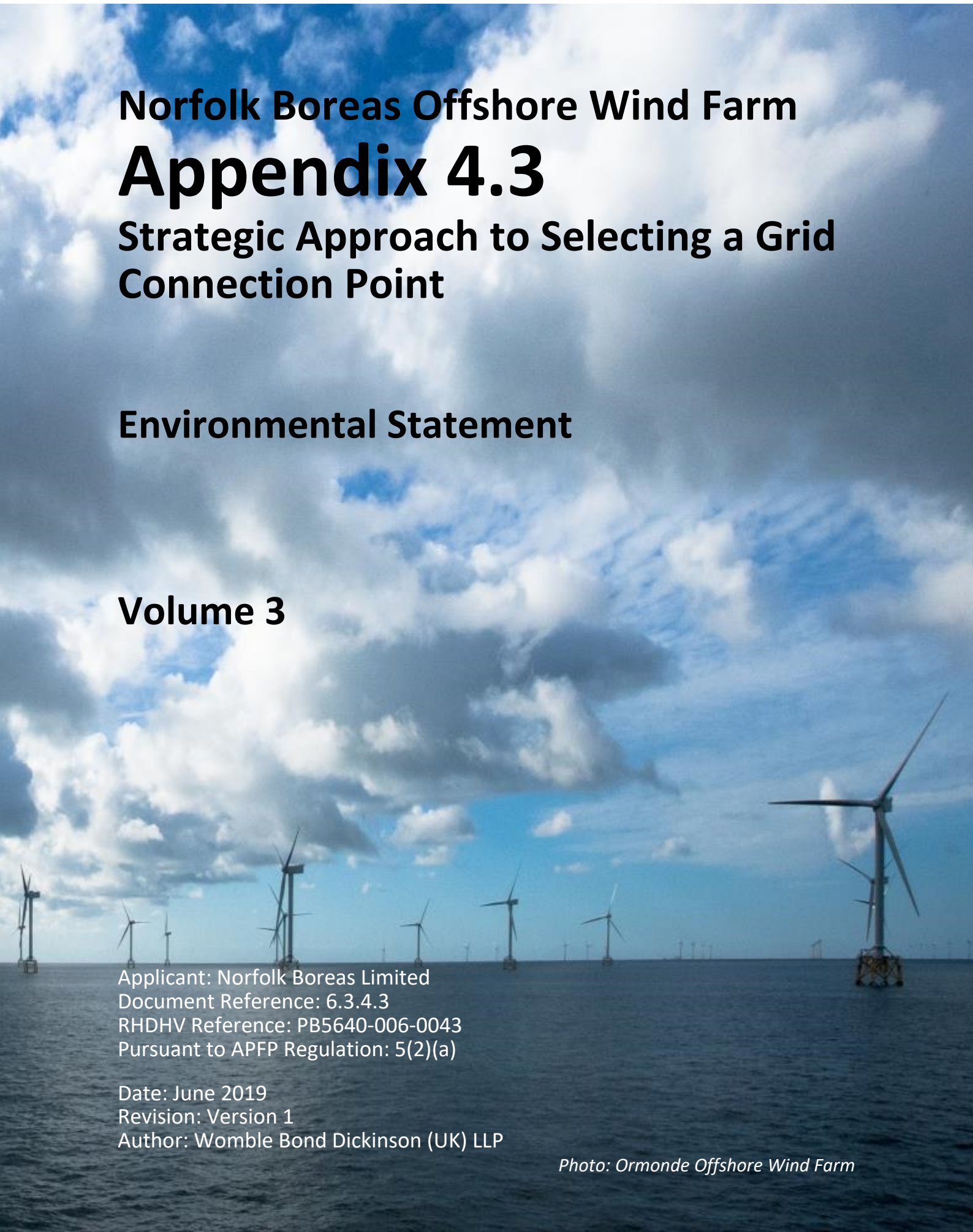
Norfolk Boreas Offshore Wind Farm

Appendix 4.3

Strategic Approach to Selecting a Grid Connection Point

Environmental Statement

Volume 3



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Glossary of Acronyms

AfL	Agreement for Lease
CRS	Cable Relay Stations
EAOW	East Anglia Offshore Wind Limited
GW	Gigawatts
HDD	Horizontal Directional Drilling
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
kV	kilovolts
MG	Megawatts
ModApp	Modification Application
NETS	National Electricity Transmission System
OCP	Onshore Connection Point
PEXA	Planning and Exercise Areas
SPR	Scottish Power Renewables
SSSI	Site of Special Scientific Interest
TCE	The Crown Estate
VWPL	Vattenfall Wind Power Limited

1 Introduction

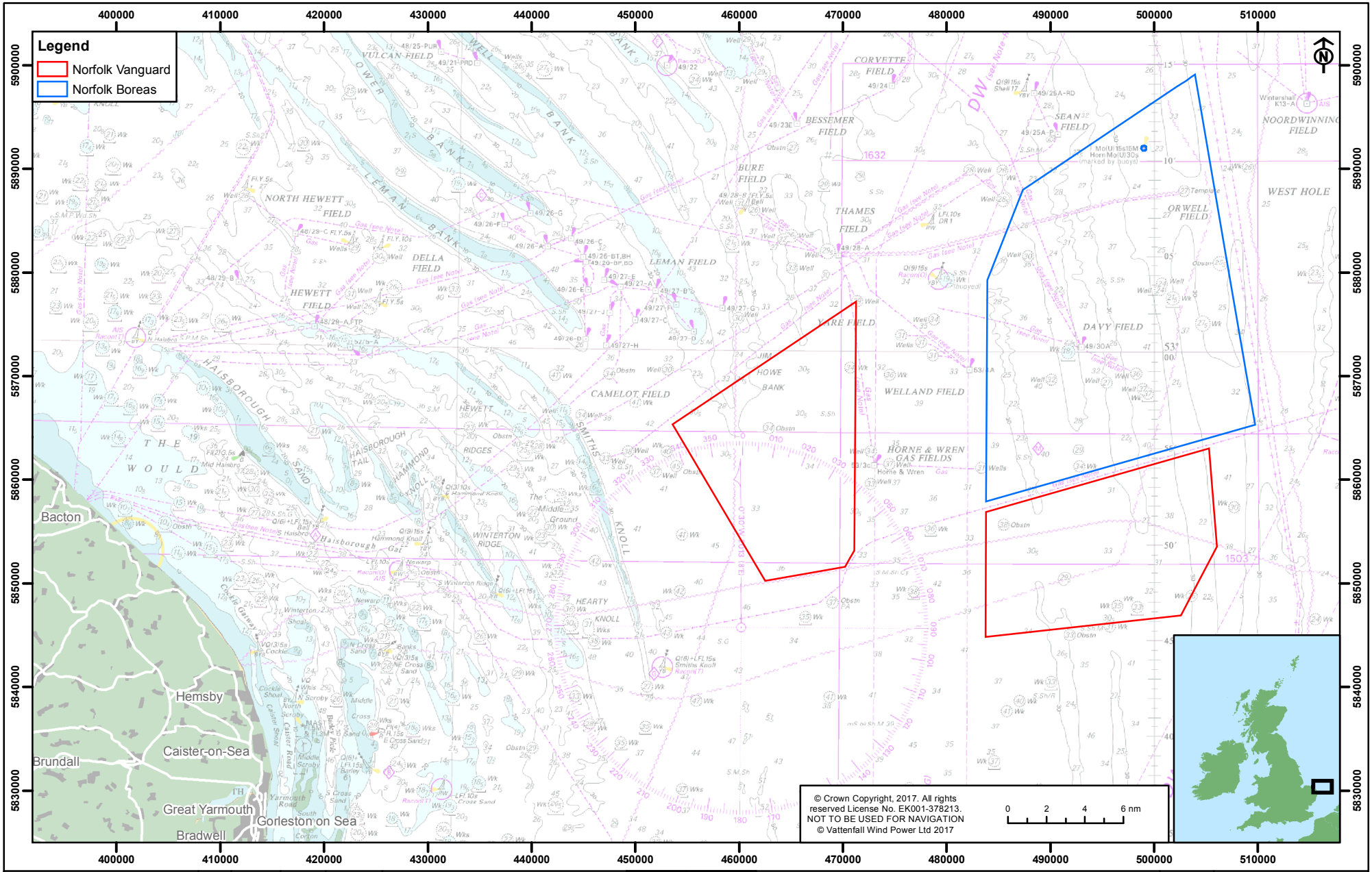
1. This further information provides a summary of the context and work carried out by National Grid and Vattenfall Wind Power Limited to select an appropriate location to connect up to 3.6 gigawatts (GW) of offshore generation to the national electricity transmission system (NETS) for the development of the Norfolk Vanguard and Norfolk Boreas Offshore Wind Farms.

2. This report should be read in conjunction with the Norfolk Boreas Environmental Statement, specifically:

   - Chapter 4: Site Selection and Assessment of Alternatives, which provides a description of the process to identify suitable locations for the project infrastructure, including the wind farm site, offshore cable corridor, landfall, onshore cable corridor, cable relay stations and onshore and offshore substations, and the alternatives considered.
   - Chapter 5: Project Description, which provides information on the components required for construction, operation and maintenance and decommissioning of the project.

2 Project Background

3. Once constructed, Norfolk Vanguard and Norfolk Boreas would each provide a capacity of up to 1,800 megawatts (MW). Norfolk Vanguard and Norfolk Boreas are situated within the former East Anglia Zone (Zone 5). Norfolk Vanguard is 47km from the coast at its closest point; Norfolk Boreas is 73km from the coast at its closest point (Figure 1).



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Norfolk Vanguard / Norfolk Boreas

Norfolk Vanguard & Norfolk Boreas Project Boundaries

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Figure 1

Ref: EAZ_BDSB_ZAP_v33_160304fi_25831, EAZ_EGEL_OffCabCo_v21_170530am_25831

3 Context

3.1 The Crown Estate

4. In June 2008 as part of the UK Offshore Wind Round 3 tender process, The Crown Estate (TCE) invited bids to develop 7.2GW of offshore wind farms in an area of the North Sea identified as Zone 5.

5. Vattenfall Wind Power Limited (VWPL) and Scottish Power Renewables (SPR) formed a joint venture company called East Anglia Offshore Wind Limited (EAOW) which successfully won the rights to develop Zone 5 (East Anglia Zone).

6. In 2015, a decision was made between VWPL and SPR to split the development rights of the East Anglia Zone. VWPL retained the northern half of Zone 5 and secured an agreement with TCE to develop up to 3.6GW of offshore production within this northern area. This was established via two agreements for lease (AfL) between the TCE and VWPL. Each AfL was for a development of 1.8GW and resulted in the formation of two offshore wind development projects (the Projects), known then as East Anglia North Tranche 1 and East Anglia North Tranche 2. East Anglia North Tranche 1 comprised two distinct development areas and East Anglia North Tranche 2 comprised a single development area. The three development areas are located adjacent to each other.

3.2 The Project Companies

7. East Anglia North Tranche 1 has subsequently become Norfolk Vanguard Limited (comprising NV East and NV West).

8. East Anglia North Tranche 2 has subsequently become Norfolk Boreas Limited (comprising a single development area).

9. Both companies are wholly owned by VWPL.

10. Norfolk Vanguard and Norfolk Boreas together are referred to as 'the Projects'.

4 Strategic Approach

4.1 Geography

11. From the outset of development, it was clear to VWPL that it would be more efficient to take a strategic approach to developing the Projects. Geographically the Projects are close to each other and therefore, the co-location of both projects offers opportunities to explore synergies that might reduce development and operational costs and reduce both regional and local impacts.

4.2 Programme

12. The Projects are being developed with programmes that are only one year apart. As with the geographical synergies, the closeness of the two programmes also offers the opportunities of cost saving synergies and reduction of both regional and local impacts.

5 National Grid

5.1 Connection offer

13. National Grid Electricity Transmission PLC (National Grid) owns and operates the NETS in England and Wales. When offshore wind farm developers wish to connect to the NETS, they must make a connection application to National Grid. Following initial agreement of a connection offer, a modification application (ModApp) is required if developers' proposals change significantly. When the proposed development is an offshore wind farm, the connection options are comparatively assessed to identify the most appropriate onshore connection location. This will also be revised for every significant change.

5.2 Location Identification Process

14. The aim of the location identification process is to provide an efficient, coordinated and economic assessment of available options to connect the projects to the NETS.

15. A guidance note on the National Grid website[1] explains how the assessment is carried out. The process looks at technical, commercial, regulatory, environmental, planning and deliverability aspects to identify the most preferred connection to the consumer. The Electricity Act 1989 requires National Grid, when formulating proposals, to be efficient, coordinated and economic whilst also having regard to the environment. When the development being connected is offshore, both the offshore and onshore aspects need to be considered in that evaluation too.

16. In line with the above, the assessment process for the Projects therefore included an appraisal of connection options and from this, a shortlist of potential onshore connection points was identified. Potential onshore connection points were considered from an economic and strategic perspective and included consideration of any additional cost and investment required for a connection, the capacity required and the predicted timing of the connection. An important element of this assessment was the cost that would ultimately be passed on to the consumer (the

[1] The Connection and Infrastructure Options Note (CION) Process: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=2ahUKEwjK0ueVitndAhULLcAKHapQDPQQFjAAegQICRAC&url=https%3A%2F%2Fwww.nationalgrid.com%2Fsites%2Fdefault%2Ffiles%2Fdocuments%2F43631-Connection%2520and%2520Infrastructure%2520Options%2520Note%2520%2528CION%2529%2520Process%2520Guidance%2520Note%2520-%2520Issue%2520003.pdf&usg=AOvVaw0nfFHyrfn7Ld4fcTlcbjsw

public and businesses) as a result of any works required to ensure the network could accommodate the Projects.

17. Furthermore, as part of the economic assessment, the whole life cost of the connection was considered by assessing both the capital and projected operational costs to the onshore network (over the design life of the project) to determine the most economic and efficient design option. National Grid produces the connection offer based on the result of the assessment, which is agreed by all parties involved.

5.3 Strategic Connection

18. As part of its strategic approach of developing both Norfolk Vanguard and Norfolk Boreas, VWPL elected to seek common connection points for the Projects to the NETS. The identification of suitable common connection points was undertaken by National Grid and VWPL. The Norfolk Vanguard project team acted as lead for this activity on behalf of both Projects. The outcome was two independent connection offers, one for each Project.

5.4 Grid Agreement

19. In 2010, EAOW secured an outline connection agreement of 7.2GW for the East Anglia Zone with National Grid as owner and operator of the NETS in England and Wales. This offer included connections at Norwich 400 kilovolts (kV) substation, Bramford 400kV substation and Lowestoft 400kV substation and was based on 12 offshore platforms.

20. Following the completion of the first zonal plan in 2012, a ModApp was submitted by EAOW in 2012 which altered the completion dates for each project, updated the locations of the offshore platforms in line with the latest zone layout and updated the names and capacities of individual projects. This ModApp was based on the conclusions of the Strategic Options Review carried out between EAOW and National Grid in 2012. As of June 2013, the suite of grid agreements included the following:

Table 1: Grid Connection Agreements as of June 2013

Project	Capacity	Interface Point
EA ONE	1,200MW	Bramford
EA TWO	800MW	Lowestoft
EA THREE	1,200MW	Bramford
EA FOUR	1,200MW	Bramford
EA FIVE	1,000MW	Lowestoft
EA SIX	1,800MW	Bacton
TOTAL	**7200MW**	

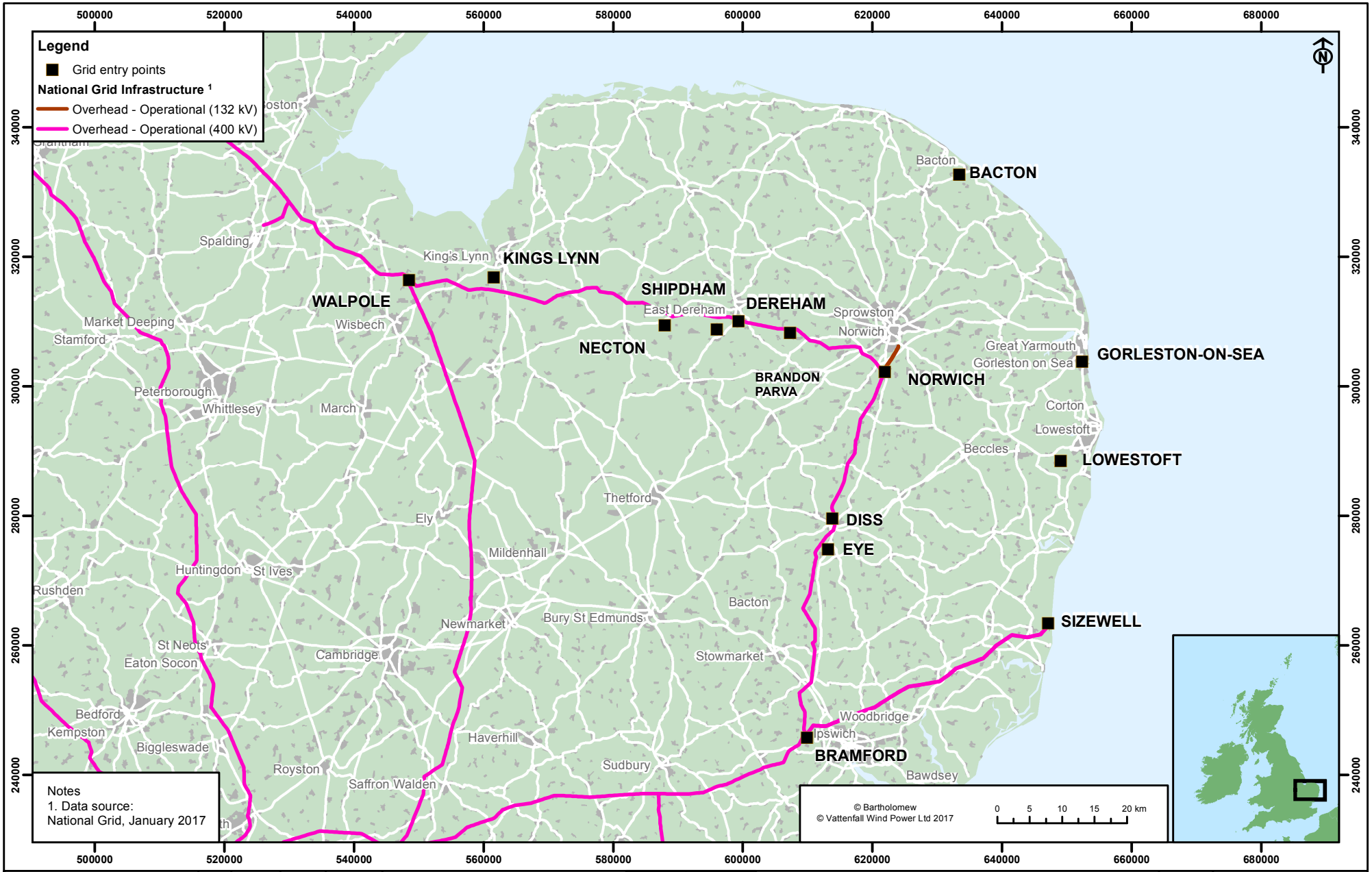
21. In July 2015, following the split of the development rights for the East Anglia Zone between VWPL and SPR, each company retained 3,600MW of grid connection capacity, i.e. half of the original agreement for the Zone. As SPR retained

development rights for the south of the Zone, and VWPL retained rights in the north of the Zone, it was agreed that SPR should take the Grid capacity with an interface point at Bramford (3.6GW) and that VWPL should take the Grid capacity with the interface points at Lowestoft and Bacton (3.6GW).

22. At this stage, VWPL were advised by National Grid that connections at Lowestoft and Bacton substations (both consented and built by National Grid)) would be extremely challenging as they would involve new overhead lines which would take at least 10 years to consent and build. This would therefore not allow VWPL to meet necessary milestones for development of the Projects and would add significant risk to the projects. Following the identification of the Projects, the existing grid connection agreements were reviewed and a further ModApp made (see section 3).

6 Initial identification of onshore connection location

23. Following the identification of the potential offshore substation locations for the Projects, a list of fourteen potential onshore connection locations for connecting the Projects to the NETS was identified (Figure 2). Options to be taken forward to the next level of assessment were assessed against the distance from the Projects, the extent of additional infrastructure required, compliance with the Security and Quality of Supply Standards (criteria and methodology for planning and operating NETS), technical limitations and high-level environmental issues.



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Norfolk Vanguard / Norfolk Boreas

Potential Onshore Grid Connection Points

Purpose	For information
Drg No	57980-1AG-700-036
Rev	A
Layout	NA

Figure 2

Ref: EAZ_EGEL_OnSStn_v02_121204fi_27700, TransmissionLine_170112

24. Norfolk and Suffolk are rural areas and therefore the grid network in this region is relatively sparse, with existing 400kV transmission substations located at Walpole, Necton, Norwich, Bramford and Sizewell. A double-circuit 400kV overhead line runs east from Walpole to Norwich Main, and another line runs south from Norwich Main to Bramford. A four-circuit spur from Bramford to Sizewell connects the Sizewell Power Station. The gas-fired power station at Great Yarmouth is connected to the 132kV local distribution network.

25. Points located north-west of Walpole (e.g. Bicker Fen and West Burton) and south of Sizewell (e.g. Bradwell, Rayleigh and Tilbury) were not included in the list of potential options as the length of the associated onshore connection routes (>150km) rendered these options technically and economically unviable.

26. The long list of potential onshore connection points included inland connection points at Walpole, King's Lynn, Necton, Shipdham, Dereham, Brandon Parva, Norwich Main, Diss, Eye and Bramford where cables would be laid underground from a landfall to the inland substation. It also included coastal connection points at Bacton, Gorleston-on-Sea, Lowestoft and Sizewell, which would require National Grid to provide a connection from the landfall to the inland grid network (most likely to be an overhead line).

27. Connection points reviewed for the Projects included:

- Existing substations (Walpole, King's Lynn, Necton, Norwich Main, Bramford and Sizewell);
- Sites where National Grid was contracted to provide 400kV connections for future generation projects (Eye Airfield);
- Other sites close to the existing network that National Grid had previously identified and assessed as possible locations for 400kV substations (Shipdham, Dereham, Brandon Parva and Diss); and
- Coastal locations (Bacton, Gorleston and Lowestoft).

28. In line with the Guidance, a review of consenting, construction and cost implications for each potential connection point was undertaken and concluded a shortlist of three inland connection points (Necton, Norwich Main and Eye Airfield) and three coastal connection points (Bacton, Gorleston-on-Sea and Lowestoft).

29. Other sites were discounted for the following reasons:

- Sites with very long (i.e. over 150km) offshore connection routes (Walpole and King's Lynn) were deemed economically and technically unviable due to the

length of subsea cabling required and (in the case of Walpole) designated areas in the Wash;

- Sites with no existing infrastructure (Shipdham, Dereham, Brandon Parva and Diss) were considered to offer no benefit over nearby sites enabling co-location with existing National Grid substations; and
- Sites with insufficient capacity for the Projects (Bramford and Sizewell).

7 Export technology options

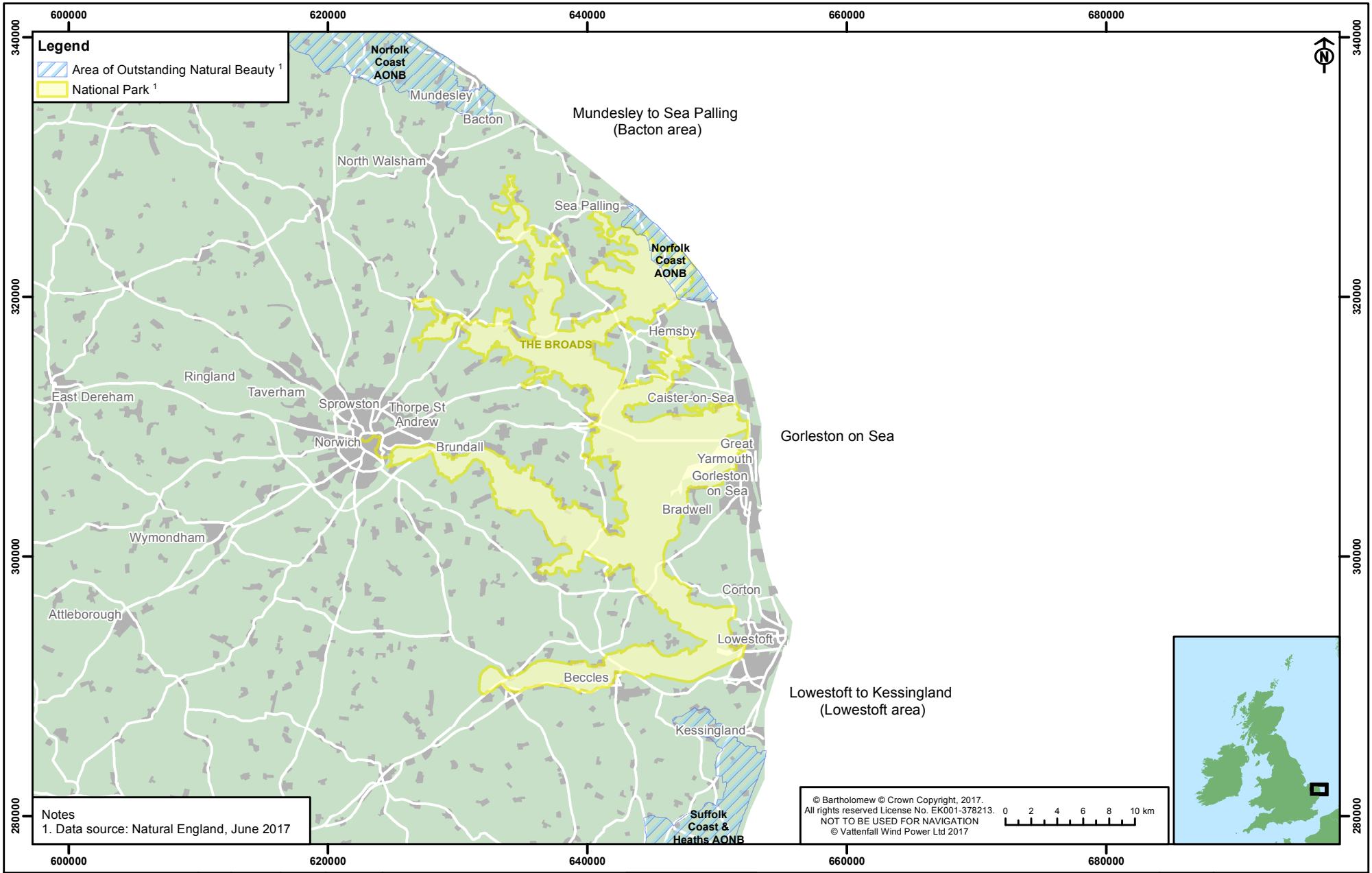
30. As part of the assessment process, potential export system technology options were reviewed. At this early stage of development, plans for both High Voltage Alternating Current (HVAC) and High Voltage Direct Current (HVDC) export options were considered.

31. Four export cable options with different technologies were assessed in terms of cost, programme, engineering feasibility and high level environmental constraints. Option 2 (a HVAC system with an inland connection point) and Option 4 (a HVDC system built in 900MW blocks, with an inland connection point) were deemed to be the most favourable.

32. The three coastal connection points identified – Bacton, Gorleston-on-Sea and Lowestoft - all assumed an HVAC export system. These connection points would provide the lowest cost option but would likely require circa 50km of 400kV overhead lines to be installed within a rural area, and which contains a number of important designated landscapes. Furthermore, these options would require one double circuit overhead line in order to connect up to 1,800MW, and a third 400kV circuit in order to connect both projects. It would therefore be unlikely that consent for and construction of this infrastructure would be deliverable in the required project timescales. All coastal connection points were therefore removed from further consideration.

8 Landfall and cable corridor options

33. The assessment work also included a detailed constraints mapping exercise, which highlighted three possible landfall areas – Bacton (encompassing the coast from Mundesley to Sea Palling), Gorleston-on-Sea and Lowestoft to Kessingland (Lowestoft area) (Figure 3). It should be noted that this area of the Norfolk coast is highly designated, and these are the only landfall areas located outside a designated area. Following identification of potential landfall areas, a Horizontal Directional Drilling (HDD) study was commissioned which identified and assessed 15 possible landfall sites within these broad landfall areas, based on geotechnical, environmental, social and constructability criteria.



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D	26/06/17	lmur	beoc	Added landfall area labels
C	26/06/17	lmur	beoc	Added settlement names
B	26/06/17	lmur	beoc	Updated terminology. Removed admiralty chart.
A	19/06/17	amah	lmur	First issue

Datum	OSGB36
Projection	OSNG
Plot	A4
Scale	1:400,000

Norfolk Vanguard / Norfolk Boreas

Landfall Locations

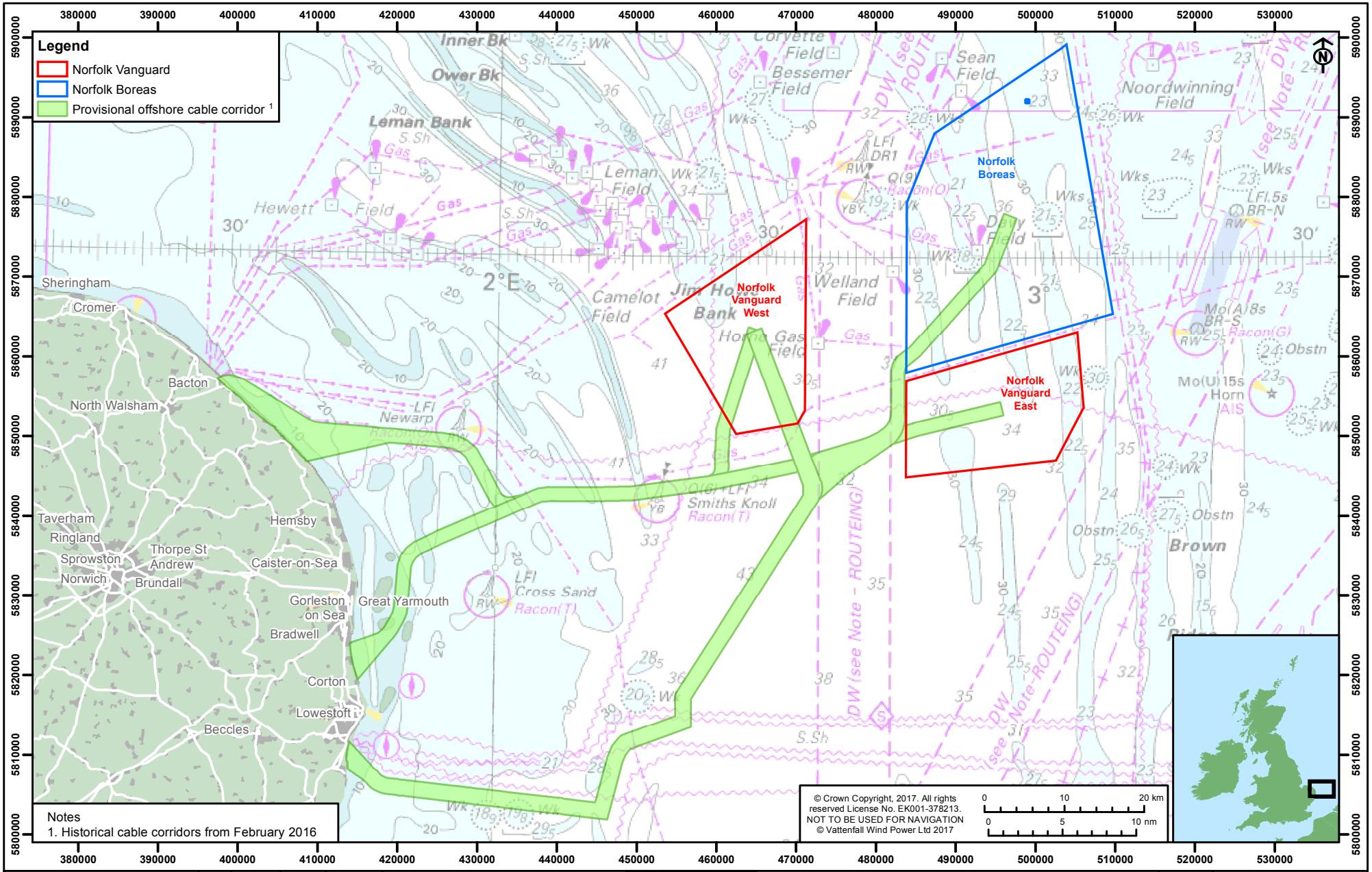
Purpose	For information
Drg No	57980-1AG-700-037
Rev	D
Layout	NA

Figure 3

Ref: AONB_England_170623, NationalParks_England_170623,

34. In parallel with the landfall assessment, the Projects identified preliminary offshore cable corridors from the Norfolk Vanguard and Norfolk Boreas offshore wind farm sites to each of the three broad landfall areas (Figure 4). At this stage, a potential landfall at Lowestoft was removed from further consideration as this would require the greatest offshore cable lengths and the highest number of offshore cable crossings. A cable constructability assessment study was then undertaken for the two remaining options; Bacton and Gorleston-on-Sea, which assessed geology and seabed topography along the proposed offshore cable corridors. The conclusion of this study was that the corridor to the Bacton area was more favourable than the corridor to Gorleston-on-Sea due to the presence of highly mobile sandwaves and proximity to existing and potential aggregate dredging grounds off the coast at Gorleston-on-Sea.

35. Based on the results of both the landfall assessment (Figure 3) and the offshore cable corridor assessment (Figure 4), the most northerly offshore cable corridor with a landfall in the Bacton area was taken forward. A further detailed review of the Bacton area landfall was therefore undertaken which concluded that the section of landfall close to Eccles on Sea should be removed from further consideration due to poor access, proximity to the Broads National Park, proximity to a coastal settlement and unsuitable geology.



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Norfolk Vanguard / Norfolk Boreas

Provisional Offshore Cable Corridors

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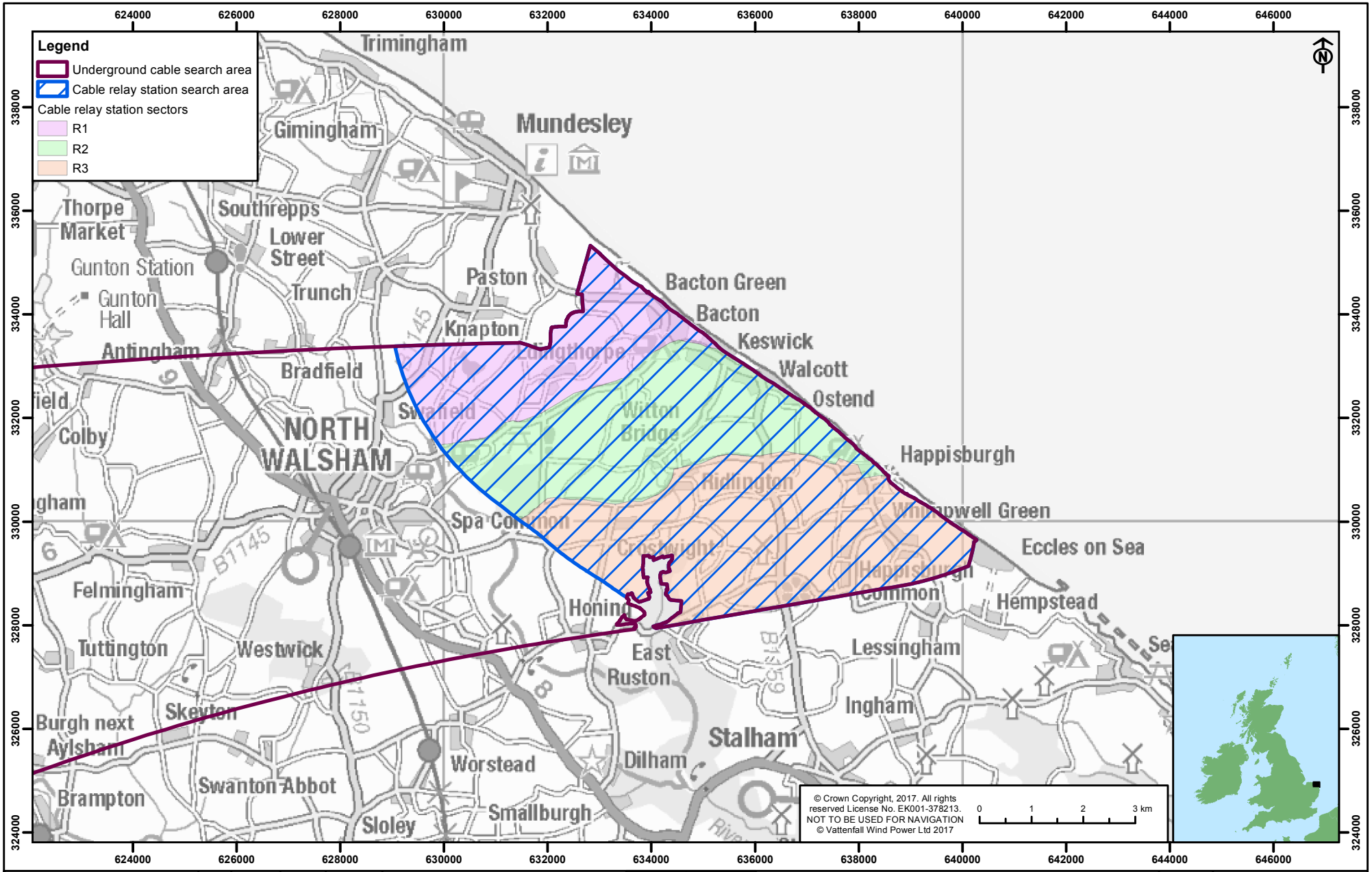
Figure 4

Ref: EAZ_BDSB_ZAP_v33_160304fi_25831, EAZ_EGEL_OffCabCo_v09_160203fi_25831



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Norfolk Vanguard / Norfolk Boreas

Landfall Seach Area

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Figure 5

EAZ_EGEL_OnCabCo_v08_160831am_27700, EAZ_EGEL_OnCabCo_v08_160831am_27700

36. The landfall search area presented within the Norfolk Vanguard Scoping Report[2] therefore included an area from Bacton Green in the north, to Cart Gap in the south (Figure 5). A detailed constraint check within the offshore cable corridor was undertaken to ensure the proposed corridor would not conflict with existing marine users including other offshore wind farms, shipping, offshore cables, offshore oil and gas infrastructure, military Planning and Exercise Areas (PEXAs), aggregate dredging grounds and commercial fishing or environmental factors such as nature conservation designations, coastal erosion and seabed features. Further information on this process is available in Chapter 4 Site Selection and Assessment of Alternatives.

8.1 Onshore cable route ducting

37. The decision to apply a strategic approach to the development of the Projects led to the logical decision to commit to laying onshore cable ducts for both Projects in a combined operation. The consequence of this decision will be a substantial reduction in the onshore works.

9 Identification of final onshore connection point

38. Following selection of the Bacton area for the landfall location (Bacton Green to Cart Gap), only the two inland connection points (both with existing National Grid substations) closest to this landfall were taken forward for further review – Necton and Norwich Main. Based on these two potential connection points, two study areas were therefore developed: one covering the onshore cable corridor for an onshore connection point (OCP) at Necton; the second covering the onshore cable corridor associated with the alternative OCP location at Norwich Main.

39. For an OCP at Necton, the study area was developed by identifying a broad area of land around the existing National Grid 400kV Necton substation and between the substation location and the landfall search area. This area was then further refined to avoid the settlements of Fakenham and Briston to the north and Norwich and surrounding settlements to the south. The area south-west of Sea Palling was also removed as this encompassed a large area of The Broads National Park.

40. For an OCP at Norwich Main, the study area was developed by identifying a broad area of land around the existing 400kV Norwich Main National Grid substation, and to join the substation location with the landfall, which was then further refined by removing the settlements of North Walsham and Aylsham to the north and The Broads National Park to the east. A small area to the west was also removed which included settlements of Reepham and Mattishall, a Site of Special Scientific Interest (SSSI) (Hockering Wood) and a wetland area associated with the River Wensum.

[2] https://infrastructure.planninginspectorate.gov.uk/projects/eastern/norfolk-vanguard/?ipcsection=docs&stage=1&filter1=Scoping+Report

41. Environmental considerations were also mapped within each of these areas, alongside high-level siting principles such as avoiding designated sites and settlements and keeping the onshore cable route length as short as practicable to reduce potential environmental impacts, in order to identify broad indicative cable corridors for each of the two connection options.

42. An initial assessment of these two options identified that an onshore cable corridor for an onshore connection point at the existing 400kV Necton National Grid Substation presented the preferred option. In general, there is an increase in all constraints such as designated sites, roads, rivers and populated areas, from west to east across the study area due to the proximity of Norwich (and the associated infrastructure and utilities) and The Broads National Park.

9.1 Scoping

43. Following acceptance of the offers to connect the Projects at the existing Necton National Grid sub-station, a common onshore scoping area was defined, and the onshore scoping process commenced. Due to the timelines of the Projects, Norfolk Vanguard took the lead for this process. The onshore scoping area included search areas for the onshore infrastructure which at that time included the onshore project substations, cable relay stations (CRS) a common onshore cable corridor, and landfall search areas.

10 Conclusion

44. As a result of the re-allocation of the original lease area for the Zone 5 offshore wind farm area by TCE, development rights for the northern half of the Zone were awarded to VWPL; this area covers a potential development site for two offshore wind farms. Following this re-allocation process, National Grid worked in conjunction with VWPL (on behalf of the Projects), undertaking a series of assessments, to ascertain the most economic and efficient electrical connection system for Norfolk Vanguard and Norfolk Boreas.

45. The assessment process included:

- A review of potential onshore connection points to the NETS from Walpole in the west to Bradwell in the south;
- A review of possible export system options, including HVDC and HVAC technologies and the use of underground cables and overhead lines;
- A review of potential landfall sites;
- A review of potential offshore cable corridors; and
- A review of potential onshore cable corridors associated with the final two connection options, Necton and Norwich Main.

46. This process was undertaken over a period of approximately 12 months and it was concluded that an onshore connection point for the Projects at the existing National Grid Necton 400kV substation was most preferred based on available information at this time.

47. In July 2016, following the process outlined above, an offer was made by National Grid for a connection point at the existing Necton National Grid substation, and this was accepted by Norfolk Vanguard Limited. In November 2016, an offer was accepted by VWPL on behalf of Norfolk Boreas Limited for a connection at the same location.