MWH Australia Pty Ltd

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Suffolk Park Electricity Substation

Noise Impact Assessment

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Suffolk Park Electricity Substation
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EXECUTIVE SUMMARY

Vipac Engineers and Scientists Ltd (VIPAC) was commissioned by MWH Australia Pty Ltd to conduct a Noise Impact Assessment (NIA) of the proposed Suffolk Park Electricity Substation, known hereafter as the 'Project', to form part of an Review of Environmental Factors (REF).

Construction Noise Impact:

Three construction stages have been considered for the Project, as follows:

- Excavation Works
- Civil Works
- Installation

The Excavation Works stage is predicted to have the highest noise impact. The predicted noise levels under neutral weather conditions, which are the most likely weather conditions in the daytime, exceed the construction noise criteria by up to 5 dB(A).

The noise levels under worst case weather conditions are predicted to be higher, however the atmospheric conditions that would trigger the worst case scenario are not likely to occur often during summer months when the Excavation Works are scheduled to occur. This is because the high solar radiation in summer is likely to produce Pasquill Stability Classes A, B and to a lesser extent C, which are more consistent with neutral weather condition.

The Civil Works stage is predicted to exceed the noise criteria by up to 1 dB(A) under neutral weather conditions. Under worst case weather for noise propagation during this stage, noise levels may be higher, however these conditions are not expected to occur often. We propose that an Environmental Management Plan (EMP) be developed to reduce the noise impact of the Civil Works stage to acceptable levels.

The installation stage was not modelled. This stage is considered to have no significant noise sources that may cause a criteria exceedance at any noise sensitive receivers.

Since no construction activities occur during the evening or night time period, no sleep disturbance due to construction noise will occur.

Operational Noise Impact:

Based on the noise modelling predictions, the Project operations will satisfy the noise criteria at all surrounding noise sensitive receivers during all periods.

The two transformers are the dominant noise sources at the closest residence to the Project site. Based on the noise modelling predictions, the Sound Power Level of the transformers up to 93 dB(A) and still comply with the noise criteria.

Ground Vibration Impact:

We do not expect any vibration impacts from the Project. However if a complaint is made, it should be investigated and ground vibration monitoring should be conducted to determine whether structural damage is likely to occur.

By following the recommendations in this report, we expect that any potential construction noise impacts will be minimised, and that the operational noise impacts will comply with all applicable noise criteria.

Recommendations

The applicable criteria serve to protect the amenity of nearby residences. For this project there are some exceedances of the noise criteria at nearby residences during the construction period. This does not necessarily indicate loss of amenity of the residents, as the criteria are designed to minimise the potential annoyance for the majority of affected residences.

For this project there are a few specific residences potentially affected. As such the amenity of each residence can best be maintained by consultation with each resident. The project has planned to implement an extensive community consultation process.

We recommend the following to further reduce noise levels:

- Community consultation
- Best practice noise management
- Respond to noise complaints with expert noise advice

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1. INTRODUCTION

Vipac Engineers and Scientists Ltd (VIPAC) was commissioned by MWH Australia Pty Ltd to conduct a Noise Impact Assessment (NIA) of the proposed Suffolk Park Electricity Substation, known hereafter as the 'Project' to form part of an Review of Environmental Factors (REF).

The proposed site is located within the rural locality of Skinners Shoot, NSW. The proposed site location is presented in Figure 1-1. The Project involves the construction of a 132/11kV zone substation including all relevant electrical plant, control and switching buildings. The new substation will be connected to the existing 66kV sub-transmission line that runs south adjacent to the proposed site. This line will be upgraded to 132kV in 2011. The existing overhead 66kV line to the north will be replaced by a 132kV underground cable in 2011.

The Project is required as part of the Lismore to Mullumbimby Electricity Network Upgrade project.

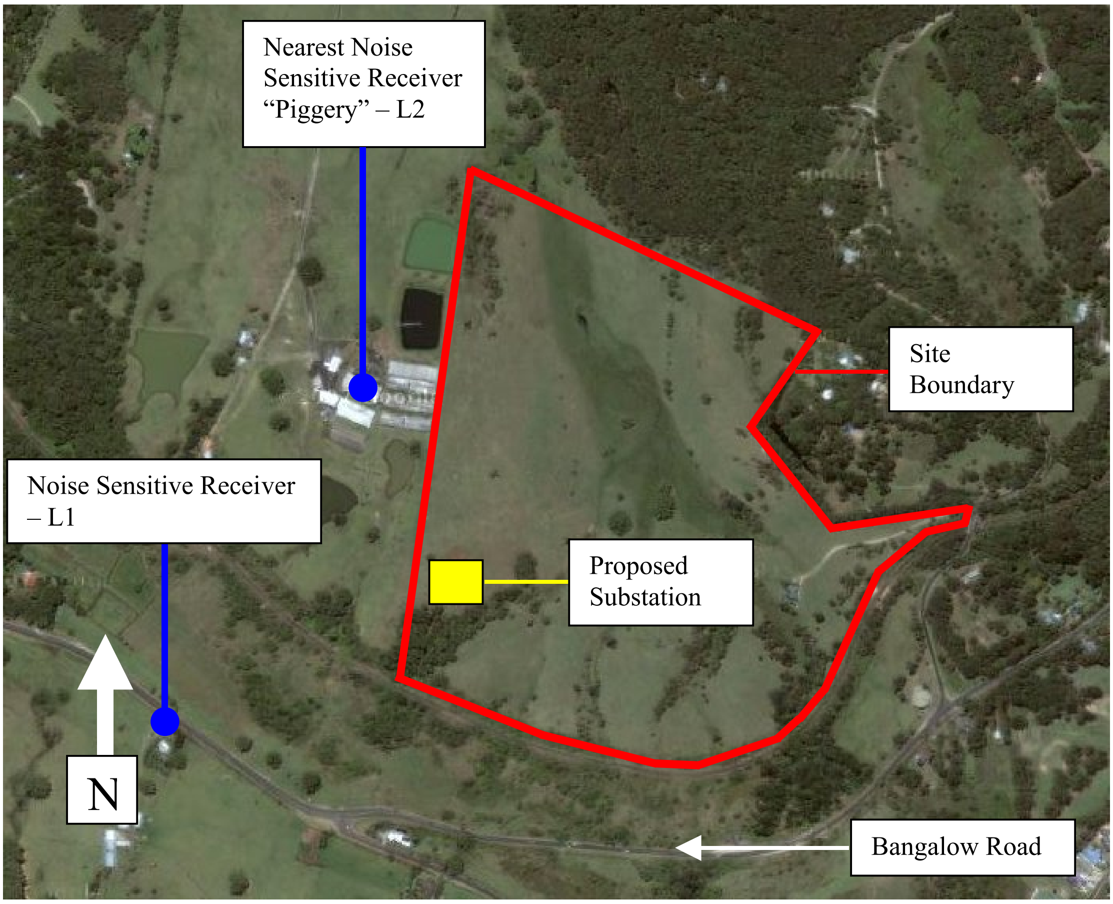

Figure 1-1: Proposed project site area

This report discusses two types of impact from the proposed development.

1. Noise and vibration impact associated with the construction of the Project; and
2. Industrial noise associated with the operation of the Project.

This assessment considers the construction and operational noise impacts of the Project and the associated infrastructure. Information pertaining to the major project components is listed as follows:

- Two 66kV feeders from the existing 66kV sub-transmission line;

- Two transformer bays containing 132/11kV 20/30MVA transformers;
- One 7.5MVA capacitor bank;
- Busbars, 132kV switches and other miscellaneous plant; and
- An oil collection tank.

The purpose of this report is to compare the results of noise modelling of the Suffolk Park Electricity Substation (both construction and operational phases) with applicable noise policies, and provide recommendations to minimise any potential negative noise impacts and environmental harm.

2. REFERENCES

The following documents will be referenced in the remainder of this report. These documents are applicable to various aspects of the Suffolk Park Electricity Substation.

[1] Australian Standard AS 1055.1 - 1997 *"Acoustics – Descriptions and measurement of environmental noise – Part 1: General procedures"*;

[2] Australian Standard AS 1055.2 - 1997 *"Acoustics – Descriptions and measurement of environmental noise – Part 2:Application to specific situations"*;

[3] Australian Standard AS 1055.3 - 1997 *"Acoustics – Descriptions and measurement of environmental noise – Part 3:Acquisition of data pertinent to land use"*;

[4] Australian Standard AS 2436 – 1981 *"Guide to noise control on construction, maintenance and demolition sites"*;

[5] British Standard 6472 – 1992 *"Evaluation of Human Exposure to Vibration in Buildings (1 Hz to 80 Hz)"*;

[6] German Standard DIN 4150-3 – 1999-02 *"Effects of vibration on structures"*;

[7] Department of Environment and Climate Change's *"NSW Industrial Noise Policy"* (2000);

[8] NSW Road Traffic Authority's *"Environmental criteria for road traffic noise (ECRTN)"* (1999)

[9] NSW Environmental Protection Agency's (EPA) *"Environmental Noise Control Manual"* (1994)

[10] Department of Environment and Climate Change's *"Assessing vibration: a technical guideline"* (2006)

3. PROPOSED SUFFOLK PARK ELECTRICITY SUBSTATION

3.1 Construction Stages

At this stage, the construction of the Project is expected to take up to six months (weather dependant), and will be divided into various stages. The construction schedule is not finalised yet, however the following details have been used to assist the modelling process:

STAGE ONE – EXCAVATION WORKS (10 – 11 weeks)

- Road Upgrade – Construction of a sealed access road onsite (4 – 5 weeks);
- Fencing – Construction of a security fence (i.e. concrete footings with chain wire fencing) to be done in conjunction with the Cut & Fill (3 weeks);
- Cut & Fill – Grading and compacting construction site for preparation of foundations (3 weeks);

STAGE TWO – CIVIL WORKS (15 – 19 weeks)

- Foundations – Conduit is installed in the building footings; the slab is then laid. (3 – 5 weeks);
- Building Construction – Construction of two masonry buildings to house equipment (12 – 14 weeks);

STAGE THREE – INSTALLATION (10 – 12 weeks)

- Installation – Transformers and major electrical equipment to be installed onsite.

The three construction stages are expected to have significantly different noise emissions due to the different equipment and types of activities to be performed.

CONSTRUCTION EQUIPMENT LIST

The equipment that will be required to complete the construction are listed as follows:

- Agitator;
- JCB Backhoe;
- Crane;
- Excavator;
- Komatsu Excavator / Loader PC300;
- Grader;
- Hand Tools;
- Wacker Packer (compactor);
- Truck.

3.2 Operational Stages

The Project is required as part of the Lismore to Mullumbimby Electricity Network Upgrade project. The substation will improve the efficiency of the local power grid. The two transformers and capacitor bank are expected to be the dominant noise sources of the substation.

4. EXISTING NOISE LEVELS

Noise monitoring was conducted to quantify the existing ambient noise environment surrounding the subject site. The noise monitoring data was contaminate due to bad weather and was therefore not used quantitatively for this assessment. However information about the character of background noise was obtained, and is presented in Section 4.

Refer to Appendix A for details of the noise logging data.

Analysis of the noise logging data indicated that the Rated Background Level during the night period was likely to be 30 dB(A) or less. As 30 dB(A) is the minimum allowable background noise level as per the Policy [7], the values used to calculate the noise criteria are likely to be the same as those that would be used if the logging data was used to calculate the noise criteria.

4.1 Noise Logging

Ambient noise levels were measured with noise loggers at the two closest noise sensitive receivers (NSRs) between 21st November and 28th November 2008. The noise logger locations were selected to be near noise sensitive receivers (NSR) such that the measured noise is representative of the noise environment at the NSR. The residences represented by each noise logger are indicated in Table 4-1. These areas are expected to represent the potentially noise affected areas that surround the Project site.

Noise monitoring was conducted in accordance with Australian Standard AS1055.1-1997 [1] and the *"NSW Industrial Noise Policy"* [7].

Table 4-1: Residences represented by each noise logger location

Logger ID	Logger Location	Areas / Dwellings represented by noise logger
L1	239 Bangalow Road, Skinners Flat (Approximately 470 metres from the proposed site)	All residences along the stretch of Bangalow Road adjacent to the proposed site, including the residence at the corner of Bangalow Road and Coopers Shoot Road.
L2	60 Yagers Lane, Skinners Flat – "Former Piggery" (Approximately 240 metres from the proposed site)	Representative of the potentially most affected residence. The former "Piggery" will be converted into an "Artist Retreat" which will become the nearest noise sensitive receiver to the Project. However at this stage a Development Application for a material change of use has not yet been lodged.

Figure 1-1 presents the locations of the noise loggers at the two representative noise-logging locations.

It was noted on site that ambient noise levels were consistent at the two noise logging locations. The observations have been listed in Table 4-2.

Table 4-2: Location of NSRs and onsite observations relevant to the ambient noise environment

Logger ID	Location and Observations
L1	The noise logger was placed on a hill with a clear view of Bangalow Road. The dominant noise source at the residence was observed to be Bangalow Road. Other noise sources onsite included noise from pets and children at the residence and local wildlife such as birds and insects.
L2	The noise logger was placed at the property boundary which is at the base of a

Logger ID	Location and Observations
	hill. Noise sources observed onsite consisted of cattle in the neighbouring property and wildlife activity such as insects and cane toads/frogs.

Sensitive Receivers

The potential noise and vibration sensitive receivers for the Project include:

- Residential dwellings located near the proposed Project site;
- Residential dwellings located along transport routes to be utilised during construction.

4.2 Meteorological Conditions

The meteorological conditions present during the noise logging period have been considered to determine the influence of weather on the recorded noise levels.

All rain affected data has been excluded from the noise logging results. Any day containing four hours total, or two hours consecutive of excluded data has not been used for assessment purposes. Precipitation fell on almost every day; as such the noise logging data was deemed invalid.

5. METEOROLOGICAL CONDITIONS USED IN MODELLING

Noise propagation can be affected by various weather conditions to either enhance or reduce noise levels. The following paragraphs detail the varying weather conditions that affect noise propagation.

The construction phases of the Project will be restricted to the daytime period. The operational phases of the Project will occur 24 hours / day. There is a different worst case weather scenario for day and night, with most adverse weather conditions that enhance noise propagation occurring at night. As such, the influence of weather on noise propagation has been assessed differently for the construction and operational phases of the Project.

The CONCAWE noise prediction algorithm has a unique set of noise calculation equations for each Meteorological Category. There are six Meteorological Categories in the CONCAWE algorithm. Categories 1 – 3 represent a temperature lapse rate with varying wind speeds from receiver-to-source. Category 4 has no meteorological influence, and is therefore a good indication of neutral weather conditions. Categories 5 & 6 represent conditions with a temperature inversion with varying wind speeds from source-to-receiver. The wind speed was combined with the temperature inversion parameters to determine the Meteorological Category used for noise modelling calculations of the Project.

VIPAC has modelled the worst case weather algorithms for noise propagation for the periods of the day during which the different phases (i.e. construction and operation) of the Project are expected to occur. As such any other set of meteorological assumptions will not produce higher predicted noise levels at a receiver.

5.1 Construction Stage Meteorological Parameters

Construction activities will be restricted to daylight hours. The meteorological parameters in Table 5-1 were used to model the worst case and neutral weather conditions for noise propagation during this period. Meteorological Category 5 invokes the worst case algorithms that can occur in the daytime period during the summer months when the heavy construction activities are scheduled to occur. Meteorological Category 4 or a 'neutral' meteorological influence is more likely to occur during the construction stages than the worst case weather conditions, due to high solar radiation during most of the daytime.

Table 5-1: Meteorological parameters used for daytime noise modelling

Meteorological Parameter	Worst Case Weather	Neutral Weather
Wind Speed (m/s)	2.5	2.5
Pasquill Stability Class	C	B
Meteorological Category Invoked	5	4
Wind Direction	Worst-case (source-to-receiver)	Worst-case (source-to-receiver)

5.2 Operational Meteorological Parameters

As part of the noise assessment, the meteorological effects on noise propagation have been considered in accordance with the *"NSW Industrial Noise Policy"* [7].

Temperature Inversions

Typically, temperature inversions have the greatest impact on noise propagation.

Based on the *"NSW Industrial Noise Policy"* [7] document, an occurrence of a temperature inversion for more than 30 percent of the total winter (June, July and August) night time period represents a significant noise impact. *The night time period for assessing temperature* *inversion frequency is from one hour before sunset to one hour after sunrise (taken to be 1800 to 0700 hours), which is the time period during which inversions are most likely.*

For this assessment, the default temperature inversion parameters for a non-arid area (annual average rainfall greater than 500 millimetres) have been used. The default temperature inversion parameters for this assessment are as follows:

Moderate (F-class stability category) inversion

- 3°C/100m temperature inversion strength for all receivers, with a $2ms^{-1}$ source-to-receiver component drainage-flow wind speed for those receivers where applicable.

Drainage-Flow Wind (Katabatic Wind)

A drainage-flow wind that increases noise propagation may occur for the Project operations. The site is elevated above some surrounding residential receivers, and a drainage flow wind would therefore increase noise emissions at these receivers.

The drainage-flow wind default value should generally be applied where a development is at a higher altitude than a residential receiver, with no intervening higher ground (for example, hills). In these cases, both the specified wind and temperature inversion default values should be used in the noise assessment for receivers at the lower altitude [7].

Note: Drainage-flow wind is the localised drainage of cold air under the influence of the local topography, and travels in one direction only, in the direction of decreasing altitude.

As such the default wind parameter of $2ms^{-1}$ has been used for this assessment.

Wind Effects (gradient wind)

Gradient wind is the regional wind in an area, governed by high and low-pressure systems i.e. synoptic factors. Since synoptic factors broadly affect large areas, the meteorological data from the Bureau of Meteorology's Cape Byron Weather Station can be considered representative of the meteorological conditions for the proposed site.

Gradient winds may occur in any direction during any assessment period (day, evening and night) and may result in adverse noise impacts from operational / construction scenarios.

Wind is considered to be a feature where source-to-receiver wind speeds (at 10m height) of $3ms^{-1}$ or below occur for thirty percent of the time or more in any assessment period (day, evening, night) in any season. [7].

It has been assumed that wind is a feature of the area, and a 'maximum impact' scenario has been applied in accordance with the *"NSW Industrial Noise Policy"* [7], as follows:

- *A default wind speed of $3ms^{-1}$ (at 10m height) is proposed for assessing the noise impacts caused by gradient winds.*

Meteorological Conditions used for Assessment Purposes

The meteorological parameters presented in Table 5-2 have been determined using the methodology outlined in the *"NSW Industrial Noise Policy"* [7] and used for assessment purposes.

Table 5-2: Determination of Pasquill stability class and meteorological category

Meteorological Parameter	Value
Wind Speed (m/s)	3
Pasquill Stability Class (PSC)	F
Meteorological Category Invoked	6
Wind Direction	Worst-case (source-to-receiver)

Wind has been considered a feature when it occurs for more than 30% of the time in a direction from source-to-receiver. To model the worst case wind direction, the wind direction has assumed to be blowing from source-to-receiver for each NSR at all times. This cannot occur in practice, however since all sources of noise in the plant are positioned quite close to each other relative to the position of each NSR, the results will be similar to the worst case wind direction. It is noted that the worst case wind direction for each receiver cannot occur simultaneously in practice.

In the noise modelling software the vector wind speed and PSC determine the Meteorological Category for each individual calculation from source to receiver. CONCAWE has a unique set of noise calculation equations for each Meteorological Category. Meteorological Category 6 algorithms would have be activated for all calculations from source to receiver for the worst case meteorological conditions with worst case wind direction.

Meteorological Category 6 is the worst case weather category for noise propagation. It will produce higher predicted noise levels than any other combination of meteorological parameters, and is therefore considered acceptable for assessment purposes.

6. NOISE AND VIBRATION CRITERIA

The applicable documents for this assessment are listed in Section 2. Construction, and operational noise impacts have separate applicable noise and vibration criteria and / or guidelines, as shown in Section 6.1 to Section 6.3

6.1 Construction Noise

In New South Wales, construction noise criteria are outlined in the *"Environmental Noise Control Manual"* [9]. A summary of the criteria is presented as follows:

- For construction periods of four weeks and under, the L_{10} noise level due to the construction site should not exceed the existing L_{90} background noise level by more than 20 dB;
- For construction periods of between four and 26 weeks, the L_{10} noise level due to the construction site should not exceed the existing L_{90} background noise level by more than 10 dB; and
- For construction periods greater than 26 weeks, the criteria for a continuously operating source would apply, which would generally mean that the L_{10} noise level due to the construction site should not exceed the existing L_{90} background noise level by more than 5 dB.

The existing background noise levels have been estimated from AS1055.2 [2] because the noise logging data was not valid. The area is considered to be an R1 noise area category.

The *"Environmental Noise Control Manual"* [9] also stipulates acceptable times for construction noise to be audible at a residential dwelling as follows:

- Monday to Friday, 7.00 am to 6.00pm;
- Saturday, 8.00 am to 1:00 pm; and
- No construction work to take place on Sunday and public holidays.

We understand that the construction stage is expected to take up to 25 weeks. However, each construction stage has been assessed individually to account for the significantly different noise emissions of each stage. As such, the applicable criteria for each of the construction stages during the allowable construction times are presented in Table 6-1.

Table 6-1: Daytime construction noise limits, in dB(A)

Construction Stage	Rating Background Noise Level (RBL),	Applicable Noise Limit	Construction Noise Limit ($L_{10,adj}$)
Stage One – Excavation Works	40 dB(A)	$L_{10} = L_{90} + 10$ dB(A)	50 dB(A)
Stage Two – Civil Works	40 dB(A)	$L_{10} = L_{90} + 10$ dB(A)	50 dB(A)
Stage Three – Installation	40 dB(A)	$L_{10} = L_{90} + 10$ dB(A)	50 dB(A)

NB: The construction noise levels must be adjusted for tonality and impulsiveness of noise sources

6.2 Operational Noise

The *"NSW Industrial Noise Policy"* [7] outlines two separate noise criteria to satisfy the environmental noise objectives of the policy, namely, the *Intrusiveness Criteria* and *Amenity Criteria*.

6.2.1 Intrusiveness Criteria

The Intrusiveness Criteria is defined as per Equation (1).

$$L_{Aeq,\ 15minute} \leq RBL + 5\ dB \quad (1)$$

Where $L_{Aeq,\ 15minute}$ represents the equivalent continuous (energy average) A-weighted sound pressure level of the source over a 15 minute period.

Due to rainfall onsite, and the upcoming school holidays one week of valid noise logging data was not obtained during the measurement period. As such, the minimum RBL of 30 dB(A) was used for the night period as per the Policy [7]. Based on AS 1055.2 [2] the area is classified as an R1 Noise area category – area with negligible transportation. An R1 noise area category has the estimated average background A-weighted sound pressure level presented in Table 6-2.

Table 6-2: Estimated average background noise levels for an area with negligible transportation

Noise Area Category	Description of neighbourhood	Average background A-weighted sound pressure level, $L_{A90,\ T}$		
		0700 – 1800	**1800 – 2200**	**2200 – 0700**
R1	Area with negligible transportation	40	35	30

Based on the minimum RBL specified by the *"NSW Industrial Noise Policy"* [7], and the estimated background noise levels in AS1055.2 [2], the Intrusiveness Criteria for each logging location is presented in Table 6-3.

Table 6-3: Intrusiveness Criteria – $L_{Aeq,15minute}$

Logger ID	Period	Existing RBL, in dB(A)	Intrusiveness Criteria: $L_{Aeq,15minute}$ in dB(A)
L1, L2	Day	40	45
	Evening	35	40
	Night	30	35

6.2.2 Amenity Criteria

The Amenity Criteria is aimed at the control and prevention of background creep due to the introduction of new industrial activities in an area. The area surrounding the proposed site is considered to be classified as "suburban" as defined by the Policy [7]. A suburban area is defined as *"an area that has local traffic with characteristically intermittent traffic flows or with some limited commerce or industry."* Bangalow Road is a transport route connecting Lismore and Suffolk Park. This road was observed to carry a significant amount of traffic, producing higher noise levels than would be expected for a "rural" area.

For residences in a suburban area, the "acceptable" and "maximum" $L_{Aeq,T}$ noise levels are presented in Table 6-4.

Table 6-4: Suburban Amenity Criteria – $L_{Aeq,T}$ in dB(A)

Period	Acceptable Noise Level, $L_{Aeq,T}$ in dB(A)	Maximum Noise Level, $L_{Aeq,T}$ in dB(A)
Day	55	60
Evening	45	50
Night	40	45

6.2.3 'Modifying Factor' Adjustments

The *"NSW Industrial Noise Policy"* [7] has 'Modifying Factor' adjustments to account for the varying characteristics of a noise source such as tonality, impulsiveness, intermittency, irregularity or dominant low frequency content. Each of these characteristics has an associated 'Modifying Factor' that is applied to the predicted source noise level at the receiver before comparison to the applicable noise criteria. The Policy [7] states – *"where two or more modifying factors are present, the maximum correction is limited to 10 dB(A)."*

Based on the sound power spectra of the major noise emitting equipment (i.e. transformers and capacitor bank) and noise measurements of similar equipment, we expect that the there will be low frequency tones present in the noise emissions. The Policy [7] states – *"Where a source emits tonal and low-frequency noise, only one 5 dB correction should be applied if the tone is in the low-frequency range."* As such the 'Modifying Factor' applied to the operational noise limits is 5 dB.

6.2.4 Limiting Criteria

The limiting noise criteria for the operation of the Project is the most stringent of the Intrusiveness Criteria and Amenity Criteria. For this assessment, the Intrusiveness Criteria is the most stringent. As the Project will be operational for 24 hours per day, seven days per week, the Intrusiveness Criteria for the night period becomes the limiting criteria. The limiting noise criterion for operational noise at each representative logging location is presented in Table 6-5.

Table 6-5: Limiting noise criteria for the Project Operations, in dB(A)

Logger ID	Period	Limiting Criteria $L_{Aeq,15minute}$ in dB(A)	Limiting Criteria with 'Modifying Factor' $L_{Aeq,15minute}$ in dB(A)
L1	All	35	30
L2	All	35	30

6.3 Vibration Criteria

The Department of Environment and Climate Change (DECC) provides preferred vibration limits to minimise the impacts on human comfort in its *"Assessing Vibration: a technical guideline"* [10] document.

For this assessment, we consider the potential vibration sources to be the construction equipment and Project infrastructure.

6.3.1 Human Comfort

The DECC vibration guideline [10] references British Standard 6472 – 1992 *"Evaluation of Human Exposure to Vibration in Buildings (1 Hz to 80 Hz)"* [5] to assess the potential human annoyance from ground vibration inside buildings and structures. VIPAC has summarised the acceptable vibration limits in peak particle velocity (PPV) that will reduce the risk of complaint at residences potentially affected by the Project's construction or operation in Table 6-6. The vibration limits are presented in terms of PPV rather than R.M.S acceleration, as this value is easily measured by most commercial available ground vibration monitors.

Table 6-6: Recommended ground vibration criteria to satisfy human comfort

Type of space	Time of day	Satisfactory peak vibration levels in mm/s over the frequency range 8 Hz to 100 Hz			
		Continuous vibration		Impulsive vibration with up to 3 occurrences per day	
		Vertical	Horizontal	Vertical	Horizontal
Residential	Day	0.3 to 0.6	0.8 to 1.6	8.4 to 12.6	24 to 36
	Night	0.2	0.6	2.8	8

6.3.2 Cosmetic Damage to Structures

VIPAC references German Standard DIN 4150-3 – 1999-02 *"Effects of vibration on structures"* [6] to assess the potential for cosmetic damage to structures from ground vibration associated with the Project. The German Standard [6] is generally accepted worldwide as being the foremost authority on limiting ground vibration at building structures to achieve zero expectation of damage.

DIN 4150-3 [6] recommends maximum peak particle velocity (PPV) vibration limits in mm/s for different frequency ranges to be associated with transient vibration sources. According to DIN 4150-3 [6], if the recommended vibration criteria are not exceeded, damage that reduces the serviceability of a building should not occur. The recommended ground vibration criteria is presented in Table 6-7.

Table 6-7: Recommended ground vibration criteria to prevent structural damage

Category	Type of Structure	Vibration Velocity Limit in mm/s			
		The maximum value of the three orthogonal components measured at the foundation at a frequency of			The maximum value measured in the plane of the floor of the uppermost storey
		< 10 Hz	10 to 50 Hz	> 50 Hz	All frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design or use	5	5 to 15	5 to 20	15
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in groups 1 or 2 and have intrinsic value (e.g. buildings that are under a preservation order)	3	3 to 8	8 to 10	8

7. NOISE MODELLING RESULTS

7.1 Model Description

Noise modelling was carried out using SoundPLAN computational software, a leading environmental noise software package used worldwide and accepted by local councils and the DECC.

The calculation method selected for the construction and operational noise predictions is the CONCAWE method, because of its capability of incorporating meteorological effects in noise calculations for distances greater than 100 metres.

7.2 Construction Noise Modelling Scenarios

We understand that the construction phase of the Project will involve the following aspects:

We expect that the following construction techniques will be used during the construction of the Project:

STAGE ONE – EXCAVATION WORKS (10 – 11 weeks)

- Road Upgrade – Construction of a sealed access road onsite (4 – 5 weeks);
- Fencing – Construction of a security fence (i.e. concrete footings with chain wire fencing) to be done in conjunction with the Cut & Fill (3 weeks);
- Cut & Fill – Grading and compacting construction site for preparation of foundations (3 weeks);

STAGE TWO – CIVIL WORKS (15 – 19 weeks)

- Foundations – Conduit is installed in the building footings; the slab is then laid. (3 – 5 weeks);
- Building Construction – Construction of two masonry buildings to house equipment (12 – 14 weeks);

STAGE THREE – INSTALLATION (10 – 12 weeks)

- Installation – Transformers and major electrical equipment to be installed onsite.

The three construction stages are expected to have significantly different noise emissions due to the different equipment and types of activities to be performed.

The noise criteria for these activities are outlined in Section 6.1. Stage One is expected to be the major noise contributing stage of the construction period.

We have been assumed that the noise sources listed in Table 7-1 will be utilised during the construction stage.

Table 7-1: Construction equipment

Construction Stage	Element	Noise Source(s)	Sound Power Level, in dB(A)
Stage One – Excavation Works (10-11 weeks)	Road Upgrade	JCB Backhoe	109.5
		Excavator	107.0
		Bitumen Truck	103.5
	Fencing	Excavator	107.0
		Concrete Truck	103.5
	Cut & Fill	Grader	107.0
		Excavator	107.0

Construction Stage	Element	Noise Source(s)	Sound Power Level, in dB(A)
		Road Truck	103.5
		Komatsu Excavator / Loader PC300	103.4
		Wacker Packer (compactor)	112.5
Stage Two – Civil Works (15-19 weeks)	Foundations	Excavator	107.0
		Concrete Truck	103.5
	Building Construction	Hand Tools	106.2
		Concrete Truck	103.5
		Crane	89.1
		Agitator	108.2
Stage Three – Installation (10-12 weeks)	Installation	Crane	89.1

At this stage we understand that the construction plan has not yet been finalised. However we understand that it will be a staged construction extending over a six month period. As such, we have modelled the construction phases separately to determine the potential noise impact of each stage.

We have been advised that the Excavation Works will be completed between 1st September 2009 and 1st December 2009. Construction will then cease until 3rd February 2010 due to school holidays and traffic congestion in Byron Bay.

The Civil Works stage will then commence and may be considered a separate construction stage from 2nd August 2010 to 11th December 2010.

The Installation Stage will occur between 3rd February 2011 and 15th May 2011 and is not expected to cause any significant noise impacts. As such it has not been modelled.

The equipment have been modelled as ‘point’ noise sources because they are likely to remain within a relatively small area over the assessment period.

The meteorological conditions presented in Table 5-1 have been used to simulate worst case weather conditions for noise propagation during the construction stage of the Project.

Figure 7-1 presents the a view of the Geodatabase model used to predict the a construction noise scenario using SoundPLAN noise modelling software.

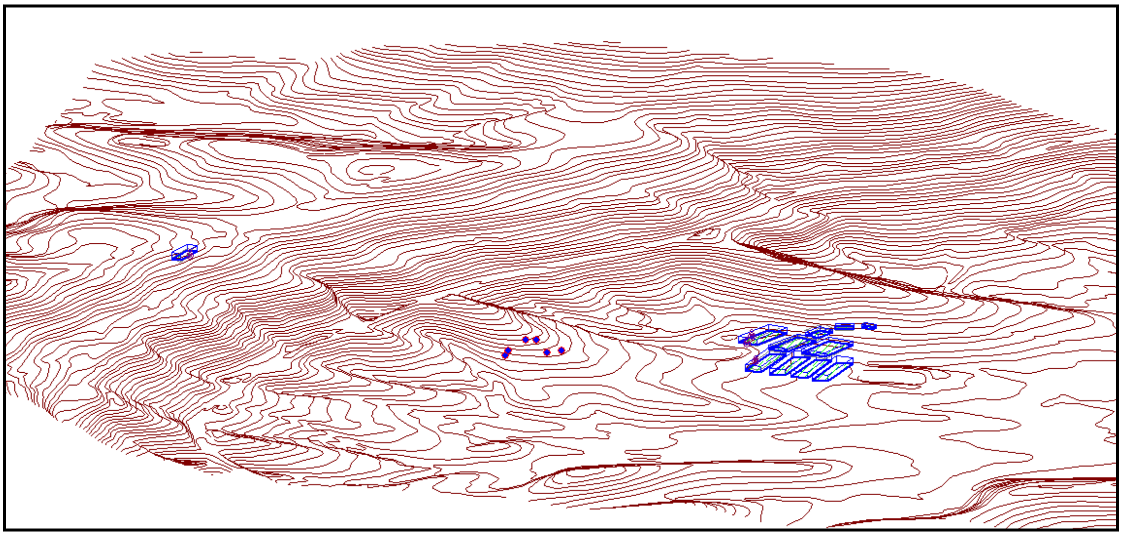

Figure 7-1: View of the Geodatabase model for the Construction Scenario

7.2.1 Construction Noise Modelling Results

Noise levels were predicted for both worst case weather and neutral weather. These scenarios correlate with Meteorological Category 5, and 4 respectively. Because of the high solar radiation in the area, and the fact that construction will occur only in the day, the worst case weather conditions in the day are not likely to occur often.

Excavation Works

The peak construction noise levels are expected to be from the Excavation Works stage. During this stage, a larger number of mobile plant will be operating over a larger area. This stage involves two parts as follows:

- Road Upgrade
- Fencing / Cut & Fill

Road Upgrade

The access road will be constructed on private property, and therefore we have not considered it to be a public road. As such we have considered noise from the construction of the access road to be assessable according to the Construction Noise Policy.

The highest predicted noise levels for the Road Upgrade at each of the noise sensitive receivers is presented in Table 7-2. Refer to Figure B-1 of Appendix B for a grid noise map for neutral weather conditions.

Table 7-2: Highest predicted noise levels from the combined Road Upgrade

Receiver	Highest Predicted Noise Level, dB(A)		Daytime Noise Criteria, dB(A)	Complies with Construction Noise Criteria?	
	Neutral weather	Worst case weather		Neutral weather	Worst case weather
60 Yagers Lane - Residence	52	55	50	+ 2 dB	+ 5 dB
60 Yagers Lane – Artist Retreat	54	57	50	+ 4 dB	+ 7 dB
239 Bangalow Road, Skinners Shoot	43	48	50	Complies	Complies

Fencing and Cut & Fill

The highest predicted noise levels for the Fencing and Cut & Fill at each of the noise sensitive receivers is presented in Table 7-3. Refer to Figure B-2 of Appendix B for a grid noise map for neutral weather conditions.

Table 7-3: Highest predicted noise levels from the combined Fencing and Cut & Fill

Receiver	Highest Predicted Noise Level, dB(A)		Daytime Noise Criteria, dB(A)	Complies with Construction Noise Criteria?	
	Neutral weather	Worst case weather		Neutral weather	Worst case weather
60 Yagers Lane - Residence	51	55	50	+ 1 dB	+ 5 dB
60 Yagers Lane – Artist Retreat	55	58	50	+ 5 dB	+ 8 dB

239 Bangalow Road, Skinners Shoot	47	51	50	Complies	+ 1 dB

It can be seen from Table 7-2 and Table 7-3 that the highest predicted noise levels from the Excavation Works stage under neutral weather conditions exceed the construction noise criteria by up to 5 dB(A).

The noise levels under worst case weather conditions are predicted to be higher, however the atmospheric conditions that would trigger the worst case scenario are not likely to occur very often during summer months when the Excavation Works are scheduled to occur. This is because the high solar radiation in summer is likely to produce Pasquill Stability Classes A, B and to a lesser extent C, which are consistent with a neutral weather condition.

Civil Works

The construction noise levels from the Civil Works stage are predicted to be lower than that of the Excavation Stage. During this stage, the noise sources will be localised in a smaller area. This stage involves two parts:

Foundations

The highest predicted noise levels for the Foundation works at each of the noise sensitive receivers is presented in Table 7-4. Refer to Figure B-3 of Appendix B for a grid noise map for neutral weather and worst case conditions.

Table 7-4: Highest predicted noise levels from the Foundation works

Receiver	**Highest Predicted Noise Level, dB(A)**		**Daytime Noise Criteria, dB(A)**	**Complies with Construction Noise Criteria?**	
	Neutral weather	**Worst case weather**		**Neutral weather**	**Worst case weather**
60 Yagers Lane - Residence	45	49	50	Complies	Complies
60 Yagers Lane – Artist Retreat	48	52	50	Complies	+ 2 dB
239 Bangalow Road, Skinners Shoot	41	45	50	Complies	Complies

Building Construction

The highest predicted noise levels for the Building Construction works at each of the noise sensitive receivers is presented in Table 7-5. Refer to Figure B-4 of Appendix B for a grid noise map for neutral weather conditions.

Table 7-5: Highest predicted noise levels from the Building Construction works

Receiver	**Highest Predicted Noise Level, dB(A)**		**Daytime Noise Criteria, dB(A)**	**Complies with Construction Noise Criteria?**	
	Neutral weather	**Worst case weather**		**Neutral weather**	**Worst case weather**
60 Yagers Lane - Residence	50	54	50	Complies	+ 4 dB
60 Yagers Lane – Artist Retreat	51	54	50	+ 1 dB	+ 4 dB
239 Bangalow Road, Skinners Shoot	44	48	50	Complies	Complies

It can be seen from Table 7-4 and Table 7-5 that the highest predicted noise levels from the Civil Works stage under neutral weather conditions exceed the construction noise criteria by up to 1 dB(A). The difference between the predicted noise levels and compliance with the noise criteria would not be perceptible (refer to Table D-1 of Appendix D). Under worst case weather for noise propagation during the construction period, noise levels may be higher, however these conditions are not expected to occur often. We propose that a Environmental Management Plan (EMP) be developed to reduce the noise impact of the Civil Works stage to acceptable levels.

Installation

The installation stage was not modelled. This stage is considered to have no significant noise sources that may cause a criteria exceedance at a noise sensitive receiver.

7.2.2 Construction Recommendations

The noise modelling results for the Excavation Works and Civil Works stage of the Project indicate that the noise criteria at the nearest noise sensitive receivers will be exceeded during the daytime period without noise mitigation and management strategies.

VIPAC expect that applying producing and complying with an EMP will minimise the impact of construction noise.

The EMP should incorporate the following noise reduction measures:

- Provide and maintain low noise equipment;
- Repair or replace defective mufflers on plant and equipment;
- Maintain buffer zones and setbacks from nuisance sensitive places;
- Consider substitution by alternative processes;
- Modify hours of work;
- Avoid dropping metal objects onto other metal objects to minimise impulsive noise;
- Turn-off equipment when not in use.

By implementing the above recommendations, and adopting best practice environmental management, VIPAC expect that the impact of construction noise criteria will be minimised.

7.3 Operational Noise

A detailed SoundPLAN noise model was created to predict noise levels for the operation of the Project.

The Project has the following major infrastructure:

- Two 66kV feeders from the existing 66kV sub-transmission line;
- Two transformer bays containing 132/11kV 20/30MVA transformers;
- One 7.5MVA 11kV capacitor bank;
- Busbars, 66kV switches and other miscellaneous plant; and
- An oil collection tank.

Of the major infrastructure, the two transformers and capacitor bank are expected to be the only significant noise sources. The sound power levels of the equipment are presented in Table 7-6.

Table 7-6: Operational Noise Sources

Noise Source	Sound Power Level, in dB(A)
132/11 kV 20/30MVA transformer	87
7.5MVA 11kV capacitor bank	81

Based on the sound power spectra of the major noise emitting equipment presented in Table 7-6 (i.e. transformers and capacitor bank), there will be low frequency tones present in the noise emissions. A tonal correction of 5 dB has been applied to the predicted noise levels as per the Policy [7].

Industrial Noise Modelling Assumptions

The following assumptions have been made for the noise assessment:

- All Project infrastructure runs simultaneously and continuously 24 hours / day;
- For this assessment, the default worst case meteorological conditions based on the *"NSW Industrial Noise Policy"* [7] have been adopted. These meteorological conditions are presented in Table 5-1.
- Worst case wind has been modelled (i.e. source-to-receiver component) for each noise source.

7.3.1 Operational Noise Modelling Results

Table 7-7 shows the predicted noise levels at the noise sensitive receivers with worst case meteorological conditions as detailed in Section 5.2. Noise contour maps in Appendix C show the predicted worst case operational noise for the Project. The lowest noise criterion for the Project operations is during the night period. Therefore the noise emissions from the Project have been compared against the night criteria. Compliance during the night period under worst case meteorological conditions will result in compliance during all periods.

Table 7-7: Predicted operational noise levels of the Project at NSRs

Receiver	Predicted worst case noise levels, in dB(A)	Noise Criteria (Night Period), in dB(A)	Complies?
60 Yagers Lane – Residence	23	30	Yes
60 Yagers Lane – Artist Retreat	24	30	Yes
239 Bangalow Rd, Skinners Shoot	24	30	Yes

Based on the predicted noise levels presented in Table 7-7, the Project operations are predicted to comply with the applicable noise criteria during all periods, and all weather conditions.

The noise contribution from the operational noise sources at the most affected NSR (i.e. 60 Yagers Lane) are presented in Table 7-8.

Table 7-8: Worst case operational noise contribution at 60 Yagers Lane – Artist Retreat

Noise Source	Noise Contribution, dB(A). Total = 24 dB(A)
2 x Transformers	23.8
2 x Capacitor Banks	12.6

Table 7-8 indicates that the transformers will be the dominant noise sources at the closest residence to the Project site.

Based on the noise modelling predictions, the SWL of the transformers may be increased to 93 dB(A) if desired before a criteria exceedance would occur.

8. GROUND VIBRATION

8.1 Operational

The operational stages of the Project are not expected to result in noticeable ground vibration levels at surrounding noise sensitive receivers due to the large distance of separation, provided that the infrastructure is isolated from the ground and maintained in good working condition.

For the operational stages we expect that both the human comfort vibration criteria presented in Table 6-6, and the cosmetic damage vibration criteria presented in Table 6-7 will be met at all surrounding residential receivers.

8.2 Construction

The construction of the Project may potentially result in an exceedance of the human comfort criteria for ground vibration presented in Table 6-6 due to the closer proximity of construction equipment to the residential dwellings whilst accessing the site. If best practice environmental management principles are applied to the construction of the Project, we expect that human annoyance to ground vibration will be minimised.

Damage that affects the serviceability of a building, as presented in Section 6.3.2 is less likely to occur due to the higher vibration limits.

8.3 Ground Vibration Recommendations

VIPAC recommends that any vibration complaints from nearby residences be investigated. Ground vibration monitoring should be conducted to determine whether structural damage is likely to occur.

9. CONCLUSION

Construction Noise Impact:

Three construction stages have been considered for the Project, as follows:

- Excavation Works
- Civil Works
- Installation

The Excavation Works stage is predicted to have the highest noise impact. The predicted noise levels under neutral weather conditions, which are the most likely weather conditions in the daytime, exceed the construction noise criteria by up to 5 dB(A).

The noise levels under worst case weather conditions are predicted to be higher, however the atmospheric conditions that would trigger the worst case scenario are not likely to occur often during summer months when the Excavation Works are scheduled to occur. This is because the high solar radiation in summer is likely to produce Pasquill Stability Classes A, B and to a lesser extent C, which are more consistent with neutral weather condition.

The Civil Works stage is predicted to exceed the noise criteria by up to 1 dB(A) under neutral weather conditions. Under worst case weather for noise propagation during this stage, noise levels may be higher, however these conditions are not expected to occur often. We propose that an Environmental Management Plan (EMP) be developed to reduce the noise impact of the Civil Works stage to acceptable levels.

The installation stage was not modelled. This stage is considered to have no significant noise sources that may cause a criteria exceedance at any noise sensitive receivers.

Since no construction activities occur during the evening or night time period, no sleep disturbance due to construction noise will occur.

Operational Noise Impact:

Based on the noise modelling predictions, the Project operations will satisfy the noise criteria at all surrounding noise sensitive receivers during all periods.

The two transformers are the dominant noise sources at the closest residence to the Project site. Based on the noise modelling predictions, the SWL of the transformers may be increased to 93 dB(A) if desired before a criteria exceedance would occur.

Vibration Impact:

We do not expect any vibration impacts from the Project. However if a complaint is made, it should be investigated and ground vibration monitoring should be conducted to determine whether structural damage is likely to occur

Recommendations:

The applicable criteria serve to protect the amenity of nearby residences. For this project there are some exceedances of the noise criteria at nearby residences during the construction period. This does not necessarily indicate loss of amenity of the residents, as the criteria are designed to minimise the potential annoyance for the majority of affected residences.

For this project there are a few specific residences potentially affected. As such the amenity of each residence can best be maintained by consultation with each resident. The project has planned to implement an extensive community consultation process.

We recommend the following to further reduce noise levels:

- Community consultation
- Best practice noise management
- Respond to noise complaints with expert noise advice

APPENDIX A: NOISE LOGGING DATA

A.1 Equipment

The instrumentation used for the noise logging is listed in Table A-1.

Table A-1: Instrumentation

Logger Location	Instrument	Serial Number	Lab Calibration Due	Field Calibration
L1	RION, NL-21 Type 2 Sound Level Meter	00276273	13/03/09	< 0.5dB drift
L2	ARL, EL-315 Type 1 Sound Level Meter	15 299 425	03/04/09	< 0.5dB drift

A.2 Noise Logging Parameters

Unattended noise logging was conducted at the two representative noise logging locations surrounding the site. The noise logging locations are presented in Figure 1-1. Noise logging was conducted with measurement parameters as listed in Table A-2.

Table A-2: Measurement Details

Detail	Information
Microphone Height	1.5m
Microphone Orientation	Pointing vertically upwards
SLM Time Weighting	Fast
SLM Frequency Weighting	A
Measurement Interval Period	15 minutes intervals

A.3 Noise Logging Results

Table A-3 presents the values of various noise descriptors at the two representative noise-logging locations. Refer to Appendix A for plots of the noise logging results and details of the noise logging instrumentation.

All rain and wind affected data has been excluded. In accordance with the *"NSW Industrial Noise Policy"* [7], data was considered to be wind affected if the maximum wind gust exceeded 5m/s at the microphone height.

Due to rainfall onsite, and the upcoming school holidays one week of acceptable noise logging data was not obtained during the measurement period. **The noise logging results in this section have not been used for assessment purposes.**

Table A-4 presents the Rated Background Levels (RBL) derived from the noise logging data.

Table A-3: Noise monitoring results at logger locations (free field), dB(A)

Noise Descriptor	Time period	Logger ID	
		L1	L2
$L_{A10,18hrs}$	6am to 12 midnight	63.7	44.9
$L_{Aeq,24hrs}$	24 hours	61.6	47.0
$L_{Aeq,1hr}$	Maximum 1 hour, 24 hours	45.4	38.9
$L_{Aeq, (Av. Day)}$	Average day period – 7am to 6pm	37.6	37.6
$L_{Aeq, (Av. Evening)}$	Average evening period – 6pm to 10pm	64.8	52.1
$L_{Aeq, (Av. Night)}$	Average night period – 10pm to 7am	56.7	44.3
$L_{A10, (Av. Day)}$	Average day period – 7am to 6pm	63.8	49.0
$L_{A10, (Av. Evening)}$	Average evening period – 6pm to 10pm	61.5	47.6

Noise Descriptor	Time period	Logger ID	
		L1	L2
$L_{A10, (Av. Night)}$	Average night period – 10pm to 7am	57.7	43.0
$L_{A90, (Av. Day)}$	Average day period – 7am to 6pm	37.9	37.5
$L_{A90, (Av. Evening)}$	Average evening period – 6pm to 10pm	45.1	41.5
$L_{A90, (Av. Night)}$	Average night period – 10pm to 7am	37.9	37.5

Table A-4: Rated Background Levels (RBL) for each noise logging location

Noise Descriptor	Time period	Logger ID	
		L1	L2
RBL, (Day)	Day Period – 7am to 6pm	41	35
RBL, (Evening)	Evening Period – 6pm to 10pm	40	38
RBL, (Night)	Night Period – 10pm to 7am	33	35

The noise logging results are presented graphically in Figure A-1 and Figure A-2 for location L1 and L2 respectively.

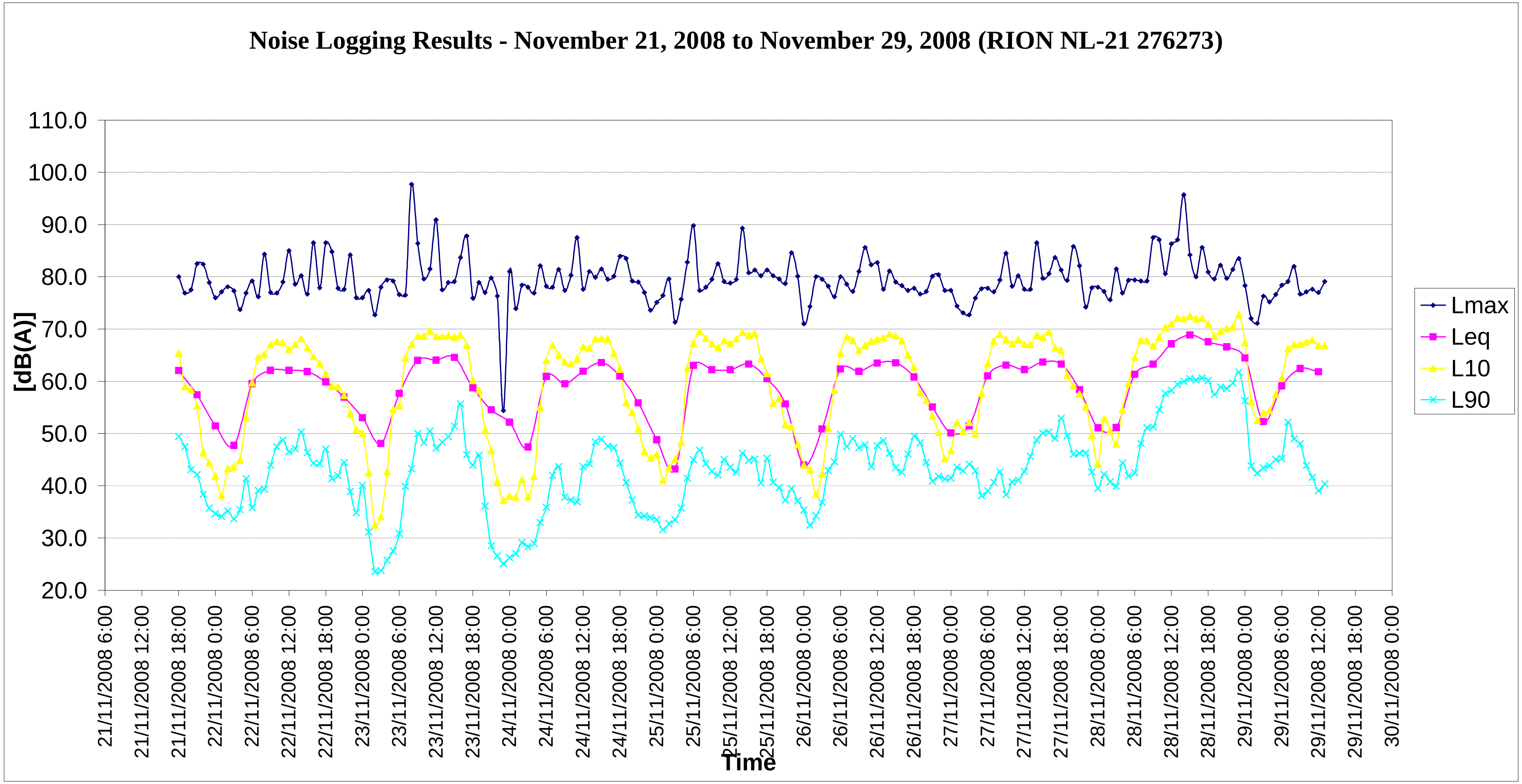

Figure A-1: Noise logging results at logger location L1 – 239 Bangalow Road, Skinners Shoot

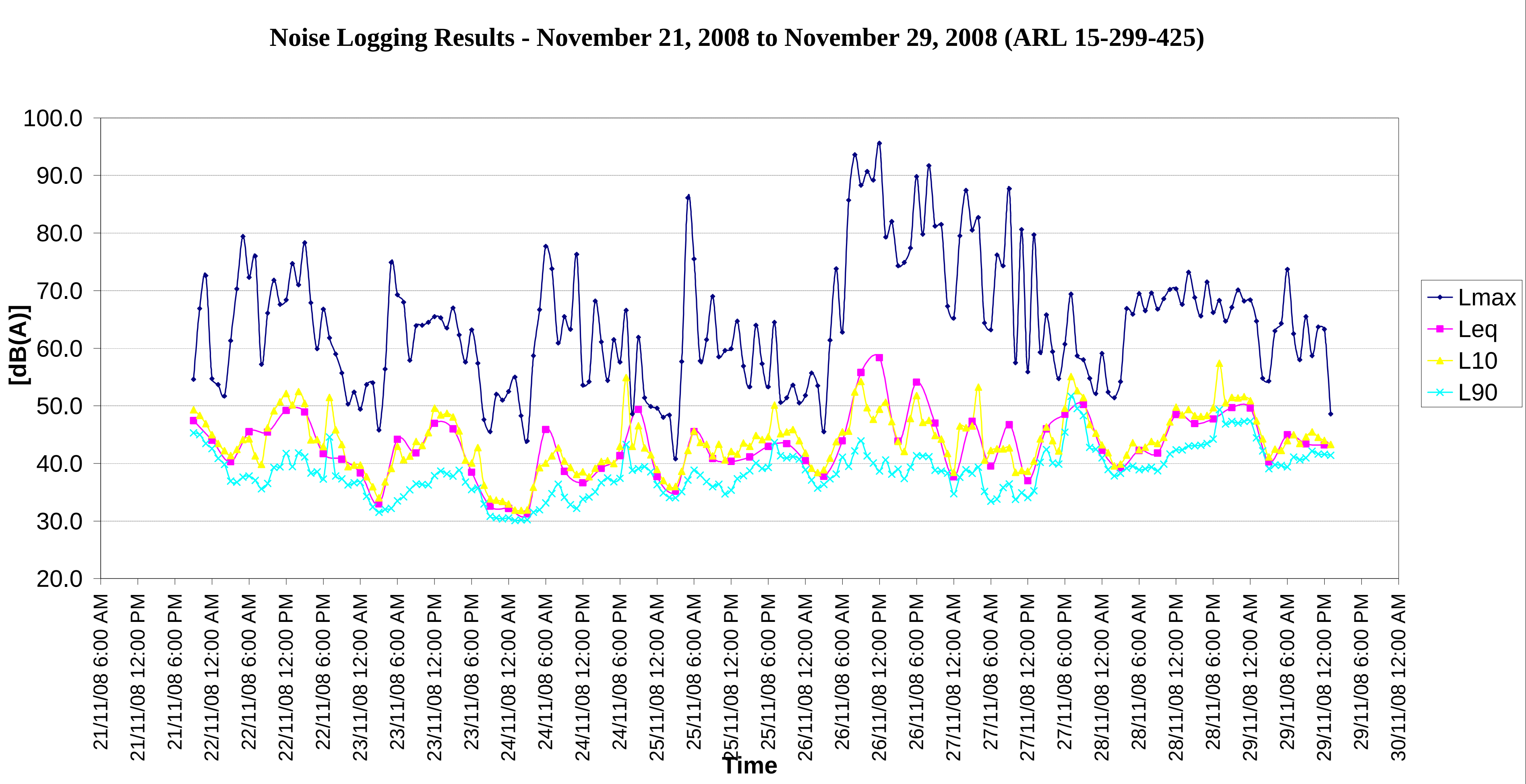

Figure A-2: Noise logging results at logger location L2 – 60 Yagers Lane, Skinners Shoot

APPENDIX B: CONSTRUCTION NOISE

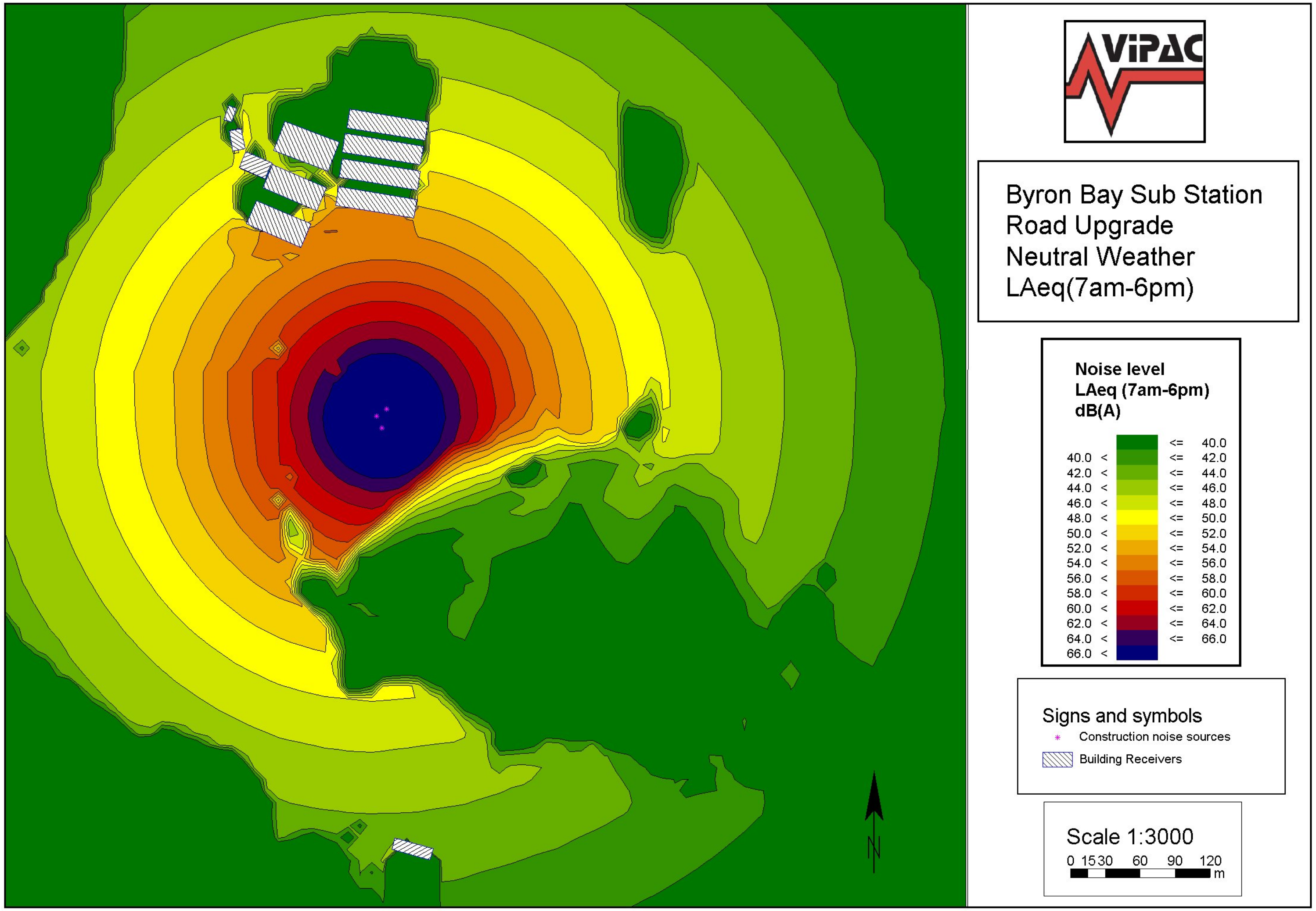

Figure B-1: Predicted noise levels from the 'Road Upgrade' stage of the Excavation Works under neutral weather conditions

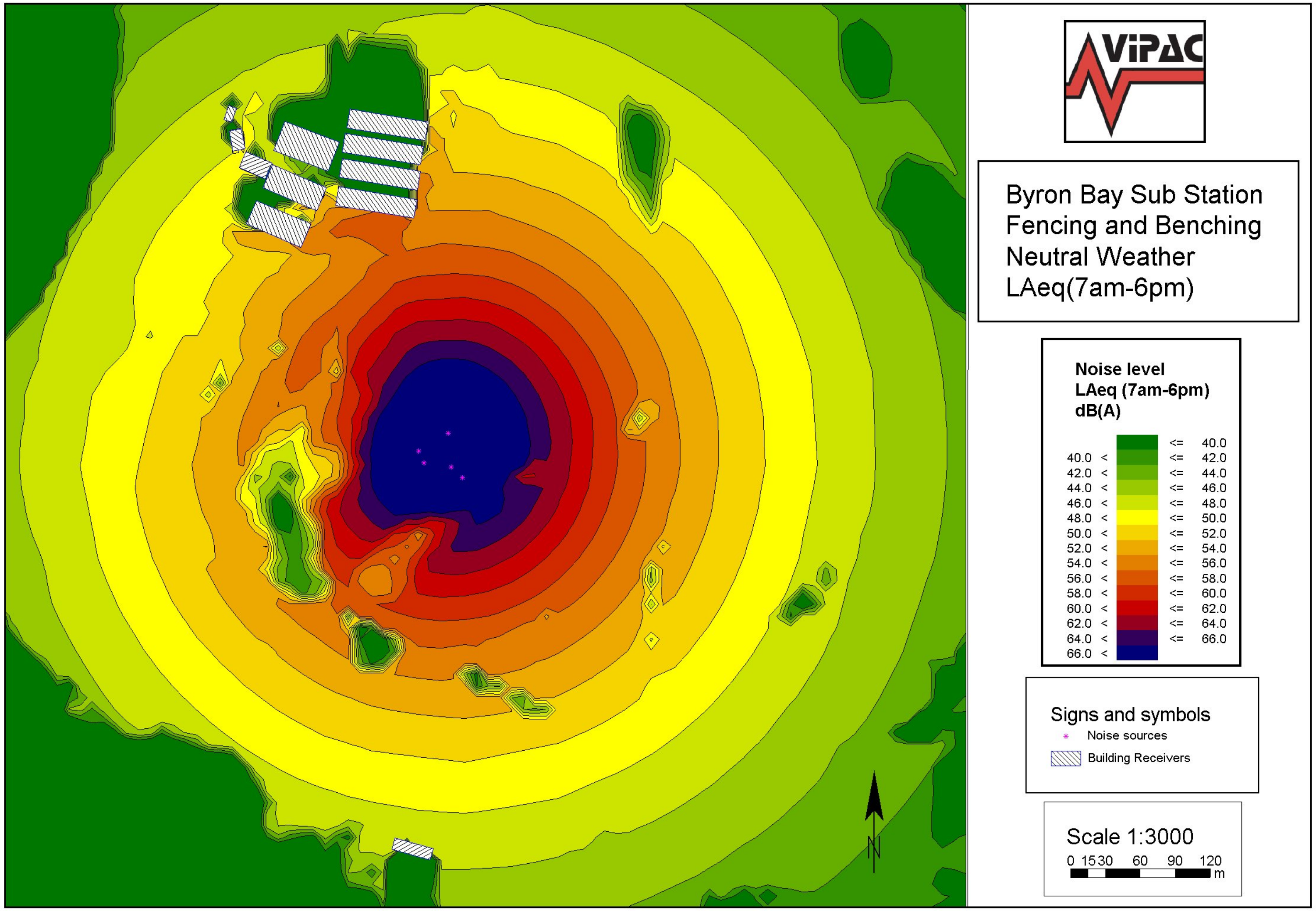

Figure B-2: Predicted noise levels from the 'Fencing and Cut & Fill' stage of the Excavation Works under neutral weather conditions

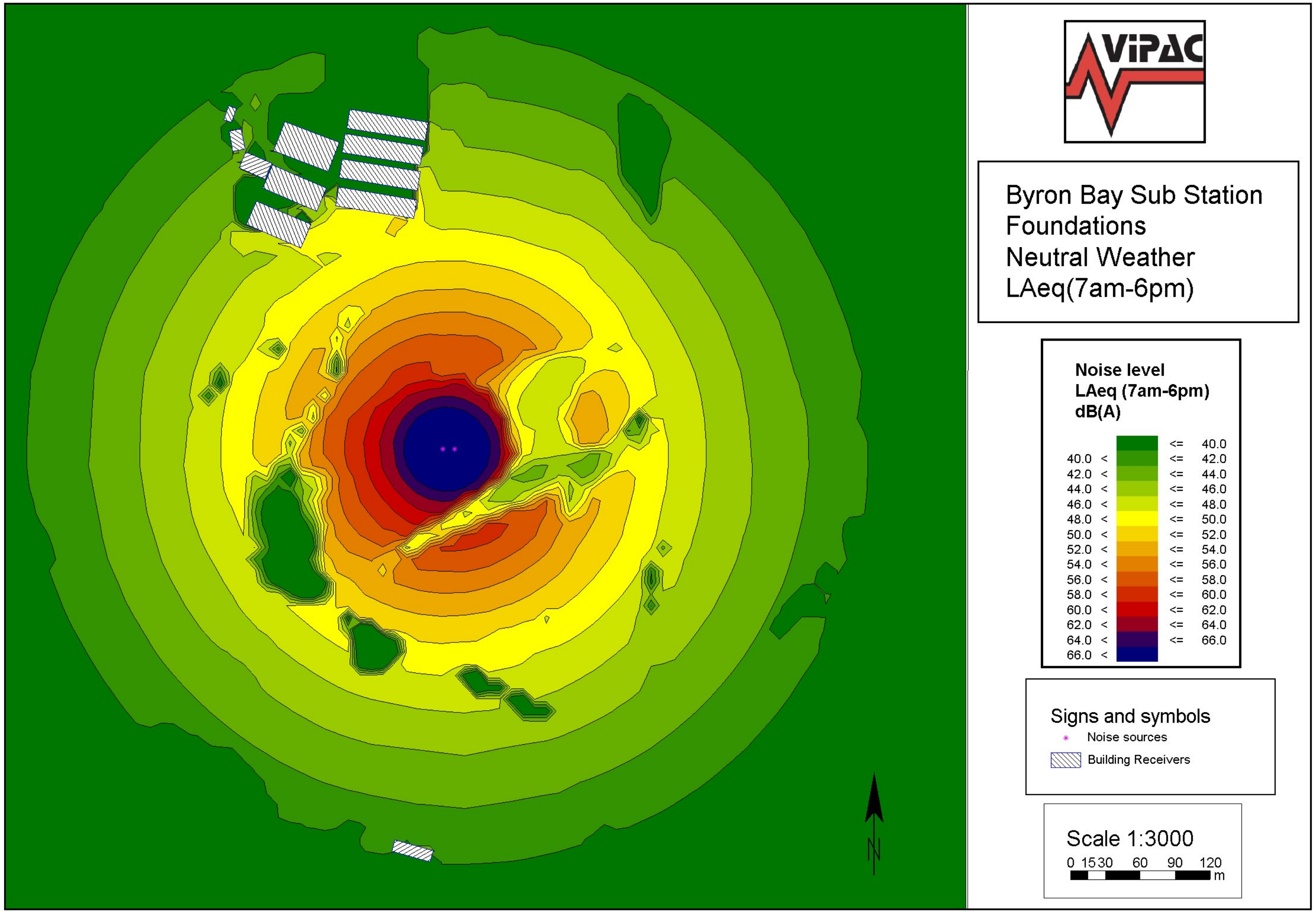

Figure B-3: Predicted noise levels from the 'Foundations' stage of the Civil Works under neutral weather conditions

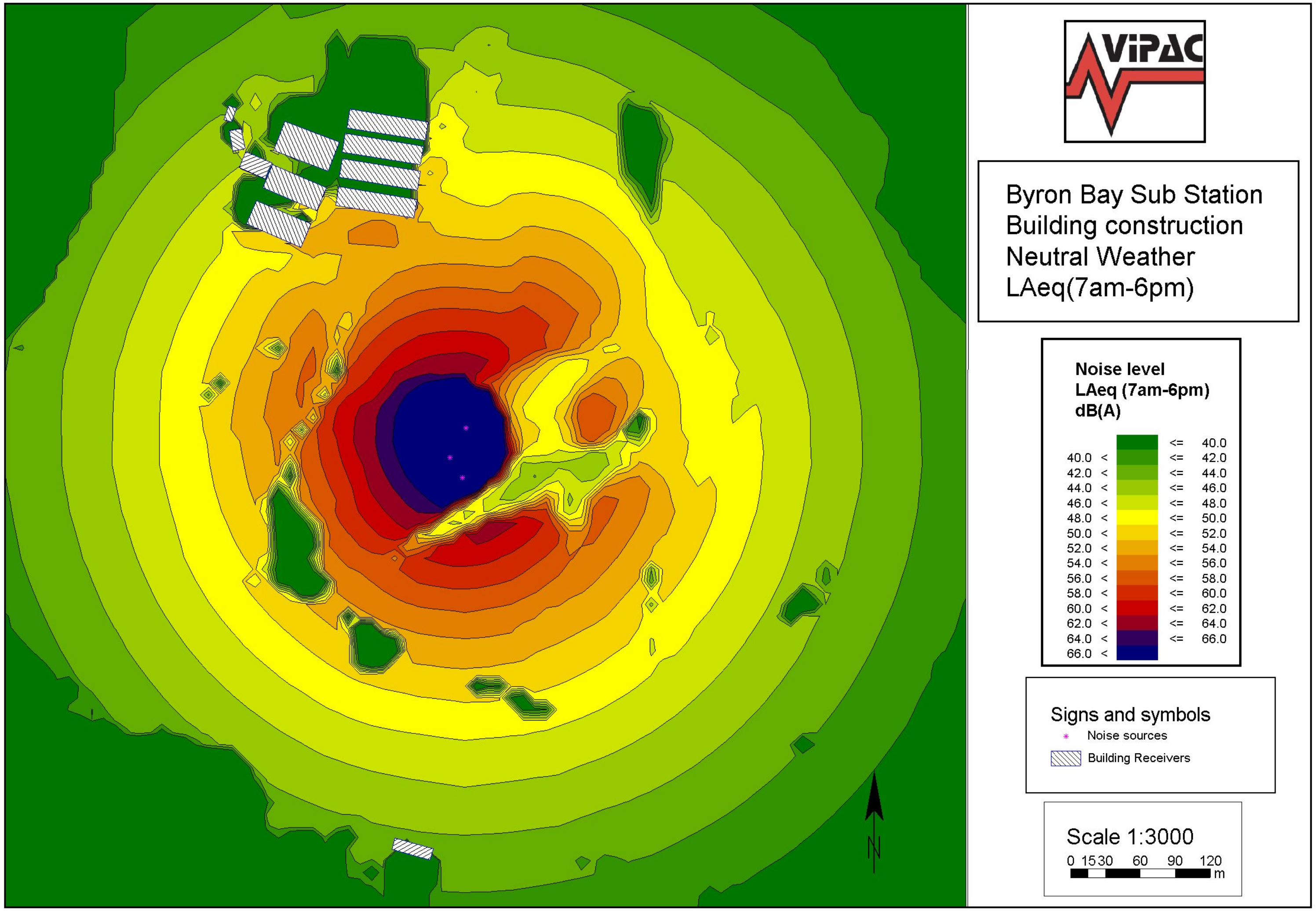

Figure B-4: Predicted noise levels from the 'Building Construction' stage of the Civil Works under neutral weather conditions

APPENDIX C: OPERATIONAL NOISE

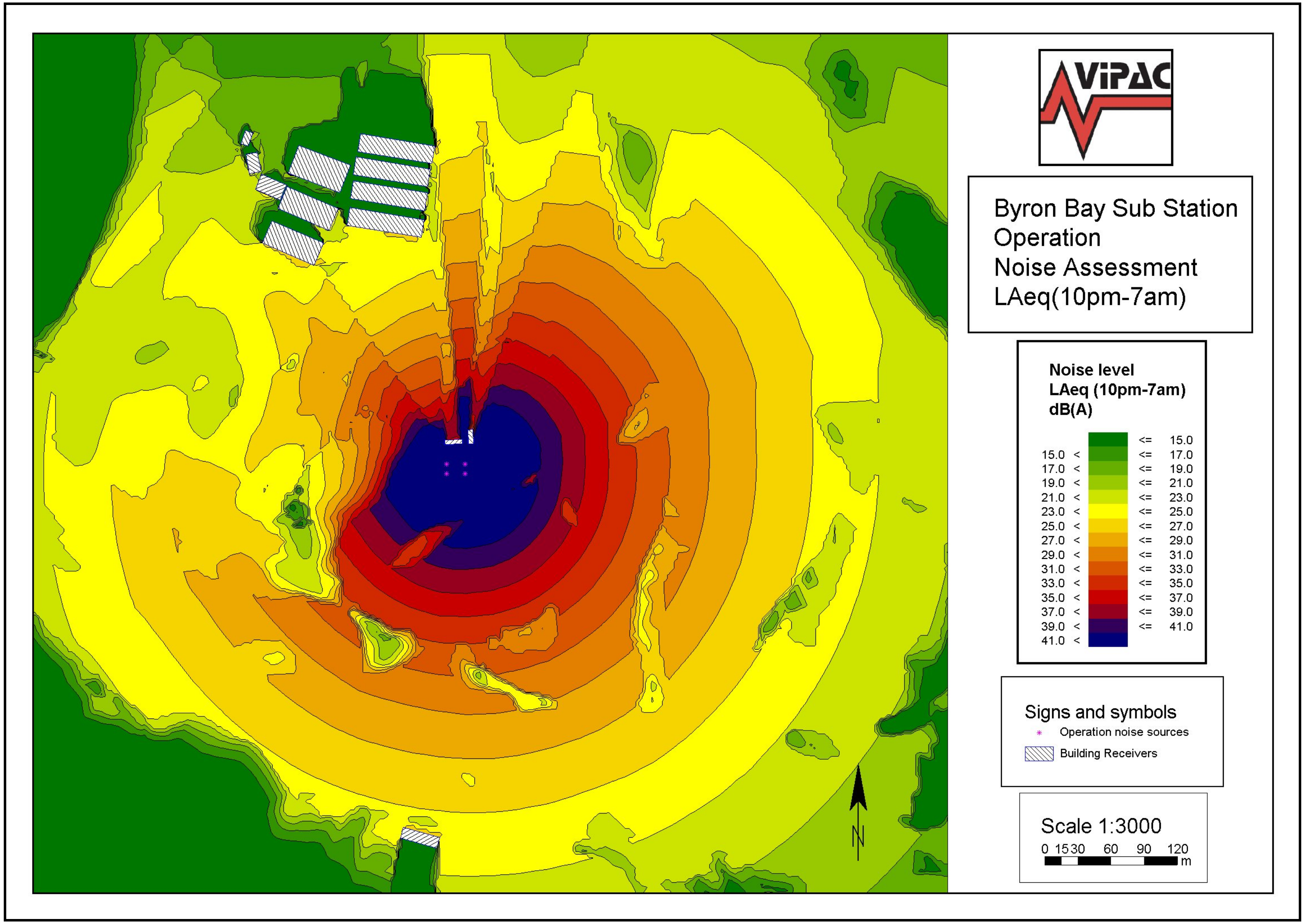

Figure C-1: Operational noise levels without tonal correction

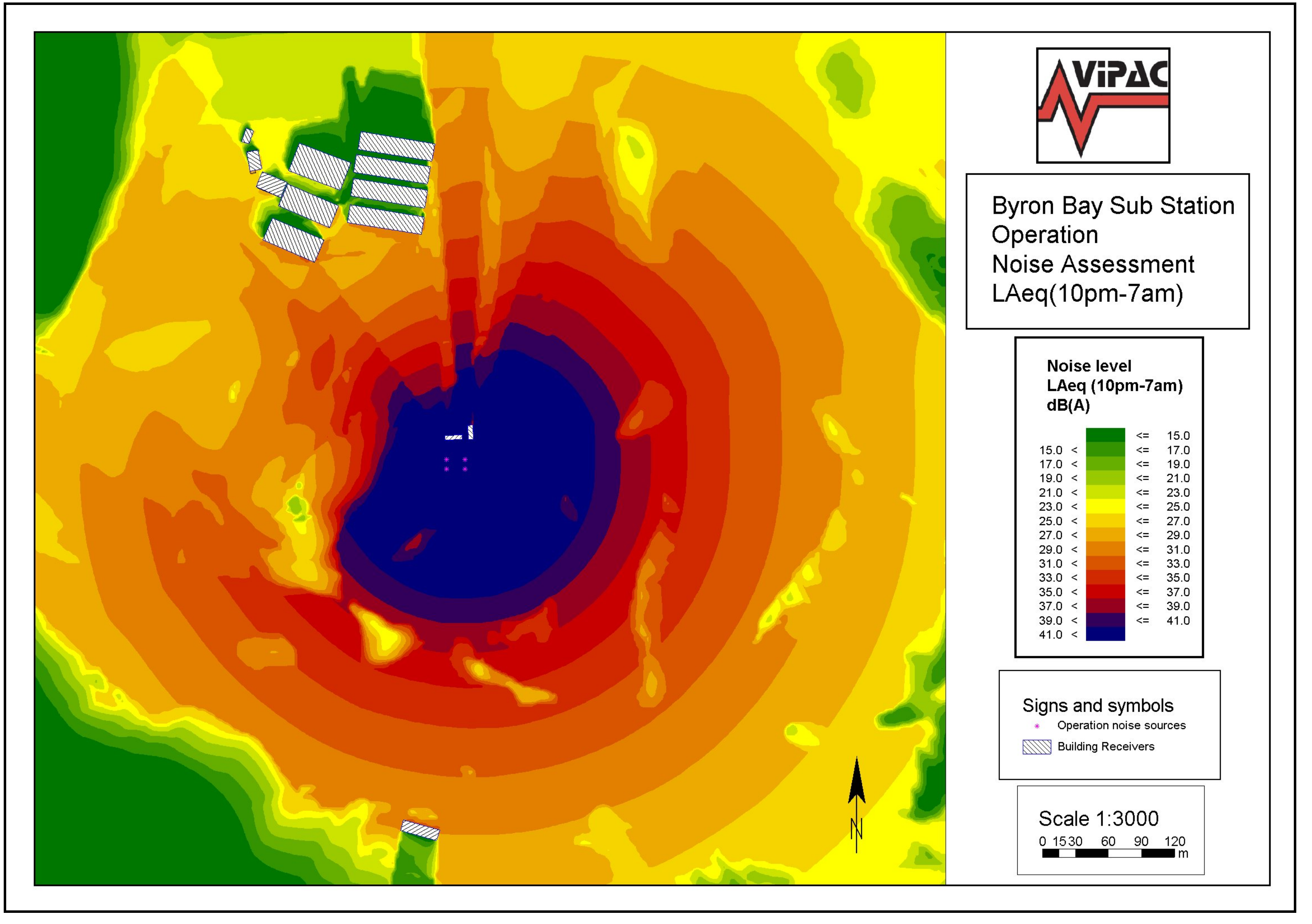

Figure C-2: Operational noise levels with tonal correction

APPENDIX D: HUMAN PERCEPTION OF LOUDNESS

Human Perception of Loudness – Table D-1 is extracted from Bies, DA and Hansen, CH, Engineering Noise Control, 3rd Ed. It presents the apparent, perceived change in loudness due to changes in sound pressure level.

Table D-1: Subjective effect of changes in Sound Pressure Level

Change in sound level (dB)	Change in (sound) power		Change in Apparent Loudness
	Decrease	Increase	
3	1/2	2	Just perceptible
5	1/3	3	Clearly noticeable
10	1/10	10	Half or twice as loud
20	1/100	100	Much quieter or louder