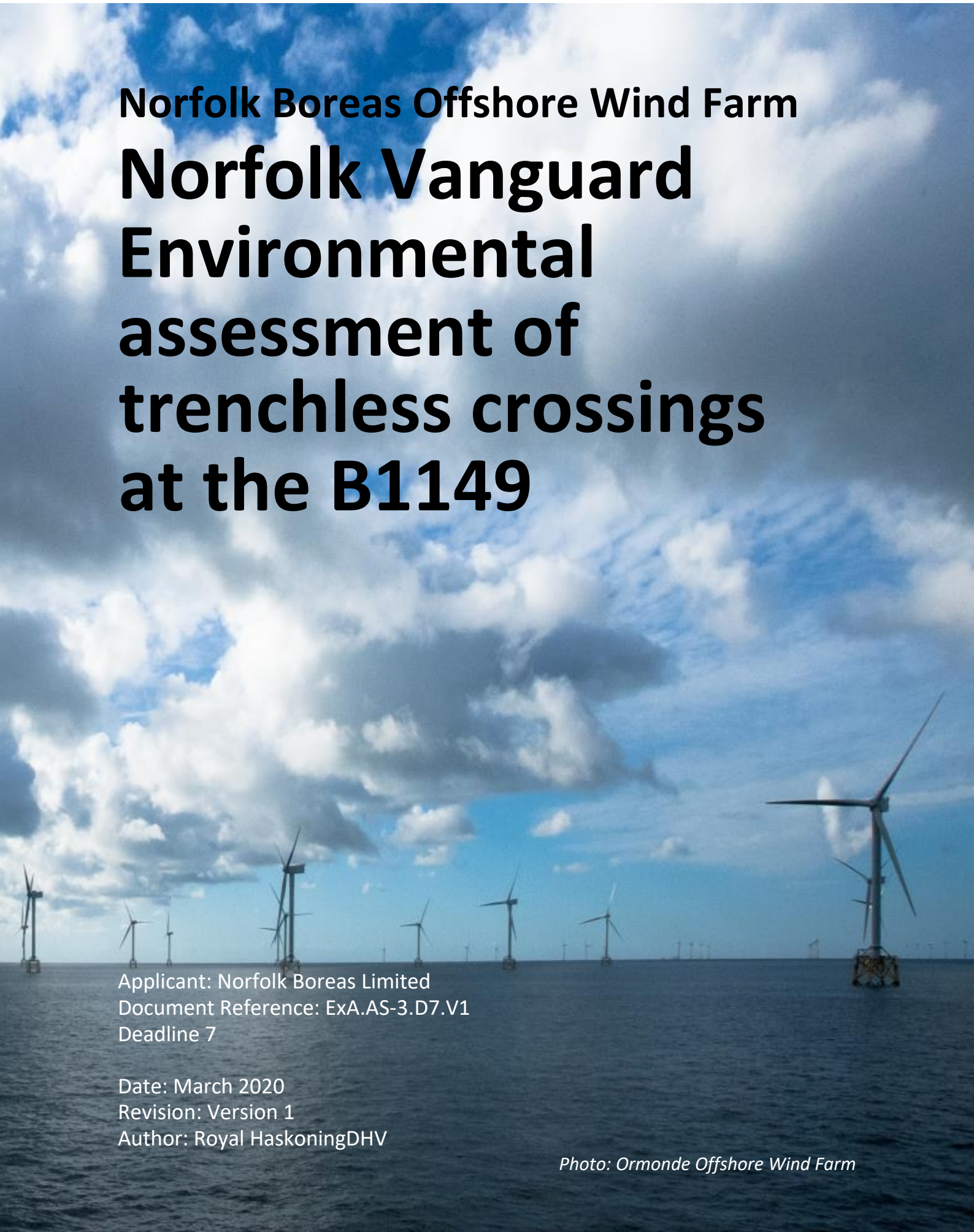
VATTENFALL

Norfolk Boreas Offshore Wind Farm

Norfolk Vanguard Environmental assessment of trenchless crossings at the B1149



Applicant: Norfolk Boreas Limited
Document Reference: ExA.AS-3.D7.V1
Deadline 7

Date: March 2020
Revision: Version 1
Author: Royal HaskoningDHV

Photo: Ormonde Offshore Wind Farm

Norfolk Vanguard Offshore Wind Farm

Applicant's Response to Request for Information

Appendix 2 Environmental assessment for trenchless crossing of B1149

Applicant: Norfolk Vanguard Limited

Document Reference: ExA;WQ;11.D10.1.App2

Deadline 10

Date: 28 February 2020
Author: Royal HaskoningDHV

Photo: Kentish Flats Offshore Wind Farm

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14/02/2020	01D	Draft for client review	RHDHV	JA	JA
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1 INTRODUCTION

1.1 Purpose of this Document

1. This environmental assessment has been prepared on behalf of Norfolk Vanguard Limited (the Applicant) in relation to the Norfolk Vanguard Offshore Wind Farm ('the Project'). The purpose of the assessment is to consider whether any future requirement for a trenchless crossing solution at the B1149, north of Cawston, would give rise to any potentially significant environmental impacts beyond those already assessed and presented in the Norfolk Vanguard Environmental Statement (ES) submitted in June 2018 (DCO document 6.1).

2 APPROACH TO CROSSING THE B1149

2.1 Crossing methodology

2. The construction methodology assessed for the B1149 crossing within the application submitted in June 2018 was for an open cut trench solution. The point at which the onshore cable route crosses the B1149 is shown on Figure 1 below. The nearest residential property (CRR12) is located approximately 165m south of the crossing point and is also identified on Figure 1.

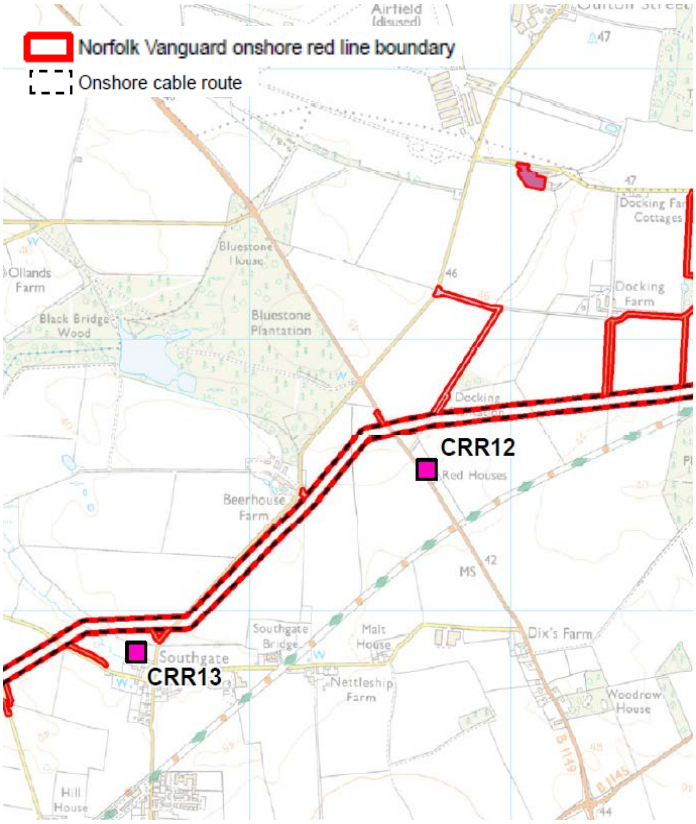

Figure 1: Norfolk Vanguard Cable route crossing the B1149

3. To implement a trenchless crossing method, additional temporary land is required for trenchless crossing compounds to accommodate the additional plant and materials (such as drilling rigs, water bowsers, generators, drilling fluids), which are specifically required for the trenchless method compared to open cut methods.

4. Typically trenchless crossing compounds are located adjacent to the launch and exit pits for the crossing. Siting the temporary compound adjacent to the launch and reception pits allows for all materials storage, welfare provision, and contractor parking to be directly accessible to the trenchless crossing equipment and work site for efficient management of the works. The additional area that is required for the trenchless crossing compounds (in comparison to an open cut trench solution) is achieved by widening the Order limits at the trenchless crossing launch and exit locations. By way of an example, two compounds (TC8) associated with trenchless crossing 8 at Reepham and which are included as part of the application are shown on Figure 2.

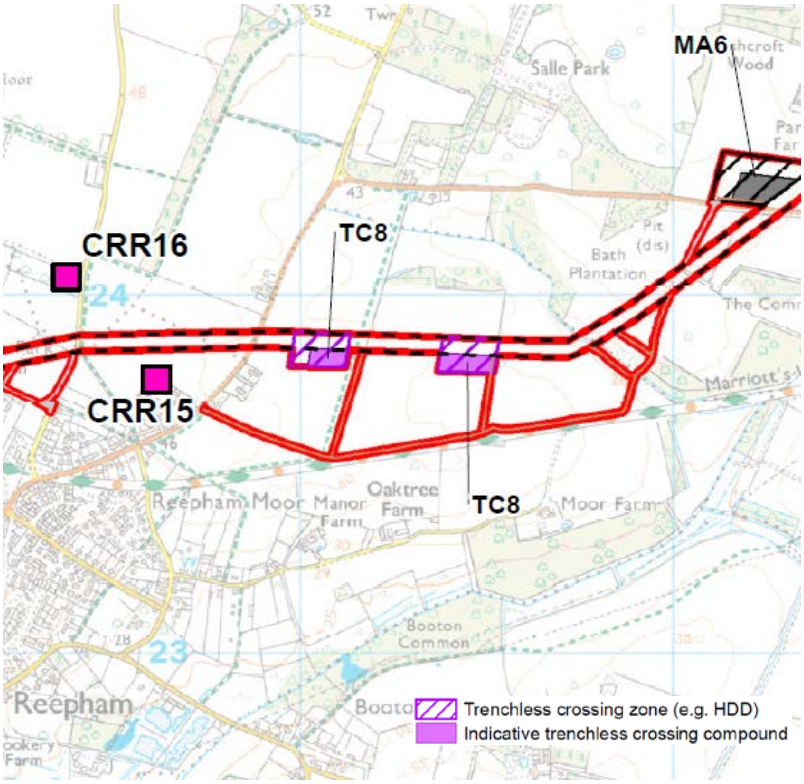

Figure 2: Example of trenchless crossing compounds required at TC8 at Reepham

5. Where the cable corridor crosses the B1149, as shown on Figure 1, no works compounds or mobilisation areas have been included within the current Order limits as submitted for the DCO application. In line with a request from Norfolk County Council, in order to accommodate a potential trenchless crossing in this location, a bespoke design has been developed whereby a single compound can be included within the existing Order limits. This compound would be set back approximately 250m from the crossing location, rather than alongside the trenchless crossing launch and exit locations. This arrangement ensures that the required trenchless crossing compound area could remain wholly within the Order limits. This bespoke arrangement is shown on Figure 3.

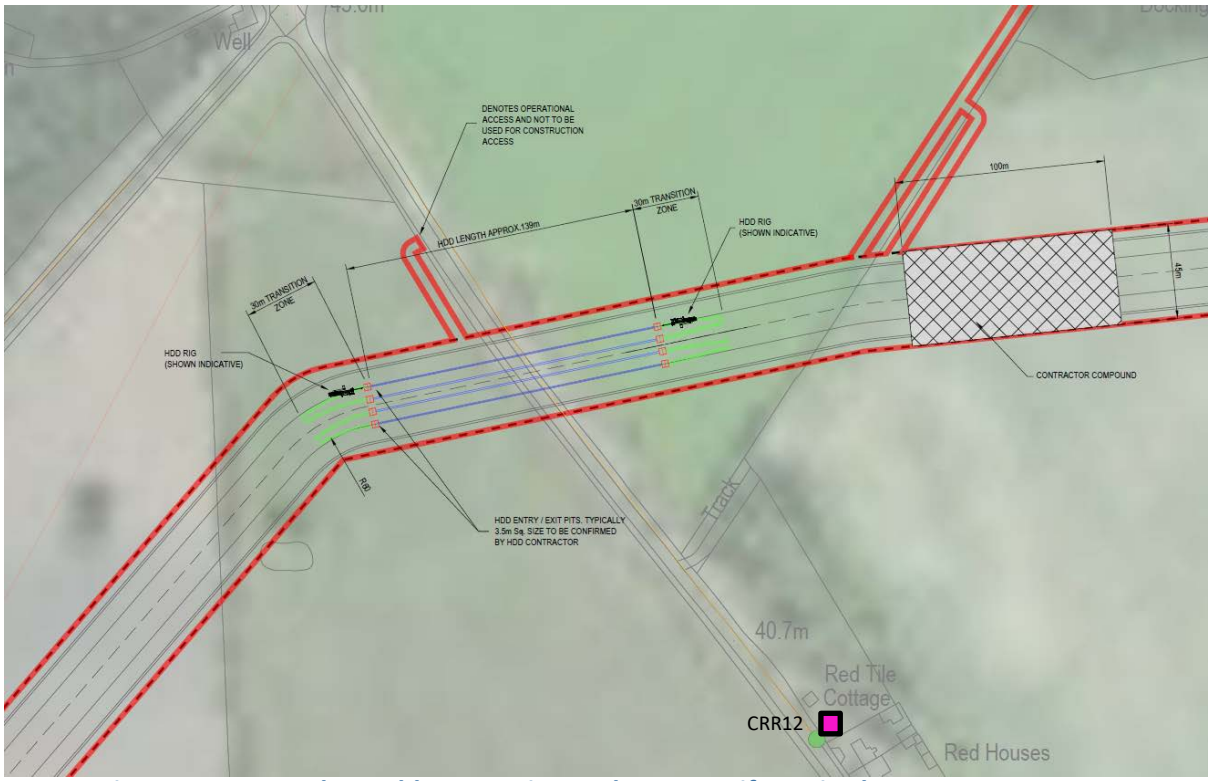

Figure 3: Proposed trenchless crossing at the B1149, if required

6. The bespoke design only accommodates the Horizontal Directional Drill (HDD) trenchless crossing method (and no other trenchless crossing method) to minimise supporting construction compound requirements, such that the compound can be contained wholly within the current Order limits. Other trenchless crossing methods such as auger boring, pipe jacking and micro tunnelling could not practicably be employed here because additional temporary land adjacent to the launch and reception pits would be needed to support the plant and materials required to sink shallow shafts at both the launch and reception pit. At all other trenchless crossing locations flexibility is retained for all trenchless crossing methods so that the most

appropriate solution can be employed following ground investigation, cable design (sizing) and detailed design of the trenchless crossing. To accommodate a HDD at this location, the Applicant is therefore constraining the Project design.

7. The HDD method minimises the temporary construction compound requirements due to the surface to surface drilling method which avoids the need to sink shallow shafts at the launch and reception pit. The bespoke design therefore includes a single temporary construction compound in the vicinity of the launch pit to support the drilling activities. A temporary construction compound at the reception pit can be excluded with this method and works can be wholly contained within the Order limits.

8. However, there is still a requirement for a separate construction compound. In order to accommodate this construction compound within the current Order limits, this would be located approximately 250m from the trenchless crossing launch site; this will result in inefficient construction methods due to double handling of materials (delivery to compound for storage with subsequent 'shuttling' between the compound and the launch site) and similar impacts to workforce double movements between the compound (for parking) and the launch site. Furthermore, the exclusion of a temporary construction compound adjacent to the reception pit will result in the intricate management and movement of materials and plant within the Order limits whilst works are being conducted.

9. Inefficiencies of the construction method compared to standard practice, and the requirement to establish a remote temporary compound, is likely to result in a programme length of approximately 9-10 weeks for this trenchless crossing, compared to 1-2 weeks for the equivalent trenched crossing .

10. The remainder of this note considers the equipment associated with a potential trenchless crossing of the B1149, the timings of the works, and the associated environmental impacts. The relevant differences between the assessed open cut methodology and the trenchless crossing methodology are presented below in **Table 1.1**.

Table 1.1 Comparison of originally assessed parameters and those associated with a trenchless crossing

Parameter	Originally assessed values (mobilisation area / open-cut trench)	Trenchless crossing values
Working hours	Consented construction hours: 07.00 – 19.00 Monday to Friday 07.00 – 13.00 Saturday No work on Sundays or public holidays. As set out in DCO Requirement 26.	Consented construction hours: 07.00 – 19.00 Monday to Friday 07.00 – 13.00 Saturday Trenchless crossings may require works to extend outside of the consented hours (for

<table>
<tr><th>Parameter</th><th>Originally assessed values (mobilisation area / open-cut trench)</th><th>Trenchless crossing values</th></tr>
<tr><td></td><td></td><td>technical reasons following commencement of drilling), i.e. works may extend into the evening or night time.

Should works be required to extend beyond the consented hours then prior approval would be required from the relevant planning authority as set out in DCO Requirement 26.</td></tr>
<tr><td>Equipment / plant and associated noise levels</td><td>Duct installation (daytime)
<table>
<tr><th>Name</th><th>LwA dB(A)*</th><th>On time Correction**</th></tr>
<tr><td>Bulldozer</td><td>108</td><td>75%</td></tr>
<tr><td>Dump Truck</td><td>107</td><td>75%</td></tr>
<tr><td>Tracked Excavator</td><td>107</td><td>75%</td></tr>
<tr><td>Generator</td><td>105</td><td>100%</td></tr>
<tr><td>Water Pump</td><td>93</td><td>75%</td></tr>
<tr><td>Dump Truck</td><td>115</td><td>15km/h</td></tr>
<tr><td>Lorry</td><td>108</td><td>15km/h</td></tr>
</table>
Temporary work areas (daytime)
<table>
<tr><th>Name</th><th>LwA dB(A)</th><th>On time Correction</th></tr>
<tr><td>Tracked Excavator</td><td>107</td><td>25%</td></tr>
<tr><td>Bulldozer</td><td>108</td><td>25%</td></tr>
<tr><td>Dumper</td><td>101</td><td>25%</td></tr>
<tr><td>Mobile Crane</td><td>106</td><td>25%</td></tr>
<tr><td>Generator</td><td>105</td><td>100%</td></tr>
</table>
Evening / night-time activities
None</td><td>Trenchless crossing (daytime)
<table>
<tr><th>Name</th><th>LwA dB(A)*</th><th>On time Correction**</th></tr>
<tr><td>Tracked Excavator</td><td>107</td><td>50%</td></tr>
<tr><td>Backhoe Loader</td><td>96</td><td>50%</td></tr>
<tr><td>Bulldozer</td><td>108</td><td>50%</td></tr>
<tr><td>Dumper</td><td>101</td><td>50%</td></tr>
<tr><td>Mobile Crane</td><td>106</td><td>25%</td></tr>
<tr><td>Cement Mixer</td><td>103</td><td>25%</td></tr>
<tr><td>Concrete Pump</td><td>108</td><td>25%</td></tr>
<tr><td>Piling</td><td>118</td><td>10%</td></tr>
<tr><td>Drilling Rig</td><td>105</td><td>75%</td></tr>
<tr><td>Water Pump</td><td>93</td><td>75%</td></tr>
<tr><td>Generator</td><td>105</td><td>100%</td></tr>
</table>
Trenchless crossing (evening / night-time)
<table>
<tr><th>Name</th><th>LwA dB(A)</th><th>On time Correction</th></tr>
<tr><td>Backhoe Loader</td><td>96</td><td>50%</td></tr>
<tr><td>Dumper</td><td>101</td><td>50%</td></tr>
<tr><td>Drilling Rig</td><td>105</td><td>75%</td></tr>
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<tr><td>Generator</td><td>105</td><td>100%</td></tr>
</table></td></tr>
</table>

Parameter	Originally assessed values (mobilisation area / open-cut trench)	Trenchless crossing values
* A-weighted sound power level in decibels ** Percentage of assessment period that plant is expected to be in operation		

2.2 Environmental Assessment

11. Table 1.2 considers the proposed change in construction methodology for the crossing of the B1149 in relation to each of the previously assessed relevant onshore EIA topics.

Table 1.2 Environmental considerations

Onshore ES topic	Consideration of potential effects	Change to previously assessed findings?
Ground conditions and contamination (Chapter 20)	The proposed change in construction methodology remains wholly within the previously assessed Order limits and is no closer to any identified sensitive receptors associated with ground conditions and contamination. On this basis there will be no change to the previously reported findings.	No change
Land use and agriculture (Chapter 21)	The proposed change in construction methodology remains wholly within the previously assessed Order limits and no additional land will be affected as a result of this change. The change in construction plant operating within this temporary works area, and the potential for works to extend into the evening / night time, is unrelated to the assessment criteria agreed for land use and agricultural receptors. Therefore there will be no change to the previously reported findings.	No change
Onshore ecology and ornithology (Chapters 22 and 23)	The proposed change in construction methodology remains wholly within the previously assessed Order limits and no additional land will be affected as a result of this change. There are no sensitive ecological receptors in proximity to this crossing and the change in construction plant operating within these areas will not change the previously reported findings.	No change
Traffic and transport (Chapter 24)	The inclusion of a new trenchless crossing would generate a new traffic peak of 96 HGV daily movements. ES Chapter 24 Traffic and Transport details within paragraphs 146 and 147 that a maximum of three trenchless crossing work gangs would be active at any one time across the whole onshore cable route. This constrains traffic demand to a level that would	No change

Onshore ES topic	Consideration of potential effects	Change to previously assessed findings?
	be generated by three trenchless crossings active at any point within the construction programme (an effective traffic demand 'cap' associated with this activity). The B1149 has already been assessed for the maximum HGV peak demand associated with three active trenchless crossing sites, i.e. the peak traffic demand assessed will not change as a result of the inclusion of the additional trenchless crossing, because there can never be more than three active trenchless crossings at any one time. Therefore, the inclusion of an additional trenchless crossing on the B1149 would result in no change to Traffic and Transport impacts as assessed within the ES Chapter 20 and subsequently within the cumulative impact assessment submitted at Deadline 5 (ExA; ISH1; 10.D5.3).	
Noise and vibration (Chapter 25)	The nearest noise sensitive receptor is CRR12 located approximately 165m from the proposed crossing. A detailed assessment of potential noise and vibration effects associated with the change to a trenchless crossing of the B1149 is provided in **Appendix A**. Open cut trenching was limited to the consented working hours, i.e. 07.00 – 19.00 Monday to Friday and 07.00 to 13.00 on Saturdays. Trenchless crossings include the potential for work to extend beyond the consented hours due to the continuous nature of the drilling. Therefore evening, weekend and night time working must be taken into consideration. In addition, a trenchless crossing method has the potential for percussive piling to anchor the drills, which is not present in the open-cut methodology.	The assessed noise levels associated with a trenchless crossing of the B1149 at the nearest noise sensitive receptor (CRR12) represent an impact of **negligible** significance during the daytime, evening and weekend reference periods (reported in full in **Appendix A**). The predicted noise levels associated with a trenchless crossing of the B1149 represent an impact of **major adverse** significance (without mitigation) at receptor CRR12 should night-time working be required. However, with the inclusion of enhanced mitigation in the form of 3.5m high standard noise absorptive barriers, the residual impact is reduced to **negligible** significance. A Construction Noise Management Plan (CNMP) will be included in the final Code of Construction Practice (CoCP), as required under Requirement 20 (2)(e) of the DCO. Enhanced mitigation (including noise absorptive barriers) is

Onshore ES topic	Consideration of potential effects	Change to previously assessed findings?
		captured in the existing outline CoCP (document reference 8.1). The CNMP provided within the final CoCP will apply throughout that stage of construction and will detail standard mitigation (best practical means) and where applicable, enhanced mitigation measures. The exact specification of any noise barriers that may be required to mitigate significant residual construction noise will be determined during detailed design. Noise barriers will be introduced with the appropriate specification for the location and noise reduction required. Piling, if required, at a distance of at least 165m (the distance between the works and CRR12) represents a vibration impact of **negligible** significance.
Air quality (Chapter 26)	The proposed change in construction methodology remains wholly within the previously assessed footprint and does not introduce any new dust generating activities compared to those previously assessed. No significant air quality impacts were identified in the original assessment. Therefore there will be no change to the previously reported findings.	No change
Human health (Chapter 27)	Potential health impacts are related to potential increases to construction noise, air quality and exposure to historic contaminants. There are no identified changes to the findings of the air quality and contaminated land assessments. However, as noted above, there are changes to the previously reported construction noise impacts due to the potential requirement for works to extend into the evening and night time due to the continuous nature of drilling works.	Noise impacts are considered earlier in this table and in detail in **Appendix A**. Without mitigation there is the potential for significant noise impacts should works extend into the night time reference period. With the inclusion of noise absorption barriers this potential effect will be reduced to not significant. Noise barriers will be introduced with the appropriate specification for the location and noise reduction required. This is captured within the OCoCP and secured through Requirement 20 (2)(e) of the DCO.

Onshore ES topic	Consideration of potential effects	Change to previously assessed findings?
		With the inclusion of appropriately designed noise absorption barriers in the event of night time working being permitted, no significant impacts to human health are anticipated as a result of the proposed change in construction methodology.
Onshore archaeology and cultural heritage (Chapter 28)	The proposed change in construction methodology remains wholly within the previously assessed footprint and will not lead to any change of effect upon known buried heritage assets or any of the receptors assessed in the heritage settings assessment. Therefore there will be no change to the previously reported findings.	No change
Landscape and visual impact (Chapter 29)	The proposed change in construction methodology remains wholly within the previously assessed footprint. It is no closer to any identified sensitive visual receptors and does not lead to any change in views from previously identified sensitive receptors. The change in methodology would not lead to any increased visibility or change in landscape character. As such, there will be no change to the previously reported findings.	No change
Tourism and recreation (Chapter 30)	The proposed change in construction methodology remains wholly within the previously assessed footprint and is no closer to any identified sensitive receptors associated with tourism and recreation, and therefore there will be no change to the previously reported findings.	No change
Socio-economics (Chapter 31)	The proposed change in construction methodology will not result in any changes to the reported construction workforce numbers, and therefore there will be no change to the previously reported findings.	No change

12. Based on the review provided in Table 1.2, there are changes to the reported findings associated with noise and vibration and human health impacts (also noise related). These changes relate to the potential requirement for drilling works to extend beyond the consented construction hours. A potential **major adverse** noise impact has been identified at the closet noise sensitive receptor (CRR12) should works be required to take place during the night.

13. With the inclusion of enhanced mitigation in the form of 3.5m high standard noise absorptive barriers, noise levels at CRR20 would be reduced to 39.5dBA representing a residual impact of **negligible** significance.

14. A CNMP will be included in the final CoCP, as required under Requirement 20 (2)(e) of the DCO. The Outline CoCP commits the Applicant to delivering a CNMP, which will apply throughout that stage of construction and will detail standard mitigation (best practical means) and where applicable, enhanced mitigation measures. The exact specification of any noise barriers that may be required to mitigate significant residual construction noise will be determined during detailed design based on the confirmed list of plant and equipment. Noise barriers will be introduced with the appropriate specification for the location and noise reduction required.

15. Piling, if required, at a distance of at least 165m from the nearest noise sensitive receptor represents a vibration impact of **negligible** significance.

16. For works taking place during the daytime, evening and weekends potential noise impacts remained of **negligible** significance.

17. There are no changes to the impacts identified for other relevant onshore EIA topics associated with the proposed change in construction methodology for a trenchless crossing of the B1149. The findings of the submitted Environmental Statement therefore remain valid for those topics.

APPENDIX A Construction Noise and Vibration Assessment

1 CONSTRUCTION NOISE ASSESSMENT

1. This construction noise impact assessment considers the potential for noise impacts at the nearest noise sensitive receptor (CRR12) associated with a potential change in the proposed method of crossing the B1149, from an open cut solution to a trenchless crossing solution. The location where the onshore cable crosses the B1149 and the nearest noise sensitive receptor CRR12 are shown below on Figure A.1.

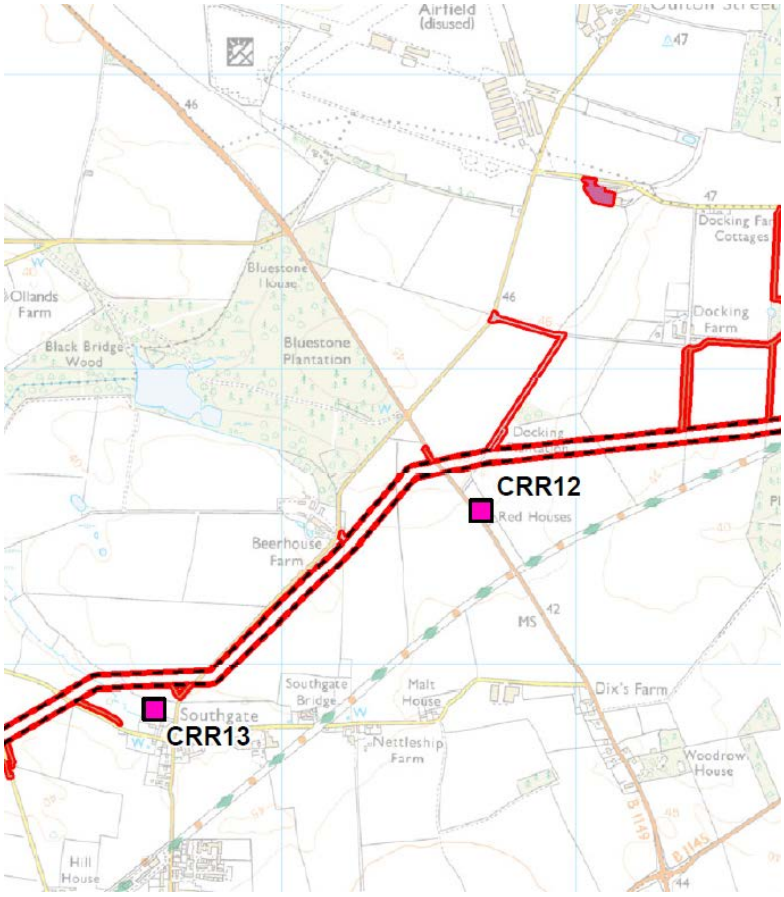

Figure A.1: Location of B1149 crossing

2. Potential noise effects of the proposed trenchless crossing of the B1149 have been assessed in accordance with the BS5228:2009+A1:2014 Daytime (07:00 to 19:00), Evening and weekends (19:00 to 23:00 Monday to Friday, 13:00 to 23:00 Saturday and 07:00 to 23:00 Sunday), and Night time (23:00 to 07:00) reference periods. Any associated impacts of the proposed Norfolk Vanguard scheme are highlighted, and mitigation is considered where appropriate.

3. This document supports Environmental Statement (ES) Chapter 25 Onshore Noise and Vibration.

1.1 Construction Noise and Vibration Assessment Methodology

4. This noise and vibration impact assessment adheres with the methodology set out in Section 25.4 of ES Chapter 25 Noise and Vibration. SoundPLAN noise modelling was utilised in the construction phase assessment.

1.1.1 Construction Phase Noise Assessment

5. BS 5228:2009+A1:2014[1] specifies a construction noise limit based on the existing ambient noise level for different periods of the day. The predicted construction noise levels were assessed against noise limits derived from advice within Annex E of BS 5228. Table A.1, reproduced from BS 5228, presents the criteria for selection of a noise limit for a specific receptor location.

Table A.1 Construction noise threshold levels based on the ABC method (BS 5228)

Assessment category and threshold value period (L_{Aeq})	Threshold value, in decibels (dB)		
	Category A[A)]	Category B[B)]	Category C[C)]
Night time (23.00 – 07.00)	45	50	55
Evenings and weekends [D)]	55	60	65
Daytime (07.00 – 19.00) and Saturdays (07.00 – 13.00)	65	70	75
A) Category A: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are less than these values.			
B) Category B: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are the same as category A values.			
C) Category C: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are higher than category A values.			
D) 19.00–23.00 weekdays, 13.00–23.00 Saturdays and 07.00–23.00 Sundays.			

6. The model used in this assessment incorporated noise sources located in the study area, nearby residential dwellings and other buildings, intervening ground cover and topographical information.

7. Noise levels for the construction phase were calculated using the methods and guidance in BS 5228. This Standard provides methods for predicting receptor noise

[1] British Standards Institution (2014) [BS] 5228-1:2009+A1:2014 Code of practice for noise and vibration control on construction and open sites – Part 1: Noise

levels from construction works based on the number and type of construction plant and activities operating on site, with corrections to account for:

- The 'on-time' of the plant, as a percentage of the assessment period;
- Distance from source to receptor;
- Acoustic screening by existing barriers, buildings or topography; and
- Ground type.

8. Construction noise impacts were assessed using the impact magnitude presented in Table A.2 for the daytime period, Table A.3 for the evening and weekend periods, and Table A.4 for the night time period.

Table A.2 Day time construction noise significance criteria

Impact magnitude	Construction noise level (dB)		
	A 65dB threshold	B 70dB threshold	C 75dB threshold
No Impact	≤65	≤70	≤75
Negligible Adverse	≥65.1 - ≤65.9	≥70.1 - ≤70.9	≥75.1 - ≤75.9
Minor Adverse	≥66.0 - ≤67.9	≥71.0 - ≤72.9	≥76.0 - ≤77.9
Moderate Adverse	≥68.0 - ≤69.9	≥73.0 - ≤74.9	≥78.0 - ≤79.9
Major Adverse	≥70	≥75	≥80

Table A.3 Evening and weekends construction noise significance criteria

Impact magnitude	Construction noise level (dB)		
	A 55dB threshold	B 60dB threshold	C 65dB threshold
No Impact	≤55	≤60	≤65
Negligible Adverse	≥55.1 - ≤55.9	≥60.1 - ≤60.9	≥65.1 - ≤65.9
Minor Adverse	≥56.0 - <57.9	≥61.0 - ≤62.9	≥66.0 - ≤67.9
Moderate Adverse	≥58.0 - <59.9	≥63.0 - ≤64.9	≥68.0 - ≤69.9
Major Adverse	≥60	≥65	≥70

Table A.4 Night time construction noise significance criteria

Impact magnitude	Construction noise level (dB)		
	A 45dB threshold	B 50dB threshold	C 55dB threshold
No Impact	≤45	≤50	≤55
Negligible Adverse	≥45.1 - ≤45.9	≥50.1 - ≤50.9	≥55.1 - ≤55.9
Minor Adverse	≥46.0 - ≤47.9	≥51.0 - ≤52.9	≥56.0 - ≤57.9
Moderate Adverse	≥48.0 - ≤49.9	≥53.0 - ≤54.9	≥58.0 - ≤59.9
Major Adverse	≥50	≥55	≥60

1.1.1.1 Assumptions and indicative plant list

9. Based on ES Chapter 5 Project Description, an indicative list of construction equipment was developed for the construction programme detailed in Table A.5.

Table A.5 Construction noise – trenchless crossing (per location)

Name	No.	Source Type	LwA dB(A)	On time Correction
Tracked Excavator	1	Point	107	50%
Backhoe Loader	1	Point	96	50%
Bulldozer	1	Point	108	50%
Dumper	1	Point	101	50%
Mobile Crane	1	Point	106	25%
Cement Mixer Truck (Discharging)	1	Point	103	25%
Truck Mounted Concrete Pump and Boom Arm	1	Point	108	25%
Piling*	1	Point	118	10%
Drilling Rig	1	Point	105	75%
Water Pump	1	Point	93	75%
Generator	1	Point	105	100%
*Modelled as 1 source with 75% on time as equivalent to 3 sources with 25% on time.				
	All plant operational during daytime. Highlighted cell indicates reduced plant operational during the evening, weekend and night time periods only.			

1.1.2 Construction Phase Vibration Assessment

10. Piling may be required, as a worst case, depending on ground conditions to temporarily anchor the drilling rigs associated with trenchless crossings.

11. Ground-borne vibration may lead to perceptible levels of vibration at nearby receptors, which at higher levels, can cause annoyance to residents. In extreme cases, cosmetic or structural building damage can occur, however vibration levels have to be of a significant magnitude for this effect to be manifested and such cases are rare.

12. High vibration levels generally arise from ‘heavy’ construction works such as piling, deep excavation, or dynamic ground compaction.

13. Annex E of BS 5228-2:2009+A1:2014 contains empirical formulae derived by Hiller and Crabb (2000) from field measurements relating to resultant peak particle velocity (PPV) which include parameters for percussive piling. These prediction equations are based on the energy approach.

14. The consequences of predicted levels in terms of human perception and disturbance can be established through direct comparison with the BS 5228-2:2009+1A:2014 guidance vibration levels.

15. Humans are very sensitive to vibration, which can result in concern being expressed at energy levels well below the threshold of damage. Guidance on the human response to vibration in buildings is found in BS 6472-1:2008 Guide to evaluation of human exposure to vibration in buildings, Part 1, Vibration sources other than blasting.

16. BS 6472 describes how to determine the vibration dose value (VDV) from frequency-weighted vibration measurements. VDV is defined by the following equation:

$$VDV_{b/d,\ day/night} = (\int_0^T a^4(t)dt)^{0.25}$$

17. The VDV is used to estimate the probability of adverse comment which might be expected from human beings experiencing vibration in buildings. Consideration is given to the time of day and use made of occupied space in buildings, whether residential, office or workshop.

18. BS 6472 states that in homes, adverse comment about building vibrations is likely when the vibration levels to which occupants are exposed are only slightly above thresholds of perception.

19. BS 6472 contains a methodology for assessing the human response to vibration in terms of either the VDV, or in terms of the acceleration or the peak velocity of the vibration, which is also referred to as PPV. The VDV is determined over a 16-hour daytime period or 8-hour night-time period.

20. The response of a building to ground-borne vibration is affected by the type of foundation, ground conditions, the building construction and the condition of the building. The vibration level and effects detailed in Table A.6 were adopted based on BS 5228. Limits for transient vibration, above which cosmetic damage could occur, are given numerically in terms of PPV.

Table A.6 Transient vibration guide values for cosmetic damage

Line	Type of building	Peak component particle velocity in frequency range of predominant pulse	
		4Hz to 15Hz	15Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	50mms^{-1} at 4Hz and above	
2	Un-reinforced or light framed structures Residential or light commercial type buildings	15mms^{-1} at 4Hz increasing to 20mms^{-1} at 15Hz	20mms^{-1} at 15Hz increasing to 50mms^{-1} at 40Hz and above

21. Table A.7 lists the minimum set-back distances at which vibration levels of reportable significance for percussive piling may occur. BS 5228 calculation methods were used to derive the set-back distances outlined in Table A.7.

Table A.7 Predicted distances at which vibration levels may occur

Activity	Set-back distance at which vibration level (PPV) occurs			
	0.3 mm/s	1.0 mm/s	10 mm/s	15 mm/s
Percussive Piling	48m	19m	3m	2m

22. Table A.8 reproduced from research (Rockhill *et al,* 2014) details minimum safe separation distances for piling activities from sensitive receptors to reduce the likelihood of cosmetic damage occurrence.

Table A.8 Receptor proximity for indicated piling methods

Building type (limits on vibrations from Eurocode 3)	Piling Method		
	Press-in	25kJ drop hammer	170 kW 27Hz vibrohammer
Architectural merit	2.6m	29.6m	27.7m
Residential	0.5m	11.8m	13.8m
Light commercial	0.14m	5.9m	5.5m
Heavy industrial	0.06m	3.9m	3.7m
Buried services	0.03m	2.9m	2.2m

23. For construction vibration, the vibration level and effects presented in Table A.9 were adopted based on Table B-1 of BS 5228-2. These levels and effects are based on human perception of vibration in residential environments.

Table A.9 Construction vibration - impact magnitude

Vibration limit PPV (mm/s)	Interpreted significance to humans	Impact magnitude
≤0.14	Vibration unlikely to be perceptible	No Impact
0.14 to 0.3	Vibration might just be perceptible in the most sensitive situations for most vibration frequencies associated with construction	Negligible - Adverse
0.3 to 1.0	Vibration might just be perceptible in residential environments	Minor – Adverse
1.0 to ≤10.0	It is likely that vibration at this level in residential environments will cause complaint, but can be tolerated if prior warning and explanation has been given to residents	Moderate – Adverse
≥10.0	Vibration is likely to be intolerable for any more than a brief exposure to this level	Major – Adverse

1.1.3 Sensitivity

24. For the construction phase assessment, the closest sensitive receptor CRR12 is detailed in Table A.10.

Table A.10 Receptor identification, sensitivity and classification

Receptor Identifier	Receptor Classification	Receptor Sensitivity	British National Grid Co-ordinates	
			Eastings	Northings
CRR12	Residential	Medium	614711	325473

1.1.4 Impact Significance

25. Following the identification of receptor sensitivity and magnitude of the effect, it is possible to determine the significance of the impact. A matrix is presented in Table A.11 as a guide.

Table A.11 Impact significance matrix

		Negative magnitude				
		High/ Major	Medium/ Moderate	Low/ Minor	Negligible	No Impact
Sensitivity	High	*Major*	*Major*	*Moderate*	*Minor*	*Minor*
	Medium	*Major*	*Moderate*	*Minor*	*Minor*	*Negligible*
	Low	*Moderate*	*Minor*	*Minor*	*Negligible*	*Negligible*
	Negligible	*Minor*	*Negligible*	*Negligible*	*Negligible*	*Negligible*

1.1.5 Baseline Sound Levels CRR20

26. Baseline sound levels were measured at CRR12 in 2017. A summary of the baseline sound data is provided in Table A.12. These measured noise levels are applicable for CRR12.

Table A.12 Baseline Sound Survey CRR12

Reference Period	Date and Time of Survey	Ambient Noise Level (dB) LAeq,T	Maximum Daily (dB) LAFmax,T	Level exceeded 10% of the time (dB) LA10,T	Level exceeded 90% of the time (dB) LA90,T	Derived BS5228 Threshold Category and Limit
Daytime (07:00 – 23:00)	04/05/2017 13:31:46 to 14:04:36	57.6	77.3	57.3	49.9	65 (A)
Night time (23:00 – 07:00	05/05/2017 00:15:22 to 00:30:22	45.5	70.7	33.2	29.8	45 (A)

1.2 Potential Noise Impacts from Trenchless Crossing Works at CRR12

1.2.1 Assumptions

27. The following assumptions for the construction programme have been made:

- Construction activities would normally take place between 0700hrs and 1900hrs Monday to Friday and between 0700hrs and 1300hrs on Saturday;
- Construction activities may require evening and night time working due to the trenchless crossing in accordance with DCO Requirement 26;

- All ground was assumed to have an absorption factor of 0.6 to represent the mixed ground conditions in the area;
- All noise sources were modelled as point sources at a height of 1.5m;
- Residential properties were modelled as two-storey buildings at a height of 8.5m;
- For daytime, receiver levels were predicted at ground floor level (+1.5m) considered representative of daytime resting and amenity space;
- For night time, receiver levels were predicted at first floor level (+4.0m) considered representative of night time resting; and
- Acoustic propagation effects were calculated using the BS 5228 methodology which takes into account distance attenuation, barriers and ground absorption.

28. The results of the calculation are presented as the dB $L_{Aeq,T}$ noise level covering the activity period highlighted in the assumptions section above, representing a conservative prediction of the noise level that might affect adjacent receptors during construction activity.

1.2.1.1 Best practice mitigation

29. Best practice construction noise mitigation techniques, which are set out within the Outline Code of Construction Practice (OCoCP) (DCO document 8.1) and within section 25.8.5.6 of ES Chapter 25 represent embedded mitigation to reduce noise impacts, such as using modern equipment, ensuring equipment is properly maintained, ensuring machinery is turned off when not in use, and application of enclosures to particularly noisy equipment. Although the effect of adopting such methods cannot be precisely quantified, it is typically expected that these methods would reduce noise levels by between 5 - 10dB(A). In order to provide a conservative approach, the construction phase assessment has assumed a 5dB(A) reduction for incorporating embedded mitigation measures.

1.2.2 Construction noise assessment

30. Table A.13 details the predicted worst-case construction phase noise levels at receptor CRR12 for the most exposed façade (including a conservative 5dB(A) allowance for the incorporation of standard embedded mitigation measures).

Table A.13 Construction noise impacts CRR12

Phase	BS5228 Threshold dB(A)	Predicted noise level $L_{Aeq,T}$ dB (Standard mitigation applied)	Impact Magnitude (Standard embedded mitigation only)	Required Enhanced Mitigation (Yes/No) and range dB(A)	Residual Impact
Receptor CRR20					
Daytime	**65**	**56.3**	No Impact	No	No Impact with standard embedded mitigation
Evening and Weekends	**55**	**51.2**	No Impact	No	No Impact with standard embedded mitigation
Night time	**45**	**51.3**	Major adverse Impact	Yes (Noise reduction of 6.3dBA required)	No Impact with enhanced mitigation
Required Mitigation Key					
No additional mitigation required beyond best practice measures (set out in the OCoCP).					
Construction mitigation techniques will be required to avoid significant adverse impact such as those detailed in ES Chapter 25. Specific construction mitigation measures will be agreed during the detailed design stage.					

31. During the daytime, evening and weekend reference periods, a trenchless crossing of the B1149 would represent an impact magnitude of "no impact" at a medium sensitivity receptor (CRR12), which represents an impact of **negligible** significance. No requirement for further mitigation has been identified.

32. During the night time reference period, a trenchless crossing of the B1149, with the inclusion of best practice mitigation only, would generate noise levels representing a major magnitude of effect at a medium sensitivity receptor (CRR12), which represents an impact of **major adverse** significance. Should this trenchless crossing be required then enhanced mitigation measures will be needed during the night time reference period to avoid significant impacts.

1.2.2.1 Enhanced Mitigation (if night time working required)

33. During the night time period, the predicted noise impact at CRR12 (after the inclusion of standard mitigation) was **major adverse**.

34. In order to ensure this impacts are mitigated as far as reasonably possible, the aforementioned standard embedded mitigation (also detailed in the OCoCP (DCO document 8.1)), coupled with more site specific solutions including the use of screening such as temporary noise barriers and/or temporary spoil bunds, would be applied.

35. As an example of the relative effectiveness of applying a temporary localised noise barrier BS 5228 states:

- *"as a working approximation, if there is a barrier or other topographic feature between the source and the receiving position, assume an approximate attenuation of 5 dB when the top of the plant is just visible to the receiver over the noise barrier, and of 10 dB when the noise screen completely hides the sources from the receiver. High topographical features and specifically designed and positioned noise barriers could provide greater attenuation."*

36. Standard noise absorptive barriers applied to three sides of the operating plant (3.5m height) were included in the noise model as mitigation. The predicted noise levels, with the application of enhanced mitigation, are detailed in Table A.14.

Table A.14 Construction noise impacts CRR12

Phase	BS5228 Threshold dB(A)	Predicted noise level $L_{Aeq,T}$ dB (Standard embedded mitigation applied + barrier)	Impact Magnitude (Standard embedded mitigation applied + barrier)	Further Enhanced Mitigation Required (Yes/No) and range dB(A)	Residual Impact
Receptor CRR20					
Night time – Combined HDD, temporary works areas 3.5m barrier	**45**	**39.5**	No Impact	No	No Impact with enhanced mitigation
Required Mitigation Key					
No additional mitigation required beyond standard embedded CoCP measures to avoid significant adverse impacts.					
Construction mitigation techniques will be required to avoid significant adverse impacts such as those detailed in Chapter 25. Specific construction mitigation measures will be agreed during the detailed design stage.					

1.2.2.2 Residual Impacts

37. With the incorporation of enhanced mitigation measures, it is predicted that the magnitude of effect would reduce to "no impact", which represents a residual impact of **negligible** significance.

38. A Construction Noise (and vibration) Management Plan (CNMP) will be included in the final CoCP, as required under Requirement 20 (2)(e) of the DCO.

39. The CNMP will apply throughout that stage of construction and will detail standard mitigation (best practical means) and where applicable, enhanced mitigation measures.

40. The exact specification of any noise barriers that may be required to mitigate significant residual construction noise will be determined during detailed design. Noise barriers will be introduced with the appropriate specification for the location and noise reduction required.

1.3 Potential Vibration Impacts from Trenchless Crossing Works at CRR12

41. Piling may be required, as a worst case, depending on ground conditions to temporarily anchor the drilling rigs associated with trenchless crossings.

42. CRR12 is approximately 165m away from the trenchless crossing at its nearest point. In accordance with Table A.7, at a setback distance of 165m any vibration levels attributed to piling would not be perceptible at CRR12.

43. Table A.8 details indicative vibration levels from various piling methods with regards to buildings of differing architectural merit[2]. Table A.9 sets out the vibration level effects. Piling, if required, at a distance of least 165m represents a vibration impact magnitude of "no impact", on a medium sensitivity receptor, which represents an impact of **negligible** significance.

1.4 Conclusions

44. Construction phasing, plant numbers, type and on-time data were provided for proposed equipment should a trenchless crossing be required of the B1149.

45. Predicted noise levels for CRR12 were calculated based on proposed trenchless crossing works during the daytime, evening, weekends, and night time periods.

[2] CRR20 is not a listed building or located within a Conservation Area.

46. The predicted noise levels resulted in impacts of **negligible** significance during the daytime, evening and weekend reference periods, with the inclusion of standard best practice embedded mitigation measures. No requirement for further mitigation has been identified.

47. The predicted noise levels resulted in an impact of **major adverse** significance during the night-time at receptor CRR12, with the inclusion of standard best practice embedded mitigation measures. A requirement for further 'enhanced mitigation' has been identified.

48. Within the inclusion of enhanced mitigation in the form of standard noise absorptive barriers at 3.5m height, the residual impact reduced to **negligible** significance.

49. A CNMP will be included in the final CoCP, as required under Requirement 20 (2)(e) of the DCO. The CNMP will apply throughout that stage of construction and will detail standard embedded mitigation (best practical means) and where applicable, enhanced mitigation measures. The exact specification of any noise barriers that may be required to mitigate significant residual construction noise will be determined during detailed design. Noise barriers will be introduced with the appropriate specification for the location and noise reduction required.

50. Piling, if required, at a distance of at least 165m represents a vibration impact of **negligible** significance. No requirement for mitigation has been identified.

References

BSI (2014). British Standards Institution [BS] 5228-1:2009+A1:2014 “Code of practice for noise and vibration control on construction and open sites – Part 1: Noise”.
BSI (2014). British Standards Institution [BS] 5228-2: 2009+A1:2014 “Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration”.
Norfolk Vanguard. (2018) Norfolk Vanguard Offshore Wind Farm Chapter 25 Onshore Noise and Vibration Environmental Statement, Volume 1 (Reference: PB4476-005-025).