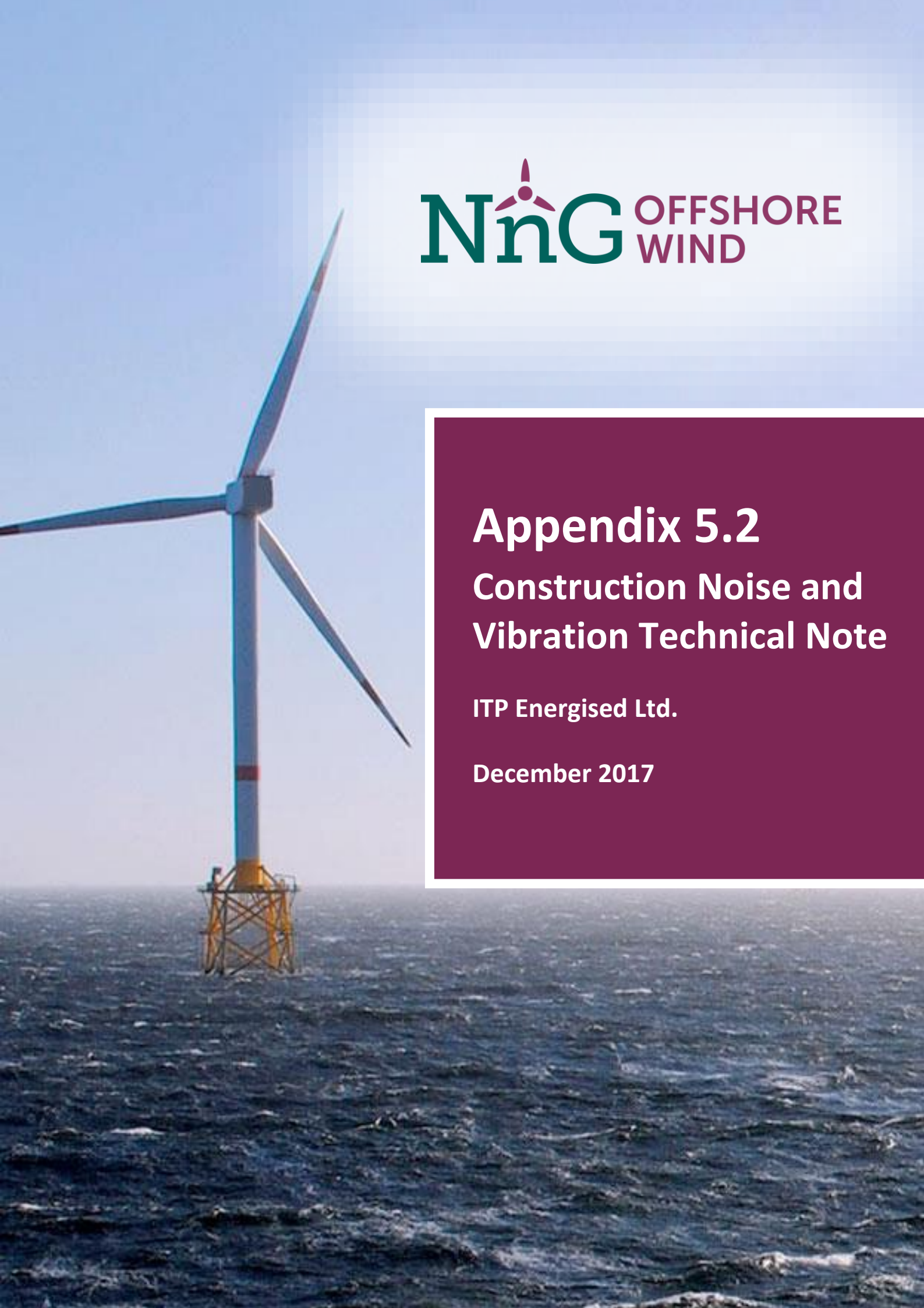


NnG OFFSHORE WIND

Appendix 5.2

Construction Noise and Vibration Technical Note

ITP Energised Ltd.

December 2017

Neart na Gaoithe Wind Farm

Construction Noise and Vibration Briefing Note

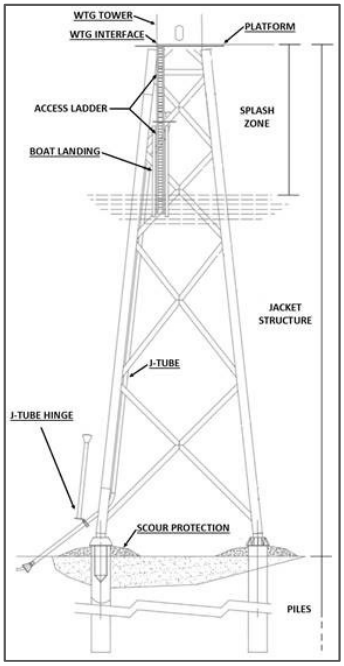
Introduction

Neart na Gaoithe (NnG) offshore wind farm is a 450 MW wind farm proposed approximately 15.5 km from the closest coastline at Fife Ness. The wind farm has achieved planning consent and construction of the project is scheduled to commence in 2019.

During public consultation questions have been raised regarding the potential for noise and vibration effects associated with the wind farm construction and specifically the installation of the foundations for the turbine towers through piling. This note provides a review of the vibration levels generated by offshore piling activities and their likely effects at the closest onshore receptors.

Foundation piling

As indicated in Plate 1 the turbines tubular steel towers will be fixed to the seabed using piles below each leg of the jacket.



The piles will comprise tubular steel which will be drilled and driven into the sea bed substrata. Each tower will be supported by a foundation of up to six piles, each of up to 3.5 m in diameter and of up to 50 m depth below sea-bed.

The steel piles will be created by a combination of driven piling and drilled pilling (see Plate 2), with successive phases of driving and drilling as necessary Pile driving has a greater potential than pile drilling for creating noise and vibration impacts. The cumulative period of pile driving for a group of up to 6 piles will be between 6 and 21 hours. Piles will be driven by a hydraulic hammer forcing the pile into the ground and breaking through the rock strata until refusal is reached.

Driven piling will operate in two phases, an initial soft start at 20% of total energy, to promote the safe dispersal of fish and sea mammals whilst underwater noise is below appropriate thresholds, and subsequently at maximum energy levels of 1,635 kJ applied hammer energy.

Plate 1 – Foundation Layout

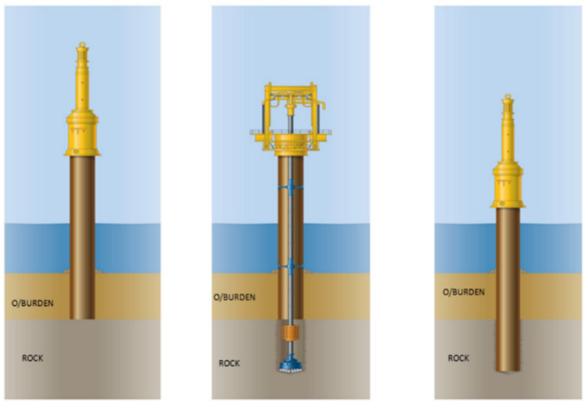


Plate 2 – Drive, drill, drive piling sequence

The energy of the hammer striking the pile generates stress waves (vibration) from the toe of the pile and the pile shaft that will propagate into the surrounding rock, i.e. ground vibrations will spread outward from the pile following each hammer strike. The strike also generates noise, which will propagate through air.

Vibration Propagation

Vibration is defined as the displacement of a material over a given time, and commonly expressed as peak particle velocity (ppv) in units of mm/s.

The pile driving process will effectively generate two types of vibration waves; vibration from the toe of the pile which will spread spherically, and vibrations from the shaft, which will spread cylindrically. The distinction between the two mechanisms of spreading is important when considering levels of vibration close to the pile, however, at long distance both sources can be considered as a single source with lateral spreading.

The propagation efficiency of vibration will depend on the medium through which the vibration waves spread. This is known as impedance and reflects the ability of the vibration wave to pass through a substance. For example, vibrations have a lower impedance through rock than through sandy soil. A level of impedance also applies to the energy passed from the hammer into the pile and then the ground.

The method of calculating vibration propagation is complex, however predictive methods have been established based on empirical measurements of vibration from sources on construction sites. A conservative formula has been used to predict vibration levels based on published research[1]. The equation has been applied for a range of assumptions, reflecting impedance levels representative of a variety of ground conditions, to present a range of likely vibration levels experienced.

The predicted vibration levels at distance from the source are presented in Figure 1. The calculations conservatively assume that all energy from the hammer strike is transmitted into a vibration wave.

Each line on the graph represents a specific calculation for differing assumptions relating to ground impedance and transmission substrate.

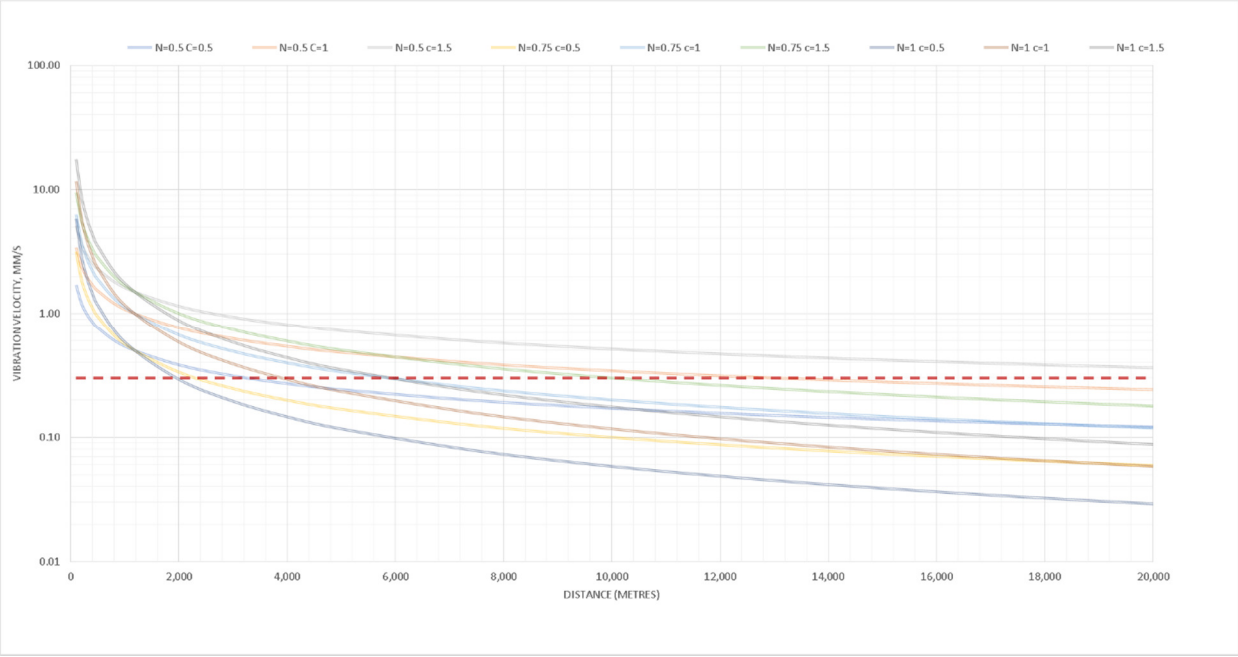


Figure 1 – Predicted vibration levels at distance from source

Vibration Limits

Assessment criteria for the evaluation of vibration is provided in British Standard BS5228-2:2009[2] and are presented in the table below.

[1] D.J Rockhill, M.D. Bolton, D.J White - British Geotechnical Association international Conference on Foundations: Innovations, observations, design and practice - Ground-borne vibrations due to press-in piling operations. (2007). T.A.Newson, pp.743-756

[2] BS 5228-2:2009+A1:2014 Code of practice for noise and vibration control on construction and open sites. Vibration Stationary Office, December 2008

Table 1 – BS5228 Vibration Evaluation Criteria

Vibration level	Effect
0.14 mm/s	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction. At lower frequencies, people are less sensitive to vibration
0.3 mm/s	Vibration might be just perceptible in residential environments.
1.0 mm/s	It is likely that vibration of this level in residential environments will cause complaint, but can be tolerated if prior warning and explanation has been given to residents.
10 mm/s	Vibration is likely to be intolerable for any more than a very brief exposure to this level

Noise Propagation

Noise from piling activities will propagate spherically from the source. Noise is attenuated by four mechanisms:

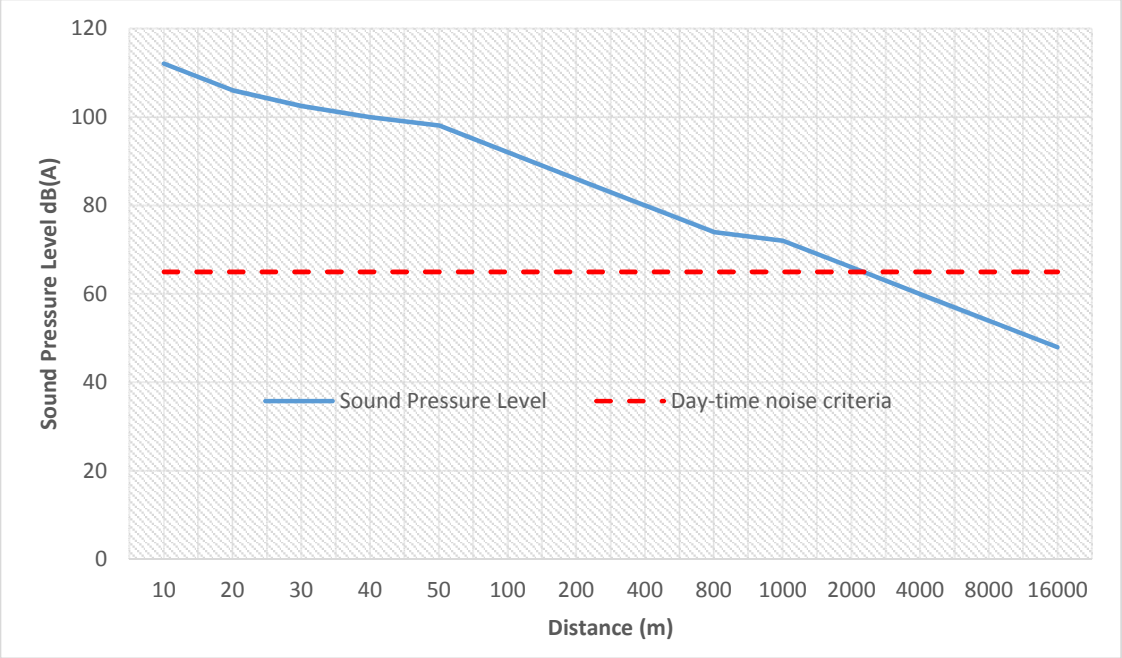
- distance attenuation, whereby the noise level falls with distance from source due to energy wave front spreading;
- ground attenuation, whereby sound energy is absorbed in the ground. In the case of this project during calm conditions the sea will act like hard ground / reflective surface, therefore ground attenuation will be minimal;
- air attenuation, where sound energy is absorbed in air depending on atmospheric conditions. Air attenuation is a minor component of attenuation; and
- barrier attenuation, whereby a source is screened by an obstacle. Due to the separation distance between the source and onshore receptors it is assumed that no barrier screening will occur.

The attenuation of sound energy, or noise, will therefore be a function of distance from source. The relationship is well established, whereby a reduction in noise of 6 dB is experienced per doubling of distance from a point source.

The effect of wind on noise propagation is complex, noise propagation in upwind conditions inhibited. The prevailing wind direction off the Fife Coast will typically be westerly and south-westerly, therefore receptors will typically be upwind of the construction site.

Noise associated with pile driving is variable, however instantaneous noise levels can be assumed to be as high as 140 dB(A), a noise level intolerable to the human ear and equivalent to being 30 m from a military jet during take-off[3]. Based on a source power level of 140 dB_{LWA} sound pressure levels at distance downwind of the source has been calculated and presented in the figure below.

[3] Horizontal Guidance Note, IPPC H3 (part 2), Horizontal Guidance for Noise, Part 2 – Noise Assessment and Control, Scottish Environment Protection Agency, 2002



Noise Limits

Assessment criteria for the evaluation of construction noise is provided in British Standard BS5228-1:2009[4] and are presented in the table below. Differing noise limits are proposed depending on the ambient noise environment.

Table 2 – BS5228 Noise Evaluation Criteria

Time period	Threshold Value in dB
Night-time (23:00 – 07:00)	45
Evening and Weekends	55
Daytime (07:00 – 19:00) and Saturdays ()7:00 – 13:00)	65

It should be noted that the noise limits do not define an averaging period, however would typically be considered over a period of 1 hour or more. Pile driving noise will relate to a short number of events in a similar period, which when 'averaged' over a longer averaging period will be substantially reduced.

Conclusions

Vibration

Based on conservative predictions of vibration transmission it can be determined that vibration levels attributable to piling activities at the closest onshore locations are below levels which would be considered perceptible in residential environments in all but the most extreme assumption case. As the calculations include for a number of conservative assumptions it can be assumed that actual vibration levels will be much lower than the theoretical.

[4] BS 5228-1:2009+A1:2014 Code of practice for noise and vibration control on construction and open sites. Noise Stationary Office, December 2008

Based on the predicted vibration levels no perceptible adverse effects are likely to occur at onshore receptors during the construction phase of NnG wind farm.

Noise

Predictions of construction noise indicate that ambient noise from piling activities at the closest noise sensitive receptors will largely be below construction noise limits. It is considered that construction noise will be at best faintly audible when considered in the context of a coastline situation (wave and wind induced noise).

Based on the predicted levels, and where unfavourable atmospheric conditions are experienced there is potential for pile driving noise to be close to night-time construction noise limits. The predictions provide a conservative estimate of construction noise levels, whilst theoretically correct are unlikely to be experienced in reality. Furthermore, the likelihood of the unfavourable conditions occurring during the construction period is considered low.

Overall, noise from pile driving activities is considered to be not significant at the closest onshore receptors.