Chapter 12:
Noise & Vibration

ROD
ROUGHAN & O'DONOVAN

Chapter 12 Noise & Vibration

12.1 Introduction

This chapter of the EIAR has been carried out by Gary Duffy of Enfonic Noise and Vibration Solutions and assesses the impact of noise and vibration associated with the proposed Trinity Wharf development.

12.2 Methodology

In order to assess the noise impact of the proposed development, the methodology in the following section was adopted.

Baseline

The first stage is to assess and quantify the existing noise environment close to sensitive receptors that may be affected by the proposed development. The noise-sensitive locations were selected as those in closest proximity to the proposed development. Attended noise surveys were conducted at several locations.

Construction Phase

The noise levels resulting from the construction phase of the proposed development are calculated using established prediction techniques.

The noise levels are predicted in accordance with guidance set out in BS5228:2009 Code of practice for noise and vibration control on construction and open sites. The results of the predicted assessment are compared against the baseline conditions and the differences are related to the likely impact of the development. Where predicted noise levels are in excess of adopted criteria or to control any risks associated with the uncertainty of the results, mitigation measures are proposed.

Operational Phase

Noise levels from operations associated with the development are estimated and their impact assessed. Operational sources considered are:

- Road traffic including changes to traffic flows on the existing road network as a result of the development and the proposed access road;
- Operations associated with the arts and cultural centre and;
- Items of mechanical and electrical plant associated with the hotel and office buildings.

These are expected to be the predominant noise sources with the potential to affect nearby Noise Sensitive Locations (NSLs) but other operations include the marina and café/restaurant. However, it is not possible to accurately predict the environmental noise impact associated with such facilities. A general noise management strategy should be developed as part of the development and management of the marina and café/ restaurant uses including hours of operation, training for staff and signage to notify the public of the potential effect their activities, particularly at night, may have on nearby residents.

Potentials for noise 'break-out' from a typical café/restaurant may include extractor fans from kitchens and leaving doors open. The design of an extractor system should consider the potential noise impact and doors should include lobby areas with automatic closing mechanisms fitted.

As the marina is expected to operate as a typical leisure facility, its operations are unlikely to adversely affect the nearby residents which are in excess of 200 metres from the proposed marina. However, large motor yachts may need to be curtailed either by limiting their arrival/departure times, enforcing the use of shore-power and/or considering their berthing location to minimise any potential impact. In addition, on-board parties should be strictly controlled to adhere with legislation to minimise the likelihood of noise complaints.

Noise from passing trains was also measured for information purposes and to add context to the existing acoustic environment.

Further details of each phase of the assessment are set out in the individual sections of this chapter.

12.3 Assessment Criteria

12.3.1 Baseline Conditions

Attended noise measurements were taken during the day and evening periods at two locations close to the site of the proposed development. Being representative of the closest residential dwellings, the impact assessment at these locations will be greater than for other dwellings located further from the site. A map of the survey locations and other relevant details is presented in Appendix 12.2.

The following parameters were recorded during each monitoring period:

- **L_{Aeq}**

  The continuous equivalent A-weighted sound pressure level. This is an "average" of the sound pressure level.

- **L_{AF10}**

  This is the A-weighted sound level that is exceeded for noise for 10% of the sample period. Used as an indicator of traffic noise.

- **L_{AF90}**

  This is the A-weighted sound level that is exceeded for 90% of the sample period. Referred to the "background" noise level in some standards.

A glossary of Acoustic Terminology is in Appendix 12.1.

A series of three non-consecutive 30minute noise measurements were taken in calm, dry conditions on Sept 29, 2018 using a B&K Type 2250 Sound Level Meter which was calibrated before and checked after the survey.

Due to access restrictions two suitable survey locations were available however these represent the nearest NSLs to the development. So, the impact assessment at the survey locations can be considered representative of the NSLs. The 'Additional Survey Location' is used for train noise measurement only and referenced under Train Noise.

Survey results are presented in Table 12.1 and identified in Plate 12.1.

Plate 12.1 Attended Noise Survey Locations

Table 12.1 Noise Survey Results

Survey Location	Start Time	Elapsed Time	L_{Aeq}	$L_{AF90.0}$	Comments
Day-time			**(dB re. $2x10^{-5}$Pa)**		
1a	21/09/2018 10:25	00:30:00	48.5	44.5	Soft ground, dense vegetation. Brid song. Road Traffic Noise (RTN) – distant. Distant dog bark. School yard noises @ 10:50
1b	21/09/2018 11:44	00:30:00	48.5	44.0	RTN. Bird song. Lawn mower nearby @ 12:02.
1c	21/09/2018 13:00	00:30:00	53.1	45.0	School yard noises from 13:05. Train @ 13:10. RTN – local. Brid song. Light drizzle 13:15-13:25
		Mean Values:	50.0	44.5	
2a	21/09/2018 11:08	00:30:00	53.7	46.0	RTN – continuous and dominant. Car turning @11:34
2b	21/09/2018 12:21	00:30:00	53.2	45.7	RTN – continuous and dominant. Car turning @12:48

Survey Location	Start Time	Elapsed Time	L_{Aeq}	$L_{AF90.0}$	Comments
2c	21/09/2018 14:00	00:30:00	53.4	45.5	RTN – continuous and dominant.
		Mean Values:	**53.5**	**45.7**	
Evening-Time					
1d	21/09/2018 19:05	00:30:00	47.5	42.6	Road Traffic Noise (RTN) – distant. Train @19:25
1e	21/09/2018 20:24	00:30:00	47.2	42.6	Road Traffic Noise (RTN) – distant. Kids playing in distance. Car @ 20:40
1f	21/09/2018 21:40	00:30:00	46.1	41.3	Road Traffic Noise (RTN) – distant
		Mean Values:	**46.9**	**42.2**	
2d	21/09/2018 19:43	00:30:00	53.0	46.0	RTN – continuous and dominant.
2e	21/09/2018 21:01	00:30:00	54.1	44.4	RTN – continuous and dominant.
2f	21/09/2018 22:17	00:30:00	53.2	43.0	RTN – continuous and dominant.
		Mean Values:	**53.4**	**44.5**	

The Mean Values of the L_{Aeq} parameter is considered representative of the Ambient noise level under the measurement conditions.

The Mean Value of the LAF90 parameter is considered representative of the Background noise level under the measurement conditions.

A night-time survey was not required as neither construction works nor significant operational activities will occur at night (23:00 to 07:00 Hrs).

Train Noise

In addition, the noise level of a passing train event was measured as L_{Aeq}, 32sec = 60.6dB. This was measured approximately. 30metres from the track in free-field conditions on the existing site, identified as 'Additional Survey Location' in Plate 12.1. The result therefore represents typical train event noise levels at the rear of the dwellings closest to the site on Trinity Street.

According to the current Irish Rail schedule, there are 8 trains (arrivals & departures) Monday to Friday during the day time period and one during the early morning/ night time period (departure from Rosslare 05:35). Six trains occur on Saturdays and Sundays during the day-period only.

12.3.2 Construction Phase

Relevant Noise Guidance Documents

There is no statutory Irish guidance relating to the maximum permissible noise level that may be generated during the construction phase of a development. Local authorities may control construction activities by imposing limits on the hours of operation and/or may consider noise limits at their discretion. In the absence of specific

noise limits, appropriate criteria relating to permissible construction noise levels for a development of this scale may be found in the following guidance:

- Transport Infrastructure Ireland (TII): Good Practice Guidance for the Treatment of Noise during the Planning of National Road Schemes – 2014

The document represents guidance for the assessment of road traffic noise, but it also presents maximum permissible noise levels at dwelling facades during construction activities as set out in Table 12.2.

Table 12.2 Limits of Construction Noise in TII Guidance Document

Days & Times	$L_{Aeq\ (1\ hour)}$	$L_{AS,\ Max}$
Monday - Friday 07:00 to 19:00 hrs	70	80
Monday - Friday 19:00 to 07:00 hrs	60	65
Saturday 08:00 to 16:30 hrs	65	75
Sundays & Bank-holidays 08:00 to 16:30 hrs	60	65

The guidance also recommends that: "*In the absence of an Irish or international standard relevant to construction noise, reference can be made to BS 5228*".

BS5228:2009 *Code of practice for noise and vibration control on construction and open sites*. The guidance adopted in this standard designates noise sensitive locations into a specific category; A, B or C as presented in Table 12.3, based on existing ambient noise levels i.e. in the absence of construction noise. This then sets threshold noise values for construction related noise that if exceeded, indicates a significant noise impact is associated with the construction activities.

Table 12.3 sets out the values which, when exceeded, indicate a significant effect at the facades of residential receptors as recommended by the above standard. Please note that these are cumulative levels, i.e. the sum of both ambient and construction noise levels.

Table 12.3 Example Threshold of Significant Effect at Dwellings

Assessment category and threshold value period (L_{Aeq})	Threshold value, in decibels (dB)		
	Category A	Category B	Category C
Night-time (23.00−07.00)	45	50	55
Evenings and weekends	55	60	65
Daytime (07.00−19.00) and Saturdays (07.00−13.00)	65	70	75
NOTE 1 A significant effect has been deemed to occur if the total L_{Aeq} noise level, including construction, exceeds the threshold level for the Category appropriate to the ambient noise level. *NOTE 2 If the ambient noise level exceeds the threshold values given in the table (i.e. the ambient noise level is higher than the above values), then a significant effect is deemed to occur if the total L_{Aeq} noise level for the period increases by more than 3 dB due to construction activity.* *NOTE 3 Applied to residential receptors only.*			
Category A: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are less than these values.			

Category B: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are the same as category A values.

Category C: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are higher than category A values.

Category D: 19.00–23.00 weekdays, 13.00–23.00 Saturdays and 07.00–23.00 Sundays.

Vibration Guidelines

There is likely to be no adverse vibration levels as a result of the operation of the development. The most likely potential vibration effects are associated with the construction phase of the development.

Vibration threshold values discussed below are therefore presented in the context of potential vibration effects from the construction phase.

Limits of transient vibration, above which cosmetic damage could occur, are given in Table 12.4.

Table 12.4 Transient Vibration Guide Values for Cosmetic Damage (Ref BS5228-2:2009)

Type of Building	Peak Particle Velocity (PPV) (mms^{-1}) in Frequency Range of Predominant Pulse	
	4Hz to 15Hz	15Hz and above
Reinforced of framed structure. Industrial and heavy commercial buildings.	$50mms^{-1}$ at 4Hz and above	$50mms^{-1}$ at 4Hz and above
Unreinforced or light framed structures. Residential or light commercial buildings.	$15mms^{-1}$ at 4Hz increasing to $20mms^{-1}$ at 15Hz	$20mms^{-1}$ at 15Hz increasing to $50mms^{-1}$ at 40Hz and above

Minor damage is possible at vibration magnitudes which are greater than twice those given in Table 12.4, and major damage to a building structure can occur at values greater than four times the tabulated values (definitions of the damage categories are presented in BS 7385-2:1993).

These guidelines refer to relatively modern buildings and therefore, these values should be reduced to 50% or less for more sensitive buildings.

People can generally perceive vibration at levels which are substantially lower than those required to cause building damage. The human body is most sensitive to vibration in the vertical direction. The effect of vibration on humans is guided by *BS 6472-1:2008 Guide to evaluation of human exposure to vibration in buildings. Vibration sources other than blasting*. This standard does not give guidance on the limit of perceptibility, but it is generally accepted that vibration becomes perceptible at levels of approximately 0.15 to 0.3 mms^{-1}.

The *Good Practice Guidance for the Treatment of Noise during the Planning of National Road Schemes – 2014* also includes a discussion of vibration levels in relation to construction activities. While the document relates to national road schemes, the advice on construction vibration is relevant to all construction activities. Table 12.5 includes allowable vibration levels during construction activities which would minimise the risk of building damage. This is the reference to be applied to the assessment of vibration in the Republic of Ireland.

Table 12.5 Allowable Vibration During Construction in Order to Minimise the Risk of Building Damage

Allowable Vibration (Peak Particle Velocity) at the Closest Park of Any Sensitive Property to the Source of Vibration, at a Frequency of		
Less than 10Hz	10Hz to 50Hz	50Hz to 100Hz and above
8mms^{-1}	12.5mms^{-1}	20mms^{-1}

Prediction of vibration levels at nearby buildings as a result of the development of the Trinity Wharf scheme is not possible without detailed analysis of the ground substrate (this is typical of most construction sites). Vibration is generally only a concern at locations close to the construction site which a number of buildings are in the case of this scheme. Therefore, a vibration monitoring programme should be adopted at the nearest building(s) during the most critical phase(s) of construction e.g. rock-breaking, pile driving (if applicable) etc.

Construction Plant, Noise Levels

A variety of items of plant will be in use during the construction works. Typical items of plant used will include rock breakers, excavators, pilling operations, dump trucks, compressors and generators in addition to general concreting plant, road surfacing and levelling equipment.

The BS5228 standard sets out sound power levels for plant items normally encountered during key phases on construction sites, which in turn enables the prediction of noise levels at selected locations.

Likely construction noise calculations have been conducted at the nearest properties to the works during the demolition and site preparation works stages. These phases are likely to produce the highest impact as therefore represent a 'worse-case' scenario.

Best practice also requires that appropriate mitigation measures be considered, and these are discussed also.

12.4 Noise Model

A computer-based prediction model has been prepared in order to quantify the noise level associated with the construction phase of the proposed development. This section discusses the methodology behind the noise modelling process and presents the results of the modelling exercise.

Noise Prediction Software

Proprietary noise calculation software was used for the purposes of this impact assessment. The selected software, Brüel & Kjær Type 7810 Predictor, calculates traffic noise levels in accordance with *ISO 9613-2:1996 Acoustics - Attenuation of sound during propagation outdoors - Part 2: General method of calculation* and NRA guidance.

The software predicts noise levels in different ways depending on the selected prediction standard. In general, however, the resultant noise level is calculated taking into account a range of factors affecting the propagation of sound, including:

- the magnitude of the noise source in terms of sound power and for moving sources, average velocity and flow;
- the distance between the source and receiver;

- the presence of obstacles such as screens or barriers in the propagation path;
- the presence of reflecting surfaces, and;
- the hardness of the ground between the source and receiver.

Input to the Noise Model

The noise model was prepared using the following data:

- Scaled map of the area around the site including 3D topographical data;
- Nearby buildings including Residential and Commercial properties;
- Sound power data of the major noise sources expected to operate during the construction phase(s) being considered.

A list of the major items of plant to be used was provided by Roughan & O'Donovan (ROD) and the equivalent sound power values of each are listed in BS 5228 tables. Where an exact size/power equivalent wasn't available, the next largest item was used as the input data to the model.

Various assumptions about the operation of the items were required and a conservative approach which over-estimates the likely noise impact has been adopted. For instance; all major plant is mobile so a larger number of movements of each than is likely during a typical day has been assumed in the model. This approach produces a higher level of predicted noise which compensate for the uncertainties associated with the assumptions.

The details of the items of plant used in the model which are presented in Table 12.6.

Table 12.6 Plant Details Used as Input into Model

Item	Model	BS 5228				Modelling Assumptions	
		Description	Ref	Power (Kw) / Size (t)	L_{Aw}	Source Height	Flow (per-day)
Tracked Excavator	JCB JS300	Tracked Excavator	C.2/2	300/71	104.9	3m	25
Piling Rig	Soilmec SR70 Continuous Flight Auger Piling Rig	Tracked drilling rig with hydraulic drifter	C.3/15	104/12.5	110.7	5m	10
Dumper Truck	Volvo A45G	Articulated dump truck	C.6/26	287/40	107.2	2m	25
Rock Breaker	TBC	Breaker mounted on wheeled backhoe	C.1/1	59	120.5	0.75m	10
Tandem Vibratory Roller	CB44B/CB 54B	Vibratory roller	C.5/21	95/12	108.4	1.5m	10

Each noise source above was modelled as moving across the site at a velocity of 10kmh^{-1} except for the rock breaker which if required, is likely to be confined to specific areas of the site.

For the purposes of modelling, it has also been assumed that all sources, subject to their assumed operations above, are working simultaneously over the course of the day period. This is unlikely to occur under practical conditions therefore the actual noise levels at the locations indicated in Table 12.7 are likely to be less than those predicted.

Output of the Noise Model

The Predictor software calculates noise levels for a set of receiver locations specified by the user. The results are presented in terms of L_{Aeq} which can then be compared to the threshold criteria set out in Table 12.3.

Choice of Receiver Locations

In the first instance, the construction noise levels are predicted at the same locations as the attended noise survey locations (illustrated in Plate 12.1) with results detailed in Table 12.7. A full construction noise impact assessment can only be made at these locations as existing ambient noise levels are known only here. However, these locations were chosen to serve as proxy locations for the closest NSLs, so the greatest likely impact is applicable to these. Other NLSs are further from the construction activity and therefore the impact at these will be less.

At some properties noise levels were predicted at different heights to represent ground, first floor levels etc. and to the front and rear of some properties. At the Talbot hotel, levels were predicted at 6 floors. In total, free-field construction noise levels have been predicted at 26 properties and 2 survey locations. The Survey and Impact Assessment locations are presented in Appendix 12.2 and the predicted construction noise levels in Appendix 12.3.

12.5 Construction Impact Assessment

The impact assessment is made by first comparing the sum of the ambient and predicted noise levels at the survey locations with the limits from the TII guidance. Secondly, the levels are compared with the Categories of BS 5228. Table 12.7 below is a summary of the results.

Table 12.7 Construction Noise Impact Assessment Results (Day-time)

	L_{Aeq} values			TII Guidance		BS 5228 Guidance		
Survey Location	**Ambient**	**Predicted**	**Sum**	**Limit**	**Exceeded?**	**Category**	**Limit**	**exceeded?**
1	50.0	56.3	57.2	70	No	A	65	No
2	53.5	56.9	58.5	70	No	A	65	No

As can be seen, the predicted noise levels are less than the TII maximum recommended limit and the lowest Category A limit of BS 5228. Assessment is made for the day-period only as construction will not take place, except in the case of emergencies, at other times.

Lower limits of 65dB (TII Guidance) / 55dB (BS5228 Guidance) apply for weekend works (see Tables 12.2 & 12.3). The Sum of the Predicted and Ambient levels above

would, in the absence of mitigation, therefore be exceeded under such circumstances. As the Predicted levels above are based on all plant in Table 12.6 operating simultaneously, care should be taken that this does not occur during weekends so as not to exceed these reduced limits.

Modelling exercises to include the hoarding have concluded that the reductions as per Table 12.8 at the Survey locations can be expected:

Table 12.8 Possible Noise Reductions from Perimeter Hoarding

Hoarding Height	Noise Reductions	
	Survey Loc 1	Survey Loc 2
3m	-2.7dB	-4.6dB
4m	-3.5dB	-5.4dB

The location as modelled in shown in Plate 12.2.

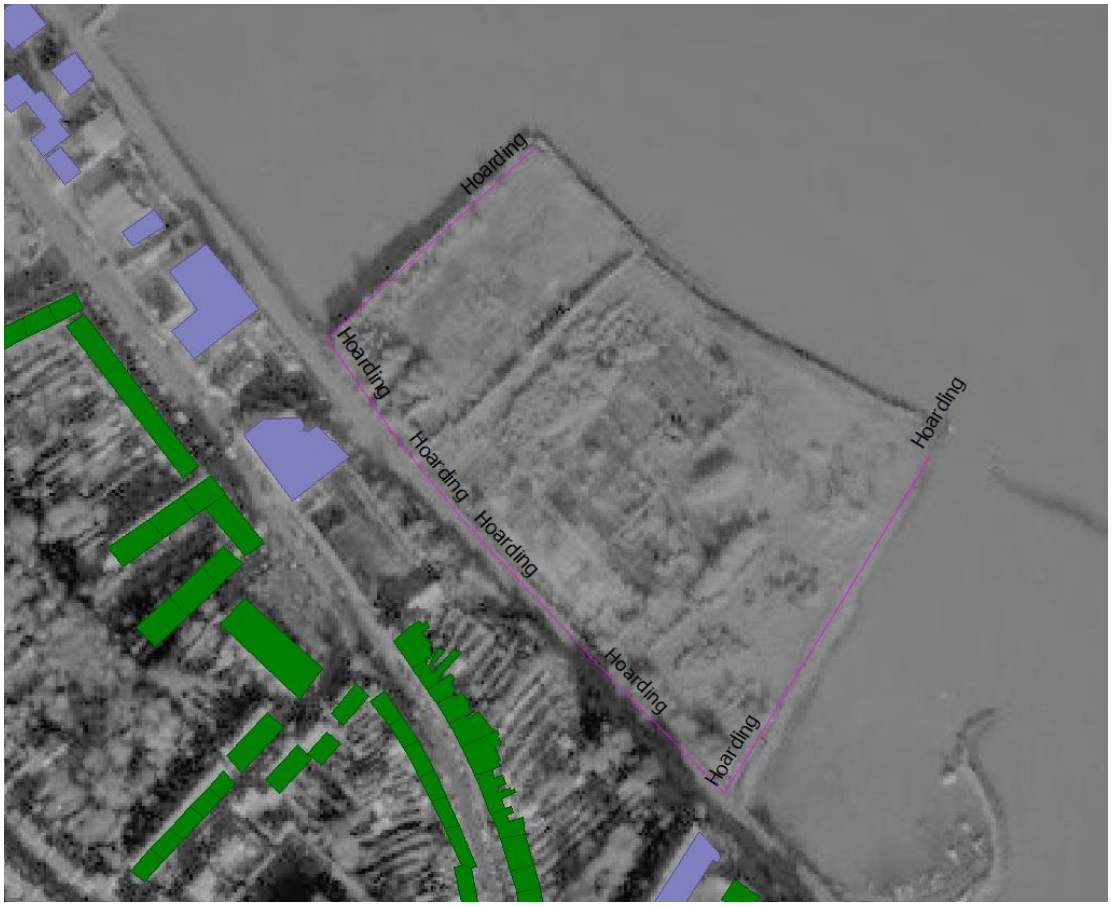

Plate 12.2 Modelled hoarding around three sides of the main construction site

The modelled hoarding described above is considered to be ideal as it is continuous with no gap along the bottom. A practical hoarding however is likely to compromise the above as a result of gaps, openings and materials. Therefore, the maximum possible attenuation figures in Table 12.8 may be at least 3dB less in reality.

Other noise amelioration strategies for individual items of plant etc may be available.

12.6 Construction Impact Assessment Conclusion

The noise assessment has indicated that construction activities can operate within the adopted noise limits for daytime periods (Monday to Friday) at the nearest properties to the works. The application of the proposed noise limits and restricted hours of operation, along with implementation of appropriate noise control measures, will ensure that noise impact is kept to within acceptable standards.

Lower limits of 65dB (TII Guidance) / 55dB (BS5228 Guidance) apply for weekend works and care should be taken to ensure that only select less noisy activities are undertaken during weekends so as not to exceed these reduced limits.

Vibration

A vibration monitoring programme will be required to be adopted at a select number of the nearest buildings during the most critical phase(s) of construction e.g. pile driving, etc.

12.7 Operational Phase

Should the proposed development proceed, increased levels of traffic noise in the vicinity is expected as well as on-site traffic accessing the car-park and circulating within the site. In addition, items of mechanical and electrical plant associated with the hotel and office blocks will be operating in the vicinity and may have an impact. Finally, operations from the cultural and performance centre may also have an impact.

All these likely noise sources are discussed, and their individual impacts are assessed in this section. The noise levels are expressed in term of L_{day}, L_{eveing}, L_{night} to show these specific periods but the L_{den} is the parameter applicable for impact assessment.

12.7.1 Traffic Noise

Baseline and Post-Development traffic figures in terms of Annual Average Daily Traffic (AADT) were provided by ROD which are shown in Table 12.9.

Table 12.9 Existing (Baseline) and Predicted Post-Development Traffic Flows

	Baseline		Post-Development		Average Speed, kph
	AADT	HGV	AADT	HGV	
Trinity Street	10154	157	11826	169	38
William Street Lower	10208	510	11494	558	38
Fisher's Row	1380	14	1476	14	30
Parnell Street	2918	12	3605	12	32
King Street	4129	41	4793	53	24
Paul Quay	12437	249	12697	249	30
Site's Access Road	N/A	N/A	3217	30	30
Site's Circulatory Rd	N/A	N/A	322	30	20

The noise and vibration assessment for the Baseline and Post-Development schemes was undertaken with reference to the following standards and guidance documents:

- *Guidelines for the Treatment of Noise and Vibration in National Road Schemes, Rev 1 2004* and *Good Practice Guidelines for the Treatment of Noise and Vibration during the Planning of National Road Schemes 2014*, Transport Infrastructure Ireland (TII, formally NRA) – the "Guidelines"

A similar noise model to that used for the prediction of noise levels in the construction phase was used to predict noise levels from traffic flow data. The Predictor software used previously implements various prediction standards including Calculation of Road Traffic Noise (CRTN) which is recommended by the *Guidelines*.

CRTN is an empirically derived noise prediction standard and predicts noise levels based on traffic volumes and velocities.

To provide hourly input data to the models, which would allow the L_{den} parameter to be calculated as recommended by the Guidelines, each AADT value was distributed using TII's Diurnal Profile as set out in Table 12.10.

Table 12.10 TII Diurnal Profile

Hour	%	Hour	%	Hour	%
1	0.84	9	5.83	17	8.02
2	0.53	10	5.26	18	8.54
3	0.38	11	5.17	19	7.34
4	0.33	12	5.72	20	5.68
5	0.37	13	6.33	21	4.35
6	0.73	14	6.63	22	3.23
7	2.20	15	6.82	23	2.25
8	4.68	16	7.32	24	1.45

The resultant hourly traffic flows for some roads were less than 200 vehicles/hour. CRTN recommended that appropriate corrections are made for such low-flow periods which have been applied.

The *Guidelines* are primarily concerned with the impact assessment of new road schemes and generally give a design goal of L_{den} <60dBA however, applying such a limit is not applicable here so a comparison between the Existing (Baseline) and Post-Development scenarios is made.

The resultant noise levels at the measurement locations are presented in Appendix D.

12.7.2 Plant Noise

Currently details on the items of plant associated with the operations of the various building in the development are available only in general terms with no specific details regarding models or installation.

Sketches of the plant rooms for each applicable building were provided in the *D1815 Environmental Analysis Report 2018-11-20 DRAFT ONLY FI (003)* document by ROD. From there the following was derived:

Table 12:11 Details of Plant Room Noise Sources

Building	Major Plant	Location	Operation duty cycles	Sound Level
Hotel	VRF condensers x15 Chiller Unit	Roof	Day: 100% Evening: 100% Night: 50%	SWL=80dBA ea* SWL=83dBA
Hotel	Combined Heath & Power (CPH) Unit	Ground	Day: 100% Evening: 100% Night: 50%	SPL=75dBA @1m
Cultural Centre	Chiller Units	Roof	Day: 100% Evening: 100% Night: 0%	SWL=83dBA
Café, Retail, Restaurant	None	N/A	N/A	N/A
Office Blocks A, B & C	VRF condensers x15 Chiller Unit	Roof	Day: 100% Evening: 0% Night: 0%	SWL=80dBA ea* SWL=83dBA
	**Total SWL: 15x 80dBA = 91.8dBA.*			

The Operation Duty Cycle parameter is used to represent when the plant will be operational over the course of a 24-hour period. For example, the offices are unlikely to occupied and the hotels' demand's will likely reduce at night with a commensurate reduction in noise.

Each of the items on the roof of the buildings are to be contained inside a 2.2m high louvered structure with no roof. Each plant 'room' is essentially identical in terms of its noise levels.

The noise levels provided in Table 12.11 are overall levels, but octave band levels are required for the purposes of noise modelling. As a result, the levels above are assumed to be in the 500Hz octave band, as is the norm[1]. The reduction due to the louver at this frequency band was assumed to be – 11dB[1].

For the purposed of noise modelling, sound power levels (SWL) are required but the sound pressure level (SPL) was given for the CHP unit. It's SWL level was calculated as follows:

$$L_w = L_p + 20\log_{10} r + C - R$$

Where:

Lw = SWL

Lp = SPL

r = distance

C^1 = Constant to account for enclosure internal acoustic condition. C has been assumed to be +9dB @500Hz or 'fairly live'. Fairly Live: all surfaces generally hard but some panel construction

R^1 = Reduction of louvered door. Assumed to be -11dB @500Hz

So,

$$L_w = 75 + 20\log_{10} 1 + 9 - 11$$
$$L_w = 73dB$$

[1] *Engineering Noise Control, Bies Hansen*

The ground-based plant room noise level is significantly less than the roof-based levels. All sources were modelled as single point-sources with the roof sources having a vertical radiation pattern.

Plate 12.3 is a 3D illustration of their positions – shown as white markers.

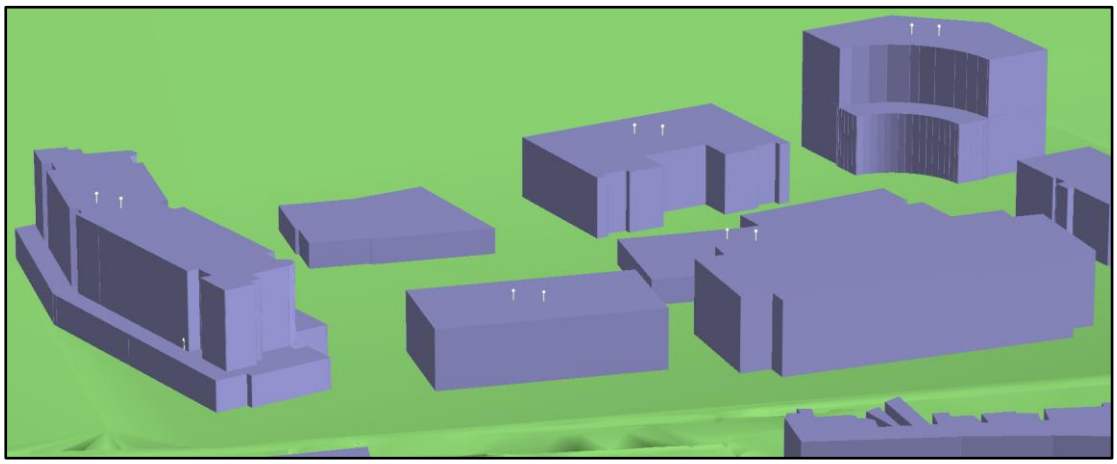

Plate 12.3 Plant room noise modelled sources

The calculated noise levels at the NSLs are presented in Appendix 12.4.

12.7.3 Cultural & Performance Centre

The programme of events for the Cultural & Performance Centre are not yet defined but it has been assumed that typical in-door events such as plays, moderate amplified music, shows etc take place inside the auditoria.

The construction build-up of the building's façade is assumed to be a 280mm cavity wall (420kg/m^2) – the final construction is likely to be denser and offer greater reduction to noise transmission, so this is considered as conservative.

Typical measured noise levels within a similar auditorium are available to Enfonic. To model the noise break-out, an indoor-outdoor calculation using these noise levels and the Sound Reduction Index (R) of the wall facing sound towards Trinity Street was used and these are presented in Table 12.12.

Table 12.12 Noise break-out Calculation for the Arts Centre's Auditoria

	63Hz	125Hz	250Hz	500Hz	1000Hz	2000Hz	4000Hz	8000Hz	Total
L_{Ap} dB	90	88	86	84	82	82	76	76	90
R (dB)	36	41	46	53	59	64	64	64	
Lw (dBA/m^2)	48	41	34	25	17	12	6	0	49

Plate 12.4 is a 3D illustration of the position of the emitting façade of the Arts Centre.

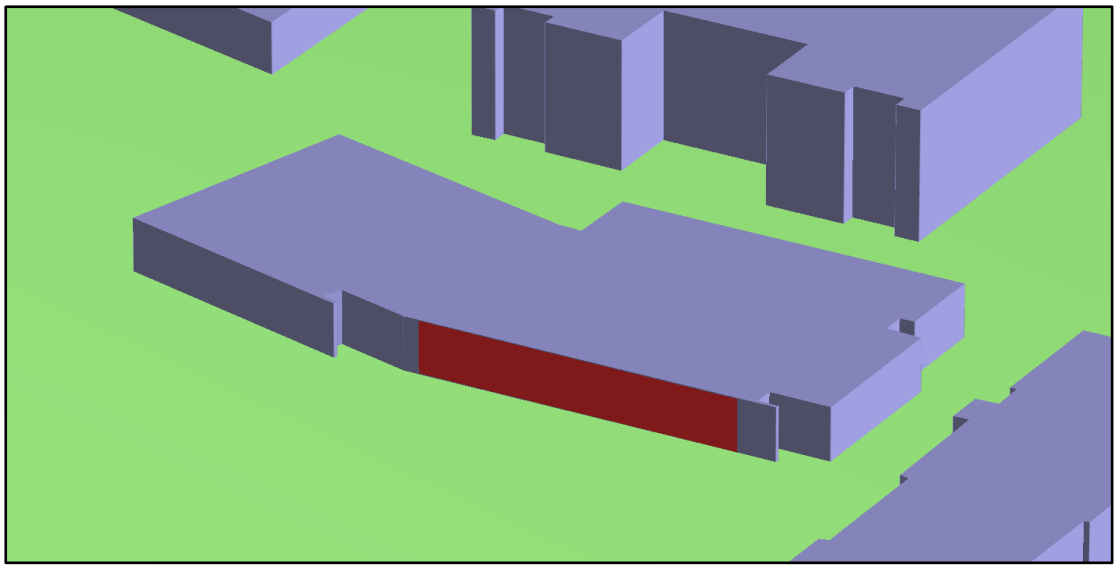

Plate 12.4 Emitting façade of the Arts Centre – shown in red

The calculated noise levels at the NSLs are presented in Appendix 12.4.

12.7.4 Total Operational Noise

The totals of the above Traffic, Plant and Arts Centre noise levels at the NSLs is presented in Appendix 12.5.

12.8 Operational Impact Assessment

As can be seen from the results, almost all locations will see an increase in noise level as a result of the development. Suitable guidance on environmental noise for planning purposes can be found in the standard *BS 4142:2014 Methods for rating and assessing industrial and commercial sound*.

Notwithstanding that *BS 4142* compares L_{AF90} and L_{Aeq} parameters and not L_{den}, generally it recommends that an increase of around 10dB or more 'indicates a significant adverse impact'. A difference of around 5dB 'indicates an adverse impact' and below 0dB indicates 'low adverse impact likely'. This however is dependent on the 'context' of the site and its environs e.g. time of day, nature of the neighbourhood, local attitudes to the development etc.

The NSLs with the most significant impact are presented in Table 12.13.

Table 12.13 NSLs with Impact Lden >5dB

			Impact Level Differences from Table 12.5			
Name	**Description**	**Height (m)**	**L_{day}**	**$L_{evening}$**	**L_{night}**	**L_{den}**
House1_A	21 William Street Lwr - Rear	1.5	7.0	7.1	6.3	6.9
House1_B	21 William Street Lwr - Rear	4.0	5.9	5.5	4.5	5.5
House5_B	Batt Street Apartments S - front1	4.0	5.0	5.1	5.0	5.1

Site-related traffic is the most significant contributor from the development at the locations in Table 12.13. It should be noted that the front of the property at 21 William

Street already experiences significantly higher levels as a result of the existing traffic on William Street than from the proposed development: existing Lden = 81.2dB (see Appendix 12.5). These residents are therefore likely be conditioned to high levels of urban traffic noise.

Following the guidance of BS4142; the *Context* that the development is to take place in is a key issue for noise assessment. It is difficult to numerically assess the matter of context, but experience suggests that considering the nature of the neighbourhood and the existing ambient noise levels including existing high levels of noise from traffic, passing trains and the existing coastal environment including mussel dredging vessels that a conservative adjustment value of -3dB is applicable to the Impact Differences in Table 12.13.

The resultant level differences with the context added are presented in Table 12.14

Table 12.14 Impact level differences with BS4142 Context correction applied

Name	Description	Height (m)	Impact Level Differences from Table 12.5		
			L_{den} Impact Level Difference from Table 12.13	BS4142 Context correction	Resultant L_{den}
House1_A	21 William Street Lwr - Rear	1.5	6.9	-3dB	3.9
House1_B	21 William Street Lwr - Rear	4.0	5.5	-3dB	2.5
House5_B	Batt Street Apartments S - front1	4.0	5.1	-3dB	2.1

As can be seen in Table 12.14 a maximum impact of 3.9dB occurs at House1_A. This and the impact at all other locations, are below the adverse impact levels identified by BS4142.

A general noise management strategy should be developed as part of the development and management of the marina and café/ restaurant uses including hours of operation, training for staff and signage to notify the public of the potential effect their activities, particularly at night, may have on nearby residents.

12.9 Noise and Human Health

There are three established concepts from toxicology that are currently being applied to noise impacts, for example, by the World Health Organisation. They are:

NOEL – No Observed Effect Level

This is the level below which no effect can be detected. In simple terms, below this level, there is no detectable effect on health and quality of life due to the noise from a proposed development.

LOAEL – Lowest Observed Adverse Effect Level

This is the level above which adverse effects on health and quality of life can be detected.

SOAEL – Significant Observed Adverse Effect Level

This is the level above which significant adverse effects on health and quality of life occur.

It is the conclusion of this impact assessment that this development falls within the LOAEL – Lowest Observed Adverse Effect Level i.e. that some impact is likely to be detectable but is not considered significant. This is supported by the results of the described in Section 10.10 (BS4142) assessment.

12.10 Mitigation Measures

12.10.1 Construction Stage Mitigation Measures

Notwithstanding that there is little likelihood of a significant adverse impact from the construction works, a comprehensive Construction Environmental Management Plan (CEMP) which includes adopting appropriate mitigation measures will manage the risk of noise impacting the community.

It is recommended that the contract documents should clearly specify that the Contractor undertaking the construction of the works will be obliged to take specific noise abatement measures and comply with the recommendations of BS5228-1 2009. These measures will typically include:

- No plant used on site will be permitted to cause an ongoing public nuisance due to noise.
- The best means practicable, including proper maintenance of plant, will be employed to minimise the noise produced by on site operations.
- All vehicles and mechanical plant will be fitted with effective exhaust silencers and maintained in good working order for the duration of the contract.
- Compressors will be attenuated models fitted with properly lined and sealed acoustic covers which will be kept closed whenever the machines are in use and all ancillary pneumatic tools shall be fitted with suitable silencers.
- Machinery that is used intermittently will be shut down or throttled back to a minimum during periods when not in use.
- Any plant, such as generators or pumps, which is required to operate before 07:00hrs or after 19:00hrs will be surrounded by an acoustic enclosure or portable screen.
- Location of plant shall consider the likely noise propagation to nearby sensitive receptors.
- During the course of the construction programme, supervision of the works will include ensuring compliance with the limits detailed in Table 2 using methods outlined in BS5228:2009 Part 1.
- Normal working times will be 07:00 to 19:00hrs Monday to Friday and 08:00 to 16:00 Saturday. Works other than the pumping out of excavations, security and emergency works should be avoided outside of these periods.
- The emergency work may include the replacement of warning lights, signs and other safety items on public roads, the repair of damaged fences, repair of water supplies and other services which have been interrupted, repair to any damaged temporary works and all repairs associated with working on public roads.
- A suitable perimeter hoarding (as described in Table 12.8) around the site on three sides will provide an effective method of reducing noise propagation from the site. This hoarding will need to be phased as it can only be constructed along

the northern and southern boundaries once the sea wall and anchors in those locations have been constructed. It shall be erected along the railway boundary as soon as practicable during site setup. The hoarding shall be regularly inspected by the Site Environmental Manager and a Site Engineer to ensure the adequacy of the hoarding from a noise and visual perspective. Technical specifications on the acoustic performance of suitable hoardings can be found the UK's Design Manual for Roads and Bridges HA 66/95 which gives guidance on acoustic performance, forms of construction and physical properties of materials.

Vibration

- A vibration monitoring programme will be required to be adopted at a select number of the nearest buildings during the most critical phase(s) of construction e.g. pile driving, etc.

12.10.2 Operational Stage Mitigation Measures

A general noise management strategy will be required to be developed as part of the development and management of the marina and café/ restaurant uses including hours of operation, training for staff and signage to notify the public of the potential effect their activities, particularly at night, may have on nearby residents.

12.11 Residual Impacts

The overall noise impact from the proposed development on the closest properties will be of low significance from an acoustic standpoint.

12.12 Difficulties Encountered

No particular difficulties were encountered in preparing the noise and vibration assessment.

12.13 Conclusion

The noise assessment has indicated that construction activities can operate within the adopted noise limits for daytime periods (Monday to Friday) at the nearest properties to the works. The application of the proposed noise limits and restricted hours of operation, along with implementation of appropriate noise control measures, will ensure that noise impact is kept to within acceptable standards.

Lower limits of 65dB (TII Guidance) / 55dB (BS5228 Guidance) apply for weekend works and care should be taken to ensure that only select less noisy activities are undertaken during weekends so as not to exceed these reduced limits.

It is the conclusion of this impact assessment that this development falls within the LOAEL – Lowest Observed Adverse Effect Level i.e. that some impact is likely to be detectable but is not considered significant. This is supported by the results of the described in Section 10.10 (BS4142) assessment.