PORTISHEAD BRANCH LINE PRELIMINARY ENVIRONMENTAL INFORMATION REPORT
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APPENDIX 13.1

Noise and Vibration

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Appendix 13.1 Approach to Significance

13.1 Approach to Significance

Introduction

13.1.1 The Noise Policy Statement for England ("NPSE"), Department for Environment Food and Rural Affairs 2010c[1]), Planning Policy Guidance – Noise ("PPG-Noise"), Department for Communities and Local Government, 2014, and the Environmental Impact Assessment Regulations ("EIA Regulations") have been considered when identifying potential significant effects of noise and vibration from the construction and operation phase of the scheme.

13.1.2 This appendix first describes the relationship between value of resource and magnitude of impact in order to arrive at a level of significance. These are used to determine the significance of project environmental impacts. The appendix then describes the approach to assigning values to the effect level in relation to Government policy.

Value of Environmental Receptors

13.1.3 No formal guidance is available on the value of noise sensitive resources. The Institute of Environmental Management and Assessment Guidelines for Environmental Noise Impact Assessment (IEMA, 2014) includes as noise sensitive receptors dwellings, schools, hospitals and commercial premises. However, it should be noted that the degree of sensitivity may not be the same for all of them. For instance, since residential premises are intended to be used as permanent living and resting places, their value is considered to be 'High'.

13.1.4 Non-residential premises, such as schools, hospital, offices and commercial buildings, are not places of permanent residence. Given that their degree of noise sensitivity may vary depending on the use of the receptor, this (i.e. being a place of permanent residence) has not been considered when classifying the magnitude of the noise impact during the construction and operation phase. Table 1 provides the outline in determining the value of a receptor for noise, and is applicable to the value when assessing both construction and operation. This is followed in most cases, but any deviation for special cases are noted in the assessment.

13.1.5 A receptor may be placed into a different category for vibration. For example, a workshop using precision equipment may not necessarily be sensitive to noise, but it could be to vibration.

Table 1: Value of environmental receptors

Value (sensitivity)	Receptor type
Very High	Internationally designated areas such as World Heritage Sites, Special cases for noise or vibration sensitivity
High	Residential[1], Schools, Hospitals, National designated areas
Medium	Places of worship, Community facilities
Low (or lower)	Commercial buildings (e.g. offices), Sports facilities
Negligible	Farmland, Industrial premises

[1] The dwellings within an 'Important Area' defined by the 2014 Noise Action Plan for Roads (Department for Environment Food and Rural Affairs, 2010a) published under The Environmental Noise Regulations would be included in this category. The difference between them and residential areas not defined as an Important Area is covered by the approach adopted for treating an effect level where a significant effect is occurring.

[1] The references are provided at the end of Chapter 13.

Magnitude of Impact

13.1.6 The magnitude of impact levels used in this project is defined in Table 2. The noise bands used for the impact (i.e. change in noise) have been taken from the noise chapter of the Design Manual for Roads and Bridges ("DMRB") – HD213/11 Revision 1 Noise and Vibration (Highways Agency and Welsh Office, 2011). These are applicable to both increases and decreases in noise, and applicable to both construction and operation. HD213/11 provides a scale for both short term and long term changes in noise and these are shown in Table 2.

Table 2: Magnitude of Impact – change in noise, dB

Magnitude of change	Short term	Long term
No change	0	0
Negligible	0.1 – 0.9	0.1 – 2.9
Minor	1.0 – 2.9	3.0 – 4.9
Moderate	3.0 – 4.9	5.0 – 9.9
Major	5.0 +	10.0 +

Source: DMRB, Volume 11, HD213/11 published by DfT

13.1.7 Table 2 is only applicable to changes in noise as possible impacts from vibration relate only to absolute levels and not change. These are described later in this appendix.

Significance of Effect

13.1.8 The significance of effect is determined from the combination of the value of the resource and the magnitude of impact as shown in Table 3. This table deviates from the example provided in the PEI Report Table 5.3 of Chapter 5. For a receptor of 'high' value and a 'minor' change in noise, Table 5.3 suggested an effect of Moderate was used. If this was used for the noise impact assessment then significant effects would have been identified for minor changes in noise and would have resulted in an unrealistic high level of mitigation being proposed. The approach presented in Table 3 is consistent with that used for the M4 Junctions 3 to 12 Smart Motorway scheme (Highways England, 2015).

Table 3: Significance of effect for noise

Magnitude of Change	Value / Sensitivity of Receptor				
	Very High	High	Medium	Low	Negligible
Major	Vary Large	Large	Large	Moderate	Slight
Moderate	Large	Moderate	Moderate	Slight	Neutral
Minor	Moderate	Slight	Slight	Neutral	Neutral
Negligible	Slight	Slight	Neutral	Neutral	Neutral
No Change	Neutral	Neutral	Neutral	Neutral	Neutral

13.1.9 A significant effect, under the meaning of the EIA Regulations, is taken to mean an adverse or beneficial effect of moderate, large, or very large significance of effect.

Effect Levels

13.1.10 As required by the NPSE and PPG-Noise, noise thresholds for the onset of adverse effects have been defined in terms of the overall levels of exposure. These effect levels and the change in noise levels predicted to occur with the scheme implemented have been considered when classifying the magnitude of the impact.

13.1.11 The 'Explanatory Note' within the NPSE provides further guidance on defining 'significant adverse effects' and 'adverse effects', using the following concepts:

- No Observed Effect Level (NOEL) - the level below which no effect can be detected. Below this level no detectable effect on health and quality of life due to noise can be established;
- Lowest Observable Adverse Effect Level (LOAEL) - the level above which adverse effects on health and quality of life can be detected; and
- Significant Observed Adverse Effect Level (SOAEL) - the level above which significant adverse effects on health and quality of life occur.
- Unacceptable Adverse Effect Level (UAEL) – the level at which significant adverse effects on health and quality of life are to be prevented.

13.1.12 The last of these, UAEL, was added within Planning Practice Guidance – Noise (Department for Communities and Local Government, 2014). The NOEL has not been used for this assessment as it is considered that the effect would be similar to that of the LOAEL for this scheme.

13.1.13 The NPSE (para 2.22) recognises that "*it is not possible to have a single objective noise-based measure that is mandatory and applicable to all sources of noise in all situations. The levels are likely to be different for different noise sources, for different receptors and at different times of the day*".

Construction Noise Effect Levels – Residential Receptors

13.1.14 Noise impact thresholds for construction activities at residential premises have been classified in terms of Government policy based on the ABC Method set out in BS5228-1:2009 + A1:2014 (British Standards Institution, 2014a). This defines thresholds at buildings based on the existing noise level and are presented in Table 4. In relation to construction noise, day is 07:00 to 19:00, evening is 19:00 to 23:00 and night is 23:00 to 07:00. The level provided for the day time is for the entire period, whereas that for evening and night is applicable to any single hour within the respective period.

Table 4: Construction noise effect levels for residential receptors

Construction noise effect level	Threshold value, 1m in front of the relevant façade
Lowest Observed Adverse Effect Level (LOAEL) – Category A in BS5228-1	Day 65 dB $L_{Aeq,daytime}$ Evening 55 dB $L_{Aeq,1h}$ Night 45 dB$L_{Aeq,1h}$
Significant Observed Adverse Effect Level (SOAEL) – Category C in BS5228-1	Day 75 dB $L_{Aeq,daytime}$ Evening 65 dB $L_{Aeq,1h}$ Night 55 dB$L_{Aeq,1h}$
Unacceptable Adverse Effect Level (UAEL)	Day 85 dB $L_{Aeq,daytime}$ Evening 75 dB $L_{Aeq,1h}$ Night 65 dB$L_{Aeq,1h}$

13.1.15 The LOAEL has been set in line with Category A from BS5228-1.

13.1.16 For the day time, recent large infrastructure projects (e.g. HS1, Thames Tideway and the A14 Cambridge to Huntington Improvement Scheme) have set the SOAEL at 75 dB L_{Aeq}. This is the Category C level given in BS5228-1:2009 + A1:2014 (British Standards Institution, 2014a). This level was given as a level that noise should not exceed outside the nearest window of an occupied room (Advisory Leaflet 72 – Noise Control on Building Sites, Department of the Environment 1976).

13.1.17 For the evening, the SOAEL is set 10 dB lower than the day-time SOAEL, consistent with the ABC criteria in BS5228-1:2009 + A1:2014 (British Standards Institution, 2014) and the accepted criteria from the Advisory Leaflet 72 - Noise Control on Building Sites (Department of the Environment, 1976).

13.1.18 For night-time, the Night Noise Guidelines for Europe published by the World Health Organisation (WHO, World Health Organisation, 2009) introduced an interim target of 55 dB $L_{Aeq,8hr}$ measured outdoors. Exceeding this noise threshold for one month or longer has been adopted as the SOAEL for night-time construction noise. The Night Noise Guidelines for Europe (World Health Organisation, 2009) are based on evidence gathered for long term exposure to primarily road and aircraft noise. There is no evidence of short-term construction noise leading to significant health effects. The WHO's interim target of 55 dB L_{Aeq} is therefore applied to construction on a precautionary basis.

13.1.19 The UAEL has been set in line with the criteria within BS 5228-1:2009 + A1:2014 (British Standards Institution, 2014a) to determine the eligibility for noise insulation and temporary re-housing. Planning Practice Guidance – Noise (Department for Communities and Local Government, 2014) states that exposure above the UAEL should be prevented, and re-housing would be a means to prevent exposure to such a noise level.

Construction and Operational Vibration Effect Levels – All Receptors

13.1.20 The potential impacts from vibration are based upon absolute levels and not a change in level. These are broken down into those relating to building damage and annoyance to occupants. Since levels of magnitude between these are large, these are treated separately for this assessment.

Buildings

13.1.21 BS 7385-2:1993 'Evaluation and measurement for vibration in buildings – Part 2: Guide to damage levels from ground borne vibration' (British Standards Institution, 1993) provides guidance on vibration levels likely to result in cosmetic damage, and is referenced in BS 5228-2:2009 + A1:2014 (British Standards Institution, 2014b). Guide values for transient vibration, above which cosmetic damage could occur, are given in Table 5.

Table 5: Transient vibration guide values for cosmetic damage

	Peak Component Particle Velocity in Frequency Range of Predominant Pulse	
Type of building	**4Hz to 15Hz**	**15Hz and above**
Reinforced or framed structures Industrial and heavy commercial buildings	50 mms^{-1} at 4Hz and above	
Unreinforced or light framed structures Residential or light commercial buildings	15 mms^{-1} at 4Hz increasing to 20 mms^{-1} at 15Hz	20 mms^{-1} at 15Hz increasing to 50 mms^{-1} at 40Hz and above

NOTE 1: Values referred to are at the base of the building.

NOTE 2: For un-reinforced or light framed structures and residential or light commercial buildings, a maximum displacement of 0.6mm (zero to peak) is not to be exceeded.

13.1.22 BS 7385-2 (British Standards Institution, 1993) indicates that for continuous vibration the threshold is around half of a transient value. The level for cosmetic damage, which would be considered as a minor impact, has therefore been set to 7.5 mm/s, which is half of the lower of the values from Table 5 for residential or light commercial buildings. In addition, the standard states that minor damage occurs at a vibration level twice that of cosmetic damage and major damage occurs at a vibration level twice that of minor damage. This has been used to set the levels of magnitude for moderate and major impacts.

13.1.23 BS 7385-2 (British Standards Institution, 1993) also states that that the probability of damage tends towards zero at 12.5 mm/s peak component particle velocity, which can be halved for a conservative level for continuous vibration. Although now superseded, BS 5228-4:1992 (British Standards Institution, 1992) suggested a threshold for cosmetic damage at peak particle velocities of 10 mm/s for intermittent vibration and 5 mm/s for continuous vibrations. This lower level has been used to assign the level for negligible / no change. The thresholds within BS 5228-4:1992 (British Standards Institution, 1992) have not been updated within the more recent version but it assumed that they are still valid.

13.1.24 Table 6 presents the magnitude of impact for building damage from vibration. These are based on a building that is structurally sound. If a building is structurally unsound then these values may be reduced. It should be noted that BS 7385-2 (British Standards Institution, 1993) states (para 7.5.2) "*A building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive*". As the receptor is a building and not a human receptor, no values for the effect level can be assigned.

Table 6: Magnitude of impact for vibration damage

Magnitude of Impact	Damage risk	PPV mm/s[1]
Major	Major	30
Moderate	Minor	15
Minor	Cosmetic	7.5
Negligible / No change	Negligible	5

[1] Peak Particle Velocity ("PPV") is defined as the maximum instantaneous positive or negative peak of the vibration signal. It is specified in millimetres per second (mm/s). It is important to note that the PPV refers to the movement within the ground of molecular particles and not surface movement.

People

13.1.25 The effect of building vibration on people inside buildings is often assessed using the Vibration Dose Value ("VDV") index, as described in BS 6472-1:2008 (British Standards Institution, 2008). However, a simpler approach is often initially to establish if there is potential for perceptible effects, and this is possible with the PPV index. This approach is described by BS 5228-2:2009 + A1:2014 (British Standards Institution, 2014b), which states in para B.2 "*BS 6472, as stated, provides guidance on human response to vibration in buildings. Whilst the assessment of the response to vibration in BS 6472 is based on the VDV and weighted acceleration, for construction it is considered more appropriate to provide guidance in terms of the PPV, since this parameter is likely to be more routinely measured based upon the more usual concern over potential building damage. Furthermore, since many of the empirical vibration predictors yield a result in terms of PPV, it is necessary to understand what the consequences might be of any predicted levels in terms of human perception and disturbance.*"

13.1.26 Further, BS 5228-2:2009 + A1:2014 (British Standards Institution, 2014b) states (para B.2) that *"Human beings are known to be very sensitive to vibration, the threshold of perception being typically in the PPV range of 0.14 mm/s to 0.3 mm/s. Vibrations above these values can disturb, startle, cause annoyance or interfere with work activities. At higher levels they can be described as unpleasant or even painful. In residential accommodation, vibrations can promote anxiety lest some structural mishap might occur"*. Based on this, the LOAEL has been set at 0.3 mm/s and the SOAEL at 1.0 mm/s. A table of guidance levels is provided in BS 5228-2:2009 + A1:2014 (British Standards Institution, 2014b) and is shown in Table 7, together with the assigned effect levels.

Table 7: Magnitude of impact for vibration annoyance

Vibration level, mm/s	Effect	Magnitude of impact	Effect level
10	Vibration is likely to be intolerable for any more than a very brief exposure to this level	Major	UAEL
1.0	It is likely that vibration of this level in residential environments will cause complaint, but can be tolerated if prior warning and explanation has been given to residents.	Moderate	SOAEL
0.3	Vibration might be just perceptible in residential environments	Minor	LOAEL
0.14	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction. At lower frequencies, people are less sensitive to vibration.	Negligible / No Change	LOAEL

13.1.27 If the predicted levels for a single event for construction are above the SOAEL then the duration of the construction activity will be considered first to determine if further investigation is required using the VDV index. For operation, if any single events are predicted above the SOAEL then a further assessment will be undertaken using the VDV index.

Operation Noise Effect Levels – Residential Receptors

13.1.28 The effect levels assigned for operation noise are shown in Table 8, with an explanation of how they have been derived provided after the table.

Table 8: Operation noise effect levels for residential receptors

Effect level	Period	Noise level[1]
UAEL	Day	74 dB $L_{Aeq,16h}$
	Night	-
SOAEL	Day	66 dB $L_{Aeq,16h}$
	Night	55 dB $L_{Aeq,8h}$
LOAEL	Day	50 dB $L_{Aeq,16h}$
	Night	40 dB $L_{Aeq,8h}$

[1] All levels are free-field. A free-field level is one that does not contain the contribution from reflections from nearby buildings.

13.1.29 For the day-time the UAEL has been set with reference to Planning Policy Guidance - Noise (Department for Communities and Local Government, 2014), where it identifies that this level should be prevented. In the first round Noise Action Plan Major Railways (Department for Environment Food and Rural Affairs, 2010b) certain areas were defined the status of First Priority Locations, and these are where the noise levels are at least 73 dB $L_{Aeq,18h}$. The Rail Action Plan states (para 5.07) "*It is envisaged that in general the relevant rail authorities will investigate as a priority the Important Areas that contain First Priority Locations*". The level of 73 dB $L_{Aeq,18h}$ is equivalent to a level of 74 dB $L_{Aeq,16h}$ (conversion from Planning Policy Guidance Note 24: Planning and Noise, Department of Environment (1994)).

13.1.30 The UAEL at night has not been assigned as there is insufficient guidance available in order to define a level. This is acknowledged in the first round Noise Action Plan Major Railways (Department for Environment Food and Rural Affairs, 2010b), where it states in para 5.08 "*The $L_{Aeq,18h}$ indicator describes only the noise that occurs between the hours of 0600 and 2400 and doesn't cover the night period. Even so, the identification of Important Areas has been based solely on the $L_{Aeq,18h}$ value. This reflects the fact that for the first round of mapping the L_{night} values had to be based on a range of assumptions that, while perfectly adequate for strategic noise mapping, do not provide a robust basis for developing detailed actions. Furthermore, implementing many of the potential actions available to manage noise issues and effects would not only address the noise as measured by the $L_{Aeq,18h}$ indicator but also the noise that occurs at* night".

13.1.31 For daytime, the SOAEL is in relation to the daytime trigger level of 68 dB $L_{Aeq,18h}$ for Noise Insulation as defined in The Noise Insulation (Railways and Other Guided Transport Systems) Regulations 1996. The 16h level of 66 dB is derived by first correcting to a free-field level from a façade level (-2.5 dB as defined by the Calculation of Railway Noise, Department of Transport 1995) and then adding 1 dB for and 18h to 16h conversion (Planning Policy Guidance Note 24: Planning and Noise, Department of Environment

(1994). This derived level of 66.5 dB is then rounded down to 66 dB. Linking the SOAEL with the trigger level for noise insulation is consistent with a consequence of the SOAEL as stated in Planning Practice Guidance – Noise (Department for Communities and Local Government, 2014), where people start "*avoiding certain activities during periods of intrusion; where there is no alternative ventilation, having to keep windows closed most of the time because of the noise*".

13.1.32 For night-time, the SOAEL is set at 55 dB $L_{Aeq,8h}$. This aligns with the interim night-time outdoor target level provided in the WHO Night Noise Guidelines for Europe (World Health Organisation, 2009). This is also consistent with a consequence of the SOAEL as stated in Planning Practice Guidance – Noise (Department for Communities and Local Government, 2014) of "*Potential for sleep disturbance resulting in difficulty in getting to sleep, premature awakening and difficulty in getting back to sleep*".

13.1.33 The LOAEL is set at 50 dB $L_{Aeq,16h}$ and is based on the information provided in the Guidelines for Community Noise (World Health Organisation, 1999). In that document it states that 50 to 55 dB L_{Aeq} represent "*day-time levels below which the majority of the adult population will be protected from becoming moderately or seriously annoyed*". The level of 50 dB $L_{Aeq,16h}$ for moderately annoyed has therefore been chosen.

13.1.34 For night-time the LOAEL is set at 40 dB $L_{Aeq,8h}$ which is explicitly defined as the LOAEL in the WHO Night Noise Guidelines for Europe (World Health Organisation, 2009).

13.1.35 The effect levels presented in Table 8 do not provide an exact level for a certain situation and may not be applicable to all locations as the onset of annoyance will vary across the scheme and with the noise sources. The NPSE purposely does not assign values to the effect levels because they need to be considered on a project by project basis taking into account local factors. While the effect levels presented in Table 8 do follow those derived for recent major infrastructure projects they are considered to be a starting point rather than a definitive set of values.

13.1.36 A report published in 2014 by defra (Department for Environment Food and Rural Affairs (2014c)) has suggested a range of possible values that could be used as effect levels for rail projects. These are shown in Table 9.

Table 9: Operation noise effect levels for rail from defra research report

Effect level	Period	Noise level (range)
SOAEL	Day	72 dB $L_{Aeq,16h}$ (70 to 74)
	Night	59 dB $L_{Aeq,8h}$
LOAEL	Day	63 dB $L_{Aeq,16h}$ (61 to 66)
	Night	45 dB $L_{Aeq,8h}$

13.1.37 Although these values have not been used for this project, it should be noted that the suggested levels, even at the lower end of the range, are above those presented in Table 8. This could indicate that using the levels in Table 8 is a conservative approach.

Mitigation Approach

13.1.38 Table 10 presents the approach to mitigation for residential receptors at each effect level for policy and environmental impacts. As with the effect levels presented in Table 8, the suggested levels on when to mitigate presented in Table 10 are not definitive values and the decision to mitigate or not should not be based solely on a change in noise level.

Table 10: Approach to mitigation for operational noise – residential receptors

Government policy mitigation approach	**Environmental assessment mitigation approach**
Prevent	N/A – level would be prevented from occurring
Unacceptable Adverse Effect Level (UAEL) Day – 74 dB $L_{Aeq,16h}$	
Avoid - Reduce noise level through scheme design	Mitigate any increase in noise from the scheme that is above 1 dB[1].
Significant Observed Adverse Effect Level (SOAEL) 66 dB $L_{Aeq,16h}$ and 55 dB $L_{Aeq,8h}$	
No specific action unless environmentally significant	Mitigate where increases are environmentally significant in the short term (i.e. > 3 dB(A))
Lower Observed Adverse Effect Level (LOAEL) 50 dB $L_{Aeq,16h}$ and 40 dB $L_{Aeq,8h}$	
No specific action unless environmentally significant	Mitigate where increases are environmentally significant in the long term (i.e. > 5 dB(A))

[1] To reflect the adverse health effects of being above the SOAEL, a smaller increase in noise is considered sufficient to determine the need for mitigation to be considered. This is reflected in PPG-Noise as "*In cases where existing noise sensitive locations already experience high noise levels, a development that is expected to cause even a small increase in the overall noise level may result in a significant adverse effect occurring even though little to no change in behaviour would be likely to occur*".

Construction and Operational Noise Effect Levels and Mitigation Approach – Non-residential Receptors

13.1.39 The use of effect levels for non-residential receptors is not considered possible since there is very little research to arrive at the levels. Instead, a single criteria has been used in order to determine the need for mitigation. This is presented in Table 11.

13.1.40 In addition, for schools, the Acoustics of Schools: A design guide (Institute of Acoustics and the Association of Noise Consultants, 2015) states (section 2.2) *"Noise levels in unoccupied playgrounds, playing fields and other outdoor areas should not exceed 55 dB $L_{Aeq,30min}$ and there should be at least one area suitable for outdoor teaching activities where noise levels are below 50 dB $L_{Aeq,30min}$".*

Table 11: Approach to mitigation for non-residential receptors

	Impact criteria1	
Building type	**Day**	**Night (where applicable)**
Place of worship	50 dB2 LAeq and a change of ≥ 3 dB	
Schools, colleges, hospitals, and libraries	50 dB3 LAeq and a change of ≥ 3 dB	45 dB4 LAeq and a change of ≥ 3 dB
Offices	55 dB2 LAeq and a change of ≥ 3 dB	
Shops	70 dB2 LAeq and a change of ≥ 3 dB	

1 These reflect external levels based on guidance levels for internal area. The difference between internal and external has been assumed to be 15 dB that is attenuation provided by a partially open window (Source: British Standards Institution BS 8233:1999, Sound insulation and noise reduction for buildings - Code of Practice).

2 Source: BS 8233:2014 (British Standards Institution, 2014c).

3 Source: Acoustics of Schools: A design guide (Institute of Acoustics and the Association of Noise Consultants, 2015).

4 Guidelines for Community Noise (World Health Organisation, 1999).