Report to

OCEANAGOLD
WAIHI OPERATION

Vibration Assessment: Martha Mineral Zone Plan Change

Updated in Response to Further Information Request – July 2022

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TECHNICAL REPORT
VIBRATION PLAN CHANGE ASSESSMENT
GENERAL AREA 000

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1. OVERVIEW

The purpose of this technical document is to provide an assessment to support a plan change application by OceanaGold New Zealand ("OGNZL") to the Hauraki District Plan – which relates to the expansion of the Martha Mineral Zone in order to provide for a potential extension of surface mining in the Martha Pit.

Heilig Partners have been asked to provide a vibration assessment relating to the proposed rezoning of a series of properties around the township of Waihi from *Residential*, *Low Density Residential* and *Town Centre* to *Martha Mineral Zone*, and comment on the potential management of vibration as part of the plan change.

2. SCOPE

There are specific requirements set out in the Resource Management Act ("RMA"), particularly Part 2 of Schedule 1 and Section 32 in relation to the requirements of plan change applications. These specify the information that must be included in a private plan change request in terms of effects assessments. All potential changes in effects must be assessed to a level of detail that corresponds to the scale and significance of effects on the environment anticipated from the implementation of the plan change.

In light of the above, this assessment considers the potential vibration effects associated with the proposed plan change.

3. STRATEGY FOR THE MINING

With respect to the plan change application, it is proposed to rezone all land parcels that will be necessary to support an expansion of the Martha Pit and ancillary activities (i.e. noise bunds and surface facilities areas) to Martha Mineral Zone. The rezoning would facilitate a resource consent process for surface mining and mining operations by removing the Prohibited activity status which currently applies under the Residential, Low Density Residential and Town Centre Zones. This includes expanding the extent of the Martha Mineral Zone in the vicinity of Moresby Avenue, Pitt Street, Haszard Street and Seddon Street.

The expanded Martha Mineral Zone is illustrated in Figure 1 on the following page and provided at full scale in the Planning Assessment by Mitchell Daysh.

In preparing this assessment consideration has been given to the potential vibration effects that could be generated by permitted activities in an expanded Martha Mineral Zone, as well as the potential vibration that could be generated from an expansion of surface mining activities in an enlarged zone which would require resource consent as a discretionary activity.

4. ABOUT VIBRATION

Activities undertaken within the expanded Martha Mineral Zone could generate continuous, intermittent or impulsive vibrations. Each type of vibration requires different methods of assessment and is subject to different applicable performance criterion, as specified in Section 8.3.2.1 of the Hauraki District Plan or as part of the existing resource consents for activities in the Martha Pit. To some degree, each type of vibration will currently exist in some areas around the Martha Mineral Zone, including the expanded area.

The level of vibration will be a function of the sensitive receiver location, ground conditions and the source of vibration. Vibration propagated through the ground and into building structures is generally perceptible at a range of frequencies and which, if sufficiently high, can cause rattling and small movements of building contents, such as small objects on hard surfaces or loosely-hung pictures. At high levels, the vibration becomes annoying and at significantly higher levels, the vibration may result in superficial damage to the building. Only at very high levels of vibration is structural damage likely to occur.

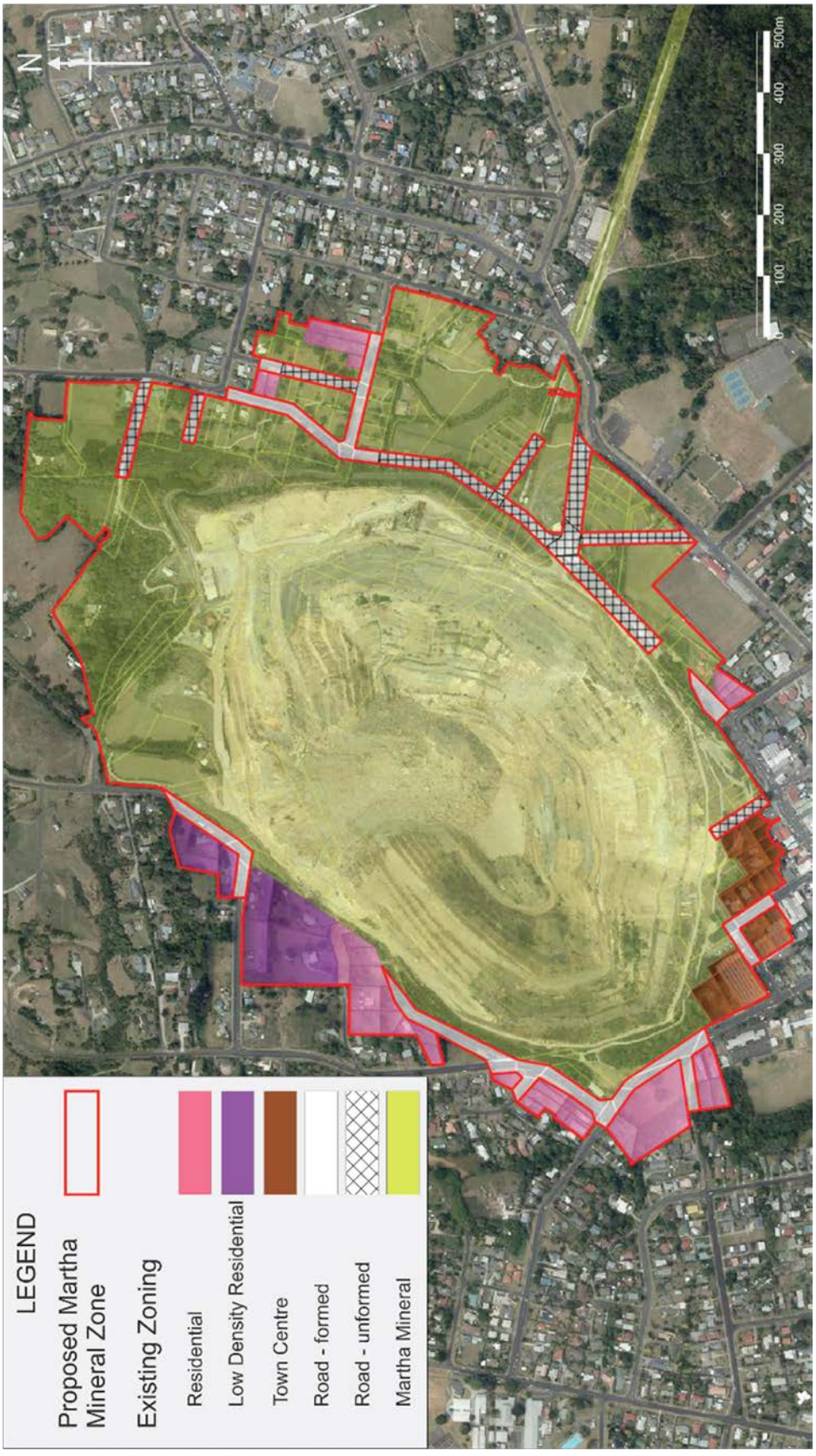


Figure 1: Existing Martha Mineral Zone (yellow) and proposed expansion areas (purple, pink, white and brown) (source: OceanaGold)

Vibration may be continuous or transient. Transient vibration is further subdivided into impulsive and intermittent vibration:

- Continuous vibration remains uninterrupted over a given time period, typically several minutes or more. International Standard ISO10137 defines continuous vibration as having a duration of more than 30 minutes per 24-hour period. A typical example of continuous vibration would be that generated by the mill at the OGNZL Processing Plant.

- Impulsive vibration is an isolated short duration (typically less than 10 seconds) rapid build-up of vibration then decay. It may be a single or many pulses. A typical example of impulsive vibration would be that occurring from blasting activities associated with open pit or underground mining.

- Intermittent vibration is a string of incidents, each generally less than a few seconds and separated by intervals of a much lower vibration. ISO10137 defines intermittent vibration as more than 10 events per 24-hour period. A typical example of intermittent vibration would be that from heavy vehicles (i.e. logging trucks).

The classification of vibration is also shown in Figure 2.

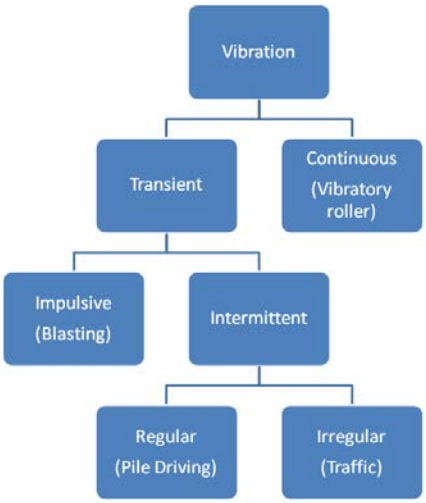


Figure 2 – Distinction of vibration

As the vibrational energy travels outward from the source, the amplitude diminishes or attenuates. With increasing distance, the affected area greatly increases, but the energy becomes widely dispersed. As a very general guide, the amplitude (i.e. level) of the vibration can be expected to decrease by approximately two-thirds for every doubling of the distance.

Many factors affect the way that vibration propagates from the source. Different rock masses affect the rate at which the vibration reduces with the distance. Competent, high strength rock masses allow more efficient transmission of vibration, whilst weaker and softer materials generally attenuate vibration to a greater degree and vibration levels are lower at the same distance from the source. Other factors, such as water, faults and fractures, open voids and so on, impact on how vibration propagates. Combined, it is not uncommon for similar equipment to generate different levels of vibration, depending on the combination of factors present in different ground. A two-fold difference in vibration level for a similar source energy and at similar distances is typical.

The assessable effects of vibration generally relate to whether they may impact upon the amenity of persons or whether they could impact upon the integrity of buildings or houses, such as causing damage. In terms of response, people generally require confirmation that any vibration will not impact

upon their properties, and this can usually be provided by comparison of the predicted or measured levels of vibration with those presented in the international standards or guidelines. At lower levels of vibration where it is accepted that damage to the property will not occur, people are concerned about the vibration on their amenity, or their quality of life.

5. VIBRATION ENVIRONMENT

5.1. Existing Vibration Environment

The existing vibration environment around the Waihi area is variable. Some areas around Waihi will be subject to multiple sources of elevated vibration, particularly those areas along State Highway 2, Tauranga Road, Kenny Street and other roads where heavy transport, like logging trucks, frequently travel and induce elevated levels of vibration beyond those typical of rural streets. Current sources of intermittent vibration would likely result only from a combination of heavy vehicle movements travelling along uneven road pavement surfaces. The level of vibration is uncontrolled with respect to a permissible level.

Other locations near the Correnso Mine will have a vibration environment affected by the mine blasting. These events are impulsive, occur at reasonably set windows during the day and are controlled to levels set in the existing resource consents. Although the Martha Pit has not been operating for a number of years, during those periods when it was active the vibration from pit mining was a feature and would have similarly characterised the existing environment.

Many of the properties around the Martha Mineral Zone are residential with most of the properties of timber, brick or block construction with some more recently constructed. Although the type and construction of the properties vary, their condition generally appears appropriate for their age and there is no indication that they would require special consideration to manage the levels of vibration that would be more stringent than that commonly applied for most properties.

In terms of commercial and industrial properties, those in the Waihi CBD are also typical of their age. No building specific vibration criterion is proposed, and none is considered to be required as a result of their condition, construction methods or sensitive equipment they may house.

5.2. Altered Vibration Environment

Like the existing Martha Mineral Zone, the assumption is that blasting within the expanded Martha Mineral Zone as part of a consented expansion of the Martha Pit could occur near to residential properties, open space areas and commercial buildings in the Waihi CBD precinct if resource consents are granted.

The proximity of the mining to the sensitive receptors influences the scale of blasting that can be undertaken. As blasting moves nearer to properties, the scale of blasting reduces. The same property could receive the same level of vibration irrespective of the distance between the blast and the property. Increasing the footprint, or adjusting the location, where blasting could occur may possibly have no impact on the vibration environment.

6. SETTING OF VIBRATION LIMITS

Vibration limits are typically set to maintain amenity and are therefore set at levels well below those at which property damage could occur. There is no one limit in use worldwide. Australia and New Zealand generally adopt the most stringent values applied anywhere in the world. Vibration limits are mainly based on research conducted over decades by various independent groups, and these data subsequently form the basis for internationally accepted standards and guidelines. By design, they are typically over-engineered to provide a high safety factor, particularly with reference to building damage.

Where the focus is the protection of amenity, vibration limits may be expressed as a single value (for example 5mm/s). Where the focus is for the protection of structure response, such as the criterion given

in the Australian, British or German Standards, the permissible value will include multiple vibration levels depending upon frequency content.

Vibration levels for the protection of amenity vary. Where vibration occurs throughout both day and night periods, residential criteria for night time periods are always less than the applicable daytime value. It is common that any vibration during the night time period is limited to a level that is imperceptible, or just above the level of perception. Vibration limits focussing on the amenity effects of continuous sources, like hammer and pile driving, roller and so on, are less than the value for short term impulsive activities like blasting.

An amenity-based limit for vibration effects on commercial buildings is typically less restrictive than would be applied to residential properties. That is a higher permissible level is allowed. When a commercial value is applied, a vibration limit at least twice that of the residential value is common.

In terms of limits for impulsive activities like blasting, whilst countries like Australia propose vibration criteria for residential properties that are based solely on protection of amenity, some countries, like the USA, apply permissible values centred only on eliminating structural damage without any requirement to consider personal amenity.

Frequency-based limits are better linked to structure response. The recommended limits in standards generally relate to the prevention of threshold cosmetic damage in the most susceptible of materials of the structure such as plaster and low-density building materials. Other materials including masonry, concrete block and mass concrete can withstand much higher levels of vibration without damage.

As a result of the influence of the other factors that may also contribute to the measured vibration levels, such as those that will be identified in the existing conditions assessment, it is common for the vibration criteria to be expressed either as a percentile value, such as 90% or 95% compliance. The percentile application of a vibration condition is to account for these unknown and varying influence factors, not to account for poor performance in selecting and implementing equipment, and never to allow for equipment that knowingly exceeds the permissible vibration criteria.

6.1. Hauraki District Plan

Section 8.3.2.1 of the Operative Hauraki District Plan provides commentary on the effects of ground vibration, how it may affect structures or amenity, and a series of permissible levels for different activities. Section 8.3.2.1 states:

(1) Introduction –

a. Ground vibration from land use activities can range in effect from structural damage to buildings (relatively extreme level of vibration) to disturbance of sleep and reduction of amenity as a result of people being able to perceive vibration. It is considered that ground vibration standards should be set in terms of human perception rather than in relation to the structural implications for buildings, thus ensuring that the amenity values of any area are not unreasonably compromised.

b. Measurement of vibration is taken in the ground rather than in affected buildings, as buildings respond differently and thus the vibration response in the building may amplify ground vibration. It is beyond the scope of this standard to define that response.

(2) Types of Ground Vibration

a. Ground vibration may be continuous or transient, with transient vibration being either impulsive or intermittent vibration.

b. Continuous vibration is vibration that remains uninterrupted over a given time period, typically a period of several minutes or more (e.g. vibration generated by construction equipment such as impact and vibratory rollers).

c. Impulsive vibration is a short duration event, that involves the rapid build-up of vibration then decay, that may comprise a single pulse or a number of pulses (e.g. vibration generated by blasting)

d. *Intermittent vibration is a string of vibration incidents, each of short duration and separated by intervals of a much lower vibration magnitude*

e. *Acceptable levels for continuous vibration are considerably less than those for transient vibration.*

(4) Transient Vibration[1]

a. *Isolated vibration events that occur infrequently and/or irregularly (e.g. only a few times a day) present special concerns to residents and accordingly must also be addressed and managed. This will be done by setting an appropriate standard for transient vibration, to ensure that amenity values are maintained at a reasonable level. Any transient vibration in excess of the standards set may be considered through the resource consent process and the standards set out in this rule will be used as? a guideline in setting conditions.*

b. *Vibrations from blasting are impulsive, of short duration and superimposed on background vibration levels*

c. *Human response to transient vibration can be wide ranging, with the same event being imperceptible to some persons, while causing nuisance to others*

d. *The standards set to control transient vibration are based on international standards and monitoring and experience, developed to protect and preserve amenity values*

e. *In considering transient vibration from the perspective of human perception the following levels have been adopted.*

Transient Vibration Level	
Less than 0.5mm/s	*Imperceptible (threshold of perception)*
0.5mm/s to 2.0mm/s	*Slightly perceptible (barely noticeable)*
Greater than 2.0mm/s	*Distinctly perceptible (noticeable)*

f. *Transient vibration levels in excess of 5mm/s have the potential to compromise amenity values*

g. *As the vibrations are of relatively short duration where V_{Max} is controlled to avoid nuisance the statistical analyses to obtain the 99 percentile vibration levels is of little meaning, as the results depend on the length of vibration record. Accordingly, when monitoring vibrations, the control will be in terms of V_{Max}.*

h. *Blasting events should be designed in such a way as to comply with the standards set. However, the Council recognises that the prediction of the maximum ground vibration experienced from any particular blast event is dependent upon distance from the source, ground conditions and design of the blasting pattern. A complex relationship exists between these factors and therefore occasional exceedances of V_{max} may occur.*

Section 8.3.2.3 gives standards for vibration and proposes values for continuous and transient vibration. The section on transient vibration is included below:

(a)The maximum limits and parameters for ground vibration exposure resulting from activities other than those using explosives or similar impulsive and energetic materials are:

Parameter	*Standard*
Monday to Saturday 0700-1800	*5mm/second peak amplitude (Vmax)*
All other times and on Sundays and public holidays	*1mm/second peak amplitude (Vmax)*

[1] Section (3) entitled Continuous Vibration has not been included in this report because of its irrelevance

(b)The maximum limits for ground vibration and overpressure exposure resulting from activities using explosives or similar impulsive and energetic materials are:

Parameter	*Standard*
(1) Blast Event[2] Duration as defined by the delay timing (ie the difference in time between the first and last charge detonation)	*1 second*
(2) Number of Blast Events per holding, or for exploration activities, per exploration or mining permit area	*3 per day, separated by an interval of not less than 10 minutes between blast events, and no more than 21 within a calendar year*
(3) Overpressure (P_{Max})	*120dBL*
(4) Peak Amplitude (V_{Max})	*5.0 mm/second*
(5) Time of Day	*0700-1800*
(6) Days	*Monday to Saturday (excluding public holidays)*

Section 8.3.2.4 of the District Plan states the following in relation to the 95-percentile:

(7) For resource consents, transient ground vibration is typically set in terms of a 95 percentile, and may include a maximum limit. The percentile limit will generally be applied to the design for each and every blast so that induced disturbances will not exceed the 95 percentile limit on more than 5 percent of occasions (and will never exceed the maximum limit where set). The 95 percentile limit has little meaning for the activities that are permitted under the transient ground vibration limits set in this standard as the derivation of the relationship between explosive charge, distance and ground response required to undertake such a design can only be achieved through a series of trial blasts. Accordingly it is the V_{Max} level as referred to and defined in this standard that is the performance standard for transient ground vibration.

6.2. Comparison with Other International Standards and Guidelines

Performance guidelines for vibration from blasting activities are typically drawn from peer reviewed standards and guidelines from Australia, Britain, Germany or the International Standards Organisation (ISO) because of the high level of detail and analyses that have been applied in developing these guidelines. Table 3 gives an overview of the relevant international standards reviewed and their relevance to the Hauraki District Plan and the existing resource consents with vibration limits

Standard	*Content*	*Relevance to Hauraki District Plan*
NZS4403: 1976[3] *The storage, handling and use of explosives (Explosives Code) (New Zealand Standard)*	Outdated and withdrawn standard developed in 1976 with no significant updates since initial version. References methods of blasting which are now rarely undertaken. Standard provides values which are significantly higher than other values specified in local district plans or other internationally accepted standards.	Initially applied to blasting at Martha Pit as per the expired Mining Licence conditions prior to the Mining Licence variation in 2017, although now no longer relevant.
ANZEC: 1990[4]	Australia and New Zealand Environment Council document specifically addressing vibration and air overpressure limits for long term activities that recognise amenity effects on adjacent residents.	Vibration levels consistent with the Hauraki District Plan.

[2] For the purposes of the above standard a "blast event" means an individual or number of linked individual blasts of not more than the total duration specified in (1) above

[3] NZS4403: 1976, Standards Association of New Zealand, Code of Practice for "The storage, handling and use of explosives (Explosives Code)", UDC 614.83:662.2

[4] Australian and new Zealand Environment Council (1990), "*Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration*".

Standard	Content	Relevance to Hauraki District Plan
AS2187.2:2006[5] *Explosives—Storage and use* *(Australian Standard)*	Specifies personal amenity criteria for blasting based upon project duration (Less than or greater than 12 months). References BS7385-2:1993 for protecting buildings from vibration related damage from blasting. Proposes ground vibration limits for blasting that are based upon human comfort which necessarily prevent cosmetic or structural damage to dwellings. Specifies a vibration limit for sensitive sites which are described as houses, theatres, schools and other similar buildings occupied by people at 5mm/s. Also specifies a limit of 25mm/s for occupied non-sensitive sites, such as factories and commercial premises.	Consistent with the Hauraki District Plan, the Mining License following the 2017 variation.
BS6472-2:2008[6] *Guide to evaluation of human exposure to vibration in buildings. Blast induced vibration* *(British Standard)*	Supersedes BS6472-1:1992 which was one of the most commonly referenced standards in terms of vibration assessment with respect to amenity. Small changes in 2008 version with respect to weighting factors associated with dosage criterion. Provides advice in respect of human exposure to blast induced vibration in buildings. Suggests human comfort criteria for building usage categories, listed below in order of increasing sensitivity: • Workshops • Offices • Residential (daytime) • Residential (evening) • Critical working areas. Maximum satisfactory vibration magnitudes for up to three blast vibration events per day vary between 2mm/s for night time residential through to 14mm/s for offices. A daytime residential criteria is set at between 6mm/s and 10mm/s, based upon 90% compliance. Satisfactory air overpressure limits are not given but this standard indicates that a level of 120dBL is around 3% of the minimum level required to crack pre-stressed, poorly mounted windows.	Permissible BS6472 levels are higher amplitude than the vibration levels in Hauraki District Plan, This standard provides a lower “compliance percentile”, requiring 90% of blast activities to be below the applicable vibration limit. Conditions of the resource consents held by OGNZL require 95% of blasts to be less than the applicable limit.
BS7385-2:1993[7] *Evaluation and measurement for vibration in buildings. Guide to damage levels from ground borne vibration* *(British Standard)*	Along with the German Standard DIN4150, also one of the widely referenced standards relating to the protection of buildings. The limits in the Australian Standard AS2187.2-2006 adopt the BS7385 values for prevention of cosmetic damage for different building categories. Provides guidance on managing buildings and structures with additional information. For example:	Necessarily complied with because of the amenity based criteria specified in the Hauraki District Plan and the Mining License following the 2017 variation

[5] AS2187.2-2006, “Explosives – Storage and use – Use of explosives, SAI Global

[6] BS6472-2:2008, “*Guide to evaluation of human exposure to vibration in buildings Part 2: Blast induced vibration”*, British Standards BSI

[7] *BS7385-2:1993, “Evaluation and measurement for vibration in buildings – Part 2: Guide to damage levels from groundborne vibration”, British Standards, BSi*

Standard	Content	Relevance to Hauraki District Plan
	• A building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive. • Structures below ground are known to sustain higher levels of vibration and are very resistant to damage unless in very poor condition. • There is little probability of fatigue damage in residential building structures due to the frequency content of blasting activities.	
DIN4150-3:1999 [8] *Structural vibration Effects of vibration on structures* *(German Standard)*	Well referenced standard that provides guidance for services and structures. For building types consistent with those around Waihi, the standard proposes acceptable values between 5mm/s and 20mm/s, depending upon the frequency of vibration. Typical blast frequencies at Waihi equate to a minimum permissible value of around 10 to 15mm/s. Higher permissible values may be applied where structure condition is sound.	Compliance with the vibration standards of the Hauraki District Plan will comply with this standard because the Hauraki District Plan standards are more stringent.

Table 3 - Summary of permissible vibration levels in international standards and guidelines

6.3. Existing Vibration Standards

The vibration conditions for mining operations at Waihi, including the former mining licence and EMMA consent conditions as well as resource consents for Project Martha (MUG and Martha Pit Stage 4) and the previous underground mines (Favona, Trio, Correnso, SUPA), are generally based around the Hauraki District Plan standards, but can include a number of additional constraints such as blast times, number of events, blast duration and so on. These ensure that OGNZL adheres to best engineering practices as well as respecting the amenity and sensitivity to vibration of surrounding land uses.

The additional constraints imposed on the Waihi operations by the conditions of resource consents are identified as further protection for the amenity of the adjacent residents. The conditions given in the various permitted activity and resource consent conditions aligns with the peak vibration criterion expressed in the Australian Standard and ANZEC Guidelines. These standards are shown to be conservative when compared to other standards. When coupled with the additional constraints on firing times, blast durations, blast types, average vibration levels and number of blast events, they are shown to appropriately address amenity and infrastructure effects. The current Company conditions require that mining at Waihi employs world's best practices to achieve compliance with values that are protective of the amenity of the residents to a far greater degree than would be ensured through adopting any other standard or guideline related to blasting.

7. ASSESSING THE PLAN CHANGE

The properties potentially affected by blasting associated with mining activities undertaken in the expanded Martha Mineral Zone are shown in Figure 3.

[8] DIN4150-3, (1999), "*Structural vibration – Effects of vibration on structures*", SAI Global

Figure 3 – Land potentially affected by vibration generated within an Expanded Martha Mineral Zone

An assessment of the potential adverse vibration effects associated with mining activities in an expanded Martha Mineral Zone requires consideration of three key matters:

- Establishing permitted vibration criteria for the impulsive vibration generated by blasting activities.
- Establishing the pathway for statutory implementation of the permitted vibration criteria, whether as Plan provisions or as conditions of individual management plans included in any resource consent application(s) to undertake further mining activities in the MMZ - as is the case at present, and
- The effect of the Plan Change on the amenity of affected land uses.

7.1. Setting of Vibration Limits

Ground vibration limits are typically set to preserve people's amenity and are at levels well below those at which property damage could occur. There is no one limit in use worldwide, with New Zealand continuing to adopt the most stringent values applied anywhere in the world. Applicable vibration limits are based on research conducted over decades by various independent groups, and subsequently form the basis for internationally accepted standards and guidelines. By design, they are typically over-engineered to provide a high safety factor, particularly with reference to building damage.

In some cases, vibration limits may be expressed as a single value, for example 5 mm/s, where the focus is the protection of amenity. Where the focus is for the protection of structure response, such as the criterion given in British and German Standards, it is more likely that the applicable value will vary based on frequency.

Vibration levels for the protection of amenity vary, but typically the most stringent of these levels is 5mm/s. Where vibration may occur throughout the day, evening periods are always less than the applicable daytime value, however it is more common that any vibration during the evening period is limited to a level that is imperceptible, or just above the level of perception. Vibration limits focussing on amenity from continuous sources are around ½ the value when compared to short term impulsive activities like blasting.

Whilst amenity based limits are generally stated as a simple single value, frequency-based limits are better linked to structure response. The recommended limits in standards generally relate to the prevention of threshold cosmetic damage in the most susceptible of materials of the structure such as plaster and low density building materials.

The permissible vibration limit will be heavily biased toward maintaining amenity for persons around the Martha Mineral Zone, consistent with Policy 5.17.2(1)(a)(iii) of the Hauraki District Plan. Because of this, there is no requirement to consider other vibration values that limit building damage as these will be higher than the amenity driven criterion.

If an amenity based vibration level is applied to commercial premises, it is typically less restrictive than that for residential properties, that is a higher permissible level. Where an alternative value is applied, a limit twice that of the residential value is common.

As a result of the influence of the uncontrollable factors that may contribute to the measured vibration levels, it is common for the vibration conditions to be expressed as a percentile value, such as the 95% compliance. The percentile application of a vibration condition is to account for these unknown and varying influence factors, not to account for poor performance in designing and implementing blasting, and never to allow for a blast pattern designed to knowingly exceed the permissible vibration criteria.

The vibration conditions have been specified in the resource consents to protect the amenity of the townspeople and to ensure the integrity of the properties is appropriately protected. It is proposed that the same approach of broadly considering the blasting vibration limits specified in Section of 8.3 of the Hauraki District Plan but having these explicitly presented in the Resource Consent continues. This represents a continuation of the approach taken to date.

It should be noted that the permitted activities in the Martha Mineral Zone (e.g. exploration drilling etc) are subject to the existing vibration standards in Section 8.3 of the Hauraki District Plan and that these standards remain appropriate for managing the amenity effects of these activities.

Endeavouring to establish vibration conditions in the District Plan for mining activities would potentially be complex, given the varying types of conditions and additional criteria relating to the different aspects of blasting, such as the type of blast, the duration, average and maximum permitted levels, management plans, the number of events and so on, each of which are detailed in the Resource Consents for each project.

7.2. The Effect of the Plan Change

This section of the assessment seeks to:

- Quantify how the existing vibration environment would change as a result of mining activities in the expanded Martha Mineral Zone.

- Describe the potential adverse effects of the changed vibration environment resulting from mining activities in the expanded Martha Mineral Zone.

The assessment adopts the methodology for setting vibration limits recommended in the preceding section (i.e., via resource consent conditions). It assumes such limits will be generally consistent with the Hauraki District Plan provisions.

The permissible scale of blasting has been analysed for a pit crest that could potentially be established within the expanded Martha Mineral Zone, a copy of which is attached to the Planning Assessment by Mitchell Daysh. In addition to the allowable explosive weights, the assessment has presented the effects as vibration contours. Figure 4 shows a representative range of properties where compliance with the vibration criterion would be required.

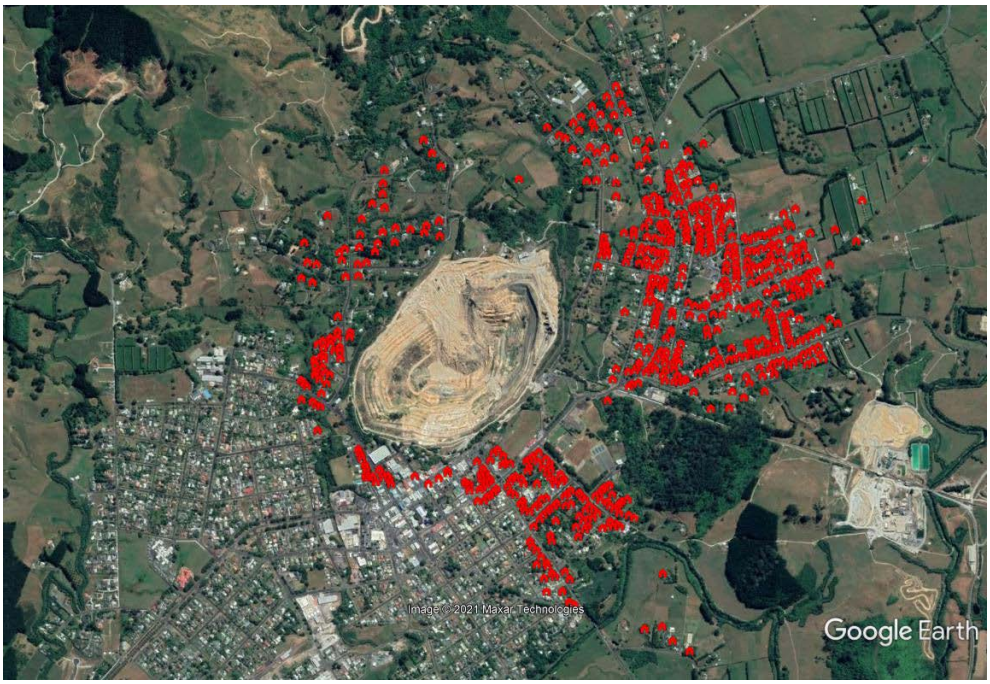


Figure 4 – Properties included in the assessment where compliance with the vibration criterion is required

The approach is as follows:

i. For the operative Martha Mineral Zone, consider a "worst case" scenario where blasting could occur at any location within a justifiable pit located in the zone. The scale of blasting will be controlled by the requirement to comply with the vibration criterion at all non-company sensitive receptors. The vibration effects at the surrounding receptors are determined by the scale of blasting and their distance from the blast. The effects can be presented as a suite of vibration contours. The vibration criterion is 5mm/s

ii. For the expanded Martha Mineral Zone, apply the same approach of establishing the scale of blasting based upon the closest non-company owned sensitive receptors and subsequently show the potential effects as a series of vibration contours.

For the operative Martha Mineral Zone, the extent of the vibration impacts assuming a "worst case" scenario as described in (i) above is shown in the following Figure 5 with the vibration contours varying between 1mm/s and 5mm/s, equivalent to vibration values that would be generally imperceptible through distinctly noticeable.

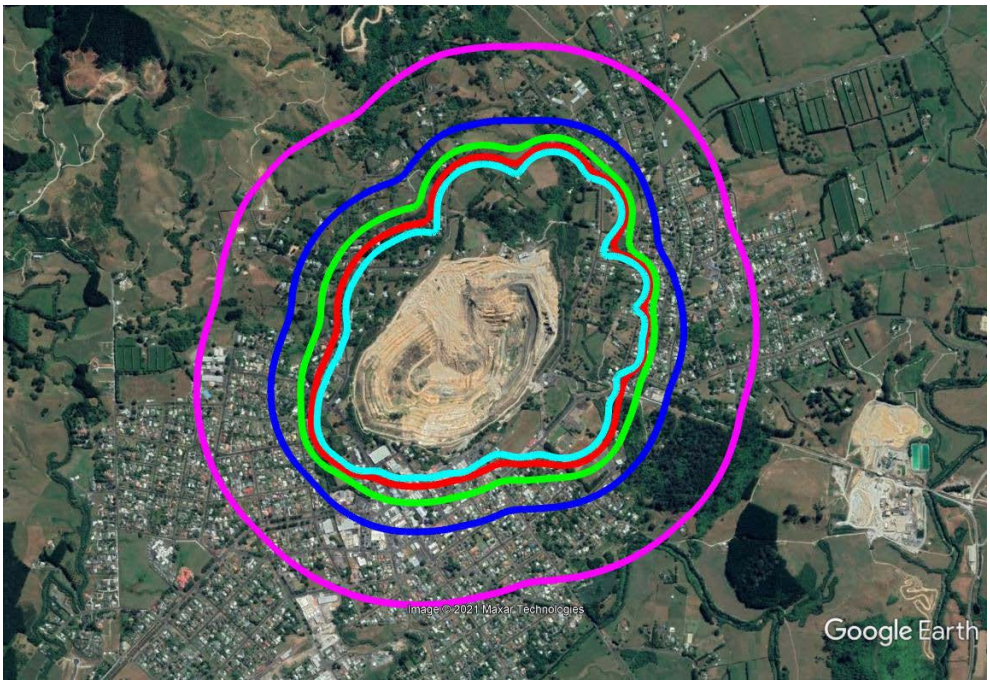


Figure 5 – Operative Martha Mineral Zone showing the maximum extent of vibration based upon blasting within a reasonably defined pit. Contours values are represented by 1mm/s (magenta), 2mm/s (blue), 3mm/s (green), 4mm/s (red) and 5mm/s (aqua)

For the expanded Martha Mineral Zone, the vibration effects of the "worst case" are shown in Figure 6 with the same vibration contours. These drawings are also shown in Appendix A.

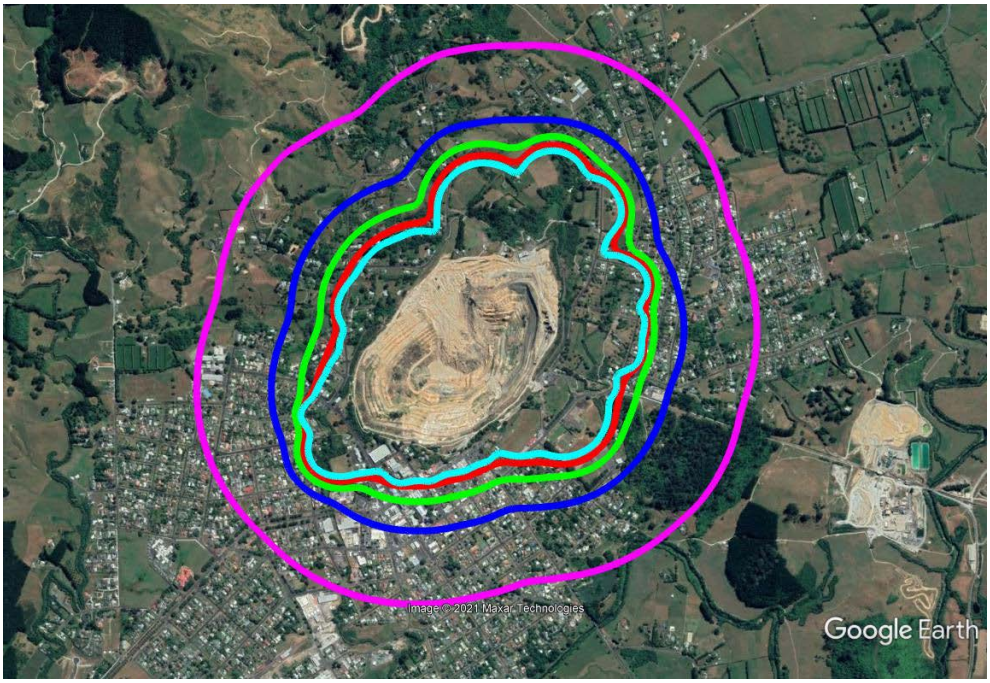


Figure 6 – Expanded Martha Mineral Zone showing the maximum extent of vibration based upon blasting within a reasonably defined pit. Contours values are represented by 1mm/s (magenta), 2mm/s (blue), 3mm/s (green), 4mm/s (red) and 5mm/s (aqua)

A comparison of the vibration contours in Figures 5 and 6 shows the extent of the vibration impacts from the expansion of mining in the extended Martha Mineral Zone are likely to be the same, with the exception of a small area in the south-west corner where the vibration effects from mining the expanded Martha Mineral Zone include a slightly larger area. Whilst the extent of any perceptible vibration from the blasting extends no further from the blasting for the Martha Mineral Zone, as shown by those areas

within the outer magenta 1mm/s contour, those properties closest to the mineralised zone may experience a marginally higher vibration level when blasting occurs nearest to their properties. An expanded view of the south-west corner for both mineralised zones is shown in Figures 7 and 8.

Figure 7 – South west corner of the operative Martha Mineral Zone showing the maximum extent of vibration based upon blasting within a reasonably defined pit

Figure 8 – South west corner of the Expanded Martha Mineral Zone showing the maximum extent of vibration based upon blasting within a reasonably defined pit

The potential effects of increasing the extent of the Martha Mineral Zone, and potentially moving blasting nearer to properties and townspeople as part of an enlarged Martha Pit, is unlikely to produce additional impacts for most neighbouring properties, with only one area showing a small increase in the effects of any vibration from blasting. The minimal additional impact occurs in the south-west corner and only for

blasting that would occur in the same area. The impact in this area is likely to be minor given both the marginal increase in vibration and the limited number of occurrences over which this would occur.

However, the resource consent process would enable the potential adverse vibration effects of any expansion of the Martha Pit in this location to be assessed and appropriate vibration limits applied via consent conditions if appropriate.

The project has developed an Air Quality Management Plan. The original document was developed in 1999 with a further 10 revisions and updates introduced into the current version. The significant history of the document ensures that it has addressed multiple sources of air quality impacts, including the potential implications from fumes associated with blasting. Section 5.2.2 of the Air Quality Management Plan specifically addresses blasting emissions and identifies:

Management of the effects from blasting in the open pit and underground is reviewed by OGNZL daily. Pending blasts are discussed and consideration given to the likely effects on nearby residents. Adverse weather conditions, and sleeping shots (where explosives have been in the ground overnight and tend to give off more fumes when fired), may require liaison with any concerned residents.

Blasting will continue to implement the same procedures that have been successfully adopted for all blasting, including the Martha open pit where blasting has occurred near to residents with impact. There have been no instances where an unacceptable level of NO_x gases has originated from the blasting events at Waihi. The key procedures of eliminating the sleeping of blasts, as well as continuing to utilise explosive products with a formulation to minimise fumes will be implemented. As a final control measure, where blasting occurs near to sensitive receiver groups, such as the Central School, the weather conditions will be monitored in advance of loading the blast pattern. Should the prevailing wind be unfavourable, and there is an identified risk of fume being generated by the blast, the blast will be postponed and blasting/mining temporarily relocated to a less critical area within the pit.

It is proposed that the mining documents will be reviewed upon start up of the Martha open pit blasting, a risk assessment completed and if the outcomes identify an unacceptable risk, the fume management controls will be updated. The current Waihi Surface Explosive Management Pan acknowledges that the blasting exclusion zone shall consider the potential for fumes and the prevailing weather conditions.

Blasting at the Martha operation has been continually and successfully completed over a thirty year period with no instances of flyrock being propelled outside of the nominated exclusion zone, aside from that originating from a single hole, or perhaps a small group of holes, within a pattern initiated on the 29th June 2007. In this instance, flyrock was scattered over an area of approximately 30 to 40 metres outside of the blast exclusion zone with some of the particles landing on the mine offices in Moresby Avenue, as well as a commercial property in Seddon Street. No injuries occurred.

The event was reviewed by several groups, including the Hauraki District Council and their advisor. The key findings included:

- Some blastholes were inadequately stemmed to only around 50% of the design stemming length.
- Some blastholes were overcharged or the explosive placed in the incorrect horizon within the blasthole.
- Some holes were incorrectly loaded with emulsion emanating from the collar hole as the stemming material was being lowered into the blasthole.
- Probe holes were not located and stemmed prior to the blast.
- Some collars of the blasthole were higher than designed and lead to a higher powder factor.

Adjustments to the Blast Management Plan were adopted to mitigate these identified flyrock causes. Blasting has continued in the areas for the following ten year period between 2007 and 2017 without further incident.

The same level of detail and key steps within the Blast Management Plan will be adopted for all blasting where the possibility of unacceptable flyrock outcomes exist.

8. RECOMMENDATIONS AND CONCLUSIONS

The vibration conditions attached to the existing resource consents held by OGNZL reflect the permissible vibration values presented in the international literature, other standards and guidelines. They are protective of amenity and therefore (given the stringency of vibration limits applied for amenity purposes) are also protective of the integrity of buildings and dwellings. They also largely reflect the existing standards in the Hauraki District Plan.

The existing limits in the District Plan are appropriate for permitted activities (noting that Rules 15.17.4.1 (P1) and (P2) are subject to specific limits as part of the former mining license and resource consent).

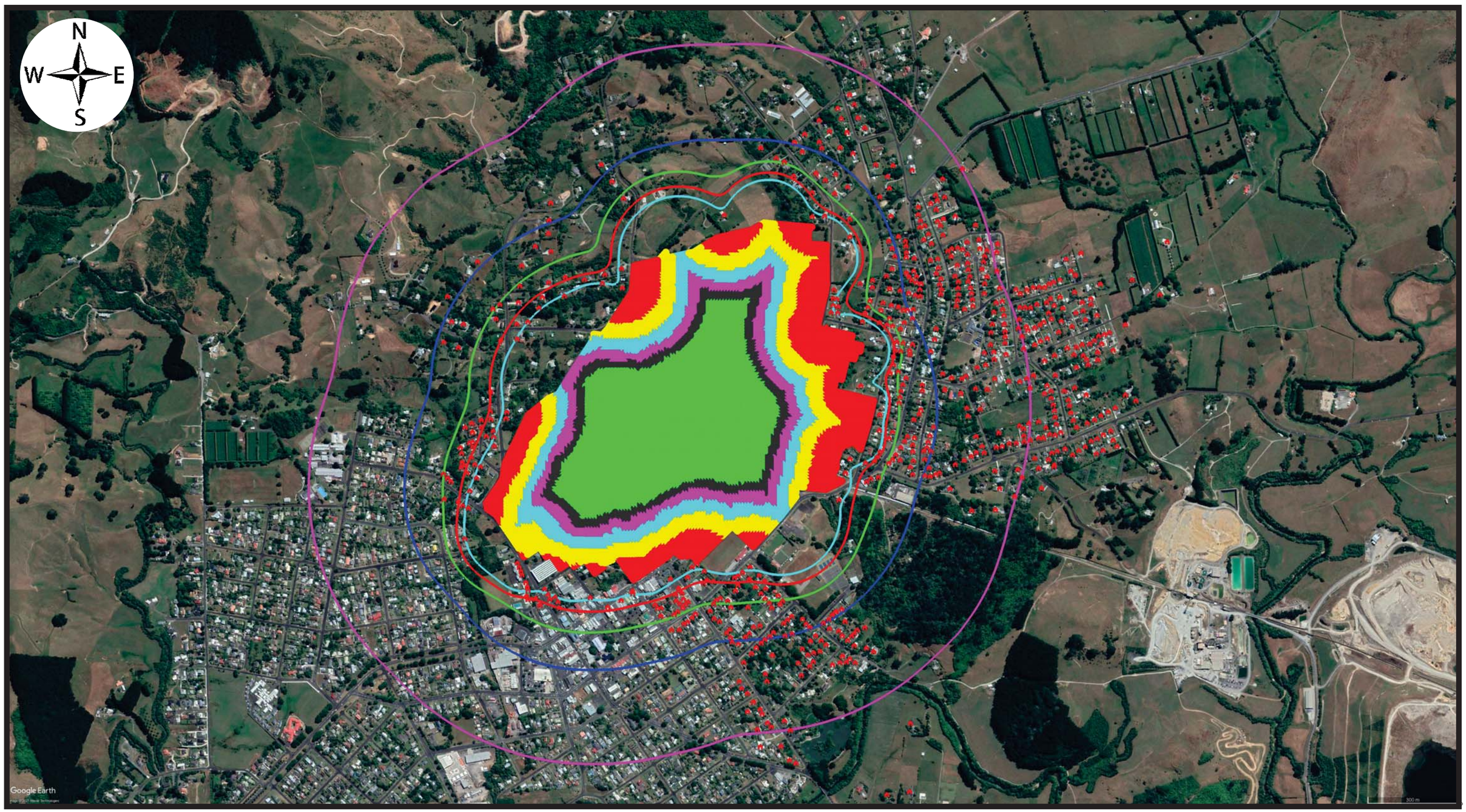
Given the appropriateness of the vibration conditions presented in the existing resource consents and that these have been successfully applied over a period of more than 30 years at the Waihi operations, it is recommended that the vibration conditions for the expanded Martha Mineral Zone continue to be presented with any resource consent application(s). The standards controlling vibration are complex, but the consent processes to date have demonstrated that an appropriate set of limits can be set through the consent process. This will allow the vibration conditions to be better assessed based on the project definition as well as allowing them to be supplemented with project specific criteria that better address other blasting that could occur concurrently within the mineralised zone. These matters could form part of the assessment criteria for any potential expansion of the Martha Pit.

An assessment of the potential adverse vibration effects of blasting within the expanded Martha Mineral Zone has concluded that the existing expectations of the Hauraki District Plan in terms of protecting amenity can be achieved (and will also avoid the potential for property damage).

Importantly, the assessment shows that potential adverse vibration effects are equivalent to those that might occur from any blasting undertaken within the operative Martha Mineral Zone. The exception is a small section close to the south-west corner of the Martha Pit where a small number of properties (less than 20) might experience vibration slightly higher than from the presently permitted blast areas. In this small area, the effect would see a property presently receiving 2mm/s increasing to 3mm/s from a small number of blasts that occur closest to the property. Whilst both levels of vibration would be perceptible, it is likely that persons may not be able differentiate between blasts generating 2mm/s or 3mm/s.

As the location of blasting moves away from those properties and towards the centre of the zone, the effects will be equivalent to those occurring from blasting within the operative Martha Mineral Zone.

9. APPENDIX A – VIBRATION MODELLING RESULTS



Created using TunnelTRAP Software

Sensitive Receivers

SCALE

0 150 300 450 600 750m

Surface Vibration Levels

- 5 mm/s Vibration Contour
- 4 mm/s Vibration Contour
- 3 mm/s Vibration Contour
- 2 mm/s Vibration Contour
- 1 mm/s Vibration Contour

Explosive Quantities

- More than 15 kilograms
- Between 12 and 15 kilograms
- Between 9 and 12 kilograms
- Between 6 and 9 kilograms
- Between 3 and 6 kilograms
- Less than 3 kilograms

Project Description: OCEANAGOLD PLAN CHANGE - Existing Martha Mineral Zone - Vibration contours from blasting activities based upon back calculated explosive weights for compliance with 5mm/s at sensitive residential receivers.

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OCEANAGOLD WAIHI OPERATION

Plate No. 1

Revision History

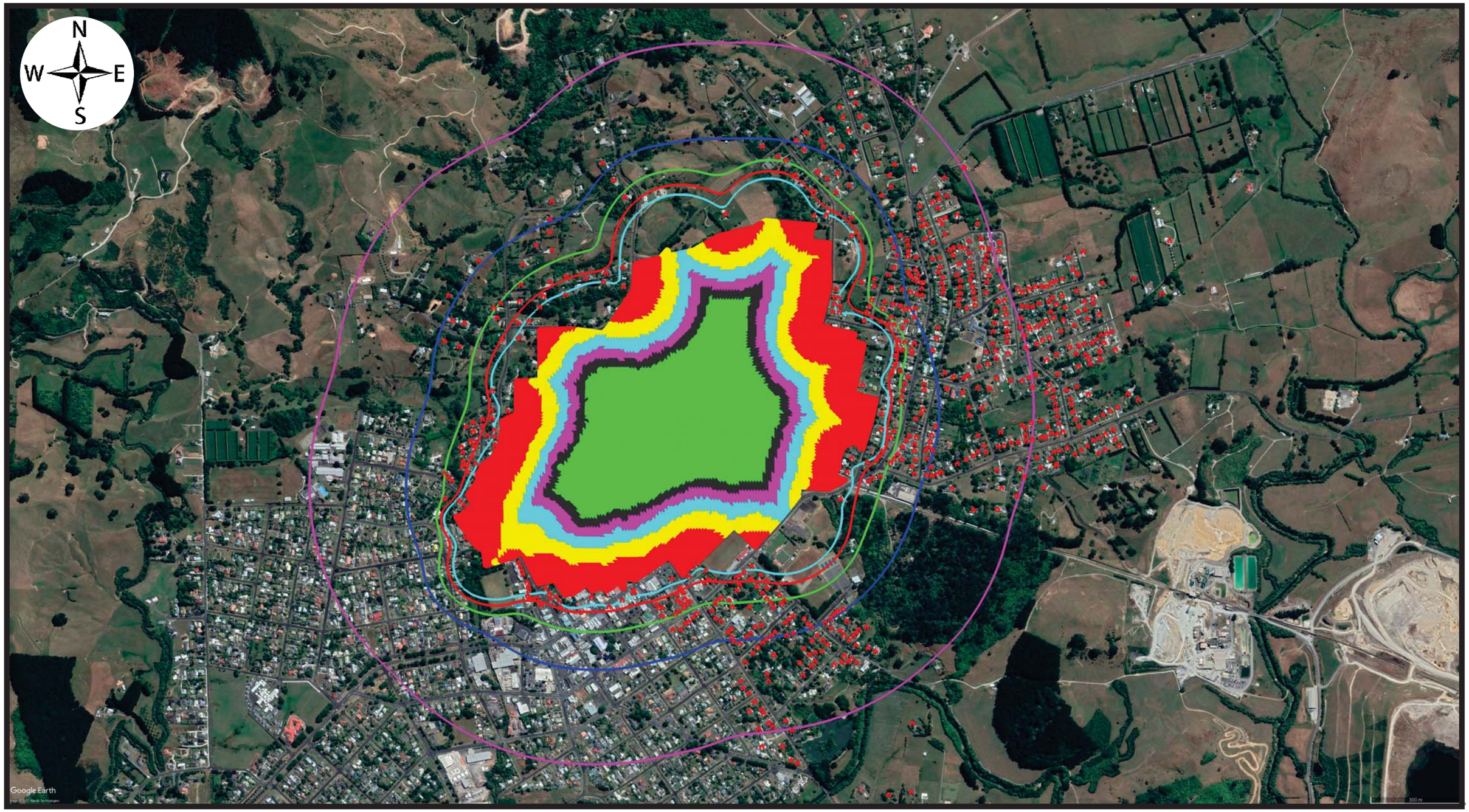
R1: Original

Date Drawn: 14 July 2021

Ref No: Oceanagold Plan Change

Job No: HP2105-2

In preparing this drawing, HP have made certain assumptions. We have assumed that all information and documents provided to us by the Client or as a result of a specific request were complete, accurate and up to date. Where we have obtained information from a Government register or database, we have assumed that the information is accurate. Where an assumption has been made, we have not made any independent investigations with respect to the matters the subject of that assumption. We are not aware why any of the assumptions are incorrect.



Created using TunnelTRAP Software

Sensitive Receivers

SCALE

0 150 300 450 600 750m

Surface Vibration Levels

- 5 mm/s Vibration Contour
- 4 mm/s Vibration Contour
- 3 mm/s Vibration Contour
- 2 mm/s Vibration Contour
- 1 mm/s Vibration Contour

Explosive Quantities

- More than 15 kilograms
- Between 12 and 15 kilograms
- Between 9 and 12 kilograms
- Between 6 and 9 kilograms
- Between 3 and 6 kilograms
- Less than 3 kilograms

Project Description: OCEANAGOLD PLAN CHANGE - Proposed Martha Mineral Zone - Vibration contours from blasting activities based upon back calculated explosive weights for compliance with 5mm/s at sensitive residential receivers.

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OCEANAGOLD WAIHI OPERATION

Plate No. 2

Revision History

R1: Original

Date Drawn: 14 July 2021

Ref No: Oceanagold Plan Change

Job No: HP2105-2

In preparing this drawing, HP have made certain assumptions. We have assumed that all information and documents provided to us by the Client or as a result of a specific request were complete, accurate and up to date. Where we have obtained information from a Government register or database, we have assumed that the information is accurate. Where an assumption has been made, we have not made any independent investigations with respect to the matters the subject of that assumption. We are not aware why any of the assumptions are incorrect.