EARBA STORAGE

A GILKES ENERGY COMPANY

Earba Pumped Storage Hydro Scheme

EIA Report

Chapter 18: Noise and Vibration

February 2024

Quality Information

Prepared by	Checked by	Approved by
SLR Consulting	Chris Pasteur	Gavin McGill

Revision History

Revision	Revision Date	Details	Authorised
01	February 2024	Issue to ECU	Gavin McGill

Contents

18. Noise and Vibration 2

18.1 Executive Summary 2
18.2 Introduction 3
18.3 Scope of Assessment 4
18.4 Legislation, Policy and Guidance 9
18.5 Methodology 12
18.6 Baseline Conditions 27
18.7 Mitigation by Design 33
18.8 Potential Significant Effects 33
18.9 Mitigation 54
18.10 Residual Effects 56
18.11 Conclusion 58

List of Appendices

Appendix 18.1 – SQA Statement and Baseline Survey Data
Appendix 18.2 – Construction Noise Modelling Exercises Input Data Summary
Appendix 18.3 – Offsite Construction Traffic Noise Impact Assessment
Appendix 18.4 – Draft Construction Noise & Vibration Management Plan (CNVMP)

18. Noise and Vibration

18.1 Executive Summary

18.1.1 This Chapter sets out the assessment of the potential noise and vibration impacts and likely effects on environmental receptors associated with the Proposed Development.

18.1.2 For this purpose, the closest residential properties to the scheme have been identified as noise sensitive receptors and a comprehensive ambient noise survey has been completed to establish the baseline ambient noise at these key receptor positions.

18.1.3 To estimate the noise and vibration impacts resulting from temporary construction works, a quantitative assessment has been completed, using predictive noise modelling, in line with guidance provided in BS 5228-1:2009+A1:2014 Code of practice for noise and vibration control on construction and open sites – Part 1: Noise and Part 2: Vibration.

18.1.4 Detailed assessment of noise from the operation of the Proposed Development has been scoped out of a quantitative assessment, as the reversible pump-turbine, generators and associated equipment would be located underground within the powerhouse, reducing noise breakout to the surface to a negligible level.

18.1.5 Predictions have been based on sound emission data applicable to the construction plant and equipment forecast for use on the main construction activities, including site establishment works, lower control works (two screened inlet/outlet structures), peninsula and works associated with upgrade, or construction, of new access roads/tracks.

18.1.6 The following key mitigating measures have been identified for the purpose of controlling noise levels produced by the construction and operation of The Proposed Development:

- Construction noise and vibration would primarily be managed through a Construction Noise & Vibration Management Plan (CNVMP), which would be formally agreed with The Highland Council (THC), prior to construction work commencing.

18.1.7 The creation of a temporary haul road to connect the lower reservoir works area to the upper reservoir and dam, provides an opportunity to supplement rock quarried within the upper reservoir, with suitable tunnel spoil from the underground works, for dam construction, thus reducing off-site disposal quantities and noise impacts resulting from associated vehicle movements.

18.1.8 The control of operational noise would be integral to the design of the power house, as all the main items of generation equipment would be located within it thus reducing potential atmospherically discharging noise impacts resulting.

18.2 Introduction

18.2.1 This Chapter considers the potential effects, including cumulative effects, of the Proposed Development on noise and vibration during construction and operation. Where likely significant effects are predicted during construction and operation, appropriate mitigation measures are proposed, and the significance predicted residual effects are assessed.

18.2.2 The noise emission that may be generated by the Proposed Development has been assessed in terms of the potential noise impact upon the nearest residential receptors and other receptors as defined during the scoping phase, with consideration being given to whether the resulting effects would be 'significant'. In general terms this requires consideration of changes to, or increases in, environmental noise levels resulting from the Proposed Development.

18.2.3 The assessment covers potential noise and vibration impacts associated with the construction and operation of the Proposed Development, with particular focus given to noise levels generated during the construction phase, which is likely to extend over a period of 5 years for the main civil engineering construction.

18.2.4 To this effect, a quantitative prediction of noise is provided, in relation to the construction activities identified as potentially providing adverse impact.

18.2.5 To establish the current baseline noise level, the assessment presents the results of a comprehensive ambient noise survey, comprising remote noise monitoring of 1-week duration, at each of the closest noise sensitive receptor locations to the Site.

18.2.6 The potential impact and likely effects of construction noise have been assessed by using predicted noise levels to evaluate the resulting noise change and allow comparison with both existing ambient noise and absolute noise limits. This recognises the advice and guidance provided in the Scottish Government Technical Advice Note (TAN) (Scottish Government, March 2011), which cites BS 5228-1 (BSI, 2014), as providing the relevant guidance and code of practice relating to construction noise and BS 5228-2 (BSI, 2014) as the relevant guidance relating to construction vibration.

18.2.7 The Chapter is supported by the following Appendices

- Appendix 18.1 – SQA Statement and Baseline Survey Data
- Appendix 18.2 – Construction Noise Modelling Exercises Input Data Summary
- Appendix 18.3 – Offsite Construction Traffic Noise Impact Assessment
- Appendix 18.4 – Draft Construction Noise & Vibration Management Plan (CNVMP)

18.2.8 This assessment has been carried out by SLR Consulting.

18.3 Scope of Assessment

Study Area

18.3.1 Study Area encompasses the area over which all desk-based and field data were gathered to inform the assessment presented in this Chapter.

18.3.2 The scope of the noise assessment covers the area defined at scoping stage that includes the Noise Sensitive Receptors (NSRs) identified as being closest to the lower reservoir works, site establishment works and associated access roads/tracks. The position of the NSR locations are described in **Table 18.1** below.

Table 18.1 NSR Locations

NSR ID	NSR	Location		Imagery
		Northing	Easting	
1	Ardverikie Estate	56°57'17.85" N	4°27'17.77"W	
2	Adverike Estate Manager Lodge And Adjacent Residential Dwelling	56°58'30.25"N	4°23'09.74"W	
3	Gallovie Farmhouse	56°58'12.12"N	4°22'57.508"W	

NSR ID	NSR	Location		Imagery
		Northing	Westing	
5	Luibliea	56°54'30.98"N	4°34'24.20"W	
4	Moy Lodge	56°54'58.78"N	4°33'43.78"W	
6	Torgulbin	56°54'24.14"N	4°34'20.00"W	
7	Pinewood And Residential Dwellings Adjacent.	56°58'27.20"N	4°24'05.88" W	
8	Binnein Shuas Climbing Crags NN468826 East of Summit	56°54'31.61" N	4°31'32.71" W	

Consultation Responses

18.3.3 To inform the scope of the assessment for the Proposed Development, consultation was undertaken with statutory and non-statutory bodies. **Table 18.2** summarises the scoping and consultation responses relevant to noise and vibration and provides information on where and/or how points raised have been addressed in this assessment.

18.3.4 Full details on the consultation responses and scoping opinion can be reviewed in **Chapter 4: Assessment Methodology, Scoping and Consultation**.

Table 18.2 Consultation Responses

Consultee	Issue Raised	Response / Action Taken
The Highland Council (THC) Scoping 31 March 2023	**Operational Noise Comment** • Majority of the operation is underground and given the separation distances, noise is unlikely to be significant at any noise sensitive property. **Operational Noise Condition Advised** • "All plant, machinery and equipment associated with this development shall be so installed, maintained and operated such that the following standards are met: - any associated operating noise must not exceed NR 20 when measured or calculated within the bedroom of any noise-sensitive premises with windows open for ventilation purposes. the operating noise • Rating level must not exceed the Background noise level including any characteristics penalty. Terms and measurements to be in accordance with BS 4142: 2014 Methods for	Noted. Full baseline survey implemented. Likely conditions noted and BS4142 considered in further in this Chapter. BS5228 construction noise assessment undertaken to reflect response received and discussed within this Chapter.

Consultee	Issue Raised	Response / Action Taken
	Rating Industrial & Commercial Sound." **Construction Noise** Planning conditions are not used to control the impact of construction noise as similar powers are available to the Local Authority under Section 60 of the Control of Pollution Act 1974. Generally, people are tolerant of construction noise during typical working hours which are taken to be 8am to 7pm Monday to Friday and 8am to 1pm on Saturdays. Works for which noise is inaudible at the curtilage of any noise sensitive property could still be carried out out-with these times. The site itself is remote from receptors therefore construction noise is unlikely to be significant. However, the access track will be closer to existing receptors so there may be some disturbance from construction traffic and any works that may be required to upgrade the access track. The site layout plan also appears to show a proposed borrow pit and temporary construction compound in closer proximity to houses. A detailed construction noise assessment will be required in respect of access track works, borrow pit operations and the construction compound. The assessment should include: 1) A description of construction activities with reference to noise generating plant and equipment. 2) A detailed plan showing the location of noise sources, noise sensitive premises and any survey measurement locations. 3) A description of any noise mitigation methods that will be employed and the predicted effect of said methods on noise levels.	

Consultee	Issue Raised	Response / Action Taken
	4) A prediction of noise levels resultant at the curtilage of noise sensitive receptors. 5) An assessment of the predicted noise levels in comparison with relevant standards. The above notwithstanding, it is expected that the developer/contractor will employ the best practicable means to reduce the impact of noise from construction activities. The applicant will be required to submit a scheme demonstrating how this will be implemented. Particular attention should be given to the use of tonal reversing alarms and ground compaction plant which are often the most intrusive noise generating elements of a large construction project.	
Mountaineering Scotland Scoping Response	We request that a Noise Sensitive Receptor be located at the base of the Binnein Shuas climbing crags where climbers gather prior to ascent, around NN468826. We request the EIA to assess the potential effect of blasting on rock stability on climbing routes on the Binnein Shuas crags and on rocks above Loch a' Bhealach Leahmain on the main walking route between the summits of Beinn a' Chlachair and Geal Charn.	Additional baseline survey location for Daytime period implemented. Considered a noise sensitive receptor during daytime only when in use. Textual assessment undertaken separately highlighting construction, operating noise and blasting related issues for consideration (where present).

Issues Scoped out of Assessment.

18.3.5 The following aspects have been scoped out of the assessment:

- Based on the location of the Site and the nature of the Proposed Development, which would require a limited number of additional staff and periodic maintenance, it is proposed to scope potential effects associated with operational road traffic noise out of the EIA.
- Additionally, noise associated with falling water to Loch Earba will likely be all sub-surface noise and any above ground noise at sensitive receptors will be imperceptible and will therefore be scoped out of the EIA.

- It is proposed to scope out noise impact assessment of the existing noise climate on operational areas of the Site, on the basis the existing noise climate is unlikely to be problematic for design of control rooms or other occupied staff areas.
- As detailed in **Chapter 2: The Proposed Development**, with proper maintenance the Proposed Development should remain functional indefinitely. If the project were to be decommissioned, it is anticipated that the potential effects on noise and vibration would be equal to or lesser than the construction impacts. As such, a separate assessment of potential decommissioning effects on noise and vibration is not included in this Chapter.

18.4 Legislation, Policy and Guidance

Legislative and Policy Context

National Planning Policy

Scottish Planning Policy

18.4.1 Section 169 within the Scottish Planning Policy (SPP) (June 2014) states that:

"Proposals for energy infrastructure developments should always take account of spatial frameworks for wind farms and heat maps where these are relevant. Considerations will vary relative to the scale of the proposal and area characteristics but are likely to include:…impacts on communities and individual dwellings, including visual impact, residential amenity, noise and shadow flicker";

Planning Advice Note 1/ 2011 Planning and Noise

18.4.2 Current national guidance on noise is contained in Planning Advice Note (PAN) 1/2011 Planning and Noise (The Scottish Government, 2011). In para 2 PAN 1/2011 states that it:

"promotes the principles of good acoustic design and a sensitive approach to the location of new development. It promotes the appropriate location of new potentially noisy development, and a pragmatic approach to the location of new development within the vicinity of existing noise generating uses, to ensure that quality of life is not unreasonably affected and that new development continues to support sustainable economic growth."

18.4.3 Para 3 of PAN 1/2011 states:

"The Environmental Noise (Scotland) Regulations 2006 transposed the European Directive 2002/49/EC (the Environmental Noise Directive) into Scottish law… They require Scottish Ministers and airport authorities to manage noise through a process of strategic noise mapping and noise action plans. In the areas affected by the

Regulations, planning authorities have a role in helping to prevent and limit the adverse effects of environmental noise."

18.4.4 There are no Noise Action Plans in proximity to the Site.

18.4.5 Technical Advice Note (TAN 2011) (The Scottish Government, 2011) accompanies PAN 1/2011 and provides technical guidance on noise assessment.

Relevant Legislation

18.4.6 The provisions of Sections 60 and 61 of the Control of Pollution Act 1974 offer protection to those living in the vicinity of construction sites.

18.4.7 Section 60 enables a local authority to serve a notice specifying its noise control requirements which may include:

- plant or machinery that is or is not to be used;
- hours of working; and
- levels of noise or vibration that can be emitted.

18.4.8 Section 61 relates to prior consent and is for situations where a contractor or developer takes the initiative and approaches the local authority before work starts to obtain approval for the methods to be used and any noise and vibration control techniques that may be required.

18.4.9 The term 'Best Practicable Means' (BPM) is defined in Section 72 of the Control of Pollution Act 1974, where 'practicable' means reasonably practicable having regard among other things to local conditions and circumstances, to the current state of technical knowledge and to the financial implications.

Local Planning Policy

18.4.10 The adopted Highland-wide Local Development Plan (HwLDP) (Ref 1) Policy 67 'Renewable Energy Developments' states "the Council will support proposals where it is satisfied that they are located, sited and designed such that they will not be significantly detrimental overall, either individually or cumulatively with other developments (see Glossary), having regard in particular to any significant effects on the following:…

"The safety and amenity of any regularly occupied buildings and the grounds that they occupy- having regard to visual intrusion or the likely effect of noise generation".

18.4.11 Policy 72 'Pollution' of the HwLDP states that:

"Proposals that may result in significant pollution such as noise (including aircraft noise), air, water and light will only be approved where a detailed assessment report on the levels, character and transmission and receiving environment of the potential pollution is provided by the applicant to show how the pollution can be appropriately avoided and if necessary mitigated."

18.4.12 Section 4.2, Hydro-Electricity of The Highland Council: Renewable Energy Strategy (THC, 2005) states it is a planning requirement that:

"Developers will need to provide details of noise levels." Under guidance it states that "Turbines can produce some noise but this can be mitigated relatively easily."

Technical Guidance

18.4.13 The following technical guidance has been considered in the assessment.

18.4.14 The noise and vibration assessment will be carried out in accordance with Institute of Environmental Management & Assessment (2014), "Guidelines for Environmental Noise Impact Assessment'.

18.4.15 Relevant sections of the following guidance documents and British Standards will be referred to. The phase of assessment that the document would be referenced in are indicated:

Significance of Effect for all Phases of the Site Life:

- Guidelines for Environmental Noise Impact Assessment, produced by the Institute of Environmental Management and Assessment (IEAM), and published in October 2014.

Construction Phase

- BS5228-1:2009+A1:2014 'Code of practice for noise and vibration control on construction and open sites – Part 1: Noise'.
- BS5228-2:2009+A1:2014 'Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration'.
- PAN 50 Annex A: 'The Control of Noise at Surface Mineral Workings and Planning Advice Note 1/2011: planning and noise'.
- PAN 56 Planning and Noise (In relation to guidance on blasting and overpressure limits).
- AQTAG09 Air Quality 'Technical Advisory Group 09 Guidance on the effects of industrial noise on wildlife'

Operational Phase:

- BS8233:2014 'Guidance on sound insulation and noise reduction for buildings'.
- The 'Guidelines for Community Noise' document (WHO, 1999) and 'Night Noise Guidelines for Europe' (WHO, 2009).
- BS4142:2014+A1:2019 'Methods for rating and assessing industrial and commercial sound'.
- AQTAG09 Air Quality 'Technical Advisory Group 09 Guidance on the effects of industrial noise on wildlife'
- Calculation of Road Traffic Noise (CRTN).
- Design Manual Roads and Bridges (DMRB) LA 111.

18.5 Methodology

Desk Study

18.5.1 An initial desk study has been undertaken to determine and confirm the sensitive receptor locations as identified at scoping stage.

18.5.2 Additional receptors identified at consultation have also been included within the assessment.

Field Study

18.5.3 Detailed site visits and walkover surveys have been undertaken by SLR on the following dates:

- 21st to 26th July 2023 to conduct baseline noise surveys in both attended and unattended locations to define thresholds for later assessment.

18.5.4 The field work has been undertaken in order to:

- verify the receptor locations; and
- characterise the existing noise climate in context.

18.5.5 The data obtained as part of the field work has been processed and interpreted to complete the impact assessment and recommend mitigation measures where appropriate.

Assessment Methodology

18.5.6 This scoping assessment aims to identify the significance of the potential effects of the Proposed Development.

18.5.7 The temporal scope of this assessment therefore includes consideration of the construction and operational phases of the Proposed Development.

18.5.8 The spatial scope of the assessment encompasses any areas where construction works are to be undertaken or operational noise sources will be located and extends to the closest noise and vibration sensitive receptors. Potential airborne noise impacts on ecological receptors are considered within **Chapter 8: Terrestrial Ecology** and **Chapter 10: Ornithology**. Potential underwater noise and vibration impacts on ecological receptors are considered within **Chapter 11: Aquatic Ecology**. Where relevant guidance has been provided within this Chapter to inform these assessments.

18.5.9 As a general overview, the assessment methodology contains the following key stages:

- identification of NSRs and rating of sensitivity;
- establishing the current (baseline) ambient noise level at NSRs by completion of noise monitoring;
- quantitative assessment, to determine (by prediction) the magnitude of each of the identified main potential impacts;

- qualitative assessment, to allow consideration of other (lesser) potential impacts where a more detailed predictive-based assessment is considered impracticable, or unnecessary; and
- evaluation of the significance of noise effects through the relationship of the receptor's sensitivity to noise and the magnitude and duration of noise impacts.

Assessment Guidance

BS 5228-1: 2009+A1:2014 Code of practice for noise and vibration control on construction and open sites. Part 1: Noise (with 2014 amendment)

18.5.10 Noise levels generated by demolition and construction activities are subject to Local Authority control under the Control of Pollution Act 1974. Supplementary advice is provided by British Standard BS 5228-1:2009 'Code of Practice for Noise and Vibration Control on Construction and Open Sites' with respect to noise assessment and mitigation.

18.5.11 BS 5228-1:2009 contains a noise emission database for individual construction plant, their associated activities, and methods of working. Unless noise level data is available from manufacturers, the BS 5228-1:2009 database is used when predicting noise levels associated with various construction activities.

18.5.12 With regard to acceptable noise levels, BS 5228 provides guidance within Annex E including the 'ABC Method' which enables the identification of potentially significant effects at dwellings. This proposes threshold values of $L_{Aeq,T}$ as a function of baseline sound levels at the receptors, as shown in **Table 18.3** below.

Table 18.3 Example Threshold of Potential Significant Effect at Dwellings

Assessment Category and Threshold Value Period	Threshold Value $L_{Aeq,T}$ dB Facade		
	Category A [a]	Category B [b]	Category C [c]
Night Time (23:00-07:00)	45	50	55
Evening and Weekend [d]	55	60	65
Daytime (07:00-19:00) and Saturdays (07:00-23:00)	65	70	75

NOTE 1: A potential significant effect is indicated if the $L_{Aeq,T}$ noise level arising from the site exceeds the threshold level for the category appropriate to the ambient noise level.

NOTE 2 If the ambient noise level exceeds the Category C threshold values given in the table (i.e. the ambient noise level is higher than the above values), then a potential significant effect is indicated if the total $L_{Aeq,T}$ noise level for the period increases by more than 3 dB due to site noise.

NOTE 3: Applies to residential receptors only.

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

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

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

(d) 19:00 – 23:00 weekdays, 13:00 – 23:00 Saturdays, 07:00 – 23:00 Sundays.

18.5.13 For the appropriate period (night, evening / weekend, day), the ambient noise level is determined and rounded to the nearest 5 decibels (dB). The appropriate Threshold Value is then determined. The total construction noise level is then compared with this Threshold Value. If the total noise level exceeds the Threshold Value, then a potentially significant effect is deemed to occur.

18.5.14 Where construction activities involve large scale and long-term earth moving activities, BS 5228 recommends noise limits more akin to surface mineral extraction than conventional construction activities.

18.5.15 For these activities the document recommends application of the Technical Guidance to the National Planning Policy Framework and suggests that a "limit of 55 dB $L_{Aeq,1h}$ [free-field] is adopted for daytime construction noise for these types of activities but only where the works are likely to occur for a period in excess of six months".

BS 5228-2:2009+A1:2014 Code of practice for noise and vibration control on construction and open sites. Part 2: Vibration (with 2014 amendments)

18.5.16 BS 5228-2:2009 addresses the need for the protection against vibration for persons living in the vicinity of construction sites and recommends procedures for vibration control. BS 5228- 2:2009 recommends that*:'.... it is considered more appropriate to provide guidance in terms of the PPV (Peak Particle Velocity), since this parameter is likely to be more routinely measured based upon the more usual concern over potential building damage'.*

18.5.17 BS 5228-2:2009 provides empirical formulae relating resultant PPV for vibratory compaction, percussive and vibratory piling, dynamic compaction, the vibration of stone columns and tunnel boring operations.

18.5.18 **Table 18.4** (adapted from Table B.1, BS 5228-2:2009) details PPV levels and their potential effect on humans and provides a semantic scale for description of vibration impacts on human receptors.

Table 18.4 Guidance on Effects of Vibration Levels

Vibration level PPV (mm/s)	Effect
0.14 to 0.3	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.
0.3 to < 1	Vibration might be just perceptible in residential environments.
1.0 to <10	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.
>= to 10	Vibration is likely to be intolerable for any more than a very brief exposure to this level.

18.5.19 BS 5228-2:2009 provides the following criteria which are the maximum vibration levels to which underground services should be subjected:

- maximum PPV for intermittent or transient vibrations 30 mm/s; and
- maximum PPV for continuous vibrations 15 mm/s.

18.5.20 It goes on to state that "even a PPV of 30 mm/s gives rise to a dynamic stress which is equivalent to approximately 5 % only of the allowable working stress in typical concrete and even less in iron or steel."

18.5.21 BS 6472-1: 2008. Guide to evaluation of human exposure to vibration in buildings. Part 1: Vibration sources other than blasting

18.5.22 BS 6472-1: 2008 provides guidance on the effects of human exposure to whole body vibration inside buildings, from internal sources such as footsteps or machinery, or external sources such as road traffic or railways. It specifically excluded consideration of blasting which is covered in BS 6472-2:2008. This Standard provides guidance on the levels of vibration that are likely to give rise to varying degrees of 'adverse comment'.

18.5.23 The vibration criteria are given in terms of the Vibration Dose Value (VDV) indicator. The VDV is given by the fourth root of the time integral of the fourth power of the acceleration after it has been frequency-weighted. BS 6472-1:2008 states that the VDV is the best indicator to use when assessing human response to whole body vibration inside buildings.

18.5.24 The criteria contained within BS 6472-1:2008 are provided in **Table 18.5**.

Table 18.5 VDV Criteria from BS 6472-1:2008

Place and time	Low probability of adverse comment $m/s^{1.75}$	Adverse comment possible $m/s^{1.75}$	Adverse comment probable $m/s^{1.75}$
Residential buildings 16 h day	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Residential buildings 8 h night	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8

18.5.25 For offices and workshops, multiplying factors of 2 and 4 respectively should be applied to the above vibration dose value ranges for a 16 h day.

18.5.26 Vibration dose values below the ranges in **Table 18.5** are rated as *'adverse comment not expected'* and vibration above the ranges in **Table 18.5** are rated as 'adverse comment very likely'.

18.5.27 These criteria apply to both the vertical and horizontal axes of vibration, although the two directions use different frequency weighting in the calculation of the VDV. The vertical direction uses the Wb weighting, while the horizontal axes use the W_d weighting. The definitions of the frequency weightings are given in BS 6472-1:2008.

18.5.28 The standard also states that if the direction of the vibration is dominated by a single axis, it is only necessary to assess the vibration response in respect to the dominant axis.

Planning Advice Note PAN 50 'Controlling the Environmental Effects of Surface Mineral Workings'

18.5.1 As mentioned above BS 5228-1:2014 references the Technical Guidance to the National Planning Policy Framework when considering noise from long-term construction sites involving large scale earth moving.

18.5.2 This Technical Guidance does not apply in Scotland however Planning Advice Note PAN 50 'Controlling the Environmental Effects of Surface Mineral Workings' provides equivalent guidance in Annex A: The Control of Noise at Surface Mineral Workings.

18.5.3 PAN 50 states *"It will often be necessary to raise the noise limits to allow temporary but exceptionally noisy phases in the mineral extraction operation which cannot meet the limits set for routine operations. A prime example would be to allow for the construction of baffle mounds. Other activities which would also merit a temporary raised limit include soil- stripping, removal of spoil heaps, and construction of new permanent landforms. These activities are in themselves noisy, but can bring long term benefits… It is suggested that 70 dB $L_{Aeq,1h}$ (free field) for periods of up to 8 weeks in a year should be considered to facilitate this, but planning authorities and operators may also wish to weigh up the effects of shortening this period and allowing higher levels of noise, in order to get such temporary operations completed as quickly as possible. However, some operations may require longer than 8 weeks for completion, and in such cases, an increased limit up to 70 dB $L_{Aeq,1h}$ (free- field) may be allowed during these periods."*

BS 6472-2: 2008. Guide to evaluation of human exposure to vibration in buildings. Part 2: Blast-induced vibration

18.5.4 BS 6472-2:2008 provides guidance on human exposure in buildings to blast-induced vibration and air overpressures. It is primarily applicable to blasting associated with mineral extraction but can also be applicable to explosives used within civil engineering and demolition.

18.5.5 BS 6472-2:2008 advises that to predict the likely vibration magnitude from a controlled blast, a series of measurements at several locations should be taken from one or more trial blasts. Using the formula provided in BS 6472-2:2008 and extrapolation of the trial blast results, the likely vibration magnitudes at a given distance (for a given maximum instantaneous charge) can be predicted to a given confidence level.

18.5.6 The standard suggests that accredited blasting contractors will appropriately design blasts to minimise effects at NSRs.

18.5.7 For blast vibration occurring up to three times per day the standard states that for residential premises the probability of adverse comment is low if the peak particle velocity (PPV) is below 6.0 to 10.0mm/s during the day. At night this reduces to 2.0mm/s. It goes on to state that "Doubling the suggested vibration magnitudes could result in adverse comment and this will increase significantly if the magnitudes are quadrupled."

18.5.8 The standard acknowledges that "blast-induced vibration is highly variable" and it qualifies that the above limits "should not be exceeded by more than 10% of the blasts" and that no blast should result in vibration that exceeds the

limit by more than 50%. It goes on to state that “working to a 90% confidence limit value means, in practice, that blasts need to be designed to ensure that the average level of vibration is approximately half of the specified limit. For example, if the satisfactory limit is required to be 6.0 mm/s at 90% confidence then blasts will be designed to produce vibration levels of approximately 3.0mm/s, and in practice most will be below this level”.

18.5.9 Should more than three blasts be required per day, BS 6472-2:2008 provides information on the acceptable vibration limits.

18.5.10 BS 6472-2:2008 states that "Accurate prediction of air overpressure (from blasting) is almost impossible due to the variable effects of the prevailing weather conditions and the large distances often involved."

18.5.11 Whilst not providing specific air overpressure limits, BS 6472-2:2008 provides the following information on acceptable overpressure pressures: “Windows are generally the weakest parts of a structure exposed to air overpressure. Research by the United States Bureau of Mines has shown that a poorly mounted window that is pre-stressed can crack at around 150 dB(lin), with most windows cracking at around 170 dB(lin). Structural damage would not be expected at air overpressure levels below 180 dB(lin).”

18.5.12 The air overpressure levels measured at properties near quarries in the United Kingdom are historically generally around 120 dB(lin), which is 30 dB(lin) below, or only 3% of, the limit for cracking pre-stressed poorly mounted windows (150 dB(lin)).

BS 7385: Part 2: 1993 Evaluation and measurement for vibration in buildings. Part 2 Guide to damage levels from groundborne vibration

18.5.13 BS 7385-2:1993 provides guidance on the levels of groundborne vibration above which building structures could be damaged. For the purposes of BS 7385-2:1993, damage is classified as cosmetic (formation of hairline cracks), minor (formation of large cracks) or major (damage to structural elements). Guide values given in BS 7385-2:1993 are associated with the threshold of cosmetic damage only, usually in wall and / or ceiling lining materials.

18.5.14 BS 7385-2:1993 provides a frequency-based vibration criterion for transient vibration induced cosmetic damage, which is reproduced in **Table 18.6**.

Table 18.6 Transient vibration guide values for cosmetic damage

Type of Structure	**Peak Component Particle Velocity in Frequency range of Predominant Pulse (1 and 2)**	
	4Hz-15Hz	**15 Hz and Above**
Reinforced or framed structures Industrial and Heavy Commercial Buildings.	50mm/s at 4Hz and above.	
Un-reinforced or light framed structures. Residential or Light Commercial type	15mm/s at 4Hz increasing to 20mm/s at 15Hz3	20mm/s at 15Hz increasing to 50mm/s at 40Hz and above.

buildings.		

1 Peak Component Particle Velocity is defined as the maximum value of any one of three orthogonal component particle velocities measured during a given time interval

2 - Values referred to are at the base of the building.

3 - At frequencies below 4 Hz, a maximum displacement of 0.6 mm (zero to peak) should not be exceeded.

18.5.15 When considering continuous vibrations, even taking the precautionary approach of halving the guideline vibration values for transient vibration induced minor cosmetic damage to buildings (from BS 7385-2:1993), the resulting guidelines are still orders of magnitude above the threshold of perception and substantially higher than equivalent values likely to provoke complaint.

18.5.16 The guidance on acceptable vibration levels in structures provided in BS 5228-2:2009 recommends adopting the building damage vibration guidelines from BS 7385-2:1993.

THC General Recommendations on Construction Noise

18.5.17 THC's general recommendations on construction noise include noise limits as shown in **Table 18.7**. This guidance has not been published but THC nevertheless ask that it is considered, primarily when setting limits within Section 61 Agreements with construction contractors under the Control of Pollution Act. A long-term construction site relates to any works ongoing for more than 6 months.

Table 18.7 Noise limits, Long-term construction sites

Days	Times	Maximum Noise Levels	
		$L_{Aeq\ (1\ hour)}$	L_{AMax}
Mondays to Saturdays	0800 to 1900 hours	55 dB(A)	-
If Permitted	1900 to 2200 hours	<10 dB(A) above background	-
If Permitted	2200 to 0800 hours	40 dB(A)	50 dB(A)
Sundays (if permitted)	0000 to 2400 hours	40 dB(A)	50 dB(A)

Notes:-

1. These standards are for guidance only. The duration of the construction works will have a significant bearing on whether limits can be relaxed or tightened. Where construction activities involve large scale and long-term earth moving activities the limits in [Table 15-6] should be applied.
2. The L_{Aeq} (1 hour) is the equivalent continuous A-weighted sound pressure level arising from work operations measured (on Fast weighting) or calculated over any continuous period of 60 minutes.
3. The $L_{pA(max)}$ is the maximum A-weighted sound pressure level (on Fast weighting) arising from work operations during the time period.

The L_{Aeq} (1 hour) and $L_{pA(max)}$ are free field measurements or calculations at the the boundary or external amenity area of any noise-sensitive premises**.

** Normal working hours for Saturdays are taken to be 0800 to 1300 hours.*

*** Noise-sensitive premises shall include dwellings, offices, schools, hospitals and similar establishments.*

18.5.18 Regarding vibration the guidance states: "The peak particle velocity generated by the operations shall not exceed 5mm / second measured at the building nearest to the operations. This applies to all operations other than blasting."

Calculation of Road Traffic Noise

18.5.19 Construction traffic from the development proposals may temporarily alter noise levels near the affected local road network. A noise assessment will be undertaken in accordance with the DMRB Volume 11 Section 3 Part 7 Noise and Vibration, considering the identified most affected links.

18.5.20 The Annual Average Weekly Traffic (AAWT) and percentage of Heavy Goods Vehicles (HGVs) will be determined "With Scheme" (with the development proposals) and "Without Scheme" (without the development proposals).

18.5.21 Based on these traffic numbers, the Basic Noise Level (BNL) will be established for the "With Scheme" and "Without Scheme" scenarios. Scenarios for the base year 2022 and base year including the development have been assessed. The BNL is the dB LA10, 18hr noise level at 10 m from the kerb of the road assessed.

The impact magnitude for each assessment of each link will be presented and the predicted changes in noise levels will be compared to the relevant impact magnitude threshold limits.

BS 4142:2014 'Methods for Rating and Assessing Industrial and Commercial Sound'

18.5.22 BS 4142:2014 contains a methodology for the assessment of the significance of effect of industrial and commercial noise in relation to the background sound level. The basis of BS 4142 is a comparison between the background sound level in the vicinity of residential locations and the rating level of the sound source under consideration, with penalties applied to the industrial sound to take account of characteristics which may cause annoyance to residents. The relevant parameters are as follows:

- Background Sound Level – $L_{A90,T}$ – defined in the Standard as the 'A' weighted sound pressure level that is exceeded by the residual sound at the assessment location for 90% of a given time interval, T, measured using time weighting F and quoted to the nearest whole number of decibels;
- Specific Sound Level – $L_{Aeq,Tr}$ – the equivalent continuous 'A' weighted sound pressure level produced by the specific sound source at the assessment location over a given reference time interval, Tr;
- Residual Sound Level - $L_{Aeq,T}$ - the equivalent continuous 'A' weighted sound pressure level at the assessment location in the absence of the specific sound source under consideration, over a given time interval, T; and
- Rating Level – $L_{Ar,Tr}$ – the specific sound level plus any adjustment made for the characteristic features of the noise.

18.5.23 The standard recognises that certain acoustic features of a sound source can increase the impact over that expected based purely on the sound level. The standard identifies the following features to be considered:

- Tonality – a penalty of 2 dB is applied for a tone which is just perceptible at the receptor, 4 dB where it is clearly perceptible and 6 dB where it is highly perceptible;
- Impulsivity - a penalty of 3 dB is applied for impulsivity which is just perceptible at the receptor, 4 dB where it is clearly perceptible and 6 dB where it is highly perceptible. An impulse is defined as the sudden onset of a sound;
- Intermittency – a penalty of 3 dB can be applied if the intermittency of the specific sound is readily identifiable against the residual acoustic environment at the receptor. I.e e. it has identifiable on / off conditions.

18.5.24 Other sound characteristics – a penalty of 3 dB can be applied where the specific sound features characteristics that are neither tonal nor impulsive but are readily distinctive against the residual acoustic environment.

18.5.25 Once any adjustments have been made, the background level and the rating levels are compared. The standard states that:

"*Typically, the greater the difference, the greater the magnitude of impact.*

A difference of around +10 dB or more is likely to be an indication of a significant adverse impact, depending upon the context.

A difference of around +5 dB is likely to be an indication of an adverse impact, depending upon the context.

The lower the rating level is to the measured background sound level, the less likely it is that the specific sound will have an adverse impact or a significant adverse impact. Where the rating level does not exceed the background sound level, this is an indication of the specific sound source having a low impact, depending upon the context."

18.5.26 The standard emphasises the importance of taking context into consideration and identifies a range of pertinent factors including:

- the absolute level of the sound;
- the character and level of the residual sound compared to the character and level of the specific sound, for example, comparing the frequency spectrum and variation over time; and
- the sensitivity of the receptor.

18.5.27 The standard specifies the specific sound level as an L_{Aeq} with a one hour assessment period during the day (07:00-23:00) and a fifteen minute assessment period at night (23:00- 07:00).

BS 8233:2014 'Guidance on sound insulation and noise reduction for buildings'

18.5.28 BS 8233:2014 provides guidance for the control of noise in and around buildings. It provides design guidance for noise generated inside or outside the building including noise level criteria and control measures, and a methodology for calculating internal noise levels depending on the performance of the building fabric.

18.5.29 Of relevance to this assessment, for "steady external noise sources" it provides guideline values for internal ambient noise levels within dwellings. These are reproduced in **Table 18.8**.

Table 18.8 Indoor Ambient Noise Levels for Dwellings

Activity	Location	07:00 to 23:00	23:00 to 07:00
Resting	Living room	35 dB $L_{Aeq,16hr}$	-
Dining	Dining Room	40 dB $L_{Aeq,16hr}$	-
Sleeping (daytime resting)	Bedroom	35 dB $L_{Aeq,16hr}$	30 dB $L_{Aeq,8hr}$

Criteria for Sensitivity of Receptors

General

18.5.30 The adopted assessment of noise and vibration effects is based on the sensitivity of the receptor and the magnitude of the exceedance of the relevant noise and vibration criteria.

18.5.31 In accordance with TAN 1/2011 and the IEMA Guidelines, the sensitivity of receptors to noise or vibration is based on their usage as defined in **Table 18.9**.

18.5.32 This classification deviates from that defined in **Chapter 4: Assessment Methodology, Scoping and Consultation**. According to the criteria in **Chapter 4**, individual residential properties would be classified as of medium sensitivity to noise impacts which would make this assessment less stringent and would not be in accordance with the relevant guidance.

18.5.33 Therefore, the below classifications **Table 18.9** has been applied.

Table 18.9 Receptor Sensitivity

Sensitivity of Receptor	Description
Very high	Concert halls / theatres, specialist vibration sensitive equipment
High	Residential properties, educational buildings, medical facilities, care homes
Medium	Places of worship, community facilities, offices
Low	Other commercial / retail premises

18.5.34 The above criteria do not apply to underground services such as water mains or electricity cables, which are classified as sensitive to vibration but not noise.

It is not considered necessary or appropriate to determine a specific sensitivity for this type of receptor.

Criteria for Magnitude of Impacts

Construction Noise

18.5.35 The magnitude of the impact of the construction noise is based on the difference between the likely construction noise level at the receptor and the Threshold Value for potentially significant effects derived using the methodology in BS 5228-1:2009 in **Table 18.3** with significance of effect as shown in **Table 18.10** below.

18.5.36 The only exception to this is the construction works which involves large-scale earth moving.

18.5.37 For these works, in accordance with THC guidance and PAN 50, a Threshold Value of 55 dB L_{Aeq} has been applied.

Table 18.10 Construction Noise Magnitude of Impact Criteria

Construction and Demolition Sound Level above Threshold Value (dB)	Magnitude of Impact
<1	Negligible
1>3	Minor
3>5	Moderate
5+	Major

18.5.38 Where short-term construction works are proposed for the purposes of mitigating the effects of the Proposed Development, consideration has therefore been given to mitigating any impacts where there is a likelihood that the construction noise levels will exceed the limit of 70 dB $L_{Aeq,1h}$ in PAN 50.

Construction Vibration

18.5.39 For all activities except blasting, construction vibration impact criteria at the nearest NSRs have been taken from BS 5228-2:2009 for this assessment as shown in **Table 18.11**.

Table 18.11 Magnitude of Impact for Construction Vibration

Magnitude of Impact	PPV (mm/s)	Effect
Negligible	0.14 to < 0.3	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.
Minor	0.3 to < 1	Vibration might be just perceptible in residential environments.
Moderate	1.0 to < 10	It is likely that vibration of this level in residential environments will cause complaint but can be tolerated if prior warning and explanation is given to residents.
Major	>= 10	Vibration is unlikely to be tolerable for any more than a very brief exposure to this level.

18.5.40 For blasting activities, the guidance in BS 6472-2:2008 has been used. Daytime PPVs of up to 6mm/s are classified as minor impact, between 6 and 10mm/s are classified as moderate, and exceedances of 10mm/s are a major impact. Night-time PPVs below 2mm/s are classified as minor impacts, between 2 and 4mm/s are classified as moderate, and exceedances of 4mm/s are a major impact. As per the requirements of BS 6472-2:2008 these limits should not be exceeded by more than 10% of blasts, and no blast should exceed them by more than 50%.

18.5.41 To avoid the potential for damage to occur to underground services, the criteria stated in BS 5228-2:2009 should not be exceeded. For continuous vibration the limit to the PPV is 15mm/s and for transient vibration it is 30mm/s.

Groundborne Noise

18.5.42 The proposed tunnelling and the operation of the turbines have the potential to generate groundborne noise at nearby receptors.

18.5.43 There are no UK legislative standards or criteria that define when groundborne noise becomes significant. The most relevant guidance is in 'Measurement and assessment of groundborne noise and vibration' (0), which described a number of published guidelines for assessing impacts of groundborne noise.

18.5.44 This includes the guidelines published by the American Public Transit Association which suggest criteria for acceptable maximum levels of groundborne noise affecting various building types, including a criterion of 35 dB L_{Amax} for groundborne noise affecting residential properties, during the day or night. This criterion is increasingly being adopted (as 35 dB L_{ASmax}) by Local Authorities in the UK when defining acceptable groundborne noise levels for new developments.

18.5.45 These criteria are typically applied to permanent groundborne noise sources, such as new underground railway lines, however in the absence of suitable alternative criteria these have also been applied to the assessment of

groundborne noise during construction. The criteria are detailed in **Table 18.12**.

Table 18.12 Magnitude of Impact for Groundborne Noise

Magnitude of Impact	Groundborne noise (dB L_{ASmax})
Negligible	30
Minor	35
Moderate	40
Major	45

Construction Traffic Noise

18.5.46 The impact of the change in noise level will be determined with reference to the classification of magnitude of impacts used in short-term traffic noise assessments presented in the DMRB Volume 11 Section 3 Part 7 Noise and Vibration and is shown in **Table 18.13**.

Table 18.13 Magnitude of Impact for Construction Traffic Noise

Magnitude of Impact	Description
Moderate	Change in $L_{A10,18hr}$ noise level between 3.0 and 4.9 dB.
Minor	Change in $L_{A10,18hr}$ noise level between 0.1 and 2.9 dB.
Negligible	No change in $L_{A10,18hr}$ noise level.

Operation – Industrial/ Noise

18.5.47 With regard to operational airborne noise, the classification of magnitude of impacts is presented in **Table 18.14** which is based upon the advice of BS 4142:2014 (levels during the operational phase and then subtracting the measured background noise level from the rating sound level).

Table 18.14 Magnitude of Impact for Operational Sound

Difference Between Rating and Background Levels	Magnitude of Impact
≤ 0	Negligible
1 to +4	Minor
+5 to +9	Moderate
≥ +10	Major

18.5.48 The above criteria do not include consideration the context, which is a requirement of BS 4142:2014.

Operation – Groundborne Vibration

18.5.49 With regard to operational groundborne vibration, the classification of magnitude of impacts is presented in **Table 18.15** which is based upon the advice of BS 6472-1:2008 for the avoidance of adverse comment. Groundborne vibration is assessed separately for construction and operation because the source is effectively permanent and therefore has the potential to result in greater effects. The guidance in BS 6472-1:2008 relates to permanent sound sources as opposed to temporary sources which are covered in BS 5228:2009.

Table 18.15 Magnitude of Impact for Operational Groundborne Vibration

Internal Vibration Level (VDV, $ms^{-1.75}$)		Magnitude of Impact
Day	Night	
< 0.2	< 0.1	Negligible
0.2 – 0.4	0.1 – 0.2	Minor
0.4 – 0.8	0.2 – 0.4	Moderate
> 0.8	> 0.4	Major

Ecological Receptors

18.5.50 The impact of construction and operational noise on ecological receptors will be determined with reference to the AQTAG 09 guidance. The impact of construction noise upon ecological receptors is considered with reference to the criteria as detailed below in **Table 18.16**.

18.5.51 Guidance considers impacts above a threshold of 55dB $L_{Aeq, T}$ and 80dB L_{AFMax} respectively.

Table 18.16 Magnitude of Impact for Ecological Receptors

Magnitude of Impact	Exceedance in the $L_{Aeq,T}$ Noise Level
High	Threshold exceeded by a maximum of 5dB
Medium	Threshold value exceeded by a maximum of 4 dB.
Low	Threshold value exceeded by a maximum of 2 dB.
Negligible	Threshold value not exceeded.

Significance of Effects

18.5.52 Based on the derived magnitude of impact and the sensitivity of the receptor to noise and / or vibration, the significance of effects is as shown in **Table 18.17**.

Table 18.17 Significance Criteria

Sensitivity Of receptor	Magnitude of Impact			
	Major	**Moderate**	**Minor**	**Negligible**
Very High	Major	Major	Moderate	Minor
High	Major	Moderate	Minor	Negligible
Medium	Moderate	Minor	Negligible	Negligible
Low	Minor	Negligible	Negligible	Negligible

18.5.53 **Table 18.18** puts the levels of the magnitude of adverse impacts and effect significance in context. This is based on the IEMA Guidelines for Environmental Noise Impact Assessment and the UK Government's Planning Practice Guidance (PPG) web-based resource.

Table 18.18 Magnitude of Impact and Significance of Effect

Magnitude of Impact	Description of Effect	Significance
Major	Disruptive, causes a material change in behaviour and / or attitude. Potential for sleep disturbance. Quality of life diminished due to change in character of the area	More likely to be significant ↑
Moderate	Intrusive, noise can be heard and causes small changes in behaviour and / or attitude. Potential for non-awakening sleep disturbance. Affects the character of an area such that there is a perceived change in the quality of life	
Minor	Non-intrusive, can be heard but does not cause any change in behaviour or attitude. Can slightly affect the character of an area but not such that there is a perceived change in the quality of life	↓ Less likely to be significant
Negligible	No discernible effect on the receptor	Not significant

18.5.54 The above significance derivation does not apply to the assessment of potential for damage to underground services. BS 5228-2:2009 does not provide significance of effect criteria for assessing vibration impacts on building services in the context of EIA.

18.5.55 The significance of effect where commented upon is therefore applied based upon whether the predicted vibration levels meet the BS 5228-2:2009 limits. Where the limits are not exceeded, this has been classified as being Not Significant. Where they are exceeded, they are considered Significant.

Assumptions and Limitations

18.5.56 For clarity any assumptions of limitations of each item of the assessment are provided below in the relevant section of the assessment.

Additional receptors

18.5.57 During scoping Binnein Shuas climbing crags where climbers gather prior to ascent, around NN468826 was identified as a potentially sensitive recreational receptor.

18.5.58 There are no specific sensitivity criteria applicable to outdoor recreational receptors in respect to the noise and vibration assessment methodologies laid out within this Chapter.

18.5.59 The receptor will ultimately be people undertaking recreational outdoor activities at the receptor location.

18.5.60 Individual attitudes will vary depending on the magnitude of impact, perception of the project and individual tolerance to noise and vibration in the context.

18.5.61 A textual assessment approach is proposed and provided below considering any relevant guidance as outlined in respect to incident impacts where reasonable in respect to each aspect of potential noise, vibration or overpressure impacts predicted at this receptor.

18.6 Baseline Conditions

Existing Baseline

18.6.1 A description of the NSRs positions chosen for the noise impact assessment is provided in **Table 18.1**. These positions were chosen as being representative of the nearest properties both to The Proposed Development and to the associated construction activities.

18.6.2 NSR's were described in the Scoping Report and are consistent with the locations assessed.

18.6.3 Where identified during consultation, or during further desktop review additional receptors have been identified and considered for assessment. The NSR locations are detailed above in **Table 18.1**.

18.6.4 Sound pressure level measurements for the purpose of describing the current ambient noise climate were captured at measurement positions deemed representative of the receptors identified.

Noise Survey Procedure and Instrumentation

18.6.5 Instrumentation used to measure sound pressure levels at each measurement position included the items listed in **Appendix 18.1.**

18.6.6 All equipment is calibrated in accordance with manufacturers requirements, and industry standard practices and intervals in line with IEMA guidance and other relevant assessment standards considered.

18.6.7 Whilst not being specific about the required survey duration at each position, it was considered that the Council's requirements would be best covered by

completion of a longer-term survey, using remote noise logging, taking in a period to include both weekday and weekend periods.

18.6.8 This would provide more detail regarding the variation to ambient noise levels through the complete daytime (07:00 to 19:00), evening (19:00-23:00) and night (23:00-07:00) periods and allow a more accurate assessment of the central tendencies for each period, to subsequently use as the reference level for the assessment.

18.6.9 Where receptors were deemed to be in relatively close proximity and subject to the same existing incident noise sources, long term measurements from the measurement locations have been considered in tandem with short term measurements in the immediate vicinity of receptors where access was feasible.

18.6.10 Details of these proxy measurements and applicability of long- and short-term survey locations to NSR is identified in the **Table 18.19**.

18.6.11 With regards to the Binnein Shuas Climbing Crags receptor, given the intervening distance from any existing noise sources such as road traffic on the A86, short term measurements were undertaken at two intervals to understand the typical daytime sound climate in the vicinity when the area may be used for recreation activity.

18.6.12 Samples of 15-minute duration were recorded contiguously through the survey period, to provide information on prevailing ambient noise levels over the shorter night time assessment period defined in BS 4142:2014.

18.6.13 As expected for an autumn period in a Highland location, weather conditions were mixed with variable wind conditions through the survey period.

18.6.14 A weather station was set up at Measurement Location 1 (ML1) at the Adverikie Estate House) for the purpose of measuring wind speed and rainfall through the period of the survey, thereby allowing the periods of fine weather with light winds to be established for the purpose of defining the ambient noise under these favourable conditions.

18.6.15 Sound pressure level samples were recorded, in terms of the following parameters:

- $L_{Aeq,T}$ the equivalent continuous noise level; and
- $LA_{90,T}$ percentile level.

18.6.16 Briefly, $L_{Aeq,T}$, the equivalent continuous noise level is used as the measure of total ambient noise, or noise from a specific source.

18.6.17 $L_{A90,T}$ is defined in BS 4142, as the measure of underlying background sound level, when it is applied to the residual noise level (the noise in the absence of the specific noise being assessed).

Noise Survey Results

18.6.18 The bulk wind speed and rainfall measurement data is included in **Appendix 18.1.**

18.6.19 Separate tables are included for each noise sensitive receptor and for each of the daytime (0700-1900), evening (1900-2300) and night time (2300-0700) periods.

18.6.20 Data is also sorted between the weekday and weekend periods of the survey.

18.6.21 Each table includes calculated central tendencies for assessment.

18.6.22 Prior to the calculation of the central tendencies, the bulk noise data has been filtered to exclude measurements taken under wind speeds of above 5m/s and during periods of rainfall.

18.6.23 With the remote monitoring survey producing a significant number of individual noise samples, the bulk noise data is large and thus best presented graphically in charts.

18.6.24 To this effect charts presented in **Appendix 18.1** illustrate the full noise data set captured at each measurement position over the survey period.

18.6.25 **Table 18.19** outlines the locations of the sound pressure level measurement positions, with reference to the relevant NSR locations from **Table 18.1**. Short term measurements where undertaken are also detailed which are considered alongside the relevant long term measurement position in the vicinity in relation to the relevant NSR.

Table 18.19: Measurement Positions, and Description of Noise Sources

Measurement Position I.D	Description of Noise Climate	Purpose
Measurement Location 1 (Long Term) ML1	Install: Main noise source from vehicles working on site and rustling of trees. Faintly hear road noise Collection: Main noise source from main road and vehicles on site	Long Term Measurement Position Representative of NSR 1. Adverikie Estate, Also used with shortened attended measurements to inform on noise climate to other receptors further to the east.
Measurement Location 2 (Long Term) ML2	Install: Main noise from main road nearby (A86), but generally quiet Collection:Main noise from main road	Long Term Measurement Position Representative of NSR 4. Moy Lodge

Measurement Position I.D	Description of Noise Climate	Purpose
Measurement Location 3 (Long Term) ML3	Install:Can faintly hear the main road in distance. Collection: Very quiet, main noise from the river adjacent then the road when cars pass	Long Term Measurement Position Representative of NSR 5 and 6.Luibliea and Torgulbin respectively.
Measurement Location 4 (Short Term) ML4	Install and Collection Very little noise in the area, main noise ecological. Can hear the main road in the distance. Secondary noise source from the adjacent stream.	Attended Measurement to inform further on noise climate further south at Torgulbin, NSR 6.
Measurement Location 5 (short term) ML5	Main noise from the main road in the distance. Otherwise, the main noise from ecological sources.	Attended Measurement to inform further on noise climate further south at Gallovie Farmhouse NSR 3..
Measurement Location 6 (short term) ML6	Main noise from the main road (A86) and ecological sources.	Attended Measurement to inform further on noise climate further south at Pinewood Residence NSR 7
Measurement Location 7 (short term) ML7	Main noise from A86 .	Attended Measurement to inform further on noise climate further south at Adverikie Estate Manager Lodge NSR 2
Measurement Location 8	Very little noise, main road faint in the distance.	Attended measurement to inform on existing baseline

Measurement Position I.D	Description of Noise Climate	Purpose
(short term) ML8	Noise from climbing activity.	noise levels at Binnein Shuas Climbing Area

18.6.26 The qualifying data has then been used to establish central tendency values.

18.6.27 However, care needs be taken in referencing modal values, as there can be multiple modes and in some noise environments the value can be unrepresentative.

18.6.28 In addition the log-mean value is only applicable to the $L_{Aeq,T}$ data, as the $L_{A90,T}$ statistical data cannot be averaged in this way.

18.6.29 Also, the log average value places greater weight to the samples with higher values, so can typically be between 3-5dB higher than the arithmetic mean.

18.6.30 Therefore, the arithmetic mean of the qualifying $L_{Aeq,15min}$ and $L_{A90,15min}$ measurement samples in context is considered to best describe the current noise environment at each of the receptor positions. As per the IEMA guidelines it is not appropriate to use the absolute worst case or lowest measured value.

18.6.31 Accordingly, Table 18.20 derives the representative value for the above metrics at the relevant NSR locations accordingly giving consideration to the long term measurement data, and the short term calibration measurement positions for individual receptors in relative proximity.

Table 18.20: Derived Assessment Dataset

NSR Location		Typical Background Sound Pressure Level dB $L_{A90, T}$				Typical Ambient Sound Pressure level dB $L_{Aeq, T}$			
		Day 07:00-19:00	Evening 19:00-23:00	Night 23:00-07:00	Weekend 07:00-19:00	Day 07:00-23:00	Evening 19:00-23:00	Night 23:00-07:00)	Weekend 07:00-19:00
1	Ardverikie Estate	39	38	36	44	43	40	39	49
2	Adverike Estate Manager Lodge And Adjacent Residential Dwelling	38	37	35	43	58	55	54	63
3	Gallovie Farmhouse	29	28	26	34	35	33	31	41
4	Moy Lodge	33	30	31	40	43	38	35	46
5	Luibliea	30	28	28	37	36	31	31	43
6	Torgulbin	29	27	27	36	34	29	29	41
7	Pinewood And Residential Dwellings Adjacent.	32	31	29	37	38	35	34	44
8	Binnein Shuas Climbing Crags NN468826. East of Summit	25	Not Applicable.		26	33	Not Applicable.		34

18.6.32 During the weekend night time periods, wind speeds were consistently at a level or below 5m/s with only infrequent gusts above this level, not atypical in context.

18.6.33 Rain was also very limited and not evidenced in any amount to be of significance to the outcomes of the assessment.

Discussion of Noise Survey Results

18.6.34 The main general points to note from a review of the noise measurement results are:

- Daytime ambient $L_{Aeq,15min}$ and background $L_{A90,15min}$ noise levels do not vary significantly between weekday and weekend periods. There is some noticed increase in the weekend in some areas, perhaps due to increases in recreational uses and road traffic from leisure use in the surround. This would be expected, as road traffic and general environmental noise sources such as running water (streams), vegetation (tree and foliage rustle) do not vary between these periods.
- Ambient $L_{Aeq,15min}$ noise levels are highest at positions NSR 1, NSR 2 and NSR 4, as would be expected where these positions are closest to the A82

and therefore exposed to higher levels of traffic noise, although it is still relatively low in real terms.

Future Baseline

18.6.35 Should the Proposed Development not proceed, any future change to baseline ambient sound would most likely result from changes to traffic flows in the area, primarily on the A86 unrelated to the Proposed Development.

18.6.36 Existing power infrastructure associated with the region comprises the fully operational existing Ardverikie and Lochaber Hydro Schemes, noise levels resulting from these developments are considered in-situ and existing and unlikely to affect future baselines through continued operation.

18.7 Mitigation by Design

18.7.1 The topography at the Site allows the opportunity for a shaft powerhouse rather than a cavern, with advantages for the cost of construction and minimising the build programme (and therefore length of potential construction noise impacts resulting).

18.7.2 The location and layout of the scheme offers the opportunity to win and use materials within the Site, which will minimise off-site transport on the road network and noise resulting.

18.7.3 Locating the majority of the operational power station underground / within a building (power house);

18.8 Potential Significant Effects

18.8.1 Based on the key parameters of the Proposed Development, without mitigation, the following potential effects have been considered:

- noise and vibration associated with construction plant and activities;
- noise and vibration associated with construction road traffic on the surrounding road network;
- vibration associated with blasting and material extraction and enabling works; and
- any above ground noise associated with the operation of plant and activities occurring at the new pumped storage power facility.

Construction Effects

18.8.1 Normal construction shifts would generally apply for the surface works (including access tracks, dams, powerhouse, upper control works, and lower control works) but these could be subject to some variation to suit the ongoing work, weather conditions and time of year.

18.8.2 It is anticipated that surface works would generally be undertaken between 07.00 and 19.00 hours, seven days a week and that underground operations would continue 24 hours a day, seven days a week.

18.8.3 As the workforce would be housed within the Site, these hours should not lead to any “out-of-hours” traffic on the local roads.

18.8.4 It is proposed that the movement of HGVs into or out of the Site would only take place between 08.00 and 18.00 on Mon - Friday and 08.00 - 16.00 hours on Saturdays and Sundays.

18.8.5 Surface blasting on Site would only take place between the hours of 09.00 to 17.00 on Monday to Friday inclusive and 10.00 to 14.00 on Saturdays, Sundays and on National Public Holidays, unless otherwise approved in advance in writing by the Planning Authority.

18.8.6 An indicative assessment of construction noise, vibration and other affects such as blasting overpressure and vibration has therefore been completed in accordance with BS5228-1.

18.8.7 Based on the noise survey undertaken all receptors clearly fall into "Category A" with regards to BS5228-1 construction noise threshold limits.

Noise Emissions

18.8.8 For the purpose of demonstrating potential impact from construction works, a qualitative assessment, to include prediction of noise levels resulting from the following activities, has been completed.

- site establishment and bridge / junction works with A86;
- upgrade and construction of existing access tracks / roads:
- promontory works;
- upper and lower control and upper dam works (screened inlet / outlet structures); and
- transportation of materials to upper dam via temporary haul road.

Prediction of Construction Noise

18.8.9 For the purpose of this assessment, noise predictions have been completed for each of the above work activities and to the NSR's identified have been summarised in **Table 18.21**, using procedures, together with construction equipment noise data, included in BS 5228-1.

18.8.10 For the upgrade of access roads/tracks and construction of a new temporary haul road, predictions have been completed in accordance with the procedures detailed in Section F.2.2 of BS 5228-1. The operating noise data, in terms of $L_{Aeq,T}$ at 10m distance, has been referenced from Annex C of the Standard. At this stage, detail of the plant requirements for road construction and upgrade works are not finalised.

18.8.11 Predictions assume a typical plant operating scenario for this item of work for such road works as has been assumed, as illustrated in the **Figure 18-A2-1** of **Appendix 18.2**.

18.8.12 The assessment reviews impact at a location representative of the closest approach for each grouping of relevant receptors individually, with respect to the works proposed. This therefore reflects the worst-case noise impact.

18.8.13 Assumes upgrade works are made sequentially along the proposed route with distance to receptor increasing after this (and magnitude of noise impact decreasing) respectively beyond this location.

18.8.14 For the site establishment works, peninsula, upper/lower control works, concrete/aggregate processing and bridge remediation activities predictions have been based on the BS 5228-1 plant sound power method, using the operating plant noise levels given in Annex C, with a +28dB(A) correction applied to the $L_{Aeq,T}$ values at 10m distance. Whilst some plant would be mobile, this would be within a limited area work zone, so for the purpose of the predictions such plant would be classified as 'quasi-stationary'.

18.8.15 A proprietary computer noise model, utilising software package CadnaA been used to calculate noise propagation corrections, to procedures defined in ISO 9613.

18.8.16 The model calculates noise levels around a site divided into the activity types identified and thus allows the reporting of the results visually through the construction of noise contours on an OS plan and individually with respect to each item identified.

18.8.17 This enhances the information provided by simple predictions made to specific receptor positions, as forecast noise levels can be reviewed across the complete region covered by the noise map for individual activites with respect to application of any warranted noise control and mitigation measures to be proposed.

18.8.18 The following set-up parameters have been used in the computer noise model:

- Ground Factor = 0.5 (mixed ground).
- Downwind conditions (C=0);
- Temperature = 10°C;
- Humidity = 60%;
- Receiver height = 1.5 m; and
- Noise source height: typically 2 m.

18.8.19 It may be noted that the noise model has been built upon scaled OS mapping that includes land height contours, at 10m distance intervals. Accordingly, the noise model takes full account of terrain screening.

18.8.20 For the predictions, it has been assumed that all the plant items, with associated numbers of each, could be operating together and continuously for the complete working day (07:00-19:00). The predictions therefore reflect the worst-case scenario, with no applied on-time correction i.e 100% on time for plant.

18.8.21 Predictions made to ISO 9613 are applicable to the worst-case noise propagation condition, where all receptors are downwind from the noise source. Noise levels experienced under other wind directions are likely to be lower than those predicted for the downwind condition.

18.8.22 Temporary haul routes are proposed to connect the lower reservoir works area to the upper reservoir, providing an opportunity to supplement rock quarried within the upper reservoir, with suitable tunnel spoil from the underground works, for dam construction.

18.8.23 For the prediction of additional noise due to dump truck movements along the haul road, the method described in Section F.2.5.2 of BS 5228-1 has been used, referencing the following expression:

$L_{Aeq,T} = L_{wA}$ *-33 + 10log Q – 10log V -10log d – 10 log (av,/180º)*

Where:

- L_{wA} is the sound power level of the Dump Trucks;
- Q is the number of vehicles per hour;
- V is the average vehicle speed (km/h);
- d is the distance of the receiving position from the centre of the haul road (m); and
- av is the angle of view of the haul road from the receptor position.

18.8.24 The basis for all the noise predictions is the noise data applicable to the items of construction plant and equipment that have been identified, at this stage, as typically being required for undertaking each of the planned work activities. The assessment assumes 8 vehicle movement in any one hour along haul routes.

18.8.25 **Note:** even if doubled this would represent a +3dB increase to the predicted levels.

18.8.26 The input construction noise data applicable to the assessments has been taken from the reference tables included in Annex C of BS 5228-1. The plant list with accompanying noise data, are reproduced in **Appendix 18.2** to this Chapter.

Table 18.21 Indicative Construction Activity and Noise Modelling Inputs

Noise Modelling Exercise ID	Model Description and Locations	Commentary
R1	Site Establishment and Bridge Works	Modelled as an area source at Site Compounds with reference to **Table 18A.1** item 1 of **Appendix 18.2**. Noise Modelling as detailed in **Section 18.9.5** to **18.9.18**
R2	Upgrade of access roads or construction of access roads	Modelled as per guidance above in **Section 18.9.8** at closest approach to relevant receptors. With reference to **Table 18A-1** item 2 of **Appendix 18.2**
R3	Peninsula Works	Modelled as detailed in **Section 18.9.5** to **18.9.18** with reference to **Table 18A-1** item 1 of **Appendix 18.2**.
R4	Lower/Upper Control works	Modelled as an area source at lower/upper control works area with reference to **Table 18A-1** item 4 of **Appendix 18.2**. Noise Modelling as detailed in **Section 4.9.5** to **4.9.18.**
R5	Concrete and aggregate processing and handling	Modelled as an area source at Borrow Pits with reference to **Table 18A-1** item 5 of **Appendix 18.2**. Noise Modelling as detailed in **Section 18.9.5** to **18.9.18.**
R6	Transportation of spoil to upper dam via temporary haul road	With reference to **Table 18A-1** item 6 of **Appendix 18.2** Modelled as per guidance above in **Section 18.9.20** at closest approach to relevant receptors.

18.8.27 The predicted noise levels from each of the construction activities at each receptor location, are summarised in **Table 18.22**.

18.8.28 In the worst and most robust case it is considered that at some point during construction all items identified could be working simultaneously as per the cumulative assessment column.

Table 18.22 Construction Noise Impact Summary

NSR ID		Construction Activity Noise dB $L_{Aeq, T}$						
		R1	R2	R3	R4	R5	R6	Cumulative
1	Ardverikie Estate	36	50	3	0	24	24	50
2	Adverikie Estate Manager Lodge And Adjacent Residential Dwelling	18	39	0	0	13	19	39
3	Gallovie Farmhouse	18	40	0	0	13	19	40
4	Moy Lodge	43	59	6	9	44	28	59
5	Luibliea	54	67	3	8	54	33	67
6	Torgulbin	54	65	3	8	56	31	66
7	Pinewood And Residential Dwellings Adjacent.	20	40	0	0	16	19	40
8	Binnein Shuas Climbing Crags NN468826. East of Summit	55	59	17	31	33	29	60

18.8.29 **Table 18.23** below identifies those receptors predicted (in the robust worst case) to have impacts exceeding BS5228 Daytime (65dB $L_{Aeq, T}$), and Evening and Weekend construction noise criteria (55dB $L_{Aeq, T}$). The evening and weekend criterion is also representative of Highland Council Monday to Saturday long-term construction noise criterion (55dB $L_{Aeq, T}$).

Table 18.23 Construction Noise Impact Criteria Comparison

NSR ID		Cumulative Construction Activity Noise dB $L_{Aeq, T}$	BS5228 Weekday Exceedance dB (Y/N)	BS5228 Weekend (Saturday) /Highland Council (Monday-Saturday) Long Term Limit dB (Y/N)
1	Ardverikie Estate	50	-15 (N)	-5 (N)
2	Adverikie Estate Manager Lodge And Adjacent Residential Dwelling	39	-26 (N)	-16 (N)
3	Gallovie Farmhouse	40	-25 (N)	-15 (N)
4	Moy Lodge	59	-6 (N)	4 (Y)
5	Luibliea	67	2 (Y)	12 (Y)
6	Torgulbin	66	1 (Y)	11 (Y)
7	Pinewood And Residential Dwellings Adjacent.	40	-25 (N)	-15 (N)
8	Binnein Shuas Climbing Crags NN468826.East of Summit	60	-5 (N)	5 (Y)

18.8.30 The predictions indicate that the highest noise impacts and therefore greater potential for adverse impacts would result from the works associated with the upgrade and construction of access roads/tracks (R2) as well as to a lesser extend Site Enabling works and works to the Junction with the A86 (R1) and Concrete and Aggregate Processing (R5) and primarily at NSR 4,5 and 6 (Moy Lodge, Luibliea, and Torgulbin respectively).

18.8.31 This is due primarily to the proximity of the access roads, the A86 Junction, and Site Compound 1 and Borrow Pit 1 to the receptor positions located to the side of/or in view of these access paths.

18.8.32 Relevant and significance of impacts on the Binnein Shuas climbing crags is discussed separately.

18.8.33 Accordingly in an unmitigated state the magnitude of impact at NSR locations 1,2, 3, and 7 is considered to be **Negligible** where neither BS5228 or THC criteria is predicted to be exceeded which is therefore **Not Significant**.

18.8.34 Impacts are predicted to be a localised temporary **Moderate** (NSR 4 Moy lodge) to **Major** (NSR 5 Luibliea and 6 Torgulbin) in magnitude which is potentially **significant.**

18.8.35 It is therefore submitted that consideration for the works identified to be the primary cause of construction noise in this region of the site to be mitigated, which is discussed in the relevant section of this document.

Construction Vibration - Surface Plant Except Piling

18.8.36 Research by the Transport and Road Research Laboratory found that the levels of groundborne vibration from tracked earth moving equipment (such as a bulldozer or excavator) are imperceptible to humans at a distance of approximately 20m, and those generated by vehicles with rubber tyres (e.g. a heavy lorry or dump truck) would be imperceptible at more than 10m from the haul road.

18.8.37 On site tracks and haul routes mobile plant will not come within 115m of an identified sensitive receptor during site access; hence vibration is not likely to be perceptible or of a magnitude that could cause complaint.

18.8.38 On public roads, vibration would be not greater than that experienced from existing HGV passes and thus is not explored further.

18.8.39 It is concluded that the magnitude of vibration impacts for surface plant would be no worse than minor at the closest NSRs. Accordingly, the worst-case significance of effects is a localised, temporary, **negligible adverse effect** for all NSRs, which is considered to be a **Not Significant.**

18.8.40 Hydraulic hammers and breakers that are mounted on excavators will cause groundborne vibration from their impulsive percussive action.

18.8.41 Typical safe working distances from this type of equipment are shown in **Table 18.24** below.

18.8.42 This table has been taken from the Australian document "Construction Noise Strategy (Rail Projects)" (NSW Transport Construction Authority) as indicative advice for safe working distance to comply with the vibration criterion levels published within BS 6472-1:2008 and BS 7385-1:1993.

Table 18.24 Recommended safe working distances for Hydraulic Hammers

Plant	Rating/Description	Safe Working Distance	
		Cosmetic Damage	Human Response
Small Hydraulic Hammer	300 kg / 5-12 t excavator	2 m	7 m
Medium Hydraulic Hammer	900 kg / 12-18 t excavator	7 m	23 m
Large Hydraulic Hammer	1,600 kg / 18-34 t excavator	22 m	73 m

18.8.43 In the worst case, at the closest interface, NSRs (3 and 4) are more than 250 m from where hydraulic hammer rock breaking may occur within the identified Borrow Pits.

18.8.44 As such the values provided within **Table 18.24** demonstrate that all identified high sensitivity NSRs are unlikely to perceive the vibration from hydraulic hammer rock breaking. Accordingly, the magnitude of impact is predicted to be **Negligible** and therefore the significance of effects is **Not Significant.**

Construction Vibration - Piling

18.8.45 Piling is anticipated to be required during the construction of the powerhouse and dams. Piling vibration impact has therefore been considered.

18.8.46 Predictions of the groundborne vibration generated by the piling have been performed using the methodology in BS 5228-2:2009+A1:2014. It is anticipated that that all piles will be driven to refusal and that the maximum pile driver hammer energy has the potential to be around 225kJ.

18.8.47 This is greater than the stated range of hammer energy in the prediction method, which is 1 to 85 kJ. BS 5228-2:2009+A1:2014 doesn't state an applicable distance range for the prediction methodology, however the research on which it is based (Groundborne vibration caused by mechanised construction works, Hiller and Crabb, 2000) validated the equation with measured levels at distances of up to 120m.

18.8.48 The closest residential NSR to the piling location is NSR 4 at a distance of 3,450m.

18.8.49 At this distance the predicted vibration level is <1mm/s. However, on the basis that the hammer energy levels and distance from the source exceed the range of accuracy of the standard the potential levels at the receptor have been considered further by examining the historic case study data in BS 5228-2:2009. There are seven reported measurements of vibration levels generated by sheet steel piling at distances in excess of 100m and these are shown below in **Table 18.25.**

Table 18.25 BS 5228-2:2009 relevant historic data on vibration from driven sheet steel piling

Soil conditions	Theoretical Energy Per Blow (kJ)	Distance (m)	PPV (mm/s)
Fill / 6 m alluvium / 4 m to 6 m peat, clay, sand and silt / 1.3 m sand and gravel / 5 m stiff clay / 9 m dense sand / hard chalk	71.6 to 143.2	130	0.1
		250	0.015 to 0.025
Not recorded	Not recorded	300	0.015

18.8.50 It should be noted that the data in **Table 18.25** are for lower energies per blow than proposed, and that it may not have been the case that piles were driven to refusal.

18.8.51 Nevertheless, given that the limit of 1mm/s (at which impact magnitudes become moderate) is 10 times the highest of the measured evidence levels from BS5228 reference data, it is considered highly likely that the actual levels will be below this noting the significantly larger intervening distances to receptors.

18.8.52 Accordingly, the magnitude of impact is predicted to be no worse than minor at the above distances and likely Negligible at the actual NSR distances on site, and therefore the significance of effects is a localised, temporary, **Negligible** effect, which is **Not Significant.**

18.8.53 SLR understand there are no sensitive underground services in the vicinity of the proposed works.

18.8.54 Therefore, further assessment of this infrastructure receptor has been scoped out of assessment.

18.8.55 Regarding the accuracy of these predictions BS 5228-2 states:

"The various formulae which have been developed empirically to predict vibration levels at a receiving point do not take into account variability of ground strata, the pile-soil interaction process, coupling between the ground and the foundations, etc. Hence these formulae can only provide a first assessment of whether or not the vibrations emanating from a site are likely to constitute a problem.

More accurate assessment can be achieved by the calibration of the site, i.e. the establishment of a site-specific formula. In the case of impact pile driving, the data necessary for the derivation of the formula can be obtained from one or more trial drive(s) using a piling rig, and recording the vibration levels at various distances from the pile position."

Construction Groundborne Noise and Vibration - Tunnelling

18.8.56 TBM or “drill and fire” techniques are anticipated to be used to excavate the Tunnels required by the development design.

18.8.57 BS 5228- 2:2009 provides guidance on calculating first estimates of potential groundborne vibration and noise levels from tunnel boring (Annex E.1). The empirical formulae within Table E.1 of the standard used to calculate groundborne vibration and noise from tunnelling are limited to the distance range of 10m to 100m. The closest NSR to the Waterway route is which is approximately 2,750m from the High-pressure Tunnel.

18.8.58 The formulae have been employed to gain an indication of the groundborne vibration and noise at a nominal distance of 100m, the groundborne vibration is predicted to be PPV 0.45mm/s. The groundborne noise level is predicted to be a sound pressure level of 19dB. The groundborne noise level generate by the TBM is anticipated to be very steady and hence it is considered that this level equates to a value of 19dB $L_{ASMax.}$

18.8.59 All NSRs are at distances greater than 100m (by an order of magnitude) from the tunnelling works proposed, and it would be expected that groundborne vibration and noise effects would decrease with increasing distance.

18.8.60 While this may be true, the authors of the original document cited by BS 5228:2009: ‘Groundborne vibration caused by mechanised construction works’ (Traffic and Transport Research Laboratory) warn that due to the formulae being derived from TBM activities over a limited range of materials, it is possible that formulae may underestimate predicted values for tunnelling in stronger rock.

18.8.61 They also caution against the extrapolation of the formulae for distance greater than 100m. However, given the very large disparity in distance to receptors relative to the above evidence, it is not considered that monitoring or further assessment is warranted.

18.8.62 These results indicate that for distances of at least 100m from the tunnelling, groundborne vibration and noise impacts are expected to be negligible respectively.

18.8.63 Given that the effects of groundborne vibration are therefore of localised, temporary **Minor Adverse Effect** and those of groundborne noise are of localised, temporary **Negligible Effect.** Both effects are **Not Significant** beyond 100m noting the receptor distance of approximately 2,750m to proposed tunnel works.

18.8.64 As mentioned above further calculations have not been carried out to determine potential vibration damage to underground services.

18.8.65 The TBM will not travel close to BT Openreach Cables, or the Scottish Water main infrastructure and therefore assessment of vibration impacts has been scoped out of further assessment.

Construction Groundborne Vibration --Blasting/Drilling

18.8.66 The level of ground-borne vibration arising from mechanised construction works, at a receptor position, is difficult to predict, as there are a number of factors that may influence the production and transmission of vibration in the ground, including:

- local ground (or soil) conditions at the construction site;
- the distance between source and receiver;
- the ground geology between source and receptor (the transmission path); and
- local ground conditions at the receptor position.

18.8.67 Whilst BS 5225-2 (Annex E) provides empirical formulae, to allow prediction of resultant PPV values from mechanised construction works, the parameter range for input distance only extends to 110m, which would tie in with the expectation that prediction of vibration to large distances would have limited accuracy.

18.8.68 Annex D and E of BS 5228-2 provides historic case data on vibration levels produced by various piling operations, which would typically produce ground vibration through percussive, or vibratory modes of piling.

18.8.69 As would be expected, the majority of the presented data relates to vibration produced at distances up to 100m, which are most representative of typical sensitivity range. However, relevant detail on larger distances includes a measurement of PPV 0.1mms-1 at 130m and 0.025mms-1 at 250m, both resulting from driving sheet piles using a diesel hammer rig.

18.8.70 The lower reservoir works would include for use of mechanised equipment, such as rock drills and drilling rigs, which have potential for producing localised ground vibration. However, a qualitative assessment, including review of BS 5228-2 guidance, would indicate that, due to the large separation distance (>1km to the closest residential noise sensitive receptor position), the resulting vibration PPV levels would be below $1mms^{-1}$, and consequently the potential impact would be negligible.

18.8.71 The more likely cause of ground vibration and associated potential impact, would be from blasting completed mainly in connection with lower reservoir works, which may include:

- blasting activities associated with construction of the inlet/outlet area;
- blasting activities associated with construction of the powerhouse shafts; and
- blasting activities associated with construction of tunnels.

18.8.72 There may also be some blasting required within the borrow pits.

18.8.73 The level of vibration resulting from blasting is dependent on site-specific factors, such as distance from the blast, explosive charge weight and ground geology between blast and receiver.

18.8.74 Whilst vibration levels due to blasting activities are likely to be low, due to the large distance separation between the blasting sites and closest receptor positions, this would be confirmed by undertaking vibration tests during either blasting trials, or during the early stages of blasting operations.

18.8.75 As outlined in section E.2 of BS 5228-2, for the purpose of predicting site-specific ground vibration resulting from blasting it is necessary to complete a series of concurrent vibration measurements at different distances from the blast site. These measurements are then used to produce a scaled-distance graph, which

can be used to indicate likely vibration magnitudes at various distances and to establish maximum instantaneous charge size, to meet acceptable vibration PPV limits.

18.8.76 Potential adverse impact from ground vibration would therefore be avoided by employing good blast design, in particular to the use of the appropriate charge sizes, to meet vibration limits appropriate to both human response and to protect buildings from damage (see **Table 18.4**). The methodology for the vibration testing programme would be provided in the CNVMP, when more detail on the design of the blasting activities are known.

Blast Generated Air Overpressure

18.8.77 BS 5228-2 states that there is no known evidence of blast generated air overpressure causing structural damage to buildings, with adverse comment more likely to result from the air overpressure exciting secondary vibrations (such as in windows) at audible frequencies.

18.8.78 The Standard further notes that, due to uncertainties with meteorological conditions, it is not possible to predict the location of the maximum air overpressure from a blast. Given the additional consideration that windy conditions can mask the blast generated air overpressure levels it is not accepted practice to set specific limits for air overpressure.

18.8.79 The best practical approach for the control of air overpressure, as noted in BS 5228-2, is to take measures in the design of the blasting technique, to minimise its generation.

18.8.80 Potential adverse impact resulting from air-overpressure produced by blasting operations would therefore be avoided by employing good blast design in consultation with the blasting specialist.

18.8.81 Additionally, monitoring of air-overpressure during blasting activities would be completed in conjunction with ground vibration measurements, using the same seismograph instrumentation. Detail of the monitoring programme would be included in the CNVMP, when more detail on the design of the blasting programme is known.

18.8.82 Potential blasting vibration impacts on ecological receptors are considered within **Chapter 8: Terrestrial Ecology** and **Chapter 10: Ornithology**.

18.8.83 Potential underwater noise and vibration impacts on ecological receptors are considered within **Chapter 11: Aquatic Ecology** and summarised below in Section 18.8.135 to 18.8.139.

Construction Traffic Noise and Vibration on Public Highways

18.8.84 Construction traffic may alter noise levels on the affected network for the duration of the construction period.

18.8.85 Traffic data for the construction stage has been provided within the “Transport and Access” chapter to the EIA.

18.8.86 It is noted that no AAWT (Average Annual Weekday Traffic) figures are provided due to the relatively low overall traffic flow. On this basis calculations have considered the AADT (Average Annual Daily Traffic) figures.

18.8.87 For the purposes of this assessment this is considered representative when considering noise change only as a result of the construction phase.

18.8.88 In accordance with the DMRB LA111, an assessment to include the following four road links for which traffic flow data has been provided based upon comparison ofr the 2029 Baseline and 2029 Baseline + Peak Construction traffic figures (Tables 13.4 and 13.6 of the transport and access chapter respectively):

18.8.89 The links below have been considered:

1 A86 Site Access

2 A86 Spean Bridge

3 A889 North of Dalwhinnie

4 A86 West of Newtonmore

5 A9 North of Kingussie

6 A9 South of Dalwhinnie

7 A82 North of Spean Bridge

8 A82 North of Corpach

18.8.90 For each link the BNL has been established for the “With” and “Without” Construction Activites of the Scheme in the 2029 baseline year.

18.8.91 The scenario presented is for the first year of construction.

18.8.92 The BNL is the L_{A10}, 18-hr dB noise level at 10m from the kerb of the road assessed.

18.8.93 The results of the assessment are provided in **Appendix 18-3** to this chapter.

18.8.94 The highest magnitude impact is found at Link 1 AA86 site access, with a noise change of 2.1dB between the 2029 baseline and 2029 baseline plus peak construction traffic.

18.8.95 The second highest magnitude of impact is found at Link 3 A889 North of Dalwhinnie with a noise change of 1.2dB between the 2029 baseline and 2029 baseline plus peak construction traffic.

18.8.96 All other links exhibit negligible magnitude impacts.

18.8.97 It should be noted that the modelling exercise is not able to accommodate and consider HGV speed limit restrictions on links which would be beneficial acting as mitigation.

18.8.98 It is also considered that ultimately the construction phase traffic will be limited in the temporal domain, resulting in **negligible** residual impacts once construction is completed.

18.8.99 A general scheme of mitigation is presented in the "Transport and Access" chapter.

18.8.100 The magnitude of impact at worst case affected links is predicted to be **Minor magnitude** at **high** sensitivity receptors and therefore the significance of effects is also of **minor effect** which is **Not Significant.**

Operational Effects

Operational Phase: Site Noise Emissions

18.8.101 The assessment of operational noise from the Proposed Development and subsequent determination of significant effects will be undertaken based on the assessment methodology defined in BS4142:2014+A1:2019 Methods for Rating and Assessing Industrial and Commercial Sound (British Standards Institution, 2019).

18.8.102 Indeed, THC proposed typical draft conditions at consultation, as reproduced below:

"All plant, machinery and equipment associated with this development shall be so installed, maintained and operated such that the following standards are met: - any associated operating noise must not exceed NR 20 when measured or calculated within the bedroom of any noise-sensitive premises with windows open for ventilation purposes, the operating Noise Rating level must not exceed the Background noise level including any characteristics penalty. Terms and measurements to be in accordance with BS 4142: 2014 Methods for Rating Industrial & Commercial Sound."

The assessment will determine the rating level from operations at the Proposed Development and compare these to the background sound level at the NSRs.

Operational Airborne Noise

18.8.103 Potential operational airborne noise sources associated with Proposed Development are as follows:

- turbines and generators;
- transformers and switchgear;
- emergency generators; and
- substation.

Underground or Enclosed Equipment

18.8.104 The turbines, generators, transformers, switchgear, and emergency generators will be located within the powerhouse.

18.8.105 The emergency generators will only operate in the event of a power cut to the Site, which is highly unlikely to occur.

18.8.106 The sound power levels of the turbines, generators, emergency generators and associated equipment are not yet known. Modern gas insulated switchgear equipment emits very low noise levels during operation.

18.8.107 At this stage, no detailed information is available regarding the sound power level or acoustic character of sound from the proposed transformers; however, these commonly produce a strong tonality at levels of 50 and / or 100Hz due to the frequency of mains electricity.

18.8.108 Given the installation is enclosed it is highly unlikely that there will be any audible operational noise from the below ground equipment and tunnels will result at the surface due to the intervening rock and building infrastructure providing significant mass and sound insulation and therefore additional attenuation over that already afforded by intervening distance.

18.8.109 Where rock is generally between 1,600kg/m^3 (sediments) and 2,600kg/m^3 granite, achieving attenuation of airborne sound of 50-55dB R_w at just 150mm depth.

18.8.110 Similarly concrete and even lightweight building materials will provide attenuation of airborne sound upwards of 35-40dB R_w

18.8.111 In addition, noting the closest residential NSR position is located at a distance of 3,500 m from the proposed operational elements at the lower loch.

18.8.112 At this propagation distance, the sound level reduction, relative to hemispherical source sound power emission above ground, would be -79 dB, taking account of distance attenuation.

18.8.113 Other propagation features, such as atmospheric attenuation, ground attenuation correction and physical screening due to topography and the intervening Binnein Shuas crag would only further increase this figure.

18.8.114 The reversible pump-turbines, motor-generators and other main equipment items would be housed inside a well-insulated surface powerhouse building, reducing noise breakout from the building to the outside environment to low levels.

18.8.115 The mitigating design features, alongside the large receptor distance, would ensure that the specific sound level at the closest receptors would likely be below 25 dB(A) outside dwellings and therefore below NR20 indoors accounting for additional losses of 12-15dB for an open window.

18.8.116 Hydro turbines are installed on concrete inertia bases, with turbines that are orientated vertically commonly being housed in the basement of the powerhouse and having the spiral casing of the turbine partially embedded in concrete. These measures are designed to minimise vibration on and local to the equipment, so preventing it entering the ground.

18.8.117 There may be potential for low frequency noise (LFN) from the operation of the turbines, but this is deemed unlikely due to the depth of the turbines installation level and the incorporated attenuation and building design as well as substantial intervening distances involved to NSR locations as noted.

18.8.118 BS4142:2014 refers to the University of Salford *'Procedure for the assessment of low frequency noise complaints - NANR45' (*2005) for the assessment of LFN.

18.8.119 LFN can be very difficult to predict with a high level of certainty and similarly hard to identify and resolve if present. This is because it can be generated by the unexpected interactions between system components and can be amplified by the geometry of the Development Site and receptor buildings.

18.8.120 However, there are several risk factors that are known to make the generation of LFN more likely. The potential issue of LFN will be considered throughout the detailed design for the Proposed Development and mitigated through design.

18.8.121 However, these are unlikely to be an issue due to the distance between the source of the vibration (the turbines) and the nearest NSR (>3,500m).

18.8.122 Even at 400m the levels at which **Minor** adverse impacts would occur (0.1 mm/s for night-time groundborne vibration and 30 dB L_{ASmax} for groundborne noise) are highly unlikely to be exceeded, clearly at higher distances as evidenced between the Site and residential NSR locations the risks are further reduced, and likely **Negligible** Impact.

18.8.123 As with LFN, groundborne noise and vibration will be mitigated through design.

18.8.124 On this basis, impacts of no greater than **Negligible** magnitude are expected. The significance of effect on high sensitive NSRs (i.e. residential properties) is a localised, **Negligible Significance.**

Above Ground Equipment- Operational Airborne Noise Limits

18.8.125 Typically, based on prior experience of PSH projects such a substation would generate sound pressure levels of no greater than 70 dB(A) at 5m from the substation fence.

18.8.126 The Developer has accepted a Grid Connection Offer from National Grid. The powerhouse would be connected to the national electricity network by a buried cable between the powerhouse switchyard and a new substation located adjacent to the Beauly Denny overhead powerline at Kinloch Laggan.

18.8.127 The switchyard buried cable and sub-station would be constructed by the Transmission Network Operator, SSE Networks, and they would be responsible for any planning consents required.

18.8.128 Equipment associated with the operation of the Powerhouse building will be at least 3,500m from any residential NSR location.

18.8.129 Based on the above findings and based on the acoustic distance losses resulting, it is considered that the risk of noise impact from static plant during the operational phase at Site is low.

18.8.130 It is submitted that the conditions as proposed can be utilised to control operational noise emissions.

18.8.131 Qualitative submission of a noise impact assessment to discharge this condition could then be provided outside the EIA framework if needed.

18.8.132 Operational airborne noise limits can be determined using the BS 4142:2014 assessment methodology, based on the measured daytime and night time background noise level at the representative NSRs as presented in **Appendix 18.1** and summarised in **Table 18.18**.

18.8.133 As per the THC Scoping Opinion response, a difference of 0dB between the background and rating sound levels has been set as a target. This will result in a magnitude of impact no greater than minor adverse. The THC Scoping Opinion

response also provided an alternative limit to the operational noise of not exceeding NR (noise rating curve) 20 inside any residential property.

18.8.134 Note that as per BS 4142:2014, the target rating level includes any potential character corrections (due to characteristics such as tonality, impulsivity and intermittency) to the specific sound level. At this stage information on the characteristics of the sound sources (e.g. any tonal features) are yet to be determined, however these will be considered during detailed design.

18.8.135 **Table 18.18** presents recommended operational limits for the power house (which includes any correction for characteristics such as tonality, impulsivity and intermittency), with recognition that the main noise generating equipment is beneath ground at depth.

18.8.136 Although the recommended rating level limits have been determined using the representative background sound levels these will be refined during detailed design stage.

18.8.137 Specific consideration will be given to the context, in particular, as the absolute levels are considered very low and such low limits may not be necessary to avoid effects on NSRs.

18.8.138 Any necessary noise control design measures will be finalised during detailed design to ensure appropriate operational noise limits are achieved, therefore impacts no greater than minor magnitude will occur.

18.8.139 There may be potential for low frequency noise (LFN) from the operation of the turbines but this is deemed unlikely due to the depth of the turbines below ground level and the incorporated attenuation and building design.

18.8.140 BS4142:2014 makes reference to the University of Salford ‘Procedure for the assessment of low frequency noise complaints - NANR45’ (2005) for the assessment of LFN.

18.8.141 LFN can be very difficult to predict with a high level of certainty and similarly hard to identify and resolve if present. This is because it can be generated by the unexpected interactions between system components and can be amplified by the geometry of the Proposed Development and receptor buildings.

18.8.142 However, there are several risk factors that are known to make the generation of LFN more likely. The potential issue of LFN will be considered throughout the detailed design for the Development and mitigated through design.

18.8.143 However, on the basis the draft conditions are put in place, and complied with by design, impacts of no greater than **Negligible** magnitude are expected. The significance of effect on high sensitive NSRs (i.e. residential properties) is a localised, **Negligible Significance.**

Ecological Receptors

18.8.144 Nosie and vibration impact on ecological receptors are discussed in **Chapter 8: Terrestrial Ecology** and **Chapter 10: Ornithology**.

18.8.145 Potential underwater noise and vibration impacts on ecological receptors are considered within **Chapter 11: Aquatic Ecology**. Where relevant guidance has been provided within this Chapter to inform these assessments.

18.8.146 In summary the Terrestrial Ecology chapter discusses potential disturbance of fauna utilising retained habitat via human presence, construction noise, vibration, and temporary construction lighting. And finds potential impacts as **Not Significant.**

18.8.147 In summary the Aquatic Ecology chapter finds potential acoustic impacts to be Minor **(Not significant).**

18.8.148 The chapter highlights that Construction noise and vibration would be managed through a Construction Noise & Vibration Management Plan (CNVMP) which would be agreed prior to construction works.

Binnein Shuas Climbing Crags Receptor

18.8.149 During scoping Binnein Shuas climbing crags where climbers gather prior to ascent, around NN468826 was identified as a potentially sensitive recreational receptor.

18.8.150 As stated above there is no specific sensitivity criteria applicable to outdoor recreational receptors in respect to the noise vibration and air overpressure assessment methodologies laid out within this Chapter.

18.8.151 The receptor will ultimately be people undertaking recreational outdoor activities at the receptor location.

18.8.152 Individual attitudes will vary depending on the magnitude of impact, perception of the project and individual tolerance to noise and vibration in the context.

Construction Noise and Vibration Impact on Binnein Shuas

18.8.153 The climbing crags are at least 900m from any area of works proposed, as this distance vibration effects are unlikely to be perceived (as indicated in the preliminary assessments at similar distances undertaken for other receptors).

18.8.154 Construction noise is indicated to not exceed BS5228 construction criteria, and slightly exceed HTC long term construction noise limits at this location. However existing ambient noise levels will clearly be increased for the construction period which is unavoidable in context.

18.8.155 The noise increase is indicated to be primarily due to the site establishment works and upgrade of access roads or construction of access roads. Clearly these phases will not be continuous for the full construction period, and thus this is a worst-case assessment.

18.8.156 Generally, the above can be mitigated though communication with the community and perception of the sustainability benefits of the project resulting, as well as general open liaison and good communication throughout the project as is detailed below in the mitigation section to this document.

Construction Blasting at Binnein Shuas

18.8.157 As the distances involved, physical safety of climbers is not indicated to be an issue, stand-off distances for operatives involved in blasting works for example would be significantly smaller and still considered safe with respect to the percussive wave experienced from blasting activity.

18.8.158 The project geologist has highlighted examples where quarry scale blasting has been undertaken in relative (horizontal and vertical proximity) to sensitive receptors as below:

"On South Uist in 1999 we did some trial blasts and vibration monitoring tests prior to recommending a quarry/borrow pit for the Eriskay causeway. The quarry was about 500m from the closest houses. This was no issue with normal small scale quarry production blasts".

"In 1998 we were blasting two or three times a week in the quarry/borrow pit for the Berneray causeway, frequently only 200m to 300m away from a small building and ferry jetty."

18.8.159 SLR highlight that climbing walls are an estimated minimum 900m distant across the Loch.

18.8.160 Previous studies such as *"Impact Assessment of Blasting on Vulnerable Landslide Area"* (Dev, Pratap et all, 2015) have shown that beyond circa 250m distance a PPV exceeding 5mms^{-1} as a result of blasting is unlikely during damn building, even with explosive charges exceeding 1000kg in size which is unlikely to reflect proposals at Earba.

18.8.161 The predicted PPV would therefore be well below the threshold for transient vibration induced minor cosmetic damage to buildings (from BS 7385-2:1993), for even light weight unreinforced structures, damage thresholds are still orders of magnitude (15mms-1) above the threshold of perception and substantially higher than equivalent values likely to provoke complaint.

18.8.162 The principal concern would be climbers being able to anticipate blasts as best as practicable so as not to be shocked by construction activity disrupting safety of a climb.

18.8.163 Again, this would be best managed through clear signage at the base of the climbing area and on any recreational signage in the surround or at parking areas, as well as on websites associated with climbing in the area, which could be frequently updated with blasting times and if possible, intervals of said blasts.

18.8.164 In all likelihood once a blasting event is experienced by an individual the phenomena would not be of further concern as a climber would become accustomed to its periodicity and magnitude.

18.8.165 Ultimately good blasting design, and review of potential geological faults in the region is likely to be sufficient to ensure rock fall and other impacts can be avoided in areas used by climbers.

Operational Noise and Vibration on Binnein Shuas

18.8.166 As discussed, operation noise from the installation is anticipated to be limited.

18.8.167 Avoidance of significant permanent noise change at the location could be achieved by design based on adhering to a similar planning condition to that put forward relating to operational noise at residential NSR locations during the daytime period considering this location also.

18.8.168 For example, provided the specific level due to operational plant and services from the lower control works and power house remains -10dB below the existing ambient noise level or does not exceed existing backgorund sound levels by 0dB at the location during the daytime period when climbers may use the area no significant adverse impact or permanent noise change would be expected to occur for the recreational user.

18.8.169 impacts from construction and operational noise and vibration are submitted to be of no greater than **Negligible** magnitude. The significance is a localised, **Negligible Significance.**

Cumulative Effects

18.8.170 When considering how contributions from two separate noise sources add together, to produce a cumulative total noise, it is important to have some understanding of the principals of noise level addition.

18.8.171 The addition of sound levels (or more correctly sound pressure levels), is sometimes referred to as ‘decibel addition’, or ‘logarithmic addition’. In arithmetic addition, the sum of 50+50 is 100, but in decibel addition, 50dB + 50dB = 53dB. As the difference between noise levels becomes greater the total value (or cumulative total) becomes closer to the higher value. For example, where two sources produce sound levels of 50dB and 45dB, respectively, the total, or cumulative, sound level is 51.2dB, representing a small 1.2dB increase to the higher of the two sound levels. When the difference between the sound levels is 10dB, e.g. 50dB + 40dB, then the total is only 50.4dB, so more or less an insignificant increase.

18.8.172 The way sound levels add together means that where a sound level from a new source is below the current ambient sound level by 10dB, or greater, there is no significant change to the current ambient sound level.

18.8.173 In a similar way, if there are two new sound sources (from two separate new developments), the contribution from each source would have to be relatively close and at least within 5dB of each other at the same receptor position, in order for the cumulative effect of the two sources to produce a perceptible increase (above 1dB). In practice, cumulative effects of noise are therefore unlikely, unless developments are closely aligned in terms of having equal sound emission and similar distance to receptors.

18.8.174 Giving consideration to these points, the favourable siting of the power station, and relatively large distance from the closest receptors, would result in an insignificant specific noise level at receptors and no change to existing ambient noise levels.

18.8.175 Accordingly, operational noise from the powerhouse would be unlikely to contribute to the specific noise resulting from any other potential developments planned in the area, of which SLR are not aware of any of significance in respect to noise generation.

18.8.176 The low noise contribution from the longer-term elements of the construction works (lower control works) would be unlikely to contribute significantly to

cumulative noise resulting from any other potential developments planned in the area.

18.8.177 It has also been demonstrated that the higher noise levels, resulting in significant change (5dB(A) or higher) to current daytime ambient noise levels, would be produced by construction activities, such as road works and some site establishment works, that would be undertaken in closer proximity to the noise sensitive receptor positions.

18.8.178 As these are only short to medium terms works, they would not contribute for a significant time period to continuous noise resulting from any other potential developments planned in the region.

18.8.179 Impacts from cumulative noise and vibration effects are submitted to be of no greater than **Negligible** magnitude. The significance is a localised, **Negligible** Significance.

18.9 Mitigation

Construction Noise and Vibration

18.9.1 Construction noise and vibration would primarily be managed through a CNVMP, which would be formally agreed with THC prior to construction work commencing.

18.9.2 Once clearer detail of the construction plant and processes are known, the appointed main contractor would develop and submit, for approval by THC, the project specific CNVMP which would detail how noise and vibration emissions would be managed during construction works. The plan would detail control measures, such as hours of work, mitigation strategy, monitoring proposals and protocol for receiving and dealing with any complaints.

18.9.3 As a general principle, consideration would be given in the CNVMP for adopting the ‘best practicable means’ to noise and vibration control, with particular consideration given to the guidance provided in Section 8 (Control of Noise) of BS5228-1, for the purpose of minimising noise emission. For information, an outline of the typical detail provided in the CNVMP, is included in **Appendix 18-4** to this chapter.

Blasting Overpressure and Vibration

18.9.4 The air overpressure and vibration effects of blasting can be reduced through good blast design, although this may come at the expense of higher drilling and detonator costs. Smaller, more frequent blasts lead to smaller but more frequent effects, and the balance between these factors will need to be discussed with THC.

18.9.5 Methods employed to control air overpressure and vibration from blasting operations will need to be agreed with THC prior to any blasting, as well as the frequency of blasting and a 90% confidence limit for blast PPV values at NSRs. The PPV blasting vibration limit should follow the guidance provided within BS 6472-2:2008 of between 6.0 and 10.0mm/s during the daytime and 2.0mm/s at night.

18.9.6 Above ground blasting should not be undertaken in the early morning, late afternoon or evening. The local community will be given advance notice prior to any blasting.

18.9.7 An air overpressure limit at NSRs should follow the guidance provided within BS 6472-2:2008 (120 - 150 dB(lin)) and be agreed with THC.

18.9.8 It is recommended that a blast monitoring scheme for air overpressure and vibration be implemented. Any scheme should include details on the location of monitoring points and vibration sensitive properties, and the equipment to be used. This should include a series of representative initial trial blasts at the start of the blasting to accurately identify allowable MICs to prevent exceedance of the identified limits at nearby receptors.

18.9.9 All blasts at the Site should be monitored and records maintained so that the historical peak particle velocity from blasts can be produced as required.

18.9.10 A close working relationship between the construction / blasting operator and the local planning authority will be required for the exchange of information regarding blasting events.

18.9.11 All blasting should be carried out using BPM where available, to ensure that the resultant noise, vibration and air overpressure are minimised in accordance with current British Standards and guidelines.

18.9.12 Blast designs should be developed with the aid of regression lines determined from a logarithmic plot of Peak Particle Velocity against scaled distances. The regression lines should be regularly updated using the blasting monitoring information. The regression lines should be made available for inspection upon request.

18.9.13 Fly rock requirements will be controlled through Health and Safety legislation.

Operational Noise and Vibration

18.9.14 The best available operational methods should be employed at all times, having regard to the principles of BPM to minimise noise and vibration from the development.

18.9.15 Control measures to prevent underground plant noise from exceeding appropriate operational noise limits will be finalised during detailed design. These control techniques may include measures such as orientation away from NSRs, vent attenuators, acoustic lining within the vent shaft, and acoustic louvres at intake and extract terminals.

18.9.16 If required, mitigation for LFN and groundborne noise and vibration could include vibration isolation, mufflers, attenuators, etc. and will be considered during the detailed design stage.

18.9.17 As the design has not been finalise items have not been included in the assessment, if they block line of sight from the main substation or other sound sources to the receptors then the specific sound level would be reduced by around 10dB. Distance attenuation noting the site layout and context would also be significantly beneficial.

Traffic Noise

18.9.18 Traffic during the construction and operation of the Proposed Development would utilise existing public roads and tracks, where possible.

18.9.19 Furthermore, the creation of a temporary haul road to connect the lower reservoir works area to the upper reservoir and dam, provides an opportunity to supplement rock quarried within the upper reservoir, with suitable tunnel spoil from the underground works, for dam construction, thus reducing off-site disposal quantities.

18.9.20 More detail regarding the options for the transportation and re-use of spoil is described in **Chapter 2: Proposed Development**.

Monitoring

18.9.21 Monitoring of noise during construction works would be covered in a section included in the CNVMP (see **Appendix 18.4**). It is expected that monitoring of noise would only be carried out in response to a specific complaint.

18.9.22 Vibration and air-overpressure monitoring would be carried out, either during trials, or during the early stages of blasting operations, for the purpose of predicting site-specific ground vibration and air-overpressure resulting from these operations. Detail of the monitoring programme would be included in the CNVMP, when more detail on the design of the blasting programme is known.

18.10 Residual Effects

Construction Works Noise and Vibration

Surface Plant - Noise from all Works

18.10.1 With the implementation of the mitigation proposed, namely the barriers/bunding to prevent line of sight between NSR3-5 and site compound 1 as the road construction activities, impacts are anticipated to be of no more than **minor** magnitude at NSR 4 and 5 and **Negligible** magnitude at remaining NSRs.

18.10.2 Worst-case residual effects at all high sensitivity NSRs will therefore be of localised, temporary **Minor** adverse effect, and therefore **Not Significant.**

Surface Plant except Piling - Vibration

18.10.3 The proposed mitigation does not alter the residual effects which remain of localised, temporary, **Negligible** effect for all high sensitivity NSRs, and therefore **Not Significant.**

Construction Piling – Vibration

18.10.4 The proposed mitigation does not alter the worst-case residual effects which remain of localised, temporary, **Minor** adverse effect for all high sensitivity NSRs, and therefore **Not Significant**.

18.10.5 If the contractor determines that alternative low noise or vibration methods are BPM, effects may be reduced to **Negligible** effect. Therefore, the effects of piling vibration are **Not Significant.**

Tunnelling

18.10.6 The proposed mitigation does not alter the residual effects of groundborne vibration from tunnelling which remain of localised, temporary **Minor** adverse effect at high sensitivity NSRs. Residual effects upon underground services also remain **Not Significant.**

18.10.7 The residual effects of groundborne noise are of localised, temporary **Negligible** effect. Therefore, the effects of tunnelling are **Not Significant.**

Blasting

18.10.8 Air overpressure and vibration effects from blasting are inevitable. Methods to control air overpressure and vibration from blasting operations will be agreed with THC prior to any blasting.

18.10.9 Blasting will be carried out using the BPM available to ensure that the resultant noise, vibration and air overpressure are minimised in accordance with current British Standards and guidelines, as required by the Control of Pollution Act 1974.

18.10.10 However, they will be temporary in nature and a liaison group will be set-up to notify the local community in advance of works.

18.10.11 The residual effect at high sensitivity NSRs remains of localised, temporary, **Minor** adverse effect and is therefore **Not Significant.** Residual effects upon underground services also remain **Not Significant.**

Construction Traffic (Offsite)

18.10.12 It is considered that ultimately the construction phase traffic will be limited in the temporal domain, resulting in **negligible** residual impact at high sensitivity NSRs once construction is completed which is **Not significant.**

18.10.13 Where appropriate mitigation (not specifically due to noise impacts) is provided in the transport and access chapter to the EIA.

Operational Phase

Airborne Noise – Underground and Enclosed Plant

18.10.14 With appropriate consideration of the airborne noise emissions during the detailed design phase the operational noise impacts are anticipated to comply with the condition limits based upon background sound levels in **Table 18.18**.

18.10.15 Hence impacts will be no greater than **Minor** adverse at high sensitivity NSRs resulting in effects which are no worse than localised, temporary, **Minor** adverse effect and therefore **Not Significant.**

Airborne Noise – Above Ground Plant

18.10.16 The proposed mitigation is unlikely to block line of sight from the substation to all nearby receptors. Hence the worst-case residual effects remain of localised, temporary **Negligible** adverse effect at high sensitivity NSRs, which is **Not Significant.**

Groundborne Noise and Vibration

18.10.17 The building design of the transformers, switchgear, workshop and pumping station will have appropriate noise attenuation measures which will mitigate any effects to no worse than **Negligible** adverse effect and therefore **Not Significant.**

18.11 Conclusion

18.11.1 An assessment of the potential effects of the Proposed Development on noise and vibration has been undertaken. The assessment includes either a qualitative, or quantitative assessment appropriate to each identified potential impact.

18.11.2 Construction noise and vibration would primarily be managed through a Construction Noise & Vibration Management Plan (CNVMP) which would be formally agreed with THC, prior to construction work commencing.

18.11.3 As a general principal, consideration would be given in the CNVMP for adopting the ‘best practicable means’ to noise and vibration control.

18.11.4 The creation of a temporary haul road to connect the lower reservoir works area to the upper reservoir and dam, provides an opportunity to supplement rock quarried within the upper reservoir, with suitable tunnel spoil from the underground works, for dam construction, thus reducing off-site disposal quantities.

18.11.5 The control of operational noise would be integral to the design of the underground power station, as all the main items of generation equipment would be located in an enclosed structure, with the bulk of the surrounding rock reducing noise breakout from tunnels to the surface to a minimum.