The Sizewell C Project

6.3 Volume 2 Main Development Site

Chapter 22 Marine Ecology and Fisheries

Appendix 22M - Sizewell C Marine Ecology and Fisheries Final Scoping Report. Edition 2.

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Sizewell C Marine Ecology and Fisheries Final Scoping Report. Edition 2.

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Please note that the red line boundary was amended after this document was finalised, therefore figures in this document do not reflect the boundaries in respect of which development consent has been sought in this application. However, amendments to the red line boundary does not have any impact on the findings set out in this document and all other information remains correct.

Executive summary

EDF Energy proposes to construct and operate a new nuclear power station (new nuclear build, or NNB) immediately to the north of the existing Sizewell B station. An Environmental Statement (ES) is required as part of the Development Consent Order (DCO). The ES must identify and describe any significant direct effects, indirect and secondary effects, cumulative effects and transboundary effects of the proposed development.

The initial scope of the ES assessments was established through a formal EIA scoping process undertaken with the Planning Inspectorate in 2014 (EDF Energy, 2014). Since such time, engineering designs and development options have advanced, and further ecological assessments and baseline monitoring has been completed. Based on this enhanced knowledge, this report identifies the primary construction and operational activities with the potential to cause effects in the marine environment.

This ‘final scoping’ exercise prior to the ES aims to summarise the development activities and associated pressures for each development component during the construction, commissioning and operational phases of Sizewell C. A separate EIA for decommissioning will be made based on the available technology, methods of decommissioning, and baseline environmental conditions at the time.

The intention of this report is to identify and describe the impacts with the potential to cause significant effects on different receptor groups, which will be assessed during the ES. The report is not intended to provide an exhaustive list of all the potential activity-pressure pathways. Activity-pressure pathways that exist, but the magnitude of the impact is considered negligibly small to warrant further investigation, are identified and scoped out with relevant justification. Where key issues are identified the report directs the reader to the relevant BEEMS Technical Reports that consider such issues in greater detail and that will provide the evidence base for the ES.

Finally, the report provides the opportunity for consultation with regulatory authorities based on the issues identified as being potentially important for the ES, and those that have been scoped out of further assessment.

Edition 2: The first edition of this report was issued in March 2019 and was presented to regulatory authorities at the Marine Technical Forum (MTF) in May 2019. Written comments on the first edition from Natural England, the Environment Agency, and the Marine Management Organisation along with discussions at the MTF have been addressed and used to further inform the scope of assessments in Edition 2. Furthermore, modifications in the environmental design and embedded mitigation are included in a revised Section 1.2.

1 Background

EDF Energy proposes to construct and operate a new nuclear power station (new nuclear build, or NNB) immediately to the north of the existing operational and decommissioned stations (Sizewell B and Sizewell A, respectively) at Sizewell on the Suffolk coast. The construction and operation of the NNB Sizewell C is referred to throughout this document as the 'proposed development'.

The Town and Country Planning (Environmental Impact Assessment) Regulations 2017, require the preparation of an Environmental Statement (ES), where the direct effects and any indirect, secondary, cumulative and transboundary significant effects of a proposed development are identified and described. The scope of this ES assessment has been established through a formal EIA scoping process undertaken with the Planning Inspectorate in 2014 (EDF Energy, 2014). The assessment methods were further informed by ongoing consultation and engagement with statutory consultees.

An Ecological Impact Assessment (EcIA) based approach has been applied to assess the effects of the proposed development on marine ecology receptors following CIEEM good practice guidelines (CIEEM, 2016). A systematic framework is required to allow meaningful assessments of the sensitivity of different receptors to anthropogenic impacts arising from a range of development activities.

The initial stage of the Marine Ecology and Fisheries ES involved identification of all potential development impacts on marine receptors relative to the established baseline. The baseline for each receptor group is provided in the following technical reports:

- Phytoplankton (BEEMS Technical Report TR346 Ed. 2.)
- Zooplankton (BEEMS Technical Report TR315 Ed. 2.)
- Benthic communities (BEEMS Technical Report TR348.)
- Fish Ecology (BEEMS Technical Report TR345.)
- Marine mammals (BEEMS Technical Report TR324 Ed. 2.)
- Commercial and Recreational Fisheries (BEEMS Technical Report TR123. Ed. 2.)

The receptor baselines have been characterized based on the current conditions at the site i.e. they represent the species and habitats present, and the spatio-temporal variability of those species, under the current pressure landscape within the Greater Sizewell Bay.

1.1 Aim of this report

This report presents the standardized approaches that have been undertaken during the ES with the aim to summarise the development activities and associated pressures for each of the development components during the construction and operational phase of Sizewell C. The impacts with the potential to cause significant effects on different receptor groups are identified for further assessment during the ES.

Where key issues are identified the report directs the reader to the relevant BEEMS Technical Reports that consider such issues in greater detail and that will provide the evidence base for the ES. The intention of this report is not to provide an exhaustive list of all the potential activity-pressure pathways, rather it identified potentially important issues. However, activity-pressure pathways that exist but the magnitude of the impact is considered negligibly small to warrant further investigation are identified and scoped out. Finally, the report provides the opportunity for consultation with regulatory bodies based on the issues identified as being potentially important for the ES, and those that have been scoped out of further assessment.

The report draws on the knowledge and understanding of the potential impacts of the development detailed in the Sizewell Coastal Geomorphology and Hydrodynamics Synthesis (BEEMS Technical Report TR311 Ed. 4.) and the Marine Water and Sediment Quality Synthesis (BEEMS Technical Report TR306 Ed. 4.).

1.1.1 Environmental Statement Chapters

This report provides a summary of the final scoping exercise and the outcome of regulatory discussions and informs the primary content of the Marine Ecology and Fisheries ES. Assessments pertaining to issues and comments received by the regulators on Edition 1 of this report and during MTF discussions will be presented in the following ES chapters within **Volume 2 Main Development Site**:

- Chapter 2: Description of the MDS
- Chapter 3: Description of Construction
- Chapter 4: Description of Operation
- Chapter 5: Description of Decommissioning
- Chapter 14: Terrestrial Ecology and Ornithology
- Chapter 20: Coastal Geomorphology and Hydrodynamics
- Chapter 21: Marine Water and Sediment Quality
- Chapter 22: Marine Ecology and Fisheries
- Chapter 24: Navigation
- Chapter 25: Radiological
- Chapter 26: Climate Change

1.2 Summary of Development Components

The following section briefly outlines the principle marine development components, how they may be constructed and their operational requirements. Full design details of each component and the embedded mitigation will be presented in further detail in the ES. The development components related to the proposed development include the:

- Coastal Defence Feature (CDF);
- Beach Landing Facility (BLF);
- Cooling Water (CW) infrastructure, including intake and outfall headworks;
- Fish Recovery and Return (FRR) systems;
- Combined Drainage Outfall (CDO).

In Edition 2 of this report the summary of development components and latest marine assumptions have been updated to reflect those used in the assessment of the ES and are up to date as of November 2019.

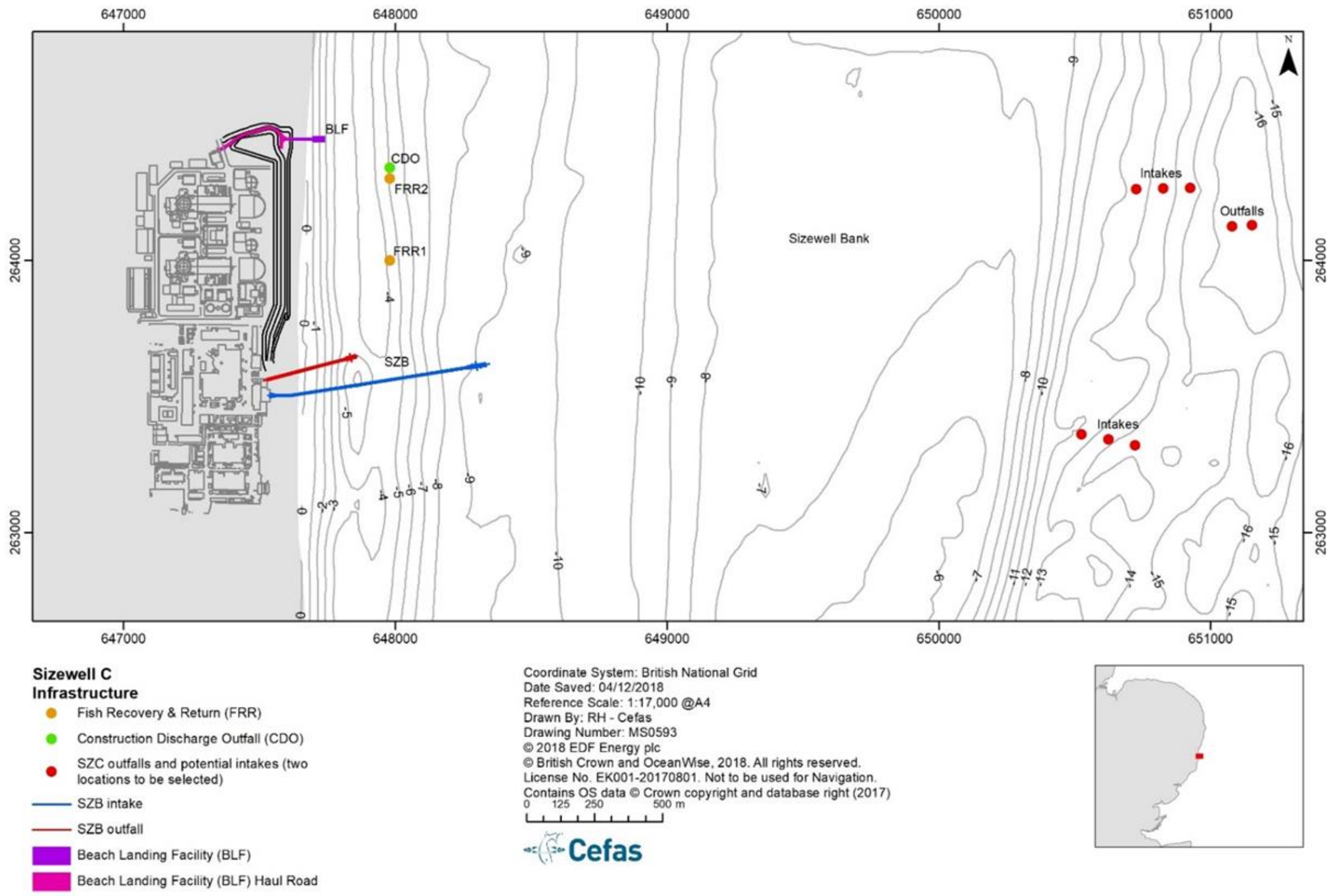

Figure 1: Schematic of the proposed location of development infrastructure in the marine environment.

1.2.1 Coastal Defence Feature

The coastal defences for the proposed development consist of a hard-engineered feature that would protect the eastern and northern flanks of the main site. A fronting soft engineering feature immediately seaward of the hard feature, made of beach grade sediments and vegetated soil would supply sediment to the foreshore when eroded during storms.

The soft-coastal defence feature (SCDF) would be made of landscaped beach grade sediments and constructed to 5m ODN elevation between the HCDF and the MHWS.

The CDFs have several embedded mitigation features:

- Sediments used to construct the SCDF would be delivered to the site rather than reprofiling the beach, resulting in a volumetric increase in the back-beach area.
- Beach grade sediments used in landscaping would be vegetated. As they erode under natural storm events, they would locally slow the rate of shoreline retreat. The location, behind the active beach, would result in the gradual release of sediment when storms erode its seaward face. Mitigation would be implemented to maintain the SCDF as required.
- The HCDF would be located landward of the SCDF and have a rock armour core dressed in a shingle/sand/soil matrix to facilitate vegetation colonisation which, like the SCDF, would stabilise the sediment.

- The HCDF positioning is as far as practical away from the shore (eastern flank) to increase its duration as a terrestrial feature.

For the majority of the operational life of the proposed development he coastal defence feature would be above MHWS. Ongoing shoreline retreat has the potential to cause future exposure of the HCDF. This is not predicted to occur for at least several decades or possibly beyond the operational phase of the proposed development. The potential for exposure would be reduced due to the SCDF, which would slow shoreline retreat at the frontage of the proposed development and because beach management (secondary mitigation) would be applied to maintain a shingle beach in front of the HCDF (BEEMS Technical Report TR311).

1.2.2 Beach Landing Facility (BLF)

The BLF would be used to receive large deliveries (including AILs) to Sizewell C by barge. Barges would be loaded at a transhipment port and on approach to the BLF the barge would be assisted by tugs and moor at the end of the BLF jetty at high water. As the water level drops, the barge would ground. Large deliveries would then be transported to site along the BLF access road. The BLF would facilitate occasional AIL deliveries during the operational life of the station, approximately every 5-10 years.

The BLF would consist of a piled platform, fenders and ramp and mooring dolphins. Piles would be positioned in the shallow subtidal. One pair of jetty piles is close to the low tide mark, and three pairs are seaward of low tide. Two fenders would be piled at the end of the jetty and two mooring dolphins would be positioned at approximately 66m and 128m from MHWS. For assessment purposes piles are assumed to be approximately 1m in diameter and the fender/dolphin piles would be 1.5m in diameter. A total of 12 piles would be installed within the marine environment below MHWS with the deepest pile located in a water depth of -3.38m ODN.

Underwater noise propagates more efficiently in deep water and the small size of the BLF in shallow waters reduces sound propagation.

The BLF would be a transmissive structure with few narrow diameter piles and a minimal effect on waves, sediment transport and the adjacent beach. The primary embedded mitigation is the small number of piles compared to alternative jetty options.

Any coatings or treatments applied to the BLF or other infrastructure must be suitable for use in the marine environment in accordance with best environmental practice (e.g. Guidance for Pollution Prevention) or undergo appropriate assessment at the time in accordance with Marine Licence conditions. Therefore, effects from chemicals leaching from structures will be mitigated.

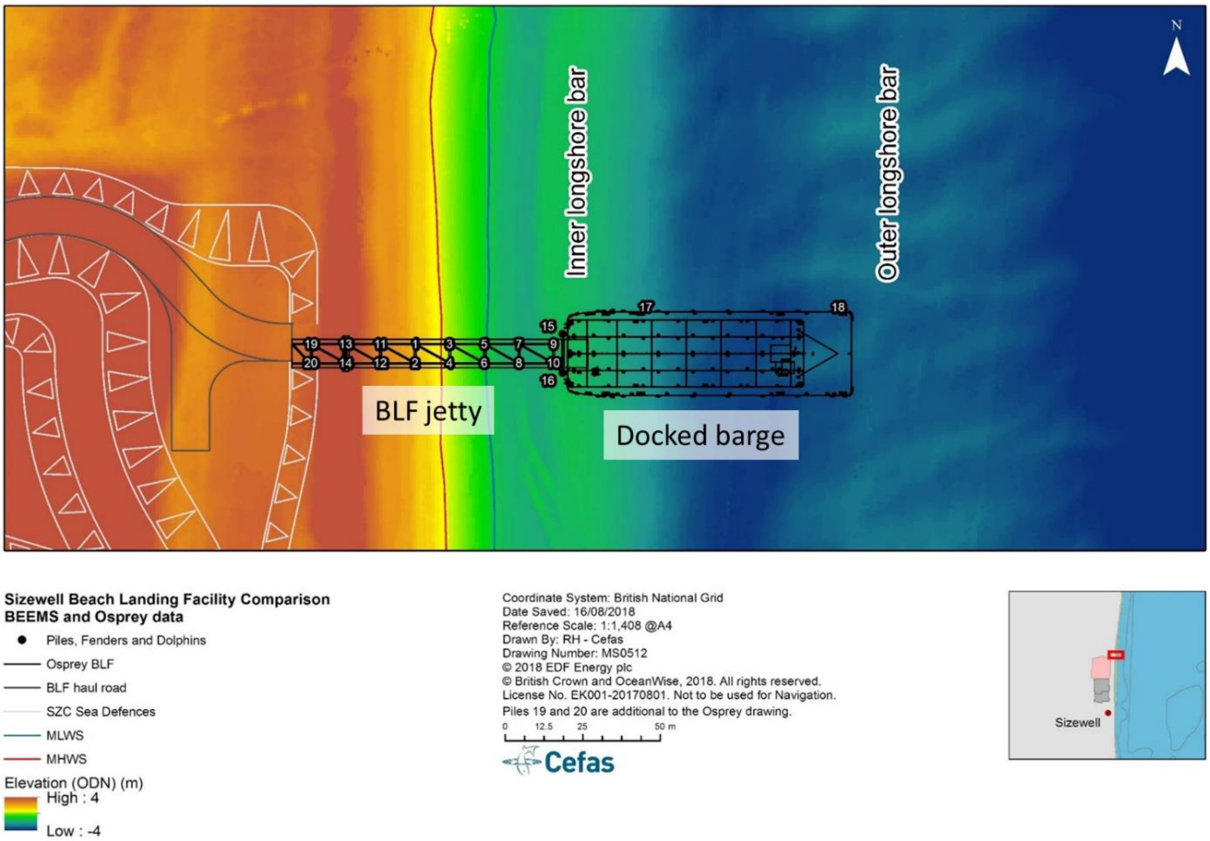

Figure 2: The Beach Landing Facility (BLF) showing the position of the jetty piles, fenders (points 15 and 16) and dolphins (points 17 and 18) relative to the longshore bars and MHWS.

1.2.2.1 Construction of the beach landing facility

Constructions of the BLF would involve landward sections being piled by a terrestrial piling machine. Marine piling would be undertaken from either a temporary rock platform (using a terrestrial piling machine) or more likely using a walking jack-up barge or similar. Should a temporary rock platform be employed, barges would not dock at the BLF until the platform was at least half removed to prevent a barrier to sediment transport (BEEMS Technical Report TR311). Dolphins could be installed from a standard jack-up barge if a walking jack-up barge were not to be used.

Pilling

Impact piling is the anticipated piling method for installing the 12 marine piles. Indicative piling specifications are:

- Maximum hammer energy of 90kJ;
- Strike rate of 46 strikes per minute;
- Each pile would require approximately 1,500 hammer blows to install (lasting 33 minutes);
- A maximum of 5 piles would be installed in each 24-hour period (the timeframe for cumulative noise assessments).

It is envisaged that a 20-minute soft start/ ramp up would be implemented where technically feasible, resulting in a total piling time of ca. 53 minutes per pile.

Underwater noise modelling was undertaken to determine the potential effects of pilling on marine mammals and fish species at Sizewell (BEEMS Technical Report TR312). Assessments modelled the indicative piling specifications provided and incorporated an additional 200kJ hammer energy option, with the same total number of hammer blows to represent a precautionary scenario and to envelope potential engineering options.

Piling activities will conform to best environmental practice in accordance with JNCC guidelines (JNCC, 2010a) to mitigate effects on marine mammals. A Marine Mammal Mitigation Protocol (MMMP) has been prepared to be submitted as part of the DCO application (BEEMS Technical Report TR509).

Dredging

A description on dredging activities associated with each development component is described in Section 1.2.6.

To accommodate the safe passage of barges and accompanying tugs to the BLF, a navigational channel and grounding area would be required in the nearshore zone occupied by the two longshore bars.

Plough dredging would be used to create a planar surface for the barges to come aground. Plough dredging agitates the sediment, which is then transported away by the tide. Sediment is not removed, and the vast majority would remain within the same sediment cell.

1.2.2.2 Vessel Traffic and pollution

A number of measures would be implemented to mitigate potential effects of vessel traffic at the site:

- Transit speeds for North Sea barges are approximately 6 knots. The potential for marine mammal collision with barges is low. Compliance with a site-wide speed restriction for all working vessels of below 10 knots is recommended for the site Vessel Management Plan (VMP).
- The potential for chemical and oil spills whilst recognised will be mitigated by compliance with IMO regulations.
- The potential for non-native species to be introduced during ballast water activities will be managed by compliance with the IMO Ballast Water Management Convention (adopted in 2004).
- Vessel waste management procedures outlined in the VMP and Site Waste Management Protocols would be in place to mitigate impacts of marine litter.

Vessel safety is a key considered and is assessed as part of the Marine Navigational assessment being completed for the ES (Volume 2 Chapter 24). A mechanism for safeguarding vessels from construction activities during the installation of offshore infrastructure would be the implementation of safety buffer effected through Notice to Mariners (NtM).

1.2.3 Cooling water infrastructure

1.2.3.1 Cooling Water Infrastructure: Construction

Offshore cooling water infrastructure consists of two subterranean intake tunnels and one outfall tunnel. Tunnels would be excavated by tunnel boring machines (TBMs) from land. The TBM heads would be left at the end of each tunnel run, approximately 30m under the seabed.

Tunnelling spoil and chemical discharges

The specific tunnel boring machine (TBM) method to be used during construction of the cooling water tunnels is dependent on the underlying geology and is still to be confirmed. Tunnelling would be subterranean, approximately 30m below the seabed. The excavated pressure (if required) would either be at ambient or slightly above ambient pressure similar to the existing conditions at such depths. Therefore, the potential for ‘frac-out’ of tunnelling materials poses minimal risks to the overlying marine environment and is not considered further. The potential for contamination in the wastewater is considered.

Based on current understanding of the underlying geology a tunnel boring machine (TBM) slurry method is the most likely scenario for tunnelling. Spoil from the cutting face would be transported to a temporary stockpile for onward management. Groundwater would be generated from digging the galleries allowing access to the tunnels. During the transport and processing of spoil material, groundwater and potentially residual TBM chemicals would be produced in wastewater that would be transported landward and treated appropriately. To encompass worst-case water quality scenarios, assessments assume discharges of wastewater from the CDO.

Bentonite, a clay mineral regularly used in construction and offshore drilling operations, may be applied at the cutter face. Bentonite is considered to pose minor risks to the environment as it is included on the OSPAR list of PLONOR substances (pose little or no risk to the environment). Modelling accounted for a tunnelling wastewater discharge rate of 34.4l/s and a discharge of 8.8mg/l bentonite. The predicted concentration of bentonite in suspension would be orders of magnitude lower than baseline SSC with 95th percentile concentrations of 10µg/l restricted to sea surface areas of <11ha and mean concentrations of 10µg/l less than 1.5ha (BEEMS Technical Report TR193). In the tidally dominated environment characterised by high resuspension rates, the potential for sedimentation of fine materials to cause ecological effects during normal tunnelling processes is negligible. No further assessment is made.

To envelope alternative tunnelling methods, assessments considered the use of indicative ground conditioning TBM chemicals. Ground conditioning chemicals may be used at the cutter head to optimise TBM efficiency and include anti-clogging agents, anti-wear components and soil-conditioning compounds. The exact chemical constituents of the ground conditioning chemicals are dependent upon the ground conditions encountered on site and therefore cannot be precisely specified in advance of drilling trials by the tunnelling contractor. Whilst a slurry method is the most likely tunnelling option, representative chemicals from those applied for Hinkley Point C assessments are considered to most accurately envelope potential tunnelling options at this stage. These include the anti- clogging agent BASF Rheosoil 143 and the soil conditioning additive CLB F5 M.

Cooling water headworks

Each tunnel would terminate in two concrete headworks. The optimal location of the outfall heads was investigated using the validated Sizewell GETM model in consultation with the Environment Agency to ensure compliance with Environment Agency guidelines to reduce environmental impacts of the thermal plume and minimise recirculation of heated water at the Sizewell B intakes.

Embedded mitigation measures implemented into the design of the intake and outfall headworks include:

- The intakes and outfalls of the cooling water infrastructure would be located east of the Sizewell-Dunwich Bank approximately 3km offshore.
- The long axis of the intakes would be positioned parallel to the current in a north-south orientation. Intake faces would be positioned on the side of the headworks perpendicular to the tidal flow. This reduces both vertical currents, which fish are susceptible to, and reduces the probability of fish being forced into the intakes by tidal currents.
- Intakes would be designed to achieve target water velocities (<0.3m/s) across the face in compliance with the UK Environment Agency best practice guidelines.
- Coarse bar screens at the intakes would prevent seals and marine debris from entering the cooling water system.
- The outfall headworks are designed to funnel thermally buoyant discharges away from the seabed thereby minimising effects on benthic receptors.

Prior to the installation of the headworks small scale capital dredging would take place to remove surficial sediments to the underlying bedrock. Dredging is anticipated to be by cutter suction dredger with local disposal. A description of dredging activities is provided in Section 1.2.6.

Following dredging, the bedrock would undergo ground preparation and a gravel bed would be installed below the proposed headwork, which would be lowered into position. Depending on the ground conditions and geotechnical calculations, seismic qualification may be required and would be achieved through the installation of piles. Piles would be installed by drilling, rather than percussive methods to reduce the levels of underwater noise.

Vertical connection shafts would be drilled with the headwork in-situ to connect the headworks to the subterranean cooling water tunnels. Drilling would occur through the centre of the headworks, within the dredge footprint.

After the headworks are installed and scour protection placed in-situ (where required), soft-sediment would be back-filled.

1.2.3.2 Cooling Water Infrastructure: Operation

During operation, the SZC intakes would abstract seawater at a rate of ca. 131.8m^3/s (two x 65.9m^3/s for each intake tunnel) during standard operating procedures. A maximum of 8.6% of the total cooling water flow would supply the essential and auxiliary cooling water systems and the remaining 91.4% (120m^3/s) would supply the main cooling water systems.

The thermal uplift of the 11.8m^3/s that supplies the essential and auxiliary cooling water systems is 6.6°C. In the absence of full details on the design of the SZC cooling water system, thermal modelling assumed 125m^3/s would be discharged at 11.6°C thermal uplift (BEEMS Technical Report TR302). This is within 1.4% of the predicted total heat flux in the cooling water discharge of 131.8m^3/s at a net thermal uplift of 11.15°C and the modelling is, therefore, of sufficient accuracy for assessment purposes.

An additional scenario was assessed during normal operation of Sizewell B and maintenance of Sizewell C, whereby two of the four pumps are not operating but the two EPR Units remain running at full power. Such circumstances are unlikely but would result in approximately half the cooling water abstraction rate with the same level of thermal energy applied. Therefore, excess temperatures could potentially rise from 11.6°C to 23.2°C (BEEMS Technical Report TR302). Modelling has demonstrated that a warmer thermal plume loses heat faster to the atmosphere resulting in less heat being mixed down into the water column. Under the maintenance scenario, the total areas in exceedance of thermal standards are lower than during standard operating procedures, as such assessments consider normal operating scenarios as the worst-case (BEEMS Technical Report TR306).

Abstracted water for the main cooling water system would arrive at the forebay at the end of each intake tunnel before being passed through four drum screens to remove fish and larger organisms, which would be returned to the receiving waters via the fish recovery and return (FRR) systems. Essential and auxiliary cooling water would pass through band screens or drum screens.

Chlorination would be applied to achieve protection of critical plant (essential cooling water systems for the nuclear island and the turbine hall, and the condensers). To reduce the annual duration of chlorinated discharges, seasonal chlorination would be applied. However, spot-chlorination may be required to protect critical plant outside these periods.

Chlorination would be applied after the drum screens to prevent exposure of impinged biota. Chlorination would be applied at a dose level to produce a total residual oxidant (TRO) concentration of 0.2mg/l after the drum screens. The TRO discharge concentration from the CW systems at the outfall would be 0.15mg/l. To represent the worst-case scenario water quality modelling considers the impacts of 0.15mg/l TRO released at the outfalls at a maximum discharge of 132m^3/s

The seasonal chlorination strategy for the proposed development involves chlorination during the period of the year when water temperatures exceed 10ºC. By 2030, predicted water temperatures at the Sizewell C intakes would exceed 10ºC from the beginning of May until the start of December (BEEMS Technical Report TR306). The potential exists for future climate change to extend the period of the year seawater temperatures exceed 10ºC, and by proxy, the seasonal duration of chlorination. Shifts in plankton phenology have been observed in the North Sea. Since the 1960s, peaks in dinoflagellates have occurred 23 days earlier, diatoms 22 days earlier, copepods 10 days earlier, and other holozooplankton groups 10 days earlier (Richardson 2008). Whilst the duration of the growing season is likely to extend in the future, temperature driven changes in phenology would be moderated by day length and solar elevation thus restricting the total growth period. In the coastal waters at Sizewell, high levels of turbidity in the winter and early spring limit biological production (BEEMS Technical Report TR346) and increases in the duration of annual chlorination is likely to be in the order of weeks at most. The influence of climate change on the seasonal chlorination strategy is considered within the Marine Ecology and Fisheries ES and as part of the project wide In-Combination Climate Impact (ICCI) assessment in (ES Volume 2 Chapter 26).

Chemicals, including hydrazine, are added to the secondary circuit to prevent corrosion and to control pH. The non-recyclable blowdown from the Steam Generator Blowdown System is sent to the Nuclear Island waste Monitoring and Discharge System [KER], for monitoring and discharge on a batch basis in admixture with Stream B (the nuclear island waste monitoring and discharge system tanks). If necessary, mitigation may be implemented at this stage to treat hydrazine to an acceptable level prior to discharge.

The admixture of stream B and C would be discharged to the outfall pond prior to release to the Greater Sizewell Bay via the common Outfall Tunnel. Additional inputs at the discharge pit including sanitary waste, groundwater and surface run-off, and daily hydrazine discharges. Discharges into the cooling water flow allows dilution prior to mixing in the receiving waters allowing a level of mitigation. The lowest volume of water abstracted under normal operating conditions would be 116m^3/s. Water quality assessments for discharged contaminants are based on this discharge rate as it represents the worst-case dilution scenario for standard operation of the power station (BEEMS Technical Report TR306).

Refuelling and maintenance outages

During the 60-year operational life, each reactor unit would undergo refuelling and maintenance shutdowns (otherwise known as ‘outages’) at approximately 18-month intervals. The duration of these outages would vary according to the maintenance and inspections required but would typically be up to two months.

1.2.4 Fish Recovery and Return (FRR)

1.2.4.1 FRR: Construction

Two fish recovery and return (FRR) systems would be constructed, one for each reactor. The small diameter FRR tunnels (approximately 0.65m internal diameter) would be drilled beneath the seabed with arisings transported to landward for disposal.

Prior to installation of the FRR outfall headworks, overlying soft sediment in the shallow subtidal (<6m) would be removed by dredging using a Cutter Suction dredger with spoil disposed locally within a licensed disposal site Section 1.2.6. The FRR outfall headwork is assumed to comprise a concrete block approximately 3m long, 4.5m high, and 3m wide buried 2m into the sediment.

The northerly position of the two FRRs is designed to be in alignment with the forebays of each reactor, minimising the required tunnel length and hence the time taken for fish to be returned to the marine environment. The optimal easterly position is determined by several interacting factors, including:

- The depth of the water at the point of discharge. Water depths must be sufficient at all stages of the tide to reduce predation by surface feeding birds.
- Avoidance of mobile geomorphic features. The two nearshore bars at Sizewell are important to sand transport and move naturally in response to the prevailing wave climate. The bars must be cleared to avoid burial of the system. The FRRs (and CDO) have been positioned on the seaward flank of the outer longshore bar, where bed level fluctuations are less, due to lower rates of transport. This location minimises the effects of the structures on geormophology to localised scour only.
- Minimising transit time of impinged biota.

- Avoiding the Sizewell B (SZB) discharge plume. The SZB outfall is positioned 150m offshore (from mean water level on the beachface). A short FRR tunnel would, therefore, release fish into the SZB TRO plume on the ebb tide. The SZB cooling water discharge is chlorinated throughout the year.
- Minimising the risk of fish re-impingement into SZB. The SZB intake is 600m offshore and there is a risk that, on the flood tide, some of the fish discharged from the FRR outfall could be re-abstracted at the SZB intake.

The proposed position for the FRR outfalls is ca. 475m from the forebays on the seaward flank of the outer longshore bar in water depths of 5.5 -6m below ODN. Transit times along the 475m tunnel to the FRR outfalls would take approximately 13 minutes at a discharge at a rate of 0.3m^3/s (BEEMS Technical Report TR333).

The exact position of the headworks will depend on constructability with the Works Plan allowing a 25m radius for deviation for all headworks. Indicative positions of the FRR headworks for assessment purposes are assumed to be:

- FRR 1 head: Easting 647980, Northing 264000 -5.6m ODN.
- FRR 2 head: Easting 647980, Northing 264300 -6.0m ODN.

1.2.4.2 FRR: Operation

Abstracted water would be transported along the intake tunnels to the station forebays where rotating drum screens would impinge larger biota, including fish and crustaceans. Impinged biota would be washed off the drum screens and returned to the GSB via the fish recovery and return (FRR) systems.

The use of one FRR per EPR would avoid the need for a complex junction system and hydraulic assessments have determined that an Archimedes screw would not be required. This reduces the ‘handling’ of impinged fish and crustaceans.

The FRR wash water would not be chlorinated. Therefore, impinged biota would not be subjected to chlorination.

1.2.5 Combined Drainage Outfall (CDO)

1.2.5.1 Construction and construction phase function of the combined drainage outfall

The combined drainage outfall (CDO) would be constructed early in the construction phase and act as the site discharge outfall. Drilling the tunnel is anticipated to take two months with directional drilling. Prior to CDO completion, station effluents would be reused where possible or tankered offsite for managed disposal.

As required, the CDO would discharge tertiary treated sewage, dewatered groundwater, surface run-off, tunnelling wastewater, and commissioning discharges. Discharges would be treated with oil separators to minimise potential hydrocarbon contamination from mobile or fixed plant operations and a silt-buster or similar technology to reduce sediment loading.

A Water Discharge Activity (WDA) Environmental Permit assessment will be required prior to any discharges.

The exact position of the CDO headwork will depend on constructability. For assessment purposes the CDO headwork is assumed to be located at 647980 E, 264340 N on the seaward flank of the outer longshore bar, approximately 400m from the HCDF, in water depths of ca. -6.2m ODN. The location limits the potential for discharges to interact with the coastline. The CDO tunnel would be drilled beneath the seabed with arisings transported to landward for disposal. The tunnels would be connected to a concrete outfall structure anticipated to be of similar dimensions to the FRR headworks.

Prior to installation of the CDO outfall headwork, overlying soft sediment in the shallow subtidal (<6m) would be removed by dredging via a Cutter Suction dredger with spoil disposed locally within a licensed disposal site with local disposal. A description of dredging activities is provided in Section 1.2.6.

To enable the plausible worst-case volume and contaminant concentrations to be considered for permitting and for assessment in the ES the following cases have been considered (Figure 3):

- **Case A** is associated with the dewatering phase of the cut-off wall for the main development site. Initial dewatering is anticipated to remove 300,000m^3 of groundwater at rate of 124l/s. Dewatering is anticipated to last 28 days and represents the worst-case for metals contamination. For the remainder of the construction period groundwater dewatering is estimated to occur at a nominal rate of 15l/s to remove rainwater and seepage through the cut-off wall.
- **Case D** is based on the expected number of personnel on site during the construction phase and represents the typical worst-case scenario for sewage discharges, nutrient inputs and un-ionised ammonia. Sewage discharge rates are anticipated to be 13.3l/s throughout much of the construction period. The biochemical oxygen demand (BOD) from these discharges is expected to be of negligible significance to the dissolved oxygen (DO) concentration and DO levels are anticipated to remain within WFD 'high' status during the construction phase (BEEMS Technical Report TR306).
- **Case D1** represents an extreme case of sewage discharge, it is likely to be highly transitory with a maximum sewage only discharge rate of 30l/s. Groundwater from main site with inputs from tunnelling are also included.
- **Case E** waste from the TBM soil conditioning chemicals, if present, is likely to make the largest contribution during Case E. his assumes consecutive TBM machines operating with the potential for two sources of ground conditioning chemicals (6l/s) to be discharged in a total estimated volume of 34.3l/s although recovery systems mean some chemical inputs are likely to be minimised.

1.2.5.2 Commissioning function of the combined drainage outfall

The CDO would act as a discharge point during part of the commissioning phase of the proposed development. Commissioning of the reactors is proposed to take place in two stages;

- cold flush testing, and;
- hot functional testing.

The commissioning process for each unit would last for about 24 months. A 12-month gap is anticipated between the completion of the two reactor units. Cold flush testing mainly involves cleansing and flushing the various plant systems with demineralised water to remove surface deposits and residual debris from the installation. Waste streams during cold flush testing of Unit 1 would be directed to a storage tank with controlled discharge via the CDO. The discharge routing for Unit 2 has yet to be confirmed. A Rochdale envelope approach was therefore applied to represent the worst-case scenario for commissioning discharges, whereby treatment tanks for both Units were assumed to discharge to the CDO. This represents a highly precautionary assessment. A second assessment assumes the case whereby cold flush testing discharges from Unit 2 are released via the CDO, whilst Unit 1 is operational. This represents a potential worst-case scenario for fish and other biota discharged from the FRR associated with Unit 1, approximately 340m south of the CDO.

Cold flush testing discharges would include small quantities of conditioning chemicals including:

- hydrazine;
- ammonia;
- phosphate, and;
- ethanolamine.

Detailed modelling and assessments have been completed to determine the fate of commissioning discharges of hydrazine.

Nutrient discharges, including DIN and phosphate are considered as part of the wider construction nutrient release scenarios. Water quality assessments indicated that ethanolamine passed initial dilution assessments and never exceeds assessment thresholds whilst un-ionised ammonia does not exceed EQS beyond 25m from the point of discharge (BEEMS Technical Report TR193). Un-ionised ammonia discharges during commissioning are lower than the worst-case construction discharges, which are assessed.

Hot flush testing takes place before fuelling the reactor once the cooling water infrastructure is operational. The effluent produced during hot functional testing would be diluted within the cooling water system before being discharged via the outfall tunnel.

1.2.5.3 Operational function of the combined drainage outfall

There is no operational function anticipated for the CDO.

1.2.6 Summary of dredging and drilling activities and assessments

This section details the proposed dredging options for the offshore infrastructure and the BLF. In the UK dredging and disposal is a licensable activity and managed by the Marine Management Organisation (MMO) under the Marine and Coastal Access Act 2009. Disposal activities are licenced under a Marine Licence (or deemed Marine Licence (DML) in the case of a DCO) which must reference a designated disposal site.

Table 1 describes the dredging and drilling scenarios for each development component as well and the disposal options. Local disposal is the intended option for capital dredging activities associated with offshore infrastructure.

A disposal site designation report (BEEMS Technical Report TR508, in prep.) will be submitted as part of the DCO application process. The disposal site designation report details:

- The need for a new disposal site;
- The characteristics of the material to be disposed;
- The disposal site characteristics, and;
- The assessment of potential impacts.

A DML condition for dredging and drilling activities includes the requirement to monitor sediment contamination levels to ensure dredge/drill material is deemed acceptable for the proposed disposal route. Samples must have been collected within three years of dredging/drilling activities and analysed in an MMO accredited laboratory.

The impact of SSC plumes and sedimentation from dredging activities has been modelled in BEEMS Technical Report TR480.

Resuspension of pollutants and nutrients from contaminated sediments has the potential to influence ecological receptors. The sandy nature of the sediments within the GSB, low organic content and sediment contamination levels present a low risk of releases of sediment-bound contaminants or nutrients to the water column (BEEMS Technical Report TR305). No further assessments on contaminants or nutrient release from sediments are made. However, dredging activities would be subject to DML conditions, which would include the requirement to verify sediment quality prior to dredging activities, thus mitigating environmental impacts.

Direct effects of increased SSC and sedimentation rates will be considered in detail for each receptor within the ES. In addition, the potential for indirect effects from elevated SSC will be considered for designated species with marine prey and for marine food webs.

The CDO and FRR headworks are located in the inshore environment. These small structures would be partially buried in the surficial sediment.

The cooling water infrastructure headworks would be located further offshore, seaward of the Sizewell-Dunwich Bank.

The northern intakes (Unit 2) and the outfalls are located in soft sediment environments. To allow for precautionary assessments of dredge volumes, plume modelling assumed overlying sediments were approximately 6m deep. Geological interpretation of the overlying sediment indicates sediment thickness varies between tens of centimetres to more than two metres in these areas. As such, volume estimates applied in plume modelling are precautionary.

The two southern intakes associated with Unit 1 would be positioned on exposed Coralline Crag deposits, with no or minimal overlying sediment. The Coralline Crag is the oldest outcropping rock in the area; it was formed during the Pliocene and consists of bryozoan-rich biogenic sands with clay horizons. Minimal overlying sediment occurs in this location.

Table 1: Summary of dredging and drilling activities and disposal routes.

Development component	Dredge/drill type and frequency	Anticipated dredge method	Disposal option
Navigational dredging for the BLF.	1. **Capital dredge:** The first instance of dredging for the BLF navigational channel would require dredging to a depth that had not occurred in the proceeding 10 years and would involve a small-scale capital dredge.. 2. **Maintenance dredge:** Maximum vessel activity at the BLF is anticipated during the 'campaign period' (31st March to 31st October), however deliveries may occur at any time. Infilling would necessitate the requirement for maintenance dredging to ensure the navigable channel. The volume and frequency of maintenance dredging would depend on ambient conditions determining infilling rates and the tolerance of the vessels. Assessments assume maintenance dredging of 10% the initial capital volume to occur at approximately monthly intervals during the campaign period.. **3. Preparatory dredging:** Each season during the construction period (or following large infilling episodes following storm events), preparatory dredging of the initial capital dredge volume would be required.	Plough dredger	Plough dredging agitates the sediment, which is transported away by tidal processes. Spoil is not extracted and a disposal Licence is not required for this activity
Installation of CDO headwork.	**Capital dredge:** To install the CDO headwork small scale capital dredging would be required required to bury the headwork within the sediment. Dredging would be a single event.	Cutter suction dredger	Marine Licence appliation required for local disposal.
Installation of FRR headworks.	**Capital dredge:** To install the two FRR headworks small scale capital dredging would be required to bury the headwork within the sediment. Dredging would occur once for each structure.	Cutter suction dredger	Marine Licence appliation required for local disposal.
Installation of Cooling water intake	**Capital dredge:** To install the cooling water headworks capital dredging would be required to remove the surficial sediments enabling the cooling water headworks to be installed on the	Cutter suction dredger	Marine Licence appliation required for local disposal.

Development component	Dredge/drill type and frequency	Anticipated dredge method	Disposal option
and outfall headworks.	underlying bedrock. Dredging would occur once for each structure including two outfall headworks and four intake headworks.		
Drilling for vertical shafts connecting cooling water tunnels with the headworks.	**Drilling:** Within the captial dredge footprint through the bedrock to connect the headworks with the cooling water tunnels.	Specific method to be confirmed.	The release of fine drill cutting is assumed to be in the surface layers as this represents the worst-case plume scenario. Drill arisings would settle locally or disperse depnding on the particle size. A disposal licence application will be sought.

1.3 Scope of the assessment and assessment scenarios

Marine Ecology and Fisheries ES assessment scenarios consider the construction, commissioning and operational phases of the proposed development. A separate EIA for decommissioning will be made based on the available technology, methods of decommissioning, and baseline environmental conditions at the time.

The construction period is expected to last between nine and 12 years. For assessment purposes, construction Year 1 is taken to be 2022. The primary construction phase is between 2022 and 2033. The station is assumed to be operational by 2033.

There are five phases to the main construction period:

- Phase 1: Site establishment and preparation for earthworks;
- Phase 2: Main earthworks;
- Phase 3: Main civil works;
- Phase 4: Mechanical and Engineering (M&E) fit out, instrumentation and commissioning, and;
- Phase 5: Removal of temporary facilities and restoration.

An understanding of the construction sequence is required in order to assess in-combination effects within the project (inter-relationships).

During Phase 1 the work will commence to construct the Beach Landing Facility (BLF) and the northern coastal defence that supports the Beach BLF haul road. The Combined Drainage Outfall (CDO) system would be constructed to allow construction discharges into the GSB.

Phase 2 would involve the primary earthworks including the excavation of made ground at the power station platform area, within the cut-off area. During Phase 2 maximum dewatering scenarios are anticipated.

The construction of the power station and ancillary infrastructure would occur in Phase 3. The accommodation campus would be in full use and associated discharges of treated sewage is assessed. Permanent infrastructure relevant to the marine environment includes:

- construction of the cooling water intake and outfall tunnels;
- insertion of the intake and outfall headworks and drilling of vertical connecting shafts;
- installation of cooling water structures and main pump house, and;
- construction of the permanent coastal defence feature.

In Phase 4, building works including the cooling water infrastructure and the two reactors would be completed and engineering of the main power station would begin. Completion of reactor Unit 1 and Unit 2 is expected to be separated by 12 months.

During commissioning, the power station would be tested including flushing of the cooling water systems. Discharges would be via the CDO during cold flush testing. Discharges from hot functional testing would be via the main cooling water infrastructure once completed.

An indicative timeline is presented in Figure 3.

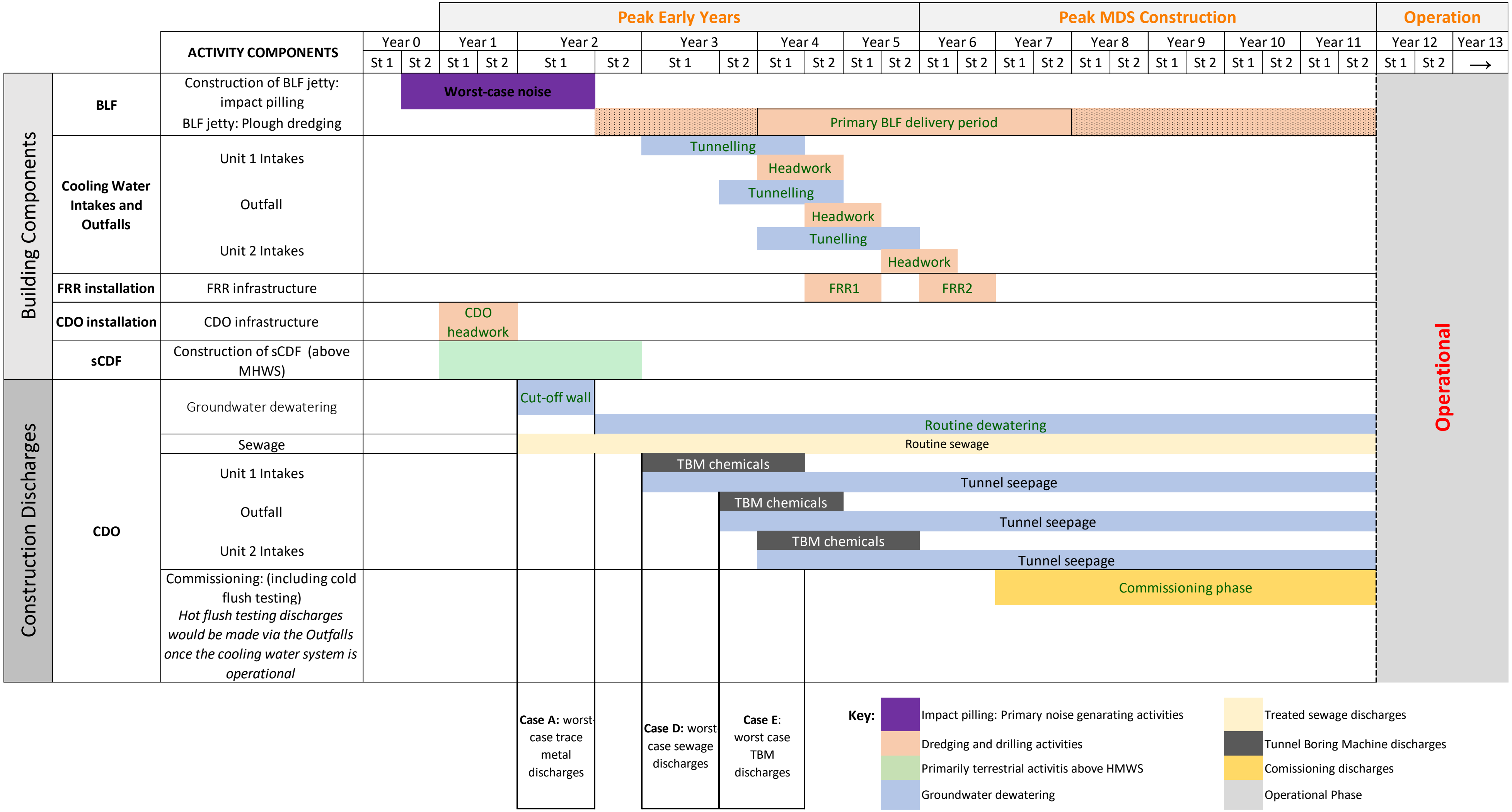

Figure 3: Indicative development timeline for assessment scenarios.

1.4 Sizewell BEEMS Studies

The geographical extent of the marine ecology study area was determined by the potential zone of influence (ZoI) for the Main Development Site.

The Greater Sizewell Bay (GSB) forms the initial reference area for marine assessment purposes. The GSB extends from Blyth Piers in the north to the Coralline Crag outcrops near Thorpeness in the south. The seaward boundary extends to the eastern flank of the Sizewell-Dunwich Bank, to include the spatial extent of the proposed cooling water infrastructure. The landward limit is delineated by the Mean High-Water Springs (MHWS) tidal mark.

The GSB is an open coastal system and water exchanges between the bay and the rest of the southern North Sea. The spatial extent of potential impacts from the proposed development are therefore dependent on the tidal regime and the transmission and persistence of the pressure. The ZoI's have been informed by the largest-scale potential impacts associated with the Main Development Site, which include:

- Results from underwater noise modelling during construction activities (impact pilling, dredging, drilling);
- Results from suspended sediment plume modelling associated with dredging and drilling activities, and;
- Thermal plume modelling of the in-combination impacts of Sizewell B (SZB) and Sizewell C (SZC) cooling water discharges (applying the 2ºC mean excess temperature contour at the seabed).

The consultation process identified the need to consider receptor specific effects beyond the ZoI, particularly for highly mobile species. Effects on marine ecological receptors are dependent on the distribution, mobility and ecology of the species being considered relative to the impact. Therefore, assessments will determine the receptor-specific spatial scale within the 'Impact Magnitude' narrative.

The boundary of the study area for commercial fisheries was determined to be the International Council for the Exploration of the Sea (ICES) rectangles accounting for the local fishery (ICES rectangle 33F1) and the regional context (ICES rectangles 32F1, 32F2, 33F2, 34F1 and 34F2). The boundary of the study area for recreational angling from beaches and boats was ICES rectangle 33F1.

1.5 Designated sites and features

A number of statutory and non-statutory designated sites are located within the ZoI of impacts arising from the proposed development.

The proposed development has the potential to effect ecological sites designated as being of European or International Importance for nature conservation. Consequently, a Shadow Habitats Regulations Assessment (HRA) will be submitted to the Planning Inspectorate for Development Consent Order (EDF Energy 2019a). The shadow HRA details the likely significant effects (LSE) on the designated features of European Sites including SPAs, SACs and Ramsar sites within the ZoI of the proposed development.

In parallel with the shadow HRA, the Marine Ecology and Fisheries ES considers the specific marine components (below MHWS) of designated European sites. Potential marine impacts of the proposed development on SSSIs and CWSs are also considered.

Direct effects on seabirds and vegetated shingle (annual vegetation of drift lines) will be considered in an ES context within the Terrestrial Ecology and Ornithology ES chapter and Coastal Geomorphology and Hydrodynamics chapter as appropriate. Indirect effects on designated features, including effects on prey species or effects on supporting habitat, are considered within the Marine Ecology and Fisheries ES. A summary of the designated sites with potential marine impact pathways assessed in the ES is presented in Table 2. It should be noted this is not an exhaustive list and the HRA will consider European sites in greater detail.

Food web effects and indirect effects on designated features mediated through changes in the abundance and distribution of marine prey species are considered within this chapter.

Table 2: Potential impacts from the proposed development on statutory designated sites and non-designated sites with marine components.

Site and location.	Description of site features with marine components.	How and where is the site assessed in the ES?
Minsmere to Walberswick SPA and Ramsar site. Located adjacent to the north-east boundary of the Main Development Site (MDS).	The site consists of a mosaic of marshes, dykes, reedbeds, brackish lagoons, mudflats, shingle and driftlines. The SPA is designated for breeding, wintering and passage bird populations of European importance, including breeding populations of marsh harrier (*Circus aeruginosus*), bittern (*Botaurus stellaris*), avocet (*Recurvirostra avosetta*) and little tern (*Sterna albifrons*). The Ramsar site supports a diverse range of wetland bird species in nationally important numbers.	Changes to coastal process and mitigation measures that could have a bearing on the SPA are considered in the Geomorphology and Hydrodynamics ES, including a narrative discussion of potential future shorelines. LSE on designated bird species will be assessed as part of the HRA (EDF Energy, 2019). The Marine Ecology and Fisheries ES chapter considers the following issues: • The potential for chemical and/or thermal discharges to impact the wetland habitats through direct intersecion, overtopping or perculation through the dune sytems. • Potential changes in the availability of marine prey speies of designated birds due to avoidance behaviours (e.g. underwater noise) or mortality (e.g. impingement). • The potential for thermal/chemical discharges to distrupt migratory pathways of glass eels into the Minsmere sluice (prey item for bitterns).
Minsmere to Walberswick Heaths and Marshes SAC Located adjacent to the north-east boundary of the Main Development Site (MDS).	The site is designated for 'annual vegetation of drift lines'. Species include sea sandwort (Honckenya peploides) and sea beet Beta vulgaris ssp. maritima.	The potential for chemical and/or thermal discharges to impact the wetland habitats through direct intersecion, overtopping or perculation through the dune sytems is considered in the Marine Ecology and Fisheries ES. Changes to coastal process and mitigation measures that could have a bearing on the SAC will be considered in the Geomorphology and Hydrodynamics ES, including a narrative discussion of potential future shorelines. Annual vegetation of drift lines is assessed within the Terrestrial Ecology and Ornithology ES.

Site and location.	Description of site features with marine components.	How and where is the site assessed in the ES?
Minsmere to Walberswick Heaths and Marshes SSSI. Adjacent to the north of the MDS.	This SSSI contains a complex series of habitats, notably mudflats, shingle beach, reedbeds, heathland and grazing marsh. These habitats combine to create an area of exceptional scientific interest that supports a diverse breeding and wintering bird assemblage and a diverse range of invertebrates.	The potential for chemical and/or thermal discharges to impact the wetland habitats through direct intersecion, overtopping or perculation through the dune sytems will be considered in the Marine Ecology and Fisheries ES. Changes to coastal process and mitigation measures that could have a bearing on the SSSI will be considered in the Geomorphology and Hydrodynamics ES, including a narrative discussion of potential future shorelines.
Alde-Ore Estuary SPA and Ramsar site. Approximately 5km south of the MDS.	The Alde-Ore Estuary is identified as a Ramsar site for its diverse and nationally important wetland bird species, and as an SPA because it supports bird populations of European importance, including breeding populations of avocet, little tern and sandwich tern (*Sterna sandvicensis*), and over-wintering ruff (*Philomachus pugnax*). The site also supports important migratory populations of lesser black-backed gull (*Larus fuscus*) during the breeding season and redshank (*Tringa tetanus*) during the winter. The site also supports a seabird assemblage of international importance (including little tern, sandwich tern, lesser black-backed gull, black headed gull (*Larus ridibundus*) & herring gull (*Larus argentatus*).	The Marine Ecology and Fisheries ES chapter considers the following issues: • Thermal and chemical plumes at ecologically relevant concentrations do not intersect the wetlands within the mouth of the Alde-Ore Estuary (further south) and are not considered further (BEEMS Technical Report TR483). • Potential changes in the availability of marine prey speies of designated birds due to avoidance behaviours or mortality. LSE on designated bird species will be assessed as part of the HRA (EDF Energy, 2019).
Benacre to Easton Bavents SPA Approximately 15km north of the MDS.	The site qualifies by supporting breeding and over wintering bittern, breeding little tern and breeding marsh harrier.	The distance of the site and restricted foraging ranges of little terns mean it is too far away to be influenced by thermal and chemical discharges at ecologically relevant levels (BEEMS Technical Report TR483). LSE on designated bird species will be assessed as part of the HRA (EDF Energy, 2019).
Outer Thames Estuary SPA Includes the area of open sea adjacent to the MDS.	The Outer Thames Estuary SPA qualifies by supporting populations of European importance of wintering red-throated diver (*Gavia stellata*).	The Marine Ecology and Fisheries ES chapter considers potential changes in the availability of marine prey speies of designated birds due to avoidance

Site and location.	Description of site features with marine components.	How and where is the site assessed in the ES?
	The site also protects foraging areas for little tern and common tern during the breeding season enhancing the protection already afforded to their feeding and nesting areas in the adjacent coastal SPAs (including the Minsmere to Walberswick SPA).	behaviours or mortality. LSE on designated bird species will be assessed as part of the HRA (EDF Energy, 2019c).
Orfordness-Shingle Street SAC. Approximately 8km south of the MDS.	The habitats that are a primary reason for selection of this site are ‘coastal lagoons’, ‘annual vegetation of drift lines’ and ‘perennial vegetation of stony banks’. The coastal lagoons are not a marine feature as they occur landward of highest astronomical tide, and form part of the percolation lagoon features on the east coast.	The distance from the site means thermal and chemical plumes during normal operating procedures would not impact the wetland habitats through direct intersecion, overtopping or perculation through the dune sytems at ecologically relevant concentrations (BEEMS Technical Report TR483).
Deben Estuary SPA and Ramsar site. Approximately 30km south of the MDS.	The SPA qualifies by supporting overwintering populations of avocet. The Deben Estuary Ramsar site supports: a population of the mollusc Vertigo angustior; and an overwintering population of dark-bellied Brent goose (*Branta bernicla bernicla*).	The site is beyond the ZoI of impacts from the proposed development, therefore there are no predicted effects on the prey of these species. No further assessment is made.
Southern North Sea SAC Includes the area of open sea adjacent to the MDS.	The Southern North Sea SAC is designated for the Annex II species harbour porpoise (*Phocoena phocoena*) for both winter and summer seasons. The area supports approximately17.5% of the UK North Sea Management Unit (MU) population.	Harbour porpoise are a key species for the the Marine Ecology and Fisheries ES. Direct effects on porpoise, and indirect effects on prey species will be considered further.
Orford Inshore MCZ. Offshore, approximately 16km south-east of the MDS and 14km from the Alde Ore estuary	The site is composed of subtidal mixed sediments that form important nursery and spawning grounds for some species of fish, including Dover sole, lemon sole and sandeels. Burrowing anemones, sea cucumbers, urchins, starfish and nationally important shark species are found at the site. The area is an important foraging area for seabirds. Harbour porpoise pass through the site. The protected features at the site are ‘subtidal mixed sediments’.	The Orford Inshore MCZ is beyond the ZoI of the impacts associated with the proposed development and is not considered to have any effect on the management objectives of the protected features at the site. No further assessment is made.

Site and location.	Description of site features with marine components.	How and where is the site assessed in the ES?
Humber Estuary SAC. Approximately 220km north of the MDS.	The site is designated for the Annex II species grey seal (*Halichoerus grypus*).	Whilst the SAC is located well beyond the ZoI of the proposed development, grey seals are highly mobile species and individuals from the Humber Estuary SAC may transit past the site or utilise the area for foraging. Grey seals are a key species for the the Marine Ecology and Fisheries ES. Direct effects on seals, and indirect effects on prey species will be considered further.
The Wash and North Norfolk Coast SAC. Approximately 120km north of the MDS.	The site is site is designated for the Annex II species harbour seal (*Phoca vitulina*).	The SAC is located well beyond the ZoI of the proposed development; however, harbour seals are highly mobile species and individuals from the Wash and North Norfolk Coast SAC may transit past the site or utilise the area for foraging. Harbour seals are a key species for the Marine Ecology and Fisheries ES. Direct effects on seals, and indirect effects on prey species will be considered further.
Leiston to Aldeburgh SSSI Approximately 1km south of the MDS.	This SSSI contains a rich mosaic of habitats, including acid grassland, heath, scrub, woodland, fen, open water and vegetated shingle. There is a gradual transition between the vegetated shingle of the strandline community and the shingle heath resulting from increasing stability and distance from tidal influence.	Changes to coastal process and mitigation measures that could have a bearing on the SSSI will be considered in the Geomorphology and Hydrodynamics ES, including a narrative discussion of potential future shorelines. Vegetated shingle will be considered within the Terrestrial Ecology and Ornithology ES. No further assessment will be made on the Leiston to Aldeburgh SSSI in the Marine Ecology and Fisheries ES.
Suffolk Shingle Beaches CWS.	The CWS forms part of the east coast vegetated shingle matrix and supports coastal sand and shingle habitats, a diverse assemblage of invertebrate species is found at the coastal site.	Vegetated shingle is considered within the Terrestrial Ecology and Ornithology ES. Changes to coastal process and mitigation measures that could have a bearing on the CWS will be considered in the Geomorphology and Hydrodynamics ES, including a narrative discussion of potential future shorelines.

2 Construction phase activity-pressure pathways

In 2014, the Sizewell C EIA Scoping Report (EDF Energy, 2014) sought to present the EIA methodologies and set out the key matters for consideration in the EIA. In 2019 an updated EIA Scoping Report (EDF Energy 2019b) was submitted to identify the potential development activities and associated pressures that marine receptors may be exposed to during the construction and operational phases of the proposed development. A thorough review of the current status of the development, accounting for potential engineering and mitigation solutions, has been undertaken to identify all potential activity-pressure pathways. Based on the current understanding of the development components, outlined in Section 1.2, anthropogenic activities during development were listed. Each activity has the potential to exert specific pressures on the marine environment resulting in impacts. The magnitude of such impacts, and the sensitivity of the receptors exposed ultimately determines if effects on a given receptor are likely to be significant[1].

The approach to identifying potential effects of the proposed development followed the activities-pressures matrix proposed by the Healthy and Biologically Diverse Seas Evidence Group (JNCC, 2013[2]). The initial step reviewed the construction and operational elements of each development component to determine the full list of activities.

The full list of activities for each development component was then cross tabulated with the OSPAR Intercessional Correspondence Group on Cumulative Effects (ICG-C) list of pressures (OSPAR, 2011). This approach allowed a common language and a consistent way to assess pressures and the resultant effects on biodiversity (DEFRA, 2015). This process was repeated for each ecological receptor group to identify activity-pressure pathways. It should be noted that whilst this approach is very useful at the scoping stage, more common language/terminology may be applied for some pressures during the ES. For example, scour may be considered as a pressure.

The Commercial and Recreational Fisheries ES section will assess effects on fisheries by considering the sensitivity of the specific fishery to development impacts during the construction and operational phase of the proposed development. Assessments will be based on the different fishing practices (e.g. potting, driftnetting, trawling). Further details will be available in the ES. Fisheries sensitivity will be informed by the results of the fish and benthic ecology ES assessments and additional fisheries specific aspects (CEFAS, 2004), these will include:

- Effects of the development on commercially important fin and shellfish populations;
- Effects of the development on recreationally targeted fish populations;
- Loss or restricted access to fishing grounds;
- Interference with fisheries activities;
- Fisheries displacement including potential increased steaming times to fishing grounds.

Potential safety issues will be assessed elsewhere as part of the Navigational assessment (ES Volume 2 Chapter 24).

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[1] Depending on the management objective, environmental assessments apply terminology in subtly different ways. A review of existing approaches to marine habitat vulnerability, commissioned by the Environment Agency, concluded that clear definitions of fundamental terms applied in the assessment procedure is required (Roberts *et al.,* 2010). The terminology that will be applied throughout the Marine Ecology ES is presented in Appendix A.1.
[2] JNCC - Marine Activities and Pressures Evidence: http://jncc.defra.gov.uk/default.aspx?page=7136 last accessed 18 December 2018

2.1 Construction Activities

Activities associated with the development components during the construction phase were informed by the JNCC 'Standard List of Human Activities in the Marine Environment'. However, due to the specific range of activities at Sizewell C, a list of development-specific activities was developed for each development component. The primary activities that would occur during the construction of the proposed development include:

- Piling;
- Installation and physical presence of infrastructure;
- Dredge extraction and disposal;
- Vessel traffic;
- Drilling activities;
- Construction discharges;

The primary construction activities and the development components they are associated with are described in Table 3. Additional construction activities, which have also been considered include;

- Construction platform operations including jack-up barges and anchoring (included in vessel traffic below);
- Heavy plant operations on the beach, including beach reprofiling (primarily above MHWS);
- Installation of a rock platform (potential option for the construction of the BLF);
- Anthropogenic presence in the marine and coastal environment.

Table 3: Primary construction activities during the proposed development with the potential to interact with the marine environment.

Primary construction activities	Development Component				Description
	BLF	CW infrastructure	FRR	CDO	
Piling	✓				Installation of BLF jetty piles is anticipated to be by impact piling either from a jack-up vessel or a terrestrial piling vessel (should a temporary rock platform be constructed).
Physical presence of structure	✓	✓	✓	✓	Installation and presence of artificial hard structure in the marine environment.
Dredging and dredge disposal	✓	✓	✓	✓	Dredging would be required for navigational access to the BLF and to create a planar surface to allow barges to come aground. Dredging will also be required to remove surficial sediments during the installation of the cooling water infrastructure, the FRRs and CDO. Assessments assume dredge disposal to occur within the site as a worst-case scenario.
Vessel traffic	✓	✓	✓	✓	Increased vessel traffic within the site, particularly in association with BLF deliveries but also includes vessel traffic and (for the purpose of this report) activities associated with vessels involved with construction operations (e.g. anchoring and positioning of jack-up barges).
Drilling		✓	✓	✓	Drilling of vertical connecting shafts through the bedrock for cooling water infrastructure and installation of piles to secure headworks to the bedrock to ensure seismic qualification. The FRR and CDO tunnels would be directionally drilled from landward.
Construction discharges				✓	Discharges including tertiary treated sewage, dewatered groundwater, surface run-off, tunnelling wastewater, and commissioning discharges. Discharges would be treated with oil separators and a silt-buster or similar technology to reduce sediment loading.

2.2 Construction Pressures

The OSPAR ICG-C list of pressures (OSPAR, 2011) were applied to allow a consistent recognisable and defined list of pressures for assessment purposes. Pressures fall within the overarching themes of:

- Hydrological changes;
- Pollution and other chemical changes from sediment resuspension or discharges
- Physical loss;
- Physical damage;
- Other physical damage (e.g. noise and light), and;
- Biological pressures;

Each pressure theme has a number of specific pressures that were cross-tabulation with the development activities. Cross tabulation allowed a formal means to scope out activities with no pressure pathways and identify all potential activity-pressure pathways on a given receptor (Table 4). Formal pressure benchmarks for sensitivity assessments have been applied through the Marine Evidence-based Sensitivity Assessment (MarESA) approach for benthic species and habitats (Tyler-Walters *et al.,* 2017) and highly mobile marine species such as fish, lobster and marine mammals (Pérez-domínguez *et al.,* 2016). Pressure benchmarks therefore provide a basis for assessing the sensitivity of a given receptor to the site-specific impacts relative to recognise standards (Appendix B.1). However, it should be noted that the benchmarks are not universally applicable and site-specific factors at Sizewell may require further scrutiny. Accordingly, pressure benchmarks form a guide rather than a regulatory standard, such as an EQS (Environmental Quality Standard).

Available evidence and expert judgment were applied to determine which of the activity-pressure pathways required further ecological investigation and which could be eliminated from further assessment. Pathways were eliminated when the magnitude of impacts and/or the sensitivity of ecological receptors exposed to such impacts was considered negligible to incur effects. A summary of the results of the activity-pressure cross tabulation during the construction phase are presented in Table 4.

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Table 4: An example extract from the cross-tabulated activity-pressure matrix for the construction phase of the BLF for plankton receptors. Potential activity-pressure pathways have been identified but are considered to have negligible impacts on plankton receptors. No further assessment is made.

Development Component: **BLF** Development Phase: **Construction** Receptor Group: **Plankton**					**Impact Magnitude /** **Evidence for Scoping out**
Activity	**Pressure Theme**	**OSPAR Pressure code**	**Pressure**	**Activity-Pressure Pathway**	
Physical presence of BLF structure	**Hydrological Changes**	H1	Temperature changes	*No impact pathway*	*No impact pathway*
		H2	Salinity changes	*No impact pathway*	*No impact pathway*
		H3	Water flow (tidal current) changes	✓	The BLF is a transitory structure that would result in small-scale changes in bed sheer stress and wave energy in the nearshore environment of the BLF structure and dredged area (BEEMS technical Report TR311). Effects of plankton receptors in the GSB are predicted to be negligible
		H4	Emergence regime changes	*No impact pathway*	*No impact pathway*
		H5	Wave exposure changes	✓	The BLF is a transitory structure that would result in small-scale changes in bed sheer stress and wave energy in the nearshore environment of the BLF structure and dredged area (BEEMS technical Report TR311). Effects of plankton receptors in the GSB are predicted to be negligible.

Table 5: Identification of pressures associated with construction activities that require further assessment. Activity-pressure pathways that exist but are considered of negligible importance are identified with an '**x**' and justification is given for scoping out. Activity-pressure pathways marked with a '✓' require further assessment. Pressures in **<u>bold and underlined</u>** are considered as key issues for the ES.

Pressure theme	OSPAR pressure	Construction activity						Further information / Justification for scoping out of further assessment	Receptors assessed (identifies receptor groups where discernible effects may occur and are considered further within the ES)
		Piling	Presence of Structure	Dredging	Vessel traffic	Drilling	Construction discharges		
Hydrological Changes (local changes in):	H1: Temperature						**X**	Minor temperature and salinity changes may occur at the immediate point of discharge from the **CDO** due to disparities between ambient seawater and freshwater discharges. The GSB is a well-mixed waterbody and maximum discharges are predicted to be 124l s^{-1} during the 28-day dewatering period. A very small proportion of the waterbody is predicted to be exposed to minor changes in temperature and reduced salinity. Negligible effects on marine ecology receptors are predicted and no further assessment is made.	NA
	H2: Salinity						**X**		
	H4: Emergence regime changes		**X**					Construction activities are not anticipated to cause changes in emergence regimes. However, sea-level rise due to climate change has the potential to interact with development components and will be considered as part of the future baselines.	Benthic receptors (intertidal)
	H3: Water flow (tidal current)		**X**	**X**				The presence of the **BLF** and the dredged navigational channel (on the occasions when the BLF is in use and the channel is maintained) would result in localised changes in wave energy and bed sheer stress. The low density of piles means that the BLF jetty is transmissive to water and sediment movement, and the local effect on current flow and wave energy transmission is expected to be minimal (BEEMS Technical Report TR311). The scale of the resultant hydrodynamic changes is small and restricted to the shallow subtidal near the BLF structure. The effects on benthic receptors will be considered in the ES, effects on other receptors are considered negligible. Hydrodynamic changes resulting from the physical presence of man-made structures such as the **CW infrastructure, FRR** and **CDO** headworks in deeper waters are negligible. See L2 for scour.	Benthic receptors
	H5: Wave exposure changes		✓	✓					
Pollution and other Chemical Changes:	P1: Sediment resuspension or discharge of transition elements & organo-metals	**X**		**X**		**X**	✓	Piling, dredging, and drilling activities associated with the **BLF, CW infrastructure, FRR** and **CDO headworks** have the potential to resuspend sediment bound heavy metals and organotin (e.g. TBT). Sediment quality samples taken as part of the BEEMS monitoring programme determined sediment contaminants levels were below Cefas Action Level 2 and are within safe ranges for disposal at sea (BEEMS Technical Report TR306). Therefore, resuspension of sediment contaminants following such activities is not predicted to effect marine ecology receptors (see section 1.2.6). Construction discharges of heavy-metal contaminants in dewatered groundwater discharged from the **CDO** is detailed in BEEMS Technical Report TR306. Effects on marine ecology receptors will be assessed further in the ES.	All receptor groups

Pressure theme	OSPAR pressure	Construction activity						Further information / Justification for scoping out of further assessment	Receptors assessed (identifies receptor groups where discernible effects may occur and are considered further within the ES)
		Piling	Presence of Structure	Dredging	Vessel traffic	Drilling	Construction discharges		
Pollution and other Chemical Changes:	P2: Sediment resuspension or discharge of Hydrocarbon & PAH contamination	X		X	X	X	X	Piling, dredging, and drilling activities associated with the **BLF, CW infrastructure, FRR** and **CDO headworks** have the potential to resuspend sediment bound PAH. Vibrocore samples from within the site showed sediment bound PAHs (dimethyl naphthalene) was above Cefas Level 1 concentrations (no Cefas Level 2 thresholds are available for PAH). However, sediment bound concentrations are typical of the local area and dissociation rates are low (BEEMS Technical Report TR306). Therefore, no significant effects on infaunal or water column marine ecology receptors are predicted from sediment resuspension. The potential for oil spills from vessels will be managed by compliance with IMO regulations and no further assessment is made here. Incorporation of oil separators within construction drainage systems will mitigate oil spills during construction activities and would be managed under the government waste management guidelines (BEEMS Technical Report TR306). No further assessment of PAH from construction discharges are made.	NA
	P3: Synthetic compound contamination		X			✓	✓	**Infrastructure:** Any coatings or treatments applied to infrastructure must be suitable for use in the marine environment in accordance with best environmental practice (Guidance for Pollution Prevention). Therefore, no effects from chemicals leaching from structures is predicted. **Drilling and drilling discharges:** The specific tunnel boring machine (TBM) method to be used during construction of the cooling water tunnels is dependent on the underlying geology and is still to be confirmed. During the transport and processing of spoil material, groundwater and potentially residual TBM chemicals would be produced in wastewater that would be transported landward and treated appropriately (see section 1.2.3.1). To encompass worst-case water quality scenarios, assessments consider discharges of bentonite and potential TBM chemicals with discharges of wastewater from the CDO. Tunnelling would be subterranean, approximately 30m below the seabed. The excavated pressure (if required) would either be at ambient or slightly above ambient pressure similar to the existing conditions at such depths. Therefore, the potential for 'frac-out' of tunnelling materials poses minimal risks to the overlying marine environment and is not considered further. Commissioning discharges, including hydrazine associated with cold flush testing via the **CDO** will be assessed in detail in the ES.	All receptor groups
	P5: Radionuclide contamination from sediment resuspension	X		X		X		Contamination by radionuclides in marine sediments in the GSB is very low or undetectable (BEEMS Technical Report TR306) no effects on marine ecology receptors are predicted from resuspension of sediment bound radionuclides from piling, dredging, and drilling activities. A dedicated chapter in the ES (Volume 2 Chapter 25) will provide an assessment of the potential radiological effects of the proposed development.	NA
	P6: Nutrient enrichment from sediment resuspension or discharge	X		X	X	X	✓	Nutrient loads in the sandy sediments of the GSB are sufficiently low that sediment resuspension during dredging activities is unlikely to influence nutrient availability to the extent that significant effects may arise, no further assessment is made. Construction discharges of treated sewage and groundwater (including DIN and un-ionised ammonia) from the **CDO** are detailed in BEEMS Technical Report TR306. Effects on marine ecological receptors will be assessed further in the ES.	Phytoplankton (DIN) All receptors (un-ionised ammonia)

Pressure theme	OSPAR pressure	Construction activity						Further information / Justification for scoping out of further assessment	Receptors assessed (identifies receptor groups where discernible effects may occur and are considered further within the ES)
		Piling	Presence of Structure	Dredging	Vessel traffic	Drilling	Construction discharges		
	P7: Organic enrichment from sediment resuspension or discharge						X	The potential effects of increases in organic loading arising from construction discharges of treated sewage and groundwater from the **CDO** is considered as part of the Biochemical Oxygen Demand (BOD) (see P8 below).	NA
	P8: De-oxygenation						X	Mean background dissolved oxygen (DO) concentrations in the Sizewell Bay are 7.5 mg l^{-1}, with lowest measured values of 6.96 -7.04mg l^{-1} recorded in July 2015. These values correspond to a 'high' WFD classification (5.7 mg l^{-1} as a 5th percentile). Organic loading from treated sewage and groundwater inputs via the **CDO** has a Biochemical Oxygen Demand (BOD) with the potential to cause oxygen sags. After discharge, BOD is predicted to fall to background concentrations within a few metres. At the immediate point of discharge DO is not expected to reduce by more than 0.5 mg l^{-1}, and therefore remains within the 'high' WFD classification (BEEMS Technical Report TR306). No further assessment is made.	NA
Physical Loss	L1: Physical loss (to land or freshwater habitat)		X					Construction activities are not anticipated to cause changes in emergence regimes. However, sea-level rise due to climate change has the potential result in coastal squeeze due to the presence of the HCDF. This will be considered as part of the future baselines (operational phase).	NA
Physical Loss	L2: Physical change (to another seabed type)		✓	X				Installation of hard infrastructure including the **BLF** piles, **CW infrastructure, FRR** and **CDO headworks** in a predominantly soft-sediment environment represents a small-scale change in habitat type that will be assessed in the ES. The presence of the structures would also result in the formation of a scour pit which is assessed here. The potential use of a rock platform to construct the BLF on intertidal and shallow subtidal benthic receptors will be assessed in the ES. Dredging for cooling water intakes and outfalls would expose bedrock, however backfilling would occur, and the presence of infrastructure represents the change in seabed type.	Benthic receptors Fish

Pressure theme	OSPAR pressure	Construction activity						Further information / Justification for scoping out of further assessment	Receptors assessed
		Piling	**Presence of Structure**	**Dredging**	**Vessel traffic**	**Drilling**	**Construction discharges**		
Physical Damage	D1: Habitat structure changes - removal of substratum (extraction)			✓		X		The construction and installation of the **CW infrastructure, FRRs** and **CDO** would require extraction of surficial sediment by dredging. Furthermore, removal/reprofiling of sediment to allow access and a planar surface for barges at the **BLF** would be required. Removal of substrate due to dredging will be assessed further in the ES. Drilling for connection tunnels associated with the **CW infrastructure, FRRs** and **CDO** would be within the footprint of dredge activities and no further assessment is made.	Plankton Benthic receptors Fish
	D2: Penetration and/or disturbance of the substrate below the surface of the seabed – (surface and subsurface)	✓	X	X	✓	X		Various construction activities including piling, vessel traffic and construction platform activities (e.g. jack-up barges and anchoring) have the potential to cause localised surface and sub-surface abrasion. Whist predicted to be very small scale and subject to infilling, such effects will be assessed further in the ES, particularly in relation to benthic receptors. The physical presence of structures would result in scour, this is assessed as part of physical change in the seabed (L2). Dredging activities are considered separately (see D1 extraction). Drilling for connection tunnels associated with the **CW infrastructure, FRRs** and **CDO** would be within the footprint of dredge activities and no further assessment is made.	Benthic receptors
	D3: Changes in suspended sediment/solids	X		✓	X	✓	X	Piling and vessel wash at the **BLF** have the potential to increase localised suspended sediment concentrations (SSC), however, such impacts in the shallow subtidal are predicted to cause negligible effects on marine receptors. Dredging and drilling activities would cause increases in SSC and will be considered in detail during the ES in relation to the **CW infrastructure, FRRs** and **CDO**. Changes in SSC may have direct fitness consequences for the primary receptor, or indirect food-web effects mediated through reductions in foraging efficiency. **To Note:** Effects on the marine prey species of SPA designated birds will be considered in the ES. Designated bird species *per se* are considered elsewhere as part of the HRA and terrestrial and ornithology ES chapters. Discharges from the **CDO** would be treated with a silt-buster or similar technology to minimise suspended sediment inputs and is not assessed further.	**All receptors**
	D4: Siltation rate changes	X		✓	X	✓	X	Piling and vessel wash have the potential to increase localised sedimentation rates, however, these effects are predicted to be negligibly small scale in the shallow subtidal areas near the **BLF**. Dredging and drilling activities would cause increases in sedimentation and will be considered in detail during the ES in relation to the **CW infrastructure, FRRs** and **CDO.** Discharges from the **CDO** would be treated with a silt-buster or similar technology to minimise sediment inputs and is not assessed further.	**Plankton** **Benthic receptors** **Fish**
Othe r	O1: Litter				X		X	Ecological receptors are vulnerable to marine litter; however, Vessel Management Procedures and Site Waste Management Protocols would be in place to mitigate effects. Such effects are not assessed further.	NA

Pressure theme	OSPAR pressure	Construction activity: Piling	Presence of Structure	Dredging	Vessel traffic	Drilling	Construction discharges	Further information / Justification for scoping out of further assessment	Receptors assessed
	<u>O3: Underwater noise</u>	✓		✓	✓	✓		The effects of underwater noise arising from dredging, drilling and impact piling and vessel traffic has been assessed in detail for each of the relevant development components (BEEMS Technical Report TR312 Ed. 2) and is a key consideration for the ES. **<u>To Note:</u>** A hypothetical UXO detonation scenario will be included in the ES and underwater noise assessment (TR312 Ed. 2). Please see section 2.3.2 for further details. Effects on the marine prey species of SPA designated birds will be considered in the ES.	Benthic receptors **<u>Fish</u>** **<u>Marine Mammals</u>**
	O4: Introduction of light		✓		✓			Embedded mitigation is designed to limit light spill from the main site, however, artificial lighting associated with the **BLF** and lighting by vessels will be considered in the ES, primarily in relation to disturbance of marine mammals (also see B1).	Marine Mammals Fish
	O5: Barriers to species movement	✓	X	✓		✓	✓	Physical barriers to species movement during the construction phase are not predicted. However, the potential for increases in SSC, underwater noise and construction discharges to cause avoidance behaviour or barriers to species movement will be assessed in the ES under the relevant pressures.	Fish Marine mammals
	O6: Death or injury by collision				✓			Collisions with delivery and working vessels during the construction phase has the potential to cause death or injury to marine mammals. Site Vessel Management Plans and speed restrictions would minimise the likelihood of such occurrences.	Marine mammals
Biological pressures	B1: Visual disturbance		✓		✓			Anthropogenic activity and vessel presence for construction and delivery purposes has the potential to cause visual disturbance, such effects will be assessed in the ES primarily in relation to disturbance for marine mammals. Pressure B1 and O4 have similar pathways.	Marine mammals
	B2: Translocation of indigenous species				X			Working vessels and barges delivering loads to the **BLF** will conform to the IMO Ballast Water Management Convention (adopted in 2004). Potential impacts arising from translocation of indigenous species and the introduction and spread of NIS in ballast water is not assessed further. During the operational phase warm water discharges coupled with potential colonising space (presence of infrastructure) will be assessed in relation to the potential spread of NIS.	NA
	B3: Introduction and spread of non-indigenous species (NIS)				X				
	B4: Introduction of microbial pathogens						X	Sewage discharges from the **CDO** would be treated. Tertiary (UV) treatment results in *E. coli* meeting bathing water standards <1 m of the discharge and intestinal *enterococci* ≤200 cfu/100ml at the point of discharge (BEEMS Technical Report TR306). No further assessment is undertaken.	NA

2.3 Key Construction Issues for the ES and the Evidence Base

Cross-tabulation of the construction phase development activities and associated pressures identified a number of pathways with the potential to effect marine ecology receptors within the Greater Sizewell Bay. The key issues identified in Table 5 are:

- **Changes in Suspended Sediment Concentration (SSC):** Dredging activities associated with the BLF navigational channel and sediment extractions for the CW infrastructure, FRRs and CDO would result in elevated SSC. Drilling the vertical tunnels to connect the CW infrastructure headworks to the subterranean tunnels would also cause smaller scale increases in SSC.
- **Changes in Sedimentation rates:** Dredging activities associated with the BLF navigational channel and sediment extractions for the CW infrastructure, FRRs and CDO would result in increases in sedimentation both locally and as the SSC plume settles out of suspension. Drilling the vertical tunnels to connect the CW infrastructure headworks to the subterranean tunnels would also cause increases in sedimentation rates.
- **Underwater Noise:** Various construction activities would introduce noise into the marine environment. Impact piling for the BLF piles, fenders and dolphins represents the largest, albeit short-lived impact. Dredging associated with the BLF navigation channel, CW infrastructure, FRRs and CDO and drilling for the vertical connection tunnels would also increase noise exposure. Increases in vessel traffic represents an additional pathway for increases in noise pollution at the site. Ambient noise recordings at the site and wider region are applied to contextualise underwater noise impacts.

2.3.1 Changes in SSC and sedimentation rates during construction

To determine the potential impacts of activities that result in changes in SSC and sedimentation a modelling study was commissioned to investigate the spatial extent, persistence, and amount of change in SSC and sedimentation rates following dredging and drilling at Sizewell (BEEMS Technical Report TR480). The MMO would be consulted in relation to all dredging options and disposal routes, which would be subject to licencing requirements. However, to encompass the worst-case conditions at the site local dredge disposal was assumed. Dredging for the FRRs and CDO and dredging and drilling for installation of the CW infrastructure is predicted to occur once per headwork. Navigational dredging, will however, need to be repeated to maintain navigational access to the BLF during delivery periods. Therefore, the rate of natural infilling will, in part, determine the frequency at which maintenance dredging is required. Infilling rates will form part of the future assessments in BEEMS Technical Report TR311 and will inform ongoing ecological assessments for the ES.

2.3.2 Underwater noise during construction

The evidence base for establishing effects of underwater noise on fish and marine mammals (harbour porpoise and seals) is in BEEMS Technical Report TR312 Ed. 2. Edition 2 of the underwater noise assessment takes into account updated marine mammal impact threshold criteria for underwater noise. Instantaneous and cumulative (24 hour) effect zones have been remodelled for dredging, drilling and piling activities based on the latest engineering specifications. Increases in noise resulting from vessel traffic associated with the BLF has been assessed within BEEMS Technical Report TR312 and will be presented in the ES.

Underwater noise assessment in BEEMS Technical Report TR312 Ed. 2 also consider the case of a hypothetical unexploded ordinance (UXO) detonation, thereby encompassing the full suite of potential auditory impacts. However, to-date UXOs have not been identified on site. Should a UXO be identified a full assessment would be completed considering the exact UXO specifications and location in relation to site-specific factors such as proximity to existing nuclear infrastructure, sensitive habitats and geomorphic features. Alternative disposal methods or relocation would be considered as well as appropriate mitigation measures in order to minimise the risk of potential impacts. Such considerations would be critical in determining management and mitigation measures in the tidally dominated, high turbidity inshore waters at

Sizewell and would be presented in a dedicated Marine Mammal Mitigation Protocol (MMMP). Given the uncertainty regarding the very presence of UXOs and mitigation/management scenarios hypothetical assessments representing hypothetical worst-case scenarios will be provided in the ES.

The Greater Sizewell Bay is within the southern North Sea SAC, designated for harbour porpoise. The results from the underwater noise assessment will inform the Cumulative Effects Assessment (CEA) section of the ES and will be put in context spatially and temporally with other projects, plans and proposals within the zone of influence. Cumulative assessments of underwater noise effects on marine mammals also consider phocids.

3 Operational phase activity-pressure pathways

3.1 Operational Activities

The primary activities that would occur during the operational phase of the proposed development include:

- Cooling water abstraction;
- Cooling water discharges;
- FRR discharges;
- Physical presence of infrastructure;
- Navigational dredging for the BLF;
- Vessel traffic.

The primary operational activities and the development components they are associated with are described in Table 6. Additional operational activities, which have also been considered include;

- Heavy plant operations on the beach, including SCDF maintenance and beach reprofiling (primarily above MHWS);
- CDO discharges (the CDO is anticipated to remain in place during the operational phase, however discharges, if any, have not been resolved at this stage);
- Anthropogenic presence in the marine and coastal environment.

Table 6: Primary operational activities during the proposed development with the potential to interact with the marine environment.

Primary operational activities	Development Component				Description
	BLF	CW infrastructure	FRR	CDO	
Cooling water abstraction		✓			During standard operating conditions water would be temporarily abstracted from the GSB at a rate of $132m^3s^{-1}$ to supply the main cooling water systems as well as the essential and auxiliary cooling water systems.
Cooling water discharges		✓			Abstracted cooling water would be returned to the receiving waters at elevated temperatures (ΔT 11.6°C from the condensers, see 1.2.3.2). The thermal effluent would be seasonally chlorinated (TRO at outfall $0.15mgl^{-1}$). Additional discharges would include surface drainage water, treated sewage and daily hydrazine discharges.
FRR discharges			✓		The FRR would discharge water and impinged biota at a rate of $0.3m^3s^{-1}$. The water would be at ambient temperature but may be chlorinated during the growth season (TRO concentration yet to be determined)
Physical presence of infrastructure	✓	✓	✓	✓	The physical presence of artificial hard structure in the predominantly sedimentary marine environment.
Vessel traffic	✓				Increased vessel traffic within the site associated with BLF deliveries. Anticipated to be infrequent during operational phase. Also includes mooring of barges at the BLF.
Navigational Dredging	✓				Dredging would be required for navigational access to the BLF and to create a planar surface to allow barges to come aground. BLF utilisation is anticipated to be limited during the operational phase.

3.2 Operational Pressures

Operational pressures differ from those during the construction phase and are primarily related to cooling water abstraction and discharges. The activity-pressures pathways with the potential to cause effects on marine ecology receptors in the GSB are identified in Table 7, below.

Table 7: Identification of pressures associated with operational activities that require further assessment. Activity-pressure pathways that exist but are considered of negligible importance are identified with an '**x**' and justification is given for scoping out. Activity-pressure pathways marked with a '✓' require further assessment. Pressures in **<u>bold and underlined</u>** are considered as key issues for the ES.

Pressure theme	OSPAR pressure	Operational activity						Further information / Justification for scoping out of further assessment	Receptors assessed (identifies receptor groups where discernible effects may occur and are considered further within the ES)
		Cooling water abstraction	Cooling water Discharges	FRR Discharges	Vessel traffic	Presence of structure	Navigational dredging		
Hydrological Changes (local changes in):	**<u>H1: Temperature</u>**	*[3]	✓					Significant effects of thermal discharges on marine receptors in the receiving waters may arise in the following ways (BEEMS SAR008); 1. Absolute temperatures reach thermal maxima of sensitive species; 2. Changes in mean temperature; 3. Fluctuating temperature interfaces; 4. Thermal barriers may be created. Thermal discharges will be assessed in detail in the ES based on standard operating conditions and the worst-case thermal input scenario as detailed in section 1.2.3.2.	**<u>All receptors</u>**
	H2: Salinity		**X**					Any freshwater inputs from surface run-off or sanitary waste would be diluted with the cooling water and represent a negligible change in salinity.	NA
	H4: Emergence regime changes					✓		Operational activities are not anticipated to cause changes in emergence regimes *per se*. However, sea-level rise due to climate change has the potential to interact with development components such as the HCDF and will be considered as part of the future baselines.	Benthic receptors (intertidal)
	H3: Water flow (tidal current)	**X**	**X**			✓	✓	The cooling water abstraction and discharge affect the very near-field local residual currents. They do not affect the peak flows or change the residual flow direction, except within 100m of the head. At slack water when background tidal currents are < 2cm s^{-1}, the flow fields due to abstraction dominate up to 150m from the headworks. This period is transitory as slack water is <20 minutes long at both high and low water (BEEMS Technical Report TR311). No further assessment is made. The presence of the **BLF** and the dredged navigational channel (on the occasions when the BLF is in use and the channel is maintained) would result in localised changes in wave energy and bed sheer stress. The low density of piles means that the BLF jetty is transmissive to water and sediment movement, and the local effect on current flow and wave energy transmission is expected to be minimal (BEEMS Technical Report TR311). The scale of the resultant hydrodynamic changes is small and restricted to the shallow subtidal near the BLF structure. The effects on benthic receptors will be considered in the ES, effects on other receptors are considered negligible. Hydrodynamic changes resulting from the physical presence of man-made structures such as the **CW infrastructure, FRR** and **CDO** headworks in deeper waters are negligible. See L2 for scour.	Benthic receptors
	H5: Wave exposure changes					✓	✓		

[3] Thermal pressures associated with primary entrainment of biota through the power station condensers are considered as a distinct issue (see SZC1 Entrainment and Impingement).

Pressure theme	OSPAR pressure	Operational activity						Further information / Justification for scoping out of further assessment	Receptors assessed (identifies receptor groups where discernible effects may occur and are considered further within the ES)
		Cooling water abstraction	Cooling water Discharges	FRR Discharges	Vessel traffic	Presence of structure	Navigational dredging		
Pollution and other Chemical	P1: Sediment resuspension or discharge of transition elements & organo-metals		**X**				**X**	Operational discharges of heavy metals in the **CW discharges** are not predicted to exceed EQS levels (BEEMS Technical Report TR193 Ed. 4.). No further assessment is made. Dredging activities associated with the **BLF** has the potential to resuspend sediment bound heavy metals and organotin (e.g. TBT). Sediment quality samples taken as part of the BEEMS monitoring programme determined sediment contaminants levels were below Cefas Action Level 2 and are within safe ranges for disposal at sea (BEEMS Technical Report TR306). Therefore, resuspension of sediment contaminants following such activities is not predicted to effect marine ecology receptors.	NA
Pollution and other Chemical Changes:	P2: Sediment resuspension or discharge Hydrocarbon & PAH contamination				**X**		**X**	The potential for oil spills from vessels will be managed by compliance with IMO regulations and no further assessment is made here. Dredging activities associated with the **BLF** has the potential to resuspend sediment bound PAH. Vibrocore samples from within the site showed sediment bound PAHs (dimethyl naphthalene) was above Cefas Level 1 concentrations (no Cefas Level 2 thresholds are available for PAH). However, sediment bound concentrations are typical of the local area and dissociation rates are low (BEEMS Technical Report TR306). Therefore, no significant effects on infaunal or water column marine ecology receptors are predicted from sediment resuspension. Monitoring of the sediments near the BLF may be required to ensure sediment quality does not deteriorate and dredging and disposal methods remain appropriate.	NA
	P3: Synthetic compound contamination		✓	**X**		**X**		**CW TRO discharges:** During the growing season chlorination would be applied to achieve an initial TRO concentration of $0.2 mgl^{-1}$. At the point of discharge TROs are predicted to be $0.15 mgl^{-1}$ in $132 m^3 s^{-1}$ and exceed EQS concentrations ($10 \mu gl^{-1}$) within the mixing zone (BEEMS Technical Report TR306). The potential effects of TROs on marine receptors in the receiving waters will be considered in the ES. **CW CBP discharges:** Depending on the water chemistry, chlorination liberates a range of chlorination-by-products (CBP). Bromoform is the predominant CBP formed in the bromine rich seawater at Sizewell. Bromoform has a recommended EQS of $5 \mu gl^{-1}$. Bromoform exceeds the EQS near the outfall (BEEMS Technical Report TR306) and the potential for effects will be assessed in the ES. **CW Hydrazine discharges:** Hydrazine is used in power plants to inhibit corrosion in steam generation circuits. Daily hydrazine discharges within the cooling water stream have been modelled based on the two potential discharge scenarios; a) $69 ngl^{-1}$ for 2.3h a day, and b) $34 ngl^{-1}$ for 4.6h a day. In both cases applied PNEC thresholds are exceeded (BEEMS Technical Report TR306). The potential effects on marine ecology receptors will be considered in the ES. **FRR TRO discharges:** Discharges for the FRR have the potential to be seasonally chlorinated. The low discharge rates ($0.3 m^3 s^{-1}$) result in no EQS exceedance (BEEMS Technical Report TR306) in the receiving waters and no further assessment is made. **Infrastructure:** Any coatings or treatments applied to infrastructure must be suitable for use in the marine environment in accordance with best environmental practice (Guidance for Pollution Prevention). Therefore, no effects from chemicals leaching from structures is predicted.	**All receptors**
	P5: Radionuclide contamination from sediment resuspension		**X**				**X**	Radionuclide discharges in CW systems are strictly regulated and fall beyond the scope of this assessment. Contamination by radionuclides in marine sediments in the GSB is very low or undetectable (BEEMS Technical Report TR306) no effects on marine ecology receptors are predicted from resuspension of sediment bound radionuclides from navigational dredging of the BLF. A dedicated chapter in the ES (Volume 2 Chapter 25) presents an assessment of the potential radiological effects of the proposed development.	NA

Pressure theme	OSPAR pressure	Operational activity						Further information / Justification for scoping out of further assessment	Receptors assessed (identifies receptor groups where discernible effects may occur and are considered further within the ES)
		Cooling water abstraction	Cooling water Discharges	FRR Discharges	Vessel traffic	Presence of structure	Navigational dredging		
	P6: Nutrient enrichment from sediment resuspension or discharge		✓				X	Operational releases of un-ionised ammonia in **CW discharges** is not predicted to exceed EQS values and is not assessed further. Likewise, DIN inputs are predicted to be minor. Daily maximum phosphate discharges are predicted to exceed mean background concentrations (BEEMS Technical Report TR306). Effects of low-level nutrient additions on marine ecological receptors will be considered in the ES, primarily in regard to phytoplankton primary producers. Nutrient loads in the sandy sediments of the GSB are sufficiently low that sediment resuspension during dredging activities for the **BLF** is unlikely to influence on nutrient availability to the extent that significant effect may arise, no further assessment is made.	Phytoplankton receptors
	P7: Organic enrichment from sediment resuspension or discharge			✓				The potential effects of increases in organic loading of dead biota from the **FRR** will be assessed in the ES. Consideration will be paid to the Biochemical Oxygen Demand, nutrient additions, un-ionised ammonia and the potential to cause localised increases in secondary production.	All receptors (and in a food web context).
	P8: De-oxygenation		X					Mean background dissolved oxygen (DO) concentrations in the Sizewell Bay are 7.5 mg l^{-1}, corresponding to a 'high' WFD classification. Dissolved oxygen is less soluble in warm water. Operational dissolved oxygen concentrations were modelled and showed potential 0.5mgl^{-1} reductions in DO over small areas (BEEMS Technical Report TR306). However, DO remains within the 'high' WFD classification (BEEMS Technical Report TR306). No further assessment is made.	NA

Pressure theme	OSPAR pressure	Operational activity						Further information / Justification for scoping out of further assessment	Receptors assessed
		Cooling water abstraction	Cooling water Discharges	FRR Discharges	Vessel traffic	Presence of structure	Navigational dredging		
Physical Loss	L1: Physical loss (to land or freshwater habitat)					✓		Operational activities are not anticipated to cause changes in emergence regimes *per se*. However, sea-level rise due to climate change has the potential to interact with development components such as the HCDF and will be considered as part of the future baselines.	Benthic receptors (intertidal)
	L2: Physical change (to another seabed type)					✓		Physical presence of hard infrastructure including the **BLF** piles, **CW infrastructure, FRR** and **CDO headworks** in a predominantly soft-sediment environment represents a small-scale change in habitat type that will be assessed in the ES. The presence of the structures would also result in scour which will be assessed in the ES.	Benthic receptors Fish
Physical Damage	D1: Habitat structure changes - removal of substratum (extraction)						✓	Removal/reprofiling of sediment to allow access and a planar surface for barges at the **BLF** would be required. Removal of substrate due to dredging will be assessed further in the ES.	Plankton Benthic receptors Fish
	D2: Penetration and/or disturbance of the substrate below the surface of the seabed – (surface and subsurface)					X		The physical presence of structures would result in scour, this is assessed as part of physical change in the seabed (L2).	Benthic receptors
	D3: Changes in suspended sediment/solids				X		✓	Vessel wash at the **BLF** has the potential to increase localised suspended sediment concentrations (SSC), however, such impacts in the shallow subtidal are predicted to cause negligible effects on marine receptors. Dredging activities would cause increases in SSC and will be considered in detail during the ES in relation to the **BLF** navigational dredging. Changes in SSC may have direct fitness consequences for the primary receptor, or indirect food-web effects mediated through reductions in foraging efficiency. **To Note:** Effects on the marine prey species of SPA designated birds will be considered in the ES. Designated bird species *per se* are considered elsewhere as part of the HRA.	**All receptor groups**
	D4: Siltation rate changes				X		✓	Vessel wash has the potential to increase localised sedimentation rates, however, these effects are predicted to be negligibly small scale in the shallow subtidal areas near the **BLF**. Dredging activities would cause increases in sedimentation and will be considered in detail during the ES in relation to the **BLF** navigational dredging**.**	**Plankton** **Benthic receptors** **Fish**
Other Physical pressures	O1: Litter		X		X			Ecological receptors are vulnerable to marine litter; however, Vessel Management Procedures and Site Waste Management Protocols would be in place to mitigate effects. Such effects are not assessed further.	NA
	O3: Underwater noise				✓		✓	The effects of underwater noise arising from dredging has been assessed in detail. Addition assessments are underway to determine increases in noise arising from vessel traffic associated with the **BLF** (BEEMS Technical Report TR312 Ed. 2).	**Fish** **Marine mammals**

Pressure theme	OSPAR pressure	Operational activity: Cooling water abstraction	Cooling water Discharges	FRR Discharges	Vessel traffic	Presence of structure	Navigational dredging	Further information / Justification for scoping out of further assessment	Receptors assessed
	O4: Introduction of light				✓	✓		Embedded mitigation is designed to limit light spill from the main site, however, artificial lighting associated with the **BLF** and lighting by vessels will be considered in the ES, primarily in relation to disturbance of marine mammals (also see B1).	Marine mammals
	O5: Barriers to species movement		✓					The potential for thermal and chemical effluents associated with **CW discharges** to impede species movements will be assessed in the ES (also see BEEMS Technical Report TR306).	Fish Marine mammals
	O6: Death or injury by collision				✓			Collisions with delivery and working vessels during the construction phase has the potential to cause death or injury to marine mammals. Site Vessel Management Plans and speed restrictions would minimise the likelihood of such occurrences.	Marine mammals
	SZC1 Site-specific: **<u>Impingement</u>** **<u>Entrainment</u>**	✓						Biota that enters the cooling water system will be transported to the forebay of each reactor where it would pass through drum screens. Fish and larger crustaceans would be impinged and returned to the receiving waters via the FRR. Plankton and smaller biota would be entrained with the cooling water stream through the power station. **Impingement:** Fish and large invertebrates impinged by the drum screens would be returned to the receiving waters by the FRR. FRR wash water would be at ambient temperature and not chlorinated. Impingement assessments form a key ES consideration. **Entrainment:** Juvenile fish, ichthyoplankton and other planktonic organisms too small to be impinged by the drum screen mesh would be entrained through the power station. During primary entrainment, biota would be subject to thermal, chemical, and mechanical pressures before being discharged back into the receiving waters via the outfall head. Entrainment assessments form a key consideration in the ES.	**<u>Plankton</u>** **<u>Benthic receptors</u>** **<u>Fish</u>**
Biological pressures	B1: Visual disturbance				✓	✓		Anthropogenic activity and vessel presence for construction and delivery purposes has the potential to cause visual disturbance, such effects will be assessed in the ES primarily in relation to disturbance for marine mammals. Pressure B1 and O4 have similar pathways.	Marine mammals Fish
	B2: Translocation of indigenous species				**X**			Working vessels and barges delivering loads to the **BLF** will conform to IMO Ballast Water Management Convention (adopted in 2004). Potential impacts arising from translocation of indigenous species and the introduction and spread of NIS in ballast water is not assessed further. During the operational phase warm water discharges coupled with potential colonising space (presence of infrastructure) will be assessed in relation to the potential spread of benthic NIS.	Benthic receptors
	B3: Introduction and spread of non-indigenous species (NIS)				**X**	✓			
	B4: Introduction of microbial pathogens		**X**					Sewage inputs in the **CW discharge** would be treated. Tertiary (UV) treatment results in microbial bathing water standards being achieved <1 m from the discharge (BEEMS Technical Report TR306). No further assessment is undertaken.	NA

3.3 Key Operational Issues for the ES and the Evidence Base

The key operational issues identified in Table 6 that require further assessment during the ES are as follows

- **Changes in Suspended Sediment Concentration (SSC) and sedimentation rates:** Dredging activities associated with the BLF navigational channel would result in elevated SSC and sedimentation both locally and as the SSC plume settles out of suspension. Sediment plume and sedimentation modelling has been completed (BEEMS Technical Report TR480) and will inform assessment in the ES.
- **Thermal Discharges:** Discharges of heated cooling water effluent (modelled as $125m^3s^{-1}$ at 11.6°C ΔT (see section 1.2.3) during normal operating conditions) have the potential to effect marine ecological receptors in the receiving waters. Unlike chemical standards which normally have a clear evidence link to ecological effects, thermal standards are not always evidence based due to a lack of reliable data (BEEMS SAR008). In order to be protective of the most sensitive species, thermal standards have, therefore, been set on an indicative basis and, as such, they act as trigger values for further investigation of potential ecological effects.

  BEEMS SAR008 reviewed the available evidence on thermal effects and concluded:

  > *"The available data confirms that adverse effects of CW outfalls are restricted to an area close to the plume, that temperature rises up to 3°C appear to be tolerable, and that resulting temperatures of less than 27°C have no clear deleterious impact on species in the receiving waters, but, in the longer term, changes in the local community may result as species with differing tolerances of elevated temperature show differing survival, growth and patterns of reproduction from those expressed under ambient conditions. Furthermore, populations that persist adjacent to a heated CW effluent will acclimate to those new local conditions and evolve in response to them"*

  Thermal inputs have been contextualised against recommended standards (trigger values) for SPA, SAC and WFD waterbodies in relation to absolute temperatures, thermal uplifts and cross-sectional areas (Appendix B.1). Thermal plume modelling, summarised in BEEMS Technical Report TR306, considered different operating scenarios including the worst-case for thermal loading and will inform the magnitude of impacts for ecological assessments in the ES.
- **Chemical Discharges:** Seasonal chlorination of the cooling water system results in exceedance of EQS standards for TROs and the most abundant CBP, bromoform. Modelling of chemical discharges including chlorinated discharges is considered in detail in (BEEMS Technical Report TR303 Ed. 3.) and the results are provided in BEEMS Technical Report TR306.

  Daily hydrazine releases are anticipated to prevent corrosion. Hydrazine releases have been modelled based on the two potential discharge scenarios; a) $69ngl^{-1}$ for 2.3h a day, and b) $34ngl^{-1}$ for 4.6h a day. These results (presented in BEEMS Technical Report TR306) will inform the ES assessments. The worst-case hydrazine discharges would potentially occur after wet lay-up of steam generators. However, treatment of the hydrazine until concentrations fall below acceptable levels is anticipated and wet lay-up is not expected in a normal refuelling outage. For example, at Sizewell B wet lay-up first occurred ~15 years after operation began (BEEMS Technical Report TR306).
- **Impingement:** Water, and associated biota, abstracted at the intake heads would transit towards the forebays. The intake headworks are located approximately 3.1km offshore. The flow velocity within the intake tunnels would be ca. $2.2ms^{-1}$, resulting in a transit time of 23.5 minutes. Once at the forebays for each reactor, abstracted water is passed through four drum screens and band screens (mesh size 10 mm for both screen types) where fish and biota larger than the mesh size would be washed off the screens and enter the FRR system. Based on the position of the FRRs outfalls ca.475m offshore (Figure 1) the transit time from the forebay would be in the order of 13 minutes (BEEMS Technical Report TR333.). Impingement assessments form a fundamental part of the ES and are considered in detail in BEEMS Technical report TR406.

- **Entrainment:** Biota too small to be impinged on the drum screens would be entrained through the power station condensers. During entrainment passage, biota would be subject to thermal uplifts of ΔT 11.6°C, seasonal chlorination at an initial TRO dosage of 0.2mgl^{-1}. The outfall tunnels are approximately 3.5km long and have a flow velocity of approximately 2.6ms^{-1}, the transit time to the outfall would be 20.3 minutes.

  Entrainment Mimic Unit (EMU) studies completed as part of the BEEMS programme to approximate the conditions at the proposed development for a range of taxa, along with literature from operational power stations provide the evidence for the ES. Laboratory experiments have also determined the effects of single and combined entrainment pressures on phytoplankton. EMU studies have informed entrainment mortality predictions for ichthyoplankton and zooplankton detailed in BEEMS Technical Report TR318 Ed. 2. Modelling the effects of entrainment on phytoplankton gross primary productivity in the Greater Sizewell Bay has been undertaken by applying a Combined Phytoplankton and Macroalgae (CPM) model (BEEMS Technical Report TR385).

4 Second order assessments

4.1 In-combination effects

In-combination effects (or inter-relationships) occur when individual pressures co-exist and can influence the overall effect on a receptor. Pressures arising from the same activity, or co-occurring activities resulting in the same or different pressures can cause in-combination effects. In-combination effects are an important consideration as individually effects may be assessed as insignificant but combine to greater effect.

In-combination effects can act additively, synergistically or antagonistically. For example, sensitivity to chemical contaminants is often temperature dependent, thus the thermal plume could enhance the toxicity of chemical discharges. In-combination effects during the proposed development that will be considered in the ES include:

- Dredging and/or drilling activities co-occurring to increase SSC plumes. It should be noted that SSC plume modelling considers worst-case scenarios for individual dredging activities including a scenario of consecutive dredging for all cooling water intakes and outfalls.
- Combined habitat loss/changes as a result of extraction and installation of infrastructure.
- The potential for activities causing underwater noise to occur simultaneously.
- The potentially synergistic effects of temperature and chemical contaminants in the thermal plume.
- The effects on receptor populations to primary entrainment through the power station and exposure to the thermal/chemical plume (secondary entrainment).

4.2 Indirect and food web effects

Development impacts have the potential to have both direct and indirect effects on ecological receptors. Indirect effects may, for example, include the loss of prey available to a predator or be behaviorally-mediated (e.g. area avoidance) affecting food web interactions. The marine ecology food web section will describe the Sizewell Bay food web and identify the potential for direct effects on specific receptors to propagate through the food web. Focus will primarily be paid towards marine mammals and the prey species of designated seabirds listed below. It should be noted that the HRA will consider the effects on designated seabirds in more detail. A depiction of the Sizewell food web is provided in BEEMS Technical Report TR501.

The southern North Sea SAC is designated for harbour porpoise and lies directly adjacent to the development site. Harbour porpoise eat a wide variety of prey items and their dietary composition varies between geographic regions, time of year, sexes and size. Porpoise tend to concentrate on small shoaling demersal and pelagic fish (BEEMS Technical Report TR324).

The proposed development is also in proximity to the Alde-Ore Estuary SPA, the Benacre to Easton Bavents SPA and the Outer Thames Estuary SPA. Designated bird species with a marine prey component to their diet include the breeding populations of sandwich tern (*Thalasseus sandvicensis*), little tern (*Sterna albifrons*), lesser black-backed gull (*Larus fuscus*), common tern (*Sterna hirundo*) and wintering populations of red-throated diver (*Gavia stellata*). The most important fish families taken by breeding piscivorous seabirds in the North Sea (in particular by terns) are sandeels and clupeids with diets varying geographically and seasonally depending on the site-specific food availability (Tasker and Furness., 1996). BEEMS Technical Report TR431 considered the available evidence and concluded that sandeel form a very small proportion of the fish assemblage at Sizewell and are, therefore, not an important component of protected species in the region of the site which will instead prey on locally abundant clupeids (herring (*Clupea harengus*), sprat (*Sprattus sprattus*), anchovy (*Engraulis encrasicolus*).

The expected diet of each protected species that feeds on marine prey is detailed in BEEMS Technical Report TR431 based upon published preferences and local availability of prey species.

4.3 Cumulative Effects Assessment (CEA)

The cumulative effects of the proposed development in relation to other plans, projects and permissions (PPP) with the potential for overlapping Zones of Influence (ZoI) will be assessed, noting that ZoIs will be receptor dependent. It is assumed infrastructure and anthropogenic activities currently occurring (operational) in the ZoI represent part of the pressure landscape during which baseline conditions were collected. As such, they will not be considered as part of the CEA. The CEA will apply a temporal and spatial screening approach at relevant receptor-specific scales in order to determine the potential for cumulative effects between the proposed development and other PPP. For example, the CEA for marine mammals will consider the impacts for harbour porpoise at the scale of the southern North Sea SAC as has been done for projects recently submitted to PINS. In this case a tiered approach to screening of projects into/out of the CEA will also be undertaken as per advice from SNCBs on recent projects. This allows for different levels of uncertainty and the quality of data to be taken into account within the assessment.

4.4 Future baselines and climate change

The proposed development may be operational for 60-years. The 60-year life-cycle of the development suggests that contemporary baselines are not necessarily appropriate for assessments for the duration of the operational period.

The future baseline is a theoretical situation that would exist in the absence of the development. Extrapolation of current baselines to predict future ecological scenarios is challenging and prone to a large degree of uncertainty, particularly across the range of receptor groups in the assessment, and in relation to natural variability, changes in anthropogenic pressures and climate change. The degree of uncertainty rises with projections further into the future. Where reasonable evidence permits, the ES will consider impacts in relation to future baselines.

Climate change represents a long-term process with the potential to interact with development pressures. The primary issues related to climate change for the marine ecological receptors at Sizewell relate to sea-level rise and sea temperatures. Future shoreline predictions detailed in BEEMS Technical Report TR311 provide a basis for assessing the potential impacts of sea-level rise and changes in shoreline position on intertidal and benthic receptors. Increases in climate driven seawater temperature would result in higher ambient thermal conditions and by association, higher entrainment temperatures. The impact of climate change on intake and entrainment temperatures will be considered by applying the UKCP09 medium emissions scenario (SRES A1B) for future climate for 2070-2100 relative to a baseline of 1961-1990. The UKCP18 does not currently provide additional sea temperatures. To allow an upper temperature estimate, the daily maximum of the UKCP09 medium emissions scenario will also be considered. Intake and entrainment temperatures will be based on the following time points:

- 2055: Beyond this date Sizewell B is not anticipated to be operational, therefore this represents the last potential date that the thermal plumes from the two stations may interact;
- 2085: Nearing the end of the projected Sizewell C operational life cycle;
- 2110: Furthest future projection.

Whist these methods allow for predictions to be made about future water temperatures, quantifying ecological responses to specific pressures is not feasible based on current understanding of the effects due to potential changes in species distribution, species specific acclimation ability, and possible phenological shifts. Possible effects of climate change will be described for primary operational issues including thermal discharges, entrainment and the in-combination effects with TROs and other chemical discharges.

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Appendix A Marine Ecology ES Terminology

A.1 Marine Ecology ES Terminology

EIA specific terminology follows guidelines from the Chartered Institute for Ecology and Environmental Management (CIEEM, 2016). Terminology applied for sensitivity assessments is based the MB0102 approach (Tillin *et al.,* 2010), and subsequent Marine Evidence-based Sensitivity Assessments (MarESA; Tyler-Walters *et al.,* 2017), which were developed to assess the sensitivity of UK Marine Protected Areas to standardized pressure benchmarks. In a slight departure from the MarESA approach, receptor sensitivity will be assessed in relation to the site-specific predicted magnitude of impacts of the proposed development.

Table 8: Terminology and definitions applied throughout the ES. Definitions are based on CIEEM (2016) and MarESA (Tyler-Walters *et al.*, 2017) guidelines, modified where necessary, to allow site-specific sensitivity assessments to be made and to conform to the EIA Scoping requirements.

Term	Applied definition	Assessment process
Development component	An overarching construction or operational procedure, such as the BLF or cooling water infrastructure.	
Activity	An anthropogenic action arising from the construction or operation of development components, which has the potential to exert pressure on the marine environment.	
Pressure	The mechanism whereby an activity changes the physical, biological or chemical environment leading to an impact. Here, pressure is a descriptive term used to identify and describe potential impact pathways.	
Impact	An impact is the result of an activity-pressure interaction resulting in a physical, biological or chemical change to an ecological feature, for example a reduction in water quality or habitat loss. The Magnitude of Impact is an assessment of factors such as the duration (timing and frequency), spatial extent, and amount of change caused by the pressure. Consideration is also paid to the reversibility of the pressure and the likelihood of it occurring.	
Receptor	Any ecological feature that is sensitive to or has the potential to be affected by a pressure. Receptors may be individual species, species groups, functional traits, or habitats. Where evidence is lacking, assessments may consider representative taxa.	
Sensitivity	Sensitivity is a measure of the resistance of a receptor to an impact and its ability to recover following such impacts (resilience).	
Resistance	The ability of a receptor to withstand an environmental impact without changing characteristics.	
Resilience	The ability of a receptor to recover following an environmental impact.	
Value	Value is a determination of the ecological, socio-economic, and/or conservation important of a receptor exposed to an impact.	
Effect	The outcome to an ecological receptor arising from an impact. Effect is determined by the sensitivity and value (where appropriate) of the receptor and the magnitude of the impact.	

Appendix B Pressure Benchmarks

B.1 Pressure benchmarks for marine ecology receptors

Pressure benchmarks provide a mechanism to contextualise development impacts. Pressure benchmarks follow legislative and regulatory standards where possible (e.g. chemical EQS values) and follow revised MarESA benchmarks proposed for benthic species and habitats in Tyler-Walters *et al*., 2017 and for highly mobile marine species such as lobster, fish and marine mammals in (Pérez-Domínguez *et al.,* 2016). It should be noted that impacts at the site have been specifically assessed to determine impact magnitude. Pressure benchmarks therefore provide a basis for assessing the sensitivity of a given receptor to the site-specific impacts relative to recognise standards.

Pressure theme	Code	Pressure	Receptor Group	Indicative pressure benchmark	Source
Hydrological Changes	H1	Temperature changes - local	All	**WFD** 'Good' Status (98th percentile): Uplift ≤ 3ºC Absolute < 23ºC **SPA** thermal triggers for further ecological investigation: 1. Temperature uplift ≤ 2ºC as a Maximum Allowed Concentration (MAC) at the edge of the mixing zone 2. 98th percentile of the absolute temperature ≤ 28ºC. **SAC:** An estuary's cross sectional should not have an area larger than 25% with a temperature uplift above 2°C, for more than 5% of the time	There are currently no uniform regulatory standards for thermal loads in transitional and coastal waters the benchmarks used in the ES assessments are based on: - The WFD thermal standards; - The WQTAG 160, "Guidance on assessing the impact of thermal discharges on European Marine Sites" cited in Turnpenny and Liney (2006), recommended interim thermal standards for assessing SAC/SPA sites in estuarine and coastal sites under the Habitats Regulations based upon standards contained within the Freshwater Fish Directive; - The recommendations of an assembled Expert Panel that reviewed existing legislation and the key issues relating to thermal tolerances for the New Nuclear Builds programme (BEEMS Science Advisory Report SAR008). The standards are receptor specific and sensitivity assessments are completed with specific benchmarks used.

Pressure theme	Code	Pressure	Receptor Group	Indicative pressure benchmark	Source
	H2	Salinity changes - local	Benthic communities	An increase or decrease in one MNCR salinity category beyond the usual range of the biotope/habitat for a year.	Tyler-Walters *et al.*, (2017)
			Fish Marine Mammals	Increase from 35 to 38 for a year / Decrease by 4-10 units (for a year)	Pérez-Domínguez *et al.*, (2016)
	H3	*Water flow (tidal current) changes - local*	All	A change in peak mean spring tide flow of 0.1 - 0.2 m/s for more than 1 year.	Tyler-Walters *et al.*, (2017)
	H4	Emergence regime changes - local Only under future scenario	All	A change in the time a species or habitat is covered or not covered by the sea for a period of ≥ 1 year. OR An increase in relative sea level or decrease in high water level for ≥ 1 year.	Tyler-Walters *et al.*, (2017)
	H5	Wave exposure changes - local	All	A change in nearshore significant wave height of > 3% but < 5% for a year	Tyler-Walters *et al.*, (2017)
Pollution and Other Chemical Changes from	P1	Transition elements & organo-metals contamination	All	Compound specific compliance with relevant EQS or national/international water/sediment quality criteria.	Tyler-Walters *et al.*, (2017) see BEEMS Technical Report TR306

Pressure theme	Code	Pressure	Receptor Group	Indicative pressure benchmark	Source
	P2	Hydrocarbon & PAH Contamination	All	Compound specific compliance with relevant EQS or national/international water/sediment quality criteria.	Tyler-Walters *et al.*, (2017) see BEEMS Technical Report TR306
	P3	Synthetic compound contamination	All	Compound specific compliance with relevant EQS or national/international water/sediment quality criteria.	Tyler-Walters *et al.*, (2017) see BEEMS Technical Report TR306
	P4	Introduction of other substances (solid, liquid or gas)		None proposed	
	P5	Radionuclide contamination		Compliance with site specific Environmental Permitting Regulations.	A dedicated chapter in the ES (Volume 2 Chapter 25) presents an assessment of the potential radiological effects of the proposed development.
	P6	Nutrient enrichment	All	Compliance with WFD criteria for current waterbody status: 'Good'	see BEEMS Technical Report TR306
	P7	Organic enrichment from sediment resuspension or discharge	All	Deposition rates of >100 g C/m^2/yr	Tyler-Walters *et al.*, (2017)
	P8	De-oxygenation	All	Compliance with WFD criteria for current waterbody status: 'High' (5.7 mg/l 95%ile)	see BEEMS Technical Report TR306
Physical Loss	L1	Physical loss (to land or freshwater habitat)	All	Permanent loss of existing marine habitat	Tyler-Walters *et al.*, (2017)
	L2	Physical change (to another seabed type)	All	Change in sediment type by 1 Folk class	Tyler-Walters *et al.*, (2017)

Pressure theme	Code	Pressure	Receptor Group	Indicative pressure benchmark	Source
Physical damage	D1	Habitat structure changes - removal of substratum (extraction)	Benthic communities	Extraction of sediments to 30 cm depth	Tyler-Walters *et al.*, (2017)
			Fish Marine Mammals	Extraction of sediments to 30 cm depth, OR, removal of >10% ecologically relevant structures, such as water column habitat and biogenic forming structures, within the site	Pérez-Domínguez *et al.*, (2016)
	D2 - Abrasion sub-categories	Penetration and/or disturbance of the substrate below the surface of the seabed-Surface	Benthic communities	Damage to surface features (e.g. species and physical structures within the habitat)	Tyler-Walters *et al.*, (2017)
			Fish Marine Mammals	Structural damage of >10% ecologically relevant structures, such as water column habitat and biogenic forming structures, within the site	Pérez-Domínguez *et al.*, (2016)
		Penetration and/or disturbance of the substrate below the surface of the seabed-Subsurface	Benthic communities	Damage to sub-surface features (e.g. species and physical structures within the habitat)	Tyler-Walters *et al.*, (2017)
			Fish Marine Mammals	Structural damage of >10% ecologically relevant structures, such as water column habitat and biogenic forming structures, within the site	Pérez-Domínguez *et al.*, (2016)
	D3	Changes in suspended sediment/solids	All	A change in one rank on the WFD scale for one year	Tyler-Walters *et al.*, (2017)

Pressure theme	Code	Pressure	Receptor Group	Indicative pressure benchmark	Source
	D4	Siltation rate changes	All	Heavy' deposition up to 30 cm of fine material in a single event 'Light' deposition up to 5 cm of fine material in a single event (assessed separately)	Tyler-Walters *et al.,* (2017)
Other physical pressures	O1	Litter	All	The introduction of manmade objects able to cause physical harm (surface, water column, sea floor and/or strandline)	Tyler-Walters *et al.,* (2017)
	O2	Electromagnetic changes	Fish	Local electric field of 1V m-1; Local magnetic field of 10µT	Pérez-Domínguez et al., (2016)
	O3	Underwater noise (and vibration)	Fish	Specific thresholds for behaviour, TTS and PTS for fish are applied	see BEEMS Technical Report TR312
			Marine Mammals	Specific thresholds for behaviour, TTS and PTS for marine mammal receptors are applied	see BEEMS Technical Report TR312
	O4	*Introduction of light*	Marine Mammals	A change in 0.1 Lux in diffuse irradiation during the period of site occupancy by the receptor; >3 distant strobe and point light sources visible over a 90° azimuth arc	Pérez-Domínguez *et al.*, (2016)

Pressure theme	Code	Pressure	Receptor Group	Indicative pressure benchmark	Source
	O5	Barrier to species movement	All	SZC mobile receptors: more than 25% of the cross-sectional area of an estuary or coastal corridor (3 km from the shoreline out to sea) is blocked (physical, thermal, chemical), for more than 5 % of the time.	Based on SAC thermal limits (H1)
	O6	Death or injury by collision	Marine Mammals	Site-specific increases in vessel traffic	Site-specific
Biological pressures	B1	Visual disturbance	All	Activity at the site provides cues within the visual range of the receptor	Pérez-Domínguez et al., (2016)
	B2	Translocation of indigenous species	NA	Not assessed here	Working vessels and barges will conform to IMO Ballast Water Management Convention (adopted in 2004). Potential impacts arising from translocation of indigenous species is not assessed further.
	B3	Introduction or spread of non-indigenous species	Benthic communities	Site-specific	Site-specific
	B4	Introduction of microbial pathogens	All	Compliance with Bathing Water Standards	see BEEMS Technical Report TR306
	B5	Removal of target species	NA		
	B6	Removal of non-target species	NA		