Vattenfall Wind Power Ltd
Thanet Extension Offshore Wind Farm

Sand Wave Clearance, Dredging and Drill Arising: Disposal Site Characterisation

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Vattenfall Wind Power Ltd

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14 Dredging and Drill Arising: Disposal Site Characterisation

14.1 Introduction

14.1.1 This document comprises the site characterisation for the Thanet Extension Offshore Wind Farm (Thanet Extension) as required to permit disposal of seabed and sub bottom geological material that may arise during the construction of the Thanet Extension project.

14.1.2 Site characterisation is the process whereby a proposed marine disposal site for dredged material and drill arisings is described in terms of its existing environment, using all available data sources. A full site characterisation report must be submitted to the Marine Management Organisation (MMO), and their scientific advisers Cefas, to inform the decision-making process with regard to the proposed marine disposal. Such a report should contain the following information as a minimum;

- The need for the new disposal site;
- The dredged and/ or drill arising material characteristics;
- The disposal site characteristics;
- The assessment of potential effects; and
- The reasons for the site selection.

14.1.3 This document outlines the site characterisation for two proposed disposal sites, the array area and the Offshore Export Cable Corridor (OECC). The disposal will involve material originating from dredging, drilling and sand wave clearance activities associated with the construction of Thanet Extension. This Disposal Site Characterisation approaches disposal within the array area and OECC separately.

Project Overview

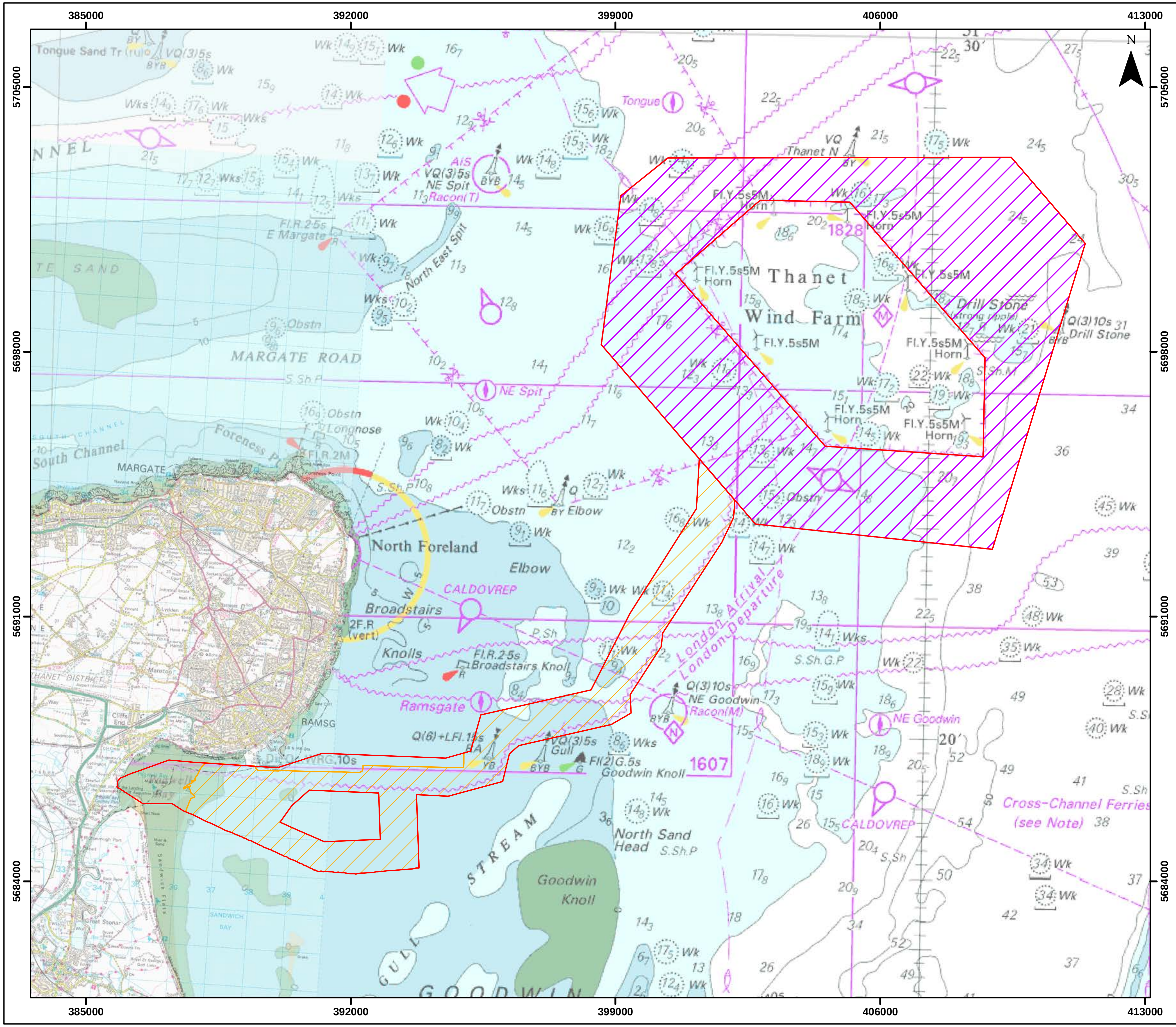
14.1.4 Vattenfall Wind Power Ltd (VWPL) is proposing the development of the Thanet Extension. The array area is approximately 69 km^2, and located approximately 8 km north-east of the Isle of Thanet and situated around the existing Thanet Offshore Wind Farm (TOWF). It would have a generating capacity of 340 MW and the offshore components will be comprised of up to 34 Wind Turbine Generators (WTGs), one meteorological mast (Met Mast) (if required), one Offshore Substation (OSS) (if required), inter-array cables and up to four offshore export cable circuits (and associated scour/ cable protection). The OECC extends approximately 30 km in length from the south-western boundary of the Thanet Extension array area in a south-westerly direction to Pegwell Bay on the Kent coast. The electricity generated will be transmitted via a maximum of four buried High Voltage Alternating Current (HVAC) cable circuits.

14.1.5 Proposed development boundaries of the offshore components are shown in Figure 14.1.

14.1.6 Three foundation options are being considered to secure the WTGs, Met Mast and OSS:

- Piled monopole foundations;
- Piled quadropod or tripod jacket foundations; and
- Suction caisson quadropod or tripod jacket foundations.

14.1.7 The final selection of foundation type(s) will be dependent on a range of factors including turbine size, seabed conditions, water depth, environmental considerations and supply chain considerations. Therefore, the type will not be confirmed until the final design and post-consent phase.



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THANET EXTENSION OFFSHORE WIND FARM

Figure 14.1

Thanet Extension Offshore Wind Farm Proposed Development Boundary.

Legend

- Offshore Red Line Boundary
- Proposed Disposal Site (Array)
- Proposed Disposal Site (OECC)

Datum: ETRS 1989
Projection: UTM31N

1:100,000 — 0 1 2 km — 0 0.55 1.1 nm

Drg No	TEOW_ES_DSL_Fig_14.1			Figure 14.1
Rev	0.1	Date	07/06/2018	
By	DP	Layout	N/A	

14.2 Predicted Source and Spoil Amounts

Sources of spoil

Array

14.2.1 Spoil is predicted to be generated from the installation of all the foundation types listed in paragraph 14.1.6.

14.2.2 Depending on site specific ground conditions, drilling may be required to install piles to their target depth. The drilling is anticipated to be to depths no greater than 30 m on average. Spoilage created by drilling is disposed of adjacent to the foundation location, and generally comprises inert sub bottom geological material that is very unlikely to result in the introduction of contaminants to the marine environment. Disposal of drill arisings adjacent to installed foundations has been used on existing UK Offshore Wind Farms (OWFs), including London Array and Hornsea Project One, amongst others. Monitoring of benthic communities associated with OWF drill arisings has indicated no long-term adverse effects on the overall benthic ecology of the study area (JNCC, 2013).

14.2.3 For suction caisson foundations, any soft mobile or unlevel sediment in the area of installation will need to be removed from the seabed to provide a firm, level surface. Initial investigations (See Environmental Statement (ES), Volume 2, Chapter 2: Marine Geology, Oceanography and Physical Processes (Document Ref: 6.2.2)) have shown some variability in the seabed topography with sand waves of 1.5 m taking up one third of the array area as well as larger 8 m sand waves in areas. For the installation of the suction caisson foundations, seabed preparation of up to 3 m depth will be required. Dredged material will be collected by a commercial-scale suction dredger which will release dredged sediment at the water surface within the array area.

OECC

14.2.4 Sand wave clearance, via dredging, is expected to be required for up to 20% of each 30 km export cable circuit within the OECC (maximum of four export cable circuits). This is to enable the export cable circuits to be installed. As with the suction dredger, it is anticipated that dredged material will be disposed of within the export cable corridor. This approach will ensure that material is retained within the local system.

Volume of spoil

Array

14.2.5 The Project Description - Offshore (Document Ref: 6.2.1) described the scope of options still being evaluated for the Thanet Extension project. This leads to a vast number of scenarios in terms of dredging and drilling. Table 14.1 shows the worst-case volumes of material which will be disposed during the construction of Thanet Extension.

Table 14.1: Summary of spoil volumes for the worst-case scenario for each foundation type. Taken from Environmental Statement Volume 2, Chapter 2: Marine Geology, Oceanography and Physical Processes (Document Ref: 6.2.2)

Aspect	Monopile (drilled) (34 x 10 MW)	Suction Caisson (dredged) (28 x 12 MW)
Spoil volume based for foundations (m^3)	19,627 (50% drilled to 30 m)	268,800 (dredged) (9,600 x 28)
Spoil volume of OSS (m^3)	1,000	9,600
Spoil volume of Met Mast (m^3)	1,155	9,600
Total (m^3):	21,782	288,000

OECC

14.2.6 The project predicts a maximum of 20% of each export cable circuit will require sand wave clearance to enable the offshore export cable circuits to be installed correctly. The export cable corridor is 30 km in length with a maximum of four export cable circuits. Therefore, it is assumed that each cable circuit will require up to 6 km of sand wave clearance leading to a maximum of 24 km of sand wave clearance in total. A more detailed understanding of the required clearance will be gained during the detailed design phase. The volumes of material associated with this activity are summarised in Table 14.2.

Table 14.2: Summary of spoil from sand wave clearance activities within the Offshore Export Cable Corridor (OECC)

Aspect	Sand wave clearance in OECC
Spoil volume (m^3) (Assumes a 20% route clearance (6 km per cable), 2 m sand wave height, 20 m wide channel, 1:5 gradient resulting in 10 m sidewalls. This leads to 60 m^3 of sand cleared per meter of route).	1,440,000

14.3 Alternative Options for Disposal

14.3.1 Once drilled or dredged material has been produced, it is classed as a waste material. Once a material has entered the waste stream it is strictly controlled. Disposal of dredged and drilled material is controlled under the London Convention (1972), the Oslo-Paris Commission (OSPAR) Convention (1992) and the EU Waste Framework Directive 2008/98/EC. At the core of the Waste Framework Directive is the Waste Hierarchy which comprises: prevention; re-use; recycle; other recovery; and disposal (Defra, 2011). Where prevention or minimisation is not possible, management options for dealing with waste material must consider the alternative options in the outlined order of priority (i.e., re-use, recycle, other recovery and then disposal). The consideration of alternatives for disposal of drilled and/ or dredged material within the array area and the cable route corridor is, therefore, an important part of the site characterisation process and is required in order to inform the decision-making process led by the MMO and their advisers. The following sections of this document present information on potential alternative options for the disposal of drilled, dredged, and cleared material produced in the construction of Thanet Extension.

Prevention

14.3.2 The Waste Hierarchy places a strong emphasis on waste prevention or minimisation of waste. However, consent is being sought for the potential use of a range of foundations for Thanet Extension (see paragraph 14.1.6). Three foundation types for WTGs are being considered at this stage. More information is required to inform the final foundation choice, i.e., which options are the most economic and technically appropriate for the project. It is possible that more than one type of foundation may be used across the array area (see paragraph 14.1.7 for reasons). For the design envelope, it is assumed that up to 50% of WTG foundations may require drilling to assist with installation. However, all monopile foundations were successfully installed at TOWF using piling alone with no drilling required.

14.3.3 If suction caisson foundations are to be installed at Thanet Extension then seabed preparation works and the associated dredging and disposal works will be unavoidable.

14.3.4 Sand wave clearance along 20% of each export cable circuit within the OECC is expected. Sand wave clearance is unavoidable when crossing areas of sand waves with gradients in excess of the working limits of the standard installation equipment. This is due to the unnecessary strain from bending of the cables, reduced ploughing efficiency and increased chance of failed burial of the cables.

Re-use

14.3.5 Where prevention is not possible, re-use of the dredged and drilled material is the preferred option. Potential options for the re-use of drilled and/ or dredged material from Thanet Extension are listed below:

- Beach nourishment schemes;
- Land reclamation schemes; and
- Habitat enhancement schemes.

14.3.6 The material proposed to be disposed of within the array and OECC could potentially have alternative uses. Transfer of the volume of material expected to be created from the construction activities to another location where this alternative use may be required would consist of 288,000 m^3 dredged within the array area (turbines, Met Mast and OSS, see Table 14.1 for details) and 1,440,000 m^3 of material from sand wave clearance in the OECC. Alternative uses are most likely to be based on land. This would require approximately 27 dredging cycles from the array and 131 dredging cycles from the OECC based on a commercial-scale suction dredger (assuming a hopper capacity of 11,000 m^3). Each cycle would form a round trip of at least 16 km per trip to the closest port of Ramsgate (8 km).

14.3.7 Collection of the drill arisings (21,782 m^3) would be costly due to the need for suction equipment as well as drilling vessels and the limited material produced at each foundation site would cause the collection to be unviable.

14.3.8 The dredger movements would lead to environmental impacts due to fuel emissions that would be avoided if the dredged material was permitted to be disposed of *in situ* within the proposed disposal sites of the array and OECC.

14.3.9 At the time of writing, no specific projects have been identified that could accept material from Thanet Extension. Therefore, it is expected that even if all this material could be re-used, this would be via multiple projects in different locations. This would, therefore, increase the number of transits to and from Thanet Extension with the related environmental impacts, such as those due to fuel emissions.

14.3.10 Another factor to consider with respect to the specific disposal of drill arisings away from Thanet Extension is that any vessel used to transport these materials from the drilling location to either an existing licensed disposal site and/ or locations where alternative uses for the material may be found would need to deploy at least a four-point pattern anchor next to the drilling barge prior to every loading event (anchoring would not be required for the removal of dredged material off-site as the vessel that would transport the materials off-site would be the same vessel that carried out the dredging activity).

14.3.11 Deployment of up to six anchors at every drilling location/ foundation installation would represent an additional impact on the seabed over and above those already identified via other construction activities. Disposal of drill arisings, and in the case of the OECC dredging sands and gravels *in situ* would, therefore, remove this impact.

Recycle

14.3.12 Recycling of drilled and dredged material is where the material is in a different form to that which it is in originally, e.g. to produce bricks or aggregate material. As outlined in the MMO guidance (MMO, 2011), these are generally land-based solutions with any material produced used in land construction projects. As such, the same issues with respect to vessel movements to transport the dredged material to land, discussed previously in the re-use section, would also apply and would be avoided if any drilled and dredged material was permitted to be disposed of *in situ*.

Other recovery

14.3.13 There are currently very few examples of recovery from dredged/ drilled material (MMO, 2011) and no such options have been identified for the drilled and/ or dredged material from Thanet Extension.

Disposal

14.3.14 With respect to disposal at an existing marine disposal site, the closest open marine disposal site to Thanet Extension is the Nemo site B disposal site, located approximately 7 km from the array area. Other dredge disposal sites are also present locally to enable disposal of harbour clearance arisings, such as those from the Ramsgate Harbour approaches. Both the disposal site characterised for Nemo, and those for Ramsgate Harbour are designated to enable specific locations to be cleared, and in turn specific locations to receive that material.

14.3.15 It is not considered desirable to try and employ the same disposal site as Nemo, as this was not designated for the additional volumes associated with Thanet Extension, and would result in either drill arisings or sands and gravels to be transported away from the immediate vicinity from which they were removed and deposited in a site that may have a different sediment composition. Disposal within the Thanet Extension project area however, ensures that a broadly similar sediment composition is retained, or in the case of drill arisings that the arisings are retained next to the WTGs and minimising the spread of the material.

14.3.16 To enable further disposal of material at the disposal sites identified in the 'Waste disposal sites' section of this document, such as Ramsgate Harbour, paragraph 14.4.57 and Table 14.5, further site characterisation of the area around the existing disposal site would be required along with hydrodynamic modelling studies to determine the capacity of this site in terms of additional disposal material.

14.3.17 Noting that this document represents the site characterisation for Thanet Extension, there is no strong argument for undertaking another site characterisation in the area around the existing sites if one has already been carried out for the Thanet Extension area, especially when the conclusions of this characterisation (as set out in the Thanet Extension ES) have demonstrated no **Major** adverse impacts of disposal activities on any receptors in the Thanet Extension project area.

14.4 Characteristics of the Disposal Sites

Physical characteristics of the array

Tidal and wave regime

14.4.1 Throughout the array area water depths range between -11.5 m and -45 m below Lowest Astronomical Tide (LAT). Eastern and north-eastern areas of the array are generally deeper, with the greatest water depths encountered along the south-east margin of the array area. The typical spring tidal range is 4.3 - 4.6 m, with a neap range of 2.4 – 2.6 m (VWPL, 2015; ABPmer et al., 2008). Extreme water levels at the proposed development are generally formed by storm surges which can reach elevations between 2.65 – 2.80 m for a 1:50 year event (VWPL, 2015). The dominant wave directions within the array area are from the north-east. Within the Thanet Extension array area, significant wave heights (Hs) are in the range 0 - 1 m for approximately 65 - 80% of the time whilst waves between 1 - 2 m in height occur for approximately 20 - 30% of the time. The maximum wave height throughout the 38-year record is 5.84 m. Mean wave periods (Tm) are typically in the range 3 - 6 seconds and are indicative of a setting in which wind waves generally dominate.

14.4.2 Mean sea level is predicted to rise during the 21st Century because of either vertical land (isostatic) movements or changes in eustatic sea level. It is predicted in UKCP09 that by 2050, relative sea level will have risen by approximately 0.35 m above 1990 levels (medium emissions scenario) at the landfall site with rates of change increasing over time (Lowe et al., 2009). A rise in sea level may allow larger waves, and therefore more wave energy, to reach the coast in certain conditions and consequently result in an increase in local rates or patterns of erosion and the equilibrium position of coastal features.

14.4.3 Current flow is stronger towards the south of the array area due to the higher tidal range and Dover Strait where land masses narrow. Within the array area, depth averaged mean spring currents are in the approximate range of 0.7 – 1.2 m/s and neap flows between 0.4 – 0.7 m/s. Maximum surface flow speeds of 1.3 – 1.7 m/s are present across the array area (ABPmer et al., 2008).

Seabed geology

14.4.4 Figure 14.2 shows that the Thanet Extension array area mainly consists of sand and gravel with variable contributions of silt and clayey/ silty sand. The north-west array area consists of mainly fine to medium sand, with clayey silty sand also present. The north and east array area consists of fine to coarse sand with pockets of clay/ silt and sand/ gravel.

14.4.5 Extensive areas of Cretaceous chalk are covered by varying thicknesses of tertiary marine sediments throughout the Thanet Extension array area, such as mudstones and fine grained muddy sands which are suggested to have high organic contents.

14.4.6 A summary of the interpreted geology is presented in Volume 2, Chapter 2: Marine Geology, Oceanography and Physical Processes (Document Ref: 6.2.2) and in Volume 4, Annex 2-1: Marine Geology, Oceanography and Physical Processes Technical Annex (Document Ref: 6.4.2.1).

Bedforms and sediment transport

14.4.7 There are a variety of bedforms within the array area. Current induced large and very large sand waves have wavelengths of 50 – 600 m and heights of up to 8 m are present in the northern section of the array area. Small to medium dunes, wavelengths 3 – 13 m and maximum height 1.5 m, occupy a third of the array area. There is potentially a reef (formed by S. spinulosa), 3.5 km by 1.3 km, in the north-east of the array area.

14.4.8 These bedforms cause gradients of generally 5 degrees or less, however, large sand waves in the north-east are associated with gradients of up to 32 degrees.

14.4.9 Tidal currents are the main cause of sediment transport within the array area with the largest material expected to be mobilised being medium to coarse sized sand (up to approximately 500 µm). The main transport direction is southerly with sand wave migration of approximately 6 – 12 m/year occurring in the north and east areas of the array site.

14.4.10 A summary of the survey types and results is presented in Volume 2, Chapter 2: Marine Geology, Oceanography and Physical Processes (Document Ref: 6.2.2) and in Volume 4, Annex 2-1: Marine Geology, Oceanography and Physical Processes Technical Annex (Document Ref: 6.4.2.1).

Suspended sediment concentrations

14.4.11 Monthly averaged satellite imagery of Suspended Particulate Matter (SPM) suggests that within the Thanet Extension array area average (surface) SPM is generally greater than 10 mg/l, increasing markedly throughout winter months to values between 30 - 80 mg/l (Eggleton et al., 2011; Cefas, 2016), occasionally reaching up to 100 mg/l. Higher values are anticipated during spring tides and storm conditions, with the greatest concentrations encountered close to the bed.

Physical characteristics of the OECC

Tidal and wave regime

14.4.12 In offshore sections of the OECC, the wave regime is dominated by waves from the north-east and southwest. However, the inshore OECC area becomes sheltered from westerly waves that propagate through the Thames Estuary such that within Pegwell Bay prevailing waves are almost entirely from the north-east and south-east. Within Pegwell Bay the maximum Hs value recorded is 2.25 m (in comparison to ~5.8 m for offshore areas within the array area).

14.4.13 Throughout inshore and offshore parts of the OECC mean spring peak currents are predominantly between approximately 0.9 - 1.1 m/s but reach approximately 1.3 m/s in localised areas (ABPmer et al., 2008).

Seabed geology

14.4.14 Seabed sediments along the OECC are predominantly characterised by sands and gravels with varying contributions of each. The north-eastern extent of the OECC (close to the Thanet Extension array area) comprises mixed sand/ gravel. Increasing contributions of sand and clay occurs within mid sections, with further fine sand and clay contributions within inshore and nearshore areas. The surficial sediment layer varies in thickness throughout the OECC, although it predominantly acts as a mobile surface layer on top of underlying geological features.

14.4.15 Sediments in Pegwell Bay comprise of fine to very fine sands. Within the bay, fine surface sediments are re-suspended, moved around in the water column as the tide ebbs and flows and eventually deposited elsewhere. A summary of the interpreted geology is presented in Volume 2, Chapter 2: Marine Geology, Oceanography and Physical Processes (Document Ref: 6.2.2) and in Volume 4, Annex 2-1: Marine Geology, Oceanography and Physical Processes Technical Annex (Document Ref: 6.4.2.1).

Bedforms and sediment transport

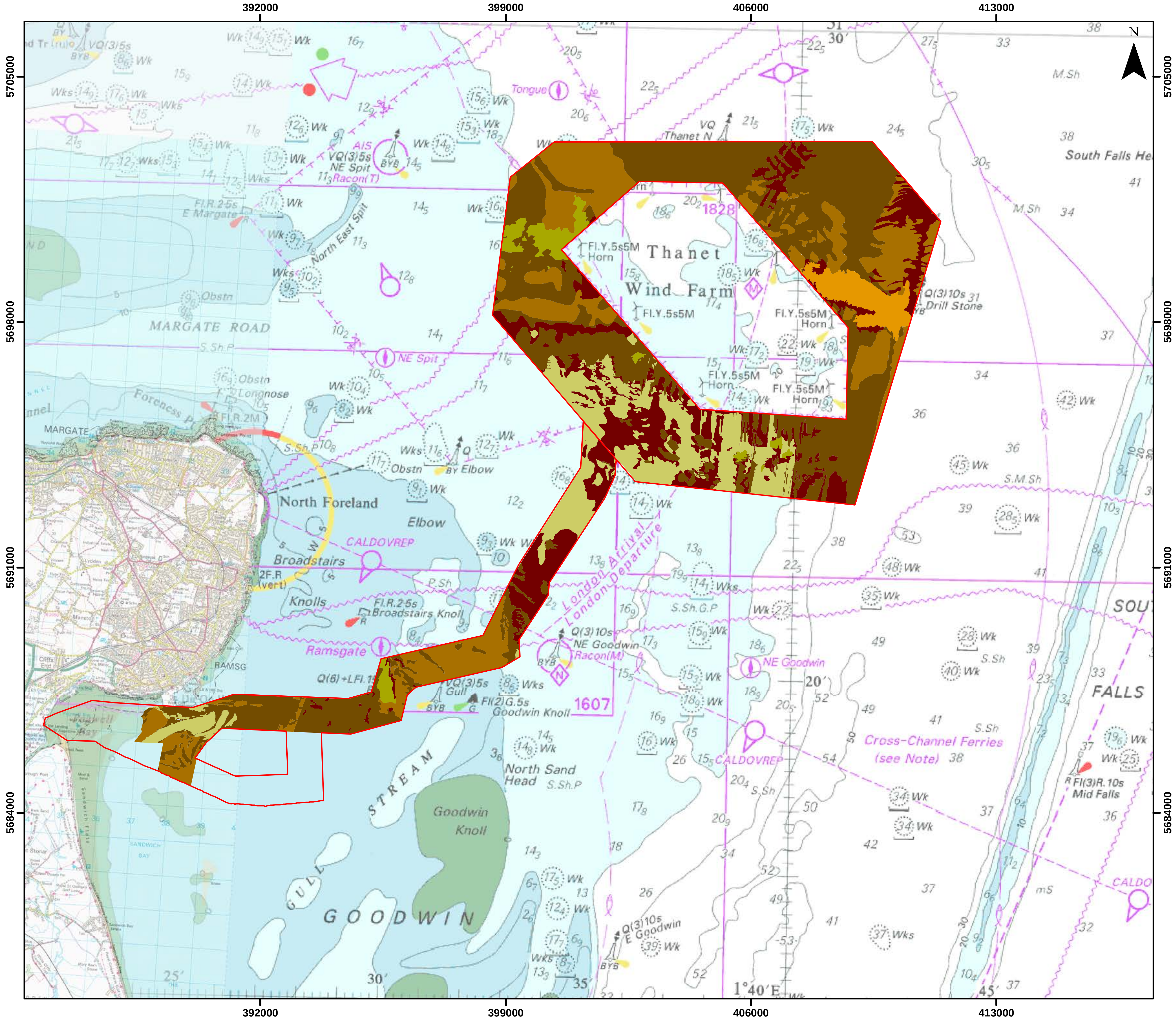
14.4.16 Water depths throughout the OECC range between 0 m and -18.0 m below the LAT, and generally increase south-west to north-east from the coastline to the boundary with the array area. Sand waves of wavelengths 8 – 250 m and height between 1 – 3 m are found predominantly in the south-western section. Smaller wavelengths of 3 – 10 m and heights of 0.1 – 0.6 m are found throughout the OECC (Figure 14.3). Bed slope gradients are typically less than 5 degrees; however, a number of localised ridges are significantly steeper (up to 35 degrees), mainly associated with plateau-like outcrops and seabed ridges within central and western sections of the OECC.

14.4.17 Tidal currents transport sand and silt as suspended load into Pegwell Bay. However, the majority of sediment transport throughout Pegwell Bay occurs during storm surge conditions.

14.4.18 A summary of the survey types and results is presented in Volume 2, Chapter 2: Marine Geology, Oceanography and Physical Processes (Document Ref: 6.2.2) and in Volume 4, Annex 2-1: Marine Geology, Oceanography and Physical Processes Technical Annex (Document Ref: 6.4.2.1).

Suspended sediment concentrations

14.4.19 Suspended sediment concentrations are found to increase with greater proximity to the coast and are at their highest within nearshore and inshore areas of the OECC. This is likely due to a combination of enhanced re-suspension from wave activity within shallower water and fluvial input of sediment. In general average (surface) SPM remains above 10 to 20 mg/l throughout summer months and above 40 mg/l during winter (Eggleton et al. 2011).



THANET EXTENSION OFFSHORE WIND FARM

Figure 14.2

Thanet Extension Offshore Wind Farm Sediment Distribution.

Legend

- Offshore Red Line Boundary

Sediment Classification[1]

- Clayey Sand
- Fine to Coarse Sand
- Gravelly Sand
- Sandy Gravel
- Outcrop
- 'Drill Stone' reef

Datum: ETRS 1989
Projection: UTM31N

Notes
[1] Data from the Thanet Extension Geophysical Survey conducted by Fugro Emu Ltd, July to September 2016

1:108,828 — 0 1 2 km — 0 0.6 1.2 nm

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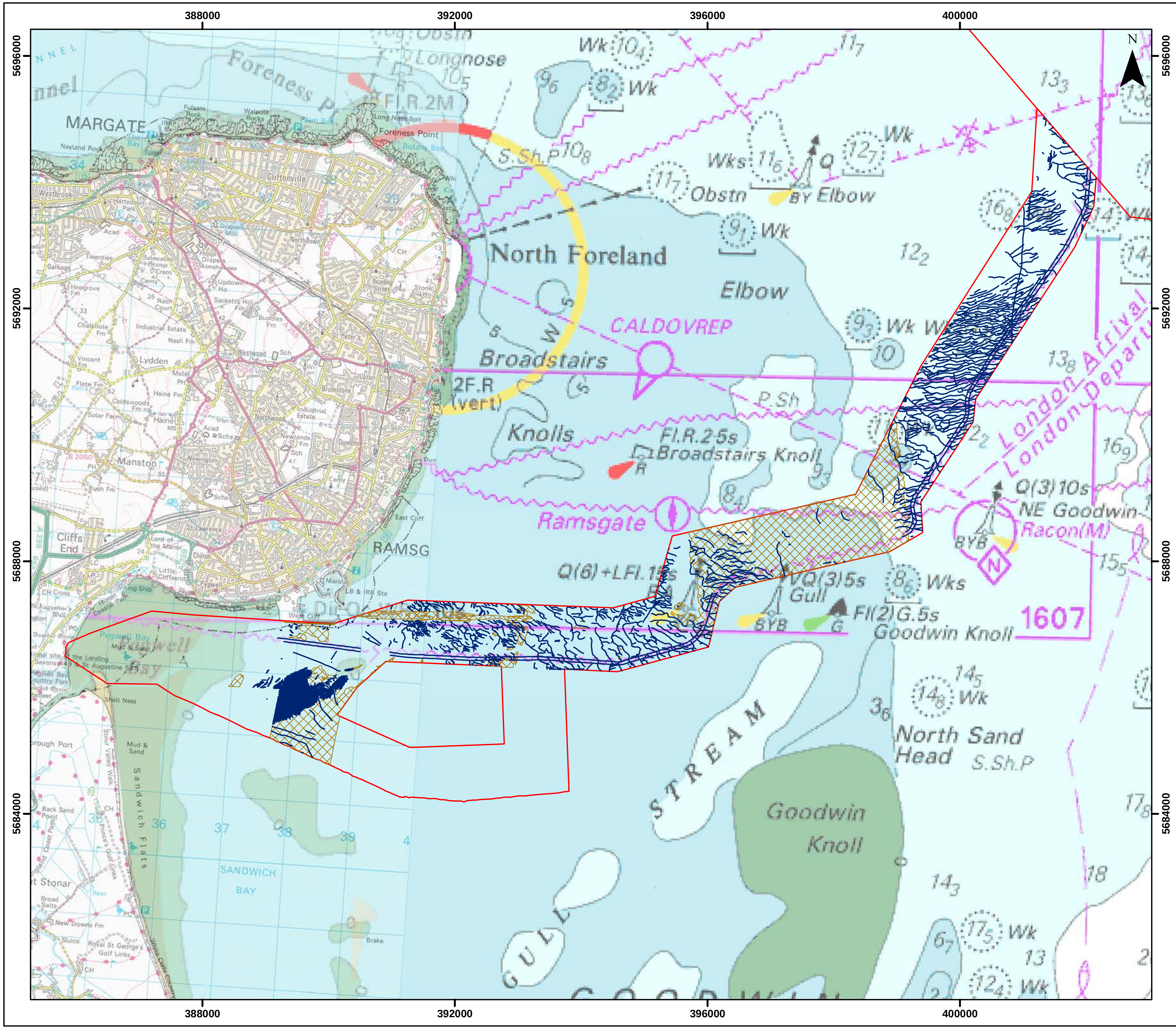
By	DP	Layout	N/A	



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THANET EXTENSION OFFSHORE WIND FARM

Figure 14.3

Seabed features within Thanet Extension OECC.

Legend

- Offshore Red Line Bounary
- Ridge Crest
- Small to Medium Sandwaves

Datum: ETRS 1989
Projection: UTM31N

1:60,000 — 0, 0.65, 1.3 km — 0, 0.35, 0.7 nm

Drg No	TEOW_ES_DSL_Fig_14.3		
Rev	0.1	Date	25/05/2018
By	DP	Layout	N/A

Figure 14.3

Biological characteristics of the array

Benthic subtidal ecology

14.4.20 Three biotopes were identified in the array area from the video surveys: sublittoral sands and muddy sands (SS.SSa) was the dominant biotope, identified at 20 sites in the array survey area; circalittoral mixed sediment (SS.SMx.CMx) was the second most common biotope, with nine sites being observed as this biotope; and soft rock communities (CR.MCR. SfR) was identified at one site in the survey area. SS.SSa observed in this area was characterised by epibiota comprising of crustaceans, gastropods and echinoderms. SS.SMx.CMx is a naturally variable habitat and was reflected in the variety of communities identified, which included polychaetes, bivalves, echinoderms and burrowing anemones. CR.MCR.SfR featured chalk overlain with sediment and the epibiota included *Actinaria*.

14.4.21 Four biotopes were identified from grab samples: Mysella bidentata and Thyasira spp. in circalittoral muddy mixed sediment (SS.SMX.CMx.MysThyMx); Sabellaria spinulosa on stable circalittoral mixed sediment (SS.BSR.PoR.SspiMx); *Fabulina fabula* and *Magelona miribalis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand (SS.SSa.IMuSa.FfabMag); and *Nephtys cirrosa* and *Bathyporeia spp*. in infralittoral sand (SS.SSa.IFiSa.NcirBat).

14.4.22 SS.SMX.CMx.MysThyMx was characterised as muddy sands and gravels in moderately exposed or sheltered, circalittoral habitats, containing bivalve species such as *Thyasira flexuosa* and *Mysella (Kurtiella) bidentata*. Infaunal species included (but is not limited to) the polychaetes *Lumbrineris gracillis*, *Chaetozone setosa* and *Scoloplops armiger* whilst amphipods of the genus *Ampelisca* may also be present. Epibiota identified included brittlestars and bryozoans.

Fish and shellfish ecology

14.4.23 Fish monitoring undertaken at the existing TOWF recorded numerous flatfish; particularly dab (*L. limanda*), plaice (*P. platessa*), Dover sole (*S. solea*), and to a lesser extent, flounder (*P. flesus*) and lemon sole (*M. kitt*). Round fish included whiting (*M. merlangus*), pouting (*T. luscus*), gobies (*Gobidae*), and *Clupeidae* (the family that herring belong to).

14.4.24 A total of 11 commercially important species of fish and four species of shellfish were recorded in the array area with the most abundant fish species being pouting and the most abundant shellfish species being the common whelk (*B. undatum*). Sampling undertaken across the survey area revealed a diverse fish and epifaunal assemblage with a total of 69 taxa recorded. A total of 20 species of fish and 49 species of macroinvertebrate were recorded with the most abundant invertebrate species being the brittlestar, (*Ophiuroidea. albida*), and the most abundant fish species group being the Dover sole.

14.4.25 Only two species of elasmobranch were recorded across the survey area, the small-spotted catshark (*Scyliorhinus canicular*) and the thornback ray (*Raja clavate*). The small-spotted catshark was the more abundant of the two elasmobranch species sampled from the survey area and was widespread, recorded across a range of habitat types.

14.4.26 The array area overlaps with several fish species spawning areas. Sole and plaice are the only species with high intensity spawning grounds within the array site whilst cod, sandeel and lemon sole are characterised as low intensity.

14.4.27 Herring, thornback ray, cod, whiting, sandeel, mackerel, plaice and sole are the only fish species who use the site as a low intensity nursery area.

Marine mammals

14.4.28 The most abundant marine mammals surveyed within the Thanet Extension array area were Harbour porpoises (*Phocoena phocoena*), harbour seals (*Phoca vitulina*) and grey seals (*Halichoerus grypus*). The most reliable data for harbour porpoises gave a density of 0.607 porpoises/ km^2 and a total abundance of 19,064 within the surveyed area. The harbour porpoise population does fluctuate over the year with higher values in late winter.

14.4.29 Harbour seals are found around the UK. The only harbour seal density data available was produced from at-sea usage maps and estimates 0.142 seals/ km^2 within the array area.

14.4.30 There are no key breeding regions for Grey seals within the Thanet Extension project area and the population is growing. The only grey seal density data available was produced from at-sea usage maps and estimates 0.04 seals/ km^2 within the array area.

14.4.31 Dolphin and whale species were either not recorded during the survey, or their numbers were recorded in such low quantities that they could be removed from the impact assessment for Thanet Extension.

14.4.32 For information regarding survey methods and results see ES, Volume 2, Chapter 7: Marine Mammals (Document Ref: 6.2.7).

Designated sites of nature conservation importance

14.4.33 The array area overlaps with the eastern section of the southern North Sea cSAC (Candidate Special Area of Conservation). It is located 3.1 km to the East of Margate and Long Sands SCI; 4.3 km to the East of the Outer Thames Estuary SPA (Figure 14.4). Benthic surveys within the array identified a potential *S. spinulosa* reef which is of importance for conservation. This type of reef has been identified previously in the array area and the TOWF.

14.4.34 The sites highlighted as the most sensitive to increased sediment deposition were evaluated as being under no significant effect from the proposed disposal activities.

14.4.35 A full pre-construction survey for *S. spinulosa* reefs will be conducted as part of the Biogenic Reef Mitigation Plan (Document Ref: 8.15). The outcome of this survey will ensure that adequate micrositing will be used to avoid any impact from construction and disposal.

Biological characteristics of the OECC

Benthic subtidal ecology

14.4.36 The same biotopes identified within the array area were identified in the subtidal area of the OECC. The landfall location within Pegwell Bay is characterised by rocky platforms with sandmason worms (*Lanice conchilega*) and mussels (*M. edulis*) at the top of the shore and extensive areas of sand/ muddy sand flats characterised by *Lanice spp., Arenicola* beds, *M. balthica* and cockles, while *C. volutator* and a variety of polychaetes with fringing saltmarsh and muddier habitats are found further to the south around the Stour Estuary. The rocky platforms comprise of wave-cut chalk outcroppings found along the base of the chalk cliffs to the very north of the OECC (Pegwell Bay landfall option) and along the sea defences from Pegwell round to Ramsgate Harbour. Boulders are a common feature throughout this area and *M. edulis* is known to form reef structures on the chalk.

14.4.37 The midshore region comprises primarily of muddy sandflats, dominated by sandmason worms (*L conchilega*). Further to the south of the bay, closer to the River Stour, the sediment is muddier and the polychaetes (*A. marina* and *Nephtys spp*.) are common.

Fish and shellfish ecology

14.4.38 The fish and shellfish assemblages within the OECC are similar to that of the array area. However, some species such as the small-spotted catshark, showed sexual segregation with females exclusively using the inshore area.

14.4.39 Herring is the only species with a high intensity nursery area located within the OECC. However, this may have shifted location according to the International Herring Larval Survey data (IHLS) (2005 - 2015) which suggest that there has been a shift to a population in the East English Channel.

Marine Mammals

14.4.40 The most abundant marine mammals surveyed within the Thanet Extension study area were Harbour porpoises (*Phocoena phocoena*), harbour seals (*Phoca vitulina*) and grey seals (*Halichoerus grypus*). The most reliable data for harbour porpoises gave a density of 0.607 porpoises/ km^2 and a total abundance of 19,064 within the surveyed area.

14.4.41 Harbour seals are found around the UK and a small haul-out site is located in Pegwell Bay (52 animals counted in August 2015) where the proposed OECC makes landfall. The only harbour seal density data available was produced from at-sea usage maps and estimates 0.186 seals/ km^2 in the OECC.

14.4.42 There are no key breeding regions for Grey seals within the Thanet Extension project area and the population is growing. The only grey seal density data available was produced from at-sea usage maps and estimates 0.05 seals/ km^2 in the OECC.

14.4.43 For information regarding survey methods and results see ES, Volume 2, Chapter 7: Marine Mammals (Document Ref: 6.2.7).

Designated sites of nature conservation importance

14.4.44 The OECC makes landfall within the Sandwich Bay Special Area of Conservation (SAC), Thanet Coast Marine Conservation Zone (MCZ), Sandwich Bay to Hacklinge Marshes Site of Special Scientific Interest (SSSI) and Thanet Coast and Sandwich Bay Special Protection Area (SPA) (Figure 14.4). The OECC is also situated to the south of the Thanet Coast SAC and the Thanet Coast SSSI, which is overlapped by the Sandwich Bay and Thanet Coast SPA and the Thanet Coast SAC and MCZ. Pegwell Bay supports an unusual reef assemblage of *M. edulis* and *S. spinulosa* which are habitats of conservation importance. Goodwin Sands rMCZ (recommended Marine Conservation Zone) has a potential overlap with the OECC. However, this site has not been designated and was therefore scoped out of the EIA for designated sites.

14.4.45 The location of current existing sites with respect to the OECC and the 12 km buffer at which any material produced by drilling or dredging will travel can be seen in Figure 14.4.

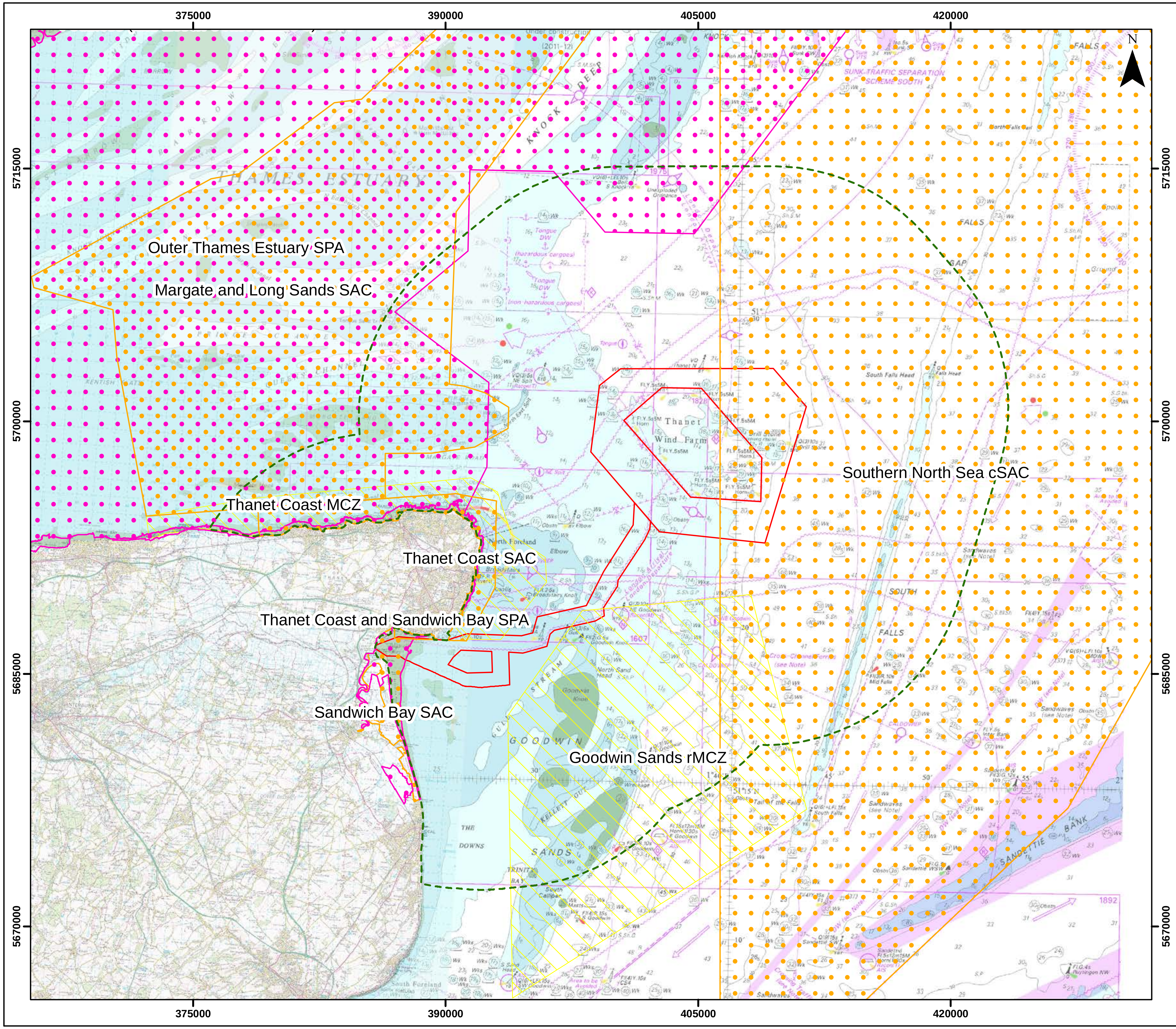
14.4.46 The sites highlighted as the most sensitive to increased sediment deposition were evaluated as being under no significant effect from the proposed disposal activities.

GoBe VATTENFALL

THANET EXTENSION OFFSHORE WIND FARM

Figure 14.4

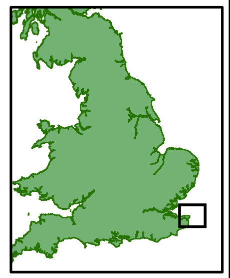
Designated Sites of Interest.



Legend

- Offshore Red Line Boundary
- 12 km predicted sediment buffer
- Special Protection Area
- Special Area of Conservation
- Marine Conservation Zone

Datum: ETRS 1989
Projection: UTM31N



1:225,000 — 0, 2.5, 5 km — 0, 1, 2 nm

Drg No	TEOW_ES_DSL_Fig_14.4			Figure 14.4
Rev	0.1	Date	25/05/2018	
By	DP	Layout	N/A	

Human environment characteristics of the array

Commercial fisheries

14.4.47 Commercial fisheries within the Thanet Extension project were assessed using surveillance and consultations. Several nations commercially use the area using a range of methods. These are summarised in Table 14.3 and in more detail in the ES, Volume 2, Chapter 9: Commercial Fisheries (Document Ref: 6.2.9).

14.4.48 The key ports identified in the MMO's Scoping response were the local ports of Margate, Broadstairs, Ramsgate, Whitstable, Deal, Queenborough, Dover and Folkestone. However, consultation undertaken directly by Thanet Fisherman's Association, as requested by VWPL, indicated that the vessels fishing in and around the proposed development were predominantly from four main ports: Ramsgate, Broadstairs, Margate and Whitstable.

14.4.49 Several methods are employed throughout the year including potting, trawling and drift netting. Seasonal methods are static netting for sole (March to November) and drift netting for cod (November to April).

14.4.50 The principle target species identified during consultation with local fisheries stakeholders include Dover sole, bass, skate, cod, plaice, mullet, herring, cuttlefish and shellfish (lobsters, edible crabs, whelks, mussel spate).

14.4.51 The grounds encompassed by the proposed development are extensively worked by the local fishing fleet with methods overlapping due to the specific seasonality of each fishery. Potting for lobsters and crabs can occur throughout the year in the area of the existing TOWF array area, the proposed development and OECC but is concentrated to the north of TOWF. Whelk pots can be found throughout the area to the west and south of the site, but are most intense along the OECC.

Table 14.3: Surveillance sightings (2011-2015) in ICES rectangle 31F1 by nationality and method

Nationality	Method	% of total Sightings in 31F1
United Kingdom	Potter/ Whelker	31.4
	Gill Netter	24.4
	Trawler (All)	14.7
	Other Dredges (Including Mussel)	5.8
	Scallop Dredger (French/ Newhaven)	2.2
	Drift Netter	1.3
	Beam Trawler	1.2
	Stern Trawler (Pelagic/ Demersal)	1.1
	Demersal Stern Trawler	0.8
	Rod and Line	0.7
	Bottom Seiner (Anchor/ Danish/ Fly/ Scots)	0.3
	Suction Dredger	0.1
	United Kingdom % of total sightings (all gears)	**84.0**
France	Trawler (All)	6.7
	Stern Trawler (Pelagic/ Demersal)	0.5
	Beam Trawler	0.1
	Demersal Stern Trawler	0.1
	Pair Trawler (All)	0.1
	Pelagic Stern Trawler	0.1
	Suction Dredger	0.1
	France % of total sightings (all gears)	**7.5**
Belgium	Beam Trawler	6.7
	Belgium % of total sightings (all gears)	**6.7**
Netherlands	Beam Trawler	1.2
	Trawler (All)	0.4
	Bottom Seiner (Anchor/ Danish/ Fly/ Scots)	0.1
	Pelagic Stern Trawler	0.1
	Stern Trawler (Pelagic/ Demersal)	0.1
	Netherlands % of total sightings (all gears)	**1.8**
Denmark	Bottom Seiner (Anchor/ Danish/ Fly/ Scots)	0.1
	Industrial Trawler (Sandeeler)	0.1
	Denmark % of total sightings (all gears)	**0.1**
Germany	Trawler (All)	0.1
	Germany % of total sightings (all gears)	**0.1**

Renewable energy developments

14.4.52 There are several consented offshore wind farms (OWF) within 30 km of the Thanet Extension project. These are summarised in Table 14.4. There are also a number of OWFs under construction across the southern North Sea. The closest is Galloper OWF (34 km from the array area and 45 km from the OECC).

Table 14.4: Offshore wind farms located within the infrastructure and other users study area

Offshore Wind Farm	Distance from array area (km)	Distance from OECC (km)
TOWF	0	3
London Array	11	19
Kentish Flats	27	21
Kentish Flats Extension	26	21

Cable and pipelines

14.4.53 Thanet Extension is in close proximity to the existing TOWF cables, which almost entirely overlap with the Thanet Extension boundary. Two existing telecommunications cables, Tangerine and the Pan-European Crossing, are located 3 and 4 km from the array area, respectively.

14.4.54 The Thanet Extension array area will come within 5 km of the Nemo Interconnector. The next nearest cables are the BritNed and London Array export cable circuits, which pass 5 km and 13 km from the array area respectively and are therefore outside of the 1 km study area.

14.4.55 No pipelines have been identified within the vicinity of Thanet Extension.

Oil and gas operations

14.4.56 No oil or gas operations were found to be within justifiable proximity to analyse.

Waste disposal sites

14.4.57 There are several active disposal sites, summarised in Table 14.5, within a 12 km radius of the Thanet Extension array area. These could be used for the disposal of drilling and dredging material from the array area. However, assessment and characterisation of these areas for disposal material from the array would be needed. Furthermore, the total volume of material produced by these activities would cause no significant impact if disposed in the array area. This removes the need for other disposal sites to accommodate all or some spoil from the construction activities within the array.

Table 14.5: Disposal sites identified within the infrastructure and other users study area

Disposal site	Distance from array area (km)	Distance from OECC (km)
Nemo disposal site B	7	12
Nemo disposal site C	12	0 (located within)
Pegwell Bay disposal site A	13	0 (located within)
Pegwell Bay disposal site B	12	0 (located within)
Ramsgate Harbour site A	13	0 (located within)
Ramsgate Harbour site B	14	0 (located within)

Shipping lanes and anchorages

14.4.58 Thanet Extension is located north of the Dover Strait and the English Channel, an extremely busy area with regard to shipping. Analysis showed seven preferred traffic routes within 5 nm of the existing TOWF. These routes had between 30 and 370 transits per month, mostly by commercial cargo vessels and tankers.

14.4.59 Fishing vessels are seen transiting directly through the Thanet Extension proposed array area and the TOWF array area. Recreational vessels make approximately ten transits per month; however, data is lacking for that category of vessel.

14.4.60 There were 50 marine navigation incidents recorded between 2010 and 2015. Fishing vessels accounted for 46% of incidents and only two significant collisions occurred within 3 km of the wind farm boundary.

14.4.61 The closest anchorage to Thanet Extension is located at Margate Roads.

14.4.62 See ES, Volume 2, Chapter 10: Shipping and Navigation for more detail and figures of shipping lanes (Document Ref: 6.2.10).

Marine archaeology

14.4.63 There are no designated or known sites within the array area. However, there is potential for important archaeological material to be discovered. The area of the Thames Estuary and the county of Kent is an important area for artefacts relating to Palaeolithic times. The Southern North Sea has seen periods of low sea levels leading to exposed landscapes that would have been habitable by hominins (human ancestors). This means areas of seabed within the array area could contain prehistoric artefacts of archaeological importance.

14.4.64 The array site and surrounding area is also historically important in terms of navigational history. 226 vessels have been recorded as lost, with no remains found, in the study area. There is also potential for numerous aircraft and other artefacts, particularly relating to the First and Second World Wars.

14.4.65 Surveys identified 174 geophysical anomalies of potential archaeological interest within the array area.

14.4.66 More information on this topic can be found in ES, Volume 2, Chapter 13: Offshore Archaeology and Cultural Heritage (Document Ref: 6.2.13).

Recreational activities

14.4.67 A wide range of recreational activities are conducted along the coast and inshore areas of the Kent and Essex coasts. These include bathing, surfing, windsurfing, kitesurfing, sailing, scuba diving and recreational fishing. None solely use the Thanet Extension array area but some, such as fishing and sailing, may occur within the array area periodically. The activities of drilling and dredging are not predicted to cause any significant impact on these activities as the sediment will be deposited within the array area.

Human characteristics of the OECC

Commercial fisheries

14.4.68 Information for commercial fisheries is based on the ICES rectangle 31F1 which encompasses the array and OECC area. See paragraph 14.4.47 to 14.4.51 for details on commercial fisheries.

Renewable developments

14.4.69 There are several consented offshore wind farms (OWF) within 30 km of the Thanet Extension project. These are summarised in Table 14.4. There are also a number of OWFs under construction across the southern North Sea. The closest is Galloper OWF (45 km from the OECC).

Cable and pipelines

14.4.70 The OECC encompasses the existing TOWF cables, which almost entirely overlap with the Thanet Extension boundary. The OECC crosses two existing telecommunications cables: Tangerine and the Pan-European Crossing as well as the Nemo Interconnector.

14.4.71 The next nearest cables are the BritNed and London Array export cable circuits, which pass 12 km and 17 km from the OECC, and are therefore outside of the 1 km study area.

14.4.72 No pipelines have been identified within the vicinity of Thanet Extension.

Oil and gas operations

14.4.73 No oil or gas operations were found to be within justifiable proximity to analyse.

Waste disposal sites

14.4.74 There are several active disposal sites, summarised in Table 14.5, within the OECC. These could be used for the disposal of dredging material from sand wave clearance. However, assessment and characterisation of these areas for disposal material would be needed. Furthermore, the total volume of material produced by these activities would cause no significant impact if disposed in the array area. This removes the need for other disposal sites to accommodate all or some spoil from sand wave clearance.

Shipping lanes and anchorages

14.4.75 Shipping and navigation analysis was conducted for the entire Thanet Extension project. See paragraph 14.4.58 for details on shipping and anchorage within the OECC area.

Marine archaeology

14.4.76 The OECC is not considered to be of archaeological potential but some areas show modern seabed sediment which maybe covering archaeological sites, such as shipwrecks, especially in areas of mobile sand sediment where larger sand waves can form.

14.4.77 More information on this topic can be found in ES, Volume 2, Chapter 13: Offshore Archaeology and Cultural Heritage (Document Ref: 6.2.13).

Recreational activities

14.4.78 A wide range of recreational activities are conducted along the coast and inshore areas of the Kent and Essex coasts. These include bathing, surfing, windsurfing, kitesurfing, sailing, scuba diving and recreational fishing. None solely use the OECC area but some, such as fishing and sailing, may occur within the OECC periodically. The activities of sand wave clearance are not predicted to cause any significant impact on these activities as the sediment will be deposited within the area and OECC boundaries.

14.4.79 There are three designated bathing waters within 2 km of the OECC, however, the volume of sediment, transportation and deposition is not expected to cause any long-term impact on the water quality.

14.5 Characteristics of the Material Being Disposed

Physical characteristics of the array

Drilled material

14.5.1 The material that will potentially be disposed of following drilling activities is different in nature to that disposed of via seabed preparation as these drilled materials will include seabed sediments and also sediment from deeper in the soil profile.

14.5.2 Extensive areas of Cretaceous chalk are covered by varying thicknesses of tertiary marine sediments throughout the Thanet Extension array area, such as mudstones and fine grained muddy sands.

14.5.3 The exact proportions of each of these deposits which will form the basis of the drill arisings deposited on the seabed will vary according to the location within the Thanet Extension array area where drilling is undertaken.

Dredged material

14.5.4 The dominant sediment types identified within the array area that will be dredged are sand and gravel with variable contributions of silt and clayey/ silty sand. The north-west array area consists of mainly fine to medium sand, with clayey silty sand also present. The north and east array area consists of fine to coarse sand with pockets of clay/ silt and sand/ gravel.

14.5.5 Although the actual process of disposal may result in a slight change in the existing particle size composition of seabed sediments, the material disposed of *in situ* via seabed preparation works will be similar to the existing material as the removal and subsequent disposal of material will take place in almost the exact same area.

Physical characteristics of the OECC

Sand wave clearance material

14.5.6 Seabed sediments along the OECC are predominantly characterised by sands and gravels There is an increase of sand and clay within mid sections, with further fine sand and clay contributions within inshore and nearshore areas. The surficial sediment layer varies in thickness throughout the OECC, although it predominantly acts as a mobile surface layer on top of underlying geological features.

Although the actual process of sand wave clearance may result in a slight change in the existing particle size composition of seabed sediments, the material disposed of *in situ* via sand wave clearance works will be similar to the existing material as the removal and subsequent disposal of material will take place in almost the exact same area.

Chemical characteristics of the array

14.5.7 The results of the metals analysis for the array samples showed that, with the exception of arsenic, concentrations of all metals within sediments were below both the Cefas alert level 1 (AL1) and the (more stringent) Canadian threshold effect level (TEL), and therefore below levels at which biological effects in benthic species could be expected.

14.5.8 Increased arsenic levels can be naturally occurring, resulting in some cases from remobilisation and erosion of arsenic rich rocks (Research Council of Norway, 2012), which vary naturally according to local geology. Anthropogenic sources of arsenic include mining and smelting (Research Council of Norway, 2012) and from burning of fossil fuels (ICES, 2004). Consequently, due to the high natural occurrences of arsenic it is often difficult to discern between natural and anthropogenic sources (OSPAR, 2005).

14.5.9 Hydrocarbon concentrations in the sediment were below the limit of detection at one of the four locations in the wind farm, with the concentrations at the other sites being below the Canadian marine sediment quality guidelines and are therefore unlikely to pose a threat to benthic ecology.

14.5.10 Levels of all organotins and polychlorinated biphenyls (PCBs) were below the limit of detection in all samples.

14.5.11 None of the samples analysed showed tributyltin, Polycylic Aromatic Hydrocarbons, hydrocarbons or organic pollutants above the Cefas Action Level 1.

Chemical characteristics of the OECC

14.5.12 None of the samples analysed showed metals, hydrocarbons or organic pollutants above the Cefas Action Level 1.

Biological characteristics of the array

Dredged material

14.5.13 Biological characteristics were similar in both the array area and the OECC. Sublittoral sands and muddy sands (SS.SSa) circalittoral mixed sediment (SS.SMx.CMx) soft rock communities (CR.MCR.SfR) circalittoral muddy mixed sediment (SS.SMX.CMx.MysThyMx) stable circalittoral mixed sediment (SS.BSR.PoR.SspiMx) infralittoral compacted fine muddy sand (SS.SSa.IMuSa.FfabMag) infralittoral sand (SS.SSa.IFiSa.NcirBat). Epibiota comprising of crustaceans, gastropods, echinoderms, polychaetes, bivalves, echinoderms, anemones and *S. spinulosa*.

14.5.14 More information on all aspects of the baseline environmental data, methods and conclusions can be found in the relevant ES Chapter stated in Table 14.6.

Biological characteristics of the OECC

Sand wave clearance material

14.5.15 Biological characteristics were similar in both the array area and the OECC. Sublittoral sands and muddy sands (SS.SSa) circalittoral mixed sediment (SS.SMx.CMx) soft rock communities (CR.MCR.SfR) circalittoral muddy mixed sediment (SS.SMX.CMx.MysThyMx) stable circalittoral mixed sediment (SS.BSR.PoR.SspiMx) infralittoral compacted fine muddy sand (SS.SSa.IMuSa.FfabMag) infralittoral sand (SS.SSa.IFiSa.NcirBat). Epibiota comprising of crustaceans, gastropods, echinoderms, polychaetes, bivalves, echinoderms, anemones and *S. spinulosa*.

14.5.16 More information on all aspects of the baseline environmental data, methods and conclusions can be found in the relevant ES Chapter stated in Table 14.6.

Table 14.6: Location for more detailed information for specific data categories

Data category:	Relevant section of Thanet Extension Environmental Statement:
Metal analysis	Volume 2, Chapter 5: Benthic subtidal and Intertidal Ecology (Document Ref: 6.2.5)
Seabed geology	Volume 2, Chapter 2: Marine Geology, Oceanography and Physical Processes (Document 6.2.2). Volume 4, Annex 2-1: Marine Geology, Oceanography and Physical Processes Technical Annex (Document Ref: 6.4.2.1).
Contamination	Volume 2, Chapter 3: Marine Water and Sediment Quality (Document Ref: 6.2.3). Volume 2, Chapter 5: Benthic subtidal and Intertidal Ecology (Document Ref: 6.2.5). MESL, 2017, Volume 4, Annex 5-1 (Document Ref: 6.4.5.1).
Biotope and infauna	Volume 2, Chapter 5: Benthic subtidal and Intertidal Ecology (Document Ref: 6.2.5).

14.6 Assessment of the potential adverse effects of in-situ disposal

Physical environment of the array

14.6.1 Marine processes are not themselves receptors in the majority of cases. However, changes to these processes may have an impact on other sensitive receptors. This section will summarise the findings of the impact assessment of these physical changes on sensitive biological and human receptors.

Dredged material

14.6.2 No adverse effect is predicted on marine geology, oceanography and physical processes due to the disposal of dredged material for the preparation of the seabed in the array area. The maximum design scenario involves dredging by hopper suction dredger with a split bottom for disposal (i.e. release of material at the water surface). The dredger will operate at a given location until the required volume has been dredged or the hopper is sufficiently full. The dredged material (spoil) will then be returned to the seabed nearby as a relatively sudden release from under the vessel. If the volume to dredge at a given location is greater than the hopper capacity (11,000 m^3) then multiple dredging and disposal cycles will be required. It will take the equivalent of 1 dredging cycle for one (large) 12 MW WTG; and 27 dredging cycles for all 28 (larger) MW WTGs and the OSS.

14.6.3 Dredging of the coarse sediment units would not create persistent plumes as the coarse material would quickly settle to the seabed. However, the disturbance of the finer grained sediments has the potential to give rise to more persistent plumes that settle out of suspension over a wider area than for coarse grained sediments.

14.6.4 When dredged material is released, approximately 90% will fall directly to the seabed as a single mass (termed the dynamic phase of the plume). The remaining approximately 10% will become more dispersed and stay in suspension (termed the passive phase of the plume). Sand sized material could remain in suspension for up to 15 minutes and be transported up to approximately 0.5 km at peak tidal currents. Overall direction of transport would be north or south, depending on the ebb and flood tides respectively. Finer sediment could remain suspended for longer, in the order of hours to days. Localised increases in SSC of up to several hundred mg/l in the immediate vicinity of the release location will be considerably higher than background levels but are very localised and last for a very short period of time (less than two hours).

14.6.5 In terms of bed level changes associated with dredging for installation of all foundations using suction cessions (up to 28 WTGs, one OSS and one met mast), it is found that if the total volume of dredge spoil from all foundations (288,000 m^3) was distributed equally across the array area (69 km^2), the average increase in bed elevation would be 0.005 m.

14.6.6 An area equal to approximately 7.6% of the array area could potentially be covered by an average thickness of 0.06 m of material. However, in practice, the change will comprise a series of discrete deposits (smaller overlapping or non-overlapping deposits, potentially from multiple dredging cycles around each dredged area), distributed throughout the parts of the array area that WTGs are located.

14.6.7 If multiple activities causing sediment disturbance (such as dredging, drilling or cable installation) are undertaken simultaneously at two or more locations that are aligned in relation to the ambient tidal streams, then there is potential for overlap between the areas of effect on SSC and sediment deposition. Given that the minimum spacing between foundations is 480 m, it is unlikely that sands or gravels put into suspension will be dispersed far enough (i.e. between adjacent foundation locations) to cause any overlapping effects before being redeposited to the seabed. In general, only relatively fine sediment (e.g. clay, silt and fine sand sized material) is likely to be advected far enough to potentially cause overlapping effects on SCC.

Drill arising material

14.6.8 The impact of drilling operations mainly relates to the release of drilling spoil at or above the water surface which will put sediment into suspension and the subsequent redeposition of that material to the seabed. The nature of this disturbance will be determined by the rate and total volume of material to be drilled, the seabed and subsoil material type, and the drilling method (affecting the texture and grain size distribution of the drill spoil).

14.6.9 Monopile foundations and pin-piles for quadropod foundations will be installed into the seabed using standard piling techniques. In some locations, the particular geology may present some obstacle to piling, in which case, some or all of the seabed material might be drilled from within the pile footprint to assist in the piling process. Up to 50% of WTG foundations may require drilling to assist with installation. However, all monopile foundations were successfully installed at TOWF using piling alone with no drilling required.

14.6.10 Sediment deposition as a result of drilling for a single foundation installation could deposit coarse grained and clastic sediment within an area in the order of approximately 10 - 100 m downstream/ upstream and a few tens of metres wide from individual foundations, with an average thickness in the order of one to ten metres.

14.6.11 Deposits of mainly sandy sediment will concentrate within an area in the order of approximately 150 - 500 m downstream/ upstream and tens to one hundred metres wide from individual foundations, with an average thickness in the approximate order of tens of centimetres to approximately one metre.

14.6.12 Fine grained material will be dispersed widely within the surrounding region and will not settle with measurable thickness.

14.6.13 SSC will be increased by tens to hundreds of thousands of mg/l at the point of sediment release, which is at or near the water surface. However, outside of the area up to one tidal excursion upstream and downstream of the foundation location, SSC less than 10 mg/l may occur more widely due to ongoing dispersion and dilution of material.

14.6.14 It is noted that, while the absolute width, length, shape and thickness of local sediment deposition as a result of drilling is estimated. It cannot be predicted with certainty and is likely to vary due to the nature of the drill spoil, the local water depth and the ambient environmental conditions during the drilling activity. Other possible combinations of shape, area and thickness of sediment deposition are provided in Volume 4, Annex 2-1: Marine Geology, Oceanography and Physical Processes Technical Annex (Document Ref: 6.4.2.1).

14.6.15 If the total volume of drill arisings (21,782 km^3) from all foundations was distributed equally across the array area (69 km^2), the average increase in bed elevation would be 0.0004 m. An area equal to approximately 0.9% of the array area could potentially be covered by an average thickness of 0.04 m of material. However, in reality the change will comprise a series of discrete deposits (smaller overlapping or non-overlapping deposits), distributed throughout the parts of the array area that WTGs are located. Individual deposits are likely to be relatively thicker on average, however, monitoring of drill arising mounds on the Lynn and Inner Dowsing Offshore Wind Farm found that after four mouths mounds had been reduced from 3 m to 1.2 m (COWRIE, 2010). This figure is a guide as sediment and oceanographic conditions may be significantly different at the Thanet Extension site.

Physical environment of the OECC

14.6.16 Marine processes are not themselves receptors in the majority of cases. However, changes to these processes may have an impact on other sensitive receptors. This section will summarise the findings of the impact assessment of these physical changes on sensitive biological and human receptors (Table 14.7).

Sand wave clearance material

14.6.17 No adverse effect is predicted on marine geology, oceanography and physical processes due to disposal of sand wave clearance material within the OECC (Table 14.7). The maximum design scenario involves dredging by hopper suction dredger with a split bottom for disposal (i.e. release of material at the water surface). The dredger will operate at a given location until the required volume has been dredged or the hopper is sufficiently full. The dredged material (spoil) will then be returned to the seabed nearby as a relatively sudden release from under the vessel. If the volume to dredge at a given location is greater than the hopper capacity (11,000 m^3) then multiple dredging and disposal cycles will be required. It will take the 131 dredging cycles to remove the predicted 1,440,000 m^3 of material (based on 20% of each export cable circuit within the OECC requiring sand wave clearance).

14.6.18 Dredging of the coarse sediment units would not create persistent plumes as the coarse material would quickly settle to the seabed. However, the disturbance of the finer grained sediments has the potential to give rise to more persistent plumes that settle out of suspension over a wider area than for coarse grained sediments.

14.6.19 When dredged material is released, approximately 90% will fall directly to the seabed as a single mass (termed the dynamic phase of the plume). The remaining approximately 10% will become more dispersed and stay in suspension (termed the passive phase of the plume). Sand sized material could remain in suspension for up to 15 minutes and be transported up to approximately 0.5 km at peak tidal currents. Overall direction of transport would be north or south, depending on the ebb and flood tides respectively. Finer sediment could remain suspended for longer, in the order of hours to days. Localised increases in SSC of up to several hundred mg/l in the immediate vicinity of the release location will be considerably higher than background levels but are very localised and last for a very short period of time (less than two hours).

14.6.20 In terms of bed level changes associated with sand wave clearance within the OECC, it is estimated that if the total volume of spoil (1,440,000 m^3) was distributed equally across the OECC area (26.93 km^2), the average increase in bed elevation would be 0.05 m.

14.6.21 If the material was disposed of equally across 20% of the OECC area (5.39 km^2) the average increase in bed elevation would be 0.28 m.

14.6.22 However, in practice, the change will comprise a series of discrete deposits (smaller overlapping or non-overlapping deposits, potentially from multiple dredging cycles around each dredged area), distributed throughout the parts of the OECC where the sand waves are located.

14.6.23 If activities causing sediment disturbance are undertaken at two or more locations that are aligned in relation to the ambient tidal streams, then there is potential for overlap between the areas of effect on SSC and sediment deposition. Until detailed construction surveys are conducted it is not yet known where within the OECC will require sand wave clearance. However, sand wave clearance is only anticipated to occur across 20% of each export cable circuit within the OECC, and if separated throughout the area it is unlikely for sands or gravels put into suspension to be dispersed far enough to cause any overlapping effects before being redeposited to the seabed. In general, only relatively fine sediment (e.g. clay, silt and fine sand sized material) is likely to be advected far enough to potentially cause overlapping effects on SCC.

Biological and human environment in the array and OECC

14.6.24 The ES for Thanet Extension provides detailed impact assessments related to disposal activities on a number of sensitive biological and human environment receptors, including benthic habitats, fish spawning and nursery habitats, marine mammals, birds, commercial fisheries, marine archaeology, shipping and navigation and other marine users and infrastructure.

14.6.25 Table 14.7 provides a summary of the key impacts on biological and human receptors assessed within the ES. The relevant section of the ES, where further details of these impact assessments can be found, is also provided.

Table 14.7: Summary of impacts from disposal of sand wave clearance, dredged and drilled seabed material within the boundaries of Thanet Extension array and OECC

Potential impact	Relevant section of environmental statement	Sensitivity of receptor	Magnitude of impact	Significance of effect including designed in measures	Notes
Physical Processes					
Impact on sand bank receptors due to construction activities	Volume 2, Chapter 2: Marine Geology, Oceanography and Physical Processes. Section 2.10 (Document Ref: 6.2.2)	High	Low	**Negligible** adverse	No sediment is removed from the system and therefore the rate at which sediment is supplied to the adjacent banks will remain unaltered.
Benthic Subtidal and Intertidal Ecology					
Temporary increases in SSC and associated sediment deposition in the intertidal area	Volume 2, Chapter 5: Benthic Subtidal and Intertidal Ecology. Section 5.10 (Document Ref: 6.2.5).	Medium	Low	**Minor** adverse	The intertidal zone within Pegwell Bay is a naturally accreting site, with most sediment transported in during storm surges and consequently, the habitats will have to tolerate these events which are similar to the impacts
Temporary increases in suspended sediment and associated sediment deposition in the subtidal area	Volume 2, Chapter 5: Benthic Subtidal and Intertidal Ecology. Section 5.10 (Document Ref: 6.2.5).	Medium	Low	**Minor** adverse	Post-construction surveys undertaken for TOWF identified that changes in faunal composition between pre- and post-construction were only as a result of natural variation, suggesting no long-term impacts from increased SSC or increased sediment deposition
Fish and Shellfish Ecology					
Direct damage (e.g. crushing) and disturbance to mobile demersal and pelagic fish and shellfish species arising from construction activities	Volume 2, Chapter 6: Fish and Shellfish Ecology. Section 6.10 (Document Ref: 6.2.6).	Medium	Low	**Minor** adverse	A maximum of 5.05 km^2 of seabed is predicted to be directly impacted during the construction of Thanet Extension, with the potential for direct damage to mobile demersal and pelagic fish and shellfish within this footprint. The impact is predicted to be of local spatial extent, of short-term duration, intermittent and reversible.
Temporary localised increases in suspended sediment concentrations and smothering	Volume 2, Chapter 6: Fish and Shellfish Ecology. Section 6.10 (Document Ref: 6.2.6).	Low to Medium	Low	**Minor** adverse	Most receptors are predicted to have some tolerance to this impact.

Potential impact	Relevant section of environmental statement	Sensitivity of receptor	Magnitude of impact	Significance of effect including designed in measures	Notes
Direct and indirect seabed disturbances leading to the release of sediment contaminants	Volume 2, Chapter 6: Fish and Shellfish Ecology. Section 6.10 (Document Ref: 6.2.6).	Low to Medium	Negligible	**Minor** adverse	Levels of contaminants were below guideline levels all except arsenic which may occur naturally. The resuspension of contaminants as a result of sediment disturbance is predicted to occur on a small scale, with contaminants predicted to be rapidly dispersed by the tide
Marine Mammals					
Non-piling construction noise	Volume 2, Chapter 7: Marine Mammals. Section 7.11 (Document Ref: 6.2.7).	Low	Low	**Minor** adverse	None
Vessel Interactions - collisions	Volume 2, Chapter 7: Marine Mammals. Section 7.11 (Document Ref: 6.2.7).	Low	Low	**Minor** adverse	The adoption of a vessel management plan that includes preferred transit routes and guidance for vessel operation in the vicinity of marine mammals and around seal haul-outs will minimise the potential for any impact.
Indirect effects on marine mammals as a result of impacts on prey species	Volume 2, Chapter 7: Marine Mammals. Section 7.11 (Document Ref: 6.2.7).	Negligible	Negligible	No significant indirect effect	None
Changes to water quality	Volume 2, Chapter 7: Marine Mammals. Section 7.11 (Document Ref: 6.2.7).	Low	Low	**Minor** adverse	The sediment release from dredging will be quickly dispersed by tidal currents.
Ornithology					
Direct disturbance and displacement	Volume 2, Chapter 4: Offshore Ornithology. Section 4.11 (Document Ref: 6.2.4).	High (Red-throated diver) Low to Medium (Razorbill, Guillemot)	Negligible Negligible	**Minor** adverse **Negligible** adverse	None
Indirect impacts through effects on habitats and prey species	Volume 2, Chapter 4: Offshore Ornithology. Section 4.11 (Document Ref: 6.2.4).	Negligible	Negligible	**Minor** adverse	None

Potential impact	Relevant section of environmental statement	Sensitivity of receptor	Magnitude of impact	Significance of effect including designed in measures	Notes
Marine Water and Sediment Quality					
Deterioration in water quality due to re--suspension of sediments and release of contaminants	Volume 2, Chapter 3: Marine Water and Sediment Quality. Section 3.10 (Document Ref: 6.2.3).	Medium to High	Negligible	**Minor** to **Negligible** Adverse	The levels found are all comparable to the wider regional background and not considered to be of a low quality and will not result in a significant effect-receptor pathway if made bioavailable.
Designated sites					
Temporary habitat loss/ disturbance due to installation works (jack-up vessels operations, cable installation)	Volume 2, Chapter 8: Offshore Designated Sites. Section 8.10 (Document Ref: 6.2.8).	High	Low	**Negligible** adverse	Focus is mainly on disturbance to *S. spinulosa* reefs which are known to be present in the area. A mitigation plan and pre-construction surveys will ensure direct impacts to the core reef is avoided.
Offshore Archaeology					
Permanent physical loss/ disturbance of known and potential seabed receptors in shallow sediments from seabed preparation and construction activities	Volume 2, Chapter 13: Offshore Archaeology and Cultural Heritage. Section 13.11 (Document Ref: 6.2.13).	Low	Low	**Minor** adverse	Mitigation measures reduce both sensitivity and magnitude from high to low.
Infrastructure and Other Users					
Increased burial of existing cables and pipelines as a result of increased sediment deposition	Volume 2, Chapter 11: Infrastructure and Other Users. Section 11.9 (Document Ref: 6.2.11)	High	Negligible	**Minor** adverse	None
Impacts to disposal sites from increased sediment deposition	Volume 2, Chapter 11: Infrastructure and Other Users. Section 11.9 (Document Ref: 6.2.11)	Medium	Negligible	**Minor** adverse	None
Disturbance to existing cables and pipelines during construction	Volume 2, Chapter 11: Infrastructure and Other Users. Section 11.9 (Document Ref: 6.2.11)	High	Negligible	**Minor** adverse	Crossing agreements will be in place before any interaction occurs.

14.7 Monitoring

14.7.1 Based on the findings of the impact assessments presented in the Thanet Extension ES (Vattenfall, 2018) and summarised within this document, long-term impacts of disposal of spoil within the Thanet Extension array area and OECC are not anticipated. This is due to the limited increase in seabed level, the temporary nature of any sediment plumes and the increased suspended sediment concentrations related to these plumes.

14.7.2 The deposition of sediment from disposal activities is also predicted to only result in short-term, spatially discrete impacts and the fact that the seabed material due to be dredged and disposed of *in situ* has been shown, via specific sampling, not to be heavily contaminated indicates that contamination via this activity will also not arise.

14.7.3 The only potential longer-term impact of disposal that may arise will be the deposition of drill arisings on the seabed which may comprise of large, granular materials that are too large to be moved by tidal currents and may remain *in situ* for long periods of time. The exact scope for this potential impact will rely upon the nature of the materials drilled out during monopile installation. As specified in the draft dML bathymetric monitoring will be conducted post-construction. Other than this no other monitoring is required.

14.8 Conclusions

14.8.1 This document represents the site characterisation for the Thanet Extension array area and OECC. It forms the proposal for a licensed disposal site, within the array area for drill arising and dredged material and sand wave clearance material within the OECC. This is required by the MMO, to allow them to consider the potential impact of disposal within these sites.

14.8.2 Noting that all the information required for site characterisation to support a disposal application would be contained within the Thanet Extension ES, this document takes the form of a 'framework' document that provides a summary of the key points relevant to site characterisation and refers the reader back to the more detailed information and data presented within various sections of the ES (Vattenfall, 2018).

14.8.3 The source of material proposed to be disposed of within the array area will be sediment dredged from the upper 3m of the existing seabed via a suction hopper dredger as part of seabed preparation works prior to gravity base foundation installation and/or materials from the deeper soil profile (30 m) and top layers of upper sediments derived from drilling activities associated with monopile installation. Source material being proposed for disposal within the OECC will consist of sand wave clearance sediment formed of the top mobile layer of sea bed sediment.

14.8.4 Within the array area of Thanet Extension, an upper estimate of 288,000 m^3 of material will be disposed of *in situ* in the form of shallow dredged sediments or an upper estimate of 21,782 m^3 of material from drill arisings which will be disposed of *in situ*. Within the OECC an estimated 1,440,000 m^3 of material will be disposed of *in situ* from sand wave clearance activities.

14.8.5 With respect to the disposal of dredged material, this is expected to take place approximately 500 m from the seabed preparation site, in an easterly or westerly direction (to avoid the dominant tidal flows transporting the material back to the seabed preparation site).

14.8.6 Where drilling is required to facilitate the installation of piles to target depth, the drill arisings will be disposed of at sea, adjacent to the foundation location.

14.8.7 The impacts of disposal via either the return of dredged material to the water column and seabed and/or the placement of drill arisings adjacent to foundations has been fully assessed within the Thanet Extension ES (Vattenfall, 2018). No **Moderate** or **Major** adverse impacts (i.e. significant in EIA terms) have been identified, with only **Negligible** to **Minor** adverse impacts predicted on certain receptors, including benthic habitats.

14.8.8 In conclusion, as the ES has not identified any significant adverse impacts on receptors via this proposed disposal activity, it is concluded that whilst potential alternative options for use of this material may exist, disposal *in situ* remains the most viable option.

14.9 References

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