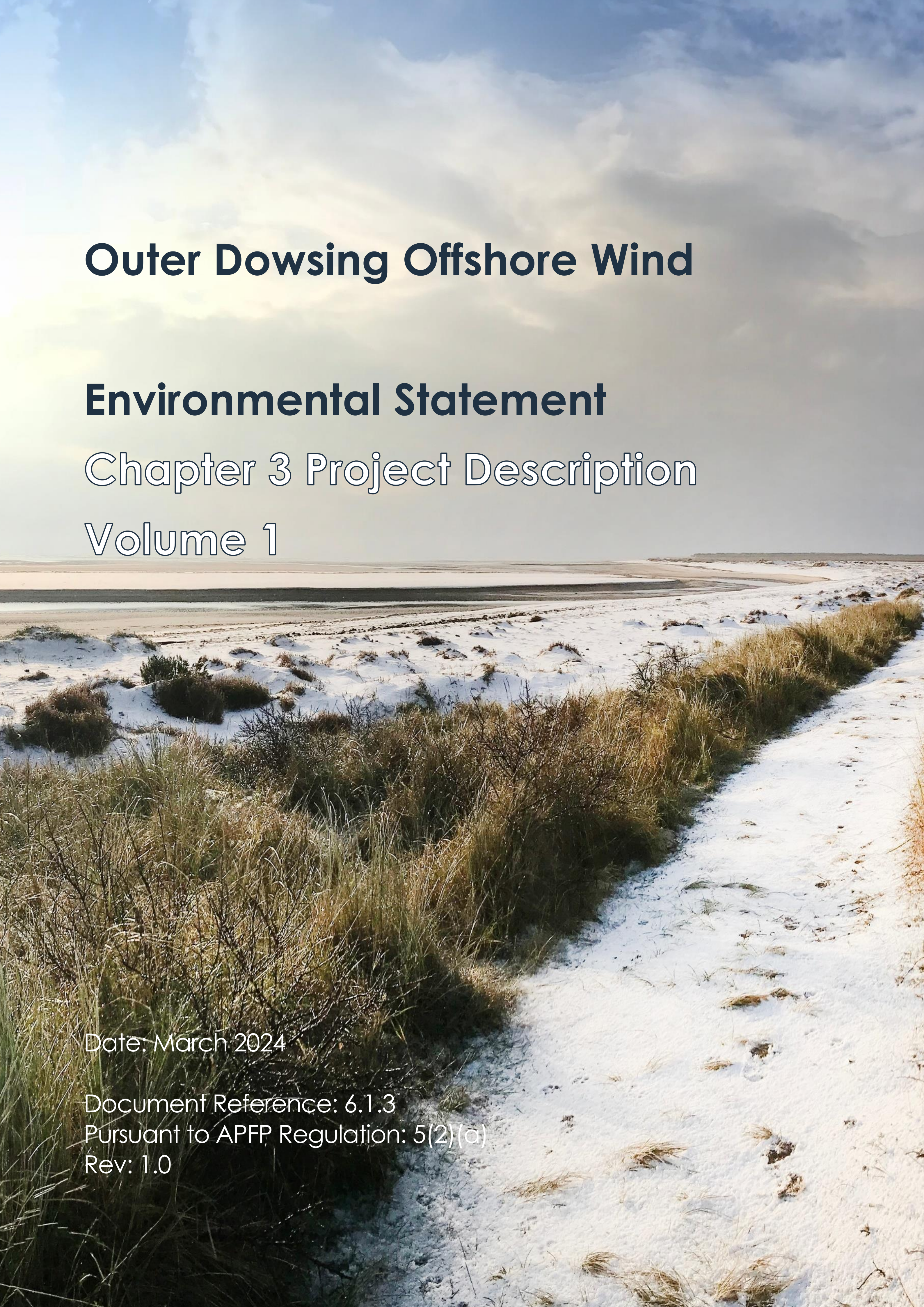

Outer Dowsing Offshore Wind

Environmental Statement

Chapter 3 Project Description

Volume 1

Date: March 2024

Document Reference: 6.1.3
Pursuant to APFP Regulation: 5(2)(a)
Rev: 1.0

Company:	**Outer Dowsing Offshore Wind**	Asset:	**Whole Asset**
Project:	**Whole Wind Farm**	Sub Project/Package:	Whole Asset
Document Title or Description:	Chapter 3 Project Description		
Internal Document Number:	PP1-ODOW-DEV-CS-PDE-0001	3rd Party Doc No (If applicable):	N/A
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Rev No.	**Date**	**Status / Reason for Issue**	**Author**	**Checked by**	**Reviewed by**	**Approved by**
1.0	March 2024	DCO Application	Outer Dowsing	Outer Dowsing	Shepherd and Wedderburn	Outer Dowsing

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Acronyms & Definitions

Abbreviations / Acronyms

Acronym	Expanded name
AEZs	Archaeological Exclusion Zones
AfL	Agreement for Lease
AIS	Air Insulated Switchgear
ANS	Artificial Nesting Structure
AtNs	Aids to Navigation
CAA	Civil Aviation Authority
CBS	Cement Bound Sand
DAD	Design Approach Document
DCO	Development Consent Order
DECC	Department of Energy & Climate Change, now the Department for Energy Security and Net Zero (DESNZ)
Defra	Department for Environment, Food and Rural Affairs
DESNZ	Department for Energy Security and Net Zero, formerly Department of Business, Energy and Industrial Strategy, which was previously Department of Energy & Climate Change (DECC)
DPD	Design Principles Document
DPV	Dynamic Positioning Vessel
ECC	Export Cable Corridor
EIA	Environmental Impact Assessment
EMP	Ecological Management Plan
EPP	Evidence Plan Process
ES	Environmental Statement
ETG	Expert Topic Group
FFC	Flamborough and Filey Coast
FGL	Finished Ground Level
FLiDAR	Floating LiDAR
GBS	Gravity Base Structure
GIS	Gas Insulated Switchgear
GT R4 Ltd	The Applicant. The special project vehicle created in partnership between Corio Generation (a wholly owned Green Investment Group portfolio company), Gulf Energy Development and TotalEnergies
HDD	Horizontal Directional Drilling
HGV	Heavy Goods Vehicles
HLV	Heavy Lifting Vessel
HRA	Habitats Regulations Assessment
HV	High Voltage
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
IAC	Inter-Array cables
IALA	International Association of Marine Aids to Navigation and Lighthouse Authorities
IDB	Internal Drainage Board
JB	Joint Bays
JUV	Jack Up Vessel
LAT	Lowest Astronomical Tide

Acronym	Expanded name
LBs	Link Boxes
LiDAR	Light Detection and Ranging
LMP	Landscape Management Plan
LV	Low Voltage
MCA	Maritime Coastguard Agency
MDS	Maximum Design Scenario
MGN	Marine Guidance Note
MHWS	Mean High Water Springs
MLWS	Mean Low Water Springs
MMO	Marine Management Organisation
MSL	Mean Sea Level
MV	Medium Voltage
NEQ	Net Explosive Quantity
NGESO	National Grid Electricity System Operator
NGET	National Grid Electricity Transmission
NGSS	National Grid Onshore Substation
NPS	National Policy Statement
NtM	Notice to Mariners
O&M	Operation and Maintenance
ODOW	Outer Dowsing Offshore Wind (The Project)
OP	Offshore Platform
ORCP	Offshore Reactive Compensation Platform
OnSS	Onshore Substation
OREI	Offshore Renewable Energy Installation
OSS	Offshore Substation
PEIR	Preliminary Environmental Information Report
PLGR	Pre-Lay Grapnel Run
RIAA	Report to Inform Appropriate Assessment
ROV	Remote Operated Vehicle
SAC	Special Area of Conservation
SCADA	Supervisory Control and Data Acquisition
SF6	Sulphur Hexaflouride
SMP	Soil Management Plan
SOV	Service Operations Vessel
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest
SWMP	Site Waste Management Plan
THLS	Trinity House Lighthouse Service
TJB	Transition Joint Bay
TP	Transition Piece
TSHD	Trailing Suction Hopper Dredger
UKHO	UK Hydrographic Office
UPS	Uninterrupted Power Supply
UXO	Unexploded Ordnance
WSI	Written Scheme of Investigation
WTG	Wind Turbine Generator

Terminology

Term	Definition
400kV cables	High-voltage cables linking the OnSS to the NGSS.
400kV cable corridor	The 400kV cable corridor is the area within which the 400kV cables connecting the onshore substation to the NGSS will be situated.
The Applicant	GT R4 Ltd. The Applicant making the application for a DCO. The Applicant is GT R4 Limited (a joint venture between Corio Generation, TotalEnergies and Gulf Energy Development (GULF)), trading as Outer Dowsing Offshore Wind. The Project is being developed by Corio Generation (a wholly owned Green Investment Group portfolio company), TotalEnergies and GULF.
AfL array area	The area of the seabed awarded to GT R4 Ltd through an Agreement for Lease (AfL) for the development of an offshore wind farm, as part of The Crown Estate's Offshore Wind Leasing Round 4.
Array area	The area offshore within which the generating station (including wind turbine generators (WTG) and inter array cables), offshore accommodation platforms, offshore transformer substations and associated cabling will be positioned.
Baseline	The status of the environment at the time of assessment without the development in place.
Cable circuit	A number of electrical conductors necessary to transmit electricity between two points bundled as one cable or taking the form of separate cables, and may include one or more auxiliary cables (normally fibre optic cables).
Cable ducts	A duct is a length of underground piping which is used to house the Cable Circuits.
Connection Area	An indicative search area for the NGSS.
Deemed Marine Licence (dML)	A marine licence set out in a Schedule to the Development Consent Order and deemed to have been granted under Part 4 (marine licensing) of the Marine and Coastal Access Act 2009.
Development Consent Order (DCO)	An order made under the Planning Act 2008 granting development consent for a Nationally Significant Infrastructure Project (NSIP).
Effect	Term used to express the consequence of an impact. The significance of an effect is determined by correlating the magnitude of the impact with the sensitivity of the receptor, in accordance with defined significance criteria.
Environmental Impact Assessment (EIA)	A statutory process by which certain planned projects must be assessed before a formal decision to proceed can be made. It involves the collection and consideration of environmental information, which fulfils the assessment requirements of the EIA Regulations, including the publication of an Environmental Statement (ES).

Term	Definition
Environmental Statement (ES)	The suite of documents that detail the processes and results of the EIA.
Export cables	High voltage cables which transmit power from the Offshore Substations (OSS) to the Onshore Substation (OnSS) via the Offshore Reactive Compensation Platform (ORCP) if required, which may include one or more auxiliary cables (normally fibre optic cables).
Habitats Regulations Assessment (HRA)	A process which helps determine likely significant effects and (where appropriate) assesses adverse impacts on the integrity of European conservation sites and Ramsar sites. The process consists of up to four stages of assessment: screening, appropriate assessment, assessment of alternative solutions and assessment of imperative reasons of over-riding public interest (IROPI) and compensatory measures.
Haul Road	The track within the onshore ECC which the construction traffic would use to facilitate construction.
High Voltage Alternating Current (HVAC)	High voltage alternating current is the bulk transmission of electricity by alternating current (AC), whereby the flow of electric charge periodically reverses direction.
High Voltage Direct Current (HVDC)	High voltage direct current is the bulk transmission of electricity by direct current (DC), whereby the flow of electric charge is in one direction.
Impact	An impact to the receiving environment is defined as any change to its baseline condition, either adverse or beneficial.
Inter-array cables	Cables which connect the wind turbines to each other and to the offshore substation(s) which may include one or more auxiliary cables (normally fibre optic cables).
Interlink Cables	Cables which connect the Offshore Substations (OSS) to one another which may include one or more auxiliary cables (normally fibre optic cables).
Intertidal	The area between Mean High Water Springs (MHWS) and Mean Low Water Springs (MLWS)
Joint bays	An excavation formed with a buried concrete slab at sufficient depth to enable the jointing of high voltage power cables.
Landfall	The location at the land-sea interface where the offshore export cables and fibre optic cables will come ashore.
Link boxes	Underground metal chamber placed within a plastic and/or concrete pit where the metal sheaths between adjacent export cable sections are connected and earthed.
Maximum Design Scenario	The project design parameters, or a combination of project design parameters that are likely to result in the greatest potential for change in relation to each impact assessed
Mitigation	Mitigation measures are commitments made by the Project to reduce and/or eliminate the potential for significant effects to arise as a result of the Project. Mitigation measures can be embedded (part of the project design) or secondarily added to reduce impacts in the case of potentially significant effects.

Term	Definition
National Grid Onshore Substation (NGSS)	The National Grid substation and associated enabling works to be developed by the National Grid Electricity Transmission (NGET) into which the Project's 400kV Cables would connect.
National Policy Statement (NPS)	A document setting out national policy against which proposals for Nationally Significant Infrastructure Projects (NSIPs) will be assessed and decided upon
Offshore Export Cable Corridor (ECC)	The Offshore Export Cable Corridor (Offshore ECC) is the area within the Order Limits within which the export cables running from the array to landfall will be situated.
Offshore Reactive Compensation Platform (ORCP)	A structure attached to the seabed by means of a foundation, with one or more decks and a helicopter platform (including bird deterrents) housing electrical reactors and switchgear for the purpose of the efficient transfer of power in the course of HVAC transmission by providing reactive compensation
Offshore Substation (OSS)	A structure attached to the seabed by means of a foundation, with one or more decks and a helicopter platform (including bird deterrents), containing— (a) electrical equipment required to switch, transform, convert electricity generated at the wind turbine generators to a higher voltage and provide reactive power compensation; and (b) housing accommodation, storage, workshop auxiliary equipment, radar and facilities for operating, maintaining and controlling the substation or wind turbine generators
Onshore Export Cable Corridor (ECC)	The Onshore Export Cable Corridor (Onshore ECC) is the area within which the export cables running from the landfall to the onshore substation will be situated.
Onshore Infrastructure	The combined name for all onshore infrastructure associated with the Project from landfall to grid connection.
Onshore substation (OnSS)	The Project's onshore HVAC substation, containing electrical equipment, control buildings, lightning protection masts, communications masts, access, fencing and other associated equipment, structures or buildings; to enable connection to the National Grid
Outer Dowsing Offshore Wind	The Project.
Order Limits	The area subject to the application for development consent. The limits shown on the works plans within which the Project may be carried out.
The Planning Inspectorate	The agency responsible for operating the planning process for Nationally Significant Infrastructure Projects (NSIPs).
Pre-construction and post-construction	The phases of the Project before and after construction takes place.
Preliminary Environmental Information Report (PEIR)	The PEIR was written in the style of a draft Environmental Statement (ES) and provided information to support and inform the statutory consultation process during the pre-application phase.

Term	Definition
The Project	Outer Dowsing Offshore Wind, an offshore wind generating station together with associated onshore and offshore infrastructure.
Project Design Envelope	A description of the range of possible elements that make up the Project's design options under consideration, as set out in detail in the project description. This envelope is used to define the Project for Environmental Impact Assessment (EIA) purposes when the exact engineering parameters are not yet known. This is also often referred to as the "Rochdale Envelope" approach.
Receptor	A distinct part of the environment on which effects could occur and can be the subject of specific assessments. Examples of receptors include species (or groups) of animals or plants, people (often categorised further such as 'residential' or those using areas for amenity or recreation), watercourses etc.
Spudcan	Spudcans are the base cones on mobile-drilling jack-up platform. These inverted cones are mounted at the base of the jack-up and provide stability to lateral forces on the jack-up rig when deployed into ocean-bed systems.
Statutory consultee	Organisations that are required to be consulted by the Applicant, the Local Planning Authorities and/or The Planning Inspectorate during the pre-application and/or examination phases, and who also have a statutory responsibility in some form that may be relevant to the Project and the DCO application. This includes those bodies and interests prescribed under Section 42 of the Planning Act 2008.
Study Area	Area(s) within which environmental impact may occur – to be defined on a receptor-by-receptor basis by the relevant technical specialist.
Subsea	Subsea comprises everything existing or occurring below the surface of the sea.
Transboundary impacts	Transboundary effects arise when impacts from the development within one European Economic Area (EEA) state affects the environment of another EEA state(s)
Transition Joint Bay (TJBs)	The offshore and onshore cable circuits are jointed on the landward side of the sea defences/beach in a Transition Joint Bay (TJB). The TJB is an underground chamber constructed of reinforced concrete which provides a secure and stable environment for the cable.
Trenched technique	Trenching is a construction excavation technique that involves digging a trench in the ground for the installation, maintenance, or inspection of pipelines, conduits, or cables.
Trenchless technique	Trenchless technology is an underground construction method of installing, repairing and renewing underground pipes, ducts and cables using techniques which minimize or eliminate the need for excavation. Trenchless technologies involve methods of new pipe installation with minimum surface and environmental disruptions. These techniques may include Horizontal Directional Drilling (HDD), thrust boring, auger boring,

Term	Definition
	and pipe ramming, which allow ducts to be installed under an obstruction without breaking open the ground and digging a trench.
Wind turbine generator (WTG)	A structure comprising a tower, rotor with three blades connected at the hub, nacelle and ancillary electrical and other equipment which may include J-tube(s), transition piece, access and rest platforms, access ladders, boat access systems, corrosion protection systems, fenders and maintenance equipment, helicopter landing facilities and other associated equipment, fixed to a foundation.

Reference Documentation

Document Number	Title
3.1	Draft Development Consent Order
5.1	Consultation Report
5.1.2a	Scoping Opinion
5.1.2b	Scoping Report
6.1.2	Chapter 2: Need, Policy and Legislation
6.1.4	Chapter 4: Site Selection and Consideration of Alternatived
6.1.6	Chapter 6 Technical Consultation
6.3.6.1	Appendix 6.1 Evidence Plan Process Consultation
6.1.22	Chapter 22 Onshore Ornithology
6.1.26	Chapter 26 Noise and Vibration
6.1.28	Chapter 28 Landscape and Visual Impact Assessment
7.1	Report to Inform Appropriate Assessment
7.5	Without prejudice Derogation Case
8.1	Outline Code of Construction Practice
8.1.3	Outline Soil Management Plan
8.1.4	Outline Onshore Pollution Prevention and Emergency Response Plan
8.1.5	Outline Surface Water and Drainage Strategy
8.10	Outline Landscape and Ecological Management Plan
8.11	Outline Artificial Light Emissions Management Plan,
8.12	Outline Operational Drainage Management Plan
8.15	Construction Traffic Management Plan
9.1	The Planning Statement
9.1.1	Policy Compliance Document
9.3	Safety Zone Statement

1 Introduction

1. This chapter of the Environmental Statement (ES) provides a description of the design of Outer Dowsing Offshore Wind (hereafter referred to as 'the Project'). It details the Project's design, the components which make up both the onshore and offshore infrastructure, and the main activities associated with the whole lifecycle of the Project (construction, operation and maintenance, and decommissioning).
2. The design envelope approach (detailed in section 2) has been adopted to include sufficient flexibility in the project design to allow for further refinement during detailed design, following consent. The project's design envelope has been refined in line with the feedback received during the pre-application process, as well as the additional survey data and information that has become available to the Project.
3. The project description sets out:
   - Design Envelope Approach, Design Commitments and Consultation;
   - Project Location and Project Components;
   - Offshore Components;
   - Landfall construction;
   - Onshore Infrastructure;
   - Operation and Maintenance (O&M);
   - Decommissioning; and
   - Indicative Project Construction Programme.

2 Design Envelope Approach

2.1 Need for Project Design Flexibility

4. Design flexibility is key for large infrastructure projects, particularly offshore wind projects where technology continues to evolve. To provide flexibility at the detailed design stage, the Project has adopted an assessment approach known as the 'design envelope' approach, or the 'Rochdale Envelope' approach (The Inspectorate, 2018). This approach assesses what is considered the 'worst case' scenario based on the maximum parameters currently defined for the Project at the application stage, which are detailed throughout this chapter. The series of options, ranges of, and maximum, design parameters encompassed within the Project design envelope, from which a realistic Maximum Design Scenario (MDS) for the Project which can be considered for each assessment within the Environmental Statement (ES). A range of parameters for each aspect of the Project has been defined, with the MDS for each receptor and impact identified and then utilised in the assessment.
5. The process and the associated parameters have been refined since the Project's Preliminary Environmental Information Report (PEIR) publication, taking account of newly available survey data, design refinement through ongoing project engineering works and Project consultation feedback. The Project has undertaken three phases of consultation since the publication of the PEIR (Phase 2, Autumn consultation and Targeted Winter Consultation), as detailed within the Consultation Report (document reference 5.1) and summarised in section 3 of this chapter. Further technical consultation to inform design refinement was undertaken through the Evidence Plan Process (EPP) with Expert Topic Groups (ETGs) and is detailed in Volume 1 Chapter 6 Technical Consultation (document reference 6.1.6) and Appendix 6.1 Evidence Plan Process Consultation (document reference 6.3.6.1).
6. At this stage of the Project, the revised parameters provide sufficient flexibility to allow for further refinement through the detailed design process, within the design envelope post-consent. Such choices requiring this design flexibility include, for example, final wind turbine generator (WTG) foundation selection, specific siting of infrastructure (within the Order Limits), and final choice of construction or installation methods. This allows for future refinements in windfarm development prior to the finalisation of the project design to be reasonably accommodated during the post-consent/detailed design phase, whilst also allowing the Applicant to optimise the project economics to provide best value to the UK consumer.
7. The final design will also be dependent on factors such as ground conditions, wave and tidal conditions, project economics, and procurement approach.
8. As noted in the Inspectorate Advice Note Nine (The Planning Inspectorate, 2018), the Rochdale Envelope approach or design envelope approach, is widely recognised as appropriate and will be employed where the developer may not know the exact specifications of infrastructure that will comprise the proposed project. The note states that:

"The Rochdale Envelope assessment approach is an acknowledged way of assessing a Proposed Development comprising EIA development where uncertainty exists and necessary flexibility is sought".

9. The use and importance of the Rochdale Envelope approach is also recognised in the Overarching National Policy Statement (NPS) for Energy (NPS EN-1) (DESNZ, 2023a) and the NPS for Renewable Energy Infrastructure (NPS EN-3) (DESNZ, 2023b). This approach has been used in the majority of Development Consent Order (DCO) applications for offshore windfarm projects in the UK.
10. The requirement for flexibility is recognised in NPS EN-1 (paragraph 4.3.11 – 4.3.12) (DESNZ, 2023a):

"In some instances, it may not be possible at the time of the application for development consent for all aspects of the proposal to have been settled in precise detail. Where this is the case, the applicant should explain in its application which elements of the proposal have yet to be finalised, and the reasons why this is the case.

Where some details are still to be finalised, the ES should, to the best of the applicant's knowledge, assess the likely worst case environmental, social and economic effects of the proposed development, to ensure that the impacts of the project as it may be constructed have been properly assessed"

11. In the case of offshore windfarms, NPS EN-3 (paragraph 2.8.74) (DESNZ, 2023b) recognises that:

"Owing to the complex nature of offshore windfarm development, many of the details of a proposed scheme may be unknown to the applicant at the time of the application to the Secretary of State. Such aspects may include:

- *the precise location and configuration of turbines and associated development;*
- *the foundation type and size;*
- *the installation technique or hammer energy;*
- *the exact turbine blade tip height and rotor swept area;*
- *the cable type and precise cable or offshore transmission route; and*
- *the exact locations of offshore and/or onshore substations."*

12. Throughout NPS EN-3 there is recognition of the need for flexibility. Paragraphs 3.6.1 and 3.6.2 support this by stating:

"Where details are still to be finalised applicants should explain in the application which elements of the proposal have yet to be finalised, and the reason why this is the case.

Where flexibility is sought in the consent as a result, applicants should, to the best of their knowledge, assess the likely worst case environmental, social and economic effects of the proposed development to ensure that the impacts of the project as it may be constructed have been properly assessed."

13. NPS EN-3 (footnote 12 to paragraph 2.6.2) states that:

"Case law, beginning with R v Rochdale MBC Ex p. Tew [2000] Env.L.R.1 establishes that while it is not necessary or possible in every case to specify the precise details of development, the information contained in the ES should be sufficient to fully assess the project's impact on the environment and establish clearly defined worst case parameters for the assessment. This is sometimes known as 'the Rochdale Envelope'"

14. Therefore, as the Environmental Impact Assessment (EIA) process assesses the full extent and worst case impacts for each receptor based on the project's design scenarios, the Project design envelope approach has been taken to allow for robust and meaningful environmental assessments.

2.1.1 Relationship to the Maximum Design Scenario

15. A realistic MDS has been assessed throughout the ES, avoiding excessive conservatism in the EIA process by, for example, not considering unrealistic overly precautionary scenarios. This is achieved by assessing the parameters not necessarily in a combination of the maximum design parameters for each component. For example, the maximum seabed disturbance will not coincide with the maximum number of piles, as the first relates to multi-suction caisson jacket foundations, whilst the second relates to piled jacket foundations. Therefore, the maximum design scenario is chosen on a "receptor by receptor" and an "impact by impact" basis, based on a range of build-out scenarios. The details of these MDSs are set out within the topic chapters of this ES and summarised within each technical chapter (ES Volume 1, Chapters 7 to 32).

3 Consultation

16. Consultation is a key part of the DCO application process. Consultation regarding this Project description has been conducted through:

- the publication of the Scoping Report and consideration of the Scoping Opinion (document reference 5.1.2);
- the Project's five pre-application phases (Phase 1, Phase 1A, Phase 2, Autumn and Targeted Winter Consultations) including the publication of the PEIR and other consultation materials associated with each phase (see Consultation Report document reference 5.1);
- engagement with relevant stakeholders through the Evidence Plan Process (EPP) (ES Chapter 6 Technical Consultation and Appendix 6.2 Evidence Plan Process Consultation (document reference 6.1.6 and 6.3.6.2); and
- bilateral consultation as appropriate and referenced where relevant throughout this ES.

17. Public Consultation has been ongoing since the Project's launch in October 2022 and the Project has undergone five key phases of consultation (Phase 1, Phase 1a, Phase 2 (consultation on the PEIR), Autumn Consultation and Targeted Winter Consultation) since this time, all of which are summarised in the Consultation Report (document reference 5.1) and Volume 1, Chapter 6 Technical Consultation (document reference 6.1.6).

18. Statutory consultation has been carried out under the requirements of Sections 42, 47 and 48 of the 2008 Act, with relevant comments being considered in developing the final project design. An overview of the EIA specific consultation process is presented within Chapter 6 (document reference 6.1.6).

19. Through this consultation the Project has identified matters that have led directly to design changes and commitments that have been made to the proposed construction methodologies. These include:

- The consideration of an alternative Onshore ECC to the Weston Marsh Connection Option;
- The refinement of the Onshore ECC to reduce impacts on agricultural activities;
- The commitment to trenchless construction methods when crossing Internal Drainage Board (IDB) owned and maintained drains and Environment Agency (EA) main rivers and maintained infrastructure;
- The updated layout and inclusion of targeted mitigation measures for ornithological receptors at the landfall;
- The avoidance of the Clay Pits Site of Special Scientific Interest (SSSI);
- The avoidance of the Wolla Bank to Chapel Point SSSI,
- The avoidance of archaeological features through project design, such as at Slackholme End.

4 Project Location

20. A geographical overview of the location of the offshore and onshore project infrastructure is presented in ES Volume 2, Figure 3.1 Offshore and Onshore Order Limits (document reference 6.2.3.1).

4.1 Array Area

21. The Project array area (within which the generating station will be located) has been refined from 500km^2 to an area of 436km^2 and lies approximately 54km east of the Lincolnshire coast at its closest point. Should the Project be awarded development consent, the area in which WTGs will be located will be reduced post consent as part of detailed design. Water depths vary across the array area with a range 20m to 50m relative to Lowest Astronomical Tide (LAT).

22. The project Array Area can be seen in ES Volume 2, Figure 3.1 Offshore and Onshore Order Limits (document reference 6.2.3.1).

4.1.1 Array Area Layout Principles

23. The Project requires flexibility in the location and layout of the WTGs and offshore surface infrastructure within the Array area. As such a number of indicative layouts containing up to 100 WTGs and the OSSs have been developed to represent the worst case scenario of relevant specific topics.

24. The final layout of WTGs and OSSs will be confirmed as part of the final design process and will be submitted to the Marine Management Organisation (MMO) for approval in consultation with relevant stakeholders such as the Maritime Coastguard Agency (MCA) and Trinity House Lighthouse Service (THLS).

25. The indicative layouts are presented as appropriate in the relevant chapters and conform to the following layout principles:

    - The layout will have a minimum of one line of orientation subject to a safety justification for all infrastructure;
    - All infrastructure within the array area, including existing assets at the point of construction, will be aligned;
    - Spacing between infrastructure will be no less than 605m from the blade tips of any WTGs; and
    - “Boundary” layouts and grid layouts may be considered.

4.2 Offshore Export Cable Corridor

26. To connect the array area to the National Electricity Transmission System, offshore export cables will be required, located within an offshore Export Cable Corridor (ECC) running from the array area to the Lincolnshire coast, which will then link to the onshore ECC.

27. The offshore ECC exits to the south of the array area, with a fan leading from the southern edge of the array. The offshore ECC crosses some existing pipelines to the south of the array area, before turning west to pass through the Inner Dowsing, Race Bank and North Ridge Special Area of Conservation (SAC), south of the existing Triton Knoll offshore windfarm export cables. At the western extent of the Inner Dowsing, Race Bank and North Ridge SAC, the offshore ECC splits, to provide optionality on final routing at this stage, before the two sections join to the east of Wolla Bank, where the offshore ECC makes landfall. Further details can be found in Volume 1, Chapter 4: Site Selection and Consideration of Alternatives (document reference 6.1.4).
28. The landfall for the offshore export cables will be located at Wolla Bank, on the Lincolnshire coastline, south of Anderby Creek. The Offshore ECC can be seen in Figure 3.2 Offshore Order Limits (document reference 6.2.3.2).

4.3 Onshore Export Cable Corridor and 400kV cable corridor

29. The offshore ECC will make landfall at Wolla Bank, to the south of Anderby Creek (see Volume 2, Figure 3.1 Offshore and Onshore Order Limits (document reference 6.2.3.1), where cables will be installed using trenchless techniques to pass under the intertidal area, the sand dunes and the coastal Lincolnshire Wildlife Trust site (Anderby Marsh), to connect into the Landfall Compound which is located on agricultural land to the west of Roman Bank (road).
30. From the Transition Joint Bays (TJBs) at the Landfall Compound, the onshore ECC will run south (west of the A52) underground, to the Project's onshore substation (OnSS) location at Surfleet Marsh, located on agricultural land on the north side of the River Welland, east of the A16 and south of the Risegate Eau (Drain) to the north of Spalding as shown in Volume 2, Figure 3.4 Indicative Onshore Infrastructure (document reference 6.2.3.4).
31. 400kV cables will then run underground between the OnSS and the National Grid substation (NGSS) that will be built, owned, and operated by the National Grid Electricity Transmission (NGET) and is anticipated to be located within, or near to, an area identified by the Project as the "Connection Area" as shown in ES Volume 2, Figure 3.4 (document reference 6.2.3.4).
32. Whilst the width of the onshore ECC may fluctuate along the route to account for specific environmental and engineering constraints, the Project is expected to require a typical working width of 80m during cable construction within which a typical 60m wide permanent corridor will be located. Further detail on the site selection of the onshore ECC, OnSS and 400kV cable corridor taken forward for DCO Application and assessment within the ES has been included in Volume 1, Chapter 4 Site Selection and Assessment of Alternatives (document reference 6.1.4).
33. Where trenchless crossing techniques are proposed, this working width may need to be larger to accommodate this type of crossing. The maximum extent of the temporary footprint would be up to 220m, at the River Haven Crossing (see Appendix 3.2 Onshore Crossing Schedule (document reference 6.3.3.2)) .

34. The length of the onshore ECC from the landfall to the OnSS is approximately 70km. The length of the 400kV cable corridor is approximately 4km. The following sections describe the spatial extent of the onshore ECC that is assessed within the ES. To allow for the assessments to be undertaken, the onshore ECC and 400kV cable corridor have been split into the segments as outlined below and described in Table 4.1.

Table 4.1. Onshore ECC and 400kV cable corridor segment reference and description

Segment		General Direction	Link to Figure	Key Features and Receptors
ECC1	Landfall to A52 – Hogsthorpe	Heading west from landfall	ES Volume 2 Figure 3.3 Onshore Order Limits and Assessment Segments (reference 6.2.3.3), page 2	▪ Lincolnshire Wildlife Trust Anderby Marsh ▪ Agricultural Land ▪ Wigg Drain ▪ Large pond ▪ Langham Road and Lowgate Road ▪ A52
ECC2	A52 – Hogsthorpe to Marsh Lane	South	Figure 3.3, page 3	▪ Agricultural land ▪ Willoughby High Drain and Orby Drain ▪ Listoft Lane and Sloothby High Lane
ECC3	Marsh Lane to A158 – Skegness Road	South	Figure 3.3, page 4	▪ A158 ▪ Caravan site ▪ Fishing ponds ▪ Agricultural land ▪ Ingoldmells Road and Younger's Lane
ECC4	A158 – Skegness Road to Low Road	South	Figure 3.3, page 5	▪ Agricultural land ▪ Catchwater Drain ▪ Rookery Farm ▪ Billgate Lane and Middlemarsh Road
ECC5	Low Road to Steeping River	South	Figure 3.3, page 6	▪ Agricultural land ▪ A52 ▪ Croft Drain ▪ Havenhouse railway lines ▪ Top Yard Farm Caravan site ▪ Ponds ▪ Rose Cottage

Segment		General Direction	Link to Figure	Key Features and Receptors
ECC6	Steeping River to Fodder Dike Bank/Fen Ban	South west	Figure 3.3, page 7	▪ Church lane, Scaldgate Road, Burgh Road ▪ Agricultural land ▪ Woodland ▪ Hall Gate Road farm track
ECC7	Fodder Dike Bank/Fen Bank to Broadgate	South west	Figure 3.3, page 8	▪ Cranberry Lane, Mill Hill, Small End Road, Skirmore Road, Patmans Lane and Ivery Lane ▪ Agricultural land
ECC8	Broadgate to Ings Drove	South west	Figure 3.3, page 9	▪ Agricultural land ▪ Residential properties close to Cragmire Lane, Double Bank, Manor Lane, Seadyke Lane, Fold Hill Road, the B1184 (Church Road), pode lane and Skip Marsh Lane ▪ Woodland
ECC9	Ings Drove to Church End Lane	South south west	Figure 3.3, page 10	▪ Benington Ings and Ings Bank ▪ Agricultural land ▪ A52 ▪ Butterwick Road, Girls School Lane and Shore Road ▪ The Leverton Solar Park and Substation ▪ Lowfields Lodge
ECC 10	Church End Lane to The Haven	South west	Figure 3.3, page 11	▪ Hobhole Drain ▪ Southfield Farm ▪ Pilgrim Fathers Memorial Site ▪ Cut End Road, Woad Lane, Southfield Lane, The Graft, Scalp Road, Clampgate

Segment		General Direction	Link to Figure	Key Features and Receptors
				Road, Grovefield Lane and Mickleham Lane
ECC 11	The Haven to Marsh Road	South south west	Figure 3.3, page 12	▪ Frampton Road, Sandholme Lane ▪ Agricultural land ▪ Wyberton Branch Drain, Wyberton Marsh Pump Drain, Boundary Drain, Junction Drain, Frampton Towns Drain
ECC 12	Marsh Road to Fosdyke Bridge	South west	Figure 3.3, page 13	▪ Agricultural land ▪ Kirton Drain ▪ Thompson’s Lane, Pot Lane, Cravens Lane, Wash Road and Pullover Lane ▪ Ponds
ECC 13	Fosdyke to Surfleet Marsh OnSS/Marsh Drove	West	Figure 3.3, page 14	▪ Agricultural land ▪ Five Town Drain, Risegate Eau and Bicker Creek ▪ The Mooring’s Café ▪ Graves Farm ▪ Bram Lea ▪ Risegate Eau Pumping Station
ECC 14	Surfleet Marsh OnSS / Marsh Drove to Connection Area	South south east	Figure 3.3, page 15	▪ Agricultural land ▪ A17 ▪ Lord’s Drain ▪ The Old Row Coastguard

5 Project Components

35. The Project will be comprised of the following key components:
    - Wind turbine generators (WTGs)
    - Offshore substations (OSSs)
    - Offshore reactive compensation platforms (ORCPs)
    - Array, interlink, and export cables
    - Project onshore substation (OnSS)
    - Necessary associated development required to transmit the power generated by the turbines to the connection with the National Grid transmission network (the grid connection location).
36. Additionally the project may, if required, include:
    - Accommodation platform
    - Artificial nesting structures
    - Biogenic reef compensation
37. Additional associated development and ancillary works may be required to construct, operate, and maintain the Project, such as, for example, onshore temporary construction compounds, temporary haul roads and offshore metocean measuring instruments such as wave buoys and Floating LiDAR (FLiDAR). The Project will have a maximum of 100 WTGs installed. The WTGs will be connected in strings, branches or loops to offshore substations via array cables with the offshore substations then connected to shore by up to four offshore export cables. Offshore substations and the accommodation platform may be connected to each other using interlink cables to facilitate an electrical supply to the accommodation platform.
38. The project may require a maximum of two Artificial Nesting Structures (ANS) to provide nesting facilities to birds as a compensatory measure under the Habitats Regulations. The ANS would be located offshore, within the ANS areas as shown Figure 3.2 (document reference 6.2.3.2) located outside the main array area to the North West and/or South East.
39. The Project may also require an area for the creation and re- creation of biogenic reef within the Inner Dowsing Race Bank and North Ridge Special Area of Conservation as a compensatory measure under the Habitats Regulations. This would be located outside of the Array area within the Biogenic Reef Restoration Area (Figure 3.2).
40. The Project has confirmed that only a single transmission technology type; high voltage alternating current (HVAC) (i.e. specifically excluding high voltage direct current (HVDC) technology), will be used and this forms the basis of the relevant assessments in this ES. Additional reasoning and detail is provided below in Section 5.1, but notably the use of HVAC reduces the amount of onshore infrastructure required and associated impacts.

41. Depending on the final export cable parameters and the offshore substation locations within the array area, up to two ORCPs may also be required, which will be situated within the ORCP areas shown within the offshore ECC in Figure 3.2 (document reference 6.2.3.2).

42. At the landfall, the offshore export cables will be jointed to the onshore export cables at TJBs. The project has committed to using trenchless technology at the landfall, with a sub tidal exit.

43. There will be up to four onshore export cable circuits, typically comprised of 12 cables (3 per circuit) plus auxiliary cables (normally fibre optic), housed within[1] up to four trenches connecting to the Project's OnSS. There will then be up to two 400kV cable circuits connecting the OnSS to the NGSS.

5.1 HVAC Technology selection

44. The Project has confirmed that only a single transmission technology type; high voltage alternating current (HVAC) (i.e. specifically excluding high voltage direct current (HVDC) technology), will be used and this forms the basis of the relevant assessments in this ES.

45. HVDC type transmission is not to be used for a number of reasons, including:

- Regulatory and technical restrictions for electrical export when considering the size and location of the Project;
- A significantly more costly solution for technical and regulatory compliance would be needed;
- The supply chain for HVDC technology is more constrained compared with the selected HVAC technology supply chain which could result in delays during construction;

5.2 Overview of Main Project Components

46. The key components of the Project are summarised in Table 5.1 and subsequently described in the following sections.

[1] [1] At major trenchless crossings, more ducts may be required, and the cable circuits would be bundled accordingly (i.e. reducing the number of export cables per duct)

Table 5.1 Key project components

Project location	Project component	Detail	Details included in:
Array	Wind Turbine Generators (WTGs)	The WTGs convert wind energy to electricity. Key components include rotor blades, gearboxes (if required for WTG model), transformers, power electronics and control equipment. Offshore turbine models are continuously evolving and improving; therefore, the exact wind turbine model will be selected post-consent from the range of models available at the time of procurement, with a range of maximum parameters for turbines identified herein rather than a specific turbine output rating.	6.1 Wind Turbine Generators
Array	Offshore Substations and Accommodation Platform	Offshore Platforms (OPs) include offshore substations (OSS), which collect the power generated by WTGs through the array cables, convert the electricity from the array voltage to the transmission voltage and transmit the power to the offshore export cables. They may also include an accommodation platform to host personnel during the operational lifetime of the windfarm.	6.3 Offshore Substations 6.5 Offshore Accommodation Platform
Array	Foundations	WTGs and OPs will be supported by foundation structures installed onto the seabed. These are typically fabricated from steel or concrete. A limited number of foundation designs are currently being considered. These designs are described in Section 6.2.	6.2 Foundations
Array	Inter-Array cables	Subsea cables that will connect the WTGs to each other and to one of the offshore substations, typically in strings, branches or loops.	6.9 Offshore Cables
Array and offshore ECC	Scour and cable protection	In order to protect the seabed around the foundation structures from scour and to protect the array, export and interlink cables in the event that full or adequate burial cannot be achieved (or where other seabed assets are crossed), protection materials may be placed on the seabed.	6.8 Scour Protection 6.9.5 Cable Protection Table 6.17 Maximum Design Parameters for Cable
Array and offshore ECC	Offshore platforms	Offshore platforms (OPs) is a term to collectively describe OSSs, ORCPs and the accommodation platform all of which are described individually in this table.	6.3 Offshore Substations (OSS) 6.4 Offshore Reactive Compensation Platform (ORCP) 6.5 Offshore Accommodation Platform

Project location	Project component	Detail	Details included in:
Array Area	Interlink cables	Subsea cables that will connect the OSSs to one another and may also connect one or more OSSs to any accommodation platform. Cable parameters may be either as per array cables or offshore export cables.	6.9 Offshore Cables
Array Area and Offshore ECC	Offshore export cables	Cables connecting the OSSs and ORCPs to the onshore export cables at the landfall on the adjacent coastline.	6.9 Offshore Cables
Offshore ECC	Offshore Reactive Compensation Platforms	Depending on the final export cable route length, it may be necessary to compensate for the reactive power within the supply by installing up to two ORCPs.	6.4 Offshore Reactive Platform
Artificial Nesting Structure Areas	Artificial Nesting Structures	Offshore structures providing nesting facilities for birds, located within the Artificial Nesting Structure Area.	6.6 Artificial Nesting Structures
Biogenic Reef Restoration Area	Biogenic Reef	An area of seabed for the creation and re-creation of biogenic reef habitat, located within the Biogenic Reef Restoration Area.	6.10 Benthic Compensation
Landfall	Landfall and Transition Joint Bay	The landfall is the area where the offshore export cables are brought ashore and jointed to the onshore cables in TJBs.	7. Landfall construction
Onshore ECC	Onshore export cables	Cables installed following the route between the landfall and the OnSS.	8.1 Onshore ECC & 400kV Cable Corridor
Onshore substation (OnSS)	Onshore Substation	The OnSS will include the necessary electrical plant to meet the requirements of the National Grid Electricity System Operator (NGESO).	8.2 Project Onshore Substation
400kV Cable Corridor	Grid connection	400kV cables connecting the OnSS to the NGSS.	8.1 Onshore ECC & 400kV Cable Corridor
National Grid indicative connection area	Grid connection	Indicative search area for the NGSS.	8.3 National Grid Onshore Substation

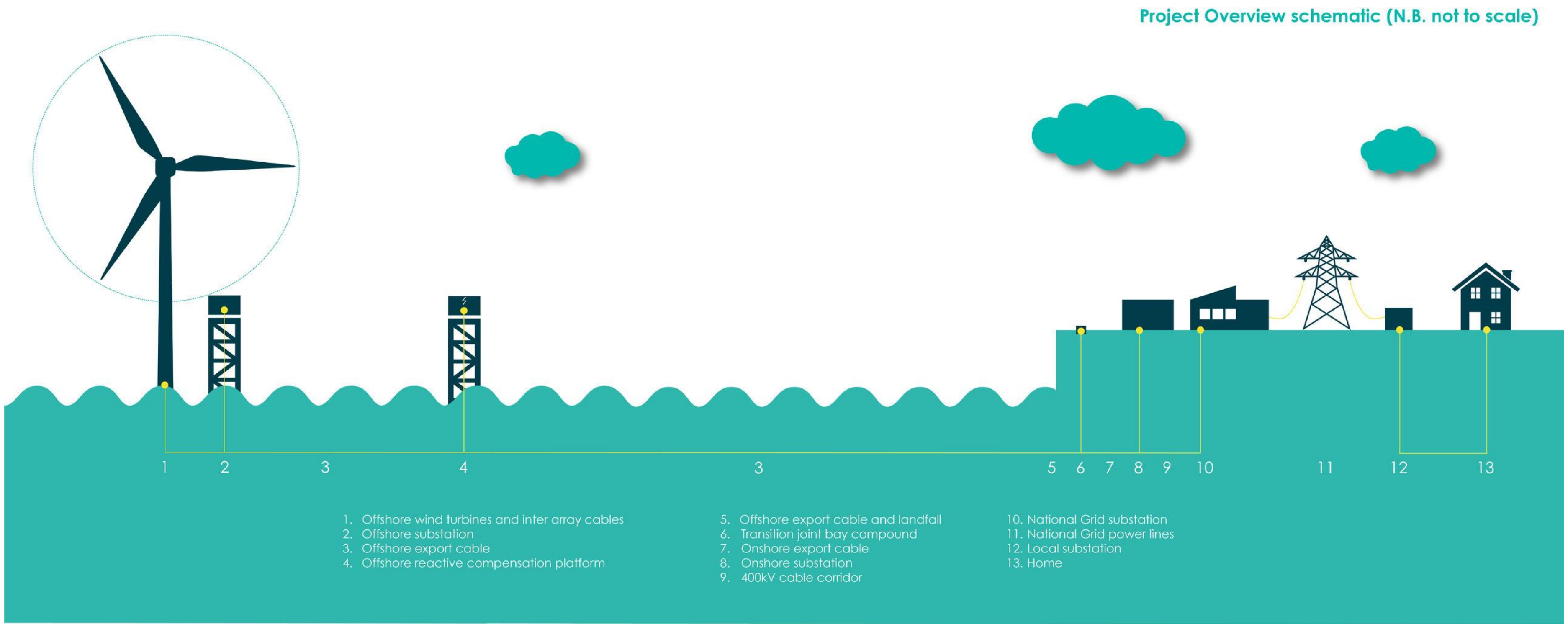

Plate 5.1 Key Project Components and the onward infrastructure required to enable power to be supplied to a home

6 Offshore Components

6.1 Wind Turbine Generators (WTGs)

6.1.1 Design

47. The key design parameters for the WTGs are presented in Table 6.1. The WTGs will incorporate tapered tubular towers supporting a nacelle housing mechanical and electrical generating equipment with three rotor blades attached to the nacelle rotor hub (Plate 6.1). All WTGs will be located within the offshore array area. The final layout of the WTGs will be determined post-consent but will be subject to final approval and governed by agreed layout principles. The final selection of WTG to be used will be identified post-consent. However, to inform the assessment, the project design envelope includes an indicative range of turbines in order to accommodate the ongoing rapid development in wind turbine technology. Accounting for this range there could be a maximum of between 50 and 100 WTGs dependent on the size and generation capacity selected post-consent.

Table 6.1 WTG indicative key design parameters

Parameters	Design Envelope
Maximum number of WTGs	100
Indicative maximum number of WTGs assuming maximum rotor diameter	50
Maximum blade tip height above LAT (m)	403
Maximum rotor diameter (m)	340
Minimum height of lowest blade tip against mean sea level (MSL) (m)	40

Table 6.2 WTG rotor sizes

Minimum rotor diameter (m)	Maximum rotor diameter (m)
236	340

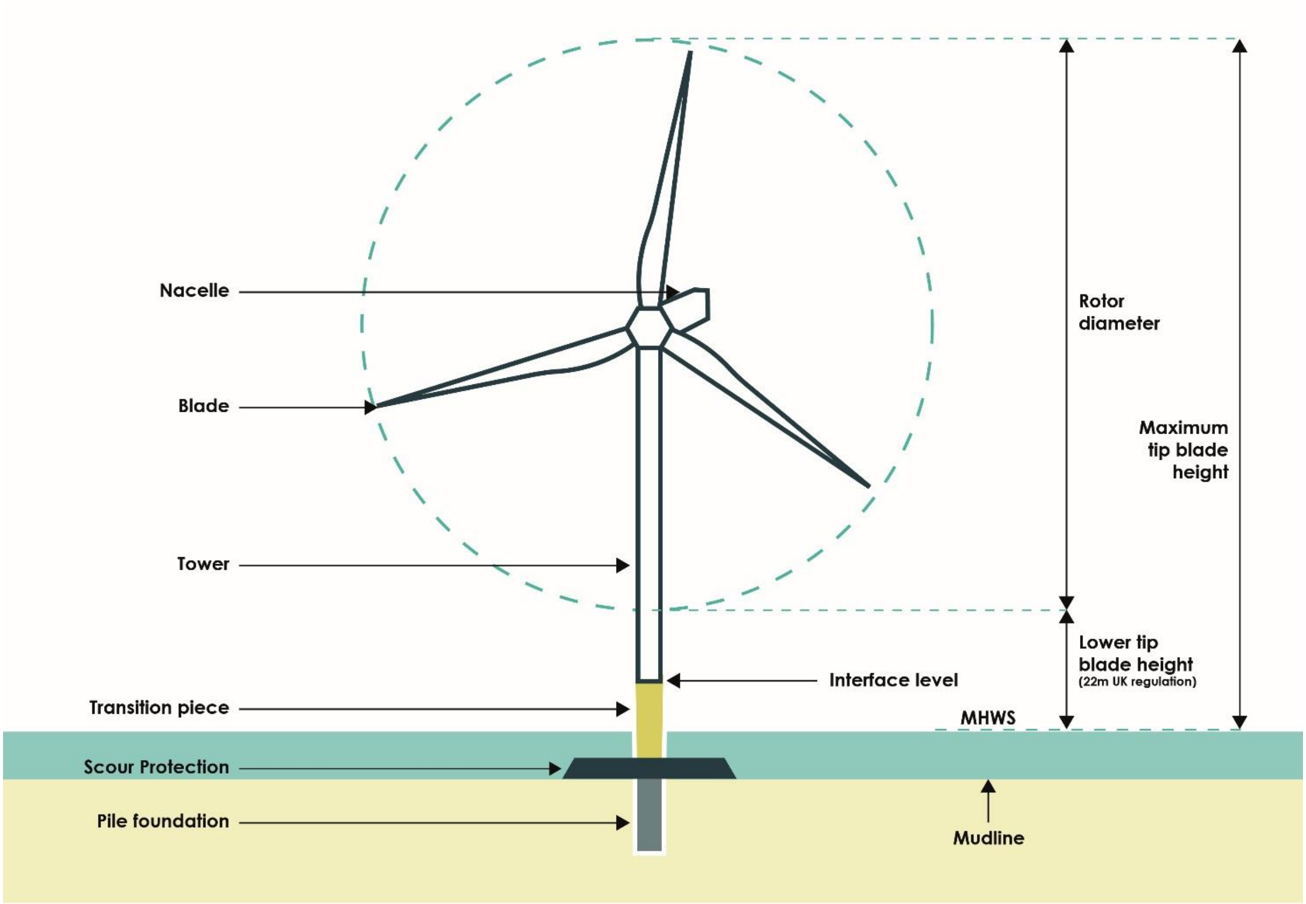

Plate 6.1 Typical Wind Turbine Generator

6.1.2 WTG Installation

48. Generally, turbines are installed using the following process:

- WTGs are installed upon their respective foundation type (see Section 6.2)
- WTG components (blades, nacelles, and towers) are collected from port by the installation vessel, typically a jack up vessel (JUV) to ensure a stable platform for installation vessels when on site.
- JUV operations will have a maximum disturbance area of 1,613m^2 per operation. Typically, the JUV will carry all of the necessary components to complete the installation of several WTGs during each trip.

49. Where additional components are brought to the installation location by supply vessels such as barges, there may be a requirement to anchor alongside the installation vessel. For such operations, there will be a maximum of 388 anchoring operations with a maximum disturbance of 800m^2 per operation for the construction phase.

50. The installation vessel will transit to the Project array area and the components will be lifted onto the pre-installed transition piece (if required) or foundation substructure, by the crane on the installation vessel. Each wind turbine generator will be assembled on site in this fashion with technicians fastening components together as they are lifted into place. The exact methodology for the assembly is dependent on WTG type and installation contractor, and will be defined in the pre-construction phase after grant of consent.

51. Alternatively, the WTG components may be loaded onto barges or dedicated transport vessels at port and installed as above by an installation vessel that remains on site throughout the installation campaign.

52. Each installation vessel or barge may be assisted by a range of support and transport vessels. These are typically smaller vessels that may be tugs, support vessels, anchor handling vessels, or similar. These vessels will primarily make the same movements to, from and around the Project array area as the installation vessels they are supporting. Helicopters may also be used for the transfer of personnel to vessels. Working distances are shown in Plate 6.3.

53. For the purposes of the EIA, assumptions have been made on the maximum number of vessels and helicopters and the number of return trips to the Project array area from port/airfield that are required throughout construction. These are presented in Table 6.20.

6.2 Foundations

54. The factors influencing the choice of WTG, OP and ANS foundation for a specific project typically include (but may not be limited to):

- Health, Safety and Environment and operational considerations;
- the type of wind turbine to be used;
- the nature of the ground conditions on the site;
- the water depth;
- sea conditions (i.e. prevailing wave and current climate); and
- supply chain constraints and overall cost.

6.2.1 Design

55. The foundation type selected will ultimately be dependent on the final detailed site investigations, engineering design studies and the procurement process. At this stage, a range of foundation types is being considered, based on the information the Applicant currently has about the prevailing site conditions and key design considerations, and these are summarised in Table 6.3.

56. Maximum design parameters for each of the Foundation types can be found in Table 6.4, Table 6.5, Table 6.6 and Table 6.7.

Table 6.3 WTG foundation options

Type	Description	Example	Details provided in
Monopile foundation	Monopile foundations are tubular structures, consisting of a number of sections of rolled steel plates welded together. In most cases a Transition Piece (TP) is fitted over the monopile and secured via a bolted or grouted connection. In other cases, the monopile will connect directly to the wind turbine tower flange (a TP-less solution).	Plate 6.4	Table 6.4
Gravity base structure (GBS) foundation	GBS are typically concrete structures which are floated or transported via barge or installation vessel to site and then ballasted when in the correct location. The stability of the foundation is achieved by its weight.	Plate 6.5	Table 6.5
Pin piled jacket foundation	Piled jacket foundations are formed of a steel lattice construction (comprising tubular steel members and welded joints). The foundation is secured to the seabed by hollow steel pin-piles sitting within a sleeve or leg which is part of the jacket. The piles rely on frictional and end bearing properties of the seabed for support. Unlike monopiles, there is no separate TP; the TP and ancillary structures are fabricated as an integral part of the jacket.	Plate 6.6	Table 6.6
Suction bucket jacket foundation	Suction bucket jacket foundations are formed of a steel lattice construction (comprising tubular steel members and welded joints) fixed to the seabed by suction caissons. The suction buckets are typically hollow steel cylinders, capped at the upper end, which are fitted underneath the legs of the jacket structure. Seabed stability is achieved principally via skin friction of the suction bucket walls with the surrounding soils. Unlike monopiles, but similar to piled jacket foundations, there is no separate TP; the TP and ancillary structure is fabricated as an integrated part of the jacket structure and is not installed separately offshore.	Plate 6.7	Table 6.7

Plate 6.2 WTG foundation types and key parameters

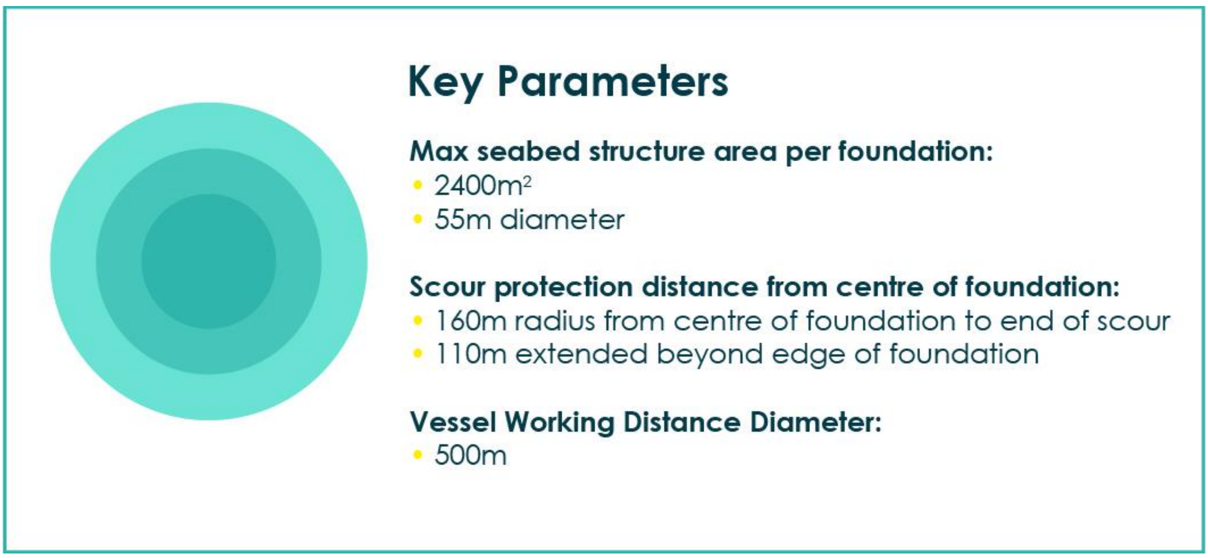

Plate 6.3 Key distance parameters including maximum foundation, scour protection and working distance diameters.

Monopile Foundations

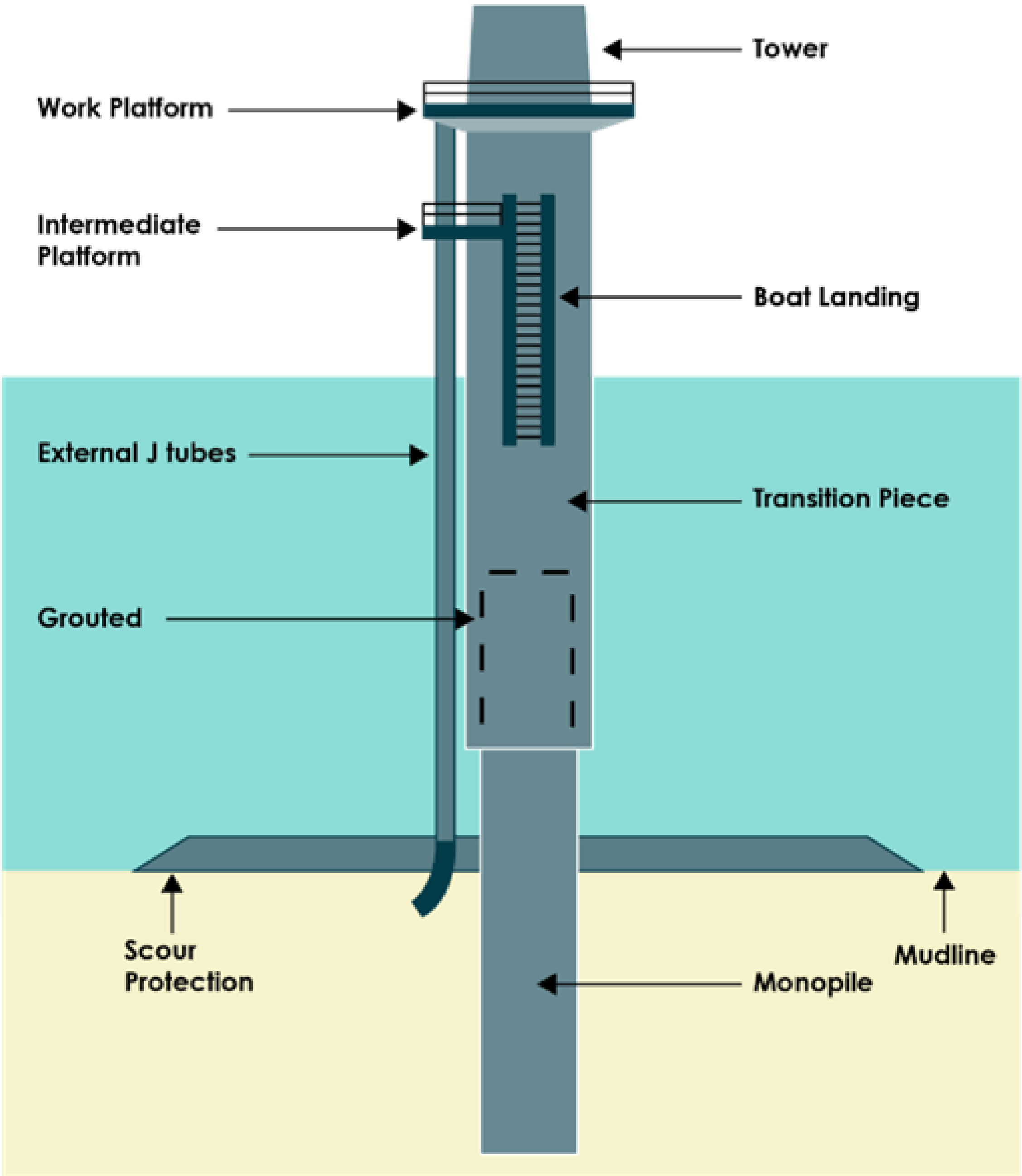

Plate 6.4 Example of indicative monopile foundation

Table 6.4 Maximum design parameters for monopile foundations

Parameter	WTG Minimum Size	WTG Maximum Size	OP	ANS
Number of piles (per foundation)	1			
Maximum diameter of monopile at seabed (m)	12.5	13	14	8
Maximum diameter of monopile at sea surface (m)	12.5	13	14	8
Maximum footprint on the seabed per foundation (excluding scour protection) (m^2)	125	135	160	55
Maximum Seabed scour protection area (m^2)	4,300	4,700	5,390	1,800
Maximum seabed total footprint (m^2)	4,425	4,835	5,550	1,855
Drill spoil volume (m^3)	6,550	7,600	11,000	3,460
Maximum seabed preparation spoil volume (m^3)	2,220	2,420	2,775	930
Maximum scour protection volume per foundation (m^3)	12,900	14,100	16,170	5,400
Maximum piling duration (hours)	8	8	8	8

GBS Foundations

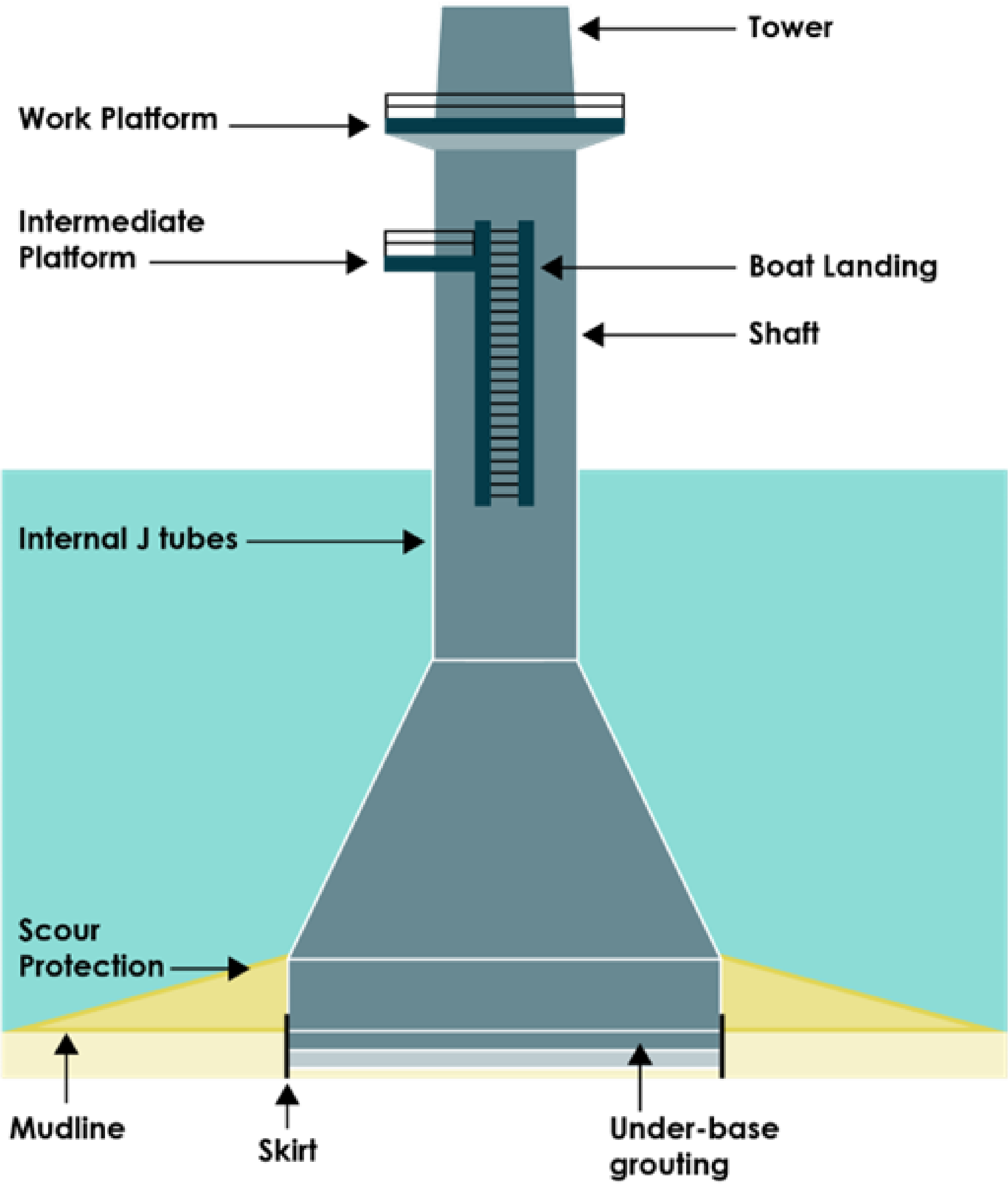

Plate 6.5 Example of indicative GBS monopile foundation type

Table 6.5 Maximum design parameters for GBS foundation type

Parameter	WTG Minimum Size	WTG Maximum Size	OP	ANS
Maximum length and width at seabed level (m)	50 (circular)	55 (circular)	72 X 36	50 (circular)
Maximum area on seabed per foundation (excluding scour protection) (m^2)	2,000	2,400	2,592	2,000
Maximum diameter at LAT (m)	14 (circular)	16 (circular)	16 (circular)	14 (circular)
Seabed preparation buffer around base (m)	24			
Seabed preparation depth (m)	4.8			
Maximum seabed scour protection area (m^2)	10,300	12,500	13,650	10,300
Maximum seabed total footprint (m^2)	12,300	14,900	16,242	12,300
Maximum seabed preparation spoil volume (m^3)	36,300	40,100	48,500	36,300
Maximum scour protection volume (m^3)	30,900	37,500	41,000	30,900

Pin-piled Jacket Foundations

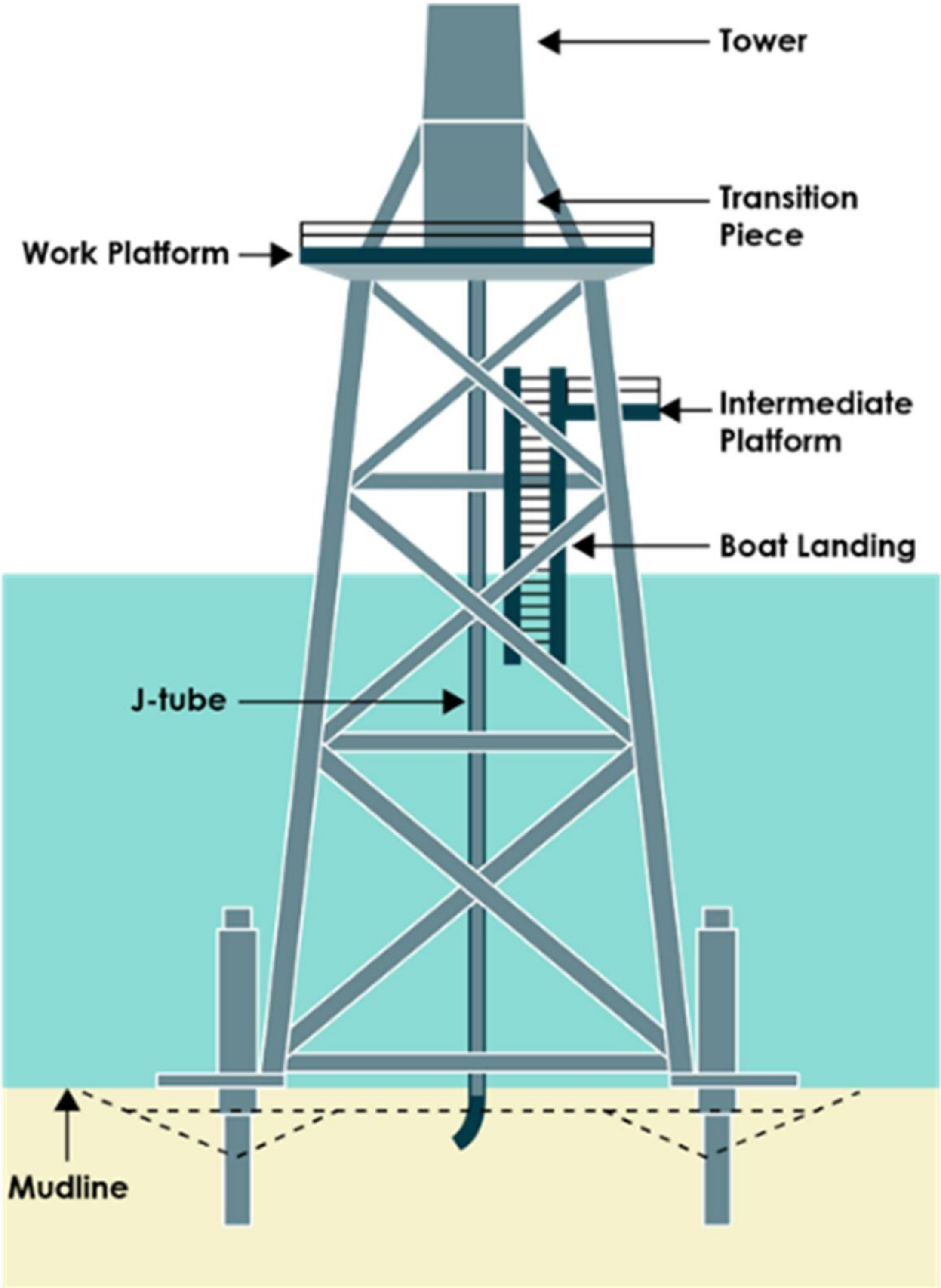

Plate 6.6 Example of indicative pin piled jacket foundation type

Table 6.6 Maximum design parameters for pin piled jacket foundations

Parameter	WTG Minimum Size	WTG Maximum Size	OP	ANS
Maximum number of piles per foundation	4		24	4
Number of piles per leg	1		3	1
Number of legs per foundation	4		8	4
Maximum separation of adjacent legs at seabed level (m)	36		80	36
Maximum separation of adjacent legs at LAT (m)	30		80	15
Maximum leg diameter (m)	4			
Maximum pile diameter (m)	5			
Maximum footprint on the seabed per foundation (excluding scour protection) (m^2)	78.6		200	78.6
Maximum seabed scour protection area (m^2)	1,000		9,600	1,000
Maximum seabed total footprint (m^2)	1,078.6		9,800	1,078.6
Maximum drill spoil volume (m3)	7,800	10,000	27,400	7,800
Maximum Seabed preparation spoil volume (m^3)	540		7,200	540
Maximum scour protection volume (m^3)	3,000		28,800	3,000
Maximum piling duration per pin (hours)	6		8	6

Suction Based Jacket Foundations

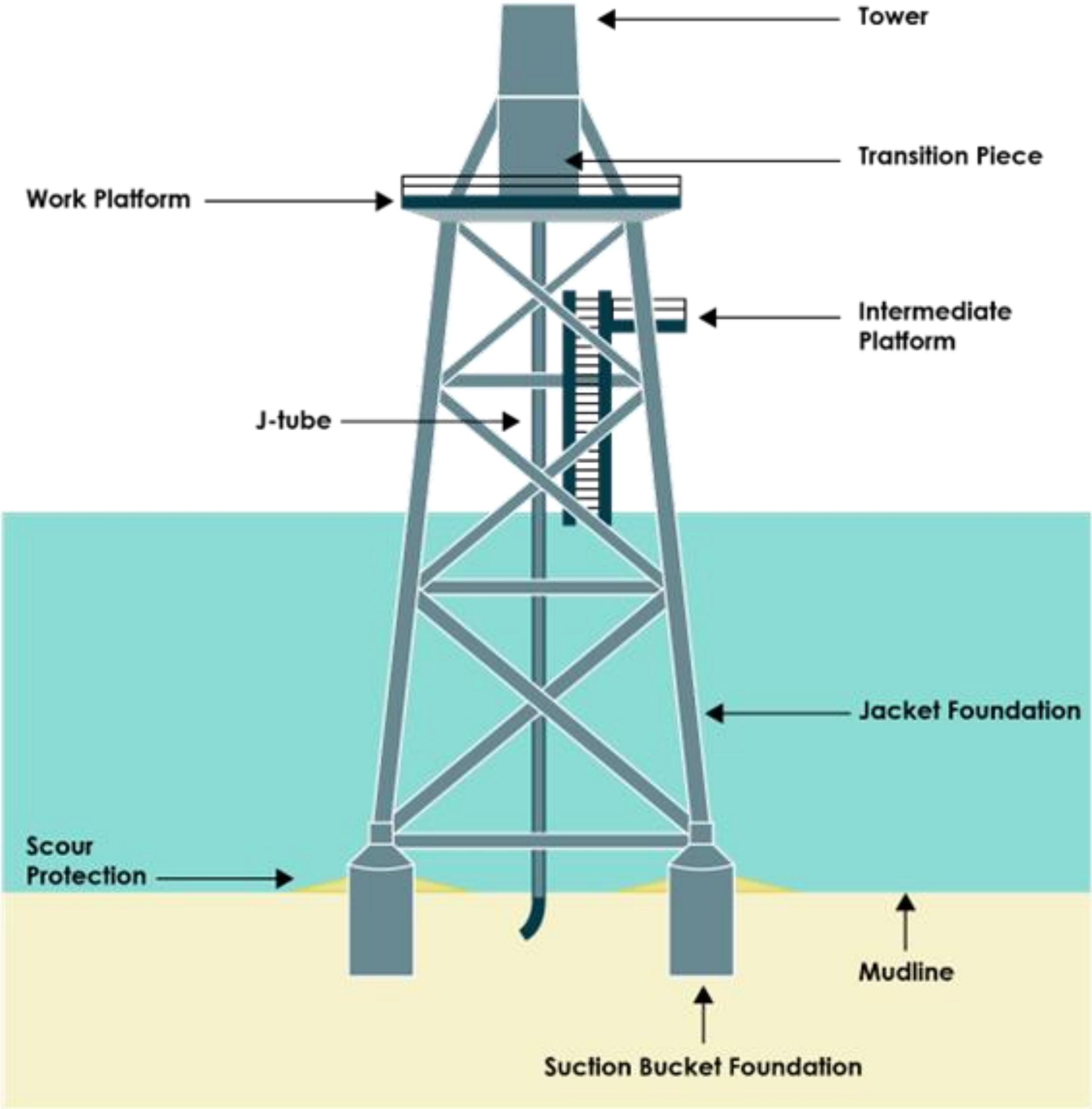

Plate 6.7 Example of indicative suction bucket jacket foundation type

Table 6.7 Maximum design parameters for suction bucket jacket foundation type

Parameter	WTG Minimum Size	WTG Maximum Size	OP	ANS
Maximum number of legs per jacket foundation	4	4	8	4
Maximum separation of adjacent legs at seabed level (m)	36	36	80	32
Maximum separation of adjacent legs at LAT (m)	30	30	80	15
Maximum suction bucket diameter (m)	18	20	20	10
Maximum suction bucket height above seabed (m)	3	3	3	3
Maximum number of suction buckets per foundation	4	4	8	4
Maximum footprint on the seabed per foundation (excluding scour protection) (m2)	324	400	2,550	100
Maximum seabed scour protection area (m2)	7,800	8,850	17,050	3,750
Maximum seabed total footprint (m2)	8,200	9,300	19,600	3,900
Maximum seabed preparation spoil volume (m3)	4,100	4,650	9,800	1,950
Maximum scour protection volume (m3)	23,400	26,550	51,150	11,250

6.2.2 Foundation Installation

57. Table 6.11 summarises the steps required for installation for each of the foundation types.

6.3 Offshore Substations (OSS)

58. The OSSs will collect the electricity generated by the WTGs via the array cables. The electricity will then be "stepped up" before transmission (to reduce energy losses) by the offshore and onshore export cables to the interface with the National Grid transmission network. The voltage at the array cables will be 66kV or 132kV, interlink cables will be 66kV, 132kV, 220kV or 275kV and offshore export cables will be 220kV or 275kV.

59. Up to four separate smaller OSSs may be required or up to two separate OSSs if they are built to the larger design. All OSSs will be located within the Project array area.

Design

60. Each of the OSSs will comprise a platform with one or more decks, attached to the seabed by means of a foundation that contains equipment required to switch, transform and convert electricity generated at the WTGs and provide reactive power compensation. It may provide means to facilitate helicopter access (including bird deterrents). They will also house auxiliary equipment and facilities for operating, maintaining, controlling the OSSs and to access the OSSs by vessels and helicopters. Accommodation, storage, workshop and logistic facilities for operating and maintaining the WTGs may also be included, such as LiDAR.

61. Key equipment in the OSSs may include grid transformers, auxiliary/earthing transformers, fixed shunt reactors, harmonic filters, if required, high voltage (HV) and Medium Voltage (MV) switchgear, Auxiliary systems and Low Voltage (LV) switchgear, Protection and metering equipment, Supervisory Control and Data Acquisition (SCADA), Emergency/standby generators, HVAC, Uninterrupted power supply (UPS) and battery systems, fire fighting systems, lighting, aids to navigation (AtNs), systems for vessel access and/or retrieval, potable water supply, black water separation, storage (including stores, fuel, and spares), communication systems, control hub facilities and lifting equipment (main crane, service cranes, and gantry cranes).

62. The maximum design parameters for the OSSs are shown below in Table 6.8.

Table 6.8 Maximum design parameters for offshore substations

Parameters	Substation type	
	Large OSS	Small OSS
Number of independent structures	2	4
Topside – maximum main structure length (m)	160	90
Topside – maximum main structure width (m)	110	90
Topside – maximum height (including auxiliary structures, such as helipad, crane, lightning protection, but excluding antennae and masts) (m LAT)	100	90
Topside maximum elevation from upper level of foundation to roof deck (m)	60	30
Topside – footprint (m^2)	17,600	8,100

Installation

63. OSSs are generally installed in two stages, firstly the foundation will be installed as described in Table 6.11, followed by the lifting of the topside from a transport vessel/barge, onto the foundation. The foundation and topside may be transported on the same transport vessel/barge, or separately. The foundation may also be transported by the installation vessel. Vessel requirements for the installation will be shown in Table 6.19.

6.4 Offshore Reactive Compensation Platform (ORCP)

64. Long distance, large capacity HVAC transmission systems can require reactive compensation equipment to reduce the reactive power generated by the capacitance of the offshore export cable to maximise the amount of power delivered to the National Grid Electricity Transmission System. The electrical equipment required, primarily shunt reactors and HV switchgear will be provided in the form of HVAC ORCPs.
65. The ORCPs will be located in the Project offshore ECC. The ORCP areas are approximately 15km^2 and 5km^2 each, and will be no closer than approximately 12km from Mean Low Water Springs (MLWS). These areas were chosen based on electrical design studies, while aiming to minimise environmental impact, for example by avoiding the Inner Dowsing, Race Bank and North Ridge SAC and minimising the visual impact from the shore.
66. The final location of the ORCPs will be defined post-consent in the detailed design stage. The siting will consider factors including final electrical design, water depth, ground conditions, marine traffic, proximity to shore, other existing/planned offshore infrastructure and other engineering and economic considerations.
67. The external design of the ORCPs will be structurally similar to the OSSs. These will comprise a platform with one or more decks, potentially including means to facilitate helicopter access. They will contain equipment required to provide reactive power compensation and housing auxiliary equipment and facilities for operating, maintaining, controlling the ORCPs and to access the ORCPs by vessels and helicopters.
68. The maximum number of ORCPs would be two. The maximum design parameters for the ORCPs would be as per the small OSS presented in Table 6.8.
69. Installation will be as for the OSSs. The vessel requirements for installation of the ORCPs are shown in Table 6.19.

6.5 Offshore Accommodation Platform

70. The Project may construct one offshore accommodation platform to allow up to 50 operations staff to be housed at the Project array area for several weeks at a time, and to allow spares and tools to be stored at the Project array area. This is with the aim to reduce trips and time spent in transit to the Project array area. It will also decrease down time for faults and repairs. The accommodation platform will be located within the Project array area. The offshore accommodation platform would be accessed by vessel and/or helicopter and may have associated captive vessels to access the turbines and substations.

6.5.1 Design

71. The offshore accommodation platform is comprised of a platform with one or more decks and means to facilitate helicopter access, attached to the seabed by means of a foundation. It may contain accommodation, storage, workshop and logistic facilities for operating and maintaining the WTGs and housing auxiliary equipment, facilities for operating, maintaining and controlling the OSSs, ORCPs and WTGs and to access the OSSs by vessels and helicopters. The maximum design parameters for the offshore accommodation platform are presented in Table 6.9.

Table 6.9 Indicative key design parameters for offshore accommodation platform

Parameters	Design Envelope
Maximum number of offshore accommodation platform	1
Accommodation Capacity (No. of Persons)	50
Length and Width (m)	84 x 84
Main structure height above LAT (m)	70.2
Structure height max above LAT (m)	80.2

Installation

72. The installation procedure would be as described for the OSSs. The vessel requirements for this process are presented in Table 6.19.

6.6 Artificial Nesting Structure (ANS)

73. The Project may construct a maximum of up to two Artificial Nesting Structures (ANS) offshore to provide a nesting location for certain bird species. This is an ecological compensation measure for potential impacts from the Project on features of the Flamborough and Filey Coast (FFC) Special Protection Area (SPA) identified as necessary under the Habitats Regulations. Please see the Report to Inform Appropriate Assessment (RIAA; document reference 7.1) and associated appendices for further details.

Design

74. The ANS would be comprised of a topside nesting structure and will be supported by a foundation structure similar in type to those presented in Table 6.3. Indicative design parameters are presented in Table 6.10 and examples of potential ANSs are shown in Plate 6.8.

Table 6.10 Indicative key design parameters for offshore Artificial Nesting Structures

Parameter	Design Envelope
Maximum number of ANSs	2
Topside length and width (m)	23x23
Structure max height above LAT (m)	60

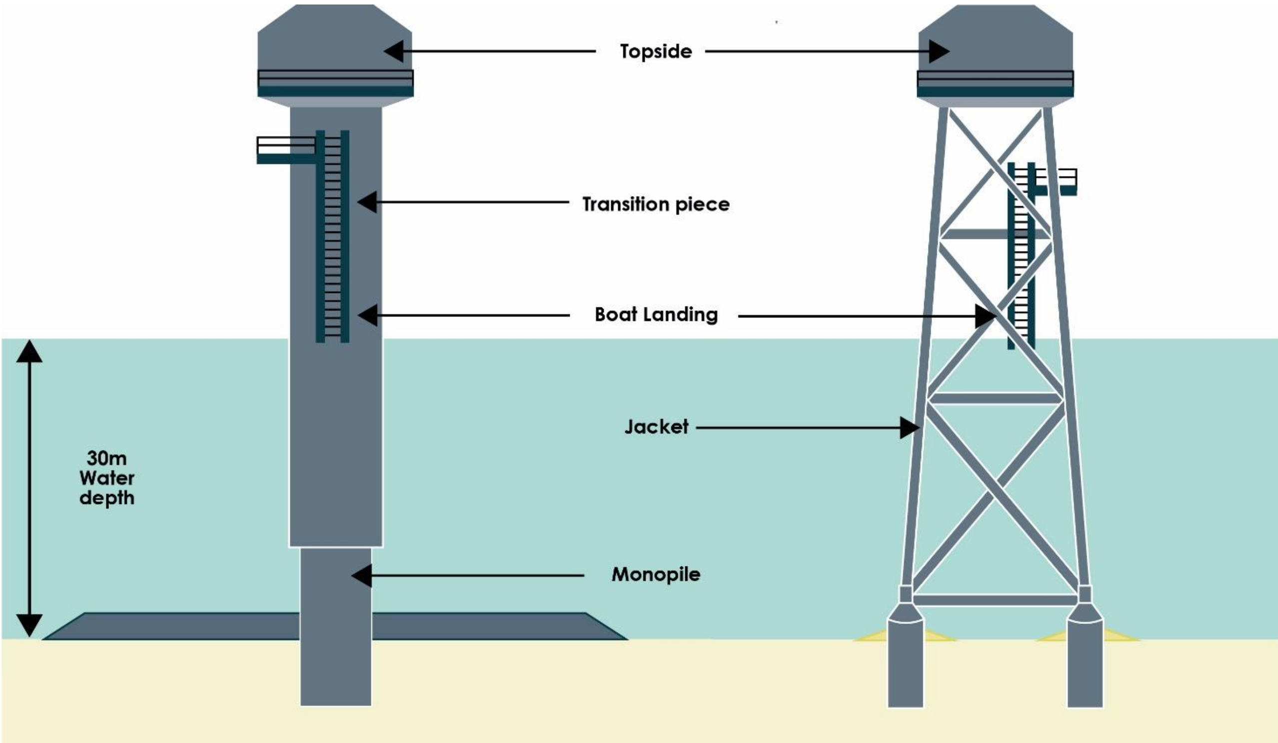

Plate 6.8 Examples of potential Offshore ANS designs

6.7 Foundation Installation

75. Table 6.11 summarises the steps required for installation for each of the foundation types.

Table 6.11 Foundation installation summary

Activity	Foundation Type			
	Monopile	Piled Jacket	Suction Bucket Jacket	Gravity Base
Site Preparation	Usually minimal. If preconstruction surveys show the presence of boulders or other seabed obstructions at foundation locations, these may be removed if the foundation cannot be micro-sited.		As well as boulder and obstruction removal this foundation type may also require some seabed levelling, to ensure that all of the buckets/gravity bases for each structure can be placed at the same level. The suction buckets require minimised slope or changes in topography, in order to form a sealed chamber within each bucket, once the foundation has landed and partially embedded under self weight into the seabed.	
Transport to Site	Either on the installation vessel (either JUV or Dynamic Positioning Vessel (DPV)), or on feeder barges.			Brought to site on barges or installation vessels, alternatively they can be floated to site. Structures are designed to be buoyant and are towed to site using tugs.
Installation	Lift monopile into the pile gripper on the side of the installation vessel; Lift hammer onto monopile and drive monopile into seabed to required embedment depth; Lift hammer from monopile and remove pile gripper; Lift transition piece onto monopile; and Secure transition piece. Where conventional piling is unable to achieve necessary pile penetration, additional	Piling template placed on seabed; Piles installed; Jacket lowered onto piles OR Jacket lowered onto seabed; Piles installed Pin piles are driven, drilled or vibrated into the seabed.	Jacket lowered onto seabed; at the desired embedment, the suction bucket voids are grouted and valves sealed.	Foundations lowered to the seabed in a controlled manner either by pumping in water, or installation of ballast (or both).

Activity	Foundation Type			
	Monopile	Piled Jacket	Suction Bucket Jacket	Gravity Base
	methods may be used (e.g. drilling, vibro-piling and/or electro-osmosis).			
Finalisation	Transition piece bolted or grouted to the monopile. The grout used is an inert cement mix that is pumped into a specially designed space between the transition piece and the monopile.	As there is no separate transition piece, there is no requirement for installing an additional foundation component .	A thin layer of grout is injected under each bucket to fill the air gap and ensure contact between the soil within the bucket, and the top of the bucket itself. As there is no separate transition piece, there is no requirement for installing an additional foundation component	None.
Vessels	The full vessel requirements for installation of foundations are shown Table 6.19.			

6.8 Scour Protection

76. Scour protection is designed to prevent WTG, OP and ANS foundations from being undermined by hydrodynamic and sedimentary processes, resulting in seabed erosion and subsequent scour hole formation. The shape of the foundation structure is an important parameter influencing the potential depth of scour hole formation.
77. Mitigation measures for scour around foundations include mattress protection, sand bags, stone bags and frond mats. The most frequently used solution is the placement of large quantities of crushed rock around the base of the foundation structure ('rock placement'). There are a number of "ecological" types of scour protection which have started to enter the market in recent years which promote the colonisation of marine life. It is possible that one of these options would be used in place of the "standard" options presented herein, however it cannot be confirmed at this stage. Any "ecological" scour protection options would not exceed the seabed footprint of the methods presented below.
78. For the Project, a typical scour protection solution will comprise a rock armour layer resting on a filter layer of smaller graded rocks. The filter layer can either be installed before the foundation is installed or afterwards. Alternatively, by using heavier rock material with a wider gradation, it is possible to avoid using a filter layer and pre-install a single layer of scour protection.
79. The amount of scour protection required will vary for the different foundation types being considered for the Project. Flexibility in scour protection choice is required to ensure that anticipated changes in available technology and Project economics can be accommodated within the Project design.

6.9 Seabed Preparation

80. Some form of seabed preparation may be required for each foundation type. Seabed preparation may include:
    - seabed levelling;
    - removing surface and subsurface debris such as boulders, lost fishing nets or lost anchors; and
    - clearance of unexploded ordnance (UXO).
81. If debris is present below the seabed surface, then excavation may be required for access and removal. The selection of removal methods shall depend on the size and distribution of the material to be recovered. For smaller dispersed material, this removal may be achieved via a subsea remote operated vehicle (ROV) suction dredger, mass flow excavation or a plough. For larger objects such as boulders, an "orange peel" hydraulic subsea grabber or a boulder plough may be used. UXO, boulder and sandwave clearance for foundations are further discussed below in the Ancillary Operations in section 16.4.1.

82. Maximum seabed preparation areas for each foundation type (that may include boulder clearance) are provided in Table 6.4, Table 6.5, Table 6.6 and Table 6.7.

83. It is likely that dredging would be required if using gravity base foundations. If required, dredging vessels would be used with suction hoppers or similar, and the spoil would be deposited on site adjacent to the turbine locations. In some cases, it may be necessary to place a layer of gravel on the seabed prior to installation of gravity base foundations. This is in addition to any boulder or obstruction removal.

6.10 Piling

84. The MDS for monopile installation (piling) will be a maximum of eight hours of piling activity (per pile) and jacket pin piles will assume a maximum of six hours per pin pile for the WTGs and ANSs and eight hours for the OPs. The primary consideration in the development of a pile driving sequence is the total energy imparted into the pile to drive it to the required depth. As such, the exact piling scenario is dependent on the maximum hammer energy and number of strikes, with the duration of the event a function of this. The pile driving scenario presented below is considered to be the MDS in terms of maximum energy imparted over the shortest period of time. The piling duration could be up to eight hours but would be unlikely to exceed the total energy for the scenario herein (i.e. the scenario may be longer and with more strikes but using lower energies to result in the same total piling energy).

85. The maximum hammer energy for the Project is 6,600kJ for monopiles. The rationale for using a maximum hammer energy is to maximise the opportunity to successfully drive all the piles. The maximum energy is considered within the MDS, however this will only be used when necessary and the energy used is likely to be significantly lower for the majority of the time. In an effort to minimise fatigue loading on the monopiles and reduce the likelihood of equipment breakdown, hammer energies are continuously set at the minimum required. They will typically start low at around 10% energy (depending on hammer capabilities) and gradually increase to the maximum required for the final metres.

86. Due to pin piles being smaller in diameter, they have a lower maximum energy of 3,500kJ. The current expected pile driving parameters for both foundation types are detailed in Table 6.12.

87. The definition of maximum hammer energy may allow the maximum piling durations to be reduced. Other reasons why higher hammer energies are required include the greater effectiveness at pile driving (due in part to the additional weight of the hammer) and greater reliability, since they are working far under their design rating for much of the time. Knowledge of the anticipated construction work will improve as additional geoscience survey campaigns are undertaken and corresponding design work is completed for the Project.

Table 6.12 Typical piling scenario for pile installation

% of max hammer energy	10%	25%	50 %	75 %	100 %
Monopile hammer energy	660	1650	3300	4950	6600
Pin pile hammer energy	350	875	1750	2625	3500
Strike rate (bl/min)	10	30	30	30	30
Duration – monopile (mins)	10	15	30	45	260

% of max hammer energy	10%	25%	50 %	75 %	100 %
Duration – pin pile (mins)	10	15	30	30	155

88. If piling is not possible due to the presence of rock or hard soils, the material may be drilled out before the monopile or jacket pin pile is driven to the required depth (known as relief drilling) or the drilling may take place prior to installation, a casing installed by jacking or driving, and then the pile is placed inside the casing and the annulus is filled with grout (known as drilled and grouted installation). The grout is pumped via dedicated pipework directly to the annulus, with volumes and flow monitored by the vessel team. If drilling is required, it is conducted at an indicative speed of 0.1 to 1.5m/hr with any spoil arising from the drilling disposed of adjacent to the foundation location on the sea surface.
89. There would be no more than two piles being driven or drilled simultaneously across the Project array.
90. It may also be possible that the piles are installed via another novel method such as vibro-piling or electro-piling. For vibro-piling the pile is embedded via vibration rather than hammering or drilling. For electro-piling, a localised electric current is used to reduce the friction between the pile surface and the surrounding sediment, reducing the energy required to drive the pile to the required depth. If any such methods were employed, the noise emissions would be less than those resulting from the piling operations using a conventional hammer.

6.11 Offshore Cables (Array, Export & Interlink)

6.11.1 Inter-Array Cables

91. Inter-Array cables (IAC) will link the turbines to the OSSs. A small number of WTGs will typically be grouped together on the same cable string, branch or loop connecting to the OSSs, and multiple array cables will connect each string back to each OSS.
92. The cable system will use HVAC technology. The IAC will consist of several conductor cores, usually made from copper or aluminium surrounded by layers of insulating material, as well as material to armour the cable for protection from external damage. The maximum design parameters for the array cables are presented in Table 6.13.

Table 6.13 Indicative key maximum design parameters for the array cables

Parameters	Design Envelope
Indicative external cable diameter (mm)	260
Total length of cable (km)	377.42
Voltage (kV)	66 or 132

6.11.2 Offshore Interlink Cables

93. The Project may require cables to interconnect between the OSSs to provide redundancy in the case of cable or grid transformer failure elsewhere, or to connect to the offshore accommodation platform to provide power for operation. The cables will have a similar design and installation process to the array and/or export cables. The parameters for design and installation of the offshore interlink cables are presented in Table 6.14.

Table 6.14 Indicative maximum design parameters for offshore interlink cables.

Parameters	Design Envelope
Number of circuits	6
Total length of cables/circuits (km)	123.75
Voltage (kV)	66, 132, 220 or 275

6.11.3 Offshore Export Cable Parameters

94. The transmission technology for the Project will be HVAC technology. Table 6.15 presents the design envelope for the offshore export cables.

Table 6.15 Indicative key maximum design parameters for offshore export cables

Parameters	Design Envelope
Maximum number of circuits	4
Indicative cable insulation technology	Cross Linked Polyethylene Cables
Maximum cable voltage (kV)	220 or 275
Indicative external cable diameter (mm)	390
Maximum offshore cable length per export cable (km)	110
Maximum permanent export cable corridor width (km)	2

6.11.4 Cable Installation

95. The following installation (burial) methodologies are considered appropriate for the export, array and interlink cables as the solutions can be similar:

- Jet-trenching;
- Pre-cut and post-lay ploughing or simultaneous lay and plough;
- Mechanical trenching (such as chain cutting);
- Dredging (typically Trailer Suction Hopper Dredger (TSHD) and backhoe dredging or water injection dredging);
- Mass flow excavation (MFE)/Controlled flow excavation (CFE);
- Rock cutting;
- Burial sledge;

- Jet sledding (hybrid of jet trencher and cable plough); and
- Vertical injector burial.

96. The cables will either be directly buried using the above techniques or pulled into a duct/pipe that will be installed using the techniques shown in Plate 6. Further detail on the landfall Horizontal Directional Drilling (HDD) cable installation is provided in section 7 Landfall construction.
97. Seabed preparation may be required prior to the installation of the cables, including, for example, the potential removal/clearance of debris, boulders and/or sandwaves as described in Section 6.9.

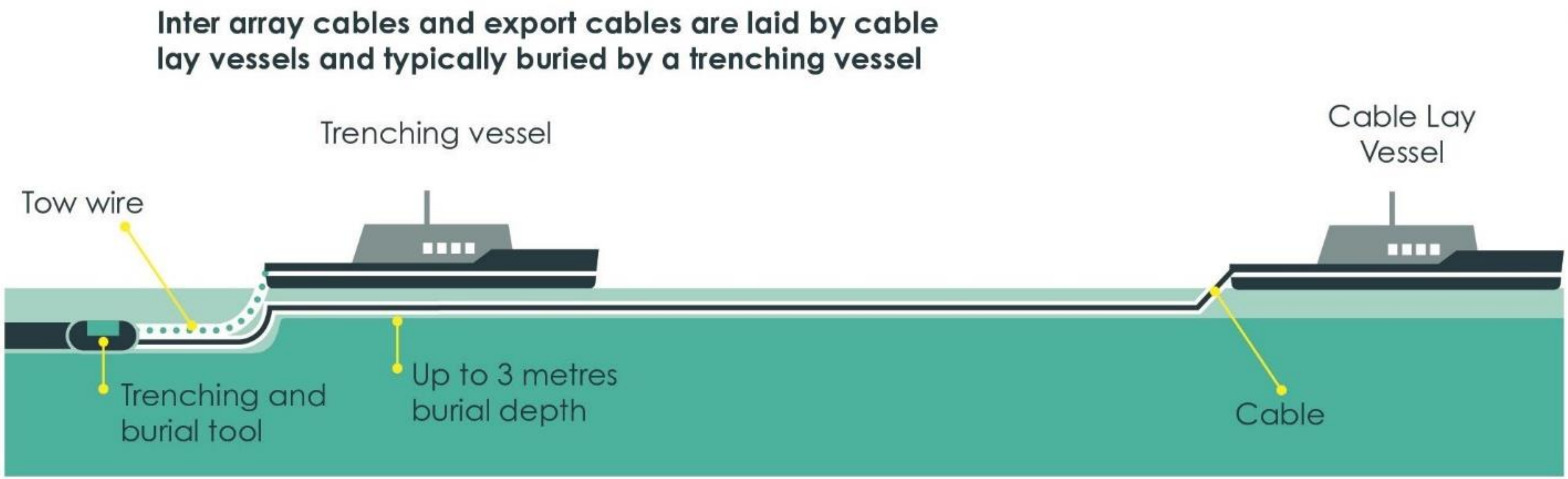

Plate 6.9 IAC, Interlink and export cable laying vessel and trenching vessel

Table 6.16 Indicative maximum design parameters for cable installation.

Parameter	Maximum design parameters		
	Array cables	Interlink	Offshore export corridor
Installation methodology	Surface lay, Simultaneous lay and burial, mechanical trenching, dredging, jetting, ploughing, controlled flow excavation, vertical injection, rock cutting.	Surface lay, Simultaneous lay and burial, mechanical trenching, dredging, jetting, ploughing, controlled flow excavation, vertical injection, rock cutting.	Mechanical Simultaneous lay and burial, trenching, dredging, jetting, ploughing, controlled flow excavation, vertical injection, rock cutting, Horizontal Directional Drilling, Trenchless Installation Methods,
Installation details – Maximum burial depth below project referenced seabed level (m)	3		
Total length of cable (km)	377.42	123.75	440
Boulder and sandwave clearance width (m), per cable	33	33	51
Cable installation width (m)	18		
Total seabed disturbed (m^2)	11,520,746	3,777,469	7,920,000
Boulder clearance – seabed disturbance (m^2)	7,472,916	2,450,250	4,316,866
Sandwave clearance – seabed disturbance (m^2)	4,047,830	1,327,219	3,214,397
Sandwave clearance spoil volume (m^3)	7,819,671	2,563,945	5,750,513
Burial spoil: jetting (m^3)	452,904	148,500	528,000
Jetting excavation rate soft soil (soft or loose soil) (m/hr)	300 (125)		
Ploughing excavation rate medium soil (hard soil) (m/hr)	125 (55)		
Burial spoil: ploughing/ mass flow excavation (m^3)	6,038,720	1,980,000	7,040,000
Duration total (months)	24	24	24

6.11.5 Cable Protection

98. The primary method of cable protection is burial into the seabed. This is the industry standard and the Project's preferred approach.

99. As far as practicable, all offshore cables will be buried to a sufficient depth below the seabed, with target burial depth informed by the findings of a Cable Burial Risk Assessment as part of the final project design process.

100. Where it is not possible to bury cables (array, interlink and export) to an adequate depth it may be necessary to install cable protection to prevent scour forming around cables and to minimise the risk of cable exposure, and to both protect the cable asset and ensure cables are not snagged by, or present a safety risk to, other sea users.

101. Save for crossings or other known areas where burial will be improbable, the use of remedial protection will be used exclusively at targeted locations as a response to having a cable at risk for any reason, this will be considered as a fallback option where other methods have been exhausted, such as additional burial attempts, alternative tools, etc. Cable crossing locations are detailed in Appendix 3 Offshore Crossing Schedule (document reference 6.3.3.3).

6.11.5.1 Rock Placement

102. Rock placement is a remedial cable protection method where the primary method (burial) of cable protection has not been successful or is possible.

103. Rocks of different grade sizes are placed from a fall pipe vessel over the cable. Initially smaller stones are placed over the cable as a covering layer. This provides protection from any impact from larger grade size rocks, which are then placed on top.

104. This rock grading generally has mean rock size in the range of 90 to 125mm and maximum rock up to 250mm. The rocks generally form a trapezium shape, up to a maximum of 1.5m above the surrounding seabed level (depending on the requirements of the Cable Burial Risk Assessment) with a 3:1 gradient.

105. It may be necessary to place larger sized rocks if protection from larger anchors is required (e.g. rocks of up to circa 500mm diameter where cables cross busier shipping routes). The cross section may vary dependent on the nature of the expected scour or the seabed profile/environment. The length of the berm is dependent on the length of cable which is either unburied or has not achieved target depth. The trapezium shape is designed to provide protection from both direct anchor strikes and anchor dragging as well as minimising impact to snagging fishing gear.

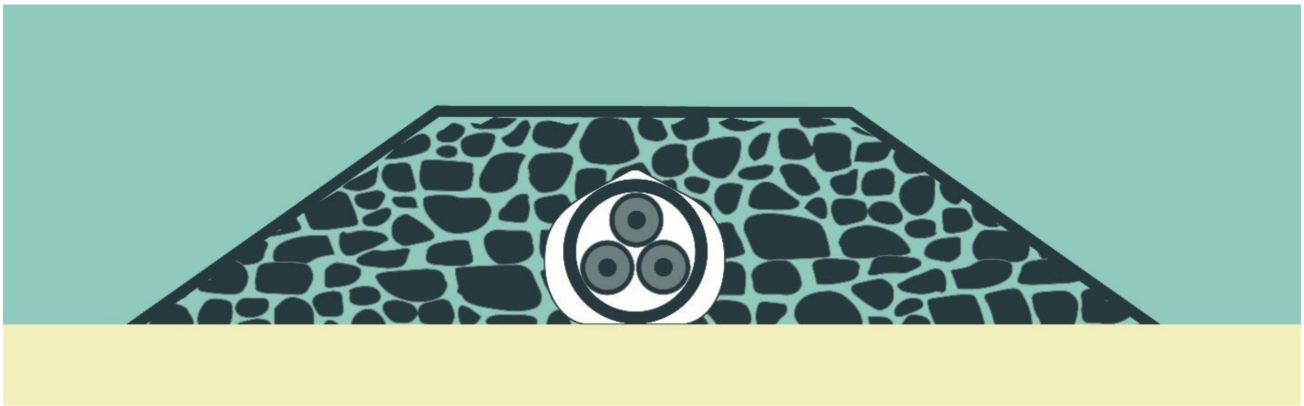

Plate 6.10 Cable Protection, Rock Placement

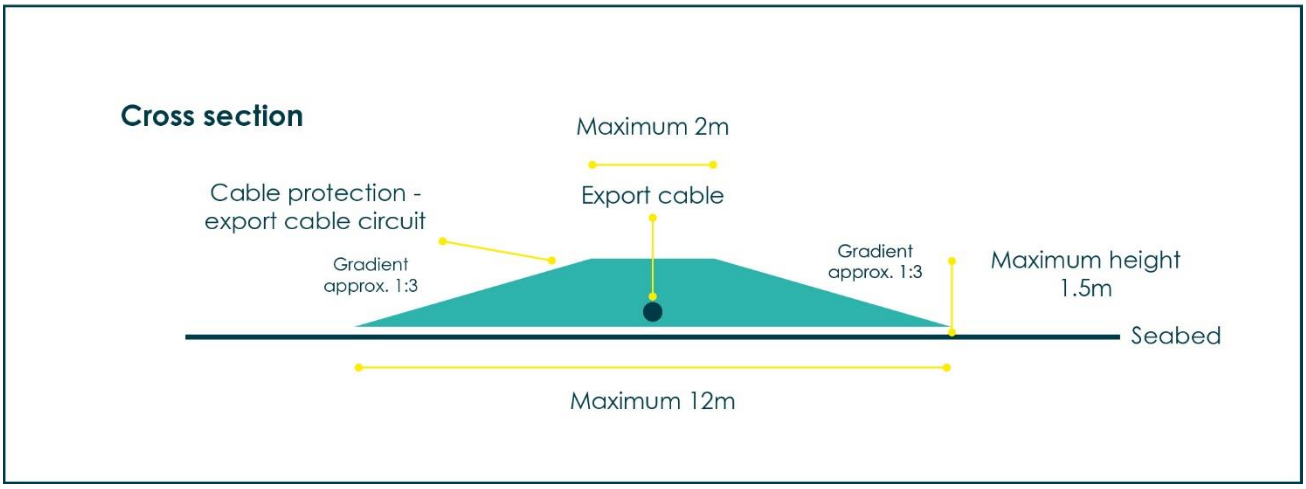

Plate 6.11 Rock protection cross section

6.11.5.2 Mattresses

106. Concrete mattresses is a remedial cable protection method where the primary method (burial) of cable protection has not been successful or is possible.

107. Mattresses generally have dimensions of 6m by 3m by 0.3m. They are formed by interweaving a number of concrete blocks with rope and wire. They are lowered to the seabed, most likely, on a frame. Once positioning over the cable has been confirmed, the frame release mechanism is triggered, and the mattress is deployed (Plate 6.12). Alternatively a crane with a release mechanism will be used. This single mattress placement will be repeated over the length of cable which is either unburied or has not achieved target depth.

108. Mattresses provide protection from direct anchor strikes but are less capable of dealing with anchor drag. Should this protection method be used for crossings, a mattress separation layer may first be laid on the seabed.

109. Mattresses are considered as a recoverable protection method by design with an operational life of 50 years when submerged and 30 years under UV exposure. Recovery will be utilised through ROVs (potentially divers) and lifting equipment (cranes) from vessels. The ROV will expose the lifting attachments of the mattresses and connect the lifting hooks to as many lifting points as required (depending on mattress specification) then the mattress will be recovered intact to the vessel. In the unforeseen event that the mattress is not recovered in a single lift, this process will be repeated until the entire mattress is removed from the seabed. In the event this is not possible due to damage, an orange peel grab will be utilised to recover any debris.

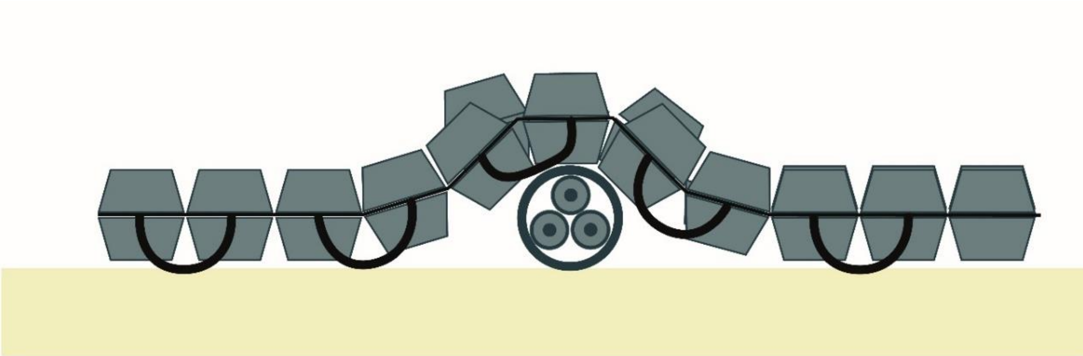

Plate 6.12 Cable Protection, Concrete Mattress Cross Section

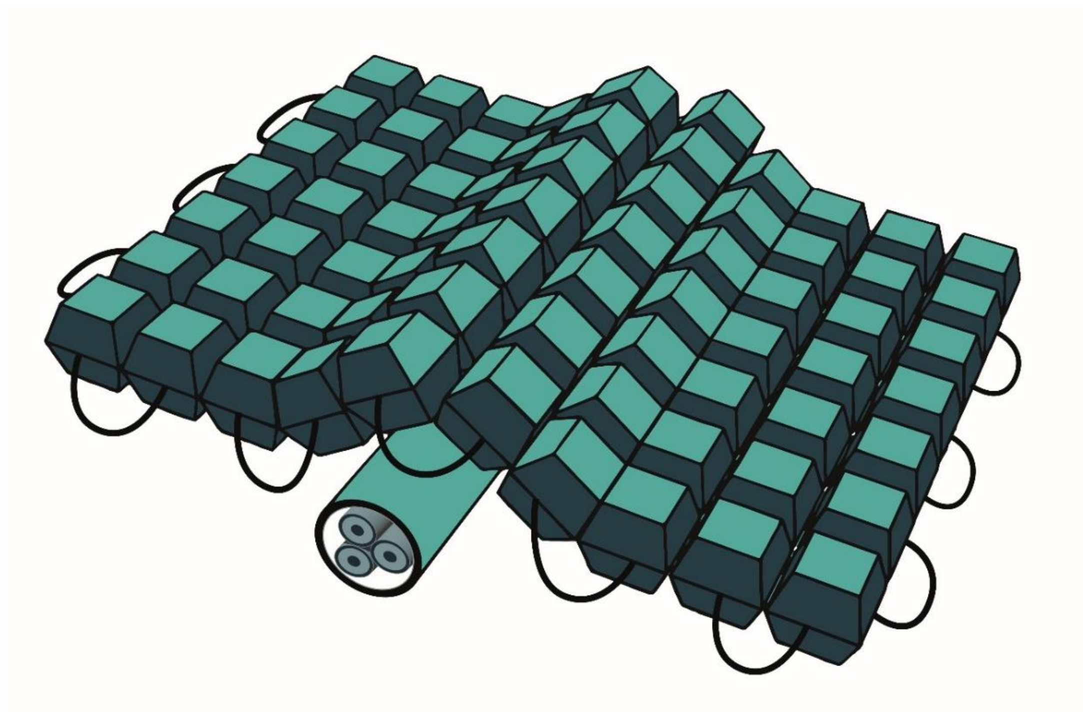

Plate 6.13 Cable Protection, Concrete Mattress 3D

6.11.5.3 Rock Bags

110. Rock bag placement is a remedial cable protection method where the primary method (burial) of the cable has not been successful.

111. Rock bags consist of various sized rocks constrained within a rope or wire netting containment. They are placed via a crane and deployed to the seabed in the correct position. Rock Bags are considered as a recoverable protection method by design, with an operational life of 50 years when submerged and 30 years under UV exposure. Rock bags will typically have a single main lifting point at the top of the bag, which due to the placement process will remain at the top, the nature of the bags setline when deposited ensure that this will be the case. Typically a ROV will be utilised to connect the lifting point to the vessel lifting mechanism, where the bag will be recovered in its entirety.

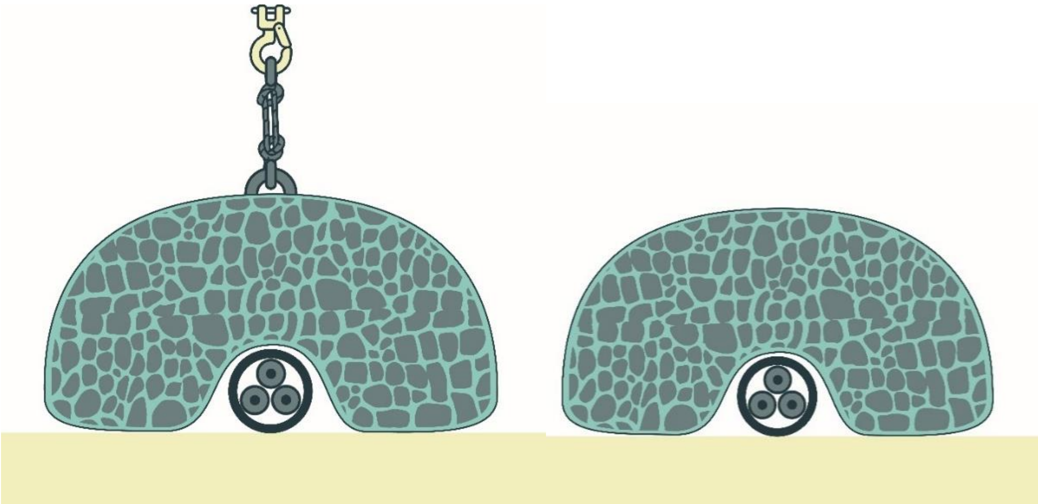

Plate 6.14 Cable Protection, Rock Bags with and without chains to facilitate removal where required

6.11.5.4 Seabed Spacers

112. Seabed spacers is a remedial cable protection method that can be used where the primary method (burial) has not been successful.

113. Propriety separation consists of plastic, or metal, half shell sections that are bolted together forming a circular protection barrier around the cable. Additionally, rock may be placed on top to provide protection from anchors or fishing gear. As they are placed onto the cable during installation, they cannot be used for remedial protection. Thus, their only use is for crossings or areas, such as rock, where it is known that burial will not be achieved.

Table 6.17 Maximum Design Parameters for Cable Protection

Parameter	Maximum design parameters		
	Array cable	Interlink	Offshore export cables (Including SAC)
Height of rock berm (m)	1.5	1.5	1.5
Width of rock berm at seabed (m)	12	12	12
Percentage of route requiring protection (%)	22.75	18.75	23.2
Cable protection: maximum rock size (m) (if required to protect from anchor strike)	D50 = 0.125	D50 = 0.125	D50 = 0.125
Cable protection area (m^2)	1,030,357	278,438	1,220,870
Rock placement volume for cable protection volume (m^3)	944,494	255,234	1,115,579
Number of crossings	30	16	38
Cable/pipe crossings: length of rock berm at seabed (m)	500	500	500
Cable/pipe crossings: rock berm area (m^2)	240,000	128,000	304,000
Cable/pipe crossings: rock berm volume (m^3)	270,000	144,000	342,000

6.11.5.5 Remedial Cable Protection

114. Remedial cable protection may be required at specific areas along the ECC (including the Inner Dowsing, Race Bank and North Ridge SAC), the Interlink and the Array Cables. The Project has undertaken a full engineering assessment of the Project with all of the information available and considered certain types of protection suitable for the Project.

115. Within the SAC remedial cable protection assessments have been undertaken on sandwaves, troughs and the remainder of the SAC to reduce uncertainty and limit over-precaution within the engineering parameters. Full details regarding the breakdown of the cable protection parameters for the SAC have been included in Table 6.18**Error! Reference source not found.**. The ground conditions within these areas are notably heterogeneous in nature, influenced greatly by being at/near the terminal moraine position of the previous ice age, and other geological processes. The image presented in Plate 6.12 indicates the SAC and the sandbanks within the SAC.

116. As such, The Project has developed a realistic plan and volume of expected remedial protection as a maximum. The Project will only install remedial cable protection where it is necessary.

Table 6.18 Maximum Design Parameters for remedial Cable Protection and dredging for Export Cables (including SAC Breakdown)

Parameter	Maximum design parameters				
	Sandbank 1	Sandbank 2	SAC (excluding sandbanks)	ECC (Excluding SAC and array)	ECC (within Array area)
Average Dredging volume per m length (m^3)	120	64	48	56	56
Dredging volume (m^3)	960,000	512,000	591,652	2,454,861	1,232,000
Dredging length % Estimation	100%	100%	13%	20%	20%
Dredging Length (m)	8,000	8,000	12,326	43,837	22,000
Remedial length % estimation	5%	5%	20%	25%	25%
Remedial length	400	400	18,963	54,796	27,500
Remedial volume per m length [m^3]	1.8	1.8	11	11	11
Remedial footprint per m length [m^2]	6	6	12	12	12
Remedial volume m^3	864	864	208,595	602,756	302,500
Remedial footprint m^2	2,880	2,880	227,558	657,552	330,000

6.11.6 Surface Infrastructure Layout

117. Designing and optimising the layout of the windfarm infrastructure is a complex, iterative process considering many inputs and constraints including;

118. Site conditions:

- Wind speed and direction;
- Water depth;
- Ground conditions;
- Environmental constraints (anthropogenic and natural);
- Seabed obstructions (e.g. wrecks, UXO, existing cables); and
- Order limits (i.e. site boundary).

119. Design Considerations:

- Turbine type;
- Installation set-up;
- Foundation design;
- Electrical design; and
- Operation and maintenance requirements.

120. The Project requires flexibility in the location and layout of the WTGs and other offshore surface infrastructure, to ensure that anticipated changes in available technology and project economics can be reasonably accommodated within the Project design envelope. However, to inform the EIA, a number of indicative layouts containing up to 100 potential WTG positions and the five potential platform positions (OSSs and accommodation platform) have been developed to represent the worst case for specific topics. The layouts are presented as appropriate in the relevant chapters and, in each case, conform to the layout principles set out in paragraph 24.

6.11.7 Crossings

121. Within the Project offshore ECC and Array area there are several oil and gas pipelines that connect to production wells in the North Sea, which the array, interlink and/or export cables may have to cross detailed in ES Volume 1 Chapter 18 Infrastructure and other Marine Users (summarised in Table 6.17). The design and methodology of these crossings will be confirmed in agreement with the relevant asset owners. An example of a type of crossing is that a berm of rock will be placed over the existing asset for protection, known as a pre-lay berm, or separation layer. The Project cable will then be laid across this, at an angle close to 90 degrees. The Project cable will then be covered by a second post lay berm to ensure that the export cable remains protected and in place.

122. The rock berms will be inspected at regular intervals and may need to be replenished with further rock placement dependent on their condition. Operational rock placement would not exceed 25% of the estimated rock volume and would occur in areas where rock was placed during construction (i.e. no new areas of cable protection above what is deployed during construction).

6.11.8 Biogenic reef promoting protection

123. Technology may be developed by the time of construction so that remedial protection measures are available that may promote increased biodiversity through creation of suitable habitat (e.g. artificial reefs). The use of such measures will be considered post consent on an area by area basis (e.g. in areas considered most sensitive to cable protection measures). The use of such measures may be in conjunction with other remedial protection measures.

6.12 Benthic Compensation

124. In the event that the Secretary of State determines a conclusion of adverse effect on the integrity of the sandbank or reef features of the Inner Dowsing, Race Bank and North Ridge SAC, the Project will be required to deliver compensation. The Without prejudice Derogation Case (document reference 7.5) for the Project identifies the creation of a biogenic reef as a potential compensation measure, which could be delivered at a project-level.

125. Whilst the final methodology to be used would be confirmed following consultation with stakeholders and approval by the Secretary of State, and is dependent on the final site selection and reef species, it is expected to comprise the following activities:

- Deployment of cultch (if required), which may comprise:
    - Natural shells (either species specific or mix of multiple species);
    - Stone/aggregate; or
    - Biodegradable material.
- Seeding of reef forming species, which may comprise:
    - Spat on shells (young juveniles attached to bivalve shells); and
    - Juveniles or adults not attached to a substrate.

126. Deployment of cultch will be undertaken using either a grab or fallpipe/chute system to place this on the seabed to ensure an even cover of material on the seabed (if required).

127. The method used for seeding will be dependent on the final site selected for the reef, the natural substrate and the likelihood of predation, amongst other factors. Therefore, seeding may comprise:

- Divers placing the seed onto the seabed or cultch;
- Use of a chute system;
- Side casting along pre-defined transects at a set speed (to achieve a specific density per m^2); or

- Placement of cages containing seed via a crane.

128. Metal cages are only expected to be required where the risk of predation is considered to be very high and will be designed to minimise predation, whilst ensuring the reef still functions as naturally as possible.

129. Where recreation of the reef is required (e.g. due to storm damage or predation), the methods as outlined above would be followed as appropriate, based on survey data and discussions with relevant stakeholders.

6.13 Vessel Activity

130. During the construction of the Project, a number and variety of vessels will be utilised for installation, support and transport of personnel, equipment and infrastructure to the Array area and the offshore ECC.

131. The currently estimated total vessel numbers, vessel movements and durations are presented in Table 6.19 and helicopter numbers presented in Table 6.20. Each vessel or helicopter movement represents a return trip to and from the Array area or the offshore ECC.

132. Currently, it would be expected that the busiest period during construction, in terms of vessel traffic, would be when up to 10 vessels (major installation and commissioning vessels) would be operating in a given 5km^2 active construction area. This level of activity is unlikely to occur across the entire array area at any one time, rather this intensity is expected across up to approximately three or four 5km^2 blocks. No jack-up vessels will be used where the ECC overlaps with the Inner Dowsing, Race Bank and North Ridge SAC during construction of the windfarm.

Table 6.19 Total values for vessel activities during construction

Vessels	Number of Vessels	Indicative maximum Number of Return Trips Per Vessel Type
WTG Installation		
Installation vessel (JUV or anchored)	2	50
WTGs installation – Number of support vessels (including SOV, service vessels for pre-rigging of towers, diver vessels)	18	1,480
Transport vessels	10	150
WTG Foundation Installation		
Installation vessel (JUV or DP HLV)	3	54
Support vessels (including tugs crew boats, drilling vessels and guard boats)	10	67
Transport/feeder vessels (including tugs)	8	400
Anchored transport/feeder vessels	8	400
OP Topside Installation (All OSSs, ORCPs and Accommodation Platform)		
Installation vessel	2	24
Support vessel	12	96
Transport vessel	4	48
OP Foundation Installation (All OSSs, ORCPs and Accommodation Platform)		
Installation vessel	2	16

Vessels	Number of Vessels	Indicative maximum Number of Return Trips Per Vessel Type
Support vessel	12	48
Transport vessel	4	32
Array and Offshore Interlink Cable Installation		
Main cable laying vessel	3	24
Main cable burial vessel	2	18
Support vessel	14	1099
Offshore Export Cables Installation		
Main cable laying vessel	3	20
Main cable jointing vessel	3	16
Main cable burial vessel	3	16
Support vessel	16	1070
ANS Foundation Installation		
Installation Vessel	2	8
Support Vessel	12	32
Transport Vessel	4	16
ANS Topside Installation		
Installation Vessel	2	8
Support Vessel	12	16
Transport Vessel	4	12
Benthic Compensation Installation		
Installation Vessel	1	10
Annual Monitoring Vessels	1	4

Table 6.20 Total values for helicopter activities during construction

Construction Activity	Maximum Number of Helicopter Return Trips
WTG Installation	176
WTG Foundation Installation	100
Offshore Platform Installation	40
Offshore Platform Foundation Installation	28
Array and Offshore Interlink Cable Installation	24
Offshore Export Cables Installation	16
ANS	0
Benthic Compensation	0

Aids to Navigation and Marking

133. All surface infrastructure throughout all stages of the Project (including WTGs, OPs and ANSs) will be marked in accordance with relevant guidance from THLS, the Civil Aviation Authority (CAA) and the MCA. The positions of all infrastructure will be conveyed to the UK Hydrographic Office (UKHO) so that they can be incorporated into Admiralty Charts and the Notice to Mariners (NtM) procedures.

134. Lighting and marking of subsea structures will be agreed with THLS, having a statutory duty as a General Lighthouse Authority, where there may be a risk to shipping. In this case, the marking would be based on the recommendations of the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA, 2021).

6.14 Safety Zones

135. During construction and decommissioning, the Project will apply for a 500m safety zone around Offshore Renewable Energy Installations (OREIs) that is under active construction. Safety zones of 50m will be applied for with regards to incomplete structures at which construction activity may be temporarily paused such as installed monopiles without transition pieces or where construction works are completed but the Project has not yet been commissioned.

136. During the operation and maintenance phase, the Project may apply for a 500m safety zone around infrastructure undergoing major maintenance (for example a blade replacement).

137. Further information regarding the Safety Zones which the Project intends to apply for post-consent is outlined in the Safety Zone Statement (document reference 9.3).

6.14.1 Ancillary Operations

138. Several activities will be required to prepare the seabed prior to construction. These activities are detailed below.

6.14.2 Unexploded Ordnance Clearance

139. It is common to encounter UXO originating from World War I, World War II or military training activity during construction. This poses a health and safety risk where it coincides with the planned location of infrastructure and associated vessel activity, and therefore it is necessary to survey for and carefully manage UXO.

140. Detailed pre-construction surveys will be completed post-consent to determine the precise nature of the seabed. As the detailed pre-construction surveys are yet to be completed, at this stage it is not possible to determine how many items of UXO will require clearance. As a result of the possibility of migration of UXO, surveys are typically undertaken close to the point of construction to ensure that data remains valid to evaluate risk to construction operations and evaluation for removal. Therefore, the Project will apply to the MMO for a separate marine licence under Part 4 the Marine and Coastal Access Act 2009 pre-construction for the removal of any UXO which may be identified in pre-construction surveys to pose a potential risk to construction activities.

141. To define a design scenario for consideration in the EIA a review of recent publicly available information on UXO disposal has been undertaken. A range of charge sizes are expected to be found across the Array area and offshore ECC, with a maximum charge size likely to be up to 800kg net explosive quantity (NEQ).

6.14.3 Boulder Clearance

142. Geophysical surveys will be undertaken within the Project array area and offshore ECC and will be used to inform boulder clearance requirements.

143. Where large volumes of boulders are present, micrositing of cables around these would be onerous and impractical. If left in-situ, these boulders can pose the following risks to the Project:

- Exposure of cables and/or shallow buried cables, which might lead to the requirement for post-lay cable protection such as rock placement or concrete mattressing;
- Obstruction risk to the cable installation equipment, leading to damage and/or multiple passes and therefore a delayed cable installation programme (with no guarantee of achieving target burial depth); and
- Risk of damage to the cable assets.

144. Based on current industry experience within similar geological conditions, the following assumptions are made:

- Boulders greater than 0.3m in any dimension, which are located within the footprint of any infrastructure, may necessitate removal;
- For cables within the Project offshore ECC, a corridor of up to 33m per cable (circuit) must be cleared to ensure that all the export cable burial tools being considered in the envelope can operate in the cleared corridors; and
- For cables within the Project array area, a corridor of up to 33m must be cleared per cable circuit as this width is sufficient for the operation of the cable burial tools under consideration.

145. There are two key methods of clearing boulders, ploughing or use of a subsea grab. Where a high density of boulders is seen, the expectation is that a plough will be required to clear the cable installation corridor. Where medium and low densities of boulders are seen, a subsea grab is expected to be employed.

146. Since geophysical/geotechnical information of sufficient spatial resolution is not currently available the worst case scenario used for the ES is presented in Table 6.21. Final numbers of boulders to be cleared will be confirmed following high resolution pre-construction surveys.

Table 6.21 Maximum design parameters for cable installation boulder clearance

Parameters	Maximum Value
Array Area	
Array cable clearance corridor width per cable (circuit) – ploughing (m)	33
Export and interlink cable clearance corridor width per cable (circuit) – ploughing (m)	33
Clearance corridor width – subsea grab (m)	33
Total clearance impact area (km^2)	14
Offshore ECC	
Clearance corridor width per cable (circuit) – ploughing (m)	33
Clearance corridor width – subsea grab (m)	33
Total seabed Potential Disturbed (Full Corridor Width) (km^2)	5
Total clearance impact area (km^2)	6

Pre-Lay Grapnel Run

147. Following the pre-construction route survey and boulder clearance works, a Pre-Lay Grapnel Run (PLGR) and an associated route clearance survey of the final cable route will be undertaken. A vessel will be mobilised with a series of grapnels, chains, recovery winch and survey spread suitable for vessel positioning and data logging. Any items recorded will be recovered onto deck where possible and disposed of onshore. The results of this survey will be used to determine the need for any further clearance. The PLGR work will take account of and adhere to any archaeological protocols developed for the Project.

148. These works will be within the 33m footprint of seabed disturbance (sandwave and boulder clearance), within which is the 18m footprint for trenching in the Project offshore export cable corridor and therefore any footprint for PLGR disturbance is already accounted for.

6.14.4 Sandwave Clearance

149. In some areas within the Project array area and along the offshore ECC, existing sandwaves and similar bedforms may be required to be attenuated or lowered to mudline in the section corresponding to the cable corridor prior to cable installation. This is done for two reasons. Firstly, many of the cable installation tools require a relatively flat seabed surface in order to work properly as it may not be possible to install the cable up or down a slope over a certain angle, or where the installation tool is working on a camber. Secondly, the cable must be buried to a depth where it may be expected to stay buried for the duration of the Project's lifetime. Sandwaves are generally mobile in nature therefore the cable must be buried beneath the level where natural sandwave movement would uncover it. Sometimes this can only be done by removing the mobile sediments before installation takes place. It has been determined the maximum design parameters for sandwave clearance is up to 32.5% of the cable lengths for the array cables, 32.5% for interlink cables and up to 20% for the export cable.

150. The maximum design parameters for overall sandwave clearance are shown in Table 6.22, with the maximum design parameters within the SAC only being presented in Table 6.22. Values have been refined since the publication of the PEIR, based on the completion of pre-construction high resolution geophysical surveys.

Table 6.22 Maximum design parameters for sandwave clearance (including within the SAC)

Array Area	
Sandwave clearance impact width – array, interlink and export cables (m)	33
Sand-wave clearance: Array cables (m^3)	7,819,671
Sand-wave clearance: Interlink cables (m^3)	2,563,945
Sand-wave clearance: Export cable (Within Array Area Only) (m^3)	1,232,000
Sand-wave clearance: Total in array area (export cables, array cables, interlink cables) (m^3)	11,615,616
Offshore ECC	
Sandwave clearance impact width (m) per cable (circuit)	51

Sandwave clearance – total (m^3)	4,518,513

Wave Buoys

151. The Project will require up to two wave buoys for the full construction period, one of which will be decommissioned following completion of construction, and the other retained for the first three years of operation. The mooring locations will be within the array area.

7 Landfall construction

152. This section of the Project Description is supported by the following figures that can be found in ES Volume 2:

- Figure 3.3 Onshore Order Limits and Assessment Segments (document reference 6.2.3.3)
- Figure 3.4 Indicative Onshore Infrastructure (document reference 6.2.3.4)
  - *This figure outlines the indicative infrastructure layers as well as associated IDs that have been assigned to each infrastructure element for reference throughout this chapter and the ES. Where an ID is relevant to this figure it is presented in square brackets e.g. [PCC-1].*

7.1 Overview

The offshore cables will be brought ashore at the landfall site (see Plate 7.1) as shown in ES Volume 2, Figure 3.3 (document reference 6.2.3.3**Error! Reference source not found.**) located at Wolla B ank, south of Anderby Creek, north of the Wolla Bank Beach car park. This section of the Project Description Chapter addresses the overlap of the offshore and onshore areas at the landfall sea defence and the intertidal regions. The trenchless technique that will be adopted at the landfall is HDD which is a proven technique[2], this method has been selected to avoid impacts on the coastal features and habitat in the area, as well as the existing infrastructure, sea defence and ornithological and ecological receptors.

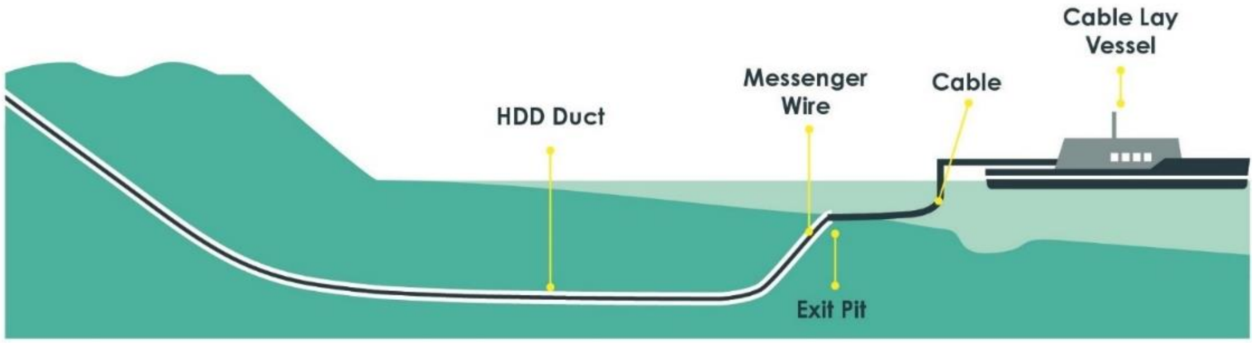

Plate 7.1 Cable Laying Vessel from the landfall exit pit offshore.

153. The HDD operations will be carried out from the landfall site located to the west of Roman Bank where ducts would be installed under the intertidal and sea-defence zone by the HDD (Plate 7.2); once complete, the offshore export cables will be brought ashore and jointed to the onshore export cables at the TJBs.

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[2] HDD is a proven technique, first deployed in the 1970s, and has been successfully utilised on numerous landfalls for offshore wind farms throughout the UK, including Dudgeon, Sheringham Shoal, East Anglia ONE, Greater Gabbard, Galloper, Westermost Rough, Walney Extension, Triton Knoll, and Hornsea Project One and Two.

154. An intrusive ground investigation campaign was undertaken in 2023 at the landfall site, the results providing a high degree of confidence in the feasibility of utilising the HDD method at the proposed site. In addition, previous installation campaigns by both Triton Knoll and Viking Link made landfall in proximity to this site, successfully utilising HDD methods. While other construction methodologies were considered by the applicant, for example open cut trenching and the creation of cofferdam structures on the beach, these alternative options were discounted due to the commitment to minimise impacts and avoid construction works on the beach.

155. The construction activities that will be undertaken at and near to the landfall site to facilitate the HDD and cable jointing, include the following:

- Construction of a section of haul road between the A52 and the Landfall Compound [PCC-1];
- Construction of a bellmouth off Roman Bank road (see paragraph 160);
- Construction of a temporary construction compound, referred to as the Landfall Compound [PCC-1] including construction of a 4m high soil bund for noise mitigation;
- Provision of a Temporary Duct Storage Compound [SCC-2] adjacent to the Landfall Compound;
- Construction of TJBs, including use of sheet piling such as the use of the silent pile method or similar to facilitate the landfall works where necessary;
- Construction of HDD launch pits, temporary bunding of the drill pit to provide protection against water ingress during drilling under the coastal flood defence/dunes;
- Excavation of temporary sub-tidal exit pits offshore, HDD works and duct installation activities. The preferred methodology is to push the ducts from the TJB site but pull-in of duct from offshore towards the TJBs may be required, subject to the detailed design, and capping and burial of duct end;
- Installation and testing of the offshore export cables and jointing to onshore export cables (cable pulling); and
- Backfilling and reinstatement work.

156. One HDD drill has been designated to install each export cable circuit (one duct per drill). The project envelope includes up to four cable circuits, however two extra drills have been allowed for contingency purposes in the unlikely event of HDD failure. Therefore, the project envelope includes up to six drills in total to install four cable circuits and therefore up to six TJBs to house the connection between the offshore and onshore cables.

157. The Landfall HDD and cable installation operations will be undertaken from the Landfall Compound on the west side of Roman Bank. The Project has committed to undertaking no construction works on the beach.

7.2 Landfall Works & Access

158. During the project's landfall works, a Landfall Compound will be required to accommodate the drill rig, TJBs, cable storage, installation activities and welfare facilities. The location will be within the landfall area set back 80m west of Roman Bank. The maximum design parameters for the TJBs are shown in Table 7.1 . Each drill would start from the Landfall Compound to the west of Roman Bank, to drill eastward below Roman Bank, Anderby Marsh LNR, the sea defence, and beach, exiting in the subtidal zone at a suitable depth seaward of MLWS (Plate 7.2).

159. The HDD technique avoids interactions with surface features by installing ducts under the intertidal area and out to sea through which the offshore export cables can be installed. The HDD will be arranged to be of sufficient depth to have no effect on the beach, intertidal area and coastal features, with a design target to exit in the subtidal zone, at greater than 500m from MLWS, subject to the assessment of geotechnical factors and detailed engineering design

160. The site for the HDD works will be located west of the Roman Bank and will be set up as follows:

- Access for the preconstruction works (pre-mobilisation preparation works) such as those outlined in section 8.1.4 will be taken from Ember lane. If required, works to facilitate the use of this access will be undertaken as set out in section 8.1.4.1";
- An access off Roman Bank Road will be installed at the start of the landfall construction phase for the installation of the noise bund[3] (up to 4m high) which will be located between the works site and Roman Bank to provide noise attenuation to mitigate potential disturbance to ornithological receptors at Anderby Marsh LNR (ES Volume 1, Chapter 22 Onshore Ornithology, document reference 6.1.22);
- Aside from the construction of the noise bund the construction access to the Landfall Compound will be taken from the haul road. The haul road will be built along the onshore ECC from the bellmouth access at the A52[4] through to the Landfall Compound;
- Following completion of the HDD and reinstatement works, the bellmouth which will be installed off Roman Bank Road for the construction of the noise bund will be retained to allow for operational access to facilitate maintenance activities. These activities are outlined in Section 9.2.1.
- Demarcation of the Landfall Compound and Temporary Duct Storage Compound (for duct storage) will be made using suitable fencing;
- Topsoil will be managed and stored within the allocated working areas;

[3] The construction of the noise bund is seasonally constrained and therefore the section of haul road which provides construction access to the landfall will not be fully constructed in time, access off the Roman Bank Road will therefore be required. To facilitate this access, the construction of a bellmouth is required.

[4] The section of haul road from a temporary access point on the A52 will need to be retained for the duration of the landfall construction programme (51 months) to facilitate access for reinstatement activities (Table 7.1). Maintenance access as required during the operational period will be from Roman Bank.

- A stone finish working platform will be constructed within the Landfall Compound for the HDD and cable installation works; and,
- Welfare and associated equipment will be placed accordingly to minimise noise and visual impacts to receptors at Roman bank.

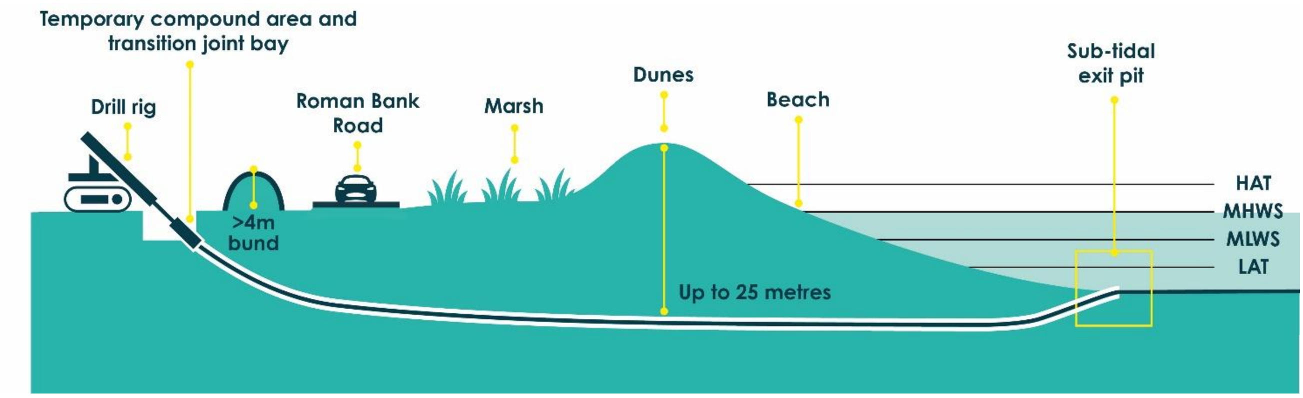

Plate 7.2 Trenchless Installation Schematic

161. The maximum anticipated durations for each of the landfall activities is outlined below and demonstrates that the activities vary in duration within the overall construction window. The overall timeframe is required to allow flexibility for shifting activities and other variables, such as weather and the timings of offshore and onshore works reaching landfall. The overall duration includes time for mobilising and demobilising vessels and equipment.

162. The landfall works are anticipated to take up to 51 months to complete (for all cables).

163. The landfall HDD operations as a base case, will take up to 12 months, with a contingency for an extra 3 months in the event of drilling delay or unforeseen circumstances. An indicative programme is described below:

- Up to 3 months site set up.
- Up to 5 months with the launch pit fully open, drilling and ducting (pull- in or push) taking place, with the option of dual drilling operations (two drills being undertaken concurrently), assuming 24/7 operations during main drilling operations; and
- Anticipated 4 month reinstatement (including backfill).

164. In addition to the above 12-month window, there may be an additional requirement for localised spot remediation, inspection, and monitoring.

Table 7.1 Maximum design parameters for landfall (HDD) works

Maximum Parameters	Design Envelope
Number of trenchless (HDD) cable ducts	6
Diameter of ducts (m)	1.2
Length of ducts (km)	2
Trenchless (HDD) launch pit area (m^2)	200
Trenchless (HDD) launch pit depth (m)	6
Trenchless (HDD) burial depth maximum (m)	25

Maximum Parameters	Design Envelope
Trenchless (HDD) burial depth minimum (m)	5
Trenchless (HDD) exit pits number	6
Trenchless (HDD) exit pit area (m^2)	1000
Trenchless (HDD) exit pit excavated material volume (m^3)	5000
Trenchless (HDD) exit pits depth (m)	5
Temporary onshore/intertidal Trenchless exit pit working area (m^2)	2500

7.2.1 Landfall HDD

165. As highlighted in section 7.1, the Project is adopting HDD techniques to facilitate the landfall works.

166. Pits will be excavated at the planned start and end point of each drilled section. These are referred to as the launch pit (onshore) and exit pit (offshore). The arrangement allows the drilling to proceed at the correct angle into the ground, manage the fluid mud returns, and install the ducts. The adjacent ground to the drill point will be prepared for the rig to be suitably placed to facilitate drilling operations; this may include localised sheet piling (silent pile method) and pushing a steel casing into the ground at the launch pit to control the drill direction and manage the fluid mud returns, this installation will be required for the duration of the drilling work only. The above arrangement will be required per drill, one each on the landward side and one each offshore. The HDD receiver offshore submarine exit pits will be up to 2,000m from the TJBs (with a target of at least 500m below MLWS). The onshore HDD site will be suitably bunded in line with design requirements.

Plate 7.3 Example of Landfall HDD rig setup

167. The HDD process uses a drilling head controlled from the rig to drill a pilot hole guided by the installed steel casing along a predetermined profile to the exit point. The pilot hole will progress in stages until the required length is reached near the exit location. The drill head (bottom hole assembly) will be guided by specialised sensors that will be closely monitored from the drilling location. The drilling operations will be assisted by using a specialised fluid mud mix (generally, a mixture of water and bentonite) to lubricate the drilling operations, control the downhole temperature of the drilling head, maintain bore integrity and remove downhole cuttings. The mud will be recycled through the processes to minimise the import of material and control onsite waste. The down-hold fluid pressure will continually be monitored to control and manage the drill route to minimise the potential for breakout of the drilling fluids. An emergency action plan will be developed with procedures in place during the drill to have controlled responses to any event, such as a drill fluid break-out.

168. Once the pilot hole is completed, it is widened through several passes with reamers until the necessary diameter for the duct is achieved.

169. The HDD exit pits will be located seaward of MLWS. These pits will be excavated or dredged to the required depth and will be prepared shortly in advance of the HDD exit.

170. Exit of the HDD is undertaken once the drill profile has been completed to the final diameter, backreamed and purged. The fluid mix before exit will be adjusted to suit the sub-marine environment, duct installation, and suitable density to ensure a homogenous seal to avoid water leaching to the pipe annulus. A small amount of drill fluid may be discharged locally to the exit within the excavated sub-marine exit pit.

171. The installation of the HDD duct will either be 'pushed down' into the drill path from the Landfall Compound or floated out to the exit pit and then submerged to facilitate a 'pullback operation'. In the event of a pushdown installation, the ducts will be assembled and stored onshore in the Duct Storage Compound [SCC-2]. However, in the event that a 'pullback operation' is required, the duct would be floated into position with the use of barges, and pulled back to the landfall via the drilled route.

172. Once the duct is installed, it will be sealed at both ends with specialised blanking plates fixed to the duct's ends with a puddle flange buried to the landward side of the string. The landward string termination will be above the level of the marine termination; however, this will be sitting proud of the Finished Ground Level (FGL) until cable installation. The sub-marine end of the duct will be secure in the exit pit with rock bags or similar until cable installation.

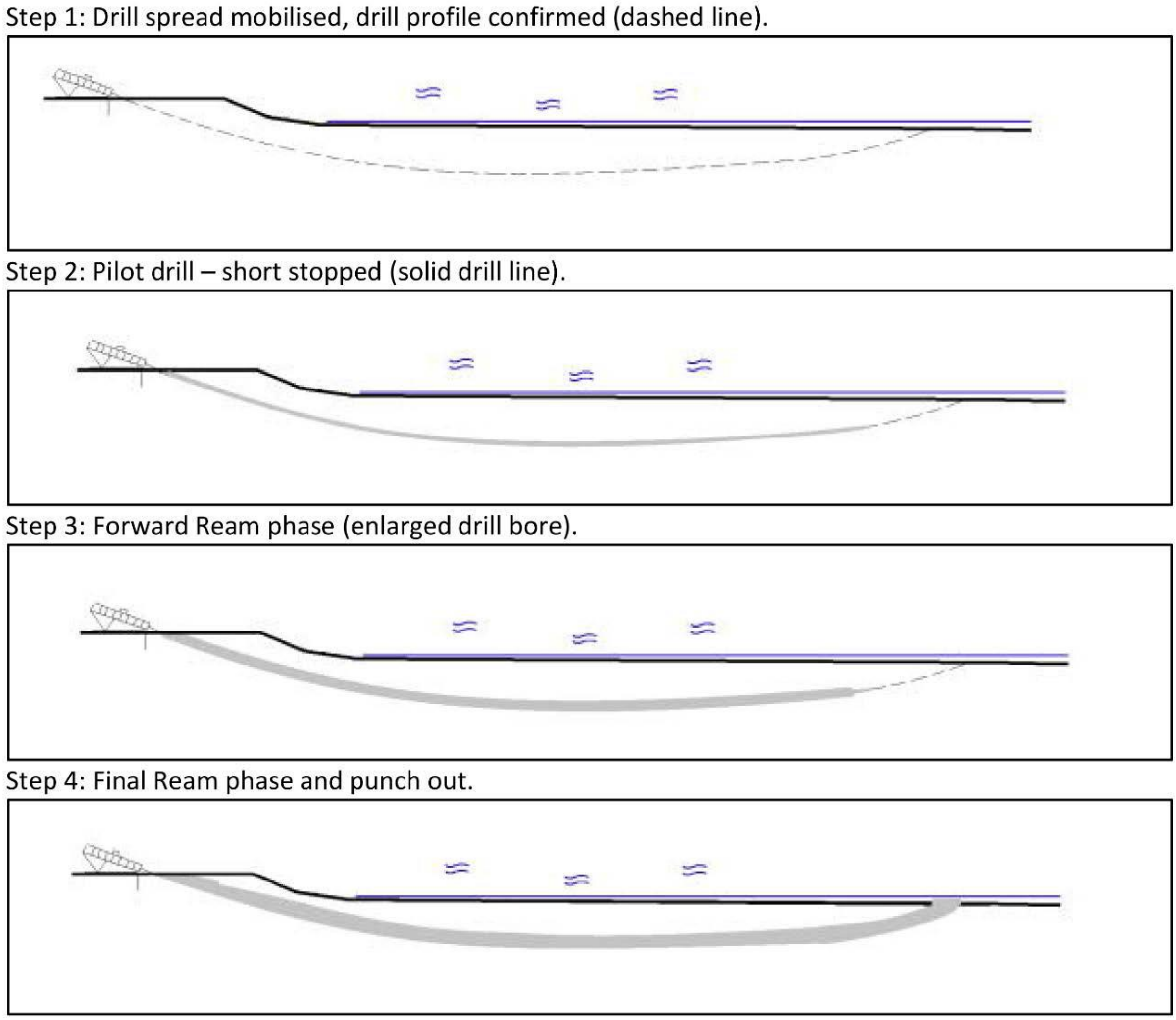

Plate 7.4 Illustration of Landfall HDD installation procedure.

7.2.2 Cable Installation

173. There will be up to four exit pits open at one time, and if an exit pit is required to be dredged, it will likely be exposed with temporary protection installed to ensure the safety of the ducts. This will be in the subtidal section and will not affect the beach.

174. A jack-up barge vessel with a backhoe excavator would most likely be used for excavation and/or installing any necessary external cable protection.

175. All excavated seabed sediments will be temporarily stored alongside the location of the work and within the export cable corridor (i.e., sidecast) before being backfilled after cable installation (storage for up to approximately twelve months). The total seabed footprint of the deposited material is estimated to be approximately 400m^2. Alternatively, the excavated sediment may be stored on a barge. Where possible, excavated material will be reused for backfilling. Some additional material (e.g., rocks) may be necessary to compensate for any loss or if the onward plough cannot bury the cable within the exit pit.

Plate 7.5 Offshore dredger – Source: dredgepoint.org

176. Assuming a jack-up barge vessel with four legs, each with a $4m^2$ spudcan, the total seabed footprint for each jacking-up operation would be up to $16m^2$. The works are expected to require up to 16 movements, resulting in a total seabed footprint of $256m^2$ during construction.

177. The ducts would be placed on pre-laid rock mattresses with rock bags placed over the duct once the HDD is completed. These rock bags would be removed following the cable pull-in. In either scenario, the ducts and cable will be buried once cable installation is completed.

Plate 7.6 Cable pull in Source: NKT Victoria – Vattenfalls Kriegers Flak wind farm[5].

178. The cable pull-in would then be undertaken, followed by backfilling at the HDD exit and jointing of the subsea and onshore cables in the onshore transition joint bay. During the cable pull phase of works, the transition joint bays would be re-excavated and exposed, allowing cables to be pulled through the pre-installed ducts and jointed. The cables would then be tested, the transition joint bays backfilled, and the landfall area would be reinstated.

7.2.3 Transition Joint Bays

179. The offshore export cables will be jointed to the onshore cables in TJBs on the landward side of the landfall site.

180. The TJB is an underground concrete structure hosting the joint between the offshore and onshore export cable circuits. TJBs are located near the landfall area to facilitate the strategic connection of the offshore export cables to the onshore export cables. The strategic location of the TJBs also minimises the installed pulling tension on the specialised submarine cable.

[5] Kriegers Flak Export Cable Makes Landfall in Denmark | Offshore Wind

181. One TJB arrangement is required per export cable circuit. Up to six TJBs will be built within the Landfall Compound. This would comprise an excavated footprint no greater than 234m^2 per bay, with a reinforced concrete base slab to allow for a working platform for jointing and winching during the cable-pulling installation. The TJB enables the joining to be completed within a clean, dry, and controlled environment and protects the cable joint post-construction. Each TJB will also have an accompanying link box. The link boxes will be required for access for planned inspections and maintenance during the operational phase. The link box associated with the TJB is accessed via a link box manhole and is located in proximity to the TJB, which will be set flush with the surrounding ground level.

182. Following cable pulling, jointing, testing, and commissioning activities, the joints would be buried to a depth of up to 3m, bedded in a stabilised backfill (such as cement bound sand), pre-excavated materials or a concrete box. The remainder of the TJB will be backfilled with native materials.

183. The FGL of the TJB will be confirmed prior to construction in consultation with the relevant consultees following detailed design and it is proposed that the land will be reinstated to the existing ground level, with the TJB covers either buried or set flush to the surrounding ground level.

7.2.4 Landfall Key Parameters

Table 7.2 Maximum design parameters for TJBs and landfall works

Parameters	Design Envelope
Number of TJBs (allowing for two failures)	6
TJB maximum width (m)	9
TJB maximum length (m)	23
TJB maximum depth (m)	6
TJB maximum area (m^2)	207
Number of manhole covers per TJB	2
Area per manhole cover (m^2)	4
Total construction area for TJBs[6] (m^2)	1,242
Landfall Compound [PCC-1] (m^2)	70,000
Landfall Compound [PCC-1] Maximum Duration (months)	51
Temporary Duct Storage Compound [SCC-2] (m^2)	40,000
Temporary Duct Storage Compound [SCC-2] (months)	18
Haul road between A52 & Landfall Compound width (m)	15
Durations of works (start-finish) (months)	51
Maximum width of the permanent access to TJB locations (m)	6

[6] The TJBs are located within the Landfall Compound

8 Onshore Infrastructure

184. This section of the Project Description is supported by the following figures that can be found in ES Volume 2:

- Figure 3.3 Onshore Order Limits and Assessment Segments (document reference 6.2.3.3)
- Figure 3.4 Indicative Onshore Infrastructure Basis of Assessment (document reference 6.2.3.4)
  - *This figure outlines the indicative infrastructure layers as well as associated IDs that have been assigned to each infrastructure element for reference throughout this chapter and the ES. Where an ID is relevant to this figure it is presented in square brackets e.g. [PCC-1].*

8.1 Onshore Export Cable Corridor & 400kV Cable Corridor

8.1.1 Overview

185. The Onshore ECC runs from the landfall TJB sites to the OnSS and will contain the high voltage alternating current (HVAC) onshore export cables and associated fibre optic cables buried underground within ducts. The onshore export cables will be buried and therefore will require trenches to be excavated or trenchless techniques to be adopted to install ducts to house the cable circuits. The Onshore ECC has a typical working width of 80m and will include a haul road[7] to deliver equipment to the installation site from the identified construction compounds, storage areas for topsoil, and subsoil, and drainage. The final working width required is expected to be narrower than the width of the Order Limits however the wider Order limits are required to allow room for micro-siting during detailed design and for onward connection of the proposed construction drainage to the existing surface water drainage network.

186. The 400kV Cable Corridor will contain high-voltage cables and will link the OnSS to the NGSS. The 400kV cables will be buried and therefore will require trenches to be excavated or trenchless techniques to be adopted to install ducts to house the cable circuits. The 400kV Cable Corridor has a typical working width of 60m and includes a haul road[7] to deliver equipment to the installation site from the identified construction compounds.

[7] Except in locations where the Project has committed to not construct a haul road, such as in locations where trenchless techniques will be adopted.

8.1.2 Location

187. The Location of the onshore ECC and 400kV Cable Corridor is presented in ES Volume 2, Figure 3.4 (document 6.2.3.4). The onshore ECC has undergone significant site selection and refinement activities to avoid and/ or minimise impacts on residential and environmental receptors as much as practicable. See ES Chapter 4 Site Selection and Consideration of Alternatives (document reference 6.1.4) for more information.

8.1.3 Onshore ECC & 400kV Cable Corridor Installation stages

188. The cable installation works can be described as five key stages:

1. Pre-construction works (pre-mobilisation preparation works) (Section 8.1.4);
2. Enabling works (mobilisation, access, and welfare establishment) (Section 8.1.5);
3. Cable infrastructure installation (Section 8.1.6) ;
4. Cable installation (cable pulling through the pre-installed cable ducts) (Section 8.1.7); and,
5. Reinstatement works & demobilisation (Section 8.1.8).

189. The cable duct installation works are continuous, with each work front progressing a section at a time. In any given location, once the cable ducts have been installed, the trench will be backfilled, and the work front will continue moving onto the next section to minimise the amount of land being worked on at any one time. The haul road will, however, need to be retained along much of the cable corridor to maintain access to the work fronts. Installing the onshore cable ducts and export cables is anticipated to take up to 42 months.

190. As described throughout this section, the installation of export cables involves several discrete activities undertaken along the length of the cable route, the duration of each activity at any location being dependent on the nature of the construction activity being undertaken.

191. These discrete construction activities broadly consist of trenchless works, cable trenching, cable duct installation, cable pulling, reinstatement works, and associated traffic management works. The pre-construction and enabling works, which broadly consist of fencing, vegetation clearance, preparation of access routes, drainage works, topsoil removal and storage, and construction of the haul road, aim to secure and prepare the cable route corridor for the main construction activities. These pre-construction and enabling works would move progressively along the entire cable route, allowing full access to the cable route for the main construction activities to follow.

192. The main construction activities of trenchless works, cable trenching, installation, and jointing would move along the corridor in sections, optimal progress being dependent on the availability of resources, weather conditions, or other engineering challenges that may arise during the work. To allow maximum flexibility in completing the works safely and efficiently, the main activities are completed sequentially at any location before the next activity commences. As such, works at any location would be intermittent; the nature of the activity determines the duration until all the main construction works are completed, and all cables are installed, jointed and successfully tested.

193. The Project considers that a construction working width of 80m would provide sufficient design flexibility to allow for micrositing. This is based on experience from similar operations on previous projects. The design, spacing, and configuration of this and all trenchless works will be defined in the detailed design phase once a contractor is appointed and crossing methodologies are agreed upon with affected third parties.

194. Upon completion of the cable installation work, the corridor would be prepared for reinstatement activities, including removal of the haul road, installation of further drainage, reinstatement of topsoil, and removal of temporary fencing and access arrangements.

8.1.4 Stage 1 Pre-Construction Works (pre-mobilisation preparation works)

195. Pre-Construction Works are expected to take place following consent award and prior to construction activities commencing. The main pre- construction activities applicable to the onshore substation and works to install the onshore export cables and 400kV cables include:

- Ground investigations and pre-construction surveys;
- Minor works to facilitate the use of existing enabling accesses (Section 8.1.4.1);
- Road/junction modifications and any new junctions off existing highways;
- Pre-construction drainage – installation of buried drainage along the cable corridor and at the substation, which requires an understanding of the existing agricultural drainage environment;
- Hedge and tree removal – hedge and tree removal is seasonal and can be influenced by ecological factors. Removing these ahead of the main works mitigates against potential programme delays;
- Ecological mitigation – any advanced pre-construction mitigation activities, for example installation of great crested newt fencing (if required);
- Archaeological mitigation – pre-construction activities as agreed with Lincolnshire County Council and Historic England; and
- Landscape planting in ‘offsite areas’.

8.1.4.1 Traffic and Access

196. Prior to commencement of the construction phase, it is necessary for workforce employees and construction machinery to gain entry to the working area before the main construction access points and haul road have been completed. To facilitate this entry, the project has identified a number of existing farm tracks and other access avenues which are currently used by landowners with farm machinery that the project intends to utilise as ‘enabling accesses’. Once the construction of the haul road and construction access points have been established, enabling accesses would no longer be required by the Project.

197. As these tracks are currently used to transport farm machinery, the work required to facilitate their use will be minimal, limited to activities such as vegetation clearance, laying of track matting and associated packing (or similar) to level the track and/ or protect the ground surface during periods of wet weather, erection of associated signage and safety goal posts to overhead servicers.

198. The use of these enabling accesses will be limited to a maximum of two months, after which vehicles needing to enter and exit the work area, will do so via the temporary construction accesses as described in Section 8.1.5.2.

199. Table 8.1 outlines the maximum number of enabling accesses identified and the maximum duration that these would be utilised by the Project.

200. Following completion of construction and demobilisation, it may also be necessary to take access at the same points for vehicles required for reinstatement and planting works after the temporary construction accesses have been reinstated.

Table 8.1 Enabling Accesses

Parameters	Design Envelope
Maximum number of Enabling Accesses	168
Maximum Duration (months)	2[8]

8.1.5 Stage 2 Enabling Works (mobilisation, access, and welfare establishment)

201. The enabling works comprise those construction activities required to enable site mobilisation such as the establishment of construction compounds and accesses.

8.1.5.1 Temporary Construction Compounds (Onshore ECC & 400 kV cable route)

202. Temporary construction compounds of various sizes will be required along the Project Onshore ECC as demonstrated in Figure 3.4 (document reference 6.2.3.4). The compounds associated with the landfall works and the OnSS are described in Section 7.2.4 and Section 8.2.6 respectively.

203. The parameters for each type of compound along the Onshore ECC and 400 kV cable corridor are outlined in Table 8.2, descriptions regarding their purpose are outlined below:

- A52 Hogsthorpe Primary Construction Compound (PCC) [PCC-3] is a temporary works area associated with the works at the landfall including the construction of TJBs and trenchless technique works required to facilitate the installation and demobilisation of the Onshore ECC and the Landfall Compound. This compound will need to be operational for up to 51 months.

[8] Due to the future presence of the BAEF Ornithological Compensation Site, the maximum duration of the use of this enabling access (at EA-88) will be at this location will be restricted to 2 weeks and will be seasonally restricted as outlined in Chapter 22 Onshore Ornithology (document reference 6.1.22)

- Primary Construction Compounds (PCCs) have been positioned at strategic locations along the onshore ECC and 400kV cable corridor to enable the overall management, logistics, and installation of the work programme, and will be maintained throughout the entire ECC and 400kV cable route construction window. These compounds will be operational for up to 36 months for any one compound.
- Secondary Construction compounds (SCCs) are smaller and will be transient with regard to the workflows (retained for between 6 and 24 months at any one location) and will be utilised for similar activities as PCCs.
- Cable Installation Compounds (CICs) will be required to facilitate the trenchless crossing works and joint bays installation works, these compounds will be transient with regard to the workflows (retained for up to 6 months at any one location).

204. The A52 Hogsthorpe PCC, PCCs and SCCs are all temporary works areas; these are construction sites including hard standings, plant and equipment, lay down and storage areas for construction materials, plant and equipment, areas for spoil, areas for vehicular parking, bunded storage areas, areas for welfare facilities including offices and canteen and washroom facilities, wheel washing facilities, workshop facilities and temporary fencing or other means of enclosure and areas for other facilities required for construction purposes.

205. The CICs are trenchless technique compounds which are construction sites where a trenchless technique is proposed including hard standings, lay down and storage areas for construction materials, plant and equipment, areas for spoil, areas for vehicular parking, bunded storage areas, areas for welfare facilities including offices and canteen and washroom facilities, wheel washing facilities, workshop facilities and temporary fencing or other means of enclosure and areas for other facilities required for construction purposes.

206. All compounds will be constructed in line with the Code of Construction Practice (CoCP) and will be required to support the construction of the onshore aspects of the Project. When the compound is no longer required, the site will be reinstated. The maximum design parameters for temporary construction compounds are presented in Table 8.2.

207. The SCCs may also operate as support bases for the onshore construction works as the cable work fronts pass through an area. They may house welfare facilities and localised stores and act as staging posts for localised secure storage for equipment and component deliveries.

208. Careful site segregation within the compounds shall ensure separation between personnel areas (welfare containers and offices) and construction areas. The compounds shall be developed to mitigate puddling, pooling, or dusty conditions deriving from non-surfaced access roads. Similarly, the compounds shall provide controlled security access and a minimum level of lighting suited to the working hours and security requirements (outlined in the artificial light emissions management section of the Outline Code of Construction Practice (document reference 8.1)).

Table 8.2 Maximum design parameters for Onshore ECC & 400kV cable corridor temporary construction compounds

Parameters	Design Envelope
A52 (Hogsthorpe) Primary Construction Compound (A52 Hogsthorpe PCC) [PCC-3]	

Parameters	Design Envelope
Maximum footprint of A52 Hogsthorpe PCC [PCC-3] (m^2)	7,500
Maximum Total number	1
Maximum duration per compound (months)	51
Onshore ECC & 400kV Cable Corridor Primary Construction Compounds (PCCs)	
Maximum footprint of all PCCs (m^2) *(not including A52 Hogsthorpe PCC)*	110,000
Maximum Total number (Onshore ECC)	6
Maximum Total number (400kV cable corridor)	1
Maximum duration per compound (months)	36
Onshore ECC & 400kV Cable Corridor Secondary Construction Compounds (SCCs)	
Maximum footprint of all SCCs (m^2)	235,000
Maximum Total number (Onshore ECC)	19
Maximum Total number (400kV cable corridor)	1
Maximum duration per compound (months)	24
Onshore ECC & 400kV Cable Corridor Cable Installation Compound (CICs)	
Maximum total footprint of all CICs (m^2)	1,724,000
Maximum Total number	324
Maximum duration per compound (months)	6

8.1.5.2 Traffic and Access

Temporary Construction Accesses

209. A number of accesses from the public highway will be required to access construction works and construction compounds for the Project (Figure 27.10). Temporary access points off the highway will be installed to facilitate vehicular access from the road and into the Project onshore ECC during construction.

210. The Heavy Goods Vehicles (HGV) traffic will only be able to enter the onshore ECC from the highway at designated access points, thus minimising the impact on the local minor road network.

211. A temporary haul road will be established along the onshore ECC and 400kV cable corridor to provide access for construction vehicles from access point/compounds to cable installation sites. Haul roads are described under section 8.1.6.6.

Table 8.3 Temporary Construction Accesses

Parameters	Design Envelope
Temporary Construction Accesses (Onshore ECC and 400kV cable corridor)	
Maximum number of Temporary Construction Accesses (onshore ECC and 400kV cable corridor)	53
Maximum Duration (per access) (months)	36
Temporary Construction Accesses between the A52 and the Landfall Compound	
Maximum number of Temporary Construction Accesses between the A52 and the Landfall Compound	2

Parameters	Design Envelope
Maximum Duration[9] (per access) (months)	51

212. Temporary construction accesses will be required from the start of construction for all access points identified (Figure 27.10). Temporary access points have been assessed for the effect on the road network in Volume 1, Chapter 27: Traffic and Transport.

213. Where the onshore ECC and 400kV cable corridor crosses the local road network, construction vehicles will need to cross the existing road to continue along the onshore ECC. HGV construction traffic will not be permitted to access the onshore ECC from the public highway at these crossings (unless identified as a defined HGV access location), and will be limited to directly crossing from one side of the road to the other to continue along the haul road. The temporary works required at each of these crossing locations will therefore be significantly less than that required at designated access locations, where HGV traffic will be exiting the public road network. Priority will be given to existing traffic on the local roads and, where necessary, the traffic entrance onto the roads will be managed. Barriers will be provided, and accesses will be controlled, to prevent members of the public accessing the construction works.

214. The traffic management measures that will be implemented during construction of the ECC and 400kV Cable corridor will be secured through the Construction Traffic Management Plan (CTMP), an outline of which has been submitted alongside this ES (document reference 8.15).

Permanent Accesses

215. Two permanent accesses will be required to be maintained throughout the Project's operational period. These accesses will be installed during the construction period depending on the intended use of the access, these can be seen in Figure 3.4 (document reference 6.2.3.4) and are outlined below:

- Permanent access to the TJB sites taken from Roman Bank Road; and
- Permanent access to the OnSS taken from the A16 / Surfleet Bank.

8.1.5.3 Demarcation of the Cable Corridor

216. The works areas will have suitable demarcation fences along the length of the ECC and 400kV cable corridor. The type of fencing to be used will be dependent on the ground conditions, location requirements and use along the route. Discrete work areas will be fenced off as required.

[9] The section of haul road from a temporary access point on the A52 will need to be retained for the duration of the landfall construction programme (51 months) to facilitate access for reinstatement activities.

8.1.5.4 Soil Management

217. All excavation and reinstatement works will be managed in line with the Soil Management plan (SMP), an outline of which has been submitted as part of the Application (document reference 8.1.3). Stripped topsoil and excavated subsoil will be stored separately within the onshore cable corridor. The area to store the topsoil would be cleared of vegetation and any waste. Topsoil would also be stripped from any land for storing subsoil.

218. Stockpiled materials are to be handled in line with the SMP and the specific handling and storing methods adopted will be adjusted according to the nature of the land and soils (e.g. organic and non-organic land). However, in general, stockpiles would be created by:

- Removing vegetation and waste materials from the area before forming stockpiles;
- Storing topsoil and subsoil layers separately;
- Placing topsoil to limit compaction and allow for optimum organic maintenance; 70k
- Locating stockpiles away from trees, hedgerows, drains, watercourses, or excavations;
- Managing the site so that soil storage periods are kept as short as possible;
- Stockpiling soils in dry conditions where practicable;
- Using tracked equipment wherever possible to reduce compaction;
- Protecting stockpiles from erosion by sealing, seeding, or covering them; and
- Subject to the time of year/weather conditions, stockpiles may be required to be covered until the seeding has germinated and to prevent windswept particles.

8.1.5.5 Construction Drainage

219. An Outline Surface Water and Drainage Plan has been submitted as part of this application (document reference 8.1.5). Surface water drainage will be installed along the edge of the working width to intercept surface water, mitigate surface water flow into the trench, and reduce the risk of the construction works contributing to flooding of the surrounding land. A water management process, in agreement with the relevant IDB, will be implemented for water discharge into drains. No water will be discharged into adjacent fields. Measures will also be reviewed to ensure controls are in place to control surface water flow within the works area.

220. Detailed agricultural land drainage will be developed post-consent by a specialist drainage contractor, considering existing land drainage, and including details of header drains, outfall locations, and cross-corridor interconnections (if applicable). Soakaway drainage pits / outfalls may be required if no suitable outfalls to nearby watercourses are possible.

221. Post-construction agricultural drainage will be reinstated, including the replacement of any drains that were damaged during the construction process.

8.1.5.6 Haul roads

222. To provide access to the Project onshore ECC and 400kV cable corridor, remove traffic from the local road network, and minimise damage to agricultural land, the haul road will be installed in a sectionalised approach throughout the construction phase. The haul road, typically 6.8m wide (Plate 8.1) (and up to 9m at passing places) including verges and drainage channels (where required) will extend the entire length of the Project onshore ECC and 400kV cable corridor (except where the Project has committed to not construct a haul road, such as in locations where trenchless techniques will be adopted). A separation of 2m will be maintained from the edge of the temporary haul road and the cable trench for safety and to maintain trench stability. The haul road provides vehicular access along the Project onshore ECC off the public highway. It will be utilised throughout the installation of the export cables and 400kV cables and for the duration of the onshore ECC construction activities. This period may extend by up to 15 months for discrete areas of the Project, such as at the Landfall, between the A52 and the Landfall Compound (Section 7.2.2).

223. The haul road would generally remain for the entire onshore ECC construction programme, however where practicable, the Project would intend to reinstate sections of the haul road that are not subject to further expected traffic before the completion of the construction works (Section 8.1.7).

224. The haul road will run parallel to the cables along the onshore ECC. Where obstacles must be crossed by the haul road, such as watercourses, rivers, and roads; the installation of temporary flumes/culverts or bridges may be installed in agreement with the asset owner and relevant authority to maintain hydraulic flows. Enabling accesses have been identified along the onshore ECC to facilitate access to each land plot to prepare the ditches from both sides before placement of the flume and to facilitate bellmouth construction.

225. When culverts need to cross watercourses, based on the haul road arrangement, location, and depth of the ditch, it is expected that in general, approximately eight meters[10] of the bank on both sides of the waterway will be cleared of vegetation. This will allow for the installation of the culvert structures and shaping of the ground.

226. The haul road will comprise a maximum thickness of 1m (average 0.6m) of suitable aggregate placed on top of a heavy-duty terram membrane or similar where required. The exact specification of the road will be determined upon the appointment of a principal contractor at detailed design stage.

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[10] The Project we will endeavour to keep crossings perpendicular. However, there will likely be locations where this is not practical and will require an increased length / surface area to accommodate an acute crossing.

227. Depending upon the ground conditions, it may not be necessary to undertake works to construct the designated haul road. Where the ground is sufficiently firm enough it may be acceptable to use significantly less granular sub-base material. Consideration will also be given to alternatives such as a specialist trackway if appropriate. The final decision will depend upon ground conditions and the contractor's preferred construction strategy and will not be confirmed until the detailed design stage.

228. Any aggregate and/or geotextile membrane installed will be removed, and the land reinstated upon completion of the construction phase.

Table 8.4 Maximum design parameters for onshore ECC and 400kV cable corridor haul road

Parameters	Design Envelope
Haul road width (m)	6.8
Haul road hardstanding width at passing places (m)	9
Maximum thickness (aggregate depth) of haul road (m)	1

8.1.6 Stage 3 Cable Infrastructure installation (Trenching and duct installation)

8.1.6.1 Cable Duct Installation

229. Cable duct installation techniques are well-established and incorporate environmental management and mitigation measures as standard practice. Precise installation methods will differ according to the environment through which the cable is being installed. Much of the onshore ECC and 400kv cable corridor will be constructed using an open cut method of cable construction (trenching). Where an open cut approach is not possible, for example, due to significant obstructions (e.g., a major road or watercourse), non-trenching techniques (also known as "trenchless techniques") may be employed, such as HDD.

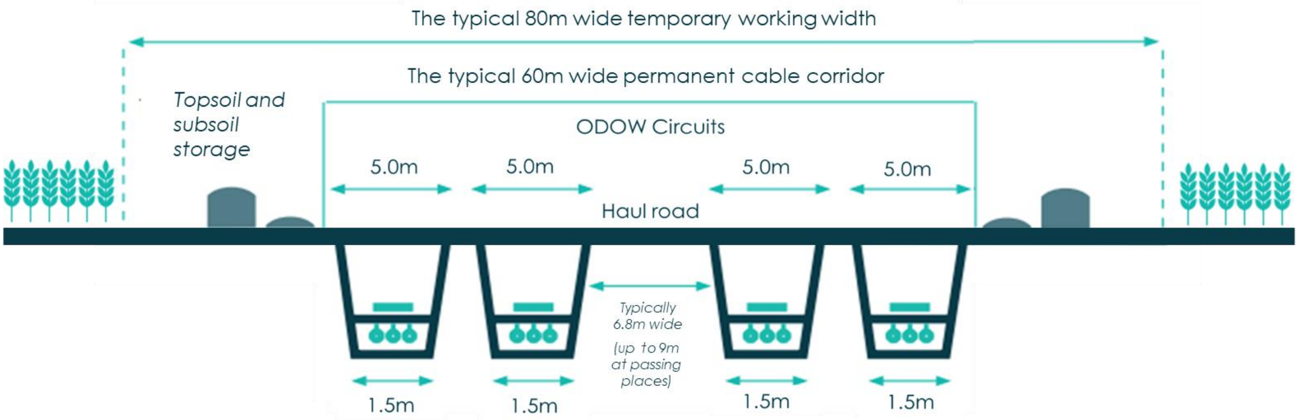

Plate 8.1 Example onshore cable construction corridor cross section for 4 cable circuits (12 cables)

8.1.6.2 Use of Trenching and Trenchless Techniques

Trenching Methods

230. During the construction of the cable trenches, the topsoil will be stripped, and the subsoil will be excavated. Both will be stored on-site within the temporary working width as the construction of each section of the onshore ECC and 400kV cable corridor advances. The topsoil and subsoil will be stored in separate stockpiles, as detailed in the soil management plan. Once the topsoil is stripped, the haul road will be installed along most of the onshore ECC and 400kV cable corridor. Topsoil will only be stored in bunds along the cable corridor adjacent to where it is removed.

231. The trenches will be excavated using a mechanical excavator or similar, and the cable ducts will be installed into the open trench directly from a specialised delivery vehicle.

232. Once the cable ducts are installed, the trenches will be backfilled in stages using the same subsoil excavated from the trench. Following installation and suitable completion of a section of duct installation, the stored topsoil will be reinstated into the trenches in line with the SMP, with the exception of the haul road, which will need to be retained for the duration of the cable duct and export cable installation (Section 8.1.7) phases (up to 51 months). The haul road will be reinstated in sections in line with the progress and completion of the cable pulling and jointing works.

233. The dimensions of the trenches are presented in Table 8.7. The export cable circuits must be spaced out to minimise the mutual heating effect of one cable on another; this enables the cables to effectively carry the large power volumes required without overheating and damaging the cable.

234. The cable ducts will be installed in separate trenches (typically up to four trenches, each containing one cable circuit[11]), the details of which are presented in Table 8.7. The onshore cable ducts will be installed in sections, topsoil will be stripped from the section of the onshore cable corridor to be worked on and stored within the temporary working width of the Project onshore ECC. The cable trenches would then be excavated, typically utilising tracked excavators with the excavated subsoil stored separately from the topsoil.

235. The procedures followed will be in line with best practice and the Code of Construction Practice (an Outline of which has been submitted as part of this DCO Application (document 8.1)).

Trenchless Methods

236. Major crossings, such as rivers, flood defences, IDB owned or maintained drains, railway lines, and major roads, will be undertaken using trenchless construction techniques such as HDD. Such methods enable the Project to avoid impacting upon existing infrastructure by drilling underneath the feature, resulting in little to no impact on the feature. The Project has also committed to utilising these methods at other key sensitive locations along the route such as to avoid a key area of archaeological interest.

237. The process uses a drilling head to drill a pilot hole along a predetermined profile based on ground conditions and cable requirements. Subject to the cable arrangement, the bore diameter may vary. Upon completion of the pilot drill, the pilot hole is widened using larger drilling heads until the drill bore is wide enough to fit the cable duct. Throughout the drilling operations, a fluid mix of water and bentonite (drilling mud) is used to assist in the downhole drilling operations; this is to control the drilling temperature, remove drill cuttings and manage and maintain the stability of the hole. Once the HDD drilling is complete, the ducts are installed (pulled) through the completed drill path. The CoCP will include risk assessment and management measures to minimise the likelihood of an unplanned release of drilling mud. In the event of a release, the Onshore Pollution Prevention and Emergency Response Plan will be implemented, an outline of which has been submitted as part of this Application (document reference 8.1.4)

238. When crossing under main rivers (Environmental Agency) or IDB maintained drains, the HDD entry and exit pits will be at least 9m from the banks of the watercourse, and the cable will be at least 2m below the hard bed of the channel. The separation between the cable entry / exit points will be increased to a minimum of 16m for tidal rivers.

[11] At major trenchless crossings, more ducts may be required, and the cable circuits would be bundled accordingly (i.e. reducing the number of export cables per circuit)

Minor Roads/tracks/Public Rights of Way and Utilities

239. Where the onshore cable corridor crosses minor roads, tracks and public rights of way, open-cut trenching methods are proposed where practical in combination with traffic management. Where appropriate, single-lane traffic management with signal controls to manage traffic movement would be utilised during installation. Where the width of the road does not permit single-lane traffic management, alternative methods such as temporary road closure and diversion have been proposed. Where standard traffic management techniques are not deemed suitable, it may be necessary to revert to a trenchless crossing solution. The proposed crossing method for each road crossing is provided in the onshore crossing schedule (Appendix 2 of this chapter (document reference 6.3.3.2)).

240. The approach for each crossing would be agreed with the relevant Authority before work begins. Temporary closures or diversions would only be required for the duration that duct installation takes place in that location (no more than 1-2 weeks for a minor road crossing). Temporary crossings of the onshore cable corridor could then be installed to allow public access to continue where the haul road is required to remain in service. The crossings would be managed to enable safe operation.

241. Re-installation and localised finishes would follow the relevant codes, practices, and specifications as agreed with the local Highway Authority.

Riparian[12] Watercourse Crossings

242. Where riparian watercourses are to be crossed, the approach will be to use open-cut trenching, combined with temporary damming and diverting of the watercourse as agreed with the asset owner and IDB where required as shown in Plate 8.2. However, trenchless methods may be considered subject to evaluation of the crossing, which is to be determined at the detailed design stage.

243. In the case of localised isolation of the riparian drain, the watercourse would be dammed at either side of the cable crossing point, using materials such as straw bales and ditching clay, and the water would be pumped or piped across the dammed section to maintain flow. The exact methods used would be subject to the specific nature of the ditch.

244. The cable trenches would then be excavated within the dammed section to allow for a clearance of 1.2m from the top of the protective tile to the hard bed level, to avoid impacts to the active channel bed once reinstated, and a concrete capping will be installed over the ducts to protect the circuits from mechanical damage.

[12] Riparian Watercourses are those not owned by the IDB.

245. The watercourse bed materials will be managed and stored separately to the adjacent subsoils, with all efforts taken to avoid cross-contamination of soils and bed materials. The reinstatement of the channel bed material and subsoils will be completed in the order they were removed, with the dams removed once the works have been suitably completed and seeded.

246. The temporary damming and diversion of watercourses would only be required for the duration that duct installation takes place in that location, with the watercourse being reinstated as shown in Plate 8.3.

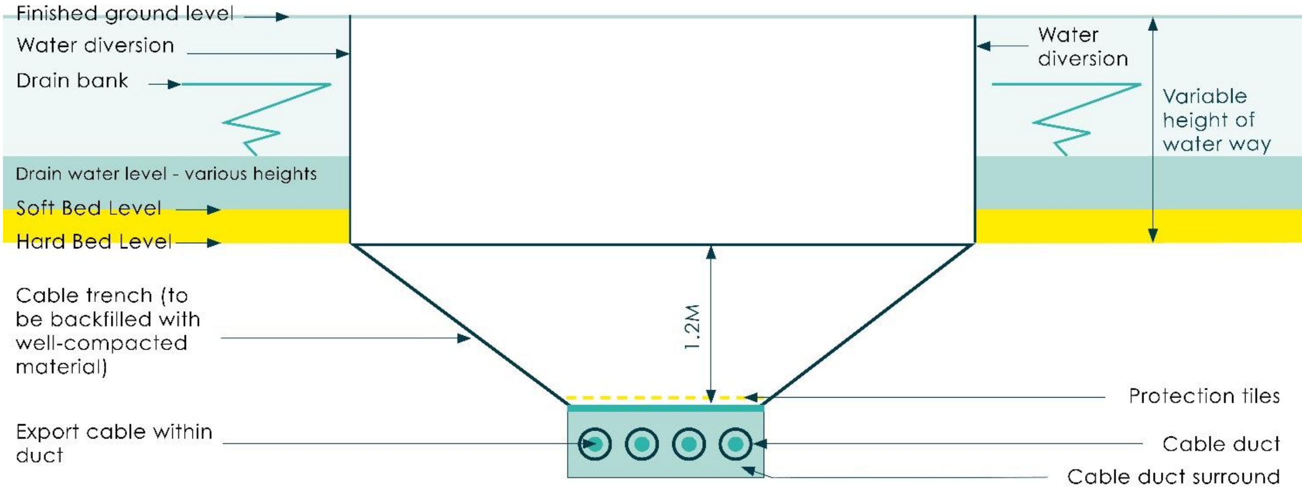

Plate 8.2 Riparian watercourse crossing cross section, showing cable installation with water diversions in place

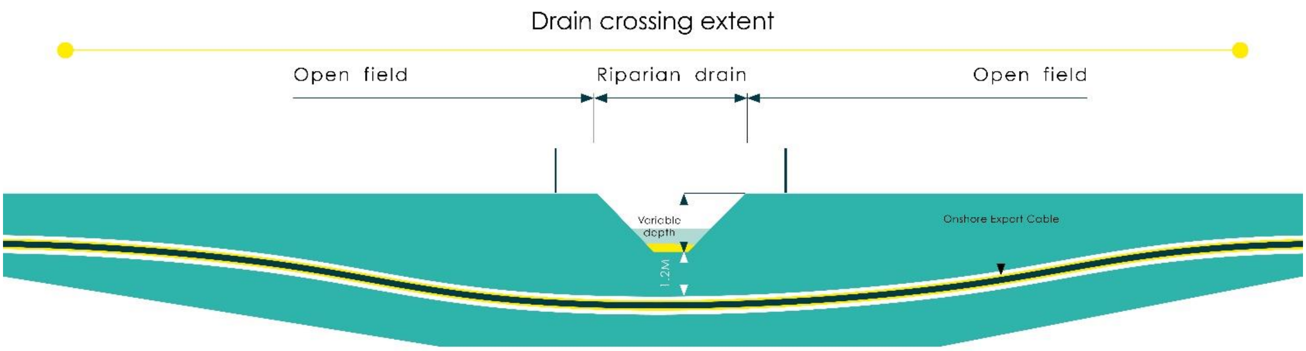

Plate 8.3 Reinstated riparian watercourse crossing cross section

Duct trailer method

247. A ducting trailer or trenching machine may be used for more extended ducting sections. This enables the ducts to be joined on the trailer platform and lowered directly into the trench as the tractor moves the trailer forward. The ducts are zipped and tied into the correct formation before leaving the working platform. Using the duct trailer or duct machine minimises the need for personnel to work in the trench.

Maximum Design Parameters

248. The indicative parameters (maximum design scenario) for the Onshore ECC and 400kV cable corridor are outlined in Table 8.7. Fibre optic cables or similar will be buried alongside the onshore export cables to allow for communication and cable monitoring to the wind farm for the various control systems in place for the Project.

Table 8.5 Maximum design parameters for the Onshore ECC and 400kv Cable Corridor

Parameters	Design Envelope
Maximum number of export cable circuits[13]	4
Maximum number of cables	12
Maximum cable voltage (kV) onshore export cables[14]	275
Maximum cable voltage (kV) 400kV cables[15]	400
Indicative length of Onshore ECC (km) (220kV or 275kV)	70
Indicative length of 400kV Cable Corridor (km) (400kV)	4
Typical width of ECC (m)	80
Typical width of permanent ECC (m)	60
Typical width of 400kV cable corridor (m)	60
Typical width of permanent 400kV cable corridor (m)	40
Trenches	
Minimum trench depth to cable protection tile[16] (m)	1.2[17]
Maximum cable trench depth (m)	3
Typical width of cable trench at surface, per cable circuit (m)	5
Typical trench width at base (m)	1.5
Trench maximum depth of stabilised backfill (m)	1.5
Total duration of onshore cable duct, export cable and 400kV installation (months)	42 months
Trenchless Crossings	
Indicative number of Trenchless Crossings[18] (Onshore ECC)	210
Indicative number of Trenchless Crossings18 (400kV cable corridor)	6
Maximum Burial Depth (m)	25
Minimum Burial Depth (m)	2

249. Major trenchless crossings, such as HDD along the ECC, may require piling to assist with the drilling operations. These crossings involve drills to critical infrastructure, complex geometry, and long drill lengths below ground. Piling, likely percussion sheets, aids drilling in complex, critical infrastructure areas with deep underground drilling. The temporary piling will be removed upon project completion.

[13] At major trenchless crossings, more ducts may be required, and the cable circuits would be bundled accordingly (i.e. reducing the number of export cables per circuit)
[14] The onshore ECC runs from landfall to the OnSS
[15] The 400Kv cable corridor runs from the OnSS to the NGSS
[16] Hard protective tiles or protective tape and marker tape are also installed in the cable trenches above the cables to ensure any third party does not damage the cable (Section 0).
[17] If required for engineering purposes, a minimum burial depth of 0.9m can be utilised.
[18] Number of trenchless crossings as reflected in the Design Basis Figure 3.4.

8.1.6.3 Cable Duct surround and backfill

250. The cable ducts are encased in an imported thermal backfill material such as cement-bound sand (CBS), ensuring the ducted cables are laid within a consistent structural and thermal environment. CBS has a high thermal conductivity which allows heat produced during electricity transmission to be dissipated away from the export cables and the surrounding soils. The specification of the CBS will be subject to detailed design to assist in managing ground temperatures.

251. The maximum volumes of imported stabilised backfill material (i.e. not originating from the excavated trench) are presented in Table 8.6, noting these values are considered a maximum for the purposes of a worst-case scenario assessment.

252. The trench is then backfilled with the excavated material. Hard protective tiles or protective tape and marker tape are also installed in the cable trenches above the cables to indicate the presence of the cables to any third party, to reduce the risk of damage to the cables.

Plate 8.4 Example of protective tiles and marker tape..

8.1.6.4 Joint Bays and Link Boxes

253. Joint bays (JBs) are underground concrete structures holding the joint between sections of the onshore export cables and are utilised for cable pulling (installation of the cables through the pre-installed ducts) activities (Section 8.1.7). The detailed design of these components will be defined post-consent. They will be buried and the land above reinstated. The maximum design parameters are presented in Table 8.6.

254. Link boxes (LBs) and earth pits (collectively referred to as LBs) will also be required along the Project onshore ECC and 400kV cable corridor. These are smaller pits, compared to JBs, and house connections between the cable shielding, joints for fibre optic cables and other auxiliary equipment. The LBs will require manhole-type covers to allow access for regular maintenance and fault-finding purposes. They may include above ground demarcation which may include fencing and marker posts. The maximum design parameters for LBs are presented in Table 8.6.

255. The construction of the JBs and LBs along the onshore ECC and 400kV cable corridor will be undertaken at a given location when these installations are required in anticipation of jointing activities.

Table 8.6 Maximum design parameters of Joint Bays (JBs) and Link Boxes (LBs)

Parameters	Design Envelope
Maximum number of JBs (Onshore ECC)	680
Maximum number of LBs (Onshore ECC)	680
Maximum number of JBs (400kV Cable Corridor)	20
Maximum number of LBs (400kV Cable Corridor)	20
Maximum distance between JB/LB on one circuit (m)	2000
The most likely minimum distance between JB/LB on one circuit (m)	450
JB maximum width (m)	9
JB maximum length (m)	26
JB maximum footprint (m^2)	234
JB maximum depth	2.5
JB maximum total area (m^2)	163,800
LB maximum width (m)	4.5
LB maximum length (m)	4
LB maximum footprint (m^2)	18
Permanent Land take per LB (m^2)	4
LB maximum depth	2.5
LB maximum total area (m^2)	12,600
Number of manhole cover(s) per LB	1
Area per manhole cover (m^2)	4
Total area (JBs and LBs) (m^2)	176,400
Spoil volume per JB (m^3)	585
Spoil volume per LB (m^3)	45
Total excavated volume (m^3)	441,000

8.1.7 Stage 4 Cable Installation (cable pulling through the pre-installed cable ducts)

256. Once the cable infrastructure installation is complete and the cable ducts are installed, the export cables will be installed by a method referred to as “cable pulling”. Cable pulling would not require trenches to be reopened, instead, the cables would be pulled through the pre-installed ducts from joint bays located along the onshore ECC and 400kV cable corridor. Access to and from the joint bays would be required to facilitate the works during this phase of the project.

257. The cable installation would be facilitated by the use of the pre-installed haul road (Section 8.1.5.6). The extent of the haul road required will be determined upon completion of the duct installation works, with a view to retaining only those sections of the haul road required for access to the joint bay locations for cable drums, winching, and jointing activities. The intention at detailed design stage would therefore be to reinstate as much of the haul road as practicable following completion of the duct installation works, while retaining enough access to facilitate the cable pulling activities. Given the extent of the haul road to be retained cannot be anticipated at this stage, for the purposes of assessment, it is assumed that 100% of the haul road will be retained for up to a maximum of 36 months in any one location with the exception of the section of haul road between the A52 and the Landfall compound which will be retained for the duration of the landfall works (51 months) (Section 7.2).

258. During the cable pulling works, a cable drum would typically be delivered by specialised transport such as a low loader, tractor, and drum trailer (example shown in Plate 8.5) to designated joint bay locations with the cable tethered to a winch cable from the adjacent joint bay. The cable would then be winched off the drum from one joint pit to another through the buried ducts.

259. Once the cable is suitably extended between joint bays, the cable jointing will be conducted in a specialised housing (controlled environment). Practical welfare and tooling must be provided to facilitate each joint operation for the jointing duration.

Plate 8.5 Example of Cable drum transport - Source: Faymonville.

8.1.8 Stage 5 Demobilisation and Reinstatement works.

260. Once commissioning is complete, demobilisation and reinstatement can occur. Activities are expected to consist of:

- Removal of haul road and temporary construction accesses;
- Joint bay ground re-instatement;
- Reinstatement of topsoil;
- Landscaping and hedge re-planting, where appropriate; and
- Demobilisation of welfare, temporary construction compounds and fence removal.

8.1.8.1 Reinstatement

261. Following the installation of the export cables and joint bays in any one section, the construction working width will be cleared and reinstated, where practicable. This reinstatement will include the replanting of hedgerows, replacing fences, removing temporary land drains and settlement ponds, and reinstating permanent land drains.

262. Reinstatement will be undertaken in line with the Code of Construction Practice (CoCP), Landscape Management Plan (LMP) and Ecological Management Plan (EMP), related outline documents of which have been provided as part of this application (documents 8.1 (Outline CoCP) and 8.10 (Outline Landscape and Ecological Management Strategy)). Reinstated habitats may be subject to an aftercare period, and the monitoring and aftercare methods will be approved through the final LMP and under individual landowner agreements.

8.2 Project Onshore Substation (OnSS)

263. This section of the Project Description is supported by the following figures that can be found in ES Volume 2:

- Figure 3.3 Onshore Order Limits and Assessment Segments (document reference 6.2.3.3)
- Figure 3.4 Indicative Onshore Infrastructure (document reference 6.2.3.4)
  - *This figure outlines the indicative infrastructure layers as well as associated IDs that have been assigned to each infrastructure element for reference throughout this chapter and the ES. Where an ID is relevant to this figure it is presented in square brackets e.g. [PCC-1].*

8.2.1 Overview

8.2.1.1 Purpose

264. One OnSS containing the electrical components for transforming and converting the power exported through the onshore cables to 400kV and to adjust the power quality and power factor, as required to meet the GB NGESO Grid Code for supply to the National Grid.

265. The function of the OnSS is to:

- Collect the power generated by the turbines via the export cables.
- Condition the power so it can be exported to the National Grid electricity network.

8.2.1.2 Location

266. The location of the OnSS has been selected based on environmental and technical considerations as well as taking consideration of interfaces with the NGSS. For details of the site selection of the OnSS location and consideration of alternatives see ES Chapter 4 (document reference 6.1.4).

267. A new permanent operational access will be required to access the onshore substation (Figure 3.4). The permanent access road will be up to 8m wide and designed to provide operation and maintenance access throughout the operational life of the substation.

8.2.1.3 Technology

268. The Project has retained the option for two types of technology for the OnSS; Air Insulted Switchgear (AIS) and Gas Insulated Switchgear (GIS). The selection of substation technology will be made during the detailed design phase and will be dependent on suitability and availability during the procurement process.

8.2.2 OnSS Construction Sequence

The following indicative construction activities will likely be undertaken:

- Enabling works consisting of:
  - Detailed Site Investigation; and
  - Ground Level Grading, including Cut and Fill.

- Formation of substation platform consisting of;
  - Laying of Foundations; and
  - Installation of below-ground services.
- Erection of Building;
- Installation of Equipment; and
- Commissioning.

269. Detailed intrusive site investigation will be undertaken to understand th’ ground's properties and allow the design completion.

270. The enabling works would then be undertaken as detailed in section 8.2.3. Once complete, the substation platform will be established by installing below-ground services such as drainage and laying the building and outdoor equipment area foundations. These foundations will likely be poured concrete, and the thickness and specification will be determined after the detailed site investigation.

271. The buildings will be erected upon the foundations, and the substation electrical equipment will be installed. Once the large equipment has been installed, secondary installation work will consist of making the electrical connections between all equipment and installing all the secondary systems required to operate it. Examples include lighting, heating, ventilation, cooling, and control systems.

272. Once installation has been completed, a commissioning process will be undertaken to test the equipment to ensure it is fit for purpose and the equipment is brought into service in a controlled manner. The commissioning and construction processes may overlap in time depending upon the overall construction programme.

8.2.3 OnSS Enabling Works

8.2.3.1 Compound Establishment

273. An OnSS Primary Construction Compound (PCC) [PCC-29] will be established adjacent to the substation site, as shown in Figure 3.4. The OnSS PCC is a temporary works area which is defined as a construction site including hard standings, plant and equipment, lay down and storage areas for construction materials, plant and equipment, areas for spoil, areas for vehicular parking, bunded storage areas, areas for welfare facilities including offices and canteen and washroom facilities, wheel washing facilities, workshop facilities and temporary fencing or other means of enclosure and areas for other facilities required for construction purposes.

274. Services such as water, sewage, electricity, and communications will be required to support the day-to-day activities. These services will be obtained from a connection to nearby infrastructure or through self-sufficient means such as temporary generators.

275. A portion (5,400m^2) of the OnSS PCC will need to be retained to facilitate the Commissioning phase, this is referred to as the ‘commissioning compound’ and will be reinstated following successful testing and commissioning of the OnSS. The remainder of the OnSS PCC will be reinstated upon completion of the construction of the OnSS.

276. An OnSS Security & Logistics compound[PCC-30] is required for the construction period of the OnSS and is a facility designed to support the various substation construction phases. It features controlled access, surveillance systems, vehicle laydown, and welfare to ensure the safety and efficiency of construction operations.

8.2.4 Onshore Substation Construction

8.2.4.1 Construction Method

277. The site would be stripped, and the ground levels graded as required by the final design. Stripped material would be reused on site where practicable. Deeper soils would be excavated from areas where the ground profile needed to be lowered (cut) and moved into the areas where the ground level needs to be raised (fill). The thickness of each fill layer would need to be determined in accordance with the specification of the material and the design of the substation platform. Where required, during the site grading, it may be necessary for deeper soils to be excavated and moved to areas where the ground level needs to be raised, subject to the design of the substation platform. Where the specification of the existing soils is not up to the required load bearing standard additional material may need to be imported to the site. Any excess material would be disposed of at a licenced disposal site.

278. After grading of the site is complete, a stoned platform will be constructed, and excavations would then proceed associated with the laying of foundations, trenches and drainage. At this stage it is not known whether the foundations would be ground bearing or piled. This will be determined by geotechnical ground investigation post consent that will inform the detailed design. However, for the purposes of the assessment piled foundations are assumed to be required at the substation.

279. Following completion of the enabling works, installation of drainage and foundations, the substation platform will need to be finished with a layer of imported stone fill combined with a concrete pour. The thickness of this concrete platform would be determined during detailed design based on the geotechnical ground investigation. The buildings would likely be constructed from a steel frame with cladding panels. The steel frame would be fabricated off site and then erected at the substation location with the use of cranes. The cladding would be fitted once the framework is in place.

280. The substation electrical equipment would then be delivered to site and installed. Due to the size and weight of assets such as the transformers, specialist delivery methods would be employed, and assets would be offloaded at site with the use of a mobile gantry crane. The onshore substation would be enclosed by a temporary perimeter fence for the duration of the construction period with a permanent fence installed as part of the construction works. The 400kV cables from the onshore substation to the NGSS would be installed within ducts. This method will require up to 2 trenches to be excavated between the OnSS and NGSS (approximately 4km in length) including a trenchless crossing under the River Welland. The construction methods and design parameters for the 400kV installation would be the same as those described in Section 8.1.6.

281. All works would be undertaken in accordance with the CoCP.

8.2.4.2 Drainage

282. The working platform would be raised to mitigate flooding with a suitable freeboard. Details of the flood modelling that has been carried out and the proposed platform level are contained in Volume 1 Chapter 24 Hydrology and Flood Risk, and the associated modelling report and flood risk assessment. Within this raised platform, a surface water drainage system would be required for the OnSS. The drainage would be designed to meet the technical requirements set out in the National Planning Policy Framework (NPPF) and agreement with the IDB for local discharge to the drainage network. This would include infiltration techniques and attenuation ditches before a controlled discharge, which can be accommodated within the development area. Discharge rates from the surface water drainage system would be controlled to the rate agreed with the relevant IDB, to prevent any increase in flood risk to surrounding land from current levels. The strategy for the permanent drainage works is provided in the Outline Operational Drainage Management Plan (document reference 8.12).

283. Any oily water system will follow best practices and guidance from the Environment Agency in line with control processes in place before the management and discharge. The system will be agreed upon in the detailed engineering stage.

284. Foul drainage would be collected through a local Authority system (if available) or septic tank within the development boundary. The specific approach would be determined during the detailed design phase considering the availability of mains connection and the number of visiting hours for site attendees during operation.

285. In areas used for temporary use, these areas will be reinstated with suitable ground drainage. This post-construction drainage will be design and installed similar to the onshore cable route (section 8.1.8), .

8.2.4.3 Construction Equipment

286. Typical construction equipment will include:

- Cranes;
- Excavators;
- Concrete Pumps;

- Dump Trucks; and
- Rollers.

287. The proposed building substructures will be predominantly composed of steel and cladding materials although brick/block-built structures may be considered. The structural steelwork is likely to be fabricated and prepared off site and delivered to site for erection activities. The steelwork may be erected with the use of cranes. Cladding panels (typically composite) may be delivered to site ready to erect and be fixed to the steelwork. In addition, there could be unhoused equipment, such as different switchgear and protective devices, grid transformers, shunt reactors, dynamic reactive compensation equipment, harmonic filters and water tanks. Lightning masts may be constructed to an approximate height of 30m.

288. The onshore electrical infrastructure facilities will be required throughout the lifetime of the Project. Their key parameters are presented in Table 8.7.

Abnormal Loads

289. A vital aspect of the substation installation will be the delivery of the transformers, shunt reactors, dynamic reactive power compensators (e.g., static synchronous compensators), and harmonic filters. Due to their size and weight, these items will be classified as Abnormal Indivisible Loads (AILs) and delivered via specialist means and offloaded with the use of cranes, Self-Propelled Modular Transporters (SPMTs) or skids. Most of the remaining equipment will be erected using a small mobile plant and lifting apparatus.

8.2.4.4 Key Equipment

290. The substation is anticipated to consist of the following equipment, subject to more detailed design:

- Switchgear;
- Cabling and Busbar connections;
- Grid Transformers;
- Shunt Reactors;
- Battery Rooms;
- Dynamic Reactive Compensation;
- Cooling equipment;
- Harmonic Filters;
- Water Tanks;
- Noise Enclosures;
- Fire Walls;
- Operational Roads;
- Control Building(s);

- Car Parking;
- Security Fence;
- Buried Earthing system;
- External Lighting;
- Lightning protection masts and
- M&E systems, such as fire detection/suppression, CCTV, security systems.

8.2.5 Design Considerations

291. The substation is an essential component of the network, housing hazardous equipment. Functionality and safety are essential to the design which must comply with appropriate technical and safety standards.

292. While aspects of the detailed design of the OnSS will take place post-consent, a Design Review Process is being undertaken by the Project to ensure the design of the OnSS is developed with the local community and relevant stakeholders. Further information regarding the Project's design review process, which includes a design review panel (an independent panel made up of a number of key stakeholders including local representative who are appointed to review the substation design) is being undertaken by the project and the key design principles which have been influenced by this process to date can be found in the Design Approach Document (DAD) and the Design Principles Document (DPD) (documents 8.16 and 8.17 respectively).

8.2.5.1 Buildings

293. Proposed building substructures will be predominantly composed of steel and cladding materials, although brick/block-built structures are sometimes employed. The structural steelwork is likely to be fabricated and prepared off-site and delivered to the site for erection activities. The steelwork may be erected with the use of cranes. Cladding panels (typically composite) may be provided to the site, ready to erect and be fixed to the steelwork.

8.2.5.2 Landscaping

294. The onshore substation site benefits from existing hedgerows along the existing field boundaries which surround the site. Additional planting to further screen the substation has been included in the Project design (refer to Chapter 28 Landscape and Visual Impact Assessment (document reference 6.1.28) and the Outline Landscape and Ecological Management Strategy (document reference 8.10)).

295. The landscaping comprises of an "onsite" landscaping perimeter that surrounds the OnSS and a number of "offsite" landscaping strips that are located in the surrounding fields and which follow existing field boundaries (Figure 3.4 Indicative Onshore Infrastructure Basis of Assessment (document reference 6.2.3.4)).

296. It is anticipated that the landscaping works will require access in order to establish and maintain the planting; it is also anticipated that drainage works may be required to reduce the likelihood that the drainage systems of the fields would be impacted by the planting.

8.2.6 Summary of Key Design Parameters

The key design parameters for the OnSS are outlined Table 8.7 and those associated with the landscaping are highlighted in Table 8.8.

Table 8.7 Indicative Key design parameters for the OnSS

Parameters	Design Envelope
Maximum number of onshore substations	1
Maximum OnSS footprint (up to fenced perimeter) (AIS) (m^2)	144,000
Dimensions of OnSS (up to fenced perimeter) (AIS) (Length m x Width m)	428 x 335
Maximum OnSS footprint (up to fenced perimeter) (GIS) (m^2)	72,600
Dimensions of OnSS (up to fenced perimeter) (GIS) (Length m x Width m)	270 x 268.5
Maximum permanent footprint of OnSS including associated infrastructure (drainage, access requirements, onsite landscaping) (m^2)	261,500
OnSS Primary Construction Compound (OnSS PCC) [PCC-29] area (m^2)	17,900
Maximum construction duration OnSS PCC [PCC-29] (months)	36
Indicative OnSS temporary commissioning compound area (m^2) *(Within the OnSS PCC footprint)*	5,400
Maximum duration temporary OnSS commissioning compound (months) *(Following use as OnSS PCC)*	15
Maximum footprint OnSS Security & Logistics Compound [PCC-30]	2,000
Maximum duration OnSS Security & Logistics Compound [PCC-30]	36
Maximum building/ equipment height (AIS) (m)	13
Maximum building height (GIS) (m)	16.5
Maximum equipment height (GIS) (m)	13
Maximum lightning protection height (m)	30

Table 8.8 Maximum Design Parameters for the Landscaping

Parameters	Design Envelope
Maximum Footprint of onsite landscaping strips (m^2)	100,170[19]
Maximum Footprint of offsite landscaping strips (m^2)	102,900[20]

[19] Includes 153m length of hedgerow with an assumed width of 1m.

[20] Includes 151m length of hedgerow with an assumed width of 1m.

8.3 National Grid Onshore Substation (NGSS)

297. The NGSS will be built, owned, and operated by National Grid Electricity Transmission (NGET) and is anticipated to be located within, or near to, an area identified by the Project as the “Connection Area” as shown in ES Volume 2, Figure 3.4 (document reference 6.2.3.4). The details of this development are not yet known and therefore the Project has adopted typical assumptions regarding the location and parameters of this infrastructure in order for a cumulative assessment to be undertaken. The details of this assessment are contained in ES Volume 1, Chapter 32 Onshore Cumulative Effects Assessment (document 6.1.32) and the topic specific onshore chapters (Chapters 19 – 31).

9 Operation and Maintenance (O&M)

298. During the operational period (anticipated to be approximately 35 years), monitoring, inspection, and maintenance (scheduled and unscheduled) of the assets will be required. The maintenance activities will be categorised as either preventative or corrective maintenance. Preventive maintenance will be undertaken according to a service schedule, whereas corrective maintenance will be needed to cover unexpected repairs, component replacements, retrofit campaigns, and breakdowns. Typical maintenance activities that may be undertaken and their operational lifetime occurrences are presented in Table 9.1.

Table 9.1 Lifetime Maximum Number of Offshore Operations and Maintenance Activities

Activity (Maximum number of)	WTG Minimum size	WTG Maximum size	OP	ANS
Component replacement events	700	350	45	39
Painting events	300	150	112	39
Marine growth and bird waste cleaning events	17,500	8,750	1,225	78
Access ladder replacement events	1,200	600	84	8
Anode replacement events	600	300	42	8
J-tube repair/ replacement events	200	100	60	0
Number of WTG visits (general maintenance)	50,400	25,200	0	0
Number of WTG Foundation visits (general maintenance)	15,400	7,700	N/A	N/A
Number of OP/ANS visits (general maintenance)	0	0	5,950	210
Seabed surveys, including scour protection visual monitoring and remediation	38	38	38	39

9.1 Offshore O&M Requirements

299. An Outline Offshore Operation and Maintenance plan has been submitted with the DCO Application, which provides an outline of the reasonably foreseeable offshore maintenance activities and the broad approach to be taken for each activity, to inform the extent to which O&M activities have been assessed in the ES.

300. A number of different vessel types may be required for O&M activities. During the operational phase of the Project there will be no planned maintenance or replacement of the subsea cables, however repairs may be required should the cable fail or be damaged. Additionally repairs to the cable protection may also be required. The MDS number of instances for these are presented in Table 9.2. Periodic surveys will be undertaken to ensure the cables remain buried and/or sufficiently protected and, if they do become exposed, then corrective maintenance will be undertaken (such as deployment of cable protection or reburial).

Table 9.2 MDS instances for cable repair and cable protection burial repair

Parameter	Maximum design parameter
Number of cable repair events outside the IDRBNR SAC	6
Number of cable repair events within the IDRBNR SAC	5
Number of remedial burial events outside the IDRBNR SAC	16
Number of remedial burial events within the IDRBNR SAC	15

301. Operations and maintenance staff can access the windfarm from a range of O&M vessels from the base port (e.g. crew transfer vessels, supply vessels, autonomous surface vessels (ASVs)) and/or helicopters. Alternatively, they could access the windfarm from an offshore base (such as an accommodation vessel, Service Offshore Vessel (SOV), or mother ship). Vessel numbers for this are presented in Table 9.3.

302. The O&M base (onshore, offshore or both) will be determined by the O&M strategy (post-consent) when the technical specifications of the development are known such as the WTG type.

303. The EIA will seek to assess expected maintenance activities based on experience and best practice, however additional consents or licences may be required during the life of the Project for unforeseen activities.

Table 9.3 MDS for offshore O&M activities

Parameter	Maximum design parameter
Operation and maintenance vessels working simultaneously – CTVs:	10
Operation and maintenance vessels working simultaneously – SOVs	2
Operation and maintenance vessels working simultaneously – supply vessels	12
JUVs working simultaneously	4
Operational hours	24 hours a day, 7 days a week

9.2 Onshore O&M Requirements

9.2.1 Landfall

304. Routine access to the landfall TJBs will be required each year to facilitate the monitoring and maintenance of link boxes.

9.2.2 Onshore ECC and 400kV cable corridor

305. There is no ongoing requirement for regular maintenance of the onshore export cables following installation, except for routine monitoring of the Link Boxes (LBs), which would require annual routine access.

306. In the case of emergency repair, access to the onshore export cables would be needed if necessary. Access to each land plot along the cable corridor would be from existing field entry points.

9.2.3 Project Onshore Substation (OnSS)

307. The OnSS will be an ordinarily unoccupied installation with no permanent on-site presence. Regular access will be required for routine maintenance activities and emergency repairs.

308. The OnSS will be monitored and operated remotely from a dedicated Wind Farm Control Room in a dedicated O&M Base or other nominated specialist facility, under normal conditions. The location of the main O&M base has not been identified at this stage and it does not form part of the OnSS.

309. The OnSS may have a facility to supervise and control the onshore and offshore equipment as a temporary back-up to the main Wind Farm Control room in the O&M base in the event of an emergency. The main operations work may include WTG and HV surveillance, condition monitoring of the equipment, alarm handling, provision of HV safety rules, coordination of on-site response where necessary, and control operations as required by the electrical system and the Transmission System Operator (TSO).

310. The security at the substation will be provided through the use of perimeter fencing and closed-circuit television (CCTV). Security lighting used will be in line with the Artificial Light Emissions Management Plan, an outline of which has been submitted as part of the Application (document reference 8.11). Access to the substation will be restricted. A security and vulnerability assessment will be undertaken at a later design stage to determine the measures required to ensure the site is secure.

9.2.3.1 Hours of operation

311. The OnSS will be capable of operating 24 hours a day and 365 days per year, with planned shutdowns only for scheduled maintenance.

9.2.3.2 Deliveries and traffic movements

312. The operation of the OnSS will not require any significant deliveries or traffic movements. There will be a limited number of movements (approx. four to eight movements per day during the annual two-week testing period) plus approximately four to eight movements per week for workers to undertake inspections and maintenance throughout the rest of the year.

9.2.3.3 Water Use

313. Potable water will be required at the site for sanitary and mess facilities. This will be obtained from the local water supply utility company.

9.2.3.4 Generation and removal of wastes and effluents

314. The operation of the OnSS will not generate any wastes other than maintenance related consumables which will be removed from the site by staff undertaking maintenance. Waste from toilets / cleaning facilities will be discharged to local sewer / septic tank.

9.2.3.5 Emissions to air

315. There are no likely sources of emissions for AIS, but potential source of sulphur hexafluoride (SF6) in GIS in the event of a leak. The project is looking as far as practical to eliminate the use of SF6 gas on site, with the requirement for SF6 free switchgear. In any case, a risk mitigation strategy would be implemented for any potential gas leak and would include for example leak detection and alarm systems. Heat from equipment cooling systems will be emitted to the atmosphere via heat exchangers, in particular from power electronic based systems.

9.2.3.6 Sources of noise

316. The OnSS will contain a number of elements including switchgear, busbars, transformers, capacitors, reactors, reactive power compensation equipment, battery rooms, filters, cooling equipment, control and welfare buildings, lightning protection rods (if required) and internal road access, all of which have the potential to emit sound.

317. The OnSS technology will employ either AIS or GIS. For the purposes of the assessment of noise, the AIS technology is considered a worst case scenario as it is not housed within buildings or enclosures which would provide a level of acoustic screening. Table 9.4 presents the sound power levels of the main plant found within the OnSS.

Table 9.4 OnSS operational plant sound power levels

OnSS Option	Item of Plant	Sound Power Level (SWL), dB	Quantity	Source Height
AIS Switchgear	400/275/33 kV supergrid auto transformer	95	4	5.3
	275 kV harmonic filters	95	4	6.1
	400 kV harmonic filters	95	2	6.25
	275 kV shunt reactor	85	8	4.7
	Emergency Generator	85	1	4.0
	33 kV STATCOM	75	4	3.5
	Earthing/auxiliary transformer 33/0,4 kV	65	4	4.0
	275 kV voltage transformer	40	16	2.4
	400 kV voltage transformer	40	2	3.5

318. Further details of the operational noise of the OnSS are presented in Environmental Statement Volume 1, Chapter 26 Noise and Vibration (document reference 6.1.26), and Appendix 4 Noise Model outputs (6.3.26.4).

9.2.3.7 Power Consumption

319. Primary power consumption for the site will be via tapping off from the wind turbine generator supply. In the case where there is no generation due to low windspeeds, power will be imported from the grid, with no additional infrastructure required to facilitate this. A secondary (back-up) power supply will likely be sought from a local electricity utility supplier to provide a source of power in case of failure of the main transmission system. Provision will also likely be made for the ability to connect the auxiliary system to a temporary standby diesel generator set.

9.2.3.8 Telecommunications

320. A hardwire connection to local existing telecommunications infrastructure will likely be sought as the primary means of communication externally primarily with project sites such as the O&M base. The OnSS will likely act as the primary routing point of communication signals coming from the OSS via the fibre-optics within the export cable.

10 Decommissioning

321. At the end of the operational lifetime of the offshore windfarm, it is anticipated that all of the offshore structures above the seabed level, together with all subsea cables, will be completely removed. Onshore, it is expected that cable would be left in-situ to avoid adverse effects on the environment and communities.

322. The decommissioning process for the ECC has not been determined regarding the final decommissioning policy for the onshore cables, considering that industry best practices, rules and legislation change over time. Should onshore cables be removed from the installed ducts, they would be recycled to allow the infrastructure to be re-used.

323. The decommissioning sequence will generally be the reverse of the construction sequence (reverse lay) and involve similar types and numbers of vessels and equipment.

324. Closer to the time of decommissioning, it may be decided that removal of infrastructure would lead to greater environmental impacts than leaving components in situ, in which case certain components may not be fully decommissioned. Any final decommissioning methodology will adhere to industry best practice, rules and regulations at the time of decommissioning.

325. In addition, at the appropriate time and subject to a new consent, it is possible that there may be an option to repower the Project by partially or fully replacing the windfarm components to extend the Project operational period.

326. A Decommissioning Plan will be developed providing further details on the decommissioning of the Project post consent.

11 Indicative Project Construction Programme

327. An indicative programme detailing anticipated timescales for the key elements of the Project is shown in Plate 11.1 below.

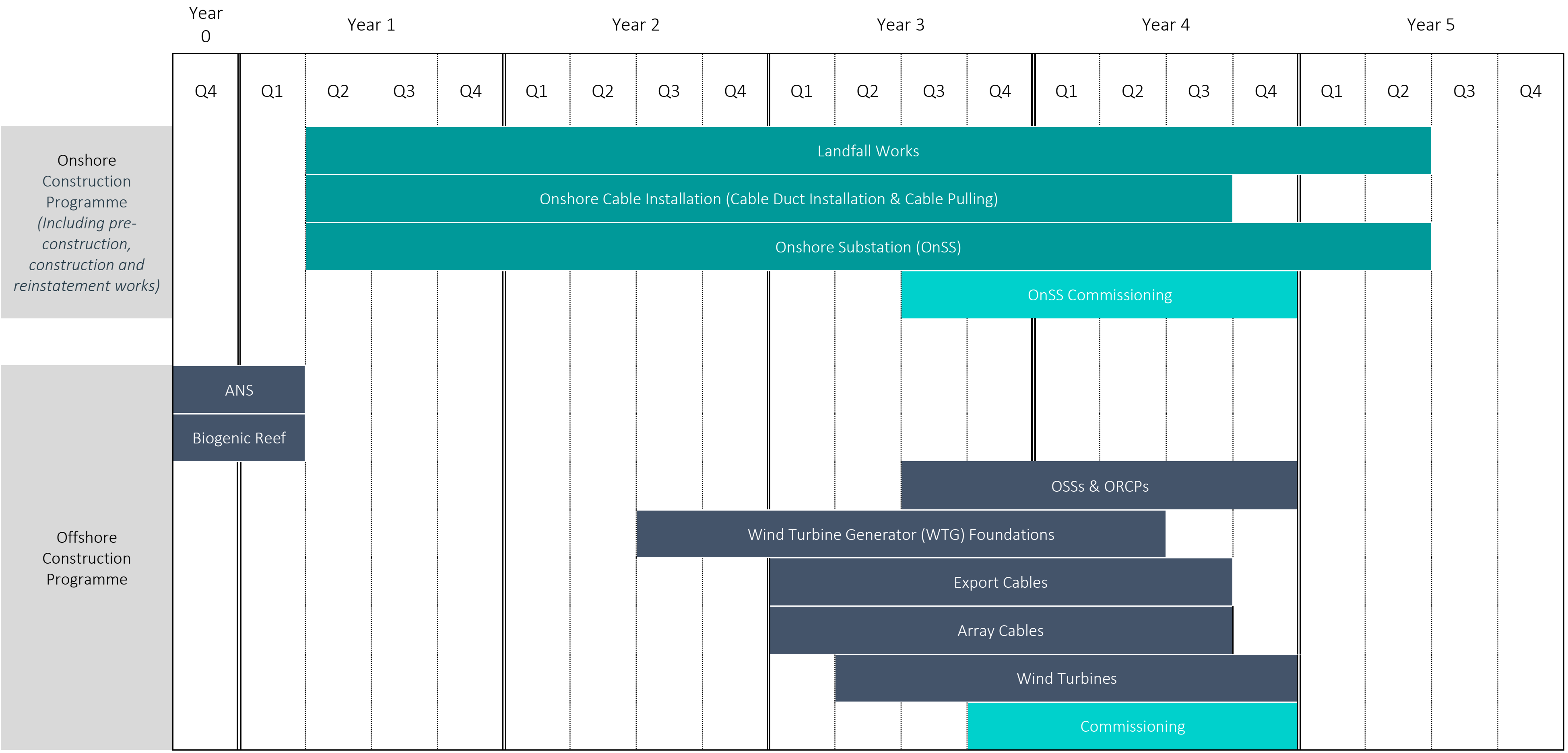

Plate 11.1 Indicative Construction Programme

12 Construction and Operational Management

12.1 Commitments

328. The Applicant has systematically identified the potential impacts and presented them in the ES. Assessments of the consequential effects on the environment, taking into account a variety of embedded mitigation measures to avoid, reduce or eliminate relevant environmental impacts are in the process of being undertaken. The commitments include, for example, avoidance and best practice and design commitments, which are classified into primary or tertiary measures in accordance with IEMA 'Guide to Shaping Quality Development' (IEMA, 2015) definitions.

329. The Project continues to progress assessments and make commitments to incorporate primary (embedded) mitigations, which form intrinsic parts of the design and construction and/or operational process. A non-exhaustive summary of embedded design commitments are described in each of the onshore and offshore Environmental Statement technical chapters and additional mitigation is summarised in the Schedule of Mitigation (document reference 8.13).

13 References

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