

A Study of the Airborne Noise aspects of the  
Proposed Dart Underground Railway  
Development

REPORT  
for  
An Bord Pleanála  
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## Executive Summary

- A. The EIS, Airborne Noise component, on the proposed Dart Underground, is quite comprehensive in coverage. However, some omissions are noted and some suggestions are made.
- B. The Dart Underground project can be built, and can be operated with all due regard to the necessary airborne noise limits required.
- C. Some recent research into the effects of noise-induced sleep disturbance, and the consequent effects of sleep deprivation indicates the very serious nature of sleep deprivation and the risks and dangers attendant on it.
- D. The two-phase nature of noise impact is noted, namely the DAMAGE phase, and the RECOVERY phase. The importance of allowing the recovery phase to take place is obvious, in order to avoid non-stop unimpeded action of the damage phase. A graphical scientific example of this process is referenced, in relation to the action of noise on the human hearing mechanism.
- E. As a result it is essential to recommend, in line with the EPA (Environmental Protection Agency) Guidelines on noise, the complete absence of Tonal noise and Impulsive noise at night (between 2200 and 0700 hours) at every noise-sensitive receptor, at every worksite, due to the construction phase of Dart Underground.

**NOTE 1** – Tonal noise contains characteristics which make the noise more intrusive, for example a hum, rumbling, buzz, or whine, hissing or brake squeal or wheel squeal. Impulsive noise could be described as clattering, battering, hammering, and other characteristics of ‘suddenness’, that is rapid signal ‘rise-time’ e.g. gunfire.

- F. We also recommend that the average night construction noise level, LAeq, be restricted to 40 LAeq<sub>5mins</sub>, in line with the British Standard BS4142, which uses 5 minute averaging periods at night. One could go further and recommend 1-minute averaging periods, as in the UK Night Noise Act 1996, but it is considered that the 5-minute period should be adequate, in conjunction with point E above.
- G. At night we recommend that construction noise alone should have a specific limit, that is, it is not to be included with the ambient noise level, which can vary by 10 dBA or more at night due to weather variations (likewise in daytime).

**NOTE 2** – A small number of exceptions to the proposed night limits are recommended. See Recommendation 29(E).

- H. Similar recommendations, for the Dart Underground construction phase, as at night time, are made with respect to Sundays and Bank Holidays.
- I. As some night time, and evening, EIS quoted noise levels, both baseline & criteria, are considered high, it is recommended that (i) all night time values of LA90<sub>5mins</sub> be checked and confirmed with Dublin City Council, and (ii) that evening-time (1900-2200) noise ‘criteria’ LAeq<sub>1hour</sub> be confirmed also, at noise-sensitive locations, the night time baseline levels to be checked and confirmed, as per Note 6; with special attention to all locations likely to be impacted by fixed permanent plant noise.

- J. Some other recommendations are also made, in respect of (i) the construction phase, and (ii) the operational phase, of the proposed Dart Underground.
- K. One of the more important recommendations made here is that, due to the fact that for some people along the proposed alignment, the evening noise levels to be expected are likely to constitute a significant noise load or burden, the proposed evening period be shortened to 3 hours (1900-2200 hours), and that the proposed Night period be from 2200 to 0700 hours, Monday to Friday.

This is in line with (a) An Bord Pleanála's decision on the Metro North Project (Ref. 22) and (b) Belfast City Council recommendations on construction noise control (Ref.24).

- L. Another significant recommendation is that the PPPCo contractor will do the required ambient noise surveys promised, by the Applicant, in the Oral Hearing, taking note of (I) above.
- M. It is further recommended that any rounding of measurement results be done to the nearest decibel (dB) and not the nearest 5 dB as in the EIS.
- N. The importance of good low-frequency (pitch) performance by site boundary hoarding for noise attenuation is stressed. Table 1 does not show any performance values for the low frequency bands centred on 16 or 31.5 or 63 Hz third-Octave bands which span the frequency range c.14 to c.71 Hertz (Hz). This is because of the difficulty of making reliable and repeatable readings at these low frequencies. However, there are very substantial amounts of such low-frequency noise in some of the noises to be reduced – for example freight train noise. Therefore it is indeed advisable to protect people from this noise as far as is reasonable.

The lowest note on a standard piano keyboard (A) has a frequency centred on a nominal 25 Hz. This means that the longest and heaviest string on a piano vibrates 25 times per second when struck by the key hammer. To attenuate such low-frequency noise requires the best available material – the sound reduction performance of which should at least be estimated.

(O) The best available noise attenuation is advised, particularly for those houses where the proposed project would cause construction noise on two or more sides of the building, as is proposed at a number of houses, in Inchicore. It is also advised where the proposed works come very close to even one side of a house or houses, as at proposed Pearse Station and at Blythe Avenue in East Wall.

## **Section 2. The Proposed Project**

The Proposed Project is an Underground Heavy Railway system running essentially East-West across Dublin city, and which will connect the existing and proposed transport infrastructure at major transport hubs, thus connecting virtually most of the major city areas in a way that facilitates travel from anywhere in Dublin City to anywhere else, either in the city or throughout the country. The proposal is to expand and connect both intercity and commuter rail services. The project is described in the Dart Underground Environmental Impact Statement (EIS) Volumes 1 to 4.

It is a major study of a considerable number of route and layout options leading to a detailed design for a very major piece of transport infrastructure.

Not all possible details have been specified, though, leaving those in which the Appointed Contractor (PPPCo) must have an input, to that contractor.

**Section 3. Summary- Environmental Impact Statement (EIS) (Airborne Noise Component)**

The Environmental Impact Statement (EIS) (Airborne Noise Component), is quite comprehensive in its coverage of airborne noise impacts. Proposed mitigation measures are substantial also. However some of the communities likely to be impacted by noise of construction particularly, are still concerned at the possibility of unacceptable noise impacts.

Some of the communities likely to be impacted by operational noise from the project also expressed concern at the possibility of unacceptable noise when in operation.

Bearing in mind that people's response to noise from a project is determined by a complex of factors, including (a) previous history of noise impacts, and (b) their attitude to the developer, which includes fears of incomplete noise mitigation and consequent damage to their health and wellbeing, especially with the long duration of the proposed works, it is recommended that the applicant's proposed Mitigation Measures and proposed comprehensive Management control and supervision of the DART Underground Project be applied with strict adherence to the EIS proposals thereon, and the Recommended Conditions in this report.

It is borne in mind that the EIS is but the first step in what is called a 'dynamic process' known as EIA (Environmental Impact Assessment). This is the dynamic process, whereby an EIS is tested and modified, and indeed improved, by the process of analysis and criticism inherent in the questions and comments of observers and the assessment process of An Bord Pleanala.

The approach taken by the Applicant, in the EIS on this Project, is to limit the effects of construction, and operation, by specifying limiting values on those quantities, such as noise, which can impact on people. This is in preference to specifying precise work methods and exact models of construction plant.

Some useful Tables in the EIS section on Airborne noise are as follows: (all are in EIS Vol.2, Book 2).

Table 8.5 'Construction Noise Significance Criteria from BS5228'

Table 8.11 'Summary of Construction Phases and Main Plant Items'

Table 8.19 'Allowable Noise Levels from Fixed Plant Items during Operation'

Table 8.20 'Envisaged Screening Heights around Construction Compounds'

Table 8.21 'Predicted Construction Noise Levels at Construction Sites with Proposed Mitigation in Place' (Results Summary)

Because of the options on construction methods and the need to leave some operational flexibility to the Appointed Contractor it is not practicable to specify every plant item, and every process, with total precision. Thus the actual sound power levels of the actual individual plant items to be used, may be slightly lower or higher than those used in the EIS calculations of the noise levels predicted. The important factor is that the overall noise levels are limited, while leaving the contractor free to choose between different machines and processes, along with the specific mitigation measures chosen, in order to achieve the desired end result.

The EIS and the data gleaned during the Oral Hearing process combine to show that it is indeed possible to construct the proposed Dart Underground project with control of the noise levels from the construction plant, when the range of potential noise reduction options is borne in mind. This conclusion is contingent on some stringent conditions, particularly on night time noise emissions.

There are, however, some locations, where some houses are so close to the proposed construction sites, it may not be possible to achieve the noise limits recommended, by construction site mitigation measures alone, in which case it may be necessary to consider supplementary, or alternative, measures to avoid undue impact on the affected residents.

A possibility for such locations is an agreement with residents on some offsetting measure. Possible options may include (a) temporary relocation of residents until the noise levels are again within limit (b) upgrading of the sound insulation values of the houses (doors, windows and roof/attic spaces), or (c) other offsetting measures e.g. possible purchase of some houses. Noise levels in the range of 75 to 80+ LAeq may occur, for significant periods of time in some locations, and we cannot recommend noise levels over 70 LAeq<sub>1hr</sub>, without appropriate safeguards for affected residents.

In those locations where initial demolition works are needed prior to construction or excavation works the same level of careful assessment and implementation of remedial measures, on each construction site, as is planned for the major works, is essential in the early stages of work.

Before the initial demolition work is even started, it should be possible for the designated site boundary hoarding/ noise barrier to be erected at every demolition site. See the Dart Underground EIS, Volume 3, Book 4, Figures as follows for demolition site locations : Area 101 - Figure 20.220 V3; Area 102 - Figure 20.221 V3; Area 103 - Figure 20.222 V3; Area 104 – Figure 20.223 V3; Area 105 - Figure 20.224 V3; Area 106 - Figure 20.225; Heuston Station - Figure 20.226 V3 and Figure 20.227 V3.

All the proposed work locations in this project will need alert and ongoing attention to noise control, because of the dynamic nature of construction work, and the fact that there are numerous houses which are close, or very close, to the proposed works. There are also a number of locations where rooms and residents are located at 2<sup>nd</sup> or 3<sup>rd</sup> or 4<sup>th</sup> or 5<sup>th</sup> or 6<sup>th</sup> floor level, and where there will be clear line of sight to the proposed works. Some hotels are examples of this situation. Likewise the apartments overlooking Sheriff St. Upper, and other apartment blocks along the alignment. These receptors will need extra care for protection from the likely construction noise, particularly in the evening, night, and early morning times.

#### **Section 4. Data Deficits**

One area of information deficit is that noise baseline data which is not presented in the EIS, for some locations of proposed substantial construction work. Some examples of this noted are : St. Patrick's Terrace, Inchicore; Mayor St., Docklands, and Crosbie's Yard Apartments. However, it can be argued in defence, for some of these locations, that other monitoring locations in the area would be representative of these locations also.

Also, no assessment of the predicted noise levels is seen for three locations, namely the Maintenance Facility operations, Sarsfield Road works, and Crosbie's Yard apartments, this latter in relation to proposed West Road Works, and other possible works. The above deficits were not noticed until after the Oral Hearing had finished. One must state, however, that the additional information on the proposal, supplied by the applicant in response to questions put to them was usually very prompt, informative and helpful.

In Vol.2, Book 2, Section 8.7.3.1 in 'Cumulative Residual Impact of DART Underground Activities' is stated 'During the operational phase, the main sources of airborne noise will be from above ground rail and fixed items of plant. These sources will occur together only in the vicinity of CIE Railway works and at West Road adjacent to the OCC building and traction station. The range of noise limits set for the fixed items of plant is such that it will be imperceptible and will in turn be of neutral impact.'

However, there is no mention of the loading and unloading activities at the proposed Maintenance Facility. This is the one substantial and significant omission found in the whole EIS section on Airborne noise. The potential for night time operational working at this location has substantial significance for many local residents – substantial potential for noise-induced disturbance of sleep.

Along much of the alignment, the ambient noise levels, at night, are sufficiently low that it is possible, for the most part, to sleep well at night. But, in contrast, there are other areas, where night time sleep has often been disturbed by noisy activities of an industrial nature.

**NOTE 3 :** There are locations where, due to changes in road traffic pattern, the ambient noise level is likely to change. Sandwith St. (for Pearse Station) is one such location. It will be desirable to distinguish between the current ambient noise levels there, and the new ambient noise scenario, in that location while the road is closed.. Where road changes essential to progressing the construction, are put in place thus causing a change in the traffic pattern, for example the volume or speed, there will be a consequent change in the road traffic noise level. This situation will need alert, ongoing monitoring. The proposed Sandwith St. road closure and traffic diversion may change traffic noise levels in other nearby streets also.

In any event, since the daily ambient noise level may change, it will be important at some sites, to have ongoing spot checks on the non-construction ambient noise level, as well as the overall level defined by BS 5228:2009.

**NOTE 4 :** Some brief exceptions to the night noise scenario are likely when some large machines or material components are being delivered on a site or being taken off it. We have the assurance of the Applicant that such night time events will be rare at any given site. We have the further assurance that for any such pre-planned events the local residents will be informed in advance. Furthermore, we understand that such events will only take place with the knowledge and written approval of Dublin City Council. See Recommendation 29(E).

**NOTE 5 :** Both (a) Unattended long term noise monitoring, and (b) Attended noise monitoring for short time periods (up to 15 minutes or longer), will occur, with the latter being used to confirm the readings obtained for either ambient or construction noise, in conjunction with the long term monitors.

Attended monitoring will be required at many locations where unattended monitoring is not required. Such locations include receptors near the compounds for Stop sites, near the proposed West Road Bridge and Sarsfield Road Bridge works, near the ongoing work sites for cut & cover operations, for construction and for track-laying.

This monitoring must be done, of course, when the works are happening, whether day or evening. We stress, however, that there should be an absolute minimum number of nights impacted by any night-time airborne construction noise, which might cause sleep disturbance at any residence.

Attended noise monitoring will also be needed for the operational scheme in its initial stages and for fixed plant and equipment commissioning at each location where such plant is located.

Since the proposed development is to be financed by a Public Private Partnership (PPP) it is understood that the applicant must consider that the contractor to be appointed may prefer some methods of construction, over other alternatives, and cannot be 100% prescriptive of the methodology to be used during the course of the project. However we accept that the CIE/Iarnrod Eireann and the Contractor, through the use of the technical expertise on hand, and the auditing and controls proposed, will meet and mitigate any noise excess to the satisfactory compliance with the noise limits required.

We also expect that no phase of the works will be initiated without having on hand, and on-site, the types and amount of portable noise mitigation materials, barriers, enclosures and devices which are likely to be needed on that site. In this latter statement we include those locations where noise emission will occur only over a few nights, as for example delivery of any large machines or materials which may otherwise require severe traffic restrictions.

Comment – The emphasis – at night - should be mainly on the pre-existing ambient levels outside people’s bedrooms. Internal noise ambient levels, at night, in many houses, both rural and suburban, around Dublin are of the order of 18 – 25 LA90, and even in daytime are not much higher. External levels of 32-35 LA90 are commonplace, in calm weather. Since the proposed fixed plant will operate for many years to come, it is very important that the noise due to that plant does not cause undue discomfort or any significant sleep disturbance. It is clear that due cognisance is to be taken, of the existing ambient noise levels and that the increase in this is to be minimised. Our recommendation is that a maximum increase of 3 dBA, on the lowest recurring LA90<sub>5mins</sub>, should be the objective.

The Applicant’s proposals for fixed plant – and night time – noise levels, are based on the correct approach. HOWEVER, we recommend that additional monitoring be done to confirm the actual noise levels LA90<sub>5mins</sub>, from 2200 to 00700 hours, at all noise-sensitive [locations, before works begin. See NOTE 6 and Recommendation 30(D).

Since the passby times of normally running trains, e.g. DARTs, is of the order of 15 – 30 seconds, depending on the speed and train length,, it is considered that, at night time, using a 1 hour period to average such noise events is not appropriate. This is because 15-30 seconds is more than sufficient time in which to disturb a person’s sleep, including their awakening.

In Figure 3.17 in reference 2 it is seen that noise stimuli with a duration as short as 0.3 seconds can significantly disturb sleep. Thus a 1-hour averaging period for night time noise events is of no help as a control measure. It is too long to be useful.

Even 5 minute periods are not ideal. If a noise event lasts for 1 minute, at e.g. 50 dBA, and the other 4 minutes are quiet, the average over the 5 minutes is 43 dBA. However the percentile values e.g. L50, L90 etc. can also be used for analysis.

If the average noise level for a train passby is 50 dBA, and the train takes 20 seconds to pass by, the average of this event spread over 5 minutes is c.38 dBA.

Two such trains passing by, in the period, would result in an average of c.41 dBA.

Our belief is that values of LA90<sub>5mins</sub> are commonplace which are considerably lower than the 45 dBA mentioned in Table 8.19 of the EIS as being a suitable Allowed noise level for Fixed Plant, at Abercorn Road and West Road. Similarly for other locations in Table 8.19.

Should such fixed plant be switched on in most of the areas along the proposed alignment, it would be a distinct shock to people who currently enjoy quiet times (LA90) of 35 dBA or lower at night. Such quiet times at night are commonplace, and any proposal to use higher levels should be established by careful assessment of night noise levels at each project site.

The proposal to use combined noise criteria (baseline + Construction or fixed plant) carries within it the risk of confusion, whereby a total level could be ascribed mainly to the weather (truthfully on a breezy night), while a lower level of construction noise could still cause disturbance due to its different character. With a single combined reading one can not be sure, without analysis, how high the construction noise level was at any time. Thus we consider that the best way to control construction and/or fixed plant noise at night is by an absolute value for each of those specific noise sources, independent of the baseline level, and the weather conditions at any time.

#### Baseline Noise Level and Fixed Plant.

We recommend that (i) the allowed noise level, for fixed plant, should not be greater than 35 LAeq<sub>5min</sub> Sound Rating Level (that is adjusted for any tonality or impulsive nature which is intrinsic to the plant.), and (ii) particular attention be paid to deriving the LA90<sub>5min</sub> between 1am and 5am, in those areas noted in Table 8;19 of the EIS where higher values than 35 LA90<sub>5min</sub> Rating Sound Level are proposed as allowed fixed plant noise levels.

**NOTE 6 :** If any Fixed Plant noise level higher than 35 LAeq<sub>5min</sub> Sound Rating Level is considered to be justified, the local noise ambient level should be established, as follows :

1. By measuring the LA90<sub>5min</sub> level over the period from 0100 to 0500 hours;  
That is 48 readings on each night.
2. On at least two relatively calm dry nights; The relevant wind speeds at the nearer of Dublin Airport or Casement Airport for each hour to be noted and given also. Wind speed should preferably not exceed Force 2 on the Beaufort scale. (See Note 33).
3. With no industrial type of activity taking place e.g. Track maintenance, or other noisy activity, e.g. Idling of engines; and
4. With only the 2 or 3 normal scheduled train passby events during the measurement period, and no stopping of trains in the locality; and
5. The appropriate LA90<sub>5min</sub> value to be agreed with Dublin City Council, for each area in which fixed plant is to be located.
6. Any rounding up or down of values should be to the nearest decibel (dB), (not the nearest 5 dB.)

### Observations in East Wall

While making some observations in East Wall on 13<sup>th</sup> July 2011, a slow moving train (freight ?) passed by at c.2250 hours in Blythe Avenue, East Wall, which was very noisy, very multi-tonal, and somewhat impulsive. At ground level it seemed that the clearly visible noise barrier of height c.3.6 to 4 metres, was quite ineffective, in that the resulting noise level heard was considered sufficient to wake some people, even with windows closed. At first floor bedroom level, the noise would be somewhat higher again.

Such noise events occurring three times per night (on average, as per the EIS) have a distinct potential to disturb sleep, on each occasion of occurrence (if each freight train passby is as noisy).

This noise could qualitatively, and subjectively, be described as a ferociously clattering and jangling din, for the approximate duration of c.1 minute. Its high low-frequency content requires a barrier material with good low-frequency ‘stopping’ (noise-reduction) performance.

As part of the proposed DART Underground works it is recommended that the effectiveness of this barrier be investigated, the resulting noise levels measured, and that a more effective barrier be installed, if needed, in order to achieve a maximum resultant noise level of 50 LAeq<sub>5mins</sub>, at 4 metres above ground level, at c. 1m to nearby houses, from any train passby, regardless of speed.

**NOTE 7:** The Lowest ambient noise baseline values of LA90<sub>5mins</sub> usually occur from 0100 to 0500 hours. Likewise for the LAeq<sub>5min</sub>. Two train passby events (each of 50 LAeq<sub>5mins</sub> ) in an hour would give a value of LAeq<sub>1hour</sub> of 42 dBA.

**NOTE 8** – One can expect a difference in LA90<sub>5mins</sub> values of the order 8-10 dBA, due to the influence of weather, on the ‘floor-level’ quietness. This refers to readings on a ‘calm’ night as opposed to those on a ‘moderately breezy’ night, the latter giving the higher readings.

In EIS Section 8.6.2.1 is stated ‘As a minimum the barrier material will have a mass per unit of surface area in excess of 7 kg/m<sup>2</sup> - - -’

Barrier height is only one of the important parameters to be considered in noise reduction. The material density is also important. An example of some potential site boundary hoarding materials, and their sound reduction capabilities is shown in the following table.

Table 1 – Sound Reduction Indices of Three Noise Barrier Materials

Material (Single-skin)	63	125	250	500	1kHz	
A. 15.5mm thick KoskiSound plywood (14.8kg/m <sup>2</sup> )	----	22	24	28	32	dB*
B. 12mm thick plywood(7kg/m <sup>2</sup> )	----	10	15	17	19	dB**
C. 18mm thick plywood(10kg/m <sup>2</sup> )	----	24	22	27	28	dB**

• Ref. [www.koskisen.com](http://www.koskisen.com) or J.McCallion@ucmtimber.co.uk

\*\* Ref. 22 Bies and Hanson, ‘Engineering Noise Control, 1988, p.200

‘Since diffraction sets the limit on the noise reduction which may be achieved, the barrier surface density is chosen to be just sufficient so that the noise reduction at the receiver is

diffraction limited.’ For this purpose, the barrier surface density will usually exceed 20 kg/m<sup>2</sup>.’ (Ref. 22 p.219)

This means that a higher barrier, which is required to give more noise reduction through diffraction, will also need a more dense material than a lower barrier.

**NOTE 9** – Material B above is more likely to allow low-frequency noise straight through it than to force it over the top of a high barrier. Double-skin noise barriers give better sound reduction data than single-skin ones. Thus 6mm + 6mm plywoods, separated by 75 to 100mm of airspace will give higher performance than 12mm single-skin barriers. The precise performance data should be confirmed before use.

Tables A8.3.61 and A8.3.62 and A8.3.68 of the EIS indicate Baseline noise levels at Night of 50 LAeq<sub>1hour</sub> in Blythe Avenue and other similarly quiet places. This figure is then taken to justify a ‘Criterion’ of 55 LAeq<sub>1hour</sub>. Calculated construction noise levels are then considered to meet this criterion, with the implied conclusion that such construction would be acceptable at night. It would not be acceptable. Our comments on this process follow:

- (a) Construction noise inevitably contains Tones and impulses;
- (b) The quoted ‘Baseline’ values, and corresponding derived ‘Criteria’ are both too high, in this writer’s opinion.
- (c) For assessment of Night time noise the appropriate reference is the LA90 (not the LAeq) (the quiet time level as opposed to the level of noisy events)
- (d) The quoted Construction noise levels would inevitably cause sleep disturbance at residences.
- (e) As a result of the foregoing, such construction work is not acceptable at night.

In EIS Table 8.12, for Spoil Removal by Ramp on Sheriff Street, at Night, is indicated ‘Neutral to major exceedance of criteria at high rise apartments - -’, and ‘Moderate to substantial exceedance at residences - -’

Clearly such exceedances of noise criteria would be totally unacceptable.

In any event it is understood that the applicant does not plan to remove spoil at night. (See page 5-42, Section 5.20.2, EIS Book 2, Volume 2.)

Some Comments on Tables 8.12 & 8.21 (In EIS Vol.2, Book 2) & Table A8.3.43 At Inchicore is indicated in Phase 1 construction ‘Neutral to moderate exceedance of evening criteria at residences to the north of the shaft site, St. Patrick’s Terrace and St. Georges Villas.’

Evening construction noise levels of 55 & 58 LAeq1hr will be noticed,

In Phase 2 is indicated Evening construction noise levels of 52 & 53 LAeq1hr. These will also be noticed, but should be bearable.

We ask, however, why only a 2.4m height of ‘Enhanced Screening’ is envisaged ?

If Light blockage is a problem, why not use glass of appropriate thickness and durability ?

Or perspex or other translucent material ? (And ensure that the material is kept clean)

In Memorial Park In Phase 1 a ‘Moderate to Significant exceedance of evening criteria at school buildings to the east and north of site’ is indicated.

Evening construction noise levels of 58 (Phase 1) & 55 (Phase 2) LAeq1hr will not be welcome

Why then is only a 4m barrier to the East and a 2.4m barrier to the North proposed ? Particularly since, both to the East and to the North-east of the site compound there are residential houses, some of which are situated at distances of c.8 metres upwards ?

**NOTE 10** – In contrast, in Tables A8.3.46 and A8.3.47 ‘Site Screening’ is indicated to be 4m construction site hoarding to both north and east of site.

Similarly at some other locations, for example, at Island St. is it sufficient to have a 6m Barrier only on the East side and 2.4m high on the N and S sides, when a 4-storey apartment block at c.30 metres to the South east will derive little if any benefit from the proposed site boundary barrier on the east ?

At Cook St. The indicated criteria are high at 65 LAeq<sub>1hr</sub> from 1900 to 2200 hours. At apartments to the West of the Shaft is indicated a 4m barrier height. Why not use a higher barrier to reduce the noise impact, and level of 64 LAeq<sub>1hr</sub> ? (Table A8.3.52)

At Pearse Station Slight to moderate Exceedance of evening criteria is indicated at Erne St., Sandwith St. and Boyne St. from the Station works. Yet only a 4m high barrier is envisaged.

The indicated criteria are high at 65 LAeq<sub>1hr</sub> from 1900 to 2200 hours. It is suggested that the Baseline values be checked, and that projected evening construction noise levels of up to 70 LAeq<sub>1hr</sub> be examined for potential reduction.

Boyne St. is a very quiet street with very little road traffic. During over 30 minutes observation time there only 1 car passed through the street (a Garda (police) patrol car).

The proposed evening criterion for this street is 68 LAeq<sub>1hr</sub> (Table A8.3.56). Construction noise at the proposed evening criterion of 68 LAeq<sub>1hr</sub> would be a shock to the residents of Boyne St. at 9 or 10pm.

Boyne St. runs East-West, parallel to the Railway line. The rear of these houses are more exposed to rail noise while the fronts have no direct rail noise, and the backs will be more exposed to the proposed construction noise also, as these 3-storey houses on the North side back on to the proposed Pearse Stop construction compound site.

Sandwith Street is a somewhat busier traffic route (relative to Boyne St.), at c.4 to 5 cars per minute, at c.50km/hr. (Traffic calming ramps)  
Construction noise at the proposed evening total ‘Criterion’ (Table A8.3.56) (‘acceptable level’) of 68 LAeq<sub>1hr</sub>, would be a shock to residents here also at 9 or 10pm.

Cook Street is a quiet traffic route in the late evening, c.1 car, or less, per minute. Similar remarks apply here as in the above 2 streets, and likewise also in numerous other quiet, or very quiet, locations, where very few noisy events can drive up the average value – LAeq – significantly, thus giving an erroneous impression of the generally quiet nature of the area.

#### Comment

The above three streets are examples of quiet streets where one points to the inadvisability of using LAeq values as reference values for assessment of noise levels in either the evening or the night time, due to the probability that 1 or 2 noisy events can drive up the average noise level by 5 to 10 dBA.

The LA50 would be a more acceptable ambient-related evening-time reference level.

#### Conclusion on Project Feasibility

Despite the data points, and the comments noted previously, one can conclude, in the light of the following facts, that the Dart Underground project can be completed in compliance with the stipulated noise limits, and with adequate consideration of any noise-related community problems which may arise, and a speedy response to, and mitigation of, any noise excess identified. The facts referred to are :

- (1) the understanding that environmental impact assessment is a dynamic process – with the inputs and clarifications arising out of the assessment process, in this case in particular the Oral Hearing, and the contributions made by various contributors to the Oral Hearing;
- (2) the commitment from CIE/Iarnrod Eireann, in the Oral Hearing, that the Contractor to be appointed will be contractually bound to undertake the additional ambient noise surveying needed, prior to any construction activity;
- (3) the commitment from the applicant that the Contractor to be appointed will be contractually bound to implement the steps and procedures indicated in the EIS and confirmed during the Oral Hearing, in addition to any conditions stipulated by An Bord Pleanála, to ensure good management and effective control of construction noise impacts;
- (4) the range of noise abatement options available to the contractor;
- (5) the range of technical expertise and controls to be employed by the applicant and the contractors, and
- (6) the proposals by CIE/Iarnrod Eireann to maintain good communications and good relations with the local communities around each work site.

#### Section 5. Pre-Construction Ambient Noise Surveys – External & Internal

It is recommended that a Pre-Construction Ambient Noise Survey be done at each one of the proposed major construction sites (Portals, Stations, Shafts and Bridge or Road works). Indeed it is understood that the contractor will do a pre-construction ambient noise survey. The recommended minimum duration of these ambient noise surveys is one week (although 2 weeks would be better). The surveys should be continuous for the full duration of the survey, with measurements/readings taken at hourly intervals, from 0700 to 2200 hours, and at 5 minute intervals, from 2200 to 0700 hours. These ambient noise surveys should be completed, at each noise-sensitive location, before any construction activity begins at that site or at any other nearby proposed Dart Underground construction site or compound within 0.5 kilometre.

It is recommended that these ambient noise surveys be completed, in each such location, before any enabling or utility works construction activity begins. However, where traffic flow changes are planned, it is considered appropriate that a 2 week duration survey can be composed of 1 week in the original situation + 1 week in the new traffic scenario.

**NOTE 11:** The term ‘Construction site’ includes the proposed major construction compounds, the proposed four (4) Bridge/road work sites and the shaft construction sites.

**(a) External pre-existing ambient Noise levels** will need to be confirmed, both day and night, at a representative set of locations, for each significant work site. This will include residences, Schools, Hotels and theatres, not already adequately considered.

This is required for the significant noise limit criteria to be established in accordance with BS 5228 (2009) and Table 5 in Vol.2, Book 2, in the EIS.

It is particularly important for the night time situation. At night we recommend a different approach, and an absolute noise limit of 40 LAeq<sub>5minute</sub> for the construction noise level, along with the complete absence of Tonal and Impulsive character in the construction noise. This limit should operate from 2200 to 0700 hours irrespective of the pre-existing ambient noise level.

If the pre-existing LA90<sub>5min</sub> is 34 a construction level of 40 LAeq<sub>5min</sub> may result in a total c.41 LAeq<sub>5min</sub>, which, with no tonal or impulsive character, is unlikely to cause any sleep disturbance with windows ajar. (Assuming that the prior ambient LA90<sub>5min</sub> is c.34 LAeq<sub>5min</sub> also – that is, the quiet time noise level is the quiet time average level.)

If the pre-existing LA90<sub>5min</sub> is 45, due to a breeze, a construction level of 40 may result in a total 46.2 LA90<sub>5min</sub>, which, with no tonal or impulsive character, is still unlikely to cause any sleep disturbance with a window ajar. The construction noise should not be audible, however, particularly with some potential masking by the breeze noise.

However, if a pre-existing ambient noise level of 45 LA90<sub>5min</sub> were to justify a Construction noise level of 45 LAeq, the total could be 48 LAeq (50 Rating noise level as per EIS Table 8.19 for fixed plant). A construction LAeq of 45 could have peaks of 55-57 dBA along with tonal or impulsive character, making it most undesirable at night.

**NOTE 12** – The word ‘ajar’ means ‘slightly open’. In terms of noise ingress to a room via an open window we understand this to mean open just enough to hear a noise if indeed there is any noise incident on the window – and then, perhaps, to close that window slightly so as to make the noise inaudible inside the room. The bigger a window is, and the greater the area exposed to the noise, the sooner a noise will be become audible, compared to a small window. Also, the higher the incident noise level is, the sooner it will become audible on opening any window. ‘Ajar’ could mean a window opening from c.5mm to 100mm wide. The window orientation, relative to the direction of the incident sound, would have a secondary effect on the noise audibility.

**NOTE 13** – It is, in our opinion, very unlikely that anywhere along the proposed alignment, the ‘Lowest night-time LA90<sub>5mins</sub>’ will be as high as 45, in the absence of industrial or maintenance works. And in our opinion, it is totally inappropriate, in equity, to measure LA90 at night, except for purposes of good forward planning, while industrial works are in progress. Such a procedure should not be used, however, to justify imposing further night time disturbance on an already suffering population.

Where a new road traffic scenario is required for the Dart Underground project, it is considered appropriate that both the original background ambient noise level and the new ambient noise conditions be established.

**(b) Internal pre-existing ambient Noise levels** may need to be established in, for example the Gaiety Theatre. For internal ambient noise readings in theatres, continuous monitoring is not considered essential, and averaging periods may be less than an hour – as little as 1-2 minutes - if desired, for daytime (0700-1900 hours) or rehearsal or show performance times.

What is recommended is that, in conjunction with management requirements, an adequate and representative set of ambient noise readings be obtained, in the main auditoria and rehearsal rooms, of any theatre, such as the Gaiety, potentially affected, and if concerned

by the works, at appropriate times. These may then be used for reference in assessment of future noise conditions. The LA90 or other suitable and agreed parameter may be used,

**Section 6. Recording and playback capability**

It may be desirable to include recording and playback capability in the noise monitoring systems installed at some locations, in order to confirm, on analysis, the actual nature of any intrusive noise which may occur at some sensitive time in either an external or internal noise-sensitive location. Such recording and playback facilities are technically feasible, and recording can be triggered by a predetermined noise or vibration level or event.

**Section 7: The Noise-related Role of the Contractor**

The role of the appointed contractor is largely defined in pages 8-47 to 8-50 of the EIS, Vol.2, Book 2. However the job of doing a pre-construction ambient noise survey is not included in this section, 8.6 ‘Mitigation Measures’.

This role, however, was outlined by Miss Harmon, for the Applicant, in her evidence to the Oral Hearing on 10<sup>th</sup> December, 2010. ‘The contractor will conduct baseline noise and vibration monitoring prior to the commencement of construction works to determine the existing environment and to confirm the construction noise criteria’.

Among other things, the contractor to be appointed will be contractually committed, it is understood :

(a). To include an adequate Ambient Noise Baseline Survey in the pre-construction works. These construction works will include, at any worksite, any necessary utility or enabling works, which must precede the main project construction works. It will be necessary also to distinguish between the current pre-project ambient and the ambient with any necessary changes in the road traffic scenario which may change the ambient noise level during the construction phase. The ambient will be included with the construction noise level for monitoring in 1-hour periods, of the total noise for day and evening noise control. Night noise will be monitored in 5-minute periods for compliance with the specified absolute construction noise limit. (This latter is not as per BS5228:2009)

(b). To implement and maintain the required noise measurement and processing instrumentation. This may include a web-based facility for community relations, which allows people to inspect the noise level scenario and history, at any given worksite. Such a system can have an option, also, to include a complaint registration facility by an affected local resident. Such a monitoring system can also have an option to include cameras, to aid in identification of the cause of any undesired or unexplained noise event.

©. To report on the measured and derived noise data, to Dublin City Council, at agreed intervals.

(d). It is understood for any proposed Mitigation Measures that the contractor will be required to discuss proposed measures with CIE/Iarnrod Eireann and the respective Stakeholders and residents as to how best achieve the limits.

**NOTE 14** : The contractor may decide to subcontract any or all of the required noise monitoring and processing and reporting to a specialist Noise Management service provider.

### **Section 8: Creeping Background Noise Levels**

A 'creeping background' noise level means a gradual and often imperceptible increase in noise level over a period of time.

Every noise source in any given area, or which is audible in any location, adds a contribution to the total noise level in that place. Each place has its own recognisable normal soundscape, made up from the types of noise and their respective levels, which go to make up the composite existing sound environment and noise level pattern there.

The characteristics of each contributing noise source vary. Sources may be long term or transient, steady in level or highly variable. They may be relatively bland (or featureless) in character, like distant road traffic, or clearly tonal like the sound of a large saw in a sawmill. They may be of pleasant character like the trickling of a nearby stream, or highly unpleasant and disturbing like the sound of hammering nearby or of repetitive gunfire. Sounds may be very welcome like that of a friend approaching, or most unwelcome like the steady unrelenting thump of a nearby music venue, coming through the structure of one's dwelling, at night, especially on a repetitive or ongoing basis.

A current noise climate which is acceptable at night – outside one's house - may be, for example, a level of 40 dBA Leq

**NOTE 15 :** dBA, A-weighted decibels (Amended decibels), is the most common unit of noise measurement, although it is not appropriate in every situation. Leq is the equivalent continuous level, or the average level. These two symbols are often combined to read LAeq (the equivalent continuous, or average, A-weighted noise level).

A proposal to locate a new noise source in the area which would also generate a noise level of 40 dBA at that receptor location, would result then in a new total noise level of c.43 dBA Leq. (Due to the logarithmic nature of decibels and their addition). This is a distinct increase which may be clearly noticeable.

In order to minimise the increase in overall noise level, a planning authority may stipulate a limit of 35 dBA Leq for the proposed new source. The addition of 35 dBA to the pre-existing 40 dBA would result in an overall c.41 dBA Leq. If the new noise source were restricted to no more than 30 LAeq, the new total would be circa 40.4 LAeq. An increase of 0.4 LAeq is unlikely to be noticed on its own, unless there are some other disturbing aspects to the new noise source. However, it is worth noting, that in relation to an industrial estate scenario, three noise sources causing a level of 30 LAeq each, at any given house or sensitive receptor, are equivalent to one such source of 35 LAeq. Similarly three sources of noise contribution 35 LAeq from each at any location, are equivalent to one noise source of 40 LAeq at that location.

A new noise source may be a new factory or quarry or sawmill or transport depot or motorway or airport runway or music venue or food takeaway venue or construction site. It may also be an extension of an existing plant, or an increase in hours of operation, or an increase in product throughput with concomitant increase in haulage traffic. Intensification of one kind or another will often result in an increased noise burden, and/or the associated noise levels.

It is desirable to minimise this increase in ambient noise level (this 'creeping background noise level') as much as possible. The values referred to above may be summarised in Table 2.

**Table 2 – Addition of Noise Levels (Creeping Noise Background)**

Existing Noise Level	Additional Noise Level	Resulting Total *
40	40	43
40	35	41 *To nearest whole number
40	30	40 (40.4)
35	30	36
35	35	38
35	35 + 35	40

**Note 16** : BS 4142:1997 ‘Method for Rating industrial noise affecting mixed residential and industrial areas’ requires that, at night, the reference time interval for determining the specific noise level (of a noise source) is 5 minutes. That is T = 5 minutes. Readings over 5 minute periods usually give some lower values of LA90 than readings over longer periods.

The WHO (World Health Organisation) Guidelines (1999) on good sleeping conditions are referenced below.

BS 8233:1999 ‘Sound insulation and noise reduction for buildings – Code of practice’ in Table 5, gives 30 LAeqT as a ‘Good’ standard, and 35 LAeqT as a ‘Reasonable’ standard for bedrooms. These values are collected in the following Table 3.

**Table 3 - Noise Levels and Sleep**

Existing Level in Bedroom dBA	Comment
30	A ‘Good’ standard *
35	A ‘Reasonable’ standard *
30	WHO guideline value
18-23	Existing night time LA90 in many rural and suburban and city bedrooms (windows closed)

\* As per BS 8233:1999 ‘Sound insulation and noise reduction for buildings – Code of practice’

The Crossrail railway scheme, currently under construction, crosses London from east to west. The Crossrail Information Paper D25 ‘Noise from Fixed Installations’, paragraph 2.7, states that Local Authorities (in London) prefer a sound rating level, for fixed plant, ( $L_R$  (Fixed plant)) which is no greater than  $L_{A90T} - 5$  dB. The rating sound level of a plant ( $L_R$ ), at a given location, is the measured noise level LAeq + a correction for tonality or impulsive character, if any. This correction factor, if required, would normally be +5 dB.

The  $L_{A90T}$  parameter is the ambient background noise level which is exceeded for 90% of any relevant 5 minute assessment period at night, in the absence of the noise under assessment, and (in the Crossrail scheme) is agreed with the Local Authorities.

It is important that an acceptable night time indoor noise level for the proposed fixed plant, is achieved at every inhabited location.

Bearing in mind that indoor noise due to fixed plant will occur on a 24/7 basis throughout the year, and for years to come, it is most important that any indoor plant noise level must not have any significant impact on sleep quality, or on any daytime activity either.

The quieter areas along the proposed alignment are expected to include houses or noise-sensitive receptors around every proposed work site, with the possible exception of St. Stephens Green at the fronts of the houses.

All such low noise ambient locations may be seen when the proposed background noise surveys are done by the Contractor.

### **Section 9. Noise and Sleep Disturbance**

By definition noise is unwanted sound. It is unwanted because it either distracts people from activities which require concentration (like work or study), or it intrudes on other necessary activities (like sleep, rest or recreation). It can also interfere with face-to-face conversation, use of the phone, and enjoyment of music. Noise is a stressor, whereas a quiet natural environment, in any given location, is usually regarded as an asset, a place where rest & recuperation are facilitated. The quiet nature of the night environment at some proposed work locations was noted in the course of evidence to the Oral Hearing.

Noise which has impulsive character like hammering, gunfire, loud shouting, heavy objects dropping on the ground, slamming of doors, strong revving of engines, use of car or train horns (especially at night) or the repetitive ‘thumping’ character of some music is often particularly disturbing and objectionable. Sounds which are tonal in character (such as a whistle, hiss, drone, rumble or hum) can also be distinctly jarring to the human nervous system, and disturbing and tiring.

The most serious effect of intruding noise is often sleep disturbance. This is quite widespread in occurrence. It occurs from a variety of sources. It often occurs on a continuing basis, and sometimes even on a constant basis.

An occasional disturbance of one’s sleep is of relatively minor consequence, on a medium to long-term perspective. Such a sleep loss can usually be taken in one’s stride and later compensated for.

The situation for many people, however, is where sleep disturbance is repetitive and ongoing, in some cases for years. This can occur on, for example, two or three nights a week from a music venue, or every night, and every weekend from an airport, or a roadway with little distance between house and road. Fans and cooling plant on factories, shops and food establishments can also cause noise related nuisance on a daily basis.

Ongoing repetitive sleep disturbance from any noise source can have serious consequences for an exposed person, either in adverse health effects or one’s home life, or work life, or in terms of safety on the roads (for example when driving). Falling asleep at the wheel, by drivers, from fatigue or drowsiness, is reported to be relatively common, having, in some cases, fatal consequences. (See Section 11 – The effects of Noise on Man and on Sleep)

### **Section 10. Night time Noise – The WHO Night Noise Guidelines for Europe (NNGE) 2009**

The WHO Night Noise Guidelines for Europe 2009 are summarised as follows :

Night Noise Guideline	$L_{\text{Night, Outside}}$	40 dB
Interim Target (IT)	$L_{\text{Night, Outside}}$	55 dB

$L_{\text{Night}}$  is the night noise indicator described in the EC Directive 2002/49/EC relating to the assessment and management of environmental noise.

**NOTE 17** -  $L_{\text{Night}}$  means the 8-hour average for the night, between 2300 and 0700 hours. However, this period can be increased.

(WHO is the World Health Organisation).

Directive 2002/49/EC on the assessment and management of environmental noise gives the default values for the periods as follows :

Day : 0700-1900 hours; evening : 1900-2300 hours; night : 2300-0700 hours local time. But Member States may shorten the evening period by one or two hours and lengthen the day and/or the night period accordingly.

The Abstract of the NNGE states :

‘The WHO Regional Office for Europe set up a working group of experts to provide scientific advice to the Member States for the development of future legislation and policy action in the area of assessment and control of night noise exposure.

The working group reviewed available scientific evidence on the health effects of night noise, and derived health-based guideline values. In December 2006, the working group and stakeholders from industry, Government and non-governmental organisations reviewed and reached general agreement on the guideline values and key texts for the final document of the Night noise guidelines for Europe.’

‘These guidelines are applicable to the Member States of the European Region, and may be considered as an extension to, as well as an update of, the previous WHO Guidelines for Community noise (1999).’

The Foreword of the NNGE states :

‘The WHO Regional Office for Europe developed the Night noise guidelines for Europe to provide expertise and scientific advice to the Member States in developing future legislations in the area of night noise exposure control and surveillance, with the support of the European Commission.’

‘Although these guidelines are neither standards nor legally binding criteria, they are designed to offer guidance in reducing the health impacts of night noise based on expert evaluation of scientific evidence in Europe.’

‘The review of scientific evidence and the derivation of guideline values were conducted by outstanding scientists.

The contents of the document were peer reviewed and discussed for a consensus among the experts and the stakeholders from industry, government and nongovernmental organisations. We at WHO are thankful for those who contributed to the development and presentation of this guidelines and believe that this work will contribute to improving the health of the people in the Region.’

On the document cover page World Health Organisation 2009 is stated :

‘The views expressed by authors, editors, or expert groups do not necessarily represent the decisions or the stated policy of the World Health Organisation.’

The Dart Underground EIS states on p.8-13. Vol.2, Book 2, ‘The recently published document recommends an  $L_{\text{night, outside}}$  target noise level of 40 dBA which is an ideological value for European consideration. This lower value has however been noted to be largely unachievable in busy urban areas. In this instance, where night-time noise levels have been set for this project, these are derived from the existing noise environment as measured during the baseline survey work.’ This is for the whole-night average. This does not give the whole picture.

**In response to the above statement** , we comment as follows :

(a). The Night Noise Guidelines for Europe (NNGE) recommends an average whole-night (8-hour) noise limit of 40 LAeq<sub>8hour</sub> as desirable for protection of people’s health. This average is frequently exceeded by the noisier events which occur at night. BUT, in many places, for MOST OF THE NIGHT, the noise level is lower than 40 dBA.

(b). The LA90 noise parameter is the noise measure/level which exists in an area when no aircraft are flying over the area, when no trucks or buses are passing by, when no factory or quarry is generating noise, when no music bar or discotheque is pumping out amplified

music, when no crowd noise is emanating from any venue, and when no bank or collection of fans or chillers or air conditioning units are heard, and when weather conditions are reasonably calm and dry - in other words when no significant noise source is heard above the quiet background. It is the noise environment which exists for 90% of a period.

(c) The quiet background is the background noise ambient which exists for MOST OF the TIME, AT NIGHT, in MOST RESIDENTIAL AREAS, in Ireland. It is a time and environmental state which most people enjoy.

It is also a time and environmental state which is essential for people to recover from the normal and unavoidable 'wear and tear' of the stresses of daily life.

(d). Experience over the years has shown that outdoor values of LA90<sub>5 minutes</sub> are frequently at 35 dBA or lower at night. This applies to MANY residential areas in Ireland, including Dublin City and suburbs. We realise also that the lowest noise levels normally occur between 1am and 5am on any night.

(e). It gives an incomplete picture to report only the LAeq or average noise values, when such values can be relatively higher as a result of just ONE truck or bus or other noisy vehicle (such as an aircraft or freight train) passby; or from a few barks by a dog. Indeed even birdsong can cause significant sound levels in the early morning time (from c.4am on). But it is unusual for anybody to consider birdsong as 'noise', and it would be misleading to believe that 50dBA from birdsong at 4 or 5 or 6am, could justify an industrial noise source or a construction project noise level of 50 dBA at these times. (We have, however, known a large collection of crows, in the evening time, to be very noisy and annoying.)

(f). We recognise that, on the other hand, there are also numerous areas in Ireland which are impacted at night by high noise levels from aircraft and road traffic, and pub or nightclub music, and other sources. But it is inaccurate to use such examples of night noise levels to justify general statements implying that night time noise levels are high everywhere.

And let us realise that the people who are subjected to high night noise levels do not enjoy them. On the contrary, such people SUFFER from them. They suffer in TWO RESPECTS- (i) they have to endure the ADDED STRESS of night noise, without (ii) the recovery time which we all need at night.

(g). Thus, for assessment of night noise, the appropriate noise level for comparison purposes, is the Quiet time noise, the LA90. It is not appropriate to use the noise from a HGV's passing by, for example, as the reference for comparison.

Nor is it appropriate to use the LA90 from an industrial source which happens to operate constantly in the area, at a high noise level, as the reference level to justify further noise in an area.

(h). Finally, it must be stated that the Night Noise Guidelines for Europe, 2009, are of significant assistance to planners who wish to curb, as much as possible, the stealthy process of 'Creeping noise Background; in their areas of influence.

(j). So, 40 dBA, at night, is not really 'largely unachievable in busy urban areas'. Such noise levels and lower, ALREADY EXIST for MOST of the NIGHT in many urban areas, as well as in rural areas.

(k). What is not generally achievable at present is an ALL NIGHT 8-hour average of 40 LAeq or lower – in many areas. A few noisy events can and do drive the whole-night average over 40 dBA . The fewer such night events the better for people's health.

(l) For consideration of night time noise in a proposed development context, the appropriate noise parameter to use for comparison purposes is the LA90, and in the UK it is the LA90<sub>5minutes</sub> , that is measured over 5 minute periods.

It is considered that the authority and value of the NNGE is, without question, widely accepted, internationally.

It is considered that the 2009 NNGE will come to be as widely regarded as the de-facto standard to be used for night time noise assessment, as was the preceding and complementary, and widely referenced, 1999 WHO guidelines.

(m) It is considered also that the experts involved in producing the NNGE understand the minimal likelihood that whole-night average noise levels of 40LAeq<sub>Night</sub> will be widely attained in the near future. Thus the choice of 55 dB as an Interim Target.

(n) What is desirable is that the current levels of night time environmental noise should, for the foreseeable future, not worsen significantly. It would be better if they could be reduced. However, in order to avoid significant deterioration of the night noise environment, alert proactive policies are required from planning authorities, which will limit the stealthy creeping up of night noise levels.

(o) This requires the lowest possible additions to the night time noise load. In other words new night time long term noise sources should be required to contain their noise emissions to levels of, for example, 35 LAeq or lower – at any noise sensitive receiver - in currently quiet areas.

We therefore consider that in areas which are essentially quiet rural in nature , in terms of soundscape an appropriate upper night time limit, outdoors, for new noise sources of a permanent nature is 35 LAeq<sub>5 Mins</sub>. And at least from 2200-0700 hours, and as per the EPA guidelines, there should be NO TONAL NOISE and NO IMPULSIVE CONTENT.

(p) For construction sites, an appropriate upper night noise limit, in those very quiet areas, is considered to be 40 LAeq<sub>5 mins</sub>. (This will effectively rule out any external, or above ground level, use of heavy plant or machinery). For construction works in urban and suburban areas the Limit of 40 LAeq<sub>5mins</sub> (2200-0700) hours is also considered appropriate; ; and as per the EPA guidelines, there should be NO TONES and NO IMPULSIVE CONTENT.

**NOTE 18:** The proposed conveyors at East Wall should be usable within this constraint. However, care with maintenance and the location & setting of material drop height will be needed, and possible damping or enclosure of any hoppers or chutes in the system.

The WHO guidance on health based noise effects indicates what the desirable ambient night time noise levels are, and thereby shows how the noise limits for new sources could be derived. This will facilitate planners to minimise the creeping background noise effect. And for this guidance the Night Noise Guidelines for Europe (2009) is a valuable document.

Furthermore, the widely experienced sense of peace and calm in what may be termed ‘very quiet areas’ is clear evidence that those areas are indeed worthy of protection from the stealthy ingress of the creeping background noise effect.

It is also of note that, by and large, the existing high night noise levels are mainly due to road traffic. This source is often quite bland in nature, and many people have found it to be an integral and even acceptable part of the sound environment in their locality.

Many other noise sources such as industrial or commercial sources have a quite different character – for example a tonality or an impulsiveness – which is more noticeable and intrusive than traffic noise of the same average level.

Thus, it is not a comparison of like with like to compare road traffic noise with other noise types of different character, (such as construction noise) without taking account of this different character.

### **Section 11. The Effects of Noise on Man and on Sleep**

Noise is a stressor generally, and a ubiquitous source of sleep disturbance throughout Ireland. Noise from many sources, industrial, commercial, and transport activities occurs virtually in most inhabited areas of the country. Even domestic noise is occasionally the source of nuisance, for example loud music or dogs barking.

Our lifestyle today, in 2011, has become quite non-stop 24/7 in nature, with many people engaged in some forms of activity both day and night. Many of the stories noted in this section from other countries are considered equally applicable to Ireland.

Hence it is considered essential to report on the effects of noise on man, which have been discovered in this study.

And it is considered essential, in this study, to report on the increased awareness of the serious nature of some of the effects of sleep disturbance. We accept from the outset that noise is not the only source of sleep deprivation, but it is too widespread to ignore.

There is increasing awareness internationally of the likely impacts of sleep deprivation.

In Ireland too this subject is now receiving some overdue attention. (See references 6 & 7)

It is still the case, however, that more attention is required from the relevant authorities, in order to bring about the changes in work practice, and possibly also in lifestyle, that are required to properly minimise the dangers of widespread sleep deprivation, at least those WHICH ARE PREVENTABLE.

#### **(a). The process of Sleep (Ref.2)**

The Autonomic nervous system is that part of the nervous system responsible for control of the bodily functions not consciously directed. Examples of such functions are breathing, heartbeat, and the digestive processes.

During sleep (1) this system is largely ‘switched off’ and (2) the ear is responsible for the sleeper’s security. (3) Cardiac activity and breathing slow down (4) Metabolism is reduced (5) Eyes are closed and the pupils are contracted (6) Inner secretion is diminished (7) The muscles are in a state of relaxation (8) The body changes from a state of ‘activity’ to a state of rest and recuperation.’

The purpose of sleep is for resting of the body’s systems and recuperation from the ‘wear and tear’ of normal everyday activities.

A good quality sleep results in a person awakening ‘refreshed’ and re-energised, and capable of meeting the demands which need to be met, and the challenges which need to be overcome. Insufficient sleep or poor quality sleep causes people to wake up with a lower capacity to cope with the demands of the day. They start off the day in a tired fatigued state

which results in poor performance of duties and lower enjoyment of life. If poor quality disturbed sleep continues on an ongoing basis the results can include a proneness to accidents both to themselves, and to those around them.

‘Life is governed by a strict rhythm. Wakefulness, bodily and mental labour, alternate with periods of but little movement - - ‘During sleep, which is a time of rest for the entire organism, the inner ‘accumulators’, as it were, are recharged, worn-out cells replaced, wastes secreted – in short, the body is rejuvenated to a degree for the exertions of the coming day.’ (Ref.2)

Sleep has five recurrent and characteristic phases defined by the ‘depth of sleep’. This is defined by the intensity of a physical stimulus required to wake the sleeper. Such stimuli include light, pressure and sound. A person’s sleep state can be observed by the electrical traces (*from electrodes placed on the body*) on an electroencephalogram (*EEG*).

‘ - - encephalography has become an important branch of medical science and a recognised tool of research. It has, among other things, provided objective proof for what had long been conjectured, namely that of all the deleterious effects of nuisances and disturbances on man those affecting his sleep are the most fateful.’ Ref.2, page 200. (Italics are ours)

Sleep progresses from the waking state to light sleep Phase 1, to deeper Phase 2, to still deeper Phase 3 (semi-profound), to Phase 4 (really profound sleep), followed shortly after by Phase 5 with rapid eye movements (REM).

In the lighter sleep phases 1, 2 and 3 it is possible to wake people with weak acoustic signals of c.40 dBA. But in the deeper sleep phases 4 and 5 considerably higher noise levels are needed.

Sleep can be disturbed by (a) Change from deep sleep stages 4 or 5 to lighter sleep stages 1, 2 or 3; and (b) by rousing the sleeper to complete wakefulness.

Researchers have used street traffic noise recordings to investigate the impact of noise at different levels on sleep. It was found that even when the test subjects did not awaken during the tests, and reported a good sleep quality, but EEG tracking showed it was clear that sleep level had been reduced, and in some cases that the profound stage was not reached at all. It was concluded that although the test persons felt they did not awaken because they had grown accustomed to it, ‘it is almost invariably possible to prove a loss of sleep or rest – which if continued for any length of time is bound to accumulate into a sleep deficit and may have tragic consequences.’

Using recordings of heavy lorries, ‘EEGs showed that (a) at noise levels (L) of 40-45 dBA profound sleep grows shallower, leading to awakenings in 10% of cases; (b) at L=50 dBA the depth of sleep of all persons tested was reduced, increasing the proportion of awakenings to 50%; (c) at L= 70 dBA nearly all test persons woke up.’

Researchers have also used finger-tip pulse measurements to study noise effects on sleep. These have shown that, even with short duration noise stimuli (0.3 to 12 seconds), there is an ‘after effect’ when the noise has ceased. The body does not immediately resume normal sleep on cessation of the stimulus.

(Ref.2) It has been reported by some people that adaptation to noise, or conditioning by noise, is possible. ‘It is, however, unknown what price the persons thus affected pay in terms of their health for the unfavourable conditions in which they ‘enjoy’ their sleep.’ Because ‘What does appear certain is that there is no physiological adaptation to noises.’

“Disturbed sleep as demonstrated by the EEG leads to a sleep deficit that is deleterious to health and has unfavourable effects on the output of modern man, who is anyway under pressure (*in 1976*) during the day and inundated by a vast variety of stimuli. Disturbances in the neurovegetative equilibrium and psychosomatic illnesses, to which practically all organs may fall prey, could well be the inevitable consequence.’

(b) Daily Variation in TTS (Temporary hearing Threshold Shift) of a Noise-exposed Worker; Two Phases of Noise Action – (i) Damage and (ii) Recovery

The hearing acuity of industrial workers is most sensitive in the morning, before their exposure to a noisy workplace begins. The action of the noise dulls their hearing gradually. In reference 5, Kryter in Figure 7.8 shows graphs of worker’s hearing level measured at different times of a typical 8-hour industrial workday. It shows a HEARING LOSS of up to 14 dB after the morning’s work (and noise exposure) and a RECOVERY in hearing level during the lunch break (no noise) of up to 7 dB. During the evening and night time the full 14 dB in sensitivity is again recovered it is understood.

This shows that two processes are at work in the development of hearing loss due to noise exposure. These are (i) a DAMAGE process, and (ii) a RECOVERY process.

It is most likely also that a similar 2-phase process is at work in other situations where people are adversely impacted by noise in their environment.

This is Graphical scientific evidence of the value of a recovery period (such as a quiet night or weekend). We are all aware of this well known reality.

We recall also that ‘*there is no physiological adaptation to noises*’.

‘Sleep may be badly disturbed objectively by noise (reduction of depth of sleep)’ ‘even when the sleeper himself claims and feels to have slept well.’ Page 211, Ref.2.

(c). Sleeping time and Sensitivity to Noise

People’s need for sleeping time varies considerably. Sleeping times from c.4 hours to 11 hours have been noted. (Ref.2)

Likewise people’s sensitivity to noise varies considerably. People with a low tolerance for noise may be described as ‘Supersensitives’. People with relatively high tolerance may be described as ‘Imperturbables’. The former may tolerate with equanimity a noise level of only 40 dBA, while the latter may be quite happy at levels of up to 60 dBA in a similar situation, at the same time of day.

This variability in susceptibility to noise impact (or disturbance by noise), needs to be kept in mind to avoid the, possibly erroneous, conclusion that any particular individual may be simply a ‘crank’ complainant. Also, some people are very sensitive to low-frequency noise – especially at night - which some others do not normally notice at all.

This variation in susceptibility to noise impacts is also reflected in the physiological results of a lifetime of industrial noise exposure by workers. Instances have been recorded of people who worked side-by-side for 30 or 40 years, in a noisy workplace, where one person ended up almost ‘stone deaf’, and the other had virtually no hearing loss at all.

Noise regulations are exclusively tailored to the requirements of the ‘average’ person of medium susceptibility to noise. This needs to be borne in mind when dealing with any particular noise situation.

Noise affects people in a number of ways, both physically and psychologically. Noise causes changes in pulse rate, blood pressure, and hormonal changes. (See Tables 4, 5, 6, 7, and 8,)

Noise-induced sleep loss reduces the ability of people to function effectively on waking, by diminishing their alertness and 'watchfulness'. Ref. 2, (Figures 3.18, 3.19). Noise causes mistakes and accelerates the onset of fatigue.

'Other experiments involving deprivation of sleep for days at a time, led to tiredness, nervousness and irritability, and as the sleepless periods increased still further, states of delirium and even paranoia were induced in the test persons.'

**( d ). Some Effects of Noise in the Range 30 – 65 dBA/dBB \***

(\* A number of sound frequency weighting schemes developed over the years, for different noise sources, to better replicate the human ear's response to sounds of different frequency (or pitch). These schemes (or weighting curves) were designated A, B, C, D, and E. The most commonly used one is the A-weighting scale.(dBA). This was originally intended for use only up to a sound level of 55 dB. However it is now widely used for all noise levels. The B - weighting frequency correction scale was originally intended for use from 55 to 85 dB. B-weighting gives more emphasis to the lower ('rumbly') sound frequencies (10 – 200 Hz) than does the dBA-Scale. (See Reference 4, page 25). Overall single-figure dBB levels can be up to c. 8 dB higher than the equivalent dBA figures for a given real life noise spectrum, depending on the actual frequency octave-band sound levels.)

**Table 4 - Some Effects of Noise in the Range 30 – 65 dBA/dBB**

The effects of Noise in the range of 30 dBA to 65 dBB, on awake people, are exclusively psychological, according to Reference 2. These effects include :

- (i) A feeling of Discomfort
- (ii) A feeling of being disturbed
- (iii). A feeling of being annoyed
- (iv) Anger at the Noise
- (v). Irritation over the Noise
- (vi) Inability to concentrate on Mental Work
- (vii) Reduced quality of the information imparted during class, lecture, etc
- (viii) Impaired ability to fall asleep

**NOTE 19.** (Noise Levels of 70+ dBA may be expected, for considerable periods, outside some residences, from the proposed Dart Underground project.

**Table 5 - Some Effects of Noise in the Range 65 to 90 dBA/dBB**

- (a) Increase in Diastolic blood pressure
- (b) A reduction in the quantity of spittle secreted
- ( c ) A decrease in the rate and amplitude of stomachal peristaltic.
- (d) Reduction in heart beat volume; Reduced blood flow as measured at Finger-tip pulse
- (e) Increase in the peripheral arterial flow resistance, due to vascular constriction
- (f) Increase in the pulse rate
- (g) Increase in the breathing rate (increased metabolism)
- (h) Increase in the liquid pressure inside the brain
- (i) Increase in the electro-encephalic frequencies at the lower end of the spectrum
- (j) Inhibition of the cortical functions of the brain
- (k) Stimulation of the sub-cortical function of the brain
- (l) Dilation of the pupils
- (m) Repercussions on the endocrine system
- (n) Noise-induced Hearing Loss

- (o) Speech Interference -- Difficulty in Hearing properly and Understanding spoken instructions or messages.

Around seven to nine hours of good quality sleep are essential to your health and cognitive functioning, according to the US Centers for Disease Control and Prevention.  
(Ref. [www.independent.co.uk/life-style/health-and-families/sleep-problems](http://www.independent.co.uk/life-style/health-and-families/sleep-problems))

**(f) U.S. Racking up huge “Sleep Debt”** Ref.3 National Geographic.com 28 October 2010  
[http://news.nationalgeographic.com/news/2005/02/0224\\_050224\\_sleep.html](http://news.nationalgeographic.com/news/2005/02/0224_050224_sleep.html))

‘Sleep experts say the average adult requires seven to eight hours of sleep per night. Anything less may harm their health. Sleep deprivation could (a) affect mental alertness, (b) impair the immune system, and even (c) increase the risk for diseases like diabetes.’

‘Sleep is just as important to our overall health as are exercise and a healthy diet.’ (Carl Hunt, Director, National Center on Sleep Disorders Research, Bethesda, Maryland USA., part of the National Institutes of Health).

‘Sleep is a biological need, much like food and water. If totally deprived of shut-eye, humans ultimately perish.’ ‘Today Americans on average sleep one hour less per night than they did 20 or 30 years ago.’ Sleep deprivation can affect people in the following ways :

**Table 6 - Some effects of sleep deprivation**

1. Lack of Mental Alertness
2. Impairment of the Immune System
3. Increase in the risk of diseases like Diabetes
4. Causes Daytime sleepiness, drowsiness, and interferes with their daily work
5. The Costs are enormous, 15 Billion in Health Care expenses, and up to 50 Billion in lost productivity in the US, according to one estimate.
6. People’s ability to concentrate
7. Depressed body temperature – feeling cold
8. Lower release of growth Hormone
9. Increase in Heart Rate
10. Increase in Blood Pressure
11. Altered glucose metabolism –
12. ‘Studies show that (d) one in five adults suffer from daytime sleepiness. Among those aged 18 to 34, 50% say that daytime sleepiness interferes with their daily work. (Note – Italics are ours).
13. ‘One recent study showed that young adult men placed on a restricted sleep schedule of four hours each night for six consecutive nights showed (e) altered metabolism of glucose. Their insulin-resistance pattern was similar to that observed in elderly men and in people developing diabetes.’
14. ‘Researchers say there is no doubt there is an association between sleep loss and (f) obesity and (g) diabetes. A lack of sufficient sleep leads to increased appetite – and late-night snacking – and to decreased physical activity.’
15. Hormone imbalance – Ghrelin, which triggers appetite in humans, was found at higher levels in people who regularly underslept, while Leptin, which helps us to stop eating, was found at lower levels in people who did not get enough sleep.
16. The Risk of developing Obesity rises by 23% with only 6 hours sleep per night;

Rises by 50% with only 5 hours sleep per night; Rises by 73% with only 4 hours sleep per night;

17. There is a strong link between sleep deprivation and traffic accidents. Drowsy Driving each year causes 4% of 100,000 to 150,000 crashes in the USA. (National Highway Traffic Safety Administration)
18. William Dement (the pioneering Stanford University sleep researcher) – ‘Most people are carrying a fairly large sleep debt, are impaired, and do not know it.’
19. ‘In September last year, Dement and colleagues published a study that documented the results of lowering the sleep debt.’  
Lowering the Sleep Deficit (Debt) produced improvements in performance, in mood, in cognitive ability, and in energy that were really dramatic (Almost superhuman)

The writer can confirm from experience that the latter statement is entirely credible.

Putting item 16 above. in tabular form we see :

**TABLE 7 – Sleep and Obesity**

<u>Nightly Sleep time</u>	<u>Increased Risk of Obesity</u>
7 to 8 hours	Zero (Baseline)
6 hours	+ 23%
5 hours	+ 50 %
4 hours	+73%

**Table 8 - Some Effects of Chronic sleep shortage :**

- (1) Increased risk of Heart disease and Strokes
- (2) High blood pressure and cholesterol build-up
- (3) Diabetes
- (4) Obesity
- (5) Erectile dysfunction
- (6) Urinary incontinence

The National Sleep Foundation recommends that adults get about seven to nine hours of sleep each night. (<http://uk.news.yahoo.com/lack-sleep-may-lead-gaining-weight-study-054910142.html>)

Christian Benedict who led the research at Uppsala University in Sweden, said ‘Our findings show that one night of sleep deprivation acutely reduces energy expenditure in healthy men, which suggests sleep contributes to the acute regulation of daytime energy expenditure in humans.’

([www.dailymail.co.uk/health/article-1387649/](http://www.dailymail.co.uk/health/article-1387649/) -)

**(g Road Traffic Accidents and Incidents**

‘Not surprisingly there is also a strong link between sleep deprivation and traffic accidents. According to the U.S. National Highway Traffic Safety Administration drowsy driving each year causes 4% of the 100,000 to 150,000 motor vehicle crashes in the United States.’ ‘What most people don’t realise, researchers say, is that sleep deprivation also accumulates over time. People who don’t get enough sleep build up a “sleep debt,” which can’t be eliminated by a simple power nap on the weekend.’

### **(h) Aircraft Pilots Asleep**

([www.telegraph.co.uk/news/worldnews/northamerica/usa/3074890/Pilots-sleep-](http://www.telegraph.co.uk/news/worldnews/northamerica/usa/3074890/Pilots-sleep-) --)

‘Two pilots who slept through their plane’s landing procedure despite repeated radio calls from air traffic controllers were fired by their airline and temporarily suspended from flying.’

‘Over a period of 17 minutes air traffic controllers made nearly a dozen calls to the men.’

### **Long-haul pilots fell asleep at controls**

([www.telegraph.co.uk/travel/travelnews/8433199/Long-haul-pilots-fell-asleep-at](http://www.telegraph.co.uk/travel/travelnews/8433199/Long-haul-pilots-fell-asleep-at) )

‘Of the 492 pilots who participated in the survey, 45 per cent said they suffered from “significant fatigue”. One in five said that their ability to fly an aircraft was “compromised” more than once a week.’

‘Tiredness is now accounting for between 15 and 20 per cent of accidents. Now incredibly the EU wants to increase flying hours.’

‘Last year the Daily Telegraph disclosed that dozens of pilots were falling sick in mid-flight every year.’

### **Feds talk to crew of plane that overshot airport**

([www.msnbc.msn.com/id/33436497/ns/us\\_news-life/](http://www.msnbc.msn.com/id/33436497/ns/us_news-life/))

‘Police say both men in cockpit passed breath tests, apologised after flight’

‘Federal investigators were interviewing the crew of the Northwest Airlines flight that overshot the Minneapolis airport by 150 miles.’

‘Air traffic controllers tried for more than an hour Wednesday night to contact the Minneapolis-bound flight, which later turned around and landed safely.’

### **(i) Train Drivers Asleep**

Perth Train Drivers ‘falling asleep’

<http://au.news.yahoo.com/the-west/a/-/breaking/9157603/perth-train-drivers-falling-asleep/>

‘One in three Perth train drivers has admitted falling asleep while at the controls, ---. The study by the University of South Australia found that one in three of 124 drivers surveyed had fallen asleep and 3 per cent did so regularly. More than 80% admitted they occasionally zoned out when they were driving.’ The research, compiled for the Public Transport Authority, and handed in to the Department in December, found pressure to make timetables run on time was exhausting drivers.

Transport minister Troy Buswell said yesterday that the study was part of ongoing review of operations to ensure ‘world’s best practice –in fatigue management.’

### **(j). Truck and Bus Drivers Asleep**

([www.nejm.org/doi/full/10.1056/NEJM199709113371106](http://www.nejm.org/doi/full/10.1056/NEJM199709113371106))

‘Fatigue and sleep deprivation are important safety issues for long-haul truck drivers. ... round the clock electro-physiologic and performance monitoring of four groups of 20 male drivers - - - We compared four driving schedules ..’ of 5 daytime trips and 5 day/night trips, for both 10 hour and 13 hour trips.

‘Drivers averaged 5.18 hours in bed per day and 4.78 hours of electro-physiologically verified sleep per day over the five-day study. This compared with a mean self-reported ideal amount of sleep of 7.1 + or – 1 hours a day. For 35 drivers naps augmented the main sleep.

No crashes or other vehicle mishaps occurred during the study.

Forty-five drivers had at least 1 six-minute interval of drowsiness while driving, as detected by video recording analysis of their faces. Two drivers had one episode each of Stage 1 sleep while driving as detected by Electroencephalography.

#### ‘Conclusions

Long-haul drivers in this study obtained less sleep than is required for alertness on the job. The greatest vulnerability to sleep or sleep-like states is in the late night & early morning.’

Sleeping truck driver kills 5, injures three at Vietnam market (Hanoi)

([www.monstersandcritics.com/news/asiapacific/news/article\\_1629052.php/Sleeping](http://www.monstersandcritics.com/news/asiapacific/news/article_1629052.php/Sleeping))

#### **NYC bus driver sober, awake before crash**

([www.msnbc.msn.com/id/42239407/ns/us\\_news/](http://www.msnbc.msn.com/id/42239407/ns/us_news/))

The driver of a tour bus that crashed on a highway, ... .. killing 15 people, claims he was sober, rested and fully awake ....’ A 74-year-old woman who survived the tour bus crash claims the driver was speeding and fell asleep.

#### **Las Vegas tour bus driver caught sleeping and driving**

([www.vegas-personalinjurylawyer.com/2011](http://www.vegas-personalinjurylawyer.com/2011))

‘A tour bus driver attending university classes in Las Vegas is facing trial for his role in the death of a 20-year old Japanese tourist during a 2010 accident.’

#### **Sleeping DDOT Bus Driver wrecked woman’s car**

‘A Detroit Department of Transportation bus plowed into two cars ... An investigation determined the driver had fallen asleep in the early morning incident.’ ...

#### **(k). Hypnagogia : nurses and doctors asleep on the job.**

([www.impactnurse.com](http://www.impactnurse.com))

‘Hypnagogia: is that half-dream state or phantasmata that is experienced between the sleeping and waking state.

It is often described by Doctors and Nurses working extended periods without sleep during night duty, or during the frequent flip-flop from daytime to night-time shiftwork.

Common experiences of hypnagogia include random two or three-dimensional geometrical visual patterns known as phosphenes, which may include speckles, lines and more complex designs.

Auditory hallucinations, such as sudden loud bangs, alarms or hearing your name being called out, or even clearly heard nonsensical spoken sentences.

Proprioceptive experiences of change in body size or proportions, sensations of floating or out-of-body experiences.

A condition described as daytime parahypnagogia (DPH) , has also been studied which consists of spontaneous intrusion of a flash image or dreamlike thought or insight into one’s waking consciousness.

The cognitive effects on doctors and nurses of having to work within highly stressful environments, requiring complex decision making, and fine motor co-ordination during periods of prolonged sleep deprivation or sleep ‘rationing’ is self-evident to all who experience it.’

Here is a list of just a few of my colleagues (**and my own**) experiences combining hypnagogia and straight out fatigue whilst working night shift:

### **Table 9 – Some Experiences of Hypnagogia**

Unable to focus on drug ampoules  
Unable to focus on writing patient notes  
Fell asleep whilst writing patient notes  
Wrote in wrong patient notes  
Dribbled all over patient notes  
Fell asleep in car on my way home (common occurrence which often happens at traffic lights)  
Got into back seat of my car after shift  
Falling asleep whilst interviewing patient  
Unable to feel any empathy for my patients  
Unable to feel my legs  
Unable to feel in touch with reality  
Kept walking into doorways  
Walked back to wrong war.  
Couldn't get the sound of a full orchestra tuning up out of my head  
Medication errors  
Fell asleep whilst performing CPR (!)  
Forgot to turn patients oxygen on during resuscitation  
Repeatedly heard someone call out my name from behind me  
Tripped over chair falling onto floor ... and then fell asleep  
Dream images mixing into reality ... feelings of detachment  
Carrying full bedpan ... let it drop to my side as if it were an empty one, spilling contents all over myself'

'And my own personal favourite story of all. I was watching a friend of mine giving an elderly patient with dementia (who was quite unsettled) her slow push IV antibiotics. As she was a little weary she pulled up a chair and sat down next to the ladies bed as she delivered the medication over several minutes. Five minutes later I happened to look back over to see the nurse soundly asleep in the chair, slumped across the patients lap. The lady was gently stroking the nurses hair and quietly singing a lullaby.'  
'impactEDnurse is also known as Ian Miller, a nurse with over 26 years experience working in a busy emergency department in Australia. - - - '

### **(l). Another Effect of Sleep Deprivation –Sleepwalking**

Sleep-walking 'it is estimated that sleep-walking, which has been linked to aggressive and injurious behaviour, affects up to 4% of people.' 'More and more adults are suffering from sleepwalking and it may be due to the fact that we are increasingly a tired, sleep deprived 24/7 society.' (<http://news.bbc.co.uk/2/hi/health/7300527.stm>)

### **(m) Sleep Apnoea and Other causes of poor quality Sleep**

Not all poor quality sleep is due to noise intrusion. The occurrence of sleep apnoea is also noted as being a significant factor. Anybody suffering from this complaint is advised to have it investigated. There are devices and machines on the market which are reported to be very helpful in combating this condition.

**(n). The AA Ezine for April 2011 had an article on the subject of 'Driver Fatigue'.**  
It was headlined 'Don't act the 'brave soldier' when it comes to driver fatigue this Easter.'

‘As Easter runs into the May bank holiday this year no doubt many of you will take the opportunity to have a longer break and drive longer distances. We would however warn you not to ignore one major killer – fatigue.’

‘Fatigue is a well known killer internationally but not here in Ireland.’

‘Driver fatigue doesn’t mean that you actually fall asleep. What happens is that concentration wavers and you drift in and out of full awareness, even with your eyes open. These moments of ‘micro-sleep’ can be lethal. Take your attention from the road for 3 seconds and at motorway speeds you will travel blind for 100 metres – the length of a football pitch.’

The article goes on to note ‘Symptoms of driver fatigue :’ as follows –

Table 10 – AA ‘Symptoms of Driver Fatigue’

‘Yawning	Blinking a lot
Fighting to keep your eyes open	
Struggling to focus on the road	Daydreaming
Rubbing your eyes	Blurred vision
Drifting across lanes	
Struggling to remember the last few kilometres	
Sensation of heavy limbs	Slower reaction times
Restlessness/Boredom	Falling asleep at the wheel’

The article also gives ‘AA advice on preventing driver fatigue.’

**NOTE 20:** There is an instrument on the market which monitors a driver’s level of alertness while driving. (See [www.seeingmachines.com/product/DSS/](http://www.seeingmachines.com/product/DSS/))

**(o). Effects on Task/Work Performance : (Ref.5, Kryter)**

Page 663 The main conclusions in this area are (1) noise can be detrimental to the performance of any task that involves audition, possibly including “internal speech”; and (2) noise can be a benefit to the performance of tasks that do not involve audition because it can cause some physiological arousal and/or prevent, by masking, the perception of distracting sounds; (3) noise can be a detriment to task performance, because of psychological concerns that are related to meanings attributed, consciously or unconsciously, by the worker to the noise.’

‘Some studies and theories suggest that reduced performance on some insoluble puzzle tasks following exposure to noise is due to feelings of “helplessness” to control the unpleasant noise environment. This interpretation implies that noise is inherently psychologically unpleasant.’

**Physiological Stress**

Page 664 (Ref.5) ‘However, noise can be an indirect cause of physiological stress by virtue of the fact that noise can interrupt and prevent behaviour dependent on hearing speech and other auditory signals, interrupt sleep, cause unpleasant house-structure vibrations, and cause feelings of fear associated with the sound of noise. Physiological stress responses to these emotion-arousing effects of the noise appear to be a cause of some mental and physical (psychosomatic) health problems in noisy industrial and residential environments’. It is not known, for sure, whether noise was a factor in any of the incidents reported in Section 11 of this report. But it MAY have been causative in some or even all the reported incidents of sleep loss and/or deprivation.

### (p). Illness and Noise

On at least two of the larger of the proposed construction locations i.e. East Wall and Inchicore, there is a significant population of older people. There were reports also of some of those, and some of the younger people too, who suffered from one illness or other. It is known that people who are unwell have less resistance to the stress caused by noise. This means that recovery from illness is delayed. It is also known that noise exposure – day or night - can exacerbate some illnesses.

### Noise and Sleep (2)

We know that there are other causes of poor quality sleep. How many we do not know.

But it is very clear to this writer that NOISE is a very common source of sleep disruption and consequent poor sleep quality. Yet there are many areas – even in Dublin city – where the night time environment is sufficiently quiet that people can and do enjoy good quality sleep.

But when people are needlessly impacted by noise at night, it is a most disappointing occurrence – especially since there are a number of measures and remedies, which can be employed to reduce the impact if not totally eliminate the nuisance caused by noise.

Furthermore, it is not acceptable that a currently noisy night time environment is to be considered a sufficient basis for introduction of yet another night source of noise – even if the current noise is mainly road traffic, which latter is the most commonly acceptable and widely experienced noise source. There is a limit to what people can tolerate.

Noise is a significant source of concern about lack of proper sleep quality, and the clearly known consequences of that.

Therefore it is appropriate to report on the dangers of night-time noise-induced sleep disturbance, and the potentially very serious consequences of this.

### A General Recommendation

Some people might wonder if these are alarmist concerns. We answer that to some people the dangers described herein have been evident for some time. To some other people these dangers are just coming to their notice/

And now that there is sufficient evidence – in this writer’s opinion – that the dangers of night time sleep disturbance by noise are seen to be real, it is incumbent on us to advise accordingly.

In other words we must recommend that there be **NO NIGHT TIME (2200 to 0700 hours) NOISE DISTURBANCE OF SLEEP FROM THE PROPOSED DART UNDERGROUND CONSTRUCTION PROJECT.**

### (q). Why Any Need for Concern ?

The EIS Non-technical Summary (page 13) states that ‘The working hours are proposed to be 24 hour, 7 days per week, at the tunnel boring machine driving site during tunnelling activities and at both portals thereafter.’ ‘Working hours for construction of the portal structures as well as the for the station and vent shaft sites will be 0700 to 2300 on weekdays and 0700 to 1500 on Saturdays, Sundays and public holidays.’

24/7 working at (a) the Proposed Eastern Portal, and (b) the Proposed Western Portal are potential areas for disturbance of sleep by noise. Also similar potential noise-induced sleep disturbance situations are the proposed Reconfiguration of railway lines in (a) East Wall, and (b) Inchicore, as well as works at every station box and shaft.

And, in Section 6.5.7.2 of Vol.2, Book 2, the Maintenance Facility is described as a 24/7 operation. (*With considerable potential for night time sleep disturbance*) (Italics are ours.)

EIS Volume 2, Book 2, Section 6.5.7.2 ‘Maintenance Facility and ESB Substation’ states ‘The maintenance facility will serve as the hub for daily maintenance activities and will house all equipment, spares and road-rail maintenance vehicles and a new ESB substation , which will occupy the south eastern corner of the site. The maintenance facility will be operational 24/7 with staff working in shifts. It is estimated that the majority of staff will be required for the night shift - - - -’

In the ‘Agreed Position’ between Iarnrod Eireann and DCC, Final Version, 30 November 2010, in Condition No. 47 is stated :

- (i) ‘The airborne noise criteria that shall apply to any surface works shall be those detailed in the EIS, which are based on the relevant British Standard BS5228 Part 1 (2009). This standard reflects changing sensitivities to the receiving environment for day-time, evening-time and night-time periods but also take account of existing ambient noise levels which are particularly important in a varying city environment for a linear scheme. BS5228 Part 1 (2009) proposes a limit of 55, 60 and 65 dB LAeq (dependent on the existing background levels) for Sunday periods between the hours of 0700 and 2300hrs.’
- (ii) PPPCo shall comply with all the requirements and directions of the Traffic authority and the Road Authority, which may require certain works on public roads and streets to be carried out outside of normal working hours. In such scenarios, where working at night-time is required to mitigate the effects of the works on other environmental aspects (i.e traffic disruption, etc) it may be possible to complete such works within the threshold limits specified in the EIS. Any works proposed outside of normal working hours will only be undertaken with the prior written permission of Dublin City Council’s Traffic Authority and/or Road Authority.’

Our Comment : The BS5228 methodology is not suitable for night time locations which are very quiet e.g with LA90<sub>5mins</sub> under 40 dBA.

In fact all our recommendations on Construction noise limits are for construction noise alone. In day and evening time, for the most part, these will be the same as the BS5228 limits.

#### ( r ) Ongoing Potential for Sleep Disturbance

The daytime and evening noise emissions (15 hours a day) will frequently be clearly noticeable to local people. There is a distinct risk, that if ANY night time disturbance of sleep occurs in the earlier days of the proposed construction works, bearing in mind that people are keenly aware of the prospect of the works continuing for up to 7 years or possibly longer, it is likely that people in any such community affected by sleep disturbance, will mount a strong objection – and possibly seek an injunction - against the works, in order to avoid ongoing disturbance of their sleep.

’ONGOING ‘ disturbance is what people would inevitably expect in view of (a) their past disturbing experiences of evening and night time noise from track-works and idling engines, and (b) the prospect of such a long construction project.

#### (s). Track realignment works

In the EIS, Vol.2, Book 2, P.8-37 is stated that Track realignment works at East Wall at 10

and 20m, are estimated to cause noise levels of 77 and 76 LAeq, without mitigation. Such levels, should they occur at any residence, would be quite intolerable – even in daytime.

In EIS Vol.4, Appendices, Table A8.3.25 ‘Rail Realignment Works’ the noise level due to rail realignment works is given as 62 dBA at 100 metres away. For the kind of highly tonal and highly impulsive nature of this noise (cutting steel, welding, grinding of welds, track tamping, vibratory rollers etc) this is an intolerable noise level to be exposed to at any time – without mitigation. (It could actually be 67 dBA at 100m).

One resident and observer at the Oral Hearing stated that it is not possible to sleep during those works. That statement is totally credible, regardless of their residential glazing quality. (These works frequently occur at night.)

#### Essential Good Management and Supervision of Environmental Controls

It is essential that the promised high quality management and supervisory measures, outlined in the EIS, and restated and clarified during the Oral Hearing, be honoured in relation to noise control of the proposed works. It is very desirable that, in the early days and nights of the proposed works, a high level of management goodwill towards neighbours is evident.

It is vital that the Supervision on the ground is alert and responsive and that the corresponding actions are seen to be effective.

It is vital that these policies and actions are seen to be in force from the beginning of works on DAY ONE.

When people see that the promises made in the Oral Hearing are being kept, and that they can RELIABLY expect, that having endured significant noise impacts for 15 hours, that, AT LEAST from 2200 to 0700 hours, their rest or sleep quality will not suffer due to the Dart Underground works, then it is considered that the realisation of such a condition will inevitably bring about an increase in goodwill towards the project and towards the promoters and the contractors.

#### Occasional Night Works – Special Exemptions

We recall that there will be need for an occasional night’s activity, which is likely to be noisy, when a very large machine or other large load has to be delivered onsite, or shipped out. But such occasions should be kept to a minimum, and advised in advance to the people affected – as well as to Dublin City Council (DCC). It is understood, in any event, that a special permit will be required from DCC for transport of any very large or hazardous load.

We recommend that the maximum number of such occasions should be no more than 10 per annum on any given site – with no more than 2 in any week, and no more than 4 in any 30 day period. See Recommendation 29(R).

#### (t). No Noise-induced Sleep Disturbance – An Essential Principle

It should be an absolutely sacrosanct principle that apart from those allowed nights, there should be NO NIGHT TIME NOISE DISTURBANCE OF SLEEP FROM THE PROPOSED DART CONSTRUCTION PROJECT, at any work location.

We recommend that the night time period be from 2200 to 0700 hours. We understand that some people would like a longer night time period. However, even while bearing in mind the very serious potential impacts of such night sleep disturbance, it is considered that 9 hours is a reasonable period of night time peace and quiet. It is the minimum recommended.

We recommend, similarly, that Sundays and Bank Holidays should also be regarded as absolutely sacrosanct times for zero above ground audible airborne construction noise in any residential room with a window ajar..

#### EPA Guidance

We recall the EPA guidance that there should be No Tonal noise and No Impulsive noise at night time – regardless of the level. It is considered virtually impossible to do any construction work, including maintenance of machines, without some tonal and/or impulsive noise.

In view of our recent findings, on the effects of sleep deprivation, we do not wish to support any possibility for night-time noise which has any potential to degrade anybody's sleep quality.

We ,therefore, must restate that there should be **NO NIGHT TIME AIRBORNE CONSTRUCTION NOISE FROM THE PROPOSED DART UNDERGROUND** project which is **AUDIBLE** at any **RESIDENTIAL LOCATION**.

#### Heuston Station

It is possible that the proposed construction works at Heuston Station, could, by virtue of the distance to nearby residences, and/or the intervening existing structural walls of the station behind which much of the proposed works would occur, allow the opportunity to state that it is possible that it may be feasible in this location to carry out construction work, above ground, on a 24/7 basis.

It may be, that the existing noise screening features, might need to be supplemented by semi-permanent portable screens, in order to ensure that there are no emissions of any construction noise to any residence, which could cause sleep disturbance to the residents therein.

We therefore recommend that under such conditions, construction work could be allowed at this location, on a 24/7 basis.

It is considered that this 24/7 overground work option simply does not exist at any other proposed work location for the Proposed Dart Underground. However, see the following section 'Tunnel Works ....'.

**NOTE 21** – It should be confirmed by (a) personal real-time observation and/or (b) unattended monitoring, at Heuston Station, that, whenever there is work in progress at night, **THAT WORK** is simply **NOT AUDIBLE** at any residence. This will require an adequate amount of personal observation/monitoring at the sensitive locations, along with observation of the wind direction (if any). This personal observation time might be optimised by suitable simultaneous monitoring of noise at one or two locations nearer the actual works location.

**NOTE 22** – Similar observation and monitoring will be needed, on an ongoing basis, during daytime and evening works – at **ALL WORK LOCATIONS**, in order to ensure compliance with the applicable noise limits.

#### Tunnel Works and Stop-Box & Shaft works.

It is expected that works within tunnels, being some 20 metres or so below ground, will only emit airborne noise to any residence at or near the portals, and Stop-boxes, and Shafts. At East Wall the proposed Gantry Enclosures are expected to contain – by suitable design – all airborne noise from activities within both the Tunnels and the Gantry enclosures

themselves. Thus whatever activities take place inside the enclosures should not be audible at any outside nearby residence from 2200 to 0700 hours.

In relation to Stop boxes and Shafts at each proposed location, we recommend that night time works on these should only take place after they have been 'roofed in' – i.e. the decks are in place, and any works would be inside the box rather outside the box.

Also, it is our view that no spoil should be extracted through the deck between the hours 2200 to 0700. Nor should any external crane – or other machine – operate, between 2200 and 0700 hours, in a manner which is audible at any residence.

#### Bank Holiday Weekends

Thus the Gantry Enclosures will need to be big enough to accommodate 64 hours of tunnelling supplies – since (we recommend that) there will be no overground outside use of Forklift Trucks or other handling of materials or parts for the tunnel works which may be audible at a residence, at night, and we recommend that Sundays and Bank Holidays should be similarly quiet at local residences.

Alternatively we recommend that the proposed nearby storage of tunnel supplies, and the travel path to the tunnel be constructed, so that any noise of forklift trucks or other source, is effectively prevented from being emitted to any local residence.

#### (u). Proposed Maintenance Building and Facility

EIS Volume 2, Book 2, Section 6.5.7.2 'Maintenance Facility and ESB Substation' states 'The maintenance facility will be operational 24/7 with staff working in shifts. --- Three 8-hour shifts starting at 8am, 4pm and 12am are expected with 10 staff required for the first two shifts and 40 for the night shift. However it is anticipated that only a portion of maintenance related staff will be required to visit this facility daily (foremen, engineers, etc) with the majority of maintenance staff spending their working day wherever the maintenance works are required.'

The proposed Maintenance Building location is c.50 - 110 metres from a number of local houses in Abercorn Road, Blythe Avenue, Malachi Place and Church Road.

In evidence to the Oral Hearing on Day 37, (18/2/2011) Mr. Flaherty, for the Applicant, stated that 'there is no maintenance work as such happening there. It is as I indicated this morning, the maintenance facility generally is a store for the materials, et cetera, that are required for the maintenance of the tunnel itself. So it is the loading and unloading of vehicles.'

Thus the main likely potential sources of activity-generated noise in this area are the loading and unloading operations which will be required there. This is likely to include (a) use of forklift trucks and (b) entry and exit of railbound engines and wagons, and (c) entry and exit of road vehicles such as vans and trucks, including, possibly, heavy goods vehicles (HGV's). There could also be noise from (d) reversing beepers/alarms on vehicles.

In the EIS, Vol.2, Book 2, p.8-3 the Maintenance facility is included in 'items of fixed plant considered to be key sources of potential noise and vibration'.

In page 8-46 the Night time LA90 at Abercorn Road is given as 45 LA90. This seems high, and should be checked and confirmed. This figure is proposed to be used as the reference value for the allowed night time level from 'fixed plant'.

However, we understand that all activities in or at the proposed Maintenance facility, must be considered in assessing its impact on the local environment. This must include all

associated vehicle noise, as well as any PA system or other plant such as the AHU, which may be at the facility.

In page 8-59 'The range of noise limits set for the fixed items of plant is such that it will be imperceptible and will in turn be of neutral impact.' We believe that this statement is applicable to the Maintenance Building AHU but not the Facility itself and its main works.

**NOTE 23** - We find no assessment, in the EIS, of the associated noise emissions from the proposed loading and unloading activities at the Maintenance Building/Facility.

In Book 2, Vol.2, Table 8.19 'Allowable noise levels from Fixed plant - - -' and LA90<sub>5mins</sub>(at night) including the Maintenance Facility AHU (Air Handling Unit or airconditioning plant), a value of 45 LA90<sub>5mins</sub> is given as the allowable value. The activities in and around the Facility are likely to be of much higher sound power level than the Facility AHU, and there is no noise assessment of the proposed loading and unloading, in the Dart Underground EIS.

EIS, Vol.2, Book 1, P.3-38 'Description of the Maintenance Facility' states 'The Maintenance Facility comprises two maintenance sidings, each providing maintenance vehicle standing of approximately 40 m in length. The lines for the on-track Maintenance vehicles are connected to the IE rail network and a route is provided via East Wall Junction to give access to the DART Underground eastbound and westbound lines.'

This means that Railway engines will need to enter the area for loading or unloading of parts & materials, and exit the area when ready for delivery of the parts to wherever required. While onsite they may need to be idling at times, and possibly to be revved up on occasion.

In the EIS, Vol.2, Book 2, P.5-41 is stated ' -both portal sites will be required to operate on a 24-hour basis for the servicing of works trains installing the permanent railway equipment.'

#### 'Trip Generation'

'The maintenance facility will generate the most traffic between 8-9am and 11-12pm, coinciding with the shift schedule.'

Any noise at 11-12pm (midnight) has the potential to disturb sleep in some local people. We cannot emphasise, sufficiently, how important it is to avoid sleep disturbance of anybody between 2200 and 0700 hours.

And we find it difficult to imagine how train engines (or any large-engined vehicle) can be brought into or out of the Maintenance Facility, in its proposed location, at night, without causing noise with significant potential for sleep disturbance locally.

There is a possibility that a light electric powered vehicle could be so operated, along with a purpose designed permanent noise screen and some partial temporary screening system. A temporary screen system is likely to be needed, which can be placed at right angles to the tracks for noise screening of some residences. Alternatively an enclosure around the sidings, with hydraulically or pneumatically operated moveable shutters/doors which do not emit any impulsive sound in operation, may be considered for the total operations.

### Maintenance Facility - Over 60 Local Residences likely to be Impacted

The proposed Location for the Maintenance Facility has over 60 nearby residences which could be affected by any noise emissions from its activity. These houses/apartments are located at distances of c.50 to 110 metres from it. They are in Abercorn Road, Blythe Avenue, Church Road and Malachi Place. There is a real potential for noise disturbance of sleep from the Proposed Maintenance Facility unless strict conditions are in place.

Such conditions would include the following :

1. Noise of Train Engines and all other noise sources, at the Facility – including entering or exiting the facility - between 2200 and 0700 hours, to comply with the recommended noise limits. Similar compliance with daytime and evening noise limits is recommended. (We cannot envisage engine or carriage movements, in this area, complying with the night time noise limits, without extensive use of screening construction both permanent and/or temporary & movable)
2. Any Noise from Idling of engines between 2200 and 0700 hours, to comply with the recommended noise limits. Similar compliance with daytime and evening noise limits is recommended. (We cannot envisage idling train engines, in this area, complying with the proposed night time noise conditions. Other means of keeping engines hot should be considered.)
3. Determination of the existing LA90<sub>5mins</sub> between the hours of 0100 and 0500 hours (48 readings), on at least two reasonably calm and dry nights – with no rail activity except for the 2 or 3 freight trains which pass by nightly. This to be done in each of the four areas noted above, at an appropriate & representative location in each area.
4. That the relevant night time values for the lowest recurring LA90<sub>5minutes</sub> be agreed with the Environmental and Engineering Department of Dublin City Council.

### Table 11 - Some Proposed Works at the Eastern Portal

Works at the Eastern Portal constitute by far, the greatest potential for noise emission to nearby residential areas, of any of the proposed construction sites, over the lifetime of the proposal. These works and Activities include the following :

1. Installing of Site Boundary Hoarding
2. Site Clearance works using earthmoving machines
3. Installing of site Portacabins and Offices
4. Installing of site services (Electricity, Water, Sewage, Communications)
5. Proposed Reconfiguration of site Track system & Layout
6. General Construction Compound Activities including FLT (Fork Lift Truck) movements of supplies to Tunnels and around surface site, and importing of supplies via rail vehicles to the Maintenance facility – NOT AT NIGHT.
7. Construction of proposed Launch Pit for Tunnel Boring Machines (TBM's)
8. Construction of proposed Portal
9. Operation of the proposed Portal
10. Installation of Proposed Gantry Cranes
11. Construction of proposed Gantry Crane Enclosures
12. Installation of Tower Cranes
13. Operation of Tower Cranes
14. Cut and Cover works and Retained Cut Works
15. Earthworks and Construction of proposed Ramp up to Northern Line Tie-in

Table 11 (continued) - Some Proposed Works at the Eastern Portal

16. Operation of the proposed ramp as a Haul Route
17. Earthworks for and Construction of Maintenance Facility
18. Operation of proposed maintenance facility – ‘The maintenance facility will serve as the hub for daily maintenance activities and will house all equipment, spares and road-rail maintenance vehicles - - ‘
19. Earthworks for and Construction of proposed Substation
20. Operation of the proposed Substation
21. Earthworks for and Construction of proposed Operation and Control Centre (OCC)
22. Operation of the proposed OCC
23. Earthworks for and Construction of proposed Ramp to Sheriff St. Upper
24. Operation of the proposed Ramp to Sheriff St.- Haulage of Spoil
25. Diversion of West Road
26. Construction of proposed New Bridge on West Road
27. Construction of proposed Railhead for Materials Delivery
28. Construction of potential proposed Railhead for potential Rail Haulage of Spoil
29. Construction of Proposed Spoil Conveyor system
30. Operation of Proposed Spoil Conveyor system
31. Construction of proposed East Intervention Shaft
32. Construction of proposed Fork Lift Truck Garage/Maintenance shed
33. ‘Consolidation area’ for supplies to the tunnels, as well as supplies for the works at the Eastern Portal and other structures in the East Wall Area.
34. Delivery of Large Machines and Large Supply Loads. These include Cranes (Tower and Gantry), Drilling/Piling Rigs, Hydrofraise Rigs, Excavators.

This is in addition to operational passenger and freight train noise, and engine idling noise.

Criteria - Industrial Noise - Community Response

Environmental Noise Impact is the effect of noise on People. So it is inevitable that reactions to undue noise are subjective, and sometimes emotional. ‘The residents of entire quarters very often deeply hate the racket of motor scooters and ‘mopeds’ (which are rarely equipped with effective exhaust silencers), which is the very heart of the enjoyment youngsters derive from them. Reactions are even more acute when the owner of a noise source is positively disliked as a person or when the noise source itself is the object of the aversion. If, despite all efforts, the impact of noise cannot be reduced, more often than not a process of psychological ‘self-escalation’ sets in, which may lead to neurotic illnesses in individuals and even entire families – not to speak of the possibility of mayhem.’ (Par. 3.2.4.8 Ref.2)

This means that it is illogical to expect people to ignore their painful historical experiences of a particular noise source, such as, in this instance, a railway station or railway yard, and the consequent need for effective reassurance that such experiences will not recur in a proposed new scenario, such as the current Dart Underground proposal.

We recognise that, while ‘painful historical experiences’ were probably a result of an older historical culture, by which things were done as they always had been done, with little thought about environmental matters, there is now in place a new and younger cadre of management and professional people who are promoting the Dart Underground project.

Thus we can expect that the proposed level of management and supervisory controls for the Dart Underground project will result in an entirely acceptable level of sensitivity towards neighbours, and respect for them, in each proposed Dart Underground work location.

(v). Conclusion Regarding Sleep

We now must acknowledge receipt of the evidence herein that sleep disturbance has serious impact and that sleep deprivation has adverse consequences for those people who are affected by it.

And to respond to this evidence positively, we must give a clear and unambiguous recommendation that the proposed Dart Underground works should not cause any noise-induced sleep disturbance between 2200 and 0700 hours (Monday to Saturday) and that Sundays & Bank Holidays should likewise be days of rest, for neighbours, from audible Construction Noise.

It is considered that the traditional reduction from Daytime noise level to Evening noise level is not a great help to a student needing quiet to study for an important examination. Thus we should be prepared to ENSURE, that after 15 hours of noise, we can afford such a person an undisturbed 9-hour period for rest and sleep. Likewise for an ill person. Good quality sleep is also important for babies and young children.

Bearing in mind that our bodies and minds need the restorative action of the night time and the traditional weekend rest, it is concluded that with such a body of evidence (collected here) concerning the value of undisturbed sleep, we simply have to conclude that it is vital for the appropriate authorities to do all in their power to protect this vital process, on behalf of their constituents, and thereby enhance their quality of life.

Thus we recommend that the proposed Dart Underground Developers and Contractors take every possible precaution to achieve a night time environment which does not cause any noise-induced sleep disturbance, but rather facilitates the enjoyment of proper sleeping conditions for all potentially affected neighbours.

Therefore we recommend the night time and weekend noise level limits given in recommendations 29 (B) and 29 (C) as both appropriate and essential.

12. Dublin City Council Construction Noise Requirements

The Dublin City Council website gives the following information on ‘Construction site Causing noise’

Ref. [www.dublincity.ie/WaterWasteEnvironment/AirQualityMonitoringandNoiseControl](http://www.dublincity.ie/WaterWasteEnvironment/AirQualityMonitoringandNoiseControl)

‘We investigate complaints regarding noise nuisance caused by construction sites. Construction sites, by their very nature, can create a great deal of noise, with some activities e.g. pile driving, causing particular disturbance. The aim of our investigation is to determine compliance with the principles of best practice with regard to the minimisation of noise from the site.’

‘Construction site work starting early in morning or continuing late into the evening’

‘The permissible hours of operation of a building site within Dublin City are :

Monday to Friday                      0700-1800

Saturday                                      0800-1400

Sundays and Public Holidays      No noisy work on site.’

‘These hours are often specifically conditioned at the planning permission stage, and therefore are enforced by the Planning Enforcement Section of Dublin City Council.’

‘In the event that a planning condition has not been applied regarding hours of operation, the Air Quality Monitoring and Noise Control Unit will deal with the complaint.’

### 13. Belfast City Council Noise Limits

(Reference - [www.belfastcity.gov.uk/noise/construction.asp](http://www.belfastcity.gov.uk/noise/construction.asp))

#### ‘Building Sites’

‘We try to make sure that, where possible, noisy building work is restricted to the following hours:

Monday to Friday – 7am to 7pm

Saturday – 8am to 1pm.

#### ‘Residential Areas’

‘In residential areas or in close proximity to dwelling accommodation, the priority is for residents to be able to sleep at night.’

‘Site noise expressed as LAeq 1 hour at the façade of noise sensitive premises may need to be as low as 40 dB(A) to avoid sleep disturbance. Work should therefore be conducted during the day, but for lengthy projects it is desirable to have some daytime respite e.g. Saturday afternoon, Sundays and Bank Holidays.’

‘Evening work needs special consideration and evening limits are typically set 10 dB(A) below daytime limits.’

The following limits may be applicable in certain circumstances:

‘Noise from construction activities shall – not exceed (at 1 metre from any façade)

- (a) 75 dB LAeq 12 hour between 0700 and 1900 hours on Mondays to Fridays  
75 dB LAeq 5 hour between 0800 and 1300 hours on Saturdays.
- (b) 65 dB LAeq 1 hour between 1900 and 2200 hours on Mondays to Fridays  
65 dB LAeq 1 hour between 1300 and 2200 hours on Saturdays.
- (c) not be audible between 2200 hrs and 0700 hrs on Mondays to Fridays, 2200-0800 hrs on Saturdays, or at any time on Sundays, at the boundary of any residential accommodation.’

‘Routine construction and demolition work which is likely to produce noise sufficient to cause annoyance will not normally be permitted between 2200 hrs and 0700 hrs.’

### 14. Noise Mitigation (Reduction) Measures

CIE/Iarnrod Eireann have shown a clear commitment to control the levels of airborne noise, through design and mitigation, from within each of the respective work sites in this proposed project. Furthermore we have heard evidence, during the Oral Hearing, that where this is not fully possible, other mitigation options will be available, such as temporary relocation of residents. In some cases the application of extra sound insulation to an affected residence may be the preferred and agreed solution to an excessive noise level.

For Proposed Trackworks for Dart Underground – and any trackworks – some noise barriers should be designed so that they may be placed across the tracks, to screen houses in more than one direction

### Noise Barriers

Noise Barriers are very effective at reducing the noise level incident on a building, whether it is a dwelling or hospital or school or church – wherever people occupy the building and their activities therein might be adversely affected by the noise.

The actual numerical noise reduction depends on a number of factors such as:

- (a) The physical size (height and width) of the barrier;
- (b) The weight/m<sup>2</sup> (or density) of the barrier material, (See Table 1 herein) and
- (c) The closeness, distance wise, of the barrier to either the noise source or the noise receiver.

Barriers may be opaque or Translucent. A minimum density of 7 kg/m<sup>2</sup> is sometimes recommended. This is the density of 12mm thick plywood. A plywood thickness of 18mm has a density of c.10kg/m<sup>2</sup>. This is the minimum density recommended here for single-skin noise barriers. (Some authorities recommend 20kg/m<sup>2</sup> or higher (Ref.22).

Glass has often been used as a Barrier Material. Being translucent, glass has the benefit of allowing daylight through thereby preventing shadowing or darkness from occurring where this is a likely problem. Some of the houses likely to be impacted by the proposed scheme may require a translucent barrier. Some such houses are so close to the proposed works that it may even be worth considering the construction of conservatories at the affected houses , particularly where the proposed works are likely to occur on the south-facing side of the dwelling. Such a conservatory could have the added advantage that it may also protect the residents from any likely dust impacts.

Rail Realignment Works ('Trackworks') are one of the noisy operations undertaken on an ongoing basis, for which it is recommended that proper and appropriate noise barriers – movable and of appropriate height and length and design – should be deployed. At least some of those barriers will need to be placed across the railway tracks, at right angles to them. It is likely that such barriers may be large and heavy, and may therefore need to be emplaced, and removed, by crane.

**British Standard BS 5228-1 : 2009** 'Code of practice for noise and vibration control on construction and open sites – Part 1 : Noise' gives a range of mitigation measures for noise control. These include Site planning, Control of noise at source, Controlling the spread of noise, noise of reversing alarms, haul routes, the use of distance, Screening, and other useful data. This includes a Table B.1 on 'Methods of reducing noise levels from construction plant'

Noise Mitigation measures should, where possible, be designed and built in before construction work begins. However there are some works which will not be confined to a simple clearly defined site. Examples of this are road works, utilities diversions, track laying and other track-works.

Accessibility or ready availability of suitable – and portable - noise barriers, or enclosures, will be important at times, particularly where, as in utilities diversions, mobile plant or normal operations are not confined to a definite location, but move along past numbers of premises at a rate determined by the nature of the work itself. Appropriate on-site management decisiveness and specialist supervision of mitigation measures on an alert ongoing basis will be needed to maintain effective control of noise emissions to minimise impacts – especially for any occasional night working which may be needed. And it is

worth bearing in mind that any such portable barriers used during the initial utilities diversions will be available for later use during the main construction phases of the project.

The site-boundary barriers of proposed height up to 4 or 5 metres, or even 7 metres, as the EIS proposes in St. Stephens Green, may at times be needed. It will be totally essential, for good noise control during night work on railway lines, for example, to have suitable portable barriers on hand, in sufficient quantity, in order to effectively minimise noise levels as far as possible, since such works – IF ALLOWED AT ALL - have the potential to generate noise levels over 70 dBA at numerous houses, and even on a short term basis such noise levels could be very disturbing at night, particularly since those works are likely to be significantly TONAL and IMPULSIVE. See Recommendations 29(B) and 29 (C).

It will be important to progress this project without undue negative feedback about the associated construction noise. Suitably rugged construction and a means of moving barriers on demand, will be needed. There may be benefit in some places for the use of bi-planar awning-type barrier constructions – if there are local constraints on barrier height. Any barriers in place for the medium to long term future may also benefit people from having suitable murals on them. These can act to ameliorate any negative impact felt by residents who live nearby.

#### 15. Construction Noise

Construction activities are a common source of noise. These by their nature are usually of limited duration so that when a structure is built and finished, the associated noise usually ends. People might, however, question the use of ‘limited duration’ for a project of projected duration 7 years or more..

People realise, nevertheless, that the building or improvement of a road, or bridge, is for the common good – for everyone’s benefit. Likewise people realise that a railway line and its associated stops or stations, is intended for their benefit as well as everybody else’s. For these reasons people have a greater tolerance for construction noise than for industrial noise, or for transport noise. This means that planning authorities can allow higher noise levels to occur at noise-sensitive premises, from construction, than they do from more permanent noise sources. There is, of course, a limit to what people can tolerate, particularly when the noise persists for long periods of time.

Construction of Dart Underground at a number of the proposed sites is projected to last up to 7 years or more – although the noisier phases of work may only last for part of that time. This is a long time for people to be exposed to high construction noise levels, all day, every day, for 6 days per week, and every effort to minimise those levels is desirable.

And with such sustained works in prospect it is important to allow as much as possible of the weekends to be free of such noise - Saturday afternoons, Sundays and Bank Holidays particularly, and it is considered essential that there be No Night time Noise-induced Sleep Disturbance due to Dart Underground construction.

**NOTE 24 :** In this context it is considered that there is merit in considering the option of allowing construction work to proceed on Saturdays at the Monday to Friday pace (Noise limit) for shorter hours, say up to 1400 hours, rather than allowing it to proceed to 1500 hours at reduced pace (lower noise limit).

Some Notes from the DECC (New South Wales) document ‘Interim Construction Noise Guideline’ (DECC is the Department of Environment and Climate Change)

See Ref. 21.

Definitions of ‘Feasible’ and ‘Reasonable’ are given on page.4;

Page 5 – ‘the bridge footings were constructed during standard hours and night-time works were limited to two non-consecutive nights of operating a crane to lift the pre-fabricated bridge sections into position.’

Pictures of Temporary Noise Barriers are shown on pages 5 and 6 .

‘Work practices that both reduce noise levels in the workplace as well as reduce noise impacts in the community should be given a high priority for any project.’ page 7.

On page 8 ‘No work on Sundays or public holidays’ is seen in Table 1 ‘Recommended standard hours for construction work’.

On page 11 ‘The proponent should also inform potentially affected parties of the activities to be carried out, the expected noise impacts and duration.’ and

‘Residents are usually most annoyed by work at night-time as it has the potential to disturb sleep. Noise from work on evenings, Saturday afternoons, Sundays and public holidays can also be annoying to most residents as it may interrupt leisure activities.’

Page 12 ‘ A strong justification would typically be required for works outside the recommended standard hours.’ (The Recommended standard hours are Monday to Friday 7am to 6pm; Saturdays 8am to 1pm; No work on Sundays or public holidays.)

Tables 2 and 3 show that the noise measure used for assessment purposes (The ‘Management level’) is LAeq(15min) , the average noise level over 15 minute periods.

Page 14 ‘The ground-borne noise levels are for evening and night-time periods only, as the objectives are to protect the amenity and sleep of people when they are at home.’

Page 15 NSW Environmental Criteria for Road Traffic Noise (EPA 1999).

Page 16 ‘A number of **activities** have proven to be **particularly annoying** to nearby residents : use of ‘beeper’ style reversing or movement alarms, particularly at night-time.

Table 12 – Particularly Annoying Activities (DECC, NSW)

Use of ‘Beeper’ type alarms on vehicles ;	Impact piling
Use of power saws, used for cutting wood, rail lines, masonry, road pavement or steel;	
Bitumen milling or profiling ;	Grinding metal, concrete or masonry
Rock drilling ;	Line drilling
Vibratory rolling ;	Rail tamping or regulating
Jackhammering, rock hammering or rock breaking	

‘If any of these activities are to be undertaken they should be factored into the quantitative assessment by **adding 5 dB to the predicted levels.**’

Page 22 ‘erect temporary shrouding from 20mm marine plywood to a height of 1.5m around the jackhammer work area’

Page 26 ‘The community is more likely to be understanding and accepting of noise if the information provided is frank, does not attempt to understate the likely noise level., and if commitments are firmly adhered to.’

Page 29 ‘where night work near residences cannot be feasibly or reasonably avoided , restrict the number of nights per week, and/or the number of nights per calendar month that the works are undertaken, in consultation with residents who will be most affected.’

Page 41 ‘Targeted Community consultation’ ‘The main benefit of this form of consultation is that it opens channels of communication with an affected community and can deal with noise issues before they become irreconcilable issues.’

Page 45 ‘In residential areas, proposed work practices included :

‘installation of a temporary enclosure at the tunnel portal, . . .

‘arranging the work site to minimise the use of movement alarms on vehicles

‘developing an agreement with residents where noise could not be mitigated to meet the night-time noise level.’

Page 46 Consider respite periods for high-noise level works.’

Page 49 ‘An example of the sound of a broadband alarm can be found at

[www.environment.nsw.gov.au/noise/constructnoise.htm](http://www.environment.nsw.gov.au/noise/constructnoise.htm)’

In fact this site has quite good sound recordings of both the common ‘Beeper’ type alarm and the more acceptable ‘Broad-band’ type of alarm.

### 16. Train and Railway noise

These have some characteristics which have resulted, over the years, in train noise being the most acceptable type of transport noise. Both road traffic noise and aircraft flight noise are more annoying than railway noise for the same average noise level. Thus a railway track causing an average noise level of, say, 55 LAeq is as generally acceptable as a road traffic or aircraft noise source generating a level of 50 LAeq over a given period of time. This is called the ‘Rail bonus’ of c.5 dBA. It has been established through research by a number of authorities over the years.

The ‘Rail Bonus’ may have its origins, to some extent at least, in the ‘romance’ of rail travel in the early days of railway development and rail travel itself, in the 19<sup>th</sup> and the first half of the 20<sup>th</sup> century. The huge noisiness of trains was an integral part of the railway experience. There was no concept of a ‘noise load’. Train schedules were light; train passby events, for many people, were relatively few on a daily basis. As a result there were long pauses between trains when the local environment returned, for long periods, to its usual peaceful state, and people returned to their normal daily dull routine.

The average noise level of trains in any hour, was relatively low in comparison to the level during the passby, due to the long quiet periods between trains.

It is here considered likely that the long pauses between train passby events gave sufficiently long recovery time from any noise-induced stress conditions, that people did not realise that there was any such thing as railway noise-induced stress.

Trains passing by at night were infrequent, and if the noise woke people up they soon returned to sleep, realising that all was well with the world – the trains were still running to schedule and on time, and the noise was of a train passing by, a predictable ‘clickety clack’ and the normally expected characteristic train rolling noise.

The impulsive nature of the ‘clickety clack’ did not bother people unduly. Today’s welded tracks are, however, a welcome development for most people. That welcome development, of itself, however, is not sufficient to offset the stress of the many other sources of noise, including railway noise, for people in 2011.

The ‘rail bonus’ applies only to normally running train noise. It does not apply to noise from train shunting, or from parked trains with engines running (idling), or from loading/unloading activities in rail yards, nor from the public address system in a railway station. Neither would it cover noise from any unnecessary use of train horns.

Likewise any similar activities from road vehicles in freight yards, or from ground running of aircraft engines, are not covered by the term 'transport noise'. Those activities are to be regarded as Industrial type noise.

Similarly, trains which generate an unusual or raucous noise, in excess of the normal sound of running trains, are not excused such noise by virtue of the 'Rail Bonus'.

**NOTE 25** : 5 dBA is an approximate figure for the 'rail bonus'. International Standard ISO 1996-1:2003 'Acoustics – Description, measurement and assessment of environmental noise' – Part 1 states that the Railway 'Level adjustment' can be from -3 to -6 dB, depending on the type of train. It also states that 'The Railway adjustments do not apply to long diesel trains or to trains travelling in excess of 250 km/h.'

It is understood that if the operational noise emissions from any trains should be of abnormal or disturbing character, that is having some distinctly **unusual** tonality or impulsive character, then any such unusual noise emissions should be assessed in the same way as industrial noise, excluding also any Railway Level Adjustment. This is particularly important during night time hours.

This is to acknowledge (i) that any such unusual tonality or impulsive character takes such a noise source out of the pure transportation noise category, putting it into a more disturbing noise type, and (ii) the Environmental Protection Agency (EPA) recommendation for industrial sources (Scheduled Activities), that, at night time, there should be no audible tones or impulsive character from any such industrial noise, irrespective of the noise level. (Ref.16, EPA Guidance Note for Noise in Relation to Scheduled Activities, 2<sup>nd</sup> Edition, paragraph 3.2)

### 17. Road Traffic Noise

Road traffic noise is now an inevitable part of everyday life for most people in the developed world. It is generally regarded as acceptable, unless the levels are very high, especially at night time, and more especially if it contains a noticeable fraction of heavy trucks or buses, or at times, tractors.

For many people road traffic noise has become such an accepted part of life that they literally do not notice it normally. And, importantly, it does not disturb or intrude on their daily activities, or cause them any nuisance or worry. However, when there is appreciable increase in traffic noise, it can become disturbing. Apart from the simple noise factor, there can be other aspects of traffic which cause more concern, such as safety of children or walkers or cyclists, on what was previously a quiet road, particularly if there are no footpaths. This aspect, and the noise factor, is magnified if there are substantial numbers of heavy vehicles involved.

The Dart Underground project is expected to cause some traffic changes, which in some areas will cause extra traffic on previously quieter roads. In some cases this will involve construction HGV traffic. On some other roads it will not include any construction traffic. It takes substantially greater volumes of road traffic to cause significant increases in road traffic noise. For example, if traffic speed and fraction of HGV's remain the same, it takes a doubling of traffic numbers to increase the noise level by 3 dBA. In purely noise terms, this is usually a just detectable noise increase

Construction Heavy Goods Vehicular traffic is unlikely to add appreciably to road traffic noise, on the designated main travel routes.

For the most part, these are roads with existing high traffic volumes which will tend to 'swamp' the construction traffic noise.

However, Boyne St. (East Side) will see a substantial increase in HGV traffic due to the proposed project, as will Kylemore Way. The associated road traffic noise will be noticed in Boyne St. particularly, as it is currently a very quiet street.. The saving grace in this situation is that this traffic and its noise will only occur between 7am and 7pm, Monday to Friday, and 7am to 3pm on Saturdays, as per the CIE/ Iarnrod Eireann proposal.

The Kylemore Way route is partly through an industrial area, and the HGV traffic here is unlikely to cause any residential problems. However, noise-induced disturbance of rest or sleep could occur in residences only c.60 metres away in Railway Avenue and Tyrconnell Park and closer still to houses in Inchicore Parade, Abercorn Square, Abercorn Terrace and St. Patrick's Terrace. Emphasis on quiet driving will be required, which with effective site hoarding are both likely to be required to minimise the noise of HGV traffic in those areas.

#### 18. Noise Measurement Periods

The tradition in some countries, including Ireland and the UK, is that daytime noise levels are measured in hourly periods. Nighttime noise measurement periods have usually been 15 minutes in Ireland, and 5 minutes (BS 4142) or 1 minute (Night Noise Act 1996) in the UK.

Periods of 15 or 20 or 30 minutes have also been used on occasion, in daytime, when it was deemed that the noise situation could be usefully analysed by such measurement periods.

Longer periods have also been used on occasion, for example 8 hours for night noise levels, and 12 hours for daytime construction noise levels. Twenty-four hour measures such as  $L_{den}$  in the EC, and  $L_{Day-Night}$  ( $L_{dn}$ ) in the USA are also used.

'Long-term' averages of these parameters are specified by some authorities, for example, the yearly average.

These longer periods give more blunt noise parameters, in that significant variations in noise level throughout the period are masked in the longer term average measures. The longer the averaging period is, the more extreme the individual variations can be. Thus in order to know when any high noise peaks occurred, and in order to take appropriate remedial action, the relevant required data is usually not accessible from such longer term measures (unless appropriate extra facilities are included in the instrumentation).

Our view is that the measurement and reporting periods should be short enough to be useful, without overburdening the system with a mass of figures, yet not so long that there is little detail to inspect. It is considered that 1-hour periods are the optimum basic measurement and readout time unit for day and evening time, while for night time it is now considered appropriate to use 5 minute measurement periods, due to people's greater sensitivity to noise at night, and the consequent need for better control.

At night, from 2200 to 0700 hours, measurement in 5-minute periods is recommended.

#### 19. Noise Level Parameters

**Ambient Background noise** and **Construction Noise** : The parameters to be recorded/ computed and reported (24/7) for these noise surveys at each location should be as follows:

**Monday to Sunday** : Location, Date and Time,  $LA_{eq1hour}$  ,  $LA_{maxFast 1Hour}$  ,  $LA_{1 1Hour}$ ,  $LA_{10 1Hour}$ ,  $LA_{50 1Hour}$  ,  $LA_{90 1Hour}$ , all to be measured, on the 'Fast' meter response setting.

All the above L parameters are to be recorded for every period, day and night.

For the Night time hours 2200-0700 : 2200-0800:

**Monday-Thursday** : LAeq<sub>5mins</sub> (2200-0700 Hours) · LAm<sub>Fast 5mins</sub>, LA1<sub>5mins</sub>, LA10<sub>5mins</sub>, LA50<sub>5mins</sub>, LA90<sub>5mins</sub>

**Fridays and Saturdays** : LAeq<sub>5mins</sub> (2200-0800 Hours) ; LAm<sub>Fast 5mins</sub>, LA1<sub>5mins</sub>, LA10<sub>5mins</sub>, LA50<sub>5mins</sub>, LA90<sub>5mins</sub>

**Sundays:** LAeq<sub>1 Hour</sub> (0800-2200 Hours) , and LAeq<sub>5Mins</sub> (2200-0800 Hours); similarly for the percentiles;

**Bank Holidays** : : LAeq<sub>1 Hour</sub> (0800-2200 Hours) , and LAeq<sub>5Mins</sub> (2200-0700 Hours); similarly for the percentiles;

The recommended 2-week long pre-construction noise level averages should be derived at the end of each week, for each of the following parameters :

Weekly Weekday(Mon-Fri) LAeq<sub>1Hour</sub> (0700-1900 Hours), and

Weekly Weekday(Mon-Fri) LAeq<sub>1 Hour</sub> (1900-2200 Hours) ·

Weekly Weekday(Mon-Fri) LAeq<sub>5min</sub> (2200-0700) Hours) ·

The pre-construction noise level records and averages should be forwarded to Dublin City Council (Environment and Engineering Dept.), at the end of each relevant period of survey.

#### Noise Descriptors – An Explanation

The following descriptors are often used to describe a noise environment over a given period:

LAeq = the average (equivalent continuous) A-weighted noise level for the period;

LA90 is the noise levels exceeded for 90% of each period – for example LA90 is the A-weighted noise level exceeded for 54 minutes in an hour. In the remaining 6 minutes there may be a number of noise events or peaks, for example road or air traffic.

LA95 is the the A-weighted noise level exceeded for 95% of each period – for example LA95 is the noise level exceeded for 57 minutes in an hour. In the remaining 3 minutes there may be a number of noise events or peaks.

LA90 and, sometimes LA95, are used to describe those times when no significant noises are heard, often referred to as the ‘Background noise level’, when no vehicles are heard, no dogs are barking, and there is not even any significant birdsong. Note, however, that sound level meters, which can measure continuously, analyse the whole noise scenario or environment, and extract the LA90 by analysis from the higher noise peaks.

Some sound level meters (SLMs) can also be set to measure and record only the peak sounds – and ignore the lower sound level environment.

LA1, LA10, and LA50 are the A-weighted noise levels exceeded for 1%, 10%, and 50% respectively, of each measurement period.

The A-weighting is an Amendment, or correction, to the basic sound pressure levels measured, which was designed to give better correlation of a single-figure noise level with the subjective experience of the ear’s response to sounds of different frequency or pitch.

Sometimes the un-weighted noise levels L1, L10, L50, L90/95, and Leq are used, for example in analysis of noise spectra.

**NOTE 26** - A sound spectrum is a graph or picture of sound level/magnitude versus frequency or pitch. It shows the relative strengths of the high-frequency ('hissy') sounds, medium frequency, and low-frequency ('rumbly') components of the noise). High-frequency sound is easier to control, absorb, and contain, than is low-frequency sound. The sound of a tin whistle is less audible to neighbours than that of drums or a double-bass.

#### 20. Microphone Placement :

'Façade' noise levels have historically been measured, not at the façade itself, but rather at 1 metre out from it.

The reason for this is that if a window were used for microphone locations, for unattended noise measuring, the window reveals were likely to give sound reflections which increased the readings unacceptably. Thus Microphones were often fitted to poles which protruded out through the windows at 1m out from the facades, to avoid the undesirable inaccuracy likely from the window reveal reflections. Alternatively they were mounted on tripods at 1 metre from the facades. Where feasible a standard microphone is still the preferred method.

Nowadays a more discreet, and more secure arrangement is possible with the new type of Surface mounted microphones attached directly to the façade of interest. These microphones can be readily connected, via suitable cabling and trunking, to the required instrumentation, which can be downloaded via internet technology, as can the alternative older system, to a reporting assessor. This avoids any need to place meters in boxes inside or at residents' homes, (the older system) with a need for ongoing inspection visits.

#### Noise Monitor/Microphone Locations

It is recommended that (a) Microphone height above ground level should be at least 1.5 to 1.8 metres; (b) for night time upper bedroom noise measurements, microphone should be at least 3.5 to 4 metres high, or at mid-window level, (c) that unattended noise monitors be placed at or on the most construction noise-exposed house and façade, which has a window or door, of each such house, at each of the significant construction sites.

Most of these locations are to be found in the EIS, Volume 2, Book 2, Table 8.1 'Baseline Monitoring locations' and/or in Tables 8.12, 8.13, 8.19, and 8.20. Other locations, mentioned in Tables A8.3.1 to A8.3.70, will also need monitoring at times. In addition there may be a small number of other locations where monitoring is needed.

In total there are a large number of receptors, which will need to be monitored. Some noise receptors may not be known until works begin and an occupier or owner requests a check on the noise levels. A mixed programme of attended and unattended monitoring will be needed, with continuous monitoring at the most impacted and/or sensitive locations. The contractor and the noise specialists on the sites will be best placed to decide on the optimum mix of attended and unattended monitoring required.

#### Table 13 – Some Recommended Noise Monitoring Locations.

At Inchicore there are many houses in the Railway Estate, and in Landen Road, in Tyrconnell Park, in Railway Avenue, as well as in St. Patrick's Terrace, St. George's Villas, and other locations, which are likely to be longer-term noise receivers from the proposed works in Inchicore. In addition there are some multi-storey (or multi-level), multi location apartment blocks which will receive construction noise. (MLR locations). For example the Sevenoaks apartment complex and the Wheaton Court apartments.

The latter are three-storey buildings near the Sports and Social Centre, and which overlook Sarsfield Road. The higher the level of any noise-sensitive receiver, the less likely it is that screening by intervening buildings will provide significant noise screening – and therefore the higher the received noise levels are likely to be.

In Sarsfield road there are the ‘Murray Cottages’ (Nos.1-5) near Dan Ryans Yard , and Inchicore Terrace North, and Wheaton Court, overlooking the road.

In Memorial Park there are two schools, and a residential quarter in the St. John of God School. Residents are housed in three buildings, it is understood.

‘Arranmore’, a single storey building is closest, at c.8 metres, to the proposed site boundary.

‘St. Johns’ is a three storey building adjacent to ‘Arranmore’,

‘Caridad’ is a one-storey building further from the site boundary.

‘Memorial Court’ apartments, 5 floors high, are just East of the St. John of God School/

At Heuston Station the nearest residents are in Parkgate Place, across the River Liffey, at c.100 metres, and the Aisling Hotel at C.250 metres plus.

At Island Street there are Apartments on the East, West, North and South sides of the proposed Shaft site. The apartments are located at distances of c.15 to 80 metres. Many of these apartments are located at 3<sup>rd</sup> or 4<sup>th</sup> or 5<sup>th</sup> or 6<sup>th</sup> floor level.

At Cook Street there are apartments – 4 floors high – adjacent to the proposed Shaft Site on the Church of the Immaculate Conception site, and a row of 2 storey houses across the road at c. 12+ metres.

At Christchurch there are 3 Hotels potentially impacted by some aspects of the Dart Underground works noise at this station.

- (a) Jurys Inn, Christchurch Place, at the top of the hill, is furthest away from the proposed works and has very substantial screening by the Cathedral and so is least likely to be impacted by construction noise;
- (b) Harding Hotel in Fishamble Street has substantial screening by the nearby Civic Offices, but has some potential for noise transmission by reflection from the walls of the Cathedral.
- (c) Frederic Handel Hotel also has substantial screening by the nearby Civic Offices, and also has some potential for noise transmission by reflection from the walls of the Civic Offices.  
Both the Harding and Frederic Handel Hotels have bedrooms up to the 5<sup>th</sup> or 6<sup>th</sup> floor level. These latter two venues are likely to require at least some initial attended noise monitoring in the early days of the works, and also during some of the noisier subsequent works.
- (d) The rooms on the East side of the nearby Franciscan Friary may also be at risk of some noise impact, and should be monitored, at appropriate times, for this.

At St. Stephens Green there is the Fitzwilliam Hotel on the West Side, and on the North side is the Shelbourne Hotel, in addition to a number of restaurants and guest houses.

At proposed Pearse station are a number of potentially noise-sensitive receivers :

- (a). Facing Bass Place is a row of 3-storey houses on Boyne Street; the rear of these houses or apartments overlooks the proposed construction compound; the South side of Boyne street has a row of 2-storey houses;
- (b). A row of houses on Erne Street Upper backs on to the proposed excavation site;
- (c). Leo Fitzgerald House – a complex of 4 and 5-storey apartments, especially the upper floors of these;
- (d). The Alexander Hotel is very substantially screened by Cumberland House, a large office complex. Screening is not complete however, in that the South western corner of the Hotel is not so screened – and these rooms will need some noise monitoring. There is a small potential for some noise impact also at the Davenport Hotel, just across Fenian Street from the Alexander Hotel.
- (e). Houses on Sandwith Street
- (f). At a TCD Student residence called Goldsmith Hall , at the rear, there is clear line of sight to the main proposed station box site, at c.140 metres, and this location should be monitored for potential noise impact.

Table 8.21 at Docklands Station, in Phase 4 indicates ‘Neutral to slight exceedance of Night-time criterion at upper floors of residences - - ‘. This is totally unacceptable. The criterion is too high to start with, & No Tonal or Impulsive noise should be heard at night.

Table A8.3.61 indicates a Night time criterion of 55 LAeq<sub>1hr</sub> in Blythe Avenue and nearby areas. This is totally unacceptable – much too high – on an already noise blighted area, in an otherwise very quiet cul-de-sac.

Projected night time construction noise levels of 47 and 48 LAeq<sub>1hr</sub> are totally unacceptable in this or any other area along the proposed alignment. There should be NO TONAL OR IMPULSIVE NOISE AT NIGHT at any residence along the alignment.

At Docklands Station, In Phase 4 is indicated ‘Moderate to Major impact (7 dBA excess) of Evening criteria at residences - - ‘. This is not acceptable.

At West Road there is an apartment block at the Crosbies Yard premises, which may be impacted by the works, especially the West Road realignment works. There has been no noise baseline monitoring there, and no apparent assessment or prediction of any potential noise impact at these apartments.

**NOTE 27** : It is recommended that representative attended monitoring should be done at any other location considered necessary. In particular we recommend that representative attended monitoring should cover any emergency night work, especially at those houses without ongoing monitoring, and for the potential night-time delivery of large machines or components. For night time monitoring the microphone height near noise-sensitive (2-storey or higher) receivers should be at least 3.5 to 4 metres above ground, or at window level.

**NOTE 28** : (MLR) – These venues are Multi-level, and/or Multi room/resident noise Receptor locations. It is advised that the Local Authority and/or the management or residents, be consulted in regard to the optimum monitoring locations in each venue, and the optimum mix of attended and/or unattended noise monitors.

## 21. Maintenance Works

Maintenance works will be required in two respects (a) for plant and equipment used in the construction phase of the works, and (b) for the permanent infrastructure (the railway lines) and associated power and support plant, including sound systems, ventilation equipment, electrical substations, as well as for the wheels of the trains, the rail tracks, and train washing plant. Maintenance is required to correct for any excessive noise due to wear and tear, as well as for any broken engine silencers, mufflers, covers, or any barriers or enclosures which may need repair. Such causes of unnecessary extra noise generation are usually relatively simple to repair or replace.

Trackworks – Rail Realignment works – are very noisy in nature. Extra care is recommended for this work, particularly where it is considered essential at night. Then every precaution should be taken, by the judicious use of portable, temporary, and/or permanent noise barriers, that noise is minimised as far as possible, to avoid undue noise induced sleep disturbance of any resident.

## 22. Management and Supervision

The applicant, it is understood, will have overall management and ongoing supervision of the proposed works. CIE/Iarnrod Eireann has proposed, and confirmed during the Oral Hearing, a multi-tier system of project management. There will be on-site management and supervision by the Contractor; there will be a CIE team of people liaising with the contractor and monitoring and auditing the day-to-day, and week-to-week, activities; and there is proposed an ‘Archaeological and environmental Monitor’ (who or which may be an Expert Panel) who may be consulted when a more difficult problem or situation arises. In the proposed ‘Construction Noise Management Plan’, the Contractor (PPPCo) is expected to put in place a continuous improvement process for noise as part of a detailed site design process and to implement all reasonable and feasible noise source controls, and noise transmission path controls, necessary to adequately reduce noise from plant and equipment.

This will require alert ongoing attention to what is occurring on every worksite, and attention to the noise monitoring results, by staff with the knowledge and authority to respond promptly to any noise excess. It is important that there be at least one (1) named person, on each major work site, with the appropriate knowledge to assume ‘ownership’ of the overall noise risk scenario, and with sufficient authority to rapidly make any changes deemed essential, for any noise problem which may arise.

Noise is, of course, only one of the factors to be managed. But the Applicant proposes a team of specialists, including noise specialists, who will be on hand, and at short notice, it is understood, to advise on noise related matters which require effective decisions to be made rapidly.

## 23. Demolition Works

Demolition is another aspect of construction which requires to be done, in order to clear a site for the actual planned construction. A significant demolition operation is required on a number of the proposed sites. The buildings, or structures involved are shown on the following EIS Drawings:

Area 101 - Figure 20.220 V3; Area 102 - Figure 20.221 V3; Area 103 - Figure 20.222 V3; Area 104 – Figure 20.223 V3; Area 105 - Figure 20.224 V3; Area 106 - Figure 20.225; Heuston Station - Figure 20.226 V3 and Figure 20.227 V3.

The existing structures must be removed before construction of the actual stop or shaft can commence. This work will cause some noise generation which will require to be controlled in the normal way. At places like Landen Road, where the site works to be done is very close to the houses, it is important that any necessary noise mitigation measure should be in place as early as possible.

#### Utilities/Enabling Works :

In a number of areas, it will be necessary to relocate water pipes or sewers or gas pipes, or telecommunications lines, or electrical power cables. Such works require excavation of roads and may necessitate traffic diversions. The proposed Diversions are shown in Chapter 17 'Material Assets' and EIS drawings such as Figures 17.1 V3 to 17.8 V3.

Noise will be generated in the course of these works, and it will be necessary to control the consequent noise levels to avoid any undue noise nuisance. Where Barriers might be the optimum mode of noise control they should be in place in sufficient quantity, and of appropriate design, to be as effective as is needed. These barriers will then be available for use during the main project works. There is potential for unmitigated noise levels at times, at some residences/receptors, in excess of 75 dBA. Thus appropriate noise monitoring, and control will also be needed at these work locations, particularly during any evening work, more especially still, should there be any night working required. It should be borne in mind also, that there are a number of hotels, with higher level rooms, near the alignment – within earshot of the proposed works. Similarly there are some schools within earshot of the proposed works, for example the Christian Brothers School in Cumberland St. This latter is not directly in line of sight to the nearby major works in Bass Place but may be at risk of receiving some HGV noise or some reflected noise.

#### 24. West Road Bridge & Sarsfield Road Bridge

The sites of the proposed works at these Bridges either overlooks, as in West Road, or has the potential to impact on, numerous houses at distances from c.15 metres upwards. At West Road there are two locations for Bridge works that is, removal of the Old Bridge and Construction of the New Bridge some c. 50 metres away.

Construction of both bridges will involve a range of plant, including Breakers, Loaders, Spoil and Dump Trucks, Poker vibrators, Spreaders and Rollers, according to Table 8.11, in EIS Book 2, Volume 2.

There is potential for unmitigated noise levels at times, in excess of 80 dBA. Thus appropriate noise monitoring, and control will be essential at both of these locations, particularly during any evening work (from 1900 to 2200 hours) or early morning work (0700-0800 hours). It may be necessary at either location, to use portable noise barriers, possibly fixed on to a wall or embankment, since there may be little room for free-standing barrier emplacement. Works at these locations have the potential for noise disturbance at a significant number of residences – disturbance which should be avoided.

Although the Sarsfield Road works are projected to take only 3 months, it is still important that every necessary precaution be taken to minimise the noise impact of these works.

#### 25. Instrumentation

The noise measuring instrumentation (microphone and signal processing equipment) should be of Class 1 precision grade, as per Irish Standard I.S. EN 61672-1:2003 'Electroacoustics – Sound Level Meters – Part 1 : Specifications (IEC 61672-1:2002).

Measurements of airborne noise should be taken with the ‘Fast’ meter response setting. This is important, especially for the LA<sub>max</sub> parameter, in Airborne Noise measurements. The system should be calibrated as per manufacturer’s instructions and/or International Standards.

Unattended long-term monitoring needs to be supplemented by short-term attended monitoring, which allows for confirmation of the construction noise level, and identifies any significant other noise contributor sources, which may or may not have been previously identified. Thus the accuracy of both the current baseline noise level readings and the construction noise level can be confirmed as and when either may be needed.

**26. Significance of Noise Impact**

The Oxford Dictionary defines ‘significant’ as ‘sufficiently great or important to be worthy of attention’ or as ‘noteworthy’.

BS 5228:2009 ‘Code of practice for noise and vibration control on construction and open sites – Part 1 : Noise’ defines construction noise levels to be ‘significant’ when the total noise (pre-construction ambient noise plus construction noise) exceeds the pre-construction ambient noise level by 5 dB or more. This is subject to lower cut-off values of 65 (daytime), 55 (evenings), and 45 (Night time) LA<sub>eq,period</sub>. It has a minimum time requirement of either (a) 10 working days in any 15 consecutive day period, or (b) over 40 days in any 6 month period (unless shorter works are likely to result in significant impact.) In other words it does not consider specifying for daytime levels lower than 65 LA<sub>eq,period</sub>, evening levels lower than 55 LA<sub>eq,period</sub> and night time levels below 45 LA<sub>eq,period</sub>.

The EIS for the proposed Dart Underground project defines ‘Significance’ of daytime construction noise in accordance with BS 5228:2009, and proposes the use of the limits therein for the Dart Underground works.

We recommend a different approach for Night time Works. This is because (a) use of a Total (ambient + construction) noise measure, at night, could lead to confusion and doubt as to the magnitude of any construction noise, and (b) the approach adopted in the EIS indicates too high a noise limit at night- at numerous locations. The ambient at night can change by c.10 dBA due to weather variation. And we recommend that there be no tonal or impulsive noise at night – irrespective of the noise level - in line with the EPA Guidelines. We recommend an absolute construction noise limit at night, (2200-0700 hours), at any residence, of 40 LA<sub>eq,5mins</sub>.

The National Roads Authority (NRA) publication “Guidelines for the Treatment of Noise & Vibration in National Road Schemes (Revision 1, 25 October 2004)” gives no guidance on appropriate night time construction noise limits.

Those criteria and hours of operation are as set out in Table 14.

**Table 14 (NRA Guidelines)**

Days and Times	Noise Levels dB(A)	
	LA <sub>eq,1hr</sub>	LA <sub>max</sub>
Monday to Friday 0700 to 1900	70	80
Monday to Friday 1900 to 2200	60	65
Saturdays 0800 to 1630	65	75
Sundays and Bank Holidays 0800 to 1630	60	65

Maximum Permissible Noise Levels at the Façade of Dwellings during Construction

### Significant Noise levels in Crossrail Project in London

The Crossrail project is a new railway line across London from East to West, currently under construction. This project is considerably larger than the proposed Dart Underground railway line, passing through 23 London Boroughs.

BS 5228:2009 defines construction noise levels to be ‘significant’ when the total noise (pre-construction ambient plus construction noise) exceeds the pre-construction ambient noise by 5 dB or more. The Crossrail Environmental Statement (ES) uses the BS 5228:2009 definition of significance.

In Volume 6(a) of the Crossrail ES, Appendix B3, Noise and Vibration, in Tables are given the Noise Survey results for 7 day ambient noise monitoring at 88 sites along the alignment, along with the results for 24-hour and 3-hour noise surveys, at a further 42 and 80 sites, respectively.

Based on the 12 hour Day (0700-1900) results, and the above 5 dB increase, it can be deduced that the average construction noise level, for the 5 weekdays (Monday-Friday), over the 210 sites measured, at which 12 hour daytime construction noise becomes ‘significant’ is c.69 LAeq<sub>Daytime</sub>.

Of course there are locations where, based on consistently high ambient noise levels, a high construction noise level is reasonably considered as simply ‘significant’

For these reasons we consider that the appropriate daytime construction noise criterion in Dart Underground locations, without further safeguards, should be 70 LAeq<sub>1 hour</sub>. For the recommended 75 LAeq<sub>1 hour</sub> it is considered essential that this must be accompanied by a suitable level of normal residential sound insulation (excluding hotels and guesthouses – overnight venues).

### 27. Some Noise Levels in Context

It is difficult to appreciate the nature and implication of various noise levels, especially for the non-technical ‘layman’. Therefore the following table is given to help in such appreciation.

Table 15 - Some Noise Levels in Context

Noise Level	Description	Reference
70 LAeq <sub>1Hour</sub>	Limit at dwelling facades, 0700-1900Hours, Monday-Friday, Construction	NRA(National Roads Authority)
55-63 LAeq <sub>0700-2300</sub>	Planning Conditions for new dwellings should ensure an adequate level of protection against noise	PPG24 (UK) for Road Traffic *
63-72 LAeq <sub>0700-2300Hours</sub>	Planning permission should not normally be granted for new dwellings	PPG24 (UK) for Road Traffic *
70-75 L <sub>dn</sub> (dBA)	Residential use compatible, IF sound insulation=30 dB, for Ground vehicle noise	Karl Kryter ‘The Effects of Noise on Man’, Second edition, Table 12.11,
70 LAeq <sub>1hour</sub>	Noise Insulation Trigger level 0700-0800,(Mon-Sat); 1800-1900;(Mon-Fri)	Crossrail Criteria (C.C.)
65 LAeq <sub>3hour</sub>	Noise Insulation Trigger level 1900-2200,(Mon-Fri); 1400-2200;(Sat)	Crossrail Criteria (C.C.)
78 LAeq <sub>c.15Min.</sub>	Virtually intolerable, Oil Drilling Rig noise	Personal experience (c.1980)
74 LAeq <sub>c.5min</sub>	Very uncomfortable, GeoThermal Drilling Rig noise	Personal experience (June 2010)
45 dBA (Indoors)	The onset of detectible Physiological Reaction	
30 dBA (Indoors)	Required for good sleeping conditions.	

\* PPG24 is Planning Policy Guidance 24 : Noise (1994). This indicated that the maximum external noise level which the noise insulation package detailed in the Noise Insulation Regulations can reduce to acceptable internal levels was 72 dBA. (Institution of Civil Engineers Briefing Sheet, July 1996). (Consequently higher external noise levels would ideally involve a higher specification sound insulation package, such as, perhaps, that used around Schipol Airport in Amsterdam.)

**NOTE 29** : 70-75  $L_{dn}$  means 70-75  $L_{Aeq_{16hr}}$  Daytime and 60-65  $L_{Aeq_{8hr}}$  Night time (USA)

**NOTE 30** : The above PPG24 noise level of 72 dBA is a 'Freefield' level. It is equivalent to a 'Façade' level of c.74.5 dBA. (A façade noise level includes the reflected sound).

(C.C.) These sound insulation trigger noise levels have some accompanying noise duration requirements also.

### 28. Hours of work

Work hours for construction sites are regulated by planning authorities. A twelve hour day (0700-1900 hours) is common. Occasionally evening work is also allowed, up to 2200 hours. Night work (2200 to 0700 hours) is usually restricted to emergency works, or works which require temporary curtailment of road traffic. In relation to this proposal, it is acknowledged that the applicant, in recognition of the importance of undisturbed sleep for potentially affected people along the proposed alignment, have stated their commitment to avoidance, as much as possible, of night work which would have a noisy character. It is recognised, however, that works within tunnels, and within Stop 'boxes' and Shafts which have been 'roofed or decked in', and which therefore do not disturb any person's sleep in any nearby premises, are acceptable.

It should be understood that these 'works' include the use of any and all vehicles used by workers going to or from the sites concerned. Thus it is expected that there will be no disturbing engine noise or noisy door slams or other disturbing noise from any such vehicles at night. Likewise loud voices, at locations where residents could be disturbed, are to be avoided at night.

The work hours proposed for the Dart Underground project, and shortened in the evenings by 1 hour (relative to the Applicant's proposed work hours), are as follows :

Monday to Friday	0700-1900 hours, daytime, and 1900-2200 hours, evenings.
Saturdays	0700-1500 hours

On Sundays & Bank Holidays and outside the above hours, it is understood that any works needing to be done, will need the explicit written approval of Dublin City Council – except for any emergency works which may be needed.

We recommend that, normally, no work on Sundays or Bank Holidays should be allowed, which is audible at any residence.

On Saturdays lower noise limits are herein recommended from 1400 hours onwards, in order to facilitate matinee performances in theatres and cinemas, where construction noise might intrude.

Indeed, it is considered that there is merit in allowing the same noise limits on Saturdays, as on Monday to Friday, and that those Saturday noise limits be generally limited to 0700-1400 hours.

It is here recommended that there be no construction work, between 2200 and 0700 hours, which exceeds  $40L_{Aeq_{5mins}}$  at any residence, and that there be no tonal or impulsive content in any such noise.

Acknowledging that there are core hours of work as indicated above, the general approach adopted in setting the noise level conditions is, following the proposal in the EIS, to recommend appropriate noise limits for daytime, evening and night time, and to allow the

contractor to work as he wishes, within those recommended noise limits. For example it is clearly not necessary to restrict work within tunnels or enclosed stop boxes, when such work is unlikely to be heard, via airborne pathways, by any local residents. Thus, in so far as airborne noise impact is the issue, such work may be undertaken on a 24/7 basis as the Applicant proposed.

The Construction noise requirements of Dublin City Council and Belfast City Council are given in Sections 12 and 13 of this report.

**NOTE 31 :** The given noise limits are to be understood in the context of ‘The aim is to achieve as soon as possible’. If there are exceptional circumstances whereby these limits may not be achieved in the early stages of construction work, at any site, the contractor should investigate the reasons for the exceedance, and within one (1) week make whatever corrections are necessary to achieve the relevant limit. This time period for remedial corrections applies to the first week of each medium or long-term (greater than 1 week duration) major construction site only. It does not apply to any night time works. And it does not apply during subsequent works. Except for the first week of work at any construction site for Dart Underground, any subsequent remedial works required to correct a daytime noise level higher than the relevant noise limit, should be done, it is recommended, within 1 day of the above-limit occurrence.

**NOTE 32 :** However, we stress again, the importance of also ensuring effective noise control – from DAY ONE - on every Dart Underground works at night, when no audible airborne construction noise either Tonal or Impulsive should be heard at any residence.

**Tonal** character includes features like ‘Rumbling’ or ‘Scraping’ or ‘Hissing’ or ‘Squeaking’ or ‘Whistling’ or Brake or Wheel ‘Squeal’ .

**Impulsive character** is due to sources or processes like Hammering, Clattering, Dropping Heavy Objects, Slamming doors, Revving engines, and Loud voices.

#### 29. Noise Recommendations for the Proposed Construction Phase of Dart Underground

It is recommended that :.

(A) there should be at least one (1) named person, on each major Dart Underground work site, with the appropriate knowledge to assume ‘ownership’ of the overall noise risk scenario for that site, and with sufficient authority to rapidly make any changes deemed essential, for any noise problem which may arise.

(B). the construction noise level, at night time, that is from 2200 to 0700 hours, at every noise-sensitive location, at every work site for Dart Underground, be no higher than 40 LAeq<sub>5mins</sub>, at any external façade, and that no construction tonal noise or impulsive noise be audible at any residence.

( C) the construction noise level, on Sundays and Bank Holidays, 24 hours, at every noise-sensitive location, at every work site for Dart Underground, be no higher than 40 LAeq<sub>5mins</sub>, and that no tonal noise or impulsive construction noise be audible at any residence.

(D) the only normal exception to (B) and (C) above, will occur in the event of an urgent emergency.

(E). some other exceptions to (B) and (C) above, may also be allowed, by informing both Dublin City Council (DCC) and the affected residents, of the need to bring on-site, or take off-site, some large machine or component. Such events should have the written permission of DCC. It is also recommended that they should not exceed 10 such nights in any year, 2 such nights in any 7-day period and 4 such nights in any 30-day period.

(F). the night time noise limits should operate from DAY ONE of works on each Dart Underground work site.

(G). the day & evening noise limits be effective from 7 days after initial works begin to allow time for initial site clearing and erection of the boundary hoarding to be effected.

(H).the proposed pre-construction ambient noise level survey be done by the contractor and that the evening time (1900-2200 hours) and night-time (2207-0700hours) ambient noise levels be agreed with Dublin City Council Environment & Engineering Department, and that the consequent construction noise Criteria from 1900-2200 hours be agreed with the City Council also.

(I).. a minimum material weight (density) of  $10\text{kg/m}^2$ , be employed for each site boundary hoarding, where the hoarding is required to perform a noise barrier function, and that the higher noise barrier hoardings should be of sufficiently dense material to ensure that most noise is directed over, and a minimum allowed through, the hoarding.

(J). the existing noise barrier along Blythe Avenue in East Wall be investigated for effectiveness, and if deemed necessary, that its effectiveness be increased.

(K). as agreed between Dublin City Council and Iarnrod Eireann, appropriately sensitive real time monitoring equipment will be installed on buildings along the route to detect and record noise levels, and that all airborne noise monitoring will be conducted external to the assessment building, in accordance with industry norm and best practice. An exception to this is where a theatre or cinema manager requires measurements inside the venue.

(L) monitoring will commence in advance of construction to ascertain preconstruction noise levels. Monitoring will continue during and post construction until equilibrium conditions have been achieved. The clear objective of the monitoring programme is to ensure all works undertaken by the PPPCo are within the limits specified in the Railway Order. The Independent Environmental and Archaeological Monitor will advise on the duration of post-construction monitoring. This latter should include the commissioning of all fixed plant at each Dart Underground site where it is needed.

The report on each receptor location should include the Met Eireann hourly wind speed and direction data for the relevant days, at Dublin Airport or Casement Airport, whichever is nearer.

**NOTE 33** – Inchicore appears to be approximately equidistant to both Dublin Airport and Casement Aerodrome. As one goes eastwards towards East Wall the distance from Casement (Baldonnel) Aerodrome increases. For the Western part of the proposed Dart Underground scheme, Casement may be the nearer. However, in the absence of on-site wind-speed measurement it might be useful to note the wind-speeds at both Met. stations.

(M). CIE and PPPCo consult (as agreed) and agree with Dublin City Council (DCC) on appropriate and easily accessible means of accessing monitoring data. PPPCo will make available monitoring data on an agreed schedule and in a format agreed between PPPCo and DCC. PPPCo shall make available any requested data relating to specific issues as soon as is practicable.

(N). 24/7 works should apply ONLY to works within tunnels or Decked-over Station boxes or Shafts, and to movement of supplies within the Gantry Enclosures to the tunnels. The Gantry Crane enclosures should be constructed such that NO NOISE EMISSION from any such night time works is heard at any local residence (since this noise is likely to be both tonal and impulsive in nature).

(O). (i) That the Gantry Enclosures should be large enough to accommodate sufficient Liners and Tracks for 64 Hours of tunnelling.(for a Bank Holiday weekend) - OR alternatively,

(ii). that tunnel supplies be kept nearby as proposed, and that deliveries of supplies be done under suitable covered-in conditions, such that no tonal noise or impulsive noise is heard at any noise-sensitive receiver, and so that a construction noise level of no higher than 40 LAeq<sub>5mins</sub>, occurs during the hours 2200-0700 or on Sundays or Bank holidays.

(P) provision be made, in the initial construction, for, and active consideration be given to, enclosing the proposed Sheriff St. Ramp effectively, in the event that HGV noise from the ramp should be disturbing to nearby residents.

(Q). all proposed barriers be examined with a view to using a higher barrier, or other measure, to reduce the noise impact at any location where a 'Moderate' or higher exceedance of noise criteria is expected.

(R). For any Rail Realignment works, pertaining to the Proposed Dart Underground, it is recommended that proper and appropriate noise barriers – movable and of appropriate height and length and design – should be deployed, in order to minimise the noise impact on local people.

(S) For the small number of occasions when Dublin City Council may grant a special permit for night time transport of any very large or hazardous load to or from any DART Underground construction site, it is recommended that the affected residents be advised in advance, so that they may make alternative sleeping arrangements if required.

We recommend that the maximum number of such occasions should be no more than 10 such nights per annum on any given site – with no more than 2 in any week, and no more than 4 in any 30 day period.

(T). Construction Noise Level Criteria\*\*\* at any Façade of a Normal Residence

Monday to Friday 75 LAeq<sub>1Hr</sub> (0700-1900 Hours) \*\*\* Construction Noise level alone  
65 LAeq<sub>1Hr</sub>(1900-2200 Hours)

Monday to Thursday 40 LAeq<sub>5mins</sub>(2200-0700Hours) To be Non Tonal and Non Impulsive.

Fridays 40 LAeq<sub>5mins</sub>(2200-0800Hours) To be Non Tonal and Non Impulsive

Saturdays 70 LAeq<sub>1Hr</sub> (0800-1500Hours); \*60 LAeq<sub>1Hr</sub> (1500-2200Hours)

\*40 LAeq<sub>5mins</sub> (2200-0800Hours) To be Non Tonal and Non Impulsive

The same noise limits are recommended for Sundays & Bank Holidays as at night time,

Sundays \* &

Bank Holidays \* 40 LAeq<sub>5mins</sub> (0800-2200Hours) To be Non Tonal and Non Impulsive.

Sundays \* 40 LAeq<sub>5mins</sub> (2200-0800Hours) To be Non Tonal and Non Impulsive.

Bank Holidays \* 40 LAeq<sub>5mins</sub> (2200-0700Hours) To be Non Tonal and Non Impulsive.

\* Construction activity at these times, except for emergency works, will normally require the explicit permission of Dublin City Council.

(U) Noise Criteria at any Façade of any School or Church

Monday to Saturday 65 LAeq<sub>0700-1900Hours</sub>

60 LAeq<sub>1900-2200Hours</sub> (For Schools during class)

Sundays & Bank Holidays\* 40 LAeq<sub>5min</sub>(0800-2200Hours) (Venues not sensitive at night)

\* Construction activity at these times, except for emergency works, will normally require the explicit permission of Dublin City Council.

(V) Noise Criteria at any Façade of any Theatre or Cinema

Monday to Friday 75 LAeq<sub>1Hr</sub>(0700-1900Hours);

60 LAeq<sub>1Hr</sub> (1900-2200Hours); (Venue working hours)

Saturdays 70 LAeq<sub>1Hr</sub> (0700-1400Hours)

60 LAeq<sub>1Hr</sub> (1400-2200Hours) To allow for Matinees  
Venues not normally sensitive at night.

Sundays & Bank Holidays\* 40 LAeq<sub>5min</sub>(0800-2200Hours)

(W). Noise Criteria at the Façade of any Hotel or Guesthouse

Monday to Friday 70 LAeq<sub>1Hr</sub> (0700-0800 Hours) ; 75 LAeq<sub>1Hr</sub> (0800-1900 Hours)

65 LAeq<sub>1Hr</sub> (1900-2200 Hours)

40 LAeq<sub>5min</sub> (2200-0700Hour) To be Non Tonal & Non Impulsive

Saturdays 70 LAeq<sub>1Hr</sub> (0800-1500Hours) ; 60 LAeq<sub>1Hr</sub> (1500-2200Hours)

\*40 LAeq<sub>5mins</sub> (2200-0800Hours) To be Non Tonal and Non Impulsive

Sundays & 40 LAeq<sub>5mins</sub>(0800-2200Hours) ; To be Non Tonal and Non Impulsive

Bank Holidays\* 40 LAeq<sub>5mins</sub> (2200-0800Hours) To be Non Tonal and Non Impulsive

Bank Holidays\* 40 LAeq<sub>5mins</sub> (2200-0700Hours) To be Non Tonal and Non Impulsive

(X) In the case of **percussive tools** such as Rockbreakers, Jackhammers (manual or mechanical), and Poker vibrators, the following recommendations are made :

That there should be no usage of percussive tools, which is audible at any noise sensitive receptor, as follows :

Mondays to Fridays from 2200 to 0700 hours

from (2200 to 0800 hours at Hotels & Guesthouses).

Saturdays from 0000 to 0800 hours, and from 1500 to 2400 hours;

From 1400 to 2400 hours at Theatres or cinemas;

Sundays and Bank Holidays – at any time.

(Y) (i) At any normal residential façade (excluding overnight accommodations) , where the construction noise level is expected to be in excess of 70 LAeq<sub>1hour</sub>(0700-1900Hours), it is recommended that the contractor be required to upgrade the sound insulation of any façade and/or attic- roof space requiring upgrade, so that the internal noise level due to the construction does not exceed 45 LAeq<sub>1Hour</sub>, in more than one (1) out of seven (7) 1-hour periods, chosen at random, which are spread over at least 3 working days, after one week

has elapsed from the start of operations on any major construction site; and it is recommended that -

(ii) Any such proposed upgrade work should be clearly described, in writing, before any such work is done, and a copy of this description given to each affected resident. In doing any checking measurements, account should be taken of the internal ambient noise background level (excluding any internally generated noise.)

Reason – In the interest of reasonable residential amenity.

(Z) The best available noise attenuation is advised, particularly for those houses where the proposed project would cause construction noise on two or more sides of the building, as is proposed at a number of houses, in Inchicore. It is also advised where the proposed works come very close to even one side of a house or houses, as at proposed Pearse Station and at Blythe Avenue in East Wall. Such attenuation measures include the best available level of noise barrier attenuation, and also the consideration of the addition of a porch or conservatory to such houses if agreeable to the owners.

(A2) Should it be agreeable to any resident, the contractor may decide to offer such resident, the reasonable cost of having the sound insulation upgrade work, referred to in paragraphs 29(Y) and 29(Z), done independently.

(B2) It is recommended that any upgrade of sound insulation needed, as per recommendation 30(Y), on any residence near a proposed Dart Underground work site be completed before any construction, or demolition work starts on the site, except where the resident concerned has opted to organise the upgrade themselves, and has received the determined reasonable cost thereof.

(C2) If it should be that both construction projects are under way at the same time, at the St. Stephens Green Stop site, it is recommended that a mutually agreed procedure be adopted by both contractors to minimise the noise impact on the local residents. If necessary, it is recommended that the good offices of Dublin City Council be sought to effect such an agreement.

(D2) It is recommended that the contractor be requested to decorate any semi-permanent (in place for over one (1) month) construction site boundary wall or noise barrier, on the side facing the nearby residences, with a tasteful Mural chosen after liaison with the nearby residents, and/or with appropriate professional advice.

**NOTE 34** : At the previously noted MLR (Multi Location Receptor) locations it is recommended that the Local Authority and/or the venue management be consulted to decide the optimum way to progress the noise surveys.

**NOTE 35** : It is recommended that the reports on all ambient noise survey locations should include a list of all the significant noise contributors in each location during each survey.

(E2) It is recommended that consideration be given to the placement of Visual Noise alert signs, Automatically Triggered at suitable Warning levels, at suitable locations, at each major worksite, as an aid to good noise control. This could, for example, take the form of a Green/Yellow/Red system.

(F2) It is recommended that, as an aid to good noise control, consideration be given to having Unattended Noise Monitors send Text Messages as Alerts/Alarms to the Mobile Phones of the relevant noise control personnel, on occurrence of a preset Noise Alarm level at any given work site.

(G2) It is recommended that, as an aid to good noise control, consideration be given to the use of Vehicle Reversing Alarms which are of the less intrusive Broadband types, or a Visual/Lights type. It is also recommended that all operators of supply vehicles, such as HGV's, trucks and vans, be advised that, where any reversing onsite may be required, vehicles should be fitted with a low-noise type of reversing alarm.

(H2) It is recommended that, should any transport of supplies or spoil by rail, be used in any overground location, that any such trains would be operated within the same recommended noise limits as for the operational phase of this proposed development.

(I2) It is recommended that if, in any Theatre, airborne Dart construction noise intrusion causes problems, during any production week or during any live performance, despite compliance with condition 29(V ) above, that the contractor would appoint an appropriately qualified person who would promptly respond to any complaint of such noise intrusion, and who would make a rapid assessment of the situation, and who would have the authority to (i) suspend the relevant construction operations for an appropriate time period, if such action were deemed necessary, and/or (ii) recommend any suitable venue sound insulation measures warranted, to prevent recurrence of the problem.

(J2) It is recommended that appropriate safeguards be in place, to ensure good communications on each Dart Underground work site, particularly for workers whose hearing, when wearing the required Ear Protectors, may not be good, or whose comprehension of English, or whatever is the predominant language on any site, may not be good, especially for Management and Supervisory staff

### 30. Noise Recommendations for the Proposed Operational Phase of Dart Underground

It is recommended that:

(A) the **operational airborne normal noise levels** from the proposed system should not exceed 55 LAeq(Period) 0700-2300Hours and 45 LAeq(Period) 2300-0700Hours , at any sensitive receptor. These are free-field values.

(B) when operational, the **operational noise emissions** from proposed Dart Underground trains should be of normal non-disturbing character, that is without any unusual tonality or impulsive character, and that any such unusual noise emissions, such as wheel squeal, be investigated and corrected promptly. Any such unusual tonality or impulsiveness should be assessed as industrial noise.

( C) in relation to recommendation 30(B) above, that the proposed Dart Underground train **noise levels and** their representative **1/3-octave frequency spectra**, for the pristine track and wheel conditions, be measured and recorded at suitable locations, in both (i) the East Wall overground track section, and (ii) the Inchicore overground track section.

These readings should be done at the normal operational speed in each area. The measurement report should include (a) precise location of microphone and its height above ground level; (b) distance from track; (c) train running speed; (d) Direction of travel; (e)

Carriage or engine numbers; (f) date & time, and (g) weather conditions, including Met Eireann wind speed and direction data at Dublin Airport or Casement Airport (whichever is nearer) for the relevant hours (in the absence of onsite wind readings).

This work will need to be done in cooperation with CIE/Iarnrod Eireann, so that precise speeds and other data can be obtained. The report should also include (h) a summary description and/or numerical data set on (i) the wheel condition of each relevant carriage and (ii) the track condition for each relevant stretch of track, on which noise readings were obtained.

A copy of the report should be given to Dublin City Council, Environment & Engineering Department.

Reason – To have a set of reference noise levels and frequency spectra against which to compare any subsequent noise readings taken in response to any complaints there may be, of unusual train operational noise emissions.

(D) the façade Rating noise level from all combined **permanent Trackside Equipment**, or Station equipment, including electrical equipment and any normally running ventilation fans, which are on at night (2200-0700 hours), at any sensitive receptor, should not exceed the lower of 35 LAeq<sub>5Mins</sub> or the lowest recurring night time ambient noise level LA90<sub>5Min</sub> during the night in any location. Night noise should be Non-tonal and non-impulsive, and should not be audible indoors with windows ajar (e.g. opening from c.5 to 100 mm wide, depending on window size and magnitude of noise level – smaller opening for larger windows and/or higher noise levels).

It is recommended that the LA90<sub>5mins</sub> increase, due to all fixed Dart Underground plant, should not exceed 3 dBA at any location.

(E) the relevant LA90<sub>5mins</sub> level should be determined jointly with Dublin County Council and/or agreed with the Council. It is recommended also that the Met Eireann hourly wind speed and direction data, at Dublin Airport (for East Wall) or Casement Airport (for Inchicore), for the relevant hours be included with the relevant ambient noise survey reports. LA90<sub>5mins</sub> levels should be derived as per NOTE 6 herein.

For any such equipment which runs in daytime only, the recommended façade Rating noise limit is 40 LAeq<sub>1hour</sub> at any noise-sensitive receptor.

(F) there should be no **idling locomotives**, which are audible overground, at any noise receptor, at any proposed Dart Underground location at night (2200 to 0700 hours). If required to keep engine oil hot, a suitable enclosure (or other heater arrangement) could be devised and made which keeps engines sufficiently hot for an easy start when required.

(G) the proposed **Maintenance Facility** noise emissions, at any residence, be no greater than 40 LAeq<sub>5mins</sub> between the hours 2200 and 0700, and likewise on Sundays and Bank Holidays, and that there should be no Tonal or Impulsive content in any such noise emissions at these times.

(H) the emergency **ventilation fans** should not generate a noise level, inside any sensitive receiver location, greater than 35 dBA at any time during test.

(I) all ventilation **fan testing** be done during daylight hours, and that any nearby residents would be advised in advance of the proposed test times for this process. A regular test day and time of test would facilitate such advance notice.

(J) **Rail Track Maintenance** : It is recommended that grinding of rail tracks be done at times and in a manner which does not cause undue disturbance to any residents. Similarly for any other system maintenance activities which are required. This is important especially on the proposed overground sections of the alignment at East Wall and Inchicore.

(K) that **Public Address systems at Stations** be set up, as per the EIS, so that sound levels at any nearby residence do not cause any noise nuisance, particularly in the evening or night time. This may be facilitated by the use of suitably placed visual signage in conjunction with the P.A. system. The  $LA_{Max_{Fast}}$  at any façade of any residence from the Stop Public Address system should not normally exceed 60 dBA. It is further recommended that the criteria for these and any audible warning systems on the alignment be agreed with Dublin City Council. A suggested criterion is  $LA_{eq\ 1minute} < 40\ dB$ , and  $LA_{Max_{Fast}} < 60\ dB$ , outside any residential window or door façade, particularly for the late evening and night time..

(L) since some proposed Stations or Shafts, for example Cook St. and Island St. Shafts , have **Air Intakes or exhausts** which are relatively close to residences, these should be designed and located in order to minimise their noise impact and comply with the night time limits.

(M) where a **Roller Shutter Door** is proposed on any proposed building facade which faces, or could impact, the nearby residents, such doors will need to be properly maintained for continuing quietest operation.

(N) in the case of any Roller Shutter Door the **appropriate noise measures** are considered to be the 1-minute values of  $LA_{eq}$ ,  $LA_{max}$ ,  $LA_1$ ,  $LA_{10}$  and  $LA_{90}$ , for the duration of (i) the opening operation, and (ii) the closing operation, of each such door. Measurement should be done at the nearest, or any location likely to be affected by the noise of operation.

(O) opening or closing of any **Roller Shutter door** should be restricted to the daytime hours (0800-1900) and should be kept closed if it has a noise containment function. Similarly, any other noise-containment door type should be kept closed.

(P) the **access road** for vehicular access to the proposed Maintenance Facility site be used only during the hours 0700-2200, except for emergency use. This is to avoid generation of tonal or impulsive noise at any local residence during the critical night hours 2200-0700. If personnel access via cars or light vans is considered essential, the drivers should be fully acquainted with (i) the essential requirement of a quiet environment at night, and (ii) the necessary quiet driving techniques.

Likewise for the proposed Access Roads to intervention/ventilation shafts, and to substations in any location of proposed Dart Underground in operation which is near any noise-sensitive receptor.

(Q) that all operators of **supply vehicles**, such as HGV's. trucks and vans, be advised that, where any reversing onsite may be required, vehicles should be fitted with a low-noise type of reversing alarm.

(R) all normal Railway Regulations be followed, including any such regulations or procedures which discourage the excessive **use of Train Horns or Hooters**, especially at night. It is further recommended that consideration be given to (i) optimising, where possible, the sound level of train horns, and (ii) the possible use of flashing lights, in conjunction with Horns, with the objective of minimising the potential for noise-induced sleep disturbance of residents close to the overground parts of the alignment at East Wall and Inchicore.

(S) appropriate signage, **lighting and CCTV** be installed (a) at each station where patrons leaving the station at night might disturb local residents by loud talking or noisy congregating, in order to discourage such nuisance behaviour.

(T) attended noise monitoring be done on the operational scheme in its initial stages and for **fixed plant and equipment commissioning** at each location where such plant is located. This should include all Ancillary systems such as power supply systems, all ventilation plant and vents, and Public address systems. It is recommended that the relevant reports on such system commissioning and initial operational noise measurements be furnished to Dublin City Council.

(U) that appropriate signage, and/or management arrangements, be put in place to ensure that service vehicles using the service bays, or service areas, at Dart Underground Stations, do not leave **engines running for unnecessarily long time periods**. A similar recommendation is made in respect of buses in Bus waiting Bays.

#### Two Commercial Websites

Two potentially useful websites discovered in this study are the following :

- (a) There is an instrument on the market which monitors a driver's level of **alertness while driving**. Information is at [www.seeingmachines.com/product/DSS/](http://www.seeingmachines.com/product/DSS/)
- (b) [www.myzeo.com](http://www.myzeo.com) is a website describing a 'Personal sleep coaching' system which
  - (a) analyses a person's sleep pattern
  - (b) allows the data to be examined
  - (c) suggests methods for sleep improvement
  - (d) has a motivational programme to achieve a better sleep pattern. It uses a sleep band sensor system which is worn on the forehead at night.

### **32. Conclusion**

Despite the scale and complexity of the Dart Underground project, one can conclude, in the light of all the evidence, that the Dart Underground project can be completed in compliance with the stipulated noise limits, and with adequate consideration of any noise-related community problems which may arise, and that a speedy and effective response to, and mitigation of, any noise excess identified will be effected by CIE/Iarnrod Eireann.

It is essential that the promised high quality management and supervisory measures, outlined in the EIS, and restated and clarified during the Oral Hearing, be honoured in practice. It is vital that the Supervision on the ground is alert and responsive and that the corresponding actions are seen to be effective.

It is vital that these policies and actions are seen to be in force from the beginning of works on DAY ONE, particularly with respect to protection of the night time environment and the avoidance of any noise-induced sleep disturbance, due to Dart Underground works, between the hours of 2200 and 0700.

Finally, we look forward to the operation of this ambitious and much needed system.

### 31. Table 16 – References

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1. The Dart Underground EIS Volumes 1, 2, 3 and 4.
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- Plus a number of additional web-based references in the text