Hornsea Project Four: Preliminary Environmental Information Report (PEIR)

Volume 1,

Chapter 3 : Site Selection and Consideration of Alternatives

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Glossary

Term	Definition
BRAG Assessment	An assessment based on quantitative assessment and expert judgement. The ranking is defined as: • Black: Potential showstopper to development; • Red: High potential to constrain development; • Amber: Intermediate potential to constrain development; and • Green: Low potential to constrain development. Black and red constraints are critical in determining features that should be avoided wherever possible to avoid consenting risk, reduce EIA complexity and reduce the cost of mitigation. Amber and green constraints are those that may be more readily minimised or managed by employing appropriate mitigation measures.
Commitment	A term used interchangeably with mitigation. Commitments are Embedded Mitigation Measures. Commitments are either Primary (Design) or Tertiary (Inherent) and embedded within the assessment at the relevant point in the EIA (e.g. at Scoping or PEIR). The purpose of Commitments is to reduce and/or eliminate Likely Significant Effects (LSE's) in EIA terms.
Developable Area Approach (DAA)	A Hornsea Four internal process for consideration of Physical, Biological and Human constraints in refining the Agreement for Lease (AfL) area. The consideration balances consenting and commercial considerations with technical feasibility for construction. The output of the DAA gives due consideration to the size and location of the Final Project that will be taken forward to consent application.
Development Consent Order (DCO)	An order made under the Planning Act 2008 granting development consent for one or more Nationally Significant Infrastructure Projects (NSIP).
Environmental Impact Assessment (EIA)	A statutory process by which certain planned projects must be assessed before a formal decision to proceed can be made. It involves the collection and consideration of environmental information, which fulfils the assessment requirements of the EIA Directive and EIA Regulations, including the publication of an Environmental Statement.
Export cable corridor (ECC)	The specific corridor of seabed (seaward of Mean High Water Springs (MHWS)) and land (landward of MHWS) from the Hornsea Project Four array area to the Creyke Beck National Grid substation, within which the export cables will be located.
Export cable corridor (ECC) search area	The broad offshore corridor of seabed (seaward of the MHWS) and land (landward of MHWS) from the Hornsea Project Four array area to the Creyke Beck National Grid substation considered within the Scoping Report, within which the refined ECR corridor will be located.
Electrical Infrastructure Study Area (EISA)	The study area between the onshore substation and offshore array area

Term	Definition
High Voltage Alternating Current (HVAC)	High voltage alternating current is the bulk transmission of electricity by alternating current (AC), whereby the flow of electric charge periodically reverses direction.
HVAC booster station(s)	Offshore HVAC booster station(s) are required in HVAC transmission systems only; they are not required in HVDC transmission systems. If required for Hornsea Four, they would be located entirely offshore.
Landfall	The generic term applied to the entire landfall area between Mean Low Water Spring (MLWS) tide and the Transition Joint Bay (TJB) inclusive of all construction works, including the offshore and onshore ECC, intertidal working area and landfall compound.
Mitigation	A term used interchangeably with Commitment(s) by Hornsea Four. Mitigation measures (Commitments) are embedded within the assessment at the relevant point in the EIA (e.g. at Scoping or PEIR).
National Grid Electricity Transmission (NGET) substation	The grid connection location for Hornsea Four.
Offshore Export cables	Cables that transfer power from the offshore substation(s) or the converter station(s) to shore.
Offshore substation(s)	One or more offshore substations to convert the power to higher voltages and/or to HVDC and transmit this power to shore.
Onshore export cables	Cables connecting the landfall first to the onshore substation and then on to the NGET substation at Creyke Beck.
Onshore substation (OnSS)	Located as close as practical to the NGET substation at Creyke Beck and will include all necessary electrical plant to meet the requirements of the National Grid.
Ørsted Hornsea Project Four Ltd.	The Applicant of proposed Hornsea Project Four offshore wind farm.
Transition Joint Bay (TJBs)	TJBs are pits dug and lined with concrete, in which the jointing of the offshore and onshore export cables takes place.

Acronyms

Acronym	Definition
AfL	Area for Lease
BRAG	Black, Red, Amber, Green
DCO	Development Consent Order
EBI	Energy Balancing Infrastructure
ECC	Export Cable Corridor
ECR	Export Cable Route
EIA	Environmental Impact Assessment
EISA	Electrical Infrastructure Study Area
ERYC	East Riding of Yorkshire Council
HDD	Horizontal Directional Drill
HVAC	High Voltage Alternating Current
LTP	Local Transport Projects Ltd
MCZ	Marine Conservation Zone
NGET	National Grid Electricity Transmission
OnSS	Onshore Substation
PEIR	Preliminary Environmental Information Report
PINS	Planning Inspectorate
RAG	Red, Amber, Green
SoS	Secretary of State
TCE	The Crown Estate
UK	United Kingdom
ZAP	Zone Appraisal and Planning
ZDA	Zone Development Agreement

Units

Unit	Definition
GW	Gigawatt (power)
m	Meter
km	Kilometre
km^2	Square Kilometre
kV	Kilovolt (electrical potential)
kW	Kilowatt (power)
%	Percentage

3.1 Introduction

3.1.1.1 This chapter of the Preliminary Environmental Information Report (PEIR) presents the results to date of the site selection and consideration of alternatives considered for the Hornsea Project Four offshore wind farm (hereafter Hornsea Four).

3.1.1.2 Ørsted Hornsea Project Four Limited (the Applicant) is proposing to develop the Hornsea Four offshore windfarm (Hornsea Four). Hornsea Four will be located approximately 65 km from the East Riding of Yorkshire in the Southern North Sea and will be the fourth project to be developed in the former Hornsea Zone please see **Volume 1, Chapter 1: Introduction** for further details on the Hornsea Zone). Hornsea Four will include both offshore and onshore infrastructure including an offshore generating station (wind farm), electrical cables, landfall, and connection to the electricity transmission network (please see **Volume 1, Chapter 4: Project Description** for full details on the Project Design).

3.1.1.3 An important part of the Hornsea Four development process is the consideration of potential options, selection and the subsequent refinement of project infrastructure. Well informed decisions on the selection and siting of infrastructure are critical and Hornsea Four recognise the need to ensure consultees and stakeholders understand how such decisions have been made.

3.1.1.4 This chapter summarises the site selection process (including route planning), [a comparison] of alternatives considered and the reasons for selecting the chosen option). All information supporting the decision-making process is contained within the three technical annexes, included in **Volume 4** of the PEIR:

- **Annex 3.1: Refinement of the Cable Landfall**;
- **Annex 3.2: Selection and Refinement of the Offshore Infrastructure**; and
- **Annex 3.3: Selection and Refinement of the Onshore Infrastructure.**

3.1.1.5 The site selection and consideration of alternatives will be finalised following completion of pre-application consultation and the final Environmental Statement (ES) will accompany the application to the Secretary of State (SoS) for Development Consent under the Planning Act 2008.

3.2 Consideration of Reasonable Alternatives

3.2.1.1 EU Directive 2011/92/EU, as amended by Directive 2014/52/EU on the assessment of environmental effects of certain public and private projects sets out the requirement for the EIA Report to provide information relating to reasonable alternatives in Annex IV:

"a description of the reasonable alternatives (for example in terms of project design, technology, location, size and scale) studied by the developer, which are relevant to the proposed project and its specific characteristics, and an indication of the main reasons for selecting the chosen option, including a comparison of the environmental effects".

3.2.1.2 The overarching need for further offshore wind farm development within UK waters to replace more environmentally damaging energy options such as traditional (fossil fuel) power stations (notably in relation to climate change) provides a key starting point for Hornsea Four. **Chapter 2: Planning and Policy Context** sets out the underlying and supporting documentation for development of such renewable energy development and associated Energy Balancing Infrastructure (EBI).

3.2.1.3 Consideration has been given to reasonable alternatives at every stage of the process of developing Hornsea Four. This has formed a fundamental driver for every decision within the project, from the technical options within the engineering side to the micro-siting and route changes during the development of the cable routes.

3.2.1.4 For example, when identifying the cable landfall location, the "Guiding Principles" listed below were identified:

- select the shortest route (hence reduce environmental impacts by minimising footprint and electrical transmission losses (most efficient project));
- avoid key sensitive features where possible and where not, seek to mitigate impacts;
- minimise disruption to sensitive receptors (e.g. populated areas) by the early adoption of primary (intrinsic design) commitments:
  - Co49: There will be no permanent High Voltage infrastructure installed above surface within 50 m of residential properties and sub surface within 25 m of residential properties;
  - Co134: Cable installation works at the landfall area will be located at least 200 m from residential receptors;
- find a site large enough to accommodate the connection technology outlined within the design envelope.

3.2.1.5 Through consideration of these principles, by default all other reasonable alternatives were considered as part of the decision process and the best identifiable option selected.

3.2.1.6 In addition to this, when mapping the most appropriate route for the offshore export cable, a detailed list of physical and third-party constraints was put together (**Table 1** of **Volume 4, Annex 3.2: Selection and Refinement of the Offshore Infrastructure**). This list sets out not only the constraint to be identified but also the mitigation measures associated with each constraint.

3.2.1.7 Consideration of these constraints, identification of the preferred option(s) and then comparison of the alternatives and the reasons for selecting the preferred option are set out in the BRAG assessments (see **Section 3.2.1.8**) that underpin the entire Hornsea Four site selection process. These can be found in the relevant technical annexes listed in **Section 3.1.1.4**.

3.2.1.8 The BRAG approach uses colour coded ratings to inform the site selection and consideration of alternatives and were defined as follows:

- **Black** - Potential showstoppers to development;
- **Red** - High potential for the development to be constrained;
- **Amber** - Intermediate potential for the development to be constrained; or
- **Green** - Low potential for the development to be constrained.

3.3 Commitments

3.3.1.1 Hornsea Four incorporates several commitments which have informed the site selection and routing process through avoidance of sensitive receptors (see **Table 3.1**). Such commitments include primary design principles inherent as part of the project (such as avoidance of sensitive sites, adoption of installation techniques and engineering designs/modifications included as part of their pre-application phase), to eliminate potentially significant impacts or reduce impacts as far as possible. Further commitments including the adoption of best practice guidance are embedded as an inherent aspect of the adopted Hornsea Four EIA process.

Table 3.1: Commitments which form an intrinsic part of Hornsea Four and applicable to site selection and consideration of alternatives.

Commitment	Description	Purpose	How it is secured
Co2	The following sensitive sites will be avoided by the permanent project footprint: Listed Buildings (580 sites), Registered Parks and Gardens (Thwaite Hall and Risby Hall), Scheduled Monuments (30 sites), Conservation Areas (19 sites), non-designated built heritage assets (368 sites) and Ancient Woodland (10 sites). Please refer to PEIR Volume 6, Annex 6.5.1 Appendix B Designated Assets Gazetteer for detailed lists of designated heritage assets that are avoided by Hornsea Four. With the exception of River Hull Headwaters SSSI and Bryan Mills Field, sensitive sites have been avoided. Please refer to PEIR Volume 6, Annex 1.1: Land Quality PRA for details. Where possible, unprotected areas of woodland, mature and protected trees (those with Tree Preservation Orders TPOs) shall also be avoided.	To minimise effects upon the biological, human and built environment	DCO Works Plan - Onshore DCO Requirement 6 (Detailed design approval onshore)
Co44	The Holderness Inshore Marine Conservation Zone (MCZ) will not be crossed by the offshore export cable corridor including the associated temporary works area.	To minimise effects upon the biological, human and marine environment	DCO Schedule 1, Part 1 Authorised Development

Commitment	Description	Purpose	How it is secured
Co45	The Holderness Offshore MCZ not be crossed by the offshore export cable corridor including the associated temporary works area.	To minimise effects upon the biological, human and marine environment	DCO Schedule 1, Part 1 Authorised Development
Co46	The offshore export cable corridor and the array will be routed so as to avoid any identified archaeological receptors pre-construction, with buffers as detailed in the Marine Written Scheme of Investigation WSI.	To minimise effects upon the marine and historic environment	DCO Schedule 11, Part 2 - Condition 12(2) and; DCO Schedule 12, Part 2 - Condition 14(2) (Marine Written Scheme of Archaeological Investigation)
Co78	Ponds will be avoided through micro-siting of the onshore export cable where practical.	To minimise effects upon the biological environment	DCO Works Plans, DCO Onshore Order limits
Co86	The offshore export cable corridor and cable landfall (below MHWS) will not cross the Greater Wash SPA, Flamborough & Filey Coast SPA and the Flamborough Head SAC.	To minimise effects upon the biological and marine environment	DCO Schedule 1, Part 1 Authorised Development
Co133	The onshore export cable corridor (ECC) will be routed to avoid residential receptors by at least 50 m.	To minimise effects upon the human environment	DCO Works Plan - Onshore DCO Requirement 6 (Detailed design approval onshore)
Co134	Cable installation works at the landfall area will be located at least 200 m from residential receptors.	To minimise effects upon the human environment	DCO Works Plan - Onshore DCO Requirement 6 (Detailed design approval onshore)
Co135	Temporary construction highway access points along the onshore export cable corridor (ECC) will be located at least 150m from residential receptors, with the exception of two receptors; Bridge Farm Holiday Cottages, Brigham, Driffield, and a receptor off the A1035 Malton Road, Beverley.	To minimise effects upon the human environment	DCO Works Plan - Onshore DCO Requirement 6 (Detailed design approval onshore)
Co150	A new access will be taken directly from the A1079, to route construction traffic associated with the onshore substation away from Cottingham and Dunswell.	To minimise effects upon the human environment	DCO Works Plan – Onshore

3.3.1.2 All the commitments adopted by Hornsea Four are set out in **Volume 4, Annex 5.2: Commitments Register.** Further discussion of the identification and use of Commitments is provided as part of **Chapter 3: EIA Methodology**.

3.4 Consultation

3.4.1.1 Consultation is a key part of the DCO application process and helps refine the project through wider spatial, design and process considerations discussed in broader forums, both formally through Evidence Plan meetings or more informally through public events.

3.4.1.2 A summary of the project consultation process and mechanisms are presented within **Chapter 6: Consultation** along with a summary of the key issues raised during the consultation process. A summary of consultation in relation to site selection is given in **Table 3.2**. and are not discussed further within this chapter.

Table 3.2: Details of Consultation Undertaken Relevant to Site Selection.

Date	Attendees	Purpose	Summary
23 May 2018	East Riding of Yorkshire Council	Overview of the RPSS and site selection criteria	Introduction to Hornsea Four's development aspirations in East Riding
22 June 2018	East Riding of Yorkshire Council	Introduction to the RPSS Process and overview of key findings to date	Presentation of the Route Planning and Site Selection (RPSS) employed by Hornsea Four in relation to selecting a suitable landfall, onshore ECC and substation site.
02 October 2018	East Riding of Yorkshire Council	RPSS Roadshow	Presentation of early findings of the RPSS for landfall options, onshore ECC development and substation site options.
21 November 2018	East Riding of Yorkshire Council	OnSS Traffic considerations	Presentation of early feedback from Local Information Events (LIEs) and implications for OnSS site selection and access requirements
18 December 2018	TCE	Developable Area Approach (DAA)	Presentation and discussion on Hornsea Four's development aspirations and discussion on potential reduction of the AfL in line with key environmental constraints and potential consent risks.
31 January 2018	MCA and THLS	Developable Area Approach	Presentation/discussion on Hornsea Four's development aspirations and discussion on human environment constraints and potential reduction of the AfL in line with key constraints and potential consent risks.

Date	Attendees	Purpose	Summary
07 February 2019	Natural England and RSPB	Developable Area Approach - Workshop	Presentation/discussion on Hornsea Four's development aspirations and discussion on ornithological constraints and potential reduction of the AfL in line with key potential consent risks.
12 March 2019	Onshore Substation Consultation Group (OSCG)	Create a consultation forum - focusing on the key areas of interest for respective Parish Councils and local communities in relation to the Hornsea Four OnSS.	Discussion methods of best practice and aspirational approaches that will guide the future development of all on-shore infrastructure. To be captured in Design Vision Statement sets out

3.5 Site Selection Process

3.5.1.1 Site selection for Hornsea Four has been progressed through five separate processes each relating to different parts of the project, which although linked due to the spatial connections between them, have been progressed in parallel and in full knowledge of interconnections and interdependencies. These five processes are listed below and discussed in more detail in the following sections of this chapter:

- Development of the Offshore Array and Infrastructure (**Volume 4, Annex 3.2**);
- Identification of the Electrical Infrastructure Study area (**Volume 4, Annex 3.1**);
- Location of the Landfall (**Volume 4, Annex 3.1**);
- Identification of the Onshore Substation (OnSS) site (**Volume 4, Annex 3.3**); and
- Development of the Onshore and Offshore Export Cable Corridor (ECC) (**Volume 4, Annexes 3.2** and **3.3**).

3.5.1.2 The development timelines of these discrete, but inter-dependant, aspects of Hornsea Four are presented in **Figure 3.1** (offshore export cable corridor (ECC)), **Figure 3.2** (Hornsea Four array); **Figure 3.3** (landfall); **Figure 3.4** (onshore ECC) and **Figure 3.5** (onshore substation).

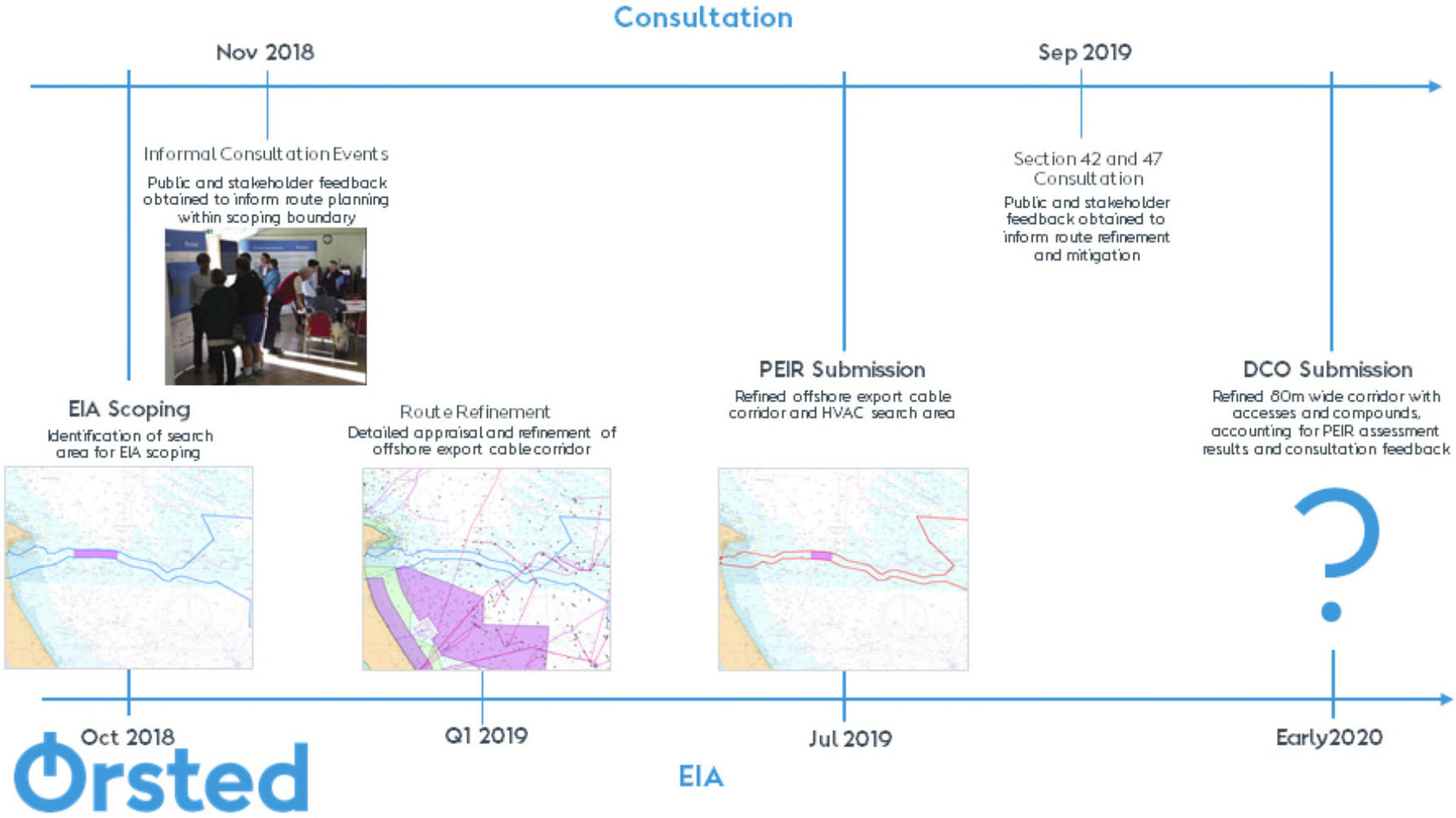

Figure 3.1: Site Selection Timeline – Offshore ECC.

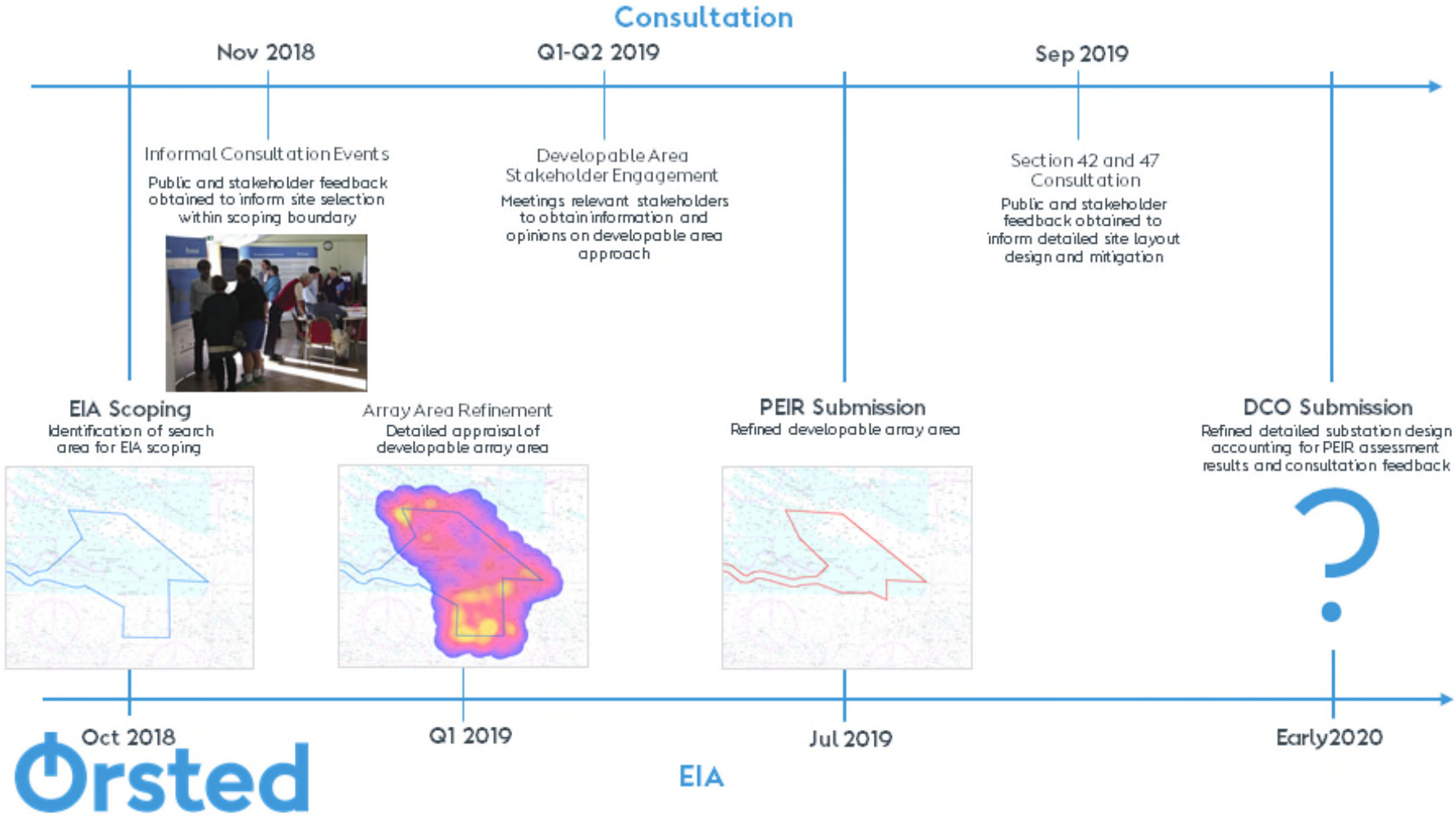

Figure 3.2: Site Selection Timeline – Offshore Array.

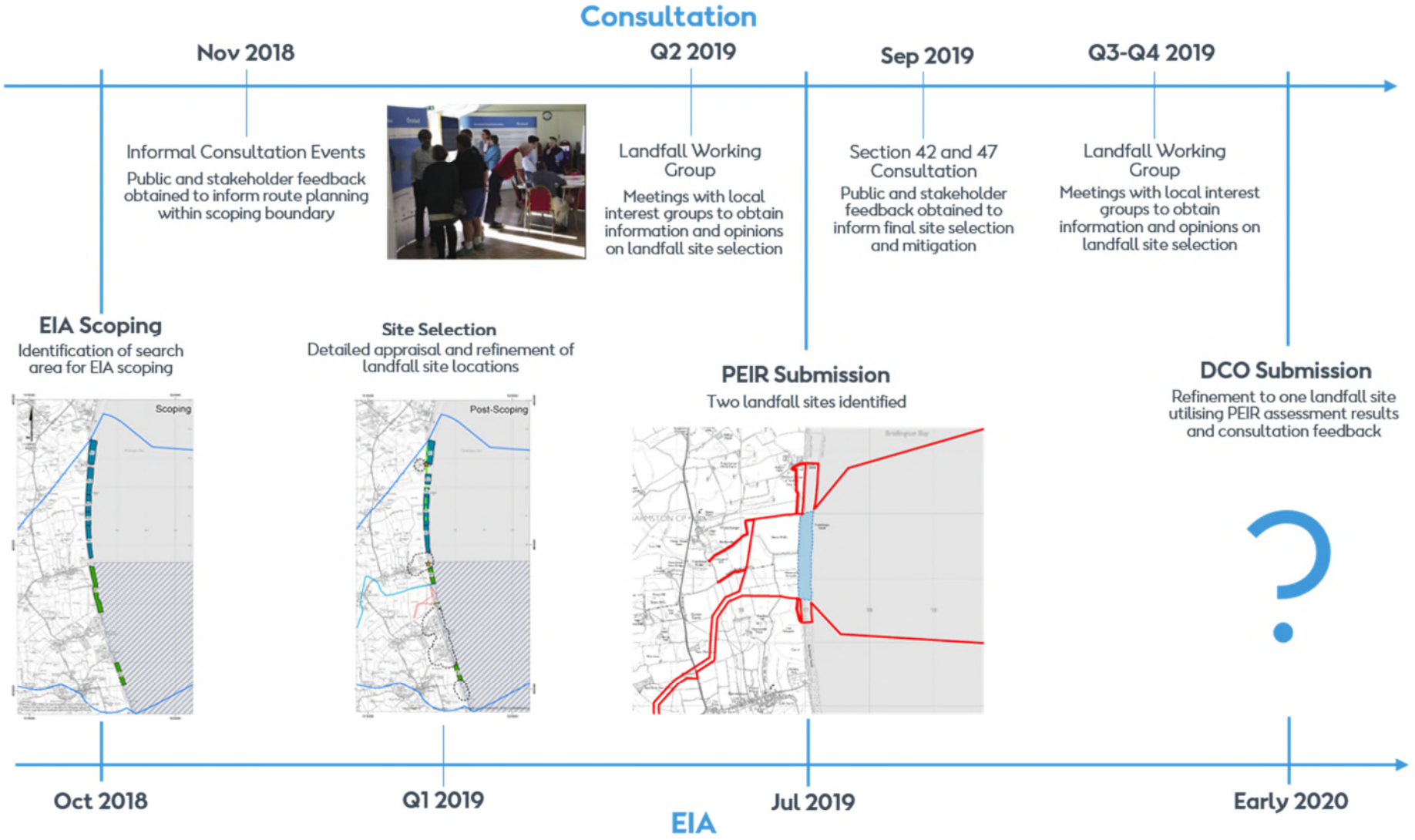

Figure 3.3: Site Selection Timeline – Landfall

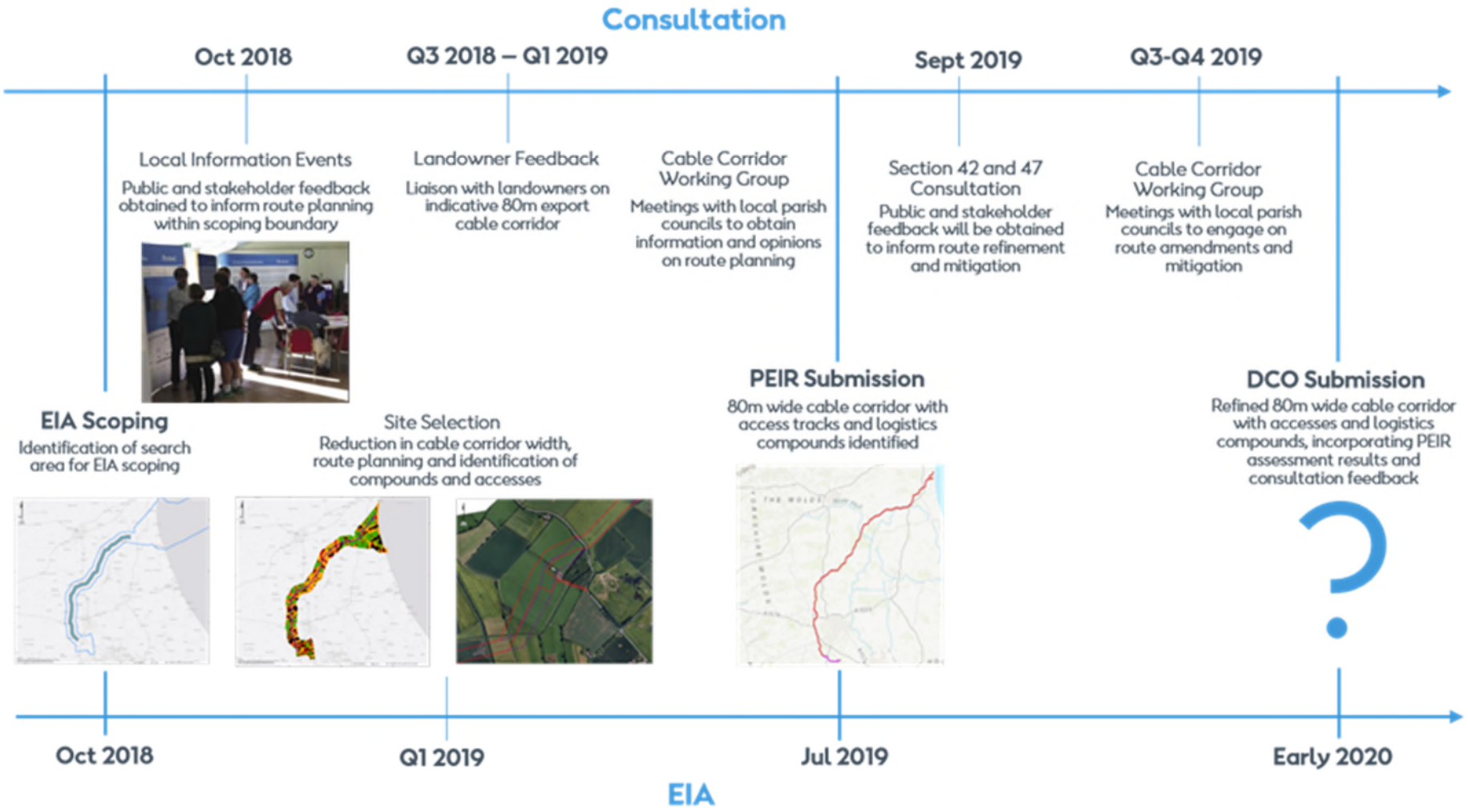

Figure 3.4: Site Selection Timeline – Onshore ECC.

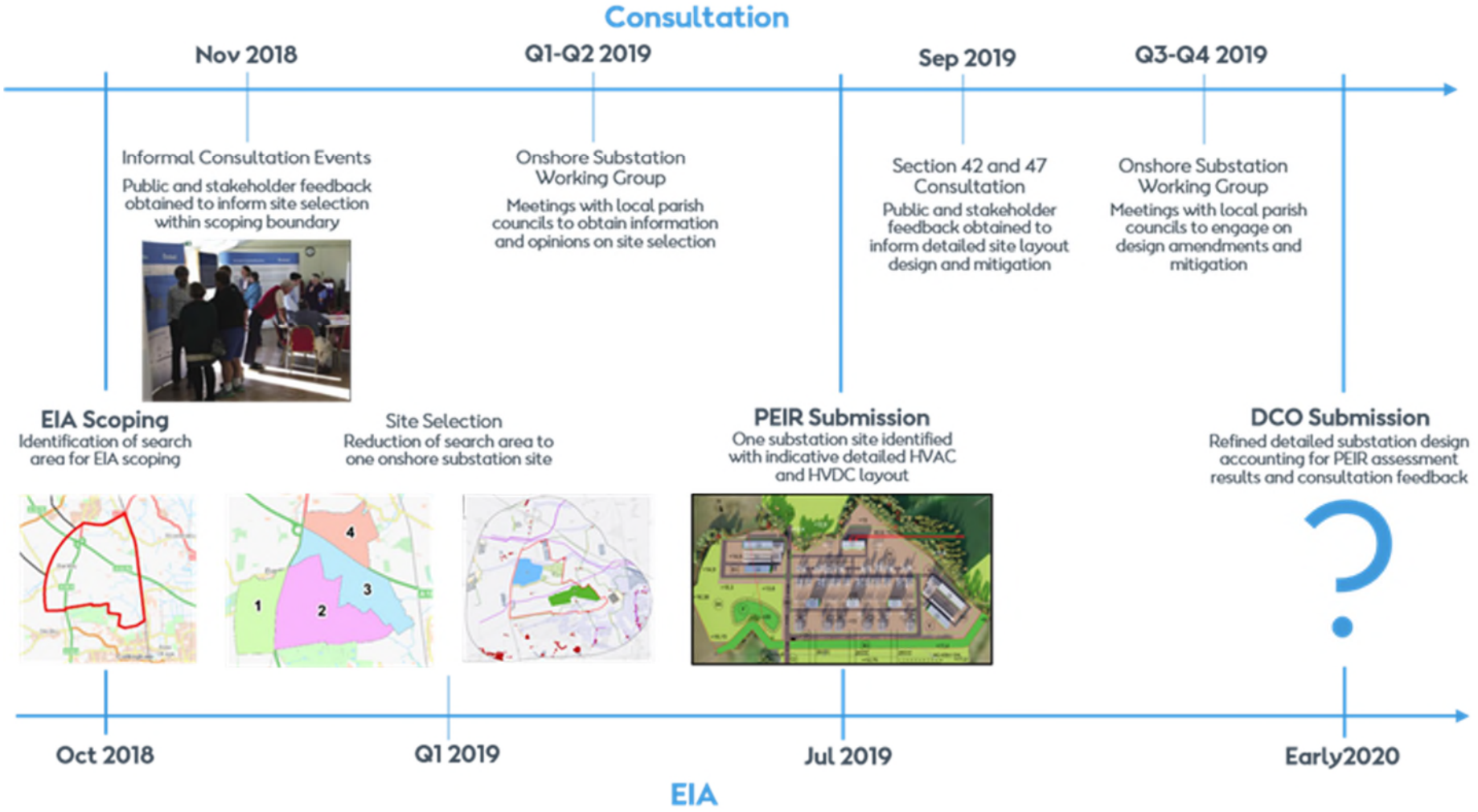

Figure 3.5: Site Selection Timeline – OnSS.

3.5.2 Identification of the Agreement for Lease (AfL) and Grid Connection

3.5.2.1 The former Hornsea Zone was one of nine offshore wind generation zones around the UK coast identified by The Crown Estate (TCE) during its third round of offshore wind licensing. In 2009 SMart Wind Ltd. were awarded the developmental rights to the former Hornsea Zone. Through the process of Zone Appraisal and Planning (ZAP), identified Hornsea Project One and Two.

3.5.2.2 Following acquisition by Ørsted (formerly DONG Energy) of the developmental rights of Hornsea Project One in February 2015 and, subsequently in August 2015, the acquisition of SMart Wind and the remainder of the former Hornsea Zone, together with the development rights for Hornsea Project Two, Hornsea Three and Hornsea Four in March 2016, the Hornsea Zone Development Agreement (ZDA) was terminated and the Hornsea Zone dissolved (and hence is referred to as the former Hornsea Zone). Following this, new project specific agreements, called Agreement for Leases (AfLs), were agreed with The Crown Estate (TCE) for Hornsea Project One, Hornsea Project Two, Hornsea Three and Hornsea Four (locations of the offshore turbines and supportng infrstructure) (see **Figure 3.6**). These new documents replaced existing AfLs relating to the former Hornsea Zone and were created in a new format by TCE.

3.5.2.3 Hornsea Four will be the fourth project to be developed in the former Hornsea Zone and will have similarities to the existing Hornsea projects both in terms of the nature of the project and general geographic location of the offshore array area.

3.5.2.4 The specific identification of the potential grid connection routes, including Landfall Zones for Hornsea Four, comprised a sequence of steps to identify the route between the start and end point for the connection. In this case the start point is the centre point of the Hornsea Four offshore array area with the endpoint being a connection made to a location established with National Grid Electricity Transmission (NGET) for connection to the UK electricity network, as shown in **Figure 3** of **Volume 4, Annex 3.2**.

3.5.2.5 NGET's decision making and thus its connection offer takes into account technical, commercial, regulatory, environmental, and socio-economic aspects. The grid connection offer process for Hornsea Four concluded that the preferred option representing the most optimal design (economic, efficient and co-ordinated) considering all criteria (i.e. technical, cost, environmental and deliverability) was the Creyke Beck substation, near Cottingham, East Riding of Yorkshire. Hornsea Four was formally offered a grid connection to Creyke Beck substation on 10 April 2017 with agreement signed on 10 December 2018.

3.5.3 Identification of an Electrical Infrastructure Study Area

3.5.3.1 The Hornsea Four Electrical Infrastructure Study Area (EISA), which spans both onshore and offshore areas, is defined by the AfL (location of the offshore turbines and suportng infrstructure) and grid connection point at Creyke Beck (location of the OnSS), as detailed in **Figure 3** of **Volume 4, Annex 3.2**.

3.5.3.2 The northern onshore extent of the EISA runs from Creyke Beck to just north of Barmston, with the southern extent running from Creyke Beck to just north of Holmpton to avoid the international environmental designations at Spurn Head and the Humber Estuary. These locations were determined by the shortest routes to shore from the northern and southern corners of the AfL area respectively. The EISA was not fixed allowing modification during the route planning and site selection process where necessary.

3.5.4 Identification of the Offshore Array and Infrastructure

3.5.4.1 During the period between acquisition of the AfL and the receipt of the Scoping Opinion (PINS, 2018) work was carried out to refine the Hornsea Four array area which ultimately resulted in the EISA discussed in **Section 3.5.3** and shown in **Figure 3.6**. Details of this process can be found in the Hornsea Four Scoping Report (Ørsted, 2018).

3.5.4.2 Following receipt of the Scoping Opinion, the project consulted with a range of interested parties on the potential for array area refinement. This process was iterative, taking account of refinements to the offshore ECC search area and the latest site-specific data to ensure that options were aligned and site appropriate. Consideration was given to several technical, commercial and environmental consenting constraints (**Section 3.5.4.3**) informed by data analysis and constraints mapping prior to presentation and consultation with key stakeholders, including Natural England, RSPB, MCA and Trinity House (detailed in **Table 3.2**).

3.5.4.3 The array area is technically constrained by variable seabed and subsurface geological conditions, presenting a challenge for turbine foundation installation (**Figure 3.8**). Furthermore, commercial considerations for array refinement included proximity and crossing options at oil and gas infrastructure assets and other commercial entities including shipping operators.

3.5.4.4 In the spirit of proportionate EIA, Hornsea Four gave due consideration to the size and location (within the AfL array area) of the final project to be taken forward to consent application. This consideration was captured internally as a "Developable Area Approach" (DAA), which includes the consideration of physical, biological and human constraints in refining the developable area, balancing consenting and commercial considerations with technical feasibility for construction.

3.5.4.5 Ornithology was identified as a principal environmental constraint due to the relative proximity of the Hornsea Four site to the Flamborough and Filey Coast Special Protection Area (SPA), hence required detailed consideration through the DAA. The review of constraints in relation to the offshore array is set out in detail in **Section 7.1** of **Volume 4, Annex 3.2**, with the final array footprint set out in **Figure 10** of **Volume 4, Annex 3.2**.

3.5.4.6 The outcome of the DAA was the adoption of a major site reduction from the Agreement for lease (AfL) presented at Scoping to the PEIR boundary (see **Figure 3.6**).

3.5.5 Identification of the Offshore ECC

3.5.5.1 Offshore ECC routeing is partially a minimisation exercise to identify the shortest possible route from the offshore AfL area to the selected landfall site, whilst avoiding key constraints dictated by: engineering limitations; physical, third-party, and environmental constraints; and existing seabed users.

3.5.5.2 Minimising interactions with physical constraints such as cables and pipelines played a key part in establishing indicative initial Offshore ECC options. As undertaken for Scoping, the identification of suitable options for the landfall, onshore Substation (OnSS), and onshore and offshore export cable corridors each followed a similar process, as summarised below.

3.5.5.3 A search area (ElSA) was defined for which constraints data were collected and teams within Hornsea Four (i.e. Environment and Consents, Land and Property, Commercial, Technical and Electrical Installation) developed selection criteria for a Black, Red, Amber and Green (BRAG) appraisal to be undertaken (**Section 3.2.1.8**).

3.5.5.4 Several options were developed that avoided key constraints within the search area based on Hornsea Four's requirements (e.g. land requirement, corridor width).

3.5.5.5 Black and red constraints are critical in determining features that should be avoided wherever possible to avoid consenting risk, reduce EIA complexity and reduce the cost of mitigation. Hornsea Four has subsequently made commitments based on the avoidance of features that were rated as black and red constraints (e.g. national and international environmental designations). These commitments are set out in the Commitments Register (**Volume 4, Annex 5.2**) and Hornsea Four will continue to identify where commitments can be made to avoid constraints based on the site selection work in order to reduce project risk and deliver a proportionate EIA.

3.5.5.6 Amber and green constraints are those that may be more readily minimised or managed by employing appropriate mitigation measures. Based on the BRAG appraisal the number of options were reduced. The remaining options will continue to be reduced as preferred options and alternatives are identified and refined for the ES.

3.5.5.7 Consideration of seabed bathymetry, physical environment as well as existing seabed infrastructure was applied as a general principle in the refinement of the offshore ECC, as detailed in **Section 2.3** of **Volume 4, Annex 3.2**.

3.5.5.8 **Figure 3.8** shows the offshore seabed constraints for Hornsea Four superimposed on the bathymetry of the area. **Table 3** in **Volume 4, Annex 3.2** also lists the physical and third-party constraints as well as any mitigation measures applied. **Table 4** in **Volume 4, Annex 3.2** details any environmental constraints and the appropriate mitigation measures applied.

3.5.5.9 Similar guiding principles are applied to the offshore ECC routeing as for the onshore. These are listed below:

- shortest route preference for cable routing to minimise impacts my minimising footprint for the offshore and onshore cable routes as well as minimising cost (hence ultimately reducing the cost of energy to the consumer) and transmission losses;
- avoidance of key sensitive features where possible and where not, seek to mitigate impacts;
- minimise the disruption to populated areas; and
- the need to accommodate the range of technology sought within the design envelope and exclude those options out with the envelope.

3.5.5.10 The initial stage of offshore ECC routeing (considering the guiding principles) resulted in the development of three straight line routes from the array area to the initial three landfall zones described in **Volume 4, Annex 3.1** and as shown in **Figure 5** in **Volume 4, Annex 3.2**.

Refinement of these initial route options, considering the considerations listed in **Section 4.1** and **4.4** of **Volume 4, Annex 3.2** resulted in the amended six route options shown in **Figure 6** in **Volume 4, Annex 3.2**.

3.5.5.11 **Figure 3.7** shows the development of what was simply a straight-line route into a more complex route which avoids those constraints identified during the refinement process (e.g. MCZ, exploration wells and known wrecks).

3.5.5.12 Further refinements to the landfall site options prompted corresponding adjustments in the offshore ECC, with the commitment to avoid the Holderness Coast Inshore (see Co44 in **Volume 4, Annex 5.2**) and Offshore (see Co45 in **Volume 4, Annex 5.2**) Marine Conservation Zone (MCZ) removing the southern landfall and cable route options from further consideration (

3.5.5.13 **Figure** 3.9). Discounting landfall and cable route options within the MCZ avoids any potential for significant adverse effects on any MCZ.

3.5.5.14 Additional modifications to promote best possible crossing angles of other linear infrastructure and to avoid wrecks (as further historic environment data became available) were also included at this point, resulting in the four route options shown in **Figure 7** in **Volume 4, Annex 3.2**.

3.5.5.15 The four-potential offshore ECCs were then assessed against a set of refinement criteria and the initial offshore ECC routes modified as described in **Section 4.2.14** of **Volume 4, Annex 3.2** and illustrated in **Figure 8** in **Volume 4, Annex 3.2**. Following this refinement assessment, one route (Route 3) was identified as the preferred offshore ECC option as it presented the optimal balance of environmental and technical constraints in comparison to the other initially identified route options. This option was then subjected to a BRAG assessment, as set out in **Section 4.2.20** of **Volume 4, Annex 3.2** and detailed in **Table 8** of **Volume 4, Annex 3.2**.

3.5.5.16 The preferred offshore ECC option then formed the scoping search area which is shown in **Figure 3.6**. The final offshore ECC route taken forwards at PEIR is shown in **Figure 10** in **Volume 4, Annex 3.2**.

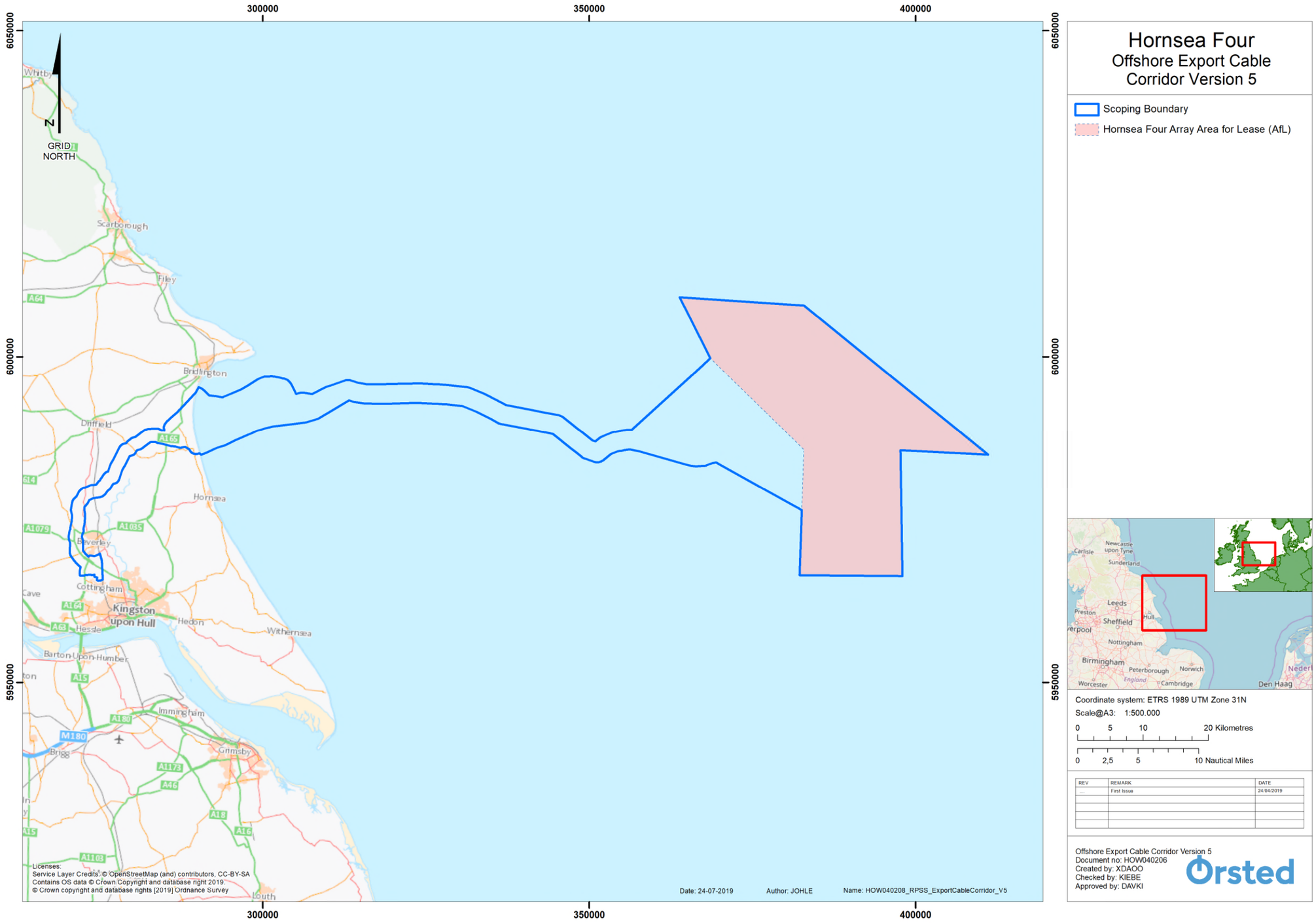

Figure 3.6: Hornsea Four Offshore Export Cable Corridor Version 5 (Not to Scale).

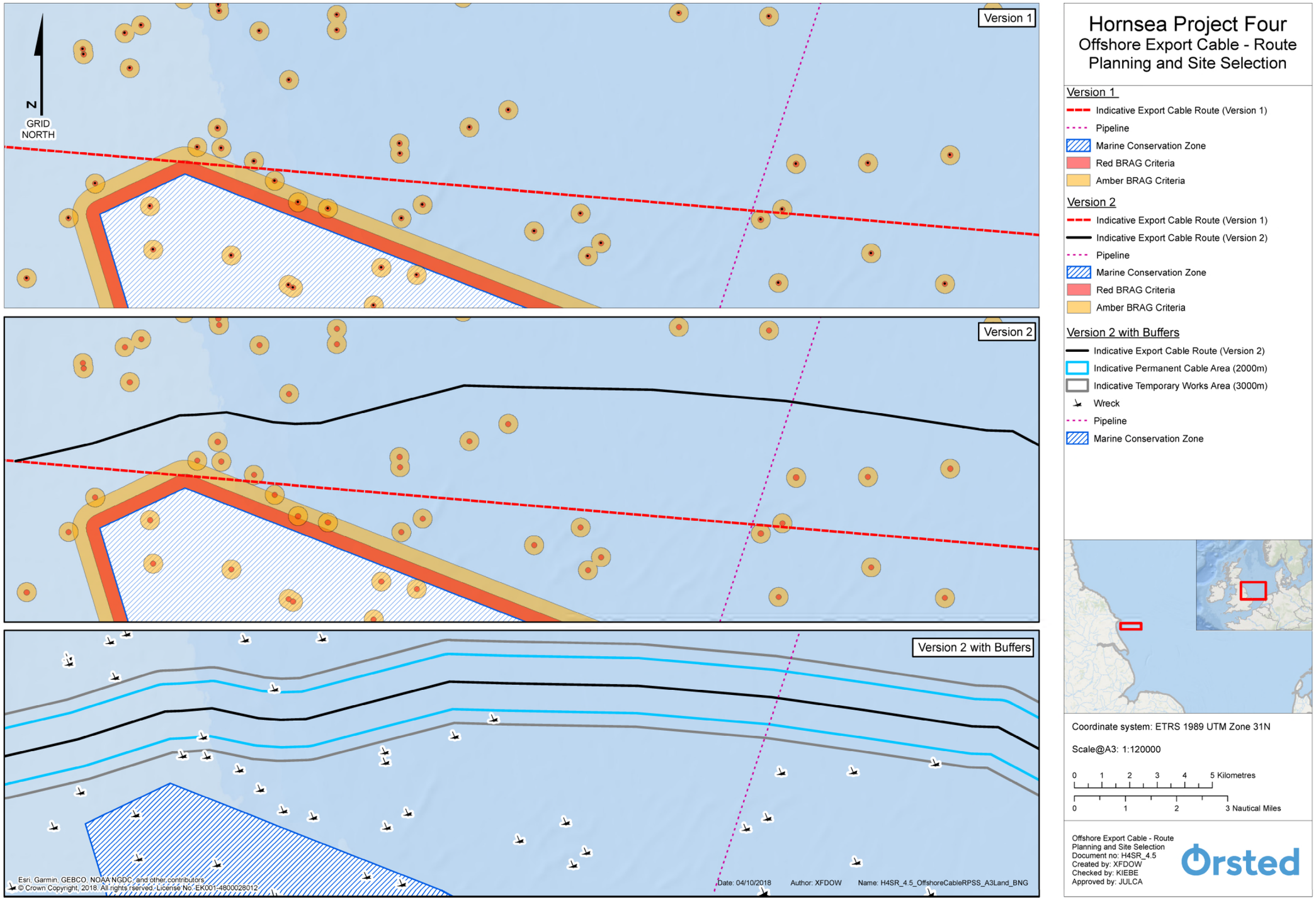

Figure 3.7: Offshore Export Cable – Route Planning and Site Selection (Not to Scale).

3.5.6 High Voltage Alternating Current (HVAC) booster station

3.5.6.1 Concurrent to the development of the offshore ECC, selection of a preferred HVAC booster station search area was also carried out, as detailed in **Section 5.3** of **Volume 4, Annex 3.2**. Hornsea Four requires up to six HVAC booster stations within this search area, with a minimum separation of 100 m.

3.5.6.2 The optimum position for a HVAC booster station along the ECC is midway (+/- 10%) between the offshore substation and OnSS, based on an assessment of energy loss (too close and the benefit of the boost could be lost and too distant, the signal is already too weak) and within the range of 50% to 60% of the total export distance, combining both on and offshore export cable lengths.

3.5.6.3 A reduced 24 km^2 area was identified to the east of the HVAC booster station search area identified at Scoping. This avoided the most challenging seabed conditions, and highest density known shipping routes. This area was deemed to provide enough scope to maintain flexibility in project design while addressing the key technical and consenting issues.

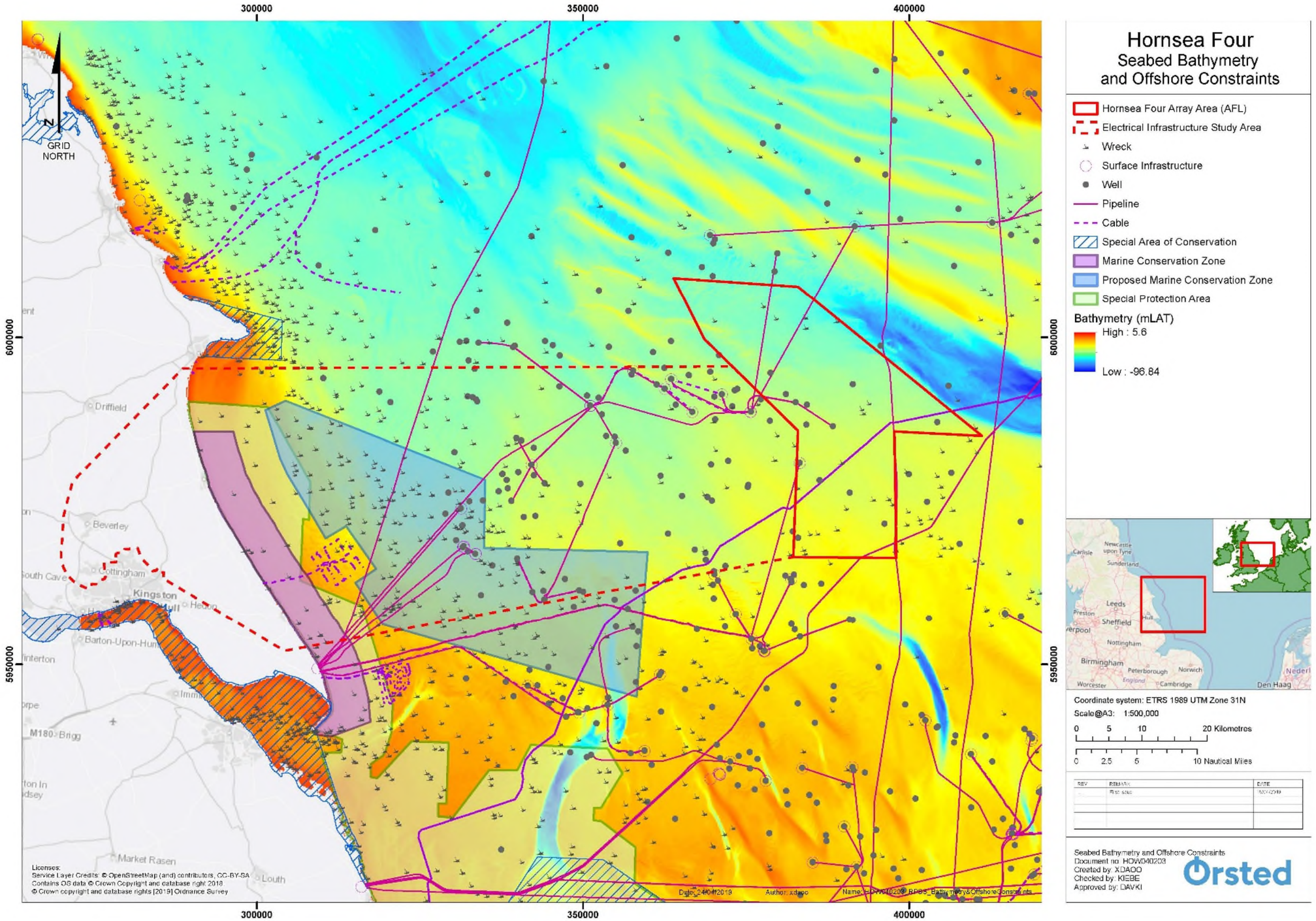

Figure 3.8: Hornsea Four Offshore Seabed Constraints (Not to Scale).

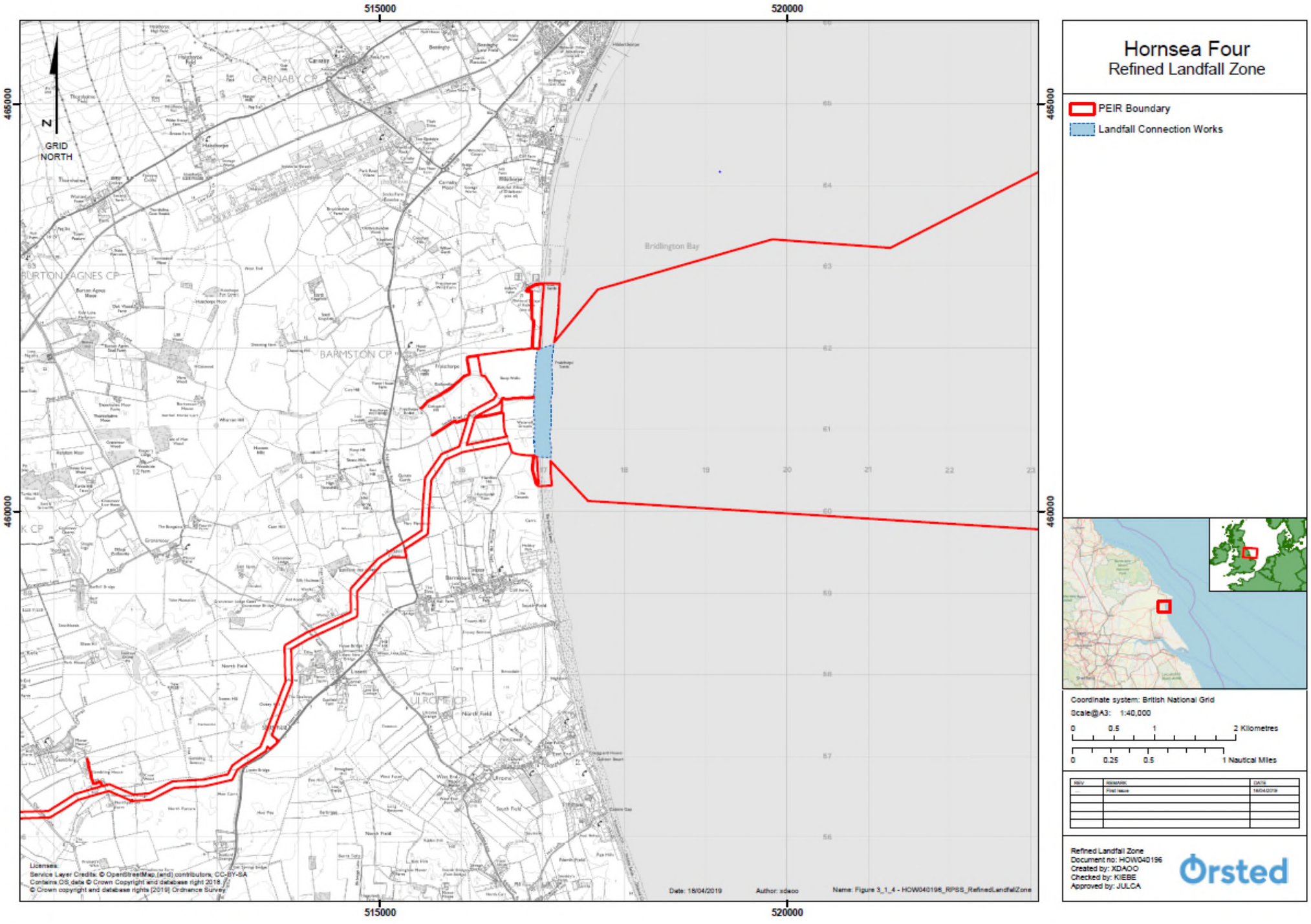

Figure 3.9: Hornsea Project Four – Landfall Zone Refinement (Not to Scale).

3.5.7 Identification of Landfall

3.5.7.1 The cable landfall point is the location at which the offshore ECC meets the coastline. The landfall covers the near-shore shallow approaches, the intertidal area and the onshore route near the transition jointing bay (in which the jointing of the onshore and offshore export cables takes place). The optimum landfall construction compound (40,000m^3 within either Option A3 or A4) will also be provided in this area.

3.5.7.2 In addition to following the guiding principles set out in **Section 2** of **Volume 4, Annex 3.1**, an appraisal to identify key technical, consenting and commercial risks was undertaken. The process utilised a colour coding approach (Black, Red, Amber and Green (BRAG)) to identify risk/constraints and further refine the landfall options (as defined in **Section 5.1** of **Volume 4, Annex 3.1**). The process of defining the most suitable landfall point went through three such iterations resulting with the current preferred options of sites A3 and A4. The rationales for discounting certain sites are summarised in **Table 3.3** and they key constraints associated are represented visually in **Figure 3.10.**

3.5.7.3 Sites A3 and A4 were considered the most favourable from all perspectives (technical, commercial, environmental and consents as set out in **Table 3.3**) and whilst some constraints remain, notably those relating to access through the village of Fraisthorpe and potential historic artefacts, these are considered a lower-risk of resulting in significant impacts when subject to appropriate mitigation.

Table 3.3: Post-Scoping Discounting Landfall Rationale.

Discounted Landfall Options	Rationale
A1, A2	Within/neighbouring Fraisthorpe Beach: • UK Seaside Award; • Popular destination with tourists and locals; • Busy café (The Cowshed Tearoom) and car park; and • "Active Coast" scheme promoting beach walking for health. Sites contain many World War II Artefacts: • Anti-tank concrete cubes/anti-invasion defences are still positioned in the sand; and • Promoted as a tourist attraction and point of cultural heritage. Onshore windfarm located directly behind the landfall Constraint for onshore cable route
A5, B1	Dogger Bank Creyke Beck offshore cable corridor borders both sites: • Considered unfeasible to cross cable in such shallow water. Caravan Park neighbours both sites: Sensitive stakeholders: tourists, residents, Barmston Beach (Rural Beach Seaside Award)
B2	• Nearby caravan parks and residential properties; • Access required through the village of Skipsea; • Located within the Greater Wash SPA;

Discounted Landfall Options	Rationale
	• Primary school present just inland of compound site; • Very high cliffs; potentially unstable due to high predicted erosion rate; and • Does not adjoin remaining landfalls; thus increasing project scope to progress geographically distinct sites. Landfall compound sited within church land; not possible to CPO therefore represents a showstopper risk to project timeline if an agreement cannot be reached.

3.5.7.4 It was therefore concluded that sites A3 and A4 would be taken forward for assessment in the PEIR. These landfalls are considered as a continuous zone (as shown in **Figure 3.9**), with the optimum landfall construction compound, onshore ECC and the exact location at which the offshore ECC will make landfall to be identified within this zone.

3.5.7.5 Refinement of the landfall at this stage in the overall process of site selection allows for detailed onshore and nearshore geophysical and geotechnical surveys to be undertaken at a relatively early stage to help identify local ground and sediment conditions – vital aspects of the buildability of the landfall and connecting of the cables. This, in combination with consultation responses, will inform the final landfall selection which will be set out in the final Environmental Statement (ES) and DCO submission.

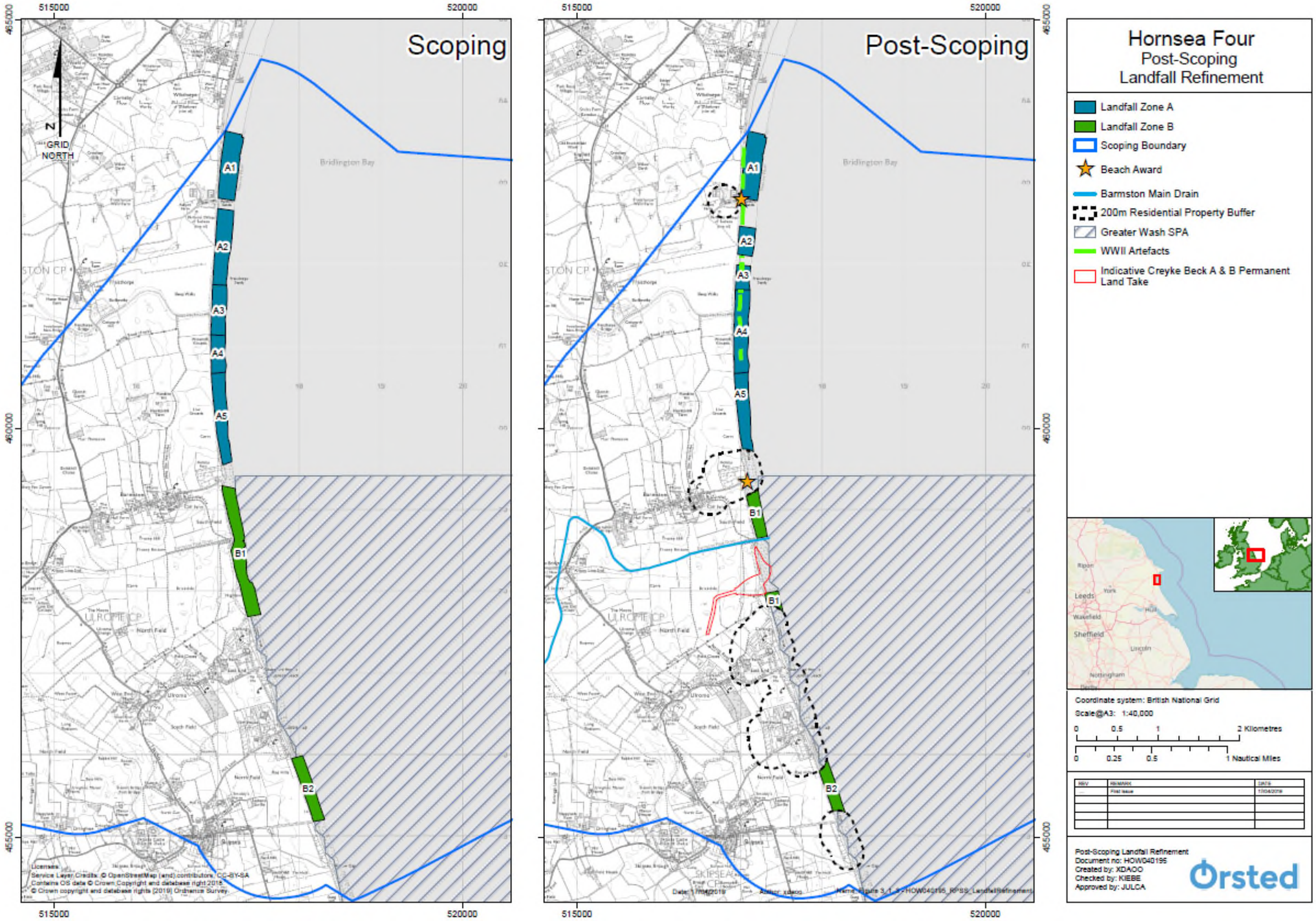

Figure 3.10: Post-Scoping Landfall Refinement (Not to Scale).

3.5.8 Identification of the Onshore Export Cable Corridor (ECC)

3.5.8.1 The onshore export cable corridor (ECC) will contain the electrical cables: connecting to the offshore ECC at the landfall (seaward end); and terminating at the OnSS (landward end). The initial onshore ECC route options were therefore driven by the initial prospective landfall zones and wider OnSS search area.

3.5.8.2 However, due to ongoing refinement of both the landfall zones (**Figure 3.10**) and the OnSS search area (**Figure 3.14**), and an initial overview of potential routing options, two potential initial onshore ECC routes (Option A and Option B) were identified (**Figure 3.11**) each comprising two sub-options (A1, A2, B1 and B2) and routed around the east and west of Beverley using Ordnance Survey Open Data base mapping and the constraints data available at the time (**Figure 3.11**).

3.5.8.3 The centre line of both onshore ECC routes was drawn using the following guiding principles, which utilised avoidance as the primary mitigation measure to avoid or reduce the potential for significant adverse effects of the ECC as far as practicable (illustrated in **Figure 3.13**). For example, Co.2 details onshore sensitive sites that are to be avoided and therefore form part of the Black (potential showstopper to development) part of the BRAG assessment and must be avoided (a full list of commitments can be found in **Volume 4, Annex 5.2**):

- Avoidance of known and/or designated archaeology sites;
- Avoidance of designated parks and gardens;
- Where possible, avoidance of statutory and non-statutory conservation designations;
- Routed through open agricultural land where possible in order to avoid towns, villages, residential areas and buildings;
- Use the shortest possible connection between the start and end points where no other constraints were apparent; and
- Where crossing major existing infrastructure (i.e. roads and National Grid infrastructure) was necessary and unavoidable, the centreline of the onshore ECC would cross perpendicular to the existing infrastructure, as the optimal approach angle for HDD crossings (or other form of trenchless crossing).

3.5.8.4 Using these routeing principles, the centreline of both onshore export cable corridor options was diverted around the various constraints (as shown in **Figure 12** of **Volume 4, Annex 3.3**). **Table 8** in **Volume 4, Annex 3.3** lists onshore ECC diversions and their rationale.

3.5.8.5 Once the two onshore ECC options had been established, a single preferred option needed to be identified and developed further. A BRAG assessment was carried out on the two route options, including constraints identified from third parties (as detailed in **Section 3.3** of **Volume 4, Annex 3.3)** and this was then fed in to a strategic appraisal covering the entire 2 km buffer around each onshore ECC option (**Table 10** in **Volume 4, Annex 3.3**).

3.5.8.6 As the initial portion of the onshore ECC (Option A1 or B1 at the seaward end) will depend on the final landfall location (yet to be determined), the main focus for site selection has been

on the latter portion of the route from the merge point of A1, B1, A2 & B2 to the OnSS (**Figure 3.11**). The comparative appraisal for onshore ECC sections A2 and B2 identified that the western route (A2) was the preferred route option due to the greater number of constraints encountered by the route east of Beverley (B2), which impacts a greater number of residential receptors than A2 as well as being unable to gain access to the OnSS site from the east.

3.5.8.7 A major pinch point for the ECC was identified around Woodmansey Road (A1174) on the approach to the OnSS. The Indicative Dogger Bank Creyke Beck cable corridor was already placed in the only possible gap between residential properties (bringing the onshore ECC within 50 m of residential receptors), not allowing any space for an additional ECC, thus removing onshore ECC B2 as a viable option.

3.5.8.8 Once a single onshore ECC option had been selected (A2), a flyover survey was undertaken to obtain high resolution imagery. The imagery was used to identify possible constraints in greater detail, resulting in the further refinement of the onshore ECC route. **Table 13** in **Volume 4, Annex 3.3** lists the diversion points for the higher resolution refinement version of the onshore ECC and the reason for that diversion.

3.5.8.9 Once this process was completed, three buffers (see below) were applied to the selected onshore ECC (route A1). The buffered areas allow for the micro-siting of the ECC (which is designed to be 80 m wide) to be developed and are as follows (and shown in **Figure 16** in **Volume 4, Annex 3.3**):

- 200 m buffer – for the Indicative Permanent Cable Area;
- 700 m buffer – for the Indicative Temporary Construction Works Area; and
- 2000 m buffer – for the Scoping Boundary. The area within which the Indicative Permanent and Temporary Cable Areas may be deviated.

3.5.8.10 After this stage of refinement, the process of identifying and incorporating potential access locations and logistics compounds was undertaken. This refinement was based on reviewing any newly received third-party data (in addition to that acquired for scoping) and by updating the BRAG assessment criteria with this additional data. The refinement of the 80 m onshore ECC was carried out with the aim of keeping the majority of the 80 m onshore ECC within the 200 m Indicative Permanent Cable Area and 700 m Indicative Temporary Works Area. The area outside of the 700 m Indicative Temporary Works Area would only be used if routeing within it was not possible due to exceptional circumstances.

3.5.8.11 Using the 200 m Indicative Permanent Cable Area and the 700 m Indicative Temporary Works Areas as the starting point, the 'Refined Indicative 80 m Export Cable Corridor (Version 1)' (referred to as the 'refined 80m onshore ECC v1' here) was developed. The two main stages of this are described in detail in **Section 4.2** of **Volume 4, Annex 3.3**.

3.5.8.12 Letters and plans showing the Refined Indicative 80 m onshore ECC (Version 1), indicative logistics compounds and accesses were sent to landowners and tenants in November 2018. Meetings were subsequently conducted with landowners and tenants as a part of the

informal consultation in order to receive feedback and comments. These were then fed into the refinement process and actioned as a change request. These are detailed in **Section 5** of **Volume 4, Annex 3.3**.

3.5.8.13 An example of how the indicative 80 m ECC was routed is shown in **Figure 3.13**.

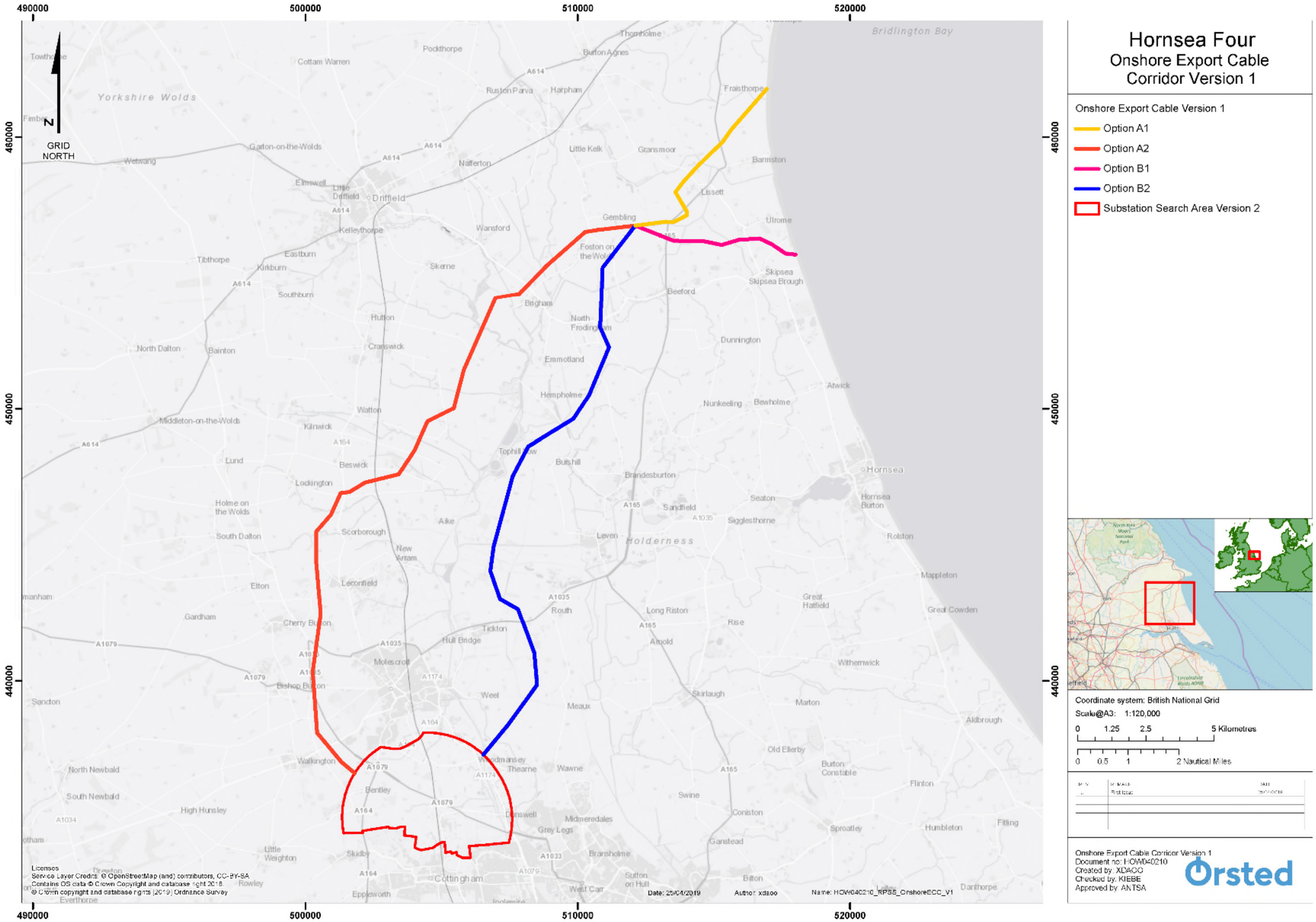

Figure 3.11: Onshore Export Cable Corridor Version 1 – Developing route options (Not to Scale).

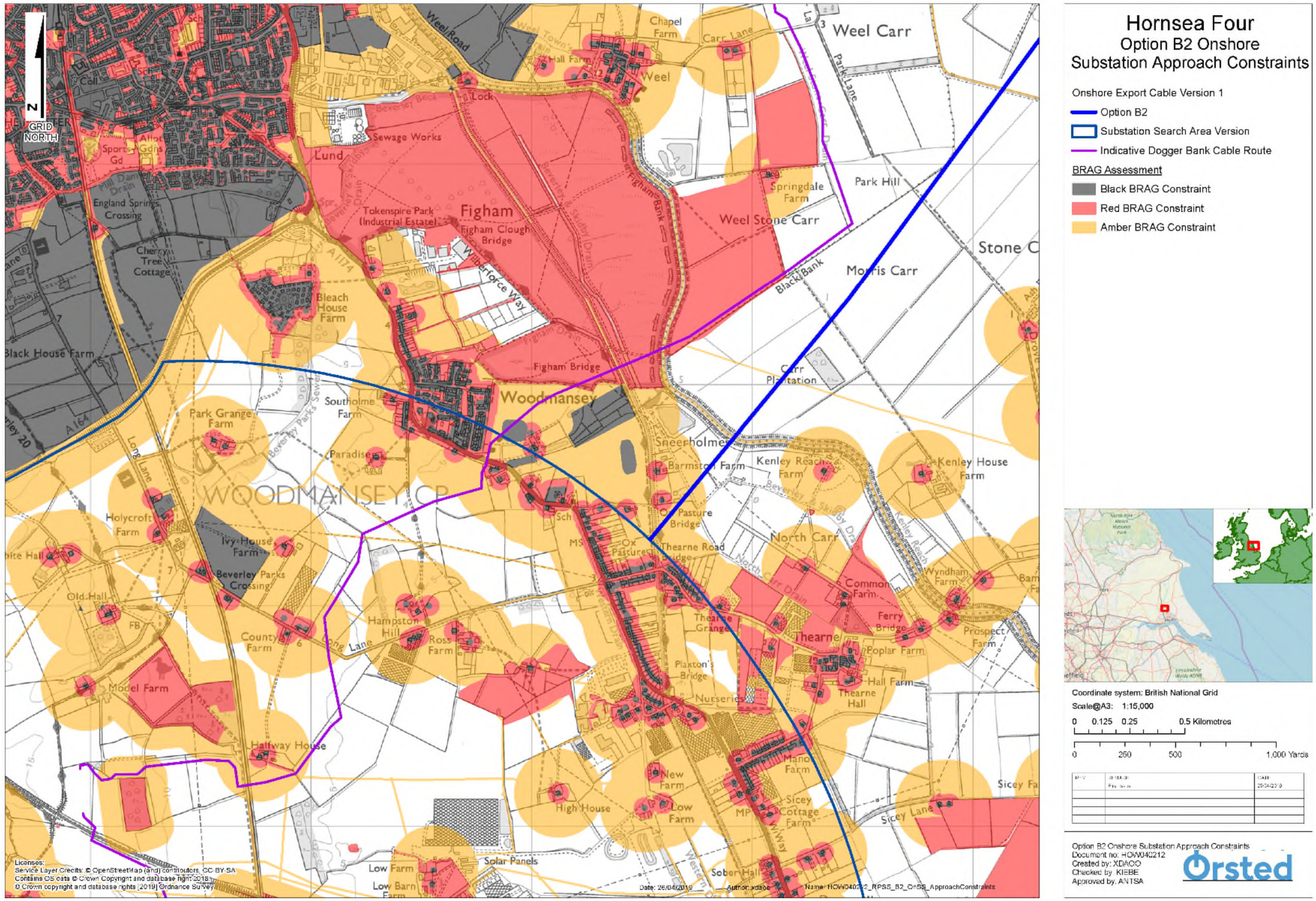

Figure 3.12: Onshore Export Cable Corridor (B2) Constraints (Not to Scale).

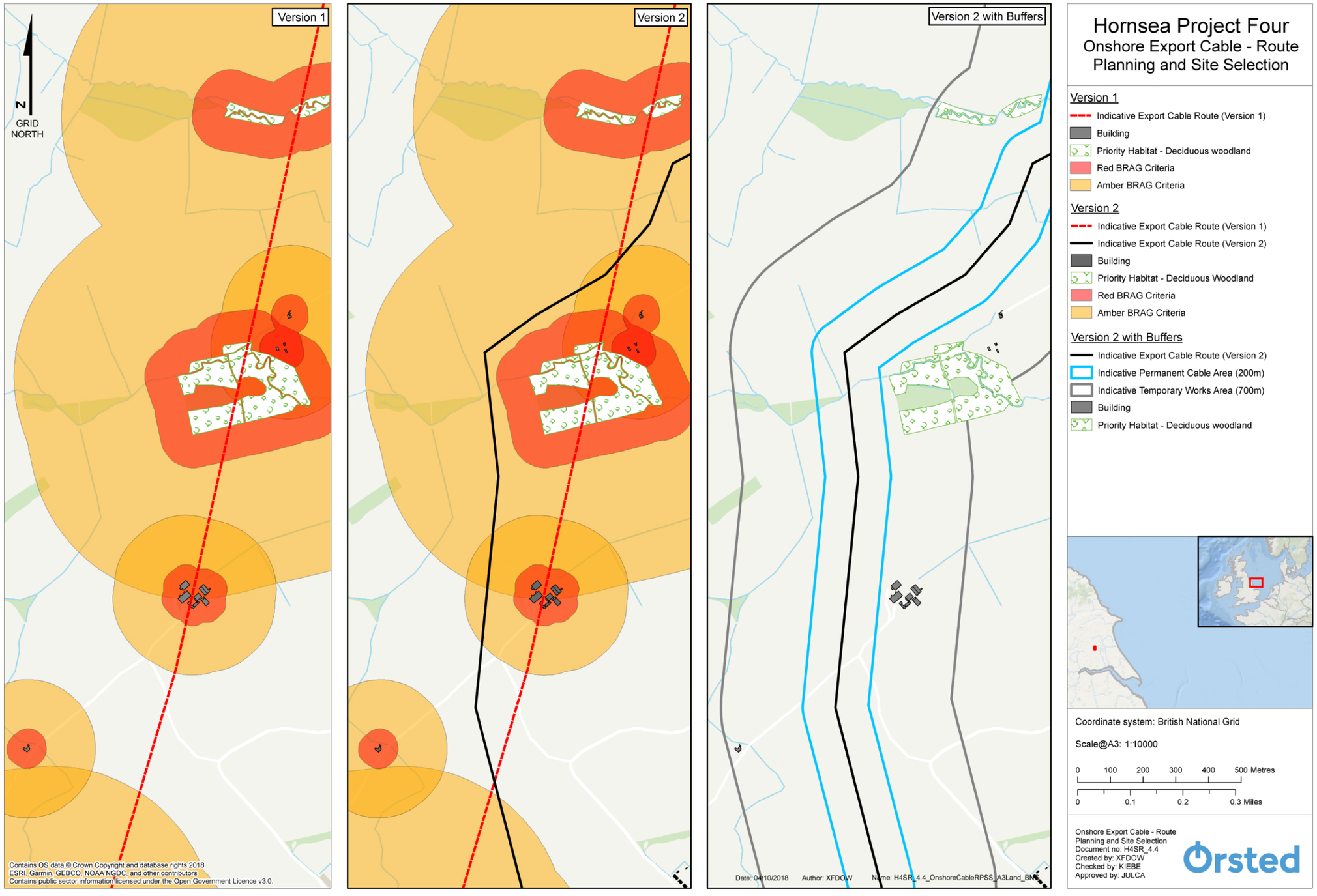

Figure 3.13: Onshore Export Cable Route Planning and Site Selection (Not to Scale).

3.6 Export Cable Corridor Approach to the Onshore Substation

3.6.1.1 Once a final OnSS site had been chosen (**Annex 3.3, Section 2.3.5**) the onshore ECC route to the site was needed to connect the cable section, which stopped at the start of the refined OnSS search area version 5 (**Figure 8** in **Annex 3.3**) at Beverley Road (A164), across Beverley Road and to the OnSS site.

3.6.1.2 Due to the high number of constraints in this area, a more refined BRAG criteria was established as shown in **Table 17** in **Annex 3.3**. Developing the refined BRAG criteria was an iterative process with additional constraints and criteria refined. For example, through the routeing process it became apparent that any interaction with the OnSS works would constrain construction, due to the different construction timelines involved for both onshore elements.

3.6.1.3 The ECC route options were then ranked using the BRAG criteria. Where an onshore ECC route fulfilled any criteria, it was given a ranking for each constraint (**Table 16** in **Volume 4, Annex 3.3**). The total number of points for each onshore ECC route option were then tallied as part of the comparative appraisal (**Table 18** and **Table 19** in **Volume 4, Annex 3.3**), with the chosen option incorporated in the ECC for the PEIR.

3.7 Onshore Substation

3.7.1.1 The OnSS site will contain the electrical components for transformer substation and electrical balancing infrastructure (EBI). The OnSS adjusts the power supplied from the offshore wind farm to 400 kV, as required to meet the UK Grid Code for supply to the National Grid.

3.7.1.2 The first stage in the OnSS site selection process was to establish an initial 3 km search boundary around the Creyke Beck substation. This radius was set to minimise the length of the connection linking the new OnSS and the National Grid connection point. Minimising this distance is necessary to reduce cable reactive power issues, mitigate transmission losses, and minimise adverse effects on economic efficiency.

3.7.1.3 The initial 3 km search area was then further refined by removing heavily constrained areas such as highly populated areas and two areas of high amenity value (i.e. golf courses). This was done to avoid unnecessary adverse effects on relatively high-density residential receptors and users of the local golf course. **Figure 4** of **Volume 4, Annex 3.3** illustrates the reduction in the overall OnSS search area.

3.7.1.4 Following this, a heat mapping exercise (as detailed in **Section 2.2.2** and illustrated in **Figure 4** of **Volume 4, Annex 3.3**) was carried out to identify areas that could be excluded from consideration and/or indicate the least environmentally constrained locations within the search area.

3.7.1.5 The ECC options to the East and West of Beverley were then developed (**Figure 3.11**). These were considered and when it was determined that the eastern route to the OnSS search area

was not useable due to the unfeasibility of crossing the railway line, the portion of the OnSS search area to the east of the railway line was then dropped from further consideration.

3.7.1.6 Once the Hornsea Four scoping boundary was finalised, a series of informal public and community consultation events were held by Ørsted in October 2018, allowing residents and landowners to comment on the proposed boundary. Their responses allowed for greater refinement of the location of the OnSS post-scoping. Full details of such consultation can be found in **Chapter 6: Consultation.**

3.7.1.7 Post-scoping, the next stage in the process was to split the refined boundary area into Search Zones. These were created by firstly excluding areas within the boundary that did not contain land parcels of a suitable size to accommodate the OnSS (as detailed in **Section 2.2.2.6** of **Volume 4, Annex 3.3**). The remaining area was then divided into four zones using established field boundaries and existing highway infrastructure as shown in **Figure 5** in **Volume 4, Annex 3.3**.

3.7.1.8 The four zones were then assessed for suitability through an initial Red, Amber, Green (RAG) appraisal as detailed in **Section 2.2.2.8** and **Table 4** of **Volume 4, Annex 3.3**. Alongside the RAG appraisal, Ørsted also explored OnSS access options. Such appraisal took account of feedback from the informal local information events, notably expressions of concern associated with the potential for construction traffic to be routed through Cottingham and turning off the A164. Noting such concerns, a local transport consultancy, Local Transport Projects Ltd (LTP), was appointed to analyse five potential access and egress points to inform the process further.

3.7.1.9 LTP's appraisal was aimed at establishing whether suitable access and egress points existed within the surrounding highway network, and the assessment identified that access from the A1079 via the existing northbound layby (Option 4) provided the most suitable point of entry/exit from those options considered for providing construction access to both Zones 2 and 3.

3.7.1.10 The OnSS search area refinement methodology and access appraisal were then presented and discussed at a meeting with East Riding of Yorkshire Council's (ERYC) Planning and Highways officers on 21 November 2018. During the meeting, it was agreed in principal (and based on available information) that of the four zones, Zone 2 was the preferred area to locate the OnSS. It was also agreed that Access Option 4 offered the best overall solution for construction access to Zone 2, through the utilisation of the existing northbound layby on the A1079.

3.7.1.11 Further to the 2018 meeting, an OnSS working group was held on 12 March 2019 with parish council representatives from Rowley, Skidby, Walkington, Cottingham and Woodmansey. The principles of the construction access and identification of Zones 2 and 3 were presented and discussed. Feedback from the working group (as documented in the meeting minutes held by Ørsted) indicated that Access Option 4 was the preferred option and that the OnSS site should be located as close to the NGET substation at Creyke Beck as possible. A second working group was held on 21 May 2019, which confirmed the approach taken was

appropriate, with attendees agreeing that Zone 2, as close to Creyke Beck NGET substation was the optimal solution.

3.7.1.12 Once Zone 2 had been identified as the most suitable area for the OnSS, and a feasible access point established, a detailed site selection exercise within the zone was able to take place. This was conducted in line with the OnSS design principles listed in **Table 5** in **Volume 4, Annex 3.3**. This enabled two potential sites (Option's A & B) to be identified within Zone 2, as shown in **Figure 3.15**. These sites provided the best fit for the proposed footprint of the OnSS given the surrounding constraints within the search area of Zone 2 (**Figure 3.15** and panel 1 of **Figure 3.14**).

3.7.1.13 The two potential options were then subjected to a BRAG assessment (detailed in **Section 2.3.4** of **Volume 4, Annex 3.3**) to determine the preferred site. From this assessment, Option B has been identified as the most preferable site for the OnSS.

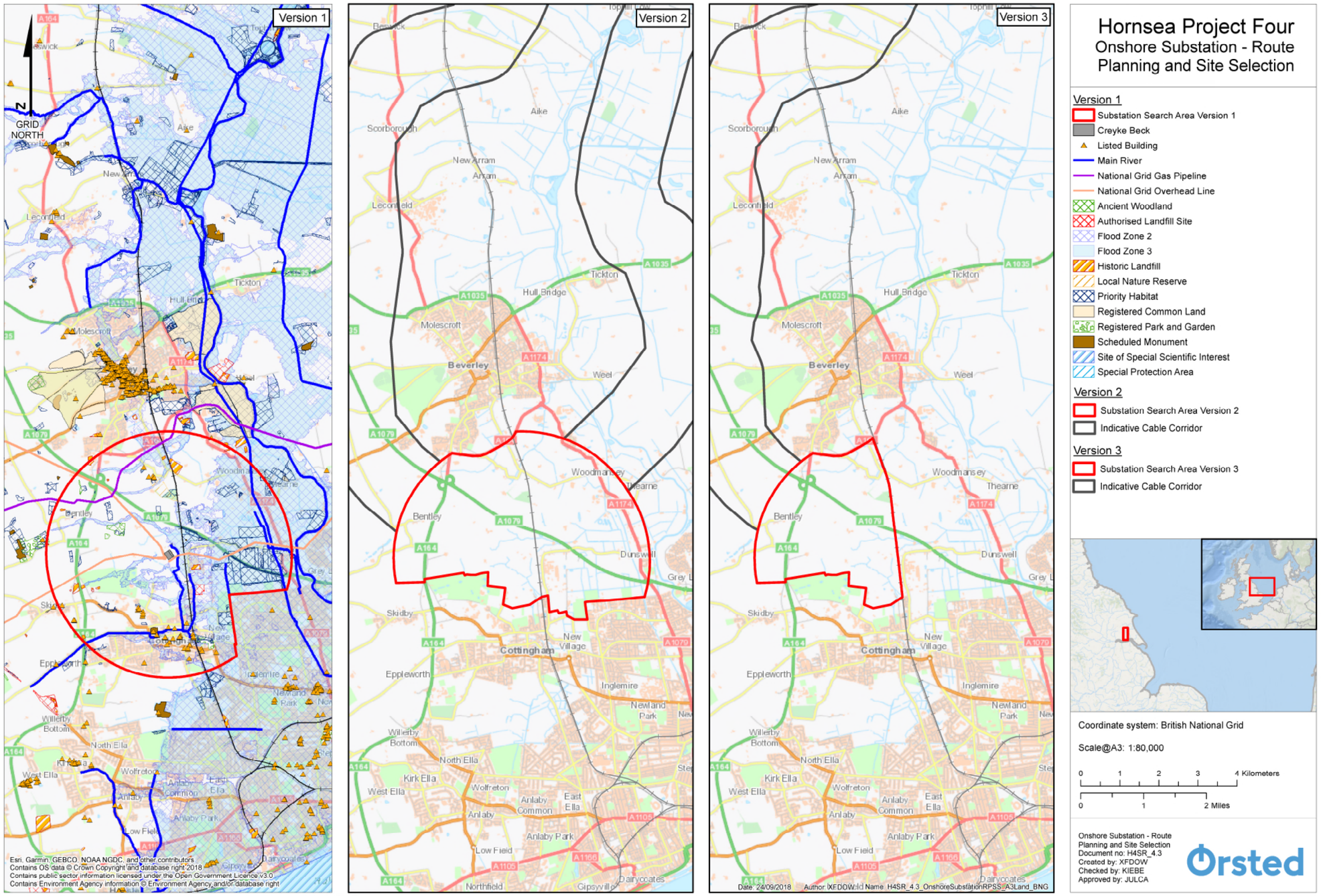

Figure 3.14: Overview of OnSS site selection (taken from Scoping) (Not to Scale).

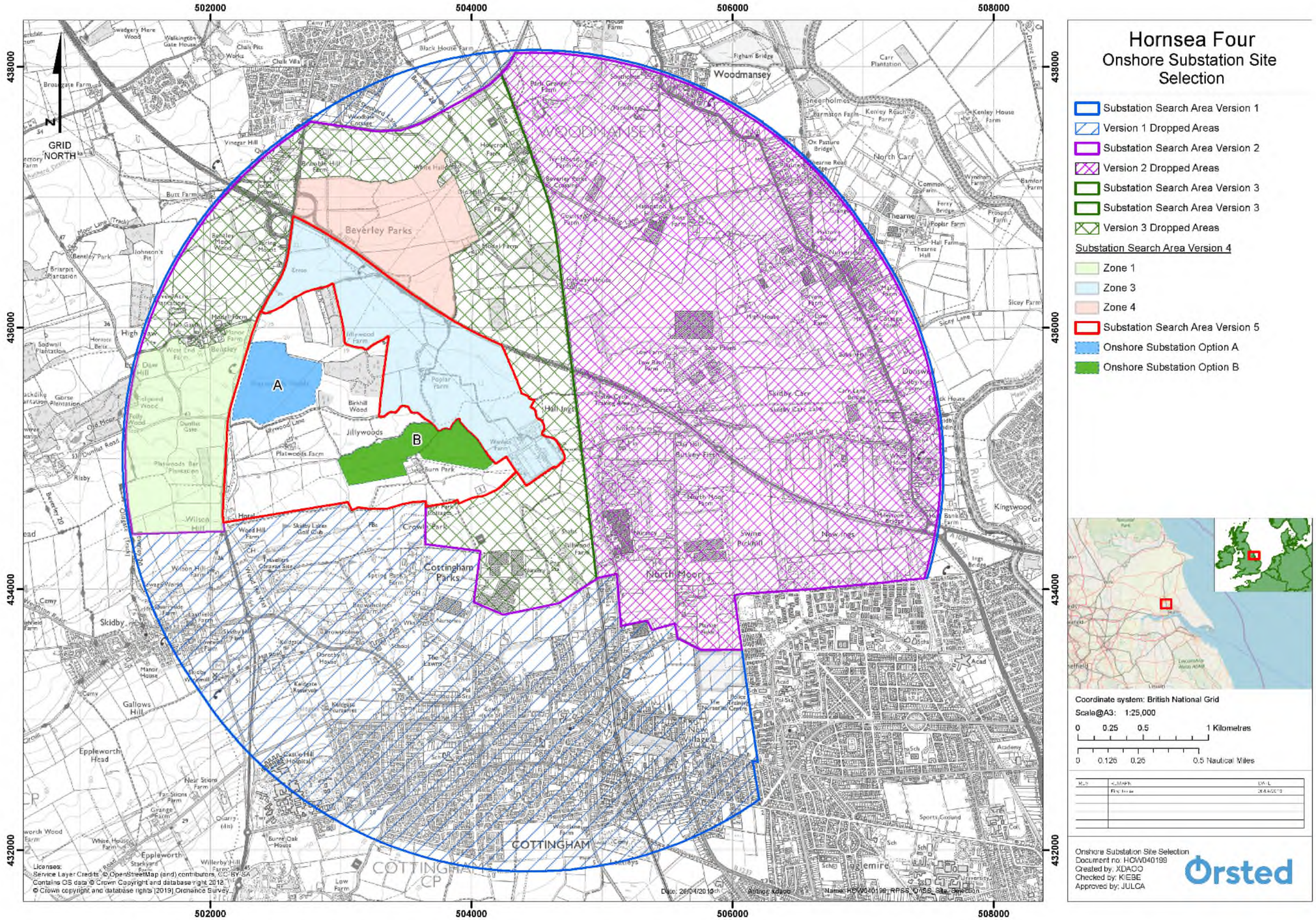

Figure 3.15: Overview of OnSS site selection (Not to Scale).

3.8 National Grid Creyke Beck Substation Connection

3.8.1.1 To distribute the power produced by Hornsea Four to UK homes, the project will need to connect in to the National Grid at the National Grid Creyke Beck Substation (**Volume 4, Annex 3.1**). National Grid plc is not required to work to the same timescales as Hornsea Four and so an exact grid connection point has not been formally offered and agreed with the project. As a result, the fields directly adjacent to the Creyke Beck Substation (denoted by the '400kV export cable corridor' area in **Figure 26** in **Volume 4, Annex 3.3**) have been included within the Hornsea Four boundary. Discussions with National Grid plc, as the operator and owner of the transmission system, are ongoing. Hornsea Four will seek to refine the project boundary in this area when a connection point or multiple connection points have been agreed with them.

3.9 Conclusion and Summary

3.9.1.1 A staged approach has been undertaken in relation to the site selection and routeing of the Hornsea Four infrastructure as illustrated in **Figure 3.1** to **Figure 3.5**. Several guiding principles have directed the work along with inputs from consultations (including local communities), data collection through survey and wider engineering considerations. Also incorporated in to the work are a number of commitments that Ørsted will apply to the project to eliminate or reduce adverse environmental effects, notably those implemented to avoid sensitive receptors both on and offshore. For example, Co. 44 dictates that "The Holderness Inshore Marine Conservation Zone (MCZ) will not be crossed by the offshore export cable corridor including the associated temporary works area. A full list of commitments can be found in **Volume 4, Annex 5.2: Commitments Register**. The process is fully documented in the accompanying Annexes which also provide relevant mapping.

3.9.1.2 Significant use of guiding principles and comparative assessments (notably BRAG **Volume 4,** assessments) has been made to continually refine, hone and ultimately select the best (i.e. least environmentally harmful and constrained) locations and routes for the required Hornsea Four infrastructure, providing a proportionate, comprehensive and iterative approach to alternative options assessment including a comparison of the environmental effects. Such assessments are integrated in to wider project decisions that also take in to account buildability (i.e. engineering constraints/opportunities), and financial considerations with appropriate and considerable emphasis placed on sustainable routing and location of infrastructure.

3.9.1.3 It should be noted that project development within the current defined Hornsea Four boundary and refinement of siting options will continue post-PIER submission, to DCO application (and beyond if micro-siting is required within DCO and Deemed Marine Licence constraints) as set out in

3.9.1.4 **Table** 3.4. This will take into consideration the acquisition of additional data, obtained through further site-specific surveys, desk based reviews and further consultation.

Table 3.4: Hornsea Four Site Selection Programme.

Stage	Description
EIA Scoping October 2018	• 2,000 m onshore ECC scoping boundary and indicative 200 m permanent ECC and 700 m temporary works area. • Onshore Substation (OnSS) search area. • Landfall search area. • 3,000 m offshore ECC scoping boundary.
Scoping – PEIR consultation	• Feedback and comments from informal public consultation events, landowner liaison and stakeholders on the scoping report and scoping boundary.
PEIR July 2019	• 80m onshore ECC inclusive of permanent and temporary works areas with indicative construction access points. • OnSS site. • Two landfall options. • 1,500 offshore permanent ECC with 500m temporary works areas buffer either side of ECC).
Section 42 and 47 consultation	• Feedback from stakeholders and members of the public upon receipt of more detailed environmental assessment work will further inform the RPSS process.
DCO Application Q2 2020	• Onshore ECC (80m) which will contain all permanent (electrical cables and Transition Joint Bays (TJBs)) and temporary works for construction works and soil storage. The details of which will be developed during detailed design. • Compounds: logistics, Horizontal Directional Drilling (HDD) and/or storage compounds outside of the permanent cable corridor for auxiliary works. • Access: Area required for access (temporary or permanent) to the construction and/or operation and maintenance activities. • OnSS: preferred site within the onshore substation search area. • Landfall: preferred site within the landfall search area. • Offshore ECC (1,500 m): the area within which the export cable route and temporary works area (500m buffer either side of ECC) are planned to be located.

3.10 References

Ørsted (2018). Hornsea Four Environmental Impact Assessment: Scoping Report (EN010098-000021-EN010098)

PINS (2018) Scoping Opinion: Proposed Hornsea Four Wind Farm (Case Reference: EN010098)