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Kamloops Area Preservation Association

Kamloops, BC.

Report

KGHM Ajax Mining Co. Application Noise and Vibration Review and Recommendations

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SUBMITTED TO

Kamloops Area Preservation Association
Kamloops, BC

SUBMITTED BY

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1. INTRODUCTION

The following letter report summarizes our review and provides comment and recommendations regarding the assessment of noise and vibration completed for the KGHM Ajax Mining Co. Ajax Mine application. The comments were prepared for the Kamloops Area Preservation Association (KAPA) in Kamloops BC, as part of a concerned citizen group looking for clarification regarding potential for health effects at homes and local schools nearby in the City of Kamloops.

The review comments on the types and appropriateness of the following aspects of the application:

- general noise and vibration assessment approach, specifically the determination of 'magnitude of change',
- sound level and vibration criteria used,
- sound level prediction approach and method,
- vibration prediction approach and method, and
- mitigation and management planning.

The approach taken was to highlight primary notes with respect to community issues currently and previously expressed. There has been no detailed numerical review within the current scope of work so results are taken at face value unless the review highlighted an unexpected data gap or result.

As an Acoustic Scientist, I am not qualified to comment directly on human health, but have practiced in the Environmental Acoustics field for over 20 years and can comment on where health related data has influenced various criteria and protection measures put in place by regulators over the years, in addition to commenting on the technical content of the Noise and Vibration Assessment.

2. GENERAL CONCEPTS: SOUND, VIBRATION, AND HEALTH

2.1 Sound

Sound can affect human health directly, as hearing loss and sleep disturbance; and indirectly, through nuisance related stress. Direct effects causing hearing loss are related to occupational exposures and are not further discussed. In an environmental context, sound resulting in sleep disturbance and nuisance are the issues that may occur.

There is a moderate body of knowledge regarding how sound levels may result in sleep disturbance. Data exists from lab studies and from general review of real-world measurement data compared to health surveys (World Health Organization studies). There is little data available in scientific literature regarding the correlation of sound to overall nuisance stress then to health. This is due to the combined influence of all sensory, social and economic factors that accumulate to result in 'stress'. There is a moderate body of knowledge of recorded complaints from industrial sound. Therefore, general practice in acoustics is to manage the stress factor we can (nuisance noise) to below levels where complaints generally do not occur. Regulations have grown around this body of data so can generally be considered a good guide, but will not typically encompass 100% of a population response as sensitivities vary.

Whether in an occupational or environmental context, the effects of sound are a combination of level and duration. Environmental sound is generally highly variable, and dependent on local conditions, therefore, the sound level indicator used is the integrated average sound level or L_{Aeq}. This geometric averaging takes into account the variability of natural and manmade sound, resulting in an 'average' that is higher than the linear or typical average. It is the indicator and method used to account for environmental sound levels over time in multiple international standards.

The preferred time basis for L_{Aeq} values depends on the local regulations, but generally follows a day/night division, with some regulations looking at a one hour maximum. The relevant thresholds will vary due to the time basis and the degree of local development.

All sound levels are measured in decibels (dB), which is the unit of measure for pressure waves that travel through the air (or water). When measuring or calculating sound relevant to human perception, all decibel values are A-weighted (dBA or L_{Aeq} in dBA). A-weighting shows that the measured sound pressure levels have been filtered using a frequency weighting network that mimics the response of the human ear.

With respect to cyclic activity or the degree of variation in sound, general guidance indicates that a change in sound level of 3 dBA is 'just noticeable' (Crocker 2007), 5 dBA changes are generally considered noticeable in an outdoor or variable environment. Corollary to this is the logarithmic mathematics of sound that indicates one sound that is 10 dBA greater than another is the dominant sound (a 30 dBA sound added to a 40 dBA sound equal a total of 40 dBA: the 30 dBA sound does not change the total). For sleep disturbance WHO recommends 40 dBA as the highest average L_{Aeq} sound level in the bedroom, 42 dBA as the L_{Amax} (1-minute maximum) to prevent waking (WHO 2009).

The resultant sound pressure level with the associated unit "dBA" is therefore a representative of the subjective response of the human ear. The weightings are assigned in a way to reflect the higher sensitivity of human ear to sound in the mid and high frequency band as shown in the curve labelled A-weighting in Figure 1 below. Generally, the human ear does not hear lower frequencies well.

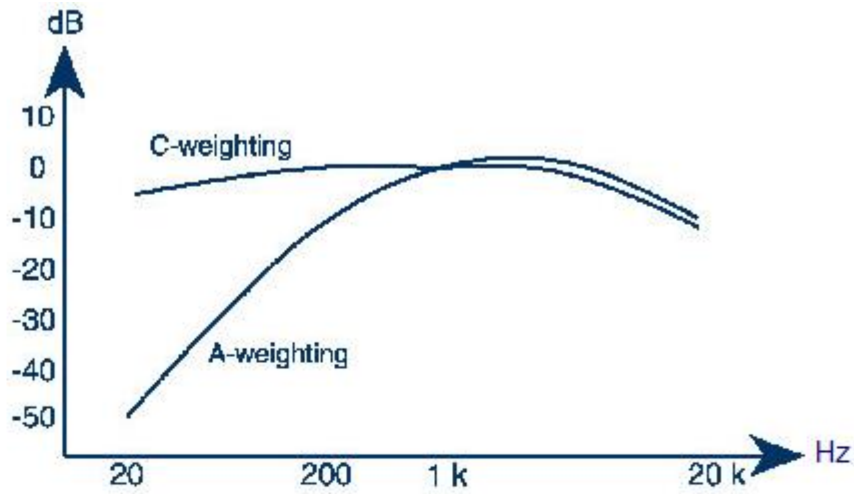

Figure 1: Sound Weighting Network

Notes: dB = decibel; unit used to measure the intensity of sound
Hz = hertz; unit of frequency of vibrations equal to one cycle per second
k = 1,000 units

Weather conditions can affect how sound moves through the atmosphere. The atmosphere itself absorbs some sound at the molecular level which is influenced by the inter-relationship of temperature and humidity. In general, as temperature increases, sound is attenuated and as relative humidity decreases, sound is attenuated. This inverse relationship means that the 'maximum' or point at which sound is least attenuated (propagates more) is at 10^0C and 70% humidity, which does often occur in Canadian weather conditions.

The final aspect of the atmosphere which affects sound propagation is wind. Again this is a complex relationship that is generally simplified to use a 'maximum' approach. Calculation standards are considered valid for wind speeds of 1-5 m/s and moderate inversion conditions; changes to sound propagation are similar for both conditions. At zero to low wind speeds, there is no turbulence to disrupt sound waves and the wind does not "carry" sound farther. The amount of sound carried for the range considered valid for the calculation standard does not vary as much as the amount of ambient sound associated with, or generated by the wind itself. Therefore, the generalized equations used for estimating environmental sound look at the 'maximum' amount of propagation for wind speeds that do not generate a greater amount of ambient sound which would mask or hide other sounds. There are calculation options to incorporate even more 'downwind' effects to look at a specific conditions for shorter periods of time (up to several hours), but the standard sites that increases of more than 2 dBA are considered 'exceptional' (ISO 9613 1996).

2.2 Vibration

Vibration from blasting occurs as a pressure wave in the ground (ground vibration) and in the air (air overpressure). Direct health effects from vibration again occur from occupational exposures and sleep disturbance with indirect effects occurring from nuisance contributions to stress. In an environmental context, sleep disturbance and nuisance are the effects which may occur. As blasting for the Ajax Mine will occur during the day, sleep disturbance is not considered; the discussion focuses on nuisance.

Ground vibration is expressed as peak particle velocity (PPV) in mm/s of the wave progress through the ground. Vibration levels that can be felt by humans are far below the levels that can cause property structural damage. Human reaction to blasting is dependent on vibration duration and amplitude and on other factors such as ambient noise levels and proximity to other vibration sources (e.g., rail lines, construction). People can start to detect ground vibration at about 0.2 mm/s, and will notice vibration to the point of disrupting a current activity between 3 and 5 mm/s.

Air overpressure or air blast is the blast wave front that travels through the atmosphere and is measured as the peak or instantaneous impulsive pressure level (no time averaging). As it is an atmospheric pressure wave, it is also measured in linear decibels (dBL), but should not be equated to 'sound' in the audible spectrum. Definitions can vary slightly in the literature regarding the frequency spectrum of blast air overpressure, but generally has a frequency range of between 0.1 Hz (Hertz) and 200 Hz. The part of the spectrum between 20 Hz and 200 Hz is technically within the audible range for people, but are not values heard well by people (see Figure 1 above). As an example, a blast with air overpressure of 115 dBL would be roughly equivalent to 90 dBA when the response of the human ear is considered. The perception of the sound is also affected by the duration. A 1 to 2 second blast would not be experienced the same way a sustained sound (like a power tool) would be.

Blasting vibration is calculated using formulae which consider the straight-line distance, explosive weights and timing. There are no three dimensional models for blasting that are commercially available. Graphic representation of blasting vibration can be made by using a calculated result and applying contour lines at appropriate distances from a defined source area.

A letter was prepared by Golder Associates, dated May 21, 2013, with respect to the potential for air overpressure effects to be excluded from the Ajax Assessment. The overall issue, that air overpressure should be included in the assessment, was correct. Ultimately, air overpressure was assessed. However, the interpretation on the behavior, audibility and perception of air overpressure waves were not correct; citation of this letter should be used with caution. Also, without any details on the blast design, formulae or attenuation factors included in the modeling conducted by Orica in the letter, RWDI cannot comment on the data presented. In practice, air overpressure will attenuate over distance, with that attenuation affected for each blast by the exact blast design, atmospheric conditions and terrain.

3. Ajax Mine Assessment Comments - Noise

A general comment on the assessment is that many details are not well defined or discussed. As an Acoustic Scientist, the implied meaning is often understood but requires assumptions be made. A number of data sources and interpretations should be better described to aid the reader in understanding the results.

3.1 Criteria

The noise level criteria cited in the assessment include both the BC Oil and Gas Commission (OGC) thresholds and Health Canada annoyance. Personal study has shown that the OGC cumulative threshold approach (which is heavily based on the Alberta Energy Regulator and Alberta Utility Commission approach) is equally stringent to the Health Canada %HA annoyance risk calculation in rural and most suburban areas. However, as human development density increases, the Health Canada %HA approach becomes more stringent (Drew, South 2011). This comparison indicates the cumulative threshold of 40 dBA, which is consistent with the WHO 2009 recommendation of 40 dBA L_{night} to prevent sleep disturbance. The WHO recommendation is relevant as the threshold is intended to protect the vulnerable portion of the population (children, the infirm, and the elderly). The recommended WHO limit to protect the general population is 55 dBA (WHO 2009).

The assessment cites the WHO recommended threshold as “42 dBA for the nighttime period”. The WHO document cites the 42 dBA value as an L_{max}, inside, in Table 5.1 of the WHO document. The final WHO recommendation of 40 dBA for nighttime noise was in Table 5.4 of the WHO document (WHO 2009). It is not clear in the definition or the results discussion that the 42 dBA value is used as a short term maximum.

- **Recommendation/Question: Proponent should clarify whether the 42 dBA value from the WHO 2009 reference was used in the context of an L_{max}, and if so, explain why short term sounds from equipment moving on the EMRSF were not evaluated to compare to this limit.**

Schools were identified as a receptor and the Health Canada criteria applied, which will generally address health issues. However, a discussion of typical expectation for school play areas and classroom setting could have been provided. Outdoor play area values (when children are present) are generally higher than the criteria used in the assessment (WHO 1999 recommends 55 dBA for outdoor areas).

Variation of sound over time was not discussed in the assessment. No easy criteria exist for variation of environmental sound, but could have been discussed in terms of human perception to changes in sound.

- **Recommendation/Question: Proponent should provide a discussion on the noticeability of changes in sound level and the expected change in sound during night and day periods.**

3.2 Receptors

Noise receptors for the assessment were identified separately from the baseline measurement receptor sites. This is a common approach where baseline studies appropriately occur long before project planning is complete. For the Ajax study, the measurement locations were considered representative of the various assessment receptors which is also acceptable. However, for continuity and clarity, the measurement receptors should have also been included in the list of assessment receptors as their exclusion created questions as to why. This would also provide control points for future confirmation/compliance monitoring.

- **Recommendation/Question: Proponent should provide assessment results for all baseline noise monitoring locations and discuss the potential change.**

3.3 Baseline Study/Existing Environment

The general methods, approach, equipment and analysis follow expectations. The duration of several days for measurement is considered sufficient for Environmental noise studies due to the available body of knowledge. Review of several days of results would indicate if local noise levels are typical of the types of area/community. If an unusual result were observed, additional monitoring to further define the area would be warranted.

Generally, measurements are not done in winter as assessments focus on the effects of sound during summer months when people may sleep with windows open. Opening a window will reduce the sound reduction of a wall by 95% so practitioners (and noise criteria) assume 100% of outdoor sound will occur indoors. In this case, use of the December data is conservative as natural and human generated sound levels are lower in winter than summer. When a lower ambient is used, the potential change from the addition of new sounds is greater.

The separation between location 1 and 6 in the Aberdeen area is relatively small. The results from December to June simply demonstrate the change in seasonal value, and are not solely due to development density. This is also supported by review of the raw data graphs in Appendix 10.5-1. For both Location 1 and 6, the lower sound levels measured in the day averaged around 35 dBA for both sites, and 30 dBA at night for both sites.

- **Recommendation/Question: Proponent should carry the discussion of variability of existing sound levels from Appendix A of Appendix 10.5-1 of Section 10 forward to Section 10.5.**

3.4 Predictions

The sound sources identified for the site and approach to defining the sound sources is appropriate. The general values of sound sources (the sound power levels) seem typical of mining projects. However, the assessment identifies the method for determining sources as through vendor data, in-house measurement data and theoretical formulae yet the references used for each source are not provided. A detailed confirmation of the validity of the source data is not possible without knowing which method was applied to which source.

The assessment identifies sound sources as being placed in the model as point line or area sources. However the tables in Section 10.5, Appendix 10.5-1 and Appendix C of Appendix 10.5-1 do not specify which method was applied to which source.

- **Recommendation/Question: Proponent should provide updated sound source tables that identify individual source references and model treatment as point, line or area sources.**

None of the sound source descriptions discuss back-up or reverse alarms. These can be included as part of the measured data for equipment operation, or as a separate theoretical value. Back-up alarms are a pure tone source, often distinguishable from other background sounds due to the nature and purpose of the alarm.

- **Recommendation/Question: Proponent should ensure the assessment results include the effect of back-up alarms on mobile mine equipment. If included in measured data, a discussion of tonal sources and effects should be included. If not included, update sound source tables and assessment results.**

Spatial placement of equipment on the site is described in generic terms and a figure showing distribution of sound sources or noise contours within the Plant Boundary that highlights sound source areas, was not provided. It must be assumed from how the Year 4/8 activity is described and the general shape of the contours outside the Plant Boundary that sound sources were placed at the EMRSF, which is the closest Ajax activity to Aberdeen.

Figures and mapping available in the assessment do not allow for easy interpretation of terrain heights with mine storage pile elevations. While terrain is 'considered' in the model, cross sections from the EMRSF to Aberdeen are not available to easily verify the final source heights and ground conditions on site that were considered in the model. Nor was a discussion provided in the Noise and Vibration assessment regarding whether there will be 'line of sight' visibility to equipment on the EMRSF.

- **Recommendation/Question: Proponent should provide updated or new figures that demonstrate the location of sound sources in the model and verify the EMSRF had sound sources located on it, and at the appropriate elevations.**

The model used in the assessment (Cadna/A) and the technical calculation standard (ISO 9613) are industry standard. The parameters used for the model are appropriate for the site. The assessment identifies that the calculation standard is valid for wind speeds of 1 to 5 m/s. It should also have stated that the equations in the standard are valid for moderately developed temperature inversion conditions (ISO 9613-2 1996). Consideration of a combination of temperature inversion and cloud cover is generally considered site specific, so would need to be defined though ongoing monitoring of sound during operations and additional mitigation if an issue was defined.

The ISO 9613 calculation standard includes multiple attenuation factors, such as distance, atmospheric absorption, meteorological conditions, barriers and ground attenuation. Caution should be used if comparing acoustic model results to available on-line calculators which may not include the same attenuation factors or do not cite specific formulae.

Results from the ISO 9613 method are generally viewed as conservative, but would not be an absolute maximum. Results are a day/night integrated average so would be expected to have variability, values above and below, over the course of a day or night.

The 'worst case' scenarios for assessment were selected on the basis of when sound starts to be generated (Year 1) and maximum equipment or sound source numbers conditions (Year 4 and 8). Operating conditions considered the average use of equipment over a typical 24 hour period (for example, mobile equipment idling versus movement under load). A comparison of when sound levels for receptors in various directions from the Plant Boundary may be greater due to spatial arrangement of the equipment on site was not discussed or included. For large sites, it is possible for the maximum off-site sound level to occur when there is less equipment on the site as a whole, but what is present, is spatially closer to a receptor. In general, the results observed in the assessment seem consistent with similar mining projects.

- **Recommendation/Question: Proponent should provide a sensitivity analysis comparing sound level predictions for the assessment model condition with the scenario where the most likely equipment is in closest proximity to Aberdeen and, if applicable, in direct line of sight to Aberdeen. Specifically for receptors 13 and 44. The results should include the partial contributions from all sound sources affecting the receptors.**

While a separate analysis of pile driving was conducted for the construction phase, no calculations or modelling was conducted to estimate variability in sound levels from mining activity at receptors. Using the same model, calculation standard and parameters as identified in the assessment, a 120 dBA sound power diesel engine in direct line of sight at 1700m distance gives a result of 34.6 dBA. Two such engines results in 37.1 dBA. This indicates that mining related sound levels at receptor 13 and 44 that were predicted to be L_{Aeq} values of 29-31.5 dBA as reported in the assessment could have cyclic increases of at least 5 dBA, dependent on the scenario.

- **Recommendation/Question: Proponent should provide model predictions for the maximum expected sound levels at receptor 13 and 44 for the conditions when the most expected equipment is operating at the top elevation of the EMRSF. Predictions should not include load factors but should discuss the operating cycle (how often do trucks place material on the pile, how long do dozers work on the pile) to indicate how often during a day or night the maximums may occur.**

4. Ajax Mine Assessment Comments - Vibration

The blasting assessment provided in Appendix D of Appendix 10.5-A of the assessment provided specific detail on the expected blast design, methods for controlling the blast performance and the environmental factors such as dust, flyrock, ground vibration and air overpressure. This was provided by a qualified blasting engineer with experience in the mining industry.

The criteria used for vibration assessment are consistent with other Canadian and US jurisdictions where mining occurs adjacent to communities. The formulae use for the calculations are industry standard which include direct distance and explosives/timing inputs. Terrain or pit depth are not considered, therefore the results assume direct line of site and blasting at surface elevation.

There are no readily found publications that identify the ‘startle’ or detection thresholds for animals, particularly dogs, although it is well documented that animals will react to sudden changes in sounds. Dogs, in particular, have similar hearing to humans in the lower frequencies, although they hear much higher frequencies that people. It may be inferred that the threshold for blast vibration pressure wave detection for dogs is likely similar to people, given the audible portion of wave is primarily composed of low frequency sound.

The blast design analysis indicates ground vibration at or over the 0.5 mm/s detectable threshold can be expected as far as 4 km from a blast. This puts most of Aberdeen within the area that may detect ground vibration. However, the Ontario Ministry of Environment (OMOE) NPC-119 criterion assigns a human comfort level for nighttime vibration of 0.2 mm/s PPV, presuming that 0.2 mm/s is the human detection limit. This would be the level detected by any night-shift workers sleeping in the day.

- **Recommendation/Question: Proponent should provide the distance at which ground vibration attenuates to below 0.2 mm/s.**

For air overpressure, human sensitivity to impulsive sound increases at levels above 110 dBL (Crocker 2007). The OMOE NPC-119 has an incremental limit of 120 dBL for annoyance and structural safety. The assessment predicts air overpressure above the 110 dBL threshold may occur up to 2400 m from a blast, which indicated some of the nearest homes in Aberdeen to the mine site may experience air overpressures. The influence of atmospheric inversions on the intensity of air overpressure will depend on the specific blast design and the nature of the inversion. Monitoring will be required to determine the influence of inversions. Some intensification may occur, but the location of the increased overpressure due to refraction of the wave is generally determined through measurement, not prediction.

- **Recommendation/Question: Proponent should conduct a similar test blasting program to the test blasts conducted previously, to test the new design. The purpose is to provide a basis for comparison of the two designs.**

At the nearest Aberdeen homes to blasting, the highest expected ground vibration is 1.7 mm/s PPV, with the highest air overpressure is 112 dBL. This indicates blasting will be noticeable, but below levels that typically result in complaints and well below levels that damage structure. The degree of noticeability of a blast will depend on atmospheric conditions, and individual activity (someone sitting quietly will notice more than someone active on a physical task).

5. Ajax Mine Assessment Comments - Management Plan

Section 11.22 outlined the expected content of the management plans to be developed, and listed the criteria commitment of Ajax, mitigation to be considered as well as a noise and vibration monitoring program.

- **Recommendation: The management plan should include scheduling of blasts based on weather conditions as a vibration and air overpressure control.**
- **Recommendation: The management plan should include scheduling of blasts outside normal classroom hours to prevent student distraction.**

The management plan discusses noise and vibration monitoring at key phases of the Project, but is vague on details regarding the type and duration of monitoring. The text says monitoring will be ‘continuous’ through the various project phases but does not clarify if this means permanent monitoring stations. While random noise monitoring durations of 24-48 hours are sufficient to establish baseline compared to similar communities, it is not enough to do this seasonally or yearly to verify long term sound levels from this type of highly mobile industrial activity. For vibration, blasting is even more variable in terms of ground and air overpressure produced even with a consistent design. This is reflected in the management plan text which states clearly a permanent vibration monitoring station will be established.

- **Recommendation: The management plan should include a commitment to clarify the use of 'continuously' rather than 'permanent' in reference to the noise monitoring locations. Is a series of noise monitoring periods envisioned or permanent stations?**

There is a complaint process planned but not a notification process.

- **Recommendation: The management plan should include a plan to notify residents within the vibration detection distance of the blasting schedule or changes in major site activity/equipment movements.**

6. Summary and Conclusion

The Ajax Mine Noise and Vibration Assessment presented an approach, criteria and results that are consistent with other mining and industrial applications near communities. The overall document organization made finding detail a challenge, and in general, the documents were vague, missing sufficient detail for a technical practitioner to recreate the results.

Taking the results at face value, and as the criteria used does represent levels of sound and vibration established in multiple jurisdictions to prevent sleep disturbance and minimize nuisance, the assessment results indicating 'minor' magnitude changes mean that health effects in terms of sleep disturbance due to sound and vibration are not expected to occur and the potential for nuisance noise and vibration is being minimized.

However, this does not mean sound and vibration will not be experienced. This review has found that sound from mining operations, ground vibration and air overpressure will all become part of the environment at the homes and school in Aberdeen, particularly the southernmost homes. Sound can be expected to be distinguishable at times, but not louder than other local sounds, when normal ambient sound levels are low such as winter or overnight in summer. Blasting in Zone 1 in particular will be noticeable, again at times, and will depend on the adaptation of blast designs for weather conditions and proximity to receptors.

While a community complaint process is planned, the best way to manage sound and vibration will be on a preventative basis. Permanent monitoring should be conducted at the Plant Boundary to determine the sound and vibration leaving the site in the direction of Aberdeen. Permanent stations can be used to allow for proactive correction of issues, or to have data available in the event of a complaint. A communications plan that notifies the community of blasting schedules and changes on on-site operating areas will also benefit the community.

7. References

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