30 NTU and 100 NTU. A general increase was observed in turbidity from near the estuary bed into the higher parts of the water column.

15.6.23 To provide an indication of suspended solids concentrations, the Environment Agency (2016) used a conversion factor of 1 NTU to 5 mg/l. Using this conversion, the baseline suspended sediment concentrations in The Haven are high, ranging from 210 mg/l to 1,790 mg/l (average 545 mg/l) near to the bed, to 134-345 mg/l (average 225 mg/l) at the water surface. This is supported by the environmental studies undertaken to inform the Boston Tidal Barrier work where background concentrations of 134 – 1,790 mg/l, with the highest concentrations being recorded nearest the seabed (see **Chapter 16 Estuarine Processes** for further detail) were monitored. Mean values, also converted from NTU readings, during construction of the Boston Tidal Barrier in February 2019 ranged from 170 mg/l to 215 mg/l (BMMJV, 2019).

Anticipated Evolution of the Baseline Condition

15.6.24 The baseline conditions for marine water and sediment quality are relatively stable within The Haven, with multiple datasets covering several years exhibiting similar patterns.

15.7 Potential Impacts

Embedded Mitigation

15.7.1 Embedded mitigation is a type of primary mitigation and is an inherent aspect of the EIA process. The Facility has committed to several techniques and engineering designs/modifications as part of the project, during the pre-application phase, to avoid several impacts or reduce the impacts as far as possible. The main embedded mitigation measures relevant to sediment and water quality have been proposed to reduce potential impacts, as outlined below:

- The volume of capital dredging will be minimised by setting the quay wall as close to the channel as possible, whilst maintaining a safe distance from the berthing point to the navigable channel to allow vessels to pass safely;
- As much of the capital dredging as possible will be completed using land-based equipment to reduce impacts in The Haven water column (these techniques reduce the spill from bucket thus reducing plume generation);
- Disposal of capital dredged sediment on land rather than at sea;

- An OCoCP has been prepared to set out principles, controls and management measures to be implemented during the construction phase to manage potential significant effects, including accidental spills and leaks to the marine environment.
- To manage the risk of spillages and pollution from marine vessels, all work practices would adhere to the requirements of the International Convention for the Prevention of Pollution from Ships (MARPOL) 73/78; specifically Annex 1 Regulations for the prevention of pollution by oil concerning machine waters, bilge waters and deck drainage and Annex IV Regulations for the prevention of pollution by sewage from ships concerning black and grey waters.
- No discharge for the construction works is anticipated to be required. However, it is anticipated that surface water discharge from the part of the Facility that is to the east of Sea (Roman) Bank is likely to be required. This discharge will require an environmental permit to control any potential pollution incidents.

Worst Case

15.7.2 Full details of the range of design options being considered are provided in **Chapter 4 Site Selection and Alternatives** and **Chapter 5 Project Description**. The principal aspect of the Facility which has the potential to affect water quality is the proposed wharf and associated dredging both during the construction and operational phases. A worst case project envelope for wharf construction and operation is considered below.

<u>Wharf Construction</u>

15.7.3 The preferred structure is a suspended deck on piles over a sloping revetment with scour protection (1 in 4 slope) and a fronting quay wall. The suspended deck would be approximately 400 m long and approximately 30 m wide and constructed on top of 300 driven piles. Excavation of approximately 75,000 m^3 of sediment would be required to enable installation of the revetment. Approximately 150,000 m^3 of sediment would require excavation to create enough water depth in the berthing areas in front of the quay wall. The construction of the wharf is anticipated to take between 12 and 18 months. The envisaged layout of the wharf is shown in **Figure 5.2**.

15.7.4 The distance from the quay wall to the centre of the channel would be set to minimise the volume of capital dredging (i.e. as close as possible to the channel) and provide a safe clearance between a berthed vessel and other vessels passing along the channel. The quay wall would be about 50 m from the centre of the channel (40 m from the western edge of the channel).

15.7.5 Elements of wharf construction that could potentially influence marine sediment and water quality are:

- 1st Phase Dredging - excavation of slope for the revetment;
- 2nd Phase Dredging - capital dredging in front of the quay wall to create berthing areas.

15.7.6 The 1st Phase Dredging of the slope for the revetment would be completed using land-based equipment. Long-arm hydraulic excavators (and/or suitable cranes equipped with a grab) would sit on top of the flood defence and excavate the slope. The dredged sediment would be recovered or disposed on land.

15.7.7 This method of excavation for the revetment slope, would not impact on marine water quality. This is because none of the sediment that is dredged (75,000m^3) can enter the water column as suspended load.

15.7.8 The 2nd Phase capital dredging of the berthing areas in front of the quay wall has the potential to temporarily increase suspended sediment concentrations. Where possible, the capital dredge would be completed from land, with equipment sitting on the suspended deck. However, the 40 m distance from the quay wall to the subtidal channel means that it would be necessary to use floating plant for part of the excavation.

15.7.9 The dredged sediment would comprise of a mix of recent intertidal mud, older Holocene mud with possible peat layers and diamicton. The boundaries between these three units in the berthing areas is difficult to establish, and so the volumes of the different units that would be dredged are also difficult to quantify.

15.7.10 The distinction between the volumes of recent, Holocene and Pleistocene sediment is important because during the dredging process the recent sediment is more likely to break down into its constituent particles (and be suspended), whereas the Holocene and Pleistocene sediments are more likely to remain as aggregated clasts of mud. If these clasts were released into the water column, they would fall rapidly to the estuary bed (in less than a minute), rather than being disaggregated into their individual fine-grained sediment components.

15.7.11 For the worst case scenario for increase in suspended sediment concentrations due to capital dredging, it is assumed that all the sediment that is released into the water column is broken down into its constituent particles.

15.7.12 In relation to the potential for concrete pouring, the worst case is considered to where in-situ pouring is required. This carries with the most risk in relation to the potential for contamination of the marine environment. It is anticipated that there would be a mix of using pre-cast concrete and in-situ pouring. Pre-cast formwork will be provided for beams and lower portion of the deck slabs, with approximately 150 to 200mm in-situ topping (overall deck thickness will be around 400mm). There will also be some in-situ concrete pouring to cast the piles into the reinforced concrete beams.

15.7.13 There would be no surface water discharges during the construction and therefore this potential effect is not considered further in this chapter.

Habitat Mitigation Area Construction

15.7.14 To mitigate the loss of roosting and foraging areas for waders, works will be completed southeast of the wharf (in advance of its construction) (**Chapter 17 Marine and Coastal Ecology**). All works would be undertaken in the dry (i.e. avoiding high water) and such works would include:

- creation of up to 4 shallow pools (maximum 15 cm deep) in the existing saltmarsh habitat;
- re-profiling the edges of existing pools and banks, including flattening and removal of the old bank in front of parts of the saltmarsh; and
- increasing the volume and height of the line of rocks in the upper intertidal part of the mitigation area by relocating rocks near the wharf to their landward side.

15.7.15 Construction activities to create these features would be relatively minor. Plant and equipment would be limited to a long-reach excavator potentially delivered to the site on a floating barge and a small workforce using hand tools. The works are unlikely to take longer than a week (weather and tide dependent).

15.7.16 Due to the works being undertaken in the dry, extremely limited sediment remobilisation will occur (to a small part of the unconsolidated sediment disturbed by the construction activities as the tide rises). Therefore, the worst case scenario for increase in suspended sediment concentrations is considered to be for the wharf capital dredging as described above.

Wharf Operation

15.7.17 During the operation of the wharf, the only potential impact on marine sediment and water quality is related to the requirement for maintenance dredging to keep the berthing areas navigable and any surface water discharges. This could impact on suspended sediments concentrations within the water column.

15.7.18 To inform maintenance dredging requirements, **Chapter 16 Estuarine Processes** uses estimated siltation rates of 0.5 m/year (50 cm/year). Using this as a baseline sedimentation rate in the berthing areas over an area of 16,000 m^2 (dredged footprint of the berthing areas; 400 m long by 40 m wide) would lead to accumulation of mud of approximately 8,000 m^3/year. All material would be lifted directly onto the wharf and any resulting run-off will be collected and transferred to a holding tank prior to use in the aggregate facility.

15.7.19 It is assumed that surface water discharge from the part of the Facility that is to the east of Sea (Roman) Bank will be required. This discharge will require an environmental permit to control any potential pollution incidents and to manage the condition and composition of the discharge to ensure that there is no unacceptable risk to the environment. This issue is discussed further in **Chapter 13 Surface Water, Flood Risk and Drainage Strategy**.

<u>Habitat Mitigation Area Operation</u>

15.7.20 Maintenance of the scrapes may be required during the operational phase; however, this would be minimal and infrequent. The worst case scenario for increase in suspended sediment concentrations is therefore considered to be for the wharf maintenance dredging as described above.

<u>Wharf Decommissioning</u>

15.7.21 The Facility would be designed to operate for a period of at least 25 years, after which ongoing operation would be reviewed and if it is not appropriate to continue operation, the plant would be decommissioned. The wharf structure is proposed to be constructed to replace a section of the current primary flood defence bank. Hence, it will form a permanent structure that is not anticipated to be decommissioned. Therefore, decommissioning impacts are not covered in this assessment because the management of the wharf beyond the life of the Facility would be negotiated and discussed in a Decommissioning Plan.

15.7.22 Should decommissioning occur in the future, the effects have been assessed as not being any worse than for construction.

<u>Design Parameters that potentially influence marine sediment and water quality</u>

15.7.23 For this chapter, only those design parameters with the potential to influence the level of impact to relevant receptors are identified. Therefore, if the design parameter is not described below in **Table 15-15**, it is not considered to have a material bearing on the outcome of this assessment.

Table 15-15 Worst Case Assumptions

Impact	Design Parameter
Construction	
Impact 1: Impacts on suspended sediment concentrations due to capital dredging of the berth	Water Quality - Physico-chemical parameters (suspended solid concentrations) Worst case equates to maximum volume of dredging to be removed and assumes all material breaks down into component parts.
Impact 2: Impacts on water quality (contaminants) due to capital dredging of the berth	Water Quality - Chemical parameters (contaminants) Worst case equates to maximum volume of dredging to be removed.
Impact 3: Impacts on water quality due to pouring of concrete in situ	Water quality – Physico-chemical parameters (pH) Worst case equates to pouring concrete in situ
Operation	
Impact 1: Impacts on suspended sediment concentrations due to maintenance dredging	Water Quality - Physico-chemical parameters (suspended solid concentrations) Worst case equates to maximum volume of dredging to be removed and assumes all material breaks down into component parts.
Decommissioning	
No significant adverse impacts are anticipated.	-

Potential Impacts during Construction

<u>Impact 1 - Impacts on suspended solids concentrations due to capital dredging</u>

<u>Magnitude of impact</u>

15.7.24 To allow access for vessels to the berths, capital dredging of approximately 150,000 m^3 of sediment from the intertidal area in front of the quay wall would be undertaken. There is the potential for the dredging activities to disturb sediment resulting in localised and short-term increases in suspended sediment concentrations as dredging progresses for up to a maximum of 18 months. The dredging method would be excavators operating from both the land and marine sides of the dredging area. The worst case scenario assumes that sediment would be dredged and then disposed or recovered on land in accordance with the waste hierarchy (**Chapter 23 Waste**).

15.7.25 Sediment would be released into the water column in two ways:

- the action of the excavator on the estuary bed would disturb the bed sediments and lift them into the water; and

- a small volume of the dredged sediment would be lost from the excavator during the dredging process and enter the water.

15.7.26 The potential for changes to suspended solids concentrations is assessed in **Chapter 16 Estuarine Processes**. To summarise, the chapter concludes that a small volume of the dredged sediment would be lost from the excavator during the dredging process and enter the water column. As a result, a plume would be created, which would be dispersed by tidal currents (and waves) away from the dredging site, either up-estuary on the flood tide or down-estuary on the ebb tide. Any sand particles would fall rapidly (within minutes) to the estuary bed immediately upon its discharge (within a few tens of metres along the axis of tidal flow).

15.7.27 Due to the small volume of sediment released and the predominantly fine size of the particles (very fine sand, silt and clay), the plume is likely to be rapidly dispersed. The plume would contain measurable but modest suspended sediment concentrations (likely to be less than 100 mg/l close to the excavator reducing to less than tens of mg/l within a few 100 m of the excavator). These suspended sediment concentrations are much lower than the natural variability in The Haven (134 mg/l to 1,790 mg/l) and would be indistinguishable from background levels. As a result, the magnitude of the impact is considered to be **low.**

Sensitivity of receptor

15.7.28 The sensitivity of the receptor is considered to be **medium** given the current overall status of bad. Additionally, the relatively small cross-sectional area will limit the ability of the water body to readily dilute any impacts on water quality parameters.

Significance of effect

15.7.29 The significance of effect is therefore **minor adverse**. Given that only **minor adverse** effects are predicted in the near vicinity of the Facility, significant effects further downstream are not anticipated.

Mitigation Measures

15.7.30 No further mitigation measures are considered necessary.

Residual Effects

15.7.31 The residual effect is therefore **minor adverse**.

Impact 2 - Impacts on water quality as a result of releasing contamination during dredging

Magnitude of impact

15.7.32 While baseline information from sediments in and around the site indicate that the sediments to be dredged are likely to contain some contamination, the reduced risk of resuspending sediment by the dredging methodology as outlined in Construction Impact 1 reduces the risk of any sediment bound contamination being released as releases of sediment will be reduced as far as possible.

15.7.33 In relation to PAHs, the compounds have a low water solubility and hydrophobic nature therefore they tend to be associated with organic material within sediments and therefore remain bound. Additionally, the short term nature of the dredging and the small scale of the plume predicted indicate that the potential for water quality effects would be localised to the dredging area and would not alter baseline concentrations in The Haven over the long term. The magnitude of the impact is therefore considered to be **negligible**.

Sensitivity of receptor

15.7.34 The sensitivity of the receptor is considered to be **medium** given the current overall status of bad and elevated levels of contaminants in the water quality. Additionally, the relatively small cross-sectional area will limit the ability of the water body to readily dilute any impacts on water quality parameters.

Significance of effect

15.7.35 The significance of effect is therefore minor adverse. Given that only **minor adverse** impacts are predicted, effects further downstream are not anticipated.

Mitigation Measures

15.7.36 No further mitigation measures are considered necessary.

Residual Effects

15.7.37 The residual effect is therefore **minor adverse**.

Impact 3 - Impacts on water quality as a result of pouring concrete in situ

Magnitude of impact

15.7.38 A solid, stable base is required for construction which is assumed to be stable slab cast in place using formers. There may also be some foundations required for trestles as per other foundations on site. However, none of these activities will be located near to the marine environment or any other water body which could indirectly impact on the marine environment.

15.7.39 It is anticipated that there would be a mix of using pre-cast concrete and in-situ pouring. Pre-cast formwork will be provided for beams and lower portion of the deck slabs, with approximately 150 to 200 mm in-situ topping (overall deck thickness will be around 400 mm). There will also be some in-situ concrete pouring to cast the piles into the reinforced concrete beams.

Mitigation Measures

15.7.40 Temporary Works Risk Assessments will be carried out alongside Temporary Works Method Statements to reduce any accidental risk to the environment in general. All wash down of mixers and forms will take place away from site in designated wash down areas which will be bunded to prevent leaks. No further mitigation measures are identified.

Residual Effects

15.7.41 There are no residual effects anticipated.

Potential Impacts during Operation

Impact 1 - Impacts on suspended solid concentrations and chemical contaminants associated with maintenance dredging

Magnitude of impact

15.7.42 The berthing areas would potentially create a sink for deposition of fine sediment, and they may require maintenance dredging to maintain depth during the operational phase. This material would have recently been deposited and therefore significant contamination is not anticipated.

15.7.43 The method of dredging would be using excavators (cf. the capital dredge) from the land side of the wharf. Loss of sediment from the excavator would be less than the capital dredge given the reduced amount to be dredged, and hence the magnitude would be lower i.e. **negligible**.

Sensitivity of receptor

15.7.44 The sensitivity of the receptor is considered to be **medium** given the WFD water body's current overall status of bad. Additionally, the relatively small cross-sectional area will limit the ability of the water body to readily dilute any impacts on water quality parameters.

Significance of effect

15.7.45 The significance of effect is therefore **minor adverse**. Given that only **minor adverse** impacts are predicted, effects further downstream are not anticipated.

Mitigation Measures

15.7.46 No further mitigation measures are required.

Residual Effects

15.7.47 The residual effect is **minor adverse**.

15.8 Cumulative Impacts

15.8.1 **Table 15-16** presents projects that are likely to have cumulative impacts when considered alongside the Facility. A wider list of potential cumulative developments is available for consideration in other technical chapters of this ES. However, the only relevant developments that have potential to cumulatively impact on marine water and sediment quality are those that will directly affect the river. Hence, **Table 15-16** only considers directly relevant schemes.

15.8.2 Given the location of the Boston Tidal Barrier upstream of the Facility, cumulative effects may result from simultaneous dredging, either during capital and/or maintenance dredging at the two sites. The two impacts that could potentially give rise to a cumulative impact are therefore sediment plumes and any associated sediment contamination.

15.8.3 A summary of the potential cumulative impacts with the Boston Tidal Barrier is set out in **Table 15-16** below. However, it is noted that due to the consenting programme for the Facility compared to the construction programme for the Boston Barrier, it is likely that the Barrier will be completed before consent is granted for the Facility and therefore what is presented is a worst case scenario.

Table 15-16 Projects in the Vicinity of the Application Site with the Potential to have Cumulative Impacts

Project	Status	Development Period	Distance from the Application Site (km)	Project Definition	Project Data Status	Included in CIA	Rationale
Boston Barrier Flood Defence	Transport and Works Act Order consented	2017 – ongoing (completed August 2021)	Boston Barrier at closest point to the Application Site is 500 m.	Environmental Statement	Complete / high	Yes	There may be the potential for cumulative impacts if the maintenance dredging programme for the Boston Barrier overlaps with the Facility's capital dredging programme

Table 15-17 Potential Cumulative Impacts

Impact	Potential for cumulative impact	Data confidence	Rationale
Construction Impact 1: Changes in suspended solid concentrations due to capital dredging	Yes	High	When capital dredging is undertaken for the Facility and the Boston Tidal Barrier, plumes could overlap
Construction Impact 2: Changes in water quality (contaminants) due to capital dredging	Yes	High	When capital dredging is undertaken for the Facility and the Boston Tidal Barrier, plumes could overlap
Decommissioning	None anticipated		

15.8.4 The impacts of the capital dredging activities on the identified receptors were identified to be of **minor adverse** for the Facility alone both for impacts on suspended solids concentrations and impacts on water quality (contaminants).

15.8.5 The construction programmes of the Facility and the Boston Tidal Barrier are not anticipated to overlap. However, as a worst case it is assumed, they could overlap if there are delays to the final construction programme for the Barrier and so there is potential for cumulative impacts. The worst case scenario from a marine sediment and water quality perspective would be for both to be capital dredged at the same time. This would provide the greatest opportunity for interaction of sediment plumes during their construction. The combined change in suspended sediment concentrations could therefore have a greater spatial extent and persist for longer than each individual project.

15.8.6 The EIA for the Boston Tidal Barrier concluded that the impact of increased suspended sediment concentrations would be **negligible**. Given this conclusion a similar conclusion can be reached for simultaneous maintenance dredging operations, where the release of suspended sediment would be lower in volume and with likely lower concentrations of contaminants given the material would have recently settled. Overall, the risk of the two projects occurring cumulatively is the same as that for the Facility alone, i.e. **minor adverse**.

15.9 Inter-Relationships with Other Topics

15.9.1 The range of effects on estuarine processes of the Facility not only has the potential to directly affect marine sediment and water quality but may also manifest as impacts upon receptors other than those considered within the context of estuarine processes. The assessments of significance of these impacts on other receptors are provided in the chapters listed in **Table 15-18**. This chapter has inter-relationships with **Chapter 17 Marine and Coastal Ecology**.

Table 15-18 Chapter Topic Inter-Relationships

Topic and description	Related Chapter	Where addressed in this Chapter
Effects on water quality (suspended sediments and contamination)	**Chapter 17 Marine and Coastal Ecology**	**Section 15.7.**

15.9.2 These inter-relationships are included because receptors of changes to suspended solid concentrations and contamination levels in the water are fish, marine mammals and marine ecology.

15.10 Interactions

15.10.1 The impacts identified and assessed in this chapter have the potential to interact with each other, which could give rise to synergistic impacts because of that interaction. The worst case impacts assessed within the chapter take these interactions into account and for the impact assessments are considered conservative and robust. For clarity, the areas of interaction between impacts are presented in **Table 15-19**, along with an indication as to whether the interaction may give rise to synergistic impacts. There are no potential for synergistic impacts in the operational phase as there is only one potential impact on water quality associated with dredging.

Table 15-19 Interaction Between Impacts

Potential interaction between impacts			
Construction			
	1. Impacts on suspended solids concentrations due to capital dredging	**2. Impacts on water quality (contamination) concentrations due to capital dredging**	**3. Impacts on water quality associated with use of concrete**
1. Impacts on suspended solids concentrations due to capital dredging	-	No	No
2. Impacts on water quality (contamination) concentrations due to capital dredging	No	-	No

Potential interaction between impacts			
Construction			
3. Impacts on water quality associated with use of concrete	No	Yes	-
Decommissioning			
No impacts on marine water and sediment quality are anticipated during the decommissioning phase.			

15.11 Summary

15.11.1 The assessment of the construction, operational and decommissioning phases of the proposed Facility could cause a range of effects on marine sediment and water quality. The magnitude of these effects has been assessed using expert assessment. In all cases, the effects that have been assessed resulted in impacts of **minor adverse** significance. A summary of impacts to these receptors are listed in **Table 15-20**.

Table 15-20 Impact Assessment Summary

Potential Impact	Receptor	Value/ Sensitivity	Magnitude	Significance	Mitigation	Residual Effects
Construction						
Impact 1: Impacts on suspended solids concentrations associated with capital dredging	Water Quality	Medium	Low	Minor Adverse	None required	Minor Adverse
Impact 2: Impacts on water quality associated with release of sediment contamination	Water Quality	Medium	Negligible	Minor Adverse	None required	Minor Adverse
Impact 3: Impacts on water quality associated with using concrete in the marine environment	Water Quality	Medium	Negligible			
Operation						
Impact 1: Impacts on suspended solids concentrations and chemical contaminants associated with maintenance dredging	Water Quality	Medium	Negligible	Minor Adverse	None required	Minor Adverse
Decommissioning						
No impacts on marine water and sediment quality are anticipated during the decommissioning phase.						

15.12 References

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