Report for:

West Cumbria Mining Limited

Woodhouse Colliery

Operational Vibration Assessment – Regulation 22 Response

Status: Final **Date: 31.08.2021**

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1. INTRODUCTION

ACCON UK Limited (ACCON) has been instructed by West Cumbria Mining to carry out an assessment of vibration from the operation of the proposed Woodhouse colliery at Whitehaven, Cumbria. The assessment is required in order to provide a Regulation 22 response for the Planning Inspector for the West Cumbria Mining Ltd (WCM) Planning Inquiry. The Inquiry relates to the Cumbria County Council planning application number 4/17/9007.

The Regulation 22 request is reproduced below:

A description of activities during operation of the development which may result in vibration (including underground blasting, where relevant) should be provided. An assessment of likely significant effects resulting from operational vibration, taking into account how the impact may vary depending on the baseline conditions and the method of excavating material, should also be provided along with a description of the forecasting methods used to assess the effects from operational vibration on the environment and sensitive receptors;

Based on the outcome of the operational vibration assessment, a description of measures envisaged to prevent, reduce or offset any significant adverse effects on the environment and sensitive receptors as a result of operational vibration should be provided, where relevant.

To identify activities and features of the proposed development that have the potential to give rise to vibration during its operation, ACCON have relied upon various sections of the Woodhouse Colliery Planning Application 4/17/9007 Environmental Statement, submitted in 2018 and various associated plans and information provided by WCM. In particular, the following documents have been reviewed or consulted:

- Environmental Statement Chapter 5: Project Description
- Environmental Statement Chapter 5, Project Description, Appendix D: Paste Plant and Process
- Environmental Statement Chapter 14: Noise and Vibration

The proposed layout plan of the main mine site, WCM drawing number 869/AM/002, is reproduced as **Figure F.1** of this report. The plan for the rail loading facility, WCM drawing number 869/AR/002, is reproduced as **Figure F.2.** A glossary of vibration terminology is provided in **Appendix 1**.

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2. THE NATURE, MEASUREMENT AND EFFECT VIBRATION

When two objects come into contact through movement (such as a train wheel acting on a rail or mining activities breaking out stone), the mechanical energy from the movement causes vibrations in the vicinity of the two objects. Vibrations in the air causes sound, but some vibrations can be felt through the ground or through structures, especially when a large amount of energy is exerted.

The propagation of vibration is governed by the propagation of various different wave types within the ground. The degree of transmission is also controlled by the soil or rock type and the associated mechanical and physical properties of these materials. Therefore, there are no simple models to predict the transmission of vibration through the ground in the same way as the propagation of a sound wave through the air. However, empirical relationships have been developed for various construction activities that facilitate approximate prediction of vibration at different distances from a source. In general, these relationships show that vibration in terms of peak particle velocity reduces by slightly more than half per doubling of distance from the source. Therefore, in most instances significant levels of vibration only occur relatively close to sources of vibration.

Groundborne vibration, especially within structures, has a number of effects both to people and to the structures themselves.

The effects of groundborne vibration on buildings are dependent upon a range of factors, not least the magnitude and duration of the vibration, the structure of the soil, the properties and quality of the building materials, the design of the structure, as well as the general condition and age of the structure. In extreme cases, vibration can cause severe structural damage, but most vibration damage manifests itself in minor cosmetic damage such as cracks in rendering and roof tiles slipping, which in turn can cause other problems such as damp. Groundborne vibration on buildings is generally measured using the Peak Particle Velocity (PPV) expressed in mm/s. This is the maximum instantaneous velocity of a particle at a point during a given time interval.

When groundborne vibration enters the structure of a building the resulting structure-borne noise can be re-radiated into the building. This phenomenon is known as groundborne noise. Groundborne noise most commonly arises in basements or ground floor rooms of buildings where railways are located in tunnels in close proximity to those properties and is commonly described as a ‘rumbling sound’.

Human exposure to vibration can cause annoyance, but in some cases can also cause health problems, especially from the stress and anxiety of prolonged annoyance. Humans are known to be very sensitive to vibration, with a threshold of perception typically in the particle velocity range of 0.15 mm/s to 0.3 mm/s at frequencies between 1 Hz and 80 Hz. Human exposure to vibration is measured using a Vibration Dose Value (VDV) expressed in m/s1.75. This measures the overall exposure to vibration that a person might receive over a given time period within a building.

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3. RELEVANT NATIONAL PLANNING POLICY

In the following policy documents, vibration is considered equivalent to noise.

3.1. National Planning Policy Framework

The revised National Planning Policy Framework (NPPF as amended in July 2021) supersedes the 2012, 2018 and 2019 versions of the NPPF. The purpose of the planning system is to contribute to the achievement of sustainable development. There are three dimensions to sustainable development: economic, social and environmental. The environmental role is to contribute to protecting and enhancing our natural, built and historic environment; and as part of this, make effective use of land, help to improve biodiversity, use natural resources prudently, minimise waste and pollution, and mitigate to adapt to climate change including moving to a low carbon economy.

One of the core planning principles is to contribute to conserving and enhancing the natural environment and reducing pollution. Allocations of land for development should prefer land of lesser value, where consistent with other policies in the Framework. The planning system should contribute to and enhance the natural and local environment by preventing both new and existing development from contributing to or being put at unacceptable risk from, or being adversely affected by, unacceptable levels of soil, air, water or noise pollution or land instability.

Paragraph 185 of the NPPF states:

"*Planning policies and decisions should also ensure that new development is appropriate for its location taking into account the likely effects (including cumulative effects) of pollution on health, living conditions and the natural environment, as well as the potential sensitivity of the site or the wider area to impacts that could arise from the development. In doing so they should:*

a) Mitigate and reduce to a minimum potential adverse impacts resulting from noise from new development – and avoid noise giving rise to significant adverse impacts on health and the quality of life (see Explanatory Note to the Noise Policy Statement for England (Department for Environment, Food and Rural Affairs, 2010));

b) Identify and protect tranquil areas which have remained relatively undisturbed by noise and are prized for their recreational and amenity value for this reason."

Additionally, Paragraph 187 states:

"*Planning policies and decisions should ensure that new development can be integrated effectively with existing businesses and community facilities (such as places of worship, pubs, music venues and sports clubs). Existing businesses and facilities should not have unreasonable restrictions placed on them as a result of development permitted after they were established. Where the operation of an existing business or community facility could have a significant adverse effect on new development (including changes of use) in its vicinity, the applicant (or 'agent of change') should be required to provide suitable mitigation before the development has been completed.*"

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3.2. Noise Policy Statement for England

The Noise Policy Statement for England (NPSE) aims to "*through the effective management and control of environmental, neighbour and neighbourhood noise within the context of Government policy on sustainable development:*

- *Avoid significant adverse impacts on health and quality of life;*
- *Mitigate and minimise adverse impacts on health and quality of life; and*
- *Where possible, contribute to the improvement of health and quality of life*".

Based on concepts from toxicology, it introduces three 'Effect Levels' relevant to the assessment of noise. These are:

- NOEL: No Observed Effect Level: This is the level below which no effect can be detected. In simple terms, below this level, there is no detectable effect on health and quality of life due to the noise;
- LOAEL: Lowest Observed Adverse Effect Level: This is the level above which adverse effects on health and quality of life can be detected; and
- SOAEL: Significant Observed Adverse Effect Level: This is the level above which significant adverse effects on health and quality of life occur.

3.3. Planning Practice Guidance

The Planning Practice Guidance for Noise (PPG-N) was published in March 2014 and most recently updated in July 2019. The PPG-N suggests that the most appropriate and cost-effective solutions to potential noise issues are best identified when good acoustic design is considered early in the planning process.

The PPG-N provides the following advice on how to determine the noise impact on development:

"*Plan-making and decision making need to take account of the acoustic environment and in doing so consider:*

- *Whether or not a significant adverse effect is occurring or likely to occur;*
- *Whether or not an adverse effect is occurring or likely to occur; and*
- *Whether or not a good standard of amenity can be achieved.*

In line with the Explanatory Note of the Noise Policy Statement for England, this would include identifying whether the overall effect of the noise exposure (including the impact during the construction phase wherever applicable) is, or would be, above or below the significant observed adverse effect level and the lowest observed adverse effect level for the given situation. As noise is a complex technical issue, it may be appropriate to seek experienced specialist assistance when applying this policy." (Paragraph 003 Reference ID 30-003-20190722)

The document goes on to acknowledge the levels of noise exposure at which an effect may occur as provided in the NPSE and introduces a fourth effect level:

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- UAE: Unacceptable Adverse Effect: Extensive and regular changes in behaviour and/or an inability to mitigate the effect of noise lead to psychological stress or physical effects.

Where residential development is proposed in the vicinity of existing businesses, community facilities or other activities that produce noise, the PPG-N advises that the applicant (or 'agent of change') will need to clearly identify the effects of the existing businesses that may cause a nuisance (including noise) and clearly define the mitigation measures being proposed to address any potential significant adverse effects that are identified. The agent of change needs to not only consider the current activities of the business, but the permitted activities too, even if they are not occurring at the time of the application being made. The PPG-N acknowledges that "*It can be helpful for developers to provide information to prospective purchasers or occupants about mitigation measures that have been put in place, to raise awareness and reduce the risk of post-purchase/occupancy complaints.*" (Paragraph 009 Reference ID 30-009-20190722).

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4. VIBRATION ASSESSMENT CRITERIA

4.1. BS 5228-2:2009+A1:2014: Code of practice for noise and vibration control on construction and open sites. Vibration

This British Standard provides general advice on controlling goundborne vibration from construction sites. BS 5228-2 includes advice on monitoring vibration and explains the applicable legislative background to vibrion control.

Annex E of BS 5228-2 includes empirical equations for the prediction of the peak particle velocity (PPV) from a number of types of construction plant or activities. These prediction equations are taken from the TRL report 429. Prediction equations are limited to the following activities:

- Vibratory compaction
- Vibratory piling
- Percussive piling
- Dynamic compaction
- Vibrated stone columns, and
- Tunnelling

Based on professional expertise and experience of vibration and different construction techniques and plant items, it is possible to carry out approximate predictions for other plant or construction or demolition activities by taking one of the specified activities as a proxy.

4.2. British Standard BS 6472-1:2008

The British Standard BS 6472-1:2008 “Guide to evaluation of human exposure to vibration in buildings” assesses the effect of building vibration on people within buildings using the vibration dose value (VDV):

$$VDV = \left(\int_0^T a^4(t)dt \right)^{0.25}$$

Where:

- VDV is the vibration dose value (in $ms^{-1.75}$) (for the day or night period);
- a(t) is the frequency weighted acceleration (in ms^{-2}) using the appropriate frequency weighting;
- T is the total period of the day or night (in seconds) during which vibration can occur.

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The standard, at paragraph 3.4.2, defines the day and night time periods as 0700 hrs to 2300 hrs for the daytime period and 2300 hrs to 0700 hrs for the night-time period.

The VDV depends both on the vibration magnitude and the duration of the vibration events in the respective period (day or night). It must be noted however that, since the acceleration is taken to the power 4, the VDV is much more strongly influenced by the vibration magnitude than by the total duration of the events.

The evaluation for the standard should be carried out at the point of entry to the body. However, since it is seldom possible to identify such a position uniquely, the evaluation is normally carried out for the location where the highest vibration magnitude is expected, usually in the middle of the room.

Table 4.1 identifies VDV ranges which might result in various probabilities of adverse comment within different types of buildings.

Table 4.1: VDV Ranges According to BS 6472

Place and time	Low probability of adverse comment	Adverse comment possible	Adverse comment probable
	VDV [$ms^{-1.75}$]		
Residential buildings 16h day	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Residential buildings 8h night	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8
Offices (16h day)	0.4 to 0.8	0.8 to 1.6	1.6 to 3.2
Workshops (16h day)	0.8 to 1.6	1.6 to 3.2	3.2 to 6.4

4.2.1. BS 5228-2:2009+A1:2014

BS 5228-2 includes some guidance on human response to vibration and includes the following text

BS 6472, as stated, provides guidance on human response to vibration in buildings. Whilst the assessment of the response to vibration in BS 6472 is based on the VDV and weighted acceleration, for construction it is considered more appropriate to provide guidance in terms of the PPV, since this parameter is likely to be more routinely measured based upon the more usual concern over potential building damage. Furthermore, since many of the empirical vibration predictors yield a result in terms of PPV, it is necessary to understand what the consequences might be of any predicted levels in terms of human perception and disturbance.

Table 4.2 reproduces Table B.1 from BS 5228-2 which provides guidance on human response for levels of vibration given in terms of PPV.

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Table 4.2: Guidance on effects of vibration levels

Vibration Level[1 2 3] mm/s	Effect
0.14	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction. At lower frequencies, people are less sensitive to vibration.
0.3	Vibration might be just perceptible in residential environments.
1.0	It is likely that vibration of this level in residential environments will cause complaint, but can be tolerated if prior warning and explanation has been given to residents.
10	Vibration is likely to be intolerable for any more than a very brief exposure to this level in most building environments.

1. The magnitudes of the values presented apply to a measurement position that is representative of the point of entry into the recipient.
2. A transfer function (which relates an external level to an internal level) needs to be applied if only external measurements are available.
3. Single or infrequent occurrences of these levels do not necessarily correspond to the stated effect in every case. The values are provided to give an initial indication of potential effects, and where these values are routinely measured or expected then an assessment in accordance with BS 6472-1 or -2, and/or other available guidance, might be appropriate to determine whether the time varying exposure is likely to give rise to any degree of adverse comment.

Vibration from mining operations would typically be similar in nature to vibration from construction activity although more continuous in nature. Empirical vibration predictions for mining activity will also provide results in terms of PPV. Hence, the guidance provided in **Table 4.2** is also relevant to mining and associated activities.

4.3. British Standard BS 7385 Part 2: Guide to damage levels from groundborne vibration

The British Standard methodology for measuring and assessing the likely impacts of damage from vibration on buildings is BS 7385: Evaluation and measurement for vibration in buildings: Part 2. Guide to damage levels from groundborne vibration.

The maximum vibration threshold levels that are recommended before cosmetic damage to buildings, such as cracking of plaster, could occur are summarised in **Table 4.3** below. The Standard notes that “minor damage” is possible at vibration magnitudes greater than twice the thresholds given in the **Table 4.3**, and “major damage” may occur at magnitudes four times those identified in the table.

Whilst this standard is specifically aimed at the vibration effects on buildings, it remains pertinent to consider it in relation to the structures being considered in this assessment, in the absence of any more specific guidance.

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Table 4.3: Transient vibration guide values for cosmetic building damage from BS 7385-2

Type of Building	Peak component particle velocity in frequency range of predominant pulse	
	4 Hz to 15Hz	15 Hz and above
Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
Unreinforced or light framed structures Residential or Light Commercial	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 15 Hz and above

4.4. Summary of Assessment Criteria

Based on the various guidance documents considered above, this vibration assessment has adopted the effect levels in respect of human vibration at residential properties set out in **Table 4.4**, in line with the guidance provided in the NPSE and PPG-N.

Table 4.4: Effect Levels for Human Vibration

Effect Level	Vibration Level or Range		
	VDV 16 hr Day $m/s^{1.75}$	VDV 8 hr Night $m/s^{1.75}$	PPV mm/s
NOEL	< 0.2	< 0.1	< 1.0
LOAEL	0.2	0.1	1.0
SOAEL	0.8	0.4	3.0
UAE	> 1.6	> 0.8	> 10

Where potential damage to buildings or structure is relevant, the lowest threshold for cosmetic damage given in BS 7385-2 is a PPV of 15 mm/s. A precautionary PPV threshold for building damage of 7.5 mm/s (50% of the threshold value) has therefore been adopted in this assessment.

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5. BASELINE CONDITIONS

In general, baseline vibration can be characterised on a qualitative basis as most potentially sensitive receptors outside of densely populated areas are not subject to measurable levels of vibration due to man-made sources. Therefore, it Is not standard practice to carry out baseline vibration surveys except in the case of railway schemes.

Inspection of aerial mapping around the proposed development site indicates that the only existing source of vibration is likely to be localised vibration affecting dwellings within 20 m of existing roads due to the occasional passage of heavy goods vehicles.

The dwellings which are considered to be vibration sensitive receptors for this assessment are marked in red text on the layout plans presented in **Figure F.1** and **Figure F.2.**

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6. ASSESSMENT OF POTENTIAL VIBRATION SOURCES

6.1. Underground Mining Operations

No blasting or use of percussive type explosives (e.g. Royex) would be used in the proposed mining operations. Therefore, there is no potential for vibration impacts associated with blasting.

The mining will be carried using excavators and plant including 5 no. Bolter Miners, and road headers to cut through the coal seams. As the mining operations will be taking place at a depth of approximately 350 m below ground level, any vibration generated by mining activity at surface receptors will be significantly lower than the NOEL identified in **Table 4.4**.

Primary crushing of the mined material to sub 10 mm size will also be carried out underground using crushers. Vibration generated by underground crushers at sensitive surface receptors will be significantly lower than the NOEL.

6.2. Surface - Coal Preparation Plant

The coal preparation plant would be comprised of a number of large items of machinery including:

- Crushers that process the raw coal – further crushing using toothed rotating drums at coal preparation plant to sub 6 mm to 8 mm
- Heavy Media Cyclone Feed Sump
- Three-Product Dense Media Cyclones
- Second Stage Cyclone
- Drain and Rinse Vibrating Screen
- Centrifugal dryer.

To operate efficiently, all of the above machinery will be designed and installed to transmit minimal vibrational energy to supporting and surrounding structures. The closest existing vibration sensitive receptors, dwellings in Hartfield Close, are located approximately 260 m from the coal preparation plant. On the east side of the High Road, a new residential development has received planning approval. The minimum separation between the new dwellings and the coal preparation plant would be approximately 145 m. At both of these separation distances any potential vibration at the receptors is expected to be below the NOEL.

6.3. Paste Processing Plant

The paste processing plant would be comprised of a number of large items of machinery including:

- Ball mill

To operate efficiently all of the above machinery will be designed and installed to transmit minimal vibrational energy to supporting and surrounding structures. The closest existing vibration sensitive receptors, dwellings in Hartfield Close, are located approximately 260 m

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from the paste processing plant. The minimum separation between the new dwellings to be built on the eastern side of the High Road and the paste processing plant would be approximately 145 m. At both of these separation distances any potential vibration at the receptors is expected to be below the NOEL.

6.4. Surface - Generators

The processing site will accommodate the following large generators to provide a contingency source of electrical power in the case of mains outages:

- 5 no. 2 MW gas generators
- 2 no. 2 MW diesel generators

To operate efficiently all of the generators will be designed and installed to transmit minimal vibrational energy to supporting and surrounding structures. The closest vibration sensitive receptor is Cabbage Hall, located approximately 300 m from the nearest generator location. At this distance any potential vibration at the receptor will be significantly lower than the NOEL.

6.5. Surface - Rail Loading Facility

Loading of rail wagons will take place in the Rail Loading Building using a hopper system. Impact vibration of the coal unloading into the rail wagons will be absorbed by the vehicle suspension and therefore would not normally be expected to generate appreciable levels of groundborne vibration. The closest vibration sensitive receptor is Stanley House, approximately 120 m from the Rail Loading Building. It is understood that this property (and Lake View) will be under the ownership of West Cumbria Mining. However, both properties will remain in use as a dwellings and therefore should still be considered to be vibration-sensitive receptors. Should any vibration generated by the loading facility or train movements be perceptible at Stanley House, it would not be expected to exceed the LOAEL identified in **Table 4.4**.

6.6. Summary of Vibration Assessment

All identified potential sources of operational vibration from the underground mine, surface mine site and rail loading facility are expected to generate levels of vibration at the nearest sensitive receptors below the lowest adverse effect level (LOAEL) at worst and at magnitudes corresponding to the No Observed Effect Level (NOEL) for the majority of potential sources. Therefore, no significant vibration impacts are expected from the operation of the proposed Woodhouse Colliery.

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7. MITIGATION & MONITORING

As no significant vibration impacts are expected from the operation of the proposed Woodhouse Colliery, no mitigation measures for vibration will be required other than those inherent in the standard design and installation of the various items of plant and machinery forming part of the proposals.

A planning condition to require vibration monitoring to be carried out at sensitive properties where a complaint is received by the Planning Authority would be acceptable to the operators**.** A possible planning condition is set out below:

(a). Prior to commencement of the operation of the colliery, the operator shall submit to the local planning authority for its written approval, a protocol for monitoring vibration following receipt of a complaint, investigating the cause of the vibration, and should it be attributable to the development, implementing mitigation measures.

(b) The colliery operator shall provide to the planning authority the independent consultant's assessment of the measurements of vibration undertaken in accordance with the protocol within 40 days of receipt of a written request from the local authority unless otherwise agreed by the planning authority. The submitted assessment shall detail mitigation measures necessary to prevent the likelihood of further exceedance of the vibration limits presented in Table 1. The mitigation measures shall be implemented within 60 days of receipt of the written request from the local planning authority to investigate the complaint unless otherwise agreed by the planning authority.

Table 1 Vibration Limits at Residential Dwellings

*Vibration Dose Value Limits**		*Peak Particle Velocity Limit**
Daytime *VDV 16 h m/s$^{1.75}$*	*Night-time* *VDV 18 h m/s$^{1.75}$*	*Daytime/Night-time*
0.2	*0.1*	*1.0*

** meeting either the vibration dose value limits or the peak particle velocity limit is sufficient to demonstrate compliance with the limits*

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8. CONCLUSIONS

This report presents an assessment of vibration from the operation of the proposed Woodhouse Colliery at Whitehaven, Cumbria.

The assessment has shown that there would be no significant adverse impacts due to vibration from the operation of the proposed colliery.

Notwithstanding this conclusion, the operators are amenable to inclusion of a planning condition in any consent requiring vibration monitoring at sensitive properties should complaints of vibration disturbance or nuisance be received.

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FIGURES

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Figure F.1: Main Mine Site Layout Plan

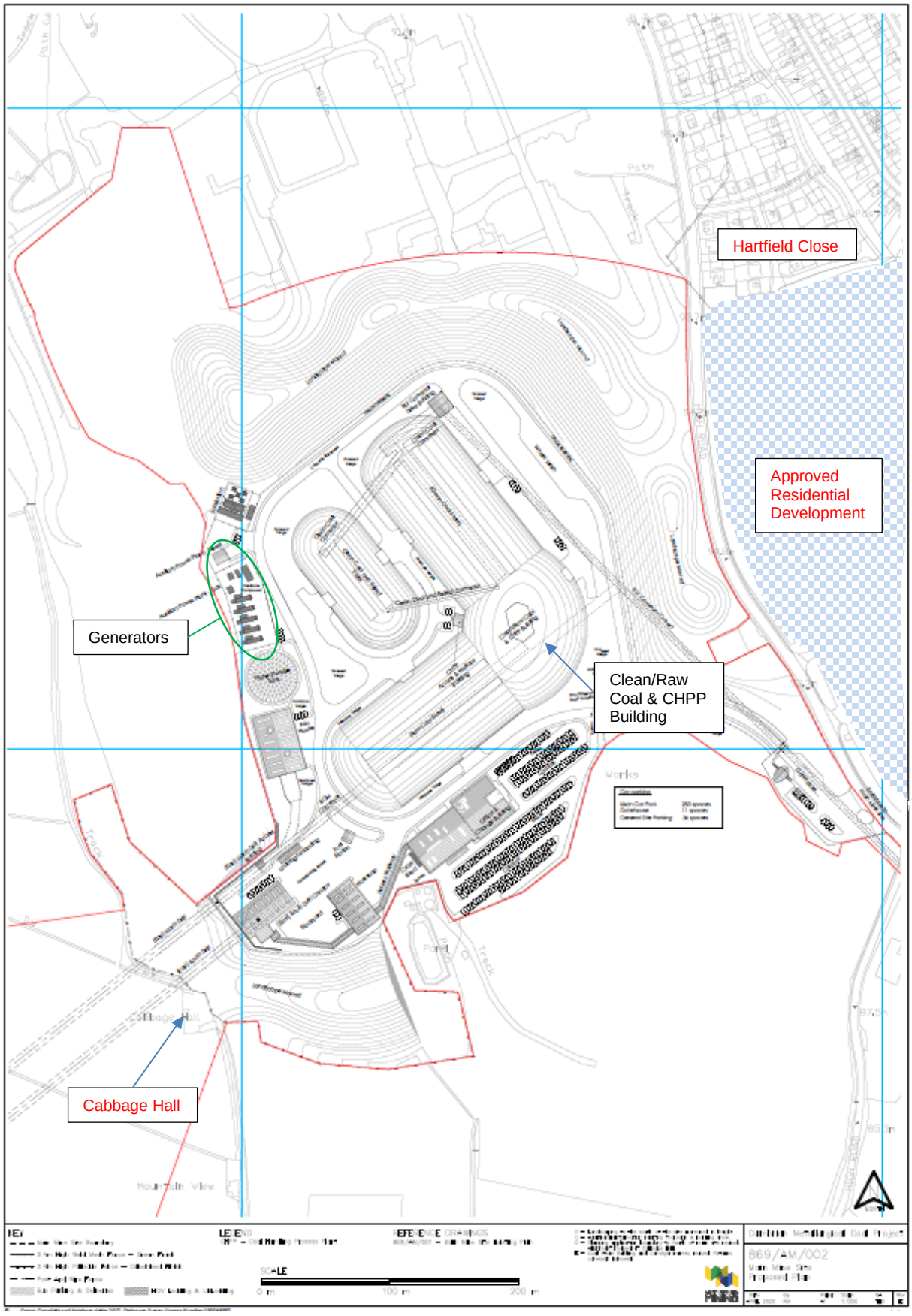
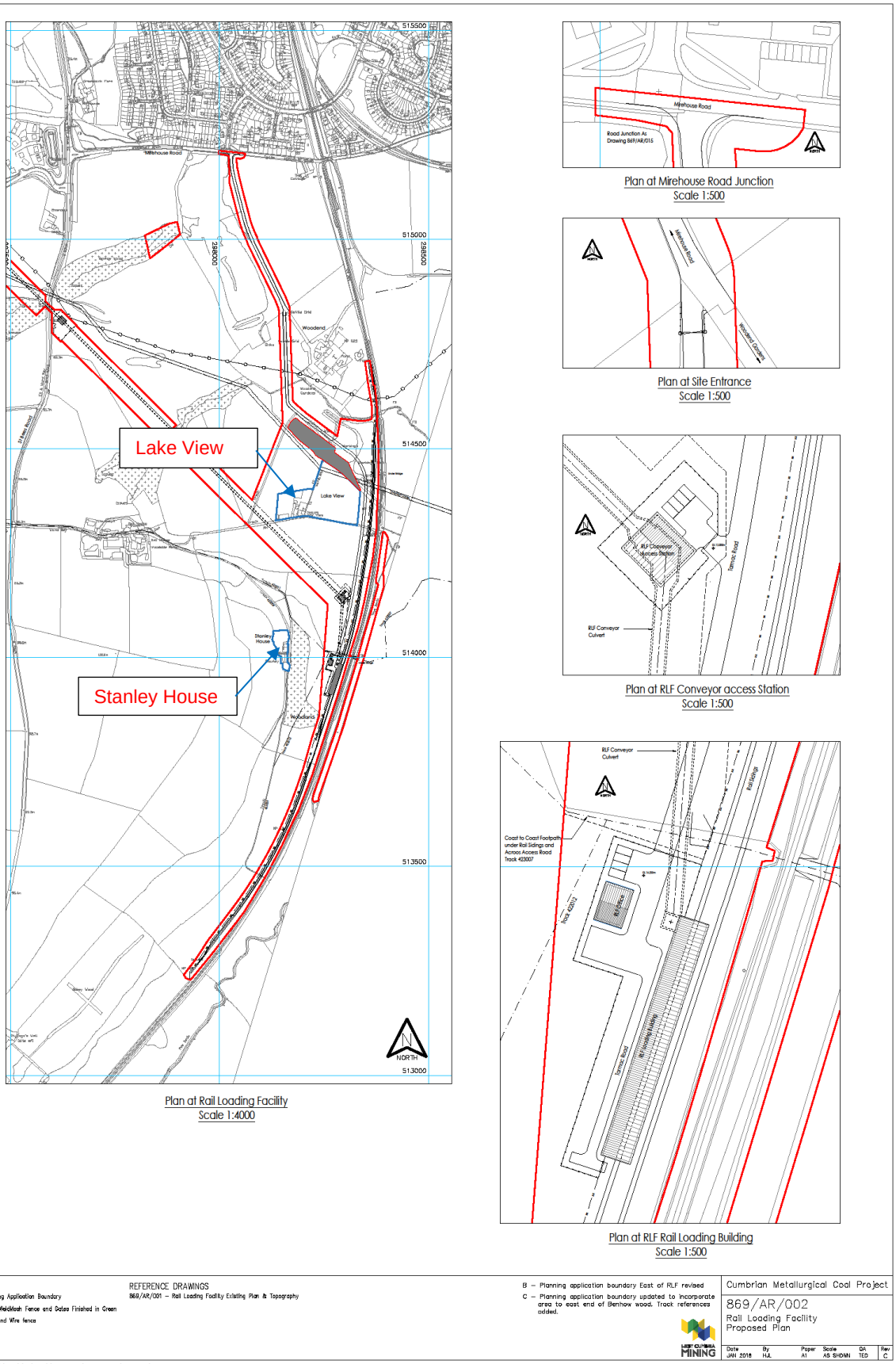


Figure F.2: Rail Loading Facility Layout Plan



Appendix 1

Glossary of Vibration Terminology

Term	Description
Frequency (Hz)	*The number of times that a vibration or other periodic motion occurs or repeats itself in a second - cycles per second. It is usually measured in Hertz (Hz).*
Octave	*Octave is a range of frequencies whose upper frequency limit is twice that of its lower frequency limit. In acoustical measurements, sound pressure level is often measured in octave bands, and the centre frequencies of these bands are defined by ISO - 31.5 Hz, 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1 kHz, 2 kHz, 4 kHz, 8 kHz, 16 kHz to divide the audio spectrum into 10 equal parts.* *The sound pressure level of sound that has been passed through an octave band pass filter is termed the octave band sound pressure level.*
1/3 Octave Band	*Octave bands sub-divided into three parts, equal to 23% of the centre frequency. Used when octave analysis is not discrete enough. Divides the audio spectrum into 33 or more equal parts with Constant Percentage Bandwidth filter.*
Acceleration (A)	*Vibration can be evaluated in terms of acceleration. Acceleration is the rate of change of velocity and is a vector quantity. The SI unit of acceleration is m/s^2 or if using Imperial units then 'g' = 9.80665 m/s^2.* *Acceleration may also be evaluated in decibels using a reference value of $10^{-6} m/s^2$.*
Vibration Dose Value (VDV)	*The VDV is calculated from the fourth root of the fourth power of of the frequency weighted acceleration. This index is used to evaluate the effect of vibration on people within buildings. The unit of VDV is the $m/s^{1.75}$*
Velocity (V)	*Vibration can be evaluated in terms of velocity. The SI unit of velocity is m/s. Alternatively, it is often useful to express velocity in mm/s.* *Velocity may also be evaluated in decibels utilising a reference value of $10^{-9} m/s$.*
Peak Particle Velocity (PPV)	*Ground vibration or vibration within a building or structure is typically evaluated using PPV. This is the maximum instantaneous velocity of a particle at a point during a given time interval and is normally expressed in mm/s.*

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