Royal HaskoningDHV
Enhancing Society Together

VATTENFALL

Norfolk Vanguard Offshore Wind Farm

Offshore Parameters

Comparison with East Anglia THREE and Hornsea Project Three (ISH2 Action 5 and Q6.13)

Applicant: Norfolk Vanguard Limited
Document Reference: ExA; ISH2; 10.D4.5
Deadline 4

Date: March 2019
Author: Royal HaskoningDHV

Photo: Kentish Flats Offshore Wind Farm

Date	Issue No.	Remarks / Reason for Issue	Author	Checked	Approved
14/02/2019	01D	First draft for Norfolk Vanguard Ltd review	GK	RD	GK
05/03/19	02D	First draft for Norfolk Vanguard Ltd review	GK	RS	GK
07/03/19	03D	Third draft for Norfolk Vanguard Ltd review	GK	VR	GK
12/03/19	04D	Fourth draft for Norfolk Vanguard Ltd review	GK	VR	GK
12/03/19	05D	Submission for Deadline 4	GK	GK	RS

Table of Contents

Tables

1 INTRODUCTION

1.1 Background

1. During the Examining Authority's (ExA)'s First Written Questions for Norfolk Vanguard, the following questions were addressed to the Applicant:

   Q6.1 Part 3, 1(d) of Schedules 11 and 12 of the dDCO for Norfolk Vanguard refers to the disposal of up to 39,732,566m3 of inert material of natural origin within the offshore Order limits. Please explain any significant differences between this figure and the corresponding figures proposed for other similar offshore windfarm projects that have either been consented or are currently proceeding through the examination process. For example, the made DCO for East Anglia THREE, Part 1, 2(d) of Schedules 10 and 11 respectively, refers to the disposal of a total of 1,646,347m3 of inert material of natural origin.
   Q6.2 Requirement 4 of the dDCO proposes a 400km length for the export cable and an associated 119,836m3 of cable protection. Please explain any significant differences between this figure and the corresponding figures proposed for other similar offshore windfarm projects that have either been consented or are currently proceeding through the examination process.

2. During the Issue Specific Hearing on Offshore Matters (ISH2), the panel asked for further clarification of the disposal of inert materials and cable protection figures. The ExA requested an explanation of the figures presented in the Development Consent Order (DCO) for Norfolk Vanguard including why the figures are substantially different from those mentioned in East Anglia THREE. As noted in the Written Summary of the Applicant's oral case at IHS2 (ExA; ISH; 10.D3.2),the Applicant has adopted a conservative approach to assessment, given the need for further detailed site investigation surveys post-consent to inform the final design. The Applicant proposed to provide a breakdown of how the figures are derived in relation to the foundation structures and pre-sweeping of cables for Deadline 4.

3. In addition, Q6.13 of the ExA's Further Written Questions states:

   Further to your responses to the ExQ1 6.1 and 6.2 [REP1-007], and to the discussions in this regard at the offshore environmental matters ISH2 [EV-009 and EV-010], please set out a summary of the key differences to account for the significant range of predicted for inert material to be disposed of and cable protection required for Norfolk Vanguard, Hornsea Project Three and East Anglia THREE.

1.2 Purpose of the Document

4. In response to the information requested during ISH2 and in Q6.13, this document provides the Applicant's comparison of assumptions and calculations used to inform the worst case scenarios of sediment disposal and cable protection for Norfolk Vanguard with the consented East Anglia THREE parameters and the Hornsea Project Three parameters. The explanation focusses on those parameters which are relevant to explaining key differences in the total volumes provided in the Norfolk Vanguard DCO.

2 DEEMED MARINE LICENCE PARAMETERS

5. It should be noted that the Hornsea Project Three, East Anglia THREE and Norfolk Vanguard Deemed Marine Licences (DMLs) have been drafted differently, as follows:

- Under the Norfolk Vanguard DMLs, the entire project (i.e. up to 1800 MW) could be constructed under one set of DMLs (i.e. one generation DML and one transmission DML). Alternatively, there is the ability to phase construction by using two generation DMLs and two transmission DMLs provided that the maximum values across the relevant set of DMLs is not exceeded.
- Under the East Anglia THREE DMLs, it would not be possible to construct the entire project under one set of DMLs, all generation/ transmission DMLs would need to be used. Therefore, the numbers given in each set of the East Anglia THREE DMLs need to be summed before they are compared to the numbers contained in the Norfolk Vanguard generation/transmission DMLs.
- Hornsea Project Three has one DML for generation and one for transmission and therefore the values can be directly compared with Norfolk Vanguard.

6. The overall totals associated with the DMLs are shown in Table 2.1 and described further in Sections 20 to 6.

Table 2.1 Comparison of seabed levelling and cable protection volumes

Parameter	East Anglia THREE		Hornsea Project Three total (m3)	Norfolk Vanguard total (m3)
	per DML (m3)	Total (m3)		
Generation DML sediment disposal	1,646,317	**3,292,634**	**1,344,318**	**39,732,566**
Transmission DML sediment disposal	394,828 + 73,746.50 from Interconnector DMLs	**937,149**	**2,218,816**	**11,475,000**
Generation DML cable protection	49,500	**99,000**	**1,055,000**	**209,000**
Transmission DML cable protection	125,940	**251,880**	**1,371,000**	**107,836**

3 OVERVIEW OF ASSUMPTIONS

7. Further to the different structure in DMLs, each project has also made different assumptions in defining the worst case scenario as a result of different engineering approaches, environmental conditions and/or availability of data. An overview of the different assumptions is provided below based on Norfolk Vanguard Ltd's understanding of available information for East Anglia THREE and Hornsea Project Three.

8. Further details on the parameters associated with each DML, based on these assumptions is provided in Sections 4 to 6.

3.1 Sediment disposal

3.1.1 Norfolk Vanguard

9. A conservative approach has been taken at Norfolk Vanguard to ensure an allowance is included in the DMLs for the option of sandwave levelling in order to install the cables within the stable reference seabed level and minimise the potential for reburial during operation and maintenance.

10. A Cable Installation Study (provided in ES Appendix 5.1) was undertaken using geophysical and geotechnical survey data in the offshore cable corridor to calculate the volume of sandwave levelling to the reference seabed level.

11. In addition, estimated volumes for sandwave levelling in the Offshore Wind Farm (OWF) sites have been calculated based on an assumption that 100% of the cable length could require levelling as the layout of Wind Turbine Generators (WTG)s and Offshore Electrical Platforms (OEP)s is not known at this stage and therefore the layout of cables within the OWF sites is also unknown.

3.1.2 East Anglia THREE

12. East Anglia THREE has identified specific areas with steep sloped sandwaves that could require levelling in order to provide a level surface for cable installation rather than to achieve burial below the reference seabed level.

13. Section 7.6.1.3 of Chapter 7 Marine Geology, Oceanography and Physical Processes of the East Anglia THREE ES describes the following assumptions with regards to sandwave levelling for array and interconnector cable installation:

    "*To investigate the likely order of magnitude of sand wave levelling that may be required for inter-array and platform link cable installation for the proposed East Anglia THREE project, comparison has been made with the work undertaken for the*

East Anglia ONE site. The area of the two sites is very similar (300km^2 for East Anglia ONE and 305km^2 for East Anglia THREE) and therefore a direct comparison can be made. It has been assumed that any sand wave with a slope greater than 10° would require sand wave levelling. This assumption is based on the fact that cable installation equipment generally becomes ineffective where slope angle becomes greater than 10 – 15°."

"Although the area occupied by steep sloped (greater the 10°) sand waves is approximately 2.7 times greater in the East Anglia ONE site than the East Anglia THREE site... a precautionary approach has been taken to estimating the amount of excavated material required. This is to assume that approximately the same amount of excavation would be required as that for East Anglia ONE."

3.1.3 Hornsea Project Three

14. Hornsea Project Three refer to burying cables within the stable reference seabed level. Appendix 11 of the Hornsea Project Three Deadline I submission, 'Sandwave Clearance Clarification Note' provides the methodology used to calculate sediment volumes for the Hornsea Project Three offshore cable corridor which describes analysis using survey data in the offshore cable corridor to calculate the volume of sandwave levelling to a reference seabed level.

3.2 Cable protection

3.2.1 Norfolk Vanguard

3.2.1.1 Crossings

15. The Norfolk Vanguard calculations for crossings are based on 100m length x 10m width x 0.9m height of protection per crossing (i.e. 900m^3 per crossing).

3.2.1.2 Potential for unburied cables

16. An allowance for cable protection for up to 10% of the cable length has been included for potential unburied cables at Norfolk Vanguard.

3.2.2 East Anglia THREE

3.2.2.1 Crossings

17. The East Anglia THREE calculations for crossings are based on 100m length x 3m width x 0.6m height with each crossing being protected by up 19 mattresses of 6 x 3m (i.e. 18m^2 per mattress) and 0.6m height (215m^3 per crossing).

3.2.2.2 Potential for unburied cables

18. In accordance with the approach taken for Norfolk Vanguard, East Anglia THREE includes the potential for 10% of the cable length to be unburied and therefore requiring cable protection.

3.2.3 Hornsea Project Three

3.2.3.1 Crossings

19. Table 3.48 of the Hornsea Project Three ES, Chapter 3 Project Description provides a volume of cable protection of 2,625m^3 per crossing, however the source of this is unclear.

3.2.3.2 Potential for unburied cables

20. In accordance with the approach taken for Norfolk Vanguard, Hornsea Project Three includes the potential for 10% of the cable length to be unburied and therefore requiring cable protection.

4 NORFOLK VANGUARD WORST CASE SCENARIO

4.1 Sediment Disposal

21. The calculation of disposal volumes is presented in relevant worst case scenario tables of the Environmental Statement (ES) (e.g. ES Chapter 10 Benthic Ecology, Table 10.12) which includes the values shown in Table 4.1 below.

22. It should be noted that the worst case scenarios in the ES for Norfolk Vanguard apportions the parameters spatially (i.e. to consider impacts in the OWF sites and in the offshore cable corridor), whereas the DCO considers the parameters which are associated with Generation (DCO Schedules 9 and 10) and Transmission (DCO Schedules 11 and 12) assets. Table 4.1 shows the division of parameters included in the draft DCO.

Table 4.1 Norfolk Vanguard Worst Case Scenario for Sediment Disposal

Parameter	Assumption	Location	Volume (m^3)
Generation DML			
WTGs	Preparation area of approximately 90 x 90m and levelling depth of up to 5m x 90 WTG	OWF sites	3,645,000
Accommodation platforms	Preparation area of approximately 75m x 100m per platform and 5m depth x 2 platforms	OWF sites	75,000
Met masts	Preparation area of 40m diameter and 5m depth x 2 met masts	OWF sites	12,566
Array cable	Trench of 600km length with an average 20m pre-sweeping width and 3m depth	OWF sites	36,000,000
Generation DML total			**39,732,566**
Transmission DML			
OEP	Preparation area of approximately 75m x 100m per platform and 5m depth x 2 platforms	OWF sites	75,000
Export cable	Informed by the Cable installation study provided in ES Appendix 5.1	Offshore cable corridor	600,000
	30km length in the OWF sites with an average 20m pre-sweeping width and 3m depth	OWF sites	1,800,000
Interconnector cable	Trench of 150km length with an average 20m pre-sweeping width and 3m depth	OWF sites and/or in offshore cable corridor	9,000,000
Transmission DML total			**11,475,000**
Project total			51,207,566

4.2 Cable Protection

23. The following calculation of cable protection volumes (Table 4.2) is presented in relevant worst case sections of the ES (e.g. ES Chapter 10 Benthic Ecology, Section 10.7.3.5.4 and Table 10.12), noting a correction that was outlined in the Applicant's response to Q6.11 at Deadline 1 (ExA; WQ; 10.D1.3).

Table 4.2 Norfolk Vanguard Worst Case Scenario for Cable Protection

Parameter	Length	Width (m)	Height (m)	Volume (m^3)
Generation DML				
Array cable – unburied cable protection	60km length based on up to 10% of the total length potentially being unburied	5	0.5	209,000
Array cable – crossing protection	1km based on 10 crossings with 100m length	10	0.9	
Array cable – approaching WTG	20km based on 100m length unburied per WTG x 200 WTG	5	0.5	
Transmission DML				
Export cable – unburied cable protection	20km (Correction in accordance with the Applicant's response to Q6.11 at Deadline 1)	5	0.5	69,836
Export cable – crossing protection	2.2km based on 22 crossings (11 per cable pair) with 100m length	10	0.9	
Export cable – protection at landfall exit points	$36m^3$ cable protection at the landfall exit points			
Interconnector cable – unburied cable protection	15km length based on up to 10% of the total length	5	0.5	38,000
Interconnector cable – approaching OEP	200m based on 100m length unburied per offshore electrical platform	5	0.5	

5 COMPARISON WITH EAST ANGLIA THREE

5.1 Sediment disposal

24. Table 5.1 provides a comparison of sediment disposal volumes in the East Anglia THREE and Norfolk Vanguard DMLs.

25. The key differences between Norfolk Vanguard and East Anglia THREE are highlighted orange in Table 5.1, which shows that these are associated with cable installation. The differences in approach to calculating sediment disposal associated with cable installation are explained further in Section 5.1.1 with a summary provided in Section 7.

Table 5.1 Comparison of seabed levelling volumes

Parameter	East Anglia THREE DML (m3)	East Anglia THREE average per unit	Norfolk Vanguard DML (m3) see Section 4.1	Norfolk Vanguard average per unit
Transmission DML				
Seabed levelling for export cables	162,242 export cables + 12,911 cable installation (relative to 332km cable length)	0.5m^3 per m of cable	2,400,000 (relative to 400km total cable length (laid in pairs)	6m^3 per m of cable
Interconnector cable[1]	73,747 (relative to 190km cable length)	0.4m^3 per m of cable	9,000,000 (relative to 150km total cable length)	60m^3 per m of cable
Offshore electrical platforms	219,675 (three platforms)	73,225m^3 per platform	75,000 (two platforms)	37,500m^3 per platform
Transmission DML Total	**394,828 (Transmission DMLs) and 73,746.50 (Interconnector DMLs)[1]**		**11,475,000**	
Generation DML				
Array cables	47,342 (relative to 275km total cable length)	0.2m^3 per m of cable	36,000,000m^3 (relative to 600km total cable length)	60m^3 per m of cable
WTGs	1,505,000 (86 turbines)	17,500m^3 per WTG	3,645,000m^3 (200 turbines)	18,225m^3 per WTG
Accommodation platforms	73,225	73,225m^3 per platform	75,000m^3 (two platforms)	37,500m^3 per platform

[1] East Anglia THREE has separate Interconnector DMLs, Schedules 14 and 15 whereas the Interconnector for Norfolk Vanguard is included in the Transmission DMLs, Schedules 11 and 12

Parameter	East Anglia THREE DML (m3)	East Anglia THREE average per unit	Norfolk Vanguard DML (m3) see Section 4.1	Norfolk Vanguard average per unit
Met masts	20,750 (two met masts)	10,375m^3 per met mast	12,566 (two met masts)	6,283m^3 per met mast
Generation DML Total	**1,646,317**		**39,732,566**	
Project Total	**4,229,783**		**51,207,566**	

5.1.1 Cable installation

5.1.1.1 Array and Interconnector cables

26. Section 7.6.1.3 of Chapter 7 Marine Geology, Oceanography and Physical Processes of the East Anglia THREE ES describes the following assumptions with regards to sandwave levelling for array and interconnector cable installation[2]:

"*..the total length of inter-array cables for the project may be up to 550km, the total length of platform link cable may be up to 195km and total length of interconnector cable may be up to 380km (installed within 190km of trench), and the worst case cable laying technique is considered to be jetting.*

The installation of the cabling has the potential to disturb the sea bed down to a sediment thickness of up to 5m, either directly through the installation method chosen, or through sea bed levelling of any steep sand waves that may be present along the route of any cables prior to cable installation."

27. As discussed in Section 3.1.2, East Anglia THREE has identified sandwave levelling requirements based on the values from the East Anglia ONE ES, for the objective of providing a level surface for cable installation, rather than the Norfolk Vanguard objective of achieving burial within the reference seabed level in order to minimise the potential for cables becoming exposed during the operational life of the project and therefore requiring remedial action. Therefore, East Anglia THREE has identified specific areas with steep sloped sandwaves, whereas a conservative approach has been taken at Norfolk Vanguard by assuming 100% of the array and interconnector cable length could require levelling in order to install the cables within the stable reference seabed level and minimise the potential for reburial during operation and

2 It is noted that the East Anglia THREE DML provides for 47,342m3 of array cable seabed levelling (94,684m3 in total) and 73,747m3 for interconnector cable seabed levelling. The difference between this and the 136,000m3 in the ES is unclear.

maintenance as the layout of WTGs is not known at this stage and therefore the layout of array cables is also unknown.

5.1.1.2 Export cables

28. Section 7.6.1.5 of Chapter 7 of the East Anglia THREE ES describes the following assumptions with regards to sandwave levelling for export cable installation:

"*...estimates are that the maximum total length of each export cable could be up to 166km in length with up to four cables being installed providing a total maximum length of 664km of export cable.*"

"The installation of the offshore cabling has the potential to disturb the sea bed down to a sediment thickness of up to 5m, either directly through the installation method chosen, or through sea bed levelling of any large sand waves that may be present along the export cable corridor prior to cable installation."

"To investigate the likely magnitude of sand wave levelling needed for cable laying during construction of the proposed East Anglia THREE project, comparison has been made with the work undertaken for the East Anglia ONE project."

"On this basis, the estimated volumes of excavated material due to sand wave clearance within the East Anglia THREE export cable corridor (including the area of overlap with the East Anglia THREE interconnector cable) would be 324,484m^3" [3]

29. As discussed in section 5.1.1.1 above, East Anglia THREE has identified sandwave levelling requirements based on specific areas with steep sloped sandwaves.

30. For Norfolk Vanguard, the offshore export cables have been considered in two sections:

- The length of export cables within the offshore cable corridor;
    - A cable installation study (provided in ES Appendix 5.1) was undertaken for the offshore cable corridor which estimated the likely area and volume of pre-sweeping that would be needed in the offshore cable corridor in order to achieve burial below the reference seabed level based on sandwave dimensions and locations informed by the 2016 geophysical and geotechnical survey.

[3] 50% of this is included in the Transmission DMLs

- The section of export cables where they enter the OWF sites in order to connect to the OEPs.
    - A conservative approach has been taken which assumes the full length of the cable installation in the OWF sites could require levelling in accordance with the assumptions for the array cables (described in section 5.1.1.1) as it is not known where the OEPs will be located and therefore the export cable route within the OWF sites is unknown.

31. The key difference between Norfolk Vanguard and East Anglia THREE export cable installation is associated with the section of the export cables where they enter the OWF sites.

5.2 Cable Protection

32. Table 5.2 provides a comparison of cable protection volumes in the East Anglia THREE and Norfolk Vanguard DMLs. For both projects, the total volumes comprise cable protection required for crossing locations and potential unburied cables. The assumptions associated with the figures adopted by East Anglia THREE and Norfolk Vanguard are explained further in Sections 5.2.1 and 5.2.2 below.

Table 5.2 Comparison of cable protection volumes

Parameter	East Anglia THREE DML (m3)	East Anglia THREE average per unit (m3 per m of cable)	Norfolk Vanguard DML (m3)	Norfolk Vanguard average per unit (m3 per m of cable)
Transmission DML				
Export cables	81,260 (664km of cable)	0.12	69,836 (400km of cable)	0.17
Interconnector cable[4]	47,960 (380km of cable)	0.13	38,000 (150km of cable)	0.25
Platform link	28,480 (240km of cable)	0.12	N/A	N/A
Generation DML				
Array cables	49,500 (550km of cable)	0.09	209,000 (600km of cable)	0.35

5.2.1 Cable crossings

33. Section 5.5.14.5 of Chapter 5 (Description of the Development) of the East Anglia THREE ES provides the following diagram showing 100m length, 3m width and 0.6m height of protection for cable crossings:

[4] It is noted that East Anglia THREE has a separate Interconnector DML, Schedules 14 and 15 whereas the Interconnector for Norfolk Vanguard is included in the Transmission DMLs, Schedules 11 and 12

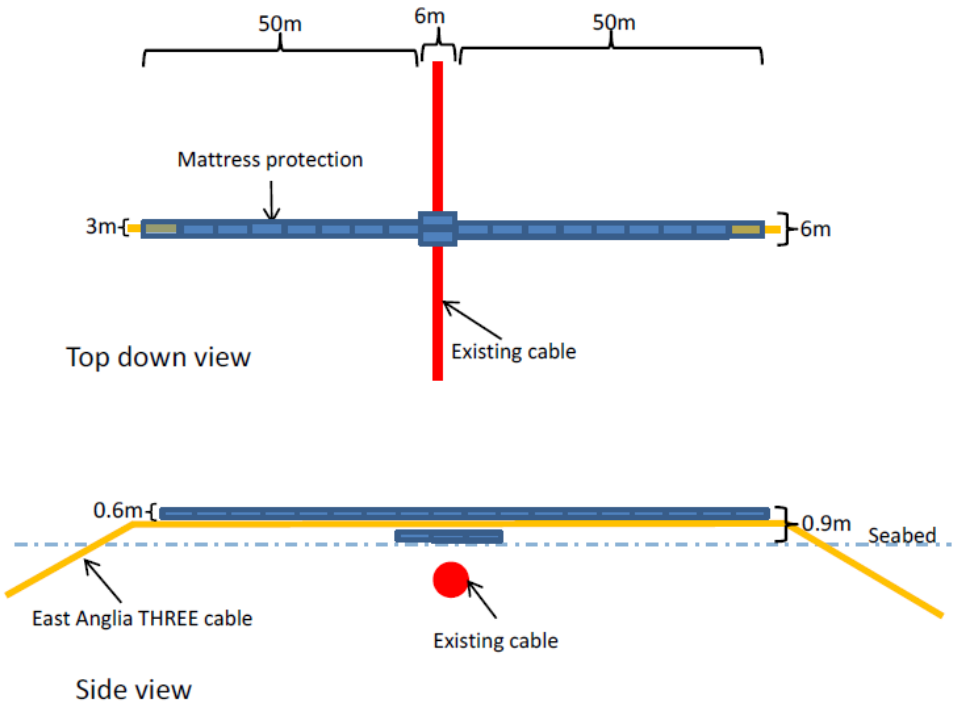

Diagram 5.17 of Section 5.5.14.5 of Chapter 5 (Description of the Development) of the East Anglia THREE ES

34. Table 5.25 (on page 66) of Chapter 5 of the East Anglia THREE ES shows that this would be achieved by 19 mattresses of 6 x 3m (i.e. 18m^2 per mattress) based on:

- 17 mattresses along the length (i.e. 102m length (17 mattresses x 6m) and 3m width);
- An additional two mattresses on the actual crossing point (as shown in Diagram 5.17 of Section 5.5.14.5 of Chapter 5 of the East Anglia THREE ES); and
- 0.6m height for each mattress

35. This provides a maximum volume of cable protection of 215m^3 for each crossing.

36. As discussed in section 4.2 of this document, the Norfolk Vanguard assumptions for cable crossings are based on 100m length x 10m width x 0.9m height of protection per crossing (i.e. 900m^3 per crossing). The assumptions taken by Norfolk Vanguard Ltd are therefore deemed to be relatively comparable with that presented in Diagram 5.17 of the East Anglia Three ES Chapter 5, with the exception of the cable protection width.

37. Whilst this provides a maximum value per crossing, the actual total up to this maximum will be subject to crossing agreements with the operators of existing cables and pipelines and must be agreed with the Marine Management Organisation

(MMO) through the Scour Protection and Cable Protection plan, as required under draft DCO Schedules 9 and 10 Condition 14(1)(e) and Schedules 11 and 12 Condition 9(1)(e).

5.2.2 Potential for unburied cables

38. Table 5.25 of Chapter 5 Project Description of the East Anglia THREE ES provides the total values for East Anglia THREE unburied cables. In accordance with the approach taken for Norfolk Vanguard, East Anglia THREE included the potential for 10% of the cable length to be unburied and therefore requiring cable protection.

39. The maximum width and height of cable protection for unburied cable at East Anglia THREE would be 3m and 0.3m respectively. Whereas the width and height of cable protection for unburied cable at Norfolk Vanguard would be 5m and 0.5m, respectively. The assumptions taken by Norfolk Vanguard Ltd (i.e. 10% length, 5m width and 0.5m height) are therefore deemed to be relatively comparable with that of the consented East Anglia Three project (i.e. 10% of the cable length, 3m width and 0.3m height).

40. As stated above, the total quantities of cable protection for Norfolk Vanguard must be agreed with the MMO through the Scour Protection and Cable Protection plan, as required under draft DCO Schedules 9 and 10 Condition 14(1)(e) and Schedules 11 and 12 Condition 9(1)(e).

6 COMPARISON WITH HORNSEA PROJECT THREE

6.1 Sediment disposal

41. Table 6.1 provides a comparison of sediment disposal volumes in the Hornsea Project Three and Norfolk Vanguard DMLs.

42. It should be noted that the values from the Hornsea Project Three, Volume 4, Annex 3.2 - Dredging and Disposal: Site Characterisation document appear to be different to the values in the Hornsea Project Three draft DCO and so values from both sources are presented in the totals in Table 6.1. The values for each infrastructure type are based on Table 2.2 of Vol 4, Annex 3.2.

43. The key differences between Norfolk Vanguard and Hornsea Project Three are highlighted orange in Table 6.1, which shows that these are associated with cable installation and seabed preparation for WTG foundations. The differences in approach to calculating sediment disposal associated with cable installation and WTG foundations are explained further in Sections 6.1.1 and 6.1.2, respectively with a summary provided in Section 7.

Table 6.1 Comparison of seabed levelling volumes

Infrastructure	Hornsea Project Three DML (m3)	Hornsea Project Three average per unit	Norfolk Vanguard DML (m3)	Norfolk Vanguard average per unit
Transmission DML				
Seabed levelling for export cables	1,202,956 (relative to 1371km total cable length) + 20,000 (3km of HDD exit pits)	0.9m^3 per m of cable	2,400,000 (relative to 400km total cable length (laid in pairs)	6m^3 per m of cable
Offshore electrical platforms	735,000 (12 offshore transformer substation) + 193,960 (four HVDC converter substation) + 245,000 (four HVAC booster station)	58,698m^3 per platform	75,000 (two platforms)	37,500m^3 per platform
Interconnector cable	Included in array cable total		9,000,000 (150km length)	60m^3 per m of cable
DML Total	**2,396,916 (**based on values from Table		**11,475,000**	

Infrastructure	Hornsea Project Three DML (m3)	Hornsea Project Three average per unit	Norfolk Vanguard DML (m3)	Norfolk Vanguard average per unit
	2.2 of Vol 4, Annex 3.2 [5]) **OR** **2,218,816** (based on transmission DML)			
Generation DML				
Array cables	71,150 (relative to 1,055km total cable length)	0.07m^3 per m of cable	36,000,000 (relative to 600km total cable length)	60m^3 per m of cable
WTGs	1,225,692 (300 WTG)	4,086m^3 per WTG	3,645,000 (200 WTG)	18,225m^3 per WTG
Accommodation platforms	63,335 (three platforms);	21,112m^3 per platform	75,000 (two platforms)	37,500m^3 per platform
Met masts	N/A	N/A	12,566 (two met masts)	6,283m^3 per met mast
DML Total	**1,360,177 (**based on values from Table 2.2 of Vol 4, Annex 3.2) **OR** **1,344,318** (based on generation DML)		**39,732,566**	
Project Total	**3,757,093** based on para 2.2.2.7 of Vol 4, Annex 3.2 OR **3,563,133** (based on Schedule 1 Part 1 of the DCO)		**51,207,566**	

6.1.1 Cable installation

6.1.1.1 Array cables

44. Table 1.11 of Hornsea Project Three, Volume 2, Chapter 1 - Marine Processes states that "*based on the available geophysical data, it is anticipated that the bedforms requiring clearance in the array area are likely to be up to 2m in height.*" Whereas for Norfolk Vanguard, sandwaves of up to 5m are anticipated in the OWF sites and an

[5] Hornsea Project Three Volume 4, Annex 3.2 - Dredging and Disposal: Site Characterisation

average sandwave depth of 3m has been assumed in the calculation of sandwave clearance for the array cables.

45. Table 3.5 of Hornsea Project Three ES Chapter 3 Project Description states the length of array cable that could be affected by sandwaves is 498,000m (i.e. 498km (47%) of the 1,055km total length). A disturbance width of 30m is quoted in Table 3.5 of Hornsea Project Three ES Chapter 3 Project Description. It is assumed by Norfolk Vanguard Ltd that the total volume of 71,150m^3 is calculated using the analysis methodology presented in Appendix 11 of the Hornsea Project Three Deadline I submission – Sandwave Clearance Clarification Note[6].

46. As discussed in section 4.1 of this document, a total array cable length of 600,000m with an average clearance width of 20m and depth of 3m has been assumed for Norfolk Vanguard. The Applicant considers these assumptions to be appropriately conservative in order to install the cables within the stable reference seabed level and minimise the potential for reburial during operation and maintenance.

6.1.1.2 Export cables

47. Table 1.11 of Hornsea Project Three, Volume 2, Chapter 1 - Marine Processes states that bedforms requiring clearance are likely to be in the range of 1 to 6 m in height in the offshore cable corridor and up to 2m in height in the wind farm site, as discussed above. Whereas for Norfolk Vanguard, sandwaves of up to 5m are anticipated through the offshore project area.

48. Table 3.4 of Hornsea Project Three ES Chapter 3 states the length of export cables that could be affected by sandwaves is 102,000m (i.e. 102km (7.4%) of the 1,371km total cable length) and 30m, respectively, with a total volume of 1,202,956m^3. Appendix 11 of the Hornsea Project Three Deadline I submission – Sandwave Clearance Clarification Note[6] provides the methodology used to calculate sediment volumes for Hornsea Project Three.

49. As discussed in sections 4.1 and 5.1.1.2 above, a total of 30,000m export cable trench length with an average clearance width of 20m and an average depth of 3m (i.e. 1,800,000m^3) has been assumed for the Norfolk Vanguard export cables in the offshore wind farm sites, in order to install the cables within the stable reference seabed level and minimise the potential for reburial during operation and maintenance.

50. In addition, a further 600,000m^3 of sandwave clearance is anticipated in the offshore cable corridor based on the detailed analysis by CWind provided in the Cable

[6] Available at: https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010080/EN010080-001133-DI_HOW03_Appendix%2011.pdf

installation study (ES Appendix 5.1), which is comparable with the Hornsea Project Three values for the offshore cable corridor.

6.1.2 WTG foundation

51. Section 2.1.3 of the Hornsea Project Three, Volume 4, Annex 3.2 - Dredging and Disposal: Site Characterisation states that "*it is assumed that in some areas of Hornsea Three, a thick layer of up to 5m of top sediment with a diameter of 61m may have to be excavated before installation of ....the largest turbines.... Based on initial site surveys, it is expected that the average thickness of the dredged layer across the Hornsea Three Array will be approximately 2m*." Table 3.22 of Hornsea Project Three ES: Chapter 3: Project Description also refers to a diameter of 61m, however ES Volume 2, Chapter 1 - Marine Processes refers to a seabed preparation area diameter of 51m and an average depth 2m, providing the total spoil volume of 1,225,692m^3 stated in Volume 4, Annex 3.2 (shown in Table 6.1 above).

52. As discussed in section 4.1 above, 3,645,000m^3 of sandwave clearance was estimated for Norfolk Vanguard WTG foundations based on an area of approximately 90 x 90m for floating wind foundations on gravity anchors and up to 5m sediment depth. However, it should be noted that floating foundations have now been removed from the design envelope for Norfolk Vanguard and the Applicant is reviewing the sandwave clearance requirements for the remaining foundation types.

6.2 Cable Protection

53. Table 5.2 provides a comparison of cable protection volumes in the Hornsea Project Three and Norfolk Vanguard DMLs. The approach to calculating cable protection volumes is outlined in Sections 6.2.1 and 6.2.2.

Table 6.2 Comparison of cable protection volumes

Parameter	Hornsea Three DML (m3)	Hornsea Three average per unit (m3 per m of cable)	Norfolk Vanguard DML (m3)	Norfolk Vanguard average per unit
Transmission DML				
Export cables	1,371,000 (1,371km of cable)	1	69,836m^3 (400km of cable)	0.17
Interconnector cable	N/A	N/A	38,000m^3 (150km of cable)	0.25
Generation DML				
Array cables	1,055,000 (1,055km of cable)	1	209,000m^3 (600km of cable)	0.35

6.2.1 Cable crossings

54. Table 3.48 of the Hornsea Project Three ES, Chapter 3 Project Description provides a volume of cable protection of 2,625m^3 per crossing, however the source of this is unclear.

55. As discussed in section 4.2 of this document, the Norfolk Vanguard assumptions for cable crossings are based on 100m length x 10m width x 0.9m height of protection per crossing (i.e. 900m^3 per crossing).

6.2.2 Potential for unburied cables

56. Hornsea Project THREE identifies a potential requirement for 10% of the cable length to require cable protection. This is comparable with the assumptions taken by Norfolk Vanguard Ltd (i.e. 10% length, 5m width and 0.5m height) although the width and height of the Hornsea Project THREE protection is not apparent.

7 SUMMARY

57. The Applicant has taken a conservative approach to calculating disposal volumes and cable protection. This is in accordance with early advice from the MMO during the Evidence Plan Process for the project to avoid requirements for additional licences or variations post-consent.

58. A Cable Installation Study (provided in ES Appendix 5.1) was undertaken for Norfolk Vanguard using geophysical and geotechnical survey data from the offshore cable corridor to calculate the volume of sandwave levelling to the stable reference seabed level for the export cables in the offshore cable corridor, in order to minimise the potential for reburial during operation and maintenance.

59. In addition, estimated volumes for sandwave levelling in the OWF sites have been calculated based on an assumption that 100% of the cable length could require levelling to the stable reference seabed level, as the layout of WTGs and OEPs is not known at this stage and therefore the layout of cables within the OWF sites is also unknown. This assumption is shown to be the main difference in the disposal volumes between Norfolk Vanguard, Hornsea Project Three and East Anglia THREE.

60. Similar assumptions have been made across the projects with regards to the requirement for 10% of the cable lengths potentially being unburied and therefore requiring cable protection for all three projects. There are slight differences in the estimated width and height of cable protection for each project as well as the solutions for cable or pipeline crossings.

61. Table 7.1 and Table 7.2 provide a summary of the assumptions and parameters that have been used by Hornsea Project Three, East Anglia THREE and Norfolk Vanguard in defining the worst case scenarios for sediment disposal and cable protection, respectively.

Table 7.1 Summary table of sediment disposal volumes

Infrastructure	Hornsea Project Three		East Anglia THREE		Norfolk Vanguard	
	Assumptions	Parameters	Assumptions	Parameters	Assumptions	Parameters
Export cable	Based on methodology provided in Appendix 11 of the Hornsea Project Three Deadline I submission –Sandwave Clearance Clarification Note[6]	**1,202,956m³ (equivalent to 0.9m³ per m)** based on • Sandwaves affecting up to 102km length of the 1,371km total cable length • 30m width • Depth of clearance variable based on the analysis	Based on estimates for East Anglia ONE	**324,484m³ (equivalent to 0.5m³ per m)** based on: • (width, length and depth unclear)	Based on: • Cable Installation study for the offshore cable corridor, provided in ES Appendix 5.1; and • Assumption that 100% of the export cables where they enter the OWF sites could require levelling	**2,400,000m³ (equivalent to 6m³ per m)** based on: • 600,000m³ in the offshore cable corridor (relative to 400km export cable pairs) • 1,800,000m³ in OWF sites (30,000m length x 20m average width x 3m average depth)
Array cable and Interconnector cable	Based on methodology provided in Appendix 11 of the Hornsea Project Three Deadline I submission –Sandwave Clearance Clarification Note	**71,150m³ (equivalent to 0.07m³ per m)** based on: • Sandwaves affecting up to 498km length of the 1,055km total cable length • 30m width • Depth of clearance variable based on the analysis	Based on estimates for East Anglia ONE	**168,431m³ (equivalent to 0.2m³ per m)** based on: • 94,684m³ array cable • 73,747m³ interconnector cable • (width, length and depth unclear)	100% of the array cable could require levelling	**45,000,000m³ (equivalent to 60m³ per m)** based on: • 36,000,000m³ array cable (600,000m length x 20m average width x 3m average depth) • 9,000,000m³ interconnector cable (150,000m length x 20m width x 3m depth)
WTG	Seabed preparation area diameter of 51m with an average depth 2m	**1,225,692m³** based on: • 300 WTG • **4,086m³ per WTG**	• Pit shaped excavation with sides of up to 1:8 gradient • Seabed preparation area of 70 x 70m at base of pit • Max depth 5m	**1,505,000m³** based on: • 86 WTG • **17,500m³ per WTG**	• Seabed preparation area of 90 x 90m • Average depth 5m	**3,645,000m³** based on: • 200 WTG • **18,225m³ per WTG**

Table 7.2 Summary table of cable protection volumes

Infrastructure	Hornsea Project Three	East Anglia THREE	Norfolk Vanguard
Crossings	• 2,625m³ per crossing (length, width and height unclear)	• 215m³ per crossing based on 17 mattresses of 6x3x0.6 to achieve protection of: ○ 100m length ○ 3m width ○ 0.6m height	• 900m³ per crossing based on: ○ 100m length ○ 10m width ○ 0.9m height of protection per crossing
Unburied cables	• 10% of cable length • Length and width unclear	• 10% of cable length • 3m width • 0.3m height	• 10% of cable length • 5m width • 0.5m height