Hornsea Project Three

Offshore Wind Farm

Cable Statement
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Date: May 2018

Hornsea 3
Offshore Wind Farm

Ørsted

Additional Application Information

Cable Statement

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Front cover picture: Kite surfer near a UK offshore wind farm © Orsted Hornsea Project Three (UK) Ltd., 2018.

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Table of Contents

1. Summary ... 1
2. Introduction ... 2
3. Proposed Cable Corridor ... 5
3.2 Hornsea Three offshore cable corridor ... 5
3.3 Hornsea Three onshore cable corridor ... 5
4. Description of Grid Connection Works ... 9
4.1 Transmission system ... 9
4.2 Project capacity ... 9
4.3 HVAC/HVDC transmission systems ... 9
4.4 Circuit description ... 10
4.5 Onshore substation ... 11
5. Offshore Cable Installation ... 12
5.1 Cable installation methods ... 12
6. Onshore Cable Installation ... 19
6.1 Transition Joint Bays ... 19
6.2 Onshore cable installation ... 19
6.3 Reinstatement ... 21
7. Status of Grid Connection ... 22

List of Tables

Table 4.1: Infrastructure required for High Voltage Alternating Current (HVAC) and High Voltage Direct Current (HVDC) systems (required (Y), may be required (M), not required (N)). ... 10
Table 4.2: Cables required per circuit. ... 11
Table 5.1: Maximum design scenario: array cable installation. ... 13
Table 5.2: Maximum design scenario: array cable installation – rock placement. ... 13
Table 5.3: Maximum design scenario: offshore interconnector cables installation. ... 14
Table 5.4: Maximum design scenario: offshore export cables installation. ... 15
Table 5.5: Maximum design scenario: offshore export cables crossings. ... 16

List of Figures

Figure 2.1: Overview of Hornsea Three infrastructure. ... 4
Figure 3.1: Offshore export cable corridor and offshore HVAC booster station search area. ... 6
Figure 3.2: Onshore export cable route and locations for onshore HVAC booster station and onshore HVDC converter/HVAC substation. ... 7
Figure 3.3: Landfall and onshore export cable route corridor. ... 8

Glossary

Term	Definition
Cable corridor	The specific corridor of seabed (seaward of Mean High Water Springs (MHWS)) and land (landward of MHWS) from the Hornsea Three array area to the Norwich Main National Grid substation, within which the export cables will be located.
Cable Circuit	A circuit is defined as a collection of conductors necessary to transmit electric power between two points. For underground cable systems, the number of conductors depends on the type of transmission technology. For HVAC transmission, there will be 3 conductors (or a multiple of 3), one for each phase. These can either take the form of three conductors bundled as one cable, or three separate cables. For HVDC transmission only two conductors (or multiple of 2) are necessary (assuming an earth return is not used). These typically are separate cables but may be attached together offshore for ease of installation. If there are multiple circuits between two points they typically will be differentiated by their ability to be isolated (by circuit breaker or disconnector) at either end. The circuit may or may not include one or more fibre optic cables for the purpose of control, monitoring, protection or general communications.
Cable Specification and Installation Plan	A document detailing the technical specification of the offshore electrical system, including a cable burial risk assessment or similar, cable protection specification and installation risk mitigation measures.
Design Envelope	A description of the range of possible elements that make up the Hornsea Project Three design options under consideration, as set out in detail in the project description. This envelope is used to define Hornsea Project Three 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.
Development Consent Order (DCO) as made	An order made under the Planning Act 2008 granting development consent for one or more Nationally Significant Infrastructure Projects (NSIP).
Former Hornsea Zone	The Hornsea Zone was one of nine offshore wind generation zones around the UK coast identified by The Crown Estate (TCE) during its third round of offshore wind licensing. In March 2016, the Hornsea Zone Development Agreement was terminated and project specific agreements, Agreement for Leases (AfLs), were agreed with The Crown Estate for Hornsea Project One, Hornsea Project Two, Hornsea Project Three and Hornsea Project Four. The Hornsea Zone has therefore been dissolved and is referred to throughout the Hornsea Project Three Scoping Report as the former Hornsea Zone.
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.
Hornsea Three intertidal area	The area between (MHWS) and (MLWS) in which all of the export cables will be landed and is the transitional area between the offshore export cabling and the onshore export cabling.
Hornsea Three onshore cable corridor	The corridor in which the onshore export cables will be located.
Hornsea Three offshore cable corridor	The corridor in which the offshore export cables will be located.
Hornsea Three array area	The area in which the Hornsea Three turbines are located.

Term	Definition
Marine Conservation Zone (MCZ)	Marine Conservation Zones (MCZs) are a new type of Marine Protected Area (MPA) brought in under the UK Marine and Coastal Access Act 2009. MCZs will form a key part of the UK MPA network.
Marine Mammal Mitigation Protocol (MMMP)	A document detailing the protocol to be implemented in the event that driven or part-driven pile foundations are proposed to be used. The protocol identifies the methods for detection, potential mitigation and monitoring/reporting protocols for marine mammals.
Nationally Significant Infrastructure Project (NSIP)	Large scale development including power generating stations which requires development consent under the Planning Act 2008. An offshore wind farm project with a capacity of more than 100 MW constitutes an NSIP.
Norwich Main National Grid Substation	The existing National Grid Norwich Main substation which Hornsea Project Three will ultimately connect to.
Offshore Decommissioning Programme	A document confirming the geographic scope/spatial extent of decommissioning activities, process for seeking approval for decommissioning, and standards/objectives for the decommissioning process. A Decommissioning Programme is to be referred to for all decommissioning activities seaward of MHWS.
Offshore HVAC booster station search area	The area in which the offshore HVAC booster stations, if required, will be located.
Onshore Decommissioning Plan	A document confirming the geographic scope/spatial extent of decommissioning activities, process for seeking approval for decommissioning, and standards/objectives for the decommissioning process. A Decommissioning Plan is to be referred to for all decommissioning activities landward of Mean High Water Springs (MHWS).
Onshore HVAC booster station area	The area in which the onshore HVAC booster station, if required, will be located.
Onshore HVDC converter/HVAC substation area	The area in which the onshore HVDC converter/HVAC substation will be located.
Planning Act 2008	The key legislation providing for national policy guidance to assist in the delivery of Nationally Significant Infrastructure Projects (NSIPs). The 2008 Act led to the development of National Policy Statements (NPSs) to guide the decision making processes for NSIPs.
Planning Inspectorate (PINS)	The executive agency of the Department for Communities and Local Government responsible for operating the planning process for NSIPs.
Project Description	A summary of the engineering design elements of Hornsea Three.

Acronyms

Acronym	Description
CBRA	Cable Burial Risk Assessment
DCO	Development Consent Order
HDD	Horizontal Directional Drilling
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
MFE	Mass Flow Excavation
NSIP	Nationally Significant Infrastructure Project
TJB	Transition Joint Bays

Units

Unit	Description
GW	Gigawatt (power)
km	Kilometre
kV	Kilovolt (electrical potential)
MV	Medium Voltage
MW	Megawatt (power)
OFTO	Offshore Transmission Operator

1. Summary

1.1.1.1 This Cable Statement has been prepared by Hornsea Project Three (UK) Ltd. ("the Applicant"), on behalf of Orsted Power (UK) Ltd., in relation to Hornsea Three in accordance with Regulation 6(1)(b)(i) of the Infrastructure Planning (Applications: Prescribed Forms and Procedures) Regulations 2009 (the 'APFP Regulations') which requires the Applicant for a Development Consent Order (DCO) for the construction of an offshore generating station, to provide details of the proposed route and method of installation for any cable.

1.1.1.2 Hornsea Three may use High Voltage Alternating Current (HVAC) or High Voltage Direct Current (HVDC) transmission, or could use a combination of both technologies in separate electrical systems. Hornsea Three is applying for consent for both HVAC and HVDC transmission to allow for suitable flexibility to ensure a low cost of energy to the UK consumer and to facilitate successful completion of Hornsea Three in a competitive market.

1.1.1.3 The offshore cable corridor extends from the proposed landfall west of Weybourne in North Norfolk, offshore in a north-easterly direction to the Hornsea Three array area. The Hornsea Three offshore cable corridor is approximately 163 km in length and 1.5 km in width.

1.1.1.4 The Hornsea Three onshore cable corridor runs southerly from the landfall west of Weybourne to the proposed substation site location at Norwich Main. The Hornsea Three onshore cable corridor is typically 80 m wide (temporary working easement, within which a 60 m permanent easement will be provided) and up to 53 km long.

1.1.1.5 Hornsea Three may be built in one or two phases of construction, including the associated cable installation. Array cables, offshore interconnector cables and offshore export cables will be installed as part of the offshore cable installation works. The method used for the installation of offshore cables will consist of a single or combination of, jetting, vertical injection, cutting, ploughing, trenching, dredging and Mass Flow Excavation (MFE).

1.1.1.6 The offshore export cables will be installed through the intertidal area with open cut installation, trenchless techniques (i.e. Horizontal Directional Drilling (HDD) or thrust boring) or self-powered bespoke installation tools (i.e. tracked vehicles). The offshore export cable is connected to the onshore export cables at the Transition Joint Bays (TJB).

1.1.1.7 Onshore export cables will be installed with a mixture of open trench and HDD techniques. Following completion of the onshore cable installation, the working area will be reinstated to its previous condition.

1.1.1.8 The current Grid Connection Agreement for Hornsea Three is for a connection at Norwich Main substation in 2023/2024.

2. Introduction

2.1.1.1 This Cable Statement has been prepared by Orsted Hornsea Project Three (UK) Ltd. ("the Applicant"), on behalf of Orsted Power (UK) Ltd., in relation to Hornsea Three in accordance with Regulation 6(1)(b)(i) of the Infrastructure Planning (Applications: Prescribed Forms and Procedures) Regulations 2009 (the 'APFP Regulations') which requires the Applicant for a Development Consent Order (DCO) for the construction of an offshore generating station, to provide details of the proposed route and method of installation for any cable. This statement also outlines a description of the grid connection works.

2.1.1.2 The information contained within this Statement on the proposed cable corridor and cable installation methods is intended to be a summary of the information contained within the Project Description chapter of the Environmental Statement (volume 1, chapter 3: Project Description, document refernce number A6.1.3).

2.1.1.3 This Statement forms part of the suite of documents submitted to the Secretary of State in support of the application for a DCO for Hornsea Three, which would authorise the construction and operation of up to 300 wind turbines and associated infrastructure. Since Hornsea Three will be an offshore generating station with a capacity of more than 100 MW it is a Nationally Significant Infrastructure Project (NSIP) as defined by the Planning Act 2008.

2.1.1.4 The DCO for Hornsea Three would authorise, among other things, the construction, operation and maintanence of the following electrical infrastructure, as shown in Figure 2.1:

- Offshore turbines;
- Offshore accommodation platforms;
- Array cables linking the individual turbines to offshore substations;
- Connection works to existing Norwich Main Substation;
- HVAC or/and HVDC transmission system including:
    - HVAC:
        - Offshore transformer substation(s);
        - Offshore interconnector cables(s);
        - Offshore export cable(s);
        - Offshore HVAC booster station(s) (unless specified otherwise this refers to both Surface and Subsea designs);
        - Onshore export cable(s);
        - Onshore HVAC booster station (either instead of, or as well as offshore HVAC booster station(s));
        - Onshore HVAC substation.; and
        - Grid connection export cable(s).

- HVDC:
  - Offshore transformer substation(s);
  - Offshore interconnector cables(s);
  - Offshore HVDC converter substation(s);
  - Offshore export cables(s);
  - Onshore export cables(s);
  - Onshore HVDC converter substation; and
  - Grid connection export cable(s).

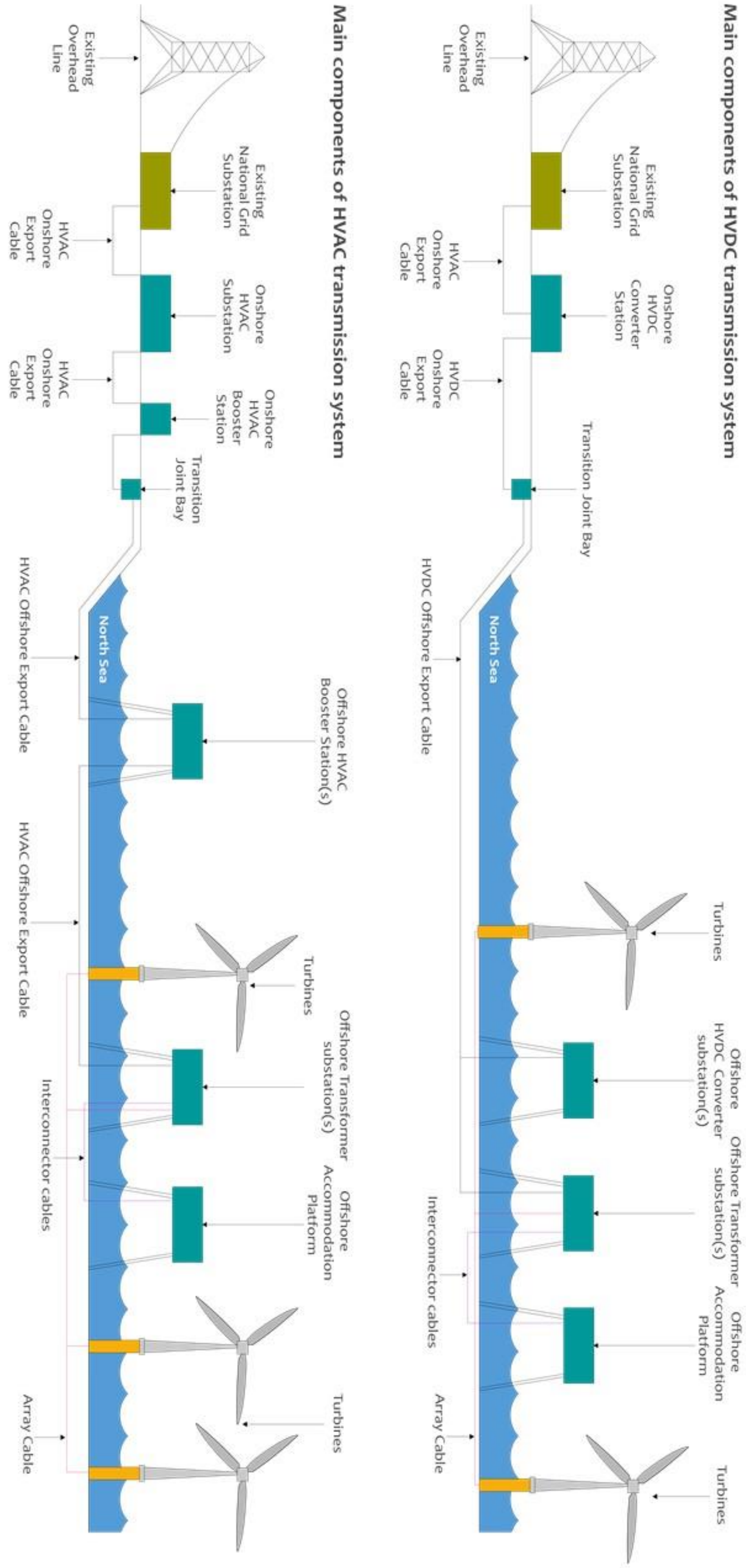

Figure 2.1: Overview of Hornsea Three infrastructure.

3. Proposed Cable Corridor

3.1.1.1 A number of fundamental principles are inherently applied to the decision making process of the site selection process, including for the onshore and offshore cable corridor, and these comprise:

- The shortest route to minimise impacts by minimising footprint for the offshore and onshore cable routes as well as minimising costs (hence ultimately reducing the cost of energy to the consumer) and transmission losses;
- Avoidance of key sensitive features where possible and where not, sought to mitigate impacts;
- Minimisation of disruption to populated areas thereby lowering effects; and
- For the accommodation of the range of connection technology sought within the design envelope, and exclude those options outwith the design envelope (i.e ruling out overhead lines).

3.1.1.2 Further details are provided in the Site Selection and Consideration of Alternatives chapter of the Environmental Statement (volume 1, chapter 4; document reference number A6.1.4).

3.2 Hornsea Three offshore cable corridor

3.2.1.1 The Hornsea Three offshore cable corridor extends from the proposed landfall west of Weybourne in North Norfolk, offshore in a north-easterly direction to the Hornsea Three array area. The Hornsea Three offshore cable corridor is approximately 163 km in length and 1.5 km in width (Figure 3.1).

3.2.1.2 The detailed coordinates for the Hornsea Three offshore cable corridor are included in the Order limits and grid coordinates plan (offshore) (document reference number A2.2.1).

3.3 Hornsea Three onshore cable corridor

3.3.1.1 The Hornsea Three onshore cable corridor runs from the landfall west of Weybourne to the proposed substation site location at Norwich Main. The Hornsea Three onshore cable corridor and landfall area is shown in Figure 3.2 and Figure 3.3.

3.3.1.2 The extent of land required for onshore works, including the export cable and substations are shown on the Works Plans - Onshore (document reference number A2.4.2).

3.3.1.3 The Hornsea Three onshore cable corridor is typically 80 m wide (temporary working easement, within which a 60 m permanent easement will be provided) and up to 53 km long, designed in accordance to a wide range of human, biological and physical constraints as well as technical and commercial considerations (further details are provided in the Site Selection and Consideration of Alternatives chapter of the Environmental Statement (volume 1, chapter 4; document reference number A6.1.4)).

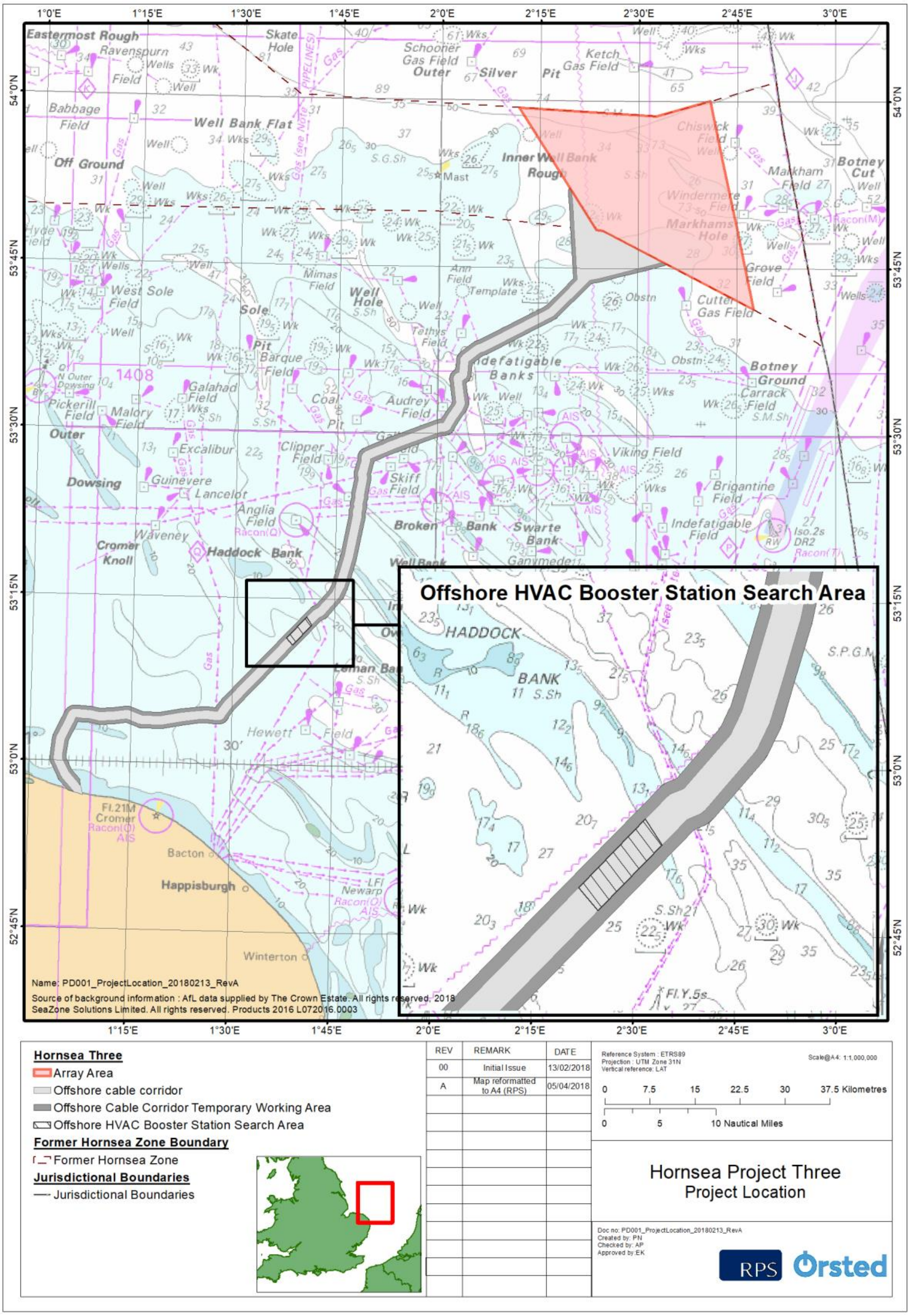

Figure 3.1: Offshore export cable corridor and offshore HVAC booster station search area.

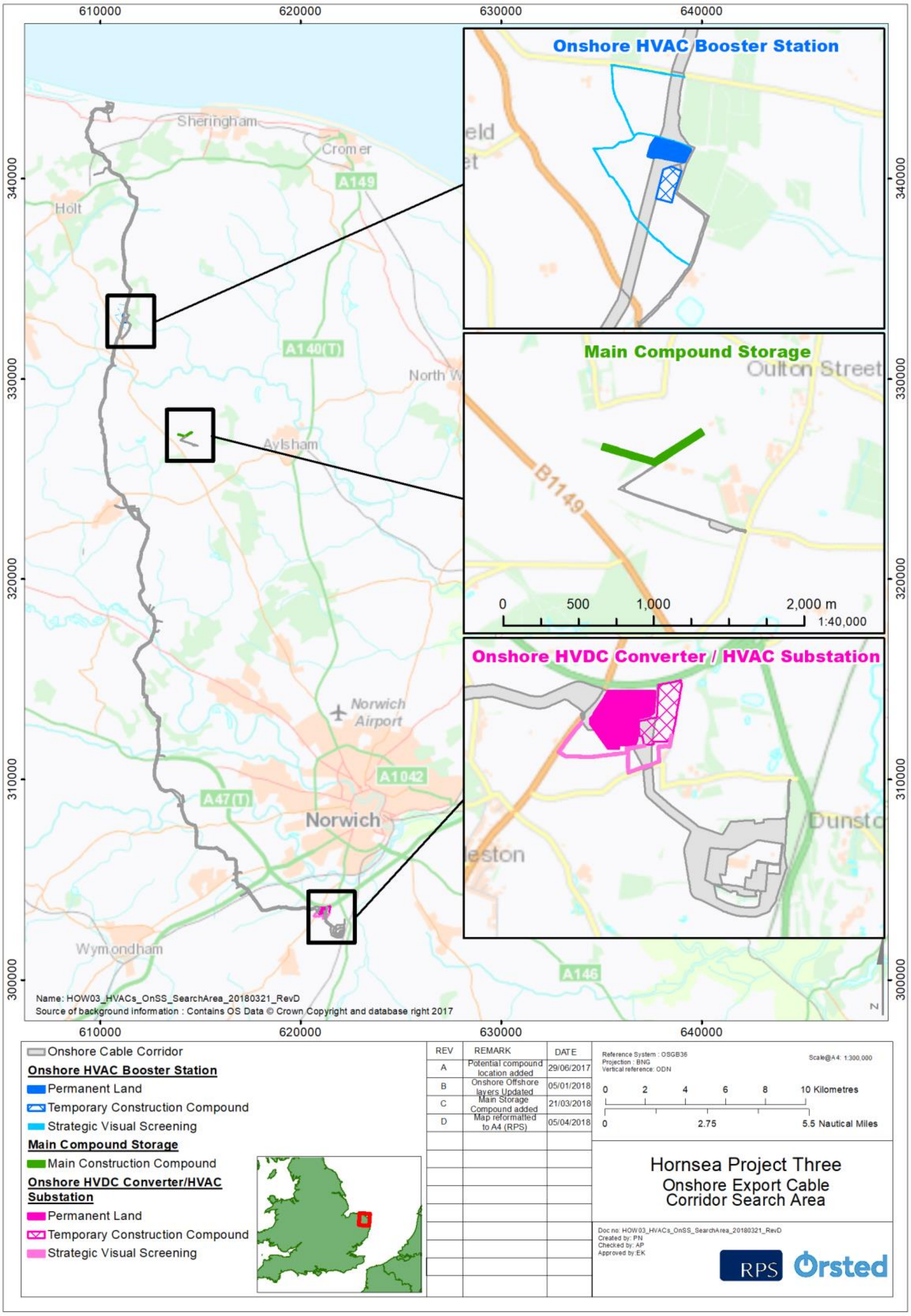

Figure 3.2: Onshore export cable route and locations for onshore HVAC booster station and onshore HVDC converter/HVAC substation.

Figure 3.3: Landfall and onshore export cable route corridor.

4. Description of Grid Connection Works

4.1 Transmission system

4.1.1.1 The Development Consent application for Hornsea Three contains the electrical grid connection works required for Hornsea Three. The wind farm transmission system is used to transport the power produced at the turbines and delivered by the array cables, to the UK National Grid. The system transforms the Medium Voltage (MV) power produced at the turbines to High Voltage at the offshore transformer substations (located in the Hornsea Three array area), and transports this via export cables and a number of other offshore and onshore components (Table 4.1).

4.1.1.2 The transmission system is usually designed, paid for and constructed by the wind farm developer (Orsted Hornsea Project Three (UK) Ltd), but under the Energy Act 2004 and the Electricity (Competitive Tenders for Offshore Transmission Licences) Regulations 2009 such assets must be purchased by an Offshore Transmission Operator (OFTO) after the wind farm is constructed in a transaction overseen by the Office of Gas and Electricity Markets (Ofgem). It is also possible that the transmission asset may be designed, procured and installed by the OFTO, however the design and installation parameters are still to be consented through this application.

4.2 Project capacity

4.2.1.1 Hornsea Three will have a capacity of approximately 2.4 GW. The total capacity of the turbines themselves may exceed 2.4 GW in order to compensate for electrical losses, as well as for turbine shut down for maintenance. However, the total number and dimensions of turbines would not exceed that stated within volume 1, chapter 5: Project Description of the Environmental Statement (document reference number A6.1.3) that accompanies this application for Development Consent.

4.3 HVAC/HVDC transmission systems

4.3.1.1 There are a range of transmission system designs that can be used to transport the power from the Hornsea Three array area to the UK National Grid. These fall under two primary transmission types; HVAC or HVDC. Both transmission types have a range of relative benefits and drawbacks. Offshore wind farms have traditionally used HVAC connections in the UK; however, HVDC connections become more technically and/or economically viable in the context of far from shore projects and have been used on a number of projects in Germany. Hornsea Three requires flexibility in transmission system choice to ensure that anticipated changes in available technology and project economics can be accommodated within the Hornsea Three design, and will make a decision on which transmission type to use during the detailed design phase (post consent). For this reason, both technologies are included in this application for Development Consent.

4.3.1.2 An overview of the main differences between the component requirements between the two technologies are outlined in Table 4.1.

Table 4.1: Infrastructure required for High Voltage Alternating Current (HVAC) and High Voltage Direct Current (HVDC) systems (required (Y), may be required (M), not required (N)).

Component	HVAC	HVDC	Comment
Offshore transformer substation(s)	Y	M	HVDC: may be combined with converter substation
Offshore interconnector cable(s)	M	M	Interconnector cables may be required between offshore substations to provide reduncancy in case of cable failure depending on the number of substations used..
Offshore HVDC converter substation(s)	N	Y	-
Offshore export cable(s)	Y	Y	-
Offshore HVAC booster station(s)	M	N	HVAC: onshore and/or offshore HVAC booster station required. The need for offshore and /or onshore will be determined based on final electrical design.
Onshore HVAC booster station	M	N	
Onshore export cable(s)	Y	Y	
Onshore HVDC converter/HVAC substation	Y	Y	HVDC systems require a taller building height (up to 25m) (ES worst case) to accommodate the converter apparatus, where HVAC requires a reduced building height (up to 15m) to accommodate the substation apparatus. Both transmission technologies require the same permanent area footprint.
Grid connection export cable	Y	Y	-
Table Key	*Required (Y)*	*May be required (M)*	*Not required (N)*

4.4 Circuit description

4.4.1.1 A circuit is an electrical system that allows the flow of electrons from one location to another. Typical HVAC transmission systems are three phase designs and require three conductors per electrical circuit to transport the power. Offshore these three conductors are usually combined into a single cable. Onshore these three conductors are usually housed within one cable per conductor (so three cables per circuit) (Table 4.2).

4.4.1.2 HVDC transmission systems require up to two conductors per circuit to transport the power. Offshore, these are generally housed in separate cables but these cables may be installed together. Onshore these conductors are housed in separate cables (Table 4.2).

Table 4.2: Cables required per circuit.[1]

	HVAC	HVDC
Offshore cables/circuit	1	2 [a]
Onshore cables/circuit	3	2
a Two HVDC offshore cables may be bundled together and installed simultaneously.		

4.5 Onshore substation

4.5.1.1 Hornsea Three may use HVAC or HVDC transmission, or could use a combination of both technologies in separate electrical systems. Depending on which transmission option is selected, including if it is a combination, either a HVAC substation or a HVDC converter substation will likely be required. For the remainder of this section, when “onshore HVDC converter/HVAC substation” is used, it is taken to mean the onshore HVDC converter substation or the HVAC substation unless otherwise stated.

4.5.1.2 The onshore HVDC converter/HVAC substation contains the electrical components for transforming the power supplied from the offshore wind farm to 400 kV. It also adjusts the power quality and power factor, as required to meet the UK Grid Code for supply to the National Grid. Electrical components include: transformers, reactors, dynamic reactive power compensation plant (As Static Compensator (STATCOM)) filters and switchgear. If an HVDC system is used it will also house equipment to convert the power from HVDC to HVAC. They also house auxiliary and supporting equipment and facilities for operating, maintaining, controlling and running the substation and to access the compound by vehicles and trucks.

4.5.2 Location

4.5.2.1 Hornsea Three will connect to the National Grid at the Norwich Main 400 kV substation, located between Swardeston and Stoke Holy Cross in South Norfolk. The Hornsea Three onshore HVDC converter/HVAC substation is located just south of the A47, to the north east of Swardeston (Figure 3.2).

[1] Irrespective of the electrical system chosen (AC or DC) the total number of export cables will not exceed 6 offshore and 18 onshore.

5. Offshore Cable Installation

5.1 Cable installation methods

5.1.1 Pre-installation activities (offshore cables)

5.1.1.1 A number of activities may be carried out prior to the cable installtion to prepare the offshore cable corridor for the works. These include:

- Geophysical and geotechnical surveys;
- Unexploded Ordnance clearance;
- Boulder clearance;
- Pre-Lay Grapnel Run; and
- Sandwave clearance;

5.1.1.2 Further details of each of these methods is provided in the Environmental Statement, volume 1, chapter 3: Project Description that accompanies this application for Development Consent (document reference number A6.1.3).

5.1.2 Array cables

5.1.2.1 Array cables will connect groups, or 'strings', of turbines in the array area to the offshore transformer substation(s). It is expected that up to 830 km of array cable will be required with 10% of these potentially requiring cable protection (further details of cable protection in section 6.1.5).

5.1.2.2 Possible installation methods include jetting, vertical injection, cutting and ploughing whereby the seabed is opened and the cable laid within the trench simultaneously using a tool towed behind the installation vessel. Alternatively, a number of these operations such as jetting, cutting or Mass Flow Excavation (MFE) may occur post cable lay. The Maximum Design Scenario for Array Cables is outlined in Table 5.1 and Table 5.2.

5.1.2.3 It may also be necessary to install the cable by pre-trenching or rock cutting whereby a trench is opened in one operation and then the cable laid subsequently from another vessel. Hornsea Three may also need to dredge the cable route prior to installation in order to level sandwaves that may hinder installation. Where pre-trenching or rock cutting is employed, and there is a gap between this activity and cable installation, in some areas the trench may partially collapse, or infill. In these cases pre-sweeping may have to be performed to clear the trench prior to installation. Pre-sweeping typically comprises the use of a jetting tool, targeted to remove the material that has partially infilled the trench.

Table 5.1: Maximum design scenario: array cable installation.

Parameter	Maximum design parameters
Installation methodology	Trenching, dredging, jetting, ploughing, mass flow excavation, vertical injection, rock cutting
Burial depth	Typically 1 to 2 m. Dependent on CBRA [a]
Width of seabed affected by installation (m)	15
Total seabed disturbed (km^2)	12.5
Seabed disturbance (m^2)	12,450,000
Burial spoil: ploughing/mass flow excavation (m^3)	4,980,000
Duration: per array link (days)	3
Duration: total (months)	30

a Typically the cable will be buried between 1 to 2 m, but in some areas could be buried up to 3 m. A Cable Burial Risk Assessment (CBRA) will inform cable burial depth, dependent on ground conditions as well as external risks. This assessment will be undertaken post-consent.

Table 5.2: Maximum design scenario: array cable installation – rock placement.

Parameter	Maximum design scenario
Height of rock berm (m)	2
Width of rock berm (m)	7
Percentage of route requiring protection	10
Replenishment during operations (% of construction total)	25
Cable rock protection: maximum rock size (m)	1, 0.25 in the Cromer Shoals Chalkbed MCZ
Rock protection area (m^2)	581,000
Rock protection volume (m^3)	830,000
Number of crossings (estimate)[a]	35
Cable/pipe crossings: total impacted area (m^2) [a]	87,500
Cable/pipe crossings: pre-lay rock berm volume (m^3) [a]	21,875
Cable/pipe crossings: post-lay rock berm volume (m^3) [a]	70,000

a Crossings include crossings for interconnector cables.

5.1.3 Offshore interconnector cables

5.1.3.1 Hornsea Three may require power cables to interconnect the offshore substations in order to provide redundancy in the case of cable failure elsewhere, to provide power during commissioning, when all export circuits may not be installed, or to connect to the offshore accommodation platforms in order to provide power for operation. The cables will have a similar design and installation process to the offshore export cables and array cables (Table 5.3). There could be up to 225 km of these cables with a voltage of up to 600 kV.

Table 5.3: Maximum design scenario: offshore interconnector cables installation.

Parameter	Maximum design scenario
Installation methodology	Trenching, dredging, jetting, ploughing, mass flow excavation, vertical injection, rock cutting
Burial Depth	Typically 1-2m. Dependent on CBRA [a]
Total seabed disturbance (m^2)	3,375,000
Burial spoil: jetting (m^3)	497,250
Burial spoil: ploughing/mass flow excavation (m^3)	1,350,000
Cable crossings	See Table 5.2 (due to the uncertainty of the specific location of interconnector and array cables at this point in time, the details for crossings interconnector and array cable have been summed)
Rock protection area (m^2)	157,500
Rock protection volume (m^3)	225,000

5.1.4 Export cables

5.1.4.1 Offshore export cables are used for the transfer of power from the offshore substations to the landfall point. For HVAC transmission systems, offshore export cables will carry electricity from the offshore transformer substations to the offshore HVAC booster station(s), if these are included in the project design, and then on to the landfall. For HVDC transmission systems, offshore export cables will carry electricity from the offshore transformer substations to the offshore HVDC converter substations and then to the landfall. Up to six offshore export cables, with a voltage of up to 600 kV for an HVDC transmission system, and 400 kV for an HVAC transmission system will be required for Hornsea Three.

5.1.4.2 Hornsea Three requires flexibility in type, location, depth of burial and protection measures for export cables to ensure that anticipated physical and technical constraints and changes in available technology and project economics can be accommodated within the Hornsea Three design.

5.1.4.3 The final export cable installation methodology will be defined by a detailed Cable Burial Risk Assessment (CBRA) which will support the development of a Cable Specification and Installation Plan as secured in the Deemed Marine Licence (Draft Development Consent Order including Draft Deemed Marine Licences, document reference number A3.1). Typically, the cable will be buried between 1 and 2 m. The CBRA will inform cable burial depth which will be dependent on ground conditions as well as external risks. This assessment will be undertaken post-consent.

5.1.4.4 It is likely the installation techniques will consist of one or a combination of trenching, dredging, jetting, ploughing, vertical injection, Mass Flow Excavation (MFE) and rock cutting (Table 5.4).

5.1.4.5 Cables will be buried wherever possible, with exceptions where this is not technically feasible, or where third party assets are crossed (further details in section 5.1). Up to 10% of the total export cable length may require protection due to ground conditions, burial tool breakdown, burial tool change or other unforeseen circumstances (this excludes cable protection due to cable crossings Table 5.5). Up to 10% of the export cable within the designated sites may include cable protection (further details of cable protection in section 6.1.5).

Table 5.4: Maximum design scenario: offshore export cables installation.

Parameter	Maximum design scenario
Installation methodology	Trenching, dredging, jetting, ploughing, mass flow excavation, vertical injection, rock cutting
Seabed disturbance – within Chromer Shoals Chalk Beds MCZ (m^2)	60,000
Seabed disturbance – within The Wash and North Norfolk Coast SAC (m^2)	999,000
Seabed disturbance – within North Norfolk Sandbanks and Saturn Reef SAC (m^2)	4,230,000
Seabed disturbance – outside designated sites (m^2)	9,351,000
Seabed disturbance – total (m^2)	14,640,000
Rock protection area (m^2)	802,200
Rock protection volume (m^3)	1,146,000
Burial spoil: jetting (m^3)	2,532,660
Burial spoil: ploughing/mass flow excavation (m^3)	6,876,000
Duration (months) (total whether over one of two phases)	36

Table 5.5: Maximum design scenario: offshore export cables crossings.

Parameter	Maximum design parameters
Number of external assets requiring crossing in Cromer Shoal Chalk Beds MCZ	0
Number of external assets requiring crossing in North Norfolk Sandbanks and Saturn Reef SAC	20
Number of external assets requiring crossing in The Wash and North Norfolk Coast SAC	0
Number of external assets requiring crossings outside of the Cromer Shoal Chalk Beds MCZ, The Wash and North Norfolk Coast SAC and North Norfolk Sandbanks and Saturn Reef SAC	24
Replenishment during operations (% of construction total)	25
Cable/pipe crossings: total seabed area – per crossing (m^3)	2,500
Cable/pipe crossings: total seabed rock volume including operation – per crossing (m^3)	2,625
Cable/pipe crossings: total seabed area (m^2)	660,000
Cable/pipe crossings: total seabed rock volume including operation (m^3)	693,000
Rock protection area (m^2)	802,200
Rock protection volume (m^3)	1,146,000

5.1.5 Cable protection

5.1.5.1 The preference for cable protection is to acheive the required cable burial depth as determined through the CBRA. Array, interconnector and export cables will need to be made secure where the cable crosses obstacles such as exposed bedrock, pre-existing cables or pipelines that mean the cable cannot be buried. In order to achieve the greatest chance of successful cable burial to the depths set out in the CBRA, a number of activities may be carried out prior to the cable installtion works. These include: rock placement (rock protection), concrete mattresses, fronded mattresses, rock bags, and seabed spacers among others. Concrete mattresses will not be used as a method of cable protection in the environmentally designated sites except where required for crossing existing assets. Further details of each of these methods is provided in the Environmental Statement, volume 1, chapter 3: Project Description (document reference number A6.1.3) that accompanies this application for Development Consent.

5.1.5.2 Where cables need to be installed across other cables or pipelines already in place on the seabed, the cable installation depth will be made gradually shallower on either side of the crossing. At the crossing itself the cable will generally be laid on a separation layer (normally rock) to further protect the cable underneath. The lengths of cable that are exposed or buried to a shallow depth will then have cable protection installed over top of them.

5.1.6 Landfall works

5.1.6.1 The techniques used to carry out the landfall works broadly fall in to two categories; open cut installation or trenchless techniques (i.e. HDD or thrust boring). However, it may also be the case that the HDD is not possible or preferred (due to ground conditions, cable design, or other factors), in which case open cut techniques would be required to install the cable from offshore to the Transition Joint Bays (TJBs) (section 6.1).

5.1.6.2 The works at the landfall would primarily be the same irrespective of whether HVAC or HVDC transmission is selected.

5.1.6.3 Open cut installation would be carried out using one of a number of methods. Installation tools, such as ploughs, rock cutters or jetting tools, similar to those used offshore, can be pulled from the offshore installation vessel, or from winches within the TJB working area, (within the Landfall Construction Compound) over a pre-laid cable to simultaneously open a trench, place the cable in the trench, and cover the cable. Alternatively, the trenching tool may open a trench in advance, the cable would be lowered into this trench and covered, after it has been pulled across the beach.

5.1.6.4 HDD involves drilling a long parabolic borehole underneath the intertidal area and shingle beach using a drilling rig located in the TJB works area on the landward side of the sea defences. Once the HDD drilling has taken place the ducts (within which the cable will be installed) are pulled through the drilled hole. These ducts are either constructed offsite, then sealed and floated to the site by tugs, or will be constructed within the landfall construction compound and, if required within the onshore export cable at landfall, then pulled over the beach on rollers. The ducts are then pulled back through the drilled hole either by the HDD rig or by separate winches. When the offshore export cable is installed it is pulled through the pre-installed HDD ducts by winches in the TJB working area.

5.1.6.5 Alternatively, self-powered bespoke installation tools may be used. These are usually tracked vehicles, that excavate a trench, lay the cable, and then bury the cable simultaneously. Alternatively, they may excavate a trench in advance, then post lay the cable after the pull to the TJB. They are similar to the tools described above, but are self-powered vehicles that are either controlled from on board the vehicles themselves, or are Remotely Operated Vehicle type systems, controlled from and connected to the offshore installation vessel.

5.1.6.6 Traditional mechanical excavators, similar to those that would be used to dig TJBs and exit pits etc., can also be used for cable installation. In this process, the cable would be pulled from the offshore installation vessel through the intertidal area on rollers placed on the ground. The cable would then be moved from the rollers into a neighbouring trench usually excavated before the cable is laid across the beach.

5.1.6.7 Further details of each landfall cable installation method is provided in the Environmental Statement, volume 1, chapter 3: Project Description (document reference number A6.1.3).

6. Onshore Cable Installation

6.1 Transition Joint Bays

6.1.1.1 The offshore export cables are connected to the onshore export cables at the TJBs which would be located in the Landfall Construction Compound. There would be a maximum of six TJBs, buried at a maximum depth of 6 m.

6.1.1.2 TJBs are pits dug and lined with concrete, in which the jointing of the offshore and onshore export cables takes place. One TJB is required per export cable circuit. They are constructed to ensure that the jointing can take place in a clean, dry environment, and to protect the joints once completed. Once the joint is completed the TJBs are covered and the land above reinstated. It is not expected that the TJBs will need to be accessed during the operation of the wind farm, however link boxes need to be located nearby that do require access during the operational phase, these will also be reinstated but may have manhole covers for access (further details on link boxes and TJBs in section 6.2.5).

6.1.1.3 During landfall works, a landfall construction compound is required on the onshore side of the beach. This will house the TJB works as well as any HDD works, including supporting equipment and facilities.

6.2 Onshore cable installation

6.2.1 Pre-installation activities (onshore cables)

6.2.1.1 A number of activities may be carried out prior to the cable installtion to prepare the onshore cable corridor for the works. These include:

- Ground investigations;
- Soil surveys;
- Drainage Management;
- Ecological surveys (volume 3, chapter 3: Ecology and Nature Conservation);
- Archaeological surveys (volume 3, chapter 5 : Historic Environment);
- Identification of water crossings (Appendix B Outline Method Statement for Crossing Techniques to the Outline Code of Construction Practice);
- Hedge removal and vegetation clearance (volume 3, chapter 3: Ecology and Nature Conservation and Outline Ecological Management Plan);
- Demarcation fencing for the cable easement;
- Access points off the highway installed; and
- Temporary haul road constructed.

6.2.1.2 These works are generally non intrusive or, such as archaeological investigations, targeted excavations. Further details of each of these methods is provided in the Environmental Statement, volume 1, chapter 3: Project Description (document reference number A6.1.3) that accompanies this application for Development Consent.

6.2.2 Onshore cable corridor permanent works

6.2.2.1 The Hornsea Three onshore cable corridor permanent works may consist of:

- Up to six cable circuits for HVAC or up to four for HVDC plus an HVAC cable circuit;
- The cables will be buried in multiple separate trenches (up to six trenches, each containing one circuit), however in some circumstances some trenches may be combined to aid installation.
- Various crossings, located where necessary to pass various obstructions;
- Jointing pits, which will be located every 750 m to 2,500 m along each cable circuit; and
- Link boxes and associated manhole covers, which will be connected to some of the jointing pits but located away from them but within the onshore cable route corridor.

6.2.3 Open trench cable installation methodology

6.2.3.1 Onshore export cable trenches will be up to 2 m deep, 1.5 m wide at the base and 5 m width at the surface. These dimensions allow for the trench walls to be tapered as necessary for stability. The trenches will be excavated using a mechanical excavator.

6.2.3.2 The export cables will be installed into the open trench from a cable drum delivered to site via HGV. The cables are buried in a layer of stabilised backfill material that ensures a consistent structural and thermal environment for the cables. All backfill from the trenches will remain on site.

6.2.3.3 The remainder of 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 ensure the cable is not damaged by any third party. Once the export cables are installed and the trenches backfilled, the stored topsoil will be replaced and the land reinstated back to its previous use. Each trench section between joint bays is expected to be open for approximately one week.

6.2.3.4 Alternatively, ducts could be installed in the trenches in the same manner as above, and the cables can then be pulled through the ducts from the joint bays. This technique decouples the trenching from the cable installation and therefore could provide more flexibility for the installation process to optimise works and delivery of components. This installation method, however, results in poorer thermal characteristics. In addition, in a two phase construction scenario, the first phase would have to impact a larger area of land which, if, the second phase subsequently didn't come forwards, would have lead to unnecessary impacts and land sterilisation for certain activities.

6.2.4 'Trenchless' duct installation methods

6.2.4.1 Various 'trenchless' techniques such as HDD, thrust boring, auger boring and pipe ramming could be used to install ducts underneath obstructions or infrastructure that the cables must cross without breaking open the ground and digging a trench. The onshore export cables and associated fibre optic cables can then be pulled into these ducts.

6.2.5 Link Boxes

6.2.5.1 Link boxes (LBs) will also be required along the Hornsea Three onshore cable corridor. They would contain cross connections between the cable shielding, arrangements for earthing, fibre optic joints, and fibre optic signal boosting equipment. These are smaller pits compared to joint bays which house connections between the cable shielding, joints for fibre optic cables and other auxiliary equipment. They will be up to 3 m wide by 3 m long and at a depth of up to 2 m. Land above the link boxes will also be reinstated, however, they may need manhole covers for access during the operational phase.

6.3 Reinstatement

6.3.1.1 Following completion of the onshore cable installation, the working area will be reinstated to its previous condition. Hornsea Three may be split into up to two phases. If a two-phased programme of works takes place, some reinstatement may take place after the initial phase of construction. Reinstatement will include:

- Reinstatement of intertidal area;
- Reinstatement of topsoil and subsoil so that normal agricultural practice can resume;
- Reinstatement of land drainage systems and, where necessary, installing a drain typically parallel to the cable route post construction;
- Reseeding of any fields of grassland, grass margins and ditch banks;
- Reconstruction of any drains, ditches or roads crossed using an open cut method;
- Replanting of any hedgerows and shrubs in consultation with the local planning authority;
- Restoration or repair of fences, gates, tracks, or hard standings;
- Reinstatement of Public Rights of Way along their former alignments where temporary diversions have been put in place during construction;
- Replacing topsoil where it has been stripped; and
- Loosening or ripping subsoil where it may have been heavily compacted.

7. Status of Grid Connection

7.1.1.1 The current Grid Connection Agreement for Hornsea Three is for a connection at Norwich Main substation in 2023/2024.