Appendix 10.1 Biospheric Engineering Ltd.: Noise Report

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Report on Noise Levels
Proposed Laois – Kilkenny Reinforcement Project

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Noise Report

Noise Levels
Proposed Laois – Kilkenny Reinforcement Project

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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 400/110kV substation in the townland of Coolnabacky near Timahoe, County Laois, a new 110kV/38kV substation at Ballyragget, Co. Kilkenny with associated overhead power lines and modifications to the existing Kilkenny 110 kV substation. The project will include 1.2 km of new 400kV overhead line to feed the Coolnabacky 400/110 kV substation, 26 km of new overhead 110kV line between Coolnabacky and Ballyragget substation, modification of approximately 3.6 km of the existing 110kV Athy-Portlaoise overhead line and uprate of approximately 22 km of the 110 kV overhead line from Ballyragget to Kilkenny.

The new 400 kV/110kV substation at Coolnabacky is to be constructed using new Gas Insulated Switchgear (GIS) and the Ballyragget substation will also use this technology. The new 400kV and 110kV power lines are to be constructed along a route as outlined on the enclosed drawing. The route is for the greater part through rural areas with dispersed housing on large sites and no large concentration of residences located in close proximity to the line. The middle section of the route (near Ballinakill) is however closer to greater concentrations of housing. The construction of the line is a relatively low intensity project, with concentrations of activity in particular sections of the route for a number of weeks. The noise emissions during construction will be a short term impact and the only significant impact during the operational phase will be due to malfunction on the line.

Background noise measurements were taken at the proposed Coolnabacky 400-110kV sub-station location, and at 21 locations on public roads along the route including the Ballyragget and Kilkenny 110kV sub-stations. Measurement locations were chosen to be representative of the proximate section of line to the monitoring location. Minor route changes may be required due to local conditions. Due to the nature of the terrain, some monitoring locations are located a short distance from the line route. This is necessitated by the requirement to take measurements from publicly available locations and to avoid creating traffic hazards on narrow country roads. The measurement locations are representative of the environment at the nearest residences.

An assessment of the potential impact of construction and operation noise are included in this assessment.

The noise monitoring was carried out in good weather conditions over the period 27th and 28th June 2012.

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 5th August 2010. 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 weatherproof enclosures 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 wind speeds 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 wind speeds 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 wind speed in which measurements are taken, it requires the reporting of the wind speed 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_{50} noise level (that noise level which is exceeded 50% of the time). Also used are the L_{10} and L_{90} noise levels.

Short-term environmental noise monitoring was undertaken at 21 locations along the proposed line route and in the vicinity of proposed substation sites. Three sets of measurements were taken along the route as follows:

- A series of 20 minute measurements at locations along the route during the day on 27th and 28th June 2012.
- 24 hour continuous measurement at the proposed Coolnabackey Sub-Station site on 16th/17th July 2012
- Additional short term monitoring at Ballyragget Sub-Station including night time measurements

The noise monitoring locations were chosen to give a good spread of geographic locations along the route and a good variety of background noise as it occurs along the route. Where the 110kV line is proximate to a national road, measurements were taken, on the road adjacent to the nearest settlement location.

The noise monitoring locations are shown in figure 1.Measurements were taken using Bruel & Kjaer 2260 and 2250 precision sound level meters.

Table 1 Noise measurements at Coolnabackey							
Site	Date	Time	Location	dB(A)			
				L_{10}	L_{50}	L_{90}	L_{Aeq}
1	28 June	23:00	Coolnabackey site night time	35	50	23	45
1	16 July	19:00	Coolnabackey site evening time	39	34	29	37
1	16/17 July	23:00	Coolnabackey site night time	40	32	25	37
1	17 July	07:00	Coolnabackey site day time	48	40	34	46

Table 2 Noise measurements Coolnabackey-Ballyragget							
Site	Date	Time	Location	dB(A)			
				L_{10}	L_{50}	L_{90}	L_{Aeq}
2	27 June	13:59	Roadside R426	61	43	33	62
3	27 June	14:25	Cremorgan	42	33	30	50
4	27 June	14:57	Raheenduff	52	38	33	56
5	27 June	15:30	Clarabaracam	51	40	35	52
6	27 June	16:15	Keelagh	40	36	33	38
7	28 June	18:03	Knockardagur	44	39	34	41
8	28 June	17:41	Boleybawn	47	45	44	46
9	27 June	16:54	Ironsmills	54	41	38	61
10	28 June	16:52	Loughall	58	51	46	54
11	27 June	17:38	Ballyoskill	40	36	34	51
12	28 June	16:11	Tinnaltan	60	54	49	56
13	27 June	18:09	Ballyragget s/stn	54	43	40	59
14	28 June	00:12	Ballyragget s/stn (nightime)	45	40	39	48
15	28 June	09:44	Ballyragget s/stn	59	45	41	58

Table 3 Noise measurements Ballyragget-Kilkenny							
Site	Date	Time	Location	dB(A)			
				L_{10}	L_{50}	L_{90}	L_{Aeq}
16	28 June	15:46	Ballyragget s/stn	55	49	46	58
17	28 June	15:08	Castlecomer road	65	51	46	67
18	28 June	14:30	Connahy	54	48	42	54
19	28 June	13:59	Foulksrath	46	41	37	46
20	28 June	13:29	Inchakill Glebe	40	37	34	55
21	28 June	13:01	Bullock Hill	49	45	41	49
22	28 June	12:28	Radestown	47	40	36	43
23	28 June	11:57	Brownstown	60	42	39	57
24	28 June	11:28	Templemartin	57	46	42	59
25	28 June	11:00	Kilkenny s/stn	79	59	49	73

4 POTENTIAL IMPACT OF PROPOSED DEVELOPMENT

High Voltage Substations

The noise levels at the site of the proposed sub-station at Coolnabacky are relatively low (L_{Aeq} levels measured at 37 dBA at night and 46 dBA during the day). The noise levels at nearby properties will be higher than this due to the relatively remote location of the site and the fact that most residential properties in the area face on the road network.

Construction activity will take place during the day when background noise levels (L_{Aeq}) at the site are at 46 dBA. Noise levels at residences in the area during the day will be in the order of 62 dBA (as measured and reported in Table 2 above) due to proximity of residences to roads and traffic that are closer to the residences than the proposed sub-station site.

The noise level at Ballyragget sub-station were 58 dBA during the day and 48 dBA during the night. Noise levels at night are considerably higher than the substation location at Coolnabacky due to proximity to roads and a large industrial site in the area

Once the substations have been commissioned, noise will continue to be emitted by much of the equipment in the station such as circuit breakers, disconnects, and alarms. Many of the noises associated with this equipment are typically of short duration and individually they would be unlikely to cause annoyance. The proposal for both sub-stations (Coolnabackey and Ballyragget) is to use GIS type switchgear which is considerably quieter in operation than the current equipment at Ballyragget. The existing equipment at Ballyragget is open to the atmosphere and of an older generation of design. Gas Insulated Swichgear (GIS) is fully enclosed and will not increase existing noise emission levels The transformer can be a significant noise source in a transmission station, again newer equipment is not as noisy as previous generations of equipment. Modern transformers are typically 20 dB quieter than equivalent models manufactured in the 1980's and work continues to increase efficiency and reduce noise related losses in transformers.

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 dwellings at all sub-stations will be located considerably further than this from the transformer. Given the distance from the proposed substation to the nearest dwelling significant noise impacts are not likely to occur.

A noise prediction model for transformer/sub-station noise is included in the next section.

Construction Noise

At the construction stage of the transmission lines or while work at the sub-stations is on-going, noise levels may be higher. But since such activity is usually confined to daylight hours and is for short durations, these temporary increases in noise levels are generally acceptable.

Typical construction activities will comprise, site clearance and foundations, concrete pouring, building construction, site perimeter security fence etc. Specialist construction techniques will comprise the bringing onto site some heavy equipment and the erection of specialist electrical equipment such as pylons, switchgear etc. which will require the use of large cranes.

Table 4 below indicates the source noise level and typical numbers of equipment on site during sub-station construction. The actual noise levels will depend on equipment duty cycles and site activity at any stage during construction.

Description	Purpose	Notes	L_w (dB)	Approx No
Earth moving Dozer	Site clearance	Diesel Engine Powered	108	1
Tracked Excavator	Site works	Diesel Engine Powered	105	2-3
Pile driver	Foundations	Diesel Engine Powered	115	1
Rock-breaker	Break up top layers and fractured rock	Diesel Engine Powered	115	1
Crawler Crane	Lifting plant, materials and equipment into position. Two may be required for some heavy plant	Heavy Plant. Tracked. Diesel engine powered	105	1-2
Dumper Truck	Transport of material on site	Typically wheeled (6 wheel drive) Diesel engine powered.	117	1-2
Concrete Truck	Mixing, transport of concrete to site and placement.	Diesel engine powered	109	2-3
Compressors & pumps	General construction purposes,	Mobile, diesel engine powered	95	2

		enclosed and silenced		
Generator	Provide electricity in for equipment, hand tools and site lighting during construction.	Diesel engine powered enclosed and silenced	97	1
Concrete mixer	Mixing of concrete on site	Diesel engine powered	105	1-2
Trucks, vans, 4x4 vehicles	Transport of materials & personnel	Generally diesel powered	101	3-10
Hand tools	Cutting, fixing, welding and general construction	Generally 110V powered by Generator	102	4

Table 4 L_{wA} = sound power of plant items

Heavy construction equipment includes the following machinery: bulldozers, backhoe loading shovels, dumper trucks, rock breakers, telehandlers, concrete delivery trucks and vans and trucks of varying sizes. The latter stages will require the use of hand-tools such as angle-grinders, drills and other cutting tools.

Costruction equipment on110kV overhead line construction will comprise:

- 4x4 vehicle
- Wheeled dumper or Track dumper (6 to 8 tons)
- 360° tracked excavator (13 ton normally, 22 ton for rock breaker)
- Transit van
- Chains and other small tools
- Road material delivered by supplier to closest convenient point (38 ton gross)
- Crew size: 3 workers

This level of equipment and activity is similar to a road repair crew or a construction crew on say an agricultural building. The activity is spread out along the length of the 110kV line and the impact on any location is limited to a few weeks duration.

Limited sections of the 110kV line will be constructed underground using either directional drilling equipment or forming trenches. Construction equipment will include the use of heavy construction equipment such as directional drills, backhoe loading shovels, dumper trucks, rock breakers, telehandlers, concrete delivery trucks and vans and trucks of varying sizes. During construction, diesel generators are also likely to be used on-site

The use of heavy equipment during construction, such as outlined above will generate significant localised noise impacts. The noise impacts will vary considerably depending on the type and level of activity on site at any one time. The most appropriate means of mitigating such impacts is by means of limiting the total noise level permitted at any point during the construction phase.

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

Table 5: NRA Construction Noise Guideline limits (Table 1)

110kV Line Operational 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, misfabrication, 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 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 noise is generally associated with very high voltage overhead lines, i.e. 400 kV and above. It is extremely rare on 110 kV lines, to the extent that it is usually measured under laboratory conditions rather than the external environment.

Corona discharge causes noise over a wide range of frequencies which sometimes can be audible. The noise level is a function of line voltage and rarely occurs on lines under 500kV. Conductor noise levels decrease as a function of lateral distance from the centre of the line. Generally noise level values at fifty metres from the line are less than ambient background noise level at the locations where measurements were taken it is not expected to give rise to complaints.

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 50m 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.

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. Such noise is likely to emanate from the isolators, particularly the older glass type units which are prone to the build-up of material resulting in a breakdown in insulation value.

Aeolian Noise

In addition to corona noise, which is of electrical origin, high voltage 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 10 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.

Construction Noise

At the construction stage of the transmission lines similar to when work on the substation is being carried out, noise levels may be higher. However, since such activities are confined to daylight hours and are for a short duration and in compliance with the NRA Guidelines, these temporary increases in noise levels are generally acceptable.

Modern 110kV Line Design

Short-term ambient noise measurements were taken along the route during June 2012. Well maintained modern overhead lines using ceramic insulators as are proposed for this project do not emit noise at any level likely to give rise to any significant environmental noise impact.

5 NOISE PREDICTION MODEL

The noise prediction model chosen was constructed using Bruel & Kjaer "Predictor" Package. The Predictor software package is a comprehensive acoustic modelling system and is widely used to predict noise impacts.

The program calculates the received noise level from specified sources, propagated via intermediate obstacles and media, based on national and international standards. Consequences of noise reduction measures can be rapidly assessed and it is possible to compare calculated, measured and permitted values.

Model data is held in a database of the Predictor model. The types of items in a model include ground contours, sound sources, objects and sound receivers. Each item has positional information, including its location, dimensions on the ground and height. The base area is superimposed upon a 2-D topographical map, the background which is used to align each item in the model relative to an actual survey of the area under study. Using the height detail from the model specifics a 3-D terrain model is created.

Models can be prepared for different times of day and calculated to predict the sound pressure levels at the receiver points. The calculation for the model is done with a specific calculation method, in this case ISO 9613.1/2 (Acoustics – Attenuation of sound during propagation outdoors).

The terrain in the baseline noise model is based on mapping provided from ESB International.

Noise Model Calculation Standards

The ISO calculation method is implemented in Predictor as separate source related modules. The primary noise source in the substation will be transformer noise. Noise from switchgear will be minimal as the equipment is Gas Insulated and located inside the sub-station building. External line breakers are only operated occasionally and are not inherently noisy in operation. The ISO 9613-1/2 industry calculation methodology has been adopted for this prediction. This is an appropriate methodology and is widely used for industrial noise calculations internationally.

The following standards are used in the ISO industry calculation method:

ISO 9613-1 Acoustics – Attenuation of sound during propagation outdoors. Part 1: Calculation of the absorption of sound by the atmosphere;

ISO 9613-2 Acoustics – Attenuation of sound during propagation outdoors. Part 2: General method of calculation.

The Sound Power Levels of the sources used to create the model are derived from data provided by ESB International and measurements taken by Biospheric Engineering Ltd. at various sub-stations. The model is based on 2 transformers at the sub-station. The sound power levels used to model the transformers were as follows:

Frequency Hz	31	63	125	250	500	1k	2k	4k	8k	Total
LwA dB	36	60	90	83	86	70	59	56	53	92

The noise model is reproduced below and can be interpreted as follows:

In the event that planning approval is granted planning permission noise limits are likely to be based on the Environmental Protection Agency recommendations for noise limits from Industrial activities, i.e. 45 dBA at night and 55 dBA during the day with a penalty for tonal noise. As the transformer noise arises on a 24/7 basis and is tonal in nature, the critical limit is the night time level of 45 dBA with an appropriate penalty for tonality.

The contours on the map indicate the predicted noise levels emanating from the sub-station. The green (outer) line indicates the predicted 23 dBA contour. At this point and inside the line, the predicted transformer noise is equal to the background (L90) noise level recorded on the site at night. The yellow contour represents the predicted 29 dBA contour corresponding to the evening time background noise level. The orange contour indicates the predicted 34 dBA contour which is the corresponding measured day time noise level. The red contour in the centre represent the 45 dBA contour line which is the area within which the predicted noise level exceeds the EPA noise limit recommendation.

Operational Noise Model

As can be seen from the noise prediction map above the worst case operating noise prediction will result in noise levels above 45 dBA confined to an area in the immediate vicinity of the proposed sub-station. Due to the low background noise levels in the immediate area of the sub-station, the transformers will be audible outside the sub-station boundary area under certain weather conditions only (indicated by the outer green line in the figure above . Weather conditions which would increase audibility are calm still conditions or with a very light breeze blowing in the direction of the receiver such as on a frosty night. The area in which the transformers are likely to be audible does not include any residences. Residences in the area are generally located along the road network and background noise measurements at these locations are considerably higher than at the sub-station site, providing sufficient masking for any noise emanating from the sub-station.

6 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.

In Ireland there are no legally defined noise limits, but the Environmental Protection Agency Act of 1992 makes provision for the setting of noise level limits where this is considered appropriate, although no statutory limits have been defined at present, the Environmental Protection Agency have set guidelines for industrial activities which they licence.

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 L_{Aeq} is the equivalent continuous sound pressure level of the overall noise fluctuations. L_{Aeq} as an energy based measurement parameter tends to be higher than the L_{A50} value for the same noise event.

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. At 50m from the 110kV line the L_{50} fair weather predicted corona noise is not audible. For L_{50} rain the predicted noise level from the line is higher but at no time will the corona noise generated by the 110kV 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.

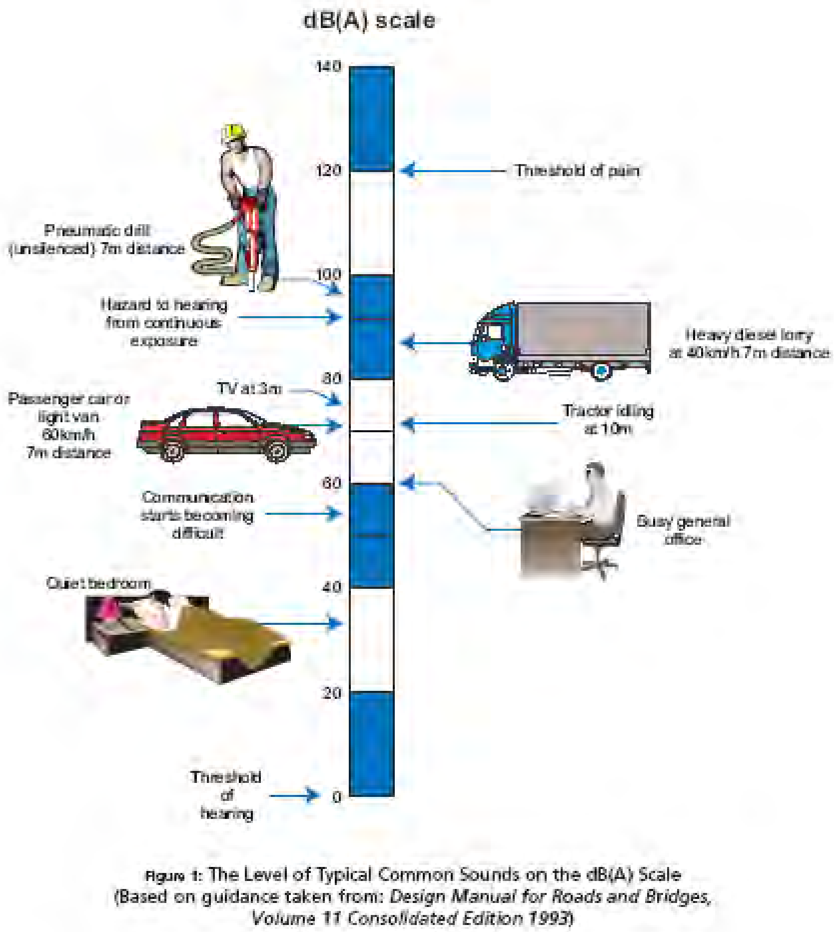

Figure 2 – Common Noise Levels

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.

7 MITIGATION MEASURES

110kV Substation construction

It is not expected that audible noise generated from the sub-station construction will cause annoyance as outlined previously. The landscaping around the sub-station sites will help to reduce the noise level further.

110kV Line

As outlined in the previous sections it is not expected that noise arising from corona will give rise to complaints. Corona noise, if present, will only be audible under certain weather conditions and in close proximity to the line. Any complaints will be investigated and mitigation measures implemented if necessary. Corona noise is caused predominantly by items of transmission line hardware, other than conductors, e.g. clamps, and can be mitigated by replacement of individual items of hardware.

Aeolian noise very rarely occurs on 110kV 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.

Radio and television interference arising from gap sparking occurs infrequently on 110kV lines. When it does arise, it is easily identifiable and can be solved by replacement of hardware. The developer is committed to a policy of rigorous investigation and resolution of such problems if they do occur. Broad utility experience suggests that less than half of the radio and television interference complaints received are attributable to power lines and only a few per cent of those specifically involve high voltage transmission lines. Gap sparking is responsible for most of the power line interference complaints.

Interference arising from corona cannot be dealt with in the same way. Experience to date indicates that corona from the proposed 110kV line will not give rise to problems with reception of radio and television signals. Mitigation measures would comprise the upgrading or re-orientation of signal receivers.

8 CONCLUSIONS

Construction noise will arise, but will be limited in intensity and duration by the nature of the construction activity. The NRA Guidelines for construction noise will not be exceeded at any stage during the construction process.

Operational noise from within the sub-stations 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 sub-stations so as not to cause annoyance. In addition, the noise level should be further reduced by the planting of trees and shrubs around the substation perimeter.

Noise from power lines, at both audible frequencies and at radio and television frequencies can be caused by a number of mechanisms, namely gap sparking, corona and Aeolian noise.

Gap sparking, which can cause radio and television interference, occurs infrequently on high voltage lines. Although it is not possible to predict the occurrences of gap sparking, it is easily identified when it does arise and is readily solved.

Corona can arise at conductors and other items of overhead line hardware. On 110kV lines corona noise rarely results in complaints of interference to radio and television signals. 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. Current design indications are that no air-flow spoilers will be required on the proposed line.

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. $L_{A90,1\ hour}$ 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	Lp	dB
A-weighted sound pressure level	LpA	dB
Percentile level, level exceeded for N% of the time	LAN,T	dB
Equivalent continuous A-weighted		
Sound pressure level	LAeq,T	dB
Rating level	$L_{Ar,T}$	dB

Approximate sound pressure levels in dB

Location	Level (dB)	Comment
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
Quiet countryside		
	20	Very Quiet area
	0	Threshold of hearing