Noise and Vibration Management Plan- Summary

Wolf Minerals (UK) Limited

Drakelands Mine

Prepared for: General Public

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1. Purpose of the Report

The report has been produced to inform the general public of the process Wolf has followed to identify the best appropriate measure to reduce the effects of Low Frequency Noise **(LFN)** emission associated with operations at the Mineral Processing Facility **(MPF)** at the Drakelands Tungsten Mine, Hemerdon, Plymouth as contained within the Noise and Vibration Management Plan **(NVMP)** submitted to and agreed by the Environment Agency **(EA)**. This document incorporates an overview of the Options Evaluation Process that was completed by the selected LFN Taskforce in order to identify the best solution contained in the Noise and Vibration Management Plan. The purpose of the NVMP is to demonstrate to the Environment Agency that Wolf has carried out all reasonable investigation and evaluation studies to identify the source of emissions from the MPF, and identified appropriate measures to address the emissions of LFN in accordance with the permit obligations and requirements of the compliance assessment reports issued by the EA.

The following process flow illustrates the adopted key steps taken to develop the NVMP:

Step 1	• EA issue a Compliance Assessment Report
Step 2	• Wolf Engages team of internationally recognised acoustic experts and acoustic engineers "LFN Taskforce" •Taskforce reviews all historic data
Step 3	• Taskforce completes independent studies to determine the source and effects of LFN • Taskforce identify LFN transmission pathway
Step 4	• Taskforce reviews all investigation data and develop conceptual options to prevent or reduce LFN emissions
Step 5	• Taskforce workshop completed to determine Noise Reduction Targets based on available standards, guidance and Best Available Technique (BAT) • Option Evaluation to determine best option from the identified conceptual options for meeting Noise Reduction Targets
Step 6	•Development of NVMP
Step 7	•Agreement of NVMP by the EA (26/01/2018)

2. Appointment of LFN Taskforce

The LFN Taskforce consisted of internationally recognised acoustic experts and acoustic engineers with a proven history of identifying and providing engineering solutions to resolve challenges of the nature experienced at the MPF. The Taskforce consisted of:

- Innova-gl – Internationally recognised engineering company with proven record of acoustic control design and implementation.
- Hatch – Internationally recognised engineering company with proven record of building acoustic control design.
- ARUP – Internationally recognised engineering company with proven record of acoustic control design.
- Field Expert, Independent Consultant in Noise Vibration and Acoustics
- SLR Consulting (Australia and UK) – Internationally recognised engineering company with proven record of vibration acoustic investigations.

3. Identification and Evaluation of Best Available Improvement Options

A rigorous approach was adopted by Wolf to assist with the identification and evaluation of appropriate improvement options. The approach used was robust and self-governing throughout and identified the options that could prevent or where that is not practicable could minimise LFN emissions. The BAT approach ensures assessment of each option against criteria including safety, operational efficiency, costs and acoustic benefit.

The following process was followed:

Stage 1 – Investigation

The LFN Taskforce carried out a range of scientific assessments to establish the interactions from source, the building, emissions pathways through to effects at the receptor. The investigations established the extent to which residents were adversely affected by reference to the standards and guidance detailed in Section 5.

- The investigations have established and quantified all relevant sound emissions and transmission pathways;
- Finite element analysis of the building has been completed to determine its response to vibrations; and
- An acoustic model has been developed that responds to building effects and calibrated to local environment.

Stage 2 – Definition

- Following the assessments from the multi-disciplinary investigations, conceptual remedial options were developed independently by the Taskforce members, prior to presentation at an LFN Workshop in December 2017; and
- Development of noise reduction targets, based on meeting standards and guidance with modelled outcomes, have been reviewed to define appropriate noise reduction targets.

Stage 3 – Option Evaluation

- The LFN Taskforce defined and conducted an evaluation process which assessed criteria including safety, operational efficiency, costs and acoustic benefit (magnitude of the benefit at individual receptors multiplied by the number of dwellings receiving the benefit) for the evaluation of all the proposed conceptual options that can be readily scoped out;
- The remaining options were appraised against the reduction criteria and sensitivity analysis completed on the highest scoring options; and
- The best appropriate measure option was then identified.

Stage 4 – Consultation

- The LFN Taskforce and Officers of the EA met on 15th December to review progress against Stages 1-3 above and to discuss preliminary findings of the options evaluation;
- At this workshop the EA provided additional guidance on their expectations as set out below.

ID	EA Feedback
E1	In consideration of the extended period of time that the LFN elevated emissions has been permitted to continue from the Minerals Processing Facility only proven measures with tangible results should be proposed.
E2	In consideration of the extended period of time that the LFN elevated emissions has been permitted to continue from the Minerals Processing Facility experimental methods are not considered to be appropriate at this stage.
E3	The options must consider achieving the highest reduction practicable to reduce the 16Hz amplitude variation and reduce the likelihood of complaints post implementation.

TABLE 1. EA OBSERVATIONS

4. Standards and Guidance

The following guidance was considered by the Taskforce:

- The Planning Practice Guidance for Minerals relating to audible sound at residential receptor locations;
- BS 4142 to identify if, using this standard, adverse impacts from audible sound are likely to occur;
- NANR45 is used to assess the effects of sound within the lower frequency range;
- ASHRAE 2015 is used to assess the probability of the perception of vibration and rattling; and
- Beating (amplitude variation) is assessed as part of the potential effects of sound.

5. Noise Reduction Targets

Following the completion of the investigation works and analysis of the collected quantitative and qualitative information the following Noise Reduction Targets **(NRTs)** at receptor locations were developed. The NRTs were developed by the LFN Taskforce collectively following a review of each LFN member's investigation findings and peer review and designed to reduce the effects of LFN internally.

- NANR45 (50 Hz 1/3 octave)
- Secondary effects (16 Hz 1/3 octave)
- Beating 16 Hz (amplitude variation)

The suggested NRTs should not be interpreted as absolute criteria or levels to be achieved post remedial works but a set of target levels that should be achieved as far as reasonably practical after BAT was applied.

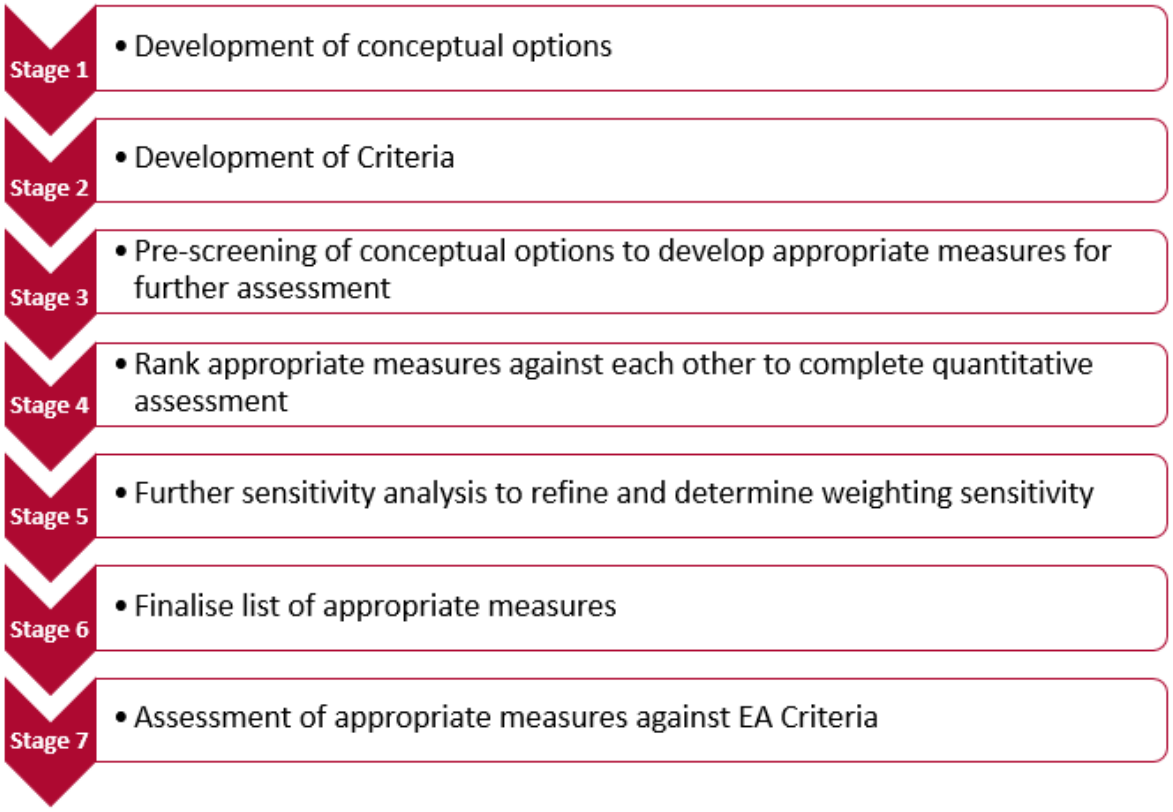
Noise Reduction Targets

- A 12 dB reduction inside neighbouring dwellings in the 50 Hz 1/3 octave band sound levels. This will ensure monitored internal noise levels post remedial works are below the NANR45 criterion, thus reducing the likelihood for noise-related complaints.
- A 10 dB reduction inside dwellings and outdoors at receptor locations in the 16 Hz 1/3 octave band sound levels. This will ensure monitored noise levels post remedial works are at or below ASHRAE criterion for the onset of a "slight possibility of rattles". In addition, it will also reduce the probability of LFN being perceived as physical sensations and the perception of the beating.

6. Options Evaluation Process

The decision-making tool applied to select the best options was a modified form of the Kepner Tregoe decision-making technique which assesses options in an unbiased and logical manner. The recognised process is adopted when a decision is required to determine the best available option based on meeting a defined set of criteria.

The option evaluation process comprised the process flow as detailed in the diagram below:



6.1 EVALUATION CRITERIA

To commence the process, a set of criteria was developed based on the fundamental objectives of the solution implementation. Once the criteria had been developed, each criterion was assigned a weighting based on the perceived importance for this particular decision. The criteria and weightings were developed with sound judgment based on the collective experience of the workshop attendees.

6.2 EVALUATION

Each option was then individually assessed against the criteria and then ranked against each other from 1 to 10. The score of 10 indicating best performance and 1 worst performance. The rank was then multiplied by the weighting to give a score, which is summed for each option. The weightings were then adjusted based on a number of different scenarios to assess the sensitivity of the outcomes.

7. Options Evaluation

Following collation of the 32 conceptual options, a screening exercise was conducted in which each option was subjected to assessment against the criteria. At this point, the options which failed to meet the criteria were excluded from the process.

Following completion of the screening exercise 11 options were considered appropriate for further evaluation and were subjected to numerical assessment (Table 2).

Option	ID	Title
1	SO1	**Building over a building with acoustic cladding** - build a new structure isolated from MPF with acoustic cladding over existing MPF, J57 wall system proposed by Innova-gl.
2	SO2	**Retrofit existing cladding** - replace entire existing cladding with acoustically designed cladding on MPF, J57 wall system proposed by Innova-gl.
3	SO3	**Retrofit existing cladding** - replace entire existing cladding with acoustically designed cladding on MPF, E45 wall system proposed by Innova-gl.
6	SO6	**Localised stiffening of existing steelwork** - stiffen existing steelwork to reduce resonance and/or reduce structural vibration.
7	SO7	**Screen synchronisation** - phase locking screens in MPF to reduce beating.
19	S19	**Nearfield acoustic enclosure** - acoustic 'room'.
20	S20	**Modify the gap between the under pan and screen** - screen Interface (leaky speaker theory).
21s	S21a	**Active noise control –** screen interface compressed air system.
25	S25	**Modular and/or spray-on acoustic treatment** - spray on acoustic cement to target resonant field within the building and offer some insulation at 16Hz and absorption at higher frequencies.
30	S30	**Improve current isolation efficiencies** - improve isolation efficiencies on individual screens.
31	S31	**Change product screen operating frequencies**

TABLE 2. 11 OPTIONS TAKEN FORWARD FOR FURTHER EVALUATION

Table 3 below details the results of the numerical assessment ranked in highest scoring order for the identified 11 options.

Ranked Options	
1 – S02	Retrofit existing cladding – J57
2 – S03	Retrofit existing cladding – E45
3 – S01	Building over a building with acoustic cladding – J57
4 – S25	Modular and/or spray-on acoustic treatment
5 – S21a	Active noise control (compressed air)
6 – S07	Screen synchronisation (beating)
7 – S19	Nearfield acoustic enclosure
8 – S06	Localised stiffening of existing steelwork
9 – S31	Change operating frequencies sizing screens
10 – S30	Improve current isolation efficiencies
11 – S20	Modify the under pans

TABLE 3. RANKED LIST OF IDENTIFIED APPROPRIATE OPTIONS BASED ON SCORING

7.1 SENSITIVITY ANALYSIS

Only options that scored within 20% of the highest scoring option were considered for further sensitivity analysis.

Ranked Options	
1 – S02	Retrofit existing cladding – J57
2 – S03	Retrofit existing cladding – E45

Ranked Options	
3 – S01	Building over a building with acoustic cladding – J57
4 – S25	Modular and/or spray-on acoustic treatment

TABLE 4. RANKED LIST OF IDENTIFIED APPROPRIATE OPTIONS

The sensitivity analysis was completed by adjusting the criteria weighting.

Altered weightings
Original Scores
Cost benefit 1 proven solution 3
Operating cost 1 speed of design 3
Proven solution 3 impact on operations 2
Speed of design 1 longevity 3
Cost benefit 1 impact on operations 3

TABLE 5. SENSITIVITY ANALYSIS OF IDENTIFIED APPROPRIATE OPTIONS

7.2 EVALUATION CONCLUSIONS

- 32 conceptual options were considered
- 21 conceptual options failed to meet the specified criteria
- 11 options were subjected to numerical evaluation
- 4 options were considered appropriate and likely to succeed
- SO2 and SO3 considered the best appropriate options
- Sensitivity analysis confirmed SO2 and SO3 (retrofit existing cladding with heavy acoustic cladding J57 and retrofit existing cladding with light acoustic cladding E45) as the most appropriate options

8. Final Conclusions of the Options Evaluation Process

Following the completion of the evaluation process, Options SO2 and SO3 were considered the best available techniques to prevent, or where that is not practicable, to minimise the LFN emissions from the MPF. Based on the participation of the EA representatives in the December Workshop a further assessment was completed on their specified requirements. Table 6 below details that further assessment. The selected best option SO2 has been assessed to meet the EA specified requirements. Option SO3 and S25 failed to meet these additional requirements.

Option	E1 - only proven measures with tangible results should be proposed.	E2 - experimental methods are not considered to be appropriate at this stage.	E3 - The options must consider achieving the highest reduction practicable to reduce the 16Hz
SO1 – Innova-gl Building J57	Innova-gl provide works guarantee for installation and noise reduction effectiveness.	Cladding treatments already tested, proven and implemented on operating industrial buildings.	Treatment performance exceed regulatory requirements (22dB reduction at 31Hz 19dB at 50Hz).
SO2 – Innova-gl Cladding J57	Innova-gl provide works guarantee for installation and noise reduction effectiveness.	Cladding treatments already tested, proven and implemented on operating industrial buildings.	Treatment performance exceed regulatory requirements (22dB reduction at 31Hz 19dB at 50Hz).
SO3 – Innova-gl Cladding E45	Innova-gl provide works guarantee for installation and noise reduction effectiveness.	Cladding treatments already tested, proven and implemented on operating industrial buildings.	Treatment will meet regulatory requirements (13dB reduction at 31Hz 10dB reduction at 50Hz).
S25 – Hatch Cladding Treatment	System not tested or implemented application to demonstrate noise reduction effectiveness.	System would require test work to prove application, noise reduction effectiveness and longevity.	Treatment is conceptual assessed to meet regulatory requirements (10dB reduction at 31Hz 15dB reduction at 50Hz).

TABLE 6. FURTHER EVALUATION SUMMARY

8.1 BEST APPROPRIATE MEASURE

The following table outlines the effectiveness of the identified best available option SO2 in relation to meeting the NRTs.

NRT	Target	Criteria	Best Available Option SO2 Effectiveness
1	12dB reduction at receptor locations in the 50 hertz 1/3 Octave.	NANR45	63 Hz - Transmission Loss 22dB 31.5 Hz - Transmission Loss 22dB 16 Hz – Transmission Loss 22dB
2	10dB reduction at receptor locations in the 16 hertz 1/3 Octave band sound levels.	ASHREA Beating	
3			

T**ABLE 7**. EFFECTIVENESS OF BEST AVAILBLE OPTION MEETING NRTs

9. NVMP Implementation

The following actions were considered appropriate:

- Implement stiffening of existing framework
- Progress detailed design and fabrication of Option SO2

A provisional implementation schedule has been provided within which a number of work streams are advanced simultaneously. A range of planning and preparation activity is being advanced by both Innova-gl and Wolf to ensure work can commence swiftly upon final agreement of contractual terms.

Implementation Schedule below.

WOLF MINERALS

Phase 3 - LFN Reduction Program

19 Dec 2017 Version - Ver.0

ACTIVITY			22-Dec	29-Dec	05-Jan	12-Jan	19-Jan	26-Jan	02-Feb	09-Feb	09-Mar	09-Apr	09-May	09-Jun	09-Jul	09-Aug	09-Sep	09-Oct
Action Plan Development & Review																		
Regulatory Interactions	**Who**	**When**																
Submission of Phase 3 Action Plan - Reg 23 Requirement	Wolf	05/10/2018																
Approval of Phase 3 Action Plan	EA	17/10/2017																
LFN Working Group meeting	Wolf	18/10/2017																
Public meeting	Wolf																	
Knowledge Gaps Scopes - What	**Who**	**When**																
Development of scope of work for trial for acoustic cement to panel	Hatch	27/10/17																
Implementation of trial for acoustic cement to panel	Hatch	27/10/17																
Assessment of application and decision to proceed	Wolf																	
Development of scope of work for trial for air induced noise cancelling	Hatch	27/10/17																
Implementation of trial for air induced noise cancelling	Hatch																	
Assessment of application and decision to proceed	Wolf																	
Provision of actual loss transmission data for treatment option	Innova																	
Construction	**Who**	**When**																
Development of cladding detailed design (structural)	Innova																	
Development of cladding detailed design (Architectural)	Innova																	
Award Contract	Innova																	
Building Panel Assembly Fab & Delivery	Innova																	
Demo Existing Cladding / Shell & Required Components	Innova																	
Structural Steel Prep for Panels	Innova																	
Install Acoustic wall Assembly / Cladding	Innova																	
Install Acoustic Roofing	Innova																	
Install Required Mechanical Components	Innova																	
Building Complete	Innova																	
Install Required Electrical Components	Innova																	
Complete																		