East Anglia ONE North Offshore Windfarm

Chapter 6

Project Description

Environmental Statement Volume 1

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Glossary of Acronyms

AIS	Air Insulated Switchgear
AONB	Area of Outstanding Natural Beauty
CAA	Civil Aviation Authority
CBS	Cement Bound Sand
CCS	Construction Consolidation Sites
CPT	Cone Penetration Test
DCO	Development Consent Order
DP	Dynamic Positioning
EIA	Environmental Impact Assessment
EMF	Electromagnetic Fields
ES	Environmental Statement
GIS	Gas Insulated Switchgear
HAT	Highest Astronomical Tide
HDD	Horizontal Directional Drilling
HVAC	High Voltage Alternating Current
IALA	International Association of Marine Aids to navigation and Lighthouses Authority
LAT	Lowest Astronomical Tide
NGET	National Grid Electricity Transmission
NPPF	
O&M	Operation and Maintenance
PEIR	Preliminary Environmental Information Report
PLGR	Pre-Lay Grapnel Run
PRoW	Public Rights of Way
ROV	Remotely Operated Vehicle
SCADA	Supervisory Control and Data Acquisition
SuDS	Sustainable Drainage System
THLS	Trinity House Lighthouse Services
UXO	Unexploded Ordnance

Glossary of Terminology

Applicant	East Anglia ONE North Limited.
Cable sealing end compound	A compound which allows the safe transition of cables between the overhead lines and underground cables which connect to the National Grid substation.
Cable sealing end (with circuit breaker) compound	A compound (which includes a circuit breaker) which allows the safe transition of cables between the overhead lines and underground cables which connect to the National Grid substation.
Construction consolidation sites	Compounds associated with the onshore works which may include elements such as hard standings, lay down and storage areas for construction materials and equipment, areas for vehicular parking, welfare facilities, wheel washing facilities, workshop facilities and temporary fencing or other means of enclosure.
Construction, operation and maintenance platform	A fixed offshore structure required for construction, operation, and maintenance personnel and activities.
Development area	The area comprising the Onshore Development Area and the Offshore Development Area (described as the 'order limits' within the Development Consent Order).
East Anglia ONE North project	The proposed project consisting of up to 67 wind turbines, up to four offshore electrical platforms, up to one construction, operation and maintenance platform, inter-array cables, platform link cables, up to one operational meteorological mast, up to two offshore export cables, fibre optic cables, landfall infrastructure, onshore cables and ducts, onshore substation, and National Grid infrastructure.
East Anglia ONE North windfarm site	The offshore area within which wind turbines and offshore platforms will be located.
European site	Sites designated for nature conservation under the Habitats Directive and Birds Directive, as defined in regulation 8 of the Conservation of Habitats and Species Regulations 2017 and regulation 18 of the Conservation of Offshore Marine Habitats and Species Regulations 2017. These include candidate Special Areas of Conservation, Sites of Community Importance, Special Areas of Conservation and Special Protection Areas.
Horizontal directional drilling (HDD)	A method of cable installation where the cable is drilled beneath a feature without the need for trenching.
HDD temporary working area	Temporary compounds which will contain laydown, storage and work areas for HDD drilling works.
Inter-array cables	Offshore cables which link the wind turbines to each other and the offshore electrical platforms. These cables will include fibre optic cables.
Jointing bay	Underground structures constructed at intervals along the onshore cable route to join sections of cable and facilitate installation of the cables into the buried ducts.
Landfall	The area (from Mean Low Water Springs) where the offshore export cables would make contact with land and connect to the onshore cables.
Link boxes	Underground chambers within the onshore cable route housing electrical earthing links.
Meteorological mast	An offshore structure which contains metrological instruments used for wind data acquisition.

Mitigation areas	Areas captured within the onshore development area specifically for mitigating expected or anticipated impacts.
Marking buoys	Buoys to delineate spatial features / restrictions within the offshore development area.
Monitoring buoys	Buoys to monitor *in situ* condition within the windfarm, for example wave and metocean conditions.
National electricity grid	The high voltage electricity transmission network in England and Wales owned and maintained by National Grid Electricity Transmission.
National Grid infrastructure	A National Grid substation, cable sealing end compounds, cable sealing end (with circuit breaker) compound, underground cabling and National Grid overhead line realignment works to facilitate connection to the national electricity grid, all of which will be consented as part of the proposed East Anglia ONE North project Development Consent Order but will be National Grid owned assets.
National Grid overhead line realignment works	Works required to upgrade the existing electricity pylons and overhead lines (including cable sealing end compounds and cable sealing end (with circuit breaker) compound) to transport electricity from the National Grid substation to the national electricity grid.
National Grid overhead line realignment works area	The proposed area for National Grid overhead line realignment works.
National Grid substation	The substation (including all of the electrical equipment within it) necessary to connect the electricity generated by the proposed East Anglia ONE North project to the national electricity grid which will be owned by National Grid but is being consented as part of the proposed East Anglia ONE North project Development Consent Order.
National Grid substation location	The proposed location of the National Grid substation.
Natura 2000 site	A site forming part of the network of sites made up of Special Areas of Conservation and Special Protection Areas designated respectively under the Habitats Directive and Birds Directive.
Offshore cable corridor	This is the area which will contain the offshore export cables between offshore electrical platforms and landfall.
Offshore development area	The East Anglia ONE North windfarm site and offshore cable corridor (up to Mean High Water Springs).
Offshore electrical infrastructure	The transmission assets required to export generated electricity to shore. This includes inter-array cables from the wind turbines to the offshore electrical platforms, offshore electrical platforms, platform link cables and export cables from the offshore electrical platforms to the landfall.
Offshore electrical platform	A fixed structure located within the windfarm area, containing electrical equipment to aggregate the power from the wind turbines and convert it into a more suitable form for export to shore.
Offshore export cables	The cables which would bring electricity from the offshore electrical platforms to the landfall, these cables will include fibre optic cables.
Offshore infrastructure	All of the offshore infrastructure including wind turbines, platforms, and cables.
Offshore platform	A collective term for the construction, operation and maintenance platform and the offshore electrical platforms.
Onshore cable corridor	The corridor within which the onshore cable route will be located.

Onshore cable route	This is the construction swathe within the onshore cable corridor which would contain onshore cables as well as temporary ground required for construction which includes cable trenches, haul road and spoil storage areas.
Onshore cables	The cables which would bring electricity from landfall to the onshore substation. The onshore cable is comprised of up to six power cables (which may be laid directly within a trench, or laid in cable ducts or protective covers), up to two fibre optic cables and up to two distributed temperature sensing cables.
Onshore development area	The area in which the landfall, onshore cable corridor, onshore substation, landscaping and ecological mitigation areas, temporary construction facilities (such as access roads and construction consolidation sites), and the National Grid Infrastructure will be located.
Onshore infrastructure	The combined name for all of the onshore infrastructure associated with the proposed East Anglia ONE North project from landfall to the connection to the national electricity grid.
Onshore preparation works	Activities to be undertaken prior to formal commencement of onshore construction such as pre–planting of landscaping works, archaeological investigations, environmental and engineering surveys, diversion and laying of services, and highway alterations.
Onshore substation	The East Anglia ONE North substation and all of the electrical equipment within the onshore substation and connecting to the National Grid infrastructure.
Onshore substation location	The proposed location of the onshore substation for the proposed East Anglia ONE North project.
Platform link cable	Electrical cable which links one or more offshore platforms. These cables will include fibre optic cables.
Safety zones	A marine area declared for the purposes of safety around a renewable energy installation or works / construction area under the Energy Act 2004.
Scour protection	Protective materials to avoid sediment being eroded away from the base of the foundations as a result of the flow of water.
Transition bay	Underground structures at the landfall that house the joints between the offshore export cables and the onshore cables.

6 Project Description

6.1 Introduction

1. This chapter provides a description of the components required for construction, operation and decommissioning of the proposed East Anglia ONE North project and the methods of installation. This description provides the basis for the assessments provided in ***Chapters 7*** to ***30*** of this Environmental Statement (ES) and the basis on which the Development Consent Order (DCO) application is made.

2. A brief overview of the proposed East Anglia ONE North project is presented in ***section 6.2*** followed by an outline of the key project characteristics in ***section 6.3***. A detailed description of all aspects of the project is provided in ***sections 6.4*** to ***6.6*** which is divided into the following three areas:

- **Offshore** - wind turbines and associated foundations, offshore electrical platforms and associated foundations, offshore construction, operation and maintenance platform and associated foundations, a meteorological mast and its foundation, and offshore export cables, fibre optic cables, platform link cables and inter-array cables. This section also describes works required to construct and access these components;
- **Landfall** - bringing of offshore export cables ashore to connect to onshore cables within an underground transition bay; and
- **Onshore** - onshore cables, the onshore substation, National Grid infrastructure, highway improvements, landscaping and work to construct and access these components.

6.1.1 Project Design Envelope

3. ***Section 3.5*** of ***Chapter 3 Policy and Legislative Context*** provides a background to the project design envelope (or Rochdale envelope) approach.

4. The project design envelope sets out a series of realistic design assumptions from which worst case parameters are drawn for the proposed East Anglia ONE North project. The project design envelope has a reasoned maximum extent for a number of key parameters. The final design would lie within the maximum extent of the consent sought. The project design envelope is used to establish the maximum extent to which the proposed East Anglia ONE North project could impact on the environment. The detailed design of the proposed East Anglia ONE North project could then vary within this 'envelope' without rendering the assessment inadequate

5. The general principle of the assessment is that for each receptor topic, the impact assessment is based on a range of project design parameters (e.g. the maximum

tip height of wind turbines that could be installed would be 300m above lowest astronomical tide (LAT) with a maximum rotor diameter of 250m), the key being that those parameters selected represent the range of options within which the greatest environmental impact would occur. The end result is an Environmental Impact Assessment (EIA) based on clearly defined environmental parameters that would govern or define the full range of development possibilities and hence the likely environmental impacts that could flow from the grant of development consent.

6. Therefore, the information presented in this chapter covers the range of potential design parameters upon which the subsequent impact assessment chapters are based.

6.1.2 Project Description Terminology

7. This project description uses specific terms for different areas offshore and onshore. These terms are also used within the technical chapters (***Chapter 7 to Chapter 30***) and are outlined in the glossary on page (v).

6.2 Consultation

8. Consultation is a key feature of the EIA process, and continues throughout the lifecycle of a project, from its initial stages through to consent and post-consent. Consultation with regards to ***Chapter 6 Project Description*** has been undertaken with both statutory and non-statutory stakeholders, the former of which has been undertaken through the formal submission of the East Anglia ONE North Scoping Report (SPR 2017) and the Preliminary Environmental Information Report (PEIR) (SPR 2019). Furthermore, several Expert Topic Group (ETG) meetings held in 2017, 2018 and 2019 which involved both statutory and non-statutory consultees, have been undertaken to inform the various technical assessments within this ES, as detailed in the relevant chapters. Feedback received through this process has been considered in preparing the ES where appropriate and this chapter has been updated for the ES submitted with the DCO application.

9. The responses received from stakeholders with regards to the Scoping Report (SPR 2017), and the PEIR (SPR 2019) are summarised in ***Appendix 6.1***, including details of how these have been taken account of within this chapter.

10. Ongoing public consultation has been conducted, principally, through a series of Public Information Days (PIDs) and Public Meetings. PIDs have been held throughout Suffolk in November 2017, March 2018, June / July 2018 and February / March 2019. A series of stakeholder engagement events were also undertaken in October 2018 as part of phase 3.5 consultation. Consultation phases are explained further in ***Chapter 5 EIA Methodology.*** Full details of the proposed East Anglia ONE North project consultation process are presented in

the Consultation Report submitted as part of the DCO application (document reference 5.1).

6.3 Overview of the Project

11. The proposed East Anglia ONE North project would consist of up to 67 wind turbines. For the purposes of establishing the worst case scenarios in this ES, two indicative wind turbine models have been considered; a ‘250m’ and ‘300m’ which refers to each models’ maximum blade tip height (above LAT). The parameters associated with each represent the worst cases for impacts related to wind turbines within the Rochdale Envelope. Within each assessment it is clearly stated which indicative wind turbine model and number determines the worst case. The maximum wind turbine hub height used would be 175m (above LAT) with maximum rotor diameter of 250m. It is possible that more than one wind turbine model within the consented parameters would be used.

12. A construction, operation and maintenance (O&M) platform may be installed within the East Anglia ONE North windfarm site which would provide accommodation for the construction and maintenance work force. There is also potential for the installation of one meteorological mast.

13. Up to four High Voltage Alternating Current (HVAC) offshore electrical platforms (connected by platform link cables) would be installed offshore and would collect electricity from the wind turbines through a network of inter-array cables to then transport it to shore via up to two offshore export cables (each buried within a separate trench). The offshore cables would also include fibre optic cables either within the cables themselves or secured to the outside.

14. Once the offshore export cables enter the underground transition bay at the landfall, they will be joined to the onshore cables. There will be up to six single core onshore cables, up to two FO cables and up to two distributed temperature sensing cables. The onshore cable corridor shall follow the route shown in ***Figure 6.2***.

15. From the landfall, cables will be routed underground to an onshore substation which will in turn connect into the national electricity grid via a National Grid substation, cable sealing end compounds and a cable sealing end (with circuit breaker) compound to be owned and operated by National Grid. In addition, there will be a requirement to undertake upgrades to the existing pylons within the National Grid overhead line realignment works area. This will require the installation of one additional pylon to allow connection to the national electricity grid via new cable sealing ends.

16. The proposed East Anglia ONE North project and the proposed East Anglia TWO project are being developed in parallel but they have been submitted as two separate DCO applications. The assessment presented in this ES will assess the

impacts of the proposed East Anglia ONE North project alone and, through the use of appropriate assessment scenarios, the potential cumulative impacts with the proposed East Anglia TWO project.

17. The onshore development area has been developed to allow for the construction of both the proposed East Anglia ONE North and East Anglia TWO projects. At this stage, it is not known whether both projects would be constructed simultaneously or sequentially. Therefore, the onshore topic assessments (***Chapters 18 – 27***) include two cumulative assessment scenarios which are considered to represent the two worst case scenarios for construction of the onshore infrastructure.

18. Scenario 1 will assess the impacts of both the proposed East Anglia ONE North and East Anglia TWO projects being built simultaneously (i.e. at the same time). Scenario 2 will assess the impacts of the proposed East Anglia ONE North and East Anglia TWO projects being built sequentially (i.e. one after the other). For the onshore infrastructure Scenario 2 assumes construction of the first project and full re-instatement of the construction works, followed by the construction of the second project. It should be noted that overlapping programmes are covered by these two scenarios.

19. ***Appendix 6.3*** covers the differences for these two scenarios relevant to the project description.

6.4 Key Project Characteristics

20. This section summarises the key characteristics of the project design. The key offshore components of the proposed East Anglia ONE North project will comprise:

- Offshore wind turbines and their associated foundations;
- Offshore platforms - up to four offshore electrical platforms and their associated foundations supporting some of the windfarm's electrical equipment, and up to one construction, operation and maintenance platform and associated foundations that may cater for personnel and activities required during the construction phase and operation and maintenance of the windfarm;
- Sub-sea cables between the wind turbines and between wind turbines and offshore electrical platforms (inter-array), between separate offshore platforms (platform link cables) and between offshore electrical platforms and the landfall (export cables);
- Scour protection around foundations and on inter-array, platform link and export sub-sea cables as required; and

- Potential for one meteorological mast (met mast) and its associated foundations for monitoring wind speeds during the operational phase of the windfarm.

21. The key onshore components of the proposed East Anglia ONE North project, including infrastructure required by National Grid to connect the proposed East Anglia ONE North project to the national electricity grid, will comprise:

- The landfall site with up to two transition bays to connect the onshore and offshore cables;
- Up to six onshore cables up to two fibre optic cables and up to two distributed temperature sensing (DTS) cables installed underground (some or all of which may be installed in ducts) and associated jointing bays installed underground;
- Onshore substation;
- Electrical cable connection between onshore substation and National Grid substation;
- National Grid substation;
- Cable sealing end compounds and a cable sealing end (with circuit breaker) compound; and
- Realignment of the existing overhead lines; including the reconstruction or replacement of up to three existing overhead pylons in proximity to the National Grid substation and the addition of up to one new pylon in close proximity to existing overhead pylons.

6.5 Offshore

6.5.1 Offshore Site Description

22. The East Anglia ONE North windfarm site is located in the southern North Sea approximately 36km from its nearest point to the port of Lowestoft and 42km from Southwold. The East Anglia ONE North windfarm site and the offshore cable corridor are shown in ***Figure 6.1*** and the onshore development area is shown in ***Figure 6.2***. ***Table 6.1*** presents distances from the boundary of the East Anglia ONE North windfarm site to settlements along the UK coastline and to the nearest point of land in the Netherlands and Belgium.

Table 6.1 Distances from the Nearest Point of the East Anglia ONE North Windfarm Site to Other Selected Locations

Geographic Location	Distance from East Anglia ONE North Windfarm Site (km)
Lowestoft	36
Southwold	42

Geographic Location	Distance from East Anglia ONE North Windfarm Site (km)
Sizewell	51
Orford	60
Netherlands (nearest point to coast)	107
Belgium (nearest point to coast)	120

23. The East Anglia ONE North windfarm site will cover an area of approximately 208km^2. Water depths within the site range from 35 to 57m (relative to the LAT) with depth generally increasing in the west.

24. The proposed East Anglia ONE North project includes one potential offshore cable corridor route from the landfall to the East Anglia ONE North windfarm site (***Figure 6.1***). The route passes to the north of the Southwold Aggregates Area and Southwold Transhipment Area.

6.5.2 Offshore Project Details Summary

25. This section details the characteristics of the offshore elements of the proposed East Anglia ONE North project. Key characteristics are listed in ***Table 6.2*** below and are discussed in more detail separately within the text.

Table 6.2 Offshore Parameters

Parameter	Characteristic
Number of wind turbines	Up to 67
East Anglia ONE North windfarm site area	208km^2
East Anglia ONE North windfarm site water depth range	35 - 57m (LAT)
Distance from East Anglia ONE North windfarm site to shore (closest point of site to Lowestoft)	36km
Maximum offshore cable corridor area	133km^2
Maximum number of export cables (HVAC)	Two
Maximum cable lengths	• Inter-array – 200km • Platform link – 75km • Export – 152km
Maximum wind turbine rotor diameter	250m
Maximum wind turbine hub height (LAT)	175m
Maximum wind turbine tip height (LAT)	300m
Minimum clearance above sea level (MHWS)	22m

Parameter	Characteristic
Minimum separation between wind turbines*	In-row spacing: 800m
	Inter-row spacing: 1200m
Maximum number of wind turbine models to be installed	Three
Wind turbine foundation type options	Jacket, gravity base structure, suction caisson, jacket on suction caisson, monopile
Number of met masts	One
Maximum height of met mast (LAT)	175m
Met mast foundation type options	Jacket, gravity base structure, suction caisson, jacket on suction caisson, monopile
Number of offshore electrical platforms	Up to four
Number of construction, operation and maintenance platforms	Up to one

** These minimum separation distances have been established for the purpose of the EIA and are based on the minimum requirements that wind turbine suppliers would accept. The nominal spacing would exceed these distance (see* ***section 6.5.3.1****).*

6.5.3 Wind Turbines

26. The maximum wind turbine hub height used would be 175m (above LAT) with maximum rotor diameter of 250m and therefore a maximum tip height of up to 300m (above LAT) and a minimum clearance above sea level of 22m (MHWS).

27. Each wind turbine will comprise a tubular steel tower atop a foundation structure, a nacelle secured at the top of the tower and a rotor with three blades rotating around a horizontal axis. ***Plate 6.1*** presents a typical wind turbine; the dimensions of various characteristics of the wind turbines to be used would be within the parameters shown in ***Table 6.2***.

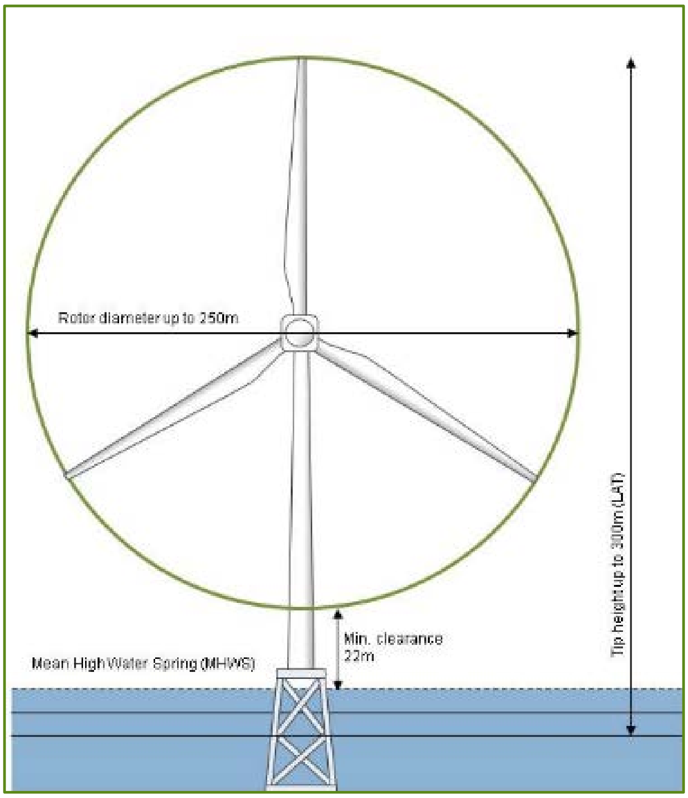

Plate 6.1 Key Dimensions of the Proposed Offshore Wind Turbines

28. The nacelle contains mechanical and electrical generating components, an example is displayed in ***Plate 6.2****.*

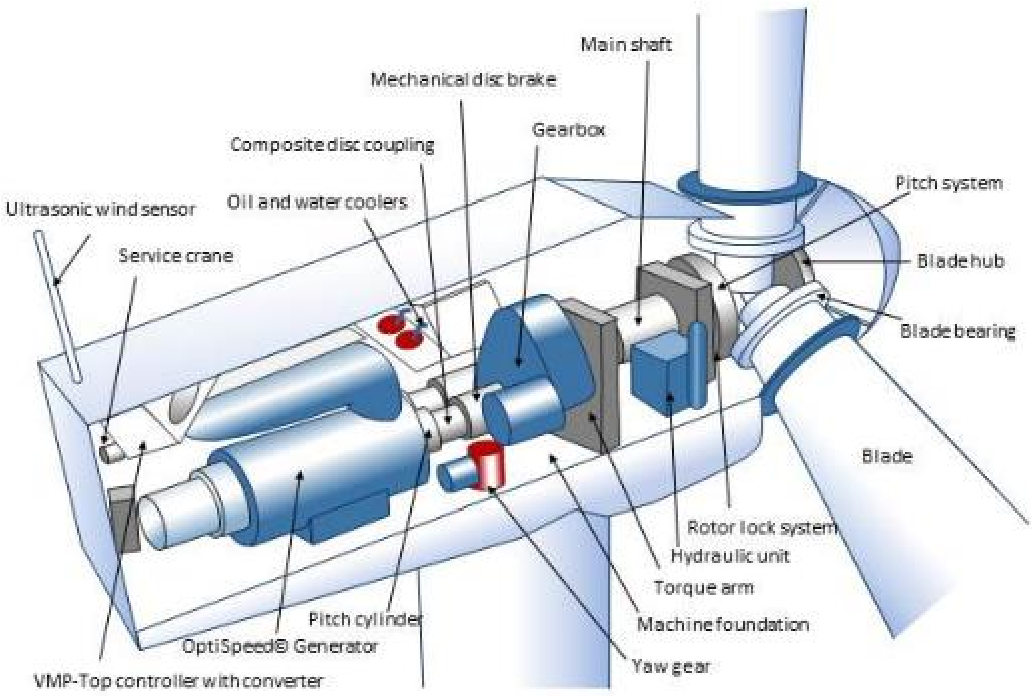

Plate 6.2 An Example of Internal Workings of a Wind Turbine Nacelle

6.5.3.1 Wind Turbine Layout

29. The layout of the East Anglia ONE North windfarm site, including wind turbines, inter-array, platform link cables and offshore platform locations have not yet been specified. Therefore, exact locations will not be included in the DCO application. This is due to the requirement for flexibility on layout pending further ground investigation, detailed design and commercial negotiations, and is one of the purposes of developing a project design envelope (as outlined in ***section 6.1.1)***. In developing the final layout, the Applicant would aim to minimise environmental impacts (e.g. through micro-siting) and impacts to other users whilst maximising energy yield and cost efficiency.

30. There is potential that the site would host more than one wind turbine type, with a maximum of three different models. At this stage, wind turbine types have not been determined.

31. The wind turbine layout can be described in general terms at this stage. The minimum separation between wind turbines would be:

- In-row spacing – 800m; and
- Inter-row spacing – 1,200m.

32. The in-row spacing is the distance separating wind turbines in the main rows, which are generally orientated perpendicular to the prevailing wind, or as close to this as is practical. Inter-row spacing is distance between the main rows. In-row spacing and inter-row spacing (spacing between rows) may vary across the site area. In the absence of detailed geophysical and geotechnical information, minimum separation distances are provided based on the likely requirements of wind turbine suppliers. The nominal separation distances are anticipated to be greater.

33. It should also be noted that there may be empty spaces within the East Anglia ONE North windfarm site for example for wake recovery but more likely due to less favourable ground conditions, e.g. locations with large mobile sand waves.

34. ***Chapter 14 Shipping and Navigation*** and the Navigational Risk Assessment (NRA***, Appendix 14.1***) that underpins that assessment is based on a 67 wind turbine layout.

35. The worst-case layout assessed for SLVIA is associated with 53 x 300m wind turbines, as shown in ***Figure 28.1*** of ***Chapter 28 Seascape, Landscape and Visual Impact Assessment***. This layout has the highest wind turbine blade tip height (300m), with largest rotor diameter (250m), with fewer wind turbines (compared to a 67 x 250m wind turbine model layout. The Rochdale Envelope would allow for wind turbines to be spread closer together however this is not considered the worst case for assessment. The 300m wind turbine layout

represents both the maximum wind turbine height and maximum lateral spread of wind turbines in the field of view on the horizon. Should the proposed East Anglia ONE North project be constructed with a wind turbine that has a blade tip height of less than 300m (with a 250m rotor swept area), or greater than 250m (with a 220m rotor swept area), the number of wind turbines could be more than 53 but fewer than 67 and dictated by factors such as the capacity at the onshore connection point, offshore site conditions and wind turbine spacing requirements. However, the worst case scenario assessed would still apply on the basis that the worst case is dictated by the largest turbines spread over the greatest lateral extent across the East Anglia ONE North windfarm site.

6.5.4 Foundations

36. ***Plate 6.3*** to ***Plate 6.6*** below illustrate typical wind turbine foundation types under consideration. The foundation types currently being considered for use are:

- Three or four-leg jackets on piles;
- Gravity base structures;
- Suction caissons;
- Three or four-leg jackets on suction caissons; and
- Monopiles.

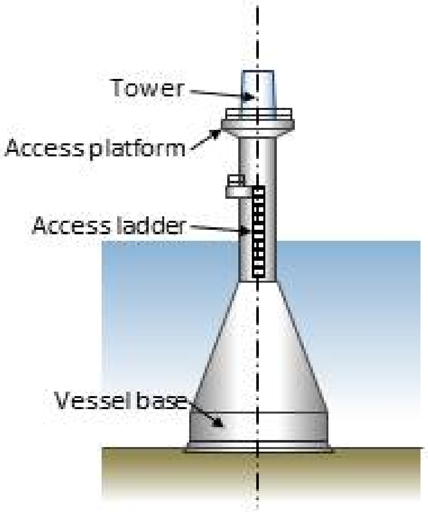

Plate 6.3 Typical Gravity Base Structure

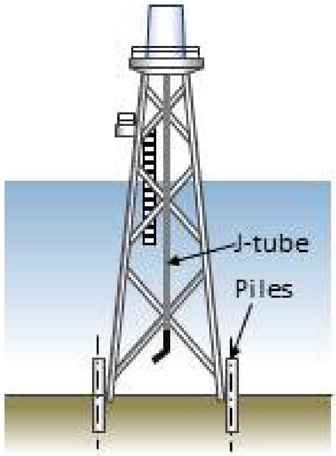

Plate 6.4 Typical Jacket

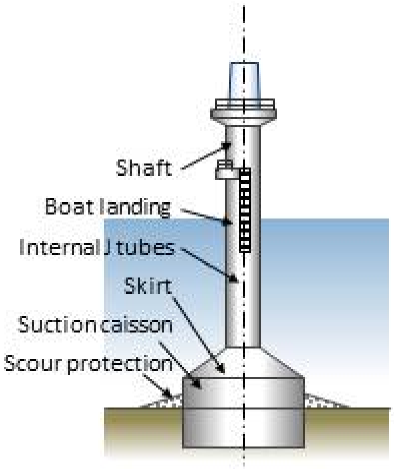

Plate 6.5 Typical Suction Caisson

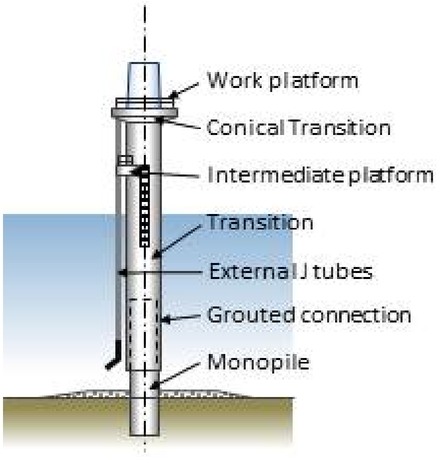

Plate 6.6 Typical Monopile

37. Foundation types would be selected following detailed design, based on suitability of the ground conditions, water depths and wind turbine models. There may be only one type used, or a combination of foundation types may be used across the East Anglia ONE North windfarm site.

38. On top of the foundations would be a platform known as a transition piece. The transition piece facilitates the connection between the foundation and the tower.

39. Foundation components would be manufactured onshore and delivered to site as close to fully assembled as practical. Pin piles, if used, would be installed separately and attached to the main structure at the offshore location. Monopile foundations, if used, would be installed first with surface structures lifted into place.

40. Fabrication, construction methods and requirements would all differ significantly depending on the foundation type selected.

6.5.4.1 Jacket Foundations

41. There are many variants of the jacket structure but there are three main categorisations:

- Pre-piled or post-piled;
- Three-legged or four-legged; and
- Straight or battered (angled) legs.

42. ***Plate 6.7*** shows three-legged jacket foundations being transported on a heavy lift vessel for installation at the East Anglia ONE windfarm site while ***Plate 6.8*** shows one of them part installed at the wind turbine foundation location of East Anglia ONE.

Plate 6.7 East Anglia ONE Three-Piled Jacket Foundations being Transported on a Heavy Lift Vessel

Plate 6.8 Three-Legged Jacket Foundation Part-Installed at the East Anglia ONE windfarm site

43. Maximum footprint sizes are outlined in ***Table 6.3*** below. The dimensions between pin pile centres are based on a square footprint.

Table 6.3 Four Pile Jacket Dimensions

Wind turbine model	Maximum leg spacing at sea bed (m)	Maximum footprint size per turbine (m^2)
250m	45 x 45	2,025
300m	52.6 x 52.6	2,766.76

44. Pin pile penetrations for jacket foundations could be up to 65m depth below sea bed. Pin piles are generally expected to be driven but drilling may be required at some locations with harder ground conditions. Other techniques, such as vibration, may also be required at some locations. This would be decided following pre-construction geotechnical surveys and receipt of interpretative reporting. Pin-pile size would vary depending on the specific design but is expected to be up to 4.6m in diameter. Pin piles are usually installed vertically but concepts are being considered that install piles on a batter (at an angle).

45. Suction caisson foundations could be used at the base of the jacket instead of pin piles. This is considered in ***section 6.5.4.3***.

6.5.4.1.1 Materials Required for Jacket Foundations

46. Jacket foundations are usually made of steel, although some secondary structures, such as handrails, gratings and ladders, could be produced using other metals, such as aluminium, or composites. Also, concrete could be used at the top of the jacket structure as part of a transition piece arrangement or just to form the working platform. The connection between the jacket structure and piles is often formed using cement grout.

6.5.4.1.2 Sea bed Preparation and Penetration for Jacket Foundations

47. Depending on the jacket concept and installation method selected, there may be a requirement to carry out minor sea bed preparation at some locations to provide a more level formation for placement of a pile installation template. ***Table 6.4*** outlines two scenarios, based on a single 250m and a single 300m wind turbine model on a jacket base structure.

Table 6.4 Estimated Dimensions of Sea Bed Preparation for Four Pile Jacket Foundations

Wind turbine model	Maximum area for sea bed preparation per wind turbine (m^2)	Maximum volume of sediment removed per wind turbine (m^3)
250m	5,737.5	19,125
300m	6,602.38	22,404.4

6.5.4.1.3 Installation Method of Piled Jacket Foundations

48. For jacket foundations, the pin piles could be pre-piled (before the jacket structure is placed on the sea bed) or post-piled. It is anticipated that pin piles would generally be driven but alternative installation techniques, i.e. drilling or vibration, may be required depending on ground conditions. More novel pile solutions, e.g. screwpiles, would also be considered.

49. Following acquisition of geophysical and geotechnical data pre-construction, foundation locations would generally be selected to avoid the need for sea bed

preparation. However, in some cases, it may not be avoidable. In such cases, the overall installation methodology for pre-piled jackets would typically be as follows:

- Confirmation investigation of the sea bed to ensure no obstructions are present (this would be on-going throughout the installation process);
- Undertake sea bed preparation and install scour protection (if required);
- Pin piles and pin pile installation template transported to site via barge or installation vessel;
- Vessel (likely a jack-up rig) with pile installation equipment and heavy craneage set up at pile installation location;
- Pin pile installation template placed on sea bed;
- Pin piles placed on sea bed within template and driven to target depth;
- Pin pile installation template recovered;
- Installed pin pile locations surveyed and jacket dimensions adjusted;
- Delivery of jacket to site via barge or installation vessel;
- Lifting of jacket onto installed pin piles via heavy lift or jack-up vessel; and
- Levelling of jacket, grouting and / or mechanical locking of jacket-to-pile connections.

50. For post-piled jackets, the sequence would typically be as follows:

- Jackets and piles transported to site via barge or installation vessel;
- Jack-up or heavy lift vessel with pile installation equipment and heavy craneage set up at jacket installation location;
- Sea bed preparation carried out if required;
- Lifting of jacket from barge or installation vessel and then lowering of the jacket onto sea bed;
- Lifting of pin piles from barge and placement into sleeves on jacket;
- Pin piles allowed to naturally penetrate sea bed (stabbing);
- Pin piles driven to depth using pilling hammer;
- Levelling of jacket via jacking off piles; and
- Grouting and / or mechanical locking of jacket to pile connections.

51. It has been estimated that the maximum hammer driving energy required to drive a pin pile with a diameter of 4.6m is 2,400kJ. If a hammer model is used that can generate energy levels greater than 2,400kJ, the hammer energy output will be modulated to a maximum of 2,400kJ. This commitment is captured within the draft DCO. It should also be noted that maximum hammer energy is only likely to be required at a few of the piling installation locations. For example, at the recently constructed Beatrice Offshore Wind Farm, where within the ES it was

estimated that each pin-pile would require 5 hours of active piling time and that the maximum hammer energy would be 2,300kJ (Beatrice Offshore Wind Farm Ltd 2018). During construction, the total duration of piling ranged from 19 minutes to 2 hours and 45 minutes, with an average duration of 1 hour and 15 minutes per pile. The maximum hammer energy required ranged between 435kJ and 2,299kJ, with an average across the site of 1,088kJ (Beatrice Offshore Wind Farm Ltd 2018).

52. Furthermore, the East Anglia ONE Offshore Windfarm piling logs for the first four jacket foundations indicate that the maximum hammer energy used was 935kJ, 52% of the potential maximum hammer energy of 1,800kJ. The average hammer energy used over these first four jacket foundations was 787kJ, only 44% of the potential maximum hammer energy of 1,800kJ (East Anglia ONE Ltd, 2019). This pattern is also shown for the remainder of the piling logs, with 74% of all the piled foundations using less than 50% of the 1,800kJ maximum hammer energy (less than 900kJ) and the remaining 24% of the piles foundations using between 50 and 63% of the 1,800kJ maximum hammer energy (up to 1,132kJ), with the actual maximum hammer of 1,132kJ only used for one pile location (taken from the Actual Pile Driving Energies Technical Note for East Anglia ONE Offshore Windfarm).

6.5.4.1.4 Spoil Removal and Disposal for Jacket Foundations

53. For jacket foundations, the amount of spoil requiring disposal is likely to be limited.

54. Some dredging may be required for levelling the sea bed prior to the installation of a pile template (if used) as outlined in ***Table 6.4****.* It should be possible to spread this material close to the installation works.

55. Based on preliminary geotechnical information, it is thought likely that pile driving would be possible across the whole East Anglia ONE North windfarm site; this would be confirmed at the pre-construction phase. Pin pile driving is unlikely to generate spoil material. However, until more detailed geotechnical assessments are carried out, the possibility of drilling must be considered at some locations. Drilling would generate some spoil material that would require removal and disposal. With a maximum drill penetration depth of 65m and a maximum drill diameter of 4.6m, each pile would potentially produce a volume of 1,080m^3 of drill arisings. As a worst case, it has been assumed that a maximum of 10% of pin-pile foundations would require drilling. The worst case is associated with 53 x 300m wind turbines and therefore a maximum volume of 17,316.46m^3 of drill arisings would potentially be released for pin-pile foundations. It is proposed the spoil would be disposed of within the East Anglia ONE North windfarm site (see ***section 6.5.13***), adjacent to each location from where the material was derived, with the spoil subsequently winnowed away by the natural tide and wave driven processes.

6.5.4.1.5 Type of Scour Protection for (all) Jacket Foundations

56. The requirement for scour protection cannot be ruled out at this stage until the jacket designs are developed further and the scour risks have been quantified. Scour protection could include rock armour, rock filled bags, pre-cast concrete block mattresses, concrete and grout filled bags, sand bags, fronded mattresses and glass fibre reinforced polymer.

57. The scour protection area and volume has been calculated based on independent areas for each pin-pile. Each individual area is not a perfect circle but an ellipsoid shape that accounts for the direction of currents. ***Table 6.5*** gives the foundation footprint sizes with the inclusion of scour protection, the form and scale of which would be decided following pre-construction surveys.

Table 6.5 Four Pile Jacket Foundations Footprint Dimensions with and without Scour Protection

Wind turbine model	Maximum footprint size per wind turbine (m^2)	Maximum footprint size per wind turbine with scour protection (m^2)	Maximum volume of scour protection per wind turbine (m^3)
250m	2,025	4,725.62	7,089
300m	2,766.76	5,330.31	7,996

6.5.4.1.6 Decommissioning of Jacket Foundations

58. The overall removal methodology for jacket foundations would typically be as follows:

- Removal of wind turbine, met mast, switchgear and ancillaries, and cutting of cables (leaving buried inter array cables *in-situ*);
- Local jetting and / or suction around legs of jacket to a depth of approximately 1 to 2m;
- Deployment of underwater remote abrasive cutting equipment from service vessel;
- Mobilisation of heavy lift Dynamic Positioning (DP) vessel or jack-up rig and attachment of crane slings to jacket;
- Abrasive cutting of piles at a depth of approximately 1 to 2m below the sea bed;
- Lifting of jacket by crane on DP vessel or jack-up rig onto barge; and
- Transportation of jacket to port and dry dock for dismantling and reuse and recycling where possible.

59. It should be noted that it would not be intended to reinstate the local excavations remaining at the pile leg locations as it is anticipated that this would refill naturally over time.

6.5.4.2 Gravity Base Structures

60. There are many possible shapes and sizes being proposed by manufacturers for gravity base structures. Gravity base structures usually comprise a base, a conical section and a cylindrical section ***(Plate 6.3)***. One of the main factors affecting size would be whether the structure is to be transported on a barge or vessel and lifted into place or whether it would be floated or semi-floated with the assistance of a barge or pontoon.

61. Most types of GBS are similar in form. Usually the base is hexagonal, octagonal or circular. Bases with a cruciform plan shape are also being considered, occupying a similar footprint.

62. Footprint sizes for the base and scour protection volumes are outlined in ***Table 6.6***.

Table 6.6 Gravity Base Structure Dimensions

Wind turbine model	Maximum base diameter per wind turbine (m)	Maximum footprint size per wind turbine (m^2)	Maximum footprint size with scour protection per wind turbine (m^2)	Maximum volume of scour protection per wind turbine (m^3)
250m	53	2,206.18	19,855.65	29,784
300m	60	2,827.43	25,446.90	38,171

63. For conical base GBS, the top of the base is usually 1 to 2m above the sea bed or slightly more if a bedding layer is used to provide a level formation. However, in areas where sand waves are present, it is possible that the top of the base would be installed below sea bed level.

64. For flat base GBS with only a cylindrical shaft, the top of base could be up to 10m above sea bed level.

6.5.4.2.1 Material Required for GBS

65. GBS are generally concrete with steel reinforcement and pre-stressing strand. There are also hybrid concepts that include a steel tower. Secondary structures, such as handrails, gratings, fenders and ladders, would be produced using steel (or possibly another metal or composite material). The working platform could also be made from steel.

66. The ballast material used is commonly sand. Other materials will be considered as an alternative, such as olivine, dolerite, basalt or pig iron. However, it is most likely that sand dredged locally to the site would be used, depending on the suitability of the material.

6.5.4.2.2 Sea bed Preparation and Penetration for GBS

67. GBS may require sea bed preparation to level the sea bed, provide a base with adequate bearing capacity and to ensure adequate contact between foundation base and sea bed.

68. Sea bed preparation would consist of dredging works to level the sea bed and the installation of a bedding and levelling layer. The dredging works are likely to be carried out using a trailer suction hopper dredger. After sea bed levelling of the bedding and levelling layer installation would be undertaken using a fall pipe vessel.

69. GBS foundations would be located and microsited to minimise ground preparation. Micrositing will allow the movement of infrastructure by up to 100m following confirmation of infrastructure positions. This is secured in the pre-commencement Design Plan under the requirements of the draft DCO. ***Table 6.7*** below shows the maximum worst case parameters for a 250 and 300m wind turbine.

Table 6.7 Estimated Dimensions of Sea Bed Preparation for GBS

Wind turbine model	Maximum area for sea bed preparation per wind turbine (m^2)	Maximum volume of sediment removed per wind turbine (m^3)
250m	6,650	22,585
300m	7,500	25,875

70. GBS may also use a skirt at their base which penetrates the sea bed giving more stability to the structure. The penetration could vary from 0.1 to 5m depending on ground conditions. Under-base grouting may also be used to strengthen the soil beneath the foundation and fill small voids.

6.5.4.2.3 Installation Method of GBS

71. A GBS would be delivered to site via one of two methods, depending on the foundation design:

- Floating – towed to site using a vessel and sunk using ballast material; or
- Transported to site by barge and installed by heavy lift crane.

72. For the first solution, it is possible that a bespoke barge would be used to support the foundation during its towed journey to site. For the second solution, it is likely that a heavy lift vessel would be required to perform the installation. This could be a jack-up or floating vessel.

73. The installation of GBS is dependent on design and fabrication methods. Definitive methodology for installation would be finalised following the completion of post-consent commercial and technical discussions.

74. The overall installation methodology would typically be as follows:

- Confirmation investigation of sea bed to ensure no obstructions are present (this would be on-going throughout the installation process);
- Prepare sea bed (if necessary);
- GBS transported to site via barge or floated to site, hauled by tugs;
- Mobilise heavy lift floating crane (if foundation is non-buoyant solution);
- Lift foundation from barge and lower to prepared area of sea bed, or adjust buoyancy of floating foundation and sink to prepared area of sea bed;
- Install ballast as necessary; and
- Install scour protection (likely to be rock dumping).

75. Ballast works would be undertaken by a trailer suction hopper dredger. The scour protection works would typically be installed by a DP rock dumping vessel equipped with a fall pipe. The scour materials would be placed in one or multiple layers.

6.5.4.2.4 Spoil Removal for GBS

76. Spoil removal would be undertaken as previously outlined in ***section 6.5.4.1.4.***

77. It would be preferable to use some of this material as ballast but in an extreme case all of it may need to be disposed of as outlined in ***section 6.5.13***, if it is unsuitable for ballast. The suitability of sediments as ballast material would be determined pre-construction following further geotechnical studies.

6.5.4.2.5 Type of Scour Protection for GBS

78. Scour protection may be necessary around the base of GBS to protect against currents and waves that may cause erosion of the sea bed. Scour protection could include rock armour, rock filled bags, pre-cast concrete block mattresses, concrete and grout filled bags, sand bags, fronded mattresses and glass fibre reinforced polymer. The requirement for scour protection would be dependent on the particular GBS foundation and ground conditions at each foundation location.

79. If this foundation type is adopted, detailed work would be required to design suitable scour protection in the post-consent period. The scour protection area would be a circle around the foundation with up to three times the diameter of the foundation which is the area required to prevent scour based on engineering calculations. ***Table 6.6*** shows the maximum footprint per foundation, including and excluding scour protection required for foundations for GBS, this also equates to the worst case scenario for scour protection regardless of the foundation type used.

6.5.4.2.6 Decommissioning of GBS

80. The removal methodology for GBS would typically be as follows:

- Removal of wind turbine, met mast, switchgear and ancillaries, and cutting of cables (leaving buried inter-array cables *in-situ*);
- Mobilisation of heavy lift DP vessel or fleet of tugs (dependent on whether foundation design is buoyant or requires heavy lift);
- Removal of marine growth and sediment from base and jetting under base plate to remove adhesive effects of grout (if present) or cohesive bearing material. If a deep skirt has been used, the skirt may require cutting;
- It may also be necessary to locally remove scour protection via dredging;
- For buoyant design: controlled de-ballasting of foundation using remote pumping equipment and / or installation of buoyancy aids. Disposal of the ballasting material (i.e. whether it is disposed of locally or requires to be transported to a designated offshore disposal area) would be agreed with the regulators as part of the decommissioning plan.
- For design requiring heavy lift: lifting of foundation from sea bed onto barge (as per installation, a bespoke transportation barge may be required dependent on the design);
- For buoyant design: foundation would become buoyant on de-ballasting; and
- Transportation of foundation to port and dry dock (via towing or on barge dependent on foundation type) for deconstruction and reuse and recycling of materials where possible.

6.5.4.3 Suction Caisson and Jacket on Suction Caisson Foundation

81. Suction caissons may comprise a single steel cylindrical tower (the shaft) with a maximum diameter of 15m, a transition structure (the lid) and cylindrical skirt with a diameter of up to 35m, which penetrates into the sea bed.

82. Alternatively, a jacket foundation on suction caissons may be used. This would consist of a jacket, that would be installed on three or four suction caisson ‘legs’. Each suction caisson would be up to 16m in diameter and spacing between caissons would be up to 64m.

83. Footprint sizes for the base and scour protection volumes are outlined in ***Table 6.8*** below.

Table 6.8 Suction Caisson and Jacket on Suction Caisson Foundation Dimensions

Wind turbine model	Maximum diameter per wind turbine (m)	Maximum footprint per wind turbine (m^2)	Maximum footprint size with scour protection per wind turbine (m^2)	Maximum volume of scour protection per wind turbine (m^3)
Suction Caisson				
250m	31	754.77	3,019.07	4,529
300m	35	962.11	3,848.45	5,773
Jacket on Suction Caisson				
250m	14.5	3,080.25	9,801	14,702
300m	16	4,096	12,544	18,816

84. The base height of the skirt of the suction caisson above sea bed is typically 5m once penetrated, although it may be possible to install it below sea bed level to reduce scour effects. The skirt penetration would be up to 5m below the sea bed.

85. There are other foundation concepts comprising a cluster of smaller diameter suction piles, instead of a single larger diameter caisson. However, the overall maximum footprint and penetration is expected to be no greater than that of either the single suction caisson or jacket on suction caisson options.

6.5.4.3.1 Material Required for Suction Caisson Foundations

86. Suction caisson foundations are usually comprised of mainly steel. However, it is possible that some secondary structures, such as handrails, gratings and ladders, could be produced using other metals, such as aluminium, or composites. Also, concrete could be used to form the working platform.

6.5.4.3.2 Sea bed Preparation and Penetration for Suction Caisson Foundations

87. In areas where the sea bed is level, the suction caisson foundation may not require significant sea bed preparation. However, measures may be required in areas in which sand waves are present to provide a level formation for the installation and to allow scour protection to be later placed around the foundation. It is possible that excavation to the trough of the sand wave would be necessary before installing the suction caisson. If this foundation type is adopted, detailed work would be required pre-construction to determine preparation required for each foundation.

88. ***Table 6.9*** shows the sea bed preparation scenarios for a 250m and a 300m wind turbine model.

Table 6.9 Estimated Dimensions of Sea Bed Preparation for Suction Caisson and Jacket on Suction Caisson

Wind turbine model	Maximum area for sea bed preparation per wind turbine (m^2)	Maximum volume of sediment removed per wind turbine (m^3)
Suction Caisson		
250m	4,296	13,840
300m	4,688	15,250
Jacket on Suction Caisson		
250m	6,948	23,732
300m	8008	27,865

6.5.4.3.3 Installation Method of Suction Caisson Foundations

89. Suction caisson foundations are most likely to be towed to site by tugs as they are designed to be buoyant. There is also the possibility that foundations structures (particularly jacket structures) may be transported to site using a heavy lift vessel or barge. It would be expected that in the case of both suction caissons or jacket on suction caissons, structures would be fully fabricated prior to transportation to site

90. The overall basic installation methodology would be expected to be as follows:

- Confirmation investigation of sea bed to ensure no obstructions are present (this would be on-going throughout the installation process);
- Prepare sea bed (if necessary) prior to installation;
- Suction caisson or jacket on suction caisson foundation transported to site;
- Suction caisson or jacket on suction caisson foundation is ballasted and lowered to sea bed;
- Initial penetration occurs under foundation self-weight;
- Pumps are attached to caisson and water evacuated. Typically, there are a number of chambers within the caisson in order to implement a controlled installation and to control levels. Water jetting may be used at the tip of the skirt to facilitate penetration;
- Install scour protection (likely to be rock dumping); and
- Spoil removal and disposal for suction caisson foundations.

91. Depending on the design of the foundations, ground conditions and requirement for scour protection, ground preparation works and scour protection installation may be done pre or post foundation installation, or will be phased.

6.5.4.3.4 Spoil Removal and Disposal for Suction Caisson Foundations

92. For suction caisson and for jacket on suction caisson foundations, sea bed preparation would be required and its required extent would be dependent on the nature of the ground conditions present underneath the structures (for example, if sand waves are present). ***Table 6.9*** provides estimates of the volume of sea bed which may require removal during sea bed preparation activities. Sediment extracted during sea bed preparation for suction caissons and jackets on suction caisson foundations would be disposed of in a designated disposal site as outlined in ***section 6.5.13***.

6.5.4.3.5 Type of Scour Protection for Suction Caisson Foundations

93. Scour protection would be provided around the installed suction caisson. The requirements would be similar to those listed for gravity base structures in ***section 6.5.4.2.5***. The quantities and extent of scour protection would be dependent on current speed, sediment type and the foundation details.

94. If either of these foundation types are adopted, detailed pre-construction work would be required to design the scour protection for each foundation however it is anticipated that the scour protection area would be a circle around the foundation with twice the diameter of the foundation for suction caissons. For jackets on suction caissons the worst case volume of scour protection required is assumed to be the square formed by the caissons and three times the diameter of them. ***Table 6.8*** gives the maximum foundation footprint for suction caissons and jackets on suction caissons that would result from the implementation of scour protection. Scour protection could include rock armour, rock filled bags, pre-cast concrete block mattresses, concrete and grout filled bags, sand bags, fronded mattresses and glass fibre reinforced polymer.

6.5.4.3.6 Decommissioning of Suction Caisson and Jacket on Suction Caisson Foundations

95. The overall removal methodology for suction caisson and jacket on suction caisson foundations would typically be as follows and would be agreed with regulators in the decommissioning plan:

- Removal of wind turbine, met mast, switchgear and ancillaries, and cutting ends of cables (leaving buried inter-array cables *in-situ*);
- Mobilisation of service vessel with pumping equipment and Remotely Operated Vehicle (ROV), and mobilisation of tugs. It may also be necessary to mobilise a DP vessel with craneage to facilitate with the re-floating and subsequent manipulation of the foundation;
- Removal of sediment and marine growth from suction caisson lid, and jetting of pump connections on lid. It may also be necessary to locally remove scour protection via dredging;
- De-ballasting or adding of buoyancy aids to foundation as required by design;

- Connection of pumping equipment to suction caisson valves;
- Controlled pumping of water into caisson chambers. The caisson would rise from its installed position to the surface as the internal pressure overcomes the side wall friction. Some manipulation from craneage on a DP vessel may also be required; and
- Transport of foundation to port and dry dock for dismantling and reuse and recycling where possible.

6.5.4.4 Monopile Foundations

96. Monopile foundations are the most common wind turbine foundation type used to date. They comprise a cylindrical steel pile and a cylindrical steel transition piece. Conical transitions are sometimes used to reduce the diameter of the structure at the top of the foundation. Site specific analysis is required to assess the suitability of this foundation option for the proposed East Anglia ONE North project. Footprint sizes for the base and scour protection volumes are outlined in ***Table 6.10***.

Table 6.10 Monopile Dimensions

Wind turbine model	Maximum diameter (m)	Maximum footprint per wind turbine (m^2)	Maximum footprint per wind turbine with scour protection (m^2)	Maximum volume of scour protection per wind turbine (m3)
250m	13	132.73	3,318.31	4,978
300m	15	176.71	4,417.86	6,627

97. Maximum foundation penetration depth would be 45m below the surface of the sea bed.

6.5.4.4.1 Material Required for Monopiles

98. Monopile foundations usually comprise mainly steel. However, it is possible that some secondary structures, such as handrails, gratings and ladders, could be produced using other metals, such as aluminium, or composites. Also, concrete could be used to form the working platform.

6.5.4.4.2 Sea bed Preparation and Penetration for Monopiles

99. In areas where the sea bed is level, the monopile foundation may not require significant sea bed preparation. However, measures may be required in areas in which sand waves are present to provide a level formation for the installation and to allow scour protection to be placed around the foundation. If this foundation type is adopted, detailed work would be required pre-construction to determine preparation required for each foundation.

100. ***Table 6.11*** shows the sea bed preparation scenarios for a single 250 and a 300m wind turbine model.

Table 6.11 Estimated Dimensions of Sea Bed Preparation for Monopile

Wind turbine model	Maximum area for sea bed preparation per wind turbine (m^2)	Maximum volume of sediment removed per wind turbine (m^3)
250m	2,730	8,485
300m	2,888	9,000

6.5.4.4.3 Installation Method of Monopiles

101. The installation of steel monopile foundations would typically consist of the following key stages:

- Confirmation investigation of sea bed to ensure no obstructions are present (this would be ongoing throughout the installation process);
- Prepare sea bed (if necessary) prior to installation; delivery of steel monopiles and transition pieces to site via barge or by installation vessel. It may also be possible to tow floated piles to site using tugs;
- Installation of scour protection;
- Mobilisation of jack-up rig (alternatively floating vessel) with heavy craneage at installation location. It may also be necessary to mobilise a support vessel;
- Monopile upended by crane to vertical position;
- Monopile lowered to sea bed;
- Locating of driving hammer onto top of pile using craneage, and monopile driven to required depth. Where ground conditions are difficult, it may also be necessary to carry out drilling using drilling equipment operated from the installation vessel before completing the driving; and
- Lifting of transition piece on to top of monopile using craneage from installation vessel, levelling of transition piece and grouting of connection.

102. It has been estimated that the hammer energy that would be needed to drive a maximum 15m diameter monopile into the substrate would be a maximum of 4,000kJ. If a hammer model is used that can generate energy levels greater than 4,000kJ, the hammer energy output will be modulated to a maximum of 4,000kJ. This commitment is captured within the requirements of the draft DCO. It should also be noted that maximum hammer energy is only likely to be required at a few of the piling installation locations (as per the pin piles, see ***section 6.5.4.1.3***).

6.5.4.4.4 Spoil Removal and Disposal for Monopiles

103. For monopile foundations sea bed preparation would be required and is dependent on the nature of the ground conditions present underneath the

structures (for example, if sand waves are present). ***Table 6.11*** provides estimates of the volume of sea bed which may require removal during sea bed preparation activities.

104. Drilling would generate some spoil material that would require removal and disposal. With a maximum drill penetration depth of 45m and a maximum pile diameter of 15m, each pile would potentially produce a volume of 7,952.16m^3 of drill arisings. As a worst case, it has been assumed that a maximum of 10% of monopile foundations would require drilling. The worst case is associated with 53 x 300m wind turbines and therefore a maximum volume of 42,146.43m^3 of drill arisings would potentially be released for monopile foundations. In keeping with the dredged material, it is proposed the spoil would be disposed of within the East Anglia ONE North windfarm site (to be designated), adjacent to each location from where the material was derived, with the spoil subsequently winnowed away by the natural tide and wave driven processes.

6.5.4.4.5 Type of Scour Protection for Monopiles

105. Dependent on the nature of the metocean conditions and final monopile design, it may be necessary to install scour protection around the base of the foundation. Scour protection could include rock armour, rock filled bags, pre-cast concrete block mattresses, concrete and grout filled bags, sand bags, fronded mattresses and glass fibre reinforced polymer.

106. The quantities and extent of scour protection would be dependent on current speed, sediment type and the foundation details. Detailed pre-construction work would be required to design the scour protection for each foundation.

107. The scour protection area for monopiles is a circle around the foundation with five times the diameter of the foundation which is the area required to prevent scour based on engineering calculations. ***Table 6.10*** gives an indication of the increase in foundation footprint that would result from the use of scour protection.

6.5.4.4.6 Decommissioning of Monopiles

108. The removal methodology for steel monopile foundations would typically be as follows:

- Removal of wind turbine, met mast, switchgear and ancillaries, and cutting ends of cables (leaving buried inter array cables *in situ*);
- Mobilisation of service vessel;
- Local jetting and / or suction around base of monopile to a depth of approximately 1 to 2m;
- Deployment of underwater remote abrasive cutting equipment from service vessel;
- Mobilisation of heavy lift DP vessel or jack-up rig and attachment of crane slings to top of monopile and transition piece;

- Abrasive cutting of monopile at a depth of approximately 1 to 2m below the sea bed;
- Lifting of combined monopile and transition piece by crane on DP vessel or jack-up rig onto barge; and
- Transportation of monopile and transition piece to port and dry dock for dismantling and reuse and recycling where possible.

109. It should be noted that it would not be intended to reinstate the local excavations remaining at the monopile locations as it is anticipated that this would refill naturally over time.

6.5.5 Aviation and Navigational Marking

110. The windfarm would be designed and constructed to satisfy the requirements of the Civil Aviation Authority (CAA) and the Trinity House Lighthouse Service (THLS) in respect of marking, lighting and fog-horn specifications. CAA guidelines as outlined in “CAA Policy and Guidelines on Wind Turbines” (February 2016) would be adhered to. THLS recommendations would be followed as described in “Provision and Maintenance of Local Aids to Navigation Marking Offshore Renewable Energy Installations” and “the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) Recommendation 0-139 on the Marking of Man-Made Offshore Structures”, (IALA 2013).

111. The colour scheme for nacelles, blades and towers is typically RAL 7035 (light grey). Foundation steelwork is generally in RAL 1023 (traffic light yellow) up to the Highest Astronomical Tide (HAT) +15m or to Aids to Navigations, whichever is the highest.

112. Lighting requirements would follow the MCA (2018) guidance, Offshore Renewable Energy Installations: Requirements, Guidance and Operational Considerations for Search and Rescue and Emergency Response. This will ensure that adequate consideration with regard to lighting of offshore structures is given for Search and Rescue and Emergency Response. In addition, the following assumptions have been made with regards to lighting of the East Anglia ONE North windfarm site:

- Red, medium intensity aviation warning lights (of variable brightness between a maximum of 2000 candela (cd)) to a minimum of 10% of the maximum which would be 200cd) will be located on either side of the nacelle of significant peripheral wind turbines. These lights will flash simultaneously with a Morse W flash pattern and will also include an infra-red component;
- All aviation warning lights will flash synchronously throughout the East Anglia ONE North windfarm site and be able to be switched on and off by means of

twilight switches (which activate when ambient light falls below a pre-set level);

- Aviation warning lights will allow for reduction in lighting intensity at and below the horizon when visibility from every wind turbine is more than 5km (to a minimum of 10% of the maximum, i.e. 200cd);
- Search and rescue (SAR) lighting of each of the non-periphery turbines will be combi infra-red (IR)/200cd steady red aviation hazard lights, individually switchable from the control centre at the request of the MCA (i.e. when conducting SAR operations in or around the East Anglia ONE North offshore windfarm site);
- All wind turbines will be fitted with a low intensity light for the purpose of helicopter winching (green hoist lamp). All wind turbines will also be fitted with suitable illumination (minimum one 5cd light) for ID signs; and
- Marine navigational lights will be fitted at the platform level on significant peripheral structures (SPS). These lights will be synchronized to display simultaneously an IALA "special mark" characteristic, flashing yellow, with a range of not less than five (5) nautical miles.

6.5.6 Meteorological Masts

113. There is the potential for one meteorological mast (met mast) to be installed within the East Anglia ONE North windfarm site. The maximum height of this met mast would be 175m (LAT).

114. The foundations used may be jacket (with pin piles or suction caissons), GBS or monopile. ***Table 6.12*** addresses the different foundation options required to support the met mast and its associated footprint, with and without scour protection and scour protection volumes.

Table 6.12 Indicative Met Mast Foundation Footprint

Foundation Type	Maximum Footprint (m^2)	Maximum Footprint with Scour Protection (m^2)	Maximum volume of scour protection (m^3)
Jacket with pin piles	400	900	1,350
Jacket with suction caissons	650.25	2,450.25	3,676
Gravity base	314.6	2,827.43	4,242
Suction caisson	176.71	706.86	1,061
Monopile	50.27	1,256.64	1,885

6.5.7 Ancillary Works

115. Ancillary works are likely to form part of the final design of the proposed East Anglia ONE North project; however, the requirement and nature of these would be determined at the detailed design phase. Ancillary works may include:

- Temporary landing places, moorings or other means of accommodating vessels in the construction and / or maintenance of the authorised development;
- Buoys, beacons, fenders and other navigational warning or ship impact protection works; and
- Temporary works for the benefit or protection of land or structures affected by the authorised development.

116. Buoys would be required across the East Anglia ONE North windfarm site, these would be LiDAR, wave or guard buoys. Each buoy would be up to four metres wide and six metres high and would include a lantern suitable for use as a navigational aid.

117. These devices would be attached to the sea bed using mooring devices such as common sinkers (small block of heavy material such as concrete, steel, etc.) or anchored by means of regular anchors. They could have one single mooring point or several points (usually up to three), with an anticipated total footprint of $4m^2$.

6.5.8 Offshore Electrical Platforms

118. The proposed East Anglia ONE North project will require a minimum of one up to a maximum of four offshore electrical platforms, which will contain electrical equipment to aggregate the power from the wind turbines and convert it into a more suitable form for export to shore.

119. The offshore electrical platforms will be located within the East Anglia ONE North windfarm site and the precise location(s) will be determined during detailed design work conducted pre-construction.

6.5.8.1 Offshore Electrical Platform Topsides

120. The offshore electrical platforms would accommodate the transformers required to increase the distribution voltage (66 to 75kV) of the inter array cables to a higher export voltage of typically 110 to 400kV.

121. The topside structure would be configured in a multiple deck arrangement at each offshore electrical platform. Decks would either be open with modular equipment or the structure may be fully clad. All weather sensitive equipment would be placed in environmentally controlled areas. ***Plate 6.9*** shows a typical offshore electrical platform.

Plate 6.9 Typical Offshore Electrical Platform (AC collector station)

122. The dimensions of the offshore electrical platforms would depend on the capacity and number of platforms constructed. However, the offshore electrical platforms will have a maximum topside width of 50m, maximum topside length of 70m and a maximum topside height of 50m (above LAT).

6.5.8.2 Offshore Electrical Platform Foundation Type

123. The offshore electrical platforms would require bespoke foundations on which to place the topsides. The types of foundation under consideration include eight-legged steel jacket (with pin piles (up to 4.6m diameter) or suction caisson) or possibly a gravity base structure. The offshore electrical platform foundations would be greater in size than the wind turbine foundations due to the size and weight of the topsides. Estimates for the maximum footprints and scour protection volumes for offshore electrical platforms are presented in ***Table 6.13***.

Table 6.13 Indicative Offshore Electrical Platform Foundation Footprints

Foundation Type	Maximum Footprint (m^2)	Maximum Scour Protection Area (per platform) (m^2)	Maximum Scour Protection Volume (per platform) (m^3)
Jacket with pin piles	4,073.16	5,330.31	7,996
Jacket with suction caissons	5,676	15,276	22,914
Gravity base	4,800	12,000	18,000

124. An alternative option is a self-installing structure, which is towed to site and then lowers legs, jacks-up to an appropriate clearance above water before being fixed *in-situ*, probably using pin piles as would be used for a jacket foundation.

125. The installation of the offshore electrical platform support structures would be as described in ***section 6.4*** relating to wind turbine foundation units (apart from the self-installing system summarised above).

126. The topsides may be installed via the following methods:

- By a suitable crane vessel (or vessels working together) in a single lift;
- By a suitable crane vessel (or vessels working together) in separate lifts of deck and sub-modules;
- Using a rail-skid transfer from a large jack-up; and
- Self-installing.

127. It should also be noted that there is potential for jack-up vessels which are commissioning the topsides of offshore electrical platforms to require scour protection around the jack-up legs. This is because the jack-up vessels will be *in situ* for a number of months at a time when commissioning offshore platforms. An assumption has been made for a requirement of up to 240m^2 of scour protection for each of a maximum of four offshore electrical platforms.

6.5.9 Offshore Construction, Operation and Maintenance Platform

128. A single construction O&M platform may be required to house construction and operation and maintenance personnel and equipment. This would require a foundation structure likely to be similar to that of the offshore electrical platforms (***section 6.4***) and would have the same footprint as outlined in ***Table 6.13****.*

129. The construction, operation and maintenance platform would have a topside up to 50m wide by 70m long and with a topside height of 50m (above LAT).

6.5.10 Electrical Infrastructure

130. The proposed East Anglia ONE North project will use a HVAC electrical system.

6.5.10.1 Export Cables: Cable Routes

131. Offshore export cables will be laid between the offshore electrical platform(s) and the landfall location. The East Anglia ONE North offshore cable corridor is shown in ***Figure 6.1***. There would be up to two export cables installed. Each cable would have a maximum length of 76km resulting in a maximum combined length of 152km. Further detail on the implementation of the East Anglia ONE North offshore cable corridor is provided within the Scheme Implementation Report submitted with this DCO application.

6.5.10.2 Export Cables: Pre-lay Works

132. The East Anglia ONE North windfarm site would be connected to landfall by up to two offshore export cables each laid in a separate trench (therefore a total of two export cable trenches), where they will join up to six cables, via a transition bay, that will connect to the onshore substation. The offshore cables themselves each have a diameter of approximately 120 to 300mm and each consist of one copper or aluminium conductor with electrical insulation material, screens, communication fibre and protective armour layers. Each export cable would have one fibre optic cable either integrated within the cable itself or secured to the outside.

133. In areas with large ripples and sand waves, the sea bed may first require levelling (subject to detailed studies), i.e. sand wave levelling by dredging before the cable could be installed.

134. Before cable-laying operations commence, it would be necessary to ensure that the offshore cable corridor is free from obstructions such as discarded trawling gear and abandoned cables identified as part of the pre-construction survey. A survey vessel would be used to clear all such identified debris, in a Pre-Lay Grapnel Run (PLGR). A PLGR would also be carried out along the inter array and platform link cable route (see ***section 6.5.10.15***).

135. The offshore export cable would be routed as far as possible in soft sediments to allow it to be buried into the sea bed. In the event that boulders or debris are encountered on the sea bed, they should be removed before the cable is laid. If the grapnel tool cannot remove all obstructions completely, some hydraulic removal works or ploughing may take place. No blasting is planned to take place in the offshore cable corridor to remove bedrock.

136. If the offshore cable corridor crosses an out of service cable it may be recovered from the sea bed before laying the offshore export cable. The removal would be dependent on depth of burial, accessibility and agreement with the cable owners that the cable or sections of it can be removed or crossed. ***Figure 6.3*** shows the

cable infrastructure in the vicinity of the offshore development area with further detail provided in ***Table 6.16*** and ***Chapter 17 Infrastructure and Other Users***

137. Crossings preparation would be informed by detailed pre-construction surveys to locate the asset and determine actual depth of burial. Following this, placement of protection would need to be carried out.

6.5.10.3 Export Cables: Installation and Burial Method Ploughing, Trenching, Jetting, Depth of Burial (Offshore)

138. The preferred construction technique and depth of burial for the offshore electrical infrastructure would be decided after the pre-construction geotechnical ground investigation, a risk assessment and a lifetime maintenance assessment. Each of the possible installation techniques (ploughing, jetting and trenching) have constraints within which they can be effectively utilised, e.g. shallow water, depth of burial required, sediment disturbance, sediment type and minimum bend radius. The offshore export cables would be buried at a depth between 1m and 3m for the majority of the route.

139. The installation practices can be divided into the following classes:

- Cables are surface laid by a laying vessel, and burial is carried out in a post-lay mode using a separate vessel and trenching / jetting equipment spread depending on the method; or
- Cables are laid and buried in a simultaneous operation with burial equipment being towed by the cable laying vessel or barge, in the case of plough or burial sled, or operated from laying vessel where a self-propelled ROV is utilised.

6.5.10.3.1 Burial Methods: Ploughing

140. Ploughing has been specified for major HVAC systems in the past and this generally produces better burial results than post lay burial in some ground conditions.

141. A forward blade cuts through the sea bed laying the cable behind. Ploughing tools could be pulled directly by a surface vessel (likely method for export cable installation) or could be mounted onto self-propelled caterpillar tracked vehicles which run along the sea bed taking power from a surface vessel (i.e. a plough trencher which is the likely installation method for inter-array and platform link cables). The plough inserts the cable as it passes through the ground.

142. Even if the primary method adopted for laying the export cables is ploughing there would still likely be local spots that would require jetting or other methods to bury and protect the cable e.g. for any jointing loops and where ploughing would be unable to negotiate obstacles, cable crossings, etc.

6.5.10.3.2Burial Methods: Jetting

143. This method involves the use of a positioned cable vessel and a hydraulically powered water jetting device that simultaneously lays and embeds the cables in one continuous trench. The equipment uses pressurised water from a water pump system on board the cable vessel to fluidize sediment.

144. There are two methods of water jetting which are:

- Laying the cable first and jetting at a later time - The cable is laid on the sea bed first and afterwards a jetting sledge is positioned above the cable. Jets on the sledge flush water beneath the cable fluidising the sand whereby the cable, by its own weight, sinks to the depth set by the operator. As the sediment is fluidised a minor amount of sediment spill is expected.
- Laying the cable and jetting at the same time - In this method water jets are used to jet out a trench and the cable is laid into the trench behind the jetting lance. As with previous method, as the sediment is fluidised a minor amount of sediment spill is expected.

145. Jetting tools can be pulled directly by a surface vessel or can be mounted onto self-propelled caterpillar tracked vehicles which run along the sea bed taking its power from a surface vessel.

6.5.10.3.3 Burial Methods: Vertical Injector

146. In shallow waters, a vertical injector could be used. This is a large jetting and cutting tool which is strapped to the side of a barge and the cable is laid in the foot of the trench. This technique can provide deeper than traditional method burial which can be utilised through areas of high sea bed mobility or whilst crossing areas of high risk.

147. The burial depth is controlled by means of raising or lowering the tool and horizontal positioning, by means of adjusting the barge anchors.

6.5.10.3.4Burial Methods: Backhoe Dredging or Cutting

148. Backhoe dredging or cutting would be used where other methods for burying the cable are not economically and / or technically feasible. One such area where this is likely to be required is in the nearshore area where a limited amount of dredging may be required at the Horizontal Directional Drilling (HDD) punch-out location.

149. This method generally consists of three operations. First a trench is excavated or cut while either placing the sediment and fill next to the trench or onto the backhoe dredging vessel where it will be subsequently disposed of (see ***section 6.5.13***). The cable is subsequently laid in the trench and lastly the sediment or fill is returned to the trench or taken to a licensed disposal site to be disposed of

(see ***section 6.5.13***) or the Site Characterisation Report (Offshore Cable Corridor) (document reference 8.16).

6.5.10.3.5 Cable Laying and Burial Speeds

150. The speed of cable laying would differ between vessel types. The speed of cable laying (for all installation methods and vessel types) will depend on the ground conditions, sea bed profile and water depth. Indicative installation rates are shown in ***Table 6.14****.*

Table 6.14 Typical Cable Installation Rates for Different Burial Methods

Method	Speed (m/hour)
Ploughing (single cable)	300
Jetting	300
Trenching	30 - 80
Vertical injector (shallow water only)	30 - 80

6.5.10.4 Export Cables: Cable Protection

151. In some cases, such as unsuitable sea bed conditions or where another cable or pipe is already in place, the above methods cannot be applied and it is necessary to use alternative methods for installing the cable. Details of some of the techniques employed are given below:

- **Rock placement** - involves the laying of rocks on top of the cable to provide protection which is effective on crossings or areas where unsuitable sea bed conditions are encountered. This can be used where long sections of cable require protection.
- **Concrete mattresses** - are prefabricated flexible concrete coverings that are laid on top of the cable, as an alternative to rock placement. The placement of mattresses is slow and as such is only be used for short sections of cable protection. Grout or sand bags, are used similarly to concrete mattressing with mattresses filled with grout and / or sand used in place of the prefabricated concrete mattresses, this method is generally applied on smaller scale applications than concrete mattressing.
- **Frond mattresses** could be used to provide protection by stimulating the settlement of sediment over the cable. This method develops a sand wave over time protecting the cable but is only suitable in certain water conditions. This method may be used near offshore structures though experience has shown that storms can strip deposited materials from the frond.
- **Uraduct** is effectively a protective shell which comes in two halves and is fixed around the cable to provide mechanical protection. Uraduct is generally used for short spans at crossings or near offshore structures where there is a high

risk from falling objects. Uraduct does not provide protection from damage due to fishing trawls or anchor drags.

152. The total worst case estimates for export cable protection required because of unsuitable ground conditions and cable crossings in the offshore cable corridor are presented in ***Table 6.15***. These have been estimated based on up to 5% of the export cables being unable to be buried because of ground conditions and therefore requiring cable protection. In reality it is likely that, due to the sandy and gravely nature of the sediment throughout the offshore cable corridor, the majority of the export cable(s) will be buried using a cable plough and will not require cable protection.

Table 6.15 Cable Protection Requirements for the Offshore Cable Corridor

Cable Type and Location	Total Area (m^2)	Total Volume (m^3)
Cable protection for export cable (see ***section 6.5.10.4***)	110,840*	124,662.4
**Includes requirement for up to 34 cable crossings and assumes 5% of export cable route will be unsuitable for burial.*		

6.5.10.5 Export Cables: Electro-Magnetic Fields and Heat Generated

153. The offshore export cables transmit the electricity from the offshore electrical platform(s) to the designated onshore landfall point at a higher voltage (known as the transmission or export voltage) than is used for the inter array cables.

154. Electro Magnetic Fields (EMF) emitted by HVAC three core offshore subsea cable is minimised by the arrangement of the cable cores: the three cores are laid together in trefoil and as the phase currents are balanced, the magnetic fields of the three cores tend to zero. For that, the magnitude of the magnetic fields in the proximity of the cable is null and its presence in the sea bottom inert. Burial of the cable will also act to minimise emission of EMF.

155. Heat loss per metre for a typical 1,000mm^2 offshore HVAC 132kV 3-core cable is 30W/m.

6.5.10.6 Export Cables: Minimum Cable Spacing, Number and Width of Cable Trenches

156. The minimum separation of the export cables is determined primarily to reduce the risk involved of damaging a pre-laid cable during installation due to the inherent difficulty of ensuring that the cable burying plough is in the precise position. In addition, following installation of the export cables, should any cable be required to be retrieved for maintenance, the separation distance allows confidence to recover a cable without disturbing others and to re-install a repaired cable on the sea bed without damaging the adjacent cable. The space required to install a repaired cable would depend on the water depth at the fault location. The primary factor that would influence this spacing and the burial depth would

be the geology of the sea bed along the route with additional influences such as sea bed obstacles including wrecks and other sub-sea cables or pipelines.

157. A practical offshore cable corridor width needs to allow for:

- Sufficient space to allow crossing of existing cables and pipelines as close as possible to a 90-degree angle;
- Sufficient space that the offshore export cable route does not inhibit the operation and maintenance activities of existing cables and pipelines;
- Sufficient width for installation vessels to manoeuvre and anchor;
- Sufficient width to allow for any maintenance activities, including space to effect cable recovery and repairs;
- To incorporate sea bed lease requirements from The Crown Estate; and
- To incorporate best practice guidelines (as far possible) from latest DNV-KEMA guidelines.

158. When two export cables are installed there needs to be sufficient space between them to:

- Minimise the risk of plough (or another burial tool) over-run;
- Allow barges in shallow water to dry out without settling on top of the cable;
- Allow for installation vessels to manoeuvre during installation where there are bends in the offshore cable corridor; and
- Allow the repair bight to be laid out where repairs are needed.

159. ***Plate 6.10*** shows the indicative distances between individual export cables, within a pair, for the proposed East Anglia ONE North and East Anglia TWO projects (50m) together with the indicative distance between each project's pair of export cables (500m). A 500m working width area either side of the export cables is also shown. This gives a total swathe width of 1,600m to accommodate both the proposed East Anglia ONE North and East Anglia TWO projects[1]. ***Plate 6.10*** also shows the indicative export cable distances for the proposed East Anglia TWO project if the southern route option was chosen i.e. 50m between export cables and a 500m working width either side. These distances allow for the above scenarios; however, they may be refined following a detailed cable burial assessment, prior to construction for the proposed East Anglia ONE North project. If the sea bed is extremely soft in nature, this spacing may be widened to ensure a safe placement of anchors.

[1] It should be noted that this scenario would only apply if the East Anglia TWO northern export cable route option was selected as this route is shared the with proposed East Anglia ONE North project.

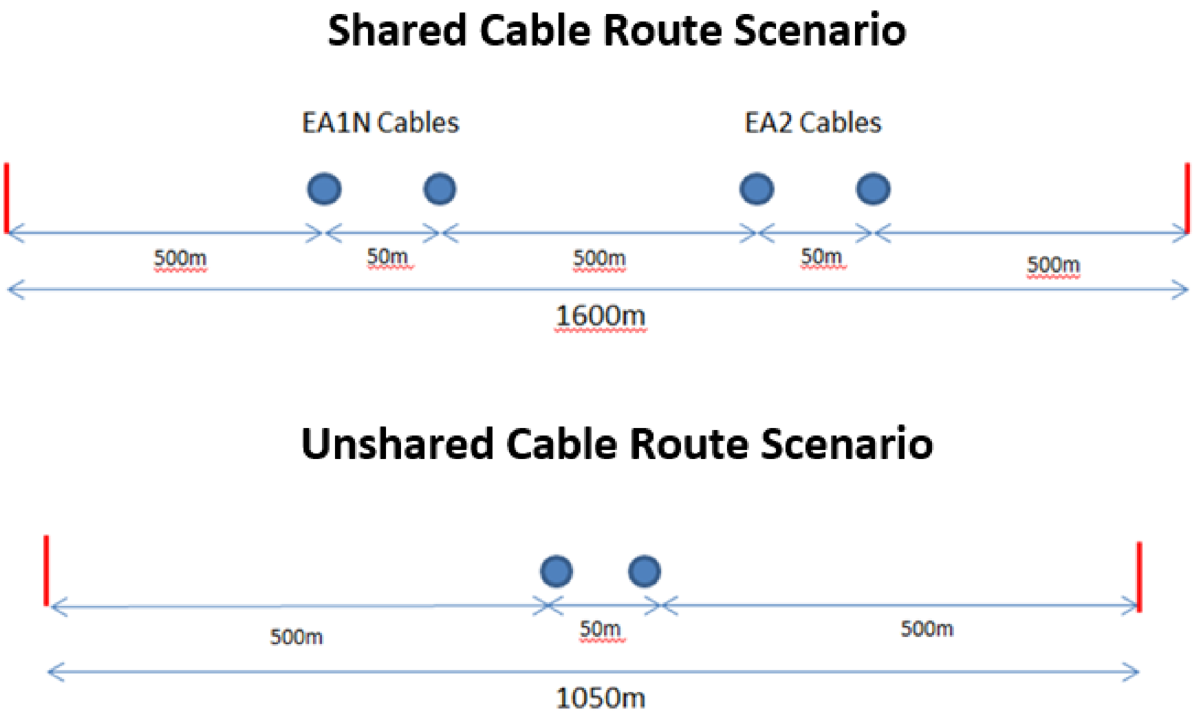

Plate 6.10 Shared Cable Route Scenario: Indicative distances between individual export cables, within a pair, for the proposed East Anglia ONE North and East Anglia TWO projects and the indicative distance between each project's pair of export cables (500m), with 500m working width either side. Unshared Cable Route Scenario: Indicative distance between export cables with 500m working width either side.

160. Additionally, a minimum of 250m is required between export cables and the boundary of the cable corridor to act as a buffer to protect the installed cables.

6.5.10.7 Export Cables: Jointing Procedure

161. The jointing of offshore export cables would require a significant weather window. Typically; the jointing can take between one and ten days after both cable ends are secured on-board the jointing vessel. Additional time is needed to recover the cables pre-jointing and rebury the cable post-jointing.

6.5.10.8 Export Cables: Cable Crossing

162. There are several existing cables within the offshore cable corridor (see ***Table 6.16*** and ***Chapter 17 Infrastructure and Other Users*** for details). Each crossing will require a cable crossing agreement signed between the owners.

Table 6.16 Summary of Offshore Cables and Pipelines Which Intersect the Offshore Cable Corridor

Asset Name	Asset Type	Operator	General Trajectory (approximate)
Concerto 1 North (1N)	Telecommunications cable (operational)	GTT Communications	East to West
Concerto 1 South (1S)	Telecommunications cable (operational)	GTT Communications	West to East
Atlantic Crossing 1	Telecommunications cable (out of service)	Global Crossing	West to East
Greater Gabbard export cable route	Three transmission cables (operational)	Equitix Management Services (EMS)[2]	North to South
Galloper export cable route	Two transmission cables (operational)	Innogy[3]	North to South
Bacton Zeebrugge	Gas pipeline (operational)	Caisse; Snam and Fluxys	North West to South East
Benacre-Zandvoort No 1	Telecommunications Cable (not in use)	British Telecoms	West to East
Benacre Zandvoort No 2	Telecommunications Cable (not in use)	British Telecoms	West to East

163. Where the offshore export cable is required to cross an out of service cable, the Applicant may wish to cut the disused cable at each end and bury the export cable through the path created. This would be subject to detailed magnetometer surveys and agreement with the cable owner. In the event that an out of service cable is cut, clump weights would be placed at each end where the cable has been cut to prevent its re-emergence.

164. Where the offshore export cable is required to cross an obstacle such as a communications cable, protection is required to protect the cable being crossed. Once protection is in place it would not be possible to bury the cable being laid, leaving it more susceptible to external damage. Therefore, protection is required over the second cable.

165. It is anticipated that, where the East Anglia ONE North export cables would cross existing cables, concrete mattressing, fronded mattressing, rock dumping,

[2] Formerly known as Greater Gabbard OFTO Plc, a consortium of Equitix Ltd and AMP Capital Ltd. Equitix Ltd became the sole owner in December 2015 (4C Offshore 2019).
[3] Innogy are leading the development and construction of the Galloper project on behalf of their partners UK Green Investment Bank, Siemens Financial Services, Sumitomo Corporation and Macquarie Capital (Russel 2017).

bridging or gravel bags would be used for protection. The maximum height of a cable crossing is predicted to be 2.25m, with a width of 8.5m and length of 160m. In shallow waters, the height of cable crossings may be required to be reduced to avoid impingement of water depth for navigation.

166. For a typical cable crossing using a concrete mattress, typical dimensions of each mattress would be 6m long by 3m wide by 0.3m high. The number of mattresses required would depend on the size, type and vertical position of the asset to be crossed, the number of cables crossed and the separation of the cables that can be achieved at the point of the crossing. An alternative may be a bespoke designed concrete bridge which is installed over the existing cable with the offshore export cable being installed perpendicular, over the bridge. A substitute to concrete mattresses would involve rock filter bags laid over the existing obstacle.

167. The anticipated maximum footprint of cable protection material due to crossings within the offshore cable corridor would be 46,240m^2 with a maximum height of 2.25m.

168. Other factors that need to be taken into account when considering an offshore crossing are:

- Avoid existing offshore cable joint locations (100m buffer) as these sites are more prone to failure and as such there exists a greater possibility for a requirement to recover the cable in the future.
- Avoid existing crossings of cables and pipelines to prevent triple crossings which increase risk and difficulty of recovery should any of the elements require repair.

169. In addition, the presence of sand waves can result in scouring of the cable or the cable being laid in suspension over time. To prevent this, the cable would ideally be placed in the troughs of sand waves, if this is not possible; an alternative would be to dredge the top of the sand waves.

170. There will be a maximum of 34 crossings required along the export cable route. This is calculated from the Applicant's current understanding of the likely cables to be present (i.e. ***Table 6.16***) but with contingency built in to include potential cable discoveries post consent which will be informed by pre-construction magnetometer surveys. An indicative figure showing potential cable and pipeline crossing locations along the export cable route is presented in ***Figure 6.3*** and ***Chapter 17 Infrastructure and Other Users***.

6.5.10.9 Inter-array and Platform Link Cables: Indicative Electrical Layout

171. Inter-array cabling within the East Anglia ONE North windfarm site would be a maximum of 200km in combined length, depending on the final layout of the wind turbines. Platform link cables (i.e. cables which transmit electricity between offshore platforms) would be a maximum of 75km in combined length. Wind turbines are normally installed in arrays or 'strings' where a series of turbines are connected to each other, with the first turbine in the 'string' connected to the offshore electrical platform. The electrical layout would be designed to minimise length of cable, number of cables and electrical losses.

6.5.10.10 Inter-array and Platform Link Cables: Cable Type, Diameter, Insulation, Armour EMF / Heat Generated

172. The inter-array cables connect the wind turbines into strings and then connect the strings to the offshore electrical platform(s). Platform link cables connect offshore platforms. Each platform link cable between offshore electrical platforms will be up to 15km in length. The components of an inter-array cable are presented in (***Plate 6.11***).

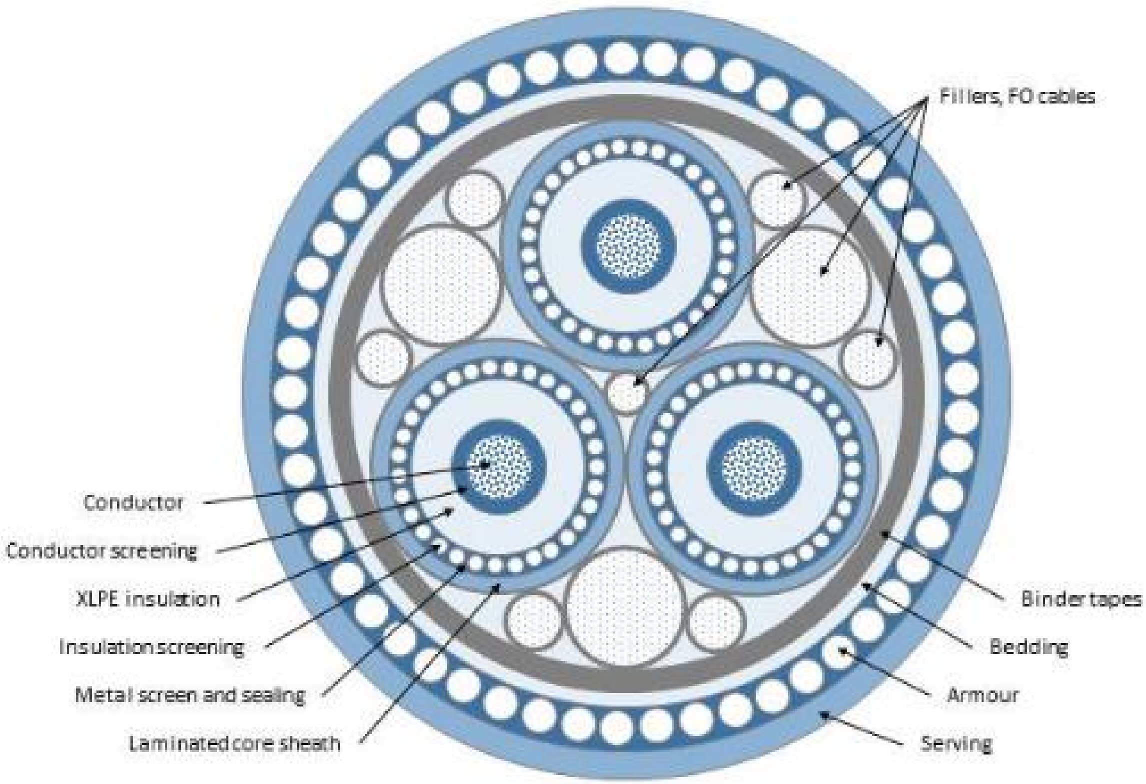

Plate 6.11 Inter-array Cables

173. The AC inter-array and platform link cables would typically be rated at 66 to 110kV with 3-core copper conductors, insulation and conductor screening and

steel wire armour. All cables would contain fibre optics either embedded between the cores or strapped to the outside, for communication purposes.

174. EMF would be minimised due to the balanced and screened three-core system.

175. Heat loss per meter for a typical 800mm^2 offshore HVAC 66kV 3-core cable is 40W/m.

6.5.10.11 Inter-array and Platform Link Cables: Installation and Burial Method

176. The cables would be supplied on drums, cages or carousels on board a cable vessel or barge.

177. Each section of cable is laid from the cable lay vessel either from a static coil or a revolving turn carousel, turntable or drum depending upon the characteristics of the cable. The cable is led via a cable pick-up arrangement and an associated cable trackway through linear cable engines and is led over board through a cable chute or stinger usually mounted at the stern of the vessel.

178. The cable would be pulled into the foundation via a J-tube (or alternative cable entry system), and later connected to the wind turbine. The rest of the cable would be laid along the sea bed and at the next wind turbine the cable would be again pulled into the foundation and later connected to the wind turbine.

179. Due to the water depths, it is not planned to use divers for any installation work. ROVs will be used when needed.

180. The inter-array and platform link cables would be installed using a mix of the following methods. See ***section 6.5.10.3*** for details of these methods:

- Ploughing;
- Pre-trenching or cutting; and
- Jetting.

6.5.10.12 Inter-array and Platform Link Cable Protection

181. In some cases, the above methods cannot be applied and it is necessary to use alternative methods other than burial (for details see ***section 6.5.10.4***):

- Rock placement;
- Concrete mattresses;
- Frond mattresses; or
- Uraduct.

182. The total worst case estimates for inter-array and platform link cable protection required because of ground conditions and cable crossings in the East Anglia ONE North windfarm site are presented in ***Table 6.17***. These have been

estimated based on up to 10% of the cables being unable to be buried because of ground conditions and therefore requiring cable protection. In reality, it is likely that, due to the sandy and gravely nature of the sediment throughout the East Anglia ONE North windfarm site, the majority of the inter-array and platform link cable(s) will be buried using a cable plough and will not require cable protection.

Table 6.17 Cable Protection Requirements for Inter-Array and Platform Link Cables

Cable Type	Total Area (m^2)	Total Volume (m^3)
Cable protection for platform link cables (see ***section 6.5.10.4***)	130,390*	146,650.4
Cable protection for the inter-array cables (see ***section 6.5.10.4***)	210,800*	237,088
**Includes requirement for up to 30 inter-array and 49 platform link cable crossings and assumes up to 10% of inter-array and platform link cable route will be unsuitable for burial.*		

6.5.10.13Inter-array and Platform Link Cable Protection: Cable Crossings

183. It has been anticipated that there could be up to 49 crossings required for platform link cables and up to 30 crossings for inter-array cables within the East Anglia ONE North windfarm site. The cables which intersect the East Anglia ONE North windfarm site are shown in ***Table 6.18***, for further details also see ***Chapter 17 Infrastructure and Other Users***.

Table 6.18 Summary of Offshore Cables Which Intersect the East Anglia ONE North Windfarm Site

Asset Name	Asset Type	Operator	General Trajectory (approximate)
Ulyssess 2	Telecommunications cable (operational)	Verizon Business	West to East
Benacre-Zandvoort No 1	Telecommunications Cable (not in use)	British Telecoms	West to East
Lowestoft Scheveningen No 1	Telecommunications Cable (not in use)	British Telecoms	West to East
Lowestoft Scheveningen No 2	Telecommunications Cable (not in use)	British Telecoms	West to East
Lowestoft Zandvoort	Telecommunications Cable (not in use)	British Telecoms	West to East
East Anglia THREE export cable route	Three transmission cables (consented)	East Anglia THREE Limited	East to West
East Anglia THREE export cable route	Three transmission cables (consented)	East Anglia THREE Limited	East to West

184. Where cable crossings occur, they will be protected using the methods as used for cable protection when cable burial is not possible (as described in ***section 6.5.10.4***). The anticipated maximum footprint of cable protection material due to crossings within the East Anglia ONE North windfarm site would be 108,704m^2 with a maximum height of 2.25m.

6.5.10.14 Inter-array and Platform Link Cables: Spacing

185. Where buried using a plough, each section of inter-array or platform link cable would be laid separately.

186. When approaching the offshore electrical platforms or wind turbine foundations, several cables may converge and the distance between cables would be reduced.

187. Methods for crossing other cables, pipelines etc. are the same as per export cables and are listed in ***section 6.5.10.8***.

6.5.10.15 Sand Wave Levelling, Backhoe Dredging and Export, Platform Link and Inter-Array Cables: Disturbance and Displacement

188. It has been estimated that the cable installation process could result in a maximum cable installation swathe of up to 20m per cable which is encompassed by the PLGR (see ***section 6.5.10.2***). A conservative maximum width of sea bed disturbance along the PLGR of 20m has been assumed to account for potential future increases in cable laying plough and PLGR requirements. For example, the width of the export cable installation plough being used on East Anglia ONE is 5.5m wide, however, these may increase in the future.

189. Some material may be disturbed before cable laying if boulders need to be moved from the cable route or if the sea bed needs to be levelled by dredging in areas with high and steep sand waves.

190. Where sand waves that require to be levelled are encountered, the profile of levelling works along the export cables would be 40m wide, with an average depth of 2.5m and a slope gradient of 1:4. Sand wave levelling would be in discrete areas and not along the full length of the corridor.

191. The sediment would be removed using a modern, commercial scale trailer hopper suction dredger (THSD) (see ***Plate 6.12***), as used to extract sand and gravel for the marine aggregates industry. Sand waves would be dredged by successive passes of the dredger head on the sea bed to remove consecutive layers of the sea bed material, with a focus on the sand wave crests, to the required depth. The dredger head will cut and erode a soil layer which would be mixed with seawater and pumped into the vessel's hopper using centrifugal pumps where the heavier sediments settle. A portion of the finer sediment would be allowed to run-off through an adjustable overflow system. When the hopper reaches capacity, or the mixture in the hopper reaches its optimum density, dredging

would be stopped and the suction pipe hoisted on deck. The THSD would then release the dredged materials in a licensed disposal area (see the Site Characterisation Report (Windfarm Site) (document reference 8.15) and Site Characterisation Report (Offshore Cable Corridor) (document reference 8.16). It is envisaged the vessel would dispose sediment in transit to aid dispersion, a process which will also be aided by natural processes. This approach will ensure material is dispersed across the whole disposal site to reduce mounding. An indicative total capacity of the THSD would be 25,000m^3 which could be deposited in a single dispersive disposal event.

Plate 6.12 Example of a trailer hopper suction dredger (THSD)

192. There may also be a requirement for backhoe dredging, for example, at the HDD pop-out location, which could result in a V-shaped trench of up to 8.6m wide x 4m deep. Additionally, up to 2,000m of backhoe dredging has been assumed along each export cable which would result in a maximum area of sea bed disturbance of 34,400m^2 (see ***Table 6.19***). Again, all sediment material generated would be disposed of in a licensed disposal area as set out in the Site Characterisation Report (Offshore Cable Corridor) (document reference 8.16) and Site Characterisation Report (Windfarm Site) (document reference 8.15).

193. The installation of subsea cables has the potential to disturb the sea bed down to 3m. It is difficult to estimate the actual volumes of sediment (and subsequent suspended sediment levels) that would be displaced during installation of cables however the types and magnitudes of effects that could be caused have previously been assessed within an industry best-practice document on cabling techniques (BERR 2008). This document has been used alongside expert judgement and analysis of site conditions to inform the relevant assessments within the ES.

194. It is important to note that the volumes of disturbed sediment from cable installation using a towed plough (see ***Plate 6.13***) (the likely method for export

cables) or a plough trencher (see ***Plate 6.14***) (the likely method for inter-array and platform link cables) would not count against the proposed East Anglia ONE North project's Disposal Licence volumes as the sediment is not extracted to a hopper and then released back to the sea bed.

Plate 6.13 Plough which was used to install the offshore export cables at the East Anglia ONE project

Plate 6.14 Photo of an indicative plough trencher (the likely installation method for platform link and inter-array cables)

195. It is anticipated that the changes in suspended sediment concentration due to cable installation would be less than those arising from the disturbance of near-surface sediments during foundation installation activities at any one location, including sea bed preparation, with the location of release changing as work progresses along the cable routes.

196. The overall sediment release volumes at any one location would be low and confined to near the sea bed along the alignment of the cable route and the rate at which sediment is released into the water column would be relatively slow.

197. The maximum length of export cable installation corridor is 152km from the offshore electrical platforms to landfall, based on an average length of 76km per installation corridor for a total of two installation corridors. The maximum volume of sediment interaction from cable burial (using ploughing) would therefore be 45,600m^3 per installation corridor (91,200m^3 for a total of two installation corridors) based on a realistic worst case average burial depth of 3m with a V-shaped cross-section for the plough share of 0.4m width at the sea bed surface. Ploughing would create temporary mounds either side of the trench and therefore

it is expected that only a small proportion of the 45,600m^3 would result in sediment plumes during cable installation.

198. The above figure for total sediment displacement from a single installation corridor is unrealistic for assessment purposes as the release would be episodic and spread along the full length of the offshore cable corridor. Furthermore, it is unrealistic to assume that the plough share (approximately 0.4m wide at the sea bed) would displace all sediment to the burial depth, as a proportion of the sediment would move around the share or be compressed laterally. Assuming a typical ploughing speed of 300m/hour (see ***Table 6.14***) and a maximum worst case continuous cable installation period of twelve hours, 3,600m of export cable could potentially be installed per day. This would therefore result in a total sediment displacement volume of 2,160m^3 per day for export cables. Some of this daily volume would be suspended into the water column.

199. For platform link and inter-array cable installation, a plough trencher is likely to be used. As a worst case, it is assumed that this would result in a trench of 2.7m wide funnelling down to 1.7m deep. This would result in a volume of sediment interaction of 458,000m^3 for 200km of inter-array cables and 171,750m^3 for 75km of platform link cables. Based on a trenching speed of 80m/hour, the worst case volumes of daily sediment interaction would be 2198.4m^3 per day.

200. ***Table 6.19*** outlines the anticipated disturbance areas and volumes from sand wave levelling and backhoe dredging together with that for the installation of export, inter-array and platform link cables.

Table 6.19 Total Area, Volume and Maximum Daily Sediment Volume Interaction Calculations during Cable Installation

Activity	Maximum Area of Sea Bed Disturbance (m^2)	Total Volume of Sediment Interaction (m^3)	Worst Case Daily Volume of Sediment Interaction (m^3)
Export cable installation	3,040,000	91,200 (45,600 per cable)	2,160
Inter-Array cable installation	4,000,000	458,000	2,198.4
Platform link cable installation	1,500,000	171,750	2,198.4
Sand wave levelling for export cables	800,000	1,000,000	n/a*
Sand wave levelling inter array cables	320,000	400,000	n/a*
Sand wave levelling for platform link cables	120,000	150,000	n/a*

Activity	Maximum Area of Sea Bed Disturbance (m^2)	Total Volume of Sediment Interaction (m^3)	Worst Case Daily Volume of Sediment Interaction (m^3)
Backhoe dredging in the offshore cable corridor e.g. at the HDD pop-out location	17,200, but this area is not used in any assessments within the ES as it is already incorporated within the areas affected for export cable installation and sand wave levelling.	68,800	n/a*

** It is not believed to be practical to calculate daily sediment interaction volumes for these activities. Disposal methods and volumes would be as set out in the Site Characterisation Report (Windfarm Site) (document reference 8.15) and Site Characterisation Report (Offshore Cable Corridor) (document reference 8.16). Maximum volumes of disposed sediment during single disposal events would be subject to the capacity of the dredger.*

6.5.11 Construction Vessels, Helicopters and Logistics

201. The number and specification of vessels employed during the construction of the proposed East Anglia ONE North project would be determined by the marine contractor and the construction strategy following successful consent to construct the proposed East Anglia ONE North project. It is anticipated that several types of construction vessel could work in parallel during the construction period.

202. The final selection of the port facilities required to construct and operate the proposed East Anglia ONE North project has not yet been determined.

203. Indicative vessel types required during the construction and operation stages are shown in ***Table 6.20***.

Table 6.20 Indicative Vessel Requirements at Construction and Operation Stages

Activity	Vessel Type	Indicative Number
Foundation installation	Dredging vessel	4
	Tugs and barges storage and transport	10
	Jack-up vessel	2
	Dynamic position heavily lift vessel	3
	Support vessel	5
Wind turbine installation	Jack-up vessel	3
	Dynamic Position Heavy Lift Vessel	1
	Windfarm service vessel	2
	Support vessels	2
Platform installation	Installation vessel	2

Activity	Vessel Type	Indicative Number
	Tug with accommodation barge	2
	Supply vessel	2
	Support vessels	3
Cable installation (see ***Plate 6.15***)	Inter-array cable laying vessel	3
	Export cable laying vessel	2
	Export cable support vessel	3
	Pre-trenching/backfilling vessel	3
	Cable jetting and survey vessel	3
Other Vessels	Workboat	15
	Accommodation and supply vessel	2

204. An example of a cable laying vessel operating at the East Anglia ONE windfarm site is shown in ***Plate 6.15***.

Plate 6.15 Cable Laying Vessel Operating at the East Anglia ONE Windfarm Site

205. It is anticipated that approximately 74 vessels would be on site at any one time during the construction of the proposed East Anglia ONE North project. Numbers of vessels will be confirmed with further input from construction contractors post-consent.

206. It is estimated that approximately 3,335 individual vessels trips would be required during the construction of the proposed East Anglia ONE North project. It is estimated that the installation of each wind turbine foundation will require up to three vessel movements of the installation vessel.

207. There will also be a requirement for helicopters to travel to and from the East Anglia ONE North windfarm site to assist with construction activities. It is estimated that approximately 981 helicopter round trips may be required during the offshore construction period.

6.5.11.1 Anticipated Safety Zones

208. Some restrictions on vessel movements within the offshore development area will be required to protect the health and safety of all users of the sea. It is anticipated that vessels would navigate to give each windfarm asset as large a clearance as possible. However, to reduce the possibility of vessel collisions, it may be considered necessary to apply for rolling safety zones.

209. The powers to make safety zones are set out in Section 95 of the Energy Act 2004, and are related to renewable energy installations, encompassing wind turbines, electrical platforms and meteorological masts. Safety zones for inter-array, or export cables are not covered within the Energy Act 2004.

210. The safety zones that could be applied for in respect of the East Anglia ONE North project are presented in ***Table 6.21*** below.

Table 6.21 Potential Rolling Safety Zones during Construction, Operation and Decommissioning

Type of Safety Zone	Area Covered
Construction[1]	Up to 500m around each foundation or renewable energy installation whilst under construction
Commissioning[2]	Up to 50m around each renewable energy installation where construction has finished but some work is ongoing, e.g. wind turbine incomplete or in the process of being tested before commissioning.
Major Maintenance[2]	Up to 500m when major maintenance is in progress (use of jack-up vessel or similar).
Decommissioning	Up to 500m at the end of the working life of a renewable energy installation when it is being removed from site
[1] The Construction, Major Maintenance and Decommissioning rolling safety zones are required to ensure a safe distance is maintained from vessels engaged in high risk activities such as jacking operations and heavy lifts.	
[2] The Commissioning safety zones are required to ensure small vessels are not adversely affected by propeller or thruster wash from vessels used for transfer whilst also ensuring no additional risk is created for personnel during access and egress. This zone also reduces risk of injury to third parties from items dropped from aloft.	

211. Whilst no formal application of a safety zone around cable laying operations is possible under Section 95 of the Energy Act 2004, it is the intention to propose rolling Advisory Exclusion Zones of up to 500m around vessels installing export cables, platform link cables and inter-array cables in the interests of the safety of

all users of the sea, and to provide clearance of 500m from laid cables until burial is confirmed in case of interaction with anchors or fishing gear.

6.5.11.2 Vessel Profiles

212. This section provides an overview of the types of vessel that would be used in the construction, operation and decommissioning of the proposed East Anglia ONE North project.

213. **Jack-up vessels:** Jack-up vessels are considered an option for the installation of jacket foundations and wind turbines along with floating vessels.

214. Floating vessels are under consideration for some operations although the techniques are not always proven so jack-up vessels are still likely to be used. Jack-up vessels would result in a maximum sea bed footprint of 3,000m^2.

215. **Dynamic positioning (DP) heavy lift vessel:** If used for the proposed East Anglia ONE North project, a heavy lift vessel would need to be capable of lifting heavy loads such as transition pieces and nacelles into place.

216. DP is a computer-controlled system which is used to automatically maintain a vessel's position and heading by using its own propellers and thrusters. Position reference sensors, combined with wind sensors, motion sensors and gyro compasses, proide information to the computer pertaining to the vessel's position and the magnitude and direction of environmental forces affecting its position.

217. DP vessels often make use of azimuth thrusters whereby the propeller is placed within a pod or a duct to allow rapid repositioning of the thruster in response to changes in vessels position. This enables the vessel to stay in a precise location.

218. **Accommodation vessel:** One or more accommodation vessels could be used as a temporary home to the workers who install and commission the wind turbines and electrical infrastructure at the windfarm. These types of vessels are sometimes known as “flotels”.

219. **Windfarm service vessel:** Windfarm service vessels are typically much smaller than the jack-up, heavy lift and accommodations vessels and are usually no greater than 30m in length. These vessels are often multi-hulled which makes them more stable and moveable especially in rough sea conditions.

220. Service vessels would vary in design and dimensions as they would be required to carry out a variety of different services and operations.

221. **Cable laying vessel:** There may be up to two separate vessels involved in laying the inter-array and export cables. In one scenario, the first vessel would lay the cable on the sea bed and the second would bury the cable. Alternatively, one vessel would lay and bury the cable at the same time.

222. Cable laying vessels are typically very large (70m or more) with lots of laydown area to accommodate the hundreds of kilometres of cable needed on an offshore windfarm.

6.5.12 Oils, Fluids and Effluents

223. Oils in the wind turbines shall be biodegradable where possible. All wind turbines would have provision to retain all spilled fluids within nacelle or tower. The volume of oil and fluids would vary depending on wind turbine design, i.e. whether conventional design or gearless or whether one or two rotor bearings are used in the design. It will also depend on the amount of redundancy designed into the system.

224. All chemicals used would be certified to the relevant standard. A brief summary of oils and fluids in the systems is given in ***Table 6.22***.

Table 6.22 Example of Volumes of Oils and Fluids in a Typical Wind Turbine

Component	Volume (L)	Comment
Gearbox	Up to 100	Mobilgear SHC XMP 320 or equivalent
Hydraulic pitch (if used)	500	ISO 32 biodegradable hydraulic fluid
Coolant systems	Approximately 1000	50% Glycol or water
Transformer	Up to 1,500	Biodegradable ester-based oil
Yaw and motors	Not determined	Soap based lithium grease

225. Examples of substances contained in the offshore electrical platforms are as follows:

- Diesel for the emergency diesel generators (in diesel storage tanks);
- Oil for the transformers;
- Deionised water for the valves cooling system;
- Glycol;
- Sewage and grey water;
- Lead acid in batteries;
- Engine oil; and
- SF6 (gas coolant).

226. To avoid discharge of oils to the environment the wind turbines and offshore electrical platforms are anticipated to be subject to best-practice design, for example with a self-contained bund to collect any possible oil spill. To avoid

discharge or spillage of oils it is anticipated that the transformers would be filled for their life and would not need interim oil changes.

6.5.13 Disposal Sites

227. It should be noted that for all foundation types and cable installation activities within the East Anglia ONE North windfarm site, sand dredged during installation that requires disposal would be deposited at an agreed disposal site as close as practical to the installation operations. The Applicant will seek to designate the East Anglia ONE North windfarm site as a disposal site. However, for locations requiring significant excavation, it is likely that some of this dredged material would be used later for infill works, and as ballast material. The Applicant is also seeking for the offshore cable corridor to be designated as a disposal site in respect of (dredged materials / materials arising) cable installation activities. Full details of the proposed disposal site locations and procedures are provided within the Site Characterisation Report (Windfarm Site) (document number 8.15) and Site Characterisation Report (Offshore Cable Corridor) (document number 8.16) reports.

228. Note that any anthropogenic material recovered to the surface (which is not of interest from a heritage perspective and therefore not covered by the Archaeological Written Scheme of Investigation (see ***Appendix 6.3***)) would be returned to shore and dealt with as waste through the waste hierarchy.

6.5.14 Offshore Infrastructure Construction Sequence

229. The key stages associated with the installation of the offshore windfarm, which will be conducted simultaneously or consecutively, are likely to be as follows:

- Detailed pre-construction site investigations (e.g. cone penetration tests (CPT), boreholes and high-resolution geophysical surveys);
- Installation of foundations;
- Installation of transition pieces;
- Installation of offshore electrical platforms;
- Installation of inter-array cables;
- Installation of platform link cables;
- Installation of wind turbine generators; and
- Installation of the monitoring meteorological mast.

230. The offshore export cables would either be installed separately or in parallel with other elements of the offshore windfarm (see ***section 6.5.10***). Prior to installation of the offshore export cables some ground preparation may be required along the route.

6.5.14.1 Pre-Construction Site Investigations

231. Pre-construction site investigations would be completed prior to construction and could include:

- Geotechnical survey
- Geophysical survey; and
- ROV survey.

232. Geophysical survey data would inform the final engineering design of wind turbine foundations, cables and offshore electrical platforms. The geophysical data would also serve to identify the location of sand waves within the East Anglia ONE North windfarm site and offshore cable corridor so that an assessment could be made as to whether such features could be avoided or, if not, what level of sea bed preparation (pre-lay sweeping) is required, and what the appropriate burial depth would be in stable (i.e. non-mobile) sea bed conditions.

233. Targeted geotechnical surveys would take place and would involve a number of boreholes, CPT and vibro-cores within the East Anglia ONE North windfarm site and offshore cable corridor up to the landfall site.

234. A PLGR and ROV survey would take place to identify any obstacles that may be in the path of the proposed cable routes. If an obstacle is detected it would either be removed or the cable would be installed in such a way as to avoid it.

6.5.14.2 UXO Clearance

235. Where the obstacle is suspected to be Unexploded Ordnance (UXO), specialist mitigation would be employed to either avoid or make the obstruction safe. As a worst case it has been assumed that there could be the requirement for up to 80 UXO devices to be cleared which is based on the most recent available information taken from the East Anglia ONE project. The UXO clearance procedure would be subject to an agreed method statement and a UXO Plan showing the area in which UXO clearance activities are proposed (see ***Appendix 6.3***).

6.5.14.3 Construction

236. It is anticipated that the installation of the offshore elements would take approximately 27 months. Construction works would be undertaken 24 hours a day and seven days a week offshore, dependent upon weather conditions.

6.5.14.3.1 Installation of Foundations

237. The time taken to install foundations would vary depending on the type and installation method chosen. Indicative foundation installation timescales for piled foundations are presented in ***Table 6.23***. Up to three foundation installation vessels could be used at the same time to install a single foundation.

Table 6.23 Indicative Time Periods for Piled Foundation Installation

Foundation Type	Active piling time per wind turbine (hr)	Maximum worst case scenario total installation time (hr)*
Jackets with pin piles	12.6	605
Monopile	5.25	252

*This is the amount of time for piling activity and does not take into account downtime of transit of installation vessels or ground preparation time

238. It should be noted that there will be no concurrent piling within the East Anglia ONE North windfarm site for wind turbines and offshore platforms. There will also be no concurrent piling between the proposed East Anglia ONE North and East Anglia TWO projects.

6.5.14.3.2 Installation of Transition Pieces and Towers

239. Following foundation installation, TPs would be fixed to the top of the foundation. The TP facilitates the connection between the foundation and the tower.

240. Both TPs and towers would be either transported to site and installed by the installation vessel or transported on a barge where they would be lifted off and installed by crane on a separate installation vessel. The most likely installation vessel would be a jack-up vessel, although DP vessels are also under consideration.

241. The TP serves several different purposes as it could be used to house the necessary electrical and communication equipment and provide a landing facility for personnel and equipment from marine vessels.

242. The design and specifications of a TP are dependent on the type of foundation on which they sit. For jackets and gravity base structure foundations the TP is often integrated with the foundation at fabrication stage, and therefore there is no additional installation process. For monopiles however a TP cannot be located on the foundation as the top side needs to be clear to allow it to be driven into the sea bed.

243. Once the TPs are in place the wind turbine tower would be lowered into place using a heavy lift vessel.

6.5.14.3.3 Installation of Wind Turbines

244. The nacelle and wind turbine blades would either be transported to site and installed by the installation vessel or transported on a barge where they would be lifted off and installed by crane on a separate installation vessel. The installation of the wind turbines would typically involve multiple lifting operations, with up to three tower sections erected, followed by the nacelle with pre-assembled hub, and then the blades.

245. ***Plate 6.16*** shows an example of a wind turbine under construction, TP tower, nacelle and the blades have all been installed and a gangway is in place permitting worker access to the tower.

Plate 6.16 Wind Turbine under Construction (photo taken from West of Duddon Sands offshore windfarm)

246. Installation of each wind turbine onto the pre-installed foundation is expected to take approximately one day, excluding transit times and weather downtime. To reduce time spent at sea installing the wind turbines, pre-commissioning works onshore would be maximised.

247. Traditional installation methods consist of tower segments lifted in place and bolted together, hub and nacelle conjoined in case of single blade installation. Also, alternative installations would be considered, such as the two bladed 'bunny ears' formation (where two blades are pre-installed on the hub) and the 'star' formation (three bladed pre-installed to the hub).

248. Although not current practice, it is possible that wind turbines could be fully assembled and commissioned onshore and transported to site as a single unit installation. This method is being explored by the wind industry but it is not possible to commit to this method as it is not technically proven at this stage.

6.5.15 Offshore Maintenance

6.5.15.1 Maintenance Activities

249. All offshore infrastructure including wind turbines, foundations, cables and offshore platforms would be monitored and maintained during this period to maximise efficiency.

250. The operation and control of the windfarm would be managed by a Supervisory Control and Data Acquisition (SCADA) system, connecting each wind turbine to the onshore control room. The SCADA system would enable the remote control of individual wind turbines, the windfarm in general, as well as remote interrogation, information transfer, storage and the shutdown or restart of any wind turbine if required.

251. There are a number of potential maintenance strategies for the windfarm. The windfarm could be maintained from shore using a number of varying O&M vessels (e.g. crew transfer vessels, supply vessels) and / or helicopters – i.e. the onshore option. Alternatively, the windfarm could be maintained primarily from an offshore base, for example a mother ship (a large offshore service vessel (possibly of the jack-up type) or a standalone construction, operation and maintenance platform within the project boundary) with transfer vessels or helicopters used to transfer personnel to or from wind turbines and platforms – i.e. the offshore option.

252. Alternatively, a combination of the onshore and offshore O&M options described above may be employed.

253. Given the design life of the offshore components, some refurbishment or replacement would be required during the lifetime of the project. Details of the anticipated maintenance requirements are included in the outline offshore operation and maintenance plan (OOOMP document reference 8.12 and see ***Appendix 6.3***) submitted with the DCO Application and secured under the requirements of the draft DCO.

254. Typical maintenance activities would include; general wind turbine service; oil sampling / change; UPS (uninterruptible power supply)-battery change; service and inspections of wind turbine safety equipment, nacelle crane, service lift, HV system, blades; major overhauls (years five, seven, ten), wind turbine repairs and restarts. The worst case scenario assumes that there will be one visit every two years to each wind turbine that requires the use of a jack-up vessel.

255. During the life of the project, it is not the intention to repair or replace the sub-sea cables, however repairs may be required and periodic inspection will be undertaken. Periodic surveys would also be required to ensure the cables remain buried and if they do become exposed, re-burial works would be undertaken. The worst case scenario estimates a maximum of five annual maintenance activities

that will require a cable laying vessel. Additionally, there will be a maximum of four annual geophysical surveys to inspect cable burial and scour.

6.5.15.2 Vessel and Helicopter Operations

256. A number of vessel and / or helicopter visits to each wind turbine would be required each year to allow for scheduled and unscheduled maintenance. The approximate number of annual helicopter roundtrips to the East Anglia ONE North windfarm site would be 981. For windfarm support vessels, it is expected that approximately 647 roundtrips would be required which includes all scheduled and unscheduled maintenance. If the onshore operation option is chosen, this would mean small crew vessels sailing to and from the windfarm on a daily basis from shore, possibly supported by helicopters. If the offshore operation option is preferred, the majority of small crew vessels would be operated on a daily basis from the offshore accommodation vessel or platform, although further support vessels are also still likely to transit to and from shore each day and helicopter operations may still be utilised. Electrical platforms are anticipated to require one visit a week.

257. Although it is not anticipated that large components (e.g. wind turbine blades or offshore electrical platforms transformers) would require replacement during the operational phase, it is a possibility. Should this be required, large jack-up vessels will need to operate continuously for significant periods to carry out these major maintenance activities.

258. During O&M activities East Anglia ONE North Limited would seek to agree appropriate safety zones around wind turbines and work areas to be applied. Safety zones are described above in ***section 6.5.11.***

6.5.15.3 O&M Port

259. The O&M facility is to be located in a service port (yet to be chosen). It is envisaged that O&M needs, in terms of laydown areas and facilities would be minimal compared to requirements during the construction phase.

260. In the event of major intervention where large components are needed (blades, gearboxes, generators), East Anglia ONE North Limited would aim to minimise the number of spares it keeps, and to supply such components directly to site from the supplier's works.

261. An office, storage or warehouse facility and quayside loading area would be needed. During the operational years of the project, operations might be coordinated and implemented from the onshore facility. Alternatively, some personnel and accommodation and O&M facilities may be undertaken offshore, either from temporary platforms such as an accommodation vessel, or from a permanent structure such as the construction, operation and maintenance platform.

6.5.16 Offshore Decommissioning

262. At the end of operational phase, it is a condition of The Crown Estate lease as well as a statutory requirement (through the provisions of the Energy Act 2004 (as amended) that the proposed East Anglia ONE North project is decommissioned.

263. The scope of the decommissioning works would be determined by the relevant legislation and guidance at the time of decommissioning and would most likely involve removal of the accessible installed components. Offshore this is likely to include; all of the wind turbine components, part of the foundations (from 1-2m below sea bed level) and the sections of the inter-array cables close to the offshore structures, as well as sections of the export cables.

264. Details for decommissioning of offshore foundations are discussed throughout ***section 6.5.4***.

265. With regards to offshore cabling, general UK practice would be followed i.e. buried cables would simply be cut at the ends and left *in-situ*.

266. Based on previous estimates and experience, it is anticipated that decommissioning of the proposed East Anglia ONE North project would occur in stages.

6.6 Landfall

6.6.1 Site and Project Description

267. It is proposed that up to two offshore export cables would make landfall north of Thorpeness in Suffolk. This landfall location was identified based on appraisal of a wider stretch of coastline and appropriate consultation.

268. A detailed description of the site selection process is presented in ***Chapter 4 Site Selection and Assessment of Alternatives*** but in summary, this site was chosen based on an appraisal of constraints and engineering feasibility from both offshore and onshore perspectives. From an offshore perspective, one such consideration was that this location allows the export cables and HDD route to be located to the south of the offshore Coralline Crag (a large sea bed geological feature) thereby avoiding impacts upon coastal processes, see ***Chapter 4 Site Selection and Assessment of Alternatives*** and ***Chapter 7 Marine Geology, Oceanography and Physical Processes***.

269. Indicative project characteristics for the proposed East Anglia ONE North project at the landfall are detailed in ***Table 6.24*****.**

Table 6.24 Indicative Proposed East Anglia ONE North Project Characteristics at Landfall

Landfall	
Landfall location	North of Thorpeness Village
Method for crossing intertidal	HDD
Number of ducts	4
Number of underground transition bays	2

270. The East Anglia ONE North landfall is characterised by a shingle beach at the wave break point, with a raised terrace of shingle at the base of low lying cliffs (approximately 10m above ordnance datum) which are partially vegetated by grasses, gorse and other small shrubs. The beach is designated as a Site of Special Scientific Interest (SSSI) for a rich mosaic of habitats including acid grassland, heath, scrub, woodland, fen, open water and vegetated shingle and is managed by Natural England. There are no formal coastal defences associated with flood prevention or coastal stability at the landfall location.

271. The transition bays would be located in arable farmland.

272. Off-site and directly south of the landfall on the cliff is Thorpeness Village. North is the residential property Ness House.

6.6.2 Landfall Project Description

273. HDD operations would be needed to install the ducts required which would accommodate up to two export cables, and two FO cables, associated with the proposed East Anglia ONE North project.

274. At the landfall the cable ducts would be installed with a minimum setback distance of 85m from the cliff top to ensure the integrity of the cliff is not compromised and to allow for natural coastal erosion. The end of the HDD ducts would be buried under the sea bed beyond the intertidal zone. Cables installed within the ducts would either be connected to the offshore export cables immediately, or the ducts would be left within the sea bed until the cables are installed within them at a later date and connected to offshore export cables.

6.6.2.1 HDD

275. HDD involves a three-stage process wherein.

1) The first stage drills a small diameter pilot bore along the designated route;
2) The second stage enlarges the bore by passing a larger cutting tool known as the reamer through the bore a number of times to progressively enlarge the bore to the requirement diameter; and
3) The third stage places the duct in the enlarged hole (the offshore export cable and/or fibre optic cables will then be pulled through this duct once the duct is installed or at a later stage in the works).

276. HDD is undertaken with the help of a viscous fluid known as drilling fluid. It is typically a mixture of water and bentonite or polymer continuously pumped to the cutting head or drill bit to facilitate the removal of cuttings, stabilise the borehole, cool the cutting head, and lubricate the passage of the duct.

6.6.2.1.1 Drilling the Profile

277. A small diameter pilot hole is drilled under directional control along a predetermined path using a mud-motor or jet bit on the end of the pilot string. As the pilot hole extends through the upper layer of ground (typically top soil and made ground), casing (typically a metal pipe or collar around 100m long) may be added to the bore to assist in maintaining the integrity of this upper ground layer. Pilot hole drilling operations continue until the exit point is approached, although the pilot hole will not break through the final section of sea bed. Then the smaller pilot string is removed with the casing (if used).

6.6.2.1.2 Enlarging the Hole

278. Reaming operations are carried out to enlarge the drilled hole to a size suitable for accepting the duct. Depending upon the duct diameter to be installed, several reaming operations may be necessary, each progressively enlarging the hole. Reaming will progress the hole to the break out point on the sea bed. Typically, reaming takes place in a forward direction, from the HDD rig outward along the pilot hole and back but may also be undertaken from an offshore support vessel towards the HDD rig.

6.6.2.1.3 Installing the Pipe

279. The drill rig is used to pull the duct (the duct being positioned on the sea bed or floating on the sea surface) into the preformed hole towards the HDD rig. The drilling fluid will consist of water and clay minerals. Once the duct is installed, the ends would be covered or plugged until the offshore export cable is ready to be installed. The offshore export cable is then passed through the duct (see ***Plate 6.17***).


Plate 6.17 HDD landfall duct site (image taken from East Anglia ONE project)

280. After installation, the duct will be backfilled and surrounded with bentonite or similar material for thermal resistivity purposes.

281. The maximum length of the HDD bore feasible is governed by the mechanical design limits on the export cable (i.e. the length of export cable that can be pulled through the duct without causing damage to the cable) and the drill profile (i.e. the angle of the bore).

282. The installation by HDD would require a fenced HDD temporary working area up to 7,000m^2. A Construction Consolidation Site (CCS) to serve the HDD area will also be required. The landfall CCS will be up to 7,040m^2 in area. There is an additional transition bay temporary working area up to 1,544m^2 in area for the excavation footprint and installation of both transition bays.

283. The HDD works would progress with the following stages:

- Mobilise equipment to landfall site and prepare temporary construction base including hardstanding, temporary office cabins and bunded fuelling areas;
- Position HDD rig close to transition bay and drill a pilot hole;
- Enlarge the pilot hole by reaming;
- Install the duct in the enlarged hole;
- If required, drawback of the offshore duct end and natural burial by sandy sediments until the offshore export cable is ready to be pulled into the duct; and
- At this point, the construction equipment may be removed and the site partially reinstated to its previous condition.

284. Once the export cable is ready to be installed in the duct at the landfall, the following steps would be required:

- Upon arrival of the export cable installation vessel, the duct exit would require to be exposed. This would most likely be achieved using a mass flow excavator (a submersible tool used to clear sediment without damaging the duct).
- The export cable installation vessel would be positioned at the HDD exit point by anchors prior to undertaking the cable pull-in operation, and the offshore export cables would be pulled ashore through the duct.
- Following completion of the pull in operation (and subsequent termination and cable testing) the export cable installation vessel would commence cable lay operations for the remainder of the export cable.
- Subsequent to the cable lay operations, the cable in the transition zone between the HDD duct and full depth of cable trench would be lowered utilising diver-based jet lancing and dredging operations, most likely supported from a small anchored or spudded barge.

6.6.2.2 Transition Bays

285. It is anticipated that two transition bays would be installed at the landfall with a setback distance of a minimum of 85m from the cliff top to ensure the integrity of the cliff is not compromised and to allow for natural coastal erosion. Each transition bay would comprise a buried concrete-lined structure. The purpose of the transition bay at the landfall would be to provide housing for the joints between the heavily armoured offshore export cables and the onshore cables.

286. The installation of the two transition bays would involve:

- Removal of the topsoil.
- Mechanical excavation of the transition pit chamber (excavation would be slightly larger than the jointing pit dimensions). Excavated material will either be used as backfill or removed from the site and suitably disposed of.
- Dewatering of excavations may be required. This will require establishment of a pump for dewatering the excavations which may be required to run overnight (see ***section 6.9*** regarding exceptions to typical working hours). A welfare unit may also be required at dewatering locations.
- Construction of concrete transition bay chamber floor and walls. This would involve either the installation of shuttered walls, reinforcement and poured concrete (which would be transported to the site) and the shuttering would be removed once the concrete is suitably cured); or the installation of precast concrete walls.
- Temporary backfill (sand or similar) of the transition bay chamber until the offshore export cables and onshore cables are installed.

287. Each transition bay would be up to 6m in width, 1.8m in height and 21m in length. Each transition bay would be buried underground to an approximate depth of 3m (the top of the transition bay being approximately 1.2m below ground level). The excavation to install both transition bays could be up to 37m in width, 3m in depth and 42m in length. The land would be fully reinstated following construction.

6.6.2.3 Construction Traffic and Plant

288. Access to the landfall will be via Sizewell Gap (no construction access for the landfall will be required via Thorpeness Road). Details of vehicle movements for construction at the landfall are provided in ***Chapter 26 Traffic and Transport.***

289. For HDD operations, plant would include (for a full list of assumed plant see ***Appendix 25.2***):

- Mud separation unit;
- Drill rig;
- Tractors;
- Excavator;
- Generators and pumps;
- Telehandler; and
- Dumper.

290. For the transition bays, plant would include (for a full list of assumed plant see ***Appendix 25.2***):

- Dozer;
- Tractors and trailers;
- Excavator;
- Generators and pumps;
- Telehandler; and
- Dumper.

6.6.2.4 Lighting

291. It has been assumed that 24-hour lighting would be required during HDD operations.

6.6.2.5 Workforce

292. The total number of construction employees required has been estimated at an average of 7 (with a peak of 33), assuming one drill rig operating over the construction duration at the landfall.

6.6.2.6 Reinstatement

293. The CCS and temporary working areas would be reinstated to its former condition. If necessary, the subsoil would be ripped prior to topsoil placement if compaction has occurred. Topsoil would be spread in such a way as to ensure that it does not become compacted.

6.6.3 Operation and Maintenance

294. Routine maintenance is anticipated to consist of one annual visit to each transition bay to carry out integrity testing, which would be accessed via man-hole covers, and possible non-intrusive checking of the cable with, for instance, ground penetrating radar or visual inspection of the ground surface.

295. Appropriate off-road vehicles would be used to access each transition bay.

296. Non-scheduled maintenance to address faults as and when these arise would also be necessary. Appropriate off-road vehicles would be used for access.

6.6.3.1.1 Operational Vehicle Movements

297. Operational vehicle movements have not been considered in respect of the landfall as regular maintenance is not anticipated to be required. In the event that limited maintenance is required, this would be through the use of light four-wheel drive commercial vehicles using farm access tracks or other routes agreed with the landowner.

6.6.4 Decommissioning

298. With regards to offshore cabling, general UK practice would be followed, i.e. buried cables would simply be cut at the ends and left *in situ*. It is considered that full removal of the buried cables would have a more damaging environmental impact than is the case when leaving them *in situ*. In the nearshore, if there is a risk of cables being exposed over time they will need to be removed via excavation or jetting.

299. The transition bays would also be left *in situ* or removed depending on the requirements of the onshore decommissioning plan approved by the local planning authority as secured under the requirements of the draft DCO.

6.7 Onshore

6.7.1 Onshore Cable Route: Site Description

300. The proposed route for the onshore cables is approximately 9km long and is shown in ***Figure 6.2***.

301. A full description of the onshore cable route is provided below. For the purposes of the assessment, the onshore cable route is split into sections. These sections are illustrated in ***Figure 6.2*** and ***Figure 26.2*** in ***Chapter 26 Traffic and Transport***.

6.7.1.1 Onshore Cable Route – Section 1

302. Commencing at the transition bay north of Thorpeness, the onshore cable route runs in a northern direction for approximately 1.5km through agricultural land (comprising small irregular shaped fields) parallel to the edge of the Leiston – Aldeburgh SSSI and Sandings SPA and coastline.

303. Approximately 1.5km from the landfall, the onshore cable route turns in a western direction and crosses the Leiston – Aldeburgh SSSI and Sandings SPA.

6.7.1.2 Onshore Cable Route – Section 2

304. After crossing the SSSI and SPA, the route runs in a south westerly direction for approximately 2km, through agricultural land.

305. The onshore cable route crosses the B1353 Thorpeness Road and continues in a south westerly direction to the crossing point of the Hundred River. This section of the onshore cable route crosses agricultural land and grazing land.

6.7.1.3 Onshore Cable Route – Section 3

306. After the Hundred River, the onshore cable route heads immediately west to the crossing point of the B1122 Aldeburgh Road. On crossing the B1122 Aldeburgh Road, the onshore cable route runs westward through woodland to the north of Fitches Lane for approximately 175m and through an agricultural smallholding for approximately 100m. It should be noted that the onshore development area has been narrowed at this point to minimise the interaction with woodland and potential environmental impacts.

307. After passing through the woodland belt the route continues in a westerly direction for approximately 1km passing through agricultural fields, travelling south of Coldfair Green until the crossing point of Sloe Lane and, further west, the crossing point of the B1069 Snape Road.

6.7.1.4 Onshore Cable Route – Section 4

308. From the crossing of the B1069 Snape Road, the onshore cable route turns in a north westerly direction for approximately 1.5km crossing more agricultural fields until the crossing point of Grove Road before turning immediately north for approximately 300m before reaching the proposed East Anglia ONE North substation location. During this final section, the route travels across agricultural land.

6.7.2 Onshore Cable Route: Project Description

309. This section describes the infrastructure that constitutes the onshore cable route, alongside the proposed construction, operation and decommissioning methodologies associated with this infrastructure.

6.7.2.1 Cables and Ducts

310. There would be up to six onshore cables and two FO cables, laid in two trenches (three onshore cables and one FO cable in each trench). Cables will be installed approximately 1.2m below ground level, to transport the electrical power from the landfall to the onshore substation location. Cables will be placed directly underground without ducting, although ducting may be used in some or all of the route. Cables would typically be up to 170mm in diameter (the ducts being larger).

311. Each cable trench will require distributed temperature sensing (DTS) cabling to be installed next to the ducts or cables. Typically, this system comprises of a fibre optic cable within a protective sheath or duct. The DTS identifies faults in the buried cables during operation, allowing the precise location of any fault to be identified and more accurate excavation of the ground to facilitate the cable repair.

6.7.2.2 Cable Jointing and Jointing Bays

312. Onshore cabling is typically provided on drums of 1,000m in length although can be provided in differing lengths ranging from 500m up to 2,000m. Buried jointing bays will be required along the onshore cable route to join each section of the onshore cable together.

313. These buried jointing bays will be constructed at intervals along the onshore cable route (to allow cable pulling and jointing at a later stage), one jointing bay per trench. Each jointing bay would be up to 15m long x 3m wide x 1.7m deep; if double jointing bays (i.e. a double jointing bay for both trenches) are constructed these will be up to 15m long x 9m wide x 2.5m deep. The precise location of the jointing bays will be determined during detailed design; however, the jointing bays will be located at a minimum of 55m from residential dwellings.

314. For the purposes of a worst case assessment of impacts, each of the chapters dealing with onshore infrastructure has assumed a worst case of 19 jointing bay locations approximately every 500m (with the potential for either two single jointing bays (one per trench) or a double jointing bay (for both trenches) at each of these locations), plus two jointing bays at each onshore HDD location should a HDD be utilised. Note that landfall HDD transition bays (as per ***section 6.6.2.2***) are not included within the 19 jointing bay locations.

6.7.3 Construction Methods for the Onshore Cable Route

315. Underground cable installation is well-established and aside from the engineering challenges it incorporates environmental management and mitigation measures as standard practice. All aspects of the construction work will be in accordance with the Construction (Design and Management) Regulations 2015.

316. Precise construction methods would differ according to the nature of the environment through which the onshore cable route was being constructed. Of particular importance are the underlying soils and strata, existing hydrological

regimes, the terrain, existing physical constraints (such as other underground services) and environmental constraints (such as development or environmentally sensitive areas).

317. The onshore cables for the proposed East Anglia ONE North project would be installed in two parallel trenches with sand and originally excavated backfill, where suitable.

318. Concrete cable protection tiles (or similar) would be fitted above the cables in each trench, featuring indented lettering warning of the danger of electricity below. Between the protection tiles and the ground surface would be plastic warning tape containing text alerting future excavators to the danger of the cables below.

319. Construction activities would be undertaken within a temporarily fenced strip of land, known as the onshore cable route width, which would generally be no wider than 32m.

6.7.3.1 Onshore Cable Route Width

320. The onshore cable route width is determined by electrical and civil engineering considerations. Underground cables generate heat which dissipates naturally to the surrounding ground during power transmission. If cables become too hot their current carrying capacity (rating) diminishes and they will not operate efficiently. Ultimately, an overheated cable may fail in service. The need to keep cable conductors from becoming too hot requires them to be separated from each other underground.

321. The onshore cable route width of 32m incorporates sufficient spacing between cable trenches to prevent cable overheating, plus room for temporary construction works. The room for temporary construction works incorporates storage space for excavated material and a haul road for the safe passage of construction personnel and machinery alongside the cable trench. In some sections the onshore cable route width would vary in order to allow special construction techniques.

322. Deliveries of construction materials and personnel along the onshore cable route would be via the use of a temporary haul road within the onshore cable route width. This haul road would run between CCSs, strategically located close to access points along the onshore cable route. These CCSs would be temporary site compounds providing facilities for the construction workforce and secure storage areas for materials. If cables were to be pulled through ducts (rather than via a direct lay method), pulling operations would also be carried out from within the onshore cable route width. Cables would be delivered via the haul road and taken by tractor or drum trailer to jointing bays for pulling operations.

323. An indicative cross section of the typical onshore cable route width is shown in ***Plate 6.18***.

6.7.3.1.1 Reduced Onshore Cable Route Width

324. The typical 32m onshore cable route width would be reduced to 16.1m within the woodland and agricultural holding to the north of Fitches Lane, and if the onshore cable route was to cross the Leiston – Aldeburgh SSSI / Sandlings SPA via trenching (rather than via HDD) technique. A reduced working width would also be applied when crossing a number of important hedgerows as identified within the DCO. This reduction in the onshore cable route width would be achieved by applying a range of special engineering techniques that could include:

- Using lower thermal resistivity backfill in the cable trench; and
- Removing the spoil to a storage area further up or down the onshore cable route (away from the reduced onshore cable route width location), thereby negating the need to store spoil adjacent to the trenches.

325. An indicative cross section of the reduced onshore cable route width is shown in ***Plate 6.19***.

6.7.3.1.2 Widened Onshore Cable Route Working Width

326. The typical 32m onshore cable route width would be widened to 90m (underground) if an HDD technique is utilised to cross the Leiston – Aldeburgh SSSI / Sandlings SPA.

327. This widened onshore cable route is to accommodate the separation distances between each HDD bore as it passes under the Leiston – Aldeburgh SSSI / Sandlings SPA.

328. The typical 32m onshore cable route width would also be widened to 50m for the crossing of the Hundred River. This widened onshore cable route is to accommodate the potential crossing of the Hundred River for construction HGVs, and for potential diversion of the river. See ***section 6.7.10.3*** for more details on the proposed techniques for the crossing of the Hundred River. The typical 32m onshore cable route width would also be widened to a width not to exceed 190m within 418m of the transition bays (associated with the landfall HDD). This widened onshore cable route is to accommodate the onshore cable route from the transition bays to reflect the potentially wider separation between the transition bays, and subsequently narrows to the typical 32m onshore cable route width as the onshore cables converge. See ***section 6.6.2.2*** for more details on the transition bays.

6.7.3.1.3 Permanent Easement

329. Post construction, a permanent cable corridor easement of approximately 20m in width is anticipated to be required, save where construction processes or other

reasons necessitate a wider permanent easement being required (i.e. where HDD is utilised, or unexpected engineering difficulties occur).

330. The permanent cable corridor easement ensures the long term protection of up to six onshore cables and two fibre optic cables and up to two DTS cables, laid in two trenches within this permanent corridor with sufficient spacing between cable trenches to prevent cable overheating, plus room for any operation and maintenance works (see ***Plate 6.20***).

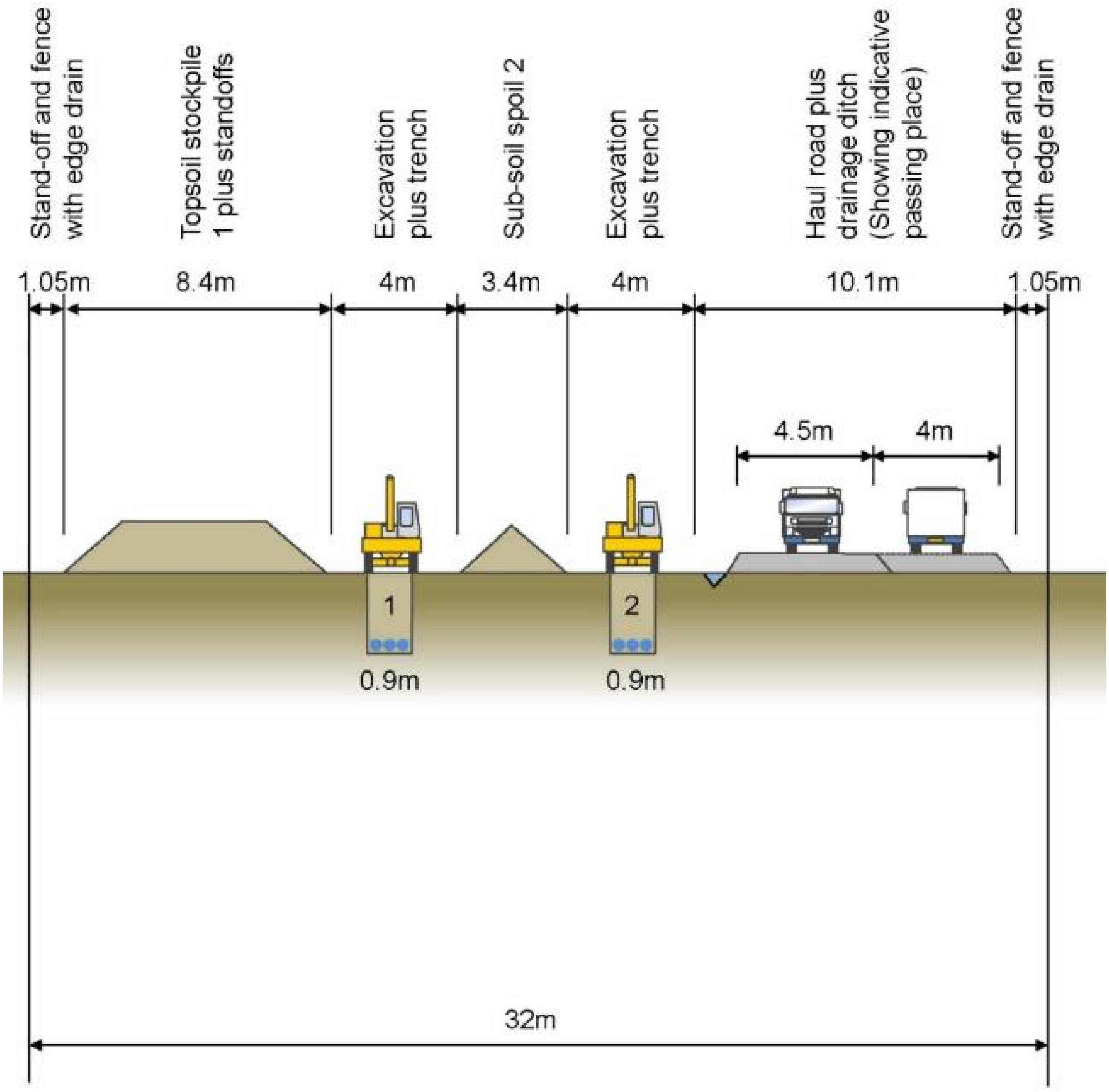

Plate 6.18 Indicative Cable Trenching Arrangement and Working Area for Typical Onshore Cable Route Width

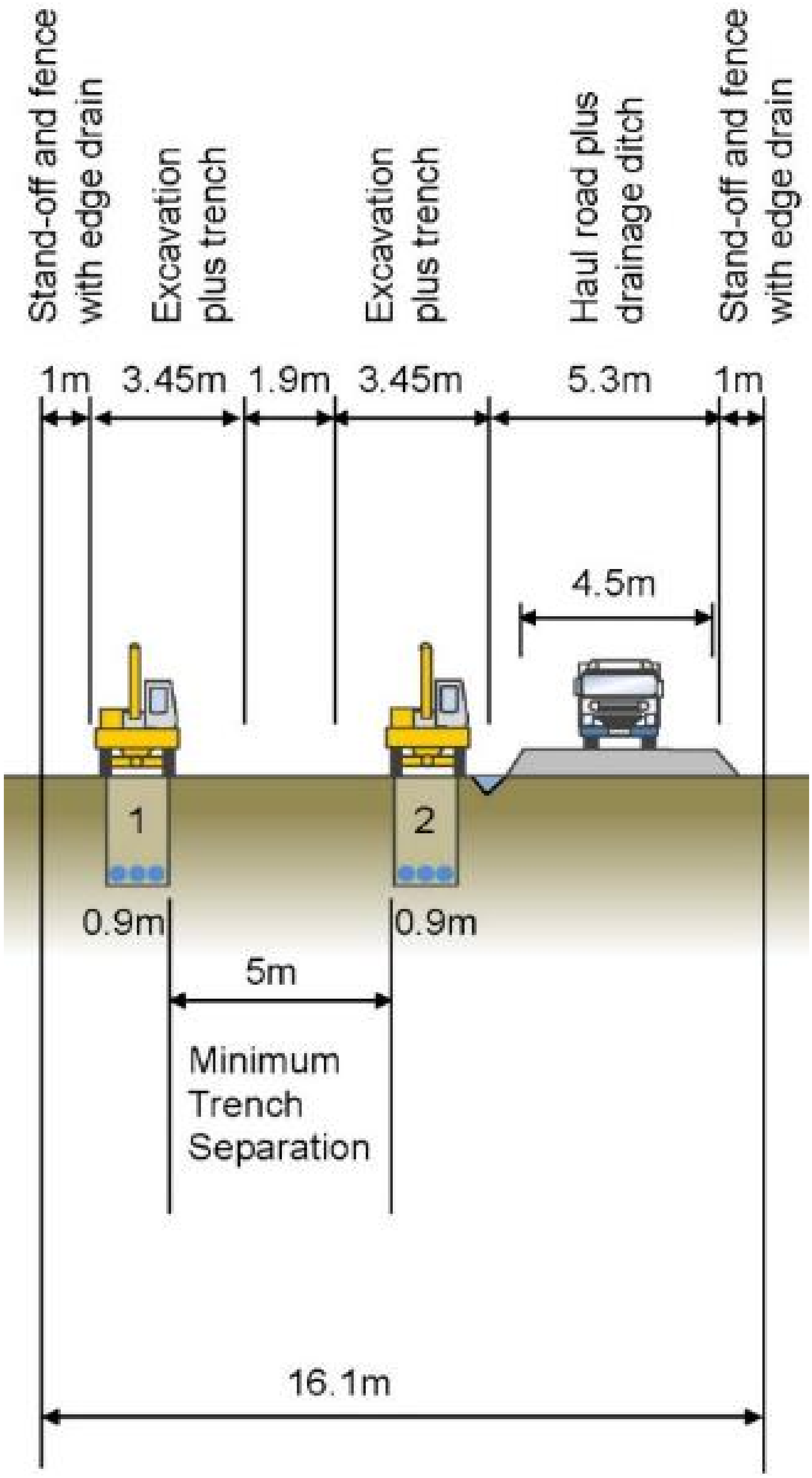

Plate 6.19 Indicative Cable Trenching Arrangement and Working Area for Reduced Onshore Cable Route Width (not applicable to reduced onshore cable route width in Cable Section 4 – west of Snape Road)

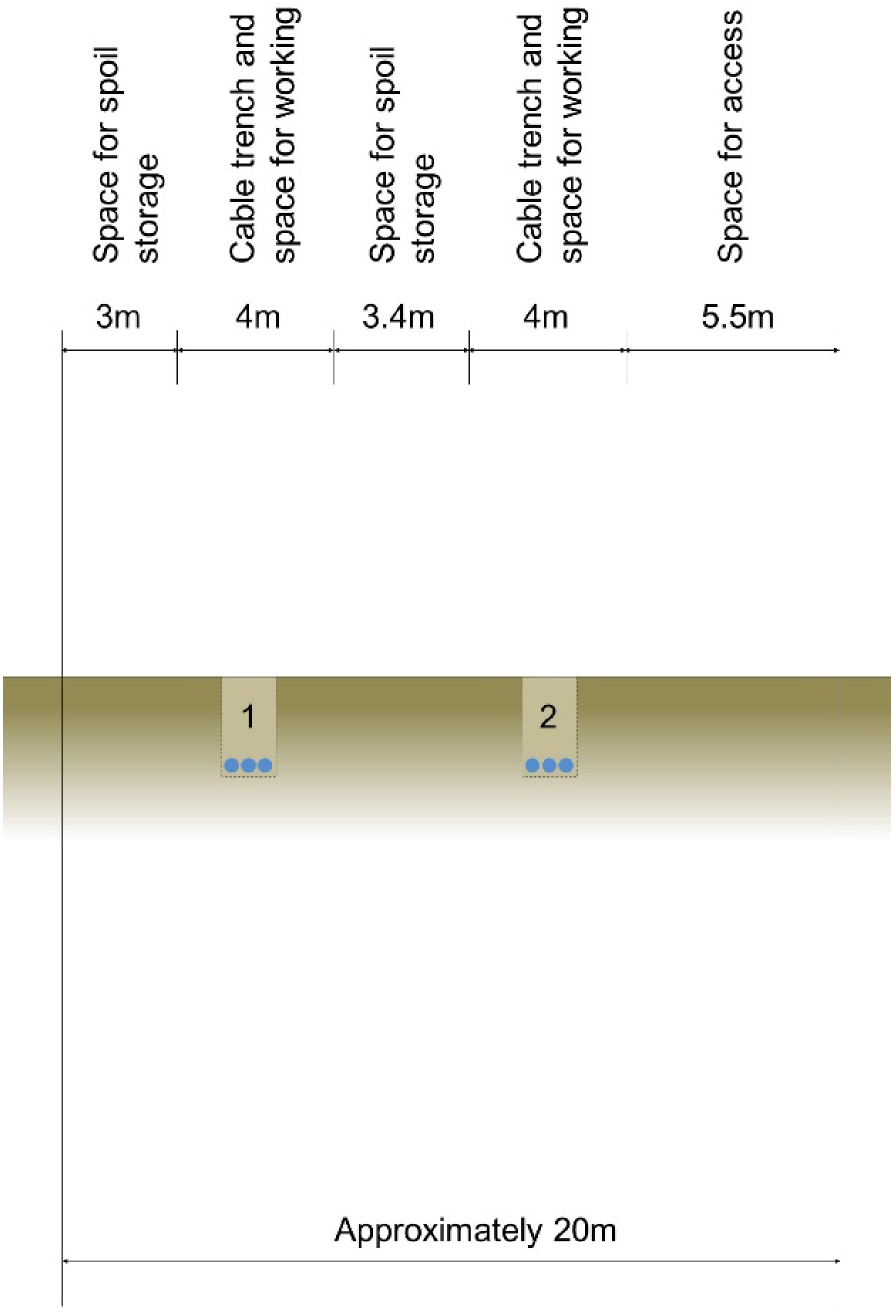

Plate 6.20 Indicative Post Construction Permanent Cable Corridor Easement

331. The following sections describe in sequence the steps involved in standard onshore cable construction technique.

6.7.3.2 Onshore Preparation Works

332. Onshore preparation work activities may include the following:

- Road Modifications – New junctions off existing highways would be required (see ***section 6.7.3.3*** for detail). Installing these ahead of the main works provides immediate access to the CCSs. In addition, offsite highway improvements would be required to facilitate access of Heavy Goods Vehicles (HGVs) and Abnormal Indivisible Loads (AILs) to the CCSs (see ***Chapter 26 Traffic and Transport Appendix 26.18*** for outline access design drawings);

- Erection of temporary site notices or advertisements;
- Erection of temporary means of enclosure;
- Topographic surveys (for engineering purposes);
- Ecological onshore preparation work (including, for instance, hedgerow removal or creation of mitigation badger setts);
- Site clearance;
- Environmental surveys;
- Archaeological investigations (further detail provided in the Outline Pre-Commencement Archaeology Execution Plan submitted with this DCO application);
- Diversion and laying of services;
- Drainage surveys;
- Geotechnical and ground stability surveys;
- Remedial work in respect of any existing ground contamination or other adverse ground conditions;
- Pre-planting of selected landscaping works;
- Public Right of Way footpath creation;
- Welfare facilities for onshore preparation works; and
- Pre-entry records and requirements for landowner condition records.

333. Accesses for all onshore preparation works are identified in ***Figure 6.6 (a-j)*** as 'Onshore Preparation Works Access'. No new physical works will be required at these access locations, and any onshore preparation works traffic will use the existing condition of the accesses and ensure that accesses are reinstated to pre-use condition.

334. Prior to commencement of construction works, it is anticipated the construction contractor would record the condition of roads, tracks, land, fences, etc., by means of schedules and photographic or video surveys. The details of infrastructure (such as water pipes) collated during the EIA process would be reviewed, in addition to a review of unrecorded services such as land drains and irrigation systems.

335. The information from such surveys would form the basis for agreement on final reinstatement of the land after construction.

6.7.3.3 Road Modifications

6.7.3.3.1 Onshore Cable Route Access

336. Road modifications could be required to facilitate the safe ingress and egress from the public highways to the onshore cable route or CCSs through construction accesses. Traffic and transport assessments have identified seven locations for where these additional accesses will be required, and further assessment will be undertaken post consent based on the final design of the project. An Outline Access Management Plan has been submitted with the DCO application. Accesses are expected to be located at each CCS and intersections between the public highway and cable route, where suitable, to facilitate access to the onshore cable route. These are identified as Access IDs in ***Figure 26.2*** within ***Chapter 26 Traffic and Transport***.

337. Additionally, six locations have been identified where the cable route crosses the public highways. These locations are identified as Crossing IDs within ***Figure 26.2*** within ***Chapter 26 Traffic and Transport***. Ingress or egress will not be sought at the Crossing IDs at Thorpeness Road, Sloe Lane and Grove Road, and traffic management will be employed to ensure safe crossing of the public highway by construction traffic along the onshore cable route haul road (including the Crossing ID locations on Aldeburgh Road, Sloe Lane and Snape Road).

338. Some localised vegetation clearance will be required at each of the Access ID or Crossing ID locations to facilitate visibility splays for construction vehicles to enable safe vehicular and plant access. These visibility splays are included within the onshore development area at these locations although any vegetation clearance works for visibility splays are considered to be minimal.

339. ***Table 6.25*** summarises the Access IDs and Crossing IDs across the onshore development area. ***Plate 6.21*** and ***Plate 6.22*** show examples of access.

Table 6.25 Summary of Access IDs and Crossing IDs across the Onshore Development Area (see *Figure 26.2* within *Chapter 26 Traffic and Transport* and *section 6.7.1* for breakdown of onshore cable route sections)

ID	Location	Purpose
Access ID 1	Sizewell Gap	Landfall and onshore cable route – section 1
Access ID 2	Sizewell Gap	Onshore cable route – section 2
Crossing ID 3	Thorpeness Road	Onshore cable route – section 2
Crossing ID 4	Thorpeness Road	Onshore cable route – section 2
Access ID 5	Aldeburgh Road	Onshore cable route – section 2 (Hundred River crossing)
Access ID 6	Aldeburgh Road	Onshore cable route – section 3 (reduced onshore cable route width through north of Fitches Lane woodland)
Crossing ID 7	Sloe Lane	Onshore cable route – section 3

ID	Location	Purpose
Crossing ID 8	Sloe Lane	Onshore cable route – section 3
Access / Crossing ID 9	Snape Road	Onshore cable route – section 3 (HGVs will access via crossing from Access ID 10; personnel may access directly from the public highway)
Access ID 10	Snape Road	Onshore substation, National Grid substation, overhead line realignment works and onshore cable route – section 4
Crossing ID 11	Grove Road	Onshore substation, National Grid substation, overhead line realignment works and onshore cable route – section 4
Crossing ID 12	Grove Road	Onshore substation, National Grid substation, overhead line realignment works and onshore cable route – section 4
Access ID 13	Saxmundham Road	Onshore substation, National Grid substation and overhead line realignment works (personnel only)

Plate 6.21 Example of an Onshore Cable Route Access from the Public Highway (image taken from East Anglia ONE project)

Plate 6.22 Example of an Onshore Cable Route Crossing of the Public Highway (image taken from East Anglia ONE project)

340. Where possible the accesses make use of existing tracks to link between the public road network and the onshore cable route. There will be a requirement to upgrade some existing tracks to make them suitable. Where this is required it would be completed using a design which is suitable for construction traffic.

6.7.3.3.2 Offsite Highway Improvements

341. In order to facilitate construction traffic and / or construction-related deliveries, highway modifications will be required at locations on the existing public road network. The purpose of the modifications would be to allow larger construction vehicles to access and navigate certain parts of the public road network. It is anticipated that the works would be concentrated at junctions.

342. It is anticipated that some or all of the modifications would be completed prior to construction starting within relevant sections of the onshore cable route.

343. The locations for modifications are identified in ***Figure 6.6k*** to ***Figure 6.6m***. Modifications at each location could potentially comprise:

- A1904 / B1069 junction (Snape Road junction) – ***Figure 6.6m***
  - Localised widening / creation of overrun areas;
  - Temporary moving or socketing of street signs; and
  - Temporary moving of street furniture.
- A12 / A1094 junction (Friday Street junction) – ***Figure 6.6l***:
  - Temporary moving or socketing of street signs; and

  - o Temporary moving of street furniture.
- Marlesford Bridge – ***Figure 6.6k***:
  - o Structural works to accommodate Abnormal Indivisible Loads;
  - o Temporary laydown area to facilitate structural works;
  - o Temporary alternative routeing of PRoW (reference: E-387/009/0)
  - o Temporary moving or socketing of street signs; and
  - o Temporary moving of street furniture.

344. Any modifications to roads would be undertaken in consultation with and in accordance with the requirements of the local Highways Authority.

6.7.3.4 Preparation of the Onshore Cable Route Width

345. Temporary fences would be erected along the boundaries of the onshore cable route width. The type of fencing to be used would be determined through consultation with the relevant landowner/occupier. Gates and stiles would be incorporated as appropriate (for example, where farm access will be maintained).

346. High visibility fencing would be installed to denote infrastructure crossings (such as gas pipelines or overhead power lines).

6.7.3.5 Topsoil Stripping

347. Once the onshore cable route width has been cleared of vegetation, the topsoil would be stripped. The precise method of stripping and the depth to which the soil would be stripped would be determined during detailed design. The topsoil would be stored to one side of the onshore cable route width in such a way that it is not mixed with subsoil. Typically, this would be in an earth bund of an approximate height of 2m to avoid compaction of topsoil from the weight of the soil. Storage time would be kept to the practicable minimum to prevent the soil deteriorating in quality. Topsoil stripped from different fields would be stored separately where possible, as would soil from hedgerow banks or woodland strips.

348. Particular care would be taken to ensure that the existing land drainage regime was not compromised as a result of construction. Land drainage systems would be maintained during construction and reinstated on completion. Temporary cut-off drains would be installed parallel to the trench-line, before the start of construction, to intercept soil and groundwater before it reaches the cable trench. These field drains would discharge to local drainage ditches through silt traps, as appropriate, to minimise sediment release.

349. Subsoil would be excavated to the required depth for each trench. This would follow the profile of the ground surface, but deeper excavations could be required at certain crossings.

350. Attenuation or settlement ponds will be established within the onshore development area to assist in surface water runoff. Where necessary, topsoil and subsoil storage areas along the onshore cable route will be cleared to accommodate attenuation or settlement ponds.

6.7.3.6 Temporary Roads

351. Temporary haul road construction would most likely involve the placement of a suitable imported material (such as aggregate onto a geotextile base and / or use of temporary mats).

6.7.3.6.1 Onshore Cable Route Haul Road (Between Landfall and Snape Road)

352. A temporary haul road would be installed along the onshore cable route between Snape Road and the landfall area (with the exception of the Leiston – Aldeburgh SSSI / Sandlings SPA crossing, see ***section 6.7.3.10.1***). The onshore cable route haul road between landfall and Snape Road would be up to 4.5m wide with passing places of an additional 4m in width at approximately 90m intervals. See ***Plate 6.23*** for a schematic of the haul road.

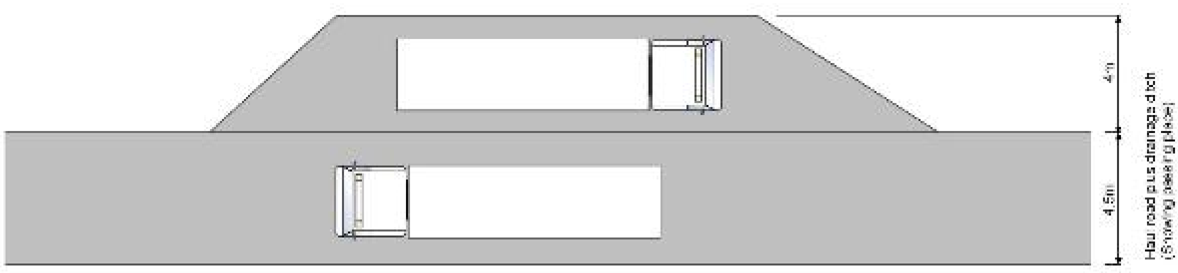

Plate 6.23 Onshore Cable Route Haul Road Schematic

6.7.3.6.2 Onshore Cable Route and Substation Construction Haul Road (between Snape Road and onshore substation / National Grid substation)

353. A temporary haul road would be installed along the onshore cable route between Snape Road and the onshore substation / National Grid substation. This would facilitate access for the installation of the onshore cable route as well as for HGV construction traffic to access the onshore substation and National Grid substation during the construction phase. The onshore cable route and substation construction haul road between Snape Road and the onshore substation / National Grid substation would be up to 9m in width.

354. The onshore cable route and substation construction haul road may be constructed in phases to accommodate works to realign the existing national electricity grid early in the construction programme, or may be laid initially with a temporary interlocking panel system.

6.7.3.6.3 Temporary Construction Access Roads

355. Temporary construction access roads (similar to the haul roads) would be installed to provide access from the public highway to onshore cable route CCSs,

the onshore cable route haul road and the onshore cable route and substation construction haul road. The temporary construction access roads would be up to 4.5m wide with passing places of an additional 4m in width at approximately 90m intervals.

6.7.3.7 Installation of Cables

356. Trenching would be the default installation method for the onshore cables. Cables will typically be installed in trenches approximately 1.2m below ground level.

357. The default arrangement assumes that cables (and ducts if used) are laid in trefoil (plus fibre-optic cables and DTS cabling) in a total of two trenches. The width of the trenches and the spacing between them would vary depending on the depth of burial. See ***section 6.7.3.1.1*** and ***Plate 6.18*** for typical onshore cable route width and spacings between trenches, and ***section 6.7.3.1.2*** and ***Plate 6.19*** for the reduced onshore cable route width and spacings between trenches.

358. The excavation would be carried out using a tracked excavator or similar. Any material retained would be kept separate from the previously stripped topsoil. Once backfilling of the trenches was completed, any surplus material would be removed from site and disposed of as waste as per the site waste management plan (secured in requirement of the draft DCO within the Outline Code of Construction Practice).

6.7.3.8 Cable Delivery

359. Cables would be delivered in drums, with the cable lengths on the drums being specified during design and procurement phases. For significant cable lengths, i.e. in excess of 1,000m, specialist hauliers will be required.

360. Upon arrival at site, the drums would be offloaded into the CCS. A mobile crane would be necessary for offloading.

6.7.3.9 Cable Pulling and Installation

361. Cable drums would be delivered to CCSs, where they would be lifted from the delivery trailer onto a hard standing for temporary storage. From there, the cables would be taken by tractor and cable drum trailer to jointing bays for pulling operations. Pulling operations would be carried out within the onshore cable route.

362. A cable pulling system will be installed. Where cables are installed in an open trench this would typically comprise a steel bond and winching system, with free spinning cable rollers placed along the bottom of the trench. Other cable pulling systems could be employed and could comprise motorised rollers or tracked caterpillar drives. Where cables are installed within ducts that are buried within the trench, a winch system would be used to pull each cable through the ducts at each jointing bay.

363. The cable drum would be placed on a raised spindle mounted on hydraulic jacks. The cable would then be pulled from the drum into the trench or the duct with sufficient cable pulled through to the far jointing bay to allow for jointing onto the next section.

364. This process would be repeated for the second and third cable to be installed in the trench or within the duct installed within the trench. The three cables would then be spaced in the trench in accordance with the design specification, separated by a spacer board to ensure the spacing is maintained during the backfilling process. A fibre-optic cable and DTS cable would then be spaced in the trench in accordance with the design specification.

365. Once the cables are laid, sand or Cement Bound Sand (CBS) would be laid around and over the cables or ducts, providing a typical depth of cover above the cable or duct of around 170mm. The cover tiles and warning tape would then be placed above the cables. At this point the supporting materials would be removed and backfilling would be carried out using the previously excavated material.

6.7.3.10 Special Crossings

366. Some crossing locations (e.g. roads, watercourses, designated sites) will require the option of using special crossing techniques where open cut trenching is not suitable due to the width and, or type of feature being crossed. The appropriate option will be determined at the detailed design stage. With trenchless methods (such as HDD, micro tunnelling or auger boring), the depth at which the cable ducts are installed depends on the topology and geology at the crossing site.

367. As previously discussed, the landfall at Thorpeness will be HDD in order to protect the cliffs and avoid disturbance of the beach and intertidal area (see ***section 6.6***).

6.7.3.10.1 SPA / SSSI Crossing

368. The use of an onshore HDD is an alternative methodology to the typical open cut trenching technique of the onshore cable route. This alternative methodology is only for consideration at the location where the onshore cable route crosses the Leiston – Aldeburgh SSSI / Sandlings SPA. However, an open-cut crossing technique is the preferred crossing methodology

369. See ***section 6.6*** for further details regarding HDD installation methods at the landfall.

370. The installation of the onshore cables by HDD (not including landfall) would require a fenced HDD entry pit working area up to 6,300m^2, and a HDD exit pit working area up to 2,700m^2.

371. ***Table 6.26*** provides a comparison of the crossing methods for onshore cable routeing across the Leiston – Aldeburgh SSSI / Sandlings SPA. Further detail on

the onshore cable route crossing of the Leiston – Aldeburgh SSSI / Sandlings SPA is provided within the Scheme Implementation Report submitted with this DCO application.

Table 6.26 Comparison of Methods for Crossing the Leiston – Aldeburgh SSSI / Sandlings SPA (trenching v onshore HDD)

Parameter	Trenched crossing	Onshore HDD
Length	120m (length of SPA to cross)	407m
Approximate duration	1 month	12 months
Notes	Temporary road matting to be used rather than imported road stone for access The Applicant retains the possibility to accelerate works within the SPA boundary by overlapping activities Works would be undertaken adhering to a seasonal restriction, as described in ***Chapter 23 Onshore Ornithology***.	HDD operations may require to be undertaken in phases over two years in order to adhere to a seasonal restriction, as described in ***Chapter 23 Onshore Ornithology***.

372. An open-cut trenching crossing of the Leiston – Aldeburgh SSSI / Sandlings SPA retains inherent benefits over the onshore HDD technique. The onshore HDD requires two additional laydown areas (entry and exit pit locations) in comparison to the trenched crossing; and works associated with the additional setup and decommissioning of the onshore HDD laydown areas (as well as the complexity of the technique) mean that the duration of the works for the onshore HDD to cross the SPA significantly exceed the duration of the works for the open-cut trenching technique.

373. Once onshore HDD drilling has commenced it cannot stop which means that the technique requires 24-hour working. This includes requirements for health and safety security and lighting; and construction personnel to be on site throughout this period. The open-cut trenching technique would operate within the project working hours (see ***section 6.9***).

374. Crossing the SPA using an open-cut methodology will last an estimated one month in duration. A temporary haul road would be laid for the duration of the open-cut methodology crossing and would be removed once cable installation is complete to enable reinstatement activities to commence as soon as possible. The Applicant has further committed to conducting this estimated one month of open-cut trenching through the SPA, or within 200m of the SPA / SSSI boundary associated with the crossing, outside of the breeding bird season, therefore minimising potential impacts to the features of the Sandlings SPA and Leiston-Aldeburgh SSSI. The breeding bird season is considered to be mid-February to

August inclusive. This will be confirmed post-consent through the production of the EMP.

375. If an HDD technique were to be employed, construction would be approximately twelve months in duration and a seasonal restriction would be imposed on such works (including the establishment and subsequent removal of HDD entry pit and exit pit working areas within 200m of the SPA / SSSI boundary). This would likely mean that works would be required in phases over two years in order to complete the twelve-month construction duration (six months per year). No temporary haul road would be required to cross the SSSI / SPA if a HDD technique were to be employed.

6.7.3.10.2Auger Boring / Micro-Tunnelling

376. For both these techniques a circular or rectangular pit (shaft or cofferdam) is constructed each side of the feature to be crossed. These are typically 1m below the invert level of the duct to be installed. The duct is driven through the side wall from the launch pit to a reception pit. The method of driving varies to suit prevailing ground conditions.

377. Auger boring is suitable in most cases with the exception of sands or obstructions such as cobbles or boulders. First a pilot pipe is jacked through the ground from the launch shaft to the reception shaft. An auger is attached to the end which clears the opening of soil and is itself followed by the permanent duct.

378. Micro-tunnelling involves remote control tunnel boring machines tunnelling themselves from the launch to reception shaft conveying spoil to the launch shaft via conveyors. The permanent duct immediately follows the machine, installed by jacking from the launch pit. This method can be used in most ground as the drilling head can be configured to prevailing ground conditions.

6.7.3.10.3Open Cut Watercourse Crossings and Rivers

379. The onshore cable route crosses the Hundred River and several surface drainage channels.

380. The Hundred River Crossing would be constructed using conventional open cut methodology, as described below. The Environment Agency would be consulted in the production of a Watercourse Crossing Method Statement governing each crossing.

381. Where possible, spoil storage would be set back 5m from water courses, to minimise potential for silt run off from the onshore cable route width.

382. A number of factors would affect the choice of crossing method, including depth of water, available space, duration of works, bed conditions, accessibility and potential ingress of water. The default crossing method of watercourses would

be trenching and would be considered worst case as a more intrusive method of installation that could affect the watercourse.

383. The onshore cable route haul road would traverse across the watercourse using a temporary bridge or temporary culvert, which would lie within the onshore cable route width.

384. The exact methodology to achieve an open trench across the Hundred River and the temporary bridge arrangements required would be decided by the works contractor. The profile of the trench running through the stream would be determined in consultation with, and with the approval of, the Environment Agency. Determining engineering factors would be the required cover underneath the stream bed, the surrounding stream bank profiles and the minimum bend radii of the ducting.

385. Open cut crossings can either be wet or dry. One dry technique involves damming the watercourse upstream and downstream of the crossing, thus creating a dry area where the cable crosses. Water is then pumped or diverted from where it has been impounded upstream and discharged downstream of the crossing area.

386. In the wet open cut technique, construction takes place within flowing water. The cable trench is typically constructed across the watercourse by equipment operating from either the banks or from flume pipes laid in the river to maintain flow and provide an equipment crossover from one bank to the other. After excavation of the trench, a section of ducting is placed into the trench.

387. For both techniques, timing of the works is important. Periods of low flow would be chosen wherever practicable.

388. Erosion control measures (e.g. silt fencing) would be installed and maintained until the area stabilised and vegetation became sufficiently re-established. Where there is a risk of sediment run-off, sediment interception techniques would be used.

6.7.3.10.4Minor Roads

389. Minor roads are those relating to a narrow width road such as a country lane in which the road will not accommodate two vehicles side by side so that vehicles can only pass at passing bays.

390. It is proposed that minor road crossings would in most cases be accomplished by open trenching techniques whilst maintaining one lane of through traffic at all times through temporary extension of the carriageway as described below. No road closures are planned to facilitate the crossing of minor roads.

391. To keep access open along the road while construction of the trenches takes place, the road could need to be temporarily widened to a width that would easily

accommodate two-way traffic of large vehicles over the construction width of the cable route and for mandatory clearance for construction personnel. This would allow half of this width to be closed off to traffic while the road is trenched to half way across and cables/ducts are laid down. The second half of the road would use traffic management signals to keep access open to road users. The level of excavation required would be determined by standard road crossing profiles and any other services running parallel with the road at detailed design stage.

6.7.3.10.5 Major Roads

392. This crossing type relates to a road suitable for two-way traffic. It follows the same method as described above for Minor Road Crossings except that generally the road will not need to be temporarily widened prior to beginning excavation operations. This would be determined following a detailed survey of the road at the crossing point and whether there is currently enough room to close one lane and perform the excavations.

393. No road closures are planned to facilitate the crossing of major roads.

394. Standard road crossings would be trenched and would conform to the New Road and Street Works Act 1991, Part III, as appropriate.

6.7.3.10.6 Public Rights of Way (PRoW)

395. Along its length, the onshore cable route crosses up to 18 PRoW. See ***section 6.7.8.2.1*** for information on PRoW affected by the onshore substation and National Grid substation.

396. Whilst construction activities along the onshore cable route are taking place which affect a PRoW, the individual right of way would be subject to a temporary closure and alternative routeing in most cases and located within agricultural land, in consultation with the local authority rights of way officer.

397. See ***Chapter 30 Tourism, Recreation and Socio-Economics*** for discussion on potential impacts associated with temporary closure and alternative routeing of PRoWs along the onshore cable route.

6.7.3.11 Temporary Works: CCS

398. CCSs would be required along the onshore cable route. The proposed areas (and dimensions) for the cable route CCSs are dependent on location and which section (see ***section 6.7.1*** for description of sections and ***Figure 6.2*** in ***Chapter 26 Traffic and Transport*** for illustration of sections) of the cable route the CCS is proposed to facilitate. Five locations have been identified for onshore cable route CCSs within the onshore development area (see ***Figure 6.6a-j***). See ***section 6.6.2.1.3*** for discussion regarding the CCS associated with the landfall. See ***section 6.7.8.2*** for discussion regarding CCSs associated with the onshore substation and National Grid substation.

399. Onshore cable route - section 1 (landfall to SPA crossing) is proposed to be facilitated by a CCS immediately south of Sizewell Gap to the west of Home Farm. This CCS would be up to 7,040m^2 in area and located within agricultural land.

400. Onshore cable route – section 2 (SPA crossing to Aldeburgh Road) is proposed to be facilitated by a CCS south of Sizewell Gap and south of Grimsey's Lane. This CCS would be up to 7,040m^2 in area and located within agricultural land;

401. The crossing of the Hundred River and cable routeing through the woodland area to the north of Gypsy Lane would be facilitated by a CCS immediately south of Thorpeness Road (not accessed via Thorpeness Road; access would be obtained via Aldeburgh Road or Sizewell Gap). This CCS would be up to 3,000m^2 in area (approximate dimensions of 60m x 50m).

402. The cable routeing to cross Aldeburgh Road and the woodland area to the north of Fitches Lane would be facilitated by a CCS immediately south of Fitches Lane (southwest of the woodland area). This CCS would be up to 3,000m^2 in area and located within agricultural land.

403. Onshore cable route – section 3 and – section 4 are proposed to be facilitated by a CCS west of the B1069 Snape Road crossing. This CCS would be up to 16,500m^2 in area and located within agricultural land.

404. It is the intention that the CCSs would be to:

- Form the main point(s) of access onto the linear construction site;
- Provide the main areas for the storage of materials and equipment; and
- House site administration and welfare facilities for the labour resources.

405. ***Chapter 26 Traffic and Transport***, ***Appendix 26.13*** illustrates the proposed delivery routes to the onshore cable route. Construction traffic is proposed to be routed to the CCSs, and thereafter the majority of construction traffic would be carried along the temporary access roads, onshore cable route haul road and onshore cable route and substation construction haul road.

406. In accessing CCSs, construction routes are proposed to be routed along strategic lorry roads identified within the Suffolk Lorry Route Network. From this Network, access points via local roads are proposed. Many of these local roads commonly handle large agricultural plant.

407. Wheel washing facilities would be provided at exit points from the haul roads, along with suitable road traffic signage at each entry / exit point both to direct construction traffic and to alert the public road users to the presence of construction traffic.

6.7.3.12 Temporary Works: Cable Route Laydown Area

408. A laydown area is proposed to the east of the B1069 Snape Road crossing point to act as an interchange hub for deliveries of material and equipment for the west of Snape Road CCS. This laydown area would be up to 1,000m^2 in area.

6.7.3.13 Security and Lighting

409. Along the length of the onshore cable route, no 24-hour lighting is anticipated to be required except that associated with HDD operations and security lighting at the CCSs. Provision of manned or unmanned 24-hour security may be required within the onshore development area. See ***section 6.9*** for exceptions to typical working hours. Task lighting will be utilised in localised areas where required.

6.7.3.14 Construction Sequencing

410. The construction programme proposes that the onshore cable route would be subdivided into sections of 500m to 2km lengths, separated by the presence of CCSs. These CCSs would facilitate concurrent or sequential working within the four sections along the onshore cable route. Each section of work would be supplied and supported by a CCS. The extent of each of the four sections has been defined by the constraints afforded by existing natural or man-made obstructions and is shown in ***Figure 26.7*** within ***Chapter 26 Traffic and Transport***.

411. Within each of the sections, work would be undertaken in a practical, logical and sequential manner. Wherever practical, the works would commence from one CCS and terminate at the next.

412. The sequence of construction activity within each section along the onshore cable route would be:

- Site clearance and topsoil strip between fence lines (fence lines established during onshore preparation works);
- Establish and prepare temporary haul road along onshore cable route;
- Excavate trenches for direct burial and / or ducted cable;
- Excavate jointing pits (this may also be undertaken after the ducting is laid and the cable trench is reinstated);
- Dewatering of excavations may be required. This will require establishment of a pump for dewatering the excavations which may be required to run overnight (see ***section 6.9*** regarding exceptions to typical working hours). A welfare unit and generator may also be required at dewatering locations;
- Install cable bedding;
- Cable / duct laying;
- Trench reinstatement;
- Cable installation within ducts (where ducts are used)

- Topsoil replacement and seeding;
- Remove temporary fencing; and
- Reinstate permanent fences and hedges.

6.7.3.15 Construction Traffic and Plant

413. A full Construction Traffic Management Plan will be developed prior to construction. This would detail temporary road closures, diversions and/or other local traffic management that will be necessary. An outline Construction Traffic Management Plan has been submitted with the DCO application.

414. An initial assessment of the number of vehicle movements[4] required (for the delivery of equipment, and personnel) associated with the construction of the onshore cable route per separate construction sections has been estimated at an average of 65 two-way movements per day for Section 1, 69 two-way movements per day for Section 2, 53 two-way movements per day for Section 3, and 105 two-way movements per day for Section 4 (including construction of the onshore cable route and substation construction haul road) (see ***Chapter 26 Traffic and Transport*** for further details).

6.7.3.16 Workforce

415. The construction workforce would consist primarily of specialist workers who travel to work on similar projects throughout the UK and abroad. To supplement this, local workers would be used where possible, subject to required skills being available. The total number of construction employees required has been estimated at approximately an average of 22 construction personnel per day associated with Section 1 of the onshore cable route, 24 personnel per day for Section 2, 19 personnel per day for Section 3, and 40 personnel per day for Section 4. Note that these numbers are included in the numbers outlined in ***section 6.7.3.15***.

6.7.3.17 Reinstatement

416. The onshore cable route, CCSs and all temporary work areas/access roads would be reinstated with the stored topsoil and subsoil following testing and commissioning of the onshore infrastructure. If necessary, the subsoil would be ripped or suitably tilled prior to topsoil placement if compaction had occurred. Topsoil would be spread in such a way as to ensure that it did not become compacted.

417. Following reinstatement of soil and subsoil, final restoration would commence where possible. Pasture and arable land would be reseeded, fences would be

[4] A movement is the process of transporting goods from a source location to a predefined destination. A two-way movement represents the inbound (laden trip from source) and the outbound unladen trip (back to source). For example, 20 two-way movements comprise 10 laden trips from source and 10 outbound unladed trips back to source.

reinstated and suitable hedgerow species replanted. Hedges and any replacement planting would be carried out during the first appropriate planting season following site restoration. In ecologically sensitive areas special restoration measures will be necessary to restore habitats to their previous condition (specifically any impacts associated with trenching of the Leiston – Aldeburgh SSSI / Sandlings SPA).

418. The onshore cable route would be marked with marker posts at field boundaries. These would be visible from the ground and all marker posts would be located to minimise interference with agricultural activities. The final stage in the cable installation process once reinstatement was established would be the removal of the temporary fencing.

6.7.4 Onshore Cable Route Operation and Maintenance

419. It is expected that normal agricultural activities would be able to continue over the onshore cable route following installation.

420. Routine maintenance on the onshore cables are not anticipated other than periodic inspection of the onshore cable route.

421. Inspection may also be undertaken via non-intrusive checking of the onshore cable between jointing bays with, for instance, ground penetrating radar.

422. Non-scheduled maintenance to address faults as and when these arise would also be necessary, and this maintenance could be required in between jointing bays.

6.7.5 Onshore Cable Route Decommissioning

423. It is anticipated that the onshore cable would be decommissioned (de-energised) and either the cables and jointing bays left *in situ* or removed depending on the requirements of the onshore decommissioning plan approved by the local planning authority secured through a requirement of the draft DCO.

6.7.6 Onshore Substations: Site Description

424. Two substations are required for the proposed East Anglia ONE North project: one is the proposed East Anglia ONE North onshore substation and the other is the National Grid substation. It is proposed that they will be sited adjacent to one another.

425. The purpose of the East Anglia ONE North onshore substation is to convert the electrical current from HVAC cables into appropriate voltage for the National Grid substation to connect into the national electricity grid.

426. From the outset, careful siting of the onshore substation and National Grid substation has set out to avoid key areas of sensitivity wherever possible. Embedded mitigation has included:

- Careful siting of the East Anglia ONE North onshore substation and National Grid substation to the west and south of existing woodland blocks to gain maximum benefit from existing screening;
- Careful siting of the East Anglia ONE North onshore substation and National Grid substation in close proximity to the existing overhead lines to reduce additional cabling requirements and to minimise proliferation of infrastructure; and
- Siting the East Anglia ONE North onshore substation and National Grid substation in an area of low flood risk (Flood Zone 1).

427. Further detail on the implementation and micro-siting of the onshore substation siting is provided within the Scheme Implementation Report submitted with this DCO application.

6.7.7 Onshore Substation Infrastructure

428. The onshore substation would be located within a single compound. The onshore substation will be a ‘gas insulated switchgear (GIS). Within a GIS substation, equipment is designed to be insulated and cooled by a pressurised gas (e.g. sulphur hexafluoride (SF6)). In addition to the main onshore substation GIS building (see ***Plate 6.24*** for an example of the electrical equipment contained within the main GIS building),the substation compound would contain electrical equipment including power transformers, switchgear, reactive compensation equipment (see ***Plate 6.25*** for example of equipment and building), harmonic filters, cables, control buildings, communications masts, backup generators, access, fencing and other associated equipment, structures or buildings. The onshore substation will have an optimised layout to ensure compliance with the requirements of the draft DCO. ***Plate 6.26*** shows the layout of the East Anglia ONE substation as an example of the arrangement of buildings.

Plate 6.24 Electrical Equipment Contained within the Main GIS Building (example taken from East Anglia ONE substation)

Plate 6.25 Example of Shunt Reactor Building to House Reactive Compensation Equipment (example taken from East Anglia ONE substation)


Plate 6.26 Example Layout of the Onshore Substation (example taken from construction of East Anglia ONE substation)

429. The onshore substation would be connected to the National Grid substation by means of up to two buried cables. These will be installed directly underground or within concrete troughs.

430. Lightning protection would be installed as part of the design of the onshore substation. The following potential lightning protection methods, most likely a combination, will be utilised:

- Lightning rods – short metal conductors, typically 2-5m in height and up to 30mm in diameter, which could be mounted on buildings or tall pieces of equipment. Up to 2 lightning rods per building.
- Lightning masts – standalone slender masts. The lightning mast structure would be a single steel tubular section up to 25m in height. Up to 6 lightning masts may be required for the site.
- Shield wires – uninsulated wires spanning over electrical equipment.

431. ***Table 6.27*** outlines key design parameters for the onshore substation outline landscaping mitigation measures are presented in ***section 6.7.8.4***. These represent the maximum dimensions. The Applicant's preferred arrangement of onshore substation is shown in ***Figure 6.5***. A Rochdale Envelope layout of the onshore substation is shown in ***Plate 6.27***.

Table 6.27 East Anglia ONE North Onshore Substation Key Parameters

Parameter	Specification
Maximum building height	15m
Substation compound dimensions	Up to a maximum of 190m (width) x 190m (length)
Maximum height of external electrical equipment	18m

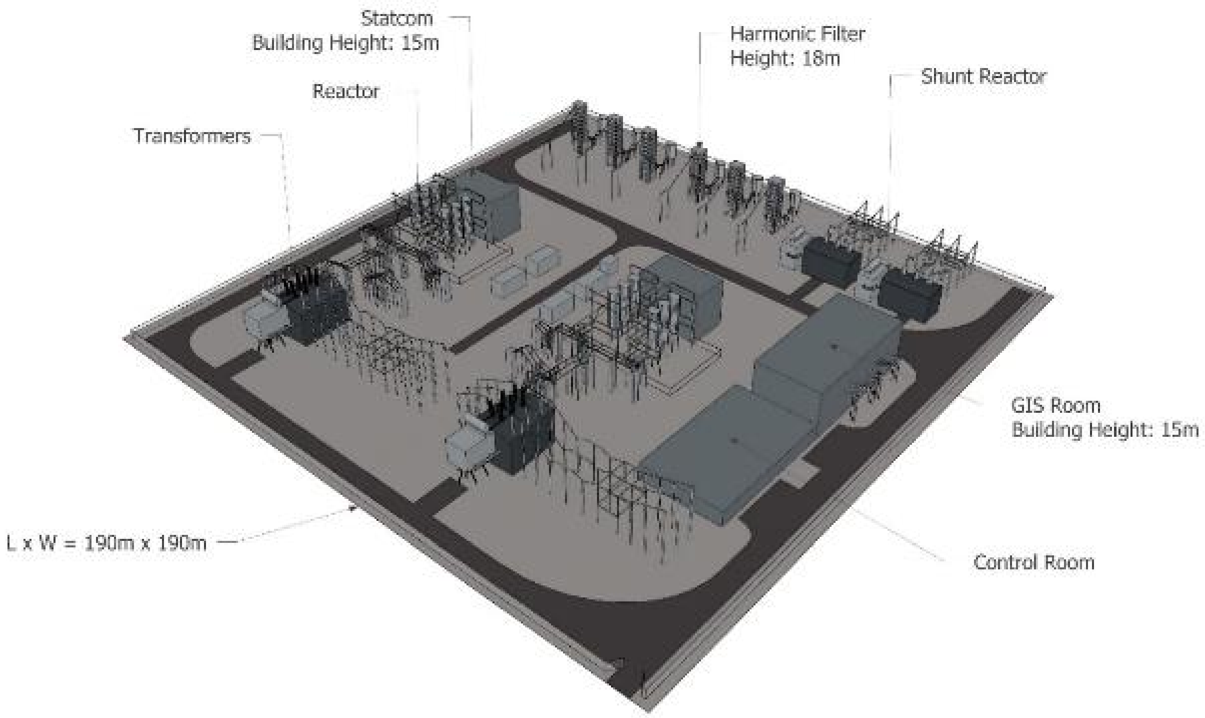

Plate 6.27 Rochdale Envelope 3D model of East Anglia ONE North Onshore Substation

6.7.8 Onshore Substation: Construction

6.7.8.1 Onshore Substation CCS

432. The onshore substation CCS will be located adjacent to the onshore substation footprint (as shown on ***Figure 6.6i***) and would be up to 17,100m^2 in area and located within agricultural land. The onshore substation CCS may be split into smaller CCSs although the cumulative footprint of these CCSs will remain within the maximum onshore substation CCS size stated above. The precise location of the onshore substation CCS will be selected with due consideration to avoid existing watercourses, hedgerows and other known infrastructure / constraints where practicable.

433. In addition, the East Anglia ONE North onshore substation footprint could be used as a site establishment and laydown area. The following would be required during the construction works:

- Temporary construction management offices;

- Canteen;
- Washroom facilities;
- Car parking;
- Wheel washing facility; and
- Workshops.

434. Construction of the onshore substation will require the use of temporary water-tight working areas within the substation footprint, formed by scaffolding wrapped in tarpaulin or similar material, to facilitate the jointing and termination of cables. These temporary water-tight working areas must be large enough to accommodate cranes or other form of lifting systems.

6.7.8.2 Onshore Preparation Works Activities

435. Prior to the commencement of the East Anglia ONE North onshore substation works, a number of pre-construction surveys and studies would be undertaken to inform the design teams when developing the final design including:

- Erection of temporary site notices or advertisements;
- Erection of a temporary means of enclosure
- Topographic surveys (for engineering purposes);
- Ecological onshore preparation work (including, for instance, hedgerow removal or creation of mitigation badger setts);
- Site clearance;
- Environmental surveys;
- Archaeological investigations (further detail in the Outline Pre-Commencement Archaeology Execution Plan submitted with this DCO application);
- Diversion and laying of services;
- Drainage surveys;
- Geotechnical and ground stability surveys;
- Remedial work in respect of any existing ground contamination or other adverse ground conditions;
- Pre-planting of selected landscaping works;
- Public Right of Way footpath creation;
- Welfare facilities for onshore preparation works; and
- Pre-entry records and requirements for landowner condition records.

6.7.8.2.1 Public Rights of Way

436. The onshore substation footprint crosses one PRoW. A permanent closure and diversion of this PRoW will be required.

437. Construction of the onshore substation potentially will impact on up to three other PRoWs. Whilst construction activities are taking place affecting a PRoW, the individual right of way would be subject to a temporary closure and / or alternative routeing in consultation with the local authority rights of way officer.

438. See ***Chapter 30 Tourism, Recreation and Socio-Economics*** for discussion on potential impacts associated with permanent and temporary closure, and alternative routeing of PRoWs in the vicinity of the onshore substation.

6.7.8.3 Landscaping Screening and Ecological Enhancement

439. The East Anglia ONE North onshore substation site benefits from substantial existing hedgerows and woodland blocks within the local area. However, the Applicant has committed to additional planting, landscaping and ecological enhancement at the onshore substation location to further screen and enhance the area surrounding the East Anglia ONE North onshore substation. The location of this proposed additional planting is provided in ***Figure 29.11*** within ***Chapter 29 Landscape and Visual Impact Assessment and*** the Outline Landscape and Ecology Mitigation Strategy (OLEMS) (document reference 8.7), which also includes further information on the proposed screening and ecological enhancements.

440. The OLEMS summarises the general landscape and ecology principles and mitigation measures to be adopted during construction and operation of the onshore infrastructure associated with the proposed East Anglia ONE North project.

441. The OLEMS has the following objectives:

- To clearly outline the framework for ecological management.
- To outline the provision of the details that would form both ecological and landscape mitigation planting schemes.
- To provide the basis for the agreement of a detailed Landscape Management Plan (LMP) for the onshore substation and National Grid substation. This scheme will detail how ecological landscape and Sustainable Drainage System (SuDS) requirements will be integrated at the substation site and should consider and act on (as appropriate) the Design and Access Statement (document reference 8.3).
- To provide the basis for the agreement of a final LMP for the protection and restoration of impacted and replanted trees and hedges in the onshore cable route secured through a requirement of the draft DCO.
- It is expected that the schemes of planting and aftercare for the onshore cable route, onshore substation and National Grid substation would be delivered by contractors who can demonstrate appropriate experience and capacity to

deliver effective and robust aftercare and provide a consistent quality of work across the proposed East Anglia ONE North project.

- To ensure all reasonable precautions are taken by the Applicant and their contractors to safeguard protected species. This OLEMS also acts as the basis for an Ecological Management Plan (EMP) and Breeding Bird Protection Plan (BBPP).
- To form the basis of a process of ongoing dialogue / forum with the Local Planning Authority leading up to and during construction to ensure that the Local Planning Authority are kept informed and satisfied of the implementation of the OLEMS (and the plans of which it forms the basis) and in order that they can also keep communities informed.

442. The mitigation planting will be designed to comprise a mix of faster growing 'nurse' species and slower growing 'core' species. The core species would comprise a mix of preferred native, canopy species that would outlive the nurse species and characterise the woodland structure over the longer term.

443. In locations where it is possible to achieve early (post-consent) planting, this will be undertaken in consultation with the local community to allow growth prior to completion of construction and commencement of operation.

6.7.8.4 Temporary Fencing

444. Temporary fences would be erected along the boundaries of the East Anglia ONE North onshore substation site for the duration of the construction period.

6.7.8.5 Onshore Cable Route and Substation Construction Haul Road

445. A temporary haul road would be installed along the onshore cable route between access points onto the local road network to facilitate construction access to the substation (as discussed previously in ***section 6.7.3.6.2***). This would run from Access ID 10 at Snape Road, across Crossing ID 11 and Crossing ID 12 at Grove Road and proceed into the onshore substation's location (see ***Figure 26.7*** within ***Chapter 26 Traffic and Transport***). The onshore cable route and substation construction haul road would be up to 9m wide to facilitate two-lane construction traffic.

446. Temporary haul road construction would most likely involve the placement of a suitable imported material (such as aggregate onto a geotextile base and / or use of temporary mats).

447. The onshore cable route and substation construction haul road may be constructed in phases to accommodate works to realign the existing national electricity grid early in the construction programme or may be laid initially with a temporary interlocking panel system.

6.7.8.6 Grading and Earthworks

448. The enabling works that are typically required to facilitate the construction of a substation facility can vary greatly. The main factors to consider are the overall topography of the site and the previous use of the land in question.

449. The location for the onshore substation and National Grid substation is agricultural land.

450. The entire area would be stripped of all organic matter and loose rocks. Any waste material encountered would be removed as required by the environmental and geotechnical investigations. Once the surface had been cleared, the grading operations would begin.

451. The preference would be to retain materials on site for use as engineering fill or landscaping depending on the material properties.

452. If it were to prove impossible or impractical to balance the earthwork quantities, it would be necessary to either export excess soil or import new fill soil. Any soil exported would be disposed of at a licensed disposal site. Excavations of foundations and trenches would commence following the completion of grading.

6.7.8.7 Surface Water Drainage

453. Impermeable areas, for instance the control and ancillary buildings within the site, would require permanent surface drainage. Discharges would be routed to a suitable watercourse or soakaway in the absence of a local authority sewer (dependant on ground permeability).

454. Surface water drainage requirements would be dictated by the final drainage study and would be designed to meet the requirements of the National Planning Policy Framework (NPPF) (June 2019)[5] with run-off limited where feasible, through the use of infiltration techniques which can be accommodated within the area of development.

455. Initial studies have indicated that a SuDS pond with volume 5,775m^3 (on the conservative assumption of requirement for 1 in 200 year rainfall event) should be employed to allow a sufficient attenuation to greenfield runoff rates into the closest watercourse or sewer connection. An indicative onshore substation SuDS pond size and location is illustrated in the OLEMS (document reference 8.7). The full specification for the SuDS pond and drainage strategy would be addressed as part of detailed design post-consent.

456. The Applicant has committed to providing an additional 'surface water management SuDS basin' (currently identified as concept within ***Figure 5*** of the

[5] Limit post development off site run-off to the existing greenfield rate and providing sufficient on site attenuation for rainfall events up to 1 in 100 year rainfall event, plus a 20% allowance for climate change over the lifetime of the development.

OLEMS (document reference 8.7)) to reduce flood risk for the village of Friston, in addition to the SuDS strategy currently proposed. Confirmation of the size, volume and location of this additional 'surface water management SuDS basin' will follow detailed design of the onshore substation and National Grid substation; following establishment of a catchment hydraulic model and final project parameters.

457. Outside of the impermeable areas the site finishes would consist of stone chippings over an appropriate thickness of sub-base to provide an access surface for plant maintenance.

6.7.8.8 Foul Drainage

458. Foul drainage would be collected in either of the following ways:

- Mains connection discharged to Local Authority sewer system, if available; or
- Septic tank located within the onshore substation location boundary.

459. The preferred method for controlling foul waste would be determined during detailed design and will depend upon the availability and cost of a mains connection and the number of visiting hours staff would attend site.

6.7.8.9 Substation Operational Access Road

460. Road modifications would be required to facilitate the safe ingress and egress from the public highway to the East Anglia ONE North onshore substation during operation. A substation operational access road will be constructed from Access ID 13 in ***Figure 26.2*** within ***Chapter 26 Traffic and Transport***. The permanent operational access road would be up to 8m in width, and up to 1,700m in length. ***Plate 6.28*** shows the construction of the East Anglia ONE substation operational access road as an example.

Plate 6.28 Construction of Substation Operational Access Road (example taken from East Anglia ONE substation)

461. Traffic and transport assessments have identified the location for this permanent access. An Outline Access Management Plan (OAMP) has been submitted with the DCO application as well as an Outline Construction Traffic Management Plan (OCTMP) and Outline Travel Plan (OTP) (see document references 8.9, 8.10 and 8.11 respectively)

462. The substation operational access road will be used for all operational vehicle access, including Abnormal Indivisible Load access (during construction and operation), and potentially (once available) for construction personnel

movements. HGVs will not use the substation operational access road during construction.

6.7.8.10 Construction: Foundations

463. The foundations would either be ground-bearing or piled based on the prevailing ground conditions.

464. The construction of the ground bearing foundations would take place in the following general sequence:

- Excavation as appropriate;
- Dewatering of excavations may be required. This will require establishment of a pump for dewatering the excavations which may be required to run overnight (see ***section 6.9*** regarding exceptions to typical working hours). A welfare unit and generator may also be required at dewatering locations.
- Installation of blinding (concrete);
- Construction and installation of timber formwork and supports;
- Installation of steel cages (rebar);
- Placement of structural concrete; and
- Curing and finishing.

465. The construction of pile foundations would take place in the following general sequence:

- Excavation as appropriate;
- Dewatering of excavations may be required. This will require establishment of a pump for dewatering the excavations which may be required to run overnight (see ***section 6.9*** regarding exceptions to typical working hours). A welfare unit and generator may also be required at dewatering locations.
- Construction of piling platform and piling;
- Installation of blinding (concrete);
- Construction and installation of pilecap formwork and supports;
- Installation of pilecap steel cages (rebar);
- Placement of pilecap structural concrete; and
- Curing and finishing.

6.7.8.11 Construction: Buildings

466. The proposed building substructures are typically predominantly composed of steel and cladding materials. The structural steelwork would be fabricated and prepared off site and delivered to site for erection activities. The steelwork would be erected with the use of cranes. Smaller buildings may be pre-fabricated.

467. Cladding panels (typically composite) would also be delivered to site ready to erect and be fixed to the steelwork. A variety of means would be used to install the cladding, depending on the area being accessed. The control building would include the construction of brick/blockwork partitions and would include a number of follow-on trades for plumbing, plastering, and low voltage mechanical/electrical installations.

6.7.8.12 Construction: Installation Works

468. For the installation and commissioning phases of the project a variety of specialist activities would be required associated with construction of the buildings within the East Anglia ONE North onshore substation footprint (e.g. GIS building, statcoms building and control building). This will also include installation of the transformers.

469. The transformers would be delivered sealed and would be particularly bulky, heavy items. Due to their size and weight they would be delivered via specialist means and offloaded with the use of a mobile gantry crane.

470. The majority of the remaining HVAC equipment would be erected with the use of small mobile plant and lifting apparatus.

6.7.8.13 Construction: Traffic and Plant

471. A final CTMP would be developed prior to construction. This would detail temporary road closures, diversions and/or other local traffic management that will be necessary. An OCTMP has been submitted with the DCO application.

472. ***Section 6.7.3*** outlines the proposed approach to construction traffic across the whole onshore cable route, including discussion of CCSs. It is proposed that construction traffic for the onshore substation and the National Grid substation would be routed to their respective substation CCS (or the CCS to the west of Snape Road) using key delivery routes identified for the East Anglia ONE North onshore substation and National Grid substation construction which are shared with the onshore cable route construction works. These are shown in ***Figure 26.7*** within ***Chapter 26 Traffic and Transport***.

473. ***Appendix 26.14 within Chapter 26 Traffic and Transport*** summarises all vehicle types associated with site deliveries and presents estimated vehicle movement numbers for the construction phase.

474. Construction will include a number of key stages, including earthworks, foundations, superstructure and equipment installation. The realistic worst case for construction assumes several activities taking place at the same time. This is expected to occur during the early stages when earthworks are being undertaken while foundations are also being constructed and other materials are being delivered.

6.7.8.14 Lighting

475. As a worst case scenario, it has been assumed that some periods of 24 hour construction will be required, for which task related flood lighting will be necessary.

476. Operational lighting requirements at the East Anglia ONE North onshore substation site would entail:

- Security lighting around perimeter fence of compound, to allow CCTV coverage, possibly motion sensitive;
- Car park lighting – as per standard car park lighting, possibly motion sensitive; and
- Repair / maintenance – task related flood lighting will be necessary.

477. No additional lighting is proposed along Grove Road or along the additional access roads within the East Anglia ONE North substation location.

478. An Operational Artificial Light Emissions Management Plan will be developed for the final design for the permanent infrastructure, as secured under the requirements of the draft DCO. The plan will detail any sensitive receptors, and describe the Operational Artificial Light Emissions Management Plan which will be implemented, including lighting requirements, positioning and hours of operation, alongside any monitoring and reporting which might be required.

6.7.8.15 Workforce

479. The construction workforce would consist primarily of specialist workers who travel to work on similar projects throughout the UK and abroad. To supplement this, local workers would be used where possible, subject to required skills being available.

6.7.9 National Grid Infrastructure

480. A new National Grid substation and National Grid overhead line realignment works (together referred to as the National Grid infrastructure) are required to connect the East Anglia ONE North onshore substation to the national electricity grid. The National Grid substation will be located to the north of the East Anglia ONE North onshore substation (as shown on ***Figure 6.4***), and the modifications to the existing overhead lines will take place within the National Grid overhead line realignment works area (as shown on ***Figure 6.2***). The existing overhead lines comprise of four 400kV circuits, two of which are supported by a northern pylon line and two on a southern pylon line, each running parallel to each other.

6.7.9.1 General Specification

6.7.9.1.1 National Grid Substation

481. The National Grid substation would be located to the immediate north west of the East Anglia ONE North substation running parallel to the existing overhead lines that connect Sizewell and Bramford.

482. The National Grid substation will either be an Air Insulated Switchgear (AIS) or a GIS depending on the technology employed. Within an AIS substation, equipment is designed to be left open to the elements and cooled by ambient air temperature. Within a GIS substation, equipment is designed to be insulated and cooled by a pressurised gas (e.g. sulphur hexafluoride (SF6)). The appropriate worst case is identified and assessed in each impact assessment chapter of this ES (***Chapters 18-27*** and ***29-30***). Parameters for both an AIS and GIS substation are presented within this chapter. The maximum footprint of the National Grid substation utilising AIS technology when operational is 44,950m^2 and would be up to 145m (wide) x 310m (long). The maximum footprint of the National Grid substation utilising GIS technology is 16,800m^2 and would be up to 140m (wide) x 120m (long). The size of the National Grid substation is dictated by electrical safety clearances and the switchgear technology used.

483. The maximum height of permanent outdoor equipment within the National Grid substation is up to 16m above finished ground level for both AIS and GIS technologies. The maximum height of buildings within the National Grid substation is 6m (for AIS technology) or 16m (for GIS technology).

484. ***Table 6.28*** and ***Table 6.29*** summarise the National Grid substation key parameter options for AIS and GIS:

Table 6.28 National Grid AIS Substation Key Parameters Summary

Element	Maximum
Maximum National Grid substation footprint	44,950m^2
Maximum National Grid substation length	310m
Maximum National Grid substation width	145m
Maximum National Grid substation building height	6m
Maximum National Grid substation equipment height	16m
Maximum National Grid infrastructure CCS Area	23,350m^2

Table 6.29 National Grid GIS Substation Key Parameters Summary

Element	Maximum
Maximum National Grid substation footprint	16,800m^2
Maximum National Grid substation length	120m
Maximum National Grid substation width	140m
Maximum National Grid substation building height	16m
Maximum National Grid substation equipment height	16m
Maximum National Grid infrastructure CCS Area	23,350m^2

485. A security fence will surround the National Grid substation. External lighting would also be installed at the National Grid substation which would entail:

- General lighting around the perimeter fence and within the National Grid substation for the purposes of security and to provide adequate lighting levels for access and inspection of equipment; and
- Task related flood lighting within the National Grid substation which will be necessary from time to time during repair/maintenance activities.

486. Whilst the above lighting is provided, the substation would not normally be lit during hours of darkness.

487. Surface water drainage requirements for the National Grid substation will be influenced by the final design of the National Grid substation. The surface water drainage design will meet the requirements of the NPPF in that the surface water run-off from the National Grid substation will be limited to the equivalent of the existing run-off rate from the undeveloped fields and will provide sufficient on-site attenuation for rainfall events of up to 1 in 100 years, plus a 20% allowance for climate change.

488. A SuDS solution will be designed and implemented to limit run-off from the National Grid substation through the use of infiltration techniques and a SuDS detention basin and/or retention pond which will hold surface water runoff from the National Grid substation during rainfall, and release the stored water to the local drainage system at a controlled rate. An indicative location for the National Grid substation SuDS detention basin and/or retention pond is shown in the OLEMS (document reference 8.7).

489. The final design of the surface water drainage system will be undertaken during the post consent detailed design of the National Grid substation and presented within the Surface Water and Drainage Management Plan which will require approval from the Local Planning Authority prior to commencement of construction.

6.7.9.1.2 National Grid Overhead Line Realignment Works

6.7.9.1.2.1 Overview

490. The National Grid substation will connect into each of the four circuits on the National Grid 400kV overhead lines. To facilitate these connections, modifications to the existing overhead lines will be required which will include the permanent realignment of a short section of the northern overhead line further north. This permanent realignment will create the necessary separation distance between the two overhead lines to enable the construction of new cable sealing end compounds to facilitate connection into the new National Grid substation. The relocation / reconstruction of up to one pylon on the southern overhead line is also required in order to facilitate the connection into the southern overhead lines. The National Grid overhead line realignment works will comprise of the following temporary and permanent stages (some of which may overlap) (see ***Plate 6.29***).

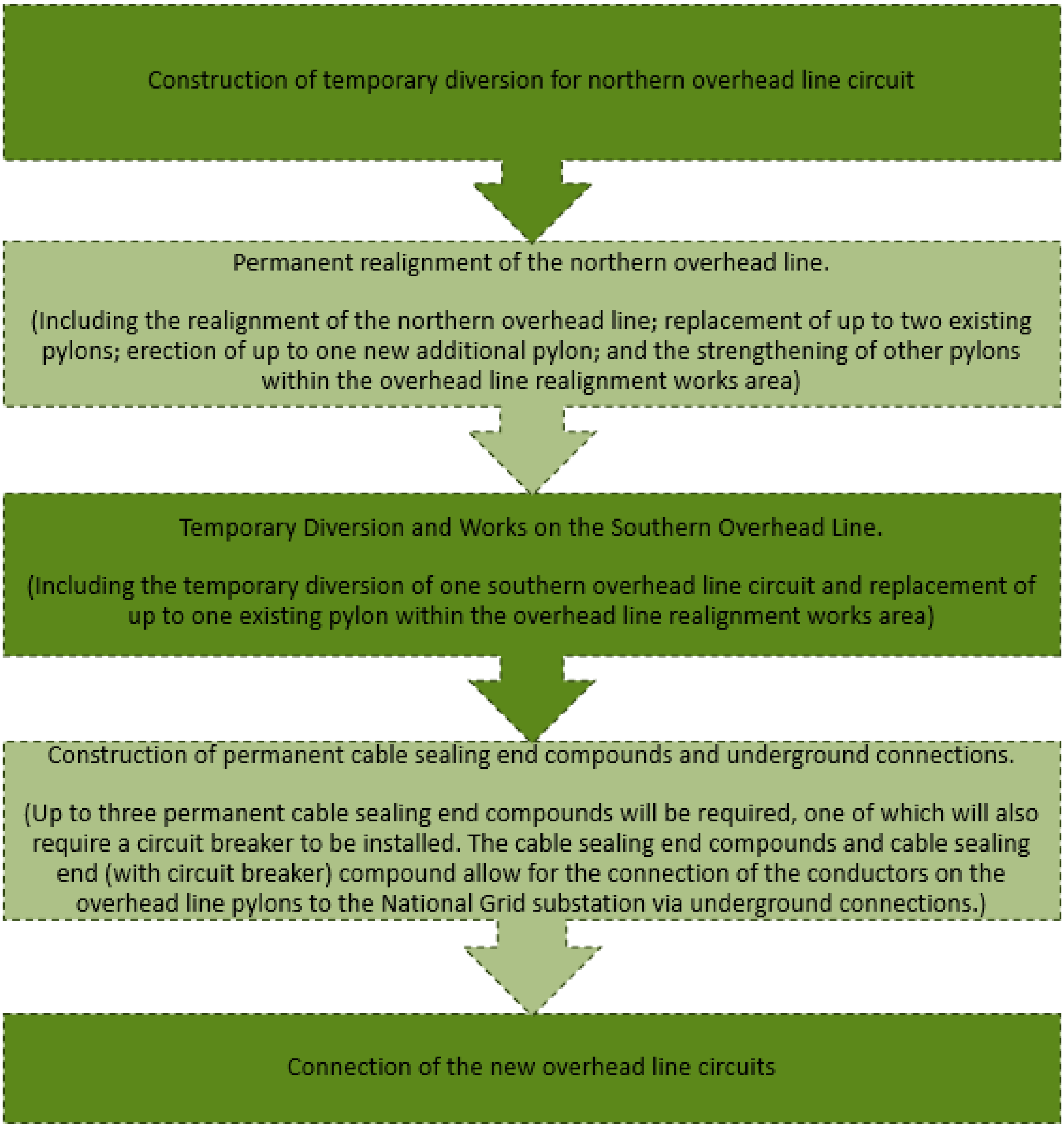

Plate 6.29 Flowchart of National Grid Overhead Line Realignment Works

491. Each stage is further discussed below.

6.7.9.1.2.2Construction of Temporary Diversion for Northern Overhead Line Circuit

492. Where it is not possible to construct replacement or new pylons due to the proximity of the existing northern overhead lines, a temporary diversion of the northern overhead lines will be required. This temporary diversion will seek to ensure that a minimum of three of the existing four circuits will remain in operational service during the National Grid overhead line realignment works.

493. The temporary diversion of the northern overhead line will use up to two temporary guyed masts or up to two temporary pylons to support the circuits during the period of realignment, the maximum height of which will be up to 42m

and up to 59.2m above ground level respectively. A temporary pylon will be of similar appearance as the existing pylons along the overhead lines. Where practical, existing pylons may be used to facilitate a temporary diversion.

494. All temporary diversion works will be undertaken entirely within the National Grid overhead line realignment works area.

495. The number and position of the temporary masts or pylons, and the location at which the temporary diversion circuits connect into the existing circuits will be determined during detailed design (post consent) and will take into account the electrical clearances between the construction works and the temporary diversion; the routeing and design of the permanent overhead line realignment; ground topography and constraints; the required temporary diversion routeing and spans; and the temporary mast/pylon design.

496. Where temporary masts are used, the footprint of each temporary mast will be up to 2m x 2m and will be constructed on a concrete foundation pad up to 2m x 2m in footprint and up to 1m deep finishing flush with the existing ground level. Each temporary mast will be supported with guys anchored by a screw anchor or by a trenched anchor (the latter requiring an excavation up to 3m x 3m in footprint and 5m deep in which an anchor is placed before backfilling of the excavation).

497. Where temporary pylons are used, each of the four legs of the pylon will be supported by a concrete foundation pad up to 5m x 5m in footprint and laid up to 5m below ground level.

498. Temporary working areas and access tracks would be required to construct each temporary mast/pylon, string the conductors and dismantle existing pylons. A temporary working area (constructed with stone) of up to 2,400m^2 (inclusive of the temporary mast/pylon footprint), will be required at each temporary mast/pylon, or any pylon within the National Grid overhead line realignment area where works are required to modify pylons or conductor cables.

499. Temporary cable stays (anchored by a screw anchor or above ground concrete anchors) may be required at any of the existing pylons within the overhead line realignment area in order to maintain the structural integrity of any pylons during the temporary diversion works.

500. At the appropriate time, one or both of the existing northern overhead line circuits (including the existing earth and fibre optic cables supported by the pylons) will be cut and a new temporary circuit(s) (and earth/fibre optic cables) pulled into place along the temporary masts/pylons and jointed to the existing circuit, bringing the temporary diversion into operation.

501. Protective measures may be required at sensitive locations when installing the new temporary circuits, such as roads or footpaths. These measures may include

erection of scaffolding, temporary closure of roads or footpaths or manned locations along the temporary diversion.

502. Vehicle access will be required to the temporary masts or pylons and any existing pylons which requires strengthening of other works undertaken, via existing farm tracks, or, where none exist a temporary track up to 4.5m wide will be created. The temporary access tracks would be either stone laid on a geotextile or interlocking panels. Some existing access tracks may also be upgraded using crushed stone. Some localised vegetation clearance will be required along some of the access routes and temporary diversion routing to enable safe vehicular and plant access.

6.7.9.1.2.3Construction of Permanent Realignment of the Northern Overhead Line

503. New pylons will require excavations around the pylon base for foundations and hard standing areas for erection of each pylon by crane.

504. Where existing foundations cannot be reused, new, relocated or replacement pylons will require each of the four legs of the pylons to be supported by a concrete foundation pad up to 5m x 5m in footprint and laid up to 5m below ground level.

505. Where overhead line pylons are to be removed from their current alignment, the area around each pylon base will be cleared and the pylons dismantled. The pylon foundations would then be removed to a depth of approximately 1m below ground level and the subsoil and topsoil reinstated.

506. Protective measures will be required at sensitive locations along the new overhead alignment such as roads or footpaths, when installing the new conductors and connecting into existing circuits. These measures will include erection of scaffolding, temporary controls around roads or footpaths along the diversion.

507. Temporary working areas and access tracks would be required to construct new/replacement pylons, string the conductors and dismantle existing pylons. A temporary working area of up to 2,400m^2 (inclusive of the pylon footprint) will be required at each new/replacement pylon location and will be constructed with stone.

508. Temporary vehicle access will be required to each pylon (within the onshore development area) and work area via existing farm tracks, or where none exist a temporary track up to 4.5m wide will be created. The temporary access tracks would be either stone laid on a geotextile or interlocking panels. Some existing access tracks will also be upgraded using crushed stone.

509. Once the replacement/new pylons are constructed along the northern realignment area, the northern overhead line circuits (including earth and fibre

optic cables) will be re-established to these new/replacement pylons allowing the temporary diversion to be disconnected. The temporary northern diversion can then be removed with associated temporary mast/pylon foundations removed to a depth of up to 1m below ground level. Subsoil and topsoil will be reinstated.

6.7.9.1.2.4 Temporary Diversion and Works on the Southern Overhead Line

510. The reconstruction and/or relocation of up to one pylon is required in order to facilitate the connection into the southern overhead lines. This will require the temporary diversion of one or both circuits on the southern overhead line using either an existing pylon, or up to two temporary guyed masts or up to two temporary pylons to support the circuits during the period of diversion, the maximum height of which will be up to 42m and up to 59.2m above ground level respectively.

511. Where temporary masts or pylons are required, the same parameters (such as maximum height, access requirements, temporary construction area requirements etc.) apply as described in ***section 6.7.9.1.2.3*** above.

512. On establishing the temporary diversion and disconnecting the circuits on the southern overhead line, an existing pylon will be removed and reconstructed to accommodate the connection to the National Grid substation. The maximum height of this replacement pylon will be up to 59.2m above ground level and will be similar in design (steel lattice) and colour to the existing pylons in the immediate area.

513. Once the replacement pylon is constructed along the southern realignment area, the southern overhead line circuits (including earth and fibre optic cables) will be re-established to the replacement pylon allowing the temporary diversion to be disconnected. The temporary southern diversion can then be removed with associated temporary mast/pylon foundations removed to a depth of up to 1m below ground level. Subsoil and topsoil will be reinstated.

6.7.9.1.2.5 Cable Sealing End Compounds and Underground Connections

514. Up to three cable sealing end compounds are required to connect the National Grid substation to each of the overhead line circuits. Two cable sealing end compounds will have a maximum permanent footprint of up to 2,500m^2 each. The third cable sealing end compound (referred to as a cable sealing end (with circuit breaker) compound) will include a circuit breaker, disconnectors and current / voltage transformers for protection purposes (i.e. to ensure safe operation and isolation / earthing of the circuit during periods of maintenance and to isolate relevant sections of the circuit during operation), and will have a maximum permanent footprint of 5,000m^2. This cable sealing end (with circuit breaker) compound will also include circuit breakers and a small modular building no greater than 3.5m in height and up to 3m x 5m in footprint, housing electrical protection and control equipment.

515. ***Plate 6.30*** and ***Plate 6.31*** shows an example of a cable sealing end compound.

Plate 6.30 Example of Cable Sealing End Compound

Plate 6.31 Example of cable sealing end compound

516. The final location of the cable sealing end compounds and cable sealing end (with circuit breaker) compound will be identified during detail design and will be influenced by the overhead line realignment final design and constraints such as residential properties and existing vegetation. Where possible, subject to electrical engineering design considerations, the cable sealing end compounds and cable sealing end (with circuit breaker) compound will be positioned close to field boundaries. The permanent and temporary works footprint will fall within the cable sealing end compound works areas shown indicatively in ***Figure 6.6i***.

517. The highest item of equipment within the cable sealing end compounds and cable sealing end (with circuit breaker) compound is the overhead line gantry at 16m above finished ground level.

518. Each cable sealing end compound (and cable sealing end (with circuit breaker) compound) is connected to the National Grid substation by underground high voltage and low voltage electrical and communications cables buried within a trench approximately 1.75m deep, the final routeing of which will be determined during detailed design.

519. A new permanent access track (tarmac covered) up to 3.7m in width will be required to each cable sealing end compound and the cable sealing end (with circuit breaker) compound for maintenance and operational purposes, accessed via the substation operational access road.

520. A permanent security fence will be required around each cable sealing end compound and the cable sealing end (with circuit breaker) compound.

521. ***Table 6.30*** below presents the overhead line realignment key parameters.

Table 6.30 National Grid Overhead Line Realignment Key Parameters Summary

Element	Maximum
Maximum number of additional pylons	1
Maximum number of reconstructed and/or relocated pylons	3
Maximum new/reconstructed/relocated pylon height	59.2m
Maximum new/reconstructed/relocated pylon width at base	20m
Maximum new/reconstructed/relocated pylon length at base	20m
Maximum number of cable sealing end compounds	3
Length of cable sealing end compound	50m
Width of cable sealing end compound	50m
Length of cable sealing end (with circuit breaker) compound	100m
Width of cable sealing end (with circuit breaker) compound	50m

Element	Maximum
Tallest structure in cable sealing end compound and the cable sealing end (with circuit breaker) compound	16m
Maximum number of temporary masts or pylons	4 (2 in place at any one time)
Maximum height of temporary masts (if used)	42m
Maximum height of temporary pylons (if used)	59.2m

6.7.9.1.2.6 Connection of the New Overhead Line Circuits

522. Following construction of the National Grid substation, the overhead line realignment, cable sealing end compounds and cable sealing end (with circuit breaker) compound, conductors (downleads) will to be installed from the overhead line pylons to the cable sealing end compounds and cable sealing end (with circuit breaker) compound to the National Grid substation.

6.7.10 National Grid Infrastructure Construction

6.7.10.1 Onshore Preparation Works

523. Prior to the construction works beginning, a number of surveys and studies would be undertaken to inform the final detailed design including ecological surveys, archaeological surveys, geotechnical investigations and mitigation requirements such as landscaping and drainage assessments (see ***Chapter 22 Onshore Ecology*** and ***Chapter 24 Archaeology and Cultural Heritage*** for further information).

524. Surface water drainage requirements would be dictated by the final drainage study and would be designed to meet the requirements of the NPPF[6]. The SuDS philosophy would be employed to limit run-off, where feasible, through the use of infiltration techniques which can be accommodated within the onshore development area.

525. Foul drainage would be collected through a mains connection to existing local authority sewer system if available or septic tank located within the development boundary. The specific approach would be determined during detailed design with consideration for the availability of mains connection and the number of visiting hours for site attendees during operation.

526. The National Grid 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 (as per ***section 6.7.9.1.1***).

[6] Limit post development off site run-off to the existing greenfield rate and providing sufficient on site attenuation for rainfall events up to 1 in 100 year rainfall event, plus a 20% allowance for climate change over the lifetime of the development.

6.7.10.2 National Grid Infrastructure CCS

527. A temporary CCS is required to serve the construction of the National Grid substation and overhead line realignment works. This CCS will accommodate construction offices, welfare facilities, car parking, workshops, spoil storage and material / equipment laydown and storage areas. Water, sewerage, electricity and communication services would be provided either via mains connection or mobile supplies (such as bowsers, septic tanks, and generators).

528. The National Grid infrastructure CCS will be located as shown indicatively on ***Figure 6.6i*** and will not exceed 23,350m^2 in footprint irrespective of whether AIS or GIS technology is adopted. The National Grid infrastructure CCS may be split into smaller CCSs although the cumulative footprint of these CCSs will remain within the maximum National Grid infrastructure CCS size stated above. The precise location of the National Grid infrastructure CCS will be selected with due consideration to avoid existing watercourses, hedgerows and other known infrastructure / constraints where practicable.

529. Construction of the National Grid substation and cable sealing end compounds and cable sealing end (with circuit breaker) compound will require the use of temporary water-tight working areas within the substation footprint, formed by scaffolding wrapped in tarpaulin or similar material, to facilitate the jointing and termination of cables. These temporary water-tight working areas must be large enough to accommodate cranes or other form of lifting systems.

6.7.10.3 Overhead Line Realignment Temporary Working Area

530. A temporary working area is required to serve the construction of the National Grid overhead line realignment works. This temporary working area will accommodate spoil storage and material/equipment laydown and storage areas.

531. The National Grid overhead line temporary working area will be located within the National Grid temporary working area (as shown on ***Figure 6.6i***) and will not exceed 5,000m^2 in footprint. The precise location of the National Grid overhead line temporary working area will be selected with due consideration to avoid existing watercourses, hedgerows and other known infrastructure / constraints where practicable.

532. The National Grid infrastructure CCS (referred to in ***section 6.7.10.2***) will also be used to serve the National Grid overhead line realignment works.

6.7.10.4 Construction of Permanent Cable Sealing End Compounds and Underground Connections

533. The cable sealing end (with circuit breaker) compound and small modular building will require an additional temporary works area of up 15,000m^2 (exclusive of the operational cable sealing end compound footprint; see ***section 6.7.9.1.2.5***) during construction.

534. The other two sealing end compounds will require an additional temporary works area of up 7,500m^2 each (exclusive of the operational cable sealing end compound footprint; see ***section 6.7.9.1.2.5***).

535. The location of works areas will be influenced by land constraints such as property boundaries around the perimeter to facilitate vehicle and personnel access.

6.7.11 East Anglia ONE North Substation and National Grid Infrastructure: Operation

536. The maintenance regime for the onshore substation would depend on the design of the adopted onshore substation. The design would incorporate extensive redundancies for cooling systems, duplicated control systems and power. This would allow most of the maintenance work to be done with no interruption to operation.

537. It is anticipated that the onshore substation would not be staffed. There would be occasional maintenance visits. Within the onshore substation location, there would be an area for storage of key components. Storage for cable repairs will be at the O&M port or strategic location near the onshore cable route.

538. Whilst the National Grid infrastructure would be continuously monitored remotely by NGET, regular visual checks and inspections will be undertaken. It is anticipated that the National Grid infrastructure would not be permanently staffed.

539. External lighting would be installed on the perimeter and within the National Grid substation, cable sealing end compounds and cable sealing end compound (with circuit breaker) compound for security purposes and to facilitate maintenance or repair works during the hours of darkness or low light, although the National Grid infrastructure would not normally be lit. Additional temporary task lighting will also be used in any area in which maintenance or repair works are being undertaken.

540. Maintenance of the National Grid infrastructure would be undertaken regularly to ensure its continued safe and efficient operation. Where National Grid infrastructure requires refurbishment or replacement, suitable vehicles would be used to transport workers, equipment and materials in and out of the National Grid infrastructure via the new substation operational access road (see ***section 6.7.8.10*** for further details on the substation operational access road). Access to the overhead lines for minor repairs, modifications, maintenance and refurbishment purposes would be achieved using 4-wheel drive type vehicles and vans.

6.7.12 East Anglia ONE North Substation and National Grid Infrastructure: Decommissioning

541. No decision has been made regarding the final decommissioning policy for the onshore substation and National Grid infrastructure, as it is recognised that industry best practice, rules and legislation change over time.

542. The East Anglia ONE North substation and National Grid infrastructure could be removed and the components reused or recycled. Should some or all of the National Grid infrastructure no longer be required for operational purposes, the equipment would be safely disconnected from the transmission system and carefully dismantled, and the land reinstated to an appropriate end use. Similar methods and equipment would be required for dismantling as outlined for construction.

543. The decommissioning methodology will be finalised immediately prior to decommissioning and will depend on the requirements of the onshore decommissioning plan approved by the local planning authority secured through the requirement in the draft DCO.

6.8 Offshore Programme

544. It is anticipated that the offshore construction works would be completed in approximately 27 months. The time periods of specific offshore activities would vary and would be encompassed within this 27 month period. It should also be noted that enabling works would be carried out prior to the offshore construction period commencing.

545. The following activity durations contribute to worst case scenarios used in the assessments in ***Chapter 11 Marine Mammals*** (piling durations) and ***Chapter 12 Offshore Ornithology*** (export cable laying installation period):

- Piling durations (see ***section 6.5.14.3.1***)
- Offshore export cable installation would take place in two separate six month periods.

6.9 Onshore Programme

546. The assessments in ***Chapters 18-27*** and ***29-30*** are based on an initial high level indicative programme which was developed for the ES. Indications of durations for activities are presented below for the purposes of the EIA. The final durations will be determined by the design and construction strategy post-consent.

547. Construction activities would normally be conducted during Monday to Friday working hours of 7am to 7pm and Saturday working hours of 7am to 1pm. Working hours are not proposed for Sundays or Bank Holidays. Exceptions to these working hours for the works are likely to include, but are not limited to:

- Continuous periods of operation that are required as assessed in the ES, such as concrete pouring, dewatering, cable pulling, cable jointing and HDD;
- Fitting out works associated with the onshore substation;
- Delivery to the transmission work of abnormal loads that may cause congestion on the local road network;
- The testing or commissioning of any electrical plant installed as part of the onshore infrastructure;
- Security monitoring; and
- Activity necessary in the instance of an emergency where there is a risk to persons, delivery of electricity or property.

548. Exceptions to these working hours for National Grid infrastructure construction are likely to include, but are not limited to:

- Continuous periods of construction that are required as assessed in the ES, such as concrete pouring and the installation and removal of conductors, pilot wires and associated protective netting across highways or public footpaths;
- Fitting out works associated with the National Grid substation;
- The completion of construction activities commenced during the approved working hours which cannot safely be stopped;
- The testing or commissioning of any electrical plant installed as part of the National Grid infrastructure;
- Security monitoring; and
- Activity necessary in the instance of an emergency where there is a risk to persons, delivery of electricity or property.

6.9.1 Onshore Preparation Works

549. Onshore preparation works (associated with offsite highway works, public highway accesses and surveys; see ***section 6.7.3.2***) would be up to 15 months.

6.9.2 Landfall

550. Construction of the landfall (including establishment of the CCS, HDD activities and construction of transition bays) would be up to 12 months.

6.9.3 Onshore Cable Route

551. Construction of the onshore cable route (including enabling works (establishment of CCSs and haul road), installation of cables and potential onshore HDD activities) would be up to 24 months.

552. Construction of the onshore cable route would be undertaken in sections whereby construction activities would overlap. See ***section 6.7.1*** for details of the onshore cable route sections.

6.9.4 East Anglia ONE North Onshore Substation

553. Construction of the East Anglia ONE North onshore substation (including establishment of CCS and haul road, foundation works and structural works) would be up to 30 months.

6.9.5 National Grid Substation

554. Construction of the National Grid substation is expected to be up to 48 months.

6.9.6 National Grid Overhead Line Realignment Works

555. Construction of the National Grid overhead line realignment works is expected to be up to 12 months undertaken within a window period of 36 months. However, the timing of the overhead line works will be subject to securing the necessary circuit outages (i.e. restricted windows where it is acceptable to temporarily de-power the overhead lines to enable the project to physically connect to them, see ***section 6.7.9.1.2.6***).

6.9.7 Commissioning and Reinstatement

556. Site clearance and reinstatement of the land at the landfall, onshore cable route, East Anglia ONE North onshore substation, National Grid substation and National Grid overhead line realignment works is expected to be up to 12 months.

6.10 Indicative Construction and Operation Plans

557. An indicative set of proposed East Anglia ONE North project construction plans are contained within ***Figure 6.6a-j***. This indicative set of plans is for illustrative purposes only and provides an early indication of the layout of the construction phase for the landfall, onshore cable route, onshore substation and National Grid infrastructure.

558. An indicative set of proposed East Anglia ONE North project operational plans are contained within the OLEMS (document reference 8.7). This indicative set of plans is for illustrative purposes only and provides an early indication of the layout of the operational phase for the onshore substation and National Grid infrastructure.

559. Details contained within these plans are subject to ongoing refinement through consultation and ES assessment outputs, including ongoing detailed design. The full specification for the construction and operation phases will be addressed as part of detailed design post-consent.

560. ***Plate 6.33*** illustrates an indicative onshore cable route construction sequence. This is illustrated to show potential key work activities, sequences and durations along the onshore cable corridor based on a ducted cable design. It does not represent an exhaustive list of activities. Onshore preparation works, CCS establishment and reinstatement, utility crossings, haul road removal and land reinstatement and excluded. Haul road removal and land reinstatement (as per

section 6.9.7) may commence at the end of illustrative programme, depending on construction and commissioning progress.

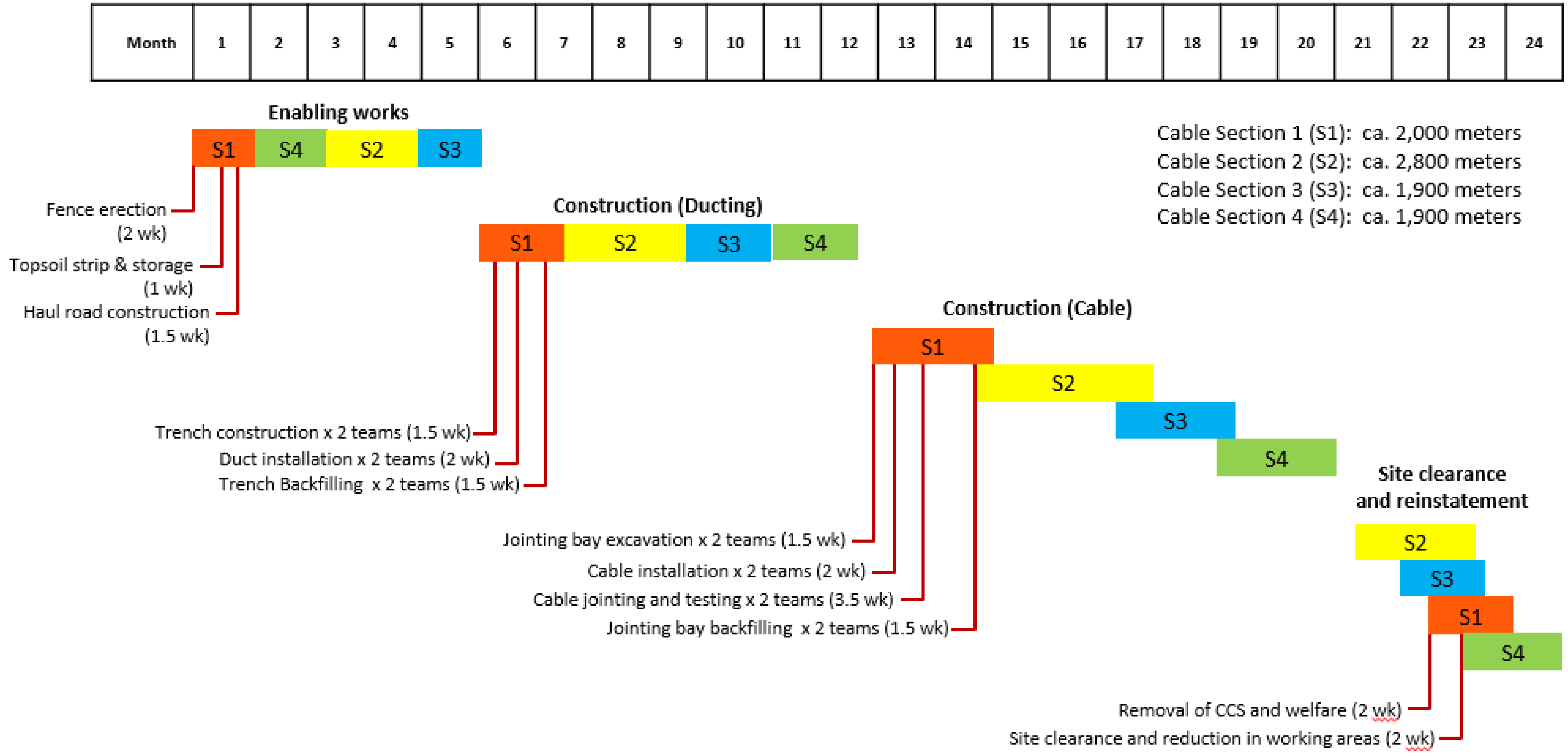

Plate 6.32 Illustration of Indicative Onshore Cable Route Construction Sequence and Timing

6.11 Discharge of Requirements

561. Post-consent, the final detailed design of the proposed East Anglia ONE North project and the development of the relevant management plan(s) will refine the worst-case parameters assessed in the EIA. During detailed design post consent, the final arrangement of buildings and infrastructure may change but will be within the parameters of the Rochdale Envelope used throughout the assessments in this ES. It is recognised that production of outline management plans is an important element in the management and verification of the impacts of the proposed East Anglia ONE North project.

562. Outline management plans, across a number of environmental topics, have been submitted with the DCO application. These outline management plans contain the key principles that provide the framework to discharge relevant DCO requirements to commence and implement construction of the proposed East Anglia ONE North project.

563. The CoCP itself contains a number of management plans and these include:

- Surface Water and Drainage Management Plan;
- A Flood Management Plan;
- Construction Phase Noise and Vibration Management Plan;
- Site Waste Management Plan;
- Soil Management Plan
- Air Quality Monitoring Plan;
- Materials Management Plan
- Pollution Prevention and Response Plan;
- Watercourses Crossing Construction Method Statement;
- Stakeholder Communications Plan; and
- Artificial Lights Emissions Management Plan.

564. ***Appendix 6.2*** and ***Appendix 6.3*** provides charts illustrating all of the onshore and offshore management plans that are secured through requirements within the draft DCO.

6.12 East Anglia ONE North and East Anglia TWO Cumulative Project Descriptions

565. As detailed in previous sections, the proposed East Anglia TWO project has submitted a separate DCO application. The two projects will share the same landfall location, onshore cable route, National Grid infrastructure; and the two onshore substations will be co-located.

566. The proposed East Anglia ONE North project CIA will therefore initially consider the cumulative impact with the proposed East Anglia TWO project against two different construction scenarios (i.e. construction of the two projects simultaneously and sequentially). The realistic worst case scenario of each impact is then carried through to the main body of the CIA assessment which considers other developments which are in close proximity to the proposed East Anglia ONE North and proposed East Anglia TWO project.

567. The two construction scenarios assessed are:

- Scenario 1 - the proposed East Anglia ONE North project and proposed East Anglia TWO project are built simultaneously; and
- Scenario 2 - the proposed East Anglia ONE North project and the proposed East Anglia TWO project are built sequentially.

568. Under scenario 2, either the proposed East Anglia ONE North project or the proposed East Anglia TWO project could be constructed first. However, there will be no difference in impact regardless of which project is constructed first. The CIA presented in this ES is presented using the intended development strategy of the proposed East Anglia TWO project being constructed first. However, in the eventuality that the proposed East Anglia ONE North project is constructed first, the impacts presented would be the same.

569. ***Appendix 6.3*** compares the East Anglia ONE North project in isolation (as described in ***section 6.7***) with construction scenario 1 and construction scenario 2.

570. As described in ***Chapter 5 EIA Methodology,*** there are two co-located onshore substation locations for either the proposed East Anglia ONE North project or the proposed East Anglia TWO project. The draft DCOs for both the proposed East Anglia ONE North and East Anglia TWO projects have the flexibility for either project to use either onshore substation location. The intended development strategy is for the proposed East Anglia ONE North project to use the eastern location and the proposed East Anglia TWO project to use the western location. Therefore, this is how the ‘project alone’ assessments in the onshore technical chapters (***Chapters 18-27***) are presented. There is no difference in the details provided in ***section 6.7.6, section 6.7.7 or section 6.7.8*** of this chapter regardless of which onshore substation location is used by the proposed East Anglia ONE North project.

6.13 Response to Potential Major Accidents and Disasters

571. The Infrastructure Planning (EIA) Regulations 2017 (the EIA Regulations 2017) require significant risks to the receiving communities and environment, for example through major accidents or disasters, to be considered. Similarly, significant effects arising from the vulnerability of the proposed development to major accidents or disasters should be considered. Relevant risks are covered in the topic chapters within this ES.

572. A major accident, as defined in the Control of Major Accident Hazards (COMAH) Regulations 2015 (as amended), means "*an occurrence such as a major emission, fire, or explosion resulting from uncontrolled developments in the course of the operation of any establishment to which these Regulations apply, and leading to serious danger to human health or the environment (whether immediate or delayed) inside or outside the establishment, and involving one or more dangerous substances*".

573. Offshore wind developments have an intrinsically low risk of causing major accidents. The wind turbines, blades, towers and foundation bases of offshore windfarms have an excellent safety record with a very low failure rate and are positioned many kilometres offshore away from populated areas and the public. On the rare occasion that offshore turbine blades have been lost into the sea or damage has been caused to a turbine by a fire within the nacelle, this has resulted without injury. The performance of each turbine is constantly monitored through the SCADA system sending performance data through to a central, partly automated monitoring and control centre. As a result, a problem can be quickly detected and pre-prepared safety management action plans rapidly enacted.

574. Specified works east of Aldeburgh Road will not commence until an emergency incident response plan (secured as a requirement of the draft DCO) relating to the construction and operation of that stage of the relevant works has been submitted for approval by the relevant planning authority.

575. Whilst exposed power cables on the sea bed can pose a snagging risk to shipping and fishing vessels, the project's export and array cables will be buried where possible to protect the cables and remove the snagging risk. This is discussed in detail in ***Chapter 14 Shipping and Navigation***, which also discusses the risk that the increased vessel movement to and from the site may pose to navigational safety during construction and operational phases.

576. The buried cables onshore and offshore pose very little risk to the public as the system is designed to detect faults and 'trip out' the circuits automatically should any failure in insulation along the cable be detected.

577. The risk of substation fires is historically low however substation fires can impact the supply of electricity and create a localised fire hazard. The highest appropriate levels of fire protection and resilience will be specified for the onshore substation and National Grid substation to minimise fire risks. The onshore substation is located sufficiently distant from populated areas to further minimise the risk of fire hazard.

578. The lubricants, fuel and cleaning equipment required within the project will be stored in suitable facilities designed to the relevant regulations and policy design guidance.

579. The offshore wind industry strives for the highest possible health and safety standards across the supply chain. However there have been incidents including a small number of worker fatalities during the construction and operation of offshore windfarms. Risks to the public onshore and other sea users offshore during construction are minimised through the use of controlled construction sites onshore and vessel safety zones offshore.

580. Safety zones are temporary exclusion areas enacted during construction and major maintenance, allowing East Anglia ONE North Limited and its contractors to control vessel movement to enable safe construction works to proceed.

581. Onshore, controlled or closed construction sites will be operated where construction works are undertaken in sections where access is strictly controlled during periods when the works are ongoing.

582. East Anglia ONE North Limited recognises the importance of the highest performance levels of health and safety to be incorporated into the project. There is a commitment to adhere to a high level of process safety, from design to operations and for all staff, contractors and suppliers to have a high level of safety awareness and knowledge of safety and safe behaviour. East Anglia ONE North Limited will enact a Code of Conduct for suppliers, contractors and subcontractors. They must all comply with the Code as well as health and safety legislation. East Anglia ONE North Limited will ensure that employees that are going to work for them have undergone necessary health and safety training.

583. With a commitment to the highest health and safety standards in design and working practises enacted, none of the anticipated construction works or operational procedures is expected to pose an appreciable risk of major accidents or disasters.

584. In conclusion, the risk of ‘major accidents and/or disasters’ occurring associated with any aspect of the project, during the construction, operation and decommissioning phases is negligible.

6.14 References

Beatrice Offshore Wind Farm Ltd (2018). Beatrice Offshore Wind Farm Piling Strategy Implementation Report. Available from: http://marine.gov.scot/sites/default/files/lf000005-rep-2397_bowlpilingstrategyimplementationreport_rev1_redacted.pdf

BERR. (2008). Review of Cabling Techniques and Environmental Effects applicable to the Offshore Windfarm Industry.

Civil Aviation Authority (2012) Lighting of Wind Turbine Generators in United Kingdom Territorial Waters

DOWL (2016). Dudgeon Offshore Wind Farm - Piling Summary and Lessons Learned. August 2016.

International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) 2008. Recommendation 0-139. The Marking of Man-Made Offshore Structures. Edition 1.

MCA (2018). Offshore Renewable Energy Installations: Requirements, Guidance and Operational Considerations for Search and Rescue and Emergency Response. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/578859/OREI_SAR_Requirments_v1.pdf

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