Appendix 7:
Report on Noise Levels at Belderra Substation, SEAI-AMETS Bulmullet

ESB International
Stephen Court,
18 - 21 St. Stephen's Green,
Dublin 2.

Report on Noise Levels at

Belderra Sub-Station

SEAI-AMETS

Bulmullet

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Noise Report

Belderra Sub-Station

ESB International

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1 INTRODUCTION

This Report was prepared by Biospheric Engineering Ltd in order to assess the potential impact of the construction and operation of a new substation at Belderra Strand on the Mullet Peninsula, Co. Mayo.

The new sub-station is a relatively small sub-station, comprising a single outdoor transformer contained in a bund and a cable chair and line bay to connect the sub-station to the national electricity grid. One single-storey building will be constructed on the site housing control rooms, switchgear, metering and battery storage rooms and toilet facilities. The construction of these elements is similar (from a noise perspective) to the construction of farm buildings or a domestic dwelling. The site will be enclosed and landscaped.

The sub-station will be linked to the Atlantic Marine Energy Test Site (AMETS) via an underground cable. This cable will comprise of laying 4 electricity cables in a trench in the ground. As with all underground cables underground joint bays (in the form of manholes) will be required along the route. While an open trench with conduits will be used to connect the sub-station to the transition joint bay, specialist construction techniques will be required to lay the cables in the intertidal zone.

The options for laying the cable in the intertidal zone comprise of horizontal directional drilling or open trenching. In either case the formation of the duct is followed by cable winching. These construction techniques, while utilising specialist equipment are similar in nature (from a noise perspective) to the use of large excavators on site.

Background noise measurements were taken at the sub-station location and at 3 locations along the access route to the substation from the R313 Regional Road linking Belmullet and Blacksod. Measurement locations were chosen to be representative of the general area. The measurement locations are representative of the noise environment at the nearest residences likely to be impacted by this proposed development.

The noise monitoring was carried out in good weather conditions over the period 17th and 18th August 2011.

2 MEASUREMENT METHODOLOGY

Measurement Equipment

Measurements were taken using Bruel & Kjaer model 2260 and 2250 type 1 sound level meters with modular real-time analysis using BZ7210 noise analysis module and BZ 7208 FFT module. The instruments were calibrated using a Bruel & Kjaer model 4231 sound level calibrator. The system was calibrated by Bruel and Kjaer 18th July 2011. No drift in calibration was evident during the monitoring period. Post Measurement analysis was carried out using Bruel & Kjaer Noise Explorer software. During measurement the height of the microphone was 1.3 metres above ground at the sampling location.

The noise measurements on site were carried out using a weatherproof enclosure with the microphone mounted on a steel pole. The measurements in the locality were taken with the microphone mounted on a tripod. In both cases the microphone was enclosed in a Bruel & Kjaer UA 1404 Outdoor Microphone Kit. This microphone kit is capable of operating at windspeeds in excess of 30 metres per second. B.S. 4142 *Rating of Industrial Noise affecting mixed residential and industrial areas* indicates that windshields are effective in wind speeds up to 5 m/s. The performance of the UA 1404 is vastly superior to that of a windshield and would appear to have no impact on measurements in windspeeds of up to 10m/s.

Noise measurements were taken in accordance with International Standards Organisation ISO 1996 – Acoustics – Description and Measurement of environmental noise. This standard does not set an upper limit to the windspeed in which measurements are taken, it requires the reporting of the windspeed at the time of measurement.

3 BACKGROUND NOISE MEASUREMENTS

Audible noise is measured with a microphone sensitive to the acoustic pressure and the associated instrumentation takes account of the varying sensitivity of the average human ear. Basically, the equipment is adjusted so that certain frequencies are given more or less weight than others. These weighted levels are then combined to yield a single number. The so-called 'A-weighting' weights the different frequencies in a manner similar to that of the human ear and is the most common weighting method used for noise measurements. A-weighting favours the mid-audio and high-audio frequencies, that is, above 500Hz, at the expense of the low frequencies.

The sensitivity of the human ear also depends on the magnitude of the sound pressure, as well as on its frequency. The variation in sound pressure of different sources is immense and for this reason sound pressures are generally expressed on a logarithmic scale in decibels (dB), which is both a common and convenient method of measuring quantities which vary over a very wide range. Note that the threshold of hearing is defined as 0 dBA and the threshold for pain is approximately 120 dBA (the L_{At} denotes that it is an A-weighted level). The zero dB reference level is a pressure of 20 micropascals (20 micronewtons per square metre).

The human ear tunes in the entire audio- frequency spectrum and thus it is desirable to characterise an instantaneous frequency spectrum of audible noise by a single number expressing an overall sound energy level. This number is referred to as the equivalent/continuous sound pressure level, L_{eq}. It has also been found convenient to derive from this number another set of numbers referring to that L_{eq}., which is exceeded for a given percentage of the time. These values are referred to as L_n, where n denotes the percentage of the time that the noise level is exceeded. Hence we refer to L_{90} noise level (that noise level which is exceeded 90% of the time). The L_{90} noise level is regarded as the ‘background’ noise level in the absence of any specific sources of noise.

Short-term environmental noise monitoring was undertaken at 3 locations along the proposed access route and in the vicinity of proposed substation site. A 24 hour log of noise levels was carried out at the sub-station site. Four sets of measurements were taken along the route as follows:

- 15 minute measurements at each location during the evening of the 17th August
- 15 minute measurements at each location during the night
- 15 Minute measurements every consecutive hour 10am to 1pm at each location in accordance with National Roads Authority procedures
- 15 Minute measurements every consecutive hour 2.44pm to 5pm at each location in accordance with National Roads Authority procedures

The long term noise measurement sequence was carried out at the proposed sub-station site on 17th and 18th August 2011. It is interesting to note that night time noise levels at the Belderra Strand area were higher on the evening and night of the 17th than on the day of the 18th. This was due principally to the noise from the surf on the beach. The surf noise was the dominant noise source in the area on the 17th and a measurement 50m from the surf edge resulted in an L_{Aeq} level of 66 dB and an L_{A90} level of 65 dB which are significantly elevated levels for a remote rural area. As the wind speed and wave height decreased during the 18th the noise levels dropped also.

The noise monitoring locations were chosen to give a good spread of geographic locations in the area and along the access route to the sub-station. The noise monitoring locations are shown in figure 1. Measurements were taken using Bruel & Kjaer 2250 and 2260 precision sound level meters.


Site Noise Log
dB
70
60
50
40
30
20
21:00:00
01:00:00
05:00:00
09:00:00
13:00:00
17:0
LAeq
LAF90
Cursor: 17/08/2011 23:05:00 - 23:10:00 LAeq=49.3 dB LAF90=47.1 dB


LEGEND
0 m
600 m
scale = 1 : 20000
origin = 64000, 329500
Cross Slab and Graveyard
Cillin
Promontory Fort
Arn
Emlybeg
Cairn
Promontory Fort
Belderra Strand
Cairn
N1
Site
N2
N3
Binghamstown
An Geata Mhór
PO
R313
Cross
Ballymacsherron
Sch
Cross Lough
Sch

Belderra Road Junction (65502, 330794) N1				
		L_{Aeq}	L_{A90}	
Evening	21:09	55.2	53.4	
Night	23:17	53.1	51.1	
Day	10:42	48.3	39.9	
	11:49	48.6	44.0	
	12:48	59.3	39.7	
	14:44	42.2	35.6	
	15:44	45.7	33.5	
	16:44	55.0	36.2	
Day (average)[1]		50	38	
Evening		55	53	
Night		53	51	

All noise measurements are for 15 minute periods. The noise levels measured at this location are consistently higher than those measured on the proposed sub-station site due to proximity to the beach and local road network.

[1] Daytime noise levels calculated using the averaging method outlined in the National Roads Authority *Guidelines for the Treatment of Noise and Vibration in National Road Schemes*

Holiday Village (66648, 330825) N2				
		L_{Aeq}	L_{A90}	
Evening	21:29	46.9	36.6	
Night	22:58	44.5	33.3	
Day	10:21	54.9	24.8	
	11:29	54.0	32.3	
	12:28	54.4	30.7	
	15:22	53.8	26.9	
	16:25	43.5	31.4	
Day (average)		52	29	
Evening		47	37	
Night		45	33	

Church Car-Park (67137, 330277) N3				
		L_{Aeq}	L_{A90}	
Evening	21:47	61.1	29.9	
Night	22:39	54.3	23.3	
Day	10:03	48.0	28.0	
	11:09	47.1	26.7	
	12:09	50.2	33.4	
	15:04	46.2	27.6	
	16:06	47.2	29.7	
Day (average)		48	29	
Evening		61	30	
Night		54	23	

4 IMPACT OF PROPOSED DEVELOPMENT

Background Noise Levels

The background noise levels in the Belderra area are typical of a rural area but can be elevated by natural sources such as surf noise. The lowest background level recorded during the day at ant of the four locations monitored was L_{A90} level of 25 dB at the holiday village and the quietest nighttime level was 23 dB at the church car-park. Noise levels in the Belderra area were consistently above levels at the other locations due to surf noise. Measurements taken at N1 were higher than those taken on the proposed site due to distance from the beach and some natural screening.

Average background noise levels in the vicinity of the proposed site can be taken to be in excess of 30 dB for the majority of the time.

Substation and Cable Trench Construction

Construction activity at the proposed site will be similar to the construction of a domestic dwelling or an agricultural outbuilding. The largest items of equipment used on the site will be excavators and dozers for site clearance and a crane for installation of the transformer. Other noise sources will include construction traffic, probably comprising a small number of private cars and vans and occasional truck traffic to deliver material. The impact on overall traffic levels and traffic noise levels on the road network will be minimal.

Construction activity on the site will comprise the traditional construction techniques of concrete work, block-laying, carpentry and roofing followed by equipment installation. None of these activities are of themselves significantly noisy.

The installation of the cable trenches will require the use of excavators and potentially rockbreakers for short periods. These activities will be carried out on the roadway connecting the proposed site to the beach at Belderra. The use of such heave equipment will give rise to elevated noise levels on a localised basis.

Source data from Biospheric Engineering's database of construction noise measurements is used to create a model based on the site map. Modelling was carried out using Bruel & Kjaer's Predictor Package. The noise predictions are illustrated on the following noise prediction maps. Predictor is a comprehensive noise modelling software package that is used by Local Authorities, Acoustic Consultancies and others for environmental noise mapping and prediction.

A construction noise prediction model has been prepared for the case where a large dozer is engaged on site clearance works and trench excavation is taking place at three locations along the cable route simultaneously to assess what the noise level is likely to be at nearby properties. This is an extreme worst case scenario as it is unlikely that all of these activities will take place at the same time.

This model also simulates the construction noise case where a cable-puller is operating on the beach area, on the basis that the cable puller noise emissions are equivalent to those from a large excavator such as a Caterpillar 365.

The only guidelines for construction related noise (in Ireland) are those published by the National Roads Authority in Table 1 of their *Guidelines for the Treatment of Noise and Vibration in National Road Schemes.* These guidelines are as follows:

Days & Times	$L_{Aeq\,(1hr)}$ dB	$L_{pA(max)slow}$ dB
Monday to Friday 07:00 to 19:00hrs	70	80[2]
Monday to Friday 19:00 to 22:00hrs	60[2]	65[2]
Saturday 08:00 to 16:30hrs	65	75
Sundays and Bank Holidays 08:00 to 16:30hrs	60[2]	65[2]

Table 1: Maximum permissible noise levels at the façade of dwellings during construction

The results of the noise model indicate that noise levels in excess of 60 dBA will occur in the immediate vicinity of the site but will drop significantly with distance, At the nearest houses levels will be in the order of 45 dBA which is within the National Road Authority Guideline figure for construction activity.


LEGEND
30.0 dB(A)
45.0 dB(A)
50.0 dB(A)
55.0 dB(A)
60.0 dB(A)
65.0 dB(A)
70.0 dB(A)
period: Day Period
Construction Phase
0 m
600 m
scale = 1 : 20000
origin = 64000, 329500
Belderra Strand
Emlybeg
Promontory Fort
Binghamstown
An Geata Mhór
Ballymacsherron
Cross
Cross Lough
R313

Operation Phase Noise Levels

Transformer Noise

A power transformer emits noise from three main sources:

- Its tap-changer, whose noise level may be high but because of its infrequent operation has not been a problem.
- Its cooling fans, whose noise levels may be considerable but covers fairly broad frequency spectrums and is usually of limited duration. It is likely that the cooling fans will only be used at times of peak load during the day.
- Transformer core -the noise associated with the transformer core is the result of electrical and magnetic forces associated with the application of voltage and the flow of electric power, acting on the components of the structure. It is primarily due to what is called magnetostriction of the core laminations, i.e. they are extended for each of the two magnetisations per cycle so that the fundamental frequency of the noise is 100Hz.

ESB specifications require that the noise level of a transformer, including all cooling fans, measured according to IEC60551, shall not exceed 70dBA. Based on this value the sound pressure level (L_p), due to the transformer alone, is estimated to be less than 30dBA at a distance of 50 metres from the transformer. The nearest dwelling will be located considerably remoter than this from the transformer. Given the distance from the proposed substation to the nearest dwelling noise complaints are not likely to occur.

Overhead Power-Line Noise

There are two types of noise generated by power lines, namely gap sparking and corona. Further to that, aeolian noise can be produced by power lines given the correct wind conditions.

Gap Sparking

Gap sparking can develop at any time on power lines at any voltage. It occurs at tiny electrical separations (gaps) that develop between mechanically connected metal parts. Combinations of factors like corrosion, vibration, wind and weather forces, mis-fabrication, poor design or insufficient maintenance contribute to gap formation.

Gap sparking can give rise to electrical noise, i.e. it occurs at frequencies higher than those that are audible to humans, including frequencies used for radio and television signals. Gap sparking can be a problem even at quite large distances from power lines.

Gap sparking is a direct efficiency loss on the transmission grid and is easily identified and resolved. Eirgrid (the national grid operators) conduct regular inspections of the grid and corrective action is put in place to minimise gap sparking.

Corona Noise

Corona occurs when the potential of a conductor in air is raised to such a value that the voltage stress at the surface of the conductor is greater than the dielectric strength of the air surrounding it. In the region where the corona appears, the air is electrically ionised and becomes a conductor of electricity. A discharge of pale violet colour appears near the adjacent metal surfaces. It is accompanied by a hissing sound and the production of trace quantities of ozone.

Corona discharge causes noise over a wide range of frequencies that can be either audible or electrical. Figure 1 shows the worst case conductor L_{50} audible corona noise levels as a function of lateral distance from the centre of the line. As the predicted value at fifty metres from the line is less than ambient background noise level at the locations where measurements were taken it is not expected to give rise to complaints.

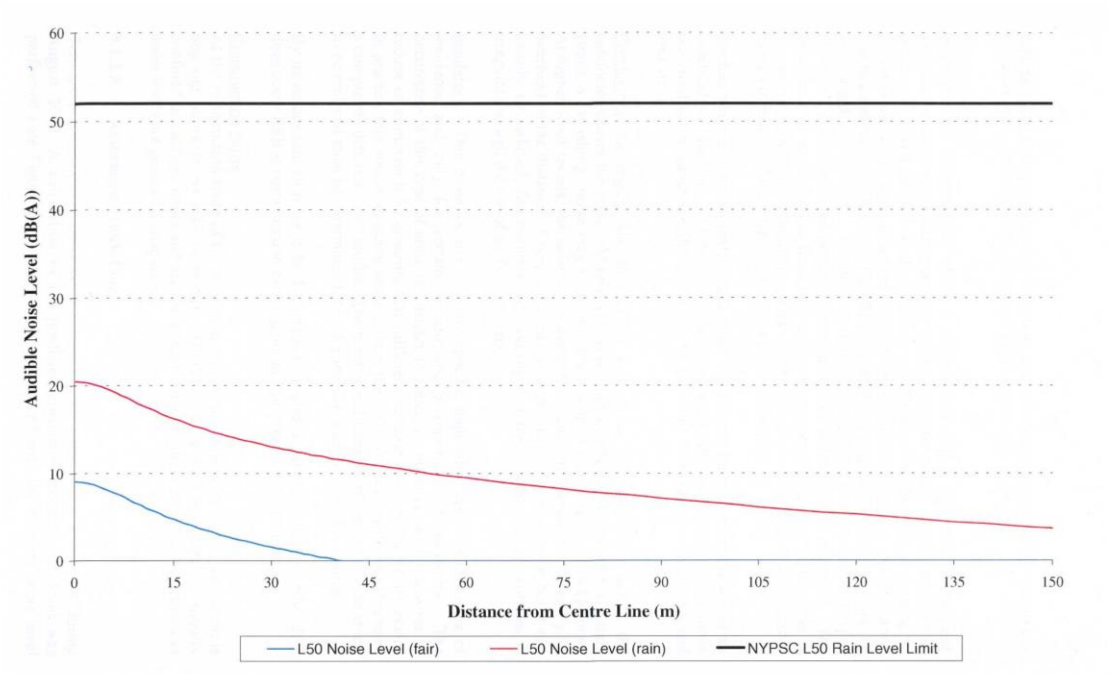

Figure 1 Corona noise level

On a properly designed line, corona noise rarely results in complaints of interference to radio or television signals except perhaps in weak signal fringe areas. Corona is rarely a problem at distances beyond 5Om from the line. The level of audible corona at any time is dependent on the prevailing weather conditions. The dielectric strength of air is lower in wet weather than in dry weather. Thus the voltage stress at a conductor surface does not have to reach such high levels in wet weather for corona noise to become audible.

In fair weather, corona sources are sufficiently few in number that this noise is generally of no concern and is often inaudible to people on the ground. Corona noise attains higher levels and may become audible in wet weather, when large numbers of corona sources form at water droplets on the conductors. However, on such occasions the background noise level of rainfall and wind tend to mask the noise from the line.

People probably find any noise from a high voltage line to be more noticeable during periods of light rain, snow or fog when they are more likely to be outdoors or to have windows open, and when the background noise is generally lower.

Aeolian Noise

In addition to corona noise, which is of electrical origin, overhead transmission lines may produce another type of acoustic noise. This form of noise occurs under well defined wind conditions and is caused by the wind impinging on the different components of a line, e.g. the steel towers, conductors and insulators. The two meteorological factors that affect the level and frequency of this noise are the wind speed and direction. The different line components give rise to different types of noise. The noise is not dependent on whether or not the line is energised. The occurrence of aeolian noise from the various components of a high voltage line is uncommon, since the conditions under which the noise occurs are very specific, though in particular localities it may occur more frequently.

Aeolian noise may occasionally occur when wind blows through a steel tower of an overhead voltage line. More important, however is the noise that is sometimes produced under rather specific conditions by the wind blowing over conductors and insulators.

Conductors: the regular shedding of air vortices as the wind flows across the conductor causes the noise. At relatively low wind speeds, i.e. below approximately lO m/s, a "swishing" noise may occur but at a low level that is seldom troublesome. At higher wind speeds, the noise is similar to the "rumbling" sound of planes flying overhead in the distance. Complaints may arise due to this type of noise but it can usually be reduced, for example by ensuring that the shedding of air vortices is irregular through the use of air flow spoilers.

Insulators: This noise occurs for only specific high wind speeds and angles of incidence and only for certain designs and arrangements of insulators. The occurrence of this type of noise is difficult to anticipate but it is usually possible to reduce or eliminate it by ensuring that sufficient acoustic resonance does not occur. In practice this means replacing some units in the insulator string with ones that have a completely different "rib" profile. The number and location of the units in the string to be replaced must be determined for each particular design of insulator string.
By its nature aeolian noise is hard to predict. It also occurs quite infrequently. If it does occur the developer is committed to carrying out appropriate mitigation measures.


LEGEND
30.0 dB(A)
45.0 dB(A)
50.0 dB(A)
55.0 dB(A)
60.0 dB(A)
65.0 dB(A)
70.0 dB(A)
period:
Night Period
Initial model
0 m
300 m
scale = 1 : 10000
origin = 65000, 330000
Belderra
Strand
Promontory
Fort
Cairn
Cairn
Ballymacsherron
10
8
8
15
32
24
18
32
20
13

5 ASSESSMENT OF NOISE IMPACTS

International Standard ISO 1996 gives guidelines for the description of noise in community environments. It recommends the adoption of the equivalent continuous A-weighted sound pressure level, $L_{(A)eq}$, as the basic quantity for describing acoustic noise, as used in this report. It does not, however, specify limits for environmental noise. That is a task that must be undertaken by national and local governments. In Ireland there are no legally defined noise limits, but the Environmental Protection Agency Act of 1992 defines the powers of local authorities and the EPA to require measures to be taken to prevent or limit noise. In addition it makes provision for the setting of noise level limits where this is considered appropriate, although no limits have been defined at present.

A useful guideline referring specifically to power lines is the New York Public Service Commission (NYPSC) following a public enquiry in 1978. This specified a L_{50} rain level limit of 52dB(A) at the edge of a right of way. The L_{50} is somewhat similar to the L_{Aeq} in that the L50 is the noise level exceeded for 50% of the time, whereas the LAeq is the equivalent continuous sound pressure level of the overall noise fluctuations.

This L_{50} noise level was based on a maximum permitted noise level of 35dB(A). This was in the bedroom of a house at the edge of a right of way. It was assumed that the noise attenuation of a partly closed window was 17dB(A). This is approximately equivalent to the night time limit of L_{Aeq} of 45 dB set by the Environmental Protection Agency for industrial noise. As can be seen from Figure 1 the predicted corona noise for the overhead lines are considerably below the L_{50} rain limit defined by the NYPSC.

An examination of the background noise measurements and the predicted corona noise indicate that noise complaints are unlikely. At 50m from the line the L_{50} fair weather predicted corona noise is zero. For L_{50} rain the predicted noise level from the line is 10.5 dB(A). At no time will the corona noise generated by the line exceed the ambient background noise.

Although providing a general guide for "acceptable" levels of transmission line audible noise, the experience just noted cannot be universally applied to all situations.

Other important factors will vary from one location to another. For example, the frequency of occurrence of wet weather, the normal levels of ambient noise and the number and location of people living in the vicinity all play a role in determining noise impact. So too do the time of day that the noise occurs, how often it occurs and how long it lasts.

Another limited approach to noise evaluation is to compare typical transmission line audible noise levels with typical levels of commonly encountered sounds, as is shown in Figure 2, taken from the NRA Guidelines. However, such comparisons must be undertaken cautiously. Corona noise is different from most commonly encountered noise in that it contains a relatively greater proportion of energy at the higher audio frequencies.

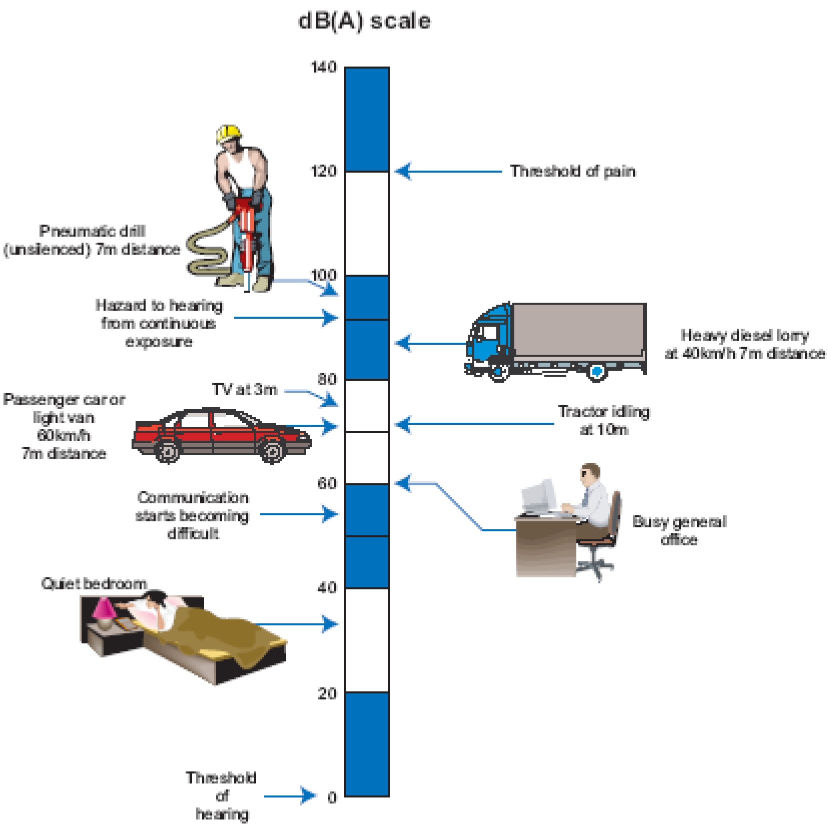

Figure 1: The Level of Typical Common Sounds on the dB(A) Scale
(Based on guidance taken from: *Design Manual for Roads and Bridges, Volume 11 Consolidated Edition 1993*)

Common Noise Levels

Studies show that this difference makes corona noise somewhat more annoying than these other noises at equal dB(A) levels. Corona noise is also highly variable with weather and there is no well accepted method for rating such variable noises. Furthermore, the highest levels of corona noise occur during rain and are thus often masked by the sound of the rain itself falling on trees, roofs, etc. The rain also discourages open windows and outdoor activities.

6 TRAFFIC NOISE & CUMULATIVE IMPACT

The proposed development is located in a relatively remote area accessed by local roads. The NRA have adopted a design criteria for new roads at a day-evening-night 60dB Lden (free field residential façade criterion). From the noise measurements taken at the three locations N1, N2 and N3 during the background noise survey it is clear that the existing noise levels are below this threshold.

Traffic Volume Increase

The proposed development will have most impact during the construction phase when materials are being delivered and the sub-station is being constructed. Traffic volumes will however be a fraction of the existing traffic level on the R313. An increase of 100% in traffic levels equates to a noise level increase of 3 dB (line source). This temporary increase would be confined to the construction phase only. Traffic levels during the operation of the substation will be equivalent to the occasional visit by either a car or van, i.e. no significant increase.

Cumulative Impacts with Other Developments

The proposed sub-station is located south-west of Belmullet. Noise from the construction and operation of the sub-station are highly localised. Traffic to and from the proposed sub-station will not be combined with other developments such as the Corrib Gas Field Development or the proposed upgrading of Frenchport pier except close to Belmullet and on the R313 east of Belmullet. Thaffic volumes on those sections of road are such that the impact of the proposed development on road traffic noise levels will be minimal.

The impact of traffic noise associated with this development is therefore considered to be neutral, i.e. no impact. There will be no change in this position in the future.

7 MITIGATION MEASURES

Construction Stage

Noise during the construction stage will be limited by the scale of the project. The noise prediction model indicates that noise levels will be maintained within the limits set in National Roads Authority Guidelines (the only 'official' construction noise guidelines in Ireland).

The construction stage contract will include provision for independent noise monitoring to ensure that noise limits are being adhered to.

Substation Operation

It is not expected that audible noise generated from within the Substation will cause annoyance as outlined previously. The landscaping and screening around the substation site will help to reduce the noise level further.

Following commissioning of the sub-station a noise assessment will be carried out to ensure that noise levels emanating from the substation do not exceed 45 dBA $L_{Aeq(15\ minutes)}$ at night and 55 dBA $L_{Aeq\ (1\ hour)}$ during the daytime at any noise sensitive location. In the event that there is a significant tonal content in the noise, the levels will be reduced by 5 dBA.

Overhead Power-line Noise

As outlined in the previous sections it is not expected that noise arising from corona will give rise to complaints. Corona noise will only be audible under certain weather conditions and in close proximity to the line.

Aeolian noise very rarely occurs on overhead lines and is not expected to arise on the proposed Line. As outlined earlier mitigation measures for aeolian noise include the fitting of air flow spoilers on conductors and the replacement of disc insulators.

Any noise complaints will be investigated and mitigation measures implemented if necessary.

8 CONCLUSIONS

Noise from within the Substation due to switch gear and alarms are not foreseen to be a problem as this would be infrequent and of short duration. It is expected that noise generated by the transformer will be sufficiently attenuated outside the substation so as not to cause annoyance at neighbouring properties. In addition, the noise level should be further reduced by landscaping and the planting of trees and shrubs around the substation perimeter.

Corona can arise at conductors and other items of overhead line hardware. Noise levels arising from power line corona under worst case weather conditions generally do not exceed background noise levels and are well within internationally recognised limits, they are not expected to give rise to complaints from local residents.

Audible aeolian noise, though hard to predict, rarely occurs on overhead lines. In the unlikely event of it occurring on the proposed line, the developer will carry out the appropriate mitigation measures, which could include the fitting of air-flow spoilers and the replacement of insulators.

DEFINITIONS

A-weighted sound pressure, in Pascals: The root mean square sound pressure determined by use of frequency network "A" (see IEC Publication 651).

Sound pressure level in decibels: The sound pressure level is given by the formula

$L_p = 10 \text{ Log } (p/p_o)^2$ where, P is the root mean square sound pressure in Pascals

p_o is the reference sound pressure (20 uPa)

Percentile level: The A-weighted sound pressure level obtained by using time-weighting "F" (see IEC Publication 651) that is exceeded for N% of the time interval considered. e.g. $L_{A90,1 \text{ hour}}$ is the A-weighted level exceeded for 90% of 1 hour.

Equivalent continuous A-weighted sound pressure level in decibels: Value of the A-weighted sound pressure level of a continuous, steady sound that, within a specified time interval T, has the same mean square sound pressure as a sound under consideration whose level varies with time.

Rating level: The equivalent continuous A-weighted sound pressure level during a specified time interval, plus specified adjustments for tonal character and impulsiveness of the sound.

Symbols for sound levels:

Quantity	***Symbol***	***Unit***
Sound Pressure Level	L_p	dB
A-weighted sound pressure level	L_{pA}	dB
Percentile level, level exceeded for N% of the time	$L_{AN,T}$	dB
Equivalent continuous A-weighted		
Sound pressure level	$L_{Aeq,T}$	dB
Rating level	$L_{Ar,T}$	dB

Approximate sound pressure levels in dB

Location	*Level (dB)*	*Comment*
	140	Threshold of pain
Airport	125	Jet take-off
	120	Uncomfortably loud
Construction site	115	Pneumatic drill
Disco or Rock concert	110	
Motorway	90	Heavy truck passing
Very busy pub	85	Voice has to be raised to be heard
		Conversation difficult
Busy restaurant	70	
Business office	65	Normal conversation possible
0.5 km from busy roadway	55	Daytime
Library	35	Whispering
	35	Quiet countryside
	20	Very Quiet area
	0	Threshold of hearing