BERWICK BANK WIND FARM
OFFSHORE ENVIRONMENTAL IMPACT ASSESSMENT

ANNEX H: PEER REVIEW OF TECHNICAL REPORT

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Environmental Impact Assessment – Appendix 10.1, Annex H
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Prepared by:	**RPS**
Prepared for:	**SSE Renewables**
Checked by:	**Douglas Watson**
Accepted by:	**Kerr MacKinnon**
Approved by:	**Ross Hodson**

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1. INTRODUCTION

1. Brian Richard (Dick) Wood has been requested by Seiche Ltd (on behalf of the Applicant) to undertake a peer review of the subsea noise technical report which investigates the potential effects of underwater noise on the marine environment from construction of the Proposed Development. The report that has been reviewed is entitled “Berwick Bank Wind Farm Offshore Environmental Impact Assessment - Subsea Noise Technical Report” (see volume 3, appendix 10.1). This was provided for peer review by Seiche Ltd on the 14 March 2022.

2. This peer review is being undertaken by Dick Wood whose experience in the field of acoustics is outlined in paragraphs 3 and 4.

3. Dick Wood has worked on industrial noise and vibration issues, both in industry and as a consultant, over a period of 50 years and has specialised in underwater noise for around 35 of these years. The latter work has mainly been involved with the reduction of underwater radiated noise from numerous oceanographic and fisheries research vessels, working both for the owners and the shipyards; but he has also been involved in the assessment of likely marine mammal disturbance due to numerous different industrial activities. He has presented several papers on underwater noise to The International Council for the Exploration of the Sea (ICES) as well as being heavily involved with specific research groups on fish avoidance of research vessels within ICES. Further, he has also been involved in the development of standards on underwater noise including American National Standards Institute/Acoustical Society of America (ANSI/ASA) and British Standards.

4. He has an honours degree in Applied Physics, a master’s degree in Advanced Acoustics and is also a Fellow of the Institute of Acoustics.

2. GENERAL COMMENTS

5. This is considered to be a well presented report which sets forward, in a clear and logical manner, the methodology that has been used in this assessment of underwater noise radiation from the site during pre-construction, construction, operation and maintenance and decommissioning activities associated with the above named development. The work appears to have been carried out in a rigorous manner and to a high standard. In my opinion, the assessment has also been carried out in a reasonably conservative manner in that worst case assumptions have generally been made to ensure that the report conclusions are robust. An aspect which was subject to question were the assumed values of the Energy Conversion Factors (ECF values) which relate underwater noise energy to hammer impact energy. This complex aspect of the work is discussed further in section 4. However, to evaluate the impact of this parameter, Seiche Ltd has undertaken a sensitivity analysis, using various values of ECF, to allow for higher (and lower) values of ECF than have been adopted in the main report.

3. THRESHOLDS AND CRITERIA

6. There is a substantial discussion set forward in section 4 of the main technical report on the injury and disturbance thresholds for five groups of marine mammals to impulsive and non-impulsive noise. These injury criteria are set forward in terms of peak (unweighted) and weighted Sound Exposure Level (SEL) acoustic thresholds for Permanent Threshold Shift (PTS) and Temporary Threshold Shift (TTS) onset (taken from Southall *et al.* (2019)). In addition, criteria are also set forward for mild and strong disturbance thresholds which are based on Root Mean Square (RMS) pressure and SEL contour levels for various types of impulsive and non-impulsive activity.

7. In addition, mortality, recoverable injury and TTS limits are set forward for four groups of fish as well as sea turtles and fish larvae. These criteria are based upon SEL values and peak pressures for fish with respect to impulsive piling, with more generalised (non-quantitative) assessments used for non-impulsive sources for fish, sea turtles and eggs and larvae. All these criteria were taken from the seminal paper by Popper *et al*. (2014).

8. However, it must be appreciated that, similar to human populations, mammal hearing thresholds are a function of many parameters including age and previous exposure to noise. This means that hearing thresholds, and associated responses, of any specific species will exhibit considerable variability when compared to the population average.

4. SOURCE LEVELS AND ASSUMPTIONS

4.1. NOISE (ENERGY CONVERSION FACTORS)

9. The derivation of source levels for piling operations is a difficult area as there are several ways of defining the sound source strength for piling operations. This report sets forward an expression of source strength which uses the pile energy and an estimated acoustic to mechanical energy efficiency term. In the main technical report, Seiche Ltd adopted energy conversion factor or ECF’s (designated β) which ranged from 4% at the onset of piling through to a value of 0.5% at the end of piling. However, Marine Scotland and NatureScot requested that Seiche Ltd also undertake a sensitivity analysis of the injury and TTS/PTS ranges presented in the Subsea Noise Technical Report using energy conversion factors of up to 10% - based upon a paper on subsea piling for the Beatrice Offshore Wind Farm, Thompson *et al.* (2020).

10. Seiche Ltd has presented, in volume 3, appendix 10.1, annex A, a technical note on ECF’s used on various other projects, including (Thompson *et al.,* 2020) to demonstrate that errors in the calculation of source levels or ECF’s can readily arise by various mechanisms – including the use of distant measurement locations for subsea noise which can give rise to significant errors upon extrapolating back to 1 m from a hypothetical monopole source. These errors are also discussed in great detail in a paper by Farcas *et al.* (2016) along with examples of the magnitude of errors that can arise - and have presented such data as spatial plots.

11. This was followed by a review, in volume 3, appendix 10.1, annex B, of the results of a sensitivity analysis of three different ECF (β) values, namely:

- 10% at the onset of piling falling to 1% at the end of piling;
- 4% at the onset of piling falling to 0.5% at the end of piling (the main study); and
- 1% throughout all piling operations.

12. It is evident, upon inspecting the results of these various assumptions, that the outcomes on the range at which TTS or PTS arises are very different, confirming the importance of the assumed ECF values. From Seiche Ltd advice on the revised piling methodology, we now understand that piles will probably be driven from just above the water surface and will terminate close to the seabed. Thus, the paper by Lippert *et al*. (2017) looks particularly relevant as there the 82 m long piles were driven in 40 m of water to approximately 17 m above the sea floor. This Lippert data was re-analysed by Seiche Ltd to provide ECF’s throughout the piling process, using noise data normalised to a hammer energy of 2,000 kJ. Since the final pile position on Lippert was a little below mid-water depth (and since, when the pile is subsea, the fall-off in energy

cited by Lippert *et al.* (2017) is ~ 2.5 dB per halving of exposed pile above the seabed) this infers a final ECF of 0.5% or less.

13. It is considered unfortunate that there is no standard methodology on how to evaluate piling source strength at an early stage in the project (such as at Environmental Impact Assessment (EIA) stage); indeed, Seiche Ltd advised that: "*The reality though for most EIA projects is that the noise study is required before the other more detailed Geotech and engineering studies can be carried out and so we have to derive the source level empirically"* (S Stephenson 2022, pers. comm.). Seiche Ltd added that it is not possible to enter into more detailed calculations at this stage of the project as *"the geotechnical surveys have not been completed nor the drivability analysis carried out. Thus preliminary values of β have to be assumed at this stage in the project"* (S Stephenson 2022, pers. comm.).

14. It is my opinion that the estimate of 4% at the onset of piling, reducing to 0.5% at the end of piling, as used by Seiche Ltd in this study, is justifiable as a realistic, and probably slightly conservative, baseline assumption. Further, it is considered that the value of 10% used in the sensitivity assessment is probably unrealistic – based upon the detailed reasoning set forward in volume 3, appendix 10.1, annex A. However, in view of the considerable variation in the variables used in evaluating these estimates of β (including ground type, pile length, pile diameter, wetted area etc) it is considered prudent to have undertaken the sensitivity analysis work – as set forward in volume 3, appendix 10.1, annex B.

4.2. PARTICLE MOTION

15. A previous concern on windfarm EIA assessments was the fact that the issue of particle motion was barely addressed or simply addressed indirectly e.g. by inferring particle motion from sound pressures. In the current study, Seiche Ltd has addressed these and other issues in a detailed particle motion review (see volume 3, appendix 10.1, annex G).

16. Seiche Ltd acknowledge from the onset that *"Due to the current state of understanding and existing (validated) modelling methodologies it is not considered possible at this time to provide a quantitative assessment of the effects of particle motion on marine life for the Berwick Bank project"* (volume 3, appendix 10.1, annex G, paragraph 20). However, in volume 3, appendix 10.1, annex G, a qualitative assessment has been made, thereby setting forward a summary of best available knowledge on this issue. Volume 3, appendix 10.1, annex G also sets forward some of the difficulties and complexities of measuring and assessing the impact of particle motion on fish and invertebrates. It is unfortunate that even a basic quantitative study is not viable at the present point in time; but that is simply due to a lack of knowledge in too many areas e.g. piling particle motion source strength; particle motion decay with distance, knowledge of the sensitivity that fish and invertebrates have to particle motion – or even the magnitude of particle motion at which damage can arise.

17. This is an area where considerable research needs to be undertaken in the future, not only in the area of assessing damage risk to fish and invertebrates from particle motion, but also in terms of measuring impact piling driving, in relatively close proximity to the piling operations, for future windfarm studies.

5. PROPAGATION AND EXPOSURE MODELLING

18. The noise propagation model used in this study is based upon a hybrid energy flux model (Weston, 1976; 1980a; 1980b). A review of the various alternative propagation methodologies was undertaken by National Physical Laboratory (NPL) who concluded that: *"The Weston energy flux model …can produce very good propagation loss predictions"*. Further, it is noted that the Weston model is particularly suited to shallow water assessments with steadily varying gradients at both low and high frequency.

19. One concern over using a model which does not compute the receiver noise at different depths, is that since fish (and probably marine mammals) often exhibit a strong diving reaction on fleeing from a given noise source (such as observed from an approaching fisheries research vessel), there was concern that the received noise level could be substantially greater at depth than that computed average over the full water column. Further, since the diving reaction is most likely to be in evidence when close to the piling operation, this could affect the strength of early received pulses which are most important in the calculation of cumulative SEL values (see Figure 6.3 of volume 3, appendix 10.1). Review of the spatial plots identified in Wood and Humphrey (2012) show that there is indeed a substantial variability in noise level at short distances from piling operations, due to the conical noise radiation associated with impact piling (Wood and Humphrey, 2012). Whilst at very short distances shadow zones are clearly identifiable near the surface, the pattern is reversed further from the source where shadow zones arise near the seabed (the authors considered only the first downward propagating pulse). However, the reflected pulse will generate a reverse conical wave pattern albeit slightly delayed. It is therefore considered that there is no consistent trend which would induce a bias in the interpretation of noise impact on fish and marine mammals due to sound variation with depth.

20. The calculation of cumulative SEL values from component strikes and allowing for the small reductions over time (with a mammal speed ranging from 1.0 to 2.3 m/s) is considered reasonably conservative as swim speeds could (presumably) exceed these values in the case of a strong "flee" reaction, particularly over the shorter distances (which are very important in terms of cumulative SEL). By adopting a moderate average swim speed, this will tend to compensate somewhat for the variability in reaction that may occur. For example, further away from the piling activity, mammals or fish may adopt paths which are more influenced by their preferred feeding and mating areas, etc. So, the approach adopted in this report is considered to be reasonable as, in the absence of other clearly established behavioural patterns, a radial flee response is a reasonable base assumption.

6. UNCERTAINTY

21. As discussed in previous sections, there are uncertainties associated with any prediction method with potential errors arising due to source strength, source path, transmission loss and the simplification of numerous different types of marine mammal into standardised frequency weighting networks. Of these the source strength is probably one of the most important – and difficult to quantify with any degree of certainty. However, volume 3, appendix 10.1, annex B sets out the results of the sensitivity assessment which utilises various extremes of the energy conversion factor. In volume 3, appendix 10.1, annex C, the transmission losses from the following propagation models were used to give an indication of likely variability or uncertainty using one transect within the survey region.

- ACTuP based Parabolic Equation solver (RAMGeo);
- ACTuP based Normal Mode solver (KrakenC); and
- Rogers (1981) semi-empirical model.

22. The results of the modelling show good correlation between the Weston, ACTuP RAMGeo and Roger's model with typically 1 dB or less difference between the models. It is therefore, considered that the Weston propagation model is well suited to the current study.

23. However, in reality, probably the greatest uncertainty arises over how marine mammal reacts to the sound. In terms of cumulative SEL noise, the assumption that marine mammals take a simple radial path away from the source is a logical base assumption and matches intuition; but in reality, as discussed in the report, the real world behaviour could be quite different. In addition, the assumed standardised frequency

weighting networks may work well in representing the impact on large fish populations, but there can be considerable variability in their hearing thresholds due to age, previous exposure to noise, etc.

7. CONCLUSIONS

24. This report is considered to be a comprehensive study that has addressed all the principal areas of concern for mammals, fish and sea turtles in the proximity of the Proposed Development. The methodology has been clearly outlined and the associated assumptions considered to be reasonably conservative yielding a robust analysis. As with any up front study, there are potential errors associated with source strength definition, source path identification and sound transmission loss. However, the greatest variability probably lies in the behavioural reaction of marine mammals and fish to the piling stimulus. It is considered that Seiche Ltd has addressed all these issues and compared predicted levels against clear and justifiable criteria as far as is practicable.

25. The absence of a quantitative assessment of the risk of damage or impairment due to high particle motion levels in the proximity of piling operations is unfortunate but emphasises the lack of knowledge in this area. It is recommended that particle motion should be addressed in more detail for future windfarm studies once the state of knowledge has increased. However, Seiche Ltd. has carried out a qualitative assessment, thereby setting forward a summary of best available knowledge on this issue.

B. R. Wood B.Tech. M.Sc. FIOA

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