Marine Mammal Mitigation Protocol

codling wind park

This Marine Mammal Mitigation Protocol (MMMP) has been updated in response to Item 10 of the Applicant's further information request (FIR) received from An Coimisiún Pleanála (The Commission) on 1st August 2025. This version of the MMMP (Rev 01) supersedes the previous revision (Rev 00) that was included with the CWP Project planning application.

The Applicant notes that cross references within this document to the EIAR and other relevant planning application documents remain relevant and unchanged but should be considered alongside the supporting **EIAR Addendum** and other relevant documents prepared in response to the Commission's FIR.

TABLE OF CONTENTS

List of tables

Abbreviations

Abbreviation	Term in Full
μPa	Micro Pascals
ADD	Acoustic Deterrent Device
BEIS	Department for Business, Energy and Industrial Strategy
CPOD	Click Pod Detector
CWP	Codling Wind Park
dB	Decibels
EIA	Environmental Impact Assessment
EIAR	Environmental Impact Assessment Report
EMP	Environmental Monitoring Plan
IAC	Inter-array Cables
IWDG	Irish Whale & Dolphin Group
JNCC	Joint Nature Conservation Committee
kg	Kilograms
kJ	Kilojoules
km	Kilometres
lb	Pounds
m	Metres
MAP	Maritime Area Planning
MDS	Maximum Design Scenario
MMMP	Marine Mammal Mitigation Protocol
MMO	Marine Mammal Observers
MW	Megawatts
NEQ	Net Explosive Quantity
NPWS	National Parks & Wildlife Service
OfTI	Offshore Transmission Infrastructure
ORJIP	Offshore Renewables Joint Industry Programme
OSS	Offshore Substation Structures
OTI	Onshore Transmission Infrastructure
PAM	Passive Acoustic Monitoring
PDA	Planning and Development Act 2000
PTS	Permanent Threshold Shift

RMS	Root Mean Squared
SEL	Sound Exposure Level
SPL	Sound Pressure Level
TJBs	Transition Joint Bays
UXO	Unexploded Ordnance
WTGs	Wind Turbine Generators

Definitions

Glossary	Meaning
Permanent Threshold Shift (PTS)	Permanent threshold shift (or PTS) is a permanent increase in the threshold of hearing (minimum intensity needed to hear a sound) at a specific frequency above a previously established reference level.
Sound Exposure Level (SEL)	The decibel level of the time integral (summation) of the squared pressure over the duration of a sound event; units of dB re 1 $\mu Pa^2/s$.
Sound Pressure Level (SPL)	A means of characterising the amplitude of a sound. There are several ways sound pressure can be measured. The most common of these are the root-mean-square (RMS) pressure, the peak pressure, and the peak-to-peak pressure.
Temporary Threshold Shift (TTS)	Temporary threshold shift (or TTS) is a temporary increase in the threshold of hearing (minimum intensity needed to hear a sound) at a specific frequency above a previously established reference level.
Passive Acoustic Monitoring (PAM)	Used to measure, monitor, and determine the sources of sound in underwater environments. This is a versatile, non-invasive, and cost-effective method to detect, classify, and track marine mammals over large areas for long periods.
Acoustic Deterrent Devices (ADDs)	A range of devices that either emit sounds, using electrical or mechanical means, or acoustically reflect those emitted by echolocating cetaceans. Often used to discourage marine mammals from an area where anthropogenic activities are occurring.
Noise Abatement	A primary mitigation methodology used to reduce the noise emissions at-source.
Marine Mammal Observer (MMO)	A marine mammal observer (MMO) is a professional in environmental consulting who specialises in whales and dolphins and is responsible for spotting and identifying animals through visual or passive acoustic means.
Monitored Zone	The zone which is required to remain clear of marine mammals for a specified time-frame, prior to a noisy activity taking place.
PTS-Onset	The distance from the sound source at which the received level decreases to below the level of PTS-onset for a specific marine mammal hearing group.

1 INTRODUCTION

1.1 The CWP Project

1. Codling Wind Park Limited (hereafter 'the Developer') is proposing to develop the Codling Wind Park (CWP) Project, which is located in the Irish sea approximately 13 - 22 km off the east coast of Ireland, at County Wicklow.

2. The Developer is applying for permission for all components of the CWP Project under Section 291 of the Planning and Development Act 2000, as amended (PDA) (as inserted by the Maritime Area Planning (MAP) Act 2021). This includes:

   - The Generating Station, located approximately 13-22 kilometres off the coast of County Wicklow, which comprises; 60 or 75 wind turbine generators (WTGs) with an output of up to 1,300 megawatts (MW) and inter-array cables (IACs) and interconnector cables linking the WTGs and offshore substation structures (OSSs);
   - The Offshore Transmission Infrastructure (OfTI) which comprises three OSSs and three offshore export cables transporting the energy produced by the WTGs from the OSSs to land at the Poolbeg Peninsula;
   - The landfall on the southern Poolbeg Peninsula, which describes the point at which the offshore export cables are brought onshore and connected at three transition joint bays (TJBs) to the onshore export cables; and
   - The Onshore Transmission Infrastructure (OTI) on the Poolbeg Peninsula, which comprises the onshore export cables, the onshore substation and associated infrastructure and network cables to a planned extension to the existing ESB Networks 220kV substation.

3. A detailed description of the CWP Project is provided in the Environmental Impact Assessment Report (EIAR) **Volume 2**, **Chapter 4 Project Description**.

1.2 Purpose of the MMMP

4. This Marine Mammal Mitigation Protocol (MMMP) supports the consent application for the CWP Project and has been updated following receipt of consultation feedback and the Further Information Request (FIR) received from An Coimisiún Pleanála . The purpose of this MMMP is to provide a framework for the final MMMP, which is anticipated to be required under conditions of the planning consent, to ensure appropriate controls are in place to manage environmental risks associated with the construction and operation of the offshore components of CWP Project as assessed in the EIAR. The MMMP is intended to be a live document which will be updated as project development progresses and will be submitted to the relevant authority (anticipated to be Marine Area Regulatory Authority (MARA) in consultation with National Parks and Wildlife Service (NPWS)) for approval, prior to the start of construction. A revised document containing the finalised details of the MMMP will also be submitted prior to the commencement of operations. The proposed schedule of submission and scope of the iterations of the MMMP are described in the following 'Scope of the MMMP' section.

1.3 Scope of the MMMP

5. It is anticipated that the development and implementation of a MMMP will form a condition of any planning consent granted. The Developer has also committed to the development of a MMMP within the EIAR and supporting documents for the CWP Project.

6. The MMMP has the following primary objectives:

1. To outline the potential mitigation measures that could be put in place during **geophysical surveys** to reduce the risk of auditory injury (PTS) to negligible levels;
2. To outline the potential mitigation measures that could be put in place during **WTG/OSS pile driving activities** to reduce the risk of auditory injury (PTS) to negligible levels;
3. To outline the potential mitigation measures that could be put in place during **onshore substation pile driving activities** in the River Liffey to reduce the risk of auditory injury (PTS) to negligible levels;
4. To outline the potential mitigation measures that could be put in place during **UXO clearance activities** to reduce the risk of auditory injury (PTS) to negligible levels; and
5. To outline the potential mitigation measures that could be put in place during **decommissioning activities** to reduce the risk of auditory injury (PTS) to negligible levels.

7. This MMMP considers the following guidance:

- DAHG (2014): Guidance document for minimising the acoustic impact of man-made sound sources on marine mammals.

1.4 Revisions of the MMMP

8. As set out above, the MMMP is considered to be a 'live' document and will be reviewed on a regular basis to allow any changes to the construction programme, operations or unforeseen issues to be incorporated at any stage, and as deemed necessary by the Developer, their agents or relevant authorities. The MMMP will be subject to regular review to address, for example:

- Any conditions stipulated in the planning consent;
- Any conditions following an Annex IV risk assessment and Regulation 54 derogation application;
- Any requirements/issues highlighted through consultation prior to construction;
- Any change/updates to best practice and available technology at the time of construction; and
- To ensure it incorporates the findings of any pre-construction surveys.

9. Beyond the regular review the MMMP submitted as part of the application will be updated to account for the final design of the proposed project. This is due to certain final aspects being subject to future survey, such as UXO for which a contemporary survey may be required in advance of construction to ensure the risk of UXO is as low as reasonably practicable. Similarly the final MMMP will confirm which of the two design options for which consent is being sought will form the final option for construction. The proposed approach to updating the MMMP, and submitting to the NPWS, is as follows:

1. MMMP for purposes of consent;
2. Detailed geophysical survey MMMP; timing of submission subject to geophysical survey(s);
3. Detailed UXO MMMP; timing of submission subject to UXO survey;
4. Detailed WTG piling MMMP, timing of submission subject to final construction programme;
5. Detailed onshore substation piling MMMP, timing of submission subject to final construction programme; and
6. Detailed decommissioning MMMP; timing of submission subject to decommissioning plans.

1.5 Structure of the MMMP

10. In line with the requirements set out above, the structure of this MMMP is outlined in

11.

12. **Table** 1-1.

Table 1-1 Structure of the MMMP

Section 1: Introduction	• Overview of the CWP Project • Purpose and scope of the MMMP
Section 2: Geophysical survey MMMP	• Overview of survey equipment; • Overview of auditory impact (PTS) ranges; • Outline of mitigation measures; • Conclusion
Section 3: WTG/OSS Piling MMMP	• Overview of piling parameters; • Overview of auditory impact (PTS) ranges • Outline of mitigation measures; • Conclusion
Section 4: Onshore Substation Piling MMMP	• Overview of piling parameters; • Overview of auditory impact (PTS) ranges • Outline of mitigation measures; • Conclusion
Section 5: UXO MMMP	• Overview of auditory impact ranges; • Outline of potential primary mitigation measures; • Outline of mitigation measures
Section 6: Decommissioning MMMP	• Short summary

13. A summary of the key aspects identified above is provided within the following sections. While it is anticipated that these will form the key elements of the MMMP, it should be noted that this list may not be exhaustive and will be reviewed and updated within the final MMMP, in line with the final design of the CWP Project and in consultation with relevant stakeholders post consent and therefore closer to the time of construction.

1.6 Implementation of the MMMP

14. Key to the implementation of this MMMP is the delegation of responsibility for the implementation of the MMMP as relevant to the specific contractor's scope, to the relevant appointed person(s) on behalf of the contractor, who will regularly liaise with and update the Developer on all environmental issues relating to the project during the construction phase. As part of the appointment of a contractor and agreement of contracts, the Developer will determine the lines of communication for environmental compliance with the relevant stakeholders.

15. The appointed contractor will be responsible for developing final construction methods and installation procedures for the CWP Project. Contractors and their subcontractors will ensure that all relevant

environmental and maritime legislation is complied with, that all necessary licences and permissions are obtained, that all design embedded mitigation measures are applied and that good working practices are adhered to, to minimise risks to the environment.

16. Contractors will be responsible for implementing the MMMP through contractual agreements with the Developer. Contractors will also be required to complete their own Environmental Management Plans (EMPs) that are specific to their works and that are compliant with the MMMP. Requirements of the MMMP will be communicated to contractors (and their subcontractors), as required, to discharge the relevant consent conditions and to communicate project requirements and standards to facilitate incorporation into contractor EMPs.

17. Project personnel are required to ensure compliance with the requirements of this MMMP (and subsequent revisions thereof) and are responsible for ensuring that their actions constitute good environmental practice. All personnel are also encouraged to provide feedback and suggestions for improvements to ensure effective environmental management of all construction activities.

2 GEOPHYSICAL SURVEY MMMP

18. This section of the MMMP details the proposed marine mammal mitigation and monitoring procedures during pre-construction geophysical surveys at the CWP Project. Exposure to loud sounds can lead to a reduction in hearing sensitivity (a shift in the hearing threshold at particular frequencies) which results from physical injury to the auditory system and can result in permanent changes to the hearing sensitivity (PTS). As such, the objective of the geophysical survey MMMP is to minimise the risk of auditory injury (PTS) to marine mammals as a result of noise generated by geophysical surveys.

2.1 Survey Equipment

19. Pre-construction geophysical equipment could include any or all of the following:

- **Multi-Beam Echo Sounder (MBES):** MBES is used to acquire detailed seabed topography and water depth by emitting a fan shaped swath of acoustic energy (sound waves) along a survey transect. The sound waves are reflected from the seabed to enable high resolution seafloor mapping. The MBES can be either hull- or ROV-mounted.
- **Sub-Bottom Imager (SBI):** provides a real-time 3D view of the sub-seabed via multiple 5 m wide data swaths that penetrates the seabed up to 8 m. The SBI uses a frequency modulated signal to identify buried objects, anomalies, geohazards, and stratigraphy to a 10 cm resolution[1]. SBIs are typically deployed on an ROV or towfish, close to the seabed, and operate at a much lower source level than sub-bottom profilers.
- **Side Scan Sonar (SSS):** SSS utilises conical or fan-shaped pulses of sounds directed at the seafloor to provide information on the surface of the seabed through analysis of reflected sound.
- **Sub Bottom Profiler (SBP) – pinger:** The pinger SBP is a type of geophysical survey tool that uses low-frequency or high frequency sounds (pings) to identify acoustic impedance of the sub-surface geology and to identify transitions from one stratigraphic sequence to another[2]. Sound sources that produce lower frequency pulses can penetrate through and be reflected by subsurface sediments (low-resolution data), whilst higher frequency pulses achieve higher resolution images but do not penetrate the subsurface sediments[3].
- **Ultra-High resolution seismic (UHRS) – sparker:** A small seismic source containing a cluster of electrodes. These systems discharge high voltage impulses which heat the surrounding water within which the device is located through the use of electrode tips. The generation of heat and subsequently, steam, results in the emission of an acoustic impulse (Hartley Anderson Ltd, 2020). While sparkers are less directional than other SBPs, the acoustic energy they emit is still focussed towards the sea floor.
- **Ultra-Short Base Line (USBL) system:** A USBL system is used to obtain accurate equipment positioning during sampling activities. This system consists of a transceiver mounted under the vessel, and a transponder on deployed equipment. The transceiver transmits an acoustic pulse which is detected by the transponder, followed by a reply of an acoustic pulse from the transponder. Range and bearing information allow an accurate estimate of the location of the deployed equipment.
- **Magnetometer:** A magnetometer is used to measure the variation in the earth's total magnetic field to detect and map ferromagnetic objects on or near the sea floor along the survey's vessel tracks. Often, two magnetometers are mounted in a gradiometer format to measure the magnetic

[1] https://krakenrobotics.com/our-services/sub-bottom-imager/
[2] https://www.aspectsurveys.com/survey-services/geophysical/sub-bottom-profiling/
[3] https://www.ixblue.com/maritime/subsea-imagery/sub-bottom-profilers/

gradient between the two sensors. The magnetometer is a passive system and, therefore, does not emit any noise.

2.2 PTS-onset impact ranges

20. The impact of PTS from geophysical surveys is expected to be very highly localised. Potential impact ranges are summarised in **Table 2-1**.

Table 2-1 Predicted auditory injury (PTS) impact ranges for geophysical survey equipment.

Equipment	PTS range
MBES	A recent comprehensive assessment of the characteristics of acoustic survey sources proposed that MBES and SSS should be considered de minimis in terms of being unlikely to result in PTS to marine mammals (Ruppel et al., 2022).
SSS	
USBL	Transmission loss from geometric spreading and frequency-dependent absorption will be such that SPLs within the main beam of the USBL can be expected to drop to below 200 dB re 1 µPa and below the PTS thresholds within a few metres of the source.
SBI	The source levels of SBI equipment are below the PTS-onset thresholds for harbour porpoise, minke whale, dolphins, and seals.
SBP	Results for both SBPs and URHS sparkers have indicated that PTS-onset for porpoise is likely to arise between 17 – 23 m from the use of this equipment at source levels of 267 dB re 1 µPa (SPL_{peak}) (BEIS, 2020). Noise modelling have previously indicated PTS-onset in minke whales within 5 m of the source when SBP pingers operate with a sound source of 220 dB re 1 µPa (SPL_{peak}) (Shell, 2017), and ~10 m for seals (BEIS, 2019).
URHS	

2.3 Mitigation of PTS

21. CWP has committed complying with the DAHG (2014) guidance.

2.3.1 Pre-Start Monitoring

22. For geophysical acoustic surveys (including: airguns, water guns, sparkers, boomers and vertical seismic profiling, multibeam, single beam, side-scan sonar and sub-bottom profiler (e.g., pinger or chirp system)) in waters <200 m deep, the DAHG (2014) guidance states the following:

- Monitored Zone of **1,000 m** radial distance of the sound source by a qualified and experienced MMO
- Activities shall only commence in **daylight hours** where effective visual monitoring by the MMO can be achieved
- MMO shall conduct pre-start-up constant effort monitoring at least **30 minutes** before the sound-producing activity is due to commence
- Sound-producing activity shall not commence until at least **30 minutes** have elapsed with no marine mammals detected within the Monitored Zone by the MMO
- Pre-Start Monitoring shall subsequently be followed by a **Ramp-Up** Procedure

2.3.2 Ramp Up Procedure

23. For the ramp up procedure, the DAHG (2014) guidance states the following:

- If output peak sound pressure level from any source exceeds 170 dB re: 1µPa @1m:
  - output shall commence from a lower energy start-up and thereafter be allowed to gradually build up to the necessary maximum output over a period of 40 minutes
- Once the Ramp-Up Procedure commences, there is no requirement to halt or discontinue the procedure at night-time, nor if weather or visibility conditions deteriorate nor if marine mammals occur within a 1,000m radial distance of the sound source, i.e., within the Monitored Zone.

2.3.3 Line changes

24. For line changes, the DAHG (2014) guidance states the following:

- If >40 minutes for survey line or station change:
  - shut down and undertake full Pre-Start Monitoring, followed by a Ramp-Up Procedure for recommencement, or
  - undergo a major reduction in seismic energy output to a lower energy state where the output peak sound pressure level from any operating source is 165-170 dB re: 1µPa @1m, and then undertake a full Ramp-Up Procedure for recommencement
- If <40 minutes for survey line or station change:
  - activity may continue as normal (i.e., under full seismic output).

2.3.4 Break in sound output

25. For breaks in sound outputs, the DAHG (2014) guidance states the following:

- <10 minute break:
  - MMO monitoring must be undertaken to check that no marine mammals are observed within the Monitored Zone prior to recommencement of the sound source at full power
- >10 minute break:
  - all Pre-Start Monitoring and a subsequent Ramp-up Procedure (where appropriate following Pre-Start Monitoring) must be undertaken.

2.4 Geophysical survey MMMP conclusion

26. There are primary mitigation measures currently available that will be implemented at the CWP Project, to reduce the risk of auditory injury from pre-construction geophysical surveys to negligible levels. These primary mitigation measures are:

- 1 km Monitored Zone
- 30 minute pre-start MMO watch
- Ramp-up if required/possible.

3 WTG/OSS PILING MMMP

27. This section of the MMMP details the proposed marine mammal mitigation and monitoring procedures during piling activities at the CWP Project. Exposure to loud sounds can lead to a reduction in hearing sensitivity (a shift in the hearing threshold at particular frequencies) which results from physical injury to the auditory system and can result in permanent changes to the hearing sensitivity (PTS). The assessment of PTS includes both instantaneous PTS using the SPL_{peak} metric (this is the PTS-onset impact range from a single strike), and cumulative PTS using the SEL_{cum} metric (this is the PTS-onset impact range from a cumulation of threshold shift across all pile strikes within a 24 hour period). As such, the objective of the Piling MMMP is to minimise the risk of auditory injury (i.e., PTS) to marine mammals as a result of noise generated by piling activities.

28. For the offshore components of the CWP Project, the representative scenario for assessment is the installation of 75 WTG foundations, in addition to the installation of three offshore substations (OSS). Only monopile foundations are proposed for the CWP Project and thus only monopile foundation types have been assessed in the Environmental Impact Assessment (EIA) undertaken for marine mammals (see EIAR **Volume 3**, **Chapter 11 Marine Mammals**).

29. The total number of days piling under the representative scenario is expected to be up to 78 days in total over the construction period for the WTGs and the OSS combined (assuming 1 pile installed per day). A summary of the piling parameters assessed are presented in Section 3.1.

30. In **Volume 3**, **Chapter 11** of the EIAR, the assessment provides predicted impacts from the representative scenario. The predicted impacts are outlined in **Section 3.2** of this document.

3.1 Piling parameters

31. Underwater noise modelling of pile driven WTG foundations has been undertaken by Subacoustech Environmental Limited using the INSPIRE model. Full details of the underwater noise modelling methods can be found in EIAR **Volume 4, Appendix 9.4 Underwater Noise Assessment** and **Appendix 9-C Underwater Noise Modelling** of the **EIAR Addendum** (prepared in response to the Commission's FIR). Four WTG model locations were selected within the array site to represent the range of ground conditions across the site as well as the varying water depth (SE, SW, NE and NW). Three piling scenarios have been assessed:

- **Scenario 1 (SE model location):** Most restrictive – 9.5 m monopile, maximum 4,400 kJ hammer energy, 1 pile per 24 hours, 3.17 hours piling, 5,594 hammer strikes;
- **Scenario 2 (NE and SW modelling locations + OSS):** Less restrictive – 9.5 m monopile, maximum 4,400 kJ hammer energy, 1 pile per 24 hours, 3.17 hours piling, 4,734 hammer strikes;
- **Scenario 3 (NW model location):** Least restrictive – 9.5 m monopile, maximum 4,400 kJ hammer energy, 2 piles per 24 hours, 6.33 hours piling, 9,468 hammer strikes.

32. The WTG piling parameters for each scenario, including soft-start and ramp-up details, are provided in **Table 3-1**. Note, the exact same piling parameters are assumed for the installation of the OSS, adopting scenario 2 which is representative of the OSS locations proposed.

3.1.1 Noise reduction

33. To mitigate potential impacts from underwater noise during the construction of the project, CWP commits to a limit on underwater noise of 169 dB $L_{E,p,ss,05}$ at 750m at WTG and OSS piling events. At this stage it is important to note that the mitigation technology is evolving, and several technologies

remain subject to a single supplier. As such, whilst the ability to mitigate to the required level is certain, using any one of the technologies, it is prudent to present options in this MMMP, and to select appropriate options. This is discussed further in a review of noise abatement methods provided at the end of this MMMP in **Appendix A: Review of noise abatement methods**.

Table 3-1 Piling parameters for WTGs under each piling scenario

Energy (kJ)	440	440	1,100	2,200	3,300	4,400	Total
Scenario 1 (SE piling location): Most restrictive (9.5 m pile diameter / 4,400kJ blow energy / 1 pile per 24 hours)							**1 pile per day**
# strikes per pile	200	1,248	1,151	1,143	899	953	**5,594**
Duration (s)	1200	2,160	1,980	1,980	1,800	2,280	**3 hours 10 minutes**
Strike rate (blows/min)	10	35	35	35	30	25	**-**
Scenario 2 (SW and NE piling locations): Less restrictive (9.5 m pile diameter / 4,400kJ blow energy / 1 pile per 24 hours)							**1 pile per day**
# strikes per pile	200	277	279	277	240	3,461	**4,734**
Duration (s)	1,200	480	480	480	480	8,280	**3.10 hours 10 minutes**
Strike rate (blows/min)	10	35	35	35	30	25	**-**
Scenario 3 (NW piling location): Least restrictive (9.5 m pile diameter / 4,400kJ blow energy / 2 piles per 24 hours)							**2 piles per day**
# strikes per pile	200	277	279	277	240	3,461	**4,734 per pile 9,468 for 2 piles**
Duration (s)	1,200	480	480	480	480	8,280	**3 hours 10 minutes per pile. 6 hours 20 minutes for 2 piles**
Strike rate (blows/min)	10	35	35	35	30	25	**-**

3.2 PTS-onset impact ranges

34. **Table 3-2** outlines the predicted PTS-onset impact ranges (assuming a limit on underwater noise of 169 dB $L_{E,p,ss,05}$ at 750mThe maximum PTS-onset impact range is 70 m.

Table 3-2 Predicted maximum auditory injury (PTS) impact ranges (m) from WTG piling (assuming a limit on underwater noise of 169 dB $L_{E,p,ss,05}$ at 750m)

Location	Scenario	# MP per day	Unweighted $L_{p,pk}$ at first strike (440 kJ)				Weighted $L_{E,p,wtd,24h}$ Cumulative			
			LF	HF	VHF	PCW	LF	HF	VHF	PCW
SE	Most restrictive	1	<50	<50	70	<50	70	<50	<50	<50
SW	Less restrictive	1	<50	<50	50	<50	<50	<50	<50	<50
NE	Less restrictive	1	<50	<50	<50	<50	<50	<50	<50	<50
NW	Less restrictive	2	<50	<50	<50	<50	<50	<50	<50	<50

3.3 Mitigation

35. CWP has committed to complying with the DAHG (2014) guidance.

36. To mitigate potential impacts from underwater noise during the construction of the project, CWP commits to a limit on underwater noise of 169 dB $L_{E,p,ss,05}$ at 750m at WTG and OSS piling events.

3.3.1 Pre-Start Monitoring

37. For pile driving, the DAHG (2014) guidance states the following:

- Monitored Zone of **1,000 m** radial distance of the sound source by a qualified and experienced MMO
- Activities shall only commence in **daylight hours** where effective visual monitoring by the MMO can be achieved
- MMO shall conduct pre-start-up constant effort monitoring at least **30 minutes** before the sound-producing activity is due to commence (PAM of the monitoring zone may occur simultaneously with the visual MMO watch as a complimentary method)
- Sound-producing activity shall not commence until at least **30 minutes** have elapsed with no marine mammals detected within the Monitored Zone by the MMO
- Pre-Start Monitoring shall subsequently be followed by a **Ramp-Up** Procedure.

3.3.2 Ramp Up Procedure

38. The DAHG (2014) guidance states that: if the output peak sound pressure level from any source including equipment testing exceeds 170 dB re: 1µPa @1m, then a ramp-up procedure ("soft-start") must be used.

- Where possible, the underwater acoustic energy output shall commence from a lower energy start-up (i.e., a peak sound pressure level not exceeding 170 dB re: 1µPa @1m) and thereafter be allowed to gradually build up to the necessary maximum output over a period of **20-40 minutes**.
- Once an appropriate and effective Ramp-Up Procedure commences, there is no requirement to halt or discontinue the procedure at night-time, nor if weather or visibility conditions deteriorate nor

if marine mammals occur within a 1,000 m radial distance of the sound source, i.e., within the Monitored Zone.

3.3.3 PAM

39. Passive acoustic monitoring (PAM) is the use of acoustic sensors to detect vocalising marine mammals. Since the mid-2000s, PAM has become a part of best practice industry standards in an effort to provide increased marine mammal monitoring capacities during periods of limited visibility, and to prevent delays in the construction and / or operations of offshore industries.

40. In the context of this MMMP, PAM is primarily used as a tool to detect and localise vocalising marine mammals. DAHG (2014) states that PAM '*may be recommended or required as part of the licence / consent conditions in order to optimise marine mammal detection around the site of a plan or project*', and highlights that while PAM is encouraged, it was not at the time of publication in 2014 considered by NPWS to be sufficiently developed to be considered the primary or only mitigation measure, as it was not considered to reliably detect all marine mammal species and has a limited detection range for some species.

41. More recent guidance from IWDG (2020) recommends that PAM is used in standard mitigation protocols to '*allow detection of cetaceans in poor visibility during the hours of darkness and for detecting animals underwater where source levels are often highest*'.

42. JNCC (2010) recommends the use of dedicated MMOs and PAM operators. They state that PAM can be a useful supplement to visual observations, though its use is limited by detection range (detecting harbour porpoise in a 500 m mitigation zone), and they also note that only vocalising animals can be detected. If used, JNCC recommend that the PAM operative should acoustically monitor for marine mammals for a minimum of 30 minutes prior to piling commencing, and if a marine mammal is detected, piling should not commence until 20 minutes after the last acoustic detection within the mitigation zone.

43. Whilst other jurisdictions, such as Scotland and continental Europe, implement PAM during poor visibility and darkness as a primary mitigation, at this stage it is noted that the DAHG (2014) guidance does not accept PAM as a primary mitigation. As such the proposed CWP project may implement PAM as a complimentary mitigation measure subject to any future revision to the relevant guidance.

3.3.4 Break in sound output

44. For breaks in sound outputs, the DAHG (2014) guidance states the following:

- >30 minute break:
  - all Pre-Start Monitoring and a subsequent Ramp-up Procedure must be undertaken
- however, for higher output pile driving operations:
  - there may be a regulatory requirement for a shorter 5-10 minute break limit after which period all Pre-Start Monitoring and a subsequent Ramp-up Procedure shall recommence as for start-up.

3.4 WTG/OSS Piling MMMP Conclusion

45. A suite of potential mitigation measures is currently available that will be implemented at the CWP Project, to reduce the risk of auditory injury from pile driving to negligible levels. These include:

- Limit on underwater noise of 169 dB $L_{E,p,ss,05}$ at 750m at WTG and OSS piling events 1 km Monitored Zone
- 30 minute pre-start MMO watch

20-40 minute ramp-up.

4 ONSHORE SUBSTATION PILING MMMP

46. Activities at the onshore substation on the northern shore of the Poolbeg Peninsula may require the installation of a combi-wall and reclamation for the ESB building at landfall on the banks of the River Liffey, Dublin. These activities will occur in the River Liffey and thus will generate underwater noise that requires consideration in the marine mammal assessment. While it is expected that the combi-wall may be installed using vibro-piling, impact piling using 2.5 m diameter tubular piles were assessed as a proven technology that may also be utilised.

47. The assessment of PTS includes both instantaneous PTS using the SPL_{peak} metric (this is the PTS-onset impact range from a single strike), and cumulative PTS using the SEL_{cum} metric (this is the PTS-onset impact range from a cumulation of threshold shift across all pile strikes within a 24 hour period). As such, the objective of the Piling MMMP is to minimise the risk of auditory injury (i.e., PTS) to marine mammals as a result of noise generated by piling activities.

4.1 Piling parameters

48. Underwater noise modelling for the onshore substation has been undertaken by Subacoustech Environmental Limited using the INSPIRE model. Full details of the underwater noise modelling methods can be found in EIAR **Volume 4**, **Appendix 9.4 Underwater Noise Assessment** and **Appendix 9-C Underwater Noise Modelling** of the **EIAR Addendum** (prepared in response to the Commission's FIR)**,** and are summarised here in **Table 4-1** below. Piling for the onshore substation will be undertaken using a crawler crane with impact hammer attachment, rather than marine vessels.

Table 4-1 Piling parameters for the onshore substation

	1 piling rig	**2 piling rigs**
Maximum hammer energy (kJ)	400	400
Total number of strikes per piling event	48,000	96,000
Duration of piling event	8 hours	8 hours

4.2 PTS-onset impact ranges

49.

50. **Table** 4-2 outlines the PTS-onset impact ranges. The maximum PTS-onset impact range is 3 km for harbour porpoise and 2 km for minke whales when 2 piling onshore rigs are piling simultaneously. For dolphins, the maximum cumulative PTS-onset impact range is <100 m. For seals, this is 300 m.

Table 4-2 Predicted maximum auditory injury (PTS) ranges (m) from piling at the onshore substation

	Minke whale	Dolphins	Harbour porpoise	Seals
Instantaneous PTS (Unweighted $L_{p,pk}$)	<50	<50	<50	<50
Cumulative PTS (Weighted $L_{E,p,wtd,24h}$) 1 rig	1,100	< 50	2,000	130
Cumulative PTS (Weighted $L_{E,p,wtd,24h}$) 2 rigs	2,000	< 100	3,000	300

4.3 Mitigation

51. CWP has committed to complying with the DAHG (2014) guidance.

4.3.1 Pre-Start Monitoring

52. For pile driving, the DAHG (2014) guidance states the following:

- Monitored Zone of **1,000 m** radial distance of the sound source by a qualified and experienced MMO
- Activities shall only commence in **daylight hours** where effective visual monitoring by the MMO can be achieved
- MMO shall conduct pre-start-up constant effort monitoring at least **30 minutes** before the sound-producing activity is due to commence
- Sound-producing activity shall not commence until at least **30 minutes** have elapsed with no marine mammals detected within the Monitored Zone by the MMO
- Pre-Start Monitoring shall subsequently be followed by a **Ramp-Up** Procedure

4.3.2 Ramp Up Procedure

53. The DAHG (2014) guidance states that: if the output peak sound pressure level from any source including equipment testing exceeds 170 dB re: 1μPa @1m, then a ramp-up procedure ("soft-start") must be used.

- Where possible, the underwater acoustic energy output shall commence from a lower energy start-up (i.e., a peak sound pressure level not exceeding 170 dB re: 1μPa @1m) and thereafter be allowed to gradually build up to the necessary maximum output over a period of **20-40 minutes**.
- Once an appropriate and effective Ramp-Up Procedure commences, there is no requirement to halt or discontinue the procedure at night-time, nor if weather or visibility conditions deteriorate nor if marine mammals occur within a 1,000 m radial distance of the sound source, i.e., within the Monitored Zone.

4.3.3 Break in sound output

54. For breaks in sound outputs, the DAHG (2014) guidance states the following:

- >30 minute break:
    - all Pre-Start Monitoring and a subsequent Ramp-up Procedure must be undertaken
- however, for higher output pile driving operations:
    - there may be a regulatory requirement for a shorter 5-10 minute break limit after which period all Pre-Start Monitoring and a subsequent Ramp-up Procedure shall recommence as for start-up

4.4 Onshore Substation Piling MMMP Conclusion

55. A suite of potential mitigation measures are currently available that could be implemented at the CWP Project, to reduce the risk of auditory injury from pile driving to negligible levels. These include:

- 1 km Monitored Zone
- 30 minute pre-start MMO watch
- 20-40 minute ramp-up.

5 UXO MMMP

56. In line with MARA's Guidance for Consent Holders on the identification of Unexploded Ordnance (UXO) in the Maritime Area, in the event that an UXO is identified, CWPL will notify MARA and the Gardai. It is noted that An Garda Síochána will in such circumstances request military assistance be provided to deal with the UXO and that the Naval Service Dive Section are responsible for dealing with any UXO within Irish Territorial waters. In those circumstances, CWPL will engage with An Garda Síochána and the Naval Service Dive Section to ensure that they are aware of the requirements to carry UXO disposal activities in accordance with the mitigation measures in this MMMP and the conditions of the permission.

57. If UXO are identified across the array site or OECC, a risk assessment will be undertaken and items of UXO will be either avoided by equipment micro-siting, moved, or detonated in situ. Recent advancements in the commercial availability of methods for UXO clearance mean that high-order detonation may be largely or completely avoided. The methods of UXO clearance considered for CWP Project include:

- Removal / relocation;
- Low-order detonation (deflagration); and,
- High-order detonation.

58. This section of the MMMP details the possible marine mammal mitigation and monitoring procedures during UXO clearance activities at the CWP Project. The objective of the UXO MMMP is to minimise the risk of auditory injury to marine mammals as a result of noise generated by UXO clearance. The metrics presented for PTS for UXO clearance are slightly different to those presented for piling, since UXO clearance is a single blast, rather the multiple pulses from pile driving activities. The assessment of PTS for UXO includes PTS using the SPL_{peak} metric (single strike) and PTS using the SEL_{ss} metric (single strike).

59. The final UXO MMMP will incorporate the most appropriate mitigation measures based upon best available information and proven methodologies at that time to mitigate the impacts of UXO clearance at CWP.

60. Whilst the risk of UXO is considered to be very low, for the purposes of the assessment it is assumed that within the Offshore Development Area of the CWP Project, up to ten UXO may require clearance. For the assessment it is assumed that a maximum charge weight of up to 525 kg Net Explosive Quantity (NEQ) may be required for 2,000 lb (907.2 kg) UXO. Detailed pre-construction surveys have not yet been completed, it is not possible at this time to determine exactly how many items of UXO will require clearance, however these assumptions are based on industry risk assessment and the very low likelihood of encountering UXO in the western Irish Sea. UXO clearance requirements will be the same regardless of the WTG option selected.

61. An overview of the auditory injury impact ranges assessed in the environmental impact assessment undertaken for marine mammals (see EIAR **Volume 3**, **Chapter 11 Marine Mammals**) and the potential mitigation measures for UXO clearance are outlined in the following sections of this MMMP.

5.1 Low order clearance

5.1.1 PTS impact ranges

62. The largest PTS-onset impact range for low order clearance (deflagration) is predicted to be 990 m.

Table 5-1 Summary of the auditory injury (PTS-onset) impact ranges (m) for low order UXO clearance

	Weighted $L_{E,p,wtd,ss}$				Unweighted $L_{p,pk}$			
	LF	HF	VHF	PCW	LF	HF	VHF	PCW
Low order (0.25 kg)	130	<50	170	<50	130	60	990	110

5.1.2 Mitigation

63. The DAHG (2014) guidance does not specifically cover UXO clearance activities, however it does cover blasting which shall be considered here.

- Monitored Zone of **1,000 m** radial distance of the sound source by a qualified and experienced MMO
- Activities shall only commence in **daylight hours** where effective visual monitoring by the MMO can be achieved
- MMO shall conduct pre-start constant effort monitoring at least **30 minutes** before the sound-producing activity is due to commence

5.2 High order clearance

64. In the event that low order deflagration fails, CWP commits to Noise Abatement Systems in the event of high order UXO clearance.

5.2.1 PTS impact ranges

65. The largest PTS-onset impact range for high order clearance (with noise abatement) is predicted to be 5.1 km. Thus, if high-order clearance is required, the predicted PTS impact ranges exceed the 1 km mitigation zone even with the use of a bubble curtain. Therefore, an ADD will be operated for a pre-determined length of time, concurrent to the pre-detonation search, to deter marine mammals to a greater distance prior to any detonation. For the site specific UXO clearance activities, it will be necessary to operate the ADD for different durations according to the UXO disposal method used, UXO/charge size, and associated predicted impact ranges.

Table 5-2 Summary of the auditory injury (PTS-onset) impact ranges (m) for high order UXO clearance with noise abatement

	Weighted $L_{E,p,wtd,ss}$				Unweighted $L_{p,pk}$			
	LF	HF	VHF	PCW	LF	HF	VHF	PCW
750 kg UXO + donor	1,100	<50	910	230	670	290	5,100	1,100

5.2.2 Mitigation

66. The DAHG (2014) guidance does not specifically cover UXO clearance activities, however it does cover blasting which shall be considered here.

- Monitored Zone of **1,000 m** radial distance of the sound source by a qualified and experienced MMO
- Activities shall only commence in **daylight hours** where effective visual monitoring by the MMO can be achieved
- MMO shall conduct pre-start constant effort monitoring at least **30 minutes** before the sound-producing activity is due to commence

6 DECOMISSIONING MMMP

67. Decommissioning activities shall include removal of offshore structures above the seabed in reverse order to the construction sequence. The effects of these activities on marine mammals are considered to be similar to, or less than those occurring during construction. The final methods chosen for decommissioning shall be dependent on the technologies available at the time, and in accordance with the decommissioning schedule.

68. DAHG (2014) guidance does not cover decommissioning activities.

69. IWDG (2020) acknowledges that at this stage it is not possible to know the decommissioning process or what impacts it may have to marine mammals. They advise that standard mitigation is used, including 24 hour detection capability and soft-start/ramp-up protocols where applicable.

70. As a minimum, it is expected that an MMO watch will likely be required for any underwater noise generating activity that has predicted the potential for auditory injury to marine mammals.

71. A full environmental assessment for decommissioning activities will be conducted prior to decommissioning activities taking place. This will outline the potential auditory impact ranges for marine mammals for the decommissioning methods identified for the project. This will also inform a MMMP appropriate for those activities.

7 SUMMARY OF MITIGATION METHODS

72. CWP has committed complying with the DAHG (2014) guidance, and has also committed to Mitigation Measures equivalent to those identified in the Appendix consistent with achievement of 169dB $L_{E,p,ss,05}$ at 750m.

Table 7-1 Summary of mitigation methods that will be used to reduce the risk of auditory injury (PTS) to marine mammals.

Activity	Mitigation methods
Pre-construction geophysical surveys	• 1 km Monitored Zone • 30 minute pre-start MMO watch • Ramp-up if required/possible
WTG/OSS Piling	• Limit on underwater noise of 169 dB $L_{E,p,ss,05}$ at 750m at WTG and OSS piling events.1 km Monitored Zone • 30 minute pre-start MMO watch (with complimentary PAM) • 20-40 minute ramp-up
Onshore substation Piling	• 1 km Monitored Zone • 30 minute pre-start MMO watch • 20-40 minute ramp-up
UXO clearance	• Low order clearance • Acoustic Deterrent Device • Implementation of noise abatement in the event high order clearance is required1 km Monitored Zone • 30 minute pre-start MMO watch

8 REFERENCES

73. AdBm Technologies. (2019). AdBm Noise Mitigation System 2018 Demonstration Results.

74. Beelen, S., M. Nijhof, C. de Jong, L. van Wijngaarden, and D. Krug. (2024). Bubble curtains for noise mitigation: one vs. two.

75. BEIS. (2019). Spectrum Seismic Survey - Record of the Habitats Regulations Assessment undertaken under Regulation 5 og the Offshore Petroleum Activitites (Conservation of Habitats) Regulations 2001 (As Amended) (DRAFT REPORT). Department for Business Energy & Industrial Strategy.

76. Bellmann, M., A. May, T. Wendt, S. Gerlach, P. Remmers, and J. Brinkmann. (2020). Underwater noise during percussive pile driving: Influencing factors on pile-driving noise and technical possibilities to comply with noise mitigation values. itap GmbH, Oldenburg.

77. Betke, K., and R. Matuschek. (2011). Messungen von Unterwasserschall beim Bau der Windenergieanlagen im Offshore-Testfeld alpha ventus. Abschlussbericht zum Monitoring nach StUK3 in der Bauphase., Institute of Technical and Applied Physics Ltd (ITAP), Oldenburg.

78. Bruns, B., P. Stein, C. Kuhn, H. Sychla, and J. Gattermann. (2014). Hydro sound measurements during the installation of large diameter offshore piles using combinations of independent noise mitigation systems.

79. DAHG. (2014). Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters.

80. Dähne, M., J. Tougaard, J. Carstensen, A. Rose, and J. Nabe-Nielsen. (2017). Bubble curtains attenuate noise from offshore wind farm construction and reduce temporary habitat loss for harbour porpoises. Marine Ecology Progress Series **580**:221-237.

81. Deng, Q., W. Jiang, and W. Zhang. (2016). Theoretical investigation of the effects of the cushion on reducing underwater noise from offshore pile driving. J Acoust Soc Am **140**:2780.

82. Elmer, K.-H. (2018). Effective Offshore Piling Noise Mitigation in Deep Waters.

83. Elmer, K.-H., K. Betke, and T. Neumann. 2007. Standardverfahren zur Ermittlung und Bewertung der Belastung der Meeresumwelt durch die Schallimmission von von Offshore-Windenergieanlagen-" Schall II": Abschlussbericht zum BMU-Forschungsvorhaben 03229947. ISD.

84. Elmer, K.-H., and J. Savery. (2014). New Hydro Sound Dampers to reduce piling underwater noise.

85. Hartley Anderson Ltd. (2020). Underwater acoustic surveys: review of source characteristics, impacts on marine species, current regulatory framework and recommendations for potential management options., NRW Evidence Report No: 448, 119pp, NRW, Bangor, UK.

86. IWDG. (2020). Offshore Wind Policy Document. Published by the Irish Whale and Dolphin Group, 2020.

87. Koschinski, S., and K. Luderann. (2020). Noise mitigation for the construction of increasingly large offshore wind turbines: Technical options for complying with noise limits. Report commissioned by the Federal Agency for Nature Conservation, Isle of Vilm, Germany.

88. Shell. (2017). Bacton Near Shore Pipeline Inspection Survey – Noise Assessment.

89. Tsouvalas, A. (2020). Underwater Noise Emission Due to Offshore Pile Installation: A Review. Energies **13**:3037.

90. Van Oord Offshore Wind BV, T., AdBm,. (2019). Underwater Noise Abatement System for Pile Driving (UNAS).

91. Verfuss, U. K., R. R. Sinclair, and C. E. Sparling. (2019). A review of noise abatement systems for offshore wind farm construction noise, and the potential for their application in Scottish waters. Scottish Natural Heritage Commissioned Report No. 1070.

92. Wang, Z., Y. Wu, G. Duan, H. Cao, J. Liu, K. Wang, and D. Wang. (2014). Assessing the Underwater Acoustics of the World's Largest Vibration Hammer (OCTA-KONG) and Its Potential Effects on the Indo-Pacific Humpbacked Dolphin (Sousa chinensis). PLoS ONE **9**:e110590.

APPENDIX A REVIEW OF NOISE ABATEMENT METHODS FOR PILING

1. This Appendix partially fulfils FIR request 10(a)(i), specifically providing realistic values for the reduction in sound possible from a suite of noise abatement technologies and a review of the suitability of the measures at the Project location.
2. To mitigate potential impacts from underwater noise during the construction of the project, CWP commits to a limit on underwater noise of 169 dB $L_{E,p,ss,05}$ at 750m at WTG and OSS piling events. The effective reduction in noise to meet this commitment is presented in **Appendix 9-C Underwater Noise Modelling Assessment** to the **EIAR Addendum**. At this stage it is important to note that the mitigation technology is relatively novel and still evolving. Several technologies can be provided only by a single supplier and have only been used in a handful of applications. Furthermore, many of the technologies demonstrate differing performance at different sites and conditions, and data is primarily from the North Sea and Baltic. In addition, there is limited global experience with the use of Noise Abatement Systems in currents above 0.75 m/s (Bellmann et al., 2020). As such, whilst the Developer is confident a solution is available to mitigate to the required level, the MMMP must include options. This will ensure a practicable solution can be selected closer to the time of construction. This is discussed below.

Appendix A.1 Methods available

Appendix A.1.1 Bubble curtains

3. "*Bubble curtains are formed by compressed air that is pumped through one or more nozzle hoses that are laid around the piling position at the seafloor. The air ascends through the nozzles into the water column up to the water surface and thereby builds a curtain of bubbles arising vertically along the tube. Piling sound will be absorbed, reflected and scattered from the ascending air bubbles, and thereby reduced*" (Verfuss et al., 2019).
4. There is now a large amount of data on the effectiveness of bubble curtains to reduce underwater noise, since it is the most common NAS used in German waters. Bellmann et al. (2020) report that a single Big Bubble Curtain (BBC) can result in 7 to 11 dB SEL re 1 $\mu Pa^2 s$ reduction in 40 water depth, an 8 to 14 dB SEL reduction in 30 m water depth and an 11 to 15 dB reduction in 25 m water depth. Additionally, an optimised double BBC (DBBC) can result in an 8 to 18 dB SEL re 1 $\mu Pa^2 s$ reduction at 40 m water depth depending on the air volume used. However it should be noted that these values are validated only to currents of max 0.75m/s, and above that noise reduction decreases (Bellmann et al., 2020).
5. BBCs tend to show increased efficacy at higher frequencies, with noise reduction improving as the frequency increases. Verfuss et al. (2019) reported better performance of BBCs at frequencies above 100 Hz, with the greatest efficacy seen at even higher frequency bands. Dähne et al. (2017) observed noise reductions between 7–12 dB with combined bubble curtains, with a pronounced reduction above 1 kHz. Koschinski and Luderann (2020) also noted that double BBCs had their best attenuation effects above 1 kHz, achieving reductions of 10 – 18 dB compared to conditions without bubble curtains. Both Beelen et al. (2024) and Koschinski and Luderann (2020) reported that splitting airflow into two separate bubble curtains increases noise attenuation. Specifically, Beelen et al. (2024) noted that a double curtain configuration provides substantial improvement in noise reduction at frequencies between 100 to 500 Hz, while Koschinski and Luderann (2020) reported additional attenuation of up to 3 dB at distances of 25 to 40 meters.
6. Tsouvalas (2020) noted that low frequencies, typical in pile driving (100 to 400 Hz), require large bubble sizes, which are challenging to create and maintain. Small bubble curtains provided noise

attenuation between 10 and 15 dB, but noise reduction was minimal below 50 Hz and most effective in the 1–10 kHz frequency range.

Appendix A.1.2 Resonators

7. Resonators are described by Verfuss et al. (2019) as follows: "*Resonators consist of an array of (solely or mainly) resonating units that are deployed around the pile to absorb the emitted sound. Unlike with BBCs which are built of ascending air bubbles from a nozzle hose laid at the seafloor, there are a variety of different ways to build resonators*". These can include air-filled balloons or foam elements.

8. There is increasing information on the effectiveness of resonators to reduce underwater noise, for example:

   - The Hydro-Sound Damper4 (HSD) developed by OffNoise Solutions GmbH5 consists of a net of foam elements of different sizes and materials has been shown to result in a 10 to 12 dB SEL re 1 μPa2s reduction alone, or a 15 to 20 dB SEL reduction when used in combination with an optimised BBC (Bellmann et al., 2020).
   - The Noise Abatement System6 of AdBm Technologies7 (AdBm-NAS) consists of standard size panels with submersible air-filled Helmholtz resonators that encircle the pile during construction, and it is tailored to the specific OWF-project. The AdBm-NAS was tested on a full-scale monopile installation for the first time at an offshore wind farm installation site in late 2018 in the Belgian North Sea (AdBm Technologies, 2019). The test showed that a configuration of 0.67 m vertical spacing of slats resulted in a 7 to 8 dB SEL re 1 μPa2s reduction compared to the unmitigated scenario, and when combined with a big bubble curtain resulted in a 14 to 15 dB SEL reduction (AdBm Technologies, 2019).

9. Koschinski and Luderann (2020) reported that by adjusting the size of HSD elements, noise attenuation can be extended effectively to very low frequencies (below 100 Hz). Experimental data support HSD efficacy across various environments and projects. For example, Elmer and Savery (2014) reported successful HSD trials in the Baltic Sea, where HSD systems reduced noise by up to 23 dB in the 100 to 600 Hz range. Another test at the London Array OWF showed that HSDs achieved noise reductions up to 21 dB within the 20 to 100 Hz range and in frequencies exceeding 1 kHz, reaching as high as 23 dB sound exposure level (SEL) (Elmer ad Savery, 2014). Additional findings by Elmer (2018) confirmed HSD effectiveness in further offshore projects, including the Sandbank OWF in the North Sea, where a combination of an HSD system and a double big bubble curtain achieved noise reductions between 19 and 27 dB (SEL). Bruns *et al.* (2014) observations at the Amrumbank West OWF further demonstrated HSD efficacy within the critical 100 to 800 Hz range, reducing noise by more than 20 dB and even attenuating higher frequencies over 1 kHz.

Appendix A.1.3 Isolation Casings

10. Casings are described by Verfuss et al. (2019) as follows: "*Casings are hard or soft shells that enclose the pile with reflective material during the piling activity to keep the sound emitted by the pile trapped within the casing. Casings range from flexible pile sleeves made of different fabrics to hollow steel tubes.*"

[4] https://www.offnoise-solutions.com/the-hydro-sound-damper-system-hsd-system/
[5] https://www.offnoise-solutions.com/
[6] https://adbmtech.com/technology/
[7] https://adbmtech.com/

11. There is increasing information on the effectiveness of casings to reduce underwater noise, for example:

- The IHC-Noise Mitigation Screen[8] (NMS) developed by IHC IQIP[9] consists of a double walled steel tube, with an air-filled interspace. This device has been shown to result in a 13 to 17 dB SEL re 1 μPa^2s reduction alone, a 17 to 23 dB SEL reduction when used in combination with an optimised BBC or a 19 to 22 dB SEL reduction when used in conjunction with an optimised double BBC (Bellmann *et al.*, 2020).
- The NMS-T-10000[10] developed by IHC IQIP is a double-wall steel screen featuring an air-filled annulus between the inner and outer screens and a multi-level and multi-size bubble injection system[11].

12. The IHC-NMS has shown substantial noise reduction capability, effectively mitigating noise by 13 to 16 dB in water depths of up to 45 meters and achieving reductions up to 40 dB at high frequencies, particularly above 500 Hz (Koschinski and Luderann, 2020). Verfuss *et al.* (2019) report that the noise-reducing efficacy of the IHC-NMS improves with increasing frequency, performing better above 100 Hz than below. The HydroNAS and IHC-NMS systems are not designed to selectively control the specific frequency range of noise reduction (Verfuss *et al.*, 2019). Verfuss *et al.* (2019) also reported that the best reduction with the HydroNAS is reached above 500 Hz. The frequency range at which NMS-T-10000 is the most efficient has not been published yet.

Appendix A.1.4 Pile cushions

13. The principle of using pile cushion method consists of reducing the driving force while acting on the pile over a longer period. Early experiments using this principle reached a reduction in SEL of up to 7 dB, but struggled with the durability of pile cushion material such as steel wire, wood, nylon and Micarta (Koschinski and Luderann, 2020). The company IQIP developed a method using water as a pile cushion called "PULSE"[12], which is a modular add-on to the standard IQIP Hydrohammer[13]. The unit is positioned between the pile driving hammer and sleeve and dampens the impact and noise with two steel plungers[14].

14. According to research by Deng *et al.* (2016), the use of a pile cushion can significantly lower the peak sound pressures produced by high-frequency noise above 500 Hz.

Appendix A.1.5 Alternative hammer types

15. There are a number of different hammer types that have been commercially deployed at offshore wind farm projects for the installation of monopiles. The purpose of these varying hammer types is to reduce the noise propagated through the water column during pile driving and thus reduce the impact of piling noise on marine life.

16. Whilst CWP have demonstrated that the project can be constructed through traditional percussive piling methods whilst avoiding significant adverse effects (see EIAR **Volume 3**, **Chapter 11 Marine Mammals**), as a responsible developer CWP will continue to review available technology and where new hammer technology is available with a demonstrable reduction in noise at source CWP will review and consider the practical implementation of alternative technology if available. The following sections

[8] https://iqip.com/products/pile-driving-equipment/noise-reduction-system/
[9] https://iqip.com/
[10] https://iqip.com/expertise/noise-mitigation/
[11] IQIP's latest and largest innovation in noise mitigation well on its way
[12] https://iqip.com/products/pile-driving-equipment/piling-under-limited-stress-equipment/
[13] https://iqip.com/products/pile-driving-equipment/hydrohammer/
[14] Tackling underwater noise at source - IQIP

describe potential or typical technology that may be available, however it is important to note that the technology is nascent, subject to ongoing development, and the specific technology described below cannot be committed to at this stage due to the potential for that technology or manufacturer to not be available at the point of construction, or not to be effective at the specific conditions of the project site.

Appendix A.1.5.1 BLUE Piling Technology

17. The BLUE Piling technology is described by Verfuss *et al.* (2019) as follows: *"The BLUE Hammer from Fistuca BV consists of a steel housing that can be filled with a large water column. The water column is accelerated upwards before dropping onto the pile. High energy levels are achievable which allow a long-lasting blow with high force levels. The cycle of raising and dropping the water column is repeated".*
18. BLUE Piling technology, produced by Fistuca BV, reduces noise at the source during installation by using the impact of a large water mass to create a pushing force on the pile (Bellmann *et al.*, 2020). This technology reduces vibrations on the pile wall and provides a significant reduction of underwater noise compared to a conventional hammer impact. Underwater noise measurements during a full-scale monopile installation have showed a reduction in underwater noise emissions of more than 20 dB SEL when compared to conventional hammers (Bellmann *et al.*, 2020).
19. Koschinski and Luderann (2020) reported that the best noise reduction was achieved reduction in third octave level bands was between 100 Hz and 4 kHz where the SEL was up to 24 dB lower (when compared to a reference pile). For broadband frequencies (10 Hz to 20 kHz) the change in SEL was 19-24 dB. In more than 95 % of strikes noise levels were below 160 dB SEL (distance of 750 m). Verfuss *et al.* (2019) found that noise reduction efficacy of BLUE Hammer is better above 100 Hz than below 100 Hz and efficacy remains flat for the frequency range of 100 Hz to 2 kHz.

Appendix A.1.5.2 Vibratory Hammers

20. Vibratory hammers are described by Verfuss *et al.* (2019) as follows: *"The vibratory hammer can be used to vibrate the pile with a certain low vibrating frequency vertically into the seabed. Pairs of counter-rotating eccentric masses generate an upwards and downwards movement, resulting in a vertical amplitude which results in a temporary reduction in soil resistance, which allows the pile to sink into the soil".*
21. Vibratory hammer has been used as an alternative or complimentary method to impact piling at several wind farms. For example, CAPE Holland's[15] Vibro Lifting Tool (VLT; i.e., vibratory hammer) can support the installation of both monopiles and jacket piles and has been commercially deployed in water depths up to 30 m, whilst Dieseko's PVE vibratory hammer[16] has been commercially deployed in water depths up to 40 m (Verfuss *et al.*, 2019). Data on the noise levels during vibratory hammer activities are lacking, however, calculations based on field measurements indicate a 15 to 20 dB lower noise emission for vibratory hammers compared to impact piling (Elmer *et al.*, 2007, Betke and Matuschek, 2011). More recently, the Moray West offshore wind farm installed 9.5 to 10 m diameter monopiles using both an impact hammer (MENK MHU 4400) and a vibratory hammer (CAPE VLT-640 Triple vibro-hammer). Stephenson *et al.* (2025) showed that at Moray West, the use of vibro-piling resulted in a 22 dB reduction in $L_{p,rms}$ and a 19-21 dB reduction in $L_{p,0\text{-}pk}$.

[15] https://capeholland.com/
[16] https://www.diesekogroup.com/our-brands/pve/

22. Since vibratory hammers produce non-impulsive (continuous) noise, they are subject to different PTS and TTS thresholds compared to impulsive sounds like pile driving. The potential impact ranges for both PTS and TTS are expected to be minimal from a vibratory hammer (<1 km).
23. It is important to note the vibratory hammer is not appropriate for use at all sites as it is highly dependent on pile design, soil conditions and site stability (Bellmann *et al.*, 2020).
24. The frequency spectrum of the noise emitted by vibratory hammer has tonal components with fundamental frequencies usually between 20 to 40 Hz plus harmonics (Verfuss *et al.*, 2019). The use of a vibratory hammer appears effective in reducing auditory risks to marine mammals, as it generates lower sound levels above 50 Hz compared to impact piling and produces 'less harmful' continuous noise. Wang *et al.* (2014) reported that the fundamental frequency of the vibratory hammer used in 22 m diameter piles ranged from 15 Hz to 16 Hz, with a dominant frequency and energy below 10 kHz. As such, it is most likely to be audible to low-frequency cetaceans, including minke whale.

Appendix A.2 Environmental conditions

25. The use and effectiveness of each at-source noise abatement method is subject to environmental conditions such as water depth, current speed, wave height and wind speed. These are described in detail in Verfuss *et al.* (2019). These system specific environmental limitations need to be taken into consideration when considering which at-source noise abatement method may be suitable for use at CWP. Site specific consideration for CWP is provided in **Appendices A.3** and **A.4**.

Appendix A.2.1 Water depth

26. Koschinski and Luderann (2020) reported that no NAS has been used commercially during OWF construction at water deeper than 45 m. Elmer (2018) reported that in terms of operational depth, HSDs are also noted for their ability to function effectively in deeper waters, ranging from approximately 40 to 60 meters. While BBC, HydroNAS, HSD, AdBm-NAS, Blue hammer and vibratory hammer could theoretically be used at waters deeper than 70 m, and the NMS to a maximum depth of 50 m, not all of these have been proven at this depth and the noise reduction levels achieved when deployed in these depths are not known (Verfuss *et al.*, 2019). In terms of operational depth, HSDs are noted for their ability to function effectively in deeper waters, ranging from 40 to 60 m, as demonstrated in the North Sea applications (Elmer, 2018).

Appendix A.2.2 Wave height

27. Verfuss *et al.* (2019) reported that wave height usually limits the NAS-use before wind speed does. According to questionnaire responses, the limiting significant wave height for most of the NAS, except alternative hammers, ranges from 1.5 to 3 m. One NAS-user mentioned that for BBC and NMS, a significant wave height of 1.5 m is the frequent limiting factor for safe deployment and operation, and that suppliers often tend to overestimate the wave height limits (Verfuss *et al.*, 2019).

Appendix A.2.3 Wind speed

The deployment and/or operation of NAS may be restricted by wind speed (Verfuss *et al.*, 2019). The upper wind speed for the deployment of the BBCs is 10 to 14 m/s and similarly for the operation (based on data from BBC-user). For NMS system, the use of crane at height may be the limiting factor. Although the HydroNAS system stability in wind conditions require careful control by the use of tag lines and winches, for the deployment the upper wind speed limit is approximately 15 m/s (Verfuss *et al.*, 2019).

Appendix A.2.4 Current speed

28. To date, there is limited data on the use of any NAS worldwide in current speeds above 0.75 m/s (Bellmann et al., 2020). It has been reported that the efficacy of a BBC is impacted by strong currents, especially in deeper waters, and that the best time to operate a BBC is during slack tide so that the bubbles do not drift away from their intended location around the pile (Verfuss et al., 2019). The upper limit for speed currents and BBC systems has been reported as 1 m/s (Verfuss et al., 2019). The experiences with the IHC-NMS yield noise reductions in the range of 13 to 17 dB up with the current of less than 0.75 m/s (Bellmann et al., 2020). Verfuss et al. (2019) reported the upper limit for speed currents and NMS systems was as 1 m/s. The experiences with the HSD-system in different constructive designs show a potential for noise reduction in the prevailing current of <0.75 m/s (Bellmann et al., 2020). Verfuss et al. (2019) reported the upper limit for speed currents and HSD systems was as 2.5 m/s for operation. Verfuss et al. (2019) also provided information about the upper limit for speed currents and AdBm-NAS systems with currents up to 3 m/s for deployment and operation.

Appendix A.3 Conditions at CWP

29. In order to match the most effective NAS technology for CWP, the environmental conditions should be considered for the array site where WTGs and offshore substation platforms will be installed.

Appendix A.3.1 Water Depth

30. Water depths across the CWP array site range from approximately -28 m to -6 m, relative to the lowest astronomical tide (LAT).

Appendix A.3.2 Wave Conditions

31. The average annual significant wave height is just over 1m, and the expected maximum annual significant wave height is 6.8m.

Appendix A.3.3 Wind Speed

32. The average annual windspeed at 10m above sea level at this site is around 8m/s, and the expected annual maximum wind speed is 29m/s.

Appendix A.3.4 Current speed

33. As the total current is dominated by the tide there is little annual (seasonal) variation of current speeds, with the variation being governed by the lunar cycle. The mean annual current speed is 0.8m/s, however as the current speed is predominantly tidal, the current speed will fluctuate from a low of 0m/s to a maximum twice daily. The maximum on any given day is dependent on the phase of the tide (e.g. neap, spring etc), and ranges from approximately 0.6m/s to approximately 1.7 m/s.

Appendix A.4 Discussion of noise abatement at CWP

34. The discussion in the appendices above demonstrate that there are several available routes for the project to abate the underwater noise emissions in order to achieve the maximum noise limit of 169 dB $L_{E,p,ss,05}$ at 750m at WTG and OSS piling events . However, there is significant uncertainty on which solution or solutions will be suitable for the project at time of construction. The Developer is confident that it will be able to find a solution to deliver the required noise reduction, without affecting the deliverability of the project. However, in order to do this, the project requires flexibility on how this noise level is delivered.

Appendix A.4.1 System Deliverability

35. Most of the technologies described in **Appendix A.1** are provided by a small number of suppliers. In order to ensure the deliverability of the Project, the Developer must have the flexibility to competitively tender the execution works once the project has progressed through consent. Committing to a particular technology during the consenting process will significantly reduce or remove this competition.

36. Furthermore, as the technology in this area is continuously advancing, there is benefit in ensuring the best available technology can be used closer to the time of construction, both in terms of reducing noise impacts but also to support the CWP project's ability to deliver the project in line with various commitments.

37. Given the development of the technology, and the current supply chain, it is considered certain that effective technology will be available through a number of systems, however there is a need to ensure deliverability of the project, and as such it is not feasible for the Developer to commit to a particular system at this stage of the project..

Appendix A.4.2 Efficacy and Practicability at the Project Site

38. Bellmann et al. (2020) conclude that there is limited data on the efficacy of noise abatement systems above 0.75m/s current. In addition to the efficacy of the systems, they must also be deployable at the site. The ability to deploy these systems is not conclusively covered by the available literature, but from initial supply chain engagement it is expected that many installation activities will be tidally limited, and deploying underwater systems, such as bubble curtains, from support vessels is expected to be challenging at the CWP site.

    As the current speed at the site is highly variable over a single day, the window for deploying a system and the system being effective may be limited, particularly combined with the daylight hour restrictions in Section 3.3.1 of the MMMP. Following grant of consent the Project will enter a process of competitively tendering for the Foundation Installation works, including solutions for delivering the committed noise level.

39. It is expected that one of, or a combination of a Pile Cushion, Resonator, or Isolation Casing will be feasible. However, a commitment to a particular solution at this stage may rule out an alternative solution that is demonstrated to be more suitable for the Project site during the procurement phase. It is imperative that the project retains the flexibility to select a solution closer to construction commencing, in order to avoid excluding solutions that are found to be a better fit to the site ecologically and technically.