MT-IT JV
18, St. John Street, Fgura FGR 1447 Malta
T: +356 21803374 E: info@ais.com.mt

Noise, Vibration & Exterior Lighting in relation to an Environmental Impact Assessment (EIA)

Undertaking of the permitting activities including environmental impact studies and related actions for the Malta-Italy Gas pipeline interconnection

Technical Report

AIS REF. NO: PRJ_ENV369
CLIENT REF. NO: PA 08757/17
Third Version

Publication Date

25 February 2020

This tender is being part-financed by the European Union under the Connecting European Facility (CEF) programme for 2014-2020

Co-financed by the Connecting Europe Facility of the European Union

DOCUMENT REVISION HISTORY

Date	Revision	Comments	Authors/Contributors
15/11/2019	1.0	First Draft	Benedict Sarton
31/01/2020	2.0	Second Draft	Benedict Sarton
25/02/2020	3.0	Third Draft – approved for submission	Benedict Sarton

AMENDMENT RECORD

Approval Level	Name	Signature
Internal Check	Sacha Dunlop	
Internal Approval	Mario Schembri	

DISCLAIMER

This report has been prepared by MT-IT- JV with all reasonable skill, care and diligence, and taking account of the manpower and resources devoted to it by agreement with the client. Information reported herein is based on the interpretation of data collected and has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Ministry of Energy & Water; no warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from MT-IT JV. MT-IT JV disclaims any responsibility to the client and others in respect of any matters outside the agreed scope of the work.

Table of Contents

Table of Figures

Table of Tables

1.0 Introduction

An Environmental Impact Assessment (EIA) is hereby being presented in relation to PA 08757/17. This application is entitled "*construction of the Malta-Italy gas pipeline EU Project of Common Interest, including a terminal station at DPS, an onshore HDD route through Delimara Peninsula and the laying of an offshore 22" diameter pipeline extending up to Gela, Sicily, Site at Delimara Power Station and offshore route within the Malta Territorial Waters, Delimara, Marsaxlokk, Malta*".

This technical study identifies the onshore and underwater effects of the proposed development with respect to noise and vibration. This chapter also describes the methods used to assess the effects; the Site and surrounding area existing baseline conditions; the mitigation measures required to prevent, reduce or offset any significant negative effects and the likely residual effects after these measures have been adopted.

The study will focus on the Maltese part of the Scheme only i.e. the area of land reclamation at Marsaxlokk bay, the trenchless tunnel route through the Delimara peninsula and the offshore pipeline until the median line between Malta and Sicily.

The project shall connect Malta to the Trans-European Gas Network in Sicily. The primary aim of the project is to import gas from the Italian National Gas network via an approximately 159km long pipeline between Delimara (Malta) and Gela (Sicily) of which approximately 151km is subsea.[1]

The assessment considers:

- the impact of noise and vibration from onshore construction activities associated with the Proposed Development upon nearby existing sensitive residential receptors;
- the impact of onshore operational noise from the Proposed Development upon nearby existing sensitive residential receptors;
- the impact of noise from the onshore construction and operational phases of the Proposed Development upon the wildlife in the identified Special Protected Areas (SPA);
- the impact of noise and vibration from underwater construction activities associated with the Proposed Development upon marine fauna species; and
- the impact of underwater operational noise from the Proposed Development upon marine fauna species.

[1] *The project was confirmed as a "project of common interest" (PCI) and re-confirmed in the 2nd, 3rd and 4th PCI lists.*

1.1 Onshore interventions

The pipeline in project has a total length of the onshore section at Gela (Italy) of about 6,862 m between the terminal station and the shore line, while the onshore portion at Delimara (Malta) is about 700 m crossing the Delimara peninsula through a trenchless method from the Malta landfall to the Delimara Terminal Station. The Micro tunnel housing the pipeline for the trenchless nearshore approach will extend to circa another 600m from shore at around 42m sea water depth. The pipeline onshore sections are foreseen to be laid underground for the whole length with the only exception of limited parts inside the terminal plants.

The onshore pipeline route selections defined during the design phase were based on a number of general criteria, with a few criteria examples listed as below:

- minimise route length;
- optimize the crossings, if any, with the existing structures;
- avoid areas with small scale irregularities;
- avoid/minimise the interference with restricted/forbidden areas and zones that can affect the integrity of the pipeline;
- minimise intervention works requirements;
- avoid interfering with new projects to be identified (e.g. new roads or infrastructures etc.); and
- prefer parallelism with other pipelines or linear infrastructures in the territory (gas and oil pipelines, power lines, roads, canals, etc.) to minimize constraints on private properties.

1.2 Offshore Pipeline Route

The approved final offshore pipeline route is indicated in Figure 1, as the predominant section of the proposed entire pipeline development.

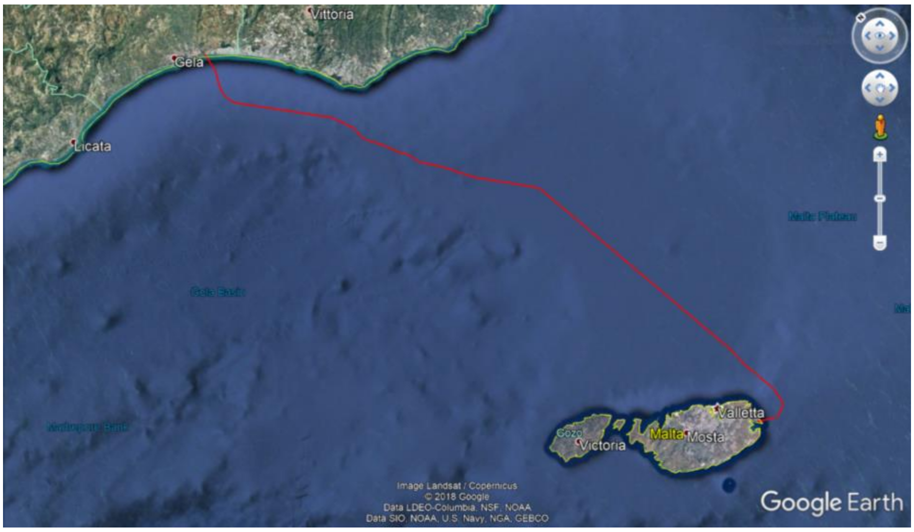


Figure 1: Proposed Overall Pipeline Route (red) Connecting Gela, Sicily and Delimara, Malta

The offshore pipeline route selection has been undertaken in order to fulfil the following criteria:

- to be within the surveyed corridor;
- to minimize the route length;
- to minimize the risk for human activity and environmental and archaeological impact;
- to minimize the number of curves;
- the horizontal radii at turn points along the routes shall be selected on the basis of layability and of curve lateral stability;
- the crossings shall be minimised and shall be in straight sections, the crossed cables angle should not be less than 30°;
- to minimize the interference with possible geohazards;
- to minimize free span formation and high bending moment; and
- to minimize the amount of the expected seabed intervention works.

1.3 Pipeline construction

1.3.1 Onshore Pipeline Construction

The construction works of an onshore gas pipeline and related plants normally consist of the execution of sequential phases distributed throughout the territory along the selected route. Therefore, each individual operation is contained in a limited section of the project route and will advance progressively along the right of way (ROW) (approximatively with a speed of about 50 to 60 m per day). These sequential phases are relating to the preparation of the ROW, pipes stringing, welding, trench excavation, laying and backfilling that are relevant to the main works along the route and will be performed in a coordinated and sequential manner in the territory. On the contrary, the plants and crossings constructions will be done with small autonomous working teams that operate simultaneously with the construction of the main line.

The onshore pipeline construction works includes also the shore approaches in Italy and Malta and the construction of the Terminal Plant at Delimara and three Block Valve stations in Gela. These activities require dedicated and special working operations with respect to the common construction phases indicated above.

SLR has been engaged by MT-IT JV to undertake a separate noise and vibration assessment study associated with the construction and operation of the onshore pipeline route within the Malta section, as part of an Environmental Impact Assessment (EIA) for the development proposals.

1.3.2 Offshore Pipeline Construction

1.3.2.1 Pipeline Preparation

Pipeline preparation activities need to be carried out prior to the offshore installation. These activities include:

- Material management and storing, i.e. transporting concrete coated line pipe from the production mill up to port area ready for offshore installation.
- Pipeline welding and non-destructive tests (NDT). The welding and NDT will be carried out offshore during pipelaying along the firing line setup on board of lay-barge. The firing line can be viewed as the factory assembly line for the pipeline.
- Field joint coating. After welding the line pipe steel, the weld area and the adjacent coating cut-back is protected by field joint coating.

1.3.2.2 Pre-Lay Activities

Prior to the pipeline installation, the following pre-lay tasks are required to be implemented:

- Pre-lay surveys. A pre-construction route survey is required to verify any omission and discrepancies relevant to the original proposal, and to ascertain the changes if any from the pre-engineering to pre-installation period as well as collect data relevant to installation, if required. During pre-construction, the as laid position of any seabed facility and their overall layout shall be identified and recorded.
- Lay corridor preparation. Modifications of the natural seabed along the proposed pipeline lay corridor that may be needed include:
- Pre-trenching/seabed clearing. The construction of pipeline trenches or the removal of outcrops to reduce free spans is normally achieved by dredging. Depending upon the type and hardness of the seabed soil different dredger types (bucket dredger, cutter-suction dredger, etc.) are deployed.
- More specifically pre-trenching may be locally requested at the horizontal directional drilling (HDD) bore hole offshore exit in Gela and the underwater micro-tunnel exit Malta shore approach, to smooth the seabed profile in the area. As regards Gela shore approach, backhoe dredger technology is assumed as the preferable one, and as regards Malta shore approach, cutter suction dredger technology is assumed as the preferable one.
- Trenching works for recovery of the TBM once it reaches the exit point at about 650m from shore at 42m water depth.
- Pre-lay pipeline supporting. As an alternative to the removal of seabed material (modify seabed profile by pre-trenching) suitable support for the pipeline may be created by grout bags or gravel installation, either along the entire section affected, or – more likely – as isolated gravel berms. The installation is typically performed by installation barges or vessels.
- Pre-lay crossings. The pipeline shall cross existing cables identified by the route survey. Some pre-lay works would be necessary and in particular installation of some mattresses very close to the crossing to get the proper gap of pipeline with existing facility.

1.3.2.3 Pipeline Installation

S-lay method is the designed installation approach for the proposed pipeline.

According to the main route features, the following chronological installation scenario is foreseen at this stage:

- S-lay of a P/L string in front of offshore trenchless bore hole exit at Malta shore approach;
- String pull-in inside trenchless bore hole at Malta shore approach;
- Standard S-lay from Malta towards Italy up to Gela shore approach where the pipeline is laid-down in the Italian landfall at the designed Above Water Tie-In (AWTI) location;
- S-lay of a P/L string in front of offshore HDD bore hole exit at Gela shore approach;
- String pull-in inside HDD at Gela shore approach;
- Standard S-lay from Gela shore approach, as needed, up to AWTI location in the Italian landfall; and
- AWTI in the Italian landfall.

Pipeline installations of all scenarios above are carried out based on a lay-barge.

1.3.2.4 Post-Lay Activities

The following post-lay activities could be taking place after the pipeline installation:

- Post-trenching. Permanent installation of the pipeline below the natural seabed is called trenching. It is named post trenching if it is carried-out on already laid pipeline.
- Post-trenching could apply to protect the pipeline from hydrodynamic forces; to protect against mechanical damage; to eliminate or reduce free spans; to prevent upheaval buckling; and to increase thermal insulation of the pipeline as needed.
- The post-trenching methods include water-jetting, mechanical cutting and ploughing etc.
- Crossings and free-span correction. After pipeline laying crossing construction finalisation, stabilisation of as-laid configuration and correction of occurred pipeline free spans would be done. The stated target can be achieved by covering the crossing area with mattresses and/or gravel installation. As-laid pipeline supporting is a typical task in uneven areas where unallowable free spans may occur.
- Protection and stabilisation. Localised covering of the pipeline may be required, for example, to protect against dropped objects at platforms, or to prevent scour in the vicinity of platform legs or other structures on the seabed. Temporary supporting could be requested for stabilisation purpose vs. on-bottom stability; the main requirements are the possibility to be easily removed.

1.4 Pipeline Operation and Maintenance

Following the pre-commissioning/commissioning activities, the pipeline will be filled by gas flowing from the Italian National Grid (from Snam Rete Gas interconnection plant at Gela). In addition to the pipeline operation and control system management, inspection and maintenance teams are to be in place to conduct inspection, maintenance and repair as required for both onshore and offshore pipeline sections, to ensure the gas transportation in a safe manner.

The Front-End Engineering Design (FEED) contractors issued a document; Melita Transgas Pipeline – Noise and Vibration Control Philosophy (Doc. No. 10-RS-E-2002). The scope of the document sets out the requirement for noise and vibration management related to Delimara and Gela Terminals and Block Valve Stations, in order to achieve optimal environmental, occupational, technical and economic benefits during the operating phase.

The guidelines aim to:

- protect the environment; and
- prevent annoyance to the neighbouring community.

This document provides technical information on how noise and vibration emissions should be considered during Front-End Engineering Design (FEED) phase of the Melita Transgas Pipeline Project.

1.5 Major Underwater Noise Generating Activities

In accordance with the project description provided to the consultants, the major underwater noise generating activities during the pipeline construction and operation phases are outlined in Table 1 below.

Table 1:Major underwater noise generating activities

Pipeline construction/ Operation stages	**Activity / scenario**	**Major equipment / noise sources**
Pre-lay activities	Pre-lay survey	Sonar surveys (echo sounding, side-scan sonar and sub-bottom profiling), e.g. EdgeTech combined sonar device
	Pre-trenching/seabed clearing	Backhoe dredger - Gela side
		Cutter suction dredger – Malta side
	Pre-lay pipeline supporting/crossings	Installation barge/vessel
Pipeline installation	Pipe-laying	Pipe-laying barge with dynamic positioning system
		Anchor handling tugs
		Supporting vessels
Post-lay activities	Post-trenching	Operating barge/vessel
	Crossings and free-span correction, protection and stabilization	
Pipeline operation and maintenance	Pipeline inspection and maintenance	

2.0 Terms of Reference

This assessment has been conducted in accordance with the Terms of Reference (ToR) as published by the Environment and Resources Authority (ERA) in March 2018.

3.0 A DESCRIPTION OF THE SITE AND ITS SURROUNDINGS (I.E. ENVIRONMENTAL BASELINE)

This description is identified by the area of influence depicted in Figure 2. This description shall include:

3.7 Noise, Vibrations and Exterior Lighting

This study should provide sufficiently detailed information on representative background levels of noise, vibration and nocturnal lighting (as relevant), as a baseline for assessing the levels and effects expected to result from the development, including any short- and long-term changes, peaks and fluctuations as well as their acute or chronic impacts. The study should also take into account other relevant factors such as:

- *Cumulation with other existing sources including maritime vessel traffic and with other predicted sources such as new developments;*
- *Sensitive receptors (e.g. fauna and avifauna, natural ecosystems); and*
- *The potential for attenuation or exacerbation by 'environmental' factors (e.g. topography, vegetation, physical barriers etc.), and for mitigation (e.g. shielding, muffling/soundproofing, reduced lighting, etc.).*

Note 1: *In the case of light pollution, the study needs to consider, among others, glare (e.g. the blinding light which is a danger to motorists/pedestrians and to fauna), light trespass (light straying into an area where it is not desired or required) and sky glow ('wasted' light directed upwards), together with any other relevant variables which are relevant to the determination of impact on the surrounding receptors.*

The study results should include measurable parameters (e.g. frequency, intensity) as relevant, and should be evaluated against appropriate reference values[2]. The reference points and measurement locations used should be approved by ERA prior to commencement of studies and, unless otherwise indicated, should be at ground level.

The methodology to be used should be submitted for ERA's evaluation prior to commencement of the studies. The Noise Study shall be conducted in accordance with Appendix 3 to these terms of reference (included as Appendix I in the Method Statement).

[2] *Unless otherwise specifically indicated, it is recommended that: ISO 1996 and ISO 9613 (all series) standards are used for the noise assessment; BS6472 (relating to human exposure to vibration) and BS7385 (covering the effects on buildings) are used when studying vibration; BS 5228 is used for the assessment of construction noise; and BS 4142 is used vis-à-vis noise complaints.*

4.0 ASSESSMENT OF ENVIORNMENTAL IMPACTS AND ENVIRONEMENTAL RISKS

All likely significant effects and risks posed by the proposed project on the environment during all relevant phases (including construction/excavation/demolition, operation and decommissioning) should be assessed in detail, taking into account the information emerging from Sections 1, 2 and 3 above. Apart from considering the project on its own merits (i.e. if taken in isolation), the assessment should also take into account the wider surrounding context and should consider the limitations and effects that the surrounding environmental constraints, features and dynamics may exert on the proposed development, thereby identifying any incompatibilities, conflicts, interferences or other relevant implications that may arise if the project is implemented.

In this regard, the assessment should address the following aspects, as applicable for any category of effects or for the overall evaluation of environmental impact, addressing the worst-case scenario wherever relevant:

1. *An exhaustive identification and description of the envisaged impacts;*
2. *The magnitude, severity and significance of the impacts;*
3. *The geographical extent/range and physical distribution of the impacts, in relation to: site coverage; the features located in the site surroundings; whether the impacts are short-, medium- or long-range; and any transboundary impacts (i.e. impacts affecting other countries);*
4. *The timing and duration of the impacts (whether the impact is temporary or permanent; short-, medium- or long-term; and reasonable quantification of timeframes);*
5. *Whether the impacts are reversible or irreversible (including the degree of reversibility in practice and a clear identification of any conditions, assumptions and pre-requisites for reversibility);*
6. *A comprehensive coverage of direct, indirect, secondary and cumulative impacts, including:*
   - *interactions (e.g. summative, synergistic, antagonistic, and vicious-cycle effects) between impacts;*
   - *interactions or interference with natural or anthropogenic processes and dynamics;*
   - *cumulation of the project and its effects with other past, present or reasonably foreseeable developments, activities and land uses and with other relevant baseline situations; and*
   - *wider impacts and environmental implications arising from consequent demands, implications and commitments associated with the project (including: displacement of existing uses; new or increased pressures on the environment in the surroundings of the project, including pressures which may be exacerbated by the proposal but of which effects may go beyond the area of influence; and impacts of any additional interventions likely to be triggered or necessitated by situations created, induced or exacerbated by the project);*
7. *Whether the impacts are adverse, neutral or beneficial;*
8. *The sensitivity and resilience of resources, environmental features and receptors vis-à-vis the impacts;*
9. *Implications and conflicts vis-à-vis environmentally-relevant plans, policies and regulations;*

10. *The probability of the impacts occurring; and*
11. *The techniques, methods, calculations and assumptions used in the analyses and predictions, and the confidence level/limits and uncertainties vis-à-vis impact prediction.*

The impacts that need to be addressed are detailed further in the sub-sections below.

4.1 Effects of the environment aspects identified in Section 3

The assessment should thoroughly identify and evaluate the impacts and implications of the project on all the relevant environmental aspects identified in Section 3 above, also taking into account the various considerations outlined in the respective sections.

With regards to Section 3.4 and 3.5 above, the ecological status of the area in question is to be evaluated, taking into consideration the definition of status by relevant EU Policy, and assessing the extent to which the project will cause deterioration in status or compromise the achievement of good status in line with Article 4(7) of the EU Water Framework Directive.

4.3 Environmental risk

The assessment should also address, in sufficient detail, any relevant environmental risk (including major-accident scenarios such as contamination, emissions, blast, flooding, major spillages, etc.) likely to result in environmental damage or deterioration. The range of accident scenarios considered should exhaustively cover, as relevant:

1. *one-time risks (e.g. during construction or decommissioning works);*
2. *recurrent risks during project operation; and*
3. *risks associated with extreme events (e.g. effect of earthquakes or natural disasters on the project).*

The assessment should include, as relevant: a quantification of the risk magnitude and probability; and risk analysis vis-à-vis any hazardous materials stored, handled, or generated on site or transported to/from the site.

Note: *Should the proposal fall within the scope of the Seveso/COMAH regulations, a stand-alone Risk Assessment may be required, to the satisfaction of the relevant Competent Authority. In such instances, separate Terms of Reference are issued for the Risk Assessment.*[3]

4.4 Effects on Human Populations resulting from impacts on the environment

This assessment should also identify any impacts of the development on the surrounding and visiting population (e.g. effects on public health or on socio-economic considerations), that may result from impacts on the environment. In the case of health-related effects, reference

[3] *Following a formal request to CPD by MEW dated 20th March 2018 and meeting carried out with COMAH authority on the 18th June 2019, it was indicated that at EIA stage, it is too premature to carry out an update to the safety report, risk assessments and internal emergency plan. These will be updated and submitted before the operational permit (IPPC) is issued.*

should be made to published epidemiological and other studies, as relevant, and the views of the Environmental Health Directorate should be sought.

4.5 Transboundary Impacts and Other Environmental Effects

The impacts whose area of influence reaches one or more neighbouring countries (affected country, i.e. Italy), should be described and assessed according to their nature and characteristics (e.g. direct and indirect, temporary or permanent, continuous or intermittent, reversible or irreversible, positive or negative, short- medium- or long-term, their magnitude, their mitigation and compensability, their transboundary nature, accumulation and synergies with other impacts).

Impacts should be identified for the construction, operation and decommissioning phases of the project, including all ancillary developments.

Any other environmental effects deemed relevant to the project but not fitting within any of the above sections should also be identified and assessed.

5.0 REQUIRED MEASURES, IDENIFITICATION OF RESIDUAL IMPACTS, AND MONITORING PROGRAMME

5.1 Mitigation Measures

*A clear identification and explanation of the measures envisaged to prevent, eliminate, reduce or offset (as relevant) the identified significant adverse effects of the project during all relevant phases including construction, operation and decommissioning [see **Section 1.2.3** above]. Such measures could include technological features; operational management techniques; enhanced site-planning and management; aesthetic measures; conservation measures; reduction of magnitude of project; and health and safety measures. Particular attention should be given to mitigation of impacts on the marine resources and of conflicts between the different uses on site.*

*As a general rule, mitigation measures for construction-phase impacts should be packaged as a holistic Construction Management Plan (CMP). Whilst the detailed workings of the CMP may need to be devised at a later stage (e.g. after the final design of the project has been approved and/or after a contractor has been appointed), the key parameters that the CMP must adhere to for proper mitigation need to be identified in the EIA. Broadly similar considerations also apply vis-à-vis operational-phase impacts [which may need to be mitigated through an operational permit] and decommissioning-phase impacts [see **Section 5.4** below], where relevant.*

Mitigation measures for accident/risk scenarios should be packaged as a holistic plan that includes the integration of failsafe systems into the project design as well as well-defined contingency measures.

The recommended measures should be feasible, realistically implementable to the required standards and in a timely manner, effective and reliable, and reasonably exhaustive. They should not be dependent on factors that are beyond the developer's and ERA's control or *which would be difficult to monitor, implement or enforce. The actual scope for, and feasibility of, effective prevention or mitigation should also be clearly indicated, also identifying all potentially important pre-requisites, conditionalities and side-effects.*

5.2 Residual Impacts

Any residual impacts [i.e. impacts that cannot be effectively mitigated, or can only be partly mitigated, or which are expected to remain or recur again following exhaustive implementation of mitigation measures] should also be clearly identified.

5.3 Additional Measures

Compensatory measures (i.e. measures intended to offset, in whole or in part, the residual impacts) should also be identified, as reasonably relevant. Such measures should be not considered as an acceptable substitute to impact avoidance or mitigation.

If the assessment also identifies beneficial impacts on the environment, measures to maximise the environmental benefit should also be identified.

In both instances, the same practical considerations as indicated vis-à-vis mitigation measures should also apply.

5.4 Decommissioning Plan

A decommissioning plan (DP) should also be proposed to address the following circumstances, as relevant:

1. *Removal of any temporary or defined-lifetime development (or of any structures, infrastructure or land use required temporarily in connection with it) upon the expiry of their permitted duration; and*
2. *Removal of the development (or of any secondary developments, infrastructure or land use ancillary to it) in the event of redundancy, cessation of operations, serious default from critical mitigation measures, or other overriding situations that may emerge in future.*

The DP should also include, as relevant, a phasing-out plan, proposals for site remediation or decontamination, and methodological guidance on site reinstatement or appropriate after-use.

5.5 Monitoring Programme

A realistic and enforceable programme for effective monitoring of those works envisaged to have an adverse or uncertain impact. The monitoring programme should include:

1. *Details regarding type and frequency of monitoring and reporting, including spot checks;*
2. *The parameters that will be monitored, their units of measurement, the monitoring indicators to be used; and standard analytical methods in line with relevant EU policy;*
3. *An effective indication of the required action to address any exceedances, risks, mitigation failures or non-compliances for each monitoring parameter;*

4. *An evaluation of forecasts, predictions and measures identified in the EIA; and*
5. *An indication of the nature and extent of any additional investigations (including EIAs or ad hoc detailed investigations, if relevant) that may be required in the event of any contingencies, unanticipated impacts, or impacts of larger magnitude or extent than predicted.*

The programme should address all relevant stages, as follows:

a) *Where relevant, monitoring of preliminary on-site investigations that may entail significant disturbance or damage to site features (e.g. marine environment in terms of the benthos, or any works that require prior site clearance or any significant destructive sampling);*
   *[**Note:** Official written consent from the competent authorities (e.g. Superintendence of Cultural Heritage) may also be required for such interventions.]*
b) *Monitoring of the construction phase, including the situation before initiation of works (including site clearance), during appropriate stages of progress, and after completion of works;*
c) *Monitoring of the operational phase, except where otherwise directed by ERA (e.g. where monitoring would be more appropriately integrated into an operating permit)(including monitoring of the marine environment in terms of the benthos, water quality and other sensitive receptors); and*
d) *Where relevant, monitoring of the decommissioning phase, including the situation before initiation of works, during appropriate stages of progress, and after completion of works.*

5.6 Identification of required authorisations

The assessment should also identify all environmentally-relevant permits, licences, clearances and authorisations (other than the development permit to which this EIA is ancillary) which must be obtained by the applicant in order to effectively implement the project if development permission is granted. Any uncertainty, as to whether any of these pre-requisites is applicable to the project, should be clearly stated.

Note on Sections 5.1 to 5.6 above:
The expected effects, the proposed measures, the residual impacts, the proposed monitoring etc. should also be summarised in a user-friendly itemised table that enables the reader to easily relate the various aspects to each other. An indicative specimen table is attached in ***Appendix 4*** *- attached to Method Statement as Appendix II.*

3.0 Legislation and Planning Policy Guidance

Environmental noise emission is noise generated within the Proposed Development, during construction or operational phases, and measured outside the facilities, at external receptors (e.g. a village).

As per IFC (2007) EHS Guidelines[4], once the Proposed Development is completed and operational, noise impact shall not result in a maximum increase in background levels of 3 dB(A) at the nearest receptor location off-site. Moreover, the precautionary levels presented in Table 2 shall not be exceeded. The noise limits shall be verified at the nearest sensitive receptors identified in the area surrounding the plants. These receptors shall be identified after a careful assessment phase. Environmental noise measurements were performed according to ISO 1996-2[5].

Table 2: Noise Level Guidelines

Receptor	One Hour Noise Level, $L_{Aeq,1h}$ [dB(A)]	
	Daytime 07:00 – 23:00	
Residential Rural (including Hospitals and Leisure area)[6]	45	Residential Rural (including Hospitals and Leisure area)[6]
Residential Urban; Institutional; Educational[7]	55	Residential Urban; Institutional; Educational[7]
Industrial; Commercial[7]	70	Industrial; Commercial[7]

The noise model shall be developed by locating noisy equipment onto digital plot plans for the plant. Noise propagation shall be estimated according to the nature, type and sound power level of the different noise sources, weather conditions, and terrain morphology.

The model shall provide noise maps characterized by equal sound pressure level (SPL) contours and SPL values at the identified receptors.

3.1 BS5228-1:2009+A1:2014

Construction noise has been assessed in accordance with British Standard 5228-1:2009+A1:2014 *Code of practice for noise and vibration control on construction and open sites – Part 1: Noise.* This standard sets out a methodology for predicting noise levels arising from a wide variety of construction and related activities and contains tables of sound power levels generated by a wide variety of mobile and fixed plant equipment.

[4] *Environmental, Health and Safety Guidelines – Noise Management., IFC (2007)*

[5] *ISO 1996-2, Acoustics – Description, Measurement and Assessment of Environmental Noise – Part 2: Determination of Environmental Noise Levels.*

[6] *WHO Guidelines for Community Noise*

[7] *IFC EHS Guidelines, (2007)*

Compliance with BS5228-1:2009+A1:2014 is expected when assessing the impact of construction noise upon the existing environment at nearby sensitive receptors.

Noise levels generated by construction operations and experienced at local receptors will depend upon a number of variables, the most significant of which are likely to be:

- the amount of noise generated by plant and equipment being used at the development site, generally expressed as a sound power level;
- the periods of operation of the plant at the development site, known as the "on-time";
- the distance between the noise source and the receptor, known as the "stand-off";
- the attenuation due to ground absorption or barrier screening effects; and
- reflections of noise due to the presence of hard vertical faces such as walls.

BS5228-1:2009+A1:2014 gives several examples of acceptable noise limits for construction or demolition noise. For this assessment, as baseline noise data will be available, the ABC method[8] will be used to determine the threshold value at the receptor locations.

Using the ABC method, a threshold value noise level is determined by establishing the existing ambient noise level at each location. This measured ambient noise level is then rounded to the nearest whole 5dB(A) and the threshold noise value for each receptor is then established from Table E.1 of BS5228-1:2009+A1:2014. This threshold value is the $L_{Aeq,T}$ noise level that should not be exceeded at the receptor location by operations at the site.

If the threshold value is exceeded, then the effect of construction noise upon nearby receptors may be significant. BS5228-1:2009+A1:2014 states that the significance of the effect will depend upon *"other project-specific factors, such as the number of receptors affected and the duration and character of the impact."*

The effects of vibration resulting from construction activities have been assessed in accordance with BS5228-2:2009+A1:2014 *Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration.* This standard sets out recommendations for basic methods of vibration control relating to construction and open sites where work activities/operations generate significant vibration levels, including industry-specific guidance. Guidance is provided concerning methods of measuring vibration and assessing its effects on the environment.

Compliance with BS5228-2:2009+A1:2014 is expected when assessing the impact of construction vibration upon the existing vibration environment at nearby sensitive receptors.

Construction activities can pose different problems of vibration control compared with most other types of industrial activity for the following reasons:

- they are mainly carried out in the open;
- they are of temporary duration although they can cause great disturbance while they last;

[8] *See section E.3.2 BS5228-1:2009+A1:2014*

- the vibration they cause arises from many different activities and kinds of plant, and its intensity and character can vary greatly at different phases of the work;
- the sites cannot be excluded by planning control, as factories can, from areas that are sensitive to vibration.

The majority of people are known to be very sensitive to vibration, the threshold of perception being typically in the peak particle velocity (PPV) range of between $0.14mms^{-1}$ and $0.3mms^{-1}$. As vibrations increase above these values, they can disturb, startle, cause annoyance or interfere with work activities.

3.2 BS4142:2014+A1:2019 (BS4142:2014+A1:2019)

Operational sound has been assessed in accordance with BS4142:2014+A1:2019 *Methods for rating and assessing industrial and commercial sound*. This standard is intended to be used to assess the potential adverse impact of sound, of an industrial and/or commercial nature, at nearby sensitive receptor locations within the context of the existing sound environment.

Where the specific sound contains tonality, impulsivity and/or other sound characteristics penalties should be applied depending on the perceptibility. For tonality a correction of either 0, 2, 4 or 6dB should be added; for impulsivity a correction of either 0, 3, 6 or 9dB should be added and if the sound contains specific sound features which are neither tonal nor impulsive a penalty of 3dB should be added.

In addition, if the sound contains identifiable operational and non-operational periods, that are readily distinguishable against the existing sound environment, a further penalty of 3dB may be applied.

The assessment of impacts contained in BS4142:2014+A1:2019 is undertaken by comparing the sound rating level, i.e. the specific sound level of the source plus any penalties, to the measured representative background sound level immediately outside the sensitive receptor location. Consideration is then given to the context of the existing sound environment at the sensitive receptor location to assess the potential impact.

Once an initial estimate of the impact is determined, by subtracting the measured background sound level from the rating sound level, BS4142:2014+A1:2019 states that the following should be considered:

- Typically, the greater the difference, the greater the magnitude of the impact;
- A difference of around +10dB or more is likely to be an indication of a significant adverse impact, depending on the context;
- A difference of around +5dB is likely to be an indication of an adverse impact, depending on the context; and
- The lower the rating level is relative to the measured background sound level, the less likely it is that the specific sound source will have an adverse impact or a significant adverse impact. It is an indication that the specific sound source has a low impact when the rating level does not exceed the background sound level, depending on the context.

BS4142:2014+A1:2019 notes that:

"Those that result from additive impacts caused by other past, present or reasonably foreseeable actions together with the plan, programme or project itself and synergistic effects (in combination) which arise from the reaction between impacts of a development plan, programme or project on different aspects of the environment."

BS4142:2014+A1:2019 outlines guidance for the consideration of the context of the potential impact including consideration of the existing residual sound levels, location and/or absolute sound levels.

3.3 AQTAG

AQTAG09 (Air Quality Technical Advisory Group 09), *Guidance on the effects of industrial noise on wildlife* is intended to be used to assess the potential adverse impact of sound, of an industrial and/or commercial nature on wildlife. The guidance enables planning officers involved with Pollution Prevention and Control applications for installations with relevant noise emissions and relates these to the requirements of the Habitats Regulations.

The Birds Directive aims to protect all of the 500 wild bird species naturally occurring in the European Union. Habitat loss and degradation are the most serious threats to the conservation of wild birds. The Birds Directive therefore places great emphasis on the protection of habitats for endangered and migratory species. It establishes a network of Special Protection Areas (SPAs) including all the most suitable territories for these species. Since 1994, all SPAs are included in the Natura 2000 ecological network, set up under the Habitats Directive 92/43/EEC.

4.0 Methodology

4.1 Area of Influence: Onshore noise and vibration

Noise measurements were carried out at four locations. The noise monitoring locations were identified on the basis to serve as a true representation of the noise climate around the Delimara Power Station. The noise monitoring locations were identified taking into consideration the noise monitoring analyses carried out in previous years.

It was agreed with ERA that the baseline noise measurements undertaken in the area around Delimara Power Station (DPS) by AIS in relation to the IPPC noise monitoring requirements of the power station would be utilised within this assessment.

The measurements consisted of one-hour readings taken over 24 hours at four locations around the Marsaxlokk Bay and are considered to be representative of the nearest receptors to the proposed development. Baseline sound surveys conducted in November 2017 and December 2018 at four survey locations are considered within this assessment.

4.1.1 Noise Monitoring Locations - 2017

The noise monitoring locations are detailed in Table 3 and illustrated in Figure 2.

Table 3: Noise Monitoring Locations – 2017

Monitoring Point	Location	Eastings	Northings	Minimum distance from DPS
A	Triq Delimara	14°33’ 32.19	35°49’ 52.67	61m
B	Side road off Triq Delimara	14°33’ 26.63	35°50’ 4.50	25m
C	Road connecting Triq Power House to Triq Delimara	14°33’ 7.64	35°50’ 13.36	151m
D	Triq tat-Trunċiera	14°32’ 43.69	35°50’ 7.30	637m

The noise surveys were conducted over a 24-hour period in November and December 2017 in accordance with BS 4142:2014.

The measurements were taken at a distance of at least 3.5m from the façade of the nearest buildings, in order to minimise the influence of reflection. In all cases, the sound level meter was mounted on the tripod at a height of 1.3m above ground level.

The noise surveys were conducted over four days in November and December as shown in Table 4.

Table 4: Dates of Noise Surveys – 2017

Date	Noise monitoring location			
	A	B	C	D
28/11/2017	-	-	X	-

29/11/2017	-	X	-	-
20/11/2017	X	-	-	-
06/12/2017	-	-	-	X

The weather for each of the survey periods was conducive for noise monitoring with wind speeds less than $5ms^{-1}$ and no rain forecast during the period. Details of the weather conditions are shown in Table 5.

Table 5: Weather Conditions - 2017

Date	Average temp (°C)	Temp max. (°C)	Temp Min. (ºC)	Humidity (%)	Wind speed (ms^{-1})
28/11/2017	13.2	16.9	11.2	59	1.6
29/11/2017	16.0	19.1	12.4	68	0.4
20/11/2017	18.7	21.8	17.1	75	0.2
06/12/2017	11.7	17.6	8.4	65	0.4

4.1.2 Noise Monitoring Locations - 2018

For the 2018 noise monitoring the locations are detailed in Table 6 and illustrated Figure 2.

Table 6: Noise Monitoring Locations – 2018

Monitoring Location	Location	Eastings	Northings
A	Triq Delimara	14°33'32.0"	35°49'52.8"
B	Side road off Triq Delimara	14°33'24.5"	35°50'06.7"
C	Road connecting Triq Power House to Triq Delimara	14°33'04.5"	35°50'13.9"
D	Triq tat-Trunċiera	14°32'44.4"	35°50'06.5"

The noise surveys were conducted over a 24-hour period in December 2018 in accordance with BS 4142:2014.

The measurements were taken at a distance of at least 3.5m from the façade of the nearest buildings. In all cases, the sound level meter was mounted on the tripod at a height of 1.3m above ground level. The noise surveys were conducted over four different days in December as shown in Table 7.

Table 7: Dates of Noise Surveys – 2018

Date	Noise monitoring location			
	A	B	C	D
12/12/18	-	-	-	X
13/12/18	X	-	-	-
19/12/18	-	X	-	-
20/12/18	-	-	X	-

The weather for each of the survey periods was conducive for noise monitoring with wind speeds less than $5ms^{-1}$ and no rain forecast during the period. Details of the weather conditions are shown in Table 8.

Table 8: Weather Conditions – 2018

Date	Average temp (°C)	Humidity (%)	Wind speed (ms^{-1})
12/12/18	17.3	65	3.5
13/12/18	18.1	71	3.2
19/12/18	16.5	67	1.2
20/12/18	18.9	69	3.7

The monitoring locations for both the 2017 and 2018 noise monitoring campaigns and the nearest noise sensitive receptors (NSR) for the purposes of this assessment can be described as follows:

- **Monitoring Location A** - The sound level meter at this location was positioned to the east of DPS on Triq Delimara and approximately 350m to the north-east of the proposed terminal station. Baseline sound levels measured at this location are used to represent NSR04, NSR05, NSR06, NSR07 & NSR08 as shown in Figure 3;
- **Monitoring Location B** - The sound level meter at this location was positioned towards the north-east of DPS on a side road off Triq Delimara and approximately 680m north of the proposed terminal station. Baseline sound levels measured at this location are used to represent NSR03 as shown in Figure 3;
- **Monitoring Location C** - The sound level meter at this location was positioned towards the north-northwest of DPS at the road connecting Triq Power House to Triq Delimara and approximately 1.1km north-west of the proposed terminal station. Baseline sound levels measured at this location are used to represent NSR02 as shown in Figure 3; and
- **Monitoring Location D** - The sound level meter at this location was positioned towards the north-west of DPS at Triq tat-Trunċiera and approximately 1.275km north-west of the proposed terminal station. Baseline sound levels measured at this location are used to represent NSR01 as shown in Figure 3.

4.1.3 Noise Sensitive Receptors

For the purposes of this assessment, the closest Noise Sensitive Receptors (NSRs) referred to in Section 4.1.2 and shown in Figure 3 are detailed in Table 9.

Table 9: Closest Noise -Sensitive Receptors

Noise Sensitive Receptor (NSR)	Eastings	Northings
NSR01	14°32'43.62"	35°50'6.95"
NSR02	14°33'7.54"	35°50'13.30"
NSR03	14°33'27.78"	35°50'4.17"
NSR04	14°33'32.36"	35°49'52.81"
NSR05	14°33'27.13"	35°49'39.18"
NSR06	14°33'29.61"	35°49'39.61"

NSR07	14°33'31.81"	35°49'35.18"
NSR08	14°33'43.20"	35°49'32.16"

4.1.4 Noise Sensitive Receptors – The Natural Habitat

The onshore area where the gas pipe will be introduced into Malta is recognised as a Special Protected Area and as such, care should be taken to avoid excess of noise, light or vibration during the construction or operational phases. Therefore, it is understood that the proposed construction methodology will generate minor possible disturbance to the flora and the wildlife, as operations will be mostly carried out below the ground surface by a drilling tunnelling system.

It is also understood that birdlife associated migratory areas, are not quite located within the designated construction or operational areas, however further advice will be given in this report to minimise any unforeseen adverse impact.

4.1.5 Monitoring Equipment

A Type 1 "Cirrus CR:831C" integrating averaging sound level meter was used to take the measurements on both of the survey periods in 2017 and 2018. It was calibrated according to BS4142:2014. The meter was also field-calibrated before and after each measurement survey and no significant variation in calibration level was observed. Details of the monitoring equipment are provided in Table 10.

Table 10: Monitoring Equipment

Monitoring location	Equipment	Serial number
A, B, C & D 2017 & 2018	Cirrus CR:831C Type 1 Sound Level Meter	D22331FF
	Cirrus CR:515 Acoustic Calibrator	80026

4.1.6 Soundscape and Context

Observations of the acoustic environment were made during the baseline sound survey at all four monitoring locations. Monitoring Location A is rural in nature and at the time of the survey set-up and decommission, construction activities which were barely audible contributed to the noise environment. Although not specifically identified in the survey notes, it is understood that DPS was operating normally throughout the survey periods and it would be anticipated that noise from the operations at the site would contribute to the noise environment at the monitoring locations due to the close proximity of the site. At Monitoring Locations B & C, which are predominantly rural/agricultural setting, the noise environment is likely to be influenced by the operational activities at DPS due to the proximity of the site and the relative isolation from other noise sources close the monitoring locations. At Monitoring Location D, the noise environment is influenced by the nearby industrial activities (not DPS), the associated noise from the restaurants and customers in addition to occasional cars and vessels.

Based on the observations made during the survey, it is considered that the measured background sound levels are representative of the prevailing acoustic environment at the closest noise-sensitive receptors and have therefore been considered as such for the purposes of the BS4142:2014 and the BS5228-1:2009+A1:2014 ABC method.

Figure 2: Sound Monitoring Locations

Figure 3:Nearest NSRs

4.2 Area of influence: Underwater noise

In order to understand the extent of underwater noise impacts throughout the proposed gas pipeline route, three representative source locations are nominated for a detailed noise modelling study. The three locations are selected based on their localities associated with the relevant pipeline construction and operation activities, as well as the propagation environment to the surrounding shallow water and deep-water regions.

The three selected source locations are presented in Figure 4, and further detailed in Table 11 below with their corresponding coordinates, water depths and localities.

Table 11: Details of the three selected source locations and associated noise generating activities for noise modelling. The coordinate system is based on WGS 84 UTM33N

Source location	Water depth, m	Coordinates [easting, northing]	Locality	Noise sources
L1	144.9	[4.643×10^5, 4.0298×10^6]	Approximately mid-point of the pipeline route, with exposure to Malta Plateau on the east and relatively deep region on the west.	PLB, AHT, OSV
L2	107.1	[4.652×10^5, 3.9632×10^6]	Pipeline route section just off Malta Island, with exposure to Malta Rise on the east and on the south.	CSD, PLB
L3	44.8	[4.339×10^5, 4.0895×10^6]	Pipeline route section just off Gela, with exposure to relatively deep offshore region on the south.	BHD, PLB

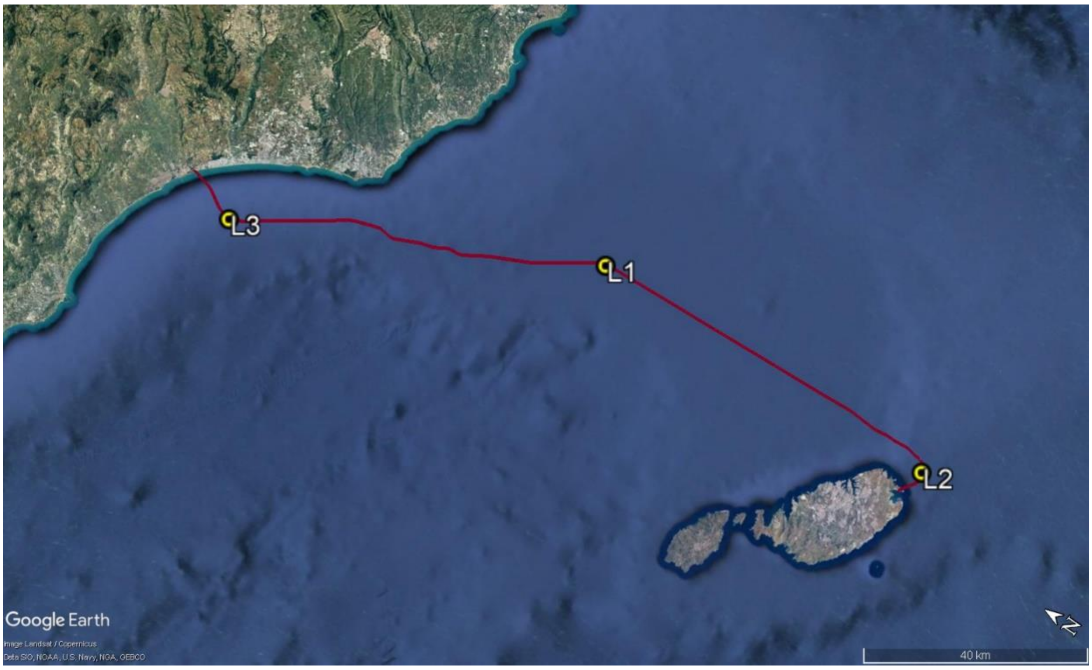


Figure 4: The selected three source locations (L1, L2 & L3) indicated as white dots. Red line indicates the proposed gas pipeline route

There is no specific national legislation or regulatory guidelines in Malta for the assessment of underwater noise impacts on marine fauna species. The assessment therefore has been undertaken with consideration of current industry best practice applied internationally, and being consistent with impact studies undertaken for other similar major offshore development projects elsewhere globally by providing the following information:

- An overview of the construction and operation of the proposed pipeline development project, as well as the possible major underwater noise generating activities associated with the project development.
- Characterisation of the existing acoustic environment, based on a review of general ocean noise environment, the site-specific shipping traffic and metocean (particularly wind) data surrounding the proposed pipeline route, as well as the baseline noise monitoring study undertaken previously (i.e. the QUIETMED Project);
- Assessment criteria for relevant general marine fauna species of concern, including marine mammals, fish species and sea turtles, based on relevant guidelines and criteria that represent current industry best practice;
- Detailed noise modelling prediction methodology and procedure, relevant modelling environmental inputs and assumptions, modelling source locations and scenarios associated with the major noise-generating activities, and source levels of these major noise emissions;
- Detailed modelling results and the subsequent zones of impact estimate for general marine fauna species based on criteria set out previously.

The effects of noise and the distances over which effects extend depend on the acoustic characteristics of the noise (e.g. level, spectral content, temporal characteristics (e.g. impulsive[9] or non-impulsive/continuous[10]), etc.). The potential impacts of noise on marine fauna species include mortality, physical and hearing damage, masking of communication and other biological important sounds, and alteration of behaviour (Richardson et al, 1995; Hasting and Popper, 2005). In general, underwater noise impacts on marine fauna species may be divided into two categories, behavioural impacts and physiological impacts.

- Behavioural responses to noise include changes in vocalisation, resting, diving and breathing patterns, changes in mother-infant relationships, and avoidance of the noise sources. Masking of biologically important sounds may interfere directly with communication and social interaction. Secondary behavioural effects such as inhibited reproduction cycles and other changes in behaviour may also occur.
- Physiological effects of underwater noise are primarily associated with the auditory system which is likely to be most sensitive to noise. The exposure of the auditory system to a high level of noise for a specific duration can cause a reduction in the animal's hearing sensitivity, or an increase in hearing threshold. If the noise exposure is below some critical sound energy level, the hearing loss is generally only temporary, and this effect is called temporary hearing threshold shift (TTS). If the

[9] Impulsive noise is typically very short (with seconds) and intermittent with rapid time and decay back to ambient levels. E.g. noise from pile driving, seismic airguns and seabed survey sonar signals.

[10] Non-impulsive or continuous noise refers to a noise event with pressure level remains above ambient levels during an extended period of time (minutes to hours), but varies in intensity with time. E.g. noise from marine vessels.

noise exposure exceeds the critical sound energy level, the hearing loss can be permanent, and this effect is called permanent hearing threshold shift (PTS).

In a broader sense, physiological impacts also include non-auditory physiological effects. Other physiological systems of marine animals potentially affected by noise include the vestibular system, reproductive system, nervous system, liver or organs with high levels of dissolved gas concentrations and gas filled spaces. Noise at high levels may cause concussive effects, physical damage to tissues and organs, cavitation or result in rapid formation of bubbles in venous system due to massive oscillations of pressure.

4.2.1 Underwater Noise Assessment Scenarios and Source Levels

A list of modelling scenarios with relevant major noise-generating equipment is developed based on pipeline construction and operation project information. These scenarios to be assessed and their relevant noise sources are summarised in Table 12 below. Due to lack of detailed specifications of equipment to be used, equipment source noise levels and their spectra have been sourced from relevant literature.

Table 12: Potential scenarios to be assessed and relevant noise sources

Activity / Scenario	**Major equipment / Noise source**
Pre-lay survey	Sonar surveys (echo sounding, side-scan sonar and sub-bottom profiling), e.g. EdgeTech combined sonar device
Pre-trenching – Malta side	Cutter suction dredger (CSD), e.g. Athena or Al Mahaar
Pre-trenching – Gela side	Backhoe dredger (BHD)
Pipe-laying along the entire offshore route	Pipe-laying barge (PLB) with dynamic positioning system, e.g. Castorone Anchor handling tug (AHTs), e.g. Katun Offshore supporting vessel (OSV), e.g. Setouchi Surveyor
Other general pipeline installation and operation activities	Offshore supporting barge/vessel (OSV)

4.2.1.1 Pre-lay survey sonar

The sonar devices for pre-lay survey produce mid to high frequency (a few kHz to hundreds of kHz) impulsive (tens of milli-seconds) signals, and their noise emissions are highly directional towards seabed, and as a result less energy propagates horizontally. Therefore, noise impact from these sources is expected to be predominantly near field immediate impact, rather than cumulative impact over time at far field distances. Spherical spreading loss is assumed to be the transmission loss estimate for the near field sonar noise propagation.

An extensive review of existing data on underwater sound produced by Oil and Gas Industry (Wyatt, 2008) has shown that seabed survey sonar devices generate impulsive signals with Pk-Pk SPL ranging 200 dB re 1µPa @ 1 m to 233 dB re 1µPa @ 1 m. Based on a worst case consideration, it is assumed that the sonar devices to be used for the pre-drilling survey have the Pk-Pk SPL of 233 dB re 1µPa @ 1 m.

4.2.1.2 Cutter suction dredger (CSD)

CSDs are best suited to removing hard substrates, as a rotating cutter head breaks up material on the seabed before its removal by suction pipe, and the major sources for noise generation for CSDs are underwater pumps and piping, and the cutting head digging the seafloor (CEDA, 2011).

The one-third octave SEL source spectral levels for the CSD was taken based on the field measurements undertaken by SLR during a port development in Northern Queensland, Australia, for the large sized CSD Athena and Al Mahaar (total installed power 11,224 KW) under their full operation conditions (BPM, 2013). The SEL source spectrum with an overall level of 184.0 dB re 1μPa^2·s @ 1 m is shown in Figure 5.

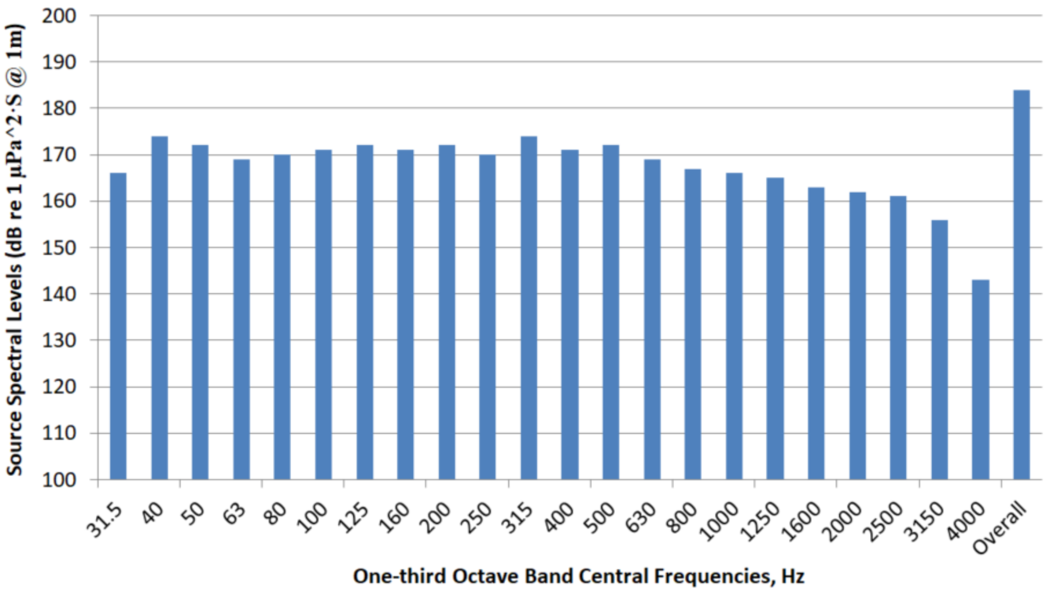


Figure 5: One-third octave SEL source spectral levels for the large size CSD Athena or Al Mahaar (Blue Planet Marine, 2013)

4.2.1.3 Backhoe Dredger (BHD)

The major sources for noise generation for BHDs are onboard engine/generator, movement of hydraulic ram, barge loading with sediment as well as anchoring of the dredge spuds (Jones et al, 2016).

Figure 6 shows the SEL source spectrum and overall level for the BHD for this study. The overall SEL level of 179 dB re 1μPa^2·s @ 1 m is the highest source level for BHD reported in the literature (Jones et al, 2016), and the one-third octave SEL source spectral curve is assumed as the same as for CSD as in Figure 5.

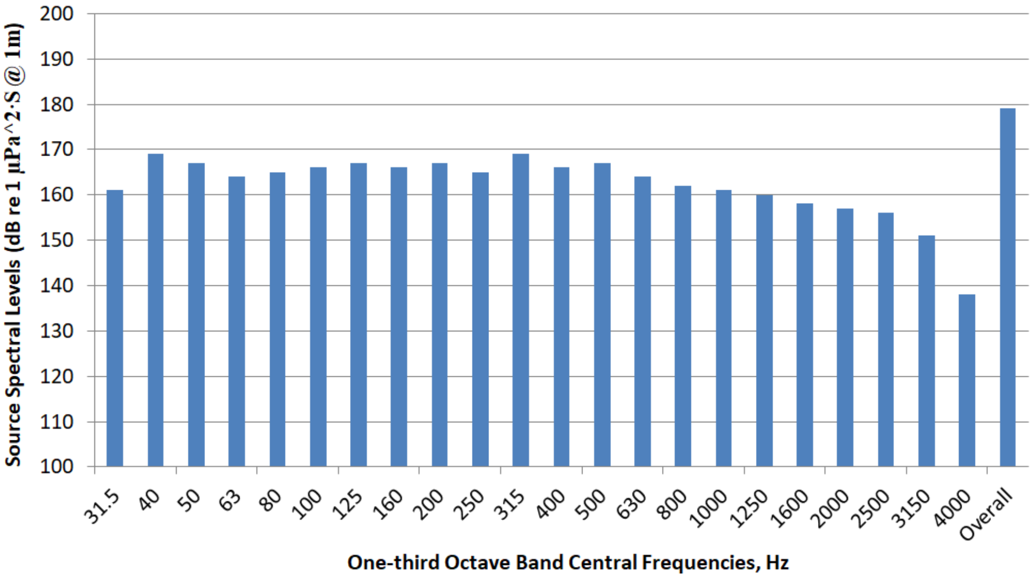


Figure 6: One-third octave SEL source spectral levels for the backhoe dredger (Jones et al, 2016)

4.2.1.4 Pipe-Laying Barge (PLB)

Underwater noise emissions from the pipe-laying vessels/barges are predominantly from propulsion operations. For deep water operations, noise emissions are also generated by the thrusters from operation of dynamic positioning system.

The SEL source spectrum with an overall level of 192 dB re 1µPa^2·s @ 1 m for the PBL for this modelling study, as shown in Figure 7, is assumed to be similar to the vessel *Castorone* with the propulsion power of 67,000 kW (Nedwell and Edwards, 2004).

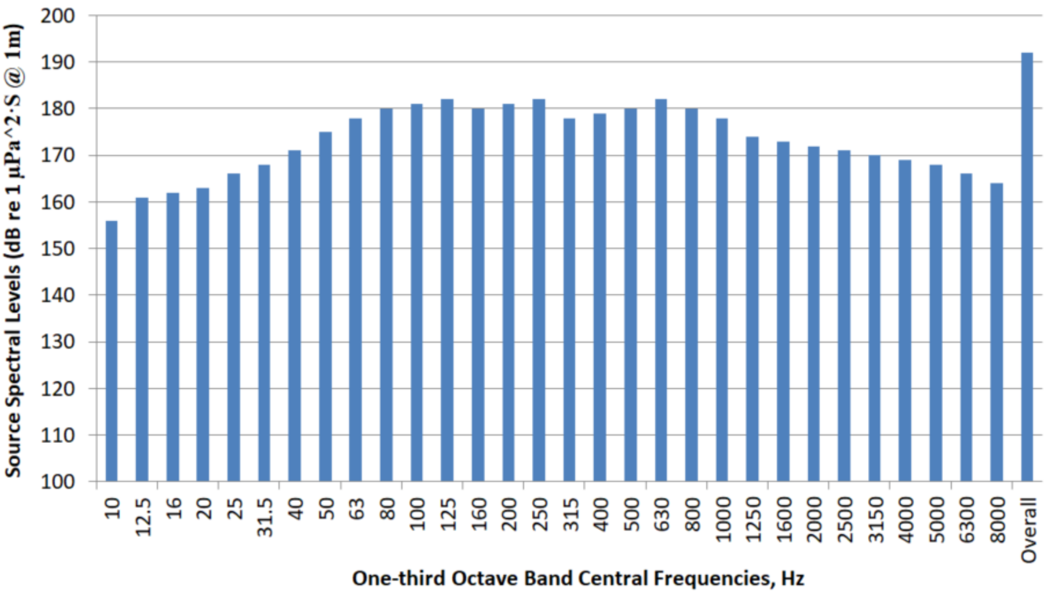


Figure 7: One-third octave SEL source spectral levels for pipelay barge Castorone (Nedwell and Edwards, 2004)

4.2.1.5 Anchor handling tug (AHT)

The major noise emissions from the AHT operations are expected to be from the cavitation noise generated by propellers and thrusters, with energy predominantly below 1 - 2 kHz.

The SEL source spectrum with an overall level of 189 dB re 1µPa^2·s @ 1 m for the AHT for this modelling study, as shown in Figure 8, is assumed to be similar to the barge Katun with the propulsion power of 9,000 kW (Hannay et al, 2004) under transiting operations. The noise emissions from AHTs under anchor pulling operations are generally lower than transiting operations (by approximately 5 dB according to Wyatt (2008)).

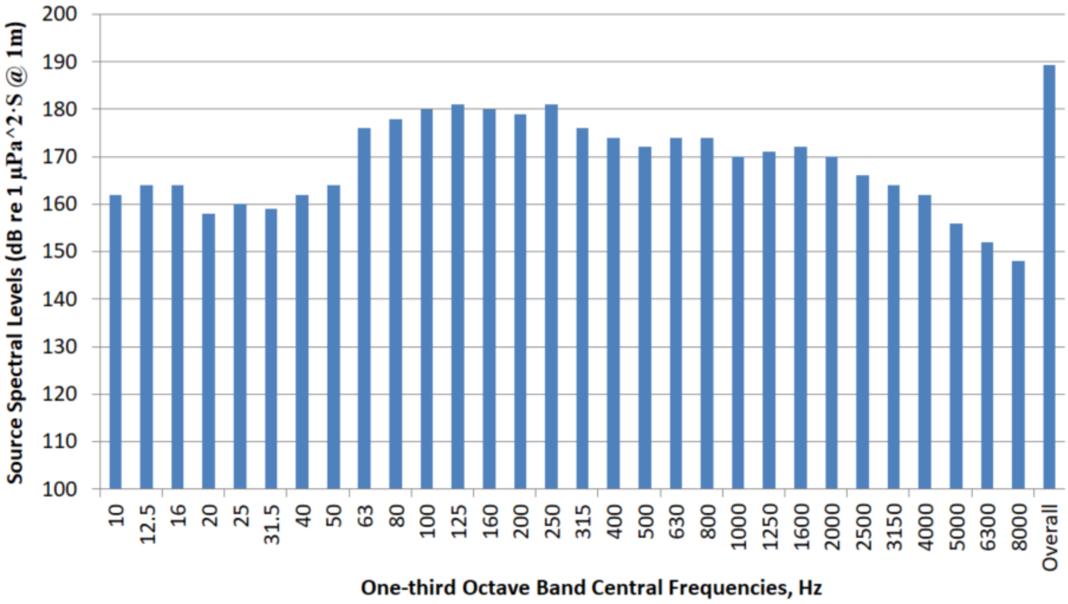


Figure 8: One-third octave SEL source spectral levels for anchor handling tug Katun (Hannay et al, 2004)

4.2.1.6 Offshore Supporting Vessel (OSV)

The source spectral levels for OSVs were assumed to be similar to source levels of the *Setouchi Surveyor* (Hannay et al, 2004) as shown in Figure 9, with an overall SEL level of 184 dB re 1µPa^2·s @ 1 m. The OSV *Setouchi Surveyor* is 64.8 m long with an 11.3 m beam, with propulsion power of 3,400 kW.

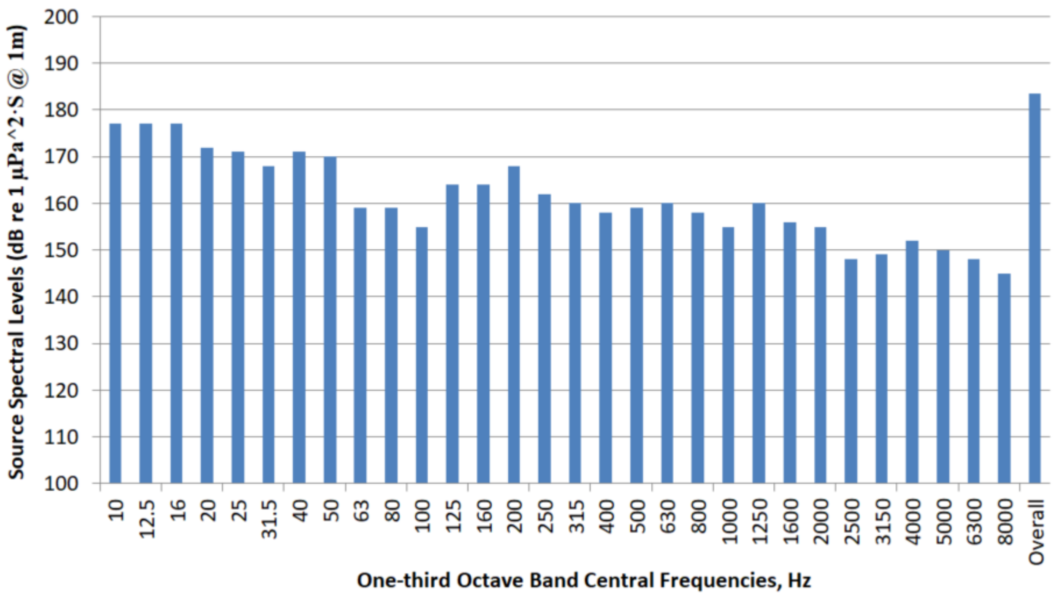


Figure 9: One-third octave SEL source spectral levels for supporting vessel Setouchi Surveyor (Hannay et al, 2004)

4.2.2 Underwater Modelling Methodology and Procedure

Underwater noise propagation models predict the sound transmission loss between the noise source and the receiver. When the source level (SL) of the noise source based on is known, the predicted transmission loss (TL) is then used to predict the received level (RL) at the receiver location as:

$$RL = SL - TL$$

The fluid parabolic equation (PE) modelling algorithm RAMGeo (Collins, 1993) is used to calculate the transmission loss between the source and the receiver. RAMGeo is an efficient and reliable PE algorithm for solving range-dependent acoustic problems with fluid seabed geoacoustic properties. The noise sources were assumed to be omnidirectional and modelled as point sources.

With the known noise source levels, either frequency weighted or unweighted, the received noise levels are calculated following the procedure outlined below.

- One-third octave source spectral levels are sourced via empirical reference data out of the historical measurements carried out on relevant noise sources in the oil and gas industry;
- Transmission loss is calculated using RAMGeo at one-third octave band central frequencies from 10 Hz to 8 kHz, based on appropriate source depths corresponding to relevant source scenarios. The acoustic energy of higher frequency range is significantly lower, and therefore is not included in the modelling;
- Propagation paths for the TL calculation have a maximum range of up to 100 km and bearing angles with a 5-degree azimuth increment from 0 degrees to 355 degrees around the source locations. The bathymetry variation of the vertical plane along each modelling path is obtained via interpolation of the bathymetry dataset;

- The one-third octave source levels and transmission loss are combined to obtain the received levels as a function of range, depth and frequency; and
- The overall received levels are calculated by summing all frequency band spectral levels.

4.2.2.1 Bathymetry

The bathymetry data used for the sound propagation modelling were obtained from the 15 arc seconds bathymetric dataset GEBCO_2019 Grid (GEBCO, 2019). The GEBCO_2019 Grid is the latest global bathymetric product released by the General Bathymetric Chart of the Oceans (GEBCO) and has been developed through the Nippon Foundation-GEBCO 'Seabed 2030 Project' (https://seabed2030.gebco.net/), which is a collaborative project between the Nippon Foundation of Japan and GEBCO.

The bathymetric imagery within and surrounding the proposed gas pipeline route is presented in Figure 10.

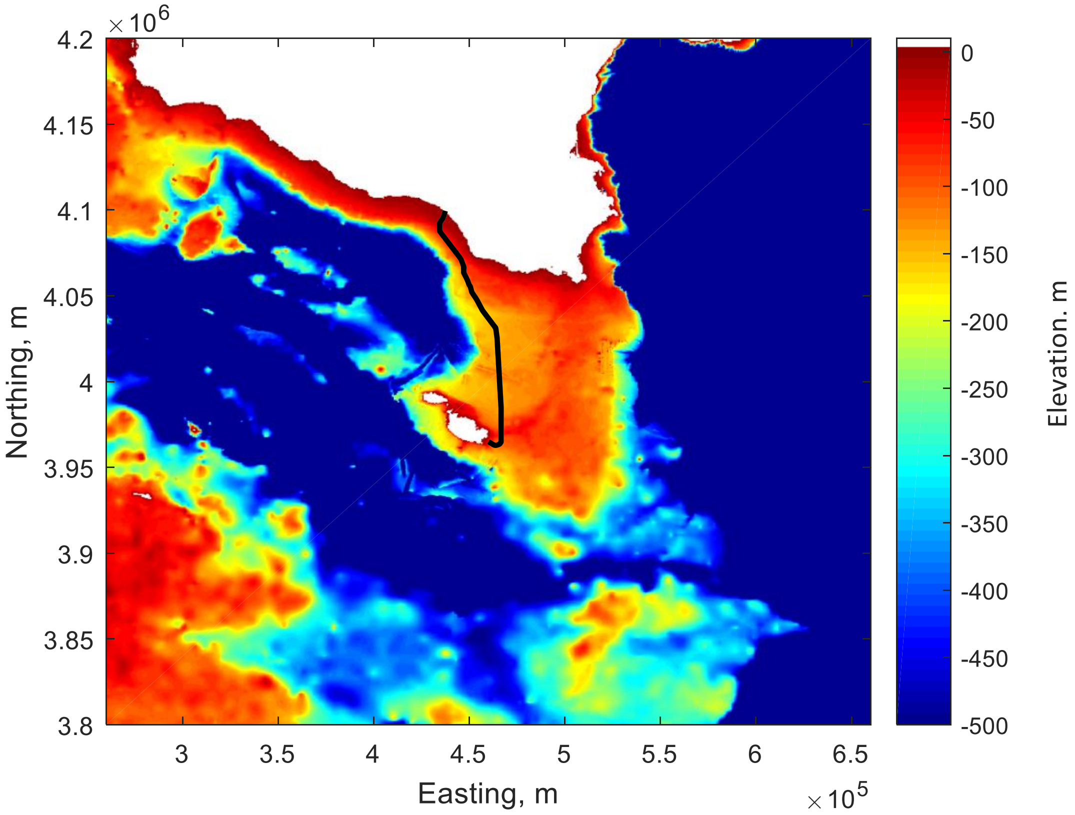


Figure 10: The bathymetric imagery within and surrounding the proposed gas pipeline route. The pipeline route is shown as the thick black line, and the onshore areas with elevation above sea level are shown as white colour. The coordinate system is based on WGS 84 UTM33N

4.2.2.2 Sound Speed Profile

Temperature and salinity data required to derive the sound speed profiles were obtained from the World Ocean Atlas 2009 (WOA09) (Locarnini et al., 2010; Antonov et al., 2010). The hydrostatic pressure needed for calculation of the sound speed based on depth and latitude of each particular sample was obtained using Sanders and Fofonoff's formula (Sanders and Fofonoff, 1976). The sound speed profiles were derived based on Del Grosso's equation (Del Grosso, 1974).

Figure 11 presents the typical sound speed profiles of four Northern Hemisphere seasons for both shallow and deep-water regions within the Mediterranean Sea surrounding the proposed gas pipeline route. The figure demonstrates that the most significant distinctions for the profiles of four seasons occur within the mixed layer near the surface. In the upper layers, propagation is characterised by upward refraction in winter and an acoustic channel in summer.

It is also noticed that the sound speed profiles differ from those in temperature zones of the open oceans (Munk et al., 1995), predominantly for a striking minimum below the seasonal thermocline and for the absence of the deep SOFAR channel which is generally located between 800 m and 1,200 m below the sea surface (Jensen et al, 2011). This is due to the thermal vertical structure of the Mediterranean Sea, characterised by a reduced or absent permanent thermocline and by warmer deep waters (Salon et al, 2003).

Due to the upward refraction within the profile, it is expected that the winter season will favour the propagation of sound from a near surface acoustic source.

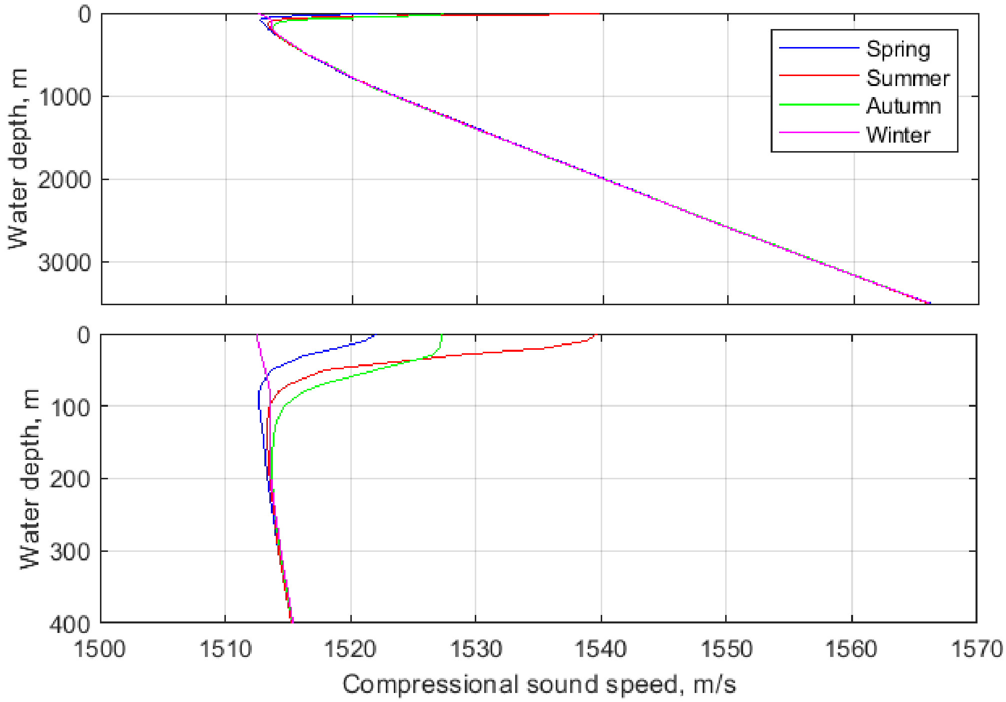


Figure 11: Typical sound speed profiles within deep (top) and shallow (bottom) water regions surrounding the proposed gas pipeline route for different northern atmosphere seasons

4.2.2.3 Seafloor Geoacoustic Model

The seafloor geoacoustic model for the modelling area is developed based on a habitat mapping study carried out for the continental shelves off the northwest coast of Malta and the east coasts of the Maltese Islands (Prampolini et al, 2017).

The study reveals that for the coastal areas off the northwest coast of Malta and the east coasts of the Maltese Islands, the seabed sediments range from coarse sand and gravel at the nearshore areas, to fine to medium sand at areas further offshore. Therefore, it is proposed that the seafloor geoacoustic model for the entire modelling area comprises of a

100-m fine to medium sand sediment layer, followed by a slightly to semi-cemented sandy half space as detailed in Table 13.

The geoacoustic properties for sandy sediments are as described in Hamilton (1980) and Jensen et al (2011). The elastic properties are treated as negligible.

Table 13: Geoacoustic parameters for the proposed seafloor model

Seafloor Materials	Thickness, M	Density, P, (kg.m^{-3})	Compressional wave	
			Speed, C_p, (m.s^{-1})	Attenuation, A_p, (db/λ)
Fine to medium sand layer	100	1900	1650	0.8
Slightly to semi-cemented sand half space	∞	1900	2100	0.1

4.3 Impact Significance Criteria

The ToRs for the preparation of an EIA states that the operational noise sources should be quantified and the impact on all noise sensitive receptors should be established with reference to the agreed acceptability criteria as specified within the ToR and illustrated below.

Once the magnitude of noise impact has been described the level of significance of impact is determined based on the sensitivity of the existing or proposed noise receptors.

The impact assessment methodology is used after potential noise impacts, which are likely to arise as a result of the proposed development, have been identified. This study is required if the proposed development will create noise (Noise Generating Development – NGD) which may affect nearby noise sensitive receptors, for example, a new commercial activity near existing residential properties.

The level of significance is determined in relation to the magnitude of impact together with the sensitivity of the receptor. Different Noise Sensitive Receptors (NSR) can be classified in three levels of sensitivity: High, Medium and Low as seen below in Table 14.

Table 14: Level of Sensitivity Associated with Various NSRs

Sensitivity	Description of NSRs
High	Receptors where people or operations are vulnerable to noise, such as: Residential, Recreational Areas, Educational Institutions, Hospitals, Homes for the elderly, Places of worship.
Medium	Receptors are moderately sensitive to noise, if it causes some distraction or disturbance, such as: Offices, Bars/Cafes/Restaurant.
Low	Receptors where distraction or disturbance from noise is minimal, such as: Night Clubs, Sports Ground, Factories.

After all noise sensitive receptors have been identified and prioritised according to their level of sensitivity as identified in the Table 14, the magnitude of the impact is classified as none/negligible, minor, moderate or major according to the noise monitoring study as shown in Table 15.

Table 15: Classification of Magnitude on Noise Impact Criteria from different Noise Sources

<table>
<tr><th colspan="2">Noise source</th><th>Noise level (db)</th><th>Impact magnitude</th></tr>
<tr><th colspan="4">Industrial or Commercial Noise</th></tr>
<tr><td rowspan="5">Target Levels</td><td rowspan="5">Rating Level – Background Noise level (L_{Ar})-(L_{A90}) < 5dB</td><td>>10</td><td>Major</td></tr>
<tr><td>≤10 but ≥5</td><td>Moderate</td></tr>
<tr><td><5 but ≥3</td><td>Minor</td></tr>
<tr><td><3 but ≥0</td><td>Negligible</td></tr>
<tr><td>0</td><td>No Change</td></tr>
</table>

The different levels of significance relating the magnitude of impact with the sensitivity of the receptor are defined in Table 16.

Table 16: Level of significance

Magnitude of adverse impact	Level of Significance relative to NSR		
	Low	**Medium**	**High**
Major	Moderate	Substantial	Severe
Moderate	Minor	Moderate	Substantial
Minor	Minor	Minor	Moderate
Negligible/no change	Minor/Neutral	Minor/Neutral	Minor/Neutral

The levels of significance are as detailed:

- **Severe** environmental significance is associated with the impacts where mitigation is not practical or would be ineffective and could influence the decision whether or not to proceed with the project.
- **Substantial** environmental significance is associated with the effects that are important considerations, which could result in adverse effects if they are not mitigated.
- **Moderate** environmental significance could have an influence on the decision unless it is mitigated.
- **Minor/Neutral** environmental significance will not have an influence on the decision or require modification on the project design or alternative mitigation and noise need not be considered as a determining factor in the decision process.

4.3.1 Onshore Construction Impact - Noise

The impact of construction noise upon residential receptors will be determined with reference to the ABC method presented in BS5228-1:2009+A1:2014. In accordance with this method the threshold noise levels for a potentially significant effect are as detailed in Table 17.

Table 17: Construction Noise Residential Receptors – Example Threshold Values

Assessment category and threshold value period (L_{Aeq})	Threshold value, in decibels (dB)		
	Category A A)	Category B B)	Category C C)
Night-time (23.00-07.00)	45	50	55
Evenings and weekends D)	55	60	65
Daytime (07.00-19.00) and Saturdays (07.00-13.00)	65	70	75
NOTE 1 A significant effect has been deemed to occur if the total LAeq noise level, including construction, exceeds the threshold level for the Category appropriate to the ambient noise level. NOTE 2 If the ambient noise level exceeds the threshold values given in the table (i.e. the ambient noise level is higher than the above values), then a significant effect is deemed to occur if the total LAeq noise level for the period increases by more than 3 dB due to construction activity. NOTE 3 Applied to residential receptors only.			
A) Category A: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are less than these values. B) Category B: threshold values to use when the ambient noise levels (when rounded to the nearest 5 dB) are the same as category A values. C) Category C: threshold values to use when the ambient noise levels (when rounded to the nearest 5 dB) are higher than category A values. D) 19.00-23.00 weekdays, 13.00-23.00 Saturdays and 07.00-23.00 Sundays.			

The impact of construction noise upon residential receptors will be determined with reference to BS5228:2009+A1:2014. The impact of construction noise upon residential receptors is as detailed in Table 18.

Table 18: Impact – Construction Noise

Magnitude	Increase in the $L_{Aeq,T}$ Noise Level
Major	Threshold value exceeded by more than 5dB
Moderate	Threshold value exceeded between 3.0 and 4.9dB
Minor	Threshold value exceeded between 1.0 and 2.9dB
Negligible	Threshold value exceeded between 0.1 and 0.9dB
No Change	Threshold value not exceeded

4.3.2 Onshore Construction Impact – Vibration

The impact of construction vibration upon residential receptors (from piling operations) will be assessed in accordance with BS5228-2:2009+A1:2014 Table B.1 of the standard provides guidance on the effects of vibration and is replicated in Table 19. The impact of construction vibration upon human response is as detailed in Table 20.

Table 19: Guidance on effects of vibration levels

Vibration level	Effect
0.14mms^{-1}	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.
0.3mms^{-1}	Vibration might be just perceptible in residential environments.
1.0mms^{-1}	Vibration 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.
10mms^{-1}	Vibration is likely to be intolerable for any more than a brief exposure to this level in most building environments.

Table 20: Impact – Vibration Levels

Magnitude	Increase in Vibration Level - Over the Threshold Value of 0.14
Major	Threshold value exceeded by more than 5.00 mms^{-1}
Moderate	Threshold value exceeded between 1.00 and 4.99 mms^{-1}
Minor	Threshold value exceeded between 0.14 and 0.99 mms^{-1}
Negligible	Threshold value exceeded between 0.05 and 0.13 mms^{-1}
No Change	Threshold value exceeded by less than 0.05 mms^{-1}

4.3.3 Onshore Operational Impact

The impact of operational sound upon residential receptors will be determined with reference to BS4142:2014+A1:2019.

Typically, the greater the difference between the rating level and the background sound level the greater the magnitude of the impact.

- a difference of around +10dB or more is likely to be an indication of a significant adverse impact, depending on the context;
- a difference of around +5dB is likely to be an indication of an adverse impact, depending on the context; and
- the lower the rating level is relative to the measured background sound level, the less likely it is that the specific sound source will have an adverse impact or a significant adverse impact. It is an indication that the specific sound source has a low impact when the rating level does not exceed the background sound level, depending on the context.

Based on the above the impact of operational noise upon residential receptors is as detailed in Table 21.

Table 21: Impact – Operational Noise Residential Receptors

Magnitude	Description
Major	Rating level is more than 10dB(A) above the background
Moderate	Rating level is ≤10 but ≥5 dB(A) above the background

Minor	Rating level is <5 but ≥3 dB(A) above the background
Negligible	Rating level is <3 but ≥0 dB(A) below the background
No Change	Rating level is 0 dB(A) or below the background

4.3.4 AQTAG Impact – Construction and Operational Phases

The Habitats Directive (92/43/EEC) specifies that, where specific noise from industry, measured at the habitat/nest site is below the levels in Table 22, it is considered unlikely that it will have an adverse impact on designated species. Where noise levels are exceeded further, more detailed assessment will be required.

Table 22: Specific Noise levels at Habitat

Parameter	Noise level, dB
$L_{Amax,F}$	80
$L_{Aeq,1hr}$	55

Based on the above precautionary levels the impact significance of the proposed development during the construction phase or once it is operational, is as detailed in Table 23.

Table 23: Impact – AQTAG

Magnitude	Description
Major	Limit value exceeded by more than 5dB
Moderate	Limit value exceeded between 3.0 and 4.9dB
Minor	Limit value exceeded between 1.0 and 2.9dB
Negligible	Limit value exceeded between 0.1 and 0.9dB

4.3.5 Underwater noise - Marine Mammals

Marine animals do not hear equally well at all frequencies within their functional hearing range. Based on the hearing range and sensitivities, Southall et al (2019) have categorised marine mammal species (i.e. cetaceans and pinnipeds) into six underwater hearing groups: low-frequency (LF), high-frequency (HF), very high-frequency (VHF) cetaceans, Sirenians (SI), Phocid carnivores in water (PCW) and Other marine carnivores in water (OCW). Examples of these marine mammal species and their underwater hearing groups are detailed in Table 24.

Table 24: Marine Mammal Species Underwater Hearing Groups

Underwater Hearing Groups	Examples of Marine Mammal Species
Low-frequency (LF) cetaceans	common minke whale, fin whale
High-frequency (HF) cetaceans	killer whale, short-beaked common dolphin
Very high-frequency (VHF) cetaceans	dwarf sperm whale, harbour porpoise
Sirenians (SI)*	West African manatee
Phocid carnivores in water (PCW)*	gray seal, leopard seal
*In general, these species are not found in this part of the Mediterranean	

The potential noise effects on animals depend on how well the animals can hear the noise. Frequency weighting is a method of quantitatively compensating for the differential frequency response of sensory systems (Southall et al, 2007 & 2019).

When developing updated scientific recommendations in marine mammal noise exposure criteria, Southall et al (2019) adopt the auditory weighting functions as expressed in the equation below, which are based on the quantitative method by Finneran (2015 & 2016) and are in consistent with the U.S. National Oceanic and Atmospheric Administration (NOAA) technical guidance (NMFS, 2016 & 2018).

$$W(f) = C + 10log10\left\{\frac{(f/f_1)^{2a}}{[1+(f/f_1)^2]^a[1+(f/f_2)^2]^b}\right\} \quad (2.1)$$

Table 25 lists the auditory weighting parameters for the six hearing groups. The corresponding auditory weighting functions for all hearing groups are presented in Figure 12.

Table 25: Parameters for the auditory weighting functions

MARINE MAMMAL HEARING GROUP	A	B	F_1 (HZ)	F_2 (HZ)	C (DB)
Low-frequency cetaceans (LF)	1.0	2	200	19,000	0.13
High-frequency cetaceans (HF)	1.6	2	8,800	110,000	1.20
Very high-frequency cetaceans (VHF)	1.8	2	12,000	140,000	1.36
Sirenians (SI)	1.8	2	4,300	25,000	2.62
Phocid carnivores in water (PCW)	1.0	2	1,900	30,000	0.75

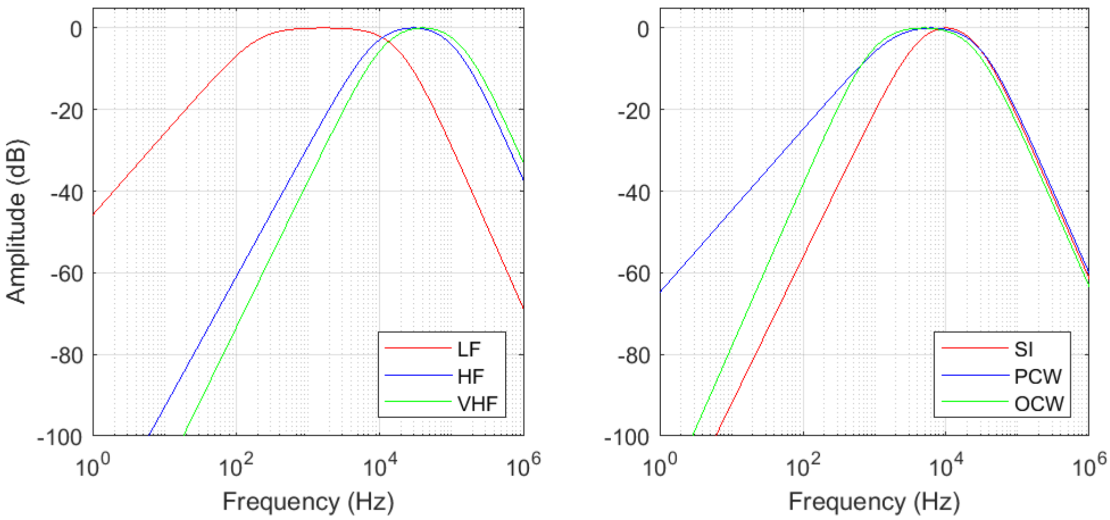


Figure 12: Auditory weighting functions - LF, HF, VHF, SI, PCW and OCW

There have been extensive scientific studies and research efforts to develop quantitative links between marine noise and impacts on marine fauna species. For example, Southall et al (2007 & 2019) have proposed noise exposure criteria associated with various sound types, including impulsive noise (e.g. piling noise and seismic airgun noise) and non-impulsive noise (e.g. vessel and drilling noise)) for certain marine mammal species (i.e. cetaceans and sirenians and carnivores), based on review of expanding literature on marine mammal hearing and on physiological and behavioural responses to anthropogenic sounds.

The newly updated scientific recommendations in marine mammal noise exposure criteria (Southall et al, 2019) propose PTS-onset and TTS-onset criteria for both impulsive noise and non-impulsive noise events. The PTS-onset and TTS-onset criteria for impulsive noise are outlined in Table 26, which incorporate a dual-criteria approach based on both peak sound pressure level (SPL) and cumulative sound exposure level (SEL) within a 24-hour period (SEL_{24hr}). The PTS-onset and TTS-onset criteria for non-impulsive noise as outlined in Table 26 are based on cumulative SEL within a 24-hour period (SEL_{24hr}) only.

It should be noted that for impulsive signals from seabed sonar surveys, only peak SPL criteria are applicable. This is because the sonar surveys are moving sources; their high frequency sound emissions are highly directional towards seabed and signal durations are short in nature. Therefore, the impacts from the sonar survey noise emission are expected to be highly localised around the moving sonar sources.

For behavioural changes, the widely used assessment criterion for the onset of possible behavioural disruption in marine mammals is root-mean-square (RMS) SPL of 160 dB re 1µPa for impulsive noise and 120 dB re 1µPa for non-impulsive noise (NMFS, 2013), as shown in Table 28.

Table 26: PTS- and TTS-onset threshold levels for marine mammals exposed to impulsive noise

Marine mammal **hearing group**	**PTS and TTS threshold levels – non-impulsive noise**			
	Injury (PTS) Onset		**Injury (PTS) Onset**	
	PK SPL, DB RE 1µPA (unweighted)	**SEL_{24HR}, DB RE 1µPA²·S (weighted)**	**PK SPL, DB RE 1µPA (unweighted)**	**SEL_{24HR}, DB RE 1µPA²·S (weighted)**
Low-frequency cetaceans (LF)	219	183	213	168
High-frequency cetaceans (HF)	230	185	224	170
Very high-frequency cetaceans (VHF)	202	155	196	140
Sirenians (SI)	226	203	220	175
Phocid carnivores in water (PCW)	218	185	212	170
Other marine carnivores in water (OCW)	232	203	226	188

Table 27: PTS- and TTS-onset threshold levels for marine mammals exposed to non-impulsive noise

Marine mammal hearing group	PTS and TTS threshold levels – non-impulsive noise	
	Injury (PTS) Onset	TTS Onset
	SEL_{24HR}, DB RE $1\mu PA^2 \cdot S$ (weighted)	SEL_{24HR}, DB RE $1\mu PA^2 \cdot S$ (weighted)
Low-frequency cetaceans (LF)	199	179
High-frequency cetaceans (HF)	198	178
Very high-frequency cetaceans (VHF)	173	153
Sirenians (SI)	206	186
Phocid carnivores in water (PCW)	201	181
Other marine carnivores in water (OCW)	219	199

Table 28: The behavioural disruption threshold level for marine mammals – impulsive and non-impulsive noise

Marine mammal hearing group	Behavioural Disruption Threshold Levels, RMS SPL, DB RE 1μPA	
	Impulsive noise	Non-impulsive noise
All hearing groups	160	120

4.3.6 Underwater noise - Fish and Sea Turtles

In general, limited scientific data are available regarding the effects of sound for fishes and sea turtles. As such, assessment procedures and subsequent regulatory and mitigation measures are often severely limited in their relevance and efficacy. To reduce regulatory uncertainty for all stakeholders by replacing precaution with scientific facts, the U.S. National Oceanic and Atmospheric Administration (NOAA) convened an international panel of experts to develop noise exposure criteria for fishes and sea turtles in 2004, primarily based on published scientific data in the peer-reviewed literature. The panel was organized as a Working Group (WG) under the ANSI-Accredited Standards Committee S3/SC 1, Animal Bioacoustics, which is sponsored by the Acoustical Society of America.

The outcomes of the WG are broadly applicable sound exposure guidelines for fishes and sea turtles (Popper *et al*., 2014), considering the diversity of fish and sea turtle species, the different ways they detect sound, as well as various sound sources and their acoustic characteristics. The sound exposure criteria for sound sources relevant to the project including impulsive noise from VSP airguns and non-impulsive noise from shipping and other sources are presented in Table 29 and Table 30 respectively.

Table 29: Sound exposure criteria applicable for VSP airgun sources – fishes and sea turtles

Type of animal		Impairment	Behaviour

	Mortality and potential mortal injury	Recovery injury	TTS	Recovery injury	
Fish: no swim bladder (particle motion detection)	>219 dB SEL_{24hr}, or >213 dB Pk SPL	>216 dB SEL_{24hr} or >213 dB Pk SPL	>>186 dB SEL_{24hr}	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish: swim bladder is not involved in hearing (particle motion detection)	210 dB SEL_{24hr} or >207 dB Pk SPL	203 dB SEL_{24hr} or >207 dB Pk SPL	>>186 dB SEL_{24hr}	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish: swim bladder involved in hearing (primarily pressure detection)	207 dB SEL_{24hr} or >207 dB Pk SPL	203 dB SEL_{24hr} or >207 dB Pk SPL	186 dB SEL_{24hr}	(N) Low (I) Low (F) Moderate	(N) High (I) High (F) Moderate
Sea turtles	210 dB SEL_{24hr} or >207 dB Pk SPL	(N) High (I) Low (F) Low	(N) High (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish eggs and fish larvae	>210 dB SEL_{24hr} or >207 dB Pk SPL	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low

Notes: peak sound pressure levels (Pk SPL) dB re 1 µPa; Cumulative sound exposure level (SEL_{24hr}) dB re 1 $\mu Pa^2 \cdot s$. All criteria are presented as sound pressure even for fish without swim bladders since no data for particle motion exist. Relative risk (high, moderate, low) is given for animals at three distances from the source defined in relative terms as near (N), intermediate (I), and far (F).

Table 30: Noise exposure criteria for shipping and continuous sounds – fishes and sea turtles

Type of animal	Mortality and potential mortal injury	Impairment			Behaviour
		Recovery injury	TTS	Recovery injury	
Fish: no swim bladder (particle motion detection)	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) Moderate (I) Moderate (F) Low
Fish: swim bladder is not involved in hearing (particle motion detection)	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) Moderate (I) Moderate (F) Low
Fish: swim bladder involved in hearing	(N) Low (I) Low	170 dB rms	158 dB rms	(N) High (I) High	(N) High

(primarily pressure detection)	(F) Low	for 48h	for 48h	(F) High	(I) Moderate (F) Low
Sea turtles	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) High (I) Moderate (F) Low
Fish eggs and fish larvae	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) High	(N) Moderate (I) Moderate (F) Low

Notes: rms sound pressure levels (RMS SPL) dB re 1 µPa. All criteria are presented as sound pressure even for fish without swim bladders since no data for particle motion exist. Relative risk (high, moderate, low) is given for animals at three distances from the source defined in relative terms as near (N), intermediate (I), and far (F).

4.3.7 Zones of Bioacoustics Impact

The received noise levels within and around the Project area can be predicted using known source levels in combination with models of sound propagation transmission loss between the source and the receiver locations. Zones of impact can be determined by comparison of the predicted received levels to the noise exposure criteria.

Predicted zones of impact define the environmental footprint of the noise generating activities and indicate the locations within which the activities may have an adverse impact on a marine fauna species, either behaviourally or physiologically. This information can be used to assess the risk (likelihood) of potential adverse noise impacts, by combining the acoustic zones of impact with ecological information such as habitat significance and migratory routes in the affected area.

5.0 Baseline Conditions

5.1 Onshore Survey Results

Measurements at all four locations were made at 1.3m above the ground in free-field conditions and were logged every one-hour.

The following noise indices were recorded at all locations:

$L_{Aeq,T}$ The A-weighted equivalent continuous noise level over the measurement period T;

L_{A90} The A-weighted noise level exceeded for 90% of the measurement period. This parameter is often used to describe background noise;

L_{A10} The A-weighted noise level exceeded for 10% of the measurement period. This parameter is often used to describe road traffic noise; and

L_{AFmax} The maximum A-weighted noise level during the measurement period.

A summary of the measured noise levels, including the median background sound level (L_{A90}) and the ambient noise level (L_{Aeq}) and the highest L_{AFmax} values are shown in Table 31 and Table 32 for all of the Monitoring Locations for both of the 2017 and 2018 noise surveys respectively. The daytime period is taken between 07:00 and 23:00 hours and the night-time between 23:00 and 07:00 hours.

Table 31: Summary of Measured Noise Levels, dB - 2017

Monitoring location	Time Period	$L_{AEQ,T}$	L_{A90}	L_{A10}	L_{AFMAX}
A	Daytime	54.7	50.8	56.4	87.4
	Night-time	49.5	46.6	49.9	65.7
B	Daytime	62.2	57.9	63.7	85.0
	Night-time	59.3	53.6	61.4	73.0
C	Daytime	50.3	44.8	51.7	81.4
	Night-time	49.6	46.5	49.6	58.5
D	Daytime	67.0	52.0	61.0	85.2
	Night-time	54.0	50.5	53.6	60.9

Table 32: Summary of Measured Noise Levels, dB - 2018

Monitoring location	Time Period	$L_{AEQ,T}$	L_{A90}	L_{A10}	L_{AFMAX}
A	Daytime	53.3	48.1	53.1	86.1
	Night-time	50.4	46.9	51.5	68.8
B	Daytime	54.3	50.2	53.6	88.6
	Night-time	52.0	49.9	53.1	71.4
C	Daytime	57.0	47.5	57.3	90.5
	Night-time	51.9	48.2	51.7	76.8
D	Daytime	59.2	57.8	60.4	109.2
	Night-time	59.7	58.6	61.0	68.9

5.1.1 Analysis of Background Sound Level, L_{A90}

In accordance with BS4142:2014+A1:2019, the rating level (associated with the operation of the development) should be assessed against a limit which is based on the existing background sound level, L_{A90}.

As per BS4142:2014+A1:2019, the L_{A90} is the underlying level of sound and *"might in part be an indication of relative quietness at a given location"*. The standard goes on to state that the L_{A90} does not *"reflect the occurrence of transient and/or higher sound level events"* (such as passing traffic in this instance) and that it is *"generally governed by continuous or semi-continuous sounds"*.

BS4142:2014+A1:2019 states that *"in using the background sound level…it is important to ensure that values are reliable and suitably represent both the particular circumstances and periods of interest. For this purpose, the objective is not simply to ascertain a lowest measured background sound level, but rather to quantify what is typical during particular time periods".*

Therefore, in this respect, further analysis of the measured background sound levels (L_{A90}) has been undertaken to quantify the most 'typical' and 'representative' value for the purposes of the assessment. Table 33 and Table 34 presents the arithmetic average, median and modal values of the measured L_{A90} for each of the monitoring locations during each of the stated time periods for 2017 and 2018 respectively.

Table 33: Analysis of Background Sound Levels, dB L_{A90} - 2017

Monitoring location	Time Period	Average L_{A90}	Median L_{A90}	Modal L_{A90}
A	Daytime	50.7	50.8	51.0
	Night-time	46.4	46.6	47.0
B	Daytime	57.2	57.9	58.0
	Night-time	53.9	53.6	56.0
C	Daytime	45.3	44.8	45.0
	Night-time	47.0	46.5	46.0
D	Daytime	53.3	52.0	53.0
	Night-time	51.0	50.5	51.0

Table 34: Analysis of Background Sound Levels, dB L_{A90} - 2018

Monitoring location	Time Period	Average L_{A90}	Median L_{A90}	Modal L_{A90}
A	Daytime	48.3	48.1	48.0
	Night-time	47.0	46.9	47.0
B	Daytime	50.0	50.2	50.0
	Night-time	49.8	49.9	50.0
C	Daytime	47.4	47.5	48.0
	Night-time	48.0	48.2	47.0
D	Daytime	57.9	57.8	58.0
	Night-time	58.3	58.6	59.0

From Table 33 and Table 34 the lowest of the derived average, median and modal values of the background sound levels, L_{A90} measured during the 2017 and 2018 surveys will be implemented within the assessment as a conservative measure. The L_{A90} values have been rounded to the nearest whole number in Table 35.

Further to this, the lowest logarithmically averaged L_{Aeq} noise levels over the 2017 and 2018 surveys will be implemented in the assessment as a worst-case scenario. A summary of the noise values to be implemented in the assessment are shown in Table 35.

Table 35: Summary of Measured Noise Levels to be used in Assessment, dB

Monitoring location	Time Period	$L_{AEQ,T}$	L_{A90}
A	Daytime	53.3	48
	Night-time	49.5	47
B	Daytime	54.3	50
	Night-time	52.0	50
C	Daytime	50.3	45
	Night-time	49.6	46
D	Daytime	59.2	52
	Night-time	54.0	51

5.2 Existing Underwater Noise Environment

Ocean ambient noise poses a baseline limitation on the use of sound by marine animals as signals of interest must be detected against noise background. The level and frequency characteristics of the ambient noise environment are the two major factors that control how far away a given sound signal can be detected (Richardson et al, 2013).

Ocean ambient noise is comprised of a variety of sounds of different origin at different frequency ranges, having both temporal and spatial variations. It primarily consists of noise from natural physical events, noise produced by marine biological species and anthropogenic noise. These sources are detailed as follows:

Natural events: the major natural physical events contributing to ocean ambient noise include, but are not limited to, wave/turbulence interactions, wind, precipitation (rain and hail), breaking waves and seismic events (e.g. earthquakes/tremors):

- The interactions between waves/turbulence can cause very low frequency noise in infrasonic range (below 20 Hz). Seismic events such as earthquakes/tremors and underwater volcanos also generate noise predominantly at low frequencies from a few Hz to a few hundred Hz;
- Wind and breaking waves, as the prevailing noise sources in much of the world's oceans, generate noise across a very wide frequency range, typically dominating the ambient environment from 100 Hz to 20 kHz in the absence of biological noise sources. The wind-dependent noise spectral levels also strongly depend on sea states which are essentially correlated with wind force; and
- Precipitation, particularly heavy rainfall, can produce much higher noise levels over a wider frequency range of approximately 500 Hz to 20 kHz.

Bioacoustic production: some marine animals produce various sounds (e.g. whistles, clicks) for different purposes (e.g. communication, navigation or detection):

- Baleen whales (e.g. great whales like humpback whales) regularly produce intense low-frequency sound (whale songs) that can be detected at long range in the open water. Odontocete whales, including dolphins, can produce rapid burst of high-frequency clicks (up to 150 kHz) that are primarily for echolocation purposes;
- Some fish species produce sounds individually, and some species also make noise in choruses. Typically fish chorusing sounds depend on species, time of day and time of season; and
- Snapping shrimps are important contributors among marine biological species to the ocean ambient noise environment, particularly in shallow coastal waters. The noise from snapping shrimps is extremely broadband in nature, covering a frequency range from below 100 Hz to above 100 kHz. Snapping shrimp noise can interfere with other measurement and recording exercises, for example it can adversely affect sonar performance.

Anthropogenic sources: anthropogenic noise primarily consists of noise from shipping activities, offshore seismic explorations, marine industrial developments and operations, as well as equipment such as sonar and echo sounders:

- Shipping traffic from various sizes of ships is the prevailing man-made noise source around nearshore port areas. Shipping noise is typically due to cavitation from propellers and thrusters, with energy predominantly below 1 kHz;
- Pile driving and offshore seismic exploration generate repetitive pulse signals with intense energy at relatively low frequencies (hundreds of Hz) that can potentially cause physical injuries to marine species close to the noise source. The full frequency range for these impulsive signals could be up to 10k Hz; and
- Dredging activities and other marine industry operations are additional man-made sources, generating broadband noise over relatively long durations.

Figure 13 provides an overview of the indicative noise spectral levels produced by various natural and anthropogenic sources, relative to typical background or ambient noise levels in the ocean. Natural physical noise sources are represented in blue; marine fauna noise sources in green; whilst human noise sources are marked in orange. Human contributions to ambient noise are often significant at low frequencies, between about 20 Hz and 500 Hz, with ambient noise in this frequency range being predominantly from distant shipping (Hildebrand, 2009). In areas located away from anthropogenic sources, background noise at higher frequencies tends to be dominated by natural physical or bioacoustics sources such as rainfall, surface waves and spray, as well as fish choruses and snapping shrimp for coastal waters.

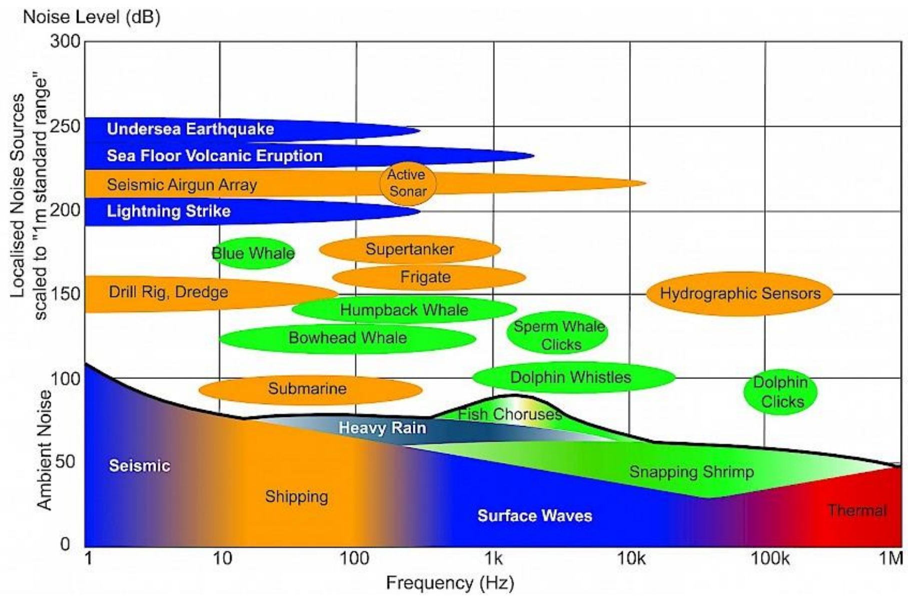


Figure 13: Levels and frequencies of anthropogenic and naturally occurring sound sources in the marine environment (Source: https://www.ospar.org/work-areas/eiha/noise)[11]

A summary of the spectra of various ambient noise sources based on a review study undertaken by Wenz (1962) is shown in Figure 14. It should be noted that although the spectral curves in the figure are based on average levels from reviewed references primarily for the North Atlantic Ocean, they are regarded as representative in general for respective ocean ambient noise spectral components.

The overall ambient noise levels are typically 80 – 120 dB re 1 µPa for the frequency range 10 – 10k Hz, from light surrounding shipping movements and calm sea surface condition, to moderate to heavy remote shipping traffic and medium to high wind conditions.

[11] *It should be noted that blue whales and bowhead whales are not found in the Mediterranean and few sightings were ever recorded for humpback whales in the last 150 years.*

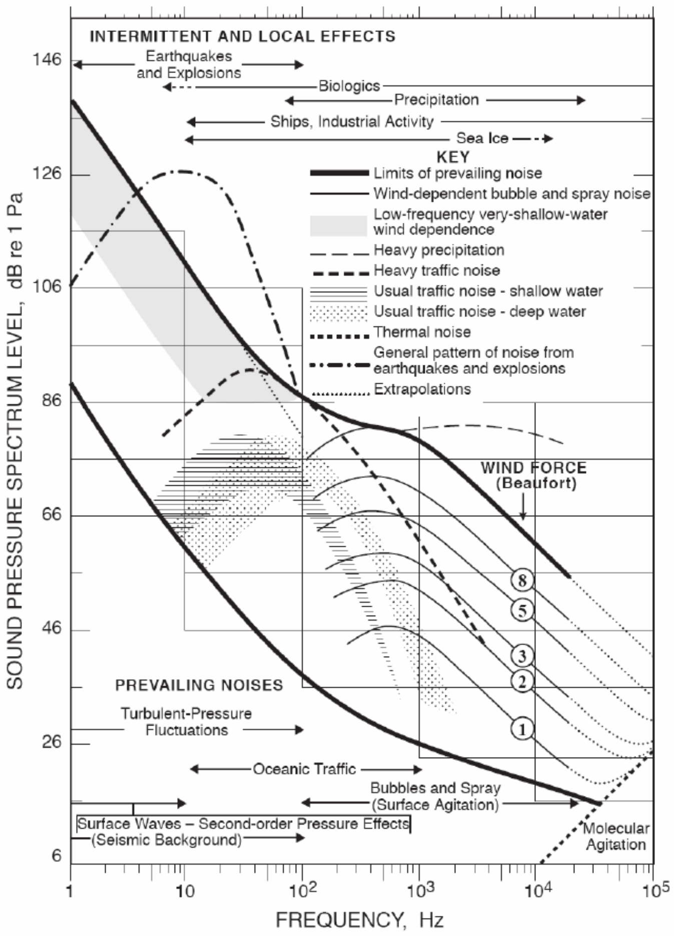


Figure 14: Composite of Ocean Ambient Noise Spectra (from Wenz, 1962)

Due to the presence of shipping lanes as and the consequent heavy traffic noise contribution as demonstrated in below, the overall ambient noise levels for the offshore area surrounding the proposed pipeline route are expected to be close to the upper limit of the typical baseline noise level range (i.e. 80 - 120 dB re 1 µPa).

5.2.1 Shipping Traffic Offshore Malta and Sicily

Figure 15 displays the traces of shipping activities around the Mediterranean Sea. As can be seen from the figure, the islands of Malta are sandwiched between busy shipping lanes that run parallel to its coastline. To the north of the islands, i.e. the Sicily channel, a number of shipping lanes interleave over this strait and consequently increases the shipping movement density in the area. A distinguishable shipping lane is also present in the south of the islands.

Information about shipping traffic across the Sicily channel has also been obtained from the Automatic Identification System (AIS) data over the one-year period of 2018 (De Caro, 2019), with the sketch of identified shipping routes based on vessel GT classes is shown in Figure 16. As demonstrated in the figure, the major shipping traffic routes with larger vessels are across the strait following the major shipping lanes, while for traffic routes off the local ports and near shore regions are predominantly smaller size vessels for fishing and passenger transport purposes.

As such, shipping noise around the islands is expected to come from a very wide range of ship types; e.g. tankers, bulk carriers, container ships, and fishing vessels. The shipping noise component of the ambient noise environment is expected to be significant for the area surrounding the proposed gas pipeline route.

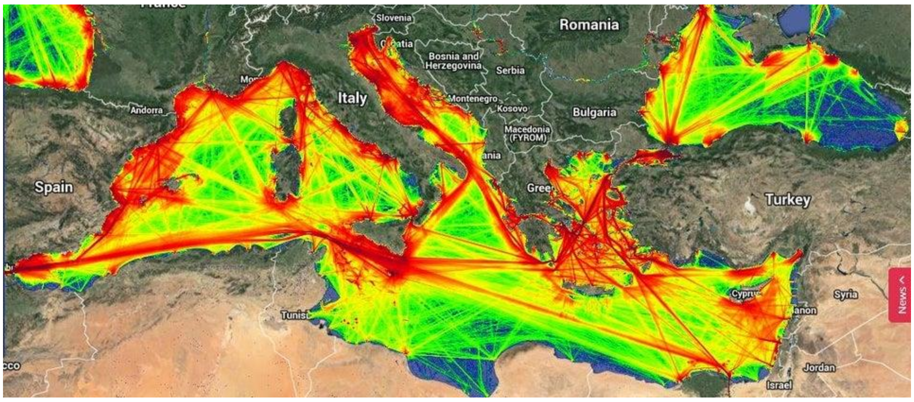


Figure 15: Traces of shipping activities around the Mediterranean Sea (Source: http://tiny.cc/bjcbgz)

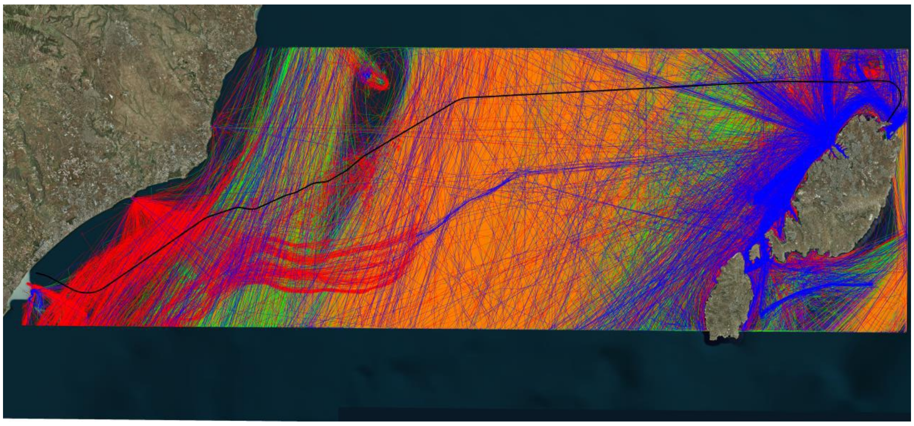


Figure 16: Identified shipping traffic route of year 2018 (Red-GT1 Class, Blue-GT2 Class, Green-GT3 Class, Purple-GT4 Class, Orange-GT5 Class, Black-Malta-Sicily pipeline route) (De Caro, 2019)

5.2.2 Metocean Conditions Offshore Malta

A comprehensive metocean study has been performed for the design of the proposed submarine pipeline, including the wind distribution analysis based on long term historical data for the Malta Channel derived from KNMI (The Royal Netherlands Meteorological Institute) observations from 1960 to 1980, hindcasted wind data during the period 1998 – 2017 at four DICCA (Dipartimento di Ingegneria Civile, Chimica e Ambientale) positions surrounding the pipeline route, as well as the long-term measurement data at one offshore monitoring location east of the pipeline route: Vega – a platform with a meteo-marine monitoring system installed (De Filippi, 2019).

The annual wind rose from historical data in Malta Channel and long-term measurements at Vega are shown in Figure 17. The frequency distributions of the wind speed vs incoming direction for the historical data based on KNMI observations from 1960 to 1980 are shown in Table 36.

As can be seen from Figure 17, the prevailing annual wind directions are westerly to north-westerly. For yearly frequency distribution, wind speeds are below the speed of 6 m/s (i.e. Beaufort scale around 3) over 50% of the one-year period, over 15% of the period the wind speeds within the range of 6 – 8 m/s (i.e. Beaufort scale around 4), and over 2% of wind speeds within the range of 16 – 20 m/s (i.e. Beaufort scale around 7 - 8).

Compared with generic ambient noise spectra in Wenz's curve in Figure 14, it illustrates that the offshore area surrounding the proposed pipeline route has generally calm sea state conditions, and has mid-range of wind induced ambient noise spectral components.

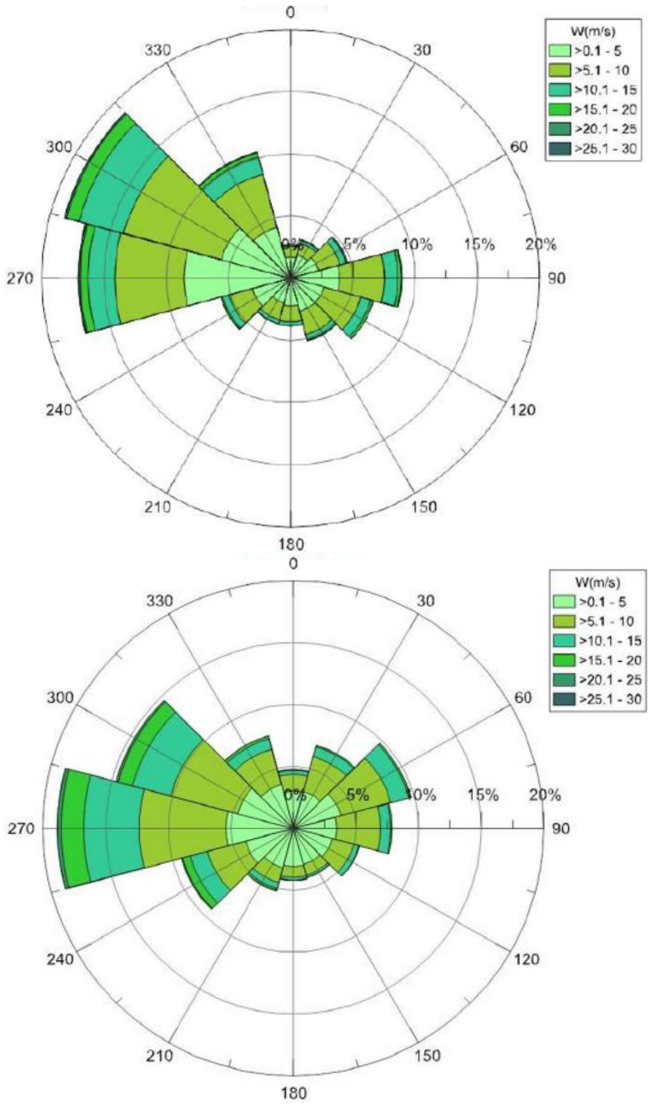


Figure 17: Annual wind rose from historical data (1960 - 1980) in Malta Channel (top) and long term measurements (2002 - 2017) at Vega (bottom)

Table 36: Frequency distribution (%) of wind speed vs incoming direction for historical data in Malta Channel (KNMI Observation 1960 - 1980)

DIRECTION (°N)	WIND SPEED (m/s)												
	4	6	8	10	12	14	16	18	20	22	24	>24	TOTAL
0	5.29	1.09	.58	.35	.11	.74	.04	.00	.01	.00	.00	.00	8.21
30	1.34	.87	.41	.26	.13	.07	.08	.02	.01	.01	.00	.00	3.19
60	1.54	1.20	.85	.48	.23	.20	.10	.05	.02	.01	.01	.00	4.69
90	2.68	1.99	1.64	1.12	.57	.40	.26	.09	.06	.01	.01	.00	8.82
120	1.81	1.71	1.35	.90	.50	.28	.15	.06	.04	.01	.00	.00	6.81
150	1.92	1.34	.88	.50	.24	.16	.08	.02	.01	.00	.00	.00	5.17
180	1.54	.97	.59	.38	.15	.12	.02	.01	.00	.00	.00	.00	3.78
210	1.47	.95	.64	.36	.18	.12	.03	.01	.00	.00	.00	.00	3.77
240	2.26	1.44	.82	.56	.27	.25	.08	.04	.02	.01	.00	.01	5.75
270	3.90	2.81	2.43	1.92	1.08	.87	.53	.17	.11	.08	.05	.02	13.96
300	3.64	3.62	3.35	3.13	1.81	1.64	.79	.33	.17	.08	.06	.02	18.64
330	2.63	2.49	2.02	1.43	.69	.63	.27	.10	.06	.03	.03	.02	10.39
TOTAL	30.02	20.49	15.56	11.40	5.96	5.47	2.43	.90	.51	.23	.15	.07	93.18
CALM:	6.82												

5.2.3 The QUIETMED Project

The QUIETMED project is running a number of pilot studies for monitoring and consequently establishing trends in acoustic noise present in the Mediterranean Sea according to requirements and guidelines adopted in the MSFD (Dekeling et al, 2017). Three research areas are the target of this monitoring; namely Cabrera (Spain), Maltese Islands, and Crete (Greece). Each site has its own equipment and procedure for deployment, retrieval and post-processing to meet the MSFD requirements. The monitoring undertaken for the Maltese Islands is mostly relevant to this noise assessment study associated with the gas pipeline development project.

Two sites were selected for the Maltese Island for underwater noise monitoring, focusing on low to mid frequency impulsive sounds at the Gozo Island's northern area, and on continuous low frequency sound (ambient noise) at the Maltese Island's southern area. The two selected sites were shown in Figure 18, with location features as listed Table 37.

The monitoring process was conducted in accordance with the MSFD requirements, including the monitoring equipment and technical specifications, experimental procedures (preparation, deployment and retrieval of monitoring systems), as well as the data processing and analysis procedures. Overall, for a duty cycle of 5 minutes on and 5 minutes off, the noise recorders captured data for 31 days at Malta South location and 21 days at Malta North location during the deployment period over the months of July and August 2018.

Table 37: Overview of the two selected monitoring locations for the Maltese Islands

Location	Depth, m	Distance to closest shore, nm	Distance to closest port	Sediments
Malta South	155.0	1.7	12.0	Silt and some rocks
Malta North	155.0	1.1	10.0	Silt

Figure 18: Two monitoring locations (red dots) at the Gozo Island's northern area and the Maltese Island's southern area

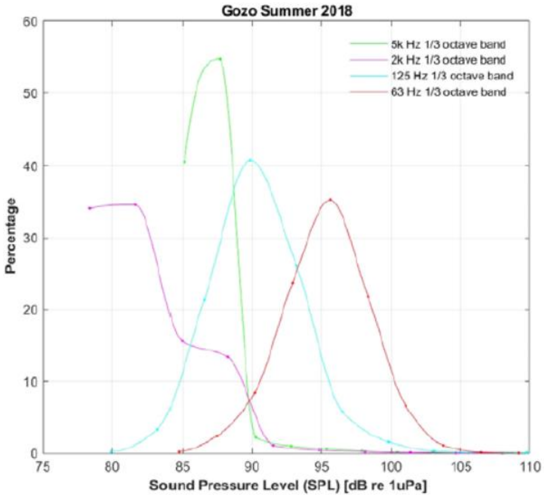
The raw data in wave files collected at the two monitoring locations were post-processed, and spectral levels were extracted in 1/3 octave bands, including 63 Hz and 125 Hz, as well as higher frequency octave bands for 2 kHz and 5 kHz, in accordance with the MSFD requirements.

Figure 19 shows the frequency distribution of the four 1/3 octave band (63 Hz, 125 Hz, 5 kHz and 5 kHz) spectral levels for the two deployment sites. The curve was fitted over ten equally sized spectral level (dB) bins where the ten bins range cover the spectral level detected with the corresponding 1/3 octave bands.

On both deployment sites, the 1/3 octave spectral levels for 63 Hz and 125 Hz show skewed normal distributions. The following are also observed:

- At Gozo deployment site, for the 63 Hz frequency band, the 10th, 50th and 90th percentiles of the spectral level distribution are approximately 91, 96 and 100 dB re 1µPa. For the 125 Hz frequency band, the 10th, 50th and 90th percentiles of the spectral level distribution are approximately 85, 90 and 96 dB re 1µPa.
- At Malta deployment site, for the 63 Hz frequency band, the 10th, 50th and 90th percentiles of the spectral level distribution are approximately 86, 94 and 100 dB re 1µPa. For the 125 Hz frequency band, the 10th, 50th and 90th percentiles of the spectral level distribution are approximately 80, 86 and 94 dB re 1µPa.
- With consideration of the corresponding 1/3 octave frequency bandwidths, the 50th percentiles of the spectral level distributions of the two deployment sites for both 63 Hz and 125 Hz are comparable with the noise spectra of heavy traffic noise within the generic ocean ambient noise spectra as in Figure 19. The levels at Gozo site are relatively higher due to the higher heavy traffic offshore north of Malta.

» Higher spectral levels at 2 kHz and 5 kHz were recorded at the two deployment sites compared with the generic ocean ambient noise spectra as in Figure 14. This is predominantly due to the close proximity from the deployment sites to the shipping lanes, with higher noise contribution from the shipping noise at higher frequency range.



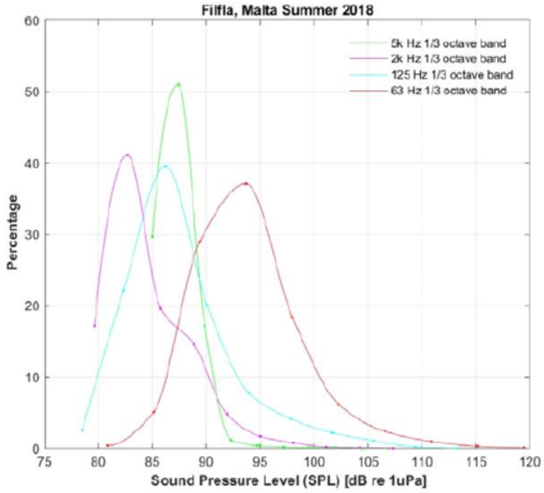


Figure 19: Spectral histogram analysis at 63 Hz, 125 Hz, 2 kHz and 5 kHz in 1/3 octave bands for Gozo (left) and Malta (right) monitoring locations

6.0 Impact Assessment

6.1 Onshore Construction Phase Noise Effects

It is inevitable with any project of this nature that some disturbance would be caused to those living and working nearby during the works should appropriate mitigation not be employed. However, it should be kept in mind that disruption due to construction is a localised phenomenon and temporary.

The sound predictions for the construction assessment have been based on the information provided by the Identification of Construction, Operation and Maintenance Methodology Report[12] and the software-based noise model, CadnaA®, which implements the full range of UK calculation methods. The calculation algorithms set out in BS5228-1:2009+A1:2014 have been used and the model assumes:

- a ground absorption factor of 0.75;
- a reflection factor of 2; and
- a daytime receiver height of 1.5m.

It is understood that there are four distinctive phases during the Delimara Terminal Plant construction, and each will be evaluated individually:

- Phase 1: Access Road Construction;
- Phase 2: Land Reclamation;
- Phase 3: Onshore landing approach in Malta; and
- Phase 4: Plant construction.

6.1.1 Noise Prediction

Table 38 presents each construction unit sound power levels to be used in each identified phase of the construction and associated on-time percentage of the total working daytime (in this instance the assumed overall working daytime of 12 hours). This data has been used to predicted likely noise emmission levels at the identified noise sensitive receptors.

The calculation has been undertaken using the proprietary noise modelling software CadnaA®, which incorporates the methodology of BS5228-1:2009+A1:2014. The noise model assumes hard ground and applies the screening effect of barriers (at 500Hz) from Figure F.3 of the standard.

During the construction phases, it is assumed that the majority of plant would be operating at ground level. However, during the construction works for the foundations and buildings it has been assumed that some plant would be operating at height (i.e. tower crane) and a height of 20m above ground level has been assumed. The location of the plant during each phase has been positioned throughout the site; at times, plant would be closer or further away depending on the stage of construction.

[12] *Report reference DOC. 00-RT-E-0131 version dated 19/07/2019*

Based on the ABC methodology, it has been assumed that the construction works will be operational during daytime only and between 07:00 am to 19:00 hours.

Note that although the information of the likely construction units and overall construction time to each phase have been made available, there is no schematics detail of the time-utilisation of each unit per construction stage and therefore, to predict the construction noise impact upon the identified NSR, the percentage of operational on-time of each unit has been based on data from other similar projects and the sound power level of each identified unit has been extracted from the BS5228-1:2009+A1:2014 guidelines.

The following table presents the used values in the noise contour propagation mapping. The related CadnaA maps have been included in Figure *20* to Figure 23.

Table 38: Construction Plant Details

Operation	Plant	Sound power level L_{wa} dB(a)	Number of plants
Phase 1	Compressor	113	1
	Crawler excavator	110	2
	Wheel loader	103	1
	Bobcat loader	110	1
	Crane	105	1
	3 axes truck	108	2
	Pneumatic breaker	115	1
	Grader	110	1
	Dozer	110	1
	Vibratory roller	106	1
Phase 2	Telescopic crawler	110	1
	3 axes truck	108	2
	Crawler excavator	110	2
	Wheel loader	103	1
	Bobcat loader	110	1
	Pneumatic breaker	115	1
Phase 3	Compressor	113	1
	Crawler excavator	110	1
	Drilling rig	106	1
	Wheel loader	103	1
	Bobcat loader	110	1
	Crane	105	1
	3 axes truck	108	2
	Generator	95	2
	Vibratory piling/drill	108	1
	Water/mud pump	112	2
Phase 4	Compressor	113	1
	Crawler excavator	110	2
	Wheel loader	103	1
	Bobcat loader	110	1
	Crane	105	1
	3 axes truck	108	2
	Grader	110	1
	Dozer	110	1

6.1.2 Predicted Noise Levels and Assessment

With reference to the methodology above, the predicted noise levels for each phase of construction at the identified closest receptors are presented in Table 39. The predicted noise levels have been rounded to the nearest decibel (dB).

Table 39: Predicted Construction Noise Levels, dB

Location	Construction phase	Predicted noise level, DB L_{AEQ}	BS5228-1:2009+A1:2014 compared to the 65 DB L_{AEQ} criterion
NSR 01	Phase 1	30	-26
	Phase 2	34	-31
	Phase 3	45	-20
	Phase 4	39	-26
NSR 02	Phase 1	43	-22
	Phase 2	36	-29
	Phase 3	46	-19
	Phase 4	41	-24
NSR 03	Phase 1	48	-17
	Phase 2	41	-24
	Phase 3	51	-14
	Phase 4	45	-20
NSR 04	Phase 1	50	-15
	Phase 2	41	-24
	Phase 3	52	-13
	Phase 4	46	-19
NSR 05	Phase 1	53	-12
	Phase 2	52	-13
	Phase 3	61	-4
	Phase 4	55	-10
NSR 06	Phase 1	50	-15
	Phase 2	50	-15
	Phase 3	61	-4
	Phase 4	55	-10
NSR 07	Phase 1	46	-19
	Phase 2	44	-21
	Phase 3	54	-11
	Phase 4	48	-17
NSR 08	Phase 1	42	-23
	Phase 2	38	-27
	Phase 3	48	-17
	Phase 4	42	-23

The predicted construction noise levels for the above identified closest receptors have been assessed against an external daytime noise limit of 65dB L_{Aeq} which has been determined from the measured ambient sound level at each location and the ABC method presented in BS5228-1:2009+A1:2014, as outlined in Table 17. The predicted construction work noise does not exceed the set threshold as defined in BS5228-1:2009+A1:2014 at any of the identified noise sensitive receptors.

Figure 20: Construction Phase 1 – access construction road (all values in dB)

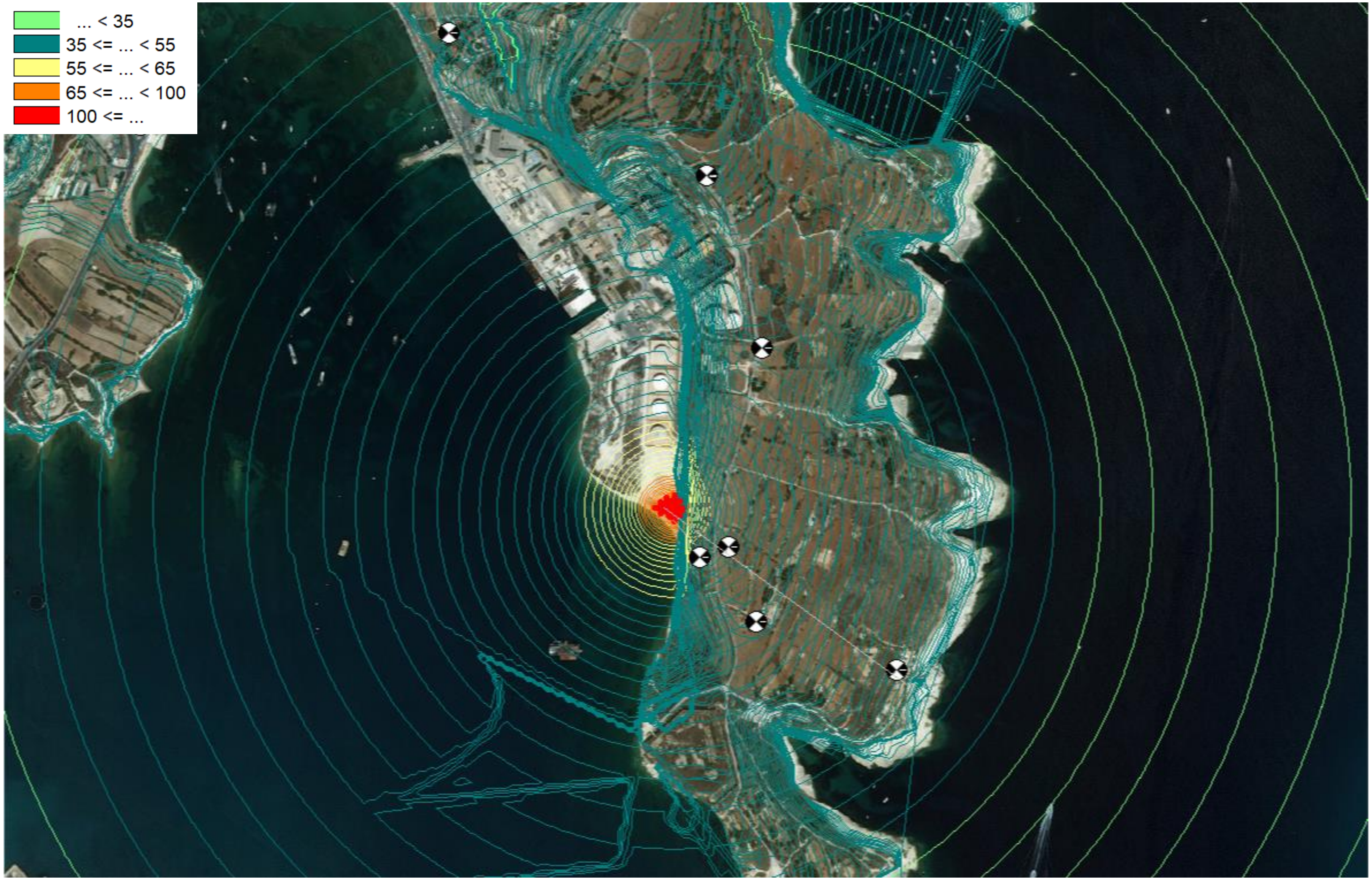


Figure 21: Construction Phase 2 – land reclamation (all values in dB)

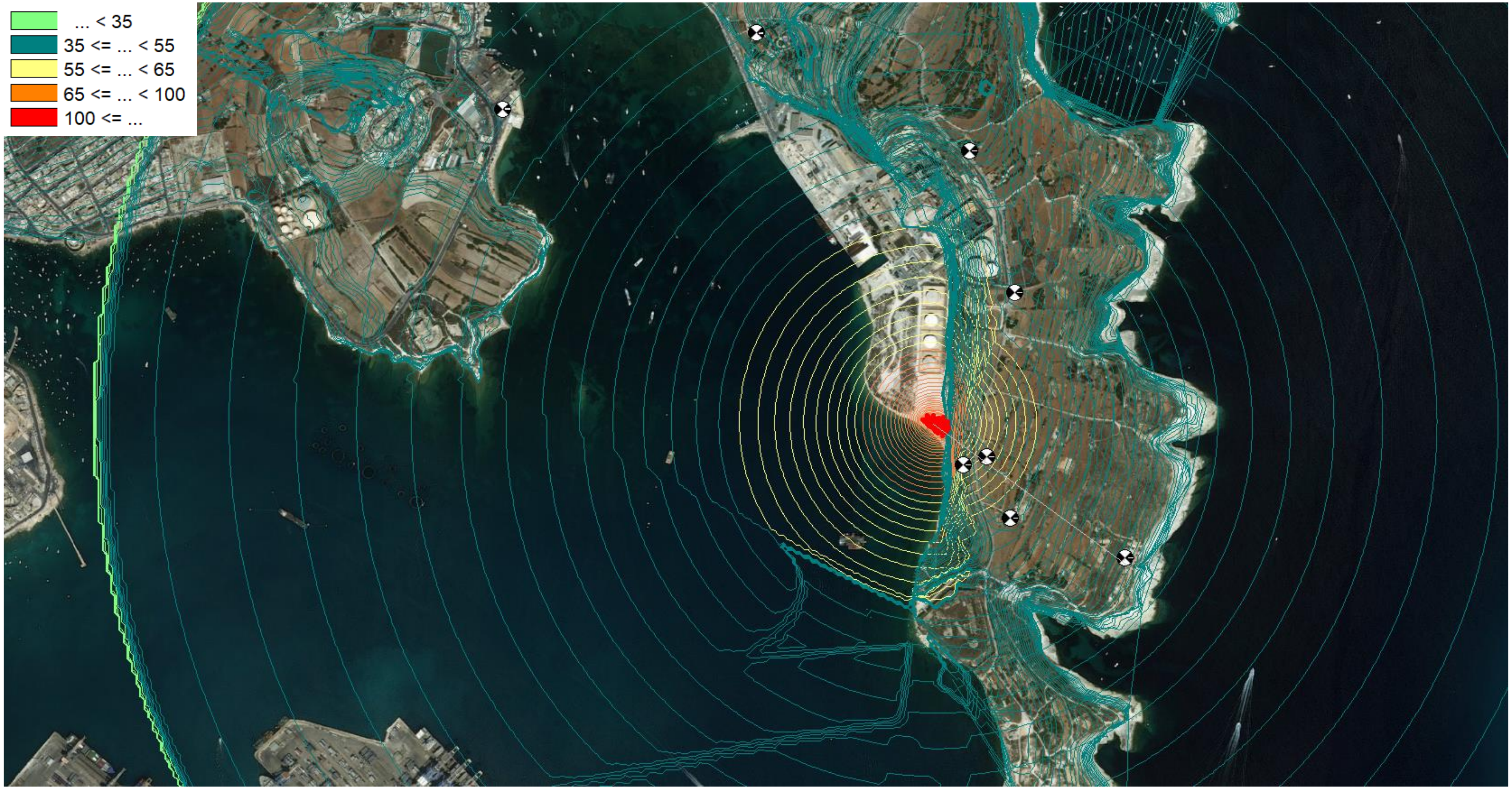


Figure 22: Construction Phase 3 – onshore landing approach (all values in dB)

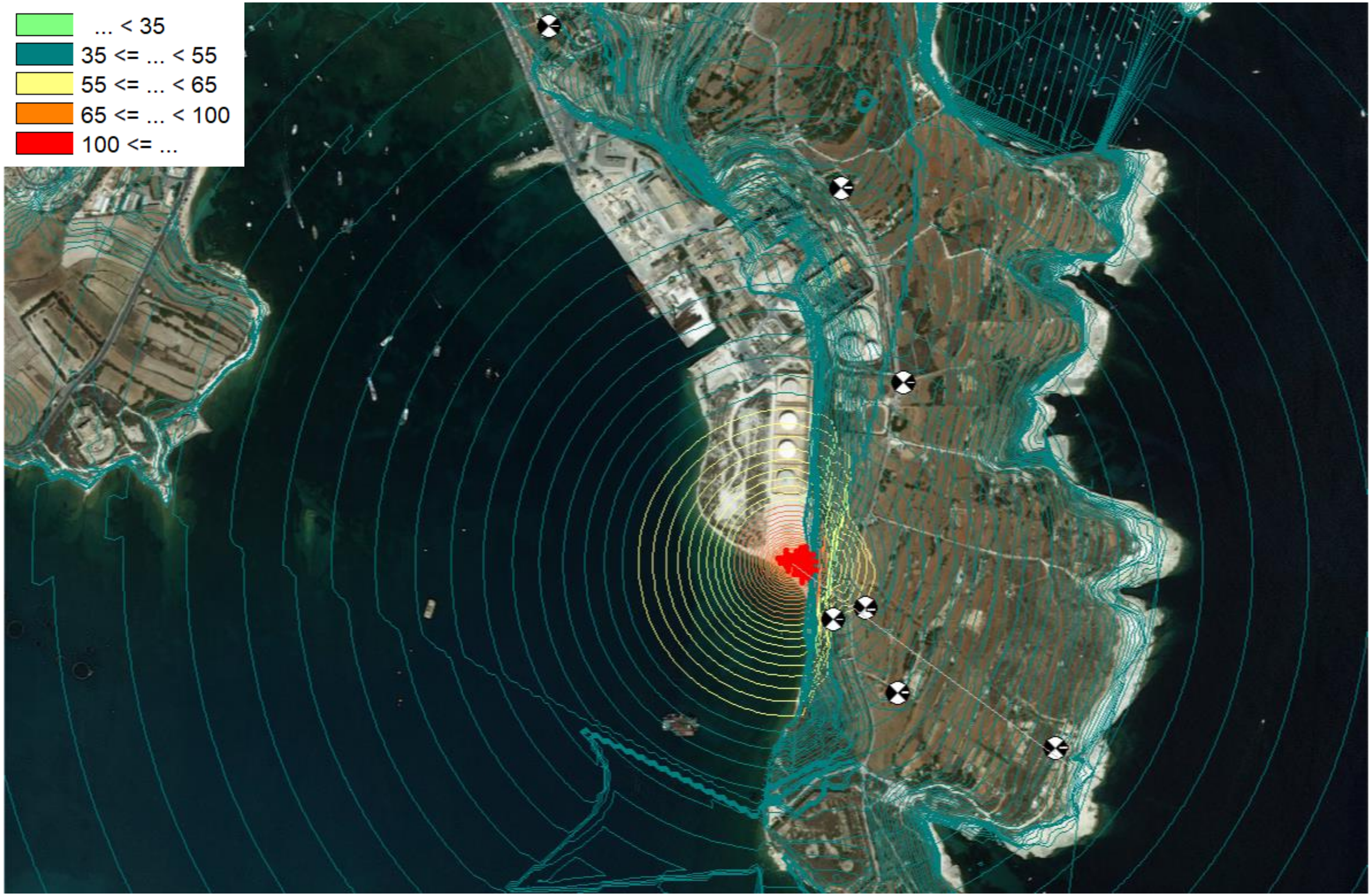


Figure 23: Construction Phase 4 – plant construction (all values in dB)

6.1.3 AQTAG9 - Construction Noise Assessment

The assessment of the noise impact in relation to the proposed development has been undertaken with reference to AQTAG09, whereby the predicted levels associated with the operational mobile plant are compared to the AQTAG09 noise level of 55dB $L_{Aeq,1hr}$ and assessed accordingly. The predicted noise levels at the surrounding areas have been calculated based on the CAdnaA noise propagation mapping.

Table 40 presents the predicted approximated distance from each of the designated area at which the noise immission levels would comply with the 55dB $L_{Aeq,1hr}$ criterion during the construction phase.

Table 40: Predicted Minimum Distance to Comply with AQTAG9 - LAeq,1hr 55 dB

Construction phase	Cardinal direction			
	North	**South**	**East**	**West**
Phase 1	215m	158m	117m	250m
Phase 2	140m	155m	66m	151m
Phase 3	445m	328m	215m	443m
Phase 4	249m	245m	125m	258m

Note that the values shown above are indicative only and that the significance of impact on the local habitat would need to be evaluated by an ecologist or other related expert. This aspect will be covered in the Ecology technical study and the coordinated assessment. However, saying that, it is understood that the nearest Natural Park Reserve (Xrobb l-Għaġin) is located circa 1km to the north-east direction, which is understood to be a substantial distance from the designated construction areas.

The vibration aspect during construction is considered not significant as will be mostly carried out underground.

6.2 Underwater Modelling Results and Zones of Impact Estimates

It should be noted that this modelling study is undertaken without detailed specifications of relevant equipment to be used for major noise-generating activities assessed. It is therefore recommended that a brief review of detailed specifications to be undertaken for major noise-generating equipment to be used once they are available, as well as comparing them with reference equipment specifications used in this study. Characterization of the source noise emissions and noise model validations via field measurements are also recommended to be considered if deemed practicable.

It is also recommended that this underwater noise study is considered in conjunction with detailed marine fauna ecological characteristics within the project area, with potential mitigation procedures and considerations to be investigated in line with ACCOBAMS guidelines.

The noise contour figures for all modelling scenarios except prelay sonar survey are presented in Figure 24 to Figure 29. The contour figures are the modelling results based on unweighted SEL source level inputs in dB re 1μPa²·S for non-impulsive noise of 1-second duration.

The weighted SEL modelling results for different marine mammal hearing groups are based on weighted SEL source level inputs which are derived by applying relevant auditory hearing functions as to the unweighted SEL source levels.

For cumulative SEL estimates, the following cumulative factor (*CF*) is applied, where T is the exposure duration:

$$CF = 10 \times \log10 (T)$$

For non-impulsive noise, it is assumed the root-mean-square sound pressure levels (RMS SPLs) are equivalent to be the sound exposure levels (SELs) of 1-second duration.

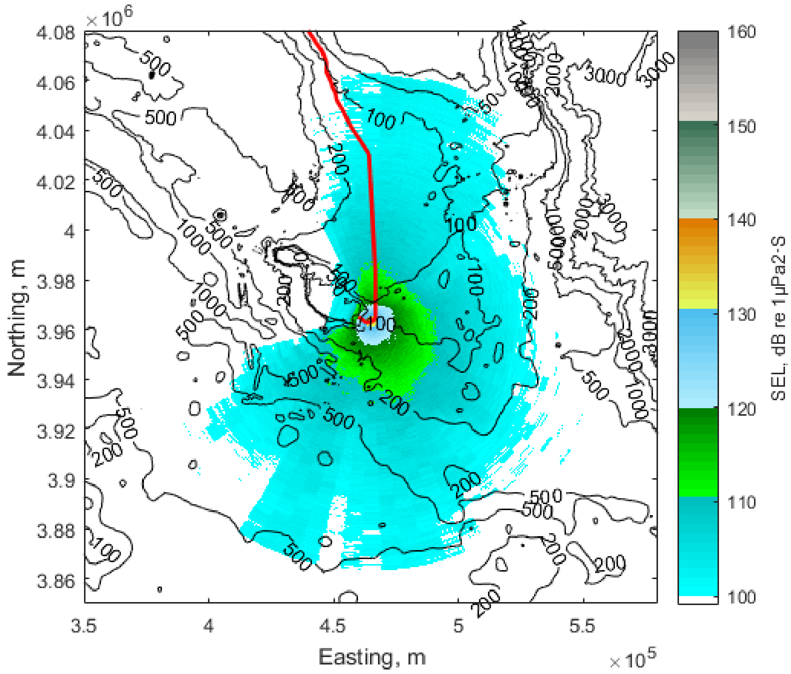


Figure 24: Modelled maximum SEL (maximum level across water column) contours for continuous CSD noise emission of 1-s duration from the source location L2 to a maximum range of 100 km, overlaying with bathymetry contour lines

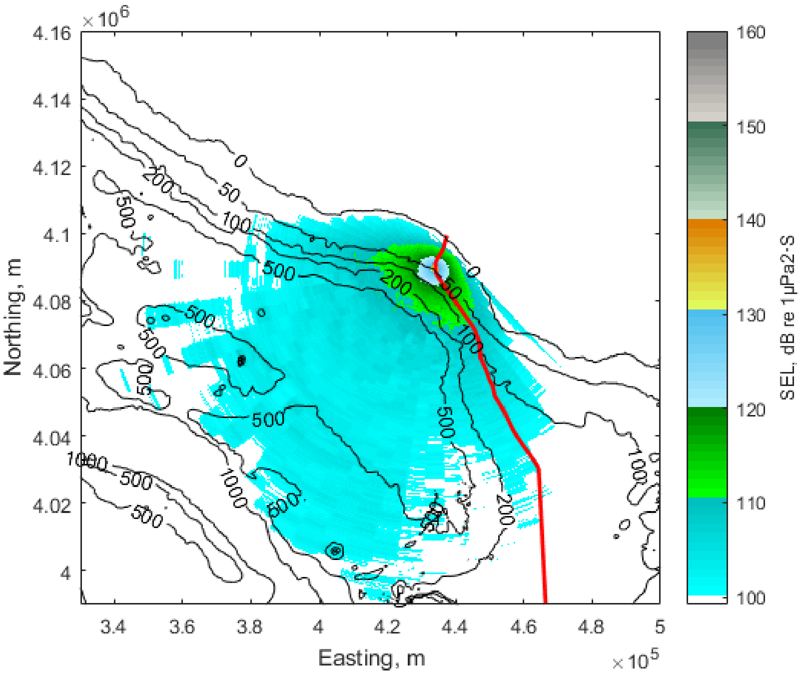


Figure 25: Modelled maximum SEL (maximum level across water column) contours for continuous BHD noise emission of 1-s duration from the source location L3 to a maximum range of 100 km, overlaying with bathymetry contour lines

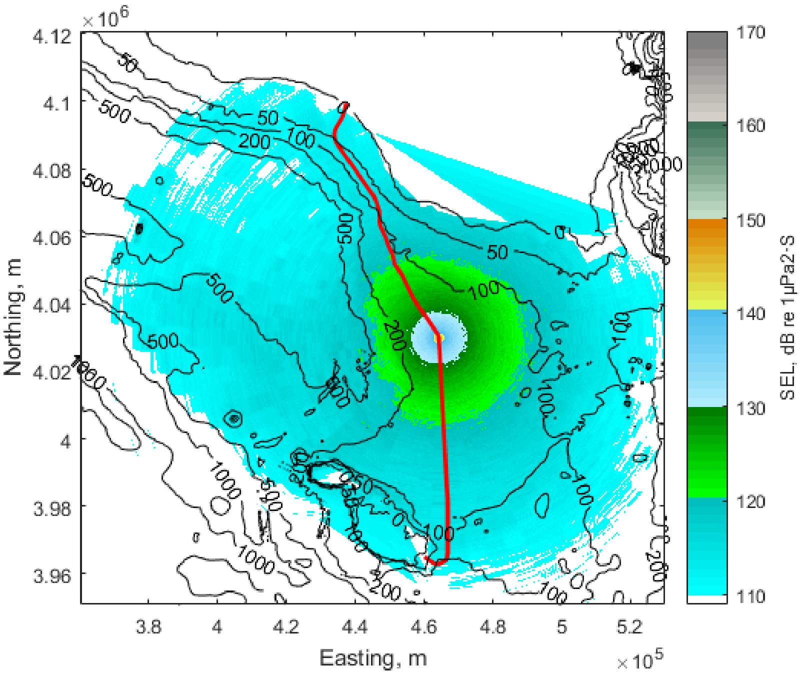


Figure 26: Modelled maximum SEL (maximum level across water column) contours for continuous PLB noise emission of 1-s duration from the source location L1 to a maximum range of 100 km, overlaying with bathymetry contour lines

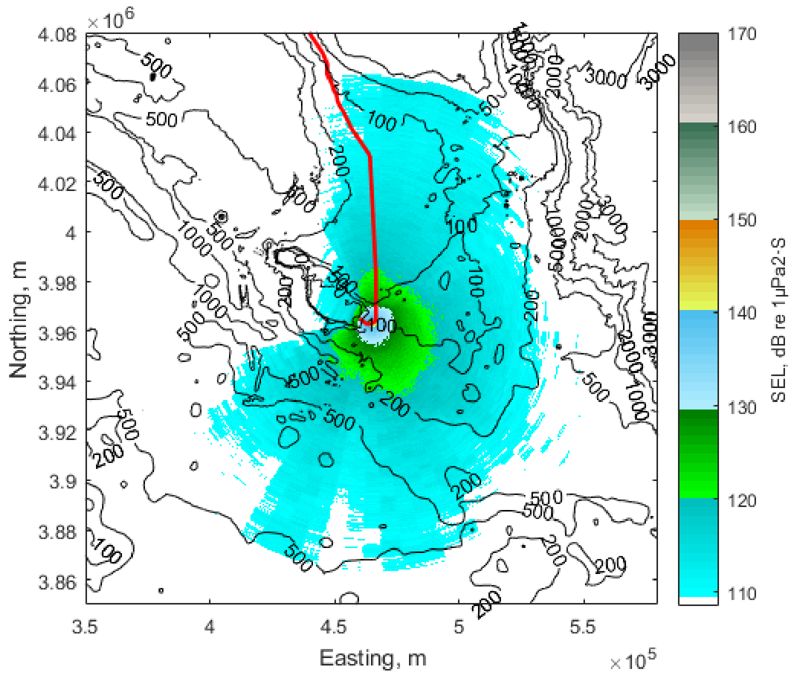


Figure 27: Modelled maximum SEL (maximum level across water column) contours for continuous PLB noise emission of 1-s duration from the source location L2 to a maximum range of 100 km, overlaying with bathymetry contour lines

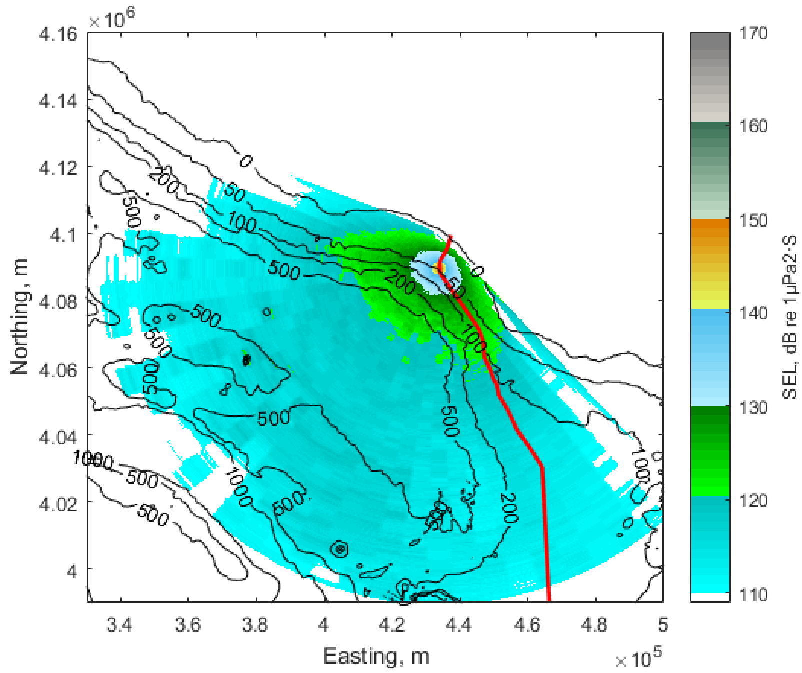


Figure 28: Modelled maximum SEL (maximum level across water column) contours for continuous PLB noise emission of 1-s duration from the source location L3 to a maximum range of 100 km, overlaying with bathymetry contour lines

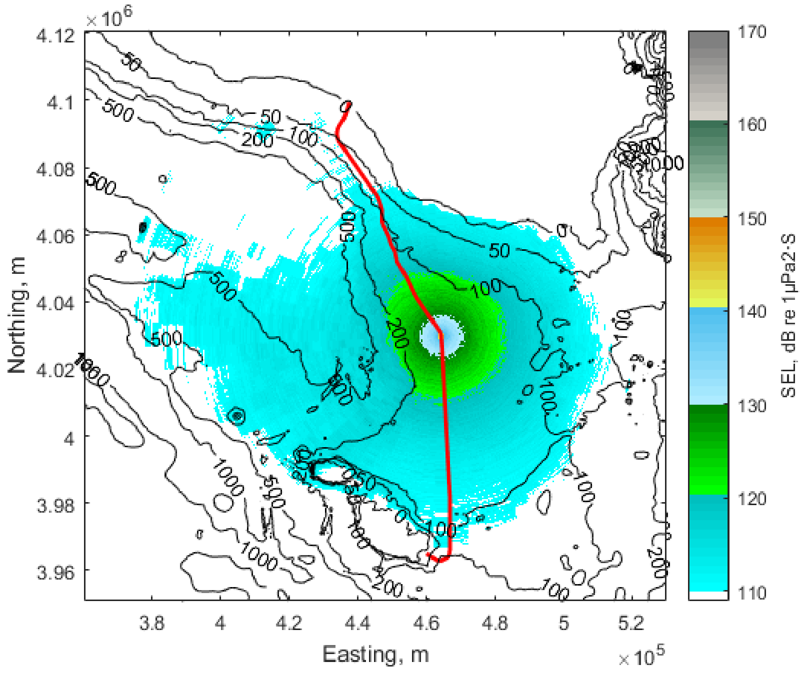


Figure 29: Modelled maximum SEL (maximum level across water column) contours for continuous AHT noise emission of 1-s duration from the source location L1 to a maximum range of 100 km, overlaying with bathymetry contour lines

Based on noise modelling prediction results and relevant post processing analysis as described above, the zones of impact for marine fauna species assessed from all modelling scenarios are detailed in the following section.

6.2.1 Estimated Zones of Impact

The predicted noise levels of all considered modelling scenarios were compared with relevant threshold criteria as listed in Section 4.3. The zones of different levels of noise impact for marine mammals and fish and sea turtle species were calculated and all results are presented in Table 41 to Table 46, including:

- Impact zones from pre-drilling sonar survey scenario with impulsive noise emissions shown in Table 41 and Table 42 regarding immediate impact from single sonar pulses;
- Impact zones from the construction and operation scenarios with non-impulsive noise emissions are shown in Table 43 and Table 44 regarding cumulative impact for marine mammals under two continuous exposure scenarios (i.e. 24-hour exposure and 0.5-hour exposure), and in Table 46 for fish and sea turtle species respectively. The modelling scenarios include the operation of five major noise generating activities as listed in Table 12, i.e. cutter suction dredger (CSD), backhoe dredger (BHD), pipe-lay barge (PLB), anchor handling tug (AHT) and offshore supporting vessel (OSV);
- Impact zones from the construction and operation scenarios as above in terms of behavioural disturbance for marine mammals are shown in Table 45;

6.2.1.1 Zones of Impact from Pre-Lay Sonar Survey Pulses

The Pk SPLs from sonar survey pulses, as can be seen from Table 41, are predicted to cause physiological impacts (both PTS on-set and TTS on-set) for the majority of marine mammal species directly adjacent to the sonar survey sources (<20 m), except very high-frequency cetaceans. Very high-frequency cetaceans have relatively larger zones of impact due to Pk SPLs, and are predicted to experience PTS-onset within 35 m from the sonar survey source, and TTS-onset within 70 m from the sonar survey source.

For fishes and sea turtle species, the Pk SPLs from sonar survey pulses may cause injury at locations directly adjacent to the sonar survey sources (<20 m), as indicated in Table 42.

It should be noted that the sonar survey sources are highly directional towards seabed, and it is expected much less energy propagates horizontally. Therefore, the zones estimated above are more in terms of vertical distances from the source location.

Table 41: Zones of immediate impact from single sonar survey pulses for PTS and TTS – marine mammals

Marine mammal hearing group	Zones of impact – Maximum horizontal distances from source to impact threshold levels			
	Injury (PTS) Onset		TTS Onset	
	Criteria - PK SPL, dB RE 1µPA	Maximum threshold distance, m	Criteria - PK SPL, dB RE 1µPA	Maximum threshold distance, m
Low-frequency cetaceans (LF)	219	10	213	10
High-frequency cetaceans (HF)	230	< 10	224	< 10
Very high-frequency cetaceans (VHF)	202	35	196	70
Sirenians (SI)	226	< 10	220	10
Phocid carnivores in water (PCW)	218	10	212	10
Other marine carnivores in water (OCW)	232	< 10	226	< 10

Table 42: Zones of immediate impact from single sonar survey pulses for mortality and recovery injury– fish, turtles, fish eggs and fish larvae

Marine mammal hearing group	Zones of impact – Maximum horizontal distances from source to impact threshold levels			
	Mortality and potential mortal injury		Recovery injury	
	Criteria - PK SPL, dB RE 1µPA	Maximum threshold distance, m	Criteria - PK SPL, dB RE 1µPA	Maximum threshold distance, m
Fish: no swim bladder (particle motion detection)	>213	10	>213	10
Fish: swim bladder is not involved in hearing (particle motion detection)	>207	20	>207	20

Fish: swim bladder involved in hearing (primarily pressure detection)	>207	20	>207	20
Sea turtles	>207	20	N/A	N/A
Fish eggs and fish larvae	>207	20	N/A	N/A

6.2.1.2 Zones of Impact from Non-Impulsive Construction and Operation Sources

Table 43 and Table 44 present the zones of cumulative impact based on SELs (SEL_{24hr}) from the individual major noise generating activity scenarios with non-impulsive noise emissions for marine mammals.

For the worst case consideration, i.e. the pipe laying operations are continuous and affected marine animals stay at the fixed location over the entire 24-hour period, LF cetaceans have the highest PTS-onset and TTS-onset impact zones among all marine mammal hearing groups, with the PTS-onset zone around 280 m and TTS-onset zone up to 7.0 km from the pipe-lay barge location.

However, considering that the average pipe laying is 4km per day in deep-water and around 2km per day in near shore areas a decreased exposure period to a more realistic 0.5h exposure scenario was analysed. With a decreased exposure period, the zones of impact will be reduced significantly. For example, for an exposure period of half an hour, the PTS-onset zone is predicted to be less than 20 m from the noise source for LF and VHF cetaceans, and TTS-onset zone within 400 m for the worst pipe-lay operation scenario. For marine mammals of other hearing groups, nearly no PTS-onset is predicted to occur due to such a short duration exposure.

As presented in Table 43, potential behavioural disturbance (based on RMS SPL which reflects an immediate effect) from the non-impulsive noise emissions is predicted to occur for marine mammals of all hearing groups up to 32.0 km from the pipe-lay barge operations and up to 24.0 km from the anchor handling tug operations. The backhoe dredger is predicted to cause the least behavioural disturbance among the five operation scenarios, with a maximum zone of impact up to 5.5 km from the barge operation locations.

The non-impulsive noise has low physiological impacts (both mortality and recovery injury) on fish and sea turtle species, as indicated in Table 46.

Table 43: Zones of cumulative impact from non-impulsive noise for PTS and TTS – marine mammals - 24 hours exposure duration

Marine mammal hearing group	**Zones of impact – Maximum horizontal distances from source to impact threshold levels**			
	Injury (PTS) onset		**TTS onset**	
	Criteria – weighted SEL_{24HR} dB RE 1 $PA^2 \cdot S$	**Maximum threshold distance, m**	**Criteria – weighted SEL_{24HR} dB RE 1 $PA^2 \cdot S$**	**Maximum threshold distance, m**
Low-frequency cetaceans (LF)	199	CSD: 40 BHD: 30 PLB: 280	179	CSD: 1,300 BHD: 800 PLB: 7,000

		AHT: 110 OSV: 15		AHT: 4,500 OSV: 350
High-frequency cetaceans (HF)	198	CSD: <10 BHD: N/A PLB: 10 AHT: <10 OSV: N/A	178	CSD: 15 BHD: 10 PLB: 150 AHT: 45 OSV: 10
Very high-frequency cetaceans (VHF)	173	CSD: 10 BHD: <10 PLB: 150 AHT: 35 OSV: 12	153	CSD: 200 BHD: 110 PLB: 5,000 AHT:1,000 OSV: 200
Sirenians (SI)	206	CSD: <10 BHD: N/A PLB: 10 AHT: <10 OSV: N/A	186	CSD: 15 BHD: 10 PLB: 120 AHT: 45 OSV: 10
Phocid carnivores in water (PCW)	201	CSD: 10 BHD: <10 PLB: 40 AHT: 25 OSV: <10	181	CSD: 200 BHD: 110 PLB: 1,200 AHT: 600 OSV: 60
Other marine carnivores in water (OCW)	219	CSD: N/A BHD: N/A PLB: <10 AHT: <10 OSV: N/A	199	CSD: 12 BHD: <10 PLB: 60 AHT: 30 OSV: <10

Table 44: Zones of cumulative impact from non-impulsive noise for PTS and TTS – marine mammals – 0.5 hours exposure duration

Marine mammal hearing group	**Zones of impact – Maximum horizontal distances from source to impact threshold levels**			
	Injury (PTS) onset		**TTS onset**	
	Criteria – weighted SEL_{24HR} dB RE 1 $PA^2 \cdot S$	**Maximum threshold distance, m**	**Criteria – weighted SEL_{24HR} dB RE 1 $PA^2 \cdot S$**	**Maximum threshold distance, m**
Low-frequency cetaceans (LF)	199	CSD: <10 BHD: <10 PLB: 18 AHT: 10 OSV: <10	179	CSD: 60 BHD: 45 PLB: 350 AHT: 200 OSV: 30
High-frequency cetaceans (HF)	198	CSD: N/A BHD: N/A PLB: N/A AHT: N/A	178	CSD: <10 BHD: N/A PLB: 15 AHT: <10

		OSV: N/A		OSV: <10
Very high-frequency cetaceans (VHF)	173	CSD: <10 BHD: N/A PLB: 15 AHT: <10 OSV: N/A	153	CSD: 15 BHD: 10 PLB: 280 AHT: 55 OSV: 10
Sirenians (SI)	206	CSD: N/A BHD: N/A PLB: N/A AHT: N/A OSV: N/A	186	CSD: <10 BHD: N/A PLB: 15 AHT: <10 OSV: <10
Phocid carnivores in water (PCW)	201	CSD: 15 BHD: N/A PLB: <10 AHT: <10 OSV: N/A	181	CSD: 15 BHD: 10 PLB: 60 AHT: 40 OSV: <10
Other marine carnivores in water (OCW)	219	CSD: N/A BHD: N/A PLB: N/A AHT: N/A OSV: N/A	199	CSD: <10 BHD: N/A PLB: <10 AHT: <10 OSV: N/A

Table 45: Zones of immediate impact from non-impulsive noise for behaviour disturbance – marine mammals

Animal type	**Zones of impact – maximum horizontal distances From source to impact threshold levels**	
	Behavioural disturbance	
	Criteria - RMS SPL, dB RE 1µpa	**Maximum threshold distance, m**
Marine mammals	120	CSD: 12,000 BHD: 5,500 PLB: 32,000 AHT: 24,000 OSV: 14,000

Table 46: Zones of cumulative impact from non-impulsive noise for mortality and recovery injury– fish, turtles, fish eggs and fish larvae

Animal type	**Zones of impact – maximum horizontal perpendicular distances from source to cumulative impact threshold levels**			
	Injury (PTS) onset		**TTS onset**	
	Criteria - SEL_{24hr} dB RE 1 µPA^2·s	**Maximum threshold distance, m**	**Criteria - SEL_{24hr} dB RE 1 µPA^2·s**	**Maximum threshold distance, m**
Fish: no swim bladder (particle motion detection)	N/A	N/A	N/A	N/A

Fish: swim bladder is not involved in hearing (particle motion detection)	N/A	N/A	N/A	N/A
Fish: swim bladder involved in hearing (primarily pressure detection)	N/A	N/A	170 dB rms for 48h	CSD: <10 BHD: <10 PLB: 15 AHT: 10 OSV: <10
Sea turtles	N/A	N/A	N/A	N/A
Fish eggs and fish larvae	N/A	N/A	N/A	N/A

6.2.2 Underwater Noise Impact Assessment

This section provides assessment of potential adverse noise impacts from major noise generating activities associated with the construction and operation of the proposed gas pipeline development, to marine fauna species of concern including marine mammals and fishes and sea turtles.

The in-principle assessment is carried out based on the zones of impact estimates for generic marine mammals and fishes and sea turtles as detailed above, with the maximum zones of estimate among all assessed scenarios summarised as Table 47. The zones of impact should be considered in conjunction with detailed information regarding the ecological characteristics of any specific marine fauna species of concern.

Table 47: Summary of the maximum zones of impact among all modelling scenarios assessed

Marine mammals	**Maximum threshold distances, m**		
Construction and operation activities	**PTS onset**	**TTS onset**	**Behaviour disturbance**
Pre-drilling	35	70	N/A
Non-impulsive noise – immediate impact	N/A	N/A	32,000 (PLB)
Non-impulsive noise – cumulative (24hr)	280 (PLB)	7,000 (PLB)	N/A
Non-impulsive noise – cumulative (0.5hr)	<20 (PLB)	350 (PLB)	
Fish & turtles	**Maximum threshold distances, m**		
Construction and operation activities	**Mortality and potential mortal injury**	**Recovery injury**	**TTS**
Pre-drilling	20	20	N/A
Non-impulsive – cumulative	N/A	15 for 48h (PLB)	40 for 48h (PLB)

6.2.2.1 Marine Mammals

For general marine mammal species, low physiological impact, particularly the PTS impact, is predicted from impulsive pre-drilling sonar survey considering the survey source locations are right above the seabed.

Among all identified non-impulsive noise emissions during construction and operation of the pipeline development, the pipe-lay barge operation is predicted to have the highest noise impact, particularly for low-frequency cetaceans. The extent of the impact is highly dependent on the exposure durations. For the worst case 24-hour exposure duration, the threshold distances for PTS and TTS onset for low-frequency cetaceans are predicted to be up to 280 m and 7.0 km from the pipe-lay barge operation location respectively. For exposure duration of 0.5 hrs, the impact extents are predicted to be significantly lower, with threshold distances for PTS and TTS onset less than 20 m and 350 m from the operation location respectively.

The pipe-lay barge operation is also predicted to cause the highest impact on behavioural disturbance (immediate effect) for all marine mammal species, with the threshold distance estimated to be up to 32 km from the barge operation location.

6.2.2.2 Fishes and Sea Turtles

For general fish species and sea turtles, low physiological impact is predicted from both impulsive pre-drilling sonar survey noise and non-impulsive noise emissions associated with construction and operation activities. Therefore, the overall adverse impact on fish species and sea turtles from the noise emissions from pipeline development are expected to be low.

6.3 Construction Phase Vibration Effects

The indicative impact of construction vibration upon residential receptors has been assessed in accordance with BS5228-2:2009+A1:2014. Table B.1 of the standard provides guidance on the effects of vibration.

The main construction source identified as potential to give rise to adverse vibration transfer effect is the drilling to be implemented at onshore landing operational area. However, it is understood that the drilling method to be implemented will be for a short duration and carried out with microtunneling, which is performed using rotary action drills and is not considered to be driven or vibratory.

The resultant predicted PPV at the nearest residential receptors is shown in Table 48.

Table 48: Predicted Construction Vibration Transfer

Location	Likely distance to the onshore drilling entrance site	PPV Vibration level (mms^{-1})
NSR 01	1290 m (and across the bay)	Distance too large to apply any empiric calculation.
NSR 02	1030 m	Distance too large to apply any empiric calculation.
NSR 03	660 m	0.04
NSR 04	364 m	0.08
NSR 05	130 m	0.32

NSR 06	150 m	0.27
NSR 07	282 m	0.12
NSR 08	550 m	0.05

The maximum predicted vibration level is 0.32mms^{-1} at NSR05 based on the assumption of microtunneling[13] being implemented at the onshore landing operational area.

The predicted vibration levels are assessed against the guidance on effects of vibration levels from Table 7 which are taken from Table B.1 of BS5228-2:2009+A1:2014. The maximum predicted PPV value of 0.32mms^{-1} is close to the vibration level of 0.3mms^{-1} which states that: *Vibration might be just perceptible in residential environments.* Therefore, a significant vibration effect is unlikely to occur during the microtunneling at the onshore landing operational area and no mitigation would be required.

It should be noted that results based on any of the suggested empirical equations given by the BS5228-2 2009+A1:2014, are an indication only, as the vibration effect along the ground is directly related to local ground characteristics and certainty of the likely vibration transfer with distance is only obtainable with an onsite vibration survey.

6.4 Operational Phase Noise Effects – BS4142:2014 Evaluation

The operational noise impact assessment is based on the plant schematics[14] and the provided noise levels of the proposed units. Note that the information has been provided with the broadband sound pressure levels at 1m from source and for modelling purposes it has been converted to sound power level (SWL), with the point source attenuation with distance algorithm; 10log $\frac{2}{4x\pi x r^{2}}$, (in this instance, distance r is 1m from source).

It is understood that all units are operational all day and during all days of the week, i.e. 24/7, therefore the characteristics of the sound generated within the plant is likely to be constant and part of the background noise environment once the plant is completed and running.

Table 49: Operational Units Sound Pressure Levels (re 20µ Pa)

Plant Unit ID	**Sound level @ 1m, dB(A) L_p**
Control Valves	85
Filters	60
Pumps	85
NVCC	80
Heaters	60
Transformer	55

The predicted immission levels at the identified NSR are presented in Table 50. The predicted immission levels have been rated with an additional 10dB to account for any tonal

[13] *Tunnelling vibration prediction Vres=180/distance$^{1.3}$*

[14] *Techfem, sps General Layout Drawing Doc no 40-DT-D-5570 revision 5 dated 19/07/2019*

and any other unpredicted characteristics, and also accommodating the frequency analysis of the sound immission that at this stage is not available.

The third column shows the existing background level L_{A90},t dB, followed by the BS4142:2014+A1:2019 assessment results summary and significance. There is no residual ambient noise as the plant is not yet operational, and therefore, the rated noise level has been directly compared to the prevailing background ambient noise as shown below.

Because the plant runs all day and every day, the assessment is based on the recorded prevailing lower level (daytime and/or night-time) of each designated study area.

Table 50: Predicted Operational Noise Levels, dB

NSR ID	Predicted rated level, dB L_{Ar}	Prevailing lower $L_{A90,t}$ dB of related area	BS4142 assessment	Significance effect
NSR 01	29	51	-22	No change in prevailing ambient noise, no adverse impact
NSR 02	31	45	-14	No change in prevailing ambient noise, no adverse impact
NSR 03	35	50	-15	No change in prevailing ambient noise, no adverse impact
NSR 04	36	47	-11	No change in prevailing ambient noise, no adverse impact
NSR 05	44	47	-3	No change in prevailing ambient noise, no adverse impact
NSR 06	41	47	-6	No change in prevailing ambient noise, no adverse impact
NSR 07	31	47	-16	No change in prevailing ambient noise, no adverse impact
NSR 08	24	47	-23	No change in prevailing ambient noise, no adverse impact

The above summary of results indicates that once the plant construction is completed and operational it is unlikely that it would generate an adverse noise impact upon the identified receptors, and therefore no further evaluation is necessary.

6.4.1 AQTAG9 - Operational Noise Assessment

The $LAeq,_{1r}$ 55dB criterion is predicted to comply with an arc of circa 128m radius distance from the site’s north, west and south border’ direction. The eastern direction would comply with the set criterion at approx. 35m from the plant east side border, i.e. a much shorter distance, due to the site’s topographic characteristics.

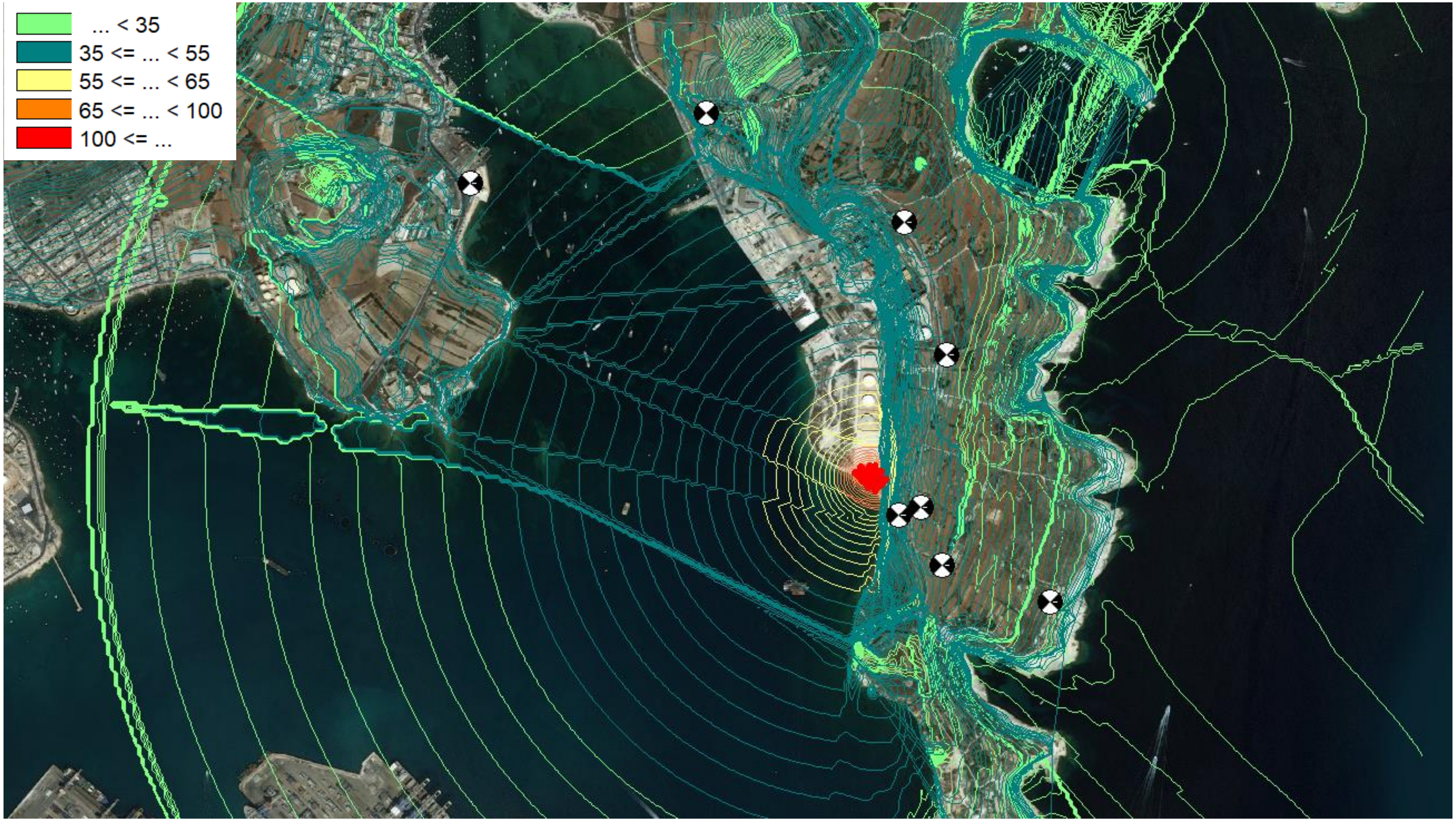


Figure 30: Operational Plant Noise Propagation

6.5 Exterior lighting

During the construction phase, exterior lighting will be necessary during night-time works whenever necessary in both onshore and offshore areas. Although the exterior lighting for the onshore construction site can be switched off when no works are underway, lay-barges will need to remain lit at night at all times for safe nautical navigation. Wherever reasonably feasible, night-time barge lighting on vessels located in SPAs should be limited to down-facing lights or red lighting to limit the effect on birds.

During the operational phase, onshore lighting will be introduced to an area which is currently unlit. Nevertheless, the area for the Terminal Plant is already affected by the night-time lighting from the abutting Power Station, so only minor additional impacts on surrounding receptors are envisaged. Offshore lighting will only be necessary during the operational phase for maintenance being carried out at night. Night-time works should therefore be limited in SPAs whenever reasonably possible.

6.6 Mitigation Measures

6.6.1 Construction Noise

For all activities, measures will be taken to reduce noise levels as stipulated in Schedule IV of the Environmental Management Construction Site Regulations, 2007 (L.N. 295 of 2007).

BS5228-1:2009+A1:2014 states that the 'attitude of the contractor' is important in minimising the likelihood of complaints and therefore consultation with the local authority and Community Liaison Group should occur along with letter drops to inform residents of intended activity. Non-acoustic factors, which influence the overall level of complaints such as mud on roads and dust generation, will also be controlled.

Furthermore, the following noise mitigation options will be implemented where appropriate:

- Consideration will be given to noise emissions when selecting plant and equipment to be used on site;
- All equipment should be maintained in good working order and fitted with the appropriate silencers, mufflers or acoustic covers where applicable;
- Stationary noise sources will be sited as far away as reasonably possible from residential properties and where necessary and appropriate, acoustic barriers will be used to screen them; and
- The movement of vehicles to and from the site will be controlled and employees will be instructed to ensure compliance with the noise control measures adopted.

There are many strategies to reduce construction noise by the limitation of activities that would result in predicted noise levels being lower than the specified target. Any such measures should be considered adequate and the mitigation adopted should not be limited to the measures proposed.

6.6.2 Construction Vibration

No significant vibration impacts are anticipated to be created by the construction phase of the Proposed Development. Vibration during construction operations is unlikely to be perceptible at most of the nearby vibration-sensitive receptors due to their distance from the site.

6.6.3 Exterior lighting

During the construction phase, night-time barge lighting on vessels located in SPAs should be limited to down-facing lights or red lighting to limit the effect on birds. This should be implemented wherever reasonably possible, taking into consideration health and safety practices.

During the operational phase, onshore lighting should be limited to down-facing lights. Night-time offshore works should therefore be limited in SPAs whenever reasonably possible.

6.7 Residual Impacts

6.7.1 Onshore construction Noise

From the BS5228-1:2009+A1:2014 predicted assessment results, the noise associated with the onshore construction is not likely to generate an adverse impact and therefore no residual effect is foreseen at this stage.

6.7.2 AQTAG - Construction Noise

The predicted noise impact upon the wildlife during the construction phases has been evaluated based on the distance that is likely to achieve the precautionary $L_{Aeq,1hr}$ 55dB limit. The maximum distance from the construction activities to which the $L_{Aeq,1hr}$ 55dB limit extends is approximately 445m to the north and west of the construction areas. It is understood that the nearest Natural Park Reserve (Xrobb l-Għaġin) is located circa 1km to the north-east direction beyond the designated construction areas. The construction noise is not likely to generate an adverse impact on the wildlife and therefore no residual effect is foreseen at this stage.

6.7.3 Construction Vibration

No significant vibration impacts are anticipated to be created by the construction phase of the Proposed Development. The construction vibration is not likely to generate an adverse impact and therefore no residual effect is foreseen at this stage.

6.7.4 AQTAG - Construction Vibration

The construction vibration is not likely to generate an adverse impact on the wildlife and therefore no residual effect is foreseen at this stage.

6.7.5 Operational Noise

According to the BS4142:2014 predicted assessment results, the operational noise is not likely to generate an adverse impact and therefore no residual effect is foreseen at this stage.

6.7.6 AQTAG - Operational Noise

The predicted noise impact upon the wildlife once the proposed development is operation, has been evaluated based on the minimum distance that is likely to achieve the precautionary $L_{Aeq,1hr}$ 55dB level, i.e. circa 128m to the north, south and west directions and

35m to the east. It is believed that the identified Special Protected Areas are located at a considerable further distance from the plant and once the plant is operational it would be unlike to generate an adverse impact, and therefore, no residual effect is foreseen at this stage.

6.7.7 Exterior lighting

Minimal residual impacts are envisaged.

7.0 Conclusion

The proposed development has been evaluated in relation to its construction and operational phases. There are four identified construction phases that will be carried out at separated areas and time.

- Phase 1 is assumed to be related to the road construction to access the proposed new development area;
- Phase 2 is assumed to be related to the land reclamation construction for the new plant;
- Phase 3 is assumed to be related to the onshore landing approach; and
- Phase 4 is the plant construction.

The predicted construction noise levels for the identified NSRs have been assessed against an external daytime noise limit of 65dB L_{Aeq} which has been determined from the measured ambient sound level at each location and the ABC method presented in BS5228-1:2009+A1:2014. The predicted construction work noise does not exceed the set threshold as defined in BS5228-1:2009+A1:2014 at all the identified noise sensitive receptors.

An operational noise assessment for the development has also been undertaken, with reference to BS4142:2014. The rating levels for the operational plant were predicted to be below the measured background sound level at all of the nearest noise sensitive receptors. Therefore, with reference to BS4142:2014, the operation of the plant at the proposed development would have a "low impact" at the nearest noise sensitive receptors to the site.

Further to this it should be noted that the gas pipeline will replace the use of the Floating Storage Unit (FSU) and the regasification station. Therefore, in the longer term, during the operational phase of the pipeline, this will lead to a beneficial impact by eliminating any noise and vibration from the operation of the FSU and the regasification station.

The potential for impact from the AQTAG assessment in relation to the local habitat has been evaluated in terms of minimum distance from the construction sites' boundary that would comply with the set sound level of $L_{Aeq,1hr}$ 55dB criterion. The predicted distance between the construction operations and the $L_{Aeq,1hr}$ 55dB criterion, is well within the distance of the nearest Natural Park Reserve.

Further to this, when the proposed development is operational, the predicted noise levels will comply with the set precautionary noise level criteria for the nearby NSR and natural habitat.

The detailed underwater noise modelling prediction and assessment results demonstrate that noise emissions from all identified construction and operation activities associated with the proposed pipeline development are predicted to have low physiological impact, particularly in regard to the PTS impact, for assessed marine fauna species. Among all identified activities, noise emissions from the pipe-laying barge operation are predicted to have the highest adverse noise impact, particularly for LF cetaceans.

Noise emissions from identified major noise-generating activities are recommended to be reviewed upon the availability of relevant detailed equipment specifications, along with possible source level characterisations and model validations via field measurements if deemed practicable. It is recommended that the study results are considered in conjunction with detailed marine fauna ecological characteristics, with possible practical mitigation measures to be investigated in line with ACCOBAMS guidelines.

7.1 Summary of Impacts table

Table 51: Summary of onshore noise and vibration construction impacts

Impact type and source				Impact receptor		Effect & Scale							Probability of impact occurring (Inevitable/ Likely/ Unlikely/ Remote/ Uncertain	Overall impact significance	Proposed mitigation measures	Residual impact significance	Other requirements
Impact type		**Specific intervention leading to impact**	**Project phase (construction/ operation/ de-commissioning)**	**Receptor type**	**Sensitivity & resilience toward impact**	**Direct/ Indirect/ Cumulative**	**Beneficial/ Adverse**	**Severity**	**Physical/ geographic extent of impact**	**Short-/ Medium-/ Long-term**	**Temporary (indicate duration)/ Permanent**	**Reversible (indicate ease of reversibility)/ Irreversible**					
Onshore Noise		Typical construction units such as trucks, diggers, etc	Construction access road	NSR and Avian	High	Direct	Adverse	Medium	Local	Short	Temporary	Reversible	Inevitable	No Change	Adoption of good practices during site works	N.A	N.A
		Typical construction units	Land reclamation	NSR and Avian	High	Direct	Adverse	Medium	Local	Short	Temporary	Irreversible	Uncertain	No Change		N.A.	N.A
		Typical construction units such as trucks, diggers, etc	Plant construction	NSR and Avian	High	Direct	Adverse	Medium	Local	Short	Temporary	Irreversible	Inevitable	No Change		N.A.	N.A
		Typical construction units such as trucks, diggers, etc.	Onshore landing	NSR and Avian	High	Direct	Adverse	Medium	Local	Short	Temporary	Reversible	Inevitable	No Change		N.A.	N.A
Underwater noise	Injury (PTS) onset	Pre-lay sonar surveys	Construction	Marine mammals	High	Direct	Adverse	High	Local	Short	Temporary	Irreversible	Unlikely	Minor		N.A	N.A
	TTS onset				Medium			Medium				Reversible					
	Mortality			Fishes and sea turtles	High			High				Irreversible	Likely			Minor and for a short time	
	Recovery injury/TTS				Medium			Medium				Reversible					
	Injury (PTS) onset	Cutter suction dredger (CSD)	Construction	Marine mammals	High	Cumulative	Adverse	High	Local	Short	Temporary	Irreversible	Unlikely	Minor		N.A	N.A
	TTS onset				Medium			Medium				Reversible	Likely	Minor /Moderate		Minor and for a short time	
	Behaviour disturbance				Low	Direct		Low	Maxi Zone Of 12 Km			Reversible	Likely				
	Mortality			Fishes and sea turtles	High	Cumulative		High	Local			Irreversible	Unlikely	Minor		N.A	
	Recovery injury/TTS				Medium			Medium	Local			Reversible					
	Masking/behaviour				Low	Direct		Low	Local			Reversible	Likely	Minor /Moderate		Minor and for a short time	
	Injury (PTS) onset	Backhoe dredger (BHD)	Construction	Marine mammals	High	Cumulative	Adverse	High	Local	Short	Temporary	Irreversible	Unlikely	Minor		N.A	N.A
	TTS onset				Medium			Medium				Reversible	Likely	Minor /Moderate		Minor and for a short time	
	Behaviour disturbance				Low	Direct		Low	Maxi Zone Of 5.5 Km			Reversible	Likely				
	Mortality			Fishes and sea turtles	High	Cumulative		High	Local			Irreversible	Unlikely	Minor		N.A	
	Recovery injury/TTS				Medium			Medium	Local			Reversible					

Impact type and source			Impact receptor		Effect & Scale											
Impact type	**Specific intervention leading to impact**	**Project phase (construction/ operation/ de-commissioning)**	**Receptor type**	**Sensitivity & resilience toward impact**	**Direct/ Indirect/ Cumulative**	**Beneficial/ Adverse**	**Severity**	**Physical/ geographic extent of impact**	**Short-/ Medium-/ Long-term**	**Temporary (indicate duration)/ Permanent**	**Reversible (indicate ease of reversibility))/ Irreversible**	**Probability of impact occurring (Inevitable/ Likely/ Unlikely/ Remote/ Uncertain**	**Overall impact significance**	**Proposed mitigation measures**	**Residual impact significance**	**Other requirements**
Masking/behaviour				Low	Direct		Low	Local			Reversible	Likely	Minor /Moderate		Minor and for a short time	
Injury (PTS) onset	Pipe-laying barge (PLB)	Construction	Marine mammals	High	Cumulative	Adverse	High	Local	Short	Temporary	Irreversible	Unlikely	Minor		N.A	N.A
TTS onset				Medium			Medium				Reversible	Likely	Minor /Moderate		Minor and for a short time	
Behaviour disturbance				Low	Direct		Low	Maxi Zone Of 32 Km			Reversible	Likely				
Mortality			Fishes and sea turtles	High	Cumulative		High	Local			Irreversible	Unlikely	Minor		N.A	
Recovery injury/TTS				Medium			Medium	Local			Reversible					
Masking/behaviour				Low	Direct		Low	Local			Reversible	Likely	Minor /Moderate		Minor and for a short time	
Injury (PTS) onset	Anchor handling tug (AHT)	Construction	Marine mammals	High	Cumulative	Adverse	High	Local	Short	Temporary	Irreversible	Unlikely	Minor	Adoption of good practices during site works	N.A	N.A
TTS onset				Medium			Medium				Reversible	Likely	Minor /Moderate		Minor and for a short time	
Behaviour disturbance				Low	Direct		Low	Maxi Zone Of 24 Km			Reversible	Likely				
Mortality			Fishes and sea turtles	High	Cumulative		High	Local			Irreversible	Unlikely	Minor		N.A	
Recovery injury/TTS				Medium			Medium	Local			Reversible					
Masking/behaviour				Low	Direct		Low	Local			Reversible	Likely	Minor /Moderate		Minor and for a short time	
Injury (PTS) onset	Offshore supporting barge/vessel (OSV)	Construction	Marine mammals	High	Cumulative	Adverse	High	Local	Short	Temporary	Irreversible	Unlikely	Minor		N.A	N.A
TTS onset				Medium			Medium				Reversible	Likely	Minor /Moderate		Minor and for a short time	
Behaviour disturbance				Low	Direct		Low	Maxi Zone Of 14 Km			Reversible	Likely				
Mortality			Fishes and sea turtles	High	Cumulative		High	Local			Irreversible	Unlikely	Minor		N.A	
Recovery injury/TTS				Medium			Medium	Local			Reversible					
Masking/behaviour				Low	Direct		Low	Local			Reversible	Likely	Minor /Moderate		Minor and for a short time	
Vibration	Pilling	Land reclamation	NSR and Avian	High	Direct	Adverse	Medium	Local	Short	Temporary	N.A.	Uncertain	Minor	Inform near NSR of activities.	Minor and for a short time	N.A

Impact type and source			Impact receptor		Effect & Scale							Probability of impact occurring (Inevitable/ Likely/ Unlikely/ Remote/ Uncertain	Overall impact significance	Proposed mitigation measures	Residual impact significance	Other requirements
Impact type	Specific intervention leading to impact	Project phase (construction/ operation/ de-commissioning)	Receptor type	Sensitivity & resilience toward impact	Direct/ Indirect/ Cumulative	Beneficial/ Adverse	Severity	Physical/ geographic extent of impact	Short-/ Medium-/ Long-term	Temporary (indicate duration)/ Permanent	Reversible (indicate ease of reversibility)/ Irreversible					
	Drilling of tunnel minimised by horizontal tunnelling system (carried out underground)	Onshore landing	NSR and Avian	High	Direct	Adverse	Medium	Local	Short	Temporary	N.A.	Uncertain	Minor	Inform near NSR of activities	Minor and for a short time	N.A
Light pollution and disorientation of avifauna	Exterior lighting	Construction	Residential areas and avifauna	Medium	Direct	Adverse	Low	Local	Short	Temporary	Reversible	Likely	Minor	Limit night-time works whenever reasonably possible, particularly in offshore SPAs	Negligible	N.A

Table 52: Summary of Operational impacts

Impact type and source			Impact receptor		Effect & Scale							Probability of impact occurring (Inevitable/ Likely/ Unlikely/ Remote/ Uncertain	Overall impact significance	Proposed mitigation measures	Residual impact significance	Other requirements
Impact type – Marine Noise	Specific intervention leading to impact	Project phase (construction / operation/ de-commissioning)	Receptor type	Sensitivity & resilience toward impact	Direct/ Indirect/ Cumulative	Beneficial / Adverse	Severity	Physical/ geographic extent of impact	Short-/ Medium -/ Long-term	Temporary (indicate duration)/ Permanent	Reversible (indicate ease of reversibility)/ Irreversible					
Injury (PTS) onset	Offshore supporting barge/vessel (OSV)	Construction/ maintenance operation	Marine mammals	High	Cumulative	Adverse	High	Local	Short	Temporary	Irreversible	Unlikely	Minor	Adoption of good practices during site works	N.A	N.A
TTS onset				Medium			Medium				Reversible	Likely	Minor /Moderate		Minor and for a short time	
Behaviour disturbance				Low	Direct		Low	Maxi Zone Of 14 Km			Reversible	Likely				
Mortality			Fishes and sea turtles	High	Cumulative		High	Local			Irreversible	Unlikely	Minor		N.A	
Recovery injury/TTS				Medium			Medium	Local			Reversible					
Masking/behaviour				Low	Direct		Low	Local			Reversible	Likely	Minor /Moderate		Minor and for a short time	

Impact type and source			Impact receptor		Effect & Scale											
Impact type – Marine Noise	**Specific intervention leading to impact**	**Project phase (construction / operation/ de-commissioning)**	**Receptor type**	**Sensitivity & resilience toward impact**	**Direct/ Indirect/ Cumulative**	**Beneficial / Adverse**	**Severity**	**Physical/ geographic extent of impact**	**Short-/ Medium -/ Long-term**	**Temporary (indicate duration)/ Permanent**	**Reversible (indicate ease of reversibility)/ Irreversible**	**Probability of impact occurring (Inevitable/ Likely/ Unlikely/ Remote/ Uncertain**	**Overall impact significance**	**Proposed mitigation measures**	**Residual impact significance**	**Other requirements**
No major noise sources are foreseen during operation	Plant operation	NSR and Avian	High	Direct	Beneficial For The Local Community	Medium	Up to 300m radius	Long	Constant Once Operational	Irreversible	Inevitable	Likely	Minor		N.A	
Light pollution and disorientation of avifauna	Plant operation and offshore maintenance	Operation	Residential areas and avifauna	Medium	Direct	Adverse	Low	Local	Short	Temporary	Reversible	Likely	Minor	Limit night-time works in offshore areas	Negligible	N.A

8.0 References

Antonov, J. I., Seidov, D., Boyer, T. P., Locarnini, R. A., Mishonov, A. V., Garcia, H. E., Baranova, O. K., Zweng, M. M., and Johnson, D. R., 2010, World Ocean Atlas 2009, Volume 2: Salinity. S. Levitus, Ed. NOAA Atlas NESDIS 69, U.S. Government Printing Office, Washington, D.C., 184 pp.

Blue Planet Marine (BPM), 2013, Final Report: July 2013 Survey – Monitoring Aquatic Ambient Noise and the Associated Pressure Impacts in Port Curtis and Port Alma – CA130043.

Central Dredging Association (CEDA), CEDA Position Paper: Underwater sound in relation to Dredging, Terra et Aqua, Number 125, December 2011.

Collins, M. D., 1993, A split-step Padé solution for the parabolic equation method, J. Acoust. Soc. Am., 93: 1736-1742.

De Caro, M., Fishing activities and marine traffic interaction assessment, Melita Transgas Pipeline – Project of Common Interest PCI 5.19, Ministry for Energy and Water Management, 29 March 2019, Contract N. CT 3108/2018, File: 171001-30-rs-e-2100_1.

Del Grosso, V. A., 1974, New equation for the speed of sound in natural waters (with comparisons to other equations), *J. Acoust. Soc. Am*. 56: 1084-1091.

De Filippi, G., Malta-Italy Gas Pipeline Interconnection Metocean Study, Lighthouse, February 2019, Job No. 5001MM-2018.

Dekeling, R. P. A., Tasker, M. L., Van der Graaf, A. J., Ainslie, M. A., Andersson, M. H., André, M., Borsani, J. F., Brensing, K., Castellote, M., Cronin, D., Dalen, J., Folegot, T., Leaper, R., Pajala, J., Redman, P., Robinson, S. P., Sigray, P., Sutton, G., Thomsen, F., Werner, S., Wittekind, D., Young, J. V., 2014, Monitoring Guidance for Underwater Noise in European Seas, Part II: Monitoring Guidance Specifications, JRC Scientific and Policy Report EUR 26555 EN, Publications Office of the European Union, Luxembourg, 2014b, doi: 10.2788/27158.

Finneran, J. J., 2015, Auditory weighting functions and TTS/PTS exposure functions for cetaceans and marine carnivores, San Diego: SSC Pacific.

Finneran, J. J., 2016, Auditory weighting functions and TTS/PTS exposure functions for marine mammals exposure to underwater noise, Technical Report, 49 pp.

GEBCO Compilation Group (2019) GEBCO 2019 Grid (doi:10.5285/836f016a-33be-6ddc-e053-6c86abc0788e).

Hamilton, E. L., 1980, Geoacoustic modelling of the sea floor, J. Acoust. Soc. Am. 68: 1313:1340.

Hannay, D., A. MacGillivray, M. Laurinolli, and R. Racca., 2004, Sakhalin Energy: Source Level Measurements from 2004 Acoustics Program, Version 1.5, Technical report prepared for Sakhalin Energy by JASCO Applied Sciences.

Hastings, M. C. and Popper, A. N., 2005, Effects of sound on fish, Sub consultants to Jones & Stokes Under California Department of Transportation Contract No. 43A0139 Report, 82 pp.

Hildebrand, A., 2009, Anthropogenic and natural sources of ambient noise in the ocean, Marine Ecology Progress Series, Vol 395:5-20.

Jensen, F. B., Kuperman, W. A., Porter, M. B. and Schmidt, H., 2011, Computational Ocean Acoustics, Springer-Verlag New York.

Jones, D. and Marten, K., 2016, Dredging sound levels, numerical modelling and EIA, Terra et Aqua, No. 144.

Locarnini, R. A., Mishonov, A. V., Antonov, J. I., Boyer, T. P., Garcia, H. E., Baranova, O. K., Zweng, M. M., and Johnson, D. R., 2010, World Ocean Atlas 2009, Volume 1: Temperature. S. Levitus, Ed. NOAA Atlas NESDIS 68, U.S. Government Printing Office, Washington, D.C., 184 pp.

Munk, W., Worcester, P., and Wunsch, C.: Ocean Acoustic Tomography, Cambridge University Press, 1995.

National Marine Fisheries Services (NMFS), 2016, Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing: Underwater Acoustics Thresholds for Onset of Permanent and Temporary Threshold Shifts. U.S. Administration, U.S. Department of Commerce, NOAA. NOAA Technical Memorandum NMFS-OPR-55. 178 pp.

National Marine Fisheries Service (NMFS), 2018, 2018 Revisions to: Technical guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0): Underwater Thresholds for Onset of Permanent and Temporary Threshold Shifts. U.S. Dept. of Commer., NOAA. NOAA Technical Memorandu, NMFS-OPR-59.

National Marine Fisheries Services (NMFS), 2013, Marine mammals: Interim Sound Threshold Guidance (webpage), National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce. http://www.westcoast.fisheries.noaa.gov/protected_species/marine_mammals/threshold_guidance.html.

Nedwell, J. R. and Edwards, B., A review of measurements of underwater man-made noise carried out by Subacoustech Ltd, 1993 – 2003, Subacoustech Report ref: 534R0109, 29 September 2004.

Popper A. N., Hawkins A. D., Fay R. R., Mann D. A., Bartol S., Carlson T. J., Coombs S., Ellison W. T., Gentry R. L., Halworsen M. B., Lokkeborg S., Rogers P. H., Southall B. L., Zeddies D. G. and Tavolga W. N., 2014, ASA S3/SC1.4 TR-2014 Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI.

Prampolini, M., Blondel, P., Foglini, F. and Madricardo, F., 2017, Habitat mapping of the Maltese continental shelf using acoustic textures and bathymetric analyses, Estuarine, Coastal and Shelf Science, 207, 483-498, doi:10.1016/j.ecss.2017.06.002.

QUIETMED – Joint programme on noise (D11) for the implementation of the Second Cycle of the MSFD in the Mediterranean Sea, Deliverable, D3.6 Detailed report on ambient noise measurements in Crete, Malta and Cabrera and the analysis of the measured data, 5th December, 2018, QUIETMED – D3.6.

Richardson W. J., Charles R. G. J., Charles I. M. and Denis H. T, 2013, Marine mammals and noise: Academic press.

Richardson W. J., Greene C. R. Jr., Malme C. I. and Thomson D. H., 1995, Marine Mammals and Noise, San Diego: Academic Press.

Salon, S., A. Crise, P. Picco., E. de Marinis., and O. Gasparini, 2003, Sound speed in the Mediterranean Sea: an analysis from a climatological data set, Annales Geophysicae, 21: 833–846,

Saunders, P. M. and Fofonoff, N. P., 1976, Conversion of pressure to depth in the ocean, Deep-Sea Res. 23: 109-111.

Southall, B., Bowles, A., Ellison, W., Finneran, J., Gentry, R., Greene, C. Jr., Kastak, D., Ketten, D., Miller, J., Nachtigall, P., Richardson, W., Thomas, J., Tyack, P., 2007, Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations. Aquatic Mammals, 33(4), 411-521.

Southall B. L., Finneran J. J., Reichmuth C., Nachtigall P. E., Ketten D. R., Bowles A. E., Ellison W. T., Nowacek D. P., Tyack P. L., 2019, Marine Mammal Noise Exposure Criteria: Updated Scientific Recommendations for Residual Hearing Effects. Aquatic Mammals 2019, 45(2), 125-232, DOI 10.1578/AM.45.2.2019.125.

Wenz, Gordon M., 1962, Acoustic ambient noise in the ocean: spectra and sources, The Journal of the Acoustical Society of America 34 (12): 1936-1956.

Wyatt, R., 2008, Review of existing data on underwater sounds produced by the oil and gas industry (Reported by Seiche Measurements Ltd): Joint Industry Program on Sound and Marine Life.

Appendix 1

Acoustic Terminology & Acronyms

Term	Definition
Sound Pressure	A deviation from the ambient hydrostatic pressure caused by a sound wave
Sound Pressure Level (SPL)	The logarithmic ratio of sound pressure to the reference pressure. The reference pressure underwater is P_{ref} = 1 μPa
Root-Mean-Square Sound Pressure Level (RMS SPL)	The mean-square sound pressure is the average of the squared pressure over the pulse duration. The root-mean-square sound pressure level is the logarithmic ratio of the root of the mean-square pressure to the reference pressure. Pulse duration is taken as the duration between the 5% and the 95% points on the cumulative energy curve
Peak Sound Pressure Level (Pk SPL)	The peak sound pressure level is the logarithmic ratio of the peak pressure over the impulsive signal event to the reference pressure
Peak-to-Peak Sound Pressure Level (Pk-Pk SPL)	The peak-to-peak sound pressure level is the logarithmic ratio of the difference between the maximum and minimum pressure over the impulsive signal event to the reference pressure
Sound Exposure Level (SEL)	SEL is a measure of energy. Specifically, it is the dB level of the time integral of the squared instantaneous sound pressure normalised to a 1-s period
Power Spectral Density (PSD)	PSD describes how the power of a signal is distributed with frequency
Source Level (SL)	The acoustic source level is the level referenced to a distance of 1m from a point source
1/3 Octave Band Levels	The energy of a sound split into a series of adjacent frequency bands, each being 1/3 of an octave wide
Sound Speed Profile	A graph of the speed of sound in the water column as a function of depth

Acronym	Definition
ACCOBAMS The Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic area	
AHT	Anchor handling tug
AIS	AIS Environment Ltd
AIS	Automatic Identification System
AWTI	Above Water Tie-In
BHD	Backhoe dredger
BPM	Blue Planet Marine
dB	Decibel
CSD	Cutter suction dredger
DICCA	Dipartimento di Ingegneria Civile, Chimica e Ambientale
EIA	Environmental impact assessment

GEBCO	General Bathymetric Chart of the Oceans
HDD	The horizontal directional drilling
HF	High-frequency
Hz	Hertz
kHz	Kilohertz
km	kilometre(s)
KNMI	The Royal Netherlands Meteorological Institute
LF	Low-frequency
M	Metre
ms	millisecond
MSFD	Marine Strategy Framework Directive
NDT	Non-destructive tests
NMFS	National Marine Fisheries Services
NOAA	National Oceanic and Atmospheric Administration
OCW	Other Marine Carnivores in Water
OSV	Offshore support vessel
PCI	Project of Common Interest
PCW	Phocid Carnivores in Water
PE	Parabolic Equation
PLB	Pipe-laying barge
PTS	Permanent hearing threshold shift
RL	Received level
ROW	The right of way
RMS	Root mean square
s	Second
SEL	Sound exposure level
SEL24hr	Cumulative SEL within a 24-hour period
SI	Sirenians
SOFAR	Sound Fixing and Ranging
SPL	Sound pressure level
SL	Source level
SLR	SLR Consulting Limited
TL	Transmission loss
TTS	Temporary hearing threshold shift
VHF	Very high-frequency
WG	Working group
WOA09	World Ocean Atlas 2009
µPa	Micropascal