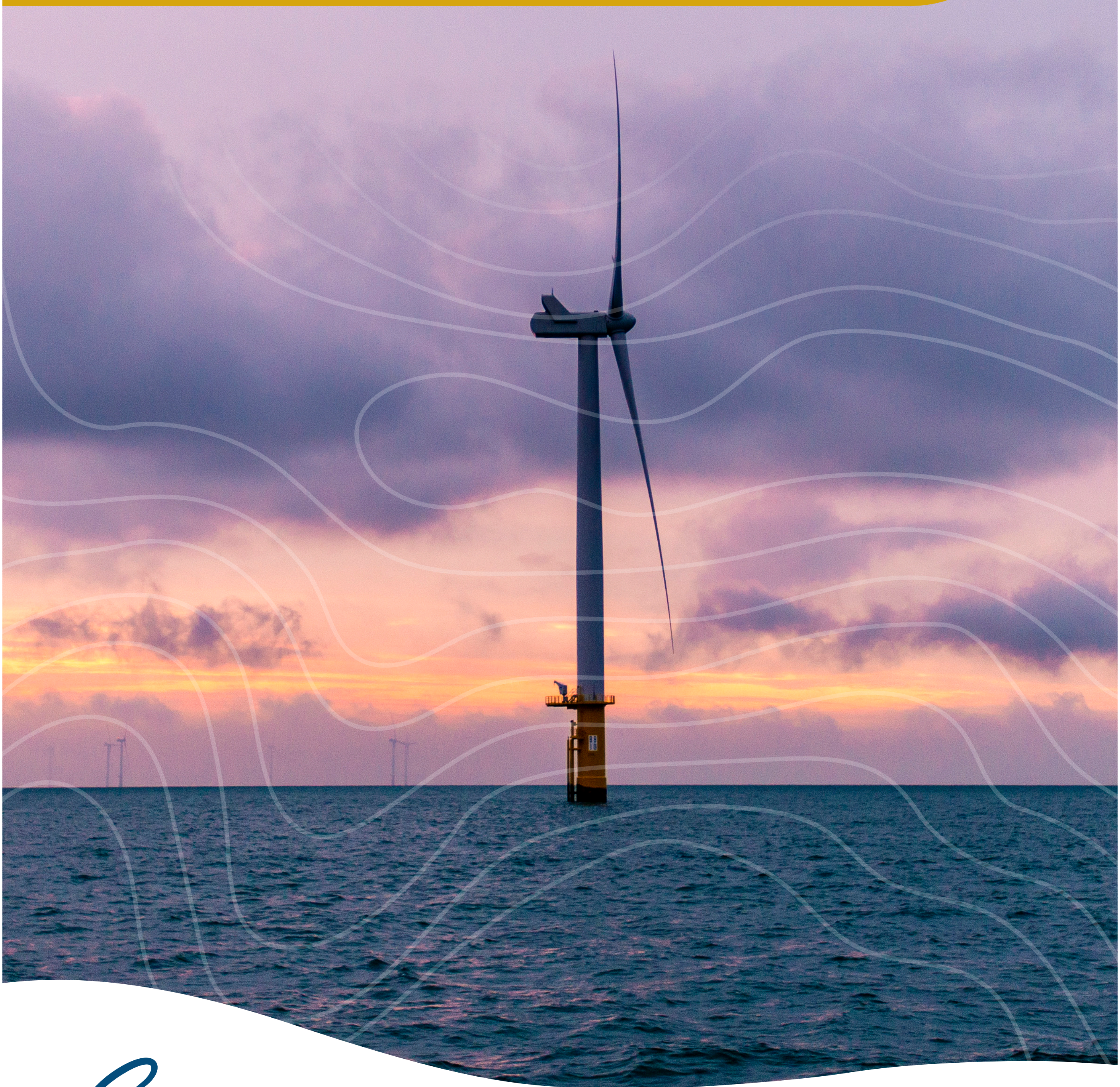
Environmental Impact Assessment Report - Volume 2C

Appendix 25-2:
Noise Modelling Methodology



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ORIEL WIND FARM PROJECT

Environmental Impact Assessment Report
Appendix 25-2: Noise Modelling Methodology

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1 NOISE MODELLING METHODOLOGY

This report sets out the noise modelling methodologies, noise modelling results, and coordinates of the Nosie Sensitive Locations (NSLs) used for predictions in the airborne noise assessment provided in chapter 25: Noise (Airborne) and Vibration of the EIAR.

1.1 Noise calculations

Noise predictions for the assessments included in chapter 25: Noise (Airborne) and Vibration have been conducted using three methods of calculation as outlined below and further described in sections 1.2- 1.4:

- International Standards Organisation (ISO) 9613 for substation operational noise;
- British Standard (BS) 5228 for onshore construction noise; and
- The Danish method for offshore noise sources outlined in BEK nr 135 Executive Order on noise from wind turbines (07/02/2019).

RPS chose these methods of calculation as the most appropriate for predicting noise for the various elements of the Project.

1.2 ISO 9613

Operational noise at the onshore substation site was modelled using ISO 9613-2:1996 *Acoustics — Attenuation of sound during propagation outdoors — Part 2: General method of calculation*, as implemented by Softnoise Predictor-LimA software. The methodology developed and used in the LimA calculation meets the quality assurance requirements for ISO 17534[1]. The models provide full 3D sound propagation including reflection and refractive effects.

The method predicts the equivalent continuous A-weighted sound pressure level (as described in ISO 1996) under average meteorological conditions favourable to propagation. Such conditions are defined as those that occur downwind of the source (approximately 5 m/s at 10 m height) or under a temperature inversion.

1.3 BS 5228

Noise modelling for the construction phase was carried out in accordance with BS 5228-1:2009+A1:2014 Code of practice for noise and vibration control on construction and open sites – Noise. Modelling was implemented using Softnoise Predictor or numerical models as appropriate.

1.4 BEK nr 135 offshore wind turbine noise prediction

Danish Executive Order BEK nr 135 describes a calculation method for sound propagation for offshore Wind Turbine Generators (WTGs). This is the only methodology which is approved for noise modelling of offshore WTGs. The method includes a correction for multiple reflections which accounts for increased received downwind noise levels at long distances over water.

The Danish method is used to predict noise levels at receivers onshore. The height of the noise source is an influencing factor on the physical mechanism represented by the multiple reflections term. In short, lower WTG hub heights result in higher noise levels at long distances over water due to earlier onset of multiple reflections. The WTG hub heights will vary from 145 m to 152 m depending on seabed conditions, and the worst-case noise levels at longer distances would result from lower hub heights. For this reason, WTG noise predictions will be undertaken for the lower range hub height of 145 m.

[1] ISO 17534-1:2015 Acoustics — Software for the calculation of sound outdoors — Part 1: Quality requirements and quality assurance

The primary equation for the sound pressure level taken from the Danish propagation model is shown in Equation 1.

Equation 1

$$L_{pA} = L_{wA} - 10log(l^2 - h^2) - 11\,dB + \Delta L_g - \Delta L_\alpha + \Delta L_m$$

Where:

L_{pA}	=	Sound pressure level
L_{wA}	=	Sound power level
l	=	Distance between the base of the wind turbine and the receiver
h	=	Wind turbine hub height
ΔL_g	=	Ground correction (1.5 dB for onshore and 3 dB for offshore turbines)
ΔL_α	=	Air absorption
ΔL_m	=	Multiple reflections correction

Where ΔL_a is calculated using the method in ISO 9613-1:1993 Acoustics -- Attenuation of sound during propagation outdoors - Part 1: Calculation of the absorption of sound by the atmosphere with the Bass[2] formula for saturation pressure ratio.

1.4.1 BEK nr 135 Offshore WTN prediction method validation

The BEK nr 135 (hereafter referred to as BEK135) method has been validated against real world measurements conducted over water, as presented in ***Long distance noise propagation over water for an elevated height-adjustable sound source***, Søndergaard *et al.*[3]. The study comprised measurements with a high sound power source set at heights of 81 m, 50 m and 30 m above ground, and measurement microphones positioned downwind (at shore and 100 m inland) of the sound source at ~3 km, ~5 km and ~7 km with sound propagation occurring only over water.

The study concluded that there was generally good agreement between noise levels predicted using the BEK135 method and the real-world measurements conducted during the measurement campaign.

1.4.2 RPS BEK nr 135 implementation validation procedure

There are no commercially available software packages which implement the BEK135 modelling method. Consequently, in-house implementation of the modelling method has been necessary.

In order to ensure accuracy, three senior RPS personnel have independently implemented the algorithm (two implementations in MATLAB and one in Microsoft Excel). Following debugging, the respective implementations have been used to construct numerical noise models of the Project WTGs, predicting noise levels at identical windspeeds, source heights and receiver coordinates.

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[2] Bass, H. E., L. C. Sutherland, A. J. Zuckerwar, D. T. Blackstock, and D. M. Hester, (1995), "Atmospheric absorption of sound: Further developments." The Journal of the Acoustical Society of America 97, no. 1 (1995): 680-683.

[3] INCE Europe 9th International Conference on Wind Turbine Noise (May 2021) - Long distance noise propagation over water for an elevated height-adjustable sound source - Lars Sommer Søndergaard, Erik Thysell, Christian Claumarch, Andrea Vignaroli, Carsten Thomsen, Kurt S. Hansen.

The results independently predicted have been subsequently compared and found to be in agreement, thus providing a high level of quality assurance and confidence in the RPS BEK135 implementation.

1.5 Source level data

1.5.1 Onshore construction noise

For construction noise the source levels were taken from BS 5228 and are shown on the tables in section 2. Noise sources were taken as operating in an open space (i.e. without reflections from acoustically hard vertical surfaces).

1.5.2 Offshore construction noise

The highest noise levels from offshore construction will arise during impact piling of the WTG and offshore substation monopile foundations. Based on the largest piling rig likely to be used, an airborne noise model was developed from existing data sources. The installation of 9.6 m diameter piles will require a large marine pile driver capable of striking the piles with an energy of 4,000 kJ. While the maximum strike energy capability of rig will be 4,000 kJ, the hammer energy used during piling will not exceed 3,500 kJ. Noise modelling, using the BEK135 methodology was used to predict the resultant noise at onshore locations.

1.5.3 Onshore substation site operational noise

The proposed onshore substation site is a hybrid of gas insulated switchgear equipment within a building and air insulated switchgear equipment located outdoors. For acoustic purposes, the modelling is based on the Air Insulated Switchgear (AIS) option as set out in chapter 5: Project Description. The electrical substation AIS equipment includes the following higher noise elements: two harmonic filters composed of capacitor banks, resistors and reactors; shunt reactor; and power transformer. The range of potential sound power levels, and assumed noise spectrum shape, for these substation elements is detailed in section 2.

1.5.4 Wind turbine operational noise

The project design parameters for the WTGs are provided in Table 1-1. There will be 25 wind turbines with a rotor diameter of 236 m and a maximum blade tip height of 270 m relative to Lowest Astronomical Tide[4] (LAT).

Table 1-1: Design parameters for the Project wind turbines.

Parameter	Project design parameter
Number of wind turbines	25
Minimum height of lowest blade tip above LAT (m)	27 m
Minimum hub height above LAT (m)	145 m
Maximum hub height above LAT (m)	152 m
Maximum blade tip height above LAT (m)	270 m
Rotor blade diameter (m)	236 m

Maximum sound power level data for the candidate turbine was provided by the Applicant. As the spectral levels are not warranted, a +2 dB correction in accordance with the IoA GPG has been added to the specified values to account for uncertainty on the spectral levels. The sound power levels are presented in Table 1-2. The table shows that noise levels generated by the WTGs plateau at 10 m/s with no further increases at higher windspeeds.

[4] Lowest Astronomical Tide (LAT) is defined as the lowest tide level which can be predicted to occur under average meteorological conditions and under any combination of astronomical conditions

Table 1-2: Source sound power levels for the candidate WTG without uncertainty.

Normal Operation – A-weighted Octave Spectra (dB)										
Frequency (Hz)	Hub Height Wind Speed (m/s)									
	4	5	6	7	8	9	10	11	12	>12
63	81	82	84.2	87.9	91.5	94.5	96	96.4	96.4	96.5
125	90	91	92.9	96.5	100	103	105	105	105	105
250	95	96	98.5	102	106	109	110	111	111	111
500	98	99	101	105	108	111	113	113	113	113
1000	98	99	101	104	108	111	112	113	113	113
2000	94	95	96.9	100	104	107	108	109	109	109
4000	88	89	90.3	93.5	96.9	99.7	101	102	102	102
8000	78	79	80.4	83.5	86.8	89.5	90.9	91.6	91.6	91.5
Sum (A)	103	104	106	110	113	116	118	118	118	118

1.6 Terrain and receiver data

The terrain data for modelling was taken from Ordnance Survey Ireland (OSI) and Ordnance Survey Northern Ireland (OSNI) contour data, supplemented with site specific data where available. The coastline and low water mark were obtained from the Marine Institute and RPS internal data sources. The sea was modelled as a flat surface with no attenuation due to acoustic scattering from surface waves.

Receiver point coordinates have been obtained from the An Post GeoDirectory dataset (Q4 2022). The NSLs are referenced by GeoDirectory ID and coordinates for the NSLs referenced are included in section 3.

2 NOISE MODELLING

2.1 Construction noise levels (onshore)

Construction noise levels have been predicted using source levels from BS 5228-1:2009+A1:2014. The noise threshold criteria are determined using BS 5228 Annex E3.2 ABC method (as set out in the main chapter) which uses ambient noise levels to provide a balance facilitating efficient construction while protecting quiet areas.

Noise levels have been predicted for NSLs within 350 m (based on 300 m construction study area definition plus 50 m for estimated average distance from site boundary) of centres of construction sites. Construction noise levels have been predicted for:

a) Offshore cable installation at the landfall;

b) Onshore cable route;

c) Onshore cable – infrastructure crossings; and

d) Onshore substation site.

In addition to the activities listed above, high level assessments of potential noise and vibration impacts have been undertaken for:

e) Construction compounds.

2.1.1 Offshore export cable landfall

Construction of the offshore cable at the landfall will utilise open trench methods. Typical equipment levels required at the landfall location are shown in Table 2-1 along with source noise levels taken from BS 5228-1:2009+A1:2014. The plant list has been based upon information provided by the client and represents equipment likely to be active at the location given site constraints and the scope of the construction. The offshore cable laying vessel cannot approach closer than 750 m from the shoreline due to shallow depths and therefore will not give rise to significant noise levels onshore. Trenching activities in the intertidal zone and further offshore will be more distant than the activities modelled.

Table 2-1: Construction equipment at cable landfall location.

Equipment	Notes	No.	BS 5228 Ref.	L_{wA}	On-time (%)
Mobile Crane	Occasional use, low source levels	1	C4.46	95	10
Rock Breakers	Typical attachment for excavator used, noisy equipment	1	C.9.13	113	20
Site Dumper	Frequent use likely	1	C.4.5	91	70
CAT 320 Excavators (8T/13T/22T)	14T capacity used in model	1	C.2.25	97	70
Compressors (Diesel) (Atlas Copco)	Low source levels	1	C5.5	93	30
Lighting Towers (Diesel)	Typically used in winter, low source levels	2	C.4.87	93	70
Ready-mix Concrete	Occasional small quantities	1	C4.22	104	-
Teleporter/Forks (JCB)	Occasional use, low source levels	1	C.4.55	98	10
Flatbed articulated truck	Occasional use	1	C.4.26	103	10
Stone Delivery Truck	Occasional small quantities	1	C.10.12	109	10

Equipment	Notes	No.	BS 5228 Ref.	L_{wA}	On-time (%)
Plastic Welding Plant (butt fusion welders)	Low source levels	1	C.3.33	85	-
Temporary Welfare Facilities (incl. diesel genies)	Low source levels	1	C4.79	92	100
Cable Winches	Start of onshore cable route	1	N/A	-	-
Cable Drums	Start of onshore cable route	1	N/A	-	-
Tipper Truck (7.5T/10T)	Regular use	1	C.2.32	102	80
Tractor with low loader trailer	Occasional use	1	C4.75	107	-
Tractor with Water Tanker	Occasional use	1	C4.76	107	-
Tractor dump trailers	Occasional use	3	C4.77	107	-
Backhoe Loader	Trenching	1	C4.66	97	-

Table 2-2 shows the predicted construction noise levels for two NSLs within 350 m of the landfall excavation.

Table 2-2: Predicted construction noise levels for NSLs within 350 m of Landfall excavation.

NSL Geodirectory ID	Distance to centre of activity (m)	BS 5228 threshold value, dB L_{Aeq}	Predicted Noise Level, dB L_{Aeq}	Initial Magnitude of Impact
80957386	75	65	66	Medium
80957626	335	65	44	Negligible

2.1.2 Onshore export cable route

Construction along the onshore cable route will be linear construction of cable ducts with static construction works at the cable Joint Bays (JB). These works are carried out using conventional excavate and fill methods. Noisy activity at any one location will be temporary and the noisiest activities (i.e. rock breaking and use of road planer) will be brief. Breaking of the road surface layer will under normal circumstances be achieved using the road planer which, depending on size of the unit and width of the drum, may achieve the required trench width in 1 – 3 passes. Requirement for rock breaking is expected to be limited and occasional and full trench depth should be achieved with use of a wheeled excavator.

Subsequent activity will involve pulling in the cable lengths which will require several vehicles to move the cable winch and cable drums to the appropriate location and limited activity during the cable jointing phase. To illustrate potential noise levels, a noise model was developed for the location at which a JB is located closest to an NSL (i.e. the maximum design parameters for all onshore cable route locations).

Typical equipment levels required along the landside cable route are shown in Table 2-3 along with source noise levels taken from BS 5228-1:2009+A1:2014 and RPS data.

Table 2-3: Construction equipment along onshore cable route.

Equipment	Notes	No.	BS 5228 Ref.	L_{wA} (dB)	On-time (%)
Mobile Crane	Occasional use, low source levels	1	C.4.46	95	-
Rock Breakers	Typical attachment for excavator used, noisy equipment	1	C.9.13	113	10
CAT 320 Excavators 8T/13T/22T	14T capacity used in model	1	C.2.25	97	70

Equipment	Notes	No.	BS 5228 Ref.	L_{WA} (dB)	On-time (%)
Lighting Towers (Diesel)	Typically used in winter, low source levels	2	C.4.87	93	70
Ready-mix Concrete	Small quantities may be needed	1	C.4.22	104	10
Teleporter/Forks (JCB)	Occasional use, low source levels	1	C.2.35	99	10
Flatbed articulated truck	Occasional use	1	N/A	-	-
Stone Delivery Truck	Occasional use	1	C.10.12	109	10
Plastic Welding Plant (butt fusion welders)	Low source levels	1	C.3.33	85	-
Temporary Welfare Facilities (incl. diesel genies)	Low source levels	1	C.4.79	92	-
Cable Winches	Occasional use	1	N/A	-	-
Cable Drums	Queued along landside cable route	1	N/A	-	-
Road Planer	1 – 3 passes assumed	1	C.5.7	110	30
Road Paver	Source levels include hotbox tipper truck	1	C.5.30	103	50
Hotbox Truck 8T	Included in paver source levels above	1	-	-	-
Tipper Truck 7.5T/10T	Regular use	1	C.2.32	102	80
8 Wheel Grab Truck	Occasional use	1	C.4.53	105	10
Vibratory Roller	Active following paver	1	C.5.27	95	10
Backhoe Loader	Low source levels	1	C.4.66	97	-

The predicted construction noise levels arising at the stated distances from onshore cable linear construction activity are shown in Table 2-4. The noise levels shown would not be expected to occur at any one location for more than 2 – 4 days. Table 2-3 shows estimated on-times for the noisiest equipment, which will be used for trenching and, following installation of the cable ducting, resurfacing of the trench. This body of work will not be completed at any one location in a single day. Therefore, noise from trenching and resurfacing activities have been predicted separately, with trenching found to have the higher predicted noise levels which are presented for the distances listed in Table 2-4.

Table 2-4: Predicted noise levels at listed distances for trenching on onshore cable route.

Distance from activity (m)	BS 5228 lower threshold value, dB L_{Aeq}	Predicted Noise Level, dB L_{Aeq}	Initial Magnitude of Impact
10	65	68	Medium
20	65	65	Medium
30	65	64	Low
40	65	63	Low
50	65	61	Low
60	65	61	Low
70	65	60	Low
80	65	59	Low
90	65	58	Low
100	65	57	Low

Onshore cable construction calls for static construction of 29 JBs with dimensions typically in the order of 8 m long, approx. 2.5 m wide and approx. 2.5 m deep and designed to be covered over following reinstatement. Five JBs will be located in agricultural land with the rest located below the public road.

Smaller link boxes and communication chambers will be required adjacent. The construction activities required are similar to the cable trench but located at a static site. Based on the assessment trenching activities, excavation of the JBs will be the noisiest activity, and an equipment list for same is shown below in Table 2-5.

Table 2-5: Construction equipment for Joint Bay excavation.

Equipment	Notes	No.	BS 5228 Ref.	L_{WA} (dB)	On-time (%)
Mobile Crane	Occasional use, low source levels	1	C.4.46	95	10
Rock Breakers	Typical attachment for excavator used, noisy equipment	1	C.9.13	113	10
CAT 320 Excavators 8T/13T/22T	14T capacity used in model	1	C.2.25	97	70
Ready-mix Concrete	Small quantities may be needed	1	C.4.22	104	10
Stone Delivery Truck	Occasional use	1	C.10.12	109	10
Road Planer	3 - 4 passes assumed	1	C.5.7	110	20

The noisiest items of plant are the rock breaker, which will only be used if required, and the road planer which will break the road surface prior to excavation. Predicted noise levels at the listed distances from the centre of activity are shown in Table 2-6.

Table 2-6: Predicted noise levels at stated distances for joint bay excavation.

Distance from activity (m)	BS 5228 threshold value, dB L_{Aeq}	Predicted Noise Level, dB L_{Aeq}	Initial Magnitude of Impact
10	65	79	High
20	65	73	High
30	65	70	High
40	65	67	Medium
50	65	65	Medium
60	65	64	Low
70	65	62	Low
80	65	61	Low
90	65	60	Low
100	65	59	Low

2.1.3 Onshore cable crossings

Onshore cable crossings will be constructed using either Horizontal Directional Drilling (HDD) or open trench techniques depending on site specific conditions. Table 2-7 lists the locations where HDD may occur.

Table 2-7: Information available regarding the onshore cable crossings.

No	Cable Crossing	Preferred Method	HDD length	Duration	Location	Distance to nearest NSL (m)
1	River Dee @ Richardstown, N33	HDD	180 m	2 months	Field	168
2	High Pressure Gas Main @ Richardstown N33	Open trench	-	-	Roadside	196

No	Cable Crossing	Preferred Method	HDD length	Duration	Location	Distance to nearest NSL (m)
3	M1 Motorway and Dublin Belfast Rail Line @ Charleville	HDD	250 m	3 months	Field	167
4	River Dee @ Drumcar	HDD	90 m	1 month	Field	125
5	High Pressure Gas Main @ Drumcar	Open trench	-	-	Road	47
6	Port Stream tributary @ Clonmore	Open trench	-	1 month	Field	57
7	Port Stream @ Togher	HDD	50 m	1 month	Field	62
8	Salterstown Stream @ Salterstown	HDD	50 m	1 month	Road	40

Typical equipment levels required at HDD sites are shown in Table 2-8 along with source noise levels taken from BS 5228-1:2009+A1:2014.

Table 2-8: Construction equipment at river and motorway crossings.

Equipment	Notes	No.	BS 5228 Ref.	L_{WA} (dB)	On-time (%)
Mobile Crane	Occasional use, low source levels	1	C4.46	95	-
Rock Breakers	Typical attachment for excavator used, noisy equipment, occasional use.	1	C.9.13	113	10
Site Dumper	Frequent use likely	1	C.4.5	91	50
CAT 320 Excavators (8T/13T/22T)	14T capacity used in model	1	C.2.25	97	40
Compressors (Diesel) (Atlas Copco)	Low source levels	1	C.5.5	93	-
Lighting Towers (Diesel)	Typically used in winter, low source levels	2	C.4.87	93	50
Ready-mix Concrete	Occasional small quantities	1	C4.22	104	-
Teleporter/Forks (JCB)	Occasional use, low source levels	1	C.4.55	98	-
Flatbed articulated truck	Occasional use	1	N/A	-	-
Stone Delivery Truck	Occasional small quantities	1	C.10.12	109	10
Concrete/Bentonite Pumps	Bentonite delivery to drill head during HDD	1	C.3.26	103	100
HDD Drilling Rig	Constant operation	1	C.4.96	105	100
Bentonite Mixing and Recycling Plant	Bentonite delivery to drill head during HDD	1	D.6.9	104	100
Plastic Welding Plant (butt fusion welders)	Low source levels	1	C.3.33	85	-
Temporary Welfare Facilities (incl. diesel genies)	Low source levels	1	C4.79	92	-
Cable Winches	Start of onshore cable route	1	N/A	-	-
Cable Drums	Start of onshore cable route	1	N/A	-	-
Tipper Truck (7.5T/10T)	Occasional use	1	C.2.32	102	10

Equipment	Notes	No.	BS 5228 Ref.	L_{WA} (dB)	On-time (%)
Tractor with low loader trailer	Occasional use	1	C4.75	107	-
Tractor with Water Tanker	Occasional use	1	C4.76	107	-
Tractor dump trailers	Occasional use	3	C4.77	107	-
Backhoe Loader	Trenching	1	C4.66	97	-

The predicted construction noise levels at NSLs within 350 m for the various planned and potential sites are shown in Table 2-9 to Table 2-14.

Table 2-9: Predicted HDD construction noise levels at River Dee Richardstown (HDD preferred).

NSL Geodirectory ID	Distance to centre of activity (m)	BS 5228 threshold value, dB L_{Aeq}	Predicted Noise Level, dB L_{Aeq}	Initial Magnitude of Impact
80956696	168	65	58	Low
80956697	168	65	58	Low
80956698	272	65	54	Negligible
38608415	295	65	53	Negligible

Table 2-10: Predicted HDD construction noise levels at M1 Motorway (HDD preferred).

NSL Geodirectory ID	Distance to centre of activity (m)	BS 5228 threshold value, dB L_{Aeq}	Predicted Noise Level, dB L_{Aeq}	Initial Magnitude of Impact
35472921	167	65	58	Low
38607722	206	65	56	Low
80956577	231	65	55	Low
80956578	235	65	55	Low
80956579	251	65	54	Negligible
80956580	256	65	54	Negligible
80956581	278	65	54	Negligible
80956582	291	65	53	Negligible
35472918	296	65	53	Negligible
80956678	325	65	52	Negligible
80956679	343	65	52	Negligible

Table 2-11: Predicted HDD construction noise levels at River Dee Drumcar (HDD preferred).

NSL Geodirectory ID	Distance to centre of activity (m)	BS 5228 threshold value, dB L_{Aeq}	Predicted Noise Level, dB L_{Aeq}	Initial Magnitude of Impact
80957595	125	65	60	Low
35474657	178	65	57	Low
80957596	217	65	56	Low

NSL Geodirectory ID	Distance to centre of activity (m)	BS 5228 threshold value, dB L_{Aeq}	Predicted Noise Level, dB L_{Aeq}	Initial Magnitude of Impact
80956631	218	65	56	Low
80957367	239	65	55	Low
80957370	309	65	53	Negligible
80957368	315	65	52	Negligible
80957599	324	65	52	Negligible
80957594	328	65	52	Negligible
80957598	328	65	52	Negligible
80957597	335	65	52	Negligible
80957593	345	65	52	Negligible

Table 2-12: Predicted HDD noise levels at Port Stream tributary Clonmore (open trench preferred).

NSL Geodirectory ID	Distance to centre of activity (m)	BS 5228 threshold value, dB L_{Aeq}	Predicted Noise Level, dB L_{Aeq}	Initial Magnitude of Impact
80958037	57	65	67	Medium
80958038	70	65	66	Medium
80957962	102	65	62	Low
80957963	110	65	62	Low
80957961	111	65	61	Low
80957965	141	65	59	Low
80957964	164	65	58	Low
37955438	167	65	58	Low
80957938	169	65	58	Low
80958033	212	65	56	Low
80958128	254	65	54	Negligible
36751742	227	65	55	Negligible
27133813	260	65	54	Negligible
36751743	266	65	54	Negligible
80958031	286	65	53	Negligible
80957959	300	65	53	Negligible
37955440	311	65	53	Negligible
80958032	313	65	53	Negligible

Table 2-13: Predicted HDD construction noise levels at Port Stream Togher (HDD preferred).

NSL Geodirectory ID	Distance to centre of activity (m)	BS 5228 threshold value, dB L_{Aeq}	Predicted Noise Level, dB L_{Aeq}	Initial Magnitude of Impact
37955452	62	65	67	Medium
37955481	70	65	65	Medium
80957990	116	65	61	Low
80957940	126	65	60	Low

40321084	147	65	59	Low
80957999	167	65	58	Low
40833466	216	65	56	Low
80958041	236	65	55	Negligible
80957946	287	65	53	Negligible
80958040	291	65	53	Negligible
80958039	322	65	52	Negligible
80203324	333	65	52	Negligible

Table 2-14: Predicted HDD construction noise levels at Salterstown Stream (HDD preferred).

NSL Geodirectory ID	Distance to centre of activity (m)	BS 5228 threshold value, dB L_{Aeq}	Predicted Noise Level, dB L_{Aeq}	Initial Magnitude of Impact
80957637	40	65	70	High
80957638	48	65	69	Medium
80958075	60	65	67	Medium
60063310	103	65	62	Low
40836063	132	65	60	Low
80957391	147	65	59	Low
80957634	182	65	57	Low
60248486	194	65	57	Low
38305204	210	65	56	Low
40716699	212	65	56	Low
80957635	231	65	55	Low
80957639	259	65	54	Negligible
80957392	279	65	54	Negligible
41030684	326	65	52	Negligible
80958074	337	65	52	Negligible

2.1.4 Construction compounds

Construction compounds will be used for storage of plant, equipment and materials. Noisy activities which will occur within construction compounds have been predicted elsewhere in this section (i.e. HDD, landfall and the onshore substation site). Other activity which will occur in the construction compounds (i.e. movements of vehicles and equipment) will result in far lower noise emissions than HDD and other construction and therefore need not be predicted in further detail.

2.1.5 Onshore substation site

The construction plant list for the onshore substation site is shown in Table 2-15 below.

Table 2-15: Construction plant list for onshore substation site.

Equipment	Notes	No.	Included in Model	BS 5228 Ref.	L_{wA} (dB)	On-time (%)
Mobile Crane	200T	2	Yes	C.3.29	98	70
Flatbed articulated truck	Regular use	2	Yes	C.4.26	103	40
Cherry Pickers (Diesel) (Genie Lift)	Regular use	5	Yes	C.4.59	106	40
Road Dump Trucks	Regular use	4	Yes	C.2.30	107	40
CAT 320 Excavators	14T capacity used in model	4	Yes	C.2.25	97	70
Compressors (Diesel) (Atlas Copco)	Low source levels	5	Yes	C.5.5	93	70
Lighting Towers (Diesel)	Typically used in winter, low source levels	6	Yes	C.4.87	93	70
Teleporter/Forks (JCB)	Frequent use likely	2	Yes	C.4.55	98	70
Concrete Pumps	Frequent use likely	2	Yes	C.4.30	107	40
Temporary Welfare Facilities (incl. diesel genies)	Low source levels	1	Yes	C4.79	92	100
Cable Winches	220 kV Cable	1	No	-	-	-
Cable Drums	220 kV Cable	3	No	-	-	-

Predicted construction noise levels from the onshore substation site are shown in Table 2-16.

Table 2-16: Predicted construction noise levels from onshore substation site.

NSL Geodirectory ID	Distance to centre of activity (m)	BS 5228 threshold value, dB L_{Aeq}	Predicted Noise Level, dB L_{Aeq}	Initial Magnitude of Impact
37934723	512	65	52	Negligible
40083594	538	65	52	Negligible
80962081	553	65	51	Negligible
80961958	568	65	51	Negligible
35438522	612	65	50	Negligible

2.2 Offshore construction noise

Source noise levels for the offshore piling have been based on real world measurements of marine hammer piling which have been scaled proportionally with hammer energy to produce the spectrum data and overall levels shown in

Table 2-17. Were the rig to be operated at the maximum hammer energy of 4,000kJ, the predicted noise levels would be 2 dB higher, a subjectively imperceptible change.

Table 2-17: Spectrum and overall noise source data for prediction of offshore piling noise.

Equipment/Energy	Octave Band and Overall Sound Power Levels (dBA)								
	63	125	250	500	1k	2k	4k	8k	Overall
Impact Hammer, 2,500kJ	101	115	126	131	133	130	122	111	137

The nearest offshore piling location to the coast is approximately 6 km distance from the nearest NSL located on the coast of the Cooley Peninsula. At long separation distances wind and other meteorological effects have large effects on noise propagation, with differences of 10 – 20 dB expected between noise levels when the receiver is upwind or downwind of the source. It is expected that the highest noise levels at NSLs from offshore piling would occur during calm or moderate downwind conditions, as at higher windspeeds the rougher sea surface due to wave action would result in transmission losses due to scattering.

To assess the potential for noise impacts, it is sufficient to predict the noise level at the nearest NSL under favourable noise propagation conditions. All other NSLs are more distant and will experience lower offshore piling noise levels due to additional distance attenuation as well as other effects such as ground absorption and topographical screening. Noise levels have been predicted, assuming a 10 m source height, using the BEK135 method for calm and moderate downwind conditions and are shown in Table 2-18.

Table 2-18: Noise predictions for offshore piling at the nearest NSL.

Noise Source/Receiver	Calm conditions	3 m/s (11 km/h) downwind conditions	Initial Magnitude of impact (daytime)
L_{Aeq} offshore piling noise (dBA) for shortest separation distance	41	52	Negligible

2.3 Operational noise modelling

Operational noise from the wind farm will arise from the operation of the turbines and at the onshore substation site. Modelling has been conducted using the Danish method for offshore wind turbine noise as outlined in section 1.1, with the ISO 9613 methodology used to predict noise from the onshore substation site.

2.3.1 Wind turbine operational noise

The candidate WTG assessed for the Project reaches maximum sound power levels at approximately 8 m/s standardised 10 m windspeed (V10). Table 2-19 shows prevailing background noise curves, limits and predicted Wind Turbine Noise (WTN) of 10 m/s V10 for the nearest NSL and the 10 monitoring locations. NML10 has been selected as the most representative location for the nearest NSL. It can be seen from the table that compliance with noise limits is predicted at all NSLs for all windspeeds. The critical windspeed (minimum difference between baseline levels and predicted WTN) has been determined to be 7 m/s V10. Predicted WTN is below the prevailing background curve at all of the sites listed and the smallest difference between background and predicted WTN at the critical windspeed is seen at NML3 and NML9.

Table 2-19: Background curves, limits and predicted WTN noise.

Site	V10 (m/s)	2	3	4	5	6	7	8	9	10
Nearest NSL (38649758)	Daytime Amenity Curve (dB L_{A90})	36.1	36.8	37.7	38.6	39.6	40.7	41.9	43.2	44.7
	Daytime Limit (dB L_{A90})	41.1	41.8	42.7	43.6	44.6	45.7	46.9	48.2	49.7
	Night-time Curve (dB L_{A90})	35.9	36.5	37.2	38.0	39.0	40.1	41.3	42.7	44.2

Site	V10 (m/s)	2	3	4	5	6	7	8	9	10
	Night-time Limit (dB L_{A90})	40.9	41.5	42.2	43.0	44.0	45.1	46.3	47.7	49.2
	Predicted WTN (dB L_{A90})	18.3	18.9	21.6	27.2	32.0	33.7	34.0	34.2	34.4
	Compliance	Y	Y	Y	Y	Y	Y	Y	Y	Y

Site	V10 (m/s)	2	3	4	5	6	7	8	9	10
NML1	Daytime Amenity Curve (dB L_{A90})	32.6	33.2	34.0	35.1	36.5	38.0	39.6	41.4	43.2
	Daytime Limit (dB L_{A90})	37.6	38.2	39.0	40.1	41.5	43.0	44.6	46.4	48.2
	Night-time Curve (dB L_{A90})	31.6	32.1	32.6	33.4	34.2	35.3	36.5	37.9	39.5
	Night-time Limit (dB L_{A90})	37.5	37.5	37.6	38.4	39.2	40.3	41.5	42.9	44.5
	Predicted WTN (dB L_{A90})	8.8	9.6	12.9	19.0	24.1	26.1	26.6	27.0	27.4
	Compliance	Y	Y	Y	Y	Y	Y	Y	Y	Y

Site	V10 (m/s)	2	3	4	5	6	7	8	9	10
NML3	Daytime Amenity Curve (dB L_{A90})	42.1	43.7	45.4	47.1	48.7	50.3	51.9	53.3	54.7
	Daytime Limit (dB L_{A90})	47.1	48.7	50.4	52.1	53.7	55.3	56.9	58.3	59.7
	Night-time Curve (dB L_{A90})	41.7	43.6	45.3	47.0	48.7	50.3	51.8	53.3	54.7
	Night-time Limit (dB L_{A90})	46.7	48.6	50.3	52.0	53.7	55.3	56.8	58.3	59.7
	Predicted WTN (dB L_{A90})	16.0	16.6	19.3	25.0	29.9	31.6	32.0	32.3	32.6
	Compliance	Y	Y	Y	Y	Y	Y	Y	Y	Y

Site	V10 (m/s)	2	3	4	5	6	7	8	9	10
NML3	Daytime Amenity Curve (dB L_{A90})	27.5	27.9	28.7	29.8	31.1	32.6	34.3	36.2	38.2
	Daytime Limit (dB L_{A90})	37.5	37.5	37.5	37.5	37.5	37.6	39.3	41.2	43.2
	Night-time Curve (dB L_{A90})	26.5	27.3	28.3	29.4	30.6	32.0	33.6	35.3	37.2
	Night-time Limit (dB L_{A90})	37.5	37.5	37.5	37.5	37.5	37.5	38.6	40.3	42.2
	Predicted WTN (dB L_{A90})	14.5	15.1	17.8	23.5	28.4	30.1	30.5	30.8	31.1
	Compliance	Y	Y	Y	Y	Y	Y	Y	Y	Y

Site	V10 (m/s)	2	3	4	5	6	7	8	9	10
NML4	Daytime Amenity Curve (dB L_{A90})	31.8	33.1	34.3	35.4	36.3	37.3	38.3	39.4	40.6
	Daytime Limit (dB L_{A90})	37.5	38.1	39.3	40.4	41.3	42.3	43.3	44.4	45.6
	Night-time Curve (dB L_{A90})	28.0	28.2	28.6	29.2	30.0	31.0	32.3	33.8	35.5
	Night-time Limit (dB L_{A90})	37.5	37.5	37.5	37.5	37.5	37.5	37.5	38.8	40.5
	Predicted WTN (dB L_{A90})	11.5	12.1	15.1	21.1	26.3	28.2	28.7	29.1	29.5
	Compliance	Y	Y	Y	Y	Y	Y	Y	Y	Y

Site	V10 (m/s)	2	3	4	5	6	7	8	9	10
NML5	Daytime Amenity Curve (dB L_{A90})	47.4	49.2	50.9	52.6	54.2	55.7	57.2	58.6	59.9
	Daytime Limit (dB L_{A90})	52.4	54.2	55.9	57.6	59.2	60.7	62.2	63.6	64.9
	Night-time Curve (dB L_{A90})	49.0	50.4	51.8	53.2	54.5	55.9	57.2	58.5	59.8
	Night-time Limit (dB L_{A90})	54.0	55.4	56.8	58.2	59.5	60.9	62.2	63.5	64.8
	Predicted WTN (dB L_{A90})	10.3	11.0	14.1	20.2	25.4	27.3	27.8	28.2	28.6
	Compliance	Y	Y	Y	Y	Y	Y	Y	Y	Y

Site	V10 (m/s)	2	3	4	5	6	7	8	9	10

Site	V10 (m/s)	2	3	4	5	6	7	8	9	10
NML6	Daytime Amenity Curve (dB LA90)	35.6	35.6	35.6	35.5	35.7	36.2	37.0	38.1	39.4
	Daytime Limit (dB LA90)	40.6	40.6	40.6	40.5	40.7	41.2	42.0	43.1	44.4
	Night-time Curve (dB LA90)	32.2	31.8	31.7	31.9	32.4	33.1	34.1	35.4	36.9
	Night-time Limit (dB LA90)	37.5	37.5	37.5	37.5	37.5	38.1	39.1	40.4	41.9
	Predicted WTN (dB LA90)	3.9	4.8	8.2	14.3	19.4	21.4	21.9	22.5	23.0
	Compliance	Y	Y	Y	Y	Y	Y	Y	Y	Y
Site	**V10 (m/s)**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
NML7	Daytime Amenity Curve (dB LA90)	34.5	34.9	35.3	35.9	36.6	37.5	38.6	40.0	41.6
	Daytime Limit (dB LA90)	39.5	39.9	40.3	40.9	41.6	42.5	43.6	45.0	46.6
	Night-time Curve (dB LA90)	27.7	28.6	29.8	31.1	32.5	34.1	35.9	37.8	39.9
	Night-time Limit (dB LA90)	37.5	37.5	37.5	37.5	37.5	39.1	40.9	42.8	44.9
	Predicted WTN (dB LA90)	5.6	6.5	9.8	15.9	21.1	23.0	23.6	24.1	24.6
	Compliance	Y	Y	Y	Y	Y	Y	Y	Y	Y
Site	**V10 (m/s)**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
NML8	Daytime Amenity Curve (dB LA90)	44.0	44.3	44.8	45.5	46.4	47.4	48.7	50.1	51.8
	Daytime Limit (dB LA90)	49.0	49.3	49.8	50.5	51.4	52.4	53.7	55.1	56.8
	Night-time Curve (dB LA90)	43.3	43.6	44.2	44.9	45.7	46.8	48.0	49.4	51.0
	Night-time Limit (dB LA90)	48.3	48.6	49.2	49.9	50.7	51.8	53.0	54.4	56.0
	Predicted WTN (dB LA90)	10.7	11.4	14.5	20.5	25.7	27.6	28.1	28.5	28.9
	Compliance	Y	Y	Y	Y	Y	Y	Y	Y	Y
Site	**V10 (m/s)**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
NML9	Daytime Amenity Curve (dB LA90)	28.7	29.2	30.0	31.1	32.4	34.1	36.0	38.1	40.5
	Daytime Limit (dB LA90)	37.5	37.5	37.5	37.5	37.5	39.1	41.0	43.1	45.5
	Night-time Curve (dB LA90)	28.2	28.2	28.6	29.4	30.5	32.0	33.8	36.0	38.5
	Night-time Limit (dB LA90)	37.5	37.5	37.5	37.5	37.5	37.5	38.8	41.0	43.5
	Predicted WTN (dB LA90)	8.2	8.9	12.2	18.3	23.4	25.4	25.9	26.3	26.6
	Compliance	Y	Y	Y	Y	Y	Y	Y	Y	Y
Site	**V10 (m/s)**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
NML10	Daytime Amenity Curve (dB LA90)	36.1	36.8	37.7	38.6	39.6	40.7	41.9	43.2	44.7
	Daytime Limit (dB LA90)	41.1	41.8	42.7	43.6	44.6	45.7	46.9	48.2	49.7
	Night-time Curve (dB LA90)	35.9	36.5	37.2	38.0	39.0	40.1	41.3	42.7	44.2
	Night-time Limit (dB LA90)	40.9	41.5	42.2	43.0	44.0	45.1	46.3	47.7	49.2
	Predicted WTN (dB LA90)	5.7	6.6	9.9	16.1	21.2	23.2	23.6	24.1	24.5
	Compliance	Y	Y	Y	Y	Y	Y	Y	Y	Y

2.3.2 Onshore substation site operational noise

Noise from the onshore substation site has been modelled using Softnoise Predictor. Sound power levels for substation operational equipment have been provided as broadband value ranges, as shown in Table 2-20.

Table 2-20: Noise information provided for air insulated switchgear (AIS) substation equipment.

Description	Height	Number	L_{WA} range (dB)	
			Min	Max
AIS Statcom Bay – Power Transformer	~5 m excluding tank	1	90	96
220kV Harmonic Filters – Filter with reactor and capacitor	~9 m to top of capacitor banks	2	87	101
220kV Reactor Bay – Shunt Reactor	~4 m excluding tank	1	86	96
MV/LV house transformer – not included in model	-	1	65	70

Noise spectrum data for the various specialist substation equipment can only be determined following detailed design and consequently is unavailable at this time. However, high voltage transformers are known to be tonal at even integer multiples of the line frequency (50 Hz) due to magnetostriction of the transformer core, thereby producing tones at 100 Hz, 200 Hz, 300 Hz, 400 Hz and so on. RPS have previously conducted measurements at high voltage stations and the spectral shape from these measurements can be applied to the broadband levels listed above. This will produce an approximate spectrum for the power transformer and, while the final noise spectra for the filters and reactor may be different, use of the approximate spectrum will allow assessment of potential tonality using the results of the modelling. The MV/LV house transformer is not included in the model because the stated sound power levels are more than 10 dB below those for the other items of equipment, therefore not contributing to the cumulative noise levels.

The list of equipment in Table 2-20 is confined to noisy equipment in the AIS compounds of the onshore substation site. All Gas Insulated Switchgear (GIS) equipment will be housed within the substation buildings and will therefore not result in significant external noise emissions.

An ISO 9613 1/3 octave band noise model has been constructed in Softnoise Predictor. The model includes large buildings to be constructed on the onshore substation site. In order to account for the height of the harmonic filter bay capacitor banks (9 m) and to avoid unrealistic screening effects of transformer and reactor blast walls, the power transformer, shunt reactor and harmonic filters have been modelled as omnidirectional vertical emissive surfaces.

Table 2-21: Measured baseline and predicted substation noise levels at the nearest NSL.

Description	Measured/Predicted L_{Aeq} (dB)				Comment
	Total	100 Hz	200 Hz	315 Hz	
Measured baseline noise for nearest NSL	45	12	16	23	Elevated baseline L_{Aeq} levels due to road traffic noise from the N33
Predicted noise at nearest NSL for highest estimated L_{WA} for all equipment	36	30	20	32	Detectible tonality is predicted for these source levels
Predicted noise at nearest NSL for lowest estimated L_{WA} for all equipment	23	19	8	20	Tonality would not be detectible using the 1/3 octave band method for these source levels, the predicted noise level is 8 dB below the background L_{A90} of 31 dB

2.3.3 Crew transfer vessels

Predictions of crew transfer vessel noise have been made based on measurements conducted on board similar vessels. The indicated noise levels are as follows:

- Idling 83 dBA @ 1 m;
- Cruising 92 dBA @ 1 m; and
- Accelerating 98 dBA @ 1 m

Based upon the noise level for acceleration, an indicative sound power level of 106 dBA has been calculated. Noise level data from BS 5228 for an articulated dump truck drive-by (ref. C.4.2) has been used to generate an indicative noise spectrum for CTV engine noise. For the purposes of modelling, the Greenore Port approach route has been selected to examine the potential impacts of CTV noise on the nearest NSLs the route was obtained from openseamap.org and ESRI satellite imagery which has sufficient resolution to discern the positions of port and starboard buoys on the shipping route. The nearest NSL is located close to Greencastle Lighthouse on the north coast of Carlingford Lough.

The above data has been used to assemble an ISO 9613 noise model in Softnoise Predictor with the CTV vessel modelled as a moving source at an average speed of 20 km/h making two trips per day, departure and return. The model inputs and predicted noise levels are detailed in Table 2-22 and Table 2-23 respectively.

Table 2-22: Model inputs for CTV on Greenore Port route.

CTV accelerating L_{wA} (dB)	Route length (km)	Average speed (km/h)	Closest distance to south shore NSL (km)	Closest distance to north shore NSL (km)	Time to traverse route (mins)
106	6	20	0.3	0.6	19

Table 2-23: Predicted noise level for CTV on Greenore Port route.

Description	Predictions (dB)	
	Nearest south shore NSL	Nearest north shore NSL
L_{Aeq} during route traverse	38	34
Contribution to daytime L_{Aeq} for both trips completed daytime	25	21
Contribution to night-time L_{Aeq} for both trips completed night-time	14	10

3 GEODIRECTORY COORDINATES OF NSLS

Table 3-1 details the Irish Transverse Mercator (ITM) coordinates for the NSLs referenced in the preceding sections.

Table 3-1: ITM coordinates for NSLs referenced by GeoDirectory ID during noise modelling.

NSL GeoDirectory ID	ITM Easting	ITM Northing
(Nearest NSL to WTGs) 38649758	721946	805371
80957386	715293	790930
80957626	715024	790916
80956696	702911	790975
80956697	702927	791297
80956698	702984	791386
38608415	703096	790947
38608415	703096	790947
37977077	703311	790892
80956696	702911	790975
80956697	702927	791297
80956698	702984	791386
35472921	703608	791062
38607722	703587	791024
80956577	703748	791046
80956578	703757	791048
80956579	703782	791048
80956580	703789	791049
80956581	703816	791046
80956582	703829	791042
35472918	703839	791047
80956678	703879	791050
80956679	703899	791050
80957595	706420	791088
35474657	706352	791143
80957596	706619	790952
80956631	706324	791075
80957367	706768	791156
80957370	706736	790920
80957368	706842	791114
80957599	706768	790930
80957594	706855	791122
80957598	706766	790921
80957597	706765	790912
80957593	706874	791132
80957282	706946	789602

NSL GeoDirectory ID	ITM Easting	ITM Northing
40085880	707033	789527
40653957	706935	789763
41068361	706928	789764
36752837	706898	789767
35473226	707069	789495
35473228	707099	789476
80958037	710879	789134
80958038	710887	789119
80957962	710908	789091
80957963	710917	789089
80957961	710731	789210
80957965	710960	789111
80957964	710977	789088
37955438	710703	789263
80957938	710989	789116
80958033	711009	789046
80958128	716111	783814
36751742	710611	789228
27133813	711037	788999
36751743	710573	789238
80958031	711018	788937
80957959	711039	788939
37955440	711108	789021
80958032	711060	788942
37955452	711566	789011
37955481	711673	789046
80957990	711720	789055
80957940	711729	789074
40321084	711751	789057
80957999	711770	789071
40833466	711402	788983
80958041	711382	788982
80957946	711884	788993
80958040	711317	789014
80958039	711287	789011
80203324	711284	788968
80957637	714439	789667
80957638	714353	789651
80958075	714389	789593
60063310	714465	789734
40836063	714398	789784
80957391	714430	789796

NSL GeoDirectory ID	ITM Easting	ITM Northing
80957634	714491	789810
60248486	714578	789732
38305204	714579	789765
40716699	714456	789857
80957635	714525	789847
80957639	714496	789893
80957392	714505	789912
41030684	714490	789339
80958074	714422	789316
37934723	698444	790487
40083594	698177	790416
80962081	698132	790407
80961958	698539	790475
35438522	697925	790422