# East Anglia ONE North Offshore Windfarm

# Chapter 8

## Marine Water and Sediment Quality

### Environmental Statement
### Volume 1

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# Glossary of Acronyms

| | |
|---|---|
| Cefas | Centre for Environment, Fisheries and Aquaculture Science |
| CIA | Cumulative Impact Assessment |
| CSEMP | Clean Seas Environmental Monitoring Programme: Metals |
| DBT | Dibutyl |
| DECC | Department of Energy and Climate Change |
| DCO | Development Consent Order |
| DIN | Dissolved Inorganic Nitrogen |
| EAOW | East Anglia Offshore Wind |
| EC | European Commission |
| EIA | Environmental Impact Assessment |
| EPP | Evidence Plan Process |
| EQS | Environmental Quality Standards |
| ES | Environmental Statement |
| ETG | Expert Topic Group |
| EU | European Union |
| HDD | Horizontal Direct Drilling |
| HM | Her Majesty's |
| IPC | Infrastructure Planning Commission |
| IPMP | In Principle Monitoring Plan |
| LAT | Lowest Astronomical Tide |
| MARPOL | International Convention for the Prevention of Pollution from Ships |
| MMO | Marine Management Organisation |
| MPCP | Marine Pollution Contingency Plan |
| MPS | Marine Policy Statement |
| MSFD | Marine Strategy Framework Directive |
| MWSQ | Marine Water and Sediment Quality |
| NERC | Natural Environment Research Council |
| NPS | National Policy Statement |
| NNMP | National Marine Monitoring Programme |
| NSIP | Nationally Significant Infrastructure Project |
| oOOMP | Outline Offshore Operations and Maintenance Plan |
| PCB | Polychlorinated Biphenyl |
| PAH | Polycyclic aromatic Hydrocarbons |
| PEIR | Preliminary Environmental Information Report |
| PEL | Probable Effects Level |
| PEMP | Project Environmental Management Plan |
| PID | Public Information Days |
| PSA | Particle Size Analysis |
| RBMP | River Basin Management Plan |
| SoS | Secretary of State |
| SPR | Scottish Power Renewables |
| SSC | Suspended Sediment Concentrations |
| TBT | Tributyl |
| TEL | Threshold Effect Levels |
| THC | Total Hydrocarbons |
| TOC | Total Organic Carbon |
| WFD | Water Framework Directive |
| ZEA | Zonal Environmental Appraisal |

# Glossary of Terminology

| | |
|---|---|
| The Applicant | East Anglia ONE North Limited |
| Construction, operation and maintenance platform | A fixed offshore structure required for construction, operation and maintenance personnel and activities. |
| East Anglia ONE North project | The proposed project consisting of up to 67 wind turbines, up to four offshore electrical platforms, up to one construction, operation and maintenance platform, inter-array cables, platform link cables, up to one operational meteorological mast, up to two offshore export cables, fibre optic cables, landfall infrastructure, onshore cables and ducts, onshore substation, and National Grid infrastructure. |
| East Anglia ONE North windfarm site | The offshore area within which wind turbines and offshore platforms will be located. |
| Evidence Plan Process | A voluntary consultation process with specialist stakeholders to agree the approach to the EIA and the information required to support HRA. |
| Horizontal directional drilling (HDD) | A method of cable installation where the cable is drilled beneath a feature without the need for trenching. |
| Inter-array cables | Offshore cables which link the wind turbines to each other and the offshore electrical platforms, these cables will also include fibre optic cables. |
| Landfall | The area (from Mean Low Water Springs) where the offshore export cables would make contact with land, and connect to the onshore cables. |
| Meteorological mast | An offshore structure which contains metrological instruments used for wind data acquisition. |
| Offshore cable corridor | This is the area which will contain the offshore export cables between offshore electrical platforms and landfall. |
| Offshore electrical platform | A fixed structure located within the windfarm area, containing electrical equipment to aggregate the power from the wind turbine and convert it into a more suitable form for export to shore. |
| Offshore development area | The East Anglia One North windfarm site and offshore cable corridor (up to Mean High Water Springs). |
| Offshore export cables | The cables which would bring electricity from the offshore electrical platforms to the landfall. These cables will also include fibre optic cables. |
| Offshore platform | A collective term for the construction, operation and maintenance platform and the offshore electrical platforms. |
| Platform link cable | Electrical cable which links one or more offshore platforms, these cables will include fibre optic cables. |
| Safety zones | A marine area declared for the purposes of safety around a renewable energy installation or works / construction area under the Energy Act 2004. |
| Scour protection | Protective materials to avoid sediment being eroded away from the base of the foundations as a result of the flow of water. |

# 8 Marine Water and Sediment Quality

## 8.1 Introduction

1. This chapter of the Environmental Statement (ES) describes the existing environment with regard to marine water and sediment quality (MWSQ) and assesses the potential impacts of the proposed East Anglia ONE North project during the construction, operation and decommissioning phases. Where the potential for significant impacts is identified, mitigation measures are presented.

2. Certain elements of the assessment are informed by ***Chapter 7 Marine Geology, Oceanography and Physical Processes*** and in turn this assessment informs ***Chapter 10 Benthic Ecology*** and ***Chapter 11 Fish and Shellfish Ecology***. Related onshore issues are considered in ***Chapter 18 Ground Conditions and Contamination*** and ***Chapter 20 Water Resources and Flood Risk***.

3. This chapter of the ES has been written by Royal HaskoningDHV. The assessment of potential impacts on MWSQ has been made with specific reference to the relevant legislation and guidance (as presented in ***section 8.4.1***) of which the primary source are the National Policy Statements (NPS).

## 8.2 Consultation

4. Consultation is a key feature of the Environmental Impact Assessment (EIA) process, and continues throughout the lifecycle of a project, from its initial stages through to consent and post-consent.

5. To date, consultation with regards to MWSQ has been undertaken via the Evidence Plan Process (EPP) and related Expert Topic Group (ETG), described within ***Chapter 5 EIA Methodology*** with meetings held in April 2017, March 2018 and June 2019, through the East Anglia One North Scoping Report (ScottishPower Renewables (SPR) 2017) and the Preliminary Environmental Information Report (PEIR) (SPR 2019). Feedback received through this process has been considered in preparing the ES where appropriate and this chapter has been updated for the final assessment submitted with the Development Consent Order (DCO) application.

6. The responses received from stakeholders with regards to the Scoping Report, PEIR, as well as feedback to data from the ETGs, are summarised in ***Appendix 8.1***, including details of how these have been taken account of within this chapter.

7. Consultation specific to Benthic Ecology, Fish and Shellfish Ecology, Marine Mammals and Commercial Fisheries are provided in ***Chapter 9 Benthic Ecology***, ***Chapter 10 Fish and Shellfish Ecology, Chapter 11 Marine Mammals*** and ***Chapter 13 Commercial Fisheries***, respectively.

8. Ongoing public consultation has been conducted in a series of Public Information Days (PIDs) and Public Meetings. PIDS have been held throughout Suffolk in November 2017, March / April 2018, June / July 2018 and February / March 2019.

9. Consultation phases are explained further in ***Chapter 5 EIA Methodology***. Full details of the proposed East Anglia One North project consultation process are presented in the Consultation Report (document reference 5.1) which has been submitted as part of the DCO application. No issues with regards to MWSQ were raised by community consultees during any of the PIDS.

## 8.3 Scope

### 8.3.1 Study Area

10. The MWSQ assessment for the proposed East Anglia ONE North project has, where appropriate, been divided into two study areas (***Figure 8.1***):

- The East Anglia ONE North windfarm site; the windfarm itself, including the foundations, offshore platform foundations and inter-array and platform link cable routes; and
- The offshore cable corridor.

11. Within this chapter, these study areas are also placed within the context of the former East Anglia Zone and wider southern North Sea. The East Anglia ONE North windfarm site and the offshore cable corridor (including the landfall location) are shown in context within the former East Anglia Zone in ***Figure 9.2*** of ***Chapter 9 Benthic Ecology***.

12. This assessment also considers impacts outside the former East Anglia Zone and the wider southern North Sea, due to the potential for impacts on the marine environment to be far reaching.

### 8.3.2 Worst Case

13. The design of the proposed East Anglia ONE North project (including number of wind turbines, layout configuration, requirement for scour protection, electrical design, etc.) is not yet fully determined, and may not be known until sometime after the DCO has been granted. Therefore, in accordance with the requirements of the Project Design Envelope (also known as the Rochdale Envelope) approach to EIA (Planning Inspectorate 2018) (as discussed in ***Chapter 5 EIA Methodology***), realistic worst case scenarios in terms of potential effects upon marine water and sediment quality are adopted to undertake a precautionary and robust impact assessment.

14. Definition of the realistic worst case scenario has been made from consideration of the proposed East Anglia ONE North project that is presented in ***Chapter 6***

***Project Description***, alongside the mitigation measures that have been embedded in the design (***section 8.3.3***).

15. ***Table 8.1*** summarises the parameters for each impact for MWSQ.

**Table 8.1 Realistic Worst Case Scenarios**

| Impact | Parameter | Rationale |
|---|---|---|
| **Construction** | | |
| Impact 1A: Deterioration in offshore water quality due to increased suspended sediment concentrations (SSCs) due to sediment plume created by sea bed preparation including sand wave levelling during installation of foundations. | The worst case scenario would involve the maximum amount of sediment disturbance through preparation of the sea bed.<br><br><u>Sea bed preparation</u><br><br>67 x 250m wind turbine four-legged jacket suction caisson foundations 23,731.88m$^3$ per wind turbine totalling 1,590,035.63m$^3$.<br><br>Installation of eight-legged jacket suction caisson foundations for up to four offshore electrical and one construction, operation and maintenance platform would result in a maximum sediment release into the water column of 668,800m$^3$.<br><br>Installation of a four-legged jacket suction caisson foundation for one meteorological mast. Therefore, the maximum possible amount of sediment released into the water column would be up to 23,731.88m$^3$.<br><br>Total suspended sediment volume =<br><br>**2,282,567.51m$^3$** | Sea bed preparation (dredging using a trailer suction hopper dredger and levelling layer) may be required up to a sediment depth of 5m. The worst case considers the maximum volumes for the project.<br><br>The worst case would be defined by 67 x 250m wind turbines mounted on four-legged jacket suction caisson foundations.<br><br>The meteorological mast would be installed on foundations which, in the worst case for sediment disturbance, would be four-legged jacket suction caisson foundations. As a worst case, the figure for sea bed preparation for a 250m four-legged jacket on suction caissons has been used and is considered conservative.<br><br>The worst case with regard to sediment disturbance during installation of offshore platform foundations (including four electrical and one construction, operation and maintenance) would be from installation of eight-legged jacket suction caissons which would require the excavation of up to 668,800m$^3$. |

| Impact | Parameter | Rationale |
|---|---|---|
| Impact 1B: Deterioration in offshore water quality due to increased SSCs due to drill arisings for installation of piled foundations. | Wind turbine foundations based on worst case volume associated with 10% of 53 x 300m wind turbines (45m depth 15m diameter) = 42,146.43m$^3$<br>Meteorological mast – 7,952.16m$^3$ (based on a 300m monopile wind turbine foundation)<br>Offshore electrical and construction, operation and maintenance platforms – 43,209.46m$^3$<br>Total = **93,308m$^3$.** | Sub-surface sediments have a different physical composition to near-surface sediments and may therefore be more widely dispersed by tidal currents. However, the volumes involved are far smaller than sea bed preparation for jacket on suction caisson foundations (***Chapter 7 Marine Geology, Oceanography and Physical Processes***) and therefore it is considered that installation of jacket on suction caisson foundations is the worst case scenario for re-suspension of sediments.<br>It should be noted that sea bed preparation is less likely to be required for piled foundations and, if required, would be significantly less than described above. Therefore, the volume of drill arisings and sea bed preparation outlined above are not aggregated. |
| Impact 2: Deterioration in water quality due to increased SSCs during installation of the offshore export cable including sand wave levelling. | Jetting is considered to be the worst case cable installation technique since it results in the largest volume of suspended sediment off the sea bed and into the water column.<br>The worst case is as set out in ***Chapter 7 Marine Geology, Oceanography and Physical Processes*** and would be associated with up to 152km of export cable (72km per cable). | The worst case scenario for the suspension of sediment during the cable installation process would be to install all electrical cables using jetting techniques. Other techniques are being considered (***Chapter 6 Project Description***, ***section 6.5.10.15***) and in reality, if jetting was used, it would only be used for a small proportion of the cable routes. |

| Impact | Parameter | Rationale |
|---|---|---|
| | The sediment removed as a result of sand wave levelling activity in the offshore cable corridor would equate to approximately 1,000,000m$^3$.<br><br>There may also be a requirement for dredging along the export cable route, e.g. around the HDD punch-out location during the installation of export cables. Based on East Anglia ONE values, although with adequate redundancy built in, it is assumed that up to 2.5% (1.9km) of each cable corridor will require dredging to a max width of 8.6m and a depth of 4m. Based on a v-shaped trench cross section the worst case volume of sediment would therefore = **68,800m$^3$** for both export cables. | |
| Impact 3: Deterioration in offshore water quality due to increased SSCs during inter-array and platform link cable installation including sand wave levelling. | Jetting is considered to be the worst case cable installation technique since it results in the largest volume of suspended sediment off the sea bed and into the water column.<br><br>Sand wave levelling:<br><br>• Inter-array cables = 400,000m$^3$<br>• Platform link cables = 150,000m$^3$<br><br>The worst case is as set out in ***Chapter 7 Marine Geology, Oceanography and Physical Processes*** and would be associated with up to 200km of inter-array and 75km of platform link cable. | |

| Impact | Parameter | Rationale |
|---|---|---|
| Impact 4: Deterioration in water and bathing water quality due to works at the offshore export cable landfall. | The offshore export cable would make landfall just north of Thorpeness. Horizontal Directional Drilling (HDD) techniques would be used to install the export cable at the landfall, ensuring no impacts on the intertidal zone. Although the achievable length of HDD would be affected by limitations of cable characteristics and the drill profile (i.e. the angle of the bore), the maximum length would be 2km.<br><br>There may also be a requirement for dredging along the export cable route, e.g. around the HDD punch-out location during the installation of export cables. Based on East Anglia ONE values, although with adequate redundancy built in, it is assumed that up to 2.5% (2km) of each cable corridor will require dredging to a max width of 8.6m and a depth of 4m. Based on a v-shaped trench cross section the worst case volume of sediment would therefore = 68,800m$^3$ for both export cables. | The worst case scenario for installation of the offshore export cable landfall would involve the maximum sediment disturbance and undertaking of works within the marine environment. |
| Impact 5: Deterioration in water quality (offshore and coastal) due to re-suspension of sediment bound contaminants. | The worst case scenario relates to activities that involve the most re-suspension of sediment as set out above. | See above calculations for realistic worst case volumes of suspended sediment affected. |
| **Operation** | | |
| Impact 1: Deterioration in offshore water quality due to increased SSCs due to scour around foundation structures. | Jackets with suction caissons (67 x 250m), reduced by a factor of five (the volume of sediment affected from scour) = 5,000m$^3$ per wind turbine = **335,000m$^3$** | Previous scour assessments showed that the maximum volumes of sediment likely to be released from sea bed preparation are considerably greater (greater than five times) |

| Impact | Parameter | Rationale |
|---|---|---|
| | | than the maximum volumes likely to be released by scour, even under the conservative worst case scour scenarios considered. Due to this, the assessment of scour during the operational phase (in the absence of scour protection) has been based on the findings from the assessments of the effect of sea bed preparation (***Chapter 7 Marine Geology, Oceanography and Physical Processes).*** |
| Impact 2: Deterioration in water quality (offshore and coastal) due to re-suspension of sediment bound contaminants as a result of scour | As for operational impact 1. | As for operational impact 1. |
| **Decommissioning** | | |
| Impact 1: Deterioration in water quality due to increased SSCs during removal of accessible installed components. | The worst case scenario would include removal of all foundation infrastructure above sea bed level and removal of unburied cables, and inter-array cables in the vicinity of wind turbines. Scour and cable protection would be left *in situ*. | The worst case scenario for increased SSCs during decommissioning is for all accessible infrastructure to be removed as this would disturb the largest amount of sediment. |

#### 8.3.2.1 Fronded Mattresses Scour Protection

16. The potential for adverse water and sediment quality impacts due to the use of plastic fronded mattresses as scour protection was raised as a potential issue by the MMO who recommended avoiding their use as far as possible (see ***Appendix 8.1***). Fronded mattresses have been included in the project design envelope on the basis that they are anticipated to reduce the overall volume of scour protection, where it is required.

17. The potential impact of plastic degradation on the marine environment has not been assessed because the specification to which the plastic material is produced ensures it does not degrade within marine environments and has an extremely high tensile strength (i.e. it has to be cut, it does not break or tear under reasonable force (SPR 2019a)).

18. The mattresses are being trialled at East Anglia ONE which will establish a knowledge base which can be used at post-consent for East Anglia ONE North. The frond mats will be weighed prior to installation and results made available for break tests. Upon recovery, the mats will be visually inspected and re-weighed, using the same test equipment to allow a direct comparison of before and after results.

19. The use of fronded mattresses will be decided post-consent based on the monitoring commitment above. This will be confirmed through the Construction Method Statement, to be provided pre construction for approval by the MMO as secured under the requirements of the draft DCO.

### 8.3.3 Best Practice and Mitigation

20. Throughout the proposed East Anglia ONE North project, best practice techniques and due diligence regarding the potential for pollution throughout all construction, operation and maintenance, and decommissioning activities will be followed. As a result, a Project Environmental Management Plan (PEMP) will be produced as secured under the requirements of the draft DCO. Moreover, a high level description of the reasonably foreseeable offshore maintenance activities, a number of which are relevant to marine water and sediment quality, and the broad approach to be taken for each activity is provided in the outline Offshore Operations and Maintenance Plan (oOOMP) (document reference 8.12). The following mitigation and best practice measures are relevant to marine water and sediment quality:

    - Oils and lubricants used in the wind turbines would be biodegradable where possible and all chemicals would be certified to the relevant standard.
    - As far as possible, offshore platforms would be transported to site having been pre-assembled or manufactured on land.

- Where grout is required, careful use to avoid excess being discharged to the environment would be ensured at all times.
- All wind turbines would incorporate appropriate provisions to retain spilled fluids within the nacelle and tower. In addition, converter and collector stations would be designed with a self-contained bund to contain any spills and prevent discharges to the environment.
- Best practice procedures would be put in place when transferring oil or fuel between converter or collector stations and service vessels.
- Appropriate spill plan procedures would also be implemented in order to appropriately manage any unexpected discharge into the marine environment, these would be included in a Marine Pollution Contingency Plan (MPCP) to be agreed post-consent. To avoid discharge or spillage of oils it is anticipated that the transformers would be filled for their operational life and would not need interim oil changes.
- Inclusion of control measures such as the requirement to carry spill kits and the requirement for vessel personnel to undergo training to ensure requirements of the PEMP and MPCP are understood and communicated; and
- All work practices and vessels 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.
- External surface preparation and external protective coating repair (including painting) will be carried out in accordance with a COSHH assessment, MARPOL and the PEMP. This will include, (but will not be limited to) appropriate storage so that water ingress and dust is minimised thereby limiting the potential for uncontrolled discharge to the marine environment topside. All waste (packaging and residual dust) will be removed and managed in accordance with the PEMP.

21. Consideration of the potential for pollutants to be released into the environment is therefore not considered further in this chapter.

### 8.3.4 Monitoring

22. Post-consent, the final detailed design of the proposed East Anglia ONE North project and the development of the relevant Management Plan will refine the worst-case parameters assessed in this ES. It is recognised that monitoring is an important element in the management and verification of the actual proposed East Anglia ONE North project impacts.

23. As stated in the In Principle Monitoring Plan (IPMP) (document reference 8.13), no monitoring is currently planned for MWSQ, subject to agreement with the MMO and relevant SNCBs.

24. The PEMP (to be submitted post consent) will be relevant to MWSQ and set out the Applicant's intentions for MWSQ monitoring and management. The requirement for and final design and scope of monitoring will be agreed with the MMO and relevant stakeholders and included within the PEMP, submitted for approval, prior to construction works commencing.

## 8.4 Assessment Methodology

### 8.4.1 Guidance

25. The assessment of potential impacts on MWSQ has been made with specific reference to the relevant NPS. These are the principal decision making documents for Nationally Significant Infrastructure Projects (NSIPs). Those relevant to the proposed East Anglia ONE North 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).

26. ***Table 8.2*** summarises the relevant NPS text and provides references to sections in this ES where each is addressed.

**Table 8.2 NPS Assessment Requirements**

| NPS Requirements | NPS Reference | Section Reference |
|---|---|---|
| "Infrastructure development can have adverse effects on the water environment, including groundwater, inland surface waters, 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''. | EN-1 Paragraph 5.15.1 | This ES Chapter covers the coastal waters with impacts on the water environment assessed in ***section 8.6***. Further assessment of the water environment can be found in ***Chapter 20 Water Resources and Flood Risk***.<br><br>Increased risks of spills and leaks are mitigated through the embedded mitigation set out in ***section 8.3.3***.<br><br>Adverse impacts on other receptors are assessed in topic specific chapters within this ES with the Water Framework Directive (WFD) considered in the WFD Assessment (***Appendix 20.4*** |

| NPS Requirements | NPS Reference | Section Reference |
|---|---|---|
| | | of ***Chapter 20 Water Resources and Flood Risk***) |
| "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 | The adverse effects on the water environment are assessed in ***Chapter 20 Water Resources and Flood Risk*** and for the marine environment in ***section 8.6***.<br>The existing status of waterbodies that might be impacted has been set out in ***section 8.5.1***. |
| "The construction, operation and decommissioning of offshore energy infrastructure can affect marine water quality through the disturbance of sea bed sediments or the release of contaminants with subsequent indirect effects on habitats, biodiversity and fish stocks''. | Paragraph 2.6.189 of EN-3 | Impacts on water quality have been assessed in ***section 8.6*** of this ES chapter.<br>Effects on habitats, biodiversity and fish stocks have been assessed in the relevant ES chapters with ***section 147*** of this chapter providing reference to relevant chapters. |
| "The Environment Agency regulates emissions to land, air and water out to 3 nautical miles (nm). Where any element of the windfarm or any associated development included in the application to the Infrastructure Planning Commission (IPC) [now the Examining Authority and the Secretary of State (SoS)] is located within 3nm of the coast, the Environment Agency should be consulted at the pre-application stage on the assessment methodology for impacts on the physical environment''.<br>"Beyond 3nm, the Marine Management Organisation (MMO) is the regulator. The applicant should consult the MMO and Centre for Environment, Fisheries and Aquaculture Science (Cefas) on the assessment methodology for impacts on the physical environment at the pre-application stage''. | Paragraphs 2.6.191 and 2.6.192 of EN-3 | The Environment Agency, MMO and Cefas have been consulted throughout the planning of this application. Consultation has been included in ***section 8.2*** of this ES chapter. |

27. The principal European and International policy and legislation used to inform the assessment of potential impacts on MWSQ 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 WFD);
- Directive 2008/105/EC Priority Substances establishing Environmental Quality Standards (EQS) for contaminants in water;
- Directive 2008/56/EC establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive (MSFD));
- Directive 2006/7/EC concerning the management of bathing water quality; and
- The MARPOL Convention 73/78.

28. These key European Directives are transposed into UK law through a number of regulations. These have been set out below and are discussed further in ***Chapter 3 Policy and Legislative Context***.

#### 8.4.1.1 Water Framework Directive

29. The WFD provides a legislative framework for the protection of surface waters (including rivers, lakes, transitional waters and coastal waters) and groundwater throughout the European Union (EU). The WFD was transposed into law in England and Wales by the Water Environment (WFD) (England and Wales) Regulations 2003 and most recently revoked and replaced in April 2017 as the Water Environment (WFD) (England and Wales) Regulations 2017.

30. UK surface waters have been divided into a number of discrete units termed 'water bodies', with typologies that relate to both their physical and ecological characteristics. Based on ecology and water quality, these water bodies have then been classified into different status classes which have specific objectives in relation to achieving good ecological status. The WFD seeks to protect and enhance the quality of the following types of water bodies:

- Surface freshwater (including lakes, streams and rivers);
- Groundwater;
- Groundwater dependent ecosystems;
- Estuaries; and
- Coastal waters up to one nautical mile (nm) from mean low water.

31. The WFD applies to all water bodies, including those that are man-made. The consideration of the proposed East Anglia ONE North project under the WFD will, therefore, need to be applied to all water bodies that have the potential to be

impacted. This chapter assesses the impacts on coastal water bodies and the marine environment with impacts on all other water bodies assessed in ***Chapter 20 Water Resources and Flood Risk***.

### 8.4.1.2 Marine Strategy Framework Directive

32. The objective of the Marine Strategy Framework Directive (2005/56/EC) (MSFD) is to achieve "*good environmental status*'' in Europe's seas by 2020, to enable the sustainable use of the marine environment and to safeguard its use for future generations.

33. The MSFD aims to be complementary to and provide the overarching framework for a number of other key Directives and legislation at the European and UK level. These include the Habitats Directive, the Birds Directive, the WFD, the Common Fisheries Policy and the UK Marine and Coastal Access Act.

34. In coastal waters out to 1nm, both the WFD and the MSFD apply. However, in these areas, the MSFD only applies for aspects of good environmental status that are not already addressed by the WFD. These include issues such as the impacts of marine noise and litter, and certain aspects of biodiversity, but not water quality.

### 8.4.1.3 Bathing Waters Directive

35. The Bathing Water Regulations 2013 transpose Council Directive 2006/7/EC concerning the management of bathing water quality into UK law and reporting commenced in 2015.

36. Compliance is measured using two microbiological parameters, *Escherichia coli* (e-coli) and intestinal *Enterococci*. Bathing waters are classed as either poor, sufficient, good or excellent. The revised Bathing Water Directive requires all bathing waters to be classed as at least 'sufficient'.

### 8.4.1.4 MARPOL Convention 73/78

37. The UK is also a signatory to the MARPOL Convention 73/78. All ships flagged under signatory countries are subject to its requirements, regardless of where they sail. The convention includes regulations aimed at preventing and minimising pollution from ships, both accidental and that arising from routine operations.

### 8.4.1.5 Other UK Policies and Plans

38. Other UK policies and plans of relevance to this chapter are the Marine Policy Statements (MPS) (Her Majesty's (HM) Government 2011) and the East Inshore and East Offshore Marine Plans (HM Government 2014). These documents guide decision making with regard to marine developments and signpost the relevant legislation to be followed.

39. The MPS provides the high-level approach to marine planning and general principles for decision making that contribute to achieving this vision. It also sets out the framework for environmental, social and economic considerations that need to be taken into account 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*."

40. With regard to the East Inshore and East Offshore Marine Plans (HM Government 2014) Objective 6 "*To have a healthy, resilient and adaptable marine ecosystem in the East Marine Plan areas*" is of relevance to this chapter as this covers policies and commitments on the wider ecosystem, set out in the MPS including those to do with the MSFD and the WFD, as well as other environmental, social and economic considerations. Elements of the ecosystem considered by this objective include:

*"water quality characteristics critical to supporting a healthy ecosystem and pollutants that may affect these".*

### 8.4.2 Data Sources

#### 8.4.2.1 Site Specific Surveys

41. In order to provide specific information in relation to the proposed East Anglia ONE North project, a site characterisation survey was conducted by Bibby HydroMap between 30th April 2018 and 19th May 2018. This survey aimed to characterise the physical, biological and chemical nature of the sea bed throughout the proposed East Anglia ONE North and East Anglia TWO offshore cable corridors. The full survey report can be found in ***Appendix 9.2*** of ***Chapter 9 Benthic Ecology***.

42. Sediment grab samples were obtained from three locations in the windfarm site and a number of locations along the offshore cable corridor using a 0.1m$^2$ Mini Hamon grab. 65 environmental grab sampling locations were subsampled for fauna, total organic carbon (TOC) and particle size analysis (PSA) with 19 samples taken for physico-chemical parameters, including PSA, TOC, heavy metals and hydrocarbons to allow contaminant analyses. Sample locations are set out in ***Figure 8.2***.

43. It should be noted that the samples for the proposed East Anglia TWO project have been included within this assessment for context. ***Figure 8.2*** displays the locations of the sediment contaminant samples. Of the 19 contaminant samples taken, four lie within the proposed East Anglia TWO windfarm site, while the remaining samples are within the proposed East Anglia ONE North offshore development area.

44. On completion of the survey, all samples were frozen and stored on the survey vessel until demobilisation, following which they were transferred to the laboratory for analysis.

45. The following contaminants were analysed by MMO accredited laboratory SOCOTEC:

- Arsenic;
- Cadmium;
- Chromium;
- Copper;
- Lead;
- Mercury;
- Nickel;
- Vanadium;
- Zinc;
- Aluminium;
- Iron;
- Barium;
- Tin;
- Polychlorinated biphenyls (PCBs);
- Polycyclic Aromatic Hydrocarbons (PAHs);
- Organotins (Dibutyl (DBT) and Tributyl (TBT)); and
- Total hydrocarbons (THC).

46. With the exception of the aforementioned contaminant sample surveys, no recent site specific surveys have been undertaken specifically for the East Anglia ONE North windfarm site. It was agreed with relevant stakeholders (see ***Appendix 8.1***) that sufficient information to provide a robust baseline was gathered as part of the surveys undertaken for other projects in the former East Anglia Zone. These have been set out in ***Table 8.3***.

**Table 8.3 Other Available Site-Specific Physical Environment Datasets**

| Data | Year | Coverage | Confidence | Notes |
|---|---|---|---|---|
| Benthic survey | 2011 | East Anglia Zone | High | PSA analysis of grab samples |
| Benthic survey | 2011 | East Anglia ONE offshore cable corridor | High | PSA analysis of grab samples |
| Benthic survey | 2011 | East Anglia ONE | High | PSA analysis of grab samples |
| Benthic survey | 2013 | East Anglia THREE cable corridor | High | PSA analysis of grab samples |
| Contaminant samples | 2013 | East Anglia THREE (Two samples collected near East Anglia ONE North windfarm site boundary). | High | 15 surface grab samples collected within the East Anglia THREE windfarm site (2) and offshore cable corridor (13). |

#### 8.4.2.2 Former East Anglia Zone

47. There is a wide range of existing data for the former East Anglia Zone. This consists of the East Anglia Offshore Wind (EAOW) Zonal Environmental Appraisal (ZEA) (EAOW 2012) and relevant data from the East Anglia ONE windfarm site, East Anglia ONE and East Anglia THREE offshore cable corridor surveys.

#### 8.4.2.3 Published Data

48. The information presented in this section has been collated from relevant published literature which is referenced throughout the text where appropriate and in ***section 8.12***. Information available on UK Government websites has also been consulted. ***Table 8.4*** summarises the key data sources used.

**Table 8.4 Data Sources**

| Data | Year | Coverage | Confidence | Notes |
|---|---|---|---|---|
| Suspended Sediment | Natural Environment Research Council (NERC) (2016) | UK rivers and coasts | High | Large scale study of riverine, atmospheric, estuarine, coastal and shelf processes. Fed into the international Land-Ocean Interactions in the Coastal Zone project[1]. Results supported by sampling of the North Sea undertaken in 1980 (Eisma and Kalf 1987). |
| Clean Seas Environmental Monitoring Programme: Metals (CSEMP) | Department for Environment, Food and Rural Affairs (Defra) 2010)) | Southern North Sea | High | The Quality Status Report 2010 describes the current status and trends in water quality for regional seas including the North Sea. |
| Bathing Water Profiles | 2017 | Coastal waters around England and Wales | High | Water quality at designated bathing water sites in England are assessed by the Environment Agency between May and September. Data is published publicly by the Environment Agency |
| Environment Agency Catchment Data Explorer | Environment Agency (2017) | Rivers, estuaries and coastal waters around England. | High | Database for information related to river basin management plans (RBMP) in England. Contains information on river basin districts and catchments and WFD compliance data. |

### 8.4.3 Impact Assessment Methodology

49. The impact assessment in this chapter follows the general approach to the assessment of the significance of each impact as detailed in ***Chapter 5 EIA Methodology***.

50. ***Chapter 5 EIA Methodology*** sets out a matrix approach which assesses impacts following best practice, EIA guidance and the approach outlined in the East Anglia ONE North Scoping Report (SPR 2017).

51. The data sources discussed in ***section 8.4.2*** were used to characterise the existing MWSQ environment (***section 8.5***).

52. The assessment of water quality impacts is based on the EQS outlined in the WFD or through the comparison of survey data to the baseline environment

[1] https://www.bodc.ac.uk/projects/data_management/uk/lois/

where possible (for example in the relation to SSCs). Assessment of sediment quality and the potential risk to water quality is based on the use of recognised sediment quality guidelines and action levels providing indications as to the level of likely concern.

53. In the first instance, Cefas Action Levels are commonly used to provide an indication of contaminant levels within sediments. Whilst these levels were specifically developed to assess dredged material, they are an accepted way of assessing the risks to the environment from other marine activities as part of the EIA process. The Cefas Action Levels are set out in ***Table 8.5***.

**Table 8.5 Cefas Action Levels (taken from 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 (TBT and DBT) | 0.1 | 1 |
| PCB (sum of ICES 7) | 0.01 | None |
| PCBs (sum of 25 congeners) | 0.02 | 0.2 |
| PAH | 0.1 (exception dibenz[a,h]anthracene which is 0.01) | None |
| THC | 100 | None |

54. 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 Cefas Action Level 2 are 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 is required before the risk can be identified. Therefore, for EIA, in the same way, if contaminant levels in the material under

consideration persistently exceed Cefas Action Levels, additional assessment is required.

55. This additional assessment can be undertaken by applying the more stringent Canadian sediment quality guidelines (CCME 2002) which also consist of two sets of concentrations: Threshold Effect Levels (TEL) and Probable Effect Levels (PEL) for many of the contaminants outlined in ***Table 8.5***. The Canadian sediment quality guidelines also include PELs for individual PAHs which do not have Cefas Action Level 2 concentrations (see ***Table 8.6***).

56. The difference between these values and the Cefas Action Levels is that ecotoxicological information has been used from field and laboratory testing. Therefore, the TEL and PEL concentrations represent concentrations where adverse effects may or may not occur. The lower level (TEL) represents a concentration below which adverse biological effects are expected to occur only rarely (in some sensitive species for example). The higher level (PEL), defines a concentration above which adverse effects may be expected in a wider range of organisms.

57. If deemed necessary, other additional assessment could be undertaken by calculating the potential partitioning of contaminants from the sediment into the water using partition coefficients or, where significant risk to water quality has been identified through persistent exceedance of Action Level 2, use of water quality modelling.

**Table 8.6 Selected Canadian SQG values (taken from CCME 2002)**

| Contaminant | Units | TEL | PEL |
|---|---|---|---|
| Arsenic | mg/kg | 7.24 | 41.6 |
| Cadmium | mg/kg | 0.7 | 4.2 |
| Chromium | mg/kg | 52.3 | 160 |
| Copper | mg/kg | 18.7 | 108 |
| Mercury | mg/kg | 0.13 | 0.7 |
| Lead | mg/kg | 30.2 | 112 |
| Zinc | mg/kg | 124 | 247 |
| Acenaphthene | µg/kg | 6.71 | 88.9 |
| Acenaphthylene | µg/kg | 5.87 | 128 |
| Anthracene | µg/kg | 46.9 | 245 |
| Benz(a)anthracene | µg/kg | 74.8 | 693 |

| Contaminant | Units | TEL | PEL |
|---|---|---|---|
| Benzo(a)pyrene | µg/kg | 88.8 | 763 |
| Chrysene | µg/kg | 108 | 846 |
| Dibenz(a,h)anthracene | µg/kg | 6.22 | 135 |
| Fluoranthene | µg/kg | 113 | 1,494 |
| Fluorene | µg/kg | 21.2 | 144 |
| Napthalene | µg/kg | 34.6 | 391 |
| Phenanthrene | µg/kg | 86.7 | 544 |
| Pyrene | µg/kg | 153 | 1,398 |

58. There are three main phases of development that are considered in conjunction with the baseline, over the life-cycle of the proposed project, namely:

- Construction;
- Operation and maintenance; and
- Decommissioning.

59. The impact assessment incorporates a combination of the sensitivity of the receptor and the magnitude of the change to determine a significance of impact.

60. During the three phases listed above, it has been identified that activities releasing sediment into the water column are likely to present the most risk to water quality. Where these activities are assessed, reference to information provided in ***Chapter 7 Marine Geology, Oceanography and Physical Processes*** is made.

#### 8.4.3.1 Sensitivity

61. The sensitivity of a receptor, in this case MWSQ, 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).

62. The sensitivity is assessed using expert judgement and described with a standard semantic scale. Definitions for each term are provided in ***Table 8.7***.

**Table 8.7 Definitions of Sensitivity Levels for MWSQ**

| 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 the 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 change with very little or no impact upon the baseline conditions detectable. |

### 8.4.3.2 Magnitude

63. Prediction of the magnitude of potential effects has been based on the consequences that the proposed project might have upon the MWSQ status. The descriptions of magnitude are specific to the assessment of MWSQ impacts and are considered in addition to the generic descriptors of impact magnitude that are provided in ***Chapter 5 EIA Methodology***. 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).

64. The magnitude of effect is assessed using expert judgement and described with a standard semantic scale. Definitions for each term are provided in ***Table 8.8***.

**Table 8.8 Definitions of Magnitude Levels for MWSQ**

| Value | 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) EQS. |
| 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 is likely to take considerable time to recover to baseline conditions. |

| Value | Definition |
|---|---|
| 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 EQS 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 activity ceases. |

### 8.4.3.3 Impact Significance

65. Following the identification of receptor sensitivity and magnitude of the effect, it is possible to determine the significance of the impact. A matrix is presented in ***Table 8.9*** as a framework to guide how a judgement of the significance will be determined.

**Table 8.9 Impact Significance Matrix**

| | | Negative Magnitude | | | | Beneficial Magnitude | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | High | Medium | Low | Negligible | Negligible | Low | Medium | High |
| Sensitivity | High | *Major* | *Major* | *Moderate* | *Minor* | *Minor* | *Moderate* | *Major* | *Major* |
| | Medium | *Major* | *Moderate* | *Minor* | *Minor* | *Minor* | *Minor* | *Moderate* | *Major* |
| | Low | *Moderate* | *Minor* | *Minor* | *Negligible* | *Negligible* | *Minor* | *Minor* | *Moderate* |
| | Negligible | *Minor* | *Negligible* | *Negligible* | *Negligible* | *Negligible* | *Negligible* | *Negligible* | *Minor* |

66. Through use of this matrix, an assessment of the significance of an impact will be made using expert judgement in accordance with the definitions in ***Table 8.10***.

**Table 8.10 Impact Significance Definitions**

| Value | Definition |
|---|---|
| Major | Very large or large change in receptor condition, both negative or beneficial, which is likely to be an important consideration at a regional or district level because the receptor contributes to achieving national, regional or local objectives, or could result in exceedance of statutory objectives and / or breaches of legislation. |
| Moderate | Intermediate change in receptor condition, which is likely to be an important consideration at a local level. |
| Minor | Small change in receptor condition, which may be raised as a local issue but which is unlikely to be important in the decision making process. |

| Value | Definition |
|---|---|
| Negligible | No discernible change in receptor condition. |
| No change | No impact, therefore no change in receptor condition. |

67. Note that for the purposes of the EIA, major and moderate impacts are deemed to be significant. In addition, whilst minor impacts are not significant in their own right, it is important to distinguish these from other non-significant impacts as they may contribute to significant impacts cumulatively or through interactions.

68. Following initial assessment, if the impact does not require additional mitigation (or none is possible) the residual impact will remain the same. If however, additional mitigation is required there should be an assessment of the post-mitigation residual impact.

### 8.4.4 Cumulative Impact Assessment

69. For a general introduction to the methodology used for the cumulative impact assessment (CIA), please see ***Chapter 5 EIA Methodology***. The CIA in ***section 8.7*** will draw from findings of earlier studies undertaken to inform the East Anglia ZEA (EAOW 2012) which considered cumulative impacts arising from the development of the whole zone and work undertaken for the EIA for East Anglia ONE (EAOW 2012b) and East Anglia THREE (EATL 2015).

70. Cumulative impacts on MWSQ have been assessed by taking into consideration other plans, projects and activities that may impact cumulatively with the development of the proposed East Anglia ONE North project. These projects include other offshore windfarm developments including; East Anglia THREE, East Anglia ONE, Norfolk Vanguard and Norfolk Boreas and the proposed East Anglia TWO project but will also give consideration to other nearby activities including marine aggregate extraction.

### 8.4.5 Transboundary Impact Assessment

71. For a general introduction to the methodology used for the transboundary assessment, please see ***Chapter 5 EIA Methodology***. Further detail on potential transboundary impacts is provided in ***section 8.8***.

### 8.4.6 Assumptions and Limitations

72. Broadscale data on offshore water quality is provided in general monitoring programmes such as CSEMP (***section 8.5.1.4***) and the WFD water body status that have been used to inform this assessment. Whilst it is acknowledged that these assessments are not specific to the offshore development area, they are considered the best available sources of information for offshore water quality assessments. Further detail on CSEMP is provided in ***section 8.5.1.4***.

73. Information regarding coastal suspended sediments is not available, however the analysis undertaken to inform ***Chapter 7 Marine Geology, Oceanography and Physical Processes*** predicts the potential change in concentrations (discussed in ***section 7.5.7***), therefore allowing an assessment of the magnitude of change that is likely during offshore works.

## 8.5 Existing Environment

74. The data sources as set out in ***section 8.4.2*** as well as peer reviewed publications, primary data and grey literature have been consulted in order to provide information relating to the current environmental baseline for MWSQ.

### 8.5.1 Water Quality

75. The majority of pollutants enter the southern North Sea through the direct discharges of effluents or terrestrial run-off. Additional potential sources include the activities associated with shipping, oil and gas extraction and the dumping of dredged material as well as atmospheric deposition.

#### 8.5.1.1 Water Framework Directive

76. The offshore cable corridor runs through the Suffolk coastal water body (GB650503520002) (***Figure 8.1***). The Suffolk coastal water body is a 'heavily modified' water body due to flood and coastal protection management and is currently classified to have an overall status of 'moderate'. Classification for physico-chemical parameters is deemed moderate as a result of dissolved inorganic nitrogen (DIN) concentrations in the water. In the RBMP, reasons for the elevated DIN concentrations are listed as diffuse pollution (arable land and therefore field runoff), and point sources associated with sewage discharges. In terms of chemical contaminants, the water body is considered to be at 'good' status, thus indicating no significant exceedances of EQS.

#### 8.5.1.2 Designated Bathing Waters

77. There are four designated bathing waters within the Suffolk coastal water body within 20km of the landfall location as set out in ***Table 8.11*** and ***Figure 8.1.***

**Table 8.11 Water quality classification**

| Bathing water | Distance from Landfall (km) | Water quality classification |
|---|---|---|
| Southwold The Denes | 7.4 | Sufficient (2017 2018) Good (prior to 2017) |
| Southwold The Pier | 8.1 | Good (2018) Excellent (prior to 2018) |
| Lowestoft (South of Claremont Pier) | 18.5 | Excellent (2014, 2015) Good (2016, 2017, 2018) |
| Lowestoft (North of Claremont Pier) | 19.0 | |

#### 8.5.1.3 Other activities

78. Aggregate extraction and marine disposal activities can also influence water quality. There are currently no aggregate dredging areas within the offshore development area. The closest dredging area is Southwold East which lies 17.5km west of the windfarm site (3.6km to the south of the offshore cable corridor route). The nearest aggregate extraction area to the offshore development area is Yarmouth which is located 10.7km to the north west (see ***Figure 17.5*** in ***Chapter 17 Infrastructure and Other Users***).

79. Disposal sites in the vicinity of the offshore development area are shown on ***Figure 8.3.*** The East Anglia ONE North windfarm site overlaps the East Anglia THREE disposal site (HU212) which will be used to dispose of sea bed sediment dredged during the construction of that project.

80. Site TH026 intersects the offshore cable corridor and windfarm site and was designated for tracers, the site is closed and not for waste disposal, records indicate that it has never been used. Site TH057: Galloper Offshore Windfarm also intersects the offshore cable corridor. The site is open for the disposal of pre-sweep material and drill arisings during construction (though construction has now been completed making further disposal unlikely).

81. Site TH075, Warren Springs, is a closed disposal site which overlaps the East Anglia ONE North windfarm site. Warren Springs disposal site was used between 1987 and 1995 to test oil dispersants in the North Sea. Approximately 157 tonnes of material was disposed of at the site during that period (EAOW 2012). In 2010, sediment samples from within the Warren Springs site were analysed to test for the presence of residual volatile and semi-volatile organic compounds. Results indicated there was no anthropologic contamination within the study area. It is likely that activities were conducted sufficiently long ago to allow the breakdown of any contaminants by physical and chemical processes.

82. Site specific surveys undertaken to support the EIA for East Anglia ONE included the collection of five sediment grab samples from within the TH057 disposal site which is at its closest point located 38.6km from the East Anglia ONE North windfarm site (***Figure 8.3***). These samples were tested for volatile and semi-volatile organic compounds (EAOW 2012).

83. The analysis found no traces of contamination suggesting that it is likely that any organic compounds disposed of were of such limited extent and sufficiently long ago that no traces remain in surface sediments. The MMO advised that impacts associated with this product test site could be scoped out of further assessment for the East Anglia THREE project. As construction for the proposed East Anglia ONE North project would commence after the construction of the East Anglia

THREE project, it is unlikely that the disposal site would influence sediment quality. Therefore, it has also been scoped out of this assessment.

84. There are 18 wells within 50km of the offshore development area with the closest being 4.6km away (***Figure 8.3***). These wells are all plugged or abandoned and are highly unlikely to be used or re-entered again (see also ***Chapter 17 Infrastructure and Other Users***). There is potential that these wells could be a source of contamination. However, the site specific surveys (see ***section 8.4.2.1***) identified no significant levels of hydrocarbon contamination within the sea bed sediments and therefore there are unlikely to be associated water and/or sediment quality issues.

#### 8.5.1.4 Clean Seas Environmental Monitoring Programme

85. CSEMP superseded the National Marine Monitoring Programme (NMMP) and was implemented to assess progress against the UK Government and the Devolved Administrations' vision of clean, healthy, safe, productive and biologically diverse oceans and seas. The most recent full reporting of CSEMP was in 'Charting Progress 2' (Department for Environment, Food and Rural Affairs (Defra) 2010).

86. The proposed East Anglia ONE North project is located in Region 2 which covers the southern North Sea. Charting Progress 2 (Defra 2010) states that in relation to toxicological hazard from metals in water samples analysed against EU Directive requirements (mainly in estuarine waters) and Shellfish Waters (mainly in coastal waters); nearly 99% of metal concentrations were below the UK EQS values in 2007 although 6% of copper concentrations exceeded the EQS. Throughout the UK in areas where exceedances were recorded, these were located within estuarine environments, not in offshore waters (Defra 2010). As a result, the report concludes that levels of contaminants in UK offshore waters are generally low.

87. Since the 2010 study, an update has been provided by OSPAR. This states that following reduced inputs of contaminants in to the North Sea from OSPAR countries, contaminant concentrations have continued to decrease (OSPAR 2017).

### 8.5.2 Suspended Sediment Concentrations

88. Baseline SSCs within the former East Anglia Zone are typically between 1mg/l and 35mg/l (Natural Environment Research Council 2016), with a clear pattern of enhancement due to wave-stirring of sediment from the sea bed during storm conditions. During such conditions, values can reach greater than 80mg/l offshore, with up to170mg/l having been recorded at the coast.

89. These SSCs provide a natural background context for the assessment of effects of any temporary increases that may arise due to the proposed East Anglia ONE North project.

### 8.5.3 Sediment Quality

#### 8.5.3.1 Sediment Grain Size

90. 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.

91. Grab samples collected from within the East Anglia ONE North windfarm site suggest that sea bed composition is primarily medium sand. The proportion of silt within samples is less than 4% in all samples bar one where the silt content is 9%.

92. Grab samples collected within the offshore cable corridor as part of the project-specific benthic survey (***Appendix 9.2*** of ***Chapter 9 Benthic Ecology***) show the majority of the sediments to be slightly gravelly sand (using the Folk scale). Coarser sediment is present in the offshore cable corridor furthest offshore, with these samples containing higher percentages of sand. Slightly gravelly sand and gravelly muddy sand are the two most common classifications of sediment in the section of the offshore cable corridor closest to the windfarm site.

93. The central section of the offshore cable corridor has the highest percentage of fines in samples collected (reaching over 90%), with sediment mainly falling within the sandy mud classification on the Folk scale. This central section also has the lowest percentages of gravel in samples.

94. Closest to landfall, sediment size is highly variable, ranging from sandy mud to sandy gravel in the samples that were taken. One sample was found to contain 53% gravel while another was calculated at less than 1% gravel.

#### 8.5.3.2 Sediment Contamination

95. Data provided within the East Anglia ONE ES (EAOL 2012) indicate low levels of contamination within the East Anglia ONE North windfarm site and surrounding area. Surveys undertaken for East Anglia THREE in 2013 found a single site within the East Anglia THREE offshore cable corridor where arsenic was above Cefas Action Level 2. Arsenic, chromium, copper and nickel levels were above Cefas Action Level 1 in eight of 15 sampling locations across the East Anglia THREE windfarm site and offshore cable corridor. These results further support the conclusions drawn from the site specific surveys discussed below and wider literature, where elevations of some contaminants can be attributed to naturally

occurring low level increases in contaminants that are common in the wider area of the offshore development area.

#### 8.5.3.3 Site Specific Survey

96. To inform the baseline for sediment quality in the offshore cable corridor, a site specific survey was carried out in 2018. The locations of the sites for which contaminant analysis was undertaken are shown in ***Figure 8.2***. Full details can be found in ***Appendix 9.2*** of ***Chapter 9 Benthic Ecology*** with a summary provided below.

97. The sediment contaminant data for heavy and trace metals are summarised in ***Table 8.12***. Levels of aluminium, iron, barium and tin were also measured however as there are no associated Cefas Action Levels or Canadian SQG values they are not further discussed in this chapter. They can however be found in the results presented in ***Appendix 9.2*** of ***Chapter 9 Benthic Ecology***.

98. Sediment contaminant analysis was also undertaken for PCBs, PAHs and organotins. The combined PCBs[2] gave a value below 0.001mg/kg. Individual PAH concentrations were all below 0.00008mg/kg and combined 2-6 ring PAH were below 0.00128mg/kg. Concentrations of organotins were highest at site C01 where they were 0.01mg/kg. None of these results exceeded Cefas Action Level 1[3] or Canadian TEL levels.

99. A number of samples (11) exceed Cefas Action Level 1 for concentrations of arsenic. The majority of samples that exceeded Cefas Action Levels 1 do so only marginally, remaining well below Action Level 2. All samples exceeded the TEL for concentrations of arsenic with three samples (C05, C07 and C16) also marginally exceeding the PEL.

100. The elevated levels of arsenic which were recorded are typical of the region; inshore these are associated with a history of arsenic waste disposal and offshore these are associated with estuarine and geological inputs and sea bed rock weathering (Royal Haskoning 2011). Given that there were no exceedances of Action Level 2 and levels are typical for the region, further assessment (i.e. comparison with additional sediment quality guidelines or other methods) is not deemed necessary.

101. One sample (C01) marginally exceeding Cefas Action Level 1 for cadmium, copper, nickel and zinc (***Table 8.12)***. Sample C01 also exceeded the TEL for cadmium, copper, lead and zinc. The exceedances did not approach the higher

[2] Based on the "ICES 7" PCBs. Seven of the 209 existing PCBs are analysed in monitoring because they are found in relatively high concentrations in technical mixtures and cover the range of toxicological properties of the PCB group
[3] An assumption is made that any values that were read as smaller than Cefas Action Level 1 were considered equivalent to, with results still showing levels below Cefas Action Level 1.

Action Level 2 or the PEL. Considering the predominantly sandy nature of the sea bed sediments, which significantly reduces the potential for any contaminants to accumulate and for sediments to be resuspended into the water column and transported over long distances (see ***section 8.6.1.6*** and ***8.6.2.2***), these are not deemed to be of concern.

102. From the information and data presented above it can be concluded that baseline water and sediment quality of the study area is generally good and site specific information in relation to concentrations of contaminants in sediments does not record significantly elevated levels.

### 8.5.4 Climate Change and Natural Trends

103. The baseline conditions for marine water and sediment quality are considered to be relatively stable within the offshore development area with multiple data sets covering several years exhibiting similar patterns.

104. Baseline conditions have been largely shaped by a combination of the physical processes which exist within the southern North Sea (***Chapter 7 Marine Geology Oceanography and Physical Processes***) and anthropogenic impacts in the area (which influence pollutant levels). These processes will continue to influence the area in the future, and conditions are likely to remain in the same range as past patterns.

105. In the nearshore areas coastal waters, the WFD and MSFD have set targets for the improvement of water quality, these goals will need to be met and considered in relation to climate change. The aim for the Suffolk water body through which the export cable will come to land is to achieve ‘Moderate Ecological Potential’ by 2027 and ‘Good Chemical Status’ by 2027 (Environment Agency 2018).

**Table 8.12 Sediment Contamination Analysis Results Compared to Cefas Action Levels (mg/kg)**

| Sample station | Arsenic | Cadmium | Chromium | Copper | Lead | Mercury | Nickel | Vanadium | Zinc | Total Hydrocarbon Content |
|---|---|---|---|---|---|---|---|---|---|---|
| C01 | 12.6* | 0.8* | 33.8 | 52.2* | 45.5* | 0.09 | 22.8 | 45.4 | 132.3* | 53.5 |
| C02 | 34.2* | 0.26 | 17.1 | 10.1 | 7.7 | 0.03 | 13.6 | 38.1 | 23.7 | 26.2 |
| C03 | 31.7* | 0.07 | 9.7 | 7 | 7.7 | 0.03 | 6.6 | 35.5 | 24 | 36.6 |
| C04 | 29* | 0.05 | 7.4 | 5.3 | 5.8 | 0.03 | 6.2 | 31.2 | 19.8 | 33.4 |
| C05 | 43.9** | 0.08 | 13.9 | 6.5 | 8.1 | 0.02 | 8.2 | 52.3 | 24.8 | 35.1 |
| C06 | 28.2* | 0.05 | 20.5 | 10.2 | 5.2 | 0.02 | 14.2 | 28.4 | 13.7 | 35.8 |
| C07 | 42.4** | 0.08 | 6.9 | 5.6 | 7.5 | 0.05 | 8.4 | 41 | 21.6 | 33.9 |
| C08 | 16.4* | <0.04 | 6 | 5.5 | 4.7 | 0.03 | 4.2 | 21.4 | 14.2 | 32.0 |
| C09 | 8.9* | <0.04 | 4.2 | 3.8 | 2.8 | 0.03 | 3.5 | 10.1 | 8.1 | 32.3 |
| C10 | 24* | 0.07 | 5.5 | 3.4 | 4.5 | 0.02 | 5.8 | 25.5 | 11.9 | 31.8 |
| C11 | 7.5* | <0.04 | 4 | 5.1 | 2.4 | 0.02 | 3.3 | 8.5 | 7.1 | 32.5 |
| C12 | 28.1 | <0.04 | 8.2 | 6.2 | 6.1 | 0.03 | 6.5 | 32.3 | 18.3 | 34.3 |
| C13 | 20.3 | 0.05 | 7.6 | 6.2 | 5.4 | 0.03 | 4.6 | 21.3 | 14.9 | 34.9 |
| C14 | 34.9 | 0.05 | 4.4 | 5 | 5.2 | 0.06 | 5.3 | 29.9 | 15.4 | 32.6 |
| C15 | 9.7* | <0.04 | 6.5 | 4.4 | 2.9 | 0.02 | 3.9 | 13.6 | 10.6 | 24.5 |
| C16 | 65.6** | 0.07 | 7.5 | 4.9 | 5.4 | 0.02 | 10.2 | 49 | 22.6 | 28.2 |

| Sample station | Arsenic | Cadmium | Chromium | Copper | Lead | Mercury | Nickel | Vanadium | Zinc | Total Hydrocarbon Content |
|---|---|---|---|---|---|---|---|---|---|---|
| **C17** | 16.6* | <0.04 | 4.5 | 3.6 | 2.9 | 0.02 | 3.8 | 15.7 | 9.6 | 26.9 |
| **C18** | 14.1* | 0.06 | 10 | 6.9 | 6.3 | 0.04 | 5.2 | 26.6 | 20.1 | 30.6 |
| **C19** | 20.8* | 0.1 | 14.4 | 7.8 | 15.7 | 0.05 | 10.7 | 34 | 41.3 | 28.5 |

Yellow highlight above Cefas Action Level 1; *Above Canadian SQC TEL; **Above Canadian SQC PEL;
Orange cells indicate sample locations in the East Anglia TWO windfarm site and southern offshore cable corridor which were gathered in the same survey and have been included for context. .
Unhighlighted cells indicate sample locations in the East Anglia ONE North offshore cable corridor and windfarm site

## 8.6 Potential Impacts

### 8.6.1 Potential Impacts during Construction

#### 8.6.1.1 Impact 1A: Deterioration in offshore water quality due to increased SSC due to sea bed preparation including sand wave levelling during installation of foundations:

106. Sediment preparation for the installation of foundations (for wind turbines, construction, operation and maintenance platforms, offshore electrical platforms, meteorological masts) has the potential to disturb sea bed sediments from (i) the sea bed (surface or shallow near-surface sediments); and (ii) from several tens of metres below the sea bed (sub-surface sediments), depending on the foundation type and installation method. The level of disturbance to sea bed sediments would be a function of sea bed type, the type of foundations and installation method, as well as hydrodynamic conditions.

107. Changes in turbidity decrease the depth to which natural light can penetrate into the water column and may therefore result in a reduction in primary productivity (see ***Chapter 9 Benthic Ecology***). Additionally, sediment plumes can create barriers to movement of marine ecological receptors such as fish and marine mammals (see ***Chapter 10 Fish and Shellfish Ecology*** and ***Chapter 11 Marine Mammals***).

108. Sea bed sediments and shallow near-bed sediments within the East Anglia ONE North windfarm site would be disturbed during any levelling or dredging activities that may be needed at each foundation location to create a suitable base prior to installation. The worst case scenario assumes that sediment would be dredged and returned to the water column at the sea surface as overflow from a dredging vessel. This process would cause localised and short-term increases in SSCs both at the sea bed and at the point of discharge into the water column.

109. As detailed in ***Chapter 7 Marine Geology, Oceanography and Physical Processes***, mobilised sediment from these activities may be transported by wave and tidal action in suspension in the water column forming a plume.

110. Effects from increased SSCs have been assessed in ***Chapter 7 Marine Geology, Oceanography and Physical Processes*** using expert judgement and comparing results to modelling undertaken for East Anglia ONE (EAOL 2012). This is relevant to this assessment due to the high level of similarity in sediment type and distribution and water depths between the sites. The assessment in ***Chapter 7 Marine Geology, Oceanography and Physical Processes*** concluded the following

- Measurable increases in SSCs will be found in the water column over a short period of time (a matter of days);

- Disturbed material will remain close to the sea bed and rapidly settle out (within tens of minutes);
- The majority of sediment released at the water surface would rapidly (within tens of minutes) settle on to the sea bed as a highly turbid dynamic plume upon discharge; and
- Finer sediment fractions will remain in the water column as a measurable but low concentration plume for up to half a tidal cycle settling within a kilometre of the disturbance or becoming indistinguishable from background levels.

111. As summarised above, the worst case scenario changes in SSCs due to sea bed preparation are predicted to be low in magnitude due to the localised and short term nature of the predicted sediment plumes. Baseline conditions of SSCs are expected to return to normal rapidly following cessation of activity, therefore any impact would only be present during the installation process. The sensitivity in the offshore development area is deemed to be low due to the large volume of the receiving water and the capacity for dilution and flushing. Therefore, a **minor adverse** impact is predicted.

#### 8.6.1.2 Impact 1B: Deterioration in offshore water quality due to increased SSC due to drill arisings for installation of piled foundations:

112. The drilling process could cause localised and short-term increases in SSCs at the point of discharge of the drill arisings. Released sediment may then be transported by wave and tidal currents in suspension in the water column.

113. Most of the sediment consists of sand or aggregated clasts which are deposited close to the drill location (***Chapter 7 Marine Geology, Oceanography and Physical Processes***). However, it is likely that there would be a larger portion of fine materials when compared to surface sediments, though these would still only be small quantities of materials.

114. The coarser sediment and aggregate clasts would settle out of suspension close to the foundation location with the finer sediments being more prone to dispersion. The small quantities of fine-sediment released are likely to be widely and rapidly dispersed resulting in only low elevations in SSCs within the water column. The disturbance effects at each wind turbine location are only likely to last for a few days of construction activity. The East Anglia ONE modelling studies (ABPmer 2012) confirm the assessments set out in ***Chapter 7 Marine Geology, Oceanography and Physical Processes*** relating to increased SSCs arising from disturbance of deeper sub-surface sediments.

115. The assessment in ***Chapter 7 Marine Geology, Oceanography and Physical Processes*** concluded the following:

- Increases in SSC are likely to be low and within natural variability away from the immediate release locations, less than 10mg/l;
- No likely cumulative effect from plumes interacting due to plumes not persisting in the water column for a sufficiently long time; and
- Modelling was undertaken conservatively with all sediment being dispersed whereas in actual fact it is likely larger clasts will settle rapidly.

116. The changes in SSCs (magnitudes, geographical extents and durations of effect) that are anticipated would move across the site with progression of the construction sequence as the point of sediment release (and hence geographic location of the zone of effect) changes with the installation of foundations at different wind turbine locations.

117. As summarised above the worst case scenario changes in SSCs due to drilling activities are predicted to be low in magnitude due to the localised and short term nature of the predicted sediment plumes. Baseline conditions of SSCs are expected to return to normal rapidly following cessation of activity, therefore any impact would only be present during the installation process. The sensitivity in the offshore development area is deemed to be low due to the large volume of the receiving water and the capacity for dilution and flushing. Therefore, a **minor adverse** impact is predicted.

#### 8.6.1.3 Impact 2: Deterioration in water quality due to increased SSC during installation of the offshore export cable including sand wave levelling

118. The installation of the offshore cables has the potential to disturb the sea bed sediment down to a sediment thickness of up to 3m directly though the installation method chosen, or down to 5m through sea bed levelling of sand waves. Current estimates are that the maximum length of each export cable could be up to 76km. Up to two cables would be installed providing a total maximum length of 152km. The worst case cable laying technique is considered to be jetting. Details of how the offshore cable would be installed and how sea bed levelling would take place will be confirmed in the final project design, post consent.

119. Effects from increased SSCs have been assessed in ***Chapter 7 Marine Geology, Oceanography and Physical Processes*** using expert judgement, comparing results to East Anglia ONE modelling where appropriate (EAOL 2012). The assessment in ***Chapter 7 Marine Geology, Oceanography and Physical Processes*** concluded the following:

- Cable installation is a relatively short term activity (days as opposed to months) and therefore the effect is generally relatively short-lived;
- Enhanced concentrations will be greatest in the shallowest sections of the offshore cable corridor. In these locations the natural background

concentrations are also greater than in deeper waters, typically up to 180mg/l;

- Sand-sized sediment would settle out of suspension within less than 1km from the point of release within a few tens of minutes with smaller particles settling out within a few hours to days;
- In shallow waters (less then 5m Lowest Astronomical Tide (LAT)) the concentrations of suspended sediment would approach 400mg/l at their peak. However, these plumes would be localised to within 1km of the release location and would persist for no longer than a few hours.; and
- After 180 hours following cessation of installation activities any plume would have been fully dispersed

120. As summarised above, during the construction period, disturbance to sea bed sediments and potential generation of plumes would be limited in temporal and spatial extent due to the temporary nature of the activity and the dominance of sand sized material along the offshore cable route and therefore the magnitude of impact would be low. Designated Bathing Waters are not located within the 1km area identified as being the most at risk of experiencing elevated levels (the nearest being over 7km away) and are therefore considered to be of low sensitivity.

121. Since the sensitivity of the receptor and the magnitude of the impact are considered to be low, an overall **minor adverse** impact is predicted.

#### 8.6.1.4 Impact 3: Deterioration in offshore water quality due to increased SSC during inter-array and platform link cable installation including sand wave levelling

122. As for the installation of the export cables, the inter-array and platform link cable installation has the potential to disturb the sea bed sediment in two ways: through sand wave levelling which may be required prior to cable installation to ensure that the cable does not become exposed post installation and through the cable installation process itself. Details of how the cables will be installed and how sand wave levelling will take place will be confirmed in the final project design, post consent however further information on these processes can be found in ***Chapter 6 Project Description***.

123. Current estimates are that the total length of inter-array cables would be up to 200km, and the total length of platform link cable would be up to 75km. The installation of inter-array cables and platform link cables will have some overlaps.

124. ***Chapter 7 Marine Geology, Oceanography and Physical Processes*** shows that the changes in SSC from cable installation would be minimal due to the predominant grain size being sand and the quantity of sediment released into the water column being low when compared to foundation installation and sea bed preparation. Finer sands and mud-sized material would remain in the water

column for longer, forming a passive measurable but modest plume (tens of mg/l) for around half a tidal cycle settling within a kilometre within a short period of time (hours) which would result in a low magnitude of impact.

125. Designated bathing waters are located at least 36km away from the activity and the WFD water body has a high capacity to accommodate change due to the high capacity for dilution and flushing, resulting in low receptor sensitivity.

126. Since the sensitivity of the receptor and the magnitude of the impact are considered to be low, an overall **minor adverse** impact is predicted.

#### 8.6.1.5 Impact 4: Deterioration in water quality due to works at the offshore export cable landfall

127. At the landfall just north of Thorpeness, the worst case scenario includes installation of two cables using HDD techniques. The HDD exit point would be in the subtidal zone beyond -5m LAT. This would require excavation of a trench to bury the offshore cable on the seaward side of the landfall HDD. This excavation has the potential to increase SSCs close to shore.

128. During excavation, the SSCs would likely increase beyond baseline levels, however once complete the high energy nearshore zone is likely to rapidly disperse any suspended sediment over a period of a few hours.

129. As previously discussed in relation to cable installation, any suspended sediment plumes arising would be localised to within approximately 1km of the release location. The two nearest designated bathing waters are located at least 7km from the proposed landfall location, however, the route does run through the WFD coastal water body Suffolk. Whilst compliance with the bathing waters directive and WFD is not dependent on meeting requirements in relation to SSCs, this has been assessed in order to provide a conservative assessment.

130. Overall therefore, given the level of disturbance to sea bed sediments and that potential generation of plumes would be limited in temporal and spatial extent due to the temporary nature of the activity and the dominance of sand sized material in the landfall area, the magnitude of the impact is anticipated to be low.

131. Designated bathing waters are located at least 7km away from the activity and the WFD water body has a high capacity to accommodate change due to the high capacity for dilution and flushing, resulting in low receptor sensitivity. Considering this, a **minor adverse** impact is anticipated.

132. Regarding the WFD water body, compliance parameters such as marine habitats could be affected. A detailed assessment can be found in the WFD Compliance Assessment in ***Appendix 20.4*** of ***Chapter 20 Water Resources and Flood Risk***).

#### 8.6.1.6 Impact 5: Deterioration in water quality due to re-suspension of sediment bound contaminants

133. Disturbance of sea bed sediments has the potential to release any sediment-bound contaminants, such as heavy metals and hydrocarbons into the water column. The data in ***Table 8.12*** illustrates that levels of contaminants within the East Anglia ONE North windfarm site and offshore cable corridor are very low.

134. There were five exceedances of Cefas Action Level 1 for arsenic within the offshore cable corridor (out of seven samples) and two out of four within the East Anglia ONE North windfarm site with three samples in the offshore development area (C05, C07 and C16) also marginally exceeding the PEL. Exceedances were marginal for arsenic and likely due to high concentrations of naturally occurring arsenic (***section 8.5.3)***. Sample site C01 also recorded levels of cadmium, copper, lead, nickel and zinc above Cefas Action Level 1. None of the increases bring the concentrations close to Cefas Action Level 2 (***Table 8.12***), therefore the potential magnitude of effect is considered to be negligible.

135. Considering the negligible magnitude of effect, low receptor sensitivity (as discussed in ***section 8.6.1.1***) and the localised nature of the impact (see above impacts on increased SSCs), the re-suspension of contaminated sediment from construction activities is considered to have a **negligible** impact on water quality.

### 8.6.2 Potential Impacts during Operation

#### 8.6.2.1 Impact 1: Deterioration in offshore water quality due to increased SSC due to scour around foundation structures:

136. As set out in ***Chapter 7 Marine Geology, Oceanography and Physical Processes*** previous studies have revealed (overly-conservative) a worst case scour volume under a 50-year return period event of about 5,000m$^3$ per wind turbine. This value is considerably less than the worst case volume of sediment potentially released following sea bed preparation activities. In addition, given the sediment types prevalent across the East Anglia ONE North windfarm site, most of the relatively small quantities of sediment released at each wind turbine foundation due to scour processes would rapidly settle within a few hundred metres of each one and settle in to the background levels of SSC. Considering this, the magnitude of effect is negligible.

137. Considering the negligible magnitude of effect, low receptor sensitivity and the localised nature of the impact as well as the fact that the increased SSC would be low compared to naturally occurring SSC (low sensitivity) an overall impact of **negligible** significance is anticipated on water quality.

#### 8.6.2.2 Impact 2: Deterioration in water quality due to re-suspension of sediment bound contaminants as a result of scour:

138. As set out above, the maximum volume of re-suspended sediment as a result from scour is considerably less when compared to volumes released during construction. Considering this as well as the worst case negligible impacts assessed under impact 5, a **negligible impact** is anticipated on water quality due to the re-suspension of sediment bound contaminants.

### 8.6.3 Potential Impacts during Decommissioning

#### 8.6.3.1 Impact 1: Deterioration in water quality due to increased SSC during removal of accessible installed components:

139. The scope of the decommissioning works for the proposed East Anglia ONE North project would most likely involve removal of the accessible installed components. Offshore, this is likely to include removal of all the wind turbine components, part of the foundations (those above sea bed level) and the sections of the inter-array cables and platform link cables.

140. With regards to export cables, general UK practice would be followed. Buried cables would be cut at the ends and left *in situ*, except for the intertidal zone where the cables may be removed.

141. The magnitude of effects would be comparable to, or more likely less than those identified for the construction phase, due to the fact that dredging, or sea bed preparation would not be required to remove the foundations. There may however, be a requirement to use jetting to remove the cables where needed.

142. Given that only negligible or minor impacts were identified for all construction impacts, it is anticipated that impacts for the decommissioning phase would be similar magnitude or less (i.e. of **minor adverse** or **negligible**).

## 8.7 Cumulative Impacts

143. The potential for all previously identified impacts to act in a cumulative manner are assessed in ***Table 8.13*** with relevant projects included in ***Table 8.14***. ***Table 8.13*** concludes for all potential impacts that effects would be highly localised to within around 1km of the offshore development area, therefore given the distances to other projects (***Table 8.14***) and limited potential of temporal overlap, there would be **no cumulative impacts**.

144. This is true even for the proposed East Anglia TWO project. The windfarm sites are 10km from each other and therefore beyond the range of potential interaction. While the proposed projects share the offshore cable corridor, it is unlikely that construction activities would occur simultaneously and close enough to have an additive effect.

**Table 8.13 Potential Cumulative Impacts**

| Impact | Potential for cumulative impact | Data confidence | Rationale |
|---|---|---|---|
| **Construction** | | | |
| Impact 1A: Deterioration in offshore water quality due to increased SSCs due to sediment plume created by sea bed preparation including sand wave levelling during installation of foundations. | No | High | As set out throughout this chapter and ***Chapter 7 Marine Geology, Oceanography and Physical Processes***, the sediment plume would extend to a maximum of 1km from the works area and dissolve in to background levels within a short period of time. Impacts are anticipated to be minor adverse at worst therefore it is not considered likely that cumulative impact would occur. |
| Impact 1B: Deterioration in offshore water quality due to increased SSCs due to drill arisings for installation of piled foundations. | No | High | |
| Impact 2: Deterioration in water quality due to increased SSCs during installation of the offshore export cable including sand wave levelling | No | High | |
| Impact 3: Deterioration in offshore water quality due to increased SSCs during inter-array and platform link cable installation including sand wave levelling | No | High | |
| Impact 4: Deterioration in water and bathing water quality due to works at the offshore export cable landfall | No | High | |

| Impact | Potential for cumulative impact | Data confidence | Rationale |
|---|---|---|---|
| Impact 5: Deterioration in water quality (offshore and coastal) due to re-suspension of sediment bound contaminants. | No | High | |
| **Operation** | | | |
| Impact 1: Deterioration in offshore water quality due to increased SSCs due to scour around foundation structures. | No | High | As set out throughout this chapter and ***Chapter 7 Marine Geology, Oceanography and Physical Processes***, the sediment plume would extend to a maximum of 1km from the works area and dissolve in to background levels within a short period of time. Impacts are anticipated to be minor adverse at worst therefore it is not considered likely that cumulative impact would occur. |
| Impact 2: Deterioration in water quality (offshore and coastal) due to re-suspension of sediment bound contaminants as a result of scour. | No | High | As above. |
| **Decommissioning** | | | |
| Impact 1: Deterioration in water quality due to increased SSCs during removal of accessible installed components. | No | High | As set out throughout this chapter and ***Chapter 7 Marine Geology, Oceanography and Physical Processes***, the sediment plume would extend to a maximum of 1km from the works area and dissolve in to background levels within a short period of time. Impacts are anticipated to be minor adverse at worst therefore it is not considered likely that cumulative impact would occur. |

**Table 8.14 Summary of Projects Considered for the CIA in Relation to MWSQ**

| Project | Development period | [4]Distance from East Anglia ONE North windfarm site (km) | [5]Distance from East Anglia ONE North offshore cable corridor (km) | Included in CIA | Rationale |
|---|---|---|---|---|---|
| Hornsea Project 1 | 2018-2020 | 154 | 163 | No | Impacts are localised to within 1km of the area where the works are taking place. There is therefore no pathway for the impacts to act cumulatively with any other projects. |
| Hornsea Project 2 | 2020-2022 | 162 | 168 | No | |
| Hornsea Project 3 | 2022-2025 | 141 | 156 | No | |
| Norfolk Boreas | 2024-2026 | 51 | 72 | No | |
| Norfolk Vanguard | 2024-2026 | 38 | 55 | No | |
| East Anglia ONE | 2018-2020 | 1 | 19 | No | |
| East Anglia TWO | 2024-2026 | 10 | 0 | No | |
| East Anglia THREE | 2022-2025 | 17 | 45 | No | |
| Greater Gabbard | 2010-2013 | 43 | 20 | No | |
| Galloper | 2016-2018 | 39 | 17 | No | |

[4] Shortest distance between the considered project and East Anglia ONE North– unless specified otherwise
[5] Shortest distance between the considered project and East Anglia ONE North– unless specified otherwise

## 8.8 Transboundary Impacts

145. ***Chapter 7 Marine Geology, Oceanography and Physical Processes*** states that there are no transboundary effects arising from sediment plumes based on there being no physical connection between other projects and sensitive receptors in Belgium, France or the Netherlands in terms of tidal currents. As these areas are also very remote it is not considered conceivable that sediment entrained within a plume would reside in the water column in sufficient quantities to reach such areas in measurable quantities.

146. Considering the above, there would be no transboundary impacts for MWSQ. For further detail also see ***Appendix 7.3*** in ***Chapter 7 Marine Geology, Oceanography and Physical Processes***.

## 8.9 Interactions

147. The impacts identified and assessed in this chapter have the potential to interact with each other, which could give rise to synergistic impacts as a result of that interaction. The areas of interaction between impacts are presented in**,** along with an indication as to whether the interaction may give rise to synergistic impacts. This provides a screening tool for which impacts have the potential to interact ***Table 8.15.***

148. ***Table 8.16*** then provides an assessment for each receptor (or receptor group) related to these impacts in two ways. Firstly, the impacts are considered within a development phase (i.e. construction, operation or decommissioning) to see if, for example, multiple construction impacts could combine. Secondly, a lifetime assessment is undertaken which considers the potential for impacts to affect receptors across development phases. The significance of each individual impact is determined by the sensitivity of the receptor and the magnitude of effect; the sensitivity is constant whereas the magnitude may differ. Therefore, when considering the potential for impacts to be additive it is the magnitude of effect which is important – the magnitudes of the different effects are combined upon the same sensitivity receptor. If minor impact and minor impact were added this would effectively double count the sensitivity.

149. There is a single receptor for potential interactions – marine water quality.

**Table 8.15 Potential Interactions Between Impacts**

| Potential Interaction between impacts | | | | | | |
|---|---|---|---|---|---|---|
| | **Impact 1A** | **Impact 1B** | **Impact 2** | **Impact 3** | **Impact 4** | **Impact 5** |
| Impact 1A: Deterioration in offshore water quality due to increased SSCs due to sediment plume created by sea bed preparation including sand wave levelling during installation of foundations. | - | Yes | No | Yes | No | Yes |
| Impact 1B: Deterioration in offshore water quality due to increased SSCs due to drill arisings for installation of piled foundations. | Yes | - | No | Yes | No | Yes |
| Impact 2: Deterioration in water quality due to increased SSCs during installation of the offshore export cable including sand wave levelling | No | No | - | No | Yes | Yes |
| Impact 3: Deterioration in offshore water quality due to increased SSCs during inter-array and platform link cable installation including sand wave levelling | Yes | Yes | No | - | No | Yes |
| Impact 4: Deterioration in water and bathing water quality due to works at the offshore export cable landfall | No | No | Yes | No | - | Yes |
| Impact 5: Deterioration in water quality (offshore and coastal) due to re-suspension of sediment bound contaminants. | Yes | Yes | Yes | Yes | Yes | - |

<table>
<tr><th colspan="7">Potential Interaction between impacts</th></tr>
<tr><th></th><th>Impact 1A</th><th>Impact 1B</th><th>Impact 2</th><th>Impact 3</th><th>Impact 4</th><th>Impact 5</th></tr>
<tr><td colspan="7">Operational Impacts</td></tr>
<tr><td></td><td colspan="3">Impact 1</td><td colspan="3">Impact 2</td></tr>
<tr><td>Impact 1: Deterioration in offshore water quality due to increased SSC due to scour around foundation structures</td><td colspan="3">-</td><td colspan="3">Yes</td></tr>
<tr><td>Impact 2: Deterioration in water quality (offshore and coastal) due to re-suspension of sediment bound contaminants as a result of scour</td><td colspan="3">Yes</td><td colspan="3">-</td></tr>
</table>

**Table 8.16 Potential Interactions Between Impacts on Marine Water and Sediment Quality**

| | Highest level significance | | | | |
|---|---|---|---|---|---|
| **Receptor** | **Construction** | **Operational** | **Decommissioning** | **Phase Assessment** | **Lifetime Assessment** |
| Marine Water Quality | Minor adverse | Minor adverse | Minor adverse | **No greater than individually assessed impact**<br><br>***Construction***<br><br>*Impacts 1a Deterioration in offshore water quality due to increased SSCs due to sediment plume created by sea bed preparation including sand wave levelling during installation of foundations, Impact 1b Deterioration in offshore water quality due to increased SSCs due to drill arisings for installation of piled foundations, Impact 3 Deterioration in offshore water quality due to increased SSCs during inter-array and platform link cable installation including sand wave levelling* and *Impact 5 Deterioration in water quality (offshore and coastal) due to re-suspension of sediment bound contaminants* have the potential to interact (for *impact 2* only if piled foundations are selected in the project design phase). All increases in SSCs will be episodic and localised, given the magnitudes of effect there is limited potential for interactions. Given the low levels of contaminants in the sediment there is limited potential for interaction between the effects of increased SSC and contaminants (also see the | **No greater than individually assessed impact**<br><br>Spatial impacts will be greatest during construction, and these impacts will be highly localised and temporary. Given the small scale of impacts from scour during operation which the installation of scour protection would suppress it is considered that over the project lifetime these impacts would not combine to represent an increase in the significance level. |

| | Highest level significance | | | | |
|---|---|---|---|---|---|
| Receptor | Construction | Operational | Decommissioning | Phase Assessment | Lifetime Assessment |
| | | | | impacts on receptors in ***Chapter 9 Benthic Ecology*** and ***Chapter 10 Fish and Shellfish Ecology***). It is therefore considered that the interaction of these impacts would not represent an increase in the significance level.<br><br>***Operation***<br><br>*Impact 1 Deterioration in offshore water quality due to increased SSC due to scour around foundation structures* and *Impact 2 Deterioration in water quality (offshore and coastal) due to re-suspension of sediment bound contaminants as a result of scour* have potential to interact however given the scale of disturbance from scour during operation there would be limited pathways for interaction for these impacts during the operational stage. It is therefore considered that the interaction of these impacts would not represent an increase in the significance level. | |

## 8.10 Inter-relationships

150. There are a number of inter-relationships between MWSQ and several other topics that have been considered within this ES. ***Table 8.17*** provides a summary of the principal inter-relationships and sign-posts where those issues have been addressed in relevant chapters

**Table 8.17 Chapter topic inter-relationships**

| Topic and description | Related Chapter | Where addressed in this Chapter | Rational |
|---|---|---|---|
| Effects on water column (SSCs) | ***Chapter 9 Benthic Ecology***<br>***Chapter 10 Fish and Shellfish Ecology***<br>***Chapter 11 Marine Mammals***<br>***Chapter 13 Commercial Fisheries*** | Construction - ***sections 8.6.1.1 – 8.6.1.5***<br>Operation – ***section 8.6.2.1***<br>Decommissioning – ***section 8.6.3.1*** | Increased SSCs could cause disturbance to fish, marine mammal and benthic species through smothering and forming a barrier. |
| Effects on water column (contamination) | ***Chapter 9 Benthic Ecology***<br>***Chapter 10 Fish and Shellfish Ecology***<br>***Chapter 11 Marine Mammals***<br>***Chapter 13 Commercial Fisheries*** | Construction – ***section 8.6.1.6***<br>Operation – ***section 8.6.2.1***<br>Decommissioning – ***section 8.6.3.1*** | Resuspended contaminants could be absorbed by organisms and so enter the food chain including a risk of human consumption if contaminated fish and shellfish are caught. |

## 8.11 Summary

151. All phases of the proposed East Anglia ONE North project could impact on MWSQ. The magnitude of these effects has been assessed using expert assessment, drawing from a wide science base that includes project-specific surveys, area specific surveys and previous numerical modelling activities. Specifically, information provided in ***Chapter 7 Marine Geology, Oceanography and Physical Processes*** is integral to the determination of the assessment of effects in this chapter.

152. The effects that have been assessed are all anticipated to result in either negligible or minor adverse impacts and these are listed in ***Table 8.18*** below.

153. No cumulative or transboundary impacts have been identified for MWSQ.

**Table 8.18 Potential Impacts Identified for Marine Water and Sediment Quality**

| Potential Impact | Receptor | Value/ Sensitivity | Magnitude | Significance | Example of Potential Mitigation Measure | Residual Impact |
|---|---|---|---|---|---|---|
| **Construction** | | | | | | |
| Impact 1a: Deterioration in offshore water quality due to increased SSCs due to sediment plume created by sea bed preparation including sand wave levelling during installation of foundations. | Water quality | Low | Low | Minor adverse | None proposed | **Minor adverse** |
| Impact 1b: Deterioration in offshore water quality due to increased SSCs due to drill arisings for installation of piled foundations. | Water quality | Low | Low | Minor adverse | None proposed | **Minor adverse** |
| Impact 2: Deterioration in water quality due to increased SSCs during installation of the offshore export | Water quality | Low | Low | Minor adverse | None proposed | **Minor adverse** |

| Potential Impact | Receptor | Value/ Sensitivity | Magnitude | Significance | Example of Potential Mitigation Measure | Residual Impact |
|---|---|---|---|---|---|---|
| cable including sand wave levelling | | | | | | |
| Impact 3: Deterioration in offshore water quality due to increased SSCs during inter-array and platform link cable installation including sand wave levelling | Water quality | Low | Low | Minor adverse | None proposed | **Minor adverse** |
| Impact 4: Deterioration in water and bathing water quality due to works at the offshore export cable landfall | Water quality | Low | Low | Minor adverse | None proposed | **Minor adverse** |
| Impact 5: Deterioration in water quality (offshore and coastal) due to re-suspension of sediment bound contaminants. | Water quality | Low | Negligible | Negligible adverse | None proposed | **Negligible** |

| Potential Impact | Receptor | Value/ Sensitivity | Magnitude | Significance | Example of Potential Mitigation Measure | Residual Impact |
|---|---|---|---|---|---|---|
| **Operation** | | | | | | |
| Impact 1: Deterioration in offshore water quality due to increased SSCs due to scour around foundation structures. | Water quality | Low | Negligible | Negligible adverse | None proposed | **Negligible** |
| Impact 2: Deterioration in water quality (offshore and coastal) due to re-suspension of sediment bound contaminants as a result of scour | Water quality | Low | Negligible | Negligible | None proposed | **Negligible** |
| **Decommissioning** | | | | | | |
| Impact 1: Deterioration in water quality due to increased SSCs during removal of accessible installed components | Water quality | Low | Low/ Negligible | Minor/ Negligible adverse | None proposed | **Negligible /minor adverse** |

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