

MEMO

Project:	Bendigo Ophir Gold Project	Document No.:	Mm 003
To:	Santana Minerals	Date:	3 March 2026
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Delivery:	Email	Project No.:	20230685
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Subject:	Blasting vibration – Effects on heritage structures		

This memo outlines the vibration criteria applicable to heritage structures and assesses how blasting activities at the Bendigo Ophir Gold Project can comply with these limits.

SUMMARY

Blasting is the mining activity most likely to generate ground vibration levels that could affect nearby heritage structures.

Our assessment shows that blasting can occur across most of the project area while still complying with recognised vibration criteria for avoiding damage.

However, when blasting occurs close to unreinforced masonry heritage structures, the blasting methodology will need to be adapted to minimise the risk of superficial damage. This is best managed through a Blasting Vibration Management Plan, which uses real site-specific vibration measurements to guide safe blasting practices.

The plan would include:

- **Dilapidation surveys** to document the condition of heritage structures and assign appropriate vibration limits.
- **Test blasts** to measure how vibration travels through the local ground conditions.
- **Blast design optimisation** (e.g., reduced charge weight) when required to ensure vibration limits are not exceeded.

This approach will allow the mining operation to proceed while appropriately managing the risk of cosmetic damage to heritage structures.

HERITAGE STRUCTURE DAMAGE CRITERIA FOR GROUND VIBRATION FROM BLASTING

The Central Otago District Plan does not specify vibration limits for blasting near heritage structures.

For the Bendigo Ophir Gold Project, recommended blasting vibration and air overpressure limits have been established with reference to Appendix J of Australian Standard AS 2187-2:2006 *Explosives – Storage and use, Part 2: Use of explosives*. However, these limits are primarily focussed on human comfort. The applicable vibration criteria to avoid damage to structures such as residential dwellings are set out in Table J4.4.2.1 and Figure J4.4.2.1 of AS 2187-2:2006 and are repeated in Table 2 and Figure 1 respectively.

Because AS 2187.2 does not include specific criteria for heritage structures, additional guidance is taken from DIN 4150-3:2016 *Vibrations in buildings – Part 3: Effects on structures*, which provides vibration limits for structures of particular historical sensitivity.

DIN 4150-3 provides vibration limits for “Structures that, because of their particular sensitivity to vibration, cannot be classified under [Commercial or Residential buildings] and are of great intrinsic value (e.g. listed buildings).”

The guideline vibration limits for structures that align with this classification are set out in Table 1.

Table 1: DIN 4150-3:2016 Guideline values for vibration velocity, for evaluating the effects of short-term vibration on structures

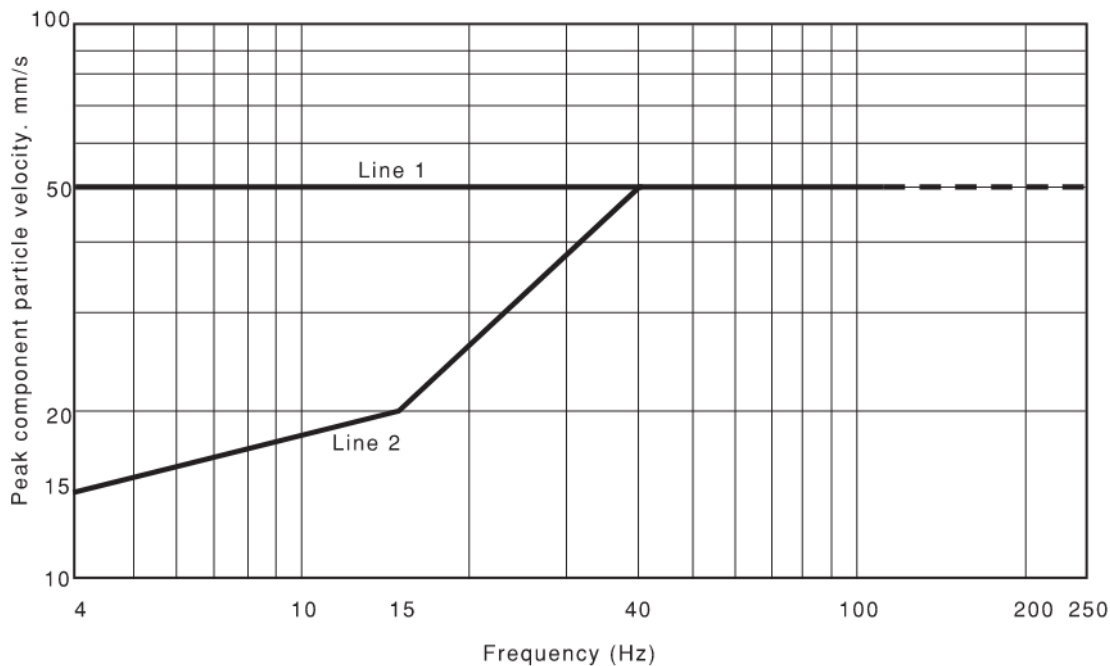
Guideline values for peak particle velocity at foundation, at all directions, at a frequency of		
1 Hz to 10 Hz	10 Hz to 15 Hz	50 to 100 Hz
3 mm/s	3 to 8 mm/s	8 to 10mm/s

Vibration limits to avoid damage to building structures are higher than those specified for human comfort. Table J4.4.2.1 and Figure J4.4.2.1 of AS 2187-2:2006 provide the following (replicated in Table 2 and Figure 1 respectively):

Table 2: J4.4.2.1 Transient vibration guide values for cosmetic damage

Line	Type of Building	Peak component particle velocity in frequency range of predominant pulse	
		4 Hz to 15 Hz	15 Hz and above
1	Reinforced or framed structures. Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
2	Unreinforced or light framed structure. Residential or light commercial type buildings	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 40 Hz and above

Figure 1: J4.4.2.1 Transient vibration guide values for cosmetic damage (BS 7385-2)

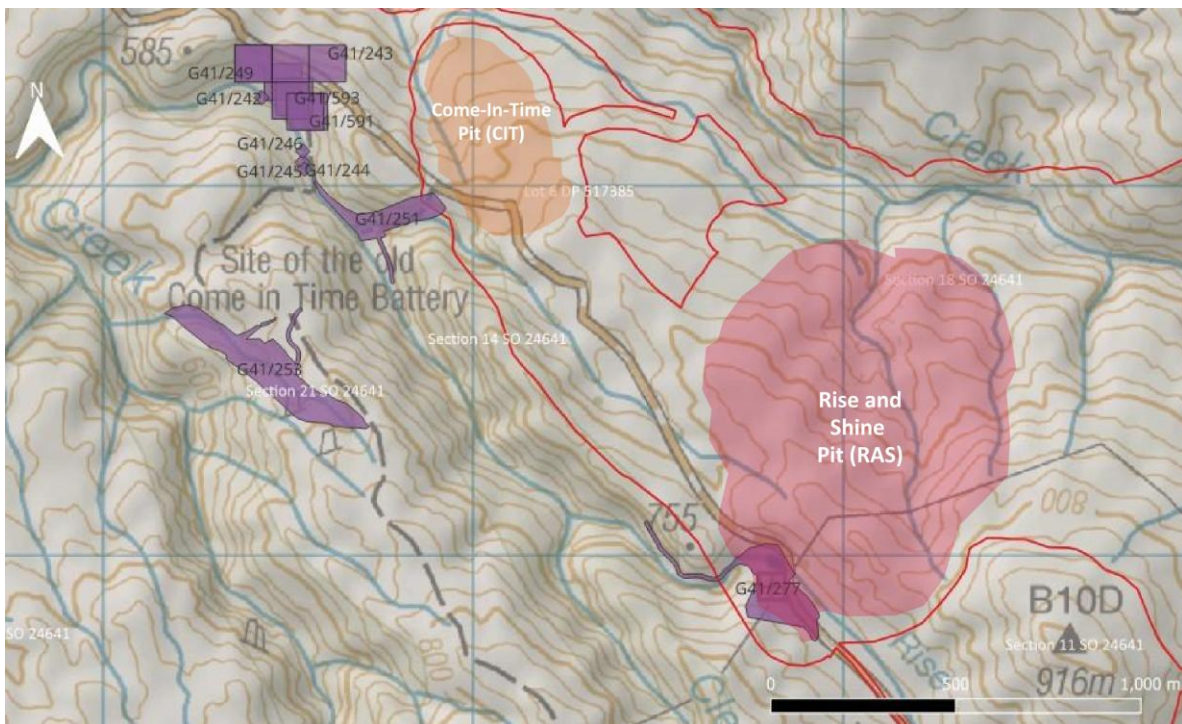


TYPICAL BLASTING VIBRATION LEVELS

We understand that blasting will be required in both the open pit and underground, and intermittently in the west quarry. At this early stage of the project, a detailed blasting plan has not been developed. However, blasting in the Rise and Shine (RAS) and Come-in-Time (CIT) Pits is closest to the identified heritage structures and therefore are of greatest interest in this assessment.

Figure 2 shows the approximate extent of the RAS and CIT pits with respect to heritage areas identified in the New Zealand Heritage Properties assessment for the project. While the RAS footprint appears to overlap heritage site G41/277, we understand the intention is to retain and protect this feature within the mining area.

Figure 2: Heritage sites (G41/ref) in relation to the CIT and RAS pits



Not all heritage items require application of the more stringent DIN 4150-3 criteria. For example, structures at G41/277 vary from concrete machine foundations to stone-work tramway revetments (Figure 3). At this stage, the DIN 4150-3 limits in Table 1 appear more appropriate for the tramway revetments, while the AS 2187-2 criteria in Table 2 may better suit the concrete foundations. These assignments can be confirmed following dilapidation surveys.

Figure 3: NZAA 2018 photos of revetted tramway (left image) and concrete machine foundations (right image)

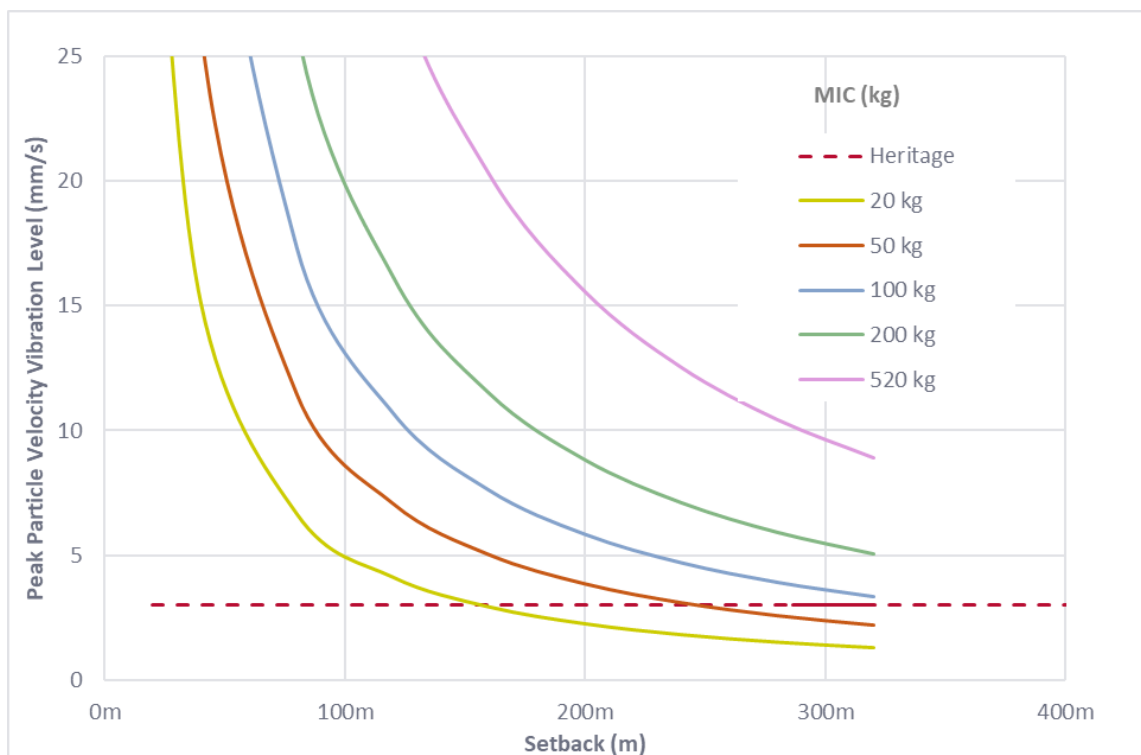


We have previously prepared blasting vibration propagation plots for the project and these are provided in Figure 4 with additional entries for an extended range of Maximum Instantaneous Charge weights (MIC). These estimates indicate that using an MIC of 20 kg, vibration levels may exceed the 3 mm/s DIN guideline value at distances of approximately 160 metres or less.

AS 2187.2-2006 recognises that predicting blast-generated ground vibration is complex due to the non-linear nature of blasting and the variability of local rock conditions. Accordingly, it is standard industry practice to conduct monitored test blasts to establish site-specific ground-response characteristics and determine blast design parameters that ensure compliance with vibration limits.

Where the applicable criterion could potentially be exceeded, mine blast engineers can employ design steps to implement a “proximity” blast that will typically include the use of smaller charge weights and blast hole diameters. Some structures may benefit from temporary shoring to minimise their vibration sensitivity.

Figure 4: Blasting Vibration Levels (mm/s PPV) over distance (metres) for various Effective Maximum Instantaneous Charge (MIC) per delay (kg) [assumed site constants $K_g = 1500$ and $B = -1.5$]



BLASTING VIBRATION MANAGEMENT PLAN

Industry best practice is to implement a comprehensive mine safety management plan for blasting. This integrates with the Noise and Vibration Management Plan (NVMP), which records the consent requirements for vibration and air overpressure. A draft NVMP has been prepared and submitted with the Application.

It will be relatively straightforward to adapt the NVMP to protect heritage structures. We anticipate the process would include the following key components:

1. Dilapidation surveys: documenting the condition of heritage structures within a nominal distance (e.g., 500 metres) of blasting activities, assigning vibration-sensitivity categories, and identifying whether temporary shoring or protection is required.
2. Reduced-scale trial blasts: conducting and monitoring small-scale blasts to determine how vibration propagates through site-specific geology and to establish safe buffer distances.
3. Blast design optimisation: using test-blast data to refine charge weights, timing delays, and other blast parameters to maintain vibration levels within the assigned limits.
4. Monitoring: installing monitors as required to confirm vibration levels during initial blasts, with records maintained for MIC, timing, meteorological conditions, and measured peak particle velocity (PPV).