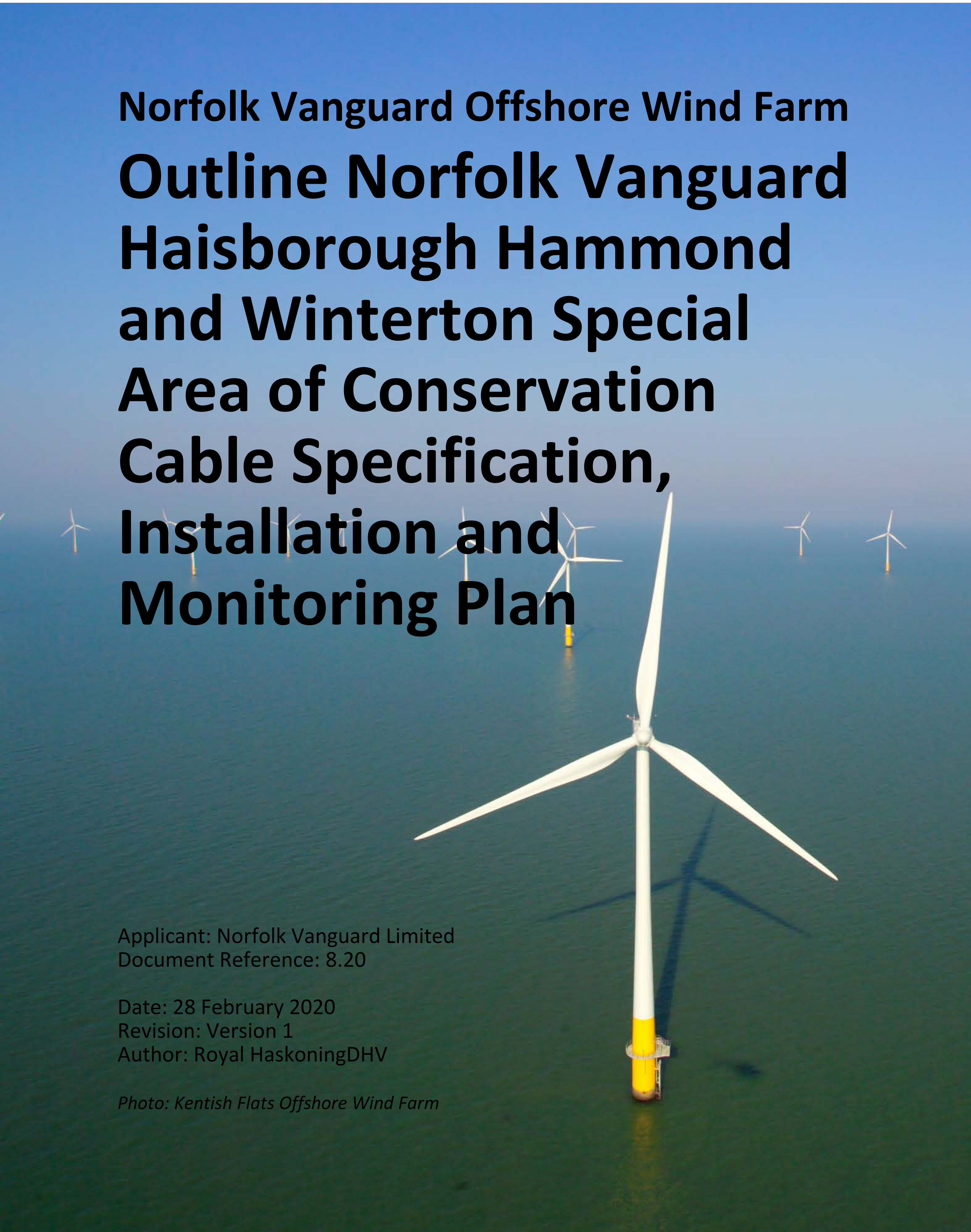

Norfolk Vanguard Offshore Wind Farm

Outline Norfolk Vanguard Haisborough Hammond and Winterton Special Area of Conservation Cable Specification, Installation and Monitoring Plan

Applicant: Norfolk Vanguard Limited
Document Reference: 8.20

Date: 28 February 2020
Revision: Version 1
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Photo: Kentish Flats Offshore Wind Farm

Date	Issue No.	Remarks / Reason for Issue	Author	Checked	Approved
22/02/20	01D	First draft for Norfolk Vanguard Limited review	ES	GK/DT	GK
28/02/2020	01F	Final Version for submission on 28 February 2020	BT	GK	RS

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1 INTRODUCTION

1.1 Project Background

1. Norfolk Vanguard Limited ('the Applicant', an affiliate company of Vattenfall Wind Power Ltd (VWPL)) is seeking a Development Consent Order (DCO) for Norfolk Vanguard ('the Project'), an offshore wind farm (OWF) located in the southern North Sea.

2. The OWF comprises two distinct areas, Norfolk Vanguard East (NV East) and Norfolk Vanguard West (NV West) ('the OWF sites'), within which the wind turbines and associated platforms and cables will be located (Figure 1.1). The offshore wind farm will be connected to the shore by offshore export cables installed within the offshore cable corridor from the OWF sites to a landfall point at Happisburgh South, Norfolk. From there onshore cables would transport power over approximately 60km to the onshore project substation and National Grid substation at Necton, Norfolk. A full project description is given in the Environmental Statement (ES), Chapter 5 Project Description.

3. Once built, Norfolk Vanguard would have an export capacity of up to 1800MW, with the offshore components comprising:

- Wind turbines;
- Offshore electrical platforms;
- Accommodation platforms;
- Met masts;
- Lidar;
- Array cables;
- Inter-connector cables; and
- Export cables.

4. This Outline HHW SAC Cable Specification, Installation and Monitoring Plan (CSIMP) relates to a section of the offshore export cables, where they overlap with the Haisborough, Hammond and Winterton (HHW) Special Area of Conservation (SAC) (Figure 1.1).

5. The Norfolk Vanguard Environmental Impact Assessment (EIA) has followed a 'Rochdale' or design envelope approach, as discussed in section 5.1.1 of ES Chapter 5 Project Description. The design envelope provides flexibility allowing the project to be optimised and refined prior to construction. Therefore, realistic worst case scenarios have been adopted in the ES (document 6.1) and Information to Support Habitats Regulations Assessment (HRA) report (document 5.3), to allow a precautionary and robust impact assessment. Through various additional

commitments made by the Applicant since the submission of the Norfolk Vanguard DCO application, the worst case scenario has been refined. A summary of the latest worst case scenario is provided in section 3.1.

6. The detailed design of Norfolk Vanguard (e.g. micrositing of the cable route and the requirement for cable protection) will be determined post-consent.

1.2 The Haisborough Hammond and Winterton Special Area of Conservation

7. The HHW SAC is located to the west of NV West, and the offshore cable corridor passes through the SAC. The SAC is designated for Annex I Sandbanks which are slightly covered by seawater all the time and Annex I Reefs (*Sabellaria spinulosa*).

8. The sandbank ridges consist of sinusoidal banks which have evolved over the last 5,000 years and comprise of Haisborough Sand, Haisborough Tail, Hammond Knoll, Winterton Ridge and Hearty Knoll. Older sandbanks, Hewett Ridge and Smiths Knoll, are present along the outer site boundary and have formed over the last 7,000 years. The more geologically recent sandbanks of Newarp Banks and North and Middle Cross Sands lie on the south west corner of the SAC[1].

9. The Joint Nature Conservation Committee (JNCC) HHW Site Details[1] state that *S. spinulosa* reef has been recorded at Haisborough Tail, Haisborough Gat and between Winterton Ridge and Hewett Ridge. *S. spinulosa* reefs within the HHW SAC can have an elevation of 5cm to 10cm and in areas where reef has been recorded, this can have between 30% to 100% coverage.

10. As discussed above and shown in Figure 1.1, the Norfolk Vanguard offshore cable corridor overlaps with the HHW SAC.

[1] http://jncc.defra.gov.uk/protectedsites/sacselection/sac.asp?EUCode=UK0030369

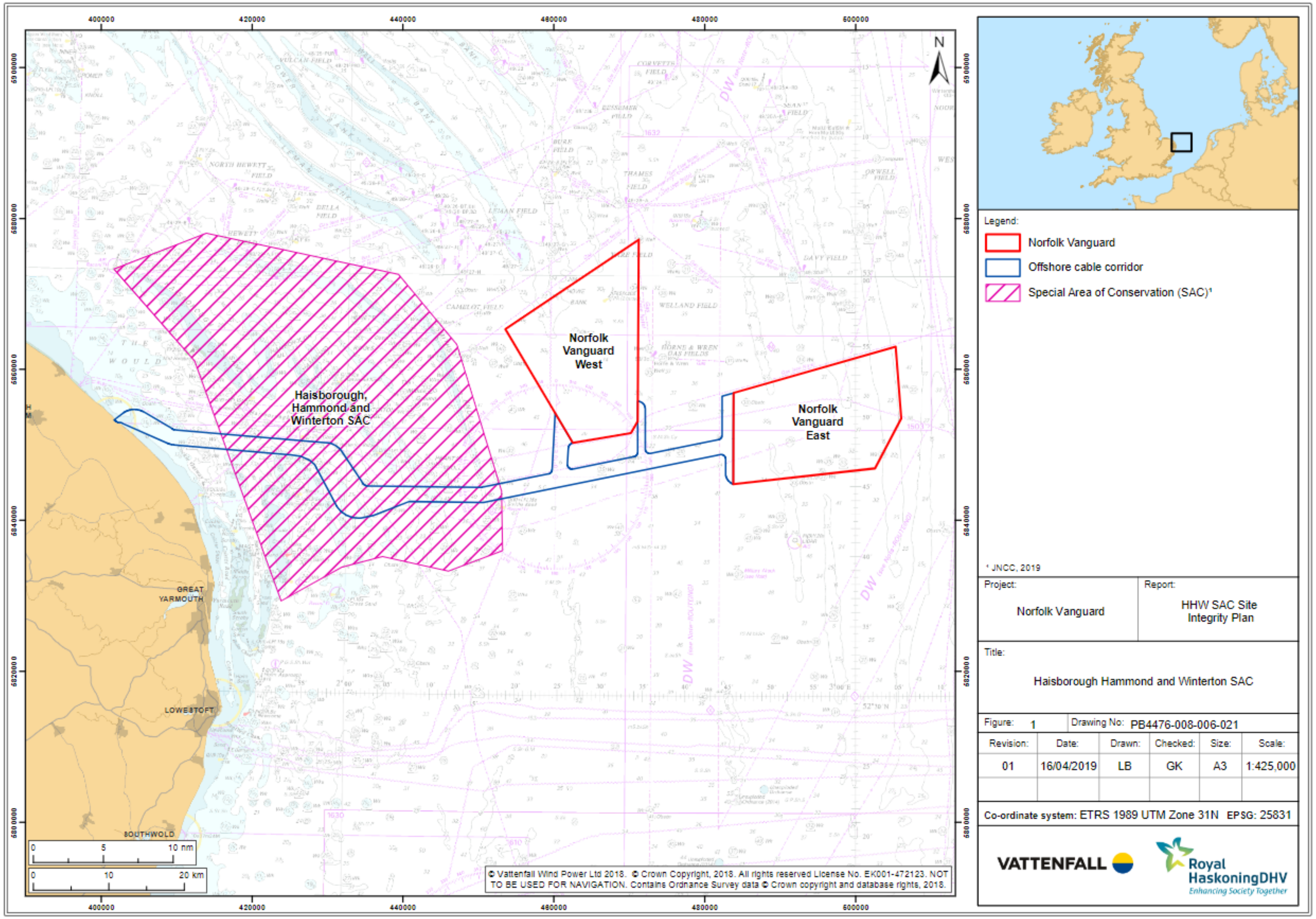


Figure 1.1: Location of Norfolk Vanguard and the Haisborough Hammond and Winterton SAC

1.3 Purpose of this Document

11. The purpose of this Outline Norfolk Vanguard HHW SAC CSIMP is to set out the information required in the final HHW SAC CSIMP in accordance with:

12. Condition 9(1)(m), Schedules 11 and 12 of the Norfolk Vanguard draft Deemed Marine Licences (DMLs) states:

"9(1) The licensed activities or any part of those activities must not commence until the following (as relevant to that part) have been submitted to and approved in writing by the MMO"

"9(1)(m) A cable specification, installation and monitoring plan for the installation and protection of cables within the Haisborough, Hammond and Winterton Special Area of Conservation which accords with the principles set out in the outline Norfolk Vanguard Haisborough, Hammond and Winterton Special Area of Conservation Cable Specification, Installation and Monitoring Plan such plan to be submitted to the MMO (in consultation with the relevant statutory nature conservation body) at least six months prior to commencement of licensed activities"

13. The above Condition secures the requirement for the HHW SAC CSIMP within the DMLs, whilst allowing scope for refinement of the precise mitigation measures to be adopted based on pre-construction surveys as well as latest guidance, evidence and consultation with the MMO and Natural England.

14. Mitigation measures are outlined in section 4.1 of this document. The final mitigation would be based on the final cable installation design, guidance, pre-construction survey data and available evidence from other projects. Mitigation measures must be agreed with the MMO in consultation with Natural England.

15. This document relates to Norfolk Vanguard alone, however consideration will also be given to Norfolk Vanguard's sister project, Norfolk Boreas to ensure mitigation solutions are compatible for both projects. Norfolk Boreas is an OWF located to the north of NV East which would share an offshore cable corridor with Norfolk Vanguard.

2 CONSULTATION

16. There will be an ongoing requirement to engage with Natural England and the MMO throughout the detailed design stage of the project, including in the planning and review of pre-construction site investigation surveys in the HHW SAC, as well as during development of the final project design, construction plans, mitigation measures and monitoring.

17. As stated in Condition 9(1)(m), Schedules 11 and 12 of the DMLs, the final HHW SAC CSIMP must be approved in writing by the MMO prior to commencing the relevant licensed activities.

3 CABLE INSTALLATION AND CABLE PROTECTION DESCRIPTION

3.1 Worst Case Scenario

18. A full description of the project design envelope and worst case scenarios were provided in the Norfolk Vanguard Environmental Statement (ES) (see ES Chapter 5 Project Description, ES Chapter 8 Marine Geology, Oceanography and Physical Processes, ES Chapter 10 Benthic Ecology) and Section 7.3.2 of the Information to Support HRA report.

19. During the Norfolk Vanguard Examination, the Applicant made commitments to additional mitigation in relation to works in the HHW SAC. Table 3.1 provides a summary of the worst case scenario, incorporating these additional mitigation commitments.

20. Details of the cable specification, cable protection and installation methods within the HHW SAC will be provided once the detailed design is known.

3.1.1 Additional mitigation since submission of the DCO application

21. During the DCO Examination, Norfolk Vanguard Limited made a commitment to limit the potential length of unburied cable in the HHW SAC to 5% of the cable length instead of 10%.

22. Following the close of Examination, the Applicant has committed to use no surface cable protection in the priority areas to be managed as reef within the HHW SAC (shown in Figure 3.1). This will ensure there is no significant loss of Annex 1 reef or potential reef habitat (discussed further in the HHW SAC Position Statement (document reference ExA; Pos; 11.D10.1)).

23. In addition, the Applicant has committed to decommissioning of cable protection at the end of the Norfolk Vanguard project life where it is associated with unburied cables due to ground conditions (where required for crossings this will be left *in situ*). This commitment ensures that there will be no permanent habitat loss as a result of cable protection and further contributes to the ability to conclude no AEoI of the HHW SAC. This is discussed further in Appendix 2 of the Additional Mitigation document (document reference ExA; Mit; 11.D10.2.App2).

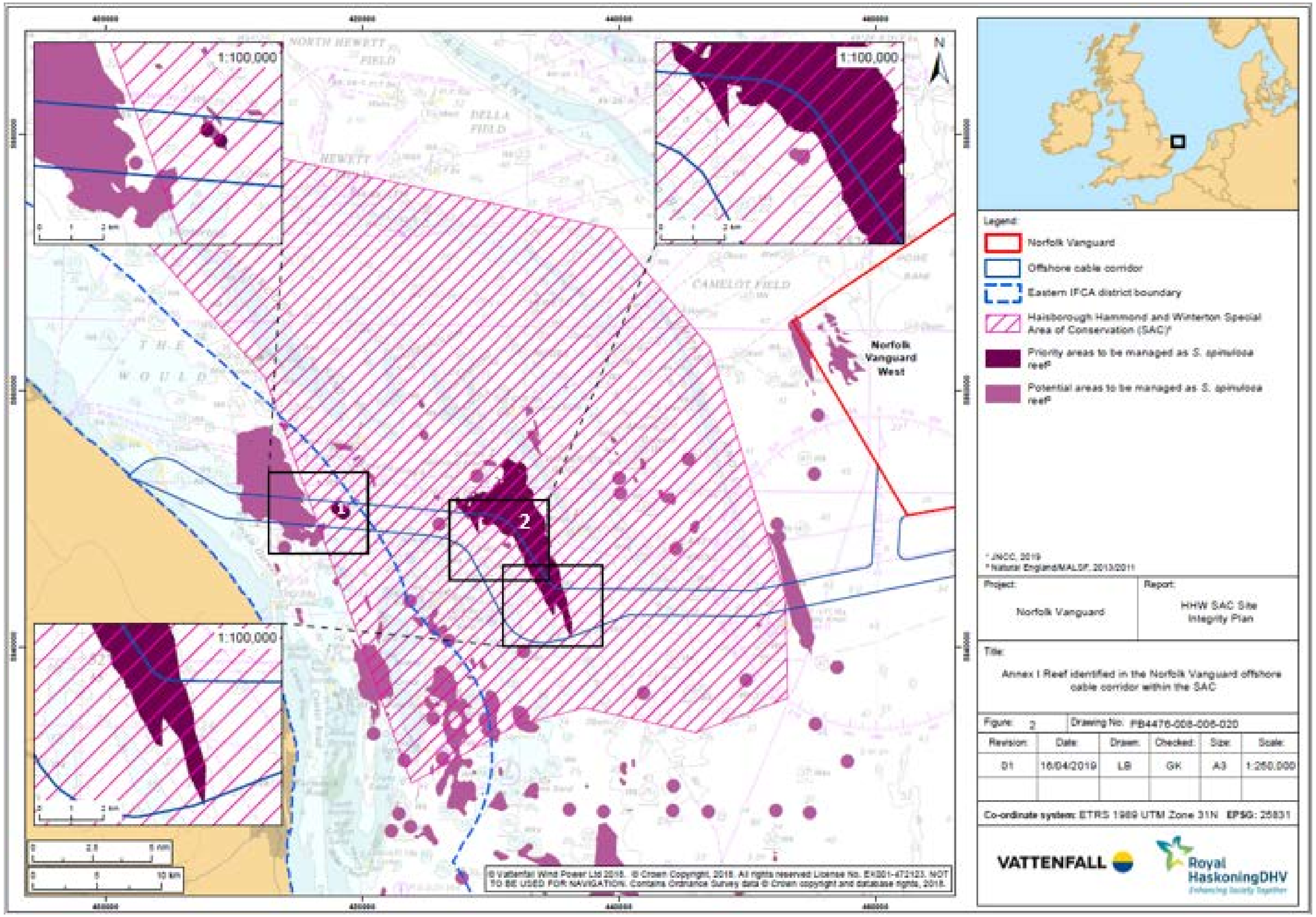


Figure 3.1 Areas to be managed as *S. spinulosa* Annex I reef by Natural England

Table 3.1 Worst Case Scenario in the HHW SAC

Impact	Parameter
Construction	
Temporary physical disturbance Annex 1 Sandbank	• Boulder clearance – 0.002km^2 (up to 100 boulders of 5m diameter) being placed outside the cable route. • Pre-sweeping area – 0.25km^2 based on ES Appendix 5.1 Cable Installation Study, of this up to 0.05km^2 could be outside the footprint of the cable installation works • Cable installation - 2.4km^2 (based on maximum potential disturbance width of 30m for a 10m wide plough with 10m of spoil either side of the trench, along 80km of export cable trenching within the SAC) • Anchor placement – 0.0003km^2 (based on two cable joints in the SAC, one per cable pair with a footprint of 150m^2 each, assuming up to 6 anchors per vessel) • Other works (e.g. lifting of boulders and pre-lay grapnel run) associated with cable installation would be encompassed by the footprints outlined above. • Therefore the total footprint for temporary disturbance on sandbanks is 2.45km^2 Dredged material from the HHW SAC will be disposed of back within the SAC (see section 4.4 for further detail). The area affected by these disposal sites will be agreed with the MMO in consultation with Natural England. As discussed in the Sandwave Study by ABPmer (Appendix 7.1 of the Information to Support HRA report (document reference 5.3.7.1)), deposited sediment will immediately re-join the local and regional sediment transport system. The area affected will be in addition to the 2.45km^2 presented here.
Temporary physical disturbance on Annex 1 Reef	Cable installation works as outlined above, however the location and extent of *S. spinulosa* reef and therefore the overlap of the installation works with reef feature is unknown and will be detailed in the final HHW SAC CSIMP based on the pre-construction surveys.
Operation	
Temporary physical disturbance on Annex 1 Sandbank	• An average of one repair per export cable pair every 10 years is estimated within the SAC. • It is estimated that 300m sections would be removed and replaced per repair. • Disturbance width of 10m = 3,000m^2 (0.003km^2) per repair • Anchor placement associated with repair works = 150m^2 based on 6 anchors per vessel • Reburial of up to 10% of the cable length (4km per pair) every 5 years may be required should pre-sweeping <u>not</u> be undertaken. The disturbance width would be approximately 10m and therefore the total disturbance would be 80,000m^2 (0.08km^2) every 5 years or approximately 400,000m^2 (0.4km^2) over the indicative 30 year project life. If reburial is required, it is likely that this would be in relatively short sections (e.g. 1km) at any one time. • If pre-sweeping is undertaken the requirement for cable reburial would be significantly reduced. The HHW SAC CSIMP requires that the installation strategy (e.g. use of pre-sweeping) is agreed with the MMO in consultation with Natural England.
Temporary physical disturbance on Annex 1 Reef	Maintenance works as estimated above, however the location and extent of *S. spinulosa* reef and therefore the overlap of the maintenance works with

Impact	Parameter
	reef feature is unknown and will be detailed in the final HHW SAC CSIMP based on the pre-construction surveys.
Persistent habitat loss on Annex 1 Sandbank	Total habitat loss within the Haisborough, Hammond and Winterton SAC could be 32,000m^2 (0.03km^2, 0.002% of the 1468km^2 SAC area and 0.005% of the area of sandbanks within the SAC) based on the following: • <0.001km^2 clump weights based on cutting two existing disused cables and placing clump weights of up to 5m^2 on either end of the disused cables. • Six crossings for each of the export cable pairs (12 crossings in total) within the Haisborough, Hammond and Winterton SAC with a total footprint of 12,000m^2 in the SAC (100m length per crossing and 10m width of protection). • A contingency of up to 2km of cable protection per cable pair, 4km in total (5% of the length) could be required in the Haisborough, Hammond and Winterton SAC in the unlikely event that unsuitable ground conditions are encountered, resulting in a footprint of 20,000m^2 based on 5m width of cable protection.
Permanent habitat loss of Annex 1 Reef	The worst case footprint of permanent infrastructure would be as outlined above, however the location and extent of *S. spinulosa* reef and therefore the overlap of the infrastructure with reef feature is unknown and will be detailed in the final HHW SAC CSIMP based on the pre-construction surveys. It is expected that there will be no loss of reef where micrositing can be undertaken (section 4.2). *S. spinulosa* can also be expected to colonise cable protection, although Norfolk Vanguard Limited recognises that Natural England does not consider this to be Annex 1 reef.
Decommissioning	
Temporary physical disturbance	Some or all of the offshore export cables may be removed. Cable protection will be removed except at cables crossings where this would be left *in situ.*

3.2 Pre-construction surveys

24. This section will provide detail of the relevant pre-construction surveys that will be required to inform cable installation and cable protection in accordance with the In-Principle Monitoring Plan (document 8.12), including:

- Geophysical survey within the offshore cable corridor in the HHW SAC;
- Targeted S. spinulosa reef surveys within the offshore cable corridor in the HHW SAC (through the interim and pre-construction surveys);
- Geotechnical assessment of the seabed within the offshore cable corridor in the HHW SAC; and
- Unexploded ordnance (UXO) survey.

25. Details of the final cable route and micrositing within the HHW SAC will be provided in the final HHW SAC CSIMP, informed by the pre-construction surveys.

3.3 Cable Burial Risk Assessment

26. This section will summarise the cable burial risk assessment which will be undertaken for the project. Once the risk assessment has been completed this section will include the following information:

- Overview of the risk assessment;
- Overview of the site (bathymetry and seabed sediments);
- Sandwaves;
- Megaripples;
- Till outcrops;
- Steep Slopes; and
- Boulders and Debris

3.4 A Sandwave Characterisation Study

27. This section will contain a summary of the sandwave characterisation study which will be undertaken within the cable route that overlaps with HHW SAC.

3.5 Cable installation strategy

28. This section will detail the steps involved in the export cable installation process of relevance to the HHW SAC once known, including:

- Seabed preparation;
- Cable route clearance;
- Placement of cable protection; and
- Cable installation method statement.

29. The installation strategy will be informed by a burial tool capability study. A summary of the study will be provided here and the study itself provided in a technical Appendix.

3.6 Cable Protection Plan

30. As detailed in the cable burial risk assessment summary above, there is the potential for target burial depth to not be achieved along sections of the export cable route within HHW SAC. Once available, this section will provide the following information:

- Decision making process on burial and protection;
- Type of cable protection;
- Location of cable protection (see Annex 3 Likely Cable Protection Locations);
- Installation method of cable protection;
- Cable Crossings cable protection, and
- Consideration of risks to other sea users, e.g. snagging of fishing gear and vessel anchors.

4 MITIGATION

31. Norfolk Vanguard Limited is committed to minimising potential effects on the HHW SAC.

32. The final mitigation measures in the HHW SAC CSIMP will be refined and updated on the basis of the principles outlined in the sections below and the commitments provided in Table 4.2, to ensure effects are minimised.

33. For the mitigation measures identified, information will be provided in the final HHW SAC CSIMP to detail how the measure will allow the conclusion of 'no adverse effect on integrity beyond reasonable scientific doubt' on the HHW SAC.

4.1 Embedded mitigation

34. During the pre-consent stage, Norfolk Vanguard Limited made the following commitments, informed by consultation with Natural England and the MMO through the Evidence Plan Process.

4.1.1 Minimising export cabling

35. Norfolk Vanguard Limited has taken the decision to use an High Voltage Direct Current (HVDC) export solution in order to reduce the number of cables and cable protection. This results in the following mitigating features:

- There will be two cable trenches instead of six for Norfolk Vanguard (and the same for Norfolk Boreas);
- The volume of sediment arising from pre-sweeping and cable installation works is reduced by 67%;
- The area of disturbance for pre-sweeping and cable installation is reduced by 67%;
- The space required for cable installation is reduced, increasing the space available within the cable corridor for micrositing to avoid constraints such as *S. spinulosa* reef;
- The potential requirement for cable protection in the unlikely event that cables cannot be buried is reduced due to the reduction in the number of cables. In addition, Norfolk Vanguard Limited has committed to further reduction in cable protection (discussed in section 4.5.2); and
- The number of export cables required to cross existing cables and pipelines and the associated cable protection is reduced.

4.1.2 Pre-construction surveys

36. An interim *S. spinulosa* survey is being planned for 2020. The scope of this survey will be agreed with the MMO and Natural England and it will encompass the full section of the offshore cable corridor that overlaps with the SAC.

37. A pre-construction survey will be undertaken within 12 months of any cable installation works and the methodology for the pre-construction surveys will be agreed with the MMO in consultation with Natural England.

38. The results of these surveys will be used to plan the routing of cables including micrositing where possible (see Section 4.2).

4.2 Micrositing

39. Norfolk Vanguard Limited is committed to micrositing around Annex 1 reef where there is sufficient space to route the cables around reef identified during interim survey (due to commence in 2020) and the pre-construction surveys. The commitments made by Norfolk Vanguard Limited to date (Section 4.1), in particular the HVDC export solution to decrease the number of cable trenches from six to two, makes it highly likely that micrositing will be possible.

40. As discussed in Section 4.1.2 and Section 5, a pre-construction survey would be undertaken within 12 months of any cable installation works and the results of this survey would inform the final routing/micrositing of cables.

41. The interim survey and pre-construction survey will be used to plan the cable routes for the two Norfolk Vanguard cable trenches as well as the two Norfolk Boreas[2] trenches. Depending on the duration between cable installation for the projects, further pre-construction surveys may be required to ensure these are undertaken within 12 months of the installation works for Norfolk Boreas. Further small scale micrositing would be undertaken where possible within the confines of the initial cable route plan, should reef have developed since the first pre-construction survey.

42. The detailed cable route, including micrositing, must be agreed with the MMO in consultation with Natural England before any installation works, including seabed preparation can commence.

4.2.1 Likelihood of successful micrositing

43. As discussed in the Information to Support HRA report (document 5.3), Norfolk Vanguard Limited commissioned a Cable Constructability Assessment by Global

[2] This document relates to Norfolk Vanguard alone, however consideration will also be given to Norfolk Boreas to ensure mitigation solutions are compatible for both projects.

Marine Systems Ltd (provided in Appendix 4.2 of the ES) to determine an appropriate cable corridor width of approximately 2km to 4.7km (a combined corridor for Norfolk Vanguard and Norfolk Boreas).

44. The space available for micrositing within the offshore cable corridor where it overlaps with the HHW SAC is a width of approximately 1.05km along most of the route (where the corridor width is 2km), with up to 3.75km of micrositing available in the 'dog-leg' area (where the corridor width is 4.7km). This takes into account the space required for Norfolk Boreas export cables[3]. The space available for micrositing is based on the following worst case scenario:

- Up to four export cable trenches (four cables in 2 trenches for Norfolk Vanguard and four cables in two trenches for Norfolk Boreas) with spacing as shown in Plate 4-1;
- The cable corridor is typically 2km in width, with a wider section of up to 4.7km where there is a dog-leg in the corridor within the SAC;
- A total width of approximately 1.35km is required for Norfolk Vanguard and Norfolk Boreas; which includes up to four cables (laid in pairs, i.e. two trenches) for each project, a contingency of 440m (0.4km), an anchor placement zone, and a buffer for potential anchor placement and cable replacement works (GMSL, 2016 unpublished; Plate 4-1); and
- The remaining width of the offshore cable corridor within the SAC is therefore approximately 0.65km to 3.35km plus the built-in contingency of 0.4km, resulting in approximately 1.05km to 3.75km available for micrositing.

[3] This SIP is for Norfolk Vanguard alone, however the space available for micrositing within the cable corridor must take account of Norfolk Boreas.

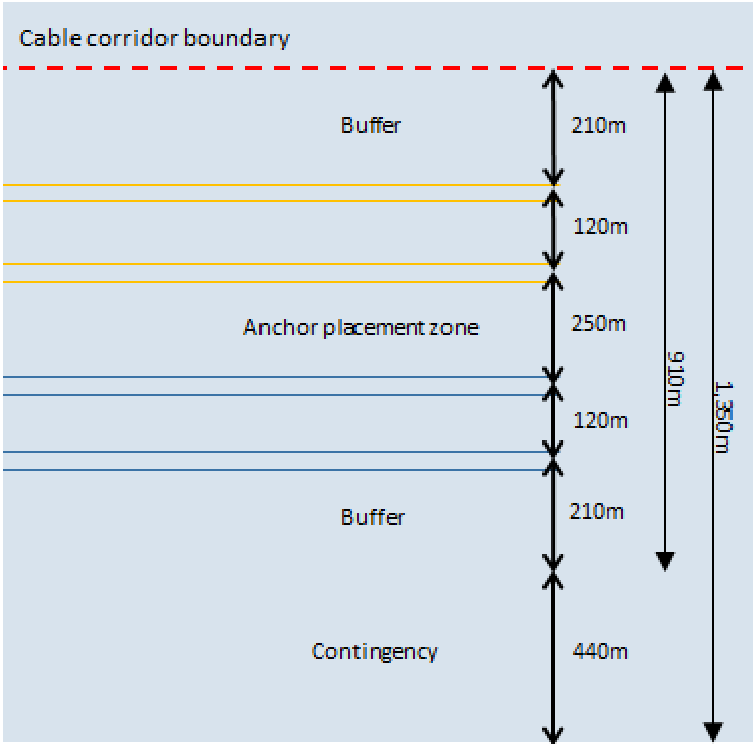


Plate 4-1 Export cables layout (two pairs of cables for Norfolk Vanguard (yellow) and two pairs of cables for Norfolk Boreas (blue)) based on 48m water depth[4]

4.3 Cable installation and seabed preparation

45. As discussed above, the commitments made by Norfolk Vanguard Limited to date (Section 4.1), in particular the HVDC export solution, greatly reduce the impact area and duration of cable installation by reducing the number of cable trenches from six to two.

46. Cables will be buried where the substrate allows burial to a depth of at least 1m. Should burial not be possible (e.g. in hard clay and sedimentary rocks), remedial action would be discussed with Natural England and the MMO (see Section 4.5.2). The circumstances within which cable burial would be deemed not possible and the approach if these circumstances are encountered (e.g. requirement for cable protection outside the priority areas to be managed as reef, Section 4.5.2), will be agreed with the MMO in consultation with Natural England, prior to construction.

47. In response to requests from Natural England during the Norfolk Vanguard Examination, the Applicant commissioned an Interim Cable Burial Study (Appendix 2) which was based on geophysical, geotechnical and environmental surveys carried

[4] The separation between cables is determined by the potential space required to undertake a cable repair which is a factor of the water depth. Depth in the SAC is less than 48m and therefore this represents a conservative worst case scenario

out by Fugro Survey B.V. in 2016 with 100% coverage of the offshore export cable corridor, including the area within the HHW SAC. This has identified that at least 95% of the offshore export cable length within the HHW SAC is likely to be able to be buried and no cable protection will be required within the priority areas to be managed as reef.

48. Section 5.4.13 of ES Chapter 5 provides a description of the cable laying process, including seabed preparation and potential installation methods. This includes:

- Boulder clearance (if required)
- Pre-lay grapnel run
- An option of pre-sweeping to level sandwaves to a reference seabed level that would minimise the potential for cables becoming unburied
- Cable burial methods, e.g.:
    - Ploughing
    - Trenching or cutting
    - Jetting

49. There will be a minimum separation of 75m between cable pairs (as shown in Figure 11 of the Export Cable Installation Study, ES Appendix 5.1) and the maximum width of disturbance from pre-sweeping is 37m (Section 7.3.2.2.1 of the Information to Support HRA report), therefore there would be no repeated disturbance of the same footprint during construction.

50. If sandwave levelling is undertaken as part of the installation strategy, this would be completed at an appropriate period before the installation of each cable pair to ensure that recovery of sandwaves does not occur prior to the installation of cables. This is likely to be in the order of weeks prior to cable installation.

51. The aim of the installation strategy for cables in the SAC would be to bury cables below the mobile sandwaves where substrate conditions allow, to avoid or minimise the requirement for routine re-burial of cables during the operational phase. This will be considered through the design and execution of the installation process, taking account of relevant knowledge regarding seabed morphology and mobility. In order to achieve this aim, it is acknowledged that some seabed preparation activities may be required prior to cable installation. While appropriate steps should be taken to control and mitigate the additional impacts of these works (e.g. sediment disposal, see section 4.3.1), the aim of securing the long-term burial and protection of the cables is the priority.

52. Norfolk Vanguard Limited acknowledges that Natural England has experienced situations (notably during and after the construction of other offshore wind projects in the Greater Wash area) where the outcome of cable installation operations has

fallen short of the undertakings that were made by developers and contractors prior to construction. Norfolk Vanguard can benefit from this experience and underpin the proposed plans (i.e. detailed design and installation methodology) by establishing a comprehensive evidence base to provide confidence that execution of the burial strategy will meet the relevant burial requirements. Where applicable, this should be achieved by citing previous projects where similar design approaches, installation methods and tools have been used together with evidence that comparable, successful outcomes were achieved. Table 4.1 outlines a scope of work that Norfolk Vanguard Limited intends to carry out in order to develop detailed plans for installation of cables in the HHW SAC, and the associated evidence base to support these plans.

53. The methodology will be informed by the pre-construction survey data and any available evidence from other relevant projects and must be agreed with the MMO in consultation with Natural England.

Table 4.1 Process for identifying a one-off burial strategy

Brief description	Activities and aims
Learning from other projects	Norfolk Vanguard Limited will undertake a 'lessons learned' exercise focusing on other projects with challenges regarding installation of subsea cables in mobile sediments. The aim will be to identify the key areas of under-performance, the primary causes of the under-performance, and 'steps to take' to avoid similar adverse outcomes.
Identifying successes	Norfolk Vanguard Limited will undertake a review of subsea cable installation projects which have also faced challenges relating to mobile sediments, but where burial objectives were generally achieved. The aim will be to compile evidence relating to successful design approaches, methods and tools.
Designing interim survey of SAC	Norfolk Vanguard Limited will design an interim offshore survey campaign to inform the development of the HHW SAC CSIMP . The primary aim of the survey will be to inform understanding of the extent and character of *Sabellaria* reef within the cable corridor.
Execution of interim survey	Norfolk Vanguard Limited will procure and manage the survey activity as per the survey design (see previous row). This survey is due to commence in 2020.
Defining burial targets	Norfolk Vanguard Limited will undertake a geotechnical assessment of the seabed in the SAC, and a Cable Burial Risk Assessment (CBRA) to determine the required depth of burial for the export cables through the SAC.
Burial tool capability study	Norfolk Vanguard Limited will undertake a review of the burial tool market, informed by the initial geotechnical and CBRA work described above. The aim will be to identify tools that will be suitable for the burial requirements in the SAC, and to define the key technical requirements (relating to tool design and burial capability) to be used for procurement of the cable installation contract.
Sandwave characterisation study - cable installation strategy	Norfolk Vanguard Limited will undertake a sandwave characterisation study, focusing on the part of the cable corridor that falls within the SAC. In parallel, Norfolk Vanguard Limited will also develop a strategy for installation of cables through areas of sandwaves. This strategy will define the seabed preparation works that would be required, the required timing of these works in relation to the cable installation activity, and the relationships between the preparation works, the reference seabed level, the target burial depth and the capability of the burial tool itself. The strategy will also consider the suitability of different methods/tools for sandwave levelling, and the selection of areas in the SAC for disposal of seabed material arising from this process. The final HHW SAC CSIMP will contain a pre-construction sandwave levelling report as requested by Natural England within their Relevant Representation (RR-099).

4.3.1 Further mitigation regarding cable installation and seabed preparation

54. Following the publication of the relevant representation made by Natural England for Norfolk Boreas (RR-099), where Natural England state: "*Examples of mitigation measures undertaken by other activities in HHW SAC include reduction of footprint associated with vessel stabilisation through use of alternative work vessels*". Norfolk Vanguard Limited has made the commitment not to use Jack-up vessels within the SAC and will use alternative work vessels in the SAC during the construction and operation of Norfolk Vanguard.

4.4 Sediment disposal

55. Norfolk Vanguard Limited has committed to the disposing of sediment arising from the HHW SAC back into the SAC to ensure no sediment is lost from the system, enabling recovery of the Sandbanks (discussed further in Section 5.4 of Appendix 7.1 of the Information to Support HRA report). Further commitment to additional mitigation designed to ensure this process occurs rapidly has also been made (see section 4.4.1).

56. Disposal licence HU213 relates to the Norfolk Vanguard Order Limits within the HHW SAC. Up to 500,000m^3 of sediment may be dredged from the SAC over an area of 250,000m^2. Any sediment arising from the SAC will be deposited within the SAC based on the analysis of pre-sweeping volumes presented in ES Appendix 5.1 Cable Installation Study. The final HHW SAC CSIMP will contain a detailed a pre-construction sandwave levelling report.

57. The location(s) of sediment disposal must include a minimum buffer of 50m from *S. spinulosa* reef and will therefore be informed by the pre-construction surveys.

58. The methodology for disposal will be informed by the detailed design following the interim and pre-construction surveys. The detail of the agreed sediment disposal strategy within the SAC will be provided within the final HHW SAC CSIMP.

59. A primary aim of the sediment disposal strategy (i.e. locations and methodology for disposal) will be to facilitate recovery. The strategy will therefore also be informed by any available evidence regarding recovery from other relevant projects and the commitments made to expedite recovery presented in section 4.4.1.

60. The location(s) and methodology for disposal must be agreed with the MMO in consultation with Natural England before works can commence.

4.4.1 Further mitigation in relation to sediment disposal

61. Following the publication of the relevant representations for Norfolk Boreas made by Natural England (RR-099) and the MMO (RR-069) and additional consultation with

both organisations, Norfolk Vanguard Limited has committed to the following additional mitigation measures should sandwave levelling be permitted. Norfolk Vanguard Limited will:

- Dispose of any material dredged from the seabed for sandwave levelling (also referred to as pre-sweeping) in a linear "strip" along the cable route.
- Dispose of material close to the seabed. This will be achieved through the use of fall pipe (also referred to as a down pipe) employed by the dredging vessel.
- Always attempt to bury any exposed cable within the HHW SAC prior to installing additional cable protection (placement of cable protection in new areas would be subject to a separate marine licence, see the Outline Operation and Maintenance Plan document reference 8.11 for further details).
- No use of Jack up vessels within the HHW SAC.

4.4.1.1 Disposal of dredged material in a linear strip close to the sea bed

62. It is recognised that it may not be possible to observe all the criteria proposed for sediment disposal at all locations and therefore when determining the location of disposal areas within the SAC the following criteria would be used:

- Priority 1 – material to be disposed of no closer than 50m to any *S. spinulosa* reef (see section 4.4).
- Priority 2- Dispose of material up drift of the cable route, to allow infill to occur as quickly as possible following cable installation.
- Priority 3 - Dispose of material as close as possible to cable route.

63. In order to ensure that material is deposited at the most appropriate locations to fulfil the criteria above Norfolk Vanguard Limited will make the commitment that, should sandwave levelling be required and permitted, material will be disposed of using a fall pipe (as discussed above), employed by the dredging vessel.

4.5 Cable protection

64. Norfolk Vanguard Limited is committed to minimising cable protection and has already made significant reductions through embedded mitigation, in particular the commitment to use HVDC cables, requiring two cable pairs as opposed to six individual cables and therefore reducing the total number of crossings and the potential length of cable which may be unburied (Section 4.1.1).

65. Norfolk Vanguard Limited is committed to using only essential cable protection (i.e. where required for cable/pipeline crossings (see Section 4.5.1) and should burial not be possible for sections of the cable length (see Section 4.5.2)), in order to minimise effects on the HHW SAC.

66. Section 5.4.14 of ES Chapter 5 provides a description of the types of cable protection that may be deployed at Norfolk Vanguard, however, only essential cable protection up to the maximum values referred to in Section 4.5.3 will be used. This will be determined based on the results of the pre-construction survey and any crossings agreements. Prior to installation the need, type, sources, quantity (up to the maximum values presented below), distribution and installation method must be agreed with the MMO in consultation with Natural England.

4.5.1 Cable and Pipeline Crossings

67. An estimate of five existing cables and one pipeline within the HHW SAC which each Norfolk Vanguard export cable would need to cross has been included in the calculation of the total area and volume of cable protection assessed in the ES and Information to Support HRA report and included in the parameters secured in the draft DCO. The estimated maximum width and length of cable protection for cable crossings would be 10m and 100m, respectively. The maximum height of cable crossings is 0.9m.

68. In addition, every effort is being made by the Applicant to reduce the number of crossings by removing disused cables where agreement can be reached with the cable owners. An Out of Service Cable Recovery Agreement has been discussed with BT Subsea who own a number of out of service assets within the HHW SAC. Appendix 4 (document reference ExA; Mit; 11.D10.2.App4) demonstrates the advanced stages of these discussions, with a formal agreement expected to be in place imminently.

69. Following the interim and pre-construction surveys and identification of preferred cable routes, Norfolk Vanguard Limited would identify potential crossing requirements and consult with the owner/operators of the cable or pipeline.

70. Consultation would be undertaken with Natural England and the MMO at the earliest opportunity to allow both parties to provide advice on the proposed location, extent, type and quantity of cable protection associated with crossings.

71. Should additional unregistered cables/pipelines be identified during the pre-construction surveys, Natural England and the MMO will be consulted at the earliest opportunity. If an additional crossing can be accommodated using cable protection that is within the maximum values presented in Section 4.5.3, no consent variation would be required, however the proposed location, extent, type and quantity of cable protection associated with crossing the unregistered cable/pipeline would be agreed with the MMO in consultation with Natural England, should it not be possible to remove a section of the unregistered cable/pipeline.

4.5.2 Potential Unburied Cable Due to Ground Conditions

72. As discussed previously, Norfolk Vanguard Limited is committed to burying cables where substrate conditions allow and therefore minimising cable protection. In addition, in response to requests from Natural England during the Norfolk Vanguard Examination, the Applicant commissioned an Interim Cable Burial Study (Appendix 2) which identified that at least 95% of the offshore export cable length within the HHW SAC is likely to be able to be buried. As a result, the length of potential cable protection required for unburied cable is 5% of the offshore export cable length within the HHW SAC, in addition to cable protection for cable/pipeline crossings (see Sections 4.5.1 and 4.5.3). This 5% represents a significant reduction in cable protection for unburied cables from the 10% assessed in the ES and Information to Support HRA report. In addition, only essential cable protection within the 5% will be used where burial is not possible due to encountering hard substrates (e.g. hard clay and sedimentary rocks) within the top 1-2m of the seabed. As discussed in Section 4.3, the circumstances within which cable burial would be deemed not possible and the approach (e.g. number of burial attempts) if these circumstances are encountered would be agreed with the MMO in consultation with Natural England, prior to construction.

73. Prior to installation, the location, extent, type and quantity of any cable protection must be agreed with the MMO in consultation with Natural England.

4.5.3 Total area and volume of cable protection in the SAC

74. The total area and volume of cable protection in the SAC for unburied cables and cable/pipeline crossing will not exceed 32,000m^2 and 20,800m^3 based on the parameters described above.

4.5.4 Further mitigation in relation to cable protection

4.5.4.1 No cable protection in priority areas to be managed as reef

75. Due to further mitigation measures and information provided in Appendix 3, the location for such cable protection is not likely to overlap with areas to be managed as *S. spinulosa* reef. Therefore, the Applicant has made a commitment not to install any cable protection in the priority areas to be managed as reef within the HHW SAC, unless otherwise agreed with the MMO in consultation with Natural England. This commitment means that, as the top priority areas to be manage as *S. spinulosa* Annex I reef are avoided, the cable protection cannot hinder the achievement of the conservation objective of maintain or restore the *S. spinulosa* Annex I reef to a favourable condition (Natural England & JNCC, 2018). Therefore, this ensures that any small scale permanent loss of habitat within the SAC would be inconsequential to the conservation objectives of Annex I reef.

4.5.4.2 Decommissioning of cable protection

76. Following a review of the supply chain, the Applicant has made a further commitment to decommission cable protection at the end of the Norfolk Vanguard project life where it is associated with unburied cables due to ground conditions (where required for crossings this will be left *in situ*).

77. Further detail on the methods for decommissioning is provided in Appendix 3 of the Additional Mitigation document (document reference ExA; Mit; 11.D10.2.App3).

78. This commitment ensures that there will be no permanent habitat loss as a result of cable protection and further contributes to the ability to conclude no AEoI of the HHW SAC. This is discussed further in Appendix 2 of the Additional Mitigation document (document reference ExA; Mit; 11.D10.2.App2).

4.6 Maintenance

79. During the life of the project, there should be no need for scheduled repair or replacement of the subsea cables, however periodic inspection would be required and where necessary, reactive repairs and reburial would be undertaken. This is considered further below.

4.6.1 Cable repairs

80. While it is not possible to determine the number and location of repair works that may be required during the life of the project, an estimate of one export cable repair every 10 years on average within the SAC is included in the Information to Support HRA.

81. It will be critical that repairs can be instigated rapidly upon identifying a failure, therefore a protocol for undertaking repairs would be agreed with the MMO in consultation with Natural England, prior to construction. Upon identifying a requirement to undertake a repair in the HHW SAC, the repair would be instigated in accordance with agreed protocol and the MMO and Natural England would be notified.

82. The protocol for any subsequent repairs would then be reviewed (if necessary) and agreed with the MMO and Natural England.

83. It is acknowledged that *S. spinulosa* reef can be expected to recover following cable installation and therefore has potential to be affected during maintenance if a repair is required at the location of a reef. The repair protocol discussed above, would include consideration of circumstances where *S. spinulosa* reef may be present at the repair location. As discussed above the protocol would be agreed with the MMO in consultation with Natural England in advance of construction.

4.6.2 Cable reburial

84. As discussed in section 4.3, the aim of the installation strategy for cables in the SAC would be to bury cables below the mobile sandwaves where substrate conditions allow, to avoid or minimise the requirement for routine re-burial of cables during the operational phase.

85. The Information to Support HRA report (document 5.3) considers a worst case scenario that cables could become exposed due to moving sand waves, if sandwave levelling/pre-sweeping were not adopted during the installation phase. During the life of the project, periodic surveys would be required to ensure the cables remain buried and if they do become exposed, re-burial works would be undertaken.

86. Reburial of up to 4km per cable within the SAC at approximately 5 year intervals has been estimated as a worst case scenario and assessed in the Information to Support HRA report based on a worst case scenario that no pre-sweeping is undertaken during cable installation. Should pre-sweeping be permitted the requirement for reburial would be greatly reduced, if not removed.

87. It will be critical that reburial can be instigated rapidly upon identifying exposed cable, therefore the protocol for undertaking reburial would be agreed with the MMO in consultation with Natural England, prior to construction.

88. Upon identifying a requirement to undertake reburial in the HHW SAC, the MMO and Natural England would be notified. The protocol for any subsequent reburial would then be discussed and agreed with the MMO and Natural England.

89. In order to limit the amount of cable protection located within the SAC as far as possible, Norfolk Vanguard Limited has made the commitment to attempt to rebury any cables which become exposed within the SAC during operation prior to the installation of any cable protection. Any placement of cable protection in new areas during operation and maintenance would be subject to a separate Marine Licence.

90. Should sandwave mobility be such that the cables have become unburied, it is unlikely that *S. spinulosa* reef would have formed in this location. However, as discussed above, reburial works would be agreed with the MMO in consultation with Natural England and this would include consideration of any *S. spinulosa* reef at the reburial location.

4.6.3 Cable protection

91. If cable protection were to be required in new areas during maintenance, this would be subject to an additional Marine Licence.

4.7 Overview of Mitigation Commitments in the HHW SAC

Table 4.2: Overview of Mitigation Commitments in the HHW SAC

Pre-consent Mitigation Commitments	Status	Final Mitigation solution following detailed design	Agreed with MMO in consultation with Natural England
Use of HVDC export cable solution to reduce the no. of cable trenches from six to two	Not subject to change	N/A	✓
Pre-construction survey to be undertaken within 12 months of commencing works	Survey methodology to be agreed with MMO in consultation with Natural England	To be confirmed	To be confirmed
Seabed preparation – potential use of pre-sweeping to minimise reburial	To be confirmed based on the pre-construction survey data, any relevant available evidence from other projects and agreed with the MMO in consultation with Natural England	To be confirmed	To be confirmed
Sediment disposal - up to 500,000m^3 of sediment arising from the SAC may be deposited within the SAC	The volume (up to this maximum) will be a factor of whether/or to what extent pre-sweeping is used (see above) and this will be agreed with the MMO in consultation with Natural England. The location and method for disposal will be agreed with the MMO in consultation with Natural England as shown below.	To be confirmed	To be confirmed
Sediment disposal – location(s) to be agreed with the MMO in consultation with Natural England	To be confirmed based on the pre-construction survey data and detailed design and agreed with the MMO in consultation with Natural England.	To be confirmed	To be confirmed
Sediment disposal - method to be agreed with the MMO in consultation with Natural England	To be confirmed based on the pre-construction survey data, any relevant available evidence from other projects and agreed with the MMO in consultation with Natural England	To be confirmed	To be confirmed
Cable installation – at least 95% of the cable length in the SAC will be buried to at least 1m. Any areas of unburied cable will be discussed with Natural England and the MMO (see also Cable Protection below)	To be confirmed based on the pre-construction survey data and detailed design and agreed with the MMO in consultation with Natural England	To be confirmed	To be confirmed
Cable installation – micrositing and cable route to be agreed with the MMO in consultation with Natural England	To be confirmed based on the pre-construction survey data and detailed design and agreed with the MMO in consultation with Natural England	To be confirmed	To be confirmed
Cable installation method to be agreed	To be confirmed based on the pre-construction survey data and	To be confirmed	To be confirmed

Pre-consent Mitigation Commitments	Status	Final Mitigation solution following detailed design	Agreed with MMO in consultation with Natural England
with the MMO in consultation with Natural England	detailed design and agreed with the MMO in consultation with Natural England		
Cable protection – up to 5% of the cable length within the SAC may require cable protection (reduction from 10%)	To be confirmed based on the pre-construction survey data and detailed design and agreed with the MMO in consultation with Natural England	To be confirmed	To be confirmed
The total area and volume of cable protection in the SAC will not exceed 32,000m^2 and 20,800m^3, respectively	Only essential cable protection up to these maximum values will be used and prior to installation the location, extent, type and quantity must be agreed with the MMO in consultation with Natural England. This will be determined based on the results of the pre-construction survey and any crossings agreements.	To be confirmed	To be confirmed
Cable repairs – approximately one cable repair every 10 years within the SAC has been assessed but any repairs would be agreed with the MMO in consultation with Natural England	The methodology for undertaking repairs would be agreed with the MMO in consultation with Natural England, prior to construction to allow a rapid response during the maintenance phase if repairs are required. Upon identifying a requirement to undertake a repairs in the HHW SAC, the MMO and Natural England would be notified. The approach for any subsequent repairs would then be discussed and agreed with the MMO and Natural England.	To be confirmed	To be confirmed
Cable reburial - approximately 10km per cable within the SAC at approximately 5 year intervals has been assessed but any reburial would be agreed with the MMO in consultation with Natural England	The methodology for undertaking reburial would be agreed with the MMO in consultation with Natural England, prior to construction to allow a rapid response during the maintenance phase if reburial is required. Upon identifying a requirement to undertake reburial in the HHW SAC, the MMO and Natural England would be notified. The approach for any subsequent reburial would then be discussed and agreed with the MMO and Natural England.	To be confirmed	To be confirmed
Additional Mitigation			
A series of additional measures relating to the sediment disposal methodology	As a result of concerns raised for Norfolk Boreas by Natural England in their Relevant Representation (RR-099) the Applicant has committed to: • disposing of any dredged sediment close to the seabed using a fall pipe from the dredging vessel,	Confirmed	To be confirmed

Pre-consent Mitigation Commitments	Status	Final Mitigation solution following detailed design	Agreed with MMO in consultation with Natural England
	• disposing of sediment within a linear strip close to the cable route; and • disposing of material updrift of the cable route to allow infill of any dredged areas as soon as possible following cable installation		
Cable Reburial- If cable becomes exposed at any point during operation, reburial will be attempted before any cable protection is considered.	As a result of concerns raised for Norfolk Boreas by Natural England and the MMO in their Relevant Representations (RR-099 and RR-069). Norfolk Vanguard Limited has committed to attempting to rebury any exposed cable rather than adding cable protection. If after unsuccessful attempts to rebury the cable, cable protection is required this would only be installed following the attainment of a separate marine license. As part of this license the additional cable protection would be subject to agreement with the MMO in consultation with Natural England.	Confirmed	To be confirmed
Installation vessels – no jack up vessels will be used during construction within the HHW SAC.	The Applicant has made this commitment in response to advice provided by Natural England in their Norfolk Boreas Relevant Representation (RR099). This commitment was made as a result of comments made in both Natural England's (RR-099) and The MMO's (RR-69) Relevant Representation on Norfolk Boreas.	Confirmed	To be confirmed
Interim *S. spinulosa* reef survey to commence in 2020	Survey methodology to be agreed with MMO in consultation with Natural England	To be confirmed	To be confirmed
Cable protection – commitment not to install any cable protection in the "*priority areas to be managed as S. spinulosa Annex I reef*" identified by NE within the HHW SAC, unless otherwise agreed with the MMO in consultation with NE.	The Applicant has made this commitment in response to the Department for Business, Energy and Industrial Strategy (BEIS) letter of 6 December which states: *'The Applicant in consultation with the Marine Management Organisation and Natural England as necessary, is invited to provide information on the specific mitigation solutions that would address the potential effects of cable protection on the SAC features."* Therefore, further mitigation measures to address the potential effects of cable protection on the SAC features are being proposed by the Applicant. The effectiveness of the proposed mitigation on	Confirmed	To be confirmed

Pre-consent Mitigation Commitments	Status	Final Mitigation solution following detailed design	Agreed with MMO in consultation with Natural England
	the HHW SAC designated features has been assessed and the outcome of the original HRA (document 5.3) remains unchanged; no AEoI of the designated features of the HHW SAC.		
Cable protection – commitment to decommission cable protection at the end of the project life where it is associated with unburied cables due to ground conditions (where required for crossings this will be left in situ).	Further detail on the methods for decommissioning is provided in Appendix 3 of the Additional Mitigation document (document reference ExA; Mit; 11.D10.2.App3). This commitment ensures that there will be no permanent habitat loss as a result of cable protection and further contributes to the ability to conclude no AEoI of the HHW SAC. This is discussed further in Appendix 2 of the Additional Mitigation document (document reference ExA; Mit; 11.D10.2.App2).	Confirmed	To be confirmed

5 MONITORING

92. Following the assessment of potential effects and identification of mitigation measures, consideration will be given to the requirement for monitoring within the HHW SAC.

93. The details of monitoring in the HHW SAC will be agreed with the MMO in consultation with Natural England prior to construction. Table 5.1 provides an overview of the likely monitoring within the HHW SAC.

94. In addition to the environmental survey and monitoring required as conditions of the DMLs within the Development Consent Order (DCO), additional studies will be undertaken for the project for engineering and design purposes. Some of these will overlap with the conditioned monitoring and wherever possible the Applicant will look to combine surveys for monitoring purposes with those already being carried out for engineering purposes. Examples of these surveys are:

- Geophysical;
- Geotechnical;
- Unexploded ordnance (UXO) survey and clearance; and
- Cable burial survey.

Table 5.1 In Principle Monitoring within the HHW SAC

Potential Effect	Receptor/s	Phase	Headline reason/s for monitoring	Monitoring Proposal	Details
Changes in seabed topography, including scour processes	Sandbanks	Pre-construction	• Engineering and design purposes • Input in to benthic and other related ecological surveys and monitoring requirements as agreed with the MMO in consultation with SNCBs	A single survey within the cable corridor survey areas using full sea floor coverage swath-bathymetric undertaken to IHO S44ed5 Order 1a standard and side-scan surveys of the area(s) within the Order limits in the SAC in which it is proposed to carry out construction works, including a 500m buffer area around the site of each works. (The "site of each works" being the area within the Order limits which is actually taken forwards to construction noting that it is possible that certain areas within the Order limits may not be developed.)	Scope of surveys and programmes and methodologies for the purposes of monitoring shall be submitted to the MMO for written approval at least 4 months prior to the commencement of any survey works.
		Post-construction	• Structural integrity / engineering (scour) • Cable burial • Monitoring of recovery at the location of works	A single survey within the agreed cable corridor survey areas using full sea floor coverage swath-bathymetric surveys undertaken to IHO S44ed5 Order 1a standard and side scan sonar surveys around the footprint of the cable installation works to assess any changes in seabed topography. For this purpose the undertaker will, prior to the first such survey, submit a desk based assessment	
Effects on *S. spinulosa* reef	*S. spinulosa* reef	Post-consent	Determine the location and extent of any *S. spinulosa* reef within areas of the Order limits in the SAC in which it is proposed to carry out construction works to inform initial cable route selection.	• A single geophysical (sidescan or Multi-Beam Echo Sounder) survey of those areas of the SAC within which it is proposed that seabed works will be carried out at a resolution sufficient to identify potential *S. spinulosa* reef; and • In areas where potential *S. spinulosa* reef is identified from the review of the geophysical data, further survey e.g. drop down video will be deployed to confirm presence, extent and elevation.	Survey methodologies shall be agreed with the MMO in consultation with Natural England.
		Pre-construction	Determine the location and extent of any *S. spinulosa* reef within areas of the Order limits in the SAC in which it is proposed to carry out construction works to inform the appropriate mitigation if found	• A single geophysical (sidescan or Multi-Beam Echo Sounder) survey of those areas of the SAC within which it is proposed that seabed works will be carried out at a resolution sufficient to identify potential *S. spinulosa* reef; and • In areas where potential *S. spinulosa* reef is identified from the review of the geophysical data, further survey e.g. drop down video will be deployed to confirm presence, extent and elevation.	• Survey programmes and methodologies for the purposes of monitoring shall be submitted to the MMO for written approval in accordance with the timeframes set out in the DMLs • Surveys may occur up to 12 months prior to the proposed construction works
		Post-construction	The requirement for post-construction monitoring will be dependent on the findings of the pre-construction surveys.	• Where no *S. spinulosa* reef is identified by the pre-construction geophysical survey of the proposed works (and associated buffers), no further post-construction surveys will be undertaken; • Where *S. spinulosa* reef is identified during the pre-construction survey and cannot be entirely avoided through micrositing, a single post-construction survey, specifically targeting those reefs identified in the baseline survey will be undertaken as a check on their condition using the same methodology set out for pre-construction monitoring.	• If required, survey programmes and methodologies for the purposes of monitoring shall be submitted to the MMO for written approval in accordance with the timeframes set out in the DMLs and conducted within the first year post commissioning of the proposed wind farm. • The duration over which monitoring of recovery is required would be agreed with the MMO following review of the post-construction survey data.

6 SUMMARY

95. The final HHW SAC CSIMP will provide detail on the cable specification, installation methods and mitigation and monitoring within the HHW SAC based on the findings of the pre-construction survey and final design. The CSIMP will be developed in consultation with the MMO and Natural England and the final CSIMP must be agreed with the MMO in consultation with Natural England.

96. The following engineering work streams and offshore surveys have been identified to inform the development of the final HHW SAC CSIMP:

- Review of available information from other offshore wind and cabling projects;
- Pre-construction survey(s);
  - Geophysical survey within the offshore cable corridor in the HHW SAC;
  - Targeted *S. spinulosa* reef surveys within the offshore cable corridor in the HHW SAC (through the interim and pre-construction surveys);
  - Geotechnical assessment of the seabed within the offshore cable corridor in the HHW SAC;
- A Cable Burial Risk Assessment;
- A burial tool capability study;
- A sandwave characterisation study; and
- A cable installation strategy.

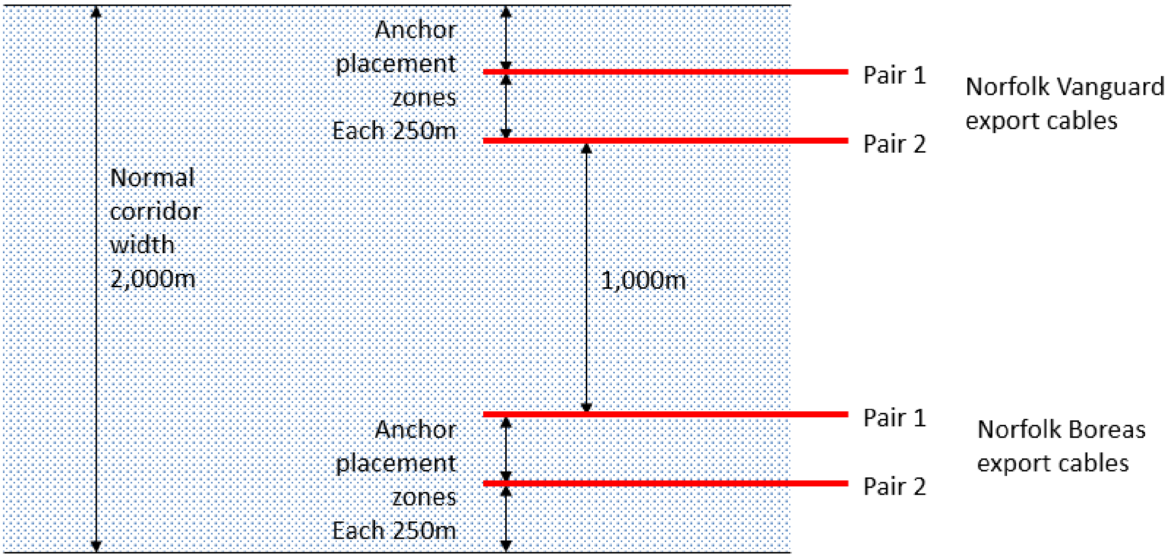
97. These will be developed and undertaken in consultation with the MMO and Natural England. The results of these studies will inform the identification of mitigation measures (section 4) in the final HHW SAC CSIMP.

7 REFERENCES

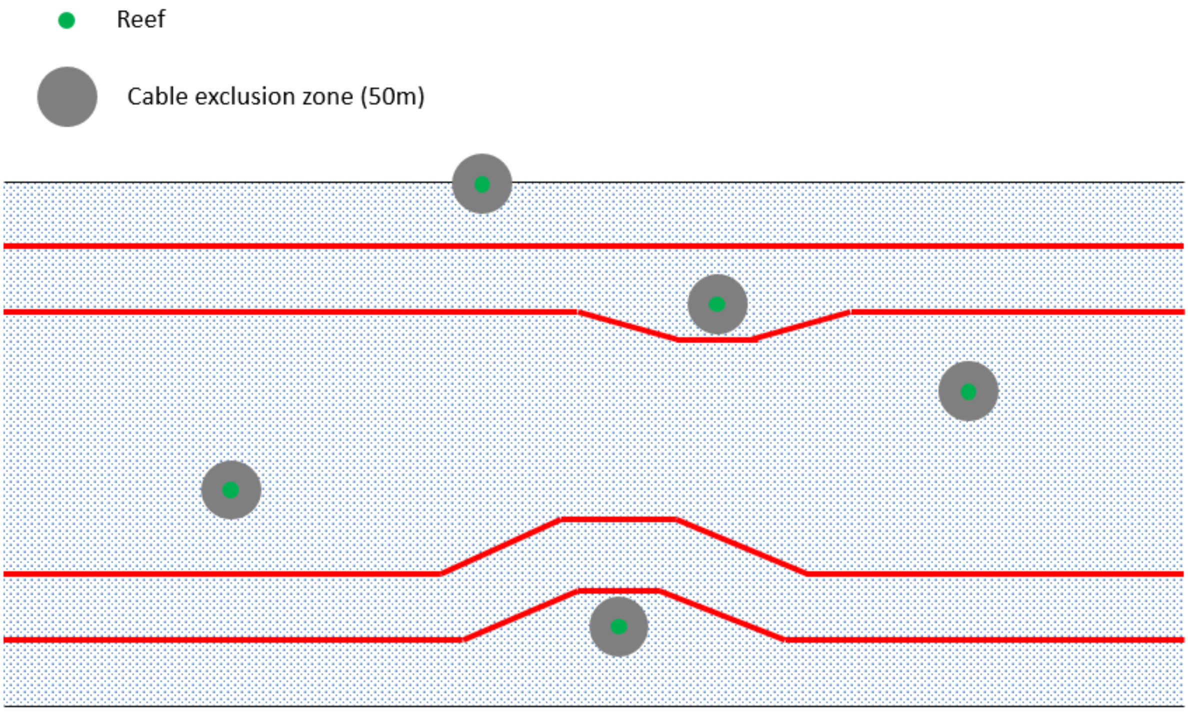
DEFRA (2016). Joint Recommendation regarding the protection of Sandbanks slightly covered by seawater all the time and Reefs features within the North Norfolk Sandbanks and Saturn Reef Site of Community Importance and the Haisborough, Hammond and Winterton Site of Community Importance under the Habitats Directive 92/43/EEC of 21 May 1992 under Articles 11 and 18 of Regulation (EU) No 1380/2013 of the European Parliament and of the Council of 11 December 2013 on the Common Fisheries Policy (the Basic Regulation). Available at: https://lbst.dk/fileadmin/user_upload/NaturErhverv/Filer/Fiskeri/Natura_2000_hav/Fiskeriregulering_i_andre_lande/WORKING_Draft_NNSSR_HWW_Joint_Recommendation_v0.7.pdf
JNCC & Natural England, 2009 Offshore Special Area of Conservation: Haisborough, Hammond and Winterton Draft Conservation Objectives and Advice on Operations. Available at: http://jncc.defra.gov.uk/pdf/HaisboroughHammondandWinterton_ConObsAOO_FINAL_2_0_030909.pdf
JNCC & Natural England, 2013 Haisborough, Hammond and Winterton candidate Special Area of Conservation Formal advice under Regulation 35(3) of The Conservation of Habitats and Species Regulations 2010 (as amended), and Regulation 18 of The Offshore Marine Conservation Regulations (Natural Habitats, &c.) Regulations 2007 (as amended) Available at: http://jncc.defra.gov.uk/pdf/HHW_Reg%2035_Conservation%20Advice_v6.0.pdf
Natural England (2018) Offshore wind cabling: ten years' experience and recommendations available at: https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010080/EN010080-001240-Natural%20England%20-%20Offshore%20Cabling%20paper%20July%202018.pdf
Natural England & JNCC (2018) Conservation Advice for Marine Protected Areas Haisborough, Hammond and Winterton SAC. Available at: Natural England and JNCC Conservation Advice for Marine Protected Areas Haisborough, Hammond and Winterton SAC
Natural England (2019) advice note regarding consideration of small scale habitat loss within Special Areas of Conservation (SACs) in relation to cable protection
Natural England (2019b) Site Condition assessment of the Haisborough Hammond and Winteron SAC available at: https://designatedsites.naturalengland.org.uk/Marine/MarineFeatureCondition.aspx?SiteCode=UK0030369&SiteName=haisborough&SiteNameDisplay=Haisborough%2c+Hammond+and+Winterton+SAC&countyCode=&responsiblePerson=&SeaArea=&IFCAArea=

APPENDIX 1 – INDICATIVE MICROSITING OPTIONS

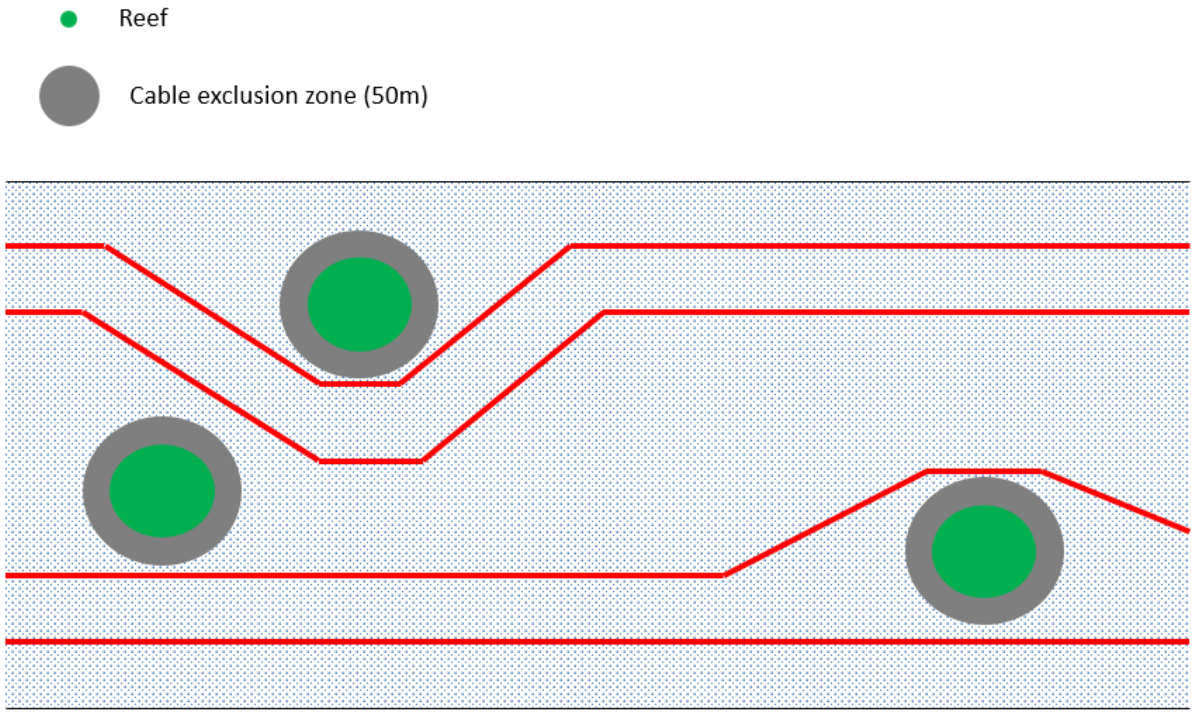
'Normal' placement of cables within the corridor, no constraints



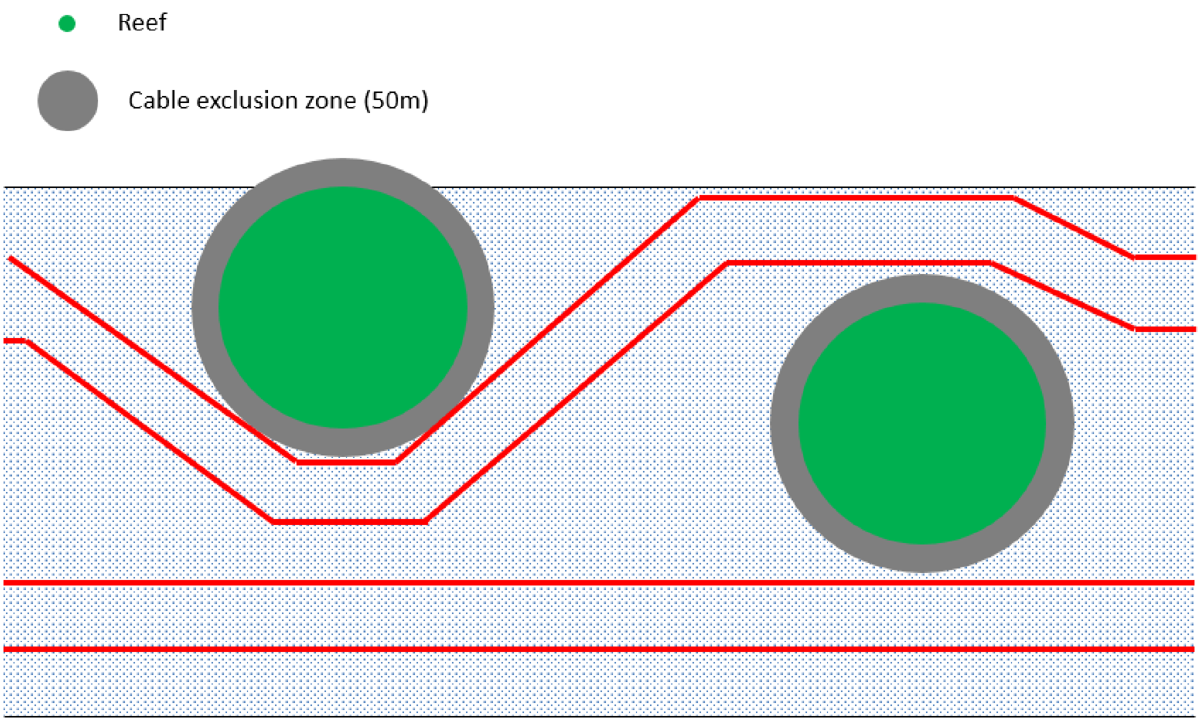
Placement of cables with small areas of reef



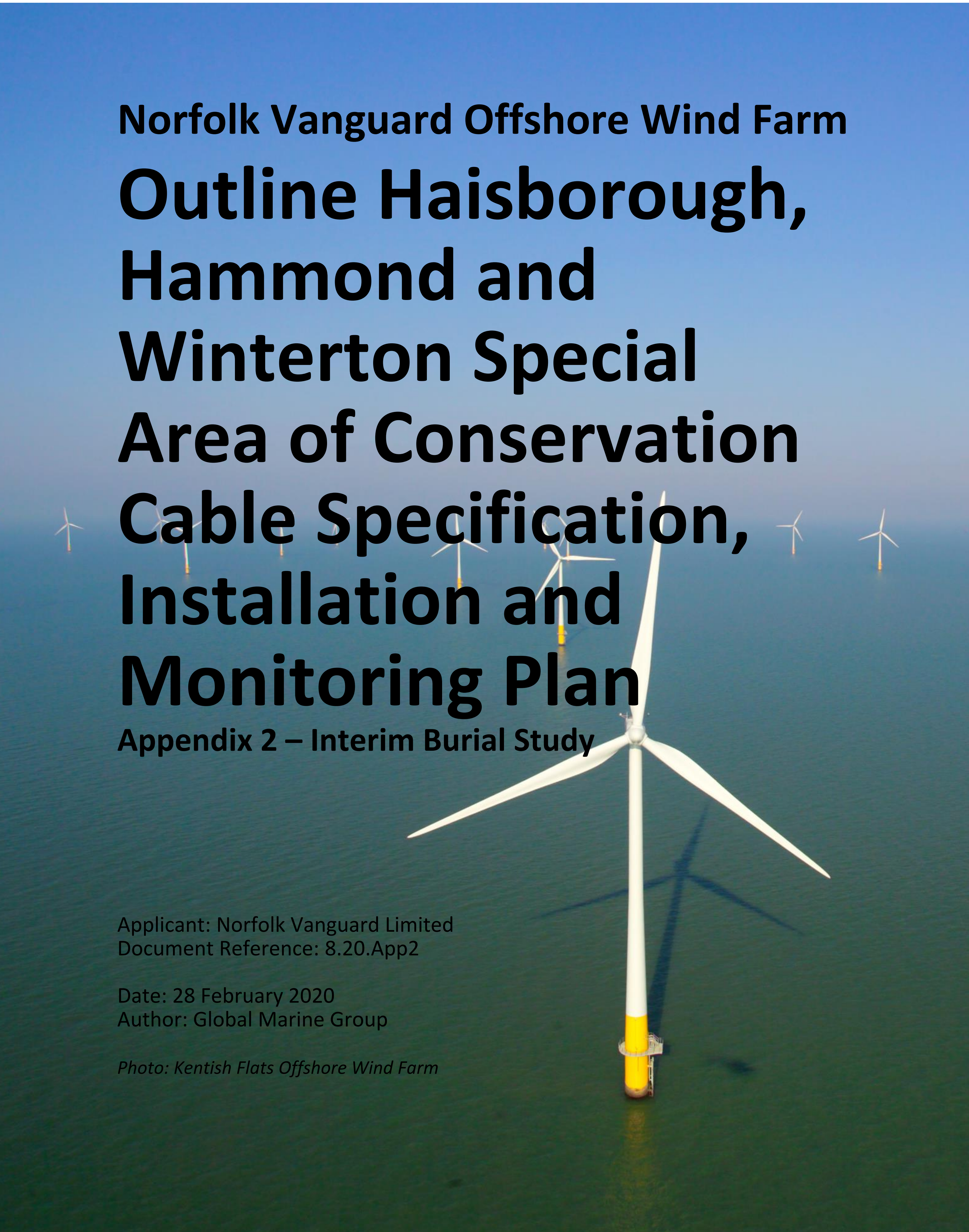
Placement of cables with larger areas of reef



Placement of cables with very large areas of reef



APPENDIX 2 INTERIM CABLE BURIAL STUDY



Norfolk Vanguard Offshore Wind Farm

Outline Haisborough, Hammond and Winterton Special Area of Conservation Cable Specification, Installation and Monitoring Plan

Appendix 2 – Interim Burial Study

Applicant: Norfolk Vanguard Limited
Document Reference: 8.20.App2

Date: 28 February 2020
Author: Global Marine Group

Photo: Kentish Flats Offshore Wind Farm

NORFOLK VANGUARD

PRELIMINARY MPA BURIAL STUDY

2210_NVOWF_Preliminary_Burial_Study_004_190501

REVISION	DATE	ISSUE DETAILS	PREPARED	CHECKED	APPROVED
001	15/03/2019	Draft issue	MW	SW	MW
002	29/03/2019	Draft Final Issue	MW	SW	MW
003	03/04/2019	Final Issue	MW	AR	MW
004	01/05/2019	Updated Final Issue	RD	MW	MW

REVISION	SECTION	PAGES	BRIEF DESCRIPTION OF CHANGES	AUTHORS OF CHANGE
002	2.3.1	9	Details of survey equipment expanded	MW
	2.4	14	Clarified lack of impact of water depths	
	2.5	14	Changed “rock outcrops” to “boulders”	
	2.5	15	Changed “safety clearances” to “separation clearances”	
	2.6	16	Inserted reference to flow volumes	
	2.6.1.1	18	Removed incorrect references to lack of 2m swords for Atlas	
003	-	-	No changes	N/A
004	All	All	Edits for clarification	RD

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ABBREVIATIONS

BMH	Beach Manhole
BSB	Below Seabed
DTS	Desk Top Study
GPS	Global Positioning System
HHW SAC	Haisborough, Hammond & Winterton SAC
LP	Landing Point
OWF	Offshore Wind Farm
RPL	Route Position List
SAC	Special Area of Conservation

1.0 INTRODUCTION

Vattenfall Wind Power are developing the Norfolk Vanguard and Norfolk Boreas offshore windfarms (OWFs). The Norfolk Vanguard development area is located more than 47km from the Norfolk Coast in the North Sea and will meet the electricity demand of around 1.3 million UK households. Norfolk Vanguard has a sister project of the same size called Norfolk Boreas, this project trails one year behind Vanguard in its development.

Both these windfarms will require export cables to carry the power generated back to shore. The export cable corridor runs generally west from the Norfolk Vanguard East, Norfolk Vanguard West and Norfolk Boreas turbine arrays to the landfall near Happisburgh. The export corridor is common for all the windfarm turbine array areas until they diverge to service each array at the eastern end of the corridor. The export cable corridor crosses the Haisborough, Hammond and Winterton Special Area of Conservation (HHW SAC) which has been primarily designated to protect biogenic reefs and sandbanks.

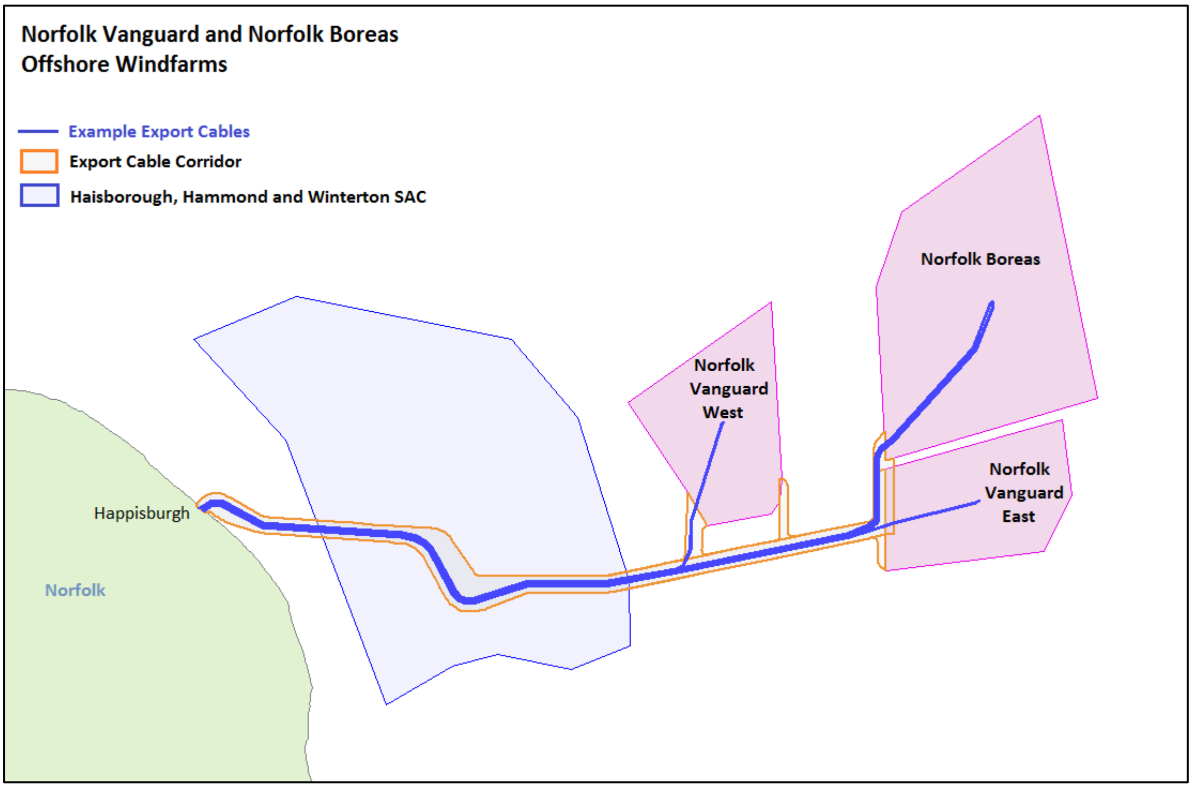


Figure 1: Norfolk Vanguard and Norfolk Boreas Site Overview

Target burial for the export cables is 1.5m below seabed (BSB). Where the burial achieved is <1m additional surface protection such as rock dump or mattresses may be needed. Within the HHW SAC this additional protection may introduce an additional permitting burden to the project. This study aims to analyse the expected burial along the export cable routes within the SAC and highlight areas where additional protection may be needed.

2.0 SITE DESCRIPTION

2.1 Haisborough, Hammond & Winterton SAC

The Haisborough, Hammond & Winterton SAC is designated for two key protected features:

- Reefs
- Sandbanks which are slightly covered by seawater all the time

The reefs are the product of *Sabellaria spinulosa* tube-building ross worms. These tubes are made up of coarse sand and shell fragments cemented together with mucus and can rise between 5-10cm above the surrounding seafloor in the SAC [1]. They can serve as a stable substrate for the development of diverse epifaunal communities and occur in the troughs between sandbanks.

The large sandbanks in the SAC are generally parallel to the coastline with crests that lie just below the sea surface (Figure 2). They are geologically recent; the oldest banks are Hewitt Ridge and Smiths Knoll at around 7,000 years old and the newest are Newarp Banks and North and Middle Cross Sands which date to around 1,500 years ago. Bank age generally increases with distance from shore. The crests of the banks are low-diversity and mainly host amphipods and cat worms that rapidly burrow into the shifting sediment. More diverse assemblages occur in the flanks and troughs of the banks which are more stable and also tend to have a higher gravel fraction in the seabed sediment.

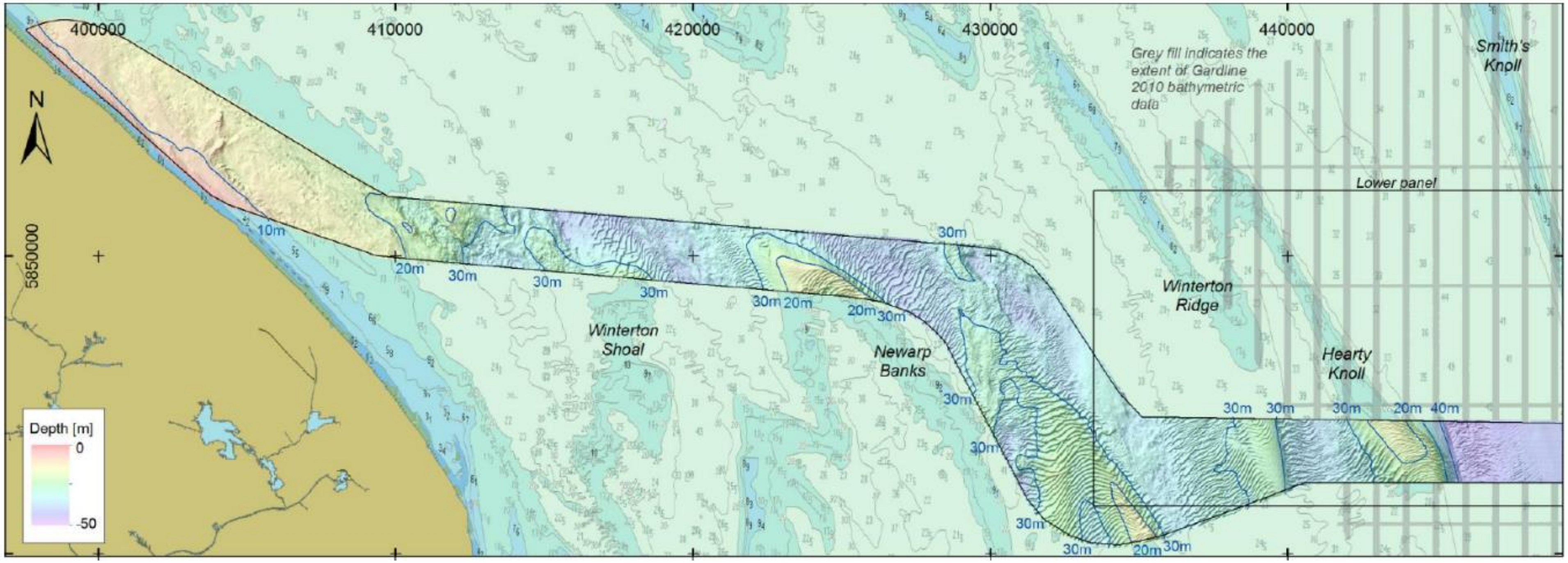


Figure 2: Sandbanks in the project area [2]

2.2 HVDC Export Cable Routes

Vattenfall have decided to use HVDC cables for the export links for Norfolk Vanguard and Norfolk Boreas. The routes used as the basis for this report are therefore the HVDC export routes previously developed by Global Marine Group [3]. Within the HHW SAC there are four distinct cable routes (ie. two per project), each with a planned length around 41.2km. Total cable length within the SAC is 164.866km.

2.3 Data Analysis

2.3.1 Data Sources

The results of two marine surveys have been supplied by Vattenfall, which cover the windfarms and export cable route:

- A geophysical, geotechnical and environmental survey carried out by Fugro Survey B.V. in 2016 with 100% coverage of the export cable routes outside of the OWF areas. This has total coverage of the area within the HHW SAC using single and multibeam echosounders, sub-bottom profiler, magnetometer, sidescan sonar and ultra-high resolution sonar sensors. Co-located cores and cone penetration tests (CPTs) were taken at points along the route, of which seven are within the HHW SAC. The environmental survey was conducted with video and grab samples to classify the biotopes along the area of interest.
- A geophysical survey undertaken by Gardline in 2010 with around 30% coverage of the OWF areas and beyond. This has only a minor overlap with the export cable route within the HHW SAC.

2.4 Seabed within the SAC

Of the survey swath captured by Fugro in 2016, 115.5km^2 lies within the HHW SAC. The breakdown of surficial sediments can be seen below:

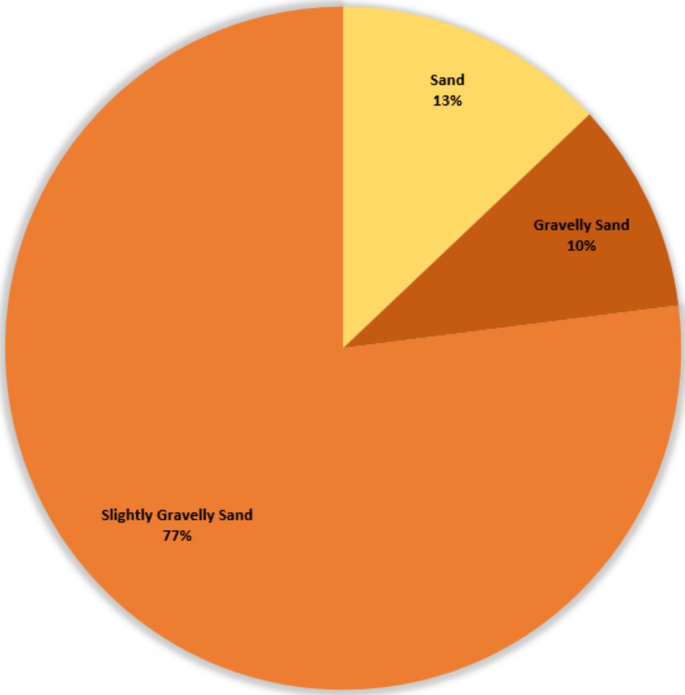


Figure 3: Surface Sediment Breakdown

The surface sediments are dominated by sand with a non-existent to minor gravel fraction. The Fugro survey results show the most common sediment type is slightly gravelly sand, with gravel fraction from 1-5%. Compared to the surveyed area as a whole, the HVDC export cable routes cross a slightly higher proportion of Sand and a lower proportion of Gravelly Sand (Figure 4). This will tend to improve the amount of burial that can be achieved.

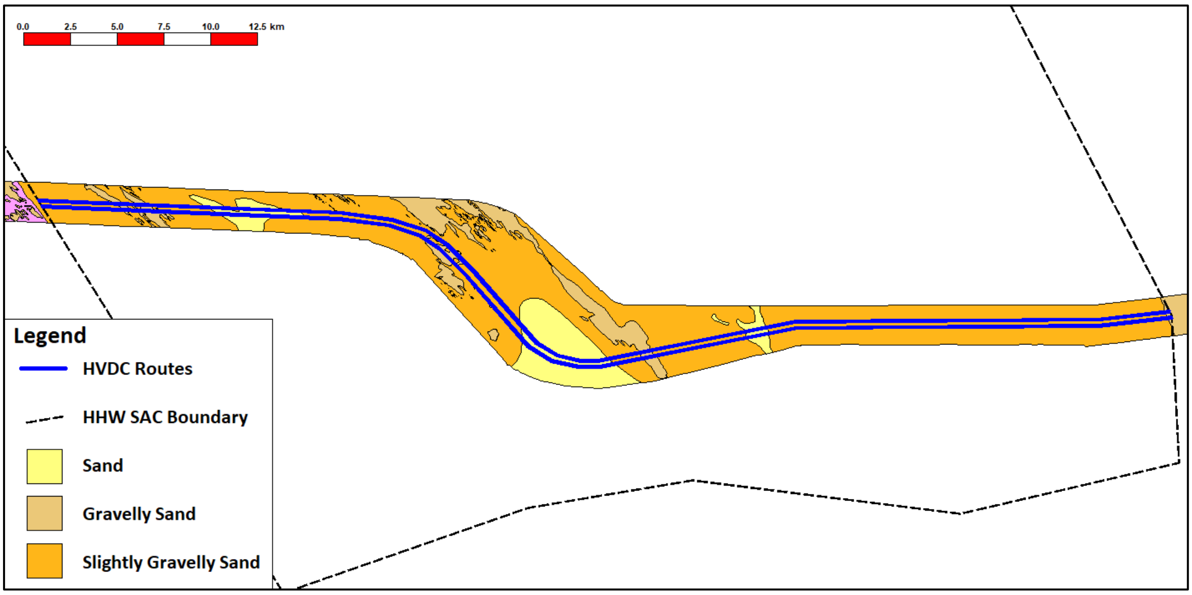


Figure 4: HHW SAC Surface Sediment

As part of the geotechnical scope of the 2016 survey, Fugro performed sixteen CPTs and vibrocores within the SAC boundaries. The findings are summarised in Table 1 below, in numerical order from east to west. Sample locations are featured on the charts in Appendix 3.2.

CPT/ VIBROCORE	MAPPED SEDIMENT	RESULTS
118	Slightly Gravelly Sand	***0.00 – 0.27m:*** extremely low strength olive grey sandy CLAY with traces of coarse sand-sized to medium gravel-sized shells and shell fragments and traces of organic matter
		0.27 – 6.82m: very loose to loose olive grey silty fine SAND, with extremely closely spaced widely spaced thin laminae to medium beds of grey clay and with traces of coarse sand-sized to fine gravel-sized shell fragments *from 0.65m:* with medium gravel-sized pockets of very dark grey clay, with traces of medium gravel-sized pockets of black staining (possibly organic) and with traces of coarse sand-sized shell fragments *from 1.05m to 1.25m:* with extremely closely spaced thin laminae of black staining (possibly organic)
119	Slightly Gravelly Sand	***0.00 – 0.14m:*** extremely low strength black sandy CLAY, with traces of fine gravel-sized shell fragments
		0.14 – 3.82m: medium dense dark grey slightly gravelly very silty fine to medium SAND, with closely spaced thin to medium beds of black sandy clay, with traces of coarse sand-sized to fine gravel-sized shell fragments and with traces of fine gravel-sized to medium gravel-sized pockets of dark grey clay. Gravel is subangular to subrounded fine to medium of various lithologies
		3.82 – 6.72m: low strength to very high strength dark grey sandy CLAY, with extremely closely to widely spaced thin laminae to medium beds of slightly clayey fine sand
120	Slightly Gravelly Sand	***0.00 – 0.40m:*** very loose to loose light olive brown medium SAND, with traces of coarse sand-sized to medium gravel-sized shells and shell fragments
		0.40 – 5.09m: dense to very dense light olive brown slightly silty fine to coarse SAND, with traces of coarse sand-sized to medium gravel-sized shells and shell fragments *at 1.55m:* with a very thin bed of black organic clay *from 2.53m to 2.73m:* with a medium bed of clay *from 2.65m:* with very closely spaced to widely spaced thin laminae to thin beds and coarse gravel-sized pockets of black silty material (possibly organic)
		5.09 – 6.69m: medium strength dark grey slightly sandy CLAY *at 5.92m:* with a medium bed of sand

121	Slightly Gravelly Sand	***0.00 – 5.75m:*** very loose becoming dense to very dense light olive brown slightly silty fine to medium SAND, with traces of coarse sand-sized shell fragments *from 0.55m:* with traces of fine to coarse gravel-sized pockets of black staining (possibly organic) *from 3.65:* slightly gravelly. Gravel is angular to subrounded fine to coarse of various lithologies from 5.45 m - with very closely spaced thick laminae to very thin beds of coarse sand and few coarse sand-sized to medium gravel-sized shell fragments at 5.70 m - end of VC121
		5.75 – 6.70m: high strength to very high strength CLAY, with medium spaced thin beds of medium dense sand
122	Slightly Gravelly Sand	***0.00 – 4.09m:*** dense to very dense light olive brown slightly silty slightly gravelly medium SAND, with traces of coarse sand-sized to medium gravel-sized shell fragments. Gravel is subangular to subrounded fine to medium of various lithologies *from 0.90m to 2.40m:* with traces of fine to medium subrounded to subangular gravel of mixed lithologies
		4.09 – 6.56m: low strength to extremely high strength dark grey gravelly sandy CLAY, with very closely spaced and medium to coarse gravel-sized pockets of dark grey sand
123	Slightly Gravelly Sand	***0.00 – 6.70m:*** very dense light olive brown slightly silty fine to medium SAND, with traces of coarse sand-sized to medium gravel-sized shell fragments
124 124A	Gravelly Sand	***0.00 – 0.34m:*** loose to medium dense olive grey slightly silty fine to medium SAND, with traces of coarse sand-sized to fine gravel-sized shell fragments
		0.34 – 6.63m: very dense greenish grey silty fine to medium SAND, with coarse sand-sized to medium gravel-sized shells and shell fragments. Gravel is subrounded fine to coarse of various lithologies *from 0.34m to 2.20m:* slightly gravelly silty. Gravel is subrounded fine to coarse of various lithologies *at 0.45m:* with siliceous concretions with iron oxide coating *at 0.60m:* with a thick laminae of dark brown staining *at 3.25m:* with a rounded coarse gravel *at 5.05m:* with an angular coarse gravel

Table 1: Geotechnical Samples

The seabed within the SAC is not flat or static. The 2016 Fugro survey identified scattered *Sabellaria* reef areas which are thought to coincide with the areas of Gravelly Sand. As well as the sandbanks for which it was designated, which can rise over 25m above the surrounding seabed, there are also smaller bedforms across large areas (Figure 5). These can clearly be seen in a depth profile along the centre of the HVDC routes through the SAC (Figure 6). Sandwave heights vary but typical peak-to-trough values in this area are in the range 2-7m. For this reason, a reference seabed level (RSBL) has been established in previous GMG reports [3]. This is taken as the level below which sediment migration is negligible and therefore the cables will remain at their target burial depth despite the migration of sandwaves. The key geotechnical parameters are therefore those within 1.5m depth of the RSBL, not the actual seabed level at the time of the survey.

Table 2 summarises the geotechnical parameters along the cable routes within the HHW SAC, based on the 2016 Fugro survey results. Where clays are present within the target burial depth shear strengths are generally 50kPa or less. Maximum relative densities of sands to this depth vary from 10% at sample 118 to over 120% at 124. There is a trend of increasing relative density as the export cable routes approach shore as well as with depth into the seabed, which is most relevant for sections in which pre-sweeping operations will be carried out to lower the height of the sandwaves.

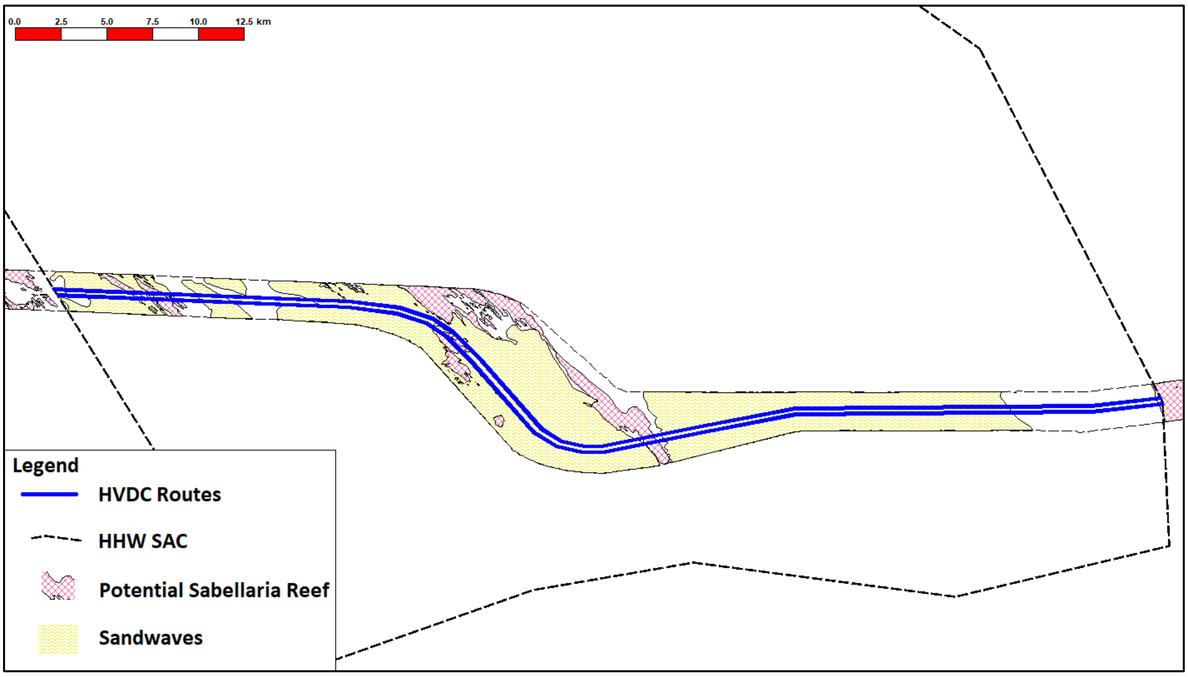


Figure 5: Natural Seabed Features in HHW SAC

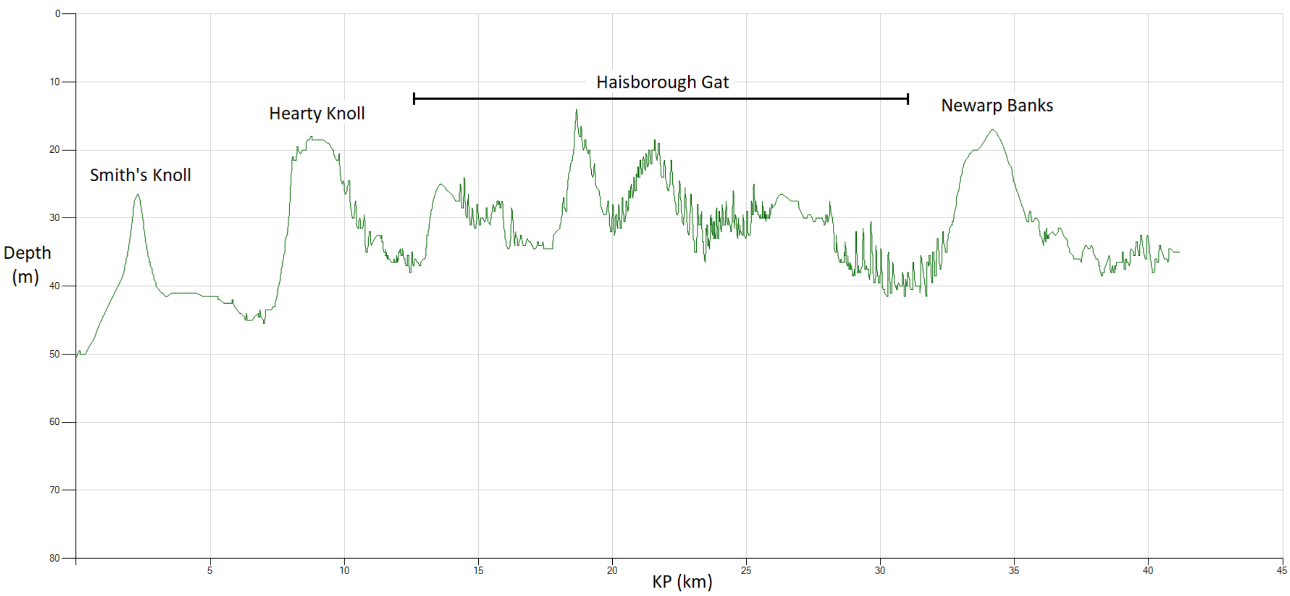


Figure 6: Depth Profile within HHW SAC

CPT/ VIBROCORE	HEIGHT ABOVE RSBL	MAX. CLAY SHEAR STRENGTH WITHIN BURIAL DEPTH	MAX. SAND RELATIVE DENSITY WITHIN BURIAL DEPTH
118	0	10kPa	10%
119	0	50kPa	55%
120	0	N/A	90%
121	0	N/A	90%
122	2-2.5	N/A	105%
123	0	N/A	105%
124, 124A	0.5-1	N/A	>120%

Table 2: Relevant Geotechnical Parameters

Water depths within the SAC vary from 12.5-51m. This means that the site is not particularly draft limited and is accessible by many potential installation vessels able to support a range of burial tool options.

2.5 Micro-routeing Potential

As described in the 2017 GMG Installation Study, micro-routeing of the cables is a potential solution to avoid areas where burial may be reduced below target, such as areas with boulders or other debris. There are a total of 352 sidescan sonar contacts of various types identified by the 2016 survey within the HHW SAC. The nature of these contacts is detailed in Table 3.

TYPE	NUMBER
Boulder	1
Debris or Suspected Debris	145
Possible *Spinulosa* Patch	191
High Backscatter Area	1
Wreck	14

Table 3: Sonar Contacts

The majority of these objects are sufficiently scattered that the cable routes are expected to be able to avoid them, depending on the separation clearances chosen.

Although Sabellaria reef does not represent a significant physical obstacle to cable burial, it is understood that avoiding areas of reef will be a key objective for detailed design of the final cable routes within the SAC. The extent of these areas is not known at this stage; the Fugro survey data indicates areas of ‘potential reef’ (Figure 5), but this mapping is not definitive. Moreover, the distribution of Sabellaria reef changes over time in response to the movement of sandbanks and other factors. To address this situation, it would be advisable to carry out an additional survey (or surveys) closer to the time of cable installation, to inform the final micro-routeing of the cables.

Should the total avoidance of reef be impossible, the affected areas of reef are expected to reinstate themselves after the initial disturbance [3]. This is evidenced by the HHW SAC Selection

Assessment document which notes that no reef disturbance is seen over buried cables in the area and that the sandbanks themselves move and displace the reefs on a continual basis [4].

2.6 Burial Tools Assessed

Many different cable burial tools are available on the market that could potentially be used for the Norfolk Vanguard project. Most fall into one or more of three major categories; jetting, ploughing or cutting.

In jet burial, water jets at high pressure are used to fluidise the seabed or excavate a clear trench into which the cable sinks. All jetting solutions considered by this report are the fluidising kind. The burial capability depends on the number, configuration and type of jetting nozzles and the water pressure and flow volumes that can be achieved. Jet trenchers are particularly effective in non-cohesive sediments such as sands, in which the water jets penetrate between the grains and force them apart.

A cable plough operates by using a share pulled through the seabed by the installation vessel. This lifts a typically V-shaped wedge of sediment. The cable is fed through the plough and laid at the bottom of the trench and the sediment wedge falls back, covering the cable. Ploughs are suitable for a wide range of seabeds but excel in cohesive sediments such as clays.

Chain cutters function using a toothed chain that rotates, cutting into the seabed. The cable is then laid into the excavated trench. Chain cutters are most used in strong cohesive seabeds such as those made of rock or consolidated clays. They are less useful in non-cohesive soils such as sand, which tend to immediately backfill behind the cutter and can jam or rapidly blunt the teeth. Cutters may be assisted with jets in a hybrid mode to improve their performance in this scenario.

NAME	MODE OF OPERATION	SUITABILITY
SMD Atlas ROV	Jetting	N
SMD Q1000 ROV (Jetting)	Jetting	Y
SMD Q1400 ROV (Jetting)	Jetting	Y
SMD Q1400 ROV (Cutting)	Chain Cutter	N
Power Cable Plough	Jetting & Plough Share	Y
Pre-Lay Plough	Plough Share	N

Table 4: Burial Tools

2.6.1 Expected Burial Performance

2.6.1.1 SMD Atlas ROV

Figure 7: Atlas ROV

CHARACTERISTIC	1.5m SWORDS
Sword Depth	1.5m
Sword Width	0.1m
Trench Width	0.44m
Nozzle Spacing	0.25m
Number of Downward Facing Nozzles	14 (2 x 7)
Downward Jet Pressure	4.0 bar
Downward Jet Diameter	17.47mm
Number of Rearward Facing Nozzles	6 (2 x 3)
Rearward Jet Pressure	4.0 bar
Rearward Jet Diameter	17.47mm

Table 5: Atlas ROV

The performance of the Atlas trencher has been analysed assuming the use of 1.5m jetting swords. The use of 2m swords is unlikely to change the results which are largely dictated by the jet pressure and flow volumes achievable.

Several passes would likely be required of each cable, with progress rates of 100-200m per hour for sand relative densities up to 100%. Clay strengths of 50kPa would result in slow progress in the region of 100m per hour. Closer to shore where sand densities can exceed 100% progress rates are likely to be extremely low and the target burial may not be achieved even after several passes. The Atlas ROV is therefore not judged to be a suitable tool for the installation of the export cables.

2.6.1.2 SMD Q1000 ROV (Jetting)

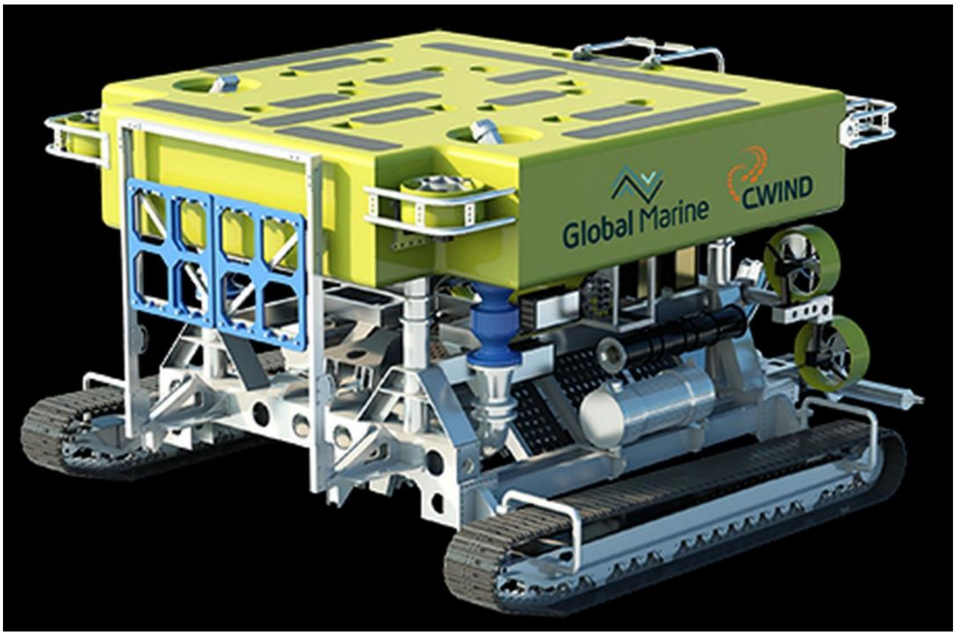


Figure 8: Q1000 ROV

CHARACTERISTIC	2.0m SWORDS
Sword Depth	2.0m
Sword Width	0.1m
Trench Width	0.44m
Nozzle Spacing	0.13m
Number of Downward/Inward Facing Nozzles	40 (2 x 20)
Downward/Inward Jet Pressure	14.7 bar
Downward/Inward Jet Diameter	12.00mm
Number of Rearward Facing Nozzles	6 (2 x 3)
Rearward Jet Pressure	14.7 bar
Rearward Jet Diameter	50.00mm

Table 6: Q1000 ROV

The Q1000 ROV can be equipped with 1m, 2m or 3m swords. The 2m swords are expected to be most suitable to achieve the 1.5m burial depth of the Norfolk Vanguard export cables. The progress rate in 50kPa clays for the Q1000 trencher with 2m jetting swords is expected to be around 100m per hour. Progress rates in 90% sand are expected to average around 280m per hour. For over-consolidated sands in the 100-120% relative density range progress rates are unknown but may be around 100m per hour.

Data on the success of burial to 1.5m by the Q1000 ROV is limited. To remedy this an analysis was carried out of a project carrying out remedial burial on power cables to a target trench depth of 2m in the eastern North Sea. In this case around 10% of the cable was not buried to target, with up to 4% being to <1m. This project was carried out at relatively high burial speeds (300m per hour) and was impeded by debris. None of the areas in which trenching was attempted achieved burial of <1m, although some required a second burial pass. The seabed type is similar but quantified soil strengths are unknown. Therefore 5% has been adopted as a reasonable conservative estimate of the length of the Norfolk Vanguard export cables that could require remedial protection in the HHW SAC.

2.6.1.3 SMD Q1400 ROV (Jetting)

Figure 9: Q1400 ROV

CHARACTERISTIC	2.0m SWORDS
Sword Depth	2.0m
Sword Width	115mm
Trench Width	0.6-1.1m (Product diameter 0.4-0.9m)
Nozzle Spacing	100mm
Number of Downward/Inward Facing Nozzles	X20 Downward + x20 Inward
Downward/Inward Jet Pressure	10 to 15 bar
Downward/Inward Jet Diameter	12-17mm dependant on soils
Number of Rearward Facing Nozzles	1 at each base of the sword
Rearward Jet Pressure (Eductor)	10 - 15 bar
Rearward Jet Diameter	40mm backwash nozzle

Table 7: Q1400 ROV

The Q1400 ROV can be equipped with 2m or 3m swords. Similar to the Q1000 ROV, the 2m swords are expected to be most suitable to achieve the 1.5m burial depth of the Norfolk Vanguard export cables.

In dense sands the Q1400 is expected to easily bury to 1.5m at a rate of 250m/hr. Assuming a 400mm separation between jetting swords, the progress rate in 50kPa clays for the Q1400 trencher is expected to be around 200m per hour. Full burial is expected to be achieved except where very local effects (e.g. a subsurface boulder under the cable) prevent cable burial.

2.6.1.4 SMD Q1400 ROV (Cutting)

Due to the lack of strong cohesive sediments (clays) reported inside the HHW SAC survey corridor the Q1400 chain cutter is not anticipated to be a suitable burial tool. If stiffer clays are found during a later survey the chain cutter with associated jets may be considered.

2.6.1.5 Power Cable Plough

There are several large power cable ploughs available that would be suitable for the installation of the Norfolk Vanguard export cables. Two of these, the SMD HD3 plough and IHC Sea Stallion are summarised below.

Figure 10: IHC Sea Stallion Plough

CHARACTERISTIC	HD3	SEA STALLION
Maximum Trench Depth	3m	3.3m
Maximum Tow Force	150Te	150Te
Cable Outer Diameter	30-300mm	30-300mm
Cable MBR	5m	5m
Steering	±12°	±10°
Width	6.5m	6.0m
Jet Pressure	6 bar	10 bar

Table 8: Power Cable Ploughs

The cable plough would need to be deployed with a jetting pack to become a viable option in the dense sands of the HHW SAC. The water jets fluidise the sand immediately ahead of the plough share, significantly easing the progress of the share through the seabed as it no longer relies solely on mechanical cutting. The burial achieved is heavily reliant on ploughing speeds as above a certain speed there may not be enough time for the jet action to take effect before the plough share encounters that portion of the seabed.

The clays found within the target trench depth inside the HHW SAC are not expected to be an obstacle to a power cable plough, which are estimated to be capable of penetrating soils with strengths up to 350kPa. The consolidated sands are expected to slow burial. Progress rates depend on the vessel and winch capability but a vessel capable of exerting a tow force of 100 tonnes or more could expect to achieve speeds of just over 90m per hour.

2.6.1.6 Osbit Scion 240 Pre-Lay Plough

GMG's pre-lay plough is designed to clear boulders and cut a trench up to 1.7m into the seabed, into which the cable is laid. The trench can then be backfilled to the required depth. Although effective, this process is optimised for performance in stiff clays. In the mobile sand seabed of the HHW SAC there is a risk that the trench would simply backfill before the cable came to be laid. The resulting backfill would however be less dense than the currently existing seabed at depth and so could allow an ROV such as the Atlas or Q1400 to more easily achieve the target cable burial across the site. For the Q1400 or Q1000 this is likely to be unnecessary whereas for the Atlas this procedure would likely be essential to achieve the burial depth.

Progress in the dense sands closer to shore within the SAC is likely to be very slow. This burial solution is not expected to be economic compared to the others explored in this report.

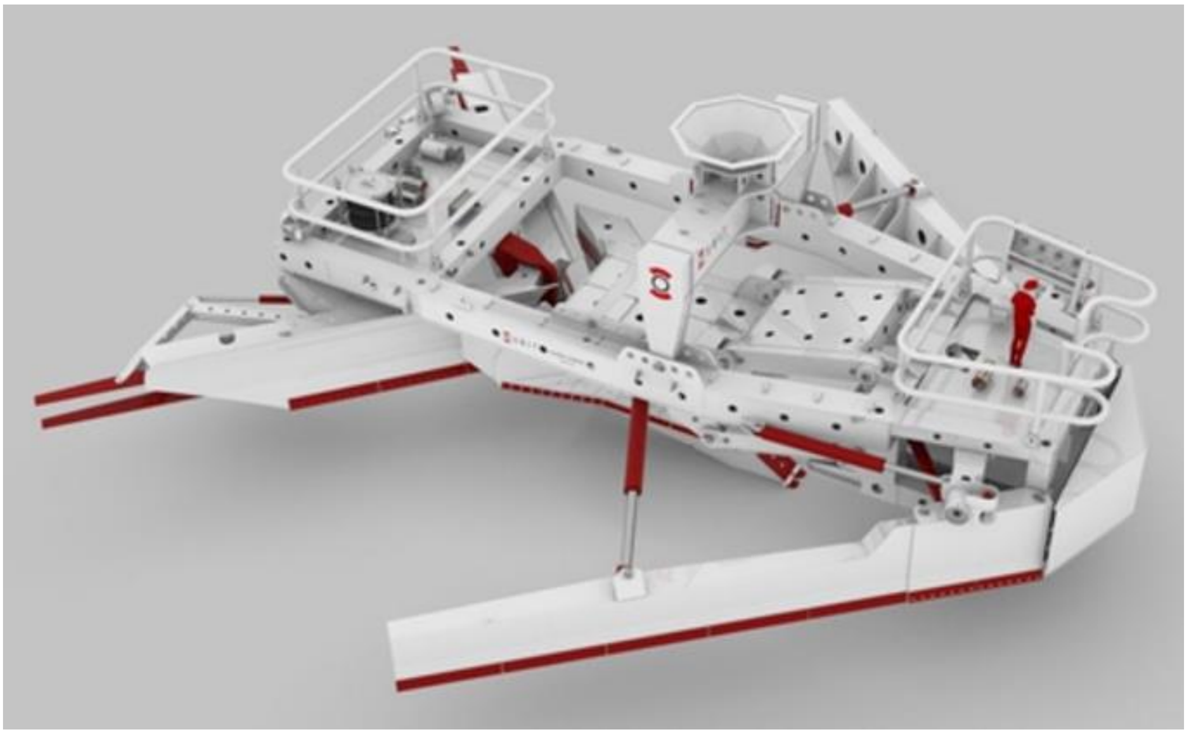


Figure 11: GMG Pre-Lay Plough Design

2.7 Expected Remedial Protection

Table 9 summarises the approximate anticipated length of cable that would remain buried to less than 1m below RSBL under each of the installation scenarios. These are believed to be conservative estimates. This is based on the survey data available which requires interpolation between the existing sites of geotechnical testing by cores and CPTs and actual conditions may vary between points. Further geotechnical survey and route engineering are likely to improve the estimates.

The geotechnical point locations on Chart 1 in Appendix 3.2 have been colour coded to indicate the level of risk of not achieving the target burial at that point. This assessment is based on the clay stiffness, relative density of sands and depth of pre-sweeping required at that point. Position 124 and 124A which are the closest inshore have the highest risk, whilst 118 and 119 which are the furthest offshore have the lowest based on the sediment types found.

In addition to the risk of reduced burial due to the seabed sediments there is a risk of reduced burial due to boulders or man-made debris lying under the cable during installation. An attempt to qualify this risk over the cable corridor inside the HHW SAC is displayed on Chart 2 in Appendix 3.2. The qualification system is based on the data available showing surface debris and known infrastructure. It is indicative only. Areas assessed as Low risk have no surface debris and so the risk of encountering subsurface objects is lowest. Areas assessed as Medium risk have scattered surface debris and so there is an increased risk of buried objects occurring under the cable route and reducing burial. Finally, areas assessed as High risk are the location of either a significant surveyed debris field, a known wreck location which could be expected to be surrounded by such a field, or are in close proximity to the Bacton to Zebrugge gas pipeline or the UK-Netherlands 14 fibre optic cable. In these areas there is a significant risk, rising to a near-certainty at the pipeline and fibre optic cable locations, that the export cables will not be able to be buried to 1.5m BSB. Out of service cables have not affected the risk classification as it has been assumed that they will be cleared prior to burial operations commencing. By area, Low risk zones cover 53% of the cable corridor, whilst Medium and High risk zones cover 38% and 9% respectively. This has been accounted for in the estimated remedial lengths in Table 9 under the assumptions that final route engineering of the export cables will seek to minimise the crossing length of areas where encountering debris is likely; not all areas where the risk is high or medium will in fact host debris on the exact line of the cable route; and that the pipeline and cable crossings identified will be unavoidable and prevent burial to the target depth of 1.5m over a short section, requiring remedial works.

The estimated remedial protection lengths in Table 9 are therefore a combination of the expected performance of the burial too in the seabed types along the route, based on Global Marine's extensive experience with such tools and an empirical model of performance based on back analysis of these or similar tools where the data are available, and the expected influence of objects and infrastructure expected to be present along the route.

NAME	REMEDIAL PROTECTION LENGTH
SMD Atlas ROV	133.36km (81%)
SMD Q1000 ROV (Jetting)	8.25km (5%)
SMD Q1400 ROV (Jetting)	8.25km (5%)
Power Cable Plough	8.25km (5%)
Pre-Lay Plough (with Atlas post-lay trenching)	11.5km (7%)

Table 9: Remedial Protection Lengths

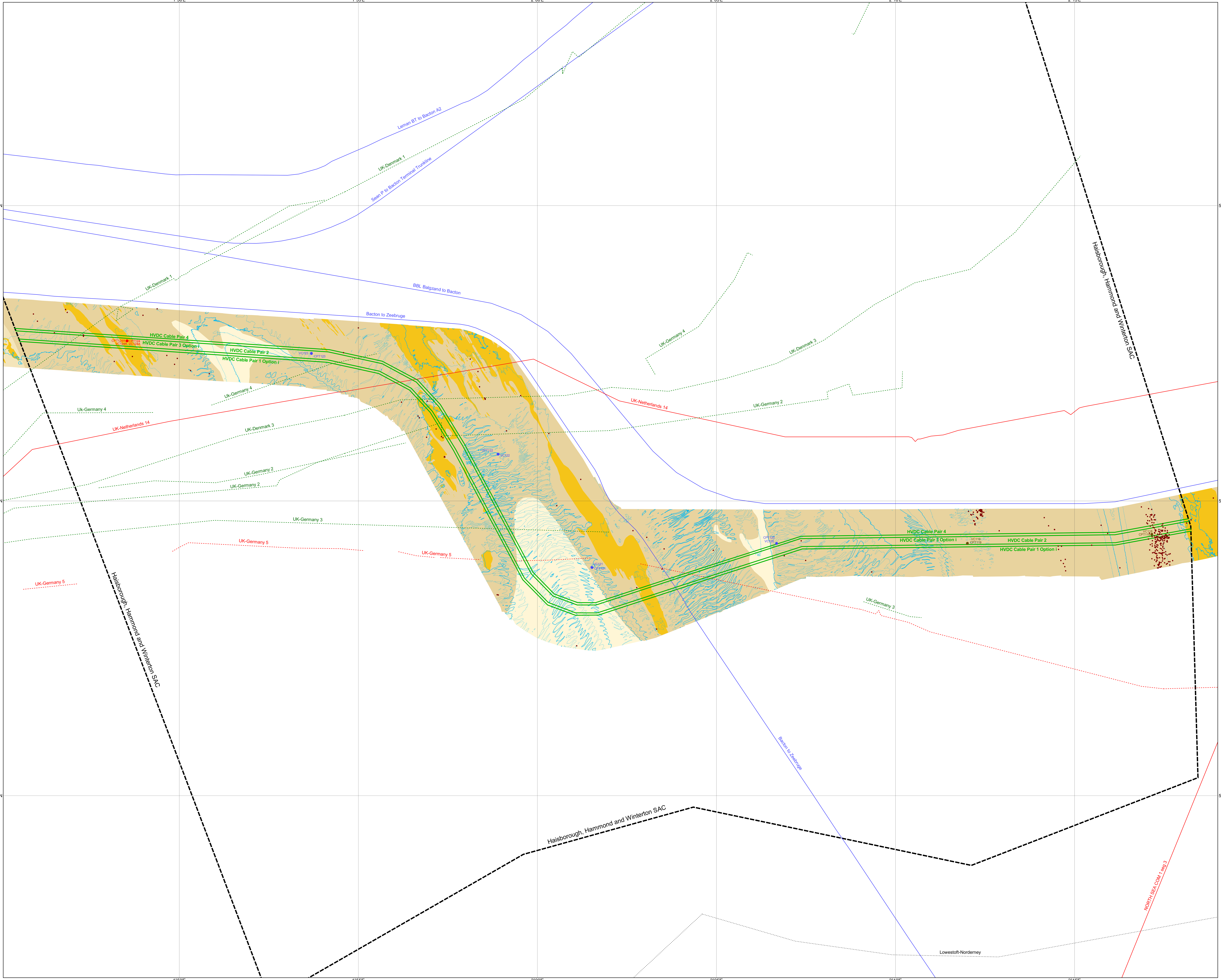
3.0 APPENDICES

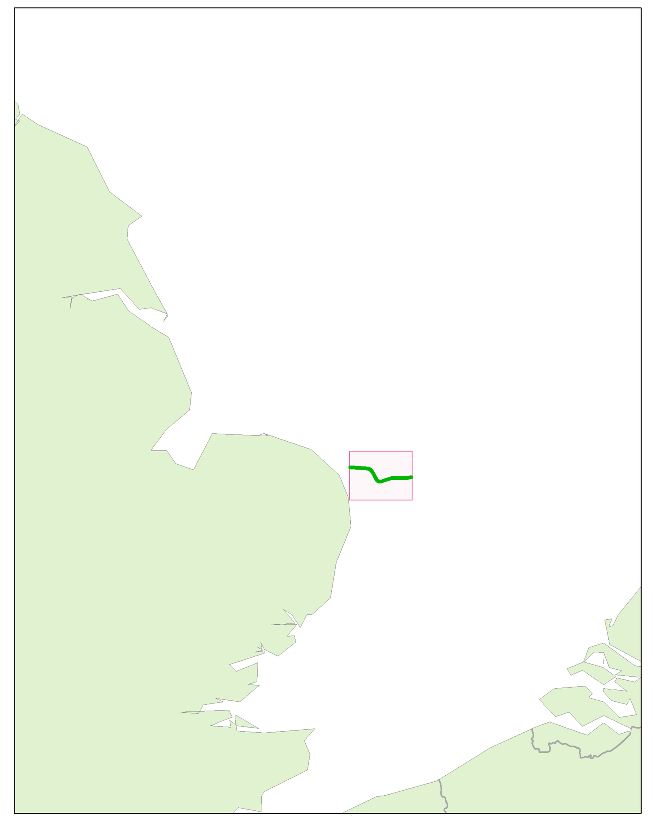
3.1 Supporting Documents

#	NAME	SOURCE
1	Haisborough, Hammond and Winterton SAC http://jncc.defra.gov.uk/page-6534	Joint Nature Conservation Committee
2	GE050-R1 Vol.3 Route Survey_Vattenfall Norfolk Vanguard	Fugro Survey B.V.
3	2210_NVOWF_Installation_Study_002_170925	Global Marine Group
4	Special Area of Conservation (SAC): Haisborough, Hammond and Winterton. SAC Selection Assessment Version 6.0	Joint Nature Conservation Committee

3.2 Charts

CHART	DESCRIPTION	REVISION
1	Overview chart	1
2	Debris risk chart	0





LEGEND

- HVDC Cables
- Fibre Optic Cable
- OOS Fibre Optic Cable
- Telegraph Cable
- OOS Coax Cable
- Pipeline
- Core/CPT: Lowest Risk of Insufficient Burial
- Core/CPT: Medium Risk of Insufficient Burial
- Core/CPT: Highest Risk of Insufficient Burial
- Seabed Feature Point
- Bathymetry Contours 5m
- Bathymetry Contours 10m
- Seabed Feature Arc
- SAND
- Sandy GRAVEL
- (Gravelly) SAND
- Gravelly SAND
- Muddy SAND
- Dredging Area
- MPA

SOURCE:-
1. Global Marine Group Cable Database
2. Joint Nature Conservation Committee

CHART HISTORY

Rev.	AMENDMENT	UPD	CKD	Date
0	Original	SB	PB	Mar 2019
1	Update	SB	PB	Mar 2019

NATURAL SCALE 1 : 40,000 at 52° N

0 1 2 3 4
Kilometres

SPHEROID & DATUM : WGS84

PROJECTION : MERCATOR

GMG

Global Marine Group
Ocean House
1 Winsford Way
Chelmsford
Essex
CM2 5PD

Tel: +44 (0) 1245 702000

www.globalmarine.group

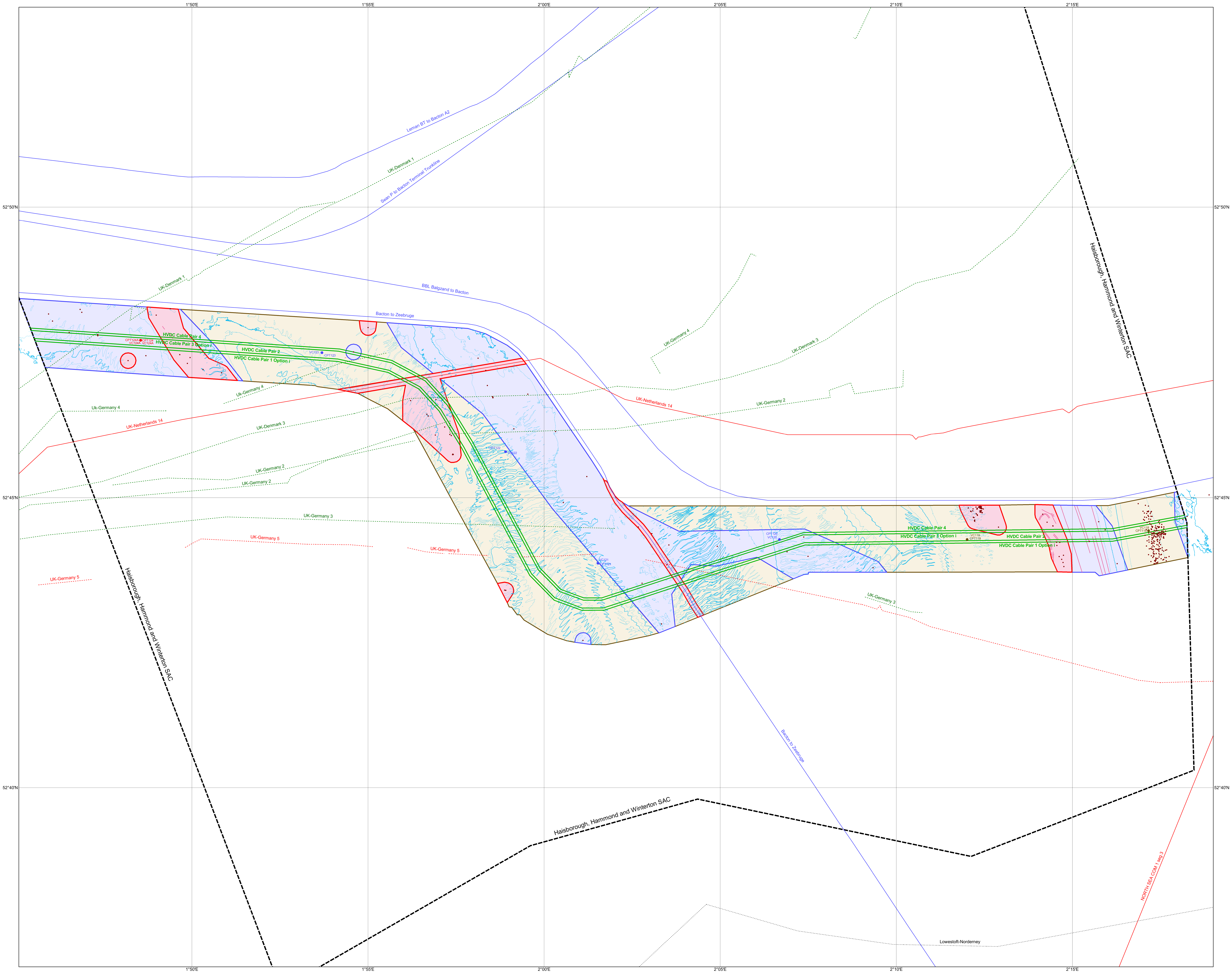
Vattenfall Preliminary

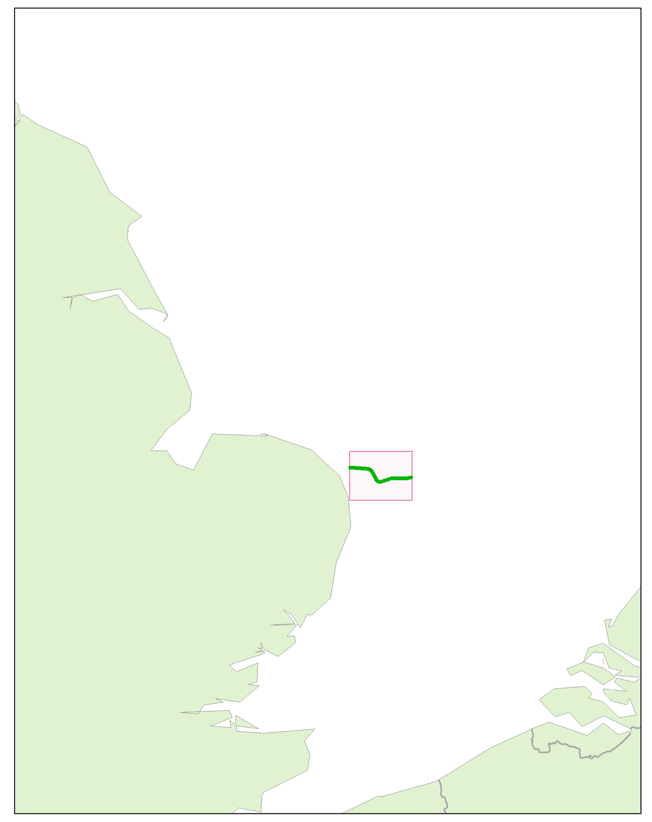
MPA Burial Study

Chart 1: Overview Chart

Revision: 1
Date: March 2019

Produced by Charting Services
Global Marine Systems Limited, Chelmsford





LEGEND

- HVDC Cables
- Fibre Optic Cable
- OOS Fibre Optic Cable
- Telegraph Cable
- OOS Coax Cable
- Pipeline
- Core/CPT: Lowest Risk of Insufficient Burial
- Core/CPT: Medium Risk of Insufficient Burial
- Core/CPT: Highest Risk of Insufficient Burial
- Seabed Feature Point
- Bathymetry Contours 5m
- Bathymetry Contours 10m
- Seabed Feature Arc
- MPA
- High Risk Debris Burial
- Medium Risk Debris Burial
- Low Risk Debris Burial

SOURCE:-
1. Global Marine Group Cable Database
2. Joint Nature Conservation Committee

CHART HISTORY

Rev.	AMENDMENT	UPD	CKD	Date
0	Original	SB	PB	Mar 2019

NATURAL SCALE 1 : 40,000 at 52° N

0 1 2 3 4
Kilometres

SPHEROID & DATUM : WGS84

PROJECTION : MERCATOR

GMG

Global Marine Group
Ocean House
1 Winsford Way
Chelmsford
Essex
CM2 5PD

Tel: +44 (0) 1245 702000

www.globalmarine.group

Vattenfall Preliminary MPA Burial Study

Chart 2: Debris Chart

Revision: 0
Date: March 2019

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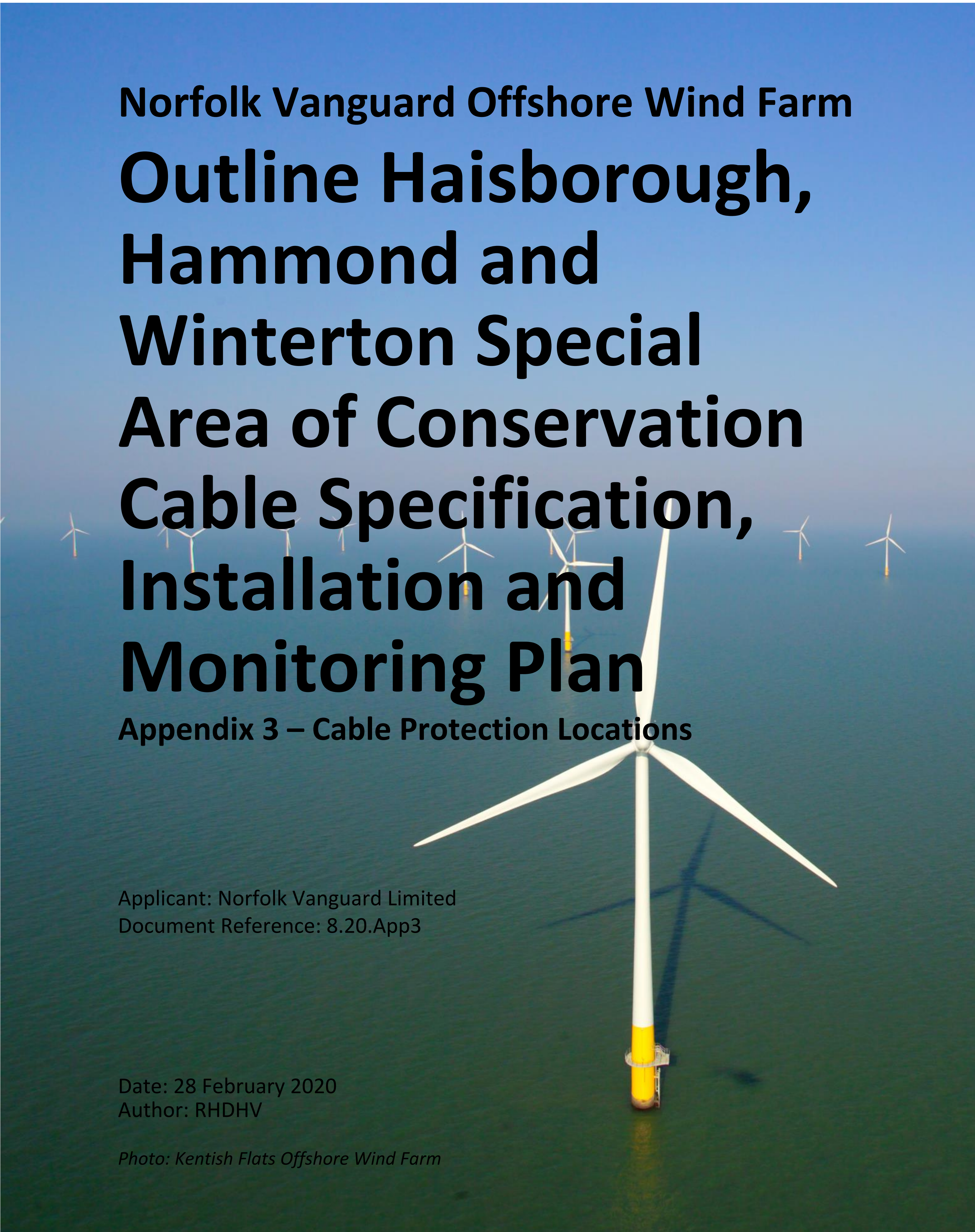
APPENDIX 3 LOCATIONS FOR CABLE PROTECTION

VATTENFALL



Norfolk Vanguard Offshore Wind Farm

Outline Haisborough, Hammond and Winterton Special Area of Conservation Cable Specification, Installation and Monitoring Plan

Appendix 3 – Cable Protection Locations

Applicant: Norfolk Vanguard Limited
Document Reference: 8.20.App3

Date: 28 February 2020
Author: RHDHV

Photo: Kentish Flats Offshore Wind Farm

Date	Issue No.	Remarks / Reason for Issue	Author	Checked	Approved
25/02/20	01D	First draft for Norfolk Vanguard Ltd review	ES	GK	GK
28/02/20	01F	Final	ES	GK	GK

Table of Contents

Tables

1 BACKGROUND

1.1 Aim of this study

1. This study builds on the findings of the Interim cable burial report (provided in Appendix 2 of the Haisborough Hammond and Winterton (HHW) Special Area of Conservation (SAC) Cable Specification, Installation and Monitoring Plan (CSIMP)) to provide evidence the cable protection will not be place in the priority areas to be managed as reef.

2. The Interim Cable burial report concluded that it may not be possible to bury up to a maximum of 5% of the export cables within the HHW SAC. This study illustrates the areas (referred to as 'zones' in this study) where this 5% is may be located if required. It is important to note when considering the information presented in this study, that cable burial will still be possible throughout much of the identified zones.

3. The study also demonstrates that using currently available information and worst case scenario calculations, the extent to which cable protection may interact with features and biotopes found within the SAC will be very small in scale.

1.2 Assumptions and data used

4. In order to undertake this study, the following assumptions have been made:

1.2.1 *S. spinulosa* reef

5. The Applicant employed Envision Mapping Limited to undertake a mapping exercise to predict the current location and extent of *S.spinulosa* reef within the Project offshore cable corridor (Appendix 7.2 of the Information to support HRA, document reference 5.3.7.2 of the Application). Natural England has questioned some of the methods used in that study and both Natural England and the MMO advocate maps produced by Natural England and JNCC which show "*Areas to be managed as Sabellaria reef*" and therefore it is these maps that are used in this study.

6. Of the areas to be managed as *S. spinulosa* reef Natural England has selected two within the Project cable corridor as *"priority sites" for management of reef due to the good evidence base and likelihood for reef to recover*[1]. These areas underpin fisheries management areas proposed by the Eastern Inshore Fisheries and Conservation Authority (EIFCA) and the Department for Environment Food and Rural Affairs.

[1] see Appendix 2.2 paragraph, 1.4.2 and 1.4.7 of Natural England's Relevant Representation (RR-099) to Norfolk Boreas.

1.2.2 Justification of why the length of cable protection used for sub optimally buried cables is realistic

7. The interim cable burial report provided in Appendix 2 of the main HHW SAC CSIMP concludes that cable burial is likely to be possible in the vast majority of locations. However, as a result of that study it was calculated conservatively that for, up to 5% of the length of export cable within the SAC, it may not be possible to undertake full burial. It should be noted that the 5% is a worst case figure, based on currently available cable burial techniques, and therefore, this figure may be reduced as more efficient cable burial techniques become available and based on the findings of the pre-construction survey.

8. 5% of the Project export cables within the HHW SAC equates to 4km of cable. If cable burial is not possible, cable protection would be required to ensure the integrity of the cables and ensure the safety of other marine users.

1.2.3 Areas where cable protection is more likely to be required

9. As part of the interim cable burial assessment (Appendix 2 of the main HHW SAC CSIMP), zones where cable burial was predicted to be more difficult were identified.

10. The 5% of cable which may not be buried would therefore be situated within these zones.

2 METHODOLOGY

11. A series of maps have been produced to show the zones where cable protection is more likely to be required and where they are in relation to the following:

- Areas to be managed as *S. spinulosa* reef (provided by Natural England);
- Biotopes identified from the surveys of the Project offshore cable corridor;
- Areas to be managed as sandbanks which are slightly covered by water at all times (provided by Natural England).

12. Calculations were made using the maximum realistic length of cable that is likely to be required to cross these zones multiplied by 5m which is the maximum width of the cable protection. Where these overlapped with the features and biotopes listed above, the maximum realistic area of overlap (or footprint) was calculated.

13. As shown in Table 3.1 of the HHW SAC CSIMP main report, a maximum of up to 20,000m^2 of cable protection could be required to be placed within the HHW SAC as a result of failure to bury cables (based on the Interim Cable Burial Report (Appendix 2 of the HHW SAC CSIMP) and 5m width of cable protection). The total secured within the DCO also allows for cable protection as a result of cable crossings (see Table 3.1 of the HHW SAC CSIMP main report for further detail).

14. Therefore, calculations of the maximum area of overlap of cable protection and feature or biotope, are either based on an area of 20,000m^2, or, if it is clear from the maps that 20,000m^2 would be an overestimate, a more estimate has been used based on the maximum realistic length of cable protection within that biotope. Therefore, it is important to recognise that the calculated worst case scenarios for each biotope should not be aggregated, and the total cable protection would not exceed 20,000m^2, throughout the entire HHW SAC.

15. The same methods have then been used to calculate the cumulative areas of overlap with the Norfolk Boreas project, thus providing cumulative areas of effect.

16. It is important to note that cable burial is expected to be possible throughout much of the identified zones.

3 RESULTS

17. The results of the mapping exercise are presented in the following sections. When interpreting the maps it is important to consider the following:

- Cable burial is expected to be possible throughout much of the identified zones.;
- Some of the zones, where cable protection could be required, may be avoided altogether; and
- The maps show the longest, realistic worst case scenario cable route through each zone. In reality, a shorter route may be taken.

3.1 Cable protection required at crossings

18. There are two linear features that have been identified where cable protection will be required. These are the Bacton-Zeebrugge gas pipeline and the Tampnet telecommunications cable connecting Lowestoft with Norway (Figure 1). Cable protection will be required to protect the Project cables as they cross these assets (see section 5.5.1 of the main HHW SIP document for further explanation on cable crossings). As there is already introduced hard substrate due to the presence of the cable and the pipeline, additional hard substrate in the form of cable protection for the Project cables would not affect Annex 1 features at these locations.

19. It can be seen in Figure 1 that the only locations where cable protection could be required which overlap with the areas to be managed as *S.spinulosa* reef are at the cable and pipeline crossings described above. There is no overlap between any of the zones and areas to be managed as *S.spinulosa* reef.

3.2 Potential areas of cable protection due to hard ground conditions

20. Excluding the locations where cable crossings would be required, the work completed to support the Interim cable burial assessment (Appendix 2 of the HHW SAC CSIMP) identified four main zones where cable protection may be required due to the ground conditions making it not possible to bury cables. These are labelled A to D in the Figures below.

21. Three other areas where cable burial may not be possible were identified however these were due to the presence of wrecks. These would be avoided by the project due to Archaeological Exclusion Zones (see Chapter 17 offshore Archaeology and Cultural Heritage of the ES, APP-230) and therefore no cable protection would be placed in these areas.

22. The maximum realistic length of cable required to cross each zone (shown in Figure 1) is provided in Table 3.1.

Table 3.1 Maximum length of cable required to cross each zone

Location	**Maximum length of export cables required to cross each zone (m)** (for two export cables)
A	3,374
B	2,392
C	2,782
D	1,336
Note the maximum area of cable protection would not exceed 20,000m^2 in the SAC	

23. It should be noted that the lengths presented in Table 3.1 are the maximum realistic length of cable required to cross each zone. Much of this would be buried however it may not be possible to bury all cable within each zone. As stated in section 2, a maximum of 20,000m^2 of cable protection due to unburied cable could be placed within the HHW SAC and this would come from within the four zones.

3.3 Maximum possible footprint of cable protection in each feature or biotope

3.3.1 Areas to be managed as *Sabellaria* reef

24. As shown in Figure 1, no zones where cable protection could be required as a result of unburied cables overlap with the areas to be managed as *S.spinulosa* reef. Therefore, the Applicant is proposing a new commitment to use no cable protection in the priority areas to be managed as reef within the HHW SAC, unless otherwise agreed with the MMO in consultation with NE.

3.3.2 Biotopes

25. The area of each biotope was derived from a survey of the Norfolk Vanguard offshore cable corridor which was undertaken by Fugro in Autumn 2016. The survey report is contained in Appendix 7.3 of the Information to Support HRA (document reference 5.3.7.3 of the Norfolk Vanguard application). The resultant biotope maps only include the offshore cable corridor and not the wider SAC. Therefore, the proportion of overlap with potential cable protection has been calculated from the overlap of the known area of biotope. In reality the area of each biotope within the SAC would be far greater and therefore the percentage figures quoted below would be much lower.

26. Figure 2 shows that there is potential for cable protection to be placed within biotope “Potential SS.SBR.PoR.SspiMx” (*Sabellaria spinulosa* on stable circalittoral mixed sediment) within zone B. The length of indicative cable route overlapping with

this biotope is 961m per cable. Cable protection would be up to 5m in width and therefore the maximum potential footprint of cable protection within potential SS.SBR.PoR.SspiMx biotope would be 9,610m^2. This equates to 0.09% of the identified area of Potential SS.SBR.PoR.SspiMx within the overlap between the Norfolk Boreas offshore cable corridor and the SAC. As agreed with Natural England through the Evidence Plan Process (see the Consultation Report document reference 5.1 of the application) the biotope SS.SBR.PoR.SspiMx does not necessarily support *S.spinulosa* reef, however where this overlaps with the areas to be managed as reef, it can be used as an indication that reef could potentially develop under the right conditions.

27. Figure 2 shows that overlap with biotope SS.SCS.CCS (Circalittoral coarse sediment) could occur within zone A. The maximum length of cable required for the two export cables to cross zone A would be 3,374m and therefore the maximum possible footprint of cable protection which could be installed in location A would be 16,870m^2. This would equate to 0.15% of the area occupied by the SS.SCS.CCS biotope within the section of the offshore cable corridor that is located within the SAC.

28. Figure 2 shows that overlap with biotope SS.SSa.CFiSa (Circalittoral fine sand) could occur within zones B, C and D. Due to the fact that this biotope is present within the three zones B, C and D the maximum footprint of cable protection that could be located across these zones would be 20,000m^2. This would equate to 0.02% of the area occupied by the SS.SSa.CFiSa biotope within the section of the offshore cable corridor that is located within the SAC.

3.3.3 Areas to be managed as sandbanks which are slightly covered by seawater at all times

29. Figure 3 shows that, although it may be possible at all of the zones to ensure that cable protection is placed outside of the confirmed Annex 1 sandbank features (shown in yellow), the worst case scenario would be that up to the full 20,000m^2 may be placed in "potential Annex 1 sand bank" and this would equate to 0.003% of the total area of sandbanks within the SAC[2].

3.3.4 Summary of maximum footprints of cable protection within features and biotopes

30. Table 3.2 provides a summary of the maximum footprint of cable protection that could be placed within each biotope and feature within the HHW SAC and the percentage area of each biotope and feature that would be affected by the cable protection.

[2] http://natura2000.eea.europa.eu/Natura2000/SDF.aspx?site=UK0030369

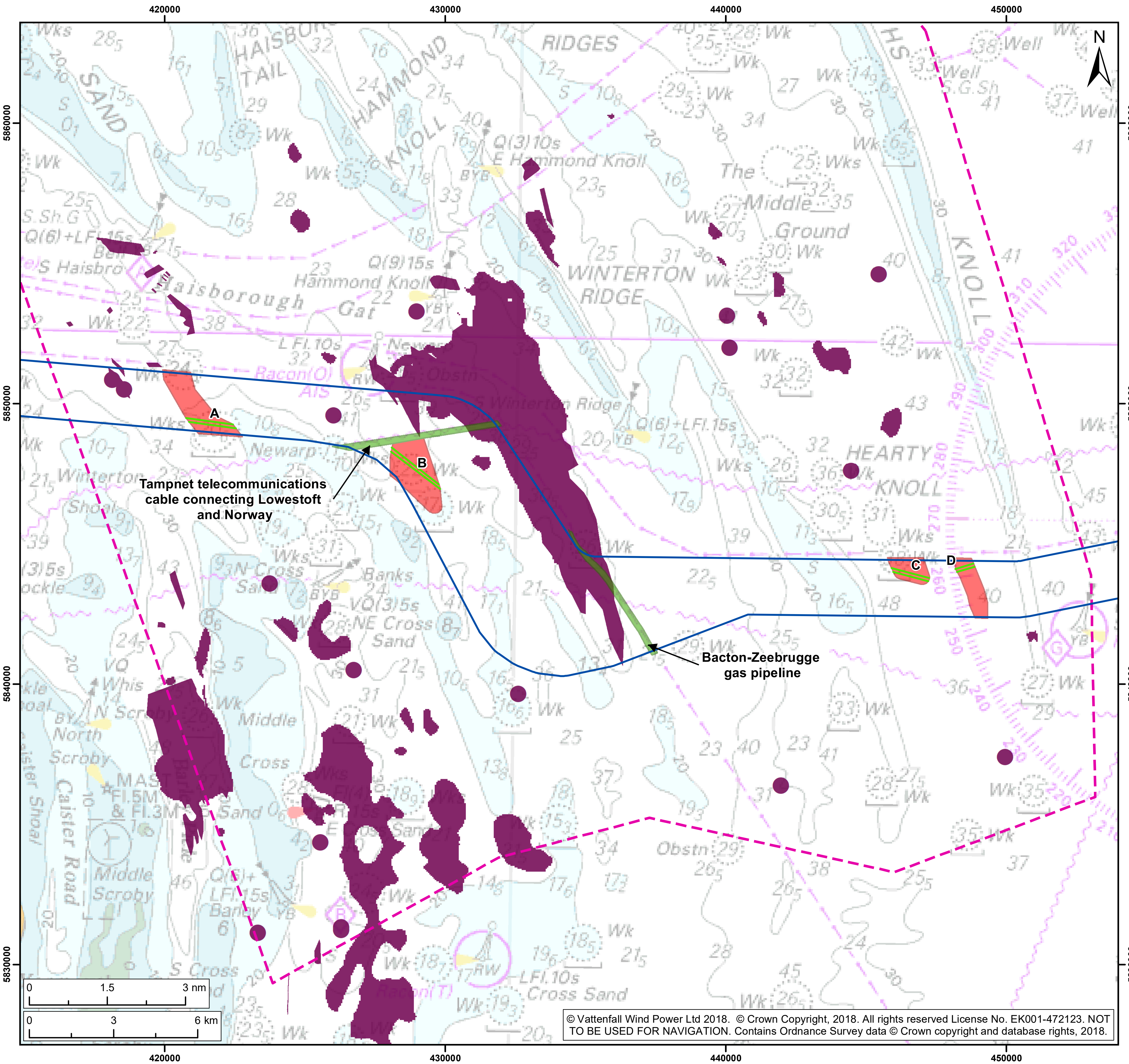
Table 3.2 Summary of the maximum worst case footprints of cable protection which could be placed within each features and biotopes of the HHW SAC for the Project alone.

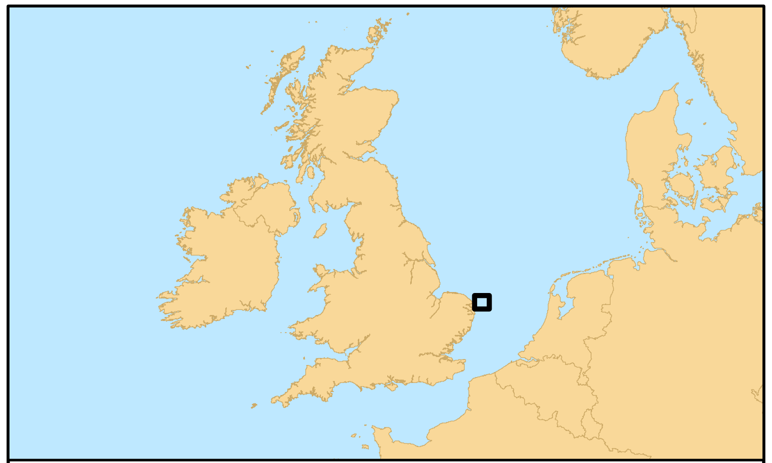
Feature or biotope	Potential footprint of cable protection (m^2)	Known area of Feature/biotope within the SAC (m^2)	% of feature or biotope occupied by cable protection
Areas to be managed as *S.spinulosa* reef	No overlap	Unknown	**0%**
Potential SS.SBR.PoR.SspiMx	9,610	11,235,914*	**0.09%**
Potential SS.SCS.CCS.MedLumVen	No overlap	884,023*	**0%**
SS.SCS.CCS	16,870	13,046,137*	**0.15%**
SS.SSa.CFiSa	20,000	83,884,219*	**0.02%**
Areas to be managed as Annex 1 Sandbank	20,000	669,000,000**	**0.003%**

* Known area within the section of the cable corridor that overlaps with the SAC.
**Known area within the full SAC

31. As set out above, these figures should not be aggregated. Cable burial will still be possible throughout much of the identified zones, however, the worst case scenarios for each biotope are presented in Table 3.2.

32. The conclusions of considering the maximum footprint in each habitat, show that these are well within the worst case scenarios assessed in the Environmental Statement (ES) (document 6.1) Chapter 10 Benthic Ecology and the Information to Support HRA report (document 5.3).





Legend:

- Offshore cable corridor
- Zones where cable protection could be required
- Zones where cable protection could be required due to infrastructure
- Haisborough Hammond and Winterton Special Area of Conservation (SAC)[1]
- Area to be managed as *S. spinulosa* reef (Natural England)[2]
- Indicative cable route

[1] JNCC, 2019
[2] Natural England/MALSF, 2013/2011

Project:	Report:
Norfolk Vanguard	Appendix 3 Likely Cable Protection Locations

Title:

Indicative cable protection locations and Area to be managed as Sabellaria reef

Figure: 1 Drawing No: PB4476-009-007-001

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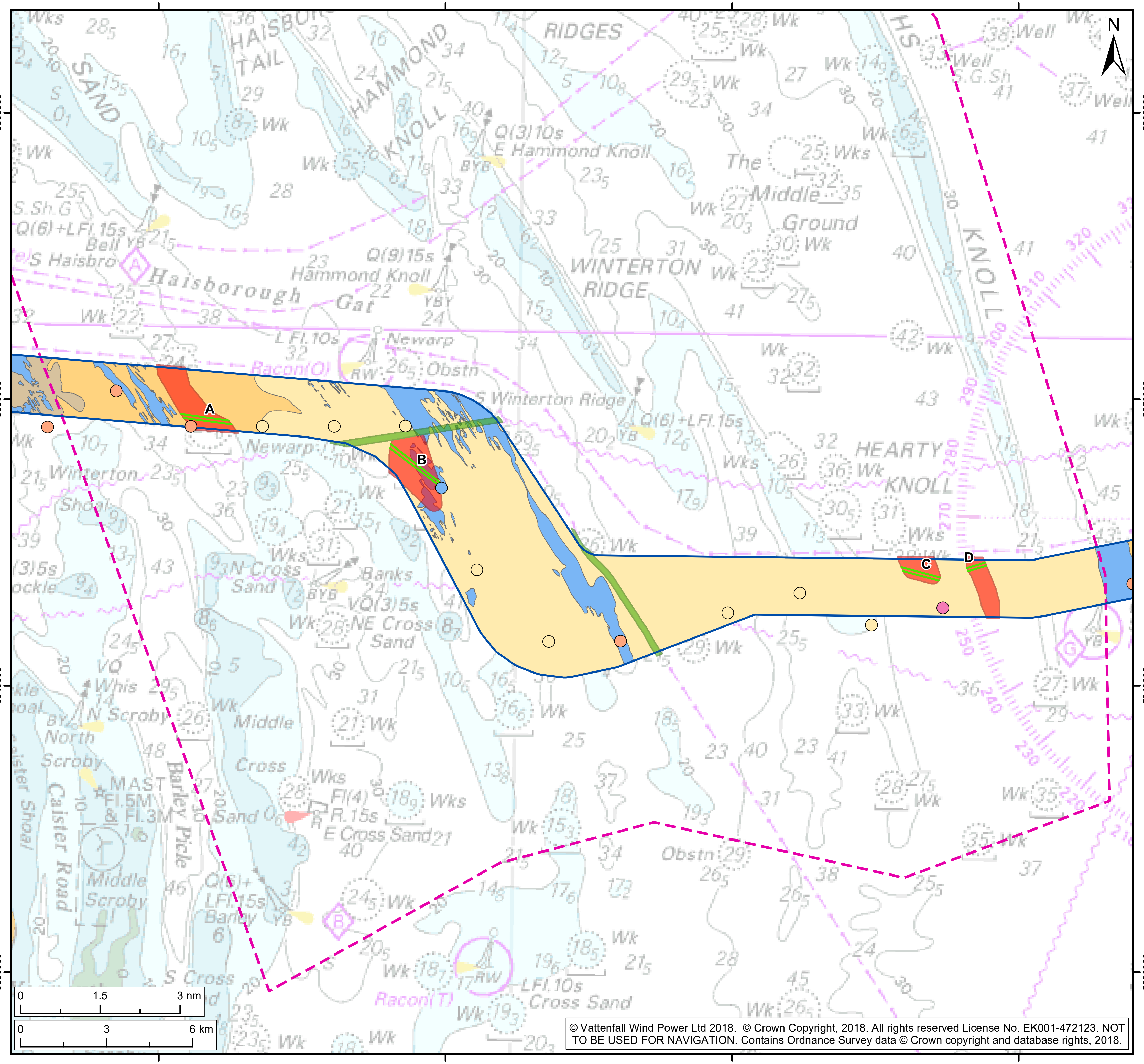

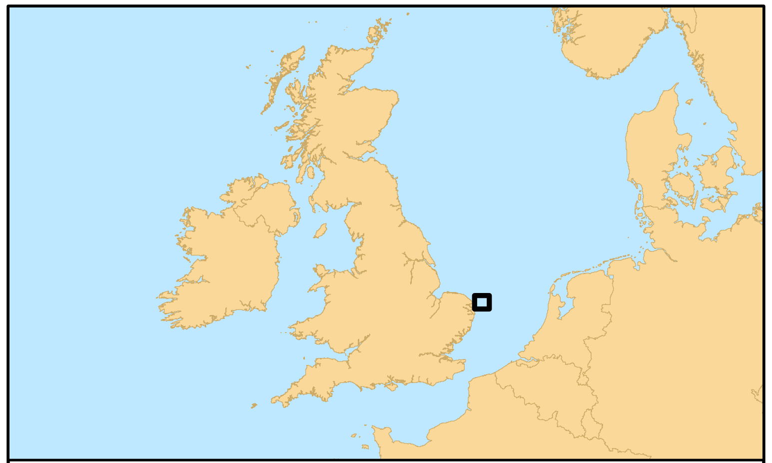

Legend:

- Offshore cable corridor
- Zones where cable protection could be required
- Zones where cable protection could be required due to infrastructure
- Haisborough Hammond and Winterton Special Area of Conservation (SAC)[1]

Biotope interpretation[1]

- SS.SCS.CCS
- SS.SSa.CFiSa
- Potential SS.SCS.CCS.MedLumVen
- Potential SS.SBR.PoR.SspiMx

Biotope[1]

- SS.SCS.CCS
- SS.SSa.CFiSa
- SS.SMu.CSaMu
- SS.SBR.PoR.SspiMx
- Indicative cable route

[1] JNCC, 2019.
[2] Fugro, 2016.

Project:	Report:
Norfolk Vanguard	Appendix 3 Likely Cable Protection Locations

Title:

Indicative cable protection locations and Biotopes

Figure: 2	Drawing No: PB4476-009-007-002				
Revision:	Date:	Drawn:	Checked:	Size:	Scale:
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Co-ordinate system: ETRS 1989 UTM Zone 31N **EPSG:** 25831

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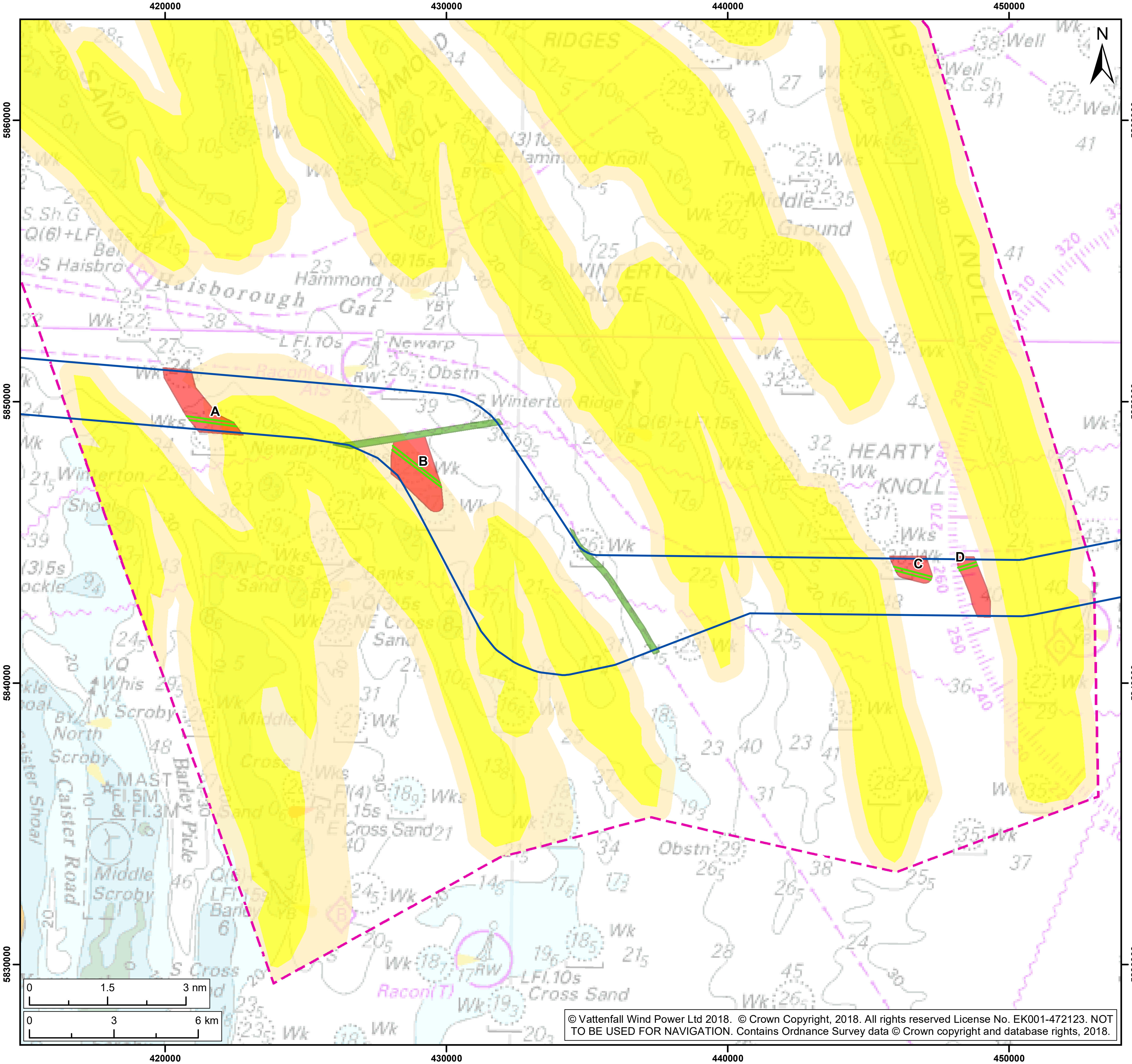

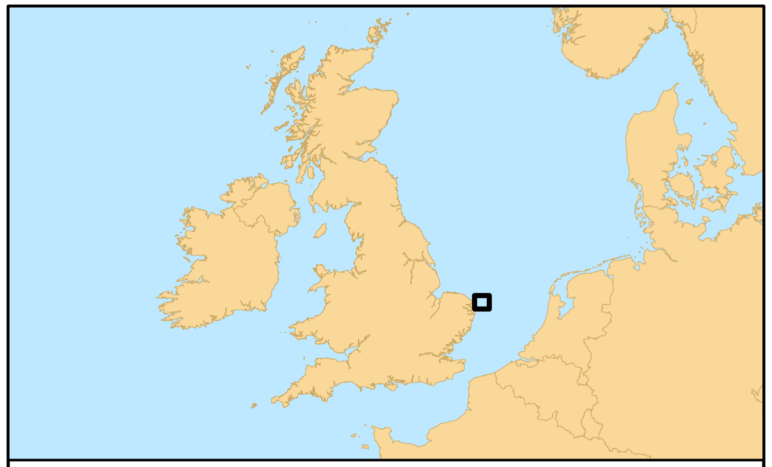

Legend:

- Offshore cable corridor
- Zones where cable protection could be required
- Zones where cable protection could be required due to infrastructure
- Haisborough Hammond and Winterton Special Area of Conservation (SAC)[1]
- Indicative cable route

Areas to be managed as sandbanks which are slightly covered by seawater at all times[2]

- Annex 1 Sandbank Area
- Potential Annex 1 Sandbank

[1] JNCC, 2019.
[2] JNCC, 2016.

Project:	Report:
Norfolk Vanguard	Appendix 3 Likely Cable Protection Locations

Title: Indicative cable protection locations and Biotopes

Figure: 3 | Drawing No: PB4476-009-007-003

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Co-ordinate system: ETRS 1989 UTM Zone 31N **EPSG:** 25831

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3.4 Cumulative affects

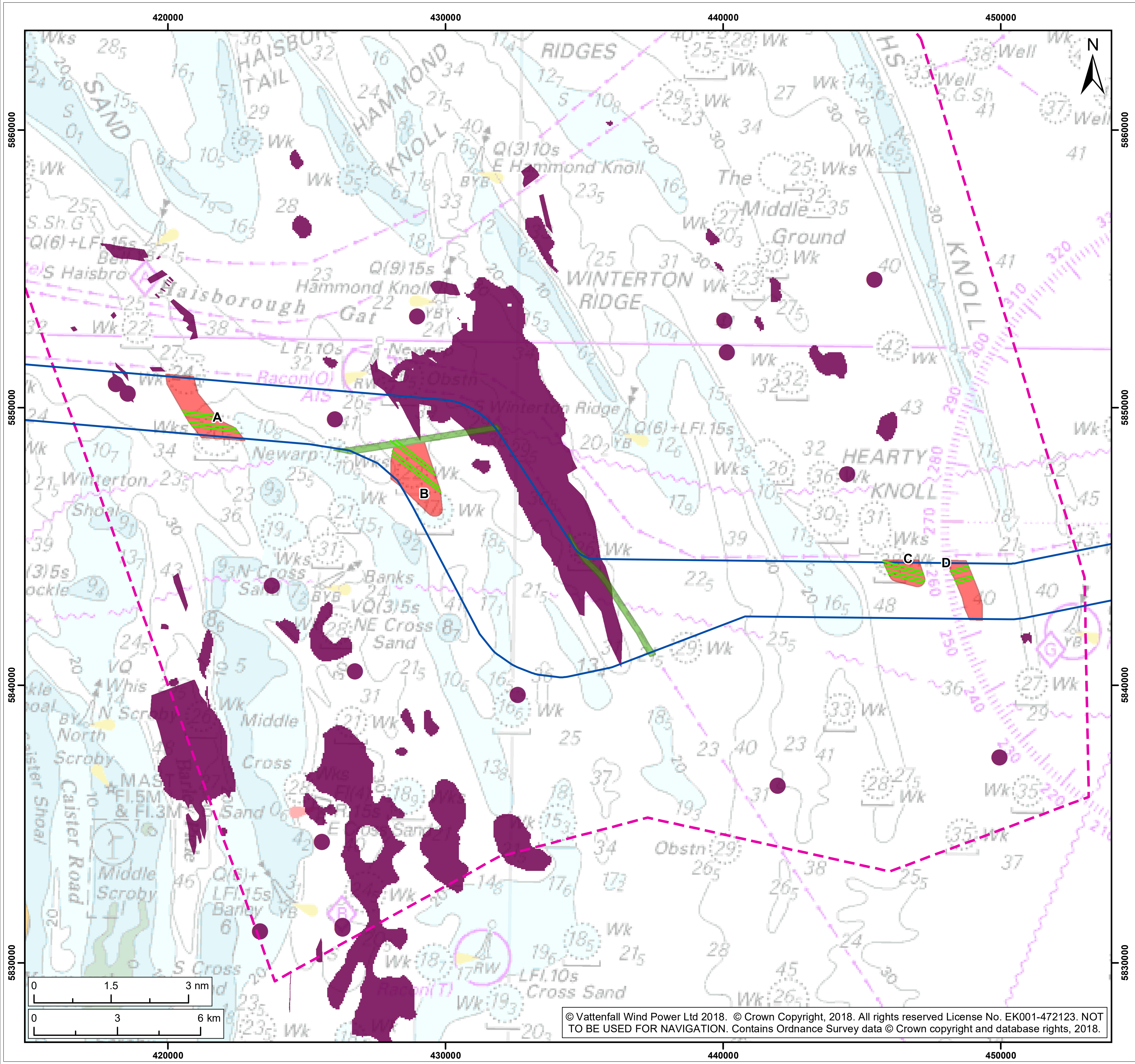
33. Figure 4 to Figure 6 below show the zones within which cable protection could be required for both Norfolk Boreas and Norfolk Vanguard projects. Using the maximum cable lengths and a cable protection width of 5m, the areas of potential overlap with the features and biotopes have been calculated and are shown in Table 3.3.

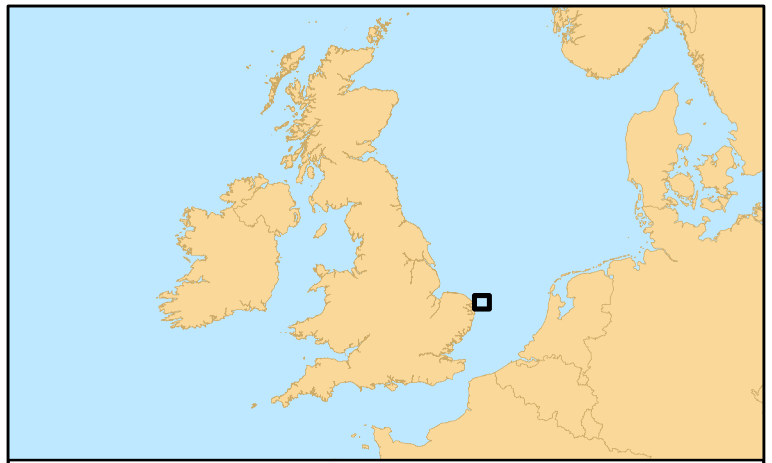
Table 3.3 Summary of the maximum worst case footprints of cable protection which could be placed within features and biotopes of the HHW SAC for Norfolk Boreas and Norfolk Vanguard.

Feature of biotope	Potential footprint of Norfolk Boreas cable protection location (m^2)	Potential footprint of Norfolk Vanguard cable protection location (m^2)	Known area of Feature/biotope within the SAC (m^2)	% of feature or biotope occupied by the combined cable protection
Areas to be managed as *S.spinulosa* reef	No overlap	No overlap	Unknown	**0%**
Potential SS.SBR.PoR.SspiMx	9,610	5,653	11,235,914*	**0.14%**
Potential SS.SCS.CCS.MedLumVen	No overlap	No overlap	884,023*	**0%**
SS.SCS.CCS	16,870	12,090	13,046,137*	**0.22%**
SS.SSa.CFiSa	20,000	20,000	83,884,219*	**0.05%**
Areas to be managed as Annex 1 Sandbank	20,000	20,000	669,000,000*	**0.006%**

* Known area within the section of the cable corridor that overlaps with the SAC.
**Known area within the full SAC

34. As noted above, these figures should not be aggregated.





Legend:

- Offshore cable corridor
- Zones where cable protection could be required
- Zones where cable protection could be required due to infrastructure
- Haisborough Hammond and Winterton Special Area of Conservation (SAC)[1]
- Area to be managed as *S. spinulosa* reef (Natural England)[2]
- Indicative cable route

[1] JNCC, 2019
[2] Natural England/MALSF, 2013/2011

Project:	Report:
Norfolk Vanguard	Appendix 3 Likely Cable Protection Locations

Title:

Cumulative impacts with Norfolk Boreas - Sabellaria Reef

Figure: 4 | Drawing No: PB4476-009-007-004

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
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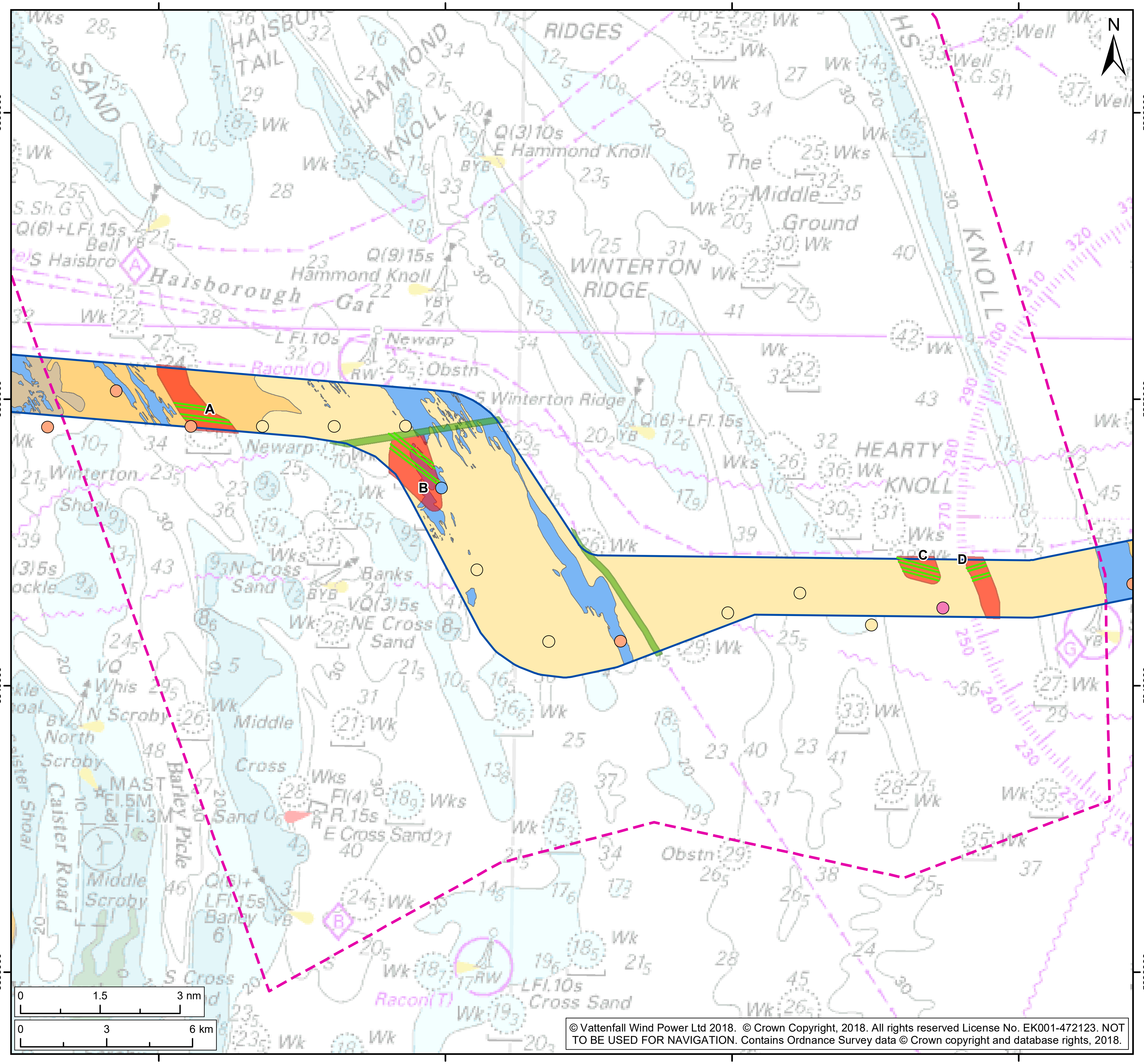

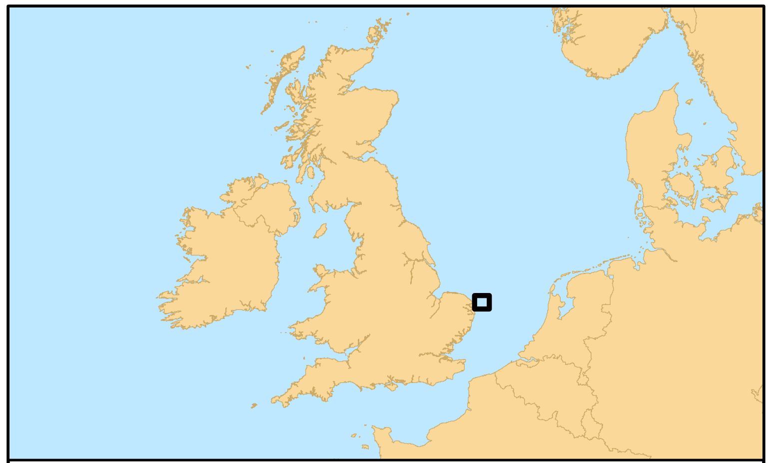

Legend:

- Offshore cable corridor
- Zones where cable protection could be required
- Zones where cable protection could be required due to infrastructure
- Haisborough Hammond and Winterton Special Area of Conservation (SAC)[1]

Biotope interpretation[1]

- SS.SCS.CCS
- SS.SSa.CFiSa
- Potential SS.SCS.CCS.MedLumVen
- Potential SS.SBR.PoR.SspiMx

Biotope[1]

- SS.SCS.CCS
- SS.SSa.CFiSa
- SS.SMu.CSaMu
- SS.SBR.PoR.SspiMx
- Indicative cable route

[1] JNCC, 2019.
[2] Fugro, 2016.

Project:	Report:
Norfolk Vanguard	Appendix 3 Likely Cable Protection Locations

Title:

Cumulative impacts with Norfolk Boreas - Biotopes

Figure: 5 Drawing No: PB4476-009-007-005

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
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Co-ordinate system: ETRS 1989 UTM Zone 31N **EPSG:** 25831

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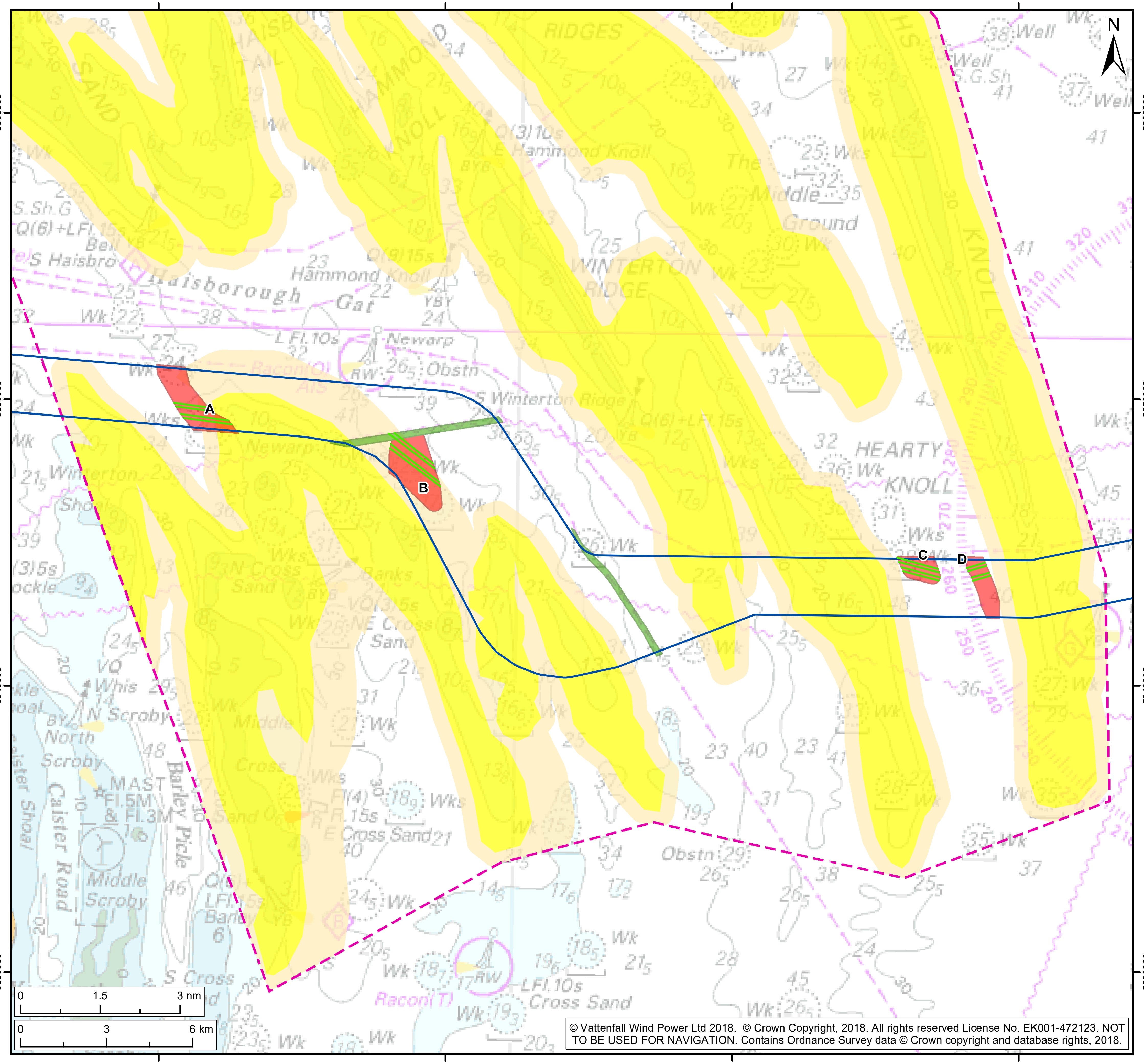

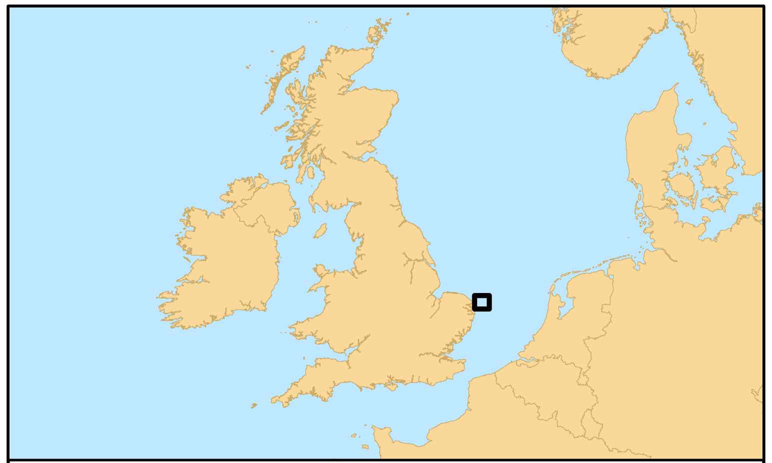

Legend:

- Offshore cable corridor
- Zones where cable protection could be required
- Zones where cable protection could be required due to infrastructure
- Haisborough Hammond and Winterton Special Area of Conservation (SAC)[1]
- Indicative cable route

Areas to be managed as sandbanks which are slightly covered by seawater at all times[2]

- Annex 1 Sandbank Area
- Potential Annex 1 Sandbank

[1] JNCC, 2019.
[2] JNCC, 2016.

Project:	Report:
Norfolk Vanguard	Appendix 3 Likely Cable Protection Locations

Title:

Cumulative impacts with Sandbanks

Figure: 6	Drawing No: PB4476-009-007-006				
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Co-ordinate system: ETRS 1989 UTM Zone 31N **EPSG:** 25831

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4 CONCLUSION

35. In light of this study, the Applicant is able to propose a new commitment to use no cable protection in the priority areas to be managed as reef within the HHW SAC, unless otherwise agreed with the MMO in consultation with NE. As a result the proposed management measures within the HHW SAC associated will not be impacted and targets for achieving the recovery of *S. spinulosa* Annex I reef will not be hindered.