APPENDIX 16

ARROW LNG PLANT

Noise and Vibration Impact Assessment

arrow energy
go further

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Arrow LNG Plant

Noise and Vibration Impact Assessment

Prepared For

Arrow CGS (Australia) Pty Ltd

and

Coffey Environments Australia Pty Ltd

S3328C6
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EXECUTIVE SUMMARY

An assessment has been made of the potential noise and vibration associated with the Arrow LNG Plant project.

The assessment has considered environmental noise and vibration criteria, evaluated the noise from the construction and operation of the project, and determined the feasibility of mitigation measures to be implemented to achieve the noise criteria.

Based upon the Environmental Protection (Noise) Policy (EPP (Noise)), appropriate criteria for noise from construction and operation of the project have been determined and are summarised below:

<table>
<tr><th rowspan="2">Activity</th><th rowspan="2">Source</th><th rowspan="2">Assessment Location</th><th colspan="3">Outdoor Noise Criterion (dB(A))</th><th rowspan="2">Assessment Meteorological Conditions</th></tr>
<tr><th>Day</th><th>Evening</th><th>Night</th></tr>
<tr><td rowspan="6">Operation (Continuous)</td><td rowspan="6">LNG plant</td><td>AL 1</td><td colspan="3" rowspan="2">33</td><td rowspan="2">Neutral (CONCAWE Category 4)</td></tr>
<tr><td>AL 6</td></tr>
<tr><td>AL 3</td><td colspan="3">33</td><td rowspan="2">Worst-case (CONCAWE Category 6)</td></tr>
<tr><td>AL 2</td><td colspan="3">28</td></tr>
<tr><td>AL 4</td><td colspan="3" rowspan="2">28</td><td rowspan="2">Neutral (CONCAWE Category 4)</td></tr>
<tr><td>AL 5</td></tr>
<tr><td rowspan="6">Operation (Intermittent</td><td rowspan="6">LNG carrier movements</td><td>AL 1</td><td rowspan="6">50</td><td rowspan="6">50</td><td rowspan="6">45</td><td rowspan="6">Neutral (CONCAWE Category 4)</td></tr>
<tr><td>AL 2</td></tr>
<tr><td>AL 3</td></tr>
<tr><td>AL 4</td></tr>
<tr><td>AL 5</td></tr>
<tr><td>AL 6</td></tr>
<tr><td rowspan="6">Construction</td><td rowspan="6">LNG plant

Marine facilities

Feed gas pipeline

Dredging</td><td>AL 1</td><td colspan="2" rowspan="6">All reasonable and practicable measures to reduce the noise impact</td><td rowspan="6">45</td><td rowspan="6">Neutral (CONCAWE Category 4)</td></tr>
<tr><td>AL 2</td></tr>
<tr><td>AL 3</td></tr>
<tr><td>AL 4</td></tr>
<tr><td>AL 5</td></tr>
<tr><td>AL 6</td></tr>
</table>

The proposed noise conditions take into account the potential for cumulative impacts from other projects and existing developments by setting noise limits which are more stringent than the requirements of the EPP (Noise), to allow similar noise contributions from other projects.

For the prediction of noise, the CONCAWE noise propagation model has been used which takes into account topography, ground absorption, air absorption and meteorological conditions. The CONCAWE noise propagation model is used around the world and is widely accepted as an appropriate model for predicting noise over significant distances.

To objectively assess the impact of vibration from the project, direct reference has been made to the Australian Standard AS 2670.2-1990 and German Standard DIN 4150.3-1999, which provide criteria for human comfort, and the prevention of structural damage to buildings and underground pipework, respectively.

The noise and vibration criteria for blasting has been based on the *Environmental Protection Act 1994* and the Department of Environment and Resource Management's "Noise and vibration from blasting" Guideline.

Based on the assessment, the noise and vibration criteria for the construction and operation of the project will be achieved with a practicable extent of acoustic treatment and mitigation measures.

Noise and vibration monitoring will be conducted during project operation at selected locations in the vicinity of the project site to confirm the assessment.

GLOSSARY

Ambient noise level	The noise level with the presence of all noise sources, both continuous and intermittent
A weighting	Frequency adjustment representing the response of the human ear
Background noise level	The noise level in the absence of intermittent noise sources
Background creep	The gradual increase in background noise levels in an area as a result of successive developments generating constant noise levels at a particular location.
CONCAWE	The oil companies' international study group for conservation of clean air and water in Europe "The propagation of noise from petrochemical complexes to neighbouring communities"
CONCAWE noise propagation model	The CONCAWE noise propagation model is a model which takes into account topography, ground absorption, air absorption and meteorological conditions. It is used around the world and is widely accepted as an appropriate model for predicting noise over significant distances. The CONCAWE noise propagation model can be implemented in a noise modelling software such as SoundPlan.
Continuous noise source	A noise source operating continuously over a 24 hour day period
dB(A)	A weighted noise or sound power level in decibels
Equivalent noise level	Energy averaged noise level
Intermittent noise source	A noise source operating over a short-term period
$L_{A1,adj,1hr}$	The A weighted noise level exceeded 1% of the time measured in decibels over a period of 1 hour and adjusted for tonality or impulsiveness, representing the maximum noise level
$L_{A10,adj,1hr}$	The A weighted noise level exceeded 10% of the time measured in decibels over a period of 1 hour and adjusted for tonality or impulsiveness, representing the typical upper noise level
L_{A90}	The A weighted noise level exceeded 90% of the time measured in decibels, representing the background noise level
$L_{A90,1hr}$	The A weighted noise level exceeded 90% of the time measured in decibels over a period of 1 hr, representing the background noise level

L_{Aeq}	The A weighted equivalent noise level measured in decibels
$L_{Aeq,\ 1\ hour}$	The A weighted equivalent noise level measured in decibels over a period of 1 hour
$L_{Aeq,\ adj,\ 1\ hour}$	The A weighted equivalent noise level measured in decibels over a period of 1 hour and adjusted for tonality
$L_{pA,LF}$	Indoor low frequency A weighted noise level
RBL	Rating Background Level
Sensitive receptor	A location in the vicinity of the proposed development, where noise may affect the amenity of the land use. For the proposed development, sensitive receptors are generally dwellings.
Sound power level	A measure of the sound energy emitted from a source of noise.
WHO	World Health Organisation
Worst-case	Conditions resulting in the highest noise level at or inside dwellings. Worst-case meteorological conditions can be characterised as no cloud at night with wind from the project site to dwellings.

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1 INTRODUCTION

Sonus Pty Ltd (Sonus) has been engaged to conduct an assessment of the impact of noise and vibration on the environment from the proposed Arrow LNG Plant (the project). The objectives of the assessment were:

- to establish the noise and vibration related environmental values of the study area;
- to determine appropriate environmental noise and vibration criteria;
- to evaluate the noise and vibration impact from the construction and operation of the project, and;
- to consider the feasibility of measures to be implemented to achieve the relevant criteria.

This report addresses the Terms of Reference (TOR) pertaining to noise and vibration, and will form part of an overall environmental impact statement (EIS) for the project.

2 PROJECT DESCRIPTION

2.1 Proponent

Arrow CSG (Australia) Pty Ltd (Arrow Energy) proposes to develop a liquefied natural gas (LNG) facility on Curtis Island off the central Queensland coast near Gladstone. The project, known as the Arrow LNG Plant, is a component of the larger Arrow LNG Project.

The proponent is a subsidiary of Arrow Energy Holdings Pty Ltd which is wholly owned by a joint venture between subsidiaries of Royal Dutch Shell plc and PetroChina Company Limited

2.2 Arrow LNG Plant

Arrow Energy proposes to construct the Arrow LNG Plant in the Curtis Island Industry Precinct at the southwestern end of Curtis Island, approximately 6 km north of Gladstone and 85 km southeast of Rockhampton, off Queensland's central coast. In 2008, approximately 10% of the southern part of the island was added to the Gladstone State Development Area to be administered by the Queensland Department of Local Government and Planning. Of that area, approximately 1,500 ha (25%) has been designated as the Curtis Island Industry Precinct and is set aside for LNG development. The balance of the Gladstone State Development Area on Curtis Island has been allocated to the Curtis Island Environmental Management Precinct, a flora and fauna conservation area.

The Arrow LNG Plant will be supplied with coal seam gas from gas fields in the Surat and Bowen basins via high-pressure gas pipelines to Gladstone, from which a feed gas pipeline will provide gas to the LNG plant on Curtis Island. A tunnel is proposed for the feed gas pipeline crossing of Port Curtis.

The project is described below in terms of key infrastructure components: LNG plant, feed gas pipeline and dredging.

2.2.1 LNG Plant

Overview. The LNG plant will have a base-case capacity of 16 Mtpa, with a total plant capacity of up to 18 Mtpa. The plant will consist of four LNG trains, each with a nominal capacity of 4 Mtpa. The project will be undertaken in two phases of two trains (nominally 8 Mtpa), with a financial investment decision taken for each phase.

Operations infrastructure associated with the LNG plant includes the LNG trains (where liquefaction occurs; see ‘Liquefaction Process’ below), LNG storage tanks, cryogenic pipelines, seawater inlet for desalination and stormwater outlet pipelines, water and wastewater treatment, a 110 m high flare stack, power generators (see ‘LNG Plant Power’ below), administrative buildings and workshops.

Construction infrastructure associated with the LNG plant includes construction camps (see ‘Workforce Accommodation’ below), a concrete batching plant and laydown areas.

The plant will also require marine infrastructure for the transport of materials, personnel and product (LNG) during construction and operations (see ‘Marine Infrastructure’ below).

Construction Schedule. The plant will be constructed in two phases. Phase 1 will involve the construction of LNG trains 1 and 2, two LNG storage tanks (each with a capacity of between 120,000 m^3 and 180,000 m^3), Curtis Island construction camp, and if additional capacity is required, a mainland workforce accommodation camp. Associated marine infrastructure will also be required as part of Phase 1. Phase 2 will involve the construction of LNG trains 3 and 4 and potentially a third LNG storage tank. Construction of Phase 1 is scheduled to commence in 2014 with train 1 producing the first LNG cargo in 2017. Construction of Phase 2 is anticipated to commence approximately five years after the completion of Phase 1 but will be guided by market conditions and a financial investment decision at that time.

Construction Method. The LNG plant will generally be constructed using a modular construction method, with preassembled modules being transported to Curtis Island from an offshore fabrication facility. There will also be a substantial stick-built component of construction for associated infrastructure such as LNG storage tanks, buildings, underground cabling, piping and foundations. Where possible, aggregate for civil works will be sourced from suitable material excavated and crushed on site as part of the bulk earthworks. Aggregate will also be sourced from mainland quarries and transported from the mainland launch site to the plant site by roll-on, roll-off vessels. A concrete batching plant will be established on the plant site. Bulk cement requirements will be sourced outside of the batching plant and will be delivered to the site by roll-on roll-off ferries or barges from the mainland launch site.

LNG Plant Power

Power for the LNG plant and associated site utilities may be supplied from the electricity grid (mains power), gas turbine generators, or a combination of both, leading to four configuration options that will be assessed:

- Base case (mechanical drive): The mechanical drive configuration uses gas turbines to drive the LNG train refrigerant compressors, which is the traditional powering option for LNG facilities. This configuration would use coal seam gas and end flash gas (produced in the liquefaction process) to fuel the gas turbines that drive the LNG refrigerant compressors and the gas turbine generators that supply electricity to power the site utilities. Construction power for this option would be provided by diesel generators.
- Option 1 (mechanical/electrical – construction and site utilities only): This configuration uses gas turbines to drive the refrigerant compressors in the LNG trains. During construction, mains power would provide power to the site via a cable (30-MW capacity) from the mainland. The proposed capacity of the cable is equivalent to the output of one gas turbine generator. The mains power cable would be retained to power the site utilities during operations, resulting in one less gas turbine generator being required than the proposed base case.
- Option 2 (mechanical/electrical): This configuration uses gas turbines to drive the refrigerant compressors in the LNG trains and mains power to power site utilities. Under this option, construction power would be supplied by mains power or diesel generators.
- Option 3 (all electrical): Under this configuration mains power would be used to supply electricity for operation of the LNG train refrigerant compressors and the site utilities. A switchyard would be required. High-speed electric motors would be used to drive the LNG train refrigerant compressors. Construction power would be supplied by mains power or diesel generators.

Liquefaction Process

The coal seam gas enters the LNG plant where it is metered and split into two pipe headers which feed the two LNG trains. With the expansion to four trains the gas will be split into four LNG trains.

For each LNG train, the coal seam gas is first treated in the acid gas removal unit where the carbon dioxide and any other acid gases are removed. The gas is then routed to the dehydration unit where any water is removed and then passed through a mercury guard bed to remove mercury. The coal seam gas is then ready for further cooling and liquefaction.

A propane, precooled, mixed refrigerant process will be used by each LNG train to liquefy the predominantly methane coal seam gas. The liquefaction process begins with the propane cycle. The propane cycle involves three pressure stages of chilling to pre-cool the coal seam gas to -33°C and to compress and condense the mixed refrigerant, which is a mixture of nitrogen, methane, ethylene and propane. The condensed mixed refrigerant and precooled coal seam gas are then separately routed to the main cryogenic heat exchanger, where the coal seam gas is further cooled and liquefied by the mixed refrigerant. Expansion of the mixed refrigerant gases within the heat exchanger removes heat from the coal seam gas. This process cools the coal seam gas from -33°C to approximately -157°C. At this temperature the coal seam gas is liquefied (LNG) and becomes 1/600th of its original volume. The expanded mixed refrigerant is continually cycled to the propane precooler and reused.

LNG is then routed from the end flash gas system to a nitrogen stripper column which is used to separate nitrogen from the methane, reducing the nitrogen content of the LNG to less than 1 mole per cent (mol%). LNG separated in the nitrogen stripper column is pumped for storage on site in full containment storage tanks where it is maintained at a temperature of -163°C.

A small amount of off-gas is generated from the LNG during the process. This regasified coal seam gas is routed to an end flash gas compressor where it is prepared for use as fuel gas.

Finally, the LNG is transferred from the storage tanks onto LNG carriers via cryogenic pipelines and loading arms for transportation to export markets. The LNG will be regasified back into sales specification gas on shore at its destination location.

Workforce Accommodation

The LNG plant (Phase 1), tunnel, feed gas pipeline, and dredging components of the project each have their own workforces with peaks occurring at different stages during construction. The following peak workforces are estimated for the project:

- LNG plant Phase 1 peak workforce of 3,500, comprising 3,000 construction workers: 350 engineering, procurement and construction (EPC) management workers and 150 Arrow Energy employees.
- Tunnel peak workforce of up to 100.
- Feed gas pipeline (from the mainland to Curtis Island) peak workforce of up to 75.
- A dredging peak workforce of between 20 and 40.

Two workforce construction camp locations are proposed: the main construction camp at Boatshed Point on Curtis Island, and a possible mainland overflow construction camp, referred to as a temporary workers accommodation facility (TWAF). Two potential locations are currently being considered for the mainland TWAF; in the vicinity of Gladstone city on the former Gladstone Power Station ash pond No.7 (TWAF7) or in the vicinity of Targinnie on a primarily cleared pastoral grazing lot (TWAF8). Both potential TWAF sites include sufficient space to accommodate camp infrastructure and construction laydown areas. The TWAF and its associated construction laydown areas will be decommissioned on completion of the Phase 1 works.

Of the 3,000 construction workers for the LNG plant, it is estimated that between 5% and 20% will be from the local community (and thus will not require accommodation) and that the remaining fly-in, fly-out workers will be accommodated in construction camps. The 350 EPC management and 150 Arrow Energy employees are expected to relocate to Gladstone with the majority housed in company facilitated accommodation.

The tunnel workforce of 100 people and gas pipeline workforce of 75 people are anticipated to be accommodated in the mainland in company facilitated accommodation. The dredging workforce of 20 to 40 workers will be housed onboard the dredge vessel.

Up to 2,500 people will be housed at Boatshed Point construction camp. Its establishment will be preceded by a pioneer camp at the same locality which will evolve into the completed construction camp.

Marine Infrastructure

Marine facilities include the LNG jetty, materials offloading facility (MOF), personnel jetty and mainland launch site.

LNG Jetty. LNG will be transferred from the storage tanks on the site to the LNG jetty via above ground cryogenic pipelines. Loading arms on the LNG jetty will deliver the product to an LNG carrier. The LNG jetty will be located in North China Bay, adjacent to the northwest corner of Hamilton Point.

MOF. Delivery of materials to the site on Curtis Island during the construction and operations phases will be facilitated by a MOF where roll-on, roll-off or lift-on, lift-off vessels will dock to unload preassembled modules, equipment, supplies and construction aggregate. The MOF will be connected to the LNG plant site via a heavy-haul road.

Boatshed Point (MOF 1) is the base-case MOF option and would be located at the southern tip of Boatshed Point. The haul road would be routed along the western coastline of Boatshed Point (abutting the construction camp to the east) and enters the LNG Plant site at the southern boundary. A quarantine area will be located south of the LNG plant and will be accessed via the northern end of the haul road.

Two alternative options are being assessed, should the Boatshed Point option be determined to be not technically feasible:

- South Hamilton Point (MOF 2): This MOF option would be located at the southern tip of Hamilton Point. The haul road from this site would traverse the saddle between the hills of Hamilton Point to the southwest boundary of the LNG plant site. The quarantine area for this option will be located southwest of the LNG plant near the LNG storage tanks.
- North Hamilton Point (MOF 3): This option involves shared use of the MOF being constructed for the Santos Gladstone LNG Project (GLNG Project) on the northwest side of Hamilton Point (south of Arrow Energy's proposed LNG jetty). The GLNG Project is also constructing a passenger terminal at this site, but it will not be available to Arrow

Energy contractors and staff. The quarantine area for this option would be located to the north of the MOF. The impacts of construction and operation of this MOF option and its associated haul road were assessed as part of the GLNG Project and will not be assessed in this EIS.

Personnel Jetty. During the peak of construction, base case of up to 1,100 people may require transport to Curtis Island from the mainland on a daily basis. A personnel jetty will be constructed at the southern tip of Boatshed Point to enable the transfer of workers from the mainland launch site to Curtis Island by high-speed vehicle catamarans (Fastcats) and vehicle or passenger ferries (ROPAX). This facility will be adjacent to the MOF constructed at Boatshed Point. The haul road will be used to transport workers to and from the personnel jetty to the construction camp and LNG plant site. A secondary access for pedestrians will be provided between the personnel jetty and the construction camp.

Mainland Launch Site. Materials and workers will be transported to Curtis Island via the mainland launch site. The mainland launch site will contain both a passenger terminal and a roll-on, roll-off facility. The passenger terminal will include a jetty and transit infrastructure, such as amenities, waiting areas and car parking. The barge or roll-on ,roll-off facility will have a jetty, associated laydown areas, workshops and storage sheds.

The two location options for the mainland launch site are:

- Launch site 1: This site is located north of Gladstone city near the mouth of the Calliope River, adjacent to the existing RG Tanna coal export terminal.
- Launch site 4N: This site is located at the northern end of the proposed reclamation area for the Fishermans Landing Northern Expansion Project, which is part of the Port of Gladstone Western Basin Master Plan. The availability of this site will depend on how far progressed the Western Basin Dredging and Disposal Project is at the time of construction.

2.2.2 Feed Gas Pipeline

An approximately 8-km long feed gas pipeline will supply gas to the LNG plant from its connection to the Arrow Surat Pipeline (formerly the Surat Gladstone Pipeline) on the mainland adjacent to Rio Tinto’s Yarwun alumina refinery. The feed gas pipeline will be constructed in three sections:

- A short length of feed gas pipeline will run from the proposed Arrow Surat Pipeline to the tunnel launch shaft, which will be located on a mudflat south of Fishermans Landing, just south of Boat Creek. This section of pipeline will be constructed using conventional open-cut trenching methods within a 40-m wide construction right of way.
- The next section of the feed gas pipeline will traverse Port Curtis harbour in a tunnel to be bored under the harbour from the mainland tunnel launch shaft to a receival shaft on Hamilton Point. The tunnel under Port Curtis will have an excavated diameter of up to approximately 6 m and will be constructed by a tunnel boring machine that will begin work at the mainland launch shaft. Tunnel spoil material will be processed through a de-sanding plant to remove the bentonite and water and will comprise mainly a finely graded fill material, which will be deposited in a spoil placement area established within bund walls constructed adjacent to the launch shaft. Based on the excavated diameter, approximately 223,000 m^3 of spoil will be treated as required for acid sulfate soil and disposed of at this location.
- From the tunnel receival shaft on Hamilton Point, the remaining section of the feed gas pipeline will run underground to the LNG plant, parallel to the above ground cryogenic pipelines. This section will be constructed using conventional open-cut trenching methods within a 30-m wide construction right of way. A permanent easement up to 30-m wide will be negotiated with the relevant land manager or owner.

Should one of the electrical plant power options be chosen, it is intended that a power connection will be provided by a third party to the tunnel launch shaft, whereby Arrow Energy would construct a power cable within the tunnel to the LNG plant.

Other infrastructure, such as communication cables, water and wastewater pipelines, may also be accommodated within the tunnel.

2.2.3 Dredging

Dredging required for LNG carrier access and swing basins has been assessed under the Gladstone Ports Corporation’s Port of Gladstone Western Basin Dredging and Disposal Project. Additional dredging within the marine environment of Port Curtis may be required to accommodate the construction and operation of the marine facilities. Up to five sites may require dredging:

- Dredge site 1 (dredge footprint for launch site 1): The dredging of this site would facilitate the construction and operation of launch site 1. This dredge site is located in the Calliope River and extends from the intertidal area abutting launch site 1, past Mud Island to the main shipping channel. The worst-case dredge volume estimated at this site is approximately 900,000 m^3.
- Dredge site 2 (dredge footprint for launch site 4N): The dredging of this site would facilitate the construction and operation of launch site 4N. This dredge site would abut launch site 4N and extend east from the launch site to the shipping channel. The worst-case dredge volume identified at this site is approximately 2,500 m^3.
- Dredge site 3 (dredge footprint for Boatshed Point MOF 1): The dredging of this site would facilitate the construction and operation of the personnel jetty and MOF at Boatshed Point. This dredge site would encompass the area around the marine facilities, providing adequate depth for docking and navigation. The worst-case dredge volume identified at this site is approximately 50,000 m^3.
- Dredge site 4 (dredge footprint for Hamilton Point South MOF 2): The dredging of this site would facilitate the construction and operation of the MOF at Hamilton Point South. This dredge site would encompass the area around the marine facilities, providing adequate depth for docking and navigation. The worst-case dredge volume identified at this site is approximately 50,000 m^3.
- Dredge site 5 (dredge footprint for LNG jetty): The dredging of this site will facilitate the construction of the LNG jetty at Hamilton Point. This dredge site extends from the berth pocket to be dredged as part of the Western Basin Strategic Dredging and Disposal Project to the shoreline and is required to enable a work barge to assist with construction of the jetty. The worst-case dredge volume identified is approximately 120,000 m^3.

The spoil generated by dredging activities will be placed and treated for acid sulfate soils (as required) in the Port of Gladstone Western Basin Dredging and Disposal Project reclamation area.

2.3 LNG Carriers

The number of expected LNG carriers to service the LNG plant is dependent on the carrier sizing. Arrow Energy is considering two LNG carrier options which are as follows:

- Option 1: 15 carriers per 1 Mtpa based on 145000 m^3, i.e., 240 carriers per year for 145000 m^3 carrier size, and;
- Option 2: 11 carriers per 1 Mtpa based on 215000 m^3, i.e., 176 carriers per year for 215000 m^3 carrier size.

2.4 Project Construction and Operation Working Hours

The workings hours during the construction of the LNG plant, gas pipeline and pipeline tunnel, the dredging, and the operation of the LNG plant, are anticipated to be as follows:

- Construction of LNG plant: The work will generally be conducted during the day, between 7am and 7pm. However, there may be project requirements for night work such as when modules arrive on vessels, concrete pour, or other construction requirements. In addition, there is the potential for staggered shifts as per the ferry movements.
- Construction of the gas pipeline: The working hours will generally be between 6am and 6pm.
- Construction of the pipeline tunnel: It is anticipated there will be eight hour shift rotations over 24 hours.
- Dredging: The work will be conducted over 24 hours with two to three shift rotations.
- Operation of LNG plant: The operational, security and maintenance works will typically have eight hour shift rotations over 24 hours.

2.5 Overview of Potential Impacts

The potential impacts of noise and vibration from the project at sensitive receptors will be directly influenced by the potential noise and/or vibration sources present during the construction and operation of the project.

2.5.1 Potential Noise Sources

The potential noise sources associated with the project include:

- LNG plant main equipment such as the process compressors, mechanical drives, power generation, process pumps, loading system and ancillary equipment. The main noise sources at the LNG plant are listed in Tables 8.1 and 8.2;
- LNG carriers, tug boats, barges and passenger ferries;

- Gas flaring;
- Construction activity and equipment during the construction of the LNG plant, construction camps, marine facilities (i.e., LNG jetty, MOF, personnel jetty and launch sites) and feed gas pipelines. The main noise sources associated with the construction of the infrastructure are listed in Tables 8.12 to 8.15;
- Construction activity at laydown areas on Curtis Island, at the launch sites and the mainland tunnel entry and exit sites. The main noise sources associated with the construction activity are listed in Tables 8.16 and 8.17;
- Dredging at the proposed dredge sites. The main noise sources associated with the activity are listed in Tables 8.18;
- Non-construction related equipment and activity at the construction camps. The main noise sources identified at the construction camps are the heating, ventilation and air conditioning systems (HVAC) and vehicle movements, such as buses, cars and trucks on site;
- Material loading and unloading activity at docks. The main noise sources are listed in Table 8.19, and;
- Blasting activity required during construction.

2.5.2 Potential Vibration Sources

The potential vibration sources associated with the project include:

- Operational equipment of the LNG plant;
- The use of the marine facilities (i.e., LNG jetty, MOF, personnel jetty and launch sites);
- Construction equipment and activity, including pile driving, and;
- Blasting activity required during construction.

3 LEGISLATIVE CONTEXT

3.1 Assessment Criteria

The legislation and guidelines which are relevant for the establishment of appropriate noise assessment conditions are:

- the *Environmental Protection Act 1994;*
- the Environmental Protection (Noise) Policy 2008;
- World Health Organisation (WHO) Guidelines 1999; and
- Department of Environment and Resource Management (DERM) “Assessment of Low Frequency Noise” Draft Guideline 2002.

For the assessment of vibration, the following standards provide the appropriate criteria:

- Australian Standard AS 2670.2-1990 “Evaluation of human exposure to whole-body vibration – Part 2: Continuous and shock induced vibration in buildings (1 to 80 HZ)”; and
- German Standard DIN 4150.3-1999 “Structural Vibration – Part 3: Effect of vibration on structures”.

For blasting activity during construction, the appropriate noise and vibration criteria are provided by the following:

- the *Environmental Protection Act 1994;* and
- the DERM “Noise and vibration from blasting” Guideline 2006.

3.2 Noise Measurements

For appropriate noise measurement conditions and methodology, the DERM “Noise Measurement Manual” 2000 provides the most relevant reference, while the DERM “Planning for noise control” Guideline 2004 provides the appropriate method in determining the indicative background noise levels based on noise monitoring data collected.

3.3 Construction Equipment

The typical equipment and the maximum sound power levels of equipment at general construction sites are provided by the Australian Standard AS 2436-1981 “Guide to Noise Control on Construction, Maintenance and Demolition Sites”.

4 STUDY METHOD

In the preparation of this report, the following steps were implemented in order to appropriately address the TOR for the project.

4.1 Establishment of Environmental Values

To determine the existing environmental values that may be affected by noise and vibration from the project, reference was made to the (EPP (Noise)), which defines the environmental values for sensitive receptors. The assessment ensured that these environmental values were preserved.

4.2 Baseline Noise and Vibration Monitoring

Noise and vibration measurements were conducted at several monitoring locations to determine the existing ambient noise and vibration levels in the vicinity of the development. The monitoring locations were selected based on having similar existing acoustic environment as the closest sensitive receptor to a project operation or construction site. Measurements at the monitoring locations will provide indicative levels at sensitive receptors which may be affected by the project.

The baseline noise monitoring determined the existing background and ambient noise levels from existing industry, and natural sounds such as wind in trees, birds and ocean waves.

4.3 Analysis of Meteorological Conditions

The analysis of meteorological data was conducted to determine the prevalent meteorological conditions for the Gladstone region and to establish appropriate modelling conditions for noise predictions. As the CONCAWE noise propagation model is used in this assessment (as described below), the appropriate meteorological conditions for noise predictions were specified in terms of the CONCAWE meteorological conditions categories.

4.4 Establishment of Assessment Criteria

Using the baseline monitoring, the resultant noise conditions in accordance with each of the relevant legislation and guidelines considered (refer Section 3) were determined. Taking into account the resultant noise conditions, the potential for cumulative noise impact from other industry proponents in the vicinity, and the analysis of meteorological conditions for the study area, the appropriate noise assessment conditions were then proposed.

The assessment criteria for vibration from the project and blasting activity during construction were directly adopted from the relevant legislation and guidelines (refer Section 3).

4.5 Noise Impact Assessment

To assess the impact of noise from the project, the noise level at sensitive receptors was predicted and compared against the established assessment criteria. Where the criteria were exceeded, appropriate mitigation measures have been considered in order to achieve the criteria.

4.5.1 Noise Predictions

<u>Noise Prediction Model</u>

The noise from the project was modelled using the CONCAWE noise propagation model in the SoundPlan noise modelling software. The CONCAWE noise propagation model is widely used around the world for predicting noise over significant distances. The CONCAWE propagation model takes into account topography, ground absorption, air absorption and meteorological conditions, and has been accepted as an appropriate sound propagation model by DERM.

<u>Modelling Inputs and Scenarios</u>

Noise levels at the noise sensitive receptors from the operation and construction of the project were predicted under the established meteorological conditions. The noise model input was based on information and noise data provided by Arrow Energy, manufacturers' data and Sonus' database of noise sources.

Noise modelling for the operation of the LNG plant was conducted for Phase 1 with two LNG trains, and Phases 1 and 2 combined with four LNG trains. Noise contours of the predicted noise levels for Phase 1 (i.e., two LNG trains) and Phases 1 and 2 combined (i.e., four LNG trains) were generated and presented in Appendix D.

Given detailed information on the equipment and techniques of construction for the project are not available at this stage, the noise model considered typical equipment at construction sites. The model assumes the “worst-case” scenario of all equipment operating continuously and simultaneously.

4.5.2 Potential Impacts and Mitigation Measures

The predicted noise level at sensitive receptors was compared against the proposed noise conditions to determine the noise impact from the project. Where the predicted noise level exceeds the proposed noise conditions, mitigation measures in order to achieve the conditions were considered. The mitigation measures were in the form of conceptual acoustic treatment to be developed during the detailed design stage of the project. Where noise from particular construction work cannot meet the noise conditions and the application of acoustic treatment is not practical, the particular construction work will be restricted to the day time period (7am to 10pm).

4.6 Vibration Impact Assessment

The assessment of vibration impact of the project on sensitive receptors has been based on previous measurements of vibration levels at facilities with similar equipment. The measured vibration levels were used to determine where there is potential for vibration impact on sensitive receptors.

For the construction of the project, the exact nature of the construction techniques and equipment on site is not known at this stage. Therefore, the assessment of vibration impact at sensitive receptors has been based on the typical construction equipment on site and a proposal to conduct a monitoring regime at critical distances from the construction site.

4.7 Blasting Impact Assessment

Considering detailed information (e.g., location, size and frequency) of any blasting work associated with the project construction is not available at this stage of the development, the appropriate provisions to be included in the construction management plan such as the blast criteria and design factors are provided. Compliance with the criteria will ensure that the noise and vibration impact at sensitive receptors will not be significant.

4.8 Cumulative Impact Assessment

A final investment decision has been made to proceed with two similar projects, the Gladstone LNG and Queensland Curtis LNG projects. Therefore, by the time that Arrow LNG Plant is constructed, the baseline level of noise will have changed. One method of dealing with the effect of these projects would be to consider the baseline level of noise with the two projects constructed and operating. The effect of this approach would be to relax the criteria for the Arrow LNG Plant project. This effect is called background creep[1] (refer Section 7.1.1). The key management intent of the Environment Protection (Noise) Policy is to avoid background creep. Therefore this approach has not been adopted but rather, the baseline level of noise used for this study was taken prior to any noise from other proposed projects.

Further, the criteria for the project have been selected at a lower level than would be selected if only a single project was proposed, in order to take account of the cumulative noise impact of this project, existing developments and other proposed projects in the region.

Therefore by ensuring that the noise from the project achieves the established noise criteria, and assuming similar noise contributions from other proposed projects (LNG and other projects in the region with an approved or completed EIS), the cumulative noise impact from industry in the Gladstone region will not have a significant impact on sensitive receptors.

The cumulative vibration impact at sensitive receptors has been considered and determined based on measured vibration levels at facilities with similar equipment.

[1] The result of successive projects relying on background noise levels elevated by previous projects to establish less stringent criteria.

5 EXISTING ENVIRONMENT

5.1 Description of Existing Environmental Values

The EPP (Noise) includes the following provision relating to environmental values:

The environmental values to be enhanced or protected under this policy are –

(a) the qualities of the acoustic environment that are conducive to protecting the health and biodiversity of ecosystems; and

(b) the qualities of the acoustic environment that are conducive to human health and wellbeing, including by ensuring a suitable acoustic environment for individuals to do any of the following –

(i) sleep;

(ii) study or learn;

(iii) be involved in recreation, including relaxation and conversation; and

(c) the qualities of the acoustic environment that are conducive to protecting the amenity of the community.

[Part 3, Clause 7]

5.2 Baseline Monitoring

5.2.1 Noise

To determine the existing acoustic environment, background noise levels (L_{A90}) and ambient noise levels (L_{Aeq}) were measured at five locations in the vicinity of the project area. The noise level measurements were made in accordance with the DERM "Noise Measurement Manual". The coordinates of the measurement locations and the period of measurement conducted at each location are provided in Table 5.1. The measurement locations (MLs) are indicated on Figure A.1 in Appendix A.

Table 5.1: Baseline Measurements.

Measurement Location	Coordinates (GDA 94 MGA 56)	Measurement Period
ML 1 – Boatshed Point	56 K 319881 E 7367383 S	29/03/2010 – 14/04/2010
ML 2 – Yarwun	56 K 309120 E 7361745 S	29/03/2010 – 14/04/2010
ML 3 – Fishermans Road	56 K 311977 E 7365279 S	01/04/2011 – 14/04/2011
ML 4 – Lord Street	56 K 322146 E 7362656 S	01/04/2011 – 14/04/2011
ML 5 – Flinders Street	56 K 321063 E 7361547 S	01/04/2011 – 14/04/2011

The measurements were made at locations representative (based on a similar existing acoustic environment) of the sensitive receptors located closest to the LNG plant or construction sites. These sensitive receptors have been identified as assessment locations (ALs), and have been selected such that compliance with appropriate noise conditions at the assessment locations will ensure compliance at all other sensitive receptors. The assessment locations are indicated on Figure A.1, in Appendix A.

Table 5.2 provides a brief description of the measurement locations and the represented assessment location.

Table 5.2: Description of measurement and assessment locations.

Measurement Location	Description of Existing Acoustic Environment	Represented Assessment Location	Description of Represented Assessment Location
ML 1	Influenced by natural sounds, predominantly from waves and wind in trees and some influence from existing marine traffic in Gladstone Harbour and Targinnie Channel	AL 1 – Tide Island and AL 6 – Witt Island	CSR to the LNG plant and marine facilities on Curtis Island, and dredge sites 3, 4 and 5.
ML 2	Some influence from road traffic but is considered to be a low noise environment relative to other locations in the Gladstone area.	AL 2 – Targinnie	CSR to TWAF8 – with low noise environment
ML 3	Influenced by natural sound, road traffic and existing industry in the vicinity	AL 3 – Fishermans Rd	CSR to Launch site 4N and LNG plant at Gladstone mainland – with influence from existing industry
ML 4	Some influence from existing industry, commerce and road traffic	AL 4 - Gladstone	CSR (on mainland Gladstone) to the LNG plant and marine facilities on Curtis Island
ML 5	Some influence from commerce and road traffic	AL 5 - Gladstone	CSR to TWAF7, Launch site 1 and dredge site 2

Note CSR – closest sensitive receptor.

Table 5.3 provides the approximate separation distances between the ALs, and the LNG plant and other closest project areas. The separation distance of the ALs from the LNG plant is taken from the centre of the first LNG train (i.e., the LNG train which is furthest south).

Table 5.3: Distances between assessment locations and the project sites.

Assessment Location	Approximate Separation Distances (km)		CPCO Site
	From LNG Plant	From CPCO Site	
AL 1	2.4	0.6	Boatshed Point Dredge Site 3
AL 2	12.5	0.3	TWAF 8
AL 3	8.5	5.3	Launch 4N
AL 4	6.7	3.0	Launch 1
AL 5	7.6	0.2	TWAF 7
AL 6	2.8	1.4	Boatshed Point Facility

Note CPCO – closest project construction or operation site other than the LNG plant.

For some areas within the Gladstone region, such as at ML 1 and ML 3, the wind may be a factor influencing the background noise level. Therefore, to ensure that the wind during the measurement periods was typical, the wind speed during the measurement periods have been compared with two long term wind speed averages (12 months and 10 years), based on data from the Bureau of Meteorology for the “Gladstone Radar” weather station.

The percentages of time that the wind speed is above 5m/s and below 2m/s have also been compared. During wind speeds above 5m/s, it is expected that natural sounds associated with the wind (e.g., wind in trees, ocean waves) will dominate the acoustic environment. During wind speeds below 2m/s, it is expected that the wind will have less influence on the background noise of the acoustic environment.

Table 5.4 summarises the average wind speed and the percentages of time that the wind speed is above 5m/s and below 2m/s.

Table 5.4: Analysis of meteorological conditions during the measurement periods.

Meteorological Condition	10 Year Period*	12 Month Period*	Measurement Period 1	Measurement Period 2
Average wind speed (m/s)	4.8 m/s	4.7 m/s	4.3 m/s	4.6 m/s
Wind speed > 5 m/s	43 %	39%	33%	50%
Wind speed < 2m/s	4 %	6%	9%	11%

Note * Based on analysis of data from the Bureau of Meteorology for the “Gladstone Radar” weather station.
Measurement Period 1 - 29/03/2010 – 14/04/2010
Measurement Period 2 - 01/04/2011 – 14/04/2011

Table 5.4 demonstrates that the wind speed during the measurement periods was slightly lower than the long term averages, indicating that the background noise levels measured are likely to be representative of background noise levels during all seasons.

Table 5.4 also confirms that high winds (i.e., above 5m/s) are a feature of the area considering such winds occur for more than 30% of the time. Therefore, the existing acoustic environment at the sensitive receptors, in particular the sensitive receptor represented as AL 1, will generally be influenced by wind related natural sounds such as wind in trees and ocean waves.

The measured background and ambient noise levels at each measurement location are presented in Appendix B. Using this measured data, the Rating Background Levels (RBL) were calculated, in accordance with the "Planning for Noise Control" Guideline released by DERM. An RBL is the monitoring period median of the daily tenth percentiles of the measured background noise levels, for a given period (i.e., day, evening or night). The calculated RBLs are summarised in Table 5.5.

Table 5.5: Calculated Rated Background Levels.

Measurement Location	Represented Assessment Location	RBL (dB(A))		
		Day	Evening	Night
ML 1	**AL 1, AL 6**	44	41	43
ML 2	**AL 2**	34	34	33
ML 3	**AL 3**	42	44	43
ML 4	**AL 4**	39	37	35
ML 5	**AL 5**	40	36	35

In addition, it is noted that the sensitive receptors in the vicinity of Gladstone Harbour and Targinnie Channel, particularly on Tide and Witt Islands (i.e., AL 1 and AL 6, respectively), are currently exposed to noise from ship and vessel movements associated with existing shipping terminals in the area, mainly the RG Tanna Coal Terminal and the Fisherman's Landing Terminal.

5.2.2 Vibration

The potential background vibration sources in the Gladstone regions include major roads, rail, shipping terminals and equipment at industrial facilities.

During inspection of the five measurement locations, no appreciable vibration in the environment could be detected by human senses. The existing vibration levels were considered to be well below the threshold of human detection (refer Table 7.8 which provides the threshold of human detection of vibration specified by AS2670).

To confirm these observations, vibration levels were manually measured at two measurement locations, ML 1 and ML 2, on the 14th of April, 2010. The measured vibration levels at each measurement location are presented in Appendix B. The measurements confirm that the existing vibration levels at the measurement locations are well below the threshold of human detection, as provided by AS2670.

Therefore, the existing vibration levels at sensitive receptors are also expected to be below the threshold of human detection, as provided by AS2670.

6 METEOROLOGICAL CONDITIONS AND ATMOSPHERIC EFFECTS

6.1 Weather Categories

The CONCAWE noise propagation model is widely accepted around the world as an appropriate model for predicting noise over significant distances. The model provides a meteorological category system to assist in accounting for the influence of meteorology on noise propagation.

The CONCAWE system divides the range of possible meteorological conditions into six separate “weather categories”, from Category 1 to Category 6. Category 1 provides “best-case” (i.e., lowest noise level) weather conditions for the propagation of noise, whilst Category 6 provides “worst-case” (i.e., highest noise level) conditions, when considering wind speed, wind direction, time of day, and level of cloud cover. Category 4 provides “neutral” weather conditions for noise propagation.

For the purposes of comparison, Categories 1, 2 and 3 weather conditions are generally characterised by wind blowing from the receptor to the noise source during the daytime with little or no cloud cover. Category 4 conditions can be characterised by no wind and an overcast day, whilst no wind and a clear night sky with a temperature inversion (increasing temperature with elevation) represent Category 5 conditions. Category 6 conditions can be characterised by a clear night sky and wind blowing from the noise source to the receptor.

In the particular circumstances of this development, it is noted that the noise levels experienced at sensitive receptors in the vicinity of the LNG plant will be significantly influenced by the weather category. For example, higher noise levels would be expected at sensitive receptors with a temperature inversion, or with wind blowing from the site to the sensitive receptor (i.e., Category 5 or 6 conditions) rather than with wind blowing from the sensitive receptor to the site (i.e., Category 1, 2, or 3 conditions).

6.2 Analysis of Meteorological Data

Twelve months of historical meteorological data measured on Curtis Island were processed to determine the likelihood of each meteorological category. The times during which the wind speed is greater than 5m/s have been listed separately and excluded from each category, as it is anticipated that ambient noise levels (from wind in trees and ocean waves) would mask the noise from the site at these times.

The meteorological category is dependent on the relative direction of a sensitive receptor from a site. Table 6.1 summarises the percentage of time in each meteorological category for sensitive receptors located at various directions from a site.

Table 6.1: Distribution of meteorological categories based on direction of sensitive receptors from a site.

Relative Direction from a Site	Percentage (%) of Time in each Meteorological Conditions Category													
	Wind speed > 5m/s		Category 1		Category 2		Category 3		Category 4		Category 5		Category 6	
	Total	Night-time	Total	Night-time	Total	Night-time	Total	Night-time	Total	Night-time	Total	Night-time	Total	Night-time
East	27	19	4	0	18	9	26	32	11	15	11	19	3	6
South	27	19	0	0	18	29	22	23	12	7	15	13	6	7
Southeast	27	19	2	0	26	27	22	25	8	8	11	13	4	7
Southwest	27	19	0	0	5	5	20	36	13	13	29	20	6	7
West	27	19	0	0	3	1	11	16	14	15	30	35	15	13

Note: Total refers to the total percentage of time in each category.
Night-time refers to the percentage of time in each category during night-time only.

6.3 Meteorological Conditions for Noise Predictions

For compliance testing, the DERM "Noise Measurement Manual" requires that the noise measurement be conducted during fine weather conditions with calm to light winds. Measurement during conditions conducive to sound propagation should only be conducted if the conditions are a true representation of the normal situation in the area.

For noise predictions of a long term noise source, it is appropriate that the occurrence of weather conditions conducive to sound propagation be considered. The meteorological conditions conducive to sound propagation (Categories 5 and 6) are considered to be a significant feature of the area if the sum of the percentages of the two categories (i.e., Category 5 plus Category 6) is at least 30% in any assessment period.

Based on Table 6.1, Categories 5 and 6 weather conditions are considered to be a feature of the area for sensitive receptors located to the west and southwest of a noise source.

6.3.1 Proposed Meteorological Conditions

For long-term or continuous noise sources, the prevalent meteorological conditions were considered in the noise predictions. For short-term or intermittent noise source, neutral meteorological conditions were considered for the noise predictions, given the nature and frequency of occurrence of the noise.

Operation

Based on the analysis conducted above, the proposed meteorological conditions for the prediction of continuous noise during the operation of the LNG plant for each assessment location are summarised in Table 6.2.

Table 6.2: The proposed meteorological conditions for the prediction of continuous noise at the assessment locations from the operation of the LNG plant.

Assessment Location	Relative Direction from LNG Plant	Proposed Meteorological Conditions
AL 1 AL 5	South	Neutral (CONCAWE Category 4) meteorological conditions
AL 4 AL 6	Southeast	
AL 2	West	Worst-case (CONCAWE Category 6) meteorological conditions
AL 3	Southwest	

For the prediction of intermittent noise during the operation of the LNG plant, such as LNG carrier movements, neutral meteorological conditions are proposed given the short-term nature and occurrence of the noise.

Construction

For the prediction of noise from construction activity associated with the project, neutral meteorological conditions are proposed for all assessment locations, given the intermittent nature of the use of equipment during the construction phase.

7 ASSESSMENT CRITERIA

This section describes the process and the different legislation and guidelines considered (as provided in Section 3) in the establishment of appropriate assessment conditions for the project.

7.1 Noise Criteria

The EPP (Noise) has been used as the primary method of objectively assessing the noise from the project. However, reference is also made to the World Health Organisation (WHO) Guidelines. To assess the low frequency noise from the project, the DERM “Assessment of Low Frequency Noise” Draft Guideline has been referenced.

Using the baseline background noise levels, the recommended criteria to achieve the intent of the EPP (Noise) and the WHO guidelines were determined. With consideration to these recommendations, and taking into account the potential cumulative impact of the project and other proponents, appropriate noise criteria were proposed. The proposed noise criteria were used in this noise impact assessment.

It is noted that separate noise criteria were proposed for the construction of the project, given the short-term and transient nature of construction noise in comparison to operational noise.

7.1.1 Operational Noise

Environmental Protection (Noise) Policy 2008

The Environmental Protection (Noise) Policy 2008 (EPP (Noise)) provides the management intent of controlling background noise creep, as well as achieving acoustic quality objectives for sensitive receptors.

A traditional approach to environmental noise has been used to measure existing background noise levels prior to a development and to set environmental noise criteria at a certain level above the existing background noise level. Where this method is used, background noise levels are measured over a period of time to incorporate a range of meteorological conditions. The background noise level used is at the lower end of the range of measured levels, in accordance with the DERM “Noise Measurement Manual”.

One of the concerns about this method is that each development may increase the background noise level allowing more relaxed criteria for future developments. This theoretical phenomenon of the degradation of the acoustic environment with successive developments is known as background creep. For this project to contribute to background creep, successive projects would need to rely on background noise levels, which have been elevated by previous projects, to set less stringent criteria.

Where there are multiple projects in an area, the cumulative noise from all projects should be considered in setting appropriate noise criteria for the individual projects to ensure that the noise from each of the projects does not contribute to background creep.

To control background creep, the EPP (Noise) includes:

> *To the extent that it is reasonable to do so, noise from an activity must not be –*
>
> *(a) For noise that is continuous noise measured by $L_{A90,T}$ - more than nil dB(A) greater than the existing acoustic environment measured by $L_{A90,T}$; or*
>
> *(b) For noise that varies over time measured by $L_{Aeq,adj,T}$ - more than 5 dB(A) greater than the existing acoustic environment measured by L_{A90T}.*
>
> *[Part 4, Clause 10]*

As the noise from the operation of the project is expected to be continuous, it is part A that applies. Based on the measured background noise levels and the calculated RBLs, the criteria associated with controlling background creep in accordance with the EPP (Noise) are shown in Table 7.1.

Table 7.1: Criteria to control background creep.

Assessment Location	Continuous Noise Source $L_{A90,1hr}$ (dB(A))		
	Day	**Evening**	**Night**
AL 1	44	41	43
AL 2	34	34	33
AL 3	42	44	43
AL 4	39	37	35
AL 5	40	36	35
AL 6	44	41	43

It is noted that intermittent noise during the operation of the project, such as LNG carrier movements, will not contribute to background creep, given the short-term and transient nature of the noise.

Since the development of the WHO Guidelines, it has become more common for regulatory authorities to base environmental noise criteria on avoiding health and wellbeing impacts rather than comparison with background noise levels. The EPP (Noise) includes acoustic quality objectives based on the WHO Guidelines. These are described in Table 7.2.

Table 7.2: The EPP (Noise) acoustic quality objectives.

Sensitive Receptor	Time of Day	Acoustic Quality Objectives (dB(A)) at the Sensitive Receptor			Environmental Value
		$L_{Aeq,adj,1hr}$	$L_{A10,adj,1hr}$	$L_{A1,adj,1hr}$	
Dwelling (for outdoors)	daytime[1] and evening[2]	50	55	65	Health and wellbeing
Dwelling (for indoors[4])	daytime and evening	35	40	45	Health and wellbeing
Dwelling (for indoors[4])	night-time[3]	30	35	40	Health and wellbeing in relation to the ability to sleep

Note:
[1] Daytime is defined by the Policy as “the period after 7am on a day to 6pm on the day”.
[2] Evening is defined by the Policy as “the period after 6pm on a day to 10pm on the day”.
[3] Night-time is defined by the Policy as “the period after 10pm on a day to 7am on the next day”.
[4] In accordance with the WHO Guidelines, indoor noise levels can be converted to outdoor levels by the addition of 15 dB(A) assuming windows being partially open for ventilation.

For continuous noise, the $L_{A90,1hr}$, $L_{A10,adj,1hr}$ and $L_{A1,adj,1hr}$ descriptors will be similar and can be approximated by the $L_{Aeq,adj,1hr}$ descriptor. Based on the measured background noise levels, the most stringent criteria in accordance with the EPP (Noise), for continuous noise, are to control background creep as provided in Table 7.3.

Table 7.3: Criteria for continuous noise to achieve EPP (Noise).

Assessment Location	Continuous Noise Source $L_{Aeq,adj,1hr}$ (dB(A))		
	Day	Evening	Night
AL 1	44	41	43
AL 2	34	34	33
AL 3	42	44	43
AL 4	39	37	35
AL 5	40	36	35
AL 6	44	41	43

For intermittent noise, given the nature of the noise sources considered in this assessment, the most stringent relevant criteria in accordance with the EPP (Noise) will be those for the $\mathbf{L_{Aeq,adj,1hr}}$ descriptor, to preserve health, wellbeing and to avoid sleep disturbance, as provided in Table 7.4.

Table 7.4: Criteria for intermittent noise to achieve EPP (Noise).

Assessment Location	Intermittent Noise Source $L_{Aeq,adj,1hr}$ (dB(A))		
	Day	**Evening**	**Night**
AL 1	50	50	45
AL 2			
AL 3			
AL 4			
AL 5			
AL 6			

All requirements of the EPP (Noise) will be met if the criteria in Tables 7.3 and 7.4 are achieved for continuous and intermittent noise sources, respectively.

<u>World Health Organisation Guidelines</u>

The WHO has developed the “Guidelines for Community Noise” in specific environments. With respect to annoyance, the guidelines state:

> *To protect the majority of people from being seriously annoyed during the daytime, the sound pressure level on balconies, terraces and outdoor living areas should not exceed 55 dB L_{Aeq} for a steady, continuous noise. To protect the majority of people from being moderately annoyed during the daytime, the outdoor sound pressure level should not exceed 50 dB(A) L_{Aeq}.*
>
> [Section 4.3.1, Page 61]

To avoid sleep disturbance, the WHO suggests that the equivalent noise level (L_{Aeq}) should be limited to 30 dB(A) inside a bedroom at night. Based on the windows being partially open, the WHO suggests that to achieve the internal level described above, the equivalent noise level outside a bedroom window should be limited to 45 dB(A).

Sonus has conducted tests of the noise reduction achieved across the facade of a number of dwellings. These tests include a range of facade constructions from lightweight transportable homes to masonry homes. The results of the testing indicate that with windows partially open for ventilation, the noise transfer is typically around 15 dB(A). The tests confirms that the WHO noise reduction of 15 dB(A) across a facade is appropriate.

If the criteria in Tables 7.3 and 7.4 are achieved, the WHO Guidelines to protect against annoyance during the day and sleep disturbance at night will also be achieved.

Low Frequency Noise Draft Guideline

In recent times, there has been an escalation of low frequency noise complaints experienced by residents in Queensland due to new industrial development (Roberts, 2004). To ensure the low frequency noise from the operation of the project does not have a significant impact on sensitive receptors, the recommendation of the DERM "Assessment of Low Frequency Noise" Draft Guideline has been considered.

The draft guideline separates the assessment of low frequency noise based on the frequency content of the noise and whether the noise is tonal or broad band. Based on measurements of similar equipment at other sites, the noise experienced at sensitive receptors will not include a significant component of infrasound (less than 20Hz) and will not be tonal.

For non-tonal, low frequency noise in the range of 20Hz to 200Hz, the draft guideline suggests that the noise is considered to be acceptable if the contribution of low frequency noise within a sensitive receptor ($L_{pA,LF}$) does not exceed 20 dB(A) during the evening or night and 25 dB(A) during the day.

The low frequency noise transfer from outside to inside sensitive receptors varies significantly based on the construction of the dwelling. Sonus has conducted tests of the noise reduction achieved across the facade of a number of dwellings. The results from these tests indicate that the low frequency noise reduction, with windows partially open, ranges from 10 dB(A) for a light weight transportable home to 20 dB(A) for a well constructed masonry home. This assessment has been based on a noise reduction of 10 dB(A), which represents a conservative assessment.

Proposed Operational Noise Conditions

The continuous noise criteria described in the sections above relate to overall noise from industry at sensitive receptors. To account for the cumulative noise impact from other projects and existing developments in the region, noise criteria which are more stringent than the requirements of the EPP (Noise) are proposed to allow for similar noise contributions from other projects.

Therefore, it has been proposed that the following noise criteria are applied for the assessment of continuous operational noise from the project:

- 33 dB(A), outside the closest sensitive receptor, represented by AL 1, AL 3 and AL 6, and;
- 28 dB(A), outside all other sensitive receptors, represented by AL 2, AL 4 and AL 5.

Table 7.5 summarises the proposed noise conditions for the operation of the project. It is noted that the noise criterion proposed for continuous noise at AL 1, AL 3 and AL 6 are less stringent than the criterion proposed for the other assessment locations considering the higher existing background noise levels (refer Table 5.4).

Table 7.5: Proposed operational noise conditions.

Operational Noise Source	Assessment Location	Outdoor Noise Criterion (dB(A))		
		Day	Evening	Night
Continuous	AL 1	33		
	AL 3			
	AL 6			
	AL 2	28		
	AL 4			
	AL 5			
Intermittent	AL 1	50	50	45
	AL 2			
	AL 3			
	AL 4			
	AL 5			
	AL 6			

7.1.2 Construction Noise

The *Environmental Protection Act 1994* and the EPP (Noise) do not include any provisions for construction noise limits, apart from blasting activity.

Nevertheless, it must be ensured that amenity during the evening or night time period at sensitive receptors is preserved to avoid sleep disturbance. In such circumstances, reference is made to the WHO Guidelines for the appropriate noise limit for construction noise during night time to avoid sleep disturbance, which is 45 dB(A) outside a dwelling.

Although a specific objective noise criterion is not proposed for daytime construction activity, all reasonable and practicable measures are to be taken to reduce the noise impact on sensitive receptors. Where necessary, any known noisy activity is to be scheduled at times when there is minimal noise impact on sensitive receptors.

Table 7.6 provides a summary of the recommended construction noise criteria.

Table 7.6: Proposed construction noise criteria.

Time Period	Outdoor Noise Criterion
Day and Evening (7am – 10pm)	*All reasonable and practicable measures to reduce the noise impact*
Night (10pm – 7am)	45 dB(A)

7.1.3 Summary of Proposed Noise Conditions

The proposed operational and construction noise criteria for the project are summarised in Table 7.7. The assessment meteorological conditions are also included in the table.

Table 7.7: Summary of proposed noise conditions.

<table>
<tr><th rowspan="2">Activity</th><th rowspan="2">Source</th><th rowspan="2">Assessment Location</th><th colspan="3">Outdoor Noise Criterion (dB(A))</th><th rowspan="2">Assessment Meteorological Conditions</th></tr>
<tr><th>Day</th><th>Evening</th><th>Night</th></tr>
<tr><td rowspan="6">Operation (Continuous)</td><td rowspan="6">LNG plant</td><td>AL 1</td><td colspan="3" rowspan="2">33</td><td rowspan="2">Neutral
(CONCAWE Category 4)</td></tr>
<tr><td>AL 6</td></tr>
<tr><td>AL 3</td><td colspan="3">33</td><td rowspan="2">Worst-case
(CONCAWE Category 6)</td></tr>
<tr><td>AL 2</td><td colspan="3">28</td></tr>
<tr><td>AL 4</td><td colspan="3" rowspan="2">28</td><td rowspan="2">Neutral
(CONCAWE Category 4)</td></tr>
<tr><td>AL 5</td></tr>
<tr><td rowspan="6">Operation (Intermittent</td><td rowspan="6">LNG carrier movements</td><td>AL 1</td><td rowspan="6">50</td><td rowspan="6">50</td><td rowspan="6">45</td><td rowspan="6">Neutral
(CONCAWE Category 4)</td></tr>
<tr><td>AL 2</td></tr>
<tr><td>AL 3</td></tr>
<tr><td>AL 4</td></tr>
<tr><td>AL 5</td></tr>
<tr><td>AL 6</td></tr>
<tr><td rowspan="6">Construction</td><td rowspan="6">LNG plant

Marine facilities

Feed gas pipeline

Dredging</td><td>AL 1</td><td colspan="2" rowspan="6">All reasonable and practicable measures to reduce the noise impact</td><td rowspan="6">45</td><td rowspan="6">Neutral
(CONCAWE Category 4)</td></tr>
<tr><td>AL 2</td></tr>
<tr><td>AL 3</td></tr>
<tr><td>AL 4</td></tr>
<tr><td>AL 5</td></tr>
<tr><td>AL 6</td></tr>
</table>

Note: Daytime is 7am to 6pm.
Evening is 6pm to 10pm.
Night-time is 10pm to 7am.

7.2 Vibration

There are two potential vibration impact components associated with the project which relate to human comfort and structural damage. For operation of the project, both components relating to human comfort and structural damage are considered, while for the short term construction of the project, the structural damage aspect of vibration is considered.

The criteria for human comfort are more stringent than the criteria which apply to the potential structural damage of buildings. The Australian Standard AS 2670.2-1990 and German Standard DIN 4150.3-1999 provide appropriate criteria to objectively assess these impacts of vibration from the project.

7.2.1 Australian Standard AS 2670.2-1990

The Australian Standard AS 2670.2-1990 provides the magnitudes of vibration that approximate the human threshold for perception. To ensure human comfort and prevent complaints due to annoyance, the measured vibration at the sensitive receptors should be less than the vibration levels provided by AS 2670.2, as shown in Table 7.8.

7.2.2 German Standard DIN 4150.3-1999

The German Standard DIN 4150.3-1999 provides short-term and long-term acceptable vibration levels, to ensure structural integrity of various building types. For dwellings, the short-term acceptable vibration levels are provided in Table 7.9, while the long-term acceptable vibration level is provided in Table 7.10.

The short-term vibration levels are used to assess the impacts of vibration during the construction works while the long-term vibration levels are used to assess the impact of vibration during project operation.

The German Standard DIN 4150.3-1999 also provides acceptable vibration levels, to ensure structural integrity of buried pipework. The acceptable vibration levels are based on the pipework material, as provided in Table 7.11. These levels are used to assess the impacts of vibration on underground pipework and telecommunication lines during the construction and operation of the project.

Table 7.8: Magnitudes of vibration that approximate human threshold for perception – AS 2670.2-1990.

1/3 Octave Band Frequency (Hz)	Acceleration (r.m.s) m/s^2		
	z-axis	x,y-axis	Sum
1	1×10^{-2}	3.6×10^{-3}	3.6×10^{-3}
1.25	8.9×10^{-3}	3.6×10^{-3}	3.6×10^{-3}
1.6	8×10^{-3}	3.6×10^{-3}	3.6×10^{-3}
2	7×10^{-3}	3.6×10^{-3}	3.6×10^{-3}
2.5	6.3×10^{-3}	4.51×10^{-3}	3.72×10^{-3}
3.15	5.7×10^{-3}	5.68×10^{-3}	3.87×10^{-3}
4	5×10^{-3}	7.21×10^{-3}	4.07×10^{-3}
5	5×10^{-3}	9.02×10^{-3}	4.3×10^{-3}
6.3	5×10^{-3}	1.14×10^{-2}	4.6×10^{-3}
8	5×10^{-3}	1.44×10^{-2}	5×10^{-3}
10	6.3×10^{-3}	1.8×10^{-2}	6.3×10^{-3}
12.5	7.81×10^{-3}	2.25×10^{-2}	7.8×10^{-3}
16	1×10^{-2}	2.89×10^{-2}	1×10^{-2}
20	1.25×10^{-2}	3.61×10^{-2}	1.25×10^{-2}
25	1.56×10^{-2}	4.51×10^{-2}	1.56×10^{-2}
31.5	1.97×10^{-2}	5.68×10^{-2}	1.97×10^{-2}
40	2.5×10^{-2}	7.21×10^{-2}	2.5×10^{-2}
50	3.13×10^{-2}	9.02×10^{-2}	3.13×10^{-2}
63	3.94×10^{-2}	1.14×10^{-1}	3.94×10^{-2}
80	5×10^{-2}	1.44×10^{-1}	5×10^{-2}

Note: x-axis = back to chest
y-axis = right side to left side
z-axis = foot (or buttocks) to head

Table 7.9: Short-term acceptable vibration levels for dwellings - DIN 4150.3-1999.

Vibration Level (mm/s)			
At the foundation of the dwelling			At horizontal plane of highest floor of dwelling
1 to 10 Hz	10 to 50 Hz	Above 50 Hz	
5	5 to 15	15 to 20	15

Table 7.10: Long-term acceptable vibration levels for dwellings - DIN 4150.3-1999.

Location	Vibration level (mm/s) at all frequencies
Horizontal plane of the highest floor of dwelling	5

Table 7.11: Acceptable vibration levels for underground pipework - DIN 4150.3-1999.

Pipework material	Vibration level (mm/s) measured on the pipe
Steel (including welded pipes)	100
Clay, concrete, reinforced concrete, pre-stressed concrete, metal (with or without flange)	80
Masonry, plastic	50

7.3 Blasting

The *Environmental Protection Act 1994* has specifically included a section for blasting activity which provides allowable noise and vibration levels from the activity. Therefore, this assessment has determined appropriate noise and vibration criteria for blasting activity based on the *Environmental Protection Act 1994,* with consideration given to the DERM "Noise and vibration from blasting" Guideline.

7.3.1 Environmental Protection Act 1994

The *Environmental Protection Act 1994* includes the following provision in relation to blasting activity:

440ZB Blasting

A person must not conduct blasting if –

(a) the airblast overpressure is more than 115dB Z Peak for 4 out of any 5 consecutive blasts; or

(b) the airblast overpressure is more than 120dB Z Peak for any blast; or

(c) the ground vibration is –

(i) for vibrations of more than 35Hz – more than 25mm a second ground vibration, peak particle velocity; or

(ii) for vibrations of no more than 35Hz – more than 10mm a second ground vibration, peak particle velocity.

[Division 3, Page 416]

7.3.2 Noise and Vibration from Blasting Guideline

The DERM "Noise and vibration from blasting" Guideline includes the following provisions:

Noise Criteria

Blasting activities must be carried out in such a manner that if blasting noise should propagate to a noise sensitive place, then

(a) the airblast overpressure must be not more than 115dB(linear) peak for nine out of any 10 consecutive blasts initiated, regardless of the interval between blasts; and

(b) the airblast overpressure must not exceed 120dB(linear) peak for any blast.

Vibration Criteria

Blasting operations must be carried out in such a manner that if ground vibration should propagate to a noise-sensitive place:

(a) the ground-borne vibration must not exceed a peak velocity of 5mm per second for nine out of any 10 consecutive blasts initiated, regardless of the interval between blasts; and

(b) *the ground-borne vibration must not exceed a peak particle velocity of 10mm per second for any blast.*

[Procedure Section, Page 1]

8 NOISE IMPACT ASSESSMENT

8.1 Operational Noise

The assessment of noise from the operation of the project involves the following steps:

- identifying the main noise sources;
- predicting the noise at the assessment locations from the identified main noise sources;
- comparing the predicted noise levels with the established noise criteria;
- determining the required noise attenuation and potential treatment to be applied in order to achieve the established noise criteria, and;
- predicting the noise at the assessment locations with the application of the appropriate treatment to ensure compliance with the established noise criteria.

To determine the main noise sources operating at the LNG plant and associated infrastructure (marine facilities and feed gas pipeline), reference has been made to the project description information provided by Arrow. Considering the selection of equipment and configuration at the LNG plant is yet to be finalised at this stage of development, indicative equipment selections, arrangements and layouts have been used for the purpose of this assessment.

8.1.1 Noise Sources

The noise sources associated with the operation of the project which were considered in the assessment are described below.

Types of Noise Sources

Two types of operational noise sources were considered in the assessment; continuous and intermittent noise sources. Continuous noise sources comprise equipment which will be operating continuously over a 24 hour day period, while intermittent noise sources are sources which will only emit noise for short-term periods, under normal operating conditions.

Main Noise Source

The main continuous noise sources considered are the fixed equipment at the LNG plant, while the main intermittent noise sources considered are the LNG carrier and associated tug boats movements.

It is noted that the noise from personnel ferries and barges between Curtis Island and mainland Gladstone during the operation of the project is expected not to have a significant impact on sensitive receptors considering the transient nature of the noise and the current noise exposure from existing marine traffic in the area.

The sound power levels, quantity of each main noise source and configuration of the equipment considered in the assessment are provided below.

LNG Plant

The total sound power levels and the quantity of each of the main continuous noise sources at LNG plant are provided in Tables 8.1 and 8.2. Table C.1 in Appendix C provides the octave band sound power levels for all of the main noise sources at the LNG plant.

Of the four LNG plant power configuration options being considered, two options have been considered for the noise impact assessment; the base case which is the mechanical drive arrangement and the alternative which is the all electric drive arrangement. The mechanical drive option is expected to have the most significant noise impact at sensitive receptors, while the all electric option is expected to have the least noise impact. For each option, both phases of development i.e., Phase 1 with two LNG trains, and Phases 1 and 2 combined with four LNG trains, were assessed.

It is noted that during normal operation, there will be no continuous flaring at the LNG plant, except for maintenance, or in an emergency situation which rarely occur. A pilot flame for ignition purpose will however operate continuously, but the noise impact at sensitive receptors will be insignificant. When maintenance is conducted, it is understood that the gas flaring (e.g., during plant shut-down or start-up) will be scheduled and designed such that any impact will be minimised at sensitive receptors.

LNG Carrier Movements

The sound power levels for the LNG carrier and tug boat have been based on similar vessels considered in the Santos Gladstone LNG assessment, as provided in the Heggies Pty Ltd “Gladstone LNG – Environmental Impact Statement Noise and Vibration (Terrestrial)” 2009 report.

Table 8.3 provides the octave band sound power levels for the LNG carrier and tug boat, and also the quantity of vessel operating at any one time.

Table 8.1: Main continuous noise source for mechanical drive option.

Noise Source	Quantity	Total Sound Power Level (dB(A))
LNG Train Equipment (per LNG train)		
Acid Gas Removal Unit		
Pump - 15kW	11	85
Solvent Air Cooler Fan	3	77
Dehydration Unit		
Centrifugal Compressor	1	95
Compressor Air Cooler Fan	1	77
Liquefaction Unit		
Hydraulic Turbine	1	87
Pump - 15kW	6	85
Process Compressors		
LP Compressor	2	125
MP/HP Compressor	2	114
C3 Compressor	2	123
Process Compressors Drives		
Gas Turbine Casing - 100MW	2	106
Gas Turbine Exhaust Stack - 100MW	2	116
Cooling Tower		
Fan Bay – 3 Fans	78	105
End Flash Gas Compression Unit		
Compressor Electric Motor	1	108
Compressor	1	97
Compressor Air Cooler Fan	3	77
Hot Water System		
Pump - 15kW	6	85
Refrigerant Handling and Storage Facilities, Drainage and Effluent Treatment		
Pump - 15kW	1	85
Substation		
Transformer - 20MVA	2	92
Other Plant Equipment for 2 Trains		
Power Generation		
Gas Turbine Casing - 30MW	4	106
Gas Turbine Exhaust Stack - 30MW	4	116
Generator	4	107
Loading System		
BOG Compressor	1	107
BOG Compressor Gear Box	1	77
BOG Compressor Electric Motor	1	108

Table 8.1: Main continuous noise sources for mechanical drive option (continued).

Noise Source	Quantity	Total Sound Power Level (dB(A))
Water Facilities		
HP Pump - 210 kW	2	100
Pump - 15kW	8	85
Instrument and Tool Air System		
Air Compressor - 55kW	2	98
Air Compressor Electric Motor - 55kW	2	87
Substations		
Power Generation Transformer - 40MVA	4	96
Other Plant Equipment for 4 Trains		
Power Generation		
Gas Turbine Casing - 30MW	7	106
Gas Turbine Exhaust Stack - 30MW	7	116
Generator	7	107
Loading System		
BOG Compressor	2	106
BOG Compressor Gear Box	2	77
BOG Compressor Electric Motor	2	108
Water Facilities		
HP Pump - 210 kW	2	100
Pump - 15kW	14	85
Instrument and Tool Air System		
Air Compressor - 55kW	3	98
Air Compressor Electric Motor - 55kW	3	87
Substations		
Power Generation Transformer - 40MVA	7	96
Other Plant Equipment for 2 and 4 Trains		
Refrigeration Handling and Storage Facility		
Pump - 15kW	1	85
Drainage and Effluent Treatment		
Pump - 15kW	5	85
Substations		
Utility Transformer - 20MVA	2	92
Storage and Loading Transformer - 10MVA	2	99
Jetty Transformer - 6.3MVA	2	85
Administration Building Transformer – 6.3MVA	2	85

Table 8.2: Main continuous noise sources for all electric drive option.

Noise Source	Quantity	Total Sound Power Level (dB(A))
LNG Train Equipment (per LNG train)		
Acid Gas Removal Unit		
Pump - 15kW	11	85
Solvent Air Cooler Fan	3	77
Dehydration Unit		
Centrifugal Compressor	1	95
Compressor Air Cooler Fan	1	77
Liquefaction Unit		
Hydraulic Turbine	1	87
Pump - 15kW	8	85
Process Compressors		
LP Compressor	2	125
MP/HP Compressor	2	114
C3 Compressor	2	123
Process Compressors Drives		
Compressor Electric Motor	4	108
Cooling Tower		
Fan Bay – 3 Fans	76	105
End Flash Gas Compression Unit		
Compressor Electric Motor	1	108
Compressor	1	97
Compressor Air Cooler Fan	1	77
Hot Water System		
Pump - 15kW	6	85
Process Heat Furnace		
Pump - 15kW	2	85
Refrigerant Handling and Storage Facilities, Drainage and Effluent Treatment		
Pump - 15kW	1	85
Substation		
Transformer - 20MVA	2	92
Other Plant Equipment for 2 LNG Trains		
Loading System		
BOG Compressor	1	107
BOG Compressor Gear Box	1	77
BOG Compressor Electric Motor	1	108
Water Facilities		
HP Pump - 210 kW	2	100
Pump - 15kW	8	85

Table 8.2: Main continuous noise sources for all electric drive option (continued).

Noise Source	Quantity	Total Sound Power Level (dB(A))
Instrument and Tool Air System		
Air Compressor - 55kW	2	98
Air Compressor Electric Motor - 55kW	2	87
Substations		
Main Supply Transformer - 120MVA	4	103
Other Plant Equipment for 4 LNG Trains		
Loading System		
BOG Compressor	2	106
BOG Compressor Gear Box	2	77
BOG Compressor Electric Motor	2	108
Water Facilities		
HP Pump - 210 kW	2	100
Pump - 15kW	14	85
Instrument and Tool Air System		
Air Compressor - 55kW	3	98
Air Compressor Electric Motor - 55kW	3	87
Substations		
Main Supply Transformer - 120MVA	8	103
Other Plant Equipment (required for 2 or 4 LNG Trains)		
Refrigeration Handling and Storage Facility		
Pump - 15kW	3	85
Drainage and Effluent Treatment		
Pump - 15kW	5	85
Substations		
Utility Transformer - 20MVA	2	92
Storage and Loading Transformer - 10MVA	2	99
Jetty Transformer - 6.3MVA	2	85
Administration Building Transformer – 6.3MVA	2	85

Table 8.3: Main intermittent noise sources during the project operation.

Noise Source	Quantity	Maximum Sound Power Level (dB re 1 pW) by Octave Band Frequency (Hz)								Total (dB(A))
		63	125	250	500	1000	2000	4000	8000	
Ship Movements										
LNG Carrier	1	121	118	113	109	105	99	90	80	111
Tug Boat	4	121	118	113	109	105	99	90	80	111

8.1.2 Noise Predictions

The noise from the operation of the LNG plant at the assessment locations has been predicted using the CONCAWE noise propagation model in the SoundPlan noise modelling software. The CONCAWE propagation model takes into account topography, ground absorption, air absorption and meteorological conditions, and is widely accepted around the world as an appropriate sound propagation model. Of particular relevance to this project is that the model includes the reflective properties of water, which ensures that the noise level at sensitive receptors at Gladstone mainland is not under predicted (i.e., as compared to an acoustically soft ground).

LNG Plant

Based on the sound power levels of equipment listed in Tables 8.1 and 8.2, the noise level at the assessment locations has been predicted under the established meteorological conditions. The predicted noise level at each assessment location for the various scenarios is summarised in Table 8.4. Noise contours of the predicted noise levels under neutral (Category 4) and worst-case (Category 6) meteorological conditions are provided in Appendix D.

Table 8.4: Predicted noise levels from operation of the LNG plant.

Assessment Location	Meteorological Conditions Category	Noise Criterion, dB(A)	Predicted Operational Noise Level, dB(A)			
			Mechanical Drive		All Electric Drive	
			2 Trains	4 Trains	2 Trains	4 Trains
AL 1	4 (Neutral-case)	33	47	49	46	48
AL 2	6 (Worst-case)	28	22	25	20	23
AL 3	6 (Worst-case)	33	31	34	30	33
AL 4	4 (Neutral-case)	28	34	37	33	35
AL 5	4 (Neutral-case)	28	28	31	27	29
AL 6	4 (Neutral-case)	33	45	47	44	46

The predictions indicate that the operational noise level at AL 1, AL 4 and AL 6 will exceed the respective proposed noise criterion without any additional acoustic treatment being applied. The predicted noise level at AL 5 will exceed the proposed noise criterion when there are four LNG trains in operation, with either drive options, while the predicted noise level at AL 3 will only exceed the proposed noise criterion with four LNG trains with the mechanical drive option.

LNG Carrier Movements

Based on the sound power level spectrum provided in Table 8.3, the noise from an LNG carrier and tug boats movements in the vicinity of the LNG jetty has been predicted under neutral meteorological conditions. The prediction assumes “worst-case” scenario that the LNG carrier and the tug boats are manoeuvring (or idling) under full load for an entire 1 hour period at the jetty. The predicted noise level at each assessment location is summarised in Table 8.5.

Given the night-time criterion will control the allowable noise level, the predicted noise levels have been compared against the night-time criterion for each noise descriptor.

Table 8.5: Predicted noise levels from ship movements at LNG jetty.

Assessment Location	Meteorological Conditions Category	Night-time Noise Criterion, dB(A)	Predicted Noise Level, dB(A)
AL 1	4 (Neutral-case)	45	35
AL 2			13
AL 3			25
AL 4			23
AL 5			20
AL 6			31

The prediction indicates that the noise at all assessment locations from ship movements in the vicinity of the LNG jetty will achieve the night-time criterion for intermittent noise.

A noise prediction of an LNG carrier and four tug boats passing-by a point along the service route (within Gladstone Harbour and Targinnie Channel) which is closest to a sensitive receptor (in this case AL 1) has also been made. The prediction assumes that the LNG carrier and tug boats will pass-by the assessed point under full load over a period of five minutes and has been made under neutral meteorological conditions, given the intermittent nature of the noise.

Based on the prediction, the noise level at AL 1, will be in the order of 42 dB(A), therefore achieving the night-time criterion of 45 dB(A). Consequently, it is expected that the noise level at all other sensitive receptors will be well below the night-time criterion.

In addition, it is noted the sensitive receptors in the vicinity of Gladstone Harbour and Targinnie Channel, particularly on Tide and Witt Islands (i.e., AL 1 and AL 6, respectively), are already exposed to noise from ship movements associated with existing shipping terminals in the area. Based on the shipping data available on the Gladstone Port Authority's webpage, there are approximately 700 ships that berth at the RG Tanner Coal Terminal and Fisherman's Landing terminal annually, which translate to approximately 1400 ship movements a year.

During full capacity of the project (i.e., LNG production of 16 Mtpa), it is anticipated that there will be approximately 10 LNG carrier movements per week (240 carriers per year for the smaller LNG carrier option) to and from the LNG jetty. Although the project will increase the total number of ship movements within the area, given the transient and short-term nature of the movements, it is expected that the noise exposure during any 1 hour will not be dissimilar to levels currently experienced.

Therefore, it is expected that the noise from LNG carrier movements associated with this project will not have a significant noise impact on sensitive receptors.

8.1.3 Mitigation Measures

In order to achieve the noise criteria for the operation of the LNG plant, additional acoustic treatment will be required to be incorporated during the detailed design stage of the project. Conceptual treatment has been considered for the noise sources in accordance with the following rationale:

- to the extent practicable, treat the dominant noise sources first; then,
- apply treatment to other equipment which typically would only require standard additional treatment (e.g., sheet steel shed for pumps).

The potential acoustic treatment is summarised in Table 8.6. The noise level reduction with the application of feasible acoustic treatment to the dominant noise sources are also provided in Table 8.6.

Table 8.6: Attenuation from acoustic treatment.

Noise Source	Noise Level Reduction (dB)							Potential Treatment
	63	125	250	500	1000	2000	4000	
LNG Train Equipment (per LNG train)								
Process Compressors								
LP Compressor	6	10	15	22	26	31	32	Sheet steel enclosure with acoustically treated ventilation
MP/HP Compressor	6	10	15	22	26	31	32	Sheet steel enclosure with acoustically treated ventilation
C3 Compressor	6	10	15	22	26	31	32	Sheet steel enclosure with acoustically treated ventilation
Process Compressors Drives								
Gas Turbine Casing – 100MW	6	10	15	22	26	31	32	Sheet steel enclosure with acoustically treated ventilation,
Gas Turbine Exhaust Stack – 100MW	9	16	18	20	12	8	0	Upgrade silencer
Cooling Tower								
Fan Bay – 3 Fans	6	13	15	15	15	8	0	Use of ultra-low noise fans, install variable fan drives (VFD) and/or incorporate discharge air sound attenuators
End Flash Gas Compression Unit								
Compressor Electric Motor	6	10	15	22	26	31	32	Sheet steel enclosure with acoustically treated ventilation
Other Equipment at LNG Export Facility								
Power Generator Drives								
Gas Turbine Casing – 30MW	6	10	15	22	26	31	32	Sheet steel enclosure with acoustically treated ventilation,
Gas Turbine Exhaust Stack – 30MW	9	16	18	20	12	8	0	Upgrade silencer
Generator	6	10	15	22	26	31	32	Sheet steel enclosure with acoustically treated ventilation,
Loading System								
BOG Compressor (excluding oil unit and piping)	6	10	15	22	26	31	32	Sheet steel enclosure with acoustically treated ventilation
BOG Compressor Electric Motor	6	10	15	22	26	31	32	Sheet steel enclosure with acoustically treated ventilation
Water Facilities								
HP Pump	6	10	15	22	26	31	32	Sheet steel enclosure with acoustically treated ventilation
Pump	6	10	15	22	26	31	32	Sheet steel enclosure with acoustically treated ventilation

Application of Mitigation Measures to LNG Plant

With additional acoustic treatment incorporated in the design and the required noise level reduction achieved (provided in Table 8.6), the noise levels at AL 1 through AL 6 have been predicted under the proposed meteorological conditions. The predicted noise level at each assessment location for the various scenarios, with additional acoustic treatment applied is summarised in Table 8.7. Noise contours of the predicted noise levels under neutral

(Category 4) and worst-case (Category 6) meteorological conditions with additional acoustic treatment are provided in Appendix E.

Table 8.7: Predicted operational noise levels with additional acoustic treatment.

Assessment Location	Meteorological Conditions Category	Noise Criterion, dB(A)	Predicted Operational Noise Level, dB(A)			
			Mechanical Drive		All Electric Drive	
			2 Trains	4 Trains	2 Trains	4 Trains
AL 1	4 (Neutral-case)	33	33	33	33	33
AL 2	6 (Worst-case)	28	11	12	11	12
AL 3	6 (Worst-case)	33	19	20	20	21
AL 4	4 (Neutral-case)	28	22	22	22	22
AL 5	4 (Neutral-case)	28	16	17	16	17
AL 6	4 (Neutral-case)	33	31	32	31	31

The predictions indicate that the operational noise level at all assessment locations, AL 1 through AL 6, will achieve the proposed noise conditions with additional acoustic treatment incorporated.

8.1.4 Low Frequency Noise

The noise from the equipment at the LNG plant is not dominated by low frequency noise (refer Table C.1 in Appendix C) but the propagation of sound over large distances attenuates the high and mid frequencies, potentially leaving a greater low frequency component. Therefore, an assessment against the recommendations of the DERM Low Frequency Noise Draft Guideline has been made.

The low frequency noise level inside the closest dwelling, at AL 1, from the operation of the LNG plant has been predicted under neutral meteorological conditions with the additional acoustic treatment provided in Table 8.6 incorporated. The predicted noise level is provided in Table 8.8.

Table 8.8: Predicted low frequency noise levels (operation) with additional acoustic treatment.

Assessment Location	Meteorological Conditions Category	Indoor Noise Criterion, dB(A)	Predicted Operational Noise Level, dB(A)			
			Mechanical Drive		All Electric Drive	
			2 Trains	4 Trains	2 Trains	4 Trains
AL 1	4 (Neutral-case)	20	19	19	18	18

The predictions indicate that the low frequency noise level inside the closest dwelling will be no greater than 19 dB(A). Therefore, the draft guideline suggestion of $L_{pA,LF}$ of 20 dB(A) inside a dwelling is achieved at all dwellings in the vicinity of the site with the recommended acoustic treatment in place.

8.2 Construction Noise

The assessment of noise from construction of the project included noise from the construction of the LNG plant, the marine facilities (comprising the LNG jetty, MOF, personnel jetty and mainland launch site), the feed gas pipeline and the construction camps. The assessment also considered construction and activity conducted at the laydown areas, the construction camps and the launch site, and dredging at the proposed dredging sites.

As the nature of construction techniques and equipment of the project will be determined based on final equipment selections, site-specific requirements and the on-going FEED process, complete details regarding the noise sources that will be used during the construction phase are not currently available.

In these circumstances, noise levels from construction of the proposed facilities and associated activity during the construction phase have been predicted based upon typical construction equipment type and numbers that may be expected to be used at the site. The sound power levels for construction equipment have been based on the Australian Standard AS 2436-1981 “Guide to Noise Control on Construction, Maintenance and Demolition Sites”, manufacturer’s data and Sonus database of noise sources.

It is noted that the noise criterion of 45 dB(A) only applies for night-time (10pm to 7am) construction activities. During the day, all reasonable and practicable measures will be taken to reduce the noise impact at sensitive receptors.

8.2.1 Main Noise Source Levels

Construction of Main Project Infrastructure

The main infrastructure associated with this project is the LNG plant, the marine facilities comprising the LNG jetty, MOF, personnel jetty and mainland launch site, the feed gas pipeline and the construction camps. The main noise sources during the construction of this infrastructure, which have been considered in this assessment, are provided in Tables 8.9 through 8.12. The tables also include the quantity of each piece of equipment at the site, and the maximum sound power levels emitted from the equipment.

Table 8.9: Main noise sources during the construction of the LNG Plant

Equipment	Quantity	Maximum Overall Sound Power Level (dB(A))
Dozer	2	120
Front end loader	4	118
Excavator	4	118
Truck	12	120
Grader	2	118
Roller	2	115
Crane	4	115
Concrete pump	4	109
Concrete mixer truck	12	112
Piling rig	1	125
Ancillary Equipment		
Concrete batch plant	1	113
Power generator	4	119
Pneumatic Testing		
Generator for air compressor	2	113
Air compressor	2	107

Table 8.10: Main noise sources during the construction of the construction camps.

Equipment	Quantity	Maximum Overall Sound Power Level (dB(A))
Dozer	1	120
Front end loader	2	118
Excavator	2	118
Truck	4	120
Grader	1	118
Roller	1	115
Crane	1	115
Concrete mixer truck	1	112

Table 8.11: Main noise sources during the construction of each of the marine facilities (i.e., LNG jetty, MOF, personnel jetty and mainland launch site).

Equipment	Quantity	Maximum Overall Sound Power Level (dB(A))
Dozer	1	120
Front end loader	2	118
Excavator	2	118
Truck	2	120
Crane	1	115
Concrete pump	1	109
Concrete mixer truck	4	112
Piling rig	1	125

Table 8.12: Main noise sources during the construction of feed gas pipeline.

Equipment	Quantity	Maximum Overall Sound Power Level (dB(A))
Open-cut Trenching at both Ends of the Tunnel		
Front end loader	1	118
Excavator	1	118
Truck	1	120
Crane	1	115
Concrete mixer truck	1	112
Generator for welding	1	113
Tunnelling Equipment		
Tunnel Boring Machine	1	*
Slurry pump	4	96

* It is noted that the noise from the tunnel boring machine (TBM) will be dominated by ground-borne noise. Based on the distance to the closest sensitive receptor, approximately 1.2km, the noise from the TBM is expected not to be significant (Speakman and Lyons, 2009)

Construction Activity at Laydown Areas

The main noise sources associated with construction activity at each of the identified laydown areas on Curtis Island and launch site options have been considered based on the typical construction equipment type and numbers expected on site, as provided in Table 8.13. The maximum sound power level and quantity of each noise source have also been provided in the table.

Table 8.13: Main noise source at each laydown area.

Noise Source	Quantity	Maximum Overall Sound Power Level (dB(A))
Generator for welding	2	113
Air compressor	2	107
Hand-held grinder	5	106
Forklift	2	110
Bobcat	2	106
Crane	1	115

The main noise sources considered at the laydown areas (including stringing and fabrication) within the mainland tunnel launch site are summarised in Table 8.14. The quantity of each piece of equipment in Table 8.14 indicates the total equipment considered to be operating at the mainland tunnel launch site at any given time.

Table 8.14: Main noise sources at the mainland tunnel launch site.

Noise Source	Quantity	Maximum Overall Sound Power Level (dB(A))
Air compressor	2	107
Hand-held grinder	5	106
Forklift	3	110
Bobcat	1	106
Crane	1	115

Dredging

The main noise sources during dredging activities at each of the five dredge sites have been determined based on the indicative dredging equipment provided by Arrow Energy, and are summarised in Table 8.15.

Table 8.15: Main noise sources at dredge sites.

Noise Source	Maximum Overall Sound Power Level (dB(A))	Quantity at Each Dredge Site (DS)				
		DS 1 Launch site 1	DS 2 Launch site 4N	DS 3 Boatshed Point	DS 4 Hamilton Point South	DS 5 LNG Jetty
Large Trailer Suction Hopper Dredger (TSHD)	112	1	1	-	-	-
Large Cutter Suction Dredger (CSD)	118	-	-	-	1	-
Small CSD	106	-	-	-	-	1
Backhoe(BH)	118	-	-	1	-	1
Tug boat	111	1	1	1	1	1
Barge	104	-	-	1	-	1

Activity Associated with the Construction Camps

Noise from activity at the Curtis Island construction camp and the mainland TWAFs, such as vehicle movements and the use of heating, ventilating and air conditioning (HVAC) systems, has also been considered. The main noise sources considered are summarised in Table 8.16.

Table 8.16: Main noise sources associated with the Construction Camps.

Noise Source	Quantity	Maximum Overall Sound Power Level (dB(A))
Bus movements	48 (per 1hr period)	98
HVAC outdoor condenser unit	625 (1 unit per 4 rooms)	65

Activity Associated with the Marine Facilities

During the construction phase of the project, completed marine facilities will be used for personnel, construction material and supplies transfer between mainland Gladstone and Curtis Island. The operation of these facilities has been included in this assessment.

It is understood that high speed catamarans (Fastcats), and vehicle or passenger ferries (ROPAX) will be used for personnel transfer, while roll-on, roll-off or lift-on, lift-off vessels will be used to transport preassembled modules, equipment, supplies and construction aggregate. The noise from the ferries and vessels while crossing the waterways has been considered.

While at dock, the noise from the ferries and vessels is expected to be negligible. However, noise from equipment used for loading or unloading material from vessels, particularly at the MOF or launch site may be significant. Therefore, the expected main noise sources at the proposed MOF and launch site options have been determined and summarised in Table 8.17.

Table 8.17: Main noise sources for material loading and unloading at docks.

Noise Source	Quantity	Maximum Overall Sound Power Level (dB(A))
Forklift	2	110
Bobcat	2	106
Crane	1	115

8.2.2 Noise Predictions

The noise from the construction of the LNG plant, the marine facilities (LNG jetty, MOF, personnel jetty, mainland launch site), the feed gas pipeline and the construction camps, the dredging, and activity associated with the construction phase of the project such as operation of the construction camps and marine facilities has been predicted under neutral meteorological conditions. The prediction assumes a “worst-case” period of all equipment operating simultaneously and continuously at the respective construction sites, through the day and night periods.

Construction of LNG Plant, Marine Facilities, Feed Gas Pipeline and Construction Camps

The predicted noise levels at the most significant assessment location (highest predicted noise level) from equipment for the construction of main project infrastructure (comprising the LNG plant, construction camps, marine facilities and feed gas pipeline) is provided in Tables 8.18 through 8.21.

Table 8.18: Predicted noise levels from construction of the LNG Plant at AL 1.

Equipment	Quantity	Predicted Noise Level (dB(A))
Assessment Location		**AL 1**
Dozer	2	33
Front end loader	4	38
Excavator	4	37
Truck	12	42
Grader	2	36
Roller	2	33
Crane	4	36
Concrete pump	4	27
Concrete mixer truck	12	33
Piling rig	1	45
Ancillary Equipment		
Concrete batch plant	1	24
Power generator	4	37
Total		**49**
Pneumatic Testing		
Generator for air compressor	2	31
Air compressor	2	26
Total		**33**

Table 8.19: Predicted noise levels from construction of marine facilities.

Equipment	Quantity	Predicted Noise Level (dB(A))				
		Boatshed Point MOF and Personnel Jetty	South Hamilton Point MOF	LNG Jetty	Launch Site 1	Launch Site 4N
Assessment Location		**AL 1**	**AL 1**	**AL 1**	**AL 1**	**AL 3***
Dozer	1	52	50	25	31	18
Front end loader	2	53	47	33	34	21
Excavator	2	52	46	32	30	16
Truck	2	53	48	32	29	15
Crane	1	48	28	27	26	11
Concrete pump	1	39	27	16	17	2
Concrete mixer truck	4	49	40	27	25	10
Piling rig	1	61	56	41	40	26
Total		**63**	**58**	**43**	**42**	**28**

Table 8.20: Predicted noise levels from construction of feed gas pipeline.

Equipment	Quantity	Predicted Noise Level (dB(A))	
Assessment Location		**AL 3**	**AL 1**
Open-cut Trenching at Each End of the Tunnel			
Front end loader	1	36	26
Excavator	1	33	21
Truck	1	33	19
Crane	1	30	17
Concrete mixer truck	1	25	11
Generator for welding	1	29	17
Total		**40**	**27**
Tunnelling Ancillary Equipment			
Slurry pump	2	33	25
Total		**33**	**25**

Table 8.21: Predicted noise levels from construction of the construction camps.

Equipment	Quantity	Predicted Noise Level (dB(A))		
		Curtis Island Construction Camp	TWAF7	TWAF8
Assessment Location		AL 1	AL 5	AL 2
Dozer	1	42	51	50
Front end loader	2	46	54	55
Excavator	2	46	53	54
Truck	4	49	58	59
Grader	1	43	49	49
Roller	1	40	46	47
Crane	1	39	46	47
Concrete mixer truck	1	33	42	44
Total		**53**	**61**	**62**

Based on the predictions, as summarised in Tables 8.18 through 8.21, the following observations have been made:

- the predicted noise level from the construction of the LNG plant is 50 dB(A) at the closest sensitive receptor to the site (AL 1), which exceeds the night-time criterion of 45 dB(A);
- the predicted noise level from the construction of the Curtis Island construction camp and TWAFs at the closest sensitive receptor to the respective camps exceeds the night-time criterion of 45 dB(A);
- the predicted noise level from the construction of marine facilities at the closest assessment location exceeds the night-time criterion of 45 dB(A). It is noted that the predicted noise from construction of the Boatshed Point and South Hamilton Point facilities significantly exceeds the night-time criterion at AL 1 (sensitive receptor on Tide Island);
- the predicted noise level from the construction of the feed gas pipeline achieves the night-time criterion of 45 dB(A) at all considered assessment locations;
- the predicted noise level from ancillary equipment associated with construction of the LNG plant achieves the night-time criterion of 45 dB(A) at the closest sensitive receptor to the site (AL 1).

Construction Activity at Laydown Areas

The noise from construction activity at designated laydown areas on Curtis Island and each of the launch sites has been predicted based on the expected construction equipment on site, as provided in Table 8.13. The predicted noise level at each assessment location is provided in Table 8.22.

The noise contribution from the different noise sources at Launch site 1 to the overall predicted noise level at AL 1 is given in Table 8.23. The table provides the contributions of each type of noise source to the overall noise level at AL 1, which may be used as an indication of the relative noise contribution of each noise source type at other assessment locations.

The predicted noise level at the closest assessment location from construction activity at the mainland tunnel launch site is provided in Table 8.24.

Table 8.22: Predicted noise levels from construction at laydown areas.

Laydown Area	Predicted Noise Level (dB(A)) at each Assessment Location					
	AL 1	AL 2	AL 3	AL 4	AL 5	AL 6
Curtis Island 7 Designated Areas	44	17	27	31	26	42
Launch site 1 1 Designated Area	33	10	18	27	30	31
Launch site 4N 1 Designated Area	23	20	19	15	15	20
Curtis Island and Launch Site 1 Combined	44	18	27	32	31	42
Curtis Island and Launch Site 4N Combined	44	22	27	31	26	42

Table 8.23: Predicted noise levels from construction activity at Launch site 1 laydown area.

Equipment	Quantity	Predicted Noise Level (dB(A))
Assessment Location		**AL 1**
Generator for welding	2	28
Air compressor	2	22
Hand-held grinder	5	19
Forklift	2	26
Bobcat	2	26
Crane	1	26
Total		**33**

Table 8.24: Predicted noise levels from construction activity at the mainland tunnel launch site.

Equipment	Quantity	Predicted Noise Level (dB(A))
Assessment Location		**AL 3**
Air compressor	2	23
Hand-held grinder	5	25
Forklift	3	28
Bobcat	1	21
Crane	1	31
Total		**34**

Based on the predictions, the noise from construction activity conducted at the laydown areas on Curtis Island and at the launch sites will achieve the night-time criterion of 45 dB(A) at all assessment locations.

The noise from construction activity at the mainland tunnel launch site (laydown area, stringing and fabrication) is predicted to be 38 dB(A) at AL 3, therefore achieving the night-time criterion of 45 dB(A) for construction.

Dredging

The predicted noise level at the assessment locations from dredging activity at the proposed dredge sites is provided in Table 8.25. The prediction has been based on indicative dredging equipment summarised in Table 8.15.

Table 8.25: Predicted noise levels from dredging.

Dredge Site	Predicted Noise Level (dB(A)) at each Assessment Location					
	AL 1	**AL 2**	**AL 3**	**AL 4**	**AL 5**	**AL 6**
DS 1 Launch site 1	29	5	13	18	23	24
DS 2 Launch site 4N	18	12	12	11	11	16
DS 3 Boatshed Point	53	12	22	29	23	45
DS 4 Hamilton Point South	50	8	21	25	19	39
DS 5 LNG Jetty	33	14	25	24	21	30

Based on the prediction, the noise from dredging activity at the proposed dredge sites achieves the criterion of 45 dB(A) at all assessment locations, except at AL 1 for dredging conducted at Dredge Sites 3 (Boatshed Point) and 4 (Hamilton Point South).

Other Activity Associated with the Construction Camps

The noise from bus movements and HVAC units at the proposed construction camps has been predicted and is summarised in Table 8.26. The prediction assumes that the vehicle movements at TWAFs 7 and 8 occur for a period of 1 minute before entering public roads, while the vehicle movements at the Curtis Island construction camp occurs for an estimated period of approximately 5 minutes. In the prediction model, all noise sources have been located near the site boundary, at the point closest to the assessment location considered.

Table 8.26: Predicted noise levels from construction camps.

Equipment	Quantity	Predicted Noise Level (dB(A))		
		Curtis Island Construction Camp	TWAF7	TWAF8
Assessment Location		AL 1	AL 5	AL 2
Bus movements	48 (per 1 hr period)	12	44	40
HVAC outdoor condenser unit	625 (1 unit per 4 rooms)	6	40	38
Total		13	45	42

Based on the prediction, the noise from bus movements and the operation of HVAC units at the construction camps will achieve the night-time criterion of 45 dB(A) at the assessment location. Further, given the location of TWAFs 7 and 8 in close proximity to public roads such as Blain Drive and Calliope River Targinnie Road, respectively, it is expected that the noise from vehicle movements at the TWAFs will be no greater than the noise from traffic on these roads.

Activity Associated with the Marine Facilities during Construction

Two components of noise have been considered in this assessment which are associated with activity at the personnel jetty, MOF and launch site during construction. The two components are the noise from ferries and vessels travelling between mainland Gladstone and Curtis Island, and noise from ancillary equipment at the dock for material loading or unloading.

Given the size and trip frequencies of the proposed ferries and vessels, and the current high volume of marine traffic in the Gladstone harbour which mainly consist of large vessels, it is expected that there will be insignificant noise impacts on sensitive receptors from the increase in marine traffic as a result of the project.

The noise at the assessment locations from the expected equipment used for material loading and unloading at the MOF and launch site options has been predicted and is summarised in Table 8.27. The noise contribution from the different noise sources at Boatshed Point MOF to the overall predicted noise level at AL 1 is provided in Table 8.28. Table 8.28 also indicates the relative noise contributions of each type of source to the overall noise level at AL 1.

Table 8.27: Predicted noise levels from equipment at MOF and launch site.

Site	Predicted Noise Level (dB(A)) at each Assessment Location					
	AL 1	**AL 2**	**AL 3**	**AL 4**	**AL 5**	**AL 6**
Boatshed Point MOF 1	51	5	18	26	19	43
South Hamilton Point MOF 2	41	9	21	23	18	32
Launch Site 1	31	8	17	22	25	28
Launch Site 4N	19	15	15	12	13	18

Table 8.28: Main noise sources for material loading and unloading at Boatshed Point MOF.

Equipment	Quantity	Predicted Noise Level (dB(A))
Assessment Location		**AL 1**
Forklift	2	46
Bobcat	2	41
Crane	1	48
Total		**51**

The prediction indicates that the noise from material loading and unloading equipment at each of the MOFs and launch sites will achieve the criterion of 45 dB(A) at all assessment locations, except at AL 1 for equipment at Boatshed Point

8.3 Construction Mitigation Measures

Based on the noise predictions summarised in Section 8.2, there will be certain construction activity which may have significant noise impact on sensitive receptors if the construction activity occurs at night. In order to reduce the noise impact on sensitive receptors from construction, standard management and mitigation measures will be implemented, which include the following:

- Incorporating all reasonable and practicable measures to reduce the noise associated with construction, regardless of the time of day. Where practicable these measures will include:
    - Locating noise making equipment or processes such that their impact on closest sensitive receptor is minimised. This will be achieved by maximising the distance to the closest sensitive receptor, or using structures or elevations to create barriers;
    - Shutting or throttling down equipment when not in actual use;
    - Ensuring noise reduction devices such as mufflers are fitted and operate effectively;
    - Ensuring machinery or equipment is not operated if maintenance or repairs would eliminate or significantly reduce a characteristic of noise from its operation that is audible at the nearest residences;
    - Operating equipment and handling material so as to minimise impact noise;
    - Using off-site or other alternative processes that eliminate or lessen resulting noise.
- Where the noise from a construction activity exceeds 45 dB(A) at a sensitive receptor, the construction work or noisy equipment used for the process will be limited to the hours of 7am to 10pm.

It is noted that the prediction assumes the “worst-case” scenario where all the identified main noise sources during construction to be operating continuously and simultaneously. The assumption was made as complete details regarding the exact equipment and processes during the construction phase were not available at this stage of the development.

In practice, it is unlikely that all equipment will operate continuously and simultaneously. Therefore, to provide a better indication of the expected noise levels and ensure compliance with the night-time criteria, noise predictions (i.e., desktop analysis) or measurements will be conducted when the schedule of construction processes is known. These will be conducted at the start of each construction activity occurring at night where there is the potential for significant noise at sensitive receptors.

Specific mitigation measures will be confirmed once the actual construction processes are known and predictions or measurements have been conducted, which may include, but not limited to the following:

- Incorporating additional attenuation devices, such as upgraded mufflers;
- Limiting the length of time for the operation of certain equipment at night;
- Restricting noisy construction activity to the daytime period, and;
- Coordination of construction equipment that may operate simultaneously.

With the appropriate mitigation measures implemented, the noise from the construction of the project will achieve the established noise conditions.

9 VIBRATION IMPACT ASSESSMENT

The level of vibration at a receiver is dependent on the equipment operating (i.e., the vibration source), and the separation distance and ground type between the receiver and the vibration sources. These factors have been considered in determining the vibration impacts on sensitive receptors, underground pipelines and telecommunication lines (i.e., existing infrastructure) from the project.

9.1 Operation

The potential vibration sources associated with the operation of the project which may result in vibration at sensitive receptors, or existing underground infrastructures include equipment at the LNG plant, the LNG jetty and the feed gas pipeline.

9.1.1 Impact at Sensitive Receptors

Sonus has previously conducted vibration measurements at a power generation facility which had similar rotary equipment operating on site, comprising gas turbine generators. The measurements indicated that the vibration levels at a distance of 150m from the facility were below the threshold levels of human detection as provided by AS 2670, and the acceptable levels provided by DIN 4150 (refer Sections 7.2.1 and 7.2.2).

Based on the above, and considering that the closest sensitive receptor to the LNG plant (at AL 1) is located approximately 2.4km away from main equipment on site, it is expected that the vibration levels will be well below the threshold of human detection and will not cause structural damage.

The vibration levels associated with the equipment and activity at the LNG jetty are also expected to be low. Considering the closest sensitive receptor to the LNG jetty (at AL 1) is located approximately 2.2km away from the jetty, it is expected that vibration level at the closest sensitive receptor will be well below the threshold of human detection.

The feed gas pipeline will be located underground, and it is understood that the associated equipment will not produce perceivable vibration. Therefore, the vibration levels at sensitive receptors in the vicinity of the feed gas pipeline are expected to be well below the threshold of human detection.

9.1.2 Impact on Underground Pipework and Telecommunication Lines

The main project infrastructure, the LNG plant and LNG jetty, are located on Curtis Island which currently does not have any significant development. It is expected that there will be no existing underground pipework or telecommunication lines in the vicinity of the site. For any exisitng underground pipework located off of Curtis Island, for example at AL 1 or AL 6, the level of vibration will be well below the acceptable levels of DIN 4150, considering the large separation distances.

As mentioned in Section 9.1.1, the feed gas pipeline will not produce perceivable vibration. Therefore, any underground pipework or telecommunication lines located in close proximity to the feed gas pipelines will not result in structural damage from vibration.

9.2 Construction

The vibration associated with the construction phase of the project includes vibration from the following:

- the construction of the LNG plant, the marine facilities, the feed gas pipeline (including the tunneling using the tunnel boring machine (TBM)) and the temporary construction camps;
- dredging; and,
- operation of the marine facilities and construction camps.

Sonus has previously conducted vibration measurements in the vicinity of a construction site which was conducting piling. Piling is a construction activity which generally produces significant levels of vibration in close proximity of the activity. Based on the measurements, the vertical, longitudinal and tangential vibration levels at approximately 50m away from the piling activity were approximately 2.2mm/s, 1.9mm/s and 1.4mm/s, respectively.

The measured vibration levels above are below the 5mm/s level recommended by DIN 4150 for prevention of structural damage to dwellings, and significantly below the 50mm/s recommended level for underground pipework.

9.2.1 Impact at Sensitive Receptors

Based on the measured levels above, and considering the large separation distances between the constructions site of the LNG plant and the closest sensitive receptor (i.e., approximately 2.4km), the expected vibration level at the sensitive receptor from construction activities at the LNG plant site will be well below the threshold of human detection. Similarly, considering the generally large separation distances (at least 200m) between the sensitive receptors and the associated noise sources from the construction of the marine facilities, the feed gas pipeline and the temporary construction camps, the construction activity at laydown areas and the proposed dredging, the vibration levels at sensitive receptors are expected to be below the threshold of human detection.

In addition, it is noted that the vibration level at the sensitive receptors (located at distances of greater than 1.2km away) from the use of the TBM is expected to be below the threshold of human detection and will not result in structural damage (Speakman & Lyons, 2009).

Nevertheless, vibration monitoring will be conducted at the start of construction activity where there is the potential for significant vibration at sensitive receptors, such as from multiple piling activities. The vibration monitoring will ensure that the established vibration criteria for the prevention of structural damage are achieved and will provide an estimate of the vibration level from similar activities that might occur later in the construction program.

Considering the nature of activities associated with the marine facilities and the separation distance from the closest sensitive receptors, the vibration from the operation of marine facilities is expected to be below the threshold of human detection at sensitive receptors and will not cause structural damage.

The activities at the construction camps will be similar to typical residential activities. Therefore the vibration level at the closest sensitive receptor is expected to achieve the vibration criteria to prevent structural damage.

9.2.2 Impact on Underground Pipework and Telecommunication Lines

At this stage, the exact locations of any existing underground pipework or telecommunication lines in the vicinity of the project construction sites on Gladstone mainland is unknown, and the potential exist for construction works to occur in close proximity to the underground infrastructure.

Where the construction activity occurs at distances greater than 10m from underground pipework, the vibration level on the pipework from activity such as pile driving will be less than 50mm/s (Wiss, 1981), and therefore achieve the DIN 4150 acceptable levels.

Where the construction activity occurs within 10m of underground pipework, vibration monitoring will be conducted at the start of activity. As above, the vibration monitoring will ensure that the established vibration criteria for the prevention of structural damage are achieved and will provide an estimate of the vibration level from similar activities that might occur later in the construction program.

10 BLASTING IMPACT ASSESSMENT

At this stage of the development, detailed information (e.g., location and frequency) of any blasting work associated with the project construction during site preparation is not known.

Under these circumstances, prior to any blasting operation being conducted, the factors which influence the measured noise and vibration levels will be considered. These include:

- the type of rock and stratography/faulting;
- the distance between the blast site and the sensitive receptors;
- the type, size and number of charges used;
- the depth and manner in which the charge is installed, and;
- meteorological conditions.

The blasting operation will therefore be designed and adjusted by professional blast providers to ensure that the vibration and noise level criteria provided by the *Environmental Protection Act 1994* and DERM “Noise and vibration from blasting” Guideline are achieved at all sensitive receptors in the vicinity of the operation.

11 CUMULATIVE IMPACT ASSESSMENT

The cumulative noise and vibration impact of the project, existing developments, and projects that have been approved by the Queensland Coordinator-General, which are located in the Gladstone region has been considered.

11.1 Cumulative Noise Impact

The cumulative noise impact of the project and other developments has been considered in setting the proposed noise conditions.

The proposed noise conditions at the closest sensitive receptor (represented by AL 1) are 10 dB more stringent than the requirements of the EPP (Noise) to allow similar noise contributions from other projects, as shown in Table 9.1. By achieving the 33 dB(A) criterion at AL 1, the noise level at all other sensitive receptors will also be 10 dB(A) below the requirement of the EPP (Noise), as indicated by the predicted noise levels in Table 11.1.

With the noise from the project achieving the proposed noise conditions, and other projects contributing similar levels, the cumulative noise from this project, existing developments and other proposed projects (LNG and other) will achieve the requirements and intent of the EPP (Noise).

Table 11.1: Noise conditions to account for cumulative noise impact.

Activity	Assessment Location	EPP (Noise) Night-time Criterion (dB(A))	Proposed Criterion (dB(A))	Meteorological Conditions Category	Predicted Noise Level with Additional Acoustic Treatment (dB(A))*
Operation (Continuous)	AL 1	43	33	4 (Neutral-case)	33
	AL 2	33	28	6 (Worst-case)	12
	AL 3	43	28	6 (Worst-case)	20
	AL 4	35	28	4 (Neutral-case)	22
	AL 5	35	28	4 (Neutral-case)	17
	AL 6	43	33	4 (Neutral-case)	32

* Mechanical drive option with four LNG trains (Phases 1 and 2 combined)

In addition, it is noted the sensitive receptors in the vicinity of Gladstone Harbour and Targinnie Channel, particularly on Tide and Witt Islands (i.e., AL 1 and AL 6, respectively), are currently exposed to noise from ship movements associated with existing shipping terminals in the area. Although the project and other project proponents will increase the total number of ship (LNG carriers, barges and ferries) movements within the area, given the transient and short-term nature of the movements, it is expected that the noise exposure during any 1 hour period will be no greater than levels currently experienced.

Therefore, it is expected that the cumulative noise from LNG carriers, barges and ferries movements associated with this project and other proponent projects will not have a significant noise impact on sensitive receptors.

11.2 Cumulative Vibration Impact

Based on the vibration impact assessment, the vibration levels at sensitive receptors from the operation of the project are expected to be below the threshold of human detection. Considering the large separation distances between the different projects (i.e., greater than 100m), it is expected that the cumulative vibration from industry in the Gladstone region will not have a significant impact on sensitive receptors.

12 NOISE AND VIBRATION MONITORING

12.1 Operation

To confirm the noise predictions and the expected vibration levels from the project during operation, noise and vibration monitoring will be conducted at selected locations in the vicinity of the project site, after the completion of each project phase. The noise and vibration monitoring will be conducted with all the plant equipment operating, under the normal load.

12.2 Construction

Noise and vibration monitoring will be conducted during the construction phase to ensure that the noise and vibration levels achieved the appropriate criteria. Monitoring conducted at the start of an activity will provide an estimate of the noise or vibration level from similar activities that might occur later in the construction program. The monitoring has been described in Sections 8.3 and 9.2, and is summarised below.

12.2.1 Noise Monitoring

Given the inability to accurately predict the noise from construction, Section 8.3 specifies noise predictions (i.e., desktop analysis) or noise monitoring (measurements) to be conducted for night-time works, when the schedule of construction processes is known. These measures will be conducted at the start of each construction activity occurring at night where there is the potential for significant noise at sensitive receptors (i.e., greater than 45 dB(A)).

12.2.2 Vibration Monitoring

Section 9.2 specifies vibration monitoring to be conducted at the start of construction activity where there is the potential for significant vibration at sensitive receptors, such as from multiple piling activities or where the activity occurs in close proximity (within 50m of the sensitive receptor).

13 CONCLUSION

This assessment has considered environmental noise from the operation and construction of the proposed LNG plant and the associated infrastructure.

Based upon the EPP (Noise), appropriate conditions for noise levels at assessment locations (representative of closest sensitive receptors) have been determined. The noise conditions take into account the potential for cumulative impacts from other projects and existing developments by setting noise limits which are more stringent than the requirements of the EPP (Noise) to allow similar noise contributions from other projects. The proposed noise conditions for the operation and construction of the project are given in Table 12.1.

Table 13.1: Summary of the proposed noise conditions.

<table>
<tr><th rowspan="2">Activity</th><th rowspan="2">Source</th><th rowspan="2">Assessment Location</th><th colspan="3">Outdoor Noise Criterion (dB(A))</th><th rowspan="2">Assessment Meteorological Conditions</th></tr>
<tr><th>Day</th><th>Evening</th><th>Night</th></tr>
<tr><td rowspan="6">Operation (Continuous)</td><td rowspan="6">LNG plant</td><td>AL 1</td><td colspan="3" rowspan="2">33</td><td rowspan="2">Neutral (CONCAWE Category 4)</td></tr>
<tr><td>AL 6</td></tr>
<tr><td>AL 3</td><td colspan="3">33</td><td rowspan="2">Worst-case (CONCAWE Category 6)</td></tr>
<tr><td>AL 2</td><td colspan="3">28</td></tr>
<tr><td>AL 4</td><td colspan="3" rowspan="2">28</td><td rowspan="2">Neutral (CONCAWE Category 4)</td></tr>
<tr><td>AL 5</td></tr>
<tr><td rowspan="6">Operation (Intermittent</td><td rowspan="6">LNG ship movements</td><td>AL 1</td><td rowspan="6">50</td><td rowspan="6">50</td><td rowspan="6">45</td><td rowspan="6">Neutral (CONCAWE Category 4)</td></tr>
<tr><td>AL 2</td></tr>
<tr><td>AL 3</td></tr>
<tr><td>AL 4</td></tr>
<tr><td>AL 5</td></tr>
<tr><td>AL 6</td></tr>
<tr><td rowspan="6">Construction</td><td rowspan="6">LNG plant

Marine facilities

Feed gas pipeline

Dredging</td><td>AL 1</td><td colspan="2" rowspan="6">All reasonable and practicable measures to reduce the noise impact</td><td rowspan="6">45</td><td rowspan="6">Neutral (CONCAWE Category 4)</td></tr>
<tr><td>AL 2</td></tr>
<tr><td>AL 3</td></tr>
<tr><td>AL 4</td></tr>
<tr><td>AL 5</td></tr>
<tr><td>AL 6</td></tr>
</table>

Noise from the operation and construction of the LNG plant, marine facilities, feed gas pipelines and construction camps has been assessed against the proposed noise conditions.

Based on historical data, the prevalent meteorological conditions have been used to model the noise using the CONCAWE noise propagation model, which are indicated in Table 8.1.

The assessment indicates that the proposed noise conditions will be achieved at the assessment locations with a feasible level of acoustic treatment applied to equipment at the LNG plant, and all reasonable and practicable measures implemented during the construction phase of the project.

To objectively assess the impact of vibration from the project, reference was made to the Australian Standard AS 2670.2-1990 and German Standard DIN 4150.3-1999, which provide the appropriate criteria for ensuring human comfort, and the prevention of structural damage to buildings and underground pipework, respectively. Depending on the equipment and the separation distance of the development site from the sensitive receptors, the vibration from the operation and construction of the project may not be significant, however vibration monitoring will be conducted where there is the potential for impact on sensitive receptors.

Noise and vibration monitoring will be conducted at selected locations in the vicinity of the project site to confirm the predicted noise levels and the expected vibration levels from the operation of the project.

Given the detailed information (e.g., location and frequency) of any blasting required at the construction sites is not known, each blast will be designed and adjusted by professional blast providers to ensure that the noise and vibration criteria provided by the *Environmental Protection Act 1994 and* the DERM “Noise and vibration from blasting” Guideline are achieved.

14 REFERENCES

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APPENDIX A: APPROXIMATE MEASUREMENT AND ASSESSMENT LOCATIONS

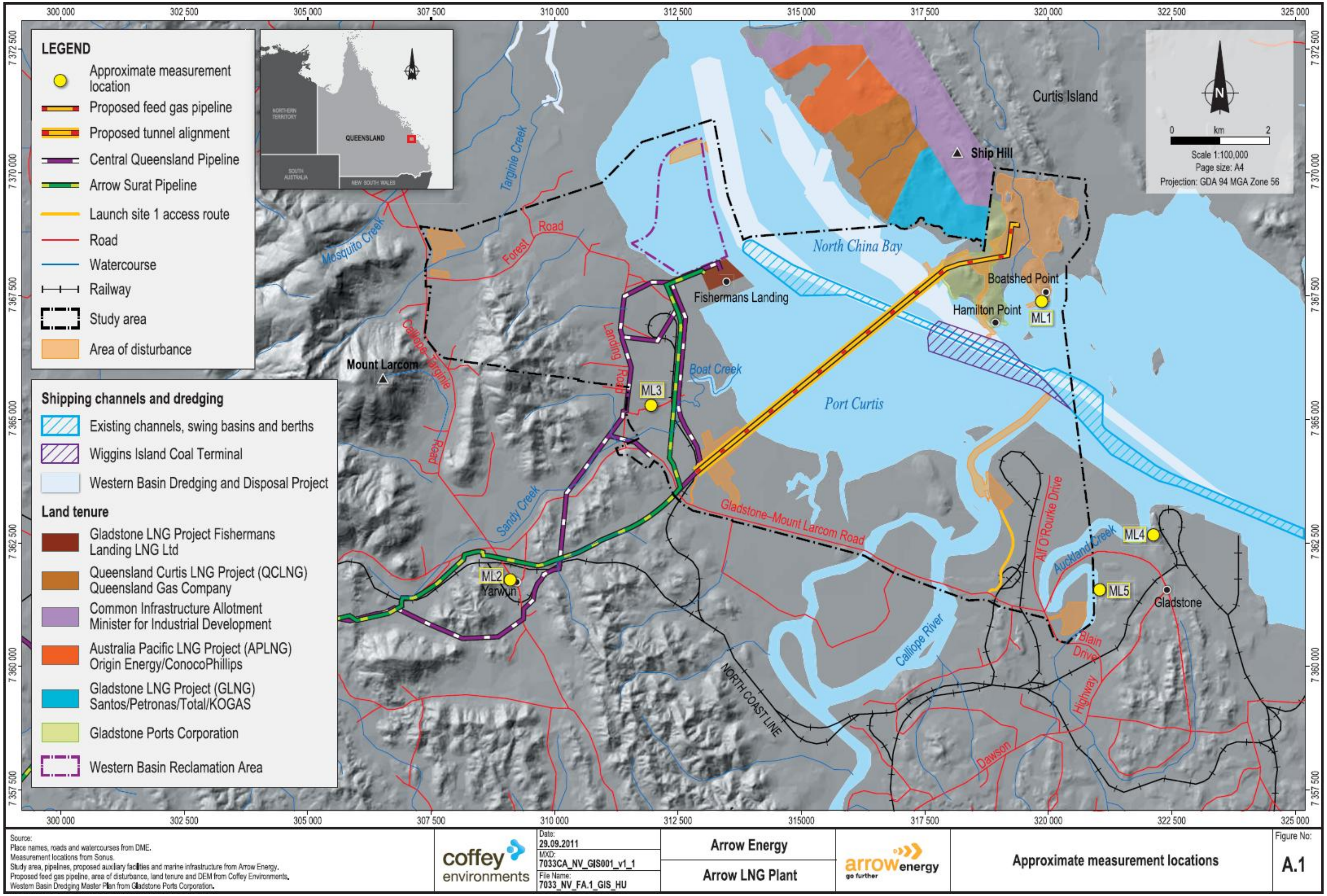

Figure A.1: Approximate measurement locations.

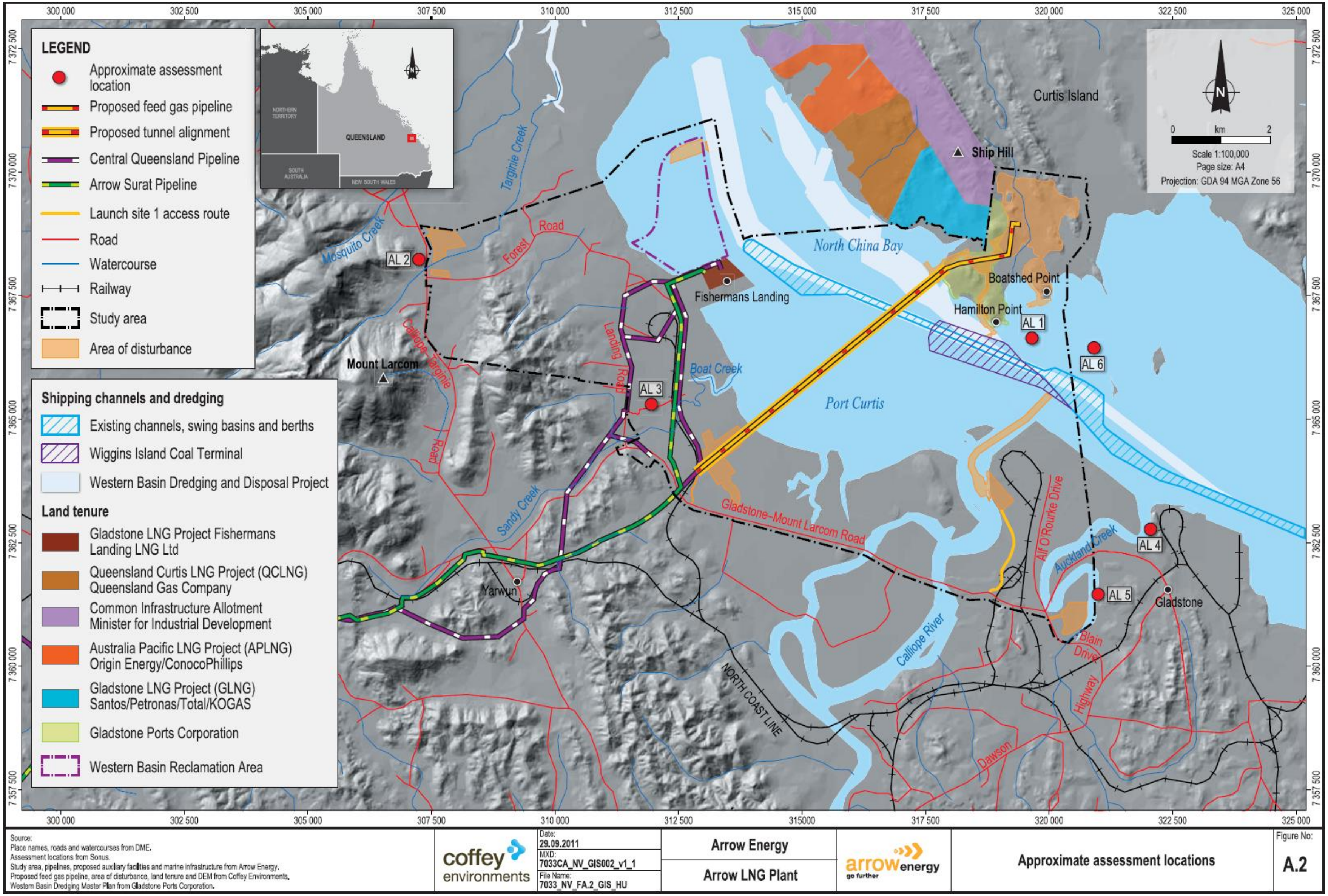

Figure A.2: Approximate assessment locations.

Appendix A: Approximate Measurement and Assessment Locations
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APPENDIX B: MEASURED BACKGROUND NOISE AND VIBRATION LEVELS

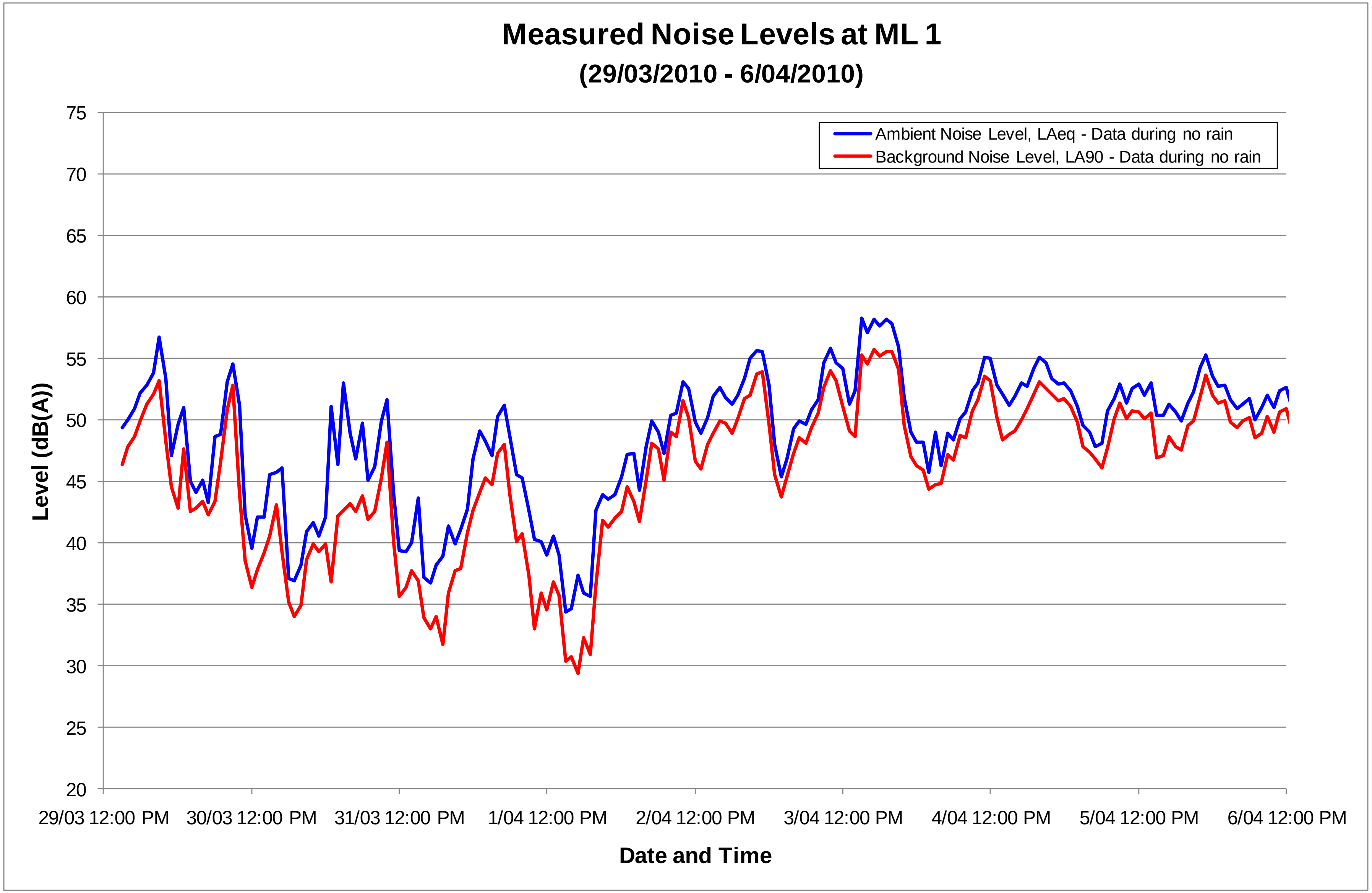

Figure B.1: Measured ambient and background noise levels at ML 1 – Period 1.

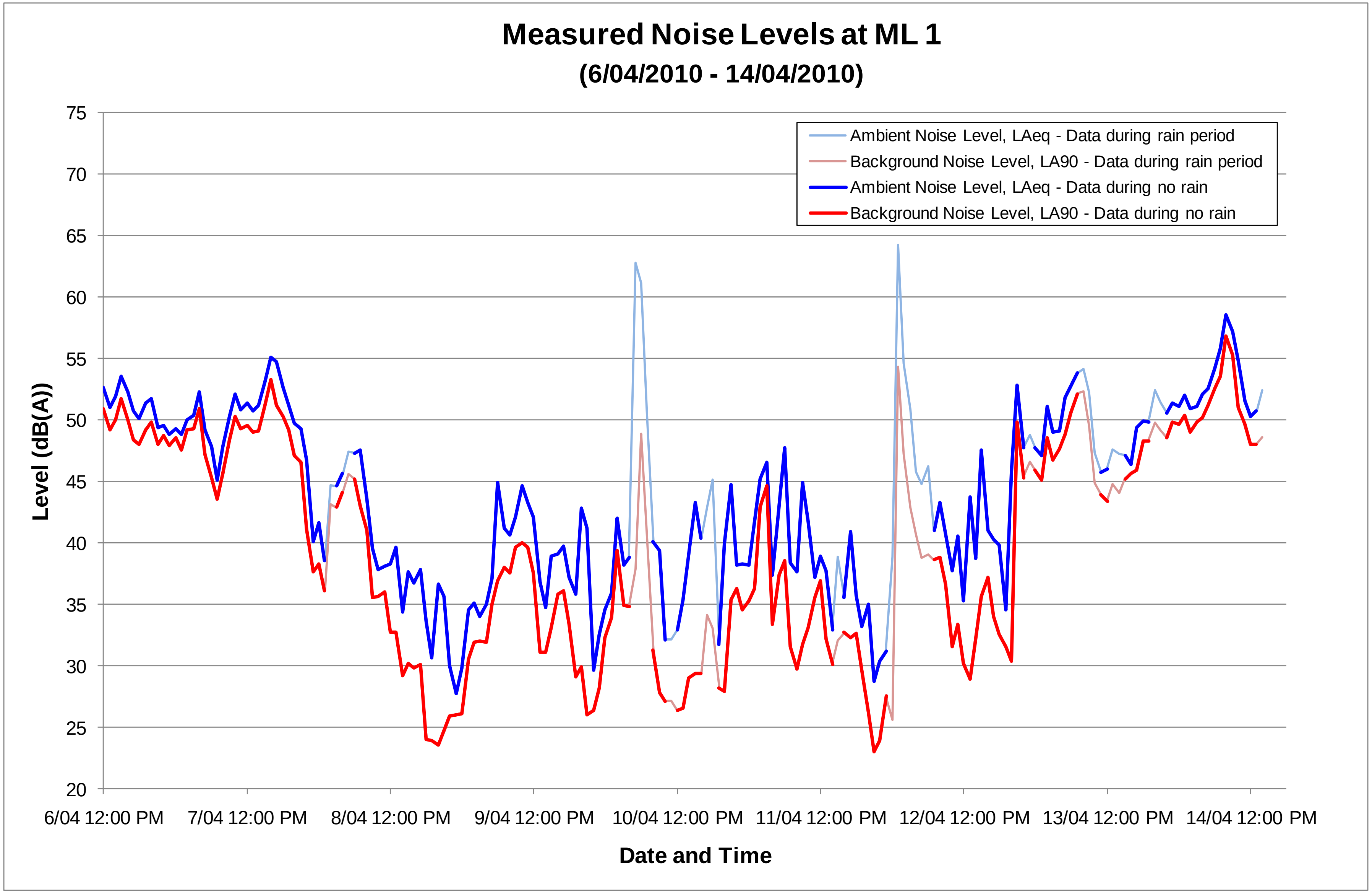

Figure B.2: Measured ambient and background noise levels at ML 1 – Period 2.

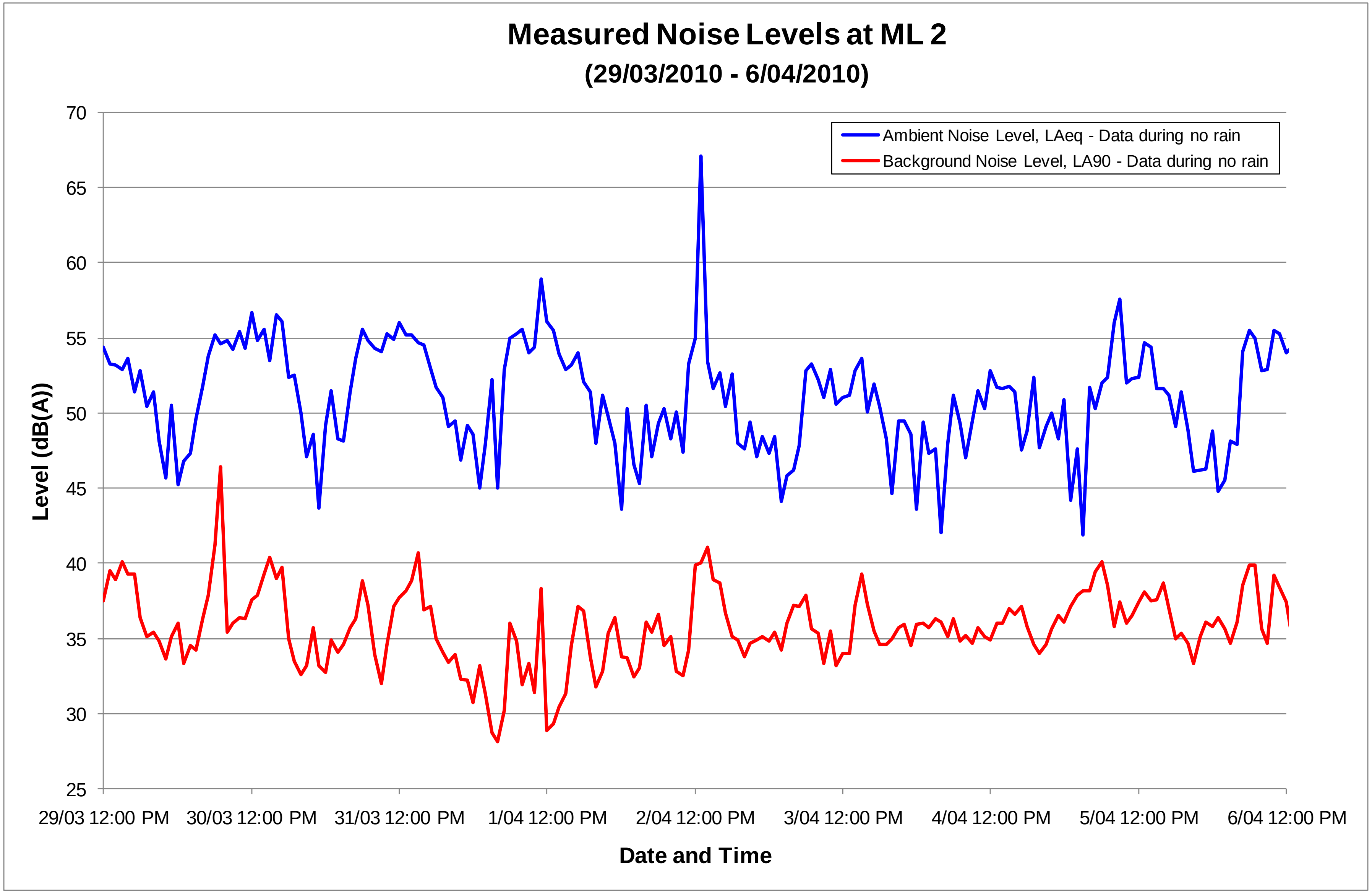

Figure B.3: Measured ambient and background noise levels at ML 2 – Period 1.

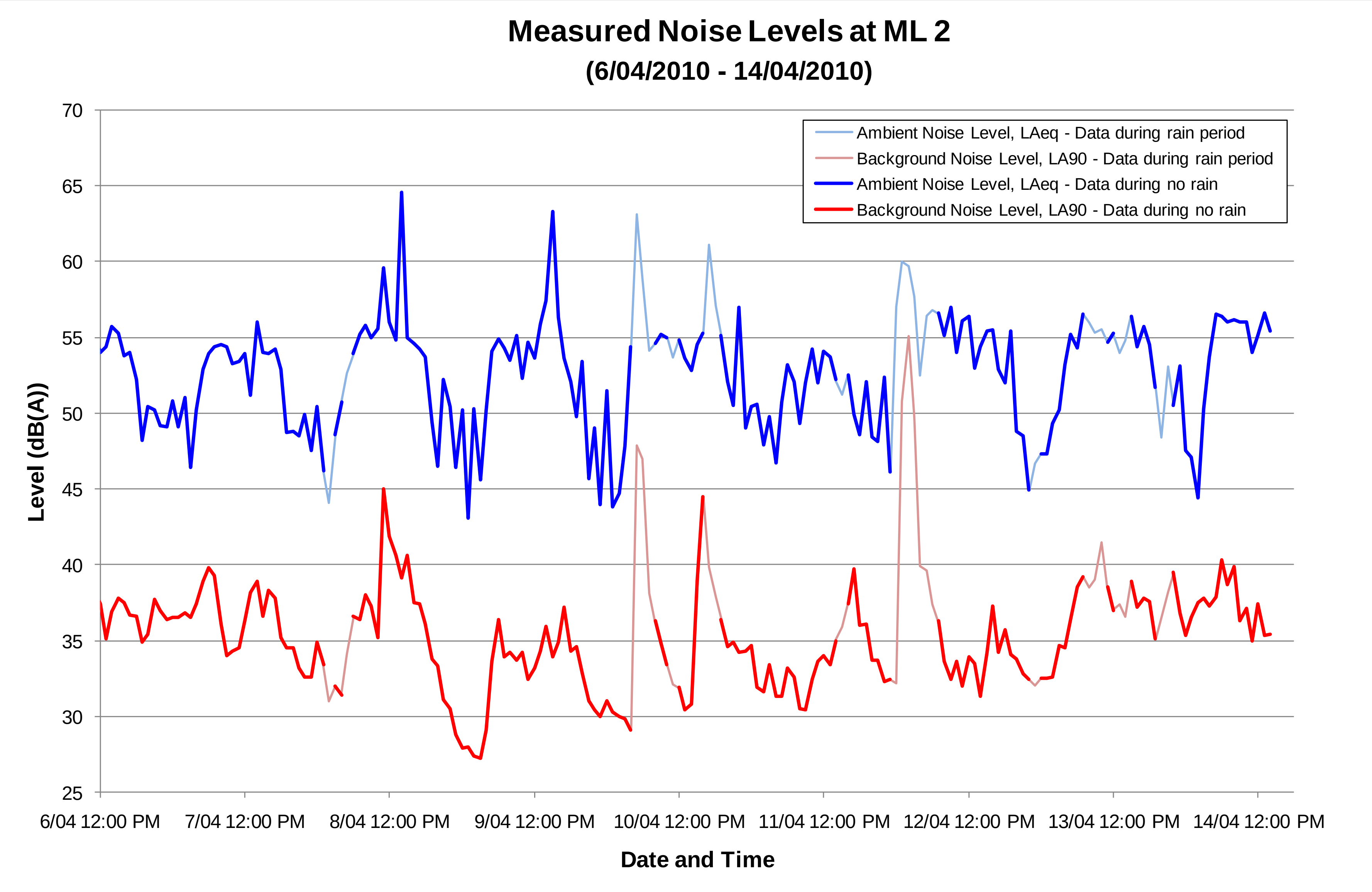

Figure B.4: Measured ambient and background noise levels at ML 2 – Period 2.

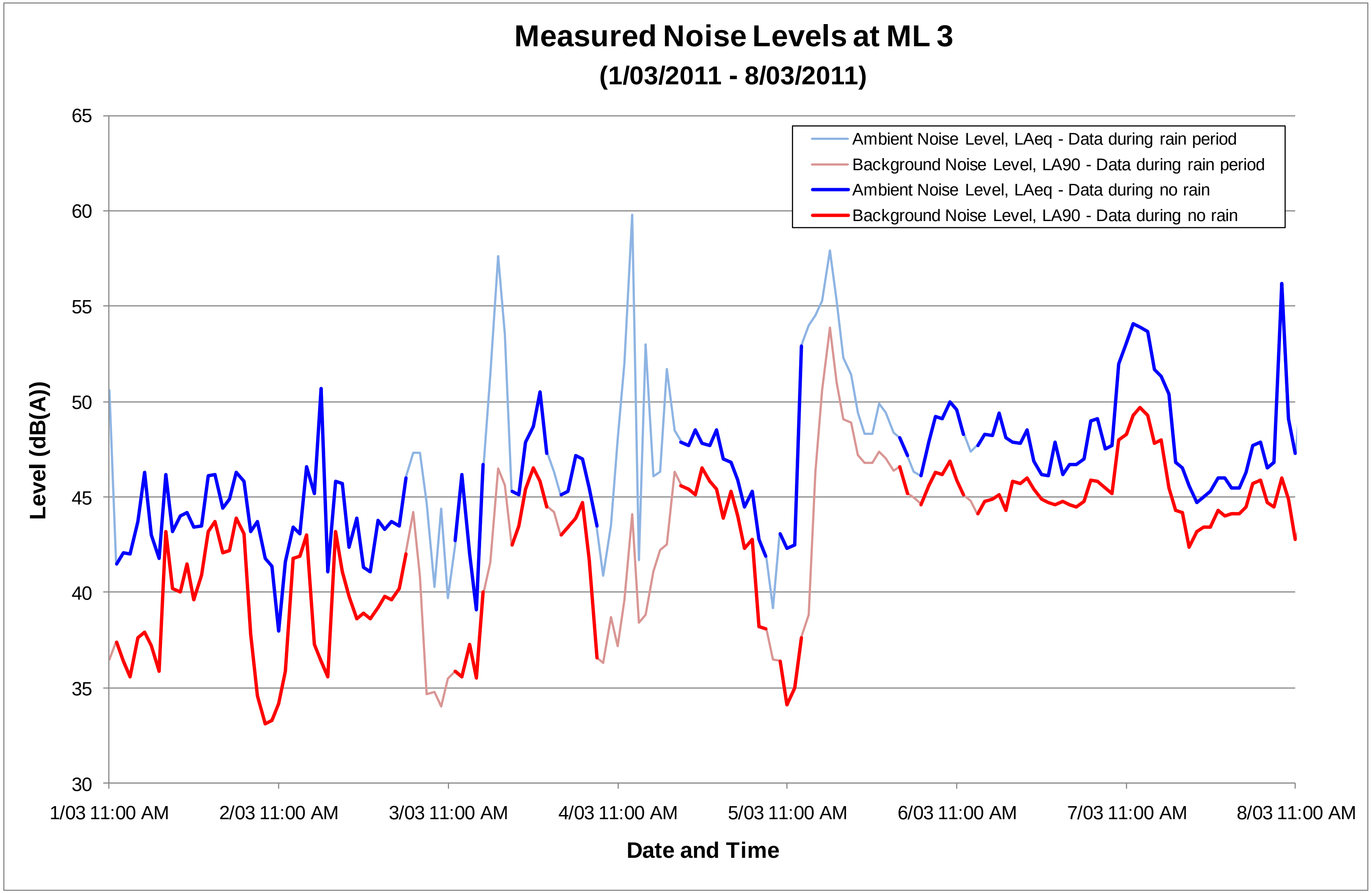

Figure B.5: Measured ambient and background noise levels at ML 3 – Period 1.

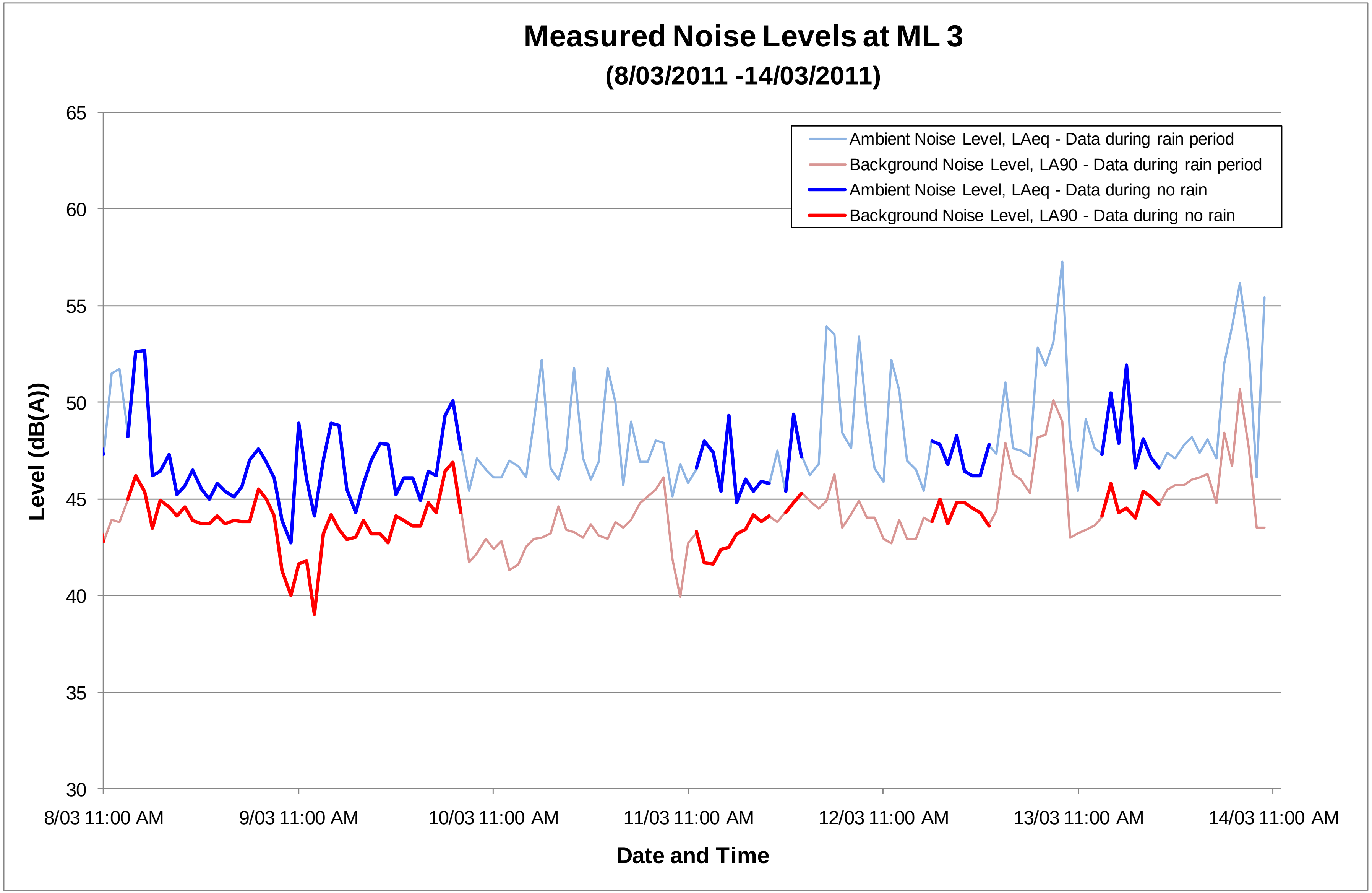

Figure B.6: Measured ambient and background noise levels at ML 3 – Period 2.

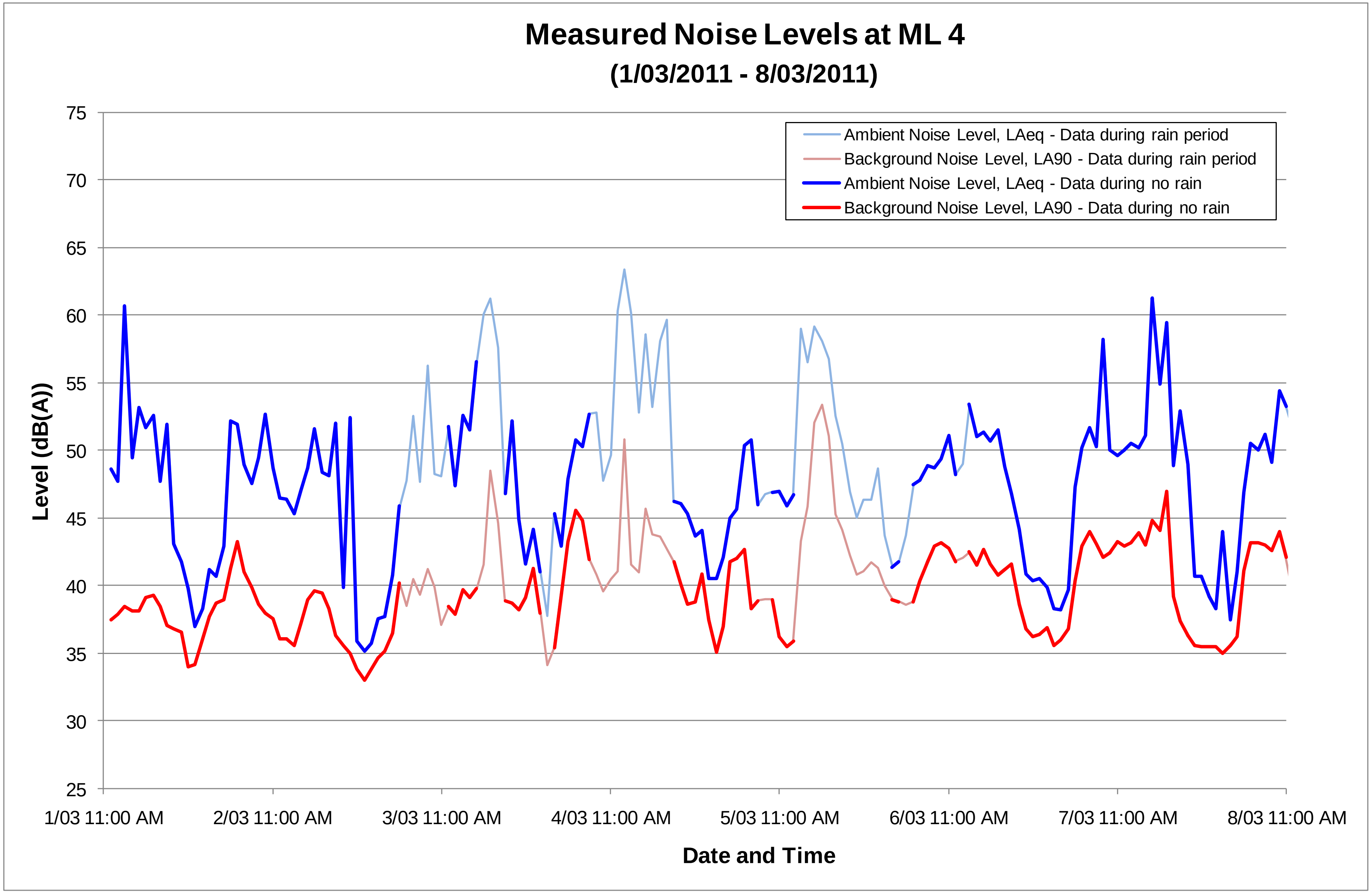

Figure B.7: Measured ambient and background noise levels at ML 4 – Period 1.

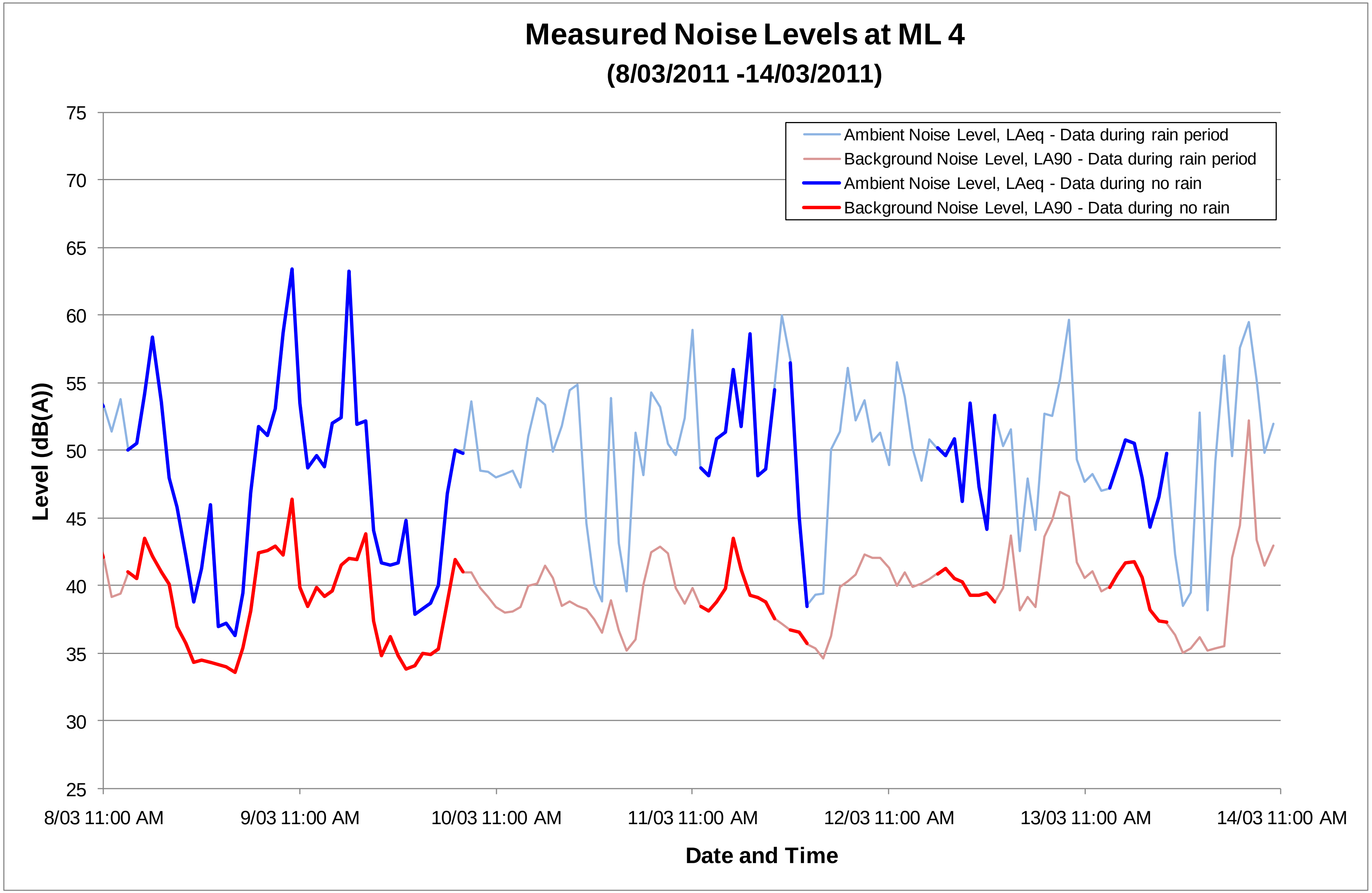

Figure B.8: Measured ambient and background noise levels at ML 4 – Period 2.

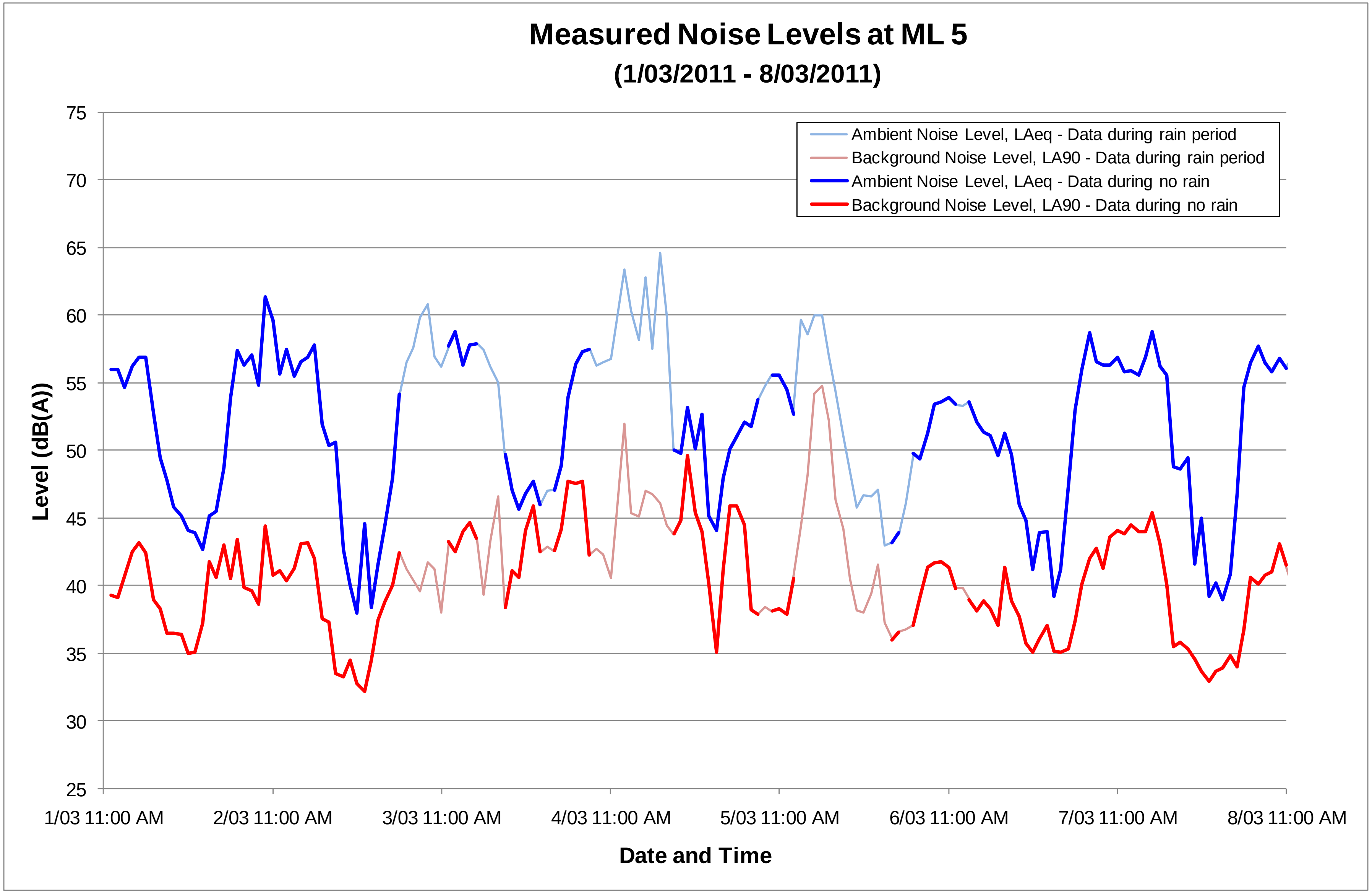

Figure B.9: Measured ambient and background noise levels at ML 5 – Period 1.

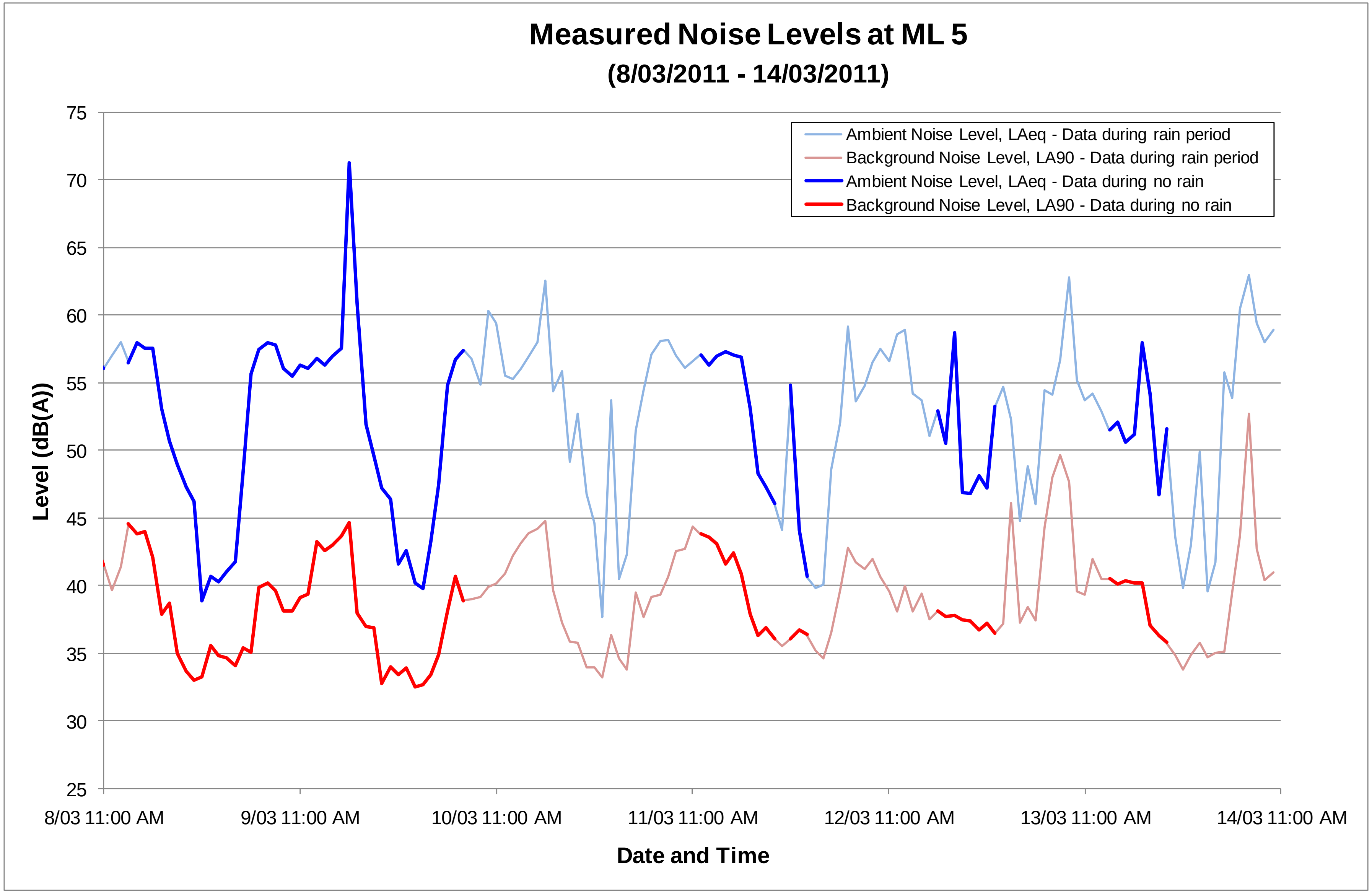

Figure B.10: Measured ambient and background noise levels at ML 5 – Period 2.

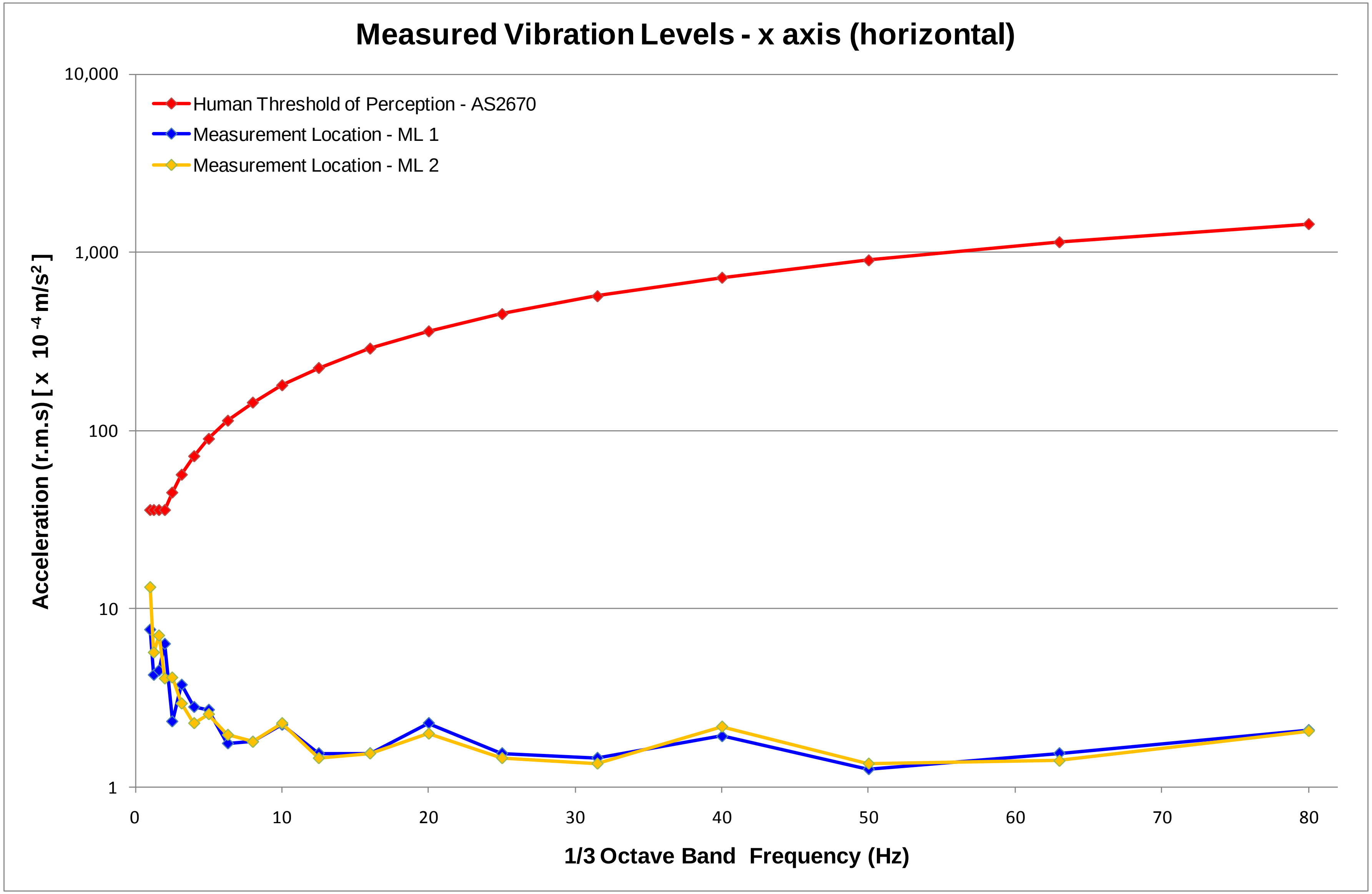

Figure B.11: Measured vibration levels at ML 1 and ML 2 – x-axis (horizontal).

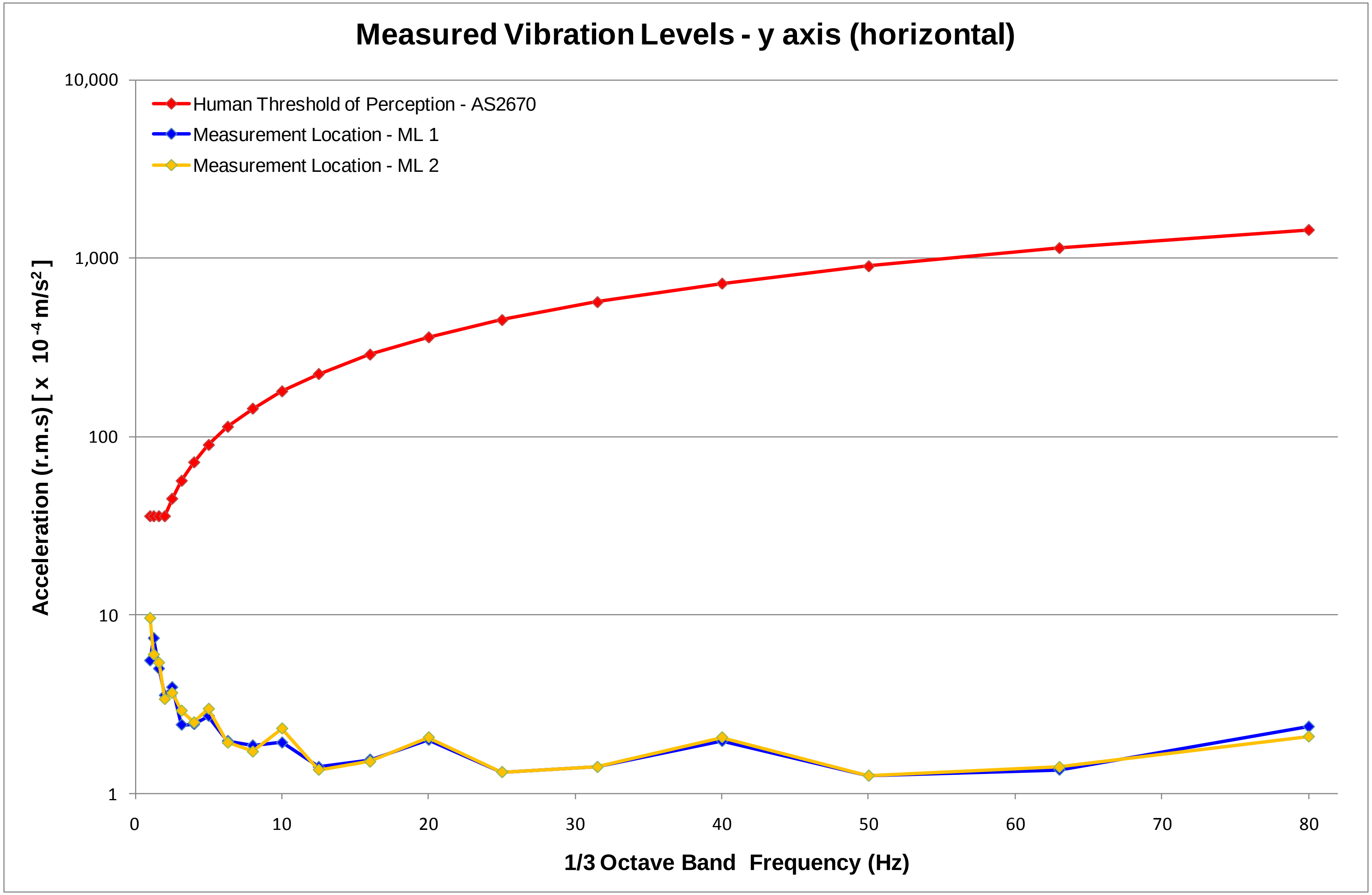

Figure B.12: Measured vibration levels at ML 1 and ML 2 – y-axis (horizontal).

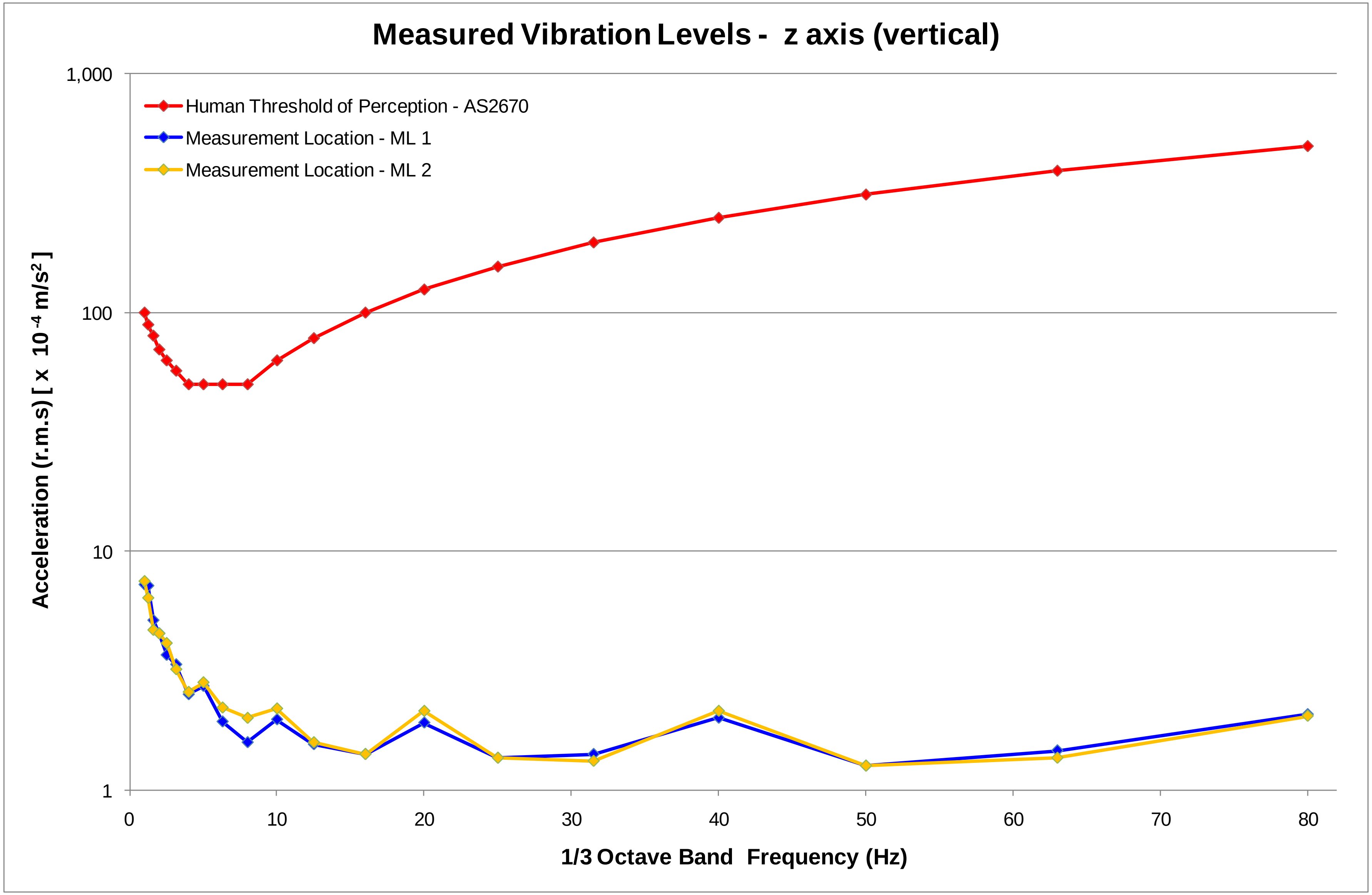

Figure B.13: Measured vibration levels at ML 1 and ML 2 – z-axis (vertical).

APPENDIX C: LNG PLANT MAIN NOISE SOURCES AND SOUND POWER LEVELS

Table C.1: Sound power levels of the main noise sources.

Noise Source	Maximum Sound Power Level (dB re 1 pW) by Octave Band Frequency (Hz)								Total (dB(A))	Remarks
	63	125	250	500	1000	2000	4000	8000		
LNG Train Equipment										
Acid Gas Removal Unit										
Pump - 15kW	85	85	83	83	81	76	71	71	85	-
Solvent Air Cooler Fan	102	86	73	63	60	57	55	51	77	-
Dehydration Unit										
Centrifugal Compressor	53	59	65	71	77	83	93	83	95	-
Compressor Air Cooler Fan	102	86	73	63	60	57	55	51	77	-
Liquefaction Unit										
Hydraulic Turbine	74	77	79	82	82	81	76	68	87	-
Pump - 15kW	85	85	83	83	81	76	71	71	85	-
Process Compressors										
LP Compressor	81	87	98	110	110	120	120	115	125	No acoustic treatment
MP/HP Compressor	101	101	113	107	110	107	103	98	114	No acoustic treatment
Compressor	107	107	112	116	119	116	112	107	123	No acoustic treatment
Process Compressors Drives										
Gas Turbine Casing - 100MW	108	108	109	105	96	93	90	69	106	With standard treatment
Gas Turbine Exhaust Stack - 100MW	121	119	117	112	103	106	110	105	116	With standard silencer
Compressor Electric Motor	97	99	100	100	103	103	95	88	108	-
Cooling Tower										
Fan Bay - 3 Fans	111	110	107	102	100	94	88	82	105	With Moore VT blades
End Flash Gas Compression Unit										
Compressor Electric Motor	97	99	100	100	103	103	95	88	108	-
Compressor	93	96	93	89	89	92	89	85	97	With acoustic enclosure
Compressor Air Cooler Fan	102	86	73	63	60	57	55	51	77	-
Hot Water System, Refrigerant Handling and Storage Facilities, Drainage and Effluent Treatment										
Pump - 15kW	85	85	83	83	81	76	71	71	85	-
Substation										
Transformer - 20MVA	97	95	96	92	81	78	70	68	92	-
Other Plant Equipment at LNG Export Facility										
Power Generation										
Gas Turbine Casing - 30MW	108	108	109	105	96	93	90	69	106	With standard treatment
Gas Turbine Exhaust Stack - 30MW	121	119	117	112	103	106	110	105	116	With standard silencer
Generator	103	103	105	105	104	102	100	97	109	-
Loading System										
BOG Compressor	105	107	103	101	101	102	95	86	107	-
BOG Compressor Gear Box	90	81	76	75	71	69	63	57	77	With acoustic enclosure
BOG Compressor Electric Motor	97	99	100	100	103	103	95	88	108	-
Water Facilities										
HP Pump	100	100	98	98	96	91	86	86	100	-
Pump - 15kW	85	85	83	83	81	76	71	71	85	-
Refrigerant Handling and Storage Facilities, Drainage and Effluent Treatment										
Pump - 15kW	85	85	83	83	81	76	71	71	85	-

Table C.1: Sound power levels of the main noise sources.

Noise Source	Maximum Sound Power Level (dB re 1 pW) by Octave Band Frequency (Hz)								Total (dB(A))	Remarks
	63	125	250	500	1000	2000	4000	8000		
LNG Train Equipment										
Instrument and Tool Air System										
Air Compressor - 55kW	105	101	96	95	94	90	84	77	98	-
Air Compressor Electric Motor - 55kW	74	77	79	82	82	81	76	68	87	-
Substations										
Transformer - 120 MVA	108	106	107	103	92	88	81	79	103	-
Transformer - 40 MVA	101	100	100	96	86	82	75	73	96	-
Transformer - 20MVA	97	95	96	92	81	78	70	68	92	-
Transformer - 10MVA	93	91	92	88	77	73	66	64	88	-
Transformer - 6.3MVA	90	88	89	85	74	71	63	61	85	-

APPENDIX D: NOISE CONTOURS – WITHOUT ADDITIONAL ACOUSTIC TREATMENT

Appendix D: Noise Contours – Without Additional Acoustic Treatment
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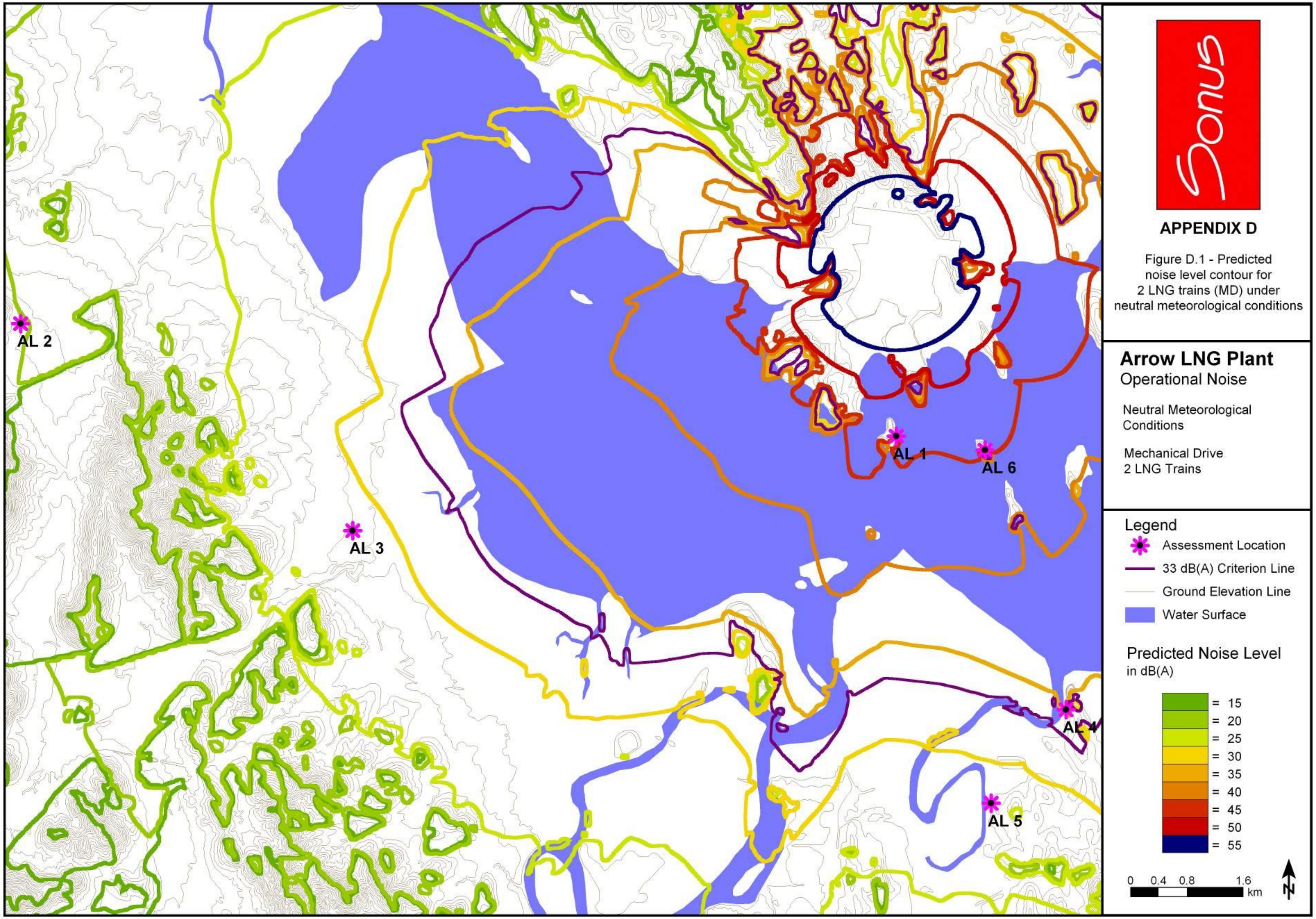

Appendix D: Noise Contours – Without Additional Acoustic Treatment
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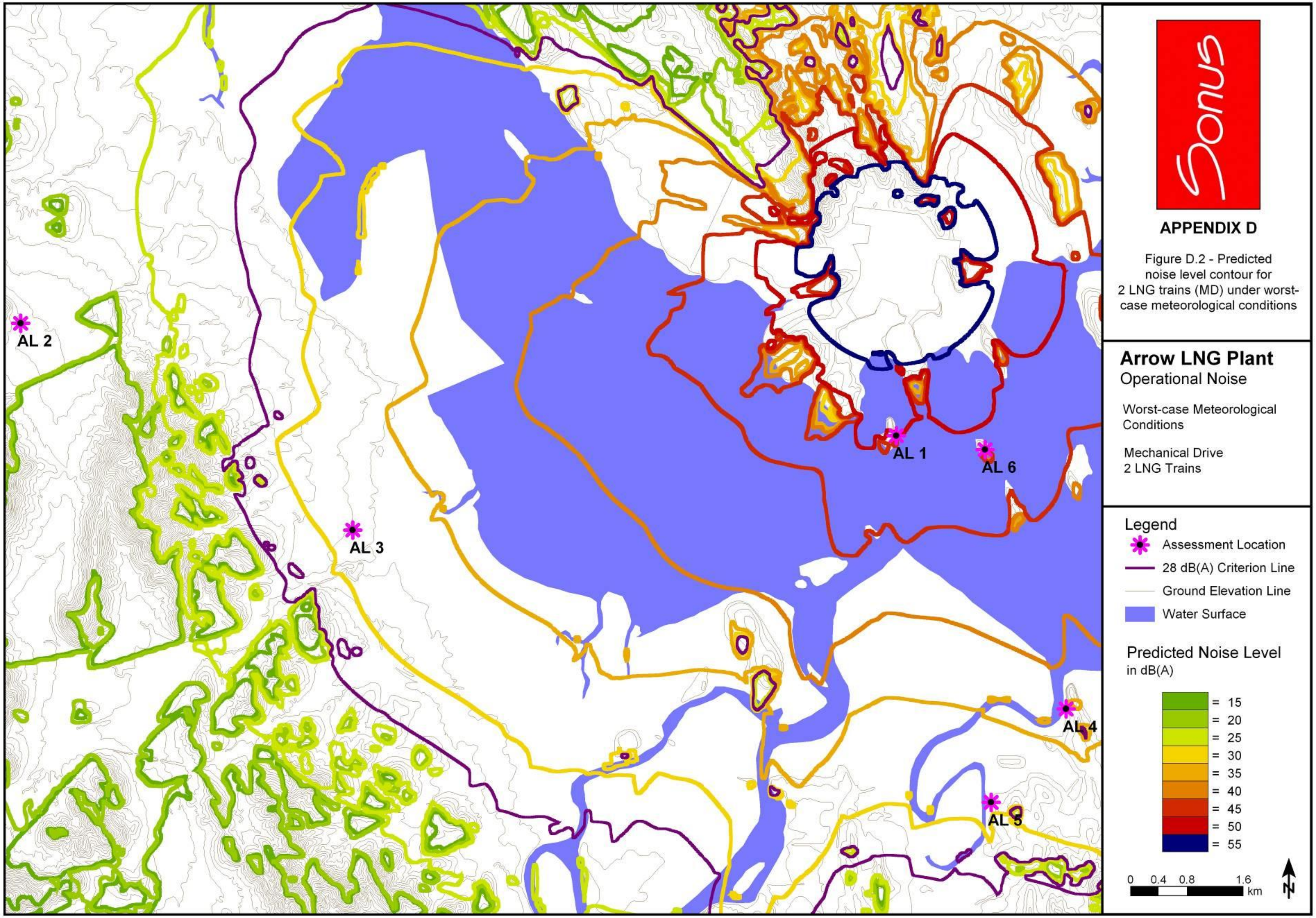

Appendix D: Noise Contours – Without Additional Acoustic Treatment
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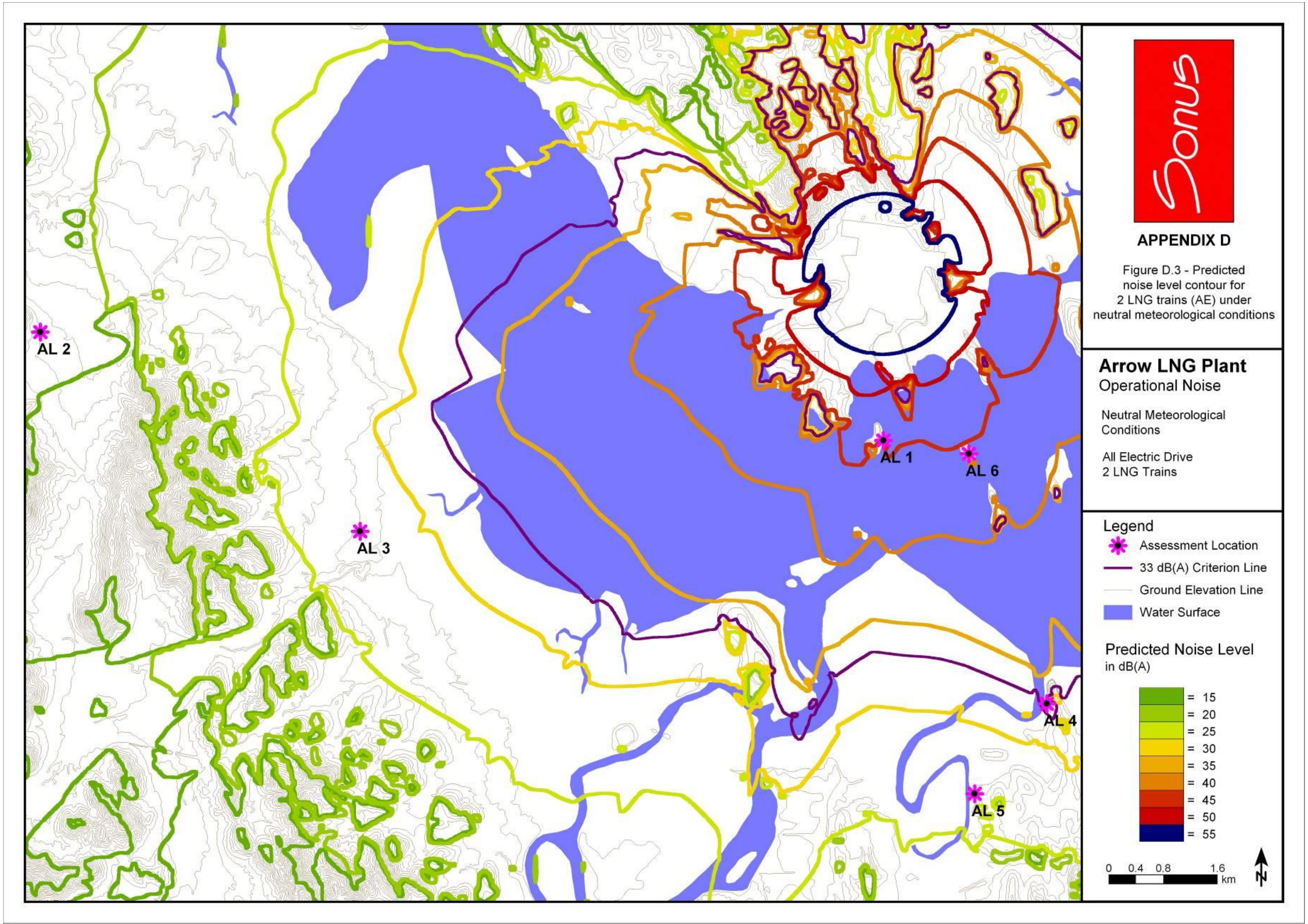

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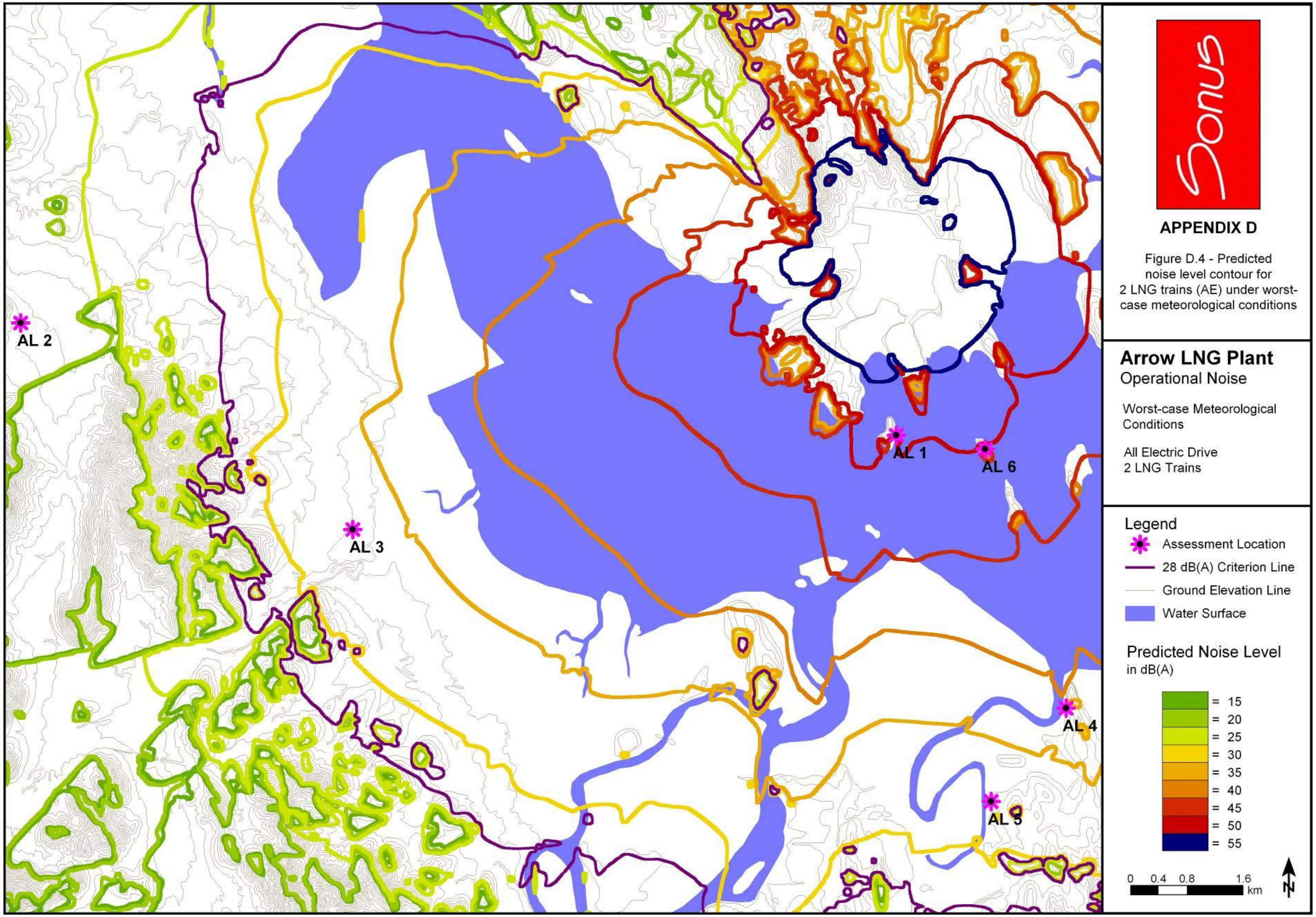

Appendix D: Noise Contours – Without Additional Acoustic Treatment
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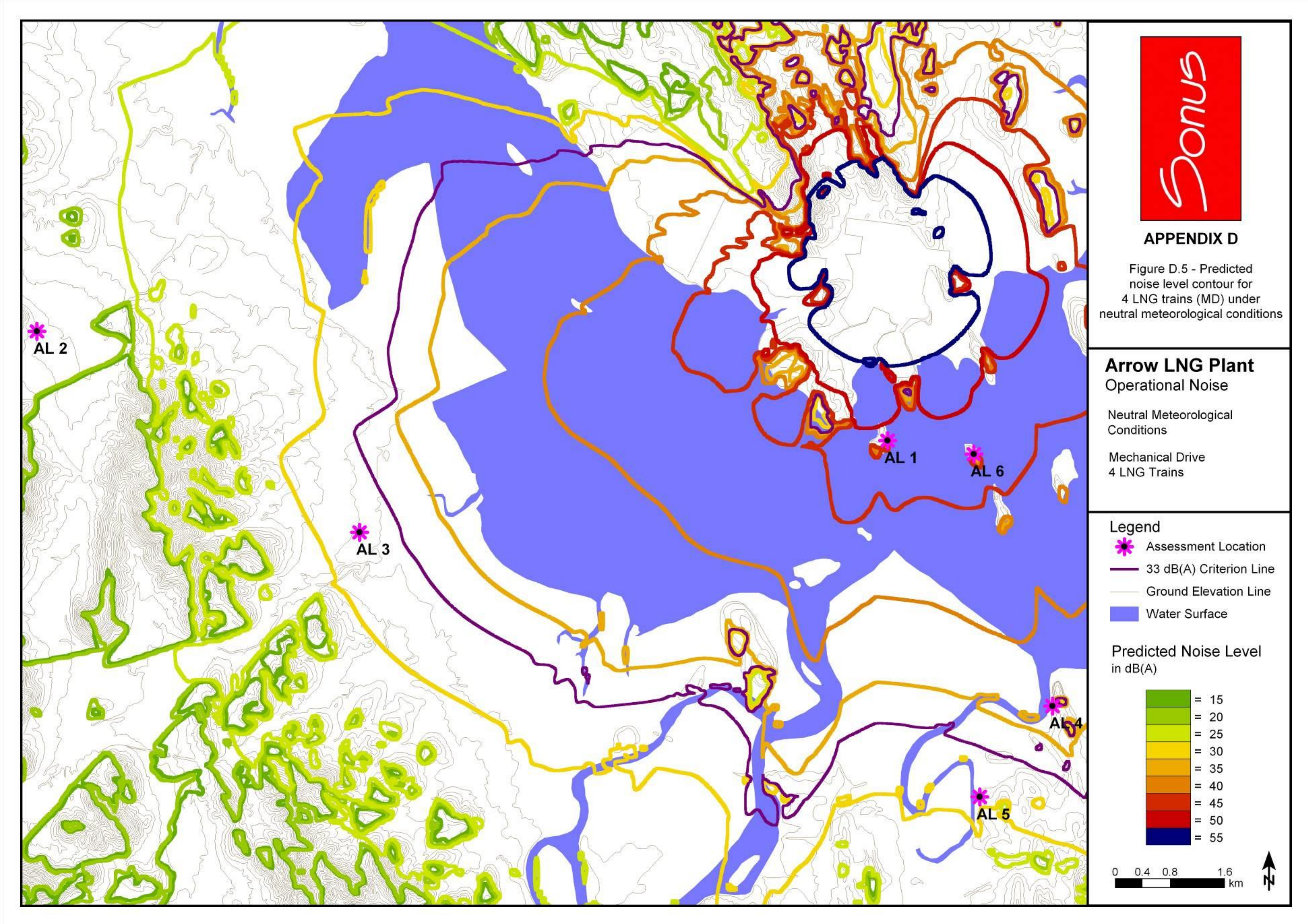

Appendix D: Noise Contours – Without Additional Acoustic Treatment
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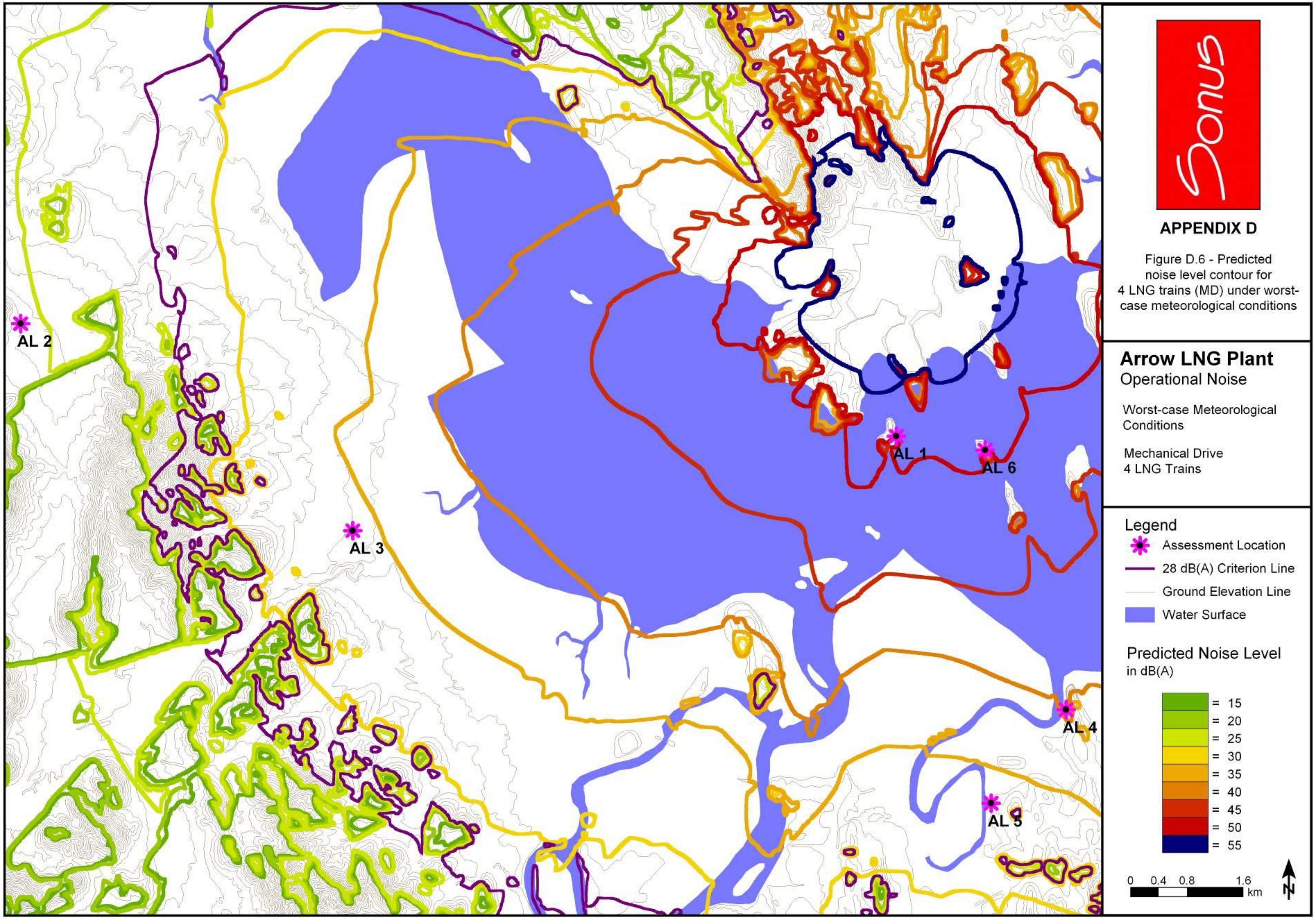
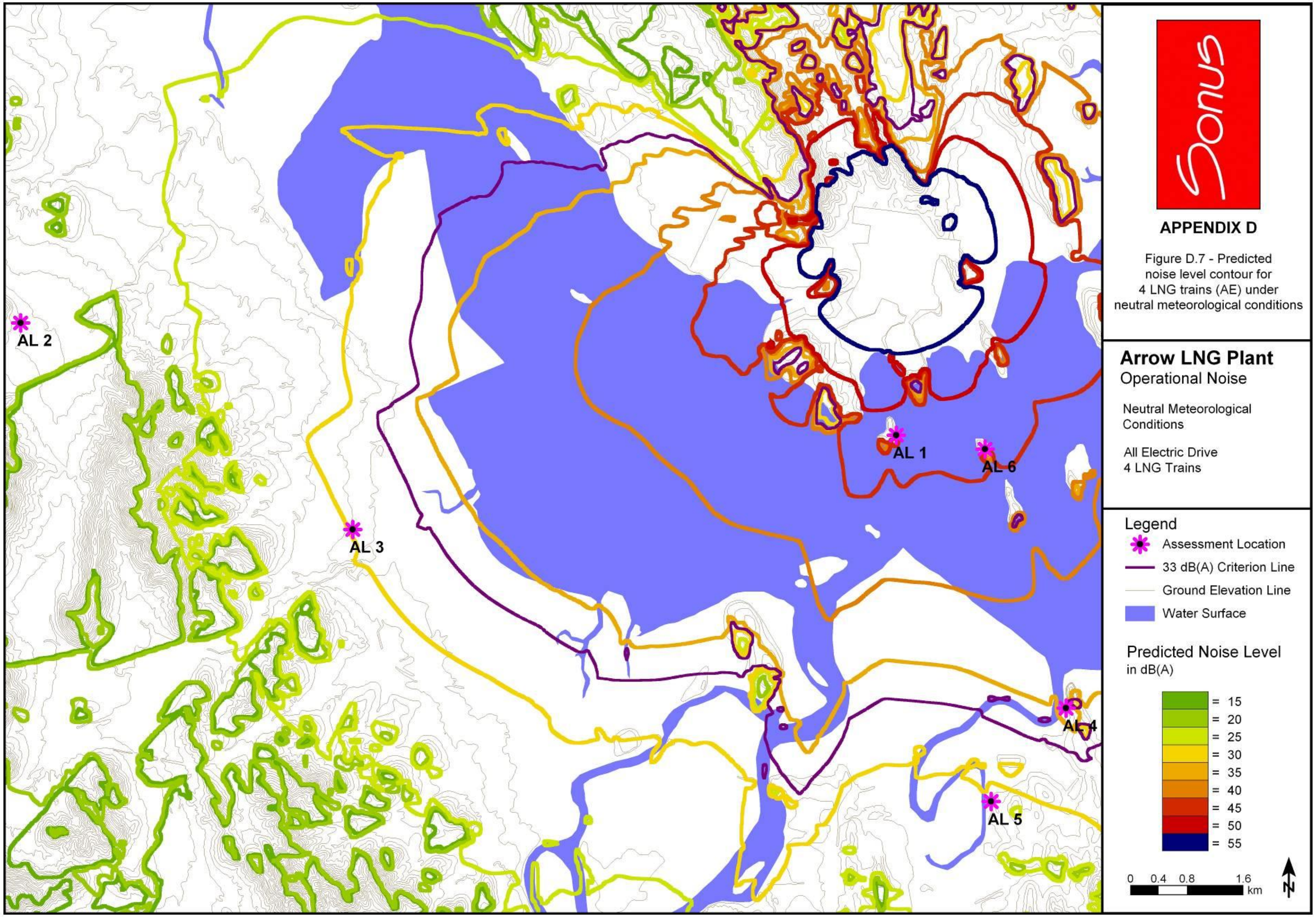
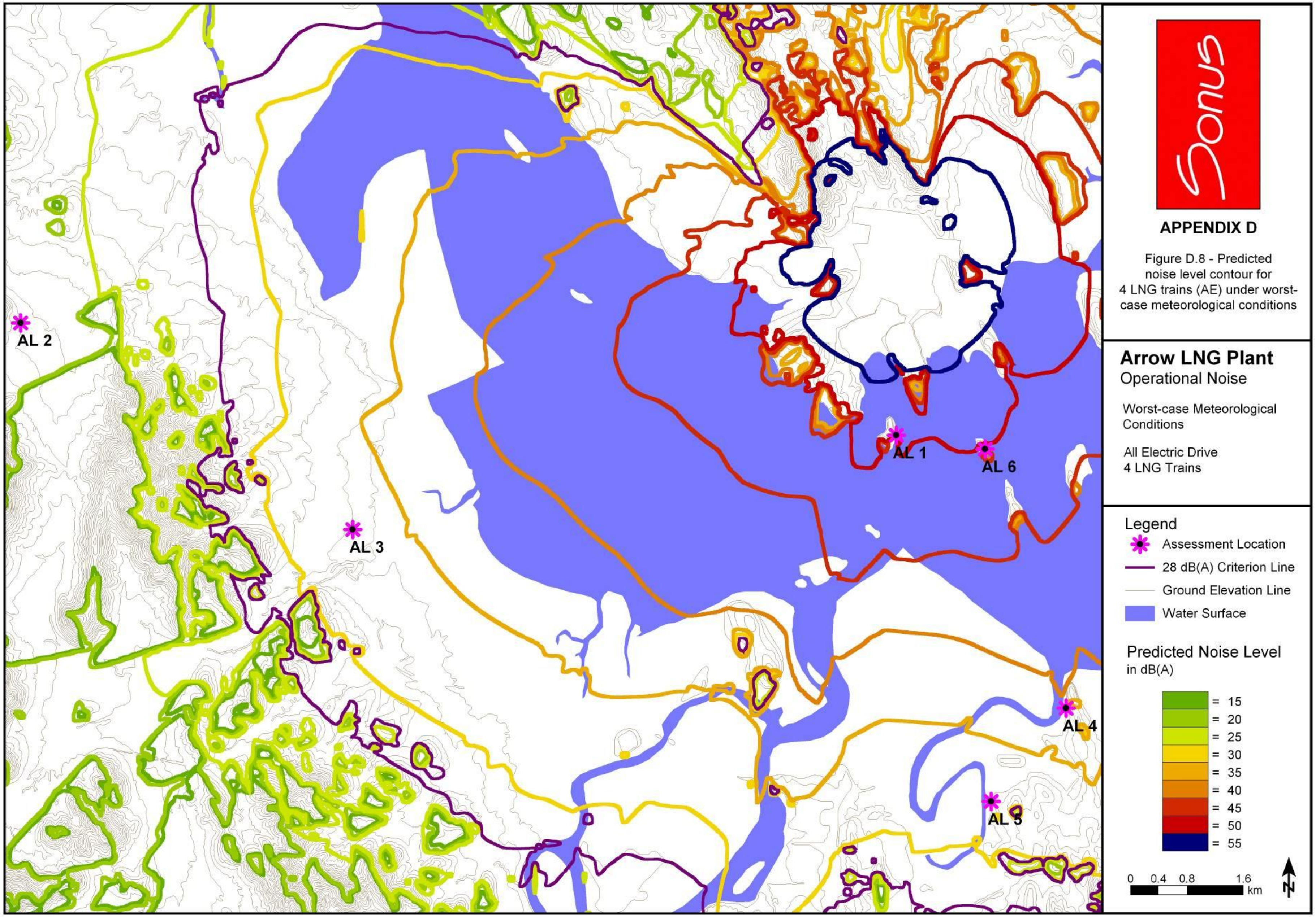



AL 1
AL 2
AL 3
AL 4
AL 5
AL 6
Sonus
APPENDIX D
Figure D.7 - Predicted noise level contour for 4 LNG trains (AE) under neutral meteorological conditions
Arrow LNG Plant
Operational Noise
Neutral Meteorological Conditions
All Electric Drive
4 LNG Trains
Legend
Assessment Location
33 dB(A) Criterion Line
Ground Elevation Line
Water Surface
Predicted Noise Level in dB(A)
= 15
= 20
= 25
= 30
= 35
= 40
= 45
= 50
= 55
0 0.4 0.8 1.6 km
N


AL 1
AL 2
AL 3
AL 4
AL 5
AL 6
Sonus
APPENDIX D
Figure D.8 - Predicted noise level contour for 4 LNG trains (AE) under worst-case meteorological conditions
Arrow LNG Plant
Operational Noise
Worst-case Meteorological Conditions
All Electric Drive
4 LNG Trains
Legend
Assessment Location
28 dB(A) Criterion Line
Ground Elevation Line
Water Surface
Predicted Noise Level
in dB(A)
= 15
= 20
= 25
= 30
= 35
= 40
= 45
= 50
= 55
0 0.4 0.8 1.6
km
N

Appendix D: Noise Contours – Without Additional Acoustic Treatment
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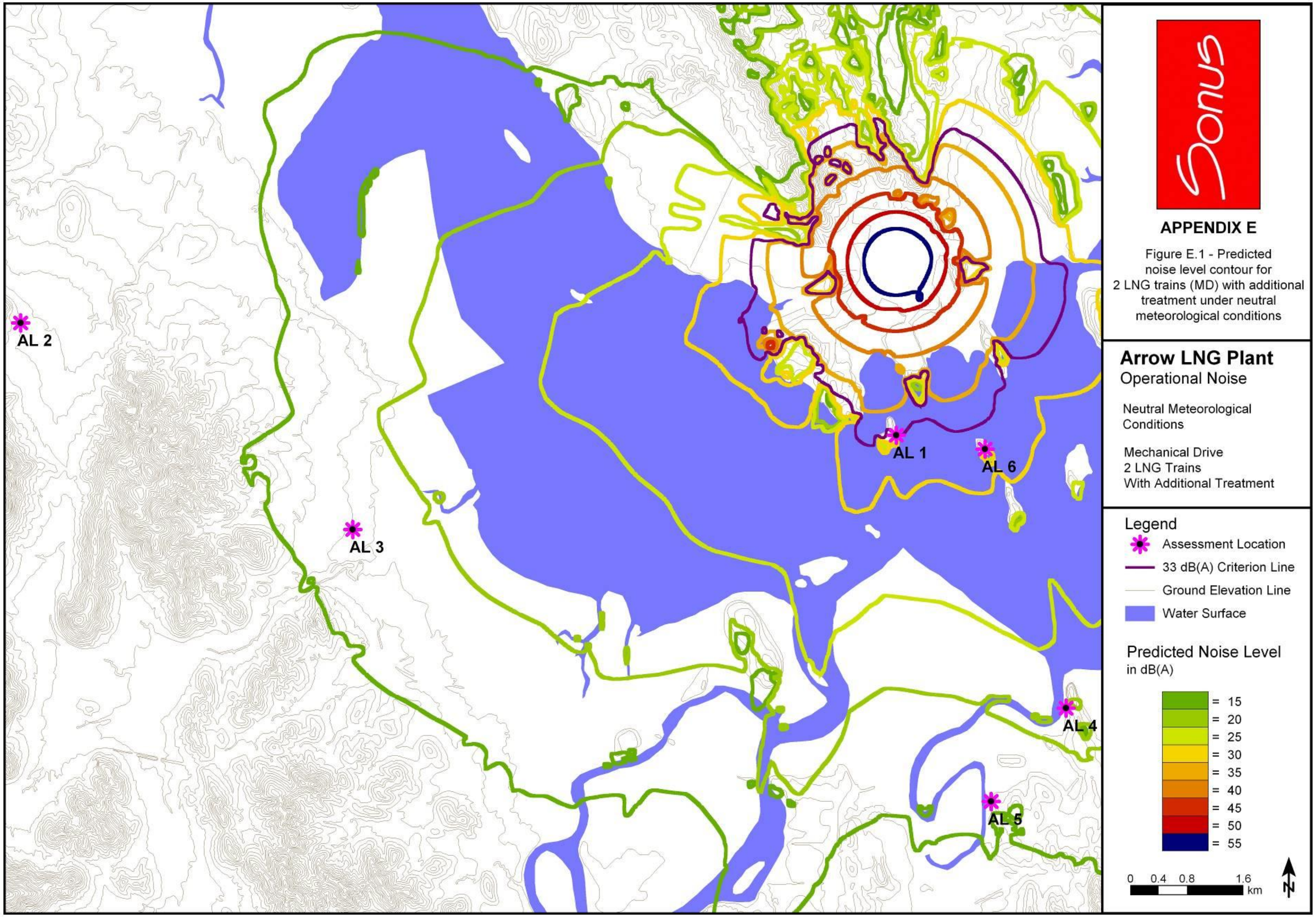
APPENDIX E: NOISE CONTOURS – WITH ADDITIONAL ACOUSTIC TREATMENT


AL 1
AL 2
AL 3
AL 4
AL 5
AL 6
APPENDIX E
Figure E.1 - Predicted noise level contour for 2 LNG trains (MD) with additional treatment under neutral meteorological conditions
Arrow LNG Plant
Operational Noise
Neutral Meteorological Conditions
Mechanical Drive
2 LNG Trains
With Additional Treatment
Legend
Assessment Location
33 dB(A) Criterion Line
Ground Elevation Line
Water Surface
Predicted Noise Level in dB(A)
= 15
= 20
= 25
= 30
= 35
= 40
= 45
= 50
= 55
0 0.4 0.8 1.6 km
N

Appendix E: Noise Contours – With Additional Acoustic Treatment
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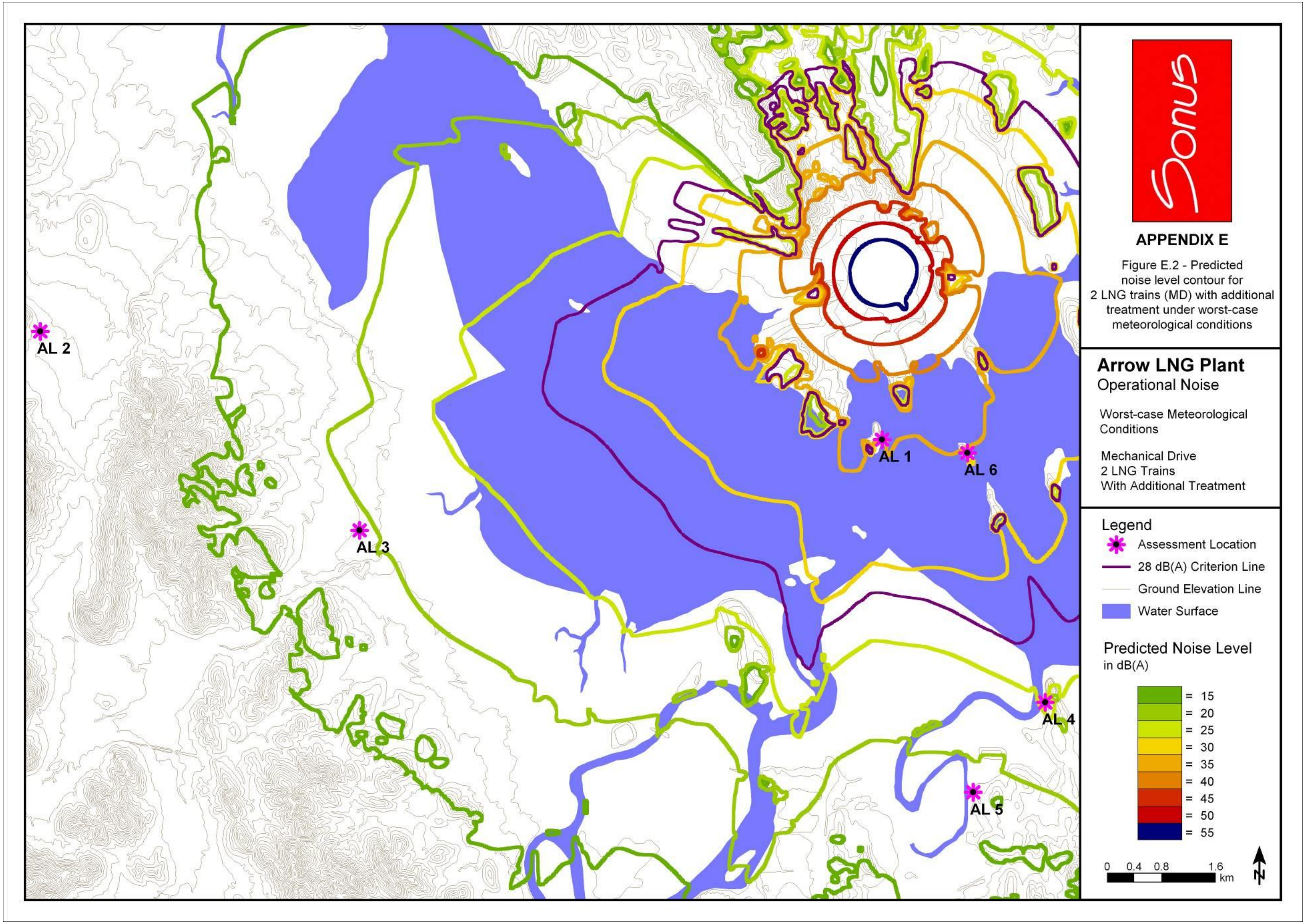

Appendix E: Noise Contours – With Additional Acoustic Treatment
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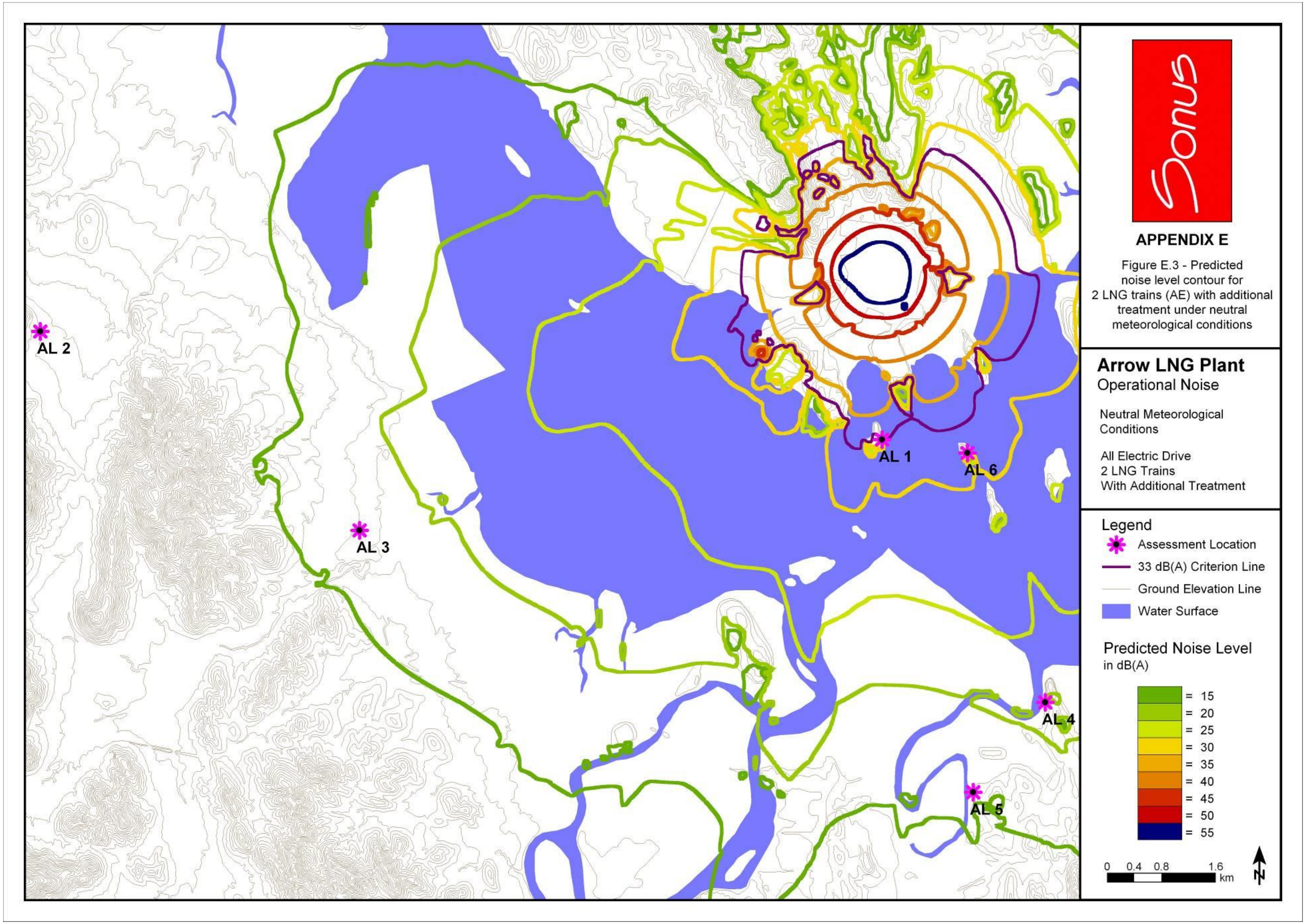

Appendix E: Noise Contours – With Additional Acoustic Treatment
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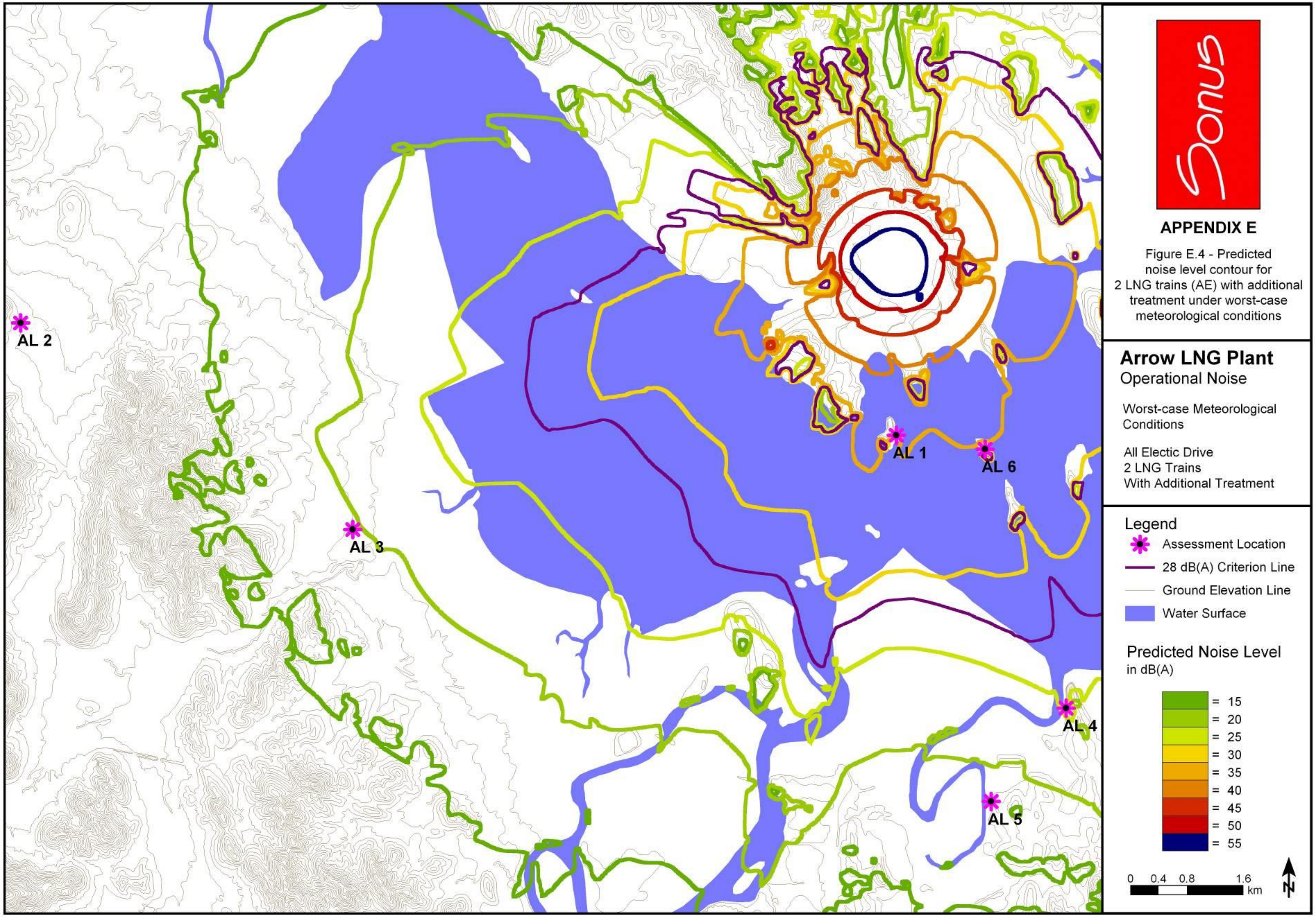

Appendix E: Noise Contours – With Additional Acoustic Treatment
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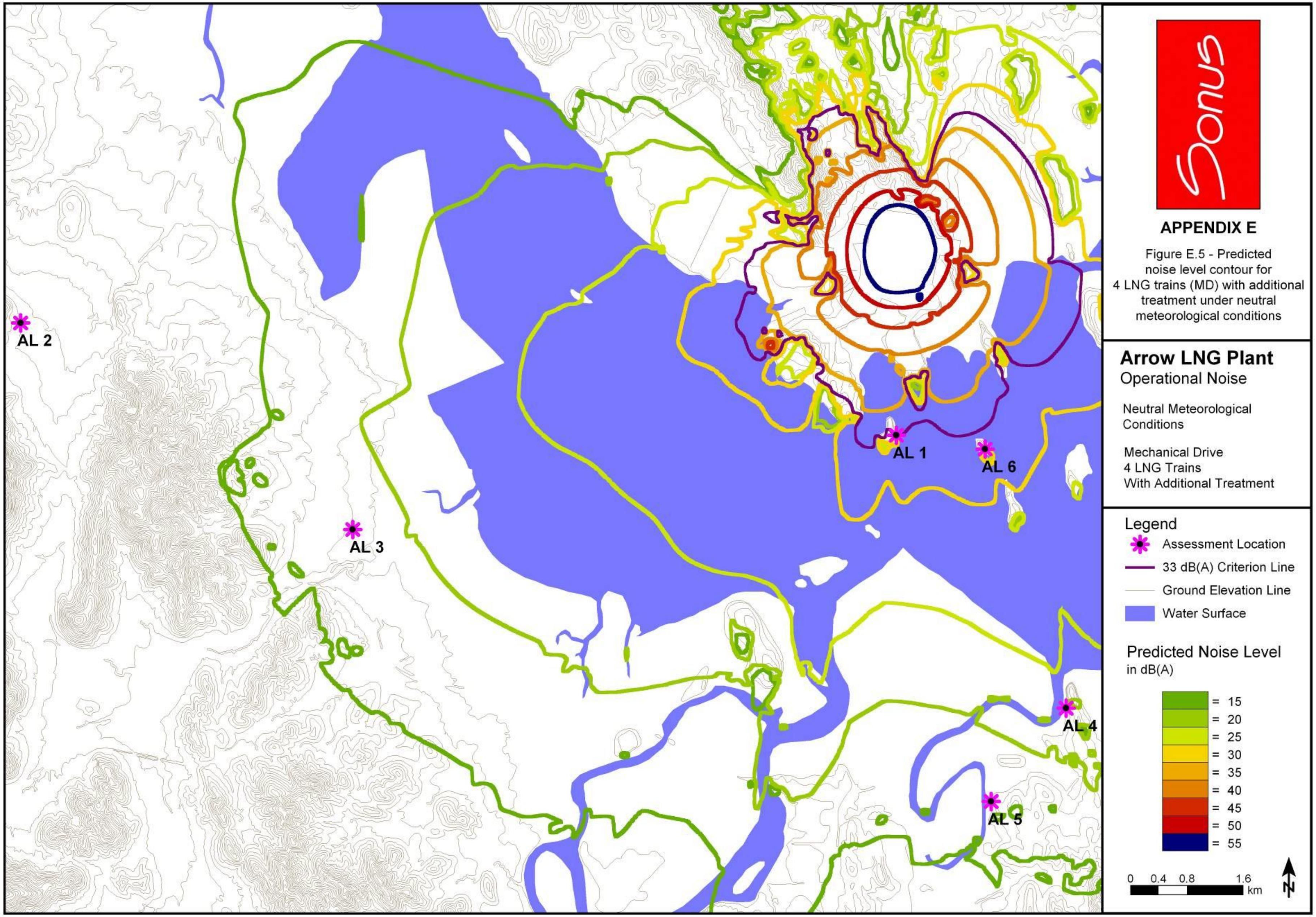

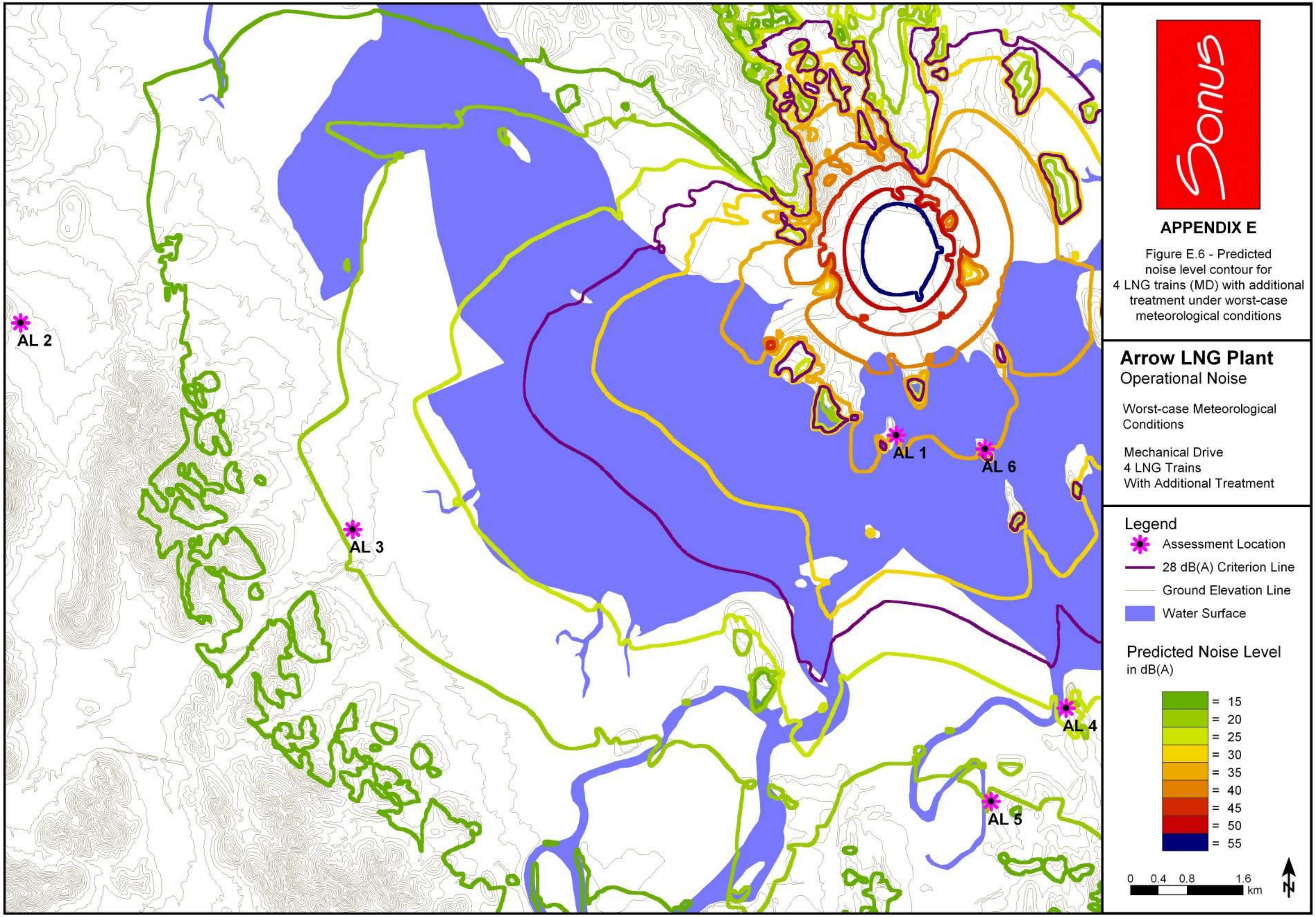
AL 2
AL 3
AL 1
AL 6
AL 4
AL 5
Sonus
APPENDIX E
Figure E.6 - Predicted noise level contour for 4 LNG trains (MD) with additional treatment under worst-case meteorological conditions
Arrow LNG Plant
Operational Noise
Worst-case Meteorological Conditions
Mechanical Drive
4 LNG Trains
With Additional Treatment
Legend
Assessment Location
28 dB(A) Criterion Line
Ground Elevation Line
Water Surface
Predicted Noise Level in dB(A)
= 15
= 20
= 25
= 30
= 35
= 40
= 45
= 50
= 55
0 0.4 0.8 1.6 km
N

Appendix E: Noise Contours – With Additional Acoustic Treatment
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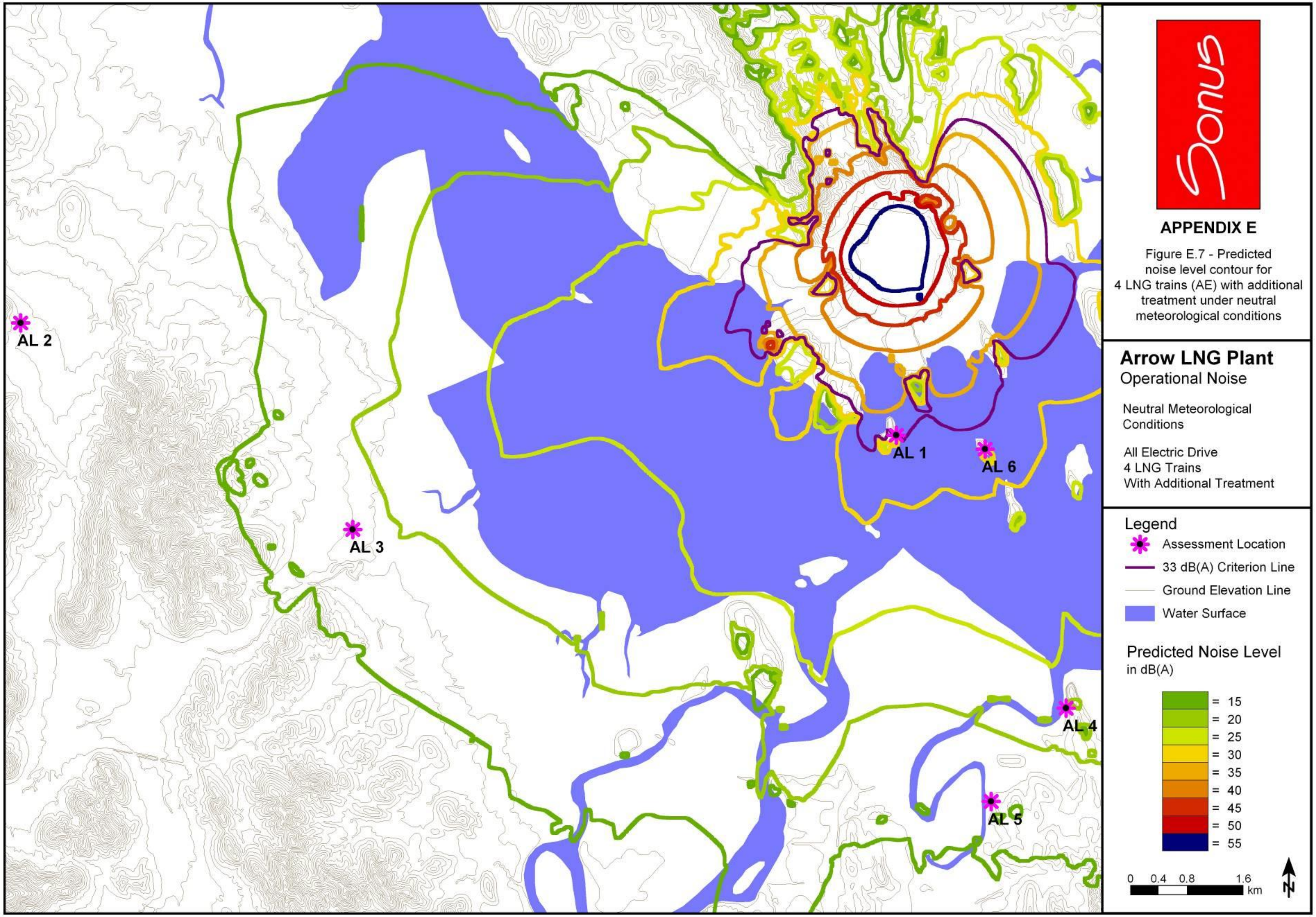

Appendix E: Noise Contours – With Additional Acoustic Treatment
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