Chapter 14: Sloy Pumped Hydro Storage Scheme: Noise and Vibration

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14. Noise and Vibration

14.1. Executive Summary

Six Noise Sensitive Receptors (NSRs) have been identified within 1,500m of the Proposed Development, all of which have been assessed for potential impacts during the construction and operational phases.

An assessment of construction noise effects has been undertaken against the criteria outlined in Section E.3 of *BS 5228: Part 1 2009+A1:2014*. The assessment indicates that construction noise levels will not exceed the guideline threshold levels and no significant effects are anticipated.

An assessment of operational noise effects has been undertaken in accordance with *BS 4142:2014+A1:2019*. The assessment indicates that operational noise levels will remain below the indicators for an adverse impact and no significant effects are anticipated.

An assessment of construction noise vibration is not possible to undertake at this stage, however a recommendation has been made that appropriate vibration level limits are set at the nearest residential property and that a scheme of vibration monitoring is agreed prior to the commencement of works.

14.2. Introduction

This chapter presents the likely significant effects in relation to environmental noise from the Proposed Development, considering both the construction and operational phases. It also considers possible impacts from vibration during the construction phase.

The aims of this chapter are to**:**

- Identify any NSRs in the vicinity of the Proposed Development;
- Present representative baseline sound levels in the vicinity of the nearest NSRs;
- Derive appropriate noise level limits considering the baseline sound levels;
- Calculate the likely levels of operational noise at the identified NSRs;
- Compare the predicted levels with the derived noise level limits; and
- If required, provide details of any required mitigation measures.

Please note the following terms and definitions, which are used throughout this chapter.

- **Emission** refers to the sound level emitted from a sound source, expressed as either a sound power level or a sound pressure level;
- **Immission** refers to the sound pressure level received at a specific location from a noise source(s);
- **SWL** indicates the sound power level in decibels (dB);
- **SPL** indicates the sound pressure level in decibels (dB);
- **NSR** (Noise Sensitive Receptor) identified receptors which are sensitive to noise;
- **NML** (Noise Monitoring Location) refers to any location where baseline noise levels have been measured; and
- **NAL** (Noise Assessment Location) refers to any location where the noise immission levels are calculated and assessed.

Unless otherwise stated, all noise levels refer to free field levels i.e. noise levels without influence from any nearby reflective surfaces.

14.3. Scope Of Assessment

14.3.1. STUDY AREA

For the scoping assessment, a desktop study was undertaken to identify all NSRs within a 1,500m search radius. **Volume 2, Figure 14.1** details the locations of the NSRs, which were categorised as high sensitivity (residential receptors), medium sensitivity (the visitor centre at Inveruglas) and low sensitivity (agricultural and industrial receptors or similar). The low sensitivity receptors were scoped out from further assessment. The coordinates for the remaining NSRs are presented in **Table** and shown on **Volume 2, Figure 14.1**.

Table 14.1: Nearest Identified NSRs

NSR ID - Name	X Coordinate (OSBNG)	Y Coordinate (OSBNG)
NSR1 - Cottage on A82	232080	709692
NSR2 - Inveruglas Farm 1	231937	709381
NSR3 - Inveruglas Farm 2	231984	709365
NSR4 - Inveruglas Farm 3	231926	709322
NSR5 - Loch Lomond Holiday Park	232056	709217
NSR6 - Inveruglas Visitor Centre	232284	709849

The nearest identified residential NSR is a cottage located approximately 100m to the south of the existing power station and identified as Sloy Power Station Bungalow. Three residential properties at Inveruglas Farm are located approximately 300m further to the south. Beyond those properties is Loch Lomond Holiday Park, the closest boundary of which is located approximately 600m south of the existing power station.

The Inveruglas Visitor Centre is located approximately 150m to the east of the Proposed Development and adjacent to the secondary construction compound / site establishment area.

14.3.2. CONSULTATION RESPONSES

A Scoping Report was issued to the Scottish Government in June 2023. **Chapter 6: Scoping and Consultation, Section 6.8** of the Scoping Report set out the proposed approach to the assessment of noise and vibration effects.

The following elements were **scoped in** to the assessment:

- Construction Noise; and
- Operational Noise.

The following elements were **scoped out** from the assessment.

- Operational Road Traffic Noise: No significant increase in road traffic is anticipated.

- Operational Vibration: No vibration effects are anticipated from operation of the Proposed Development.
- Decommissioning Noise: As detailed in **Chapter 4: Description of Development**, there are no plans for decommissioning in the future.

The Scoping Report also considered construction vibration effects and stated that these *"Will be considered within the EIA Chapter but a full assessment may not be necessary or possible."*

A Scoping Opinion was subsequently issued by the Energy Consents Unit (ECU) in December 2023. With regards to noise, the ECU stated the following: *"The noise assessment should be carried out in line with relevant legislation and standards as detailed in Chapter 6 section 6.8 of the scoping report."*

In its response to the Scoping Report, the National Park Planning Authority recommended that Argyll and Bute Council (A&BC) Environmental Health Team should be consulted in respect of the noise assessment but made no comments on the proposed assessment methodology.

No response was made to the Scoping Report from A&BC, however, a separate request for comment was issued to A&BC Environmental Health in April 2024, specifically in relation to noise and vibration. At the time of writing no response has been received.

14.4. Legislation, Policy and Guidance

14.4.1. LEGISLATION

The overarching legislative framework applicable to this EIA for the Proposed Development is outlined in **Chapter 7: Planning Policy and Context**. Over and above this, the *Control of Pollution Act 1974* (COPA 1974) is used to control noise impacts of construction works. There are no other statutory provisions of specific relevance to this assessment.

14.4.2. NATIONAL PLANNING POLICY

Of specific relevance to this chapter are *Planning Advice Note (PAN) 1/2011 – 'Planning and Noise,'* (The Scottish Government, 2011) and the associated *Technical Advice Note (TAN) – 'Assessment of Noise'* (The Scottish Government, 2011).

PAN 1/2011 provides little guidance in respect of construction noise, other than recommending that the use of planning conditions is not the preferred method for controlling temporary construction noise. Specifically, the document states:

"32. While planning conditions can be used to limit noise from temporary construction sites, it is most effectively controlled through the Control of Pollution Act 1974 (COPA74) and the Pollution and Prevention Control Act 1999 for relevant installations. Notice can be served in advance of works and site conditions set to control activities."

BS 5228:1997 'Noise and vibration control on construction and open sites. Code of practice for basic information and procedures for noise and vibration control' parts 1 to 5 (BSI, 1997) is the approved Code of Practice under COPA74, however, it is the 2009 version of the Standard that should be used for planning applications. In this regards the TAN states:

"However, under Environmental Impact Assessments and for planning purposes i.e. not in regard to the Control of Pollution Act 1974, the 2009 version of BS 5228 is applicable. The 2009 version of the standard consists of Parts 1 and 2 for noise and vibration respectively."

In regard to the assessment of operational noise from industrial sources, Appendix 1 of the TAN describes a number of standards and guidelines that may be referred to, in particular *British Standard 4142*.

14.4.3. TECHNICAL GUIDANCE

The following technical guidance has been used to inform the construction noise impact assessment and operational noise assessment:

Construction Noise

The *BS 5228:2009* standard provides useful guidance on practical noise and vibration control. Part 1 provides recommendations for basic methods of noise control, including sections on community relations, training, occupational noise effects, neighbourhood nuisance and project supervision. The annexes provide information on noise sources, noise calculation procedures, mitigation measures and their effectiveness. Part 2 provides similar guidance for the control of vibration from construction sites.

Hereafter '*BS 5228'* is used to refer collectively to *BS 5228:2009+A1:2014 'Code of practice for noise and vibration control on construction and open developments* Part 1 *Noise* and Part 2 *Vibration* (BSI, 2014);

Operational Noise

BS 4142:2014+A1:2019 'Methods for Rating and Assessing Industrial and Commercial Sound' is commonly used to assess the potential impacts of new sound sources on nearby receptors.

The *BS 4142* form of assessment is based on the predicted or measured levels of an assessed sound source compared to the measured background sound levels without the specific sound source present and uses, *"outdoor sound levels to assess the likely effects of sound on people who might be inside or outside a dwelling or premises used for residential purposes upon which sound is incident".*

ISO 9613-2:1996 Acoustics - Attenuation of sound during propagation outdoors describes the noise propagation calculation method to be used for the prediction of operational noise levels.

Vibration

In addition to Part 2 of BS 5228, the following standards are referred to in order to define appropriate vibration limits;

- *BS 7385 2:1993 Evaluation and measurement for vibration in buildings. Guide to damage levels from groundborne vibration* (BSI, 1993);
- *BS 6472-1:2008 Guide to evaluation of human exposure to vibration in buildings* (BSI, 2008);

Further description of the above documents is provided throughout **Section 14.5**.

14.5. Methodology

14.5.1. NOISE PREDICTION METHODS

To predict the noise immission levels attributable to the Proposed Development, noise propagation models have been produced using the propriety noise modelling software CadnaA. Within the software, complex models can be used to simulate the propagation of noise according to a range of international calculation standards, including *BS 5228* and *ISO 9613*.

Predictions of noise have been calculated at five NALs, which are representative of the nearest NSRs.

The *BS 5228* noise model is used for the prediction of construction noise. It considers the sound power level and percentage ON time of construction plant, the distance between the noise source(s) and receiver, and the effects of any barriers and structures (reflections and screening). However, it does not consider meteorological factors, atmospheric conditions or other factors that may attenuate the sound propagation further. As such, it is useful for the assessment of construction noise at NSRs that are close to the construction site, such as the cottage just to the south, but will tend to over predict noise levels at more distant receptors.

The *ISO 9613* model is used for the prediction of operational noise. The model is verified for use up to 1000m and takes into account of the following additional factors that influence sound propagation outdoors:

- Atmospheric absorption and some meteorological conditions;
- Topography
- Vegetation; and
- Ground attenuation.

The model uses as its acoustic input data the octave band sound power output of the noise sources and calculates, on an octave band basis, attenuation due to the factors above, as appropriate.

The noise propagation models are intended to give a good approximation of the specific level and contribution of each individual source. However, it is expected that actual levels are unlikely to be matched exactly with modelled values and the following limitations in the model should be considered:

- The predicted barrier attenuation provided by local topography, embankments, walls, buildings and other structures in the intervening ground between source and receiver can only be approximated and not all barrier attenuation will have been accounted for;
- The models assume all sound sources are operating continuously, simultaneously and at maximum noise output. In reality not all plant will be operating at the same time or at maximum noise output; and,
- In accordance with *ISO 9613*, all assessment locations are modelled as downwind of all sound sources and propagation calculations are based on a moderate ground-based temperature inversion, such as commonly occurs at night. These conditions are favourable to noise propagation.

As a result of these limitations, the models will tend to over-predict and actual noise levels are likely to be lower than those presented in this chapter for the majority of the time.

14.5.2. CONSTRUCTION NOISE ASSESSMENT METHOD

The construction noise assessment has been undertaken using the guidance and calculation methodology contained in *BS 5228: Part 1*, including published noise data for appropriate construction plant from Annex C. The following steps have been undertaken as part of the assessment:

- define NALs to represent the closest NSRs;
- identify applicable thresholds of significant effects from *BS 5228-1*;
- predict noise levels for various construction activities at each NAL;
- compare predicted noise levels against the applicable thresholds; and,
- where necessary, develop suitable mitigation measures to minimise any significant adverse effects.

Annex E, part E.3.2 of *BS 5228-1*, clearly sets criteria for assessing the significance of construction noise effects and gives examples of acceptable limits for construction noise.

Table E.1 of *BS 5228-1* (represented here as **Table 14.2**) contains an example of the significance criteria that can be used to assess construction activities.

Table 14.2: Example of Threshold of Potential Significant Effect at Dwellings (dBA)

Assessment Category and Threshold Value Period	Threshold Value L_{Aeq},T dB		
	Category A[(A)]	Category B[(B)]	Category C[(C)]
Night-Time (23:00 – 07:00)	45	50	55
Evenings and Weekends[(D)]	55	60	65
Daytime (07:00 – 19:00) and Saturdays (07:00 to 13:00)	65	70	75

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

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

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

(D) 19:00-23:00 weekdays, 13:00-23:00 Saturdays and 07:00 – 23:00 Sundays.

The threshold values in each category are to be used where the existing noise level at each location, rounded to the nearest 5 dB, is below the level given for a particular time of day. BS 5228 provides the following advice regarding the threshold limits:

"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: Applied to residential receptors only."

Therefore, the assessment of construction noise reflects a specific noise threshold for the locality for a particular period of the day, rather than an absolute noise level.

It should be noted that exceedance of the limit does not in itself indicate a significant effect, rather, the standard states; *"If the site noise level exceeds the appropriate category value, then a potential significant effect is indicated. The assessor then needs to consider other project-specific factors, such as the number of receptors affected and the duration and character of the impact, to determine if there is a significant effect".*

14.5.3. OPERATIONAL NOISE ASSESSMENT METHOD

The operational noise assessment is undertaken in accordance with *BS 4142:2014+A1:2019 'Methods for Rating and Assessing Industrial and Commercial Sound'.* The assessment is made by subtracting the measured background sound level from a calculated or measured 'Rating Level'.

BS 4142 uses the following definitions:

- **Ambient Sound:** Totally encompassing sound in a given situation at a given time, usually composed of sound from many sources, both near and far. Described using the metric, $L_{Aeq\ (t)}$.
- **Specific Sound Level:** Equivalent continuous A-weighted sound pressure level produced by the specific sound source at the assessment location over a given reference time interval, 'T'. Described using the metric $L_{Aeq\ (t)}$. Also referred to in this report as the Immission Level.
- **Residual Sound Level:** Equivalent continuous A-weighted sound pressure level of the residual sound without the specific sound source(s) present at the assessment location over a given time interval, 'T'. Described using the metric $L_{Aeq\ (t)}$.
- **Background Sound Level:** 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. Described using the metric $L_{A90\ (t)}$.
- **Rating Level:** The Specific Sound Level adjusted for the characteristics of the sound. The Rating Level is calculated by adding a penalty or penalties (if required) to the Specific Sound Level when the sound source contains audible characteristics such as tonal, impulsive or intermittent components. Described using the metric, $L_{Aeq\ (t)}$.

14.5.4. SENSITIVITY OF RECEPTORS

The sensitivity of the NSRs was determined at the Scoping stage with reference to the TAN, which notes that residential receptors are of High Sensitivity, and "*Bars/Cafes/Restaurants where external noise may be intrusive,*" are of medium sensitivity (TAN 1/2011 Table 2.1).

14.5.5. MAGNITUDE OF IMPACT

Construction Noise: The assessment of construction noise is made against the threshold levels set in *BS 5228*, which cannot be used to determine a magnitude of impact. Rather, the assessment indicates the potential for a significant effect to occur and then additional factors such as duration of exposure, need to be considered. Although not explicit, *BS 5228* suggests that a duration of exposure to noise levels above the thresholds for more than one month is likely to be significant.

Operational Noise (Residential Receptors): *BS 4142* does not define significance criteria; rather it describes a framework for the measurement of noise and provides a method to determine the likelihood of adverse impact.

The assessment is undertaken in two parts; firstly, a comparison is made between the Rating Level and the Background Sound Level. Secondly, the assessment considers the context in which the sound occurs to determine a qualitative assessment outcome. As such there is no definitive pass / fail. This is described in the standard as follows:

"*Obtain an initial estimate of the impact of the specific sound by subtracting the measured background sound level from the rating level, and consider the following…*

a) Typically, the greater this difference, the greater the magnitude of the impact.

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

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

d) The lower the rating level is relative to the measured background sound level, the less likely it is that the specific sound source 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 on the context."

With regards to qualitative assessments, the TAN states; *"The initial step in carrying out a qualitative assessment is to understand what impact the noise will have on the amenities associated with the NSR in regard to the perception of noise,"* and Table 2.5 of the TAN; '*Example of Assigning Descriptors for Qualitative Impacts from Noise on Residential Properties'* can be used to help define the Magnitude of Impact for residential receptors. TAN Table 2.5 has been replicated here as Table 14.3 and modified (in bold) to include for the *BS 4142* qualitative assessment outcome.

Table 14.3: Magnitude of Impact for Residential Receptors (Operational Noise)

Perception	Criteria of Descriptor	Descriptor for Qualitative Magnitude of Impact
Noticeable (Very disruptive)	***BS 4142* indication of significant adverse impact** Significant changes in behaviour and / or an inability to mitigate effect of noise leading to psychological stress or physiological effects, e.g. regular sleep deprivation / awakening; loss of appetite, significant, medically definable harm.	Major
Noticeable (Disruptive)	***BS 4142* indication of adverse impact** Causes an important change in behaviour and / or attitude, e.g. avoiding certain activities during periods of intrusion. Potential for sleep disturbance resulting in difficulty in getting to sleep, premature awakening and difficulty in getting back to sleep. Quality of life diminished due to change in character of the area.	Moderate
Noticeable (Mildly intrusive)	**No *BS 4142* indication of an adverse impact.** Noise can be heard and may cause small changes in behaviour and / or attitude, e.g. turning up volume of television; speaking more loudly; closing windows more often. Potential for non-awakening sleep disturbance. Can slightly affect the character of the area but not such that there is a perceived change in the quality of life.	Minor
Just Noticeable (Non-intrusive)	***BS 4142* Rating Level less than measured background sound levels.** Noise can be heard but does not cause any change in behaviour or attitude, e.g. increasing volume of television; speaking more loudly; closing windows. Can slightly affect the character of the area but not such that there is a perceived change in the quality of life.	Negligible

Not noticeable	***BS 4142* Rating Level more than 10 dB below the measured background sound levels.**	No Impact

Operational Noise (Non-Residential Receptors):

Table 3.4 of the TAN, which considers the increase in existing ambient sound levels, has been used to determine the Magnitude of Impact for non-residential receptors i.e. Inveruglas Visitor Centre, and is replicated here as **Table 14.4**.

Table 14.4: Magnitude of Impact for Non-Residential Receptors (Operational Noise)

Magnitude	Change in noise level, $L_{Aeq,T}$ dB (After - Before)
Major	= 5
Moderate	3 to 4.9
Minor	1 to 2.9
Negligible	0.1 to 0.9
No Change	0

14.5.6. SIGNIFICANCE OF EFFECTS

With due regard to the above, the assessment criteria to determine the significance of effects for construction and operational noise levels are as follows.

A significant effect is determined when the construction noise level exceeds the **BS 5228** threshold levels, as detailed in **Table 14.5.**

Table 14.5: Significance of Effects (Construction Noise)

Construction Noise Level	Duration of exposure	
	More than one month	Less than one month
Exceeding the *BS 5228* Threshold Levels	**Major**	**Moderate**
Below the *BS 5228* Threshold Levels	Minor	Minor
Below Existing Ambient Noise Levels	Negligible	Negligible

A significant effect is determined when the operational noise levels indicate a Major or Moderate Magnitude of Impact (see **Table 14.3**), as detailed in **Table 14.6**.

Table 14.6: Significance of Effects (Operational Noise)

Magnitude of Impact	Level of Significance Relative to Sensitivity of Receptor	
	High (Residential)	Medium (Visitor Centre)
Major	**Major**	**Moderate**
Moderate	**Moderate**	**Moderate**
Minor	Minor	Minor
Negligible	Negligible	Negligible

14.5.7. CONSIDERATION OF VIBRATION EFFECTS

Without detailed knowledge of the exact construction plant specifications, local geology and test measurements (which could not be undertaken until during the construction period), it is not possible to undertake useful vibration predictions. Rather, it is more appropriate at this stage to advise on a set of appropriate vibration limits that could be used for the protection of the closest receptor, NSR1 - Sloy Power Station Bungalow. These are detailed in **Volume 4, Appendix 14.1: Proposed Construction Vibrations Limits.**

14.6. Baseline

Baseline sound level monitoring was undertaken at three locations between the 10th and 25th of August 2023. Noise monitoring equipment was installed for the whole monitoring period at each location with attended observations being made at the beginning and end of the survey period. **Table 14.7** details the Noise Monitoring Locations (NMLs), which are also shown on **Volume 2, Figure 14.**

Table 14.7: Noise Monitoring Locations (NMLs)

NML ID - Name	X Coordinate (OSBNG)	Y Coordinate (OSBNG)	Comments
NML1 – Sloy Power Station Bungalow	231970	709354	Representative of this receptor only
NML2 – Inveruglas Farm	232078	709702	Representative of the three dwellings at Inveruglas farm and the Loch Lomond Holiday Park to the south
NML3 – Sloy Hydro Power Station	232167	709836	Representative of the Inveruglas Visitor Centre

All measurements were made with the Sound Level Meters (SLMs) mounted approximately 1.2m above the ground and away from nearby reflective surfaces, i.e. building façades, fences etc.

The noise monitoring equipment consisted of three Rion NL52 Sound Level Meters (SLMs) fitted with appropriate wind shields. All noise monitoring equipment (calibrator, SLM and microphones) used for the study are categorised as Class 1, as specified in *IEC 61672-1 'Electroacoustics. Sound level meters. Specifications'* (IEC, 2013). The equipment was calibrated onsite at the beginning and end of each measurement period with no significant deviations noted. **Volume 4, Appendix 14.2: Baseline Survey Records** contains the equipment and laboratory calibration details for the SLMs and microphones.

The SLMs were set to log in 15-minute measurement periods and measured continuously.

Meteorological data was collected with a Kestrel portable weather monitor and a tipping bucket rain gauge, installed along with the SLM at NML2. The Kestrel weather monitor stopped recording at 02:00 on 19 August, resulting in a lack of measured wind speed data for the latter part of the survey. Consequently, all data measured in the absence of wind speed measurements has been discarded, and baseline levels have been derived based on data captured between 10 August and 19 August only.

Baseline Data Analysis: Ambient Noise Level

Table 14.8 presents the average Ambient Noise Levels for each NML. The $L_{Aeq(t)}$ levels were calculated for each *BS 5228* assessment period (weekday daytime & Saturdays, evenings & weekends, and night-time) and then the arithmetic average reported for each period. The measured $L_{Aeq(t)}$ values for each individual assessment period are detailed in **Volume 4, Appendix 14.3: Baseline Data Analysis**.

Table 14.8: Ambient Noise Levels, dB LAeq(t)

	Daytime and Saturdays (dB $L_{Aeq,t}$)	Evenings and Weekends (dB $L_{Aeq,t}$)	Night-time (dB $L_{Aeq,t}$)
NML1 – Sloy Power Station Bungalow	60	57	52
NML2 – Inveruglas Farm	53	50	46
NML3 – Sloy Hydro Power Station	59	57	51

With due regard to the average $L_{Aeq(t)}$ values, **Table 14.9** presents the *BS 5228* Threshold Levels for each assessment period that the predicted noise levels at the NALs will be compared to.

Table 14.9: BS 5228 Threshold Levels

Noise Assessment Location (NAL)	Threshold Level, dB $L_{Aeq(t)}$ and Category		
	Daytime and Saturdays (dB $L_{Aeq,t}$)	Evenings and Weekends (dB $L_{Aeq,t}$)	Night-time (dB $L_{Aeq,t}$)
NAL1 – Sloy Power Station Bungalow	65 (A)	65 (C)	55 (C)
NAL 2 – Inveruglas Farm 1	65 (A)	55 (A)	45 (A)
NAL 3 – Inveruglas Farm 2	65 (A)	55 (A)	45 (A)
NAL 4 - Inveruglas Farm 3	65 (A)	55 (A)	45 (A)
NAL 5 – Loch Lomond Holiday Park	65 (A)	55 (A)	45 (A)

Baseline Data Analysis: Background Sound Level

To assess operational noise levels at residential receptors in line with *BS 4142*, the measured data has been analysed to determine the representative background sound level, $L_{A90(15mins)}$ daytime (07:00 – 23:00) and night-time (23:00 – 07:00).

Operational data was provided by SSE detailing the power output of the existing turbines at Sloy Hydroelectric Power Station in 15 minute periods. Although legitimately part of the background sound environment, all data measured during the operation of the turbines has been discarded, providing a conservative estimate of the existing background sound levels.

Volume 4, Appendix 14.3: Baseline Data Analysis provides a series of charts, including time series graphs and statistical and distribution analysis charts, which detail the measured meteorological data and the measured baseline sound levels. **Table 14.10** presents the representative background sound levels for NML1 and NML2.

Table 14.10: Representative Background Sound Level, dB $L_{A90(15mins)}$

Noise Monitoring Location (NML)	Daytime $L_{A90(15mins)}$	Night-time $L_{A90(15mins)}$
NML1 – Sloy Power Station Bungalow	37	30
NML2 – Inveruglas Farm	41	37

14.7. Potential Effects

14.7.1. CONSTRUCTION NOISE EFFECTS

Noise levels from construction activities would vary continually over time as activities and plant start and stop and move around the site, therefore, the assessment considers the likely levels of noise that could occur during the construction period by modelling several scenarios, with reference to the indicative construction timetable (included in **Volume 4, Appendix 14.4: Construction Noise Assessment Data**).

The scenarios have been derived based on the combination of construction tasks detailed in the timetable and through consultation with SSE. Each scenario simulates the likely overlap of several tasks that would occur throughout the construction period and represents the anticipated 'noisiest' activities that will occur. No construction activities are proposed during night-time hours, but an additional scenario has been modelled that considers the possibility of temporary generators being required to be run at night-time for lighting and providing power to site cabins.

The modelled scenarios consider the following activities:

- **Scenario 1:** Bulk excavation of rock at the location of the new pump hall using excavators and drilling rigs for chemical rock breaking. Excavated material is then transported to a storage area located immediately north of the development site by tipper lorry.
- **Scenario 2:** Bulk excavation of rock at the location of the new pump hall using excavators and drilling rigs for chemical breaking. Also, preparation of rock stabilisation in excavated area using two excavators and rock processing and tip management using a tracked crusher.
- **Scenario 3:** Bulk excavation of rock using excavators and drilling rigs with the material then moved to the material storage area by tipper lorry. Stabilisation using hydraulic hammer rigs. Rock breaking using a tracked crusher, and concrete base slab being poured.
- **Scenario 4:** Construction of concrete basement and intermediate walls using concrete mixers and pumps. Also lower wall and higher wall concrete pouring and pouring of concrete for foundations and plinths. Construction of concrete upper floor slab. Movement of materials to storage area continues.
- **Scenario 5 (Night-time)**: This scenario considers the operation of generators for lights and welfare facilities at two locations (used for material storage and staff welfare facilities).

The modelled plant considered in each scenario is detailed in **Volume 4, Appendix 14.4: Construction Noise Assessment Data**.

Table 14.11 presents the calculated immission levels for a height of 1.5 m at each NAL and **Volume 2, Figure 14.2** through to **Figure 14.6** present the noise contour plots.

Table 14.11: Predicted Construction Noise Immission Levels, dB $L_{Aeq(t)}$

NAL	Immission Level by Scenario				
	1	2	3	4	5
NAL1 - Sloy Power Station Bungalow	63	61	65	63	36
NAL2 - Inveruglas Farm 1	51	48	53	49	29
NAL3 - Inveruglas Farm 2	52	49	54	51	29

NAL	Immission Level by Scenario				
	1	2	3	4	5
NAL4 - Inveruglas Farm 3	49	47	51	48	28
NAL5 - Loch Lomond Holiday Park	51	46	51	48	27

Volume 4, Appendix 14.5: Construction Noise Results presents the margin above or below (+/-) the BS 5228 threshold levels for each assessment period.

For Scenarios 1 to 4, construction noise levels do not exceed the threshold levels at any NALs during Weekday Daytimes, Evenings and Weekends.

The noise levels for Scenario 5 (night-time operations) are below the night-time threshold levels for all NALs.

- At NAL1, 2 and 3, there are periods where construction noise levels will exceed the Ambient Noise Levels during Weekday Daytime and Saturdays but they will not exceed the *BS 5228* thresholds. The significance of effects will be **Minor** (not significant).
- At NAL 4 and 5 the construction noise levels will remain below the *BS 5228* thresholds and the Ambient Noise Levels during Weekday Daytime and Saturdays. The significance of effects will be **Negligible** (not significant).
- At all NALs there are periods where construction noise levels will exceed the Ambient Noise Levels if works are undertaken during the Evenings but they will not exceed the *BS 5228* thresholds. The significance of effects will be **Minor** (not significant).
- At all NALs any construction noise levels will remain below the Ambient Noise Levels during Night-time. The significance of effects will be **Negligible** (not significant).

The overall outcome of the construction noise assessment is that **no significant adverse effects** are anticipated. As such it is concluded that the effects of construction noise will be **not significant**.

14.7.2. OPERATIONAL NOISE EFFECTS

14.7.2.1. Operational Noise Levels

The Proposed Development would introduce new noise sources into the area in the form of fixed plant within the proposed pumphouse and external located Heating, Ventilation & Air Conditioning (HVAC) plant located on the roof of the electrical equipment building.

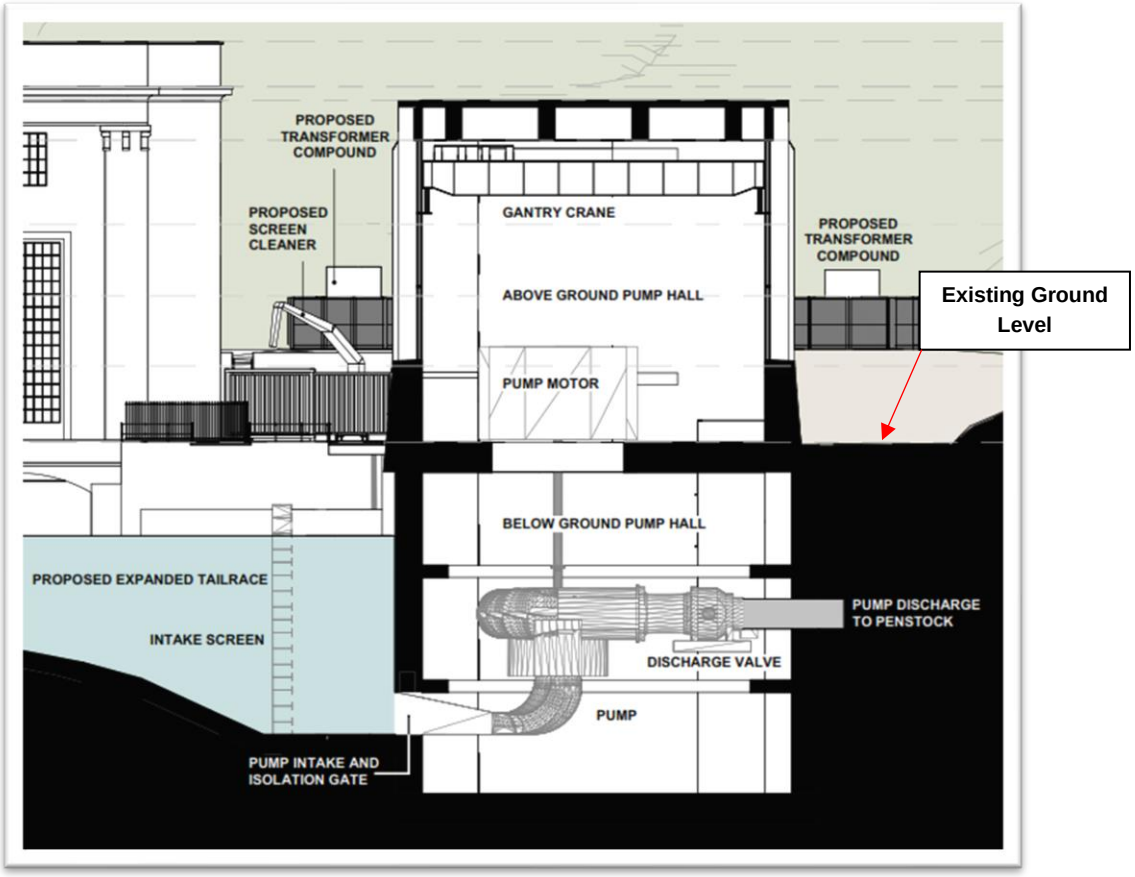
Pumphouse

The proposed pumphouse would contain all of the pumping equipment, including the pump motors and the pumps themselves. The pump motors would be located within a large open plan hall located above ground. Two underground levels would house the pumps, along with the water intake and discharge.

The above-ground section would be primarily glazed on the north, east and south facades, with solid cladding to the west; the non-glazed sections would feature two large doors for vehicle access. The roof of the pump hall would be flat, consisting of a steel space truss roof deck with insulated panels.

The underground structure housing the pumps would likely be covered by a reinforced concrete slab at the ground level. The area would likely be split into two separate levels, upper and lower, with the pumps mounted on the floor of the upper area. **Plate 1** provides an indicative illustration of how the pumps are likely to be positioned.

Plate 1: Illustrative Pump Location



The main noise sources in the pumphouse would be the pump motors, although some sound from the pumps below may also be audible. With due regard to noise levels in similar operational hydroelectric facilities, SSE estimates that the maximum reverberant sound pressure levels (SPLs) would be 100dBA within the underground lower level, 95dBA on the underground upper level, and 90dBA within the above-ground pump hall. No additional detailed acoustic information is available at this time, however, in order to undertake noise level predictions on an octave band basis, a typical frequency spectrum for a large electric motor has been scaled to equal a single-figure equivalent of 90 dBA to model the internal SPLs of the above-ground internal spaces. **Table 14.12** details the internal reverberant SPL used in the noise model.

Table 14.12: Assumed Internal SPLs for Pump Hall (above-ground), dBA

	Octave band (Hz) Sound Pressure Level, dBA								Total SPL	
	63	125	250	500	1000	2000	4000	8000	dBA	dBZ
Internal SPL	52.0	63.1	70.6	76.0	89.2	80.4	71.2	58.1	90.0	91.1

To calculate the breakout of noise from the building, each of the external facades and building elements have been assigned a transmission loss value, which represents the level of attenuation in dB that would be applied to the internal noise as it travels through the fabric of the building. **Table 14.13** details the transmission loss values used in the noise model.

Table 14.13: Assumed Building Transmission Loss Values, dB

	Transmission Loss, dB								
	63	125	250	500	1000	2000	4000	8000	Rw
Roof	10*	18	35	50	55	59	60	60*	43
Glazing (including glazed louvres)	10*	21	30	39	47	50	55	55*	41
Roller Shutter Doors	3*	11.2	13.5	10.6	20.2	23.9	23.9*	23.9*	18

** Where transmission loss data is unavailable at certain frequencies, conservative estimations have been made for consideration within the noise model.*

Electrical Equipment Building

Located to the rear of the pump hall, the electrical equipment building would house electrical plant. While there are no substantial noise sources located within the building itself, it is anticipated that a HVAC unit will be located on the roof. Whilst there is not expected to be a large requirement for cooling[1], there may be some occasions during the daytime in sunny conditions where the solar gain within the pump hall would require some mechanical ventilation. Final plant specifications are yet to be determined, however, a single industrial HVAC unit has been modelled as a point source in the centre of, and 2m above, the electrical equipment building roof.[2] **Table 14.14** details the SWL data for the unit.

[1] The existing Sloy Hydroelectric Power Station building is cooled with natural ventilation only and the Proposed Development will operate in a similar way wherever possible.

[2] The candidate plant selected for use in the model is known to TNEI and is installed on the roof deck of a similarly sized industrial building (Roosecote BESS, Cumbria).

Table 14.14: Sound Power Level of HVAC unit, dBA

	Sound Power Level (dBA)								
	63	125	250	500	1000	2000	4000	8000	Total
HVAC Cooler	62.1	70.6	77.6	79.2	83.3	80.3	84.9	84.8	90.4

It should be noted that the HVAC unit would be anticipated to run only during the day, during times when the internal temperature may increase due to solar gain from the glazed facades.

The noise immission levels at the nearest NSRs are presented in **Table 14.15** as dB $L_{Aeq(t)}$. No value is attributed to *t* as the noise model assumes that all noise sources would be operating at maximum noise output concurrently and continuously. In reality, however, the pumps and motors (internal noise sources) would generally only be running during the night-time and the HVAC (external noise sources) would only be running during the daytime. The predicted levels, therefore, represent a worst-case scenario that would be unlikely to occur during normal operations.

Table 14.15: Operational Noise Immission Levels, dB $L_{Aeq(t)}$

NAL	Specific Sound Level, dB $L_{Aeq(t)}$
NAL1 - Sloy Power Station Bungalow	22
NAL2 - Inveruglas Farm 1	11
NAL3 - Inveruglas Farm 2	10
NAL4 - Inveruglas Farm 3	7
NAL5 - Loch Lomond Holiday Park	11
NAL6 – Inveruglas Visitor Centre	33

14.7.2.2. BS 4142 Assessment

The *BS 4142* assessment is a qualitative assessment of the operational noise levels at the nearest residential receptors. It considers the predicted immission levels, the character of the sound, the existing sound environment and the context of the Proposed Development.

To undertake the assessment, the Specific Sound Level must be converted into a Rating Level. The Rating Level allows for character corrections to be added to account for particular characteristics of the sound that may be perceived as more annoying. In particular, the Rating Level considers tonality, impulsivity and intermittency of the sound, as well other sound characteristics that are neither tonal, impulsive, or intermittent, but are otherwise readily distinctive against the residual acoustic environment.

Tonality

With regards to tonality, *BS 4142* states:

"For sound ranging from not tonal to prominently tonal the Joint Nordic Method gives a correction of between 0 dB and +6 dB for tonality. Subjectively, this can be converted to a penalty of 2 dB for a tone which is just perceptible at the noise receptor, 4 dB where it is clearly perceptible and 6 dB where it is highly perceptible."

The plant considered in the prediction model, namely the electrical motors and HVAC unit, produce broadband noise and are not tonal in nature. As such, no tonal character correction is required.

Impulsivity

With regards to impulsivity, *BS 4142* states:

"A correction of up to +9dB can be applied for sound that is highly impulsive, considering both the rapidity of the change in sound level and the overall change in sound level. Subjectively this can be converted to a penalty of 3dB for impulsivity which is just perceptible at the noise receptor, 6dB where it is clearly perceptible, and 9dB where it is highly perceptible."

Impulsivity is not considered to be a relevant sound characteristic of the motor / pumps or HVAC cooler units when operational, as the noise level would be predictable and consistent.

Intermittency

The intermittency of the sound source needs to be considered when it has identifiable on / off conditions with regards to intermittency, *BS 4142* states:

"If the intermittency is readily distinctive against the residual acoustic environment, a penalty of 3 dB can be applied."

It is noted that the operation of the HVAC may be intermittent, however, the contribution of the HVAC unit to the overall noise immission level at the closest receptor (NSR1) is only 10 dBA, compared to the total level of 22 dBA. In addition, the ambient noise levels (as reported in **Table 14.8**) are significantly higher than both the HVAC sound level and the Specific Sound Level. Accordingly, no regular step changes in noise level are anticipated due to operation of the HVAC and no character correction is required for intermittency.

Other Sound Characteristics

With regards to other sound characteristics, *BS 4142* states:

"Where the specific sound features characteristics that are neither tonal nor impulsive, nor intermittent, though otherwise are readily distinctive against the residual acoustic environment, a penalty of 3 dB can be applied."

Based on TNEI's understanding and experience of the type of plant within the Proposed Development, and with due consideration of the existing sound levels, it is not anticipated that there would be any additional sound characteristics that would be considered readily distinctive against the residual acoustic environment.

Calculation of the Rating Level

With due regard to the above, no character corrections are required. Therefore, the *BS 4142* Rating Levels are equal to the Specific Sound Levels.

Assessment of Operational Noise Impacts: High-sensitivity (Residential) NALs

Table 14.16 presents the immission levels for a height of 1.5m at each High Sensitivity NAL and **Volume 2, Figure 14.7** presents the noise contour plot.

Table 14.16: Margin Above / Below (+/-) Background Sound Level, dB.

Noise Assessment Location	Rating Level	Daytime		Night-time	
		Representative Background Sound Level, dBA	Margin Above/Below (+/-) Background, dB	Representative Background Sound Level, dBA	Margin Above/Below (+/-) Background, dB
NAL1 – Sloy Power Station Bungalow	22	37	-15	30	-8
NAL2 – Inveruglas Farm 1	11	41	-30	37	-26
NAL3 - Inveruglas Farm 2	10	41	-31	37	-27
NAL4 - Inveruglas Farm 3	7	41	-34	37	-30
NAL5 - Loch Lomond Holiday Park	11	41	-30	37	-26

At all NALs during Daytime and Night-time periods, the Rating Level is below the Background Sound level, which is *"an indication of the specific sound source having a low impact, depending on the context".*

The context in which the assessment is made is as follows:

- The Proposed Development would be very similar to the existing power station. Whilst noise is audible from the existing power station it is quite unintrusive. The noise level and character of the Proposed Development would be similar in both noise level and character.
- The noise model assumes all plant associated with the Proposed Development would be operating continuously and concurrently, however this would not be the case. The pumps and related plant would operate only as required to ensure sufficient water would be available to the Sloy Hydroelectric Power Station (typically following an operational period), and the Proposed Development would therefore not be anticipated to run continuously.
- Similarly, the noise model assumes all cooling plant would be operating at 100% capacity, however, this will only occur when ambient temperatures are high (i.e. during the day). For much of the time, cooling equipment would be operating at lower capacities (or inactive) and overall sound output would be reduced.
- The Proposed Development would not operate at the same time as the existing development i.e. Sloy Power Station would either be able to generate (using existing plant) or pump water (using new proposed plant) but not generate and pump simultaneously.

Consideration of the context indicates that the Rating Level is conservative, and actual operational noise may be lower. There is therefore no change to the assessment outcome due to context and the specific sound source would have a low impact.

With due regard to **Table 14.3**, the Rating Level of operational noise at NAL1 during Night-time would be below the measured background levels and the Magnitude of Impact is **Negligible**.

At all other times, for all NALs, the Rating Level of operational noise at all NALs would be more than 10dB below the measured background levels, and as such the Magnitude of Impact is **No Impact**.

In line with the criteria described in **Table 14.6**, **t**he level of Significance of Effects from operational noise at all residential receptors is **Negligible** (not significant).

Assessment of Operational Noise Impacts: Medium-sensitivity (Non-residential) NAL

Table 14.17 presents the predicted level of change in average Ambient Noise Levels for Daytime and Saturday, and Evening and Weekend periods (i.e. during opening hours of the Inveruglas Visitor Centre).

Table 14.17: Predicted Level of Change

	Ambient level	Predicted level	Resulting level	Change
Daytime and Saturdays	59	33	59	0
Evenings and Weekends	57	33	57	0

With due regard to **Table 14.4**, the Magnitude of Impact is **No Change**.

In line with the criteria described in **Table 14.6**, the level of Significance of Effects from operational noise at the Visitor Centre is **Negligible** (not significant).

14.8. Mitigation

14.8.1. CONSTRUCTION NOISE MITIGATION

14.8.1.1. Barriers

Mitigation has been incorporated into the construction noise assessment in the form of acoustic barriers located around temporary generating plant that may be operational during night-time periods. A number of options exist for the barrier construction, including Heras type fencing fitted with acoustic blanket panels, or a more permanent structure constructed from wood or other materials. The barrier would enclose the generators / generator enclosures on three sides to prevent transmission around the sides (with no gaps or openings at the joins between sections), with the open fourth side facing away from the nearest NSRs (i.e. northwards). The barriers would have a minimum density of 10kg/m^2. An example of how they can be arranged can be seen in the construction noise contour plots, where the barriers are shown as green lines (**Volume 2, Figures 14.2 - 14.6**).

14.8.1.2. Good Practice Measures

No additional mitigation measures are necessary, however, a number of good practice measures would be implemented to minimise the likely effects. Section 8 of *BS 5228-1:2009+A1:2014* recommends a number of simple control measures, as summarised below, that would be employed on-site:

- Keep local residents informed of the proposed working schedule and working hours as set out in **Chapter 4: Description of Development**, including the times and duration of any abnormally noisy activity that may cause concern;
- All vehicles and mechanical plant should be fitted with effective exhaust silencers and be subject to programmed maintenance;
- All vehicles would use non-tonal (white noise type) reversing alarms;
- Select inherently quiet plant where appropriate - all major compressors would be 'sound reduced' models fitted with properly lined and sealed acoustic covers, which would be kept closed whenever the machines are in use;
- All ancillary pneumatic percussive tools would be fitted with mufflers or silencers of the type recommended by the manufacturers;
- Machines would be shut down between work periods (or when not in use) or throttled down to a minimum;
- Regularly maintain all equipment used on site, including maintenance related to noise emissions;
- Vehicles would be loaded carefully to ensure minimal drop heights so as to minimise noise during this operation; and
- All ancillary plant such as generators and pumps would be positioned so as to cause minimum noise disturbance and temporary acoustic screens or enclosures would be provided.

14.8.2. CONSTRUCTION VIBRATION MITIGATION

14.8.2.1. Vibration

A scheme for vibration monitoring would be developed and included within the Construction Environmental Management Plan (CEMP) prior to the commencement of works. The vibration monitoring survey would take place throughout the duration of the construction period to ensure vibration levels are controlled at the closest residential NSR (NSR1 – Sloy Power Station Bungalow).

Where appropriate vibration level limits are established prior to the commencement of construction works, and a monitoring survey undertaken for the duration of works, sufficient mitigation can be implemented where required in order to ensure that vibration level limits are met at the nearest NSRs.

14.8.3. OPERATIONAL NOISE MITIGATION

No specific mitigation measures would be required for operational noise, however while significant effects are not anticipated, noise impacts of HVAC could be reduced even further through the installation of a barrier or parapet around the roof on which the HVAC unit would be located. This could be designed in such a way to direct sound away from the direction of the nearest NSRs.

14.9. Residual Effects

14.9.1. CONSTRUCTION NOISE RESIDUAL EFFECTS

Mitigation, in the form of attenuating barriers around generators operating at night-time, would be implemented during the construction period. No other specific mitigation measures are required for

construction noise, and as such the assessment outcome remains the same as described in **Section 14.7.1**.

With the inclusions of mitigation measures, the effects of construction noise would be **not significant**.

14.9.2. OPERATIONAL NOISE RESIDUAL EFFECTS

No specific mitigation measures would be required for operational noise, and as such the assessment outcome remains the same as described in **Section 14.7.2**. The effects of operational noise would therefore be **not significant**.

14.10. Summary And Conclusion

Six NSRs have been identified within 1,500m of the Proposed Development, which have been assessed for potential noise impacts. Assessments of construction and operational noise effects resulting from the Proposed Development have been undertaken at these NSRs in line with relevant legislation, policy and technical guidance.

An assessment of construction noise effects has been undertaken against the criteria outlined in Section E.3 of *BS 5228: Part 1 2009+A1:2014*. The assessment indicates that construction noise levels would be below the guideline noise levels at all receptors for all construction phases and **no significant effects** are anticipated.

An assessment of operational noise effects has been undertaken against the criteria outlined in Section 11 of *BS 4142:2014+A1:2019* and following the guidance in the TAN. The assessment indicates that operational noise levels would be below the indicators for an adverse impact at all receptors for all time periods and **no significant effects** are anticipated.

An assessment of construction vibration is not possible to undertake at this stage, however a recommendation has been made that appropriate vibration level limits are set and a scheme of vibration monitoring is agreed prior to the commencement of works. Proposed limits are detailed within **Appendix 14.1: Proposed Construction Vibration Limits.**