Chapter 12
Noise and Vibration

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Chapter 12 Noise and Vibration

12.1 Introduction

This chapter assesses the potential noise and vibration impacts associated with the proposed Flood Defences West, hereafter referred to as the 'proposed development' in Waterford City, Co. Waterford. The proposed development aims to develop flood defence measures for the protection of critical infrastructure including the existing Iarnród Éireann Waterford (Plunkett) Station, the railway line east and west of Plunkett Station and the Rice Bridge roundabout.

The flood defence measures will comprise remedial works to the existing quay wall and the construction of a new flood defence wall, typically in the form of a driven steel sheet pile wall. The works will also involve upgrading the drainage, installation of two pumping stations, remediation of the existing drainage outfalls and extending them through the new sheet pile wall.

12.2 Methodology

12.2.1 Construction Assessment Criteria

12.2.1.1 Noise

There is no published statutory Irish guidance relating to the maximum permissible noise level that may be generated during the construction phase of a project. In lieu of statutory guidance, an assessment of significance has been undertaken as per British Standard *BS 5228-1:2009+A1:2014 Code of Practice for Noise and Vibration Control on Construction and Open Sites - Noise*.

The approach adopted here calls for the designation of a noise sensitive location into a specific category (A, B or C) based on existing ambient noise levels in the absence of construction noise. Table 12.1 sets out the values which, when exceeded, signify a significant effect at the façades of residential receptors.

Table 12.1 Example Threshold of Potential Significant Effect at Dwellings

Assessment category and threshold value period	Threshold value, in decibels (dB) ($L_{Aeq, T}$)		
	Category A[A]	Category B[B]	Category C[C]
Daytime (07:00 – 19:00) and Saturdays (07:00 – 13:00)	65	70	75
Evenings and weekends [D]	55	60	65
Night-time (23:00 to 07:00hrs)	45	50	55

[A] Category A: threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are less than these values.

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

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

[D] 19:00 – 23:00 weekdays, 13:00 – 23:00 Saturdays and 07:00 – 23:00 Sundays.

For the appropriate assessment period (i.e. daytime in this instance) the ambient noise level is determined through a logarithmic averaging of the measurements for each

location and then rounded to the nearest 5 dB. If the construction noise exceeds the appropriate category value, then a significant effect is deemed to occur.

Commercial Receptors

BS5228-1:2009+A1 gives several examples of acceptable limits for construction or demolition noise, the most simplistic being based upon the exceedance of fixed noise limits. For example paragraph E.2 states:

> *"Noise from construction and demolition sites should not exceed the level at which conversation in the nearest building would be difficult with the windows shut."*

Paragraph E.2 goes on to state:

> *"Noise levels, between say 07.00 and 19.00 hours, outside the nearest window of the occupied room closest to the site boundary should not exceed:*
>
> *70 decibels (dBA) in rural, suburban areas away from main road traffic and industrial noise;*
>
> *75 decibels (dBA) in urban areas near main roads in heavy industrial areas".*

It is considered appropriate to adopt the 75 dB(A) criterion during the day for commercial properties located in Sally Park Yard.

12.2.1.2 Vibration

In terms of vibration, BS 5228-2:2009+A1:2014 recommends that, for soundly constructed residential property and similar structures that are generally in good repair, a threshold for minor or cosmetic (i.e. non-structural) damage should be taken as a peak component particle velocity (PPV) (in frequency range of predominant pulse) of 15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz and 50 mm/s at 40 Hz and above. The standard also notes that below 12.5 mm/s PPV the risk of damage tends to zero. It is therefore common, on a cautious basis, to use this lower value. Taking the above into consideration the vibration criteria in Table 12.2 are recommended.

Table 12.2 Defined Construction Vibration Thresholds

Allowable vibration (in terms of peak particle velocity) at the closest part of sensitive property to the source of vibration, at a frequency of:-		
Less than 15 Hz	**15 to 40 Hz**	**40 Hz and above**
15 mm/s	20 mm/s	50 mm/s

Note that the above thresholds are specified for transient or intermittent vibrations. Some construction activities, such as piling, may give rise to continuous vibrations. In these instances, the guidance recommends that the previously defined thresholds are reduced by at least 50%.

12.2.2 Operational Assessment Criteria

Due to the nature of the proposed development, there are no predicted emissions during the operational phase. Therefore, there is no potential for operational phase noise impacts and no assessment is required.

12.2.3 Baseline Noise Survey

12.2.3.1 Guidelines and Standards

Noise measurements were conducted in general accordance with the guidance contained in *ISO 1996-1:2016 Acoustics – Description measurement and assessment and environmental noise. Part 1: Basic quantities and assessment procedures (ISO 2016) and ISO 1996-2:2017 Part 2: Determination of sound pressure levels (ISO 2017).*

12.2.1.3 Instrumentation

The baseline noise measurements were performed using a Brüel & Kjær Type 2250 Sound Level Meter. Before and after the survey the measurement apparatus was check calibrated using a Brüel & Kjær Type 4231 Sound Level Calibrator.

12.2.1.4 Survey Periods and Location

Baseline noise surveys have been conducted at locations representative of the nearest noise sensitive areas which have the potential to be impacted by the proposed development, typically within a 300m radius of the development. An attended noise survey was conducted at 3 locations on 22 February 2021 between 11:20 and 15:00 hours.

12.2.3.1. Procedure

Measurements were conducted on a cyclical basis at the 3 locations, refer to Section 12.3.1 below for location descriptions. Sample periods for the noise measurements were 15 minutes at each location with each location sampled three times. The results were noted onto an Environmental Noise Survey Record Sheet immediately following each sample and were also saved to the instrument memory for later analysis where required. Survey personnel noted the primary noise sources contributing to noise build-up.

12.2.3.2. Measurement Parameters

The noise survey results are presented in terms of the following five parameters:

$L_{Aeq,T}$ is the equivalent continuous sound level. It is a type of average and is used to describe a fluctuating noise in terms of a single noise level over the period T. It is typically used as a descriptor for ambient noise.

L_{Amax} is the instantaneous maximum sound level measured during the sample period.

L_{Amin} is the instantaneous minimum sound level measured during the sample period.

L_{A10} is the sound level that is exceeded for 10% of the sample period. It is typically used as a descriptor for traffic noise.

L_{A90} is the sound level that is exceeded for 90% of the sample period. It is typically used as a descriptor for background noise.

The "A" suffix denotes the fact that the sound levels have been "A-weighted" in order to account for the non-linear nature of human hearing. All sound levels in this report are expressed in terms of decibels (dB) relative to 2×10^{-5} Pa.

12.3 Description of the Receiving Environment

A baseline environmental noise survey was conducted in the vicinity of the proposed development and within Waterford City in order to quantify the existing noise environment in the vicinity of the noise-sensitive locations that may be affected by the proposed development.

12.3.1 Measurement Locations

The measurement location descriptions are presented in Table 12.3 below and illustrated in Plate 12.1. The weather during the survey period was mainly dry with mild temperatures of approximately 10°C for the duration of the survey and light winds of 5 m/s or less.

Table 12.3 Baseline Noise Monitoring Locations

Survey Location	Description
Location A	Outside the residential property located in Sally Park
Location B	Outside commercial properties in Sally Park yard
Location C	Outside residential and commercial properties on Grattan Quay

Plate 12.1 Selected Noise Survey Locations

The identified sensitive receptors are presented in Table 12.4 and illustrated in Plate 12.2.

Plate 12.2 Identified Sensitive Receptors

Table 12.4 Sensitive Receptor Descriptions

Receptor Reference	Description
R1	Waters Gate (Residential Properties)
R2	Newrath House (Residential Properties)
R3	R448 (Residential Properties)
R4	Offices (Commercial)
R5	Residences and Hotels on Grattan Quay (Residential)

12.3.2 Measurement Results

Tables 12.5 to 12.7 present the results of the attended measured noise levels for each of the three survey locations.

12.3.2.1. Location A

At location A, the noise climate was dominated by road traffic and train movements. Ambient noise levels were measured as a range between 51 and 52 dB L_{Aeq}. Background noise levels were in the range of 45 to 48 dB L_{A90}.

Table 12.5 Measurement Results for Location A

Time	L_{Aeq}	L_{AFmax}	L_{AFmin}	L_{AF10}	L_{AF90}
11:23	52	70	45	55	48
12:11	51	77	42	53	45
12:56	51	62	45	54	48

12.3.2.2. Location B

At location Location B, the noise climate was also dominated by road traffic movements. Ambient noise levels ranged from 69 to 71 dB L_{Aeq}. Background noise levels were in the range of 54 to 59 dB L_{A90}.

Table 12.6 Measurement Results for Location B

Time	L_{Aeq}	L_{AFmax}	L_{AFmin}	L_{AF10}	L_{AF90}
11:51	71	82	48	75	59
12:37	70	83	46	74	56
13:17	69	80	49	73	54

12.3.2.3. Location C

At location C, the noise climate was dominated by road traffic. Ambient noise levels ranged from 70 to 71 dB L_{Aeq}. Background noise levels were in the range of 60 to 62 dB L_{A90}.

Table 12.7 Measurement Results for Location C

Time	L_{Aeq}	L_{AFmax}	L_{AFmin}	L_{AF10}	L_{AF90}
13:43	70	85	56	73	60
14:00	70	85	56	73	62
14:21	71	84	55	74	61
14:37	71	87	55	74	62

12.3.3 Construction Noise Thresholds

Table 12.8 presents the assigned *BS 5228-1:2009+A1:2014* categories and threshold values for each receptor location. Each identified receptor has been assigned measured baseline values that are expected to represent the noise characteristics of their location and/or the expected noise levels at each location.

Table 12.8 Defined Construction Noise Thresholds

Receptor Reference	Survey Location	$L_{Aeq, 12\ hr}$	Ambient Noise Level Rounded to Nearest 5 dB L_{Aeq}	BS 5228-1:2009+A 1:2014 Category	Construction Noise Threshold Value (dB) ($L_{Aeq, T}$)	
					Day	Night
R1	Location A	51	50	A	65	45
R2	Location A	51	50	A	65	45
R3	Location A	51	50	A	65	45
R4	Location B	70	Assigned appropriate commercial threshold as per Section 12.2.1.1		75	-
R5	Location C	70	70	C	75	55

12.4 Description of Potential Impacts

12.4.1 Construction Phase

12.4.1.1. Noise

Noise levels associated with construction have been calculated in accordance with methodology set out in British Standard, *BS5228: Part 1: 2009 +A1 2014: Code of practice for noise and vibration control on construction and open sites – Noise*. This standard sets out noise levels for plant items normally encountered on construction sites, which in turn enables the prediction of noise levels at selected locations. Table 12.9 lists the noise levels of the plant used for calculations. It is often not possible, however, to conduct detailed prediction calculations for the construction phase of a project; for instance, if the programme for construction works has not been established in detail. Under such circumstances, best practice involves the consideration of appropriate mitigation measures to ensure that, where practicable, construction activities do not exceed the recommended noise criteria as set out in Table 12.1.

A variety of items of plant will be in use including breakers, excavators, piling rigs and other ancillary items of plant. Due to the nature of the activities undertaken on the proposed construction site, there is potential for generation of high levels of noise. Note that barges (2 maximum) will also be used during the works. It assumed that the barge noise levels are lower than those of the construction items of plant that will be operational during this period, hence they aren't expected to contribute significantly to overall noise levels. Additionally, it is expected that a barge's noise characteristic is not untypical of the surrounding area.

Note that the construction programme has been established in a high level, outline form only. It is noted that the majority of activities will take place during typical daytime hours of 07:00 – 19:00 hrs with the exception of night-time possession works that will occur for approx. 4 weeks for the landside piling to construct an underground isolation structure at Ch.1090 and the landside flood defence wall between Ch.900 and Ch.950. Approx. 3-4 weeks of night time works will also be required for landside drainage works. These night-time activities will occur from Monday evening to Friday morning, 21:30 to 05:30 hrs.

Predicted construction noise levels presented within this chapter are indicative and subject to change dependent on methodology and plant equipment. However, the following tables present calculations of indicative noise levels for typical noise sources associated with construction works likely to be experienced for this development.

Table 12.9 Construction Plant Noise Levels and Source of Information

Activity	Plant	Data Source	% on Time	L_{Aeq} dB at 10 m
Sheet Pile Defence Walls	Crane	BS 5228-1:2009 Table C.3:30	33	70
	Excavator (Installing Sheet Piles)	BS 5228-1:2009 Table C.3:8	33	88
	Deliveries	Average of BS 5228-1:2009 Table C.11:4-20	10	82
Sheet pile Defence Walls (incl. Underground Isolation Structure) – Rail Possession	Crane	BS 5228-1:2009 Table C.3:30	33	70
	Excavator (Installing Sheet Piles)	BS 5228-1:2009 Table C.3:8	33	88

Activity	Plant	Data Source	% on Time	L_{Aeq} dB at 10 m
	Deliveries	Average of BS 5228-1:2009 Table C.11:4-20	10	82
Quay Wall Demolition	Excavator with Breaker	BS 5228 (C1-1)	66	92
	Excavator	BS 5228 (C2-30)	10	79
	Lorry	Average of BS 5228-1:2009 Table C.11:4-20	10	82
	Cement mixer truck (Discharging)	BS 5228-1:2009 Table C.4:28	20	75
Quay Wall Remediation	Cement mixer truck (Discharging)	BS 5228-1:2009 Table C.4:28	20	75
Drainage	Excavator with Breaker	BS 5228 (C1-1)	10	92
	360 Excavator	BS 5228-1:2009 Table C.1:9	75	71
	Lorry	Average of BS 5228-1:2009 Table C.11:4-20	10	82
	Hand Tools	BS 5228-1:2009 Table C.4:72	20	75
Drainage (Night)	360 Excavator	BS 5228-1:2009 Table C.1:9	75	71
	Crane	BS 5228-1:2009 Table C.3:30	33	70
Construction of New Structures (Outfall structures and pumping stations)	Cement mixer truck (Discharging)	BS 5228-1:2009 Table C.4:28	20	75
	360 Excavator	BS 5228-1:2009 Table C.1:9	75	71
	Excavator (Lifting)	BS 5228-1:2009 Table C.4:56	20	83
	Lorry	Average of BS 5228-1:2009 Table C.11:4-20	10	82
Activities at construction Compound	Excavator (Lifting)	BS 5228-1:2009 Table C.4:56	20	83
	Lorry	Average of BS 5228-1:2009 Table C.11:4-20	10	82
	Hand Tools	BS 5228-1:2009 Table C.4:72	20	75

The results of the noise modelling exercise are presented in Table 12.10. Construction noise calculations have been conducted at receptor locations closest to the development construction works (receptor locations are identified in Plate 12.2). Mitigation measures have been included within the predictions. These are further detailed in Section 12.5.

Table 12.10 Construction Noise Predictions

Activity	Period	Noise Level at Receptor Location (dBA)				
		R1	R2	R3	R4	R5
Sheet Pile Defence Walls	Day	< 55	< 55	< 55	67	< 55
Quay Wall Demolition	Day	< 55	< 55	< 55	74	58
Quay Wall Remediation	Day	< 55	< 55	< 55	< 55	< 55
Underground Isolation Structure	Night	< 45	< 45	51	< 45	< 45
Drainage	Day	< 55	< 55	< 55	66	< 55
Drainage	Night	< 45	< 45	< 45	< 45	< 45
Construction of New Structures (Outfall structures and pumping stations)	Day	< 55	< 55	< 55	62	< 55
Compound	Day	< 55	< 55	< 55	60	< 55

Noise levels for all other day time construction activities at all other receptors are predicted to be lower than the designated construction noise thresholds defined in Table 12.8. At R4 it is predicted that a *negative, moderate and temporary impact* will occur. At other receptors it is expected that the impacts will be *negative, not significant to slight and temporary*.

The night-time piling activities to construct the underground isolation structure and a 50m section of the landside sheet pile wall will be undertaken over a four-week period during night-time possession works. It is expected that night-time piling to construct these elements of the proposed development may cause a *temporary, potentially significant* impact at receptor R3. The night-time drainage works are not predicted to cause a significant impact.

12.4.1.2. Vibration

The potential for elevated levels of vibration at sensitive locations during construction is typically associated with excavation works, rock-breaking and piling operations.

For the purposes of this assessment, vibration levels associated with vibratory driven piles are assessed in order to determine potential worst-case impacts. British Standard BS 5228 2 :2009+A1:2014: Vibration, includes measured magnitude of vibration associated with different piling types. Table 12.11 reproduces those associated with steel sheet piling.

Table 12.11 Vibration Magnitudes associated with Steel Sheet Piling

Soil Conditions	Pile Dimensions	Distance, m	PPV, mm/s
4 m to 5 m soft saturated sand over soft to firm clay	Steel sheet piling, dimensions N/R	6, 8	2.6, 2.2
N/R	Sheet steel piling, dimensions N/R	10	11
Gravel over London clay	Sheet steel piling, dimensions N/R	5	4.3

Glacial till/ gravelly sandy silt mixture with occasional cobbles	Sheet steel piling, Frodingham 3 N 12 m depth	10, 20, 40	2.4, 2.2, 0.8
Gravel	Steel sheet piling	3, 9, 25	42, 3.8, 0.95

Given that the closest receptors to the sheet piling works are the commercial properties at Sally Park yard, at approximately 20m distance from the works, it can be seen that vibration magnitudes at 20m distance are below those associated with cosmetic damage to buildings.

During breaking, there is also the potential for vibration to propagate through the ground. Empirical data for this activity is not provided in BS 5228-2:2009+A1:2014; however, the likely levels of vibration from this activity are expected to be significantly below the vibration criteria for building damage, based on experience from other sites. AWN Consulting have previously conducted vibration measurements under controlled conditions, during trial construction works, on a sample site where concrete slab breaking was carried out. The trial construction works involved the use of a 3-tonne hydraulic breaker on a small CAT tracked excavator, and a 6-tonne hydraulic breaker on a large Liebherr tracked excavator.

Vibration measurements were conducted during various staged activities and at various distances. Peak vibration levels during staged activities using the 3-tonne breaker ranged from 0.48 to 0.25 PPV (mm/s) at distances of 10m and 50m, respectively. Using the 6-tonne breaker, measured vibration levels ranged between 1.49 to 0.24 PPV (mm/s) at distances of 10m and 50m, respectively.

The range of values recorded provides some context in relation to typical ranges of vibration generated by construction breaking activity likely to be required on the proposed site. The range of vibration magnitudes indicate vibration levels at the closest neighbouring buildings are expected to be below the limits set out in Table 12.2 to avoid any cosmetic damage to buildings.

Notwithstanding the above, any construction activities undertaken on the site will be required to operate below the recommended vibration criteria set out in Table 12.2.

12.5 Mitigation & Monitoring Measures

12.5.1 Construction Phase

With regard to construction activities, best practice control measures for noise and vibration from construction sites are found within BS 5228 (2009 +A1 2014) *Code of Practice for Noise and Vibration Control on Construction and Open Sites Parts 1 and 2*. Whilst day-time construction noise and vibration impacts are expected to be minimal and well within the criteria set out in this document, there are night-time works that have the potential to cause a temporary, significant impact. The contractor will ensure that all best practice noise and vibration control methods will be used, where practicable in order to minimise emissions to external noise sensitive locations. In this regard, various mitigation measures can be considered and applied during the construction of the proposed development, such as:

- 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;

- Where practicable vehicles and mechanical plant will be fitted with effective exhaust silencers and maintained in good working order;
- 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;
- All items of plant will be subject to regular maintenance. Such maintenance can prevent unnecessary increases in plant noise and can serve to prolong the effectiveness of noise control measures;
- Limiting the hours during which site activities which are likely to create high levels of noise or vibration are permitted

Furthermore, it is envisaged that a variety of practicable noise and vibration control measures will be employed. These may include:

- Selection of plant with low inherent potential for generation of noise and/ or vibration;
- Erection of good quality site hoarding on the landward side of the main works which will act as a noise barrier to general construction activity at ground level;
- Situate any noisy plant as far away from sensitive properties as permitted by site constraints
- Erection of localised barriers as necessary or where practicable around noisy items of plant such as generators or high duty compressors, which is of particular importance during construction works that take place during the night-time.

Where practicable it is recommended that noise and vibration from construction activities to off-site residences be limited to the values set out in Table 12.2 and 12.8. This may be achieved by undertaking noise and vibration monitoring at locations representative of the closest sensitive receptors.

Noise monitoring should be conducted in accordance with the International Standard ISO 1996: 2017: Acoustics – Description, measurement and assessment of environmental noise.

Vibration monitoring should be conducted in accordance with BS 6472 for human disturbance and BS ISO 4866:2010 for building damage.

12.5.2 Operational Phase

As there are no predicted noise and vibration impacts during the operational stage, there are no mitigation measures proposed.

12.6 Residual Impacts

12.6.1 Construction Phase

12.6.1.1 Noise

At R4, daytime activities are predicted to cause a *negative, moderate and temporary* impact. At other receptors it is expected that the impacts will be *negative, not significant to slight and temporary*. Note that this is the worst case predicted noise impact, as the works are linear in nature and there will be times where they take place at a further

distance from the receptors, and hence a lower noise level will impact the receptors during those periods.

During the night possession works for the construction of an underground isolation structure and a 50m section of landside sheet pile wall, it is expected that *a negative, temporary, significant* impact will occur at R3 over the four-week period, Monday to Friday. The drainage night-time works are not predicted to cause a significant impact.

12.6.1.2 Vibration

Given the distances between works and receptor locations it is expected that vibration impacts will be *negative, temporary and imperceptible to slight*.

12.6.2 Operational Phase

There are no predicted noise and vibration impacts as a result of the operational phase of the proposed development.

12.7 Difficulties Encountered

There were no difficulties encountered when compiling this assessment.

12.8 References

British Standard BS 5228 (2009 +A1 2014): Code of Practice for Control of Noise and Vibration on Construction and Open Sites Part 1: Noise & Part 2: Vibration.

British Standard BS 7385 (1993): Evaluation and measurement for vibration in buildings Part 2: Guide to damage levels from ground borne vibration.

EPA (2002). EPA Guidelines on the Information to be contained in Environmental Impact Statements.

EPA (2003). EPA Advice Notes on Current Practice (in the preparation of Environmental Impact Statements).

EPA (2017). Draft Guidelines on the Information to be contained in Environmental Impact Assessment Reports.

ISO 1996: 2017: Acoustics – Description, measurement and assessment of environmental noise.

ISO 9613 (1996): Acoustics – Attenuation of sound during propagation outdoors, Part 2: General method of calculation.