REPORT

TECHNICAL STUDY – NOISE

Kennecott Eagle Minerals Company

Eagle Project, Marquette County, Michigan

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EXECUTIVE SUMMARY

In October 2011, Golder Associates Inc. (Golder) performed a comprehensive baseline noise survey for the Eagle Project (Project) mill site in Marquette County, Michigan. The results of the noise survey indicate that the overall baseline sound pressure levels at the mill site are well below all recognized ambient sound pressure level guidelines for noise sensitive receptors. The mill is located in a low-noise environment. The major noise sources contributing to the overall sound pressure levels in the area include periodic heavy machinery noise, road traffic noise, and typical wilderness noise sources. The overall sound pressure levels were variable throughout the monitoring periods, with greater incidences of transient noise from human activities during the daytime hours.

Coinciding with the mill noise study, a Project mine site noise and vibration study was performed to assess the blasting and typical heavy equipment activities associated with the mine. The study found that sensitive receptors that had been documented in the area would not be harmed by the blasting activities and results at these receptors were under established regulatory limits for noise and vibration monitoring.

In November 2011, Golder performed a vibration study at the Project mine site. This study was also performed to collect vibration data from blasting and typical heavy mine equipment activities emanating from the site. The study found that the estimated vibrations are well below damage thresholds and regulatory limits and that the airblast estimate is well below damage thresholds. The estimated results can be considered conservative, as the attenuating effect of the local forest is likely to be underestimated.

These studies were conducted to satisfy Rio Tinto's Noise and Vibration Control – Guidance Note, Version 2 dated January 5, 2011.

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1.0 STUDY AREA DESCRIPTION

The Eagle Project involves both a mill and mine site in Marquette County, Michigan. The Eagle Project mill site is located just south of U.S. Highway 41 (US 41) and east of State Road 95, approximately 9 miles west of the community of Ishpeming and 4 miles east of Champion. The mine site is located on the Yellow Dog Plains, west of Marquette, Michigan. The area around these sites is primarily forested and sparsely populated.

Sound pressure levels were measured at seven locations in the vicinity of the mill site from October 4 through October 6, 2011. The monitoring site descriptions are provided in Table 1-1 and are illustrated in Figure 1-1. The monitoring locations include three 24-hour measurement locations near the mill site boundary and four locations where daytime (between 7 a.m. and 10 p.m.) and nighttime (between 10 p.m. and 7 a.m.) measurements were collected for a minimum of 15 minutes near the closest residential receptors.

At the mine site, noise and vibration measurements were collected during blasting activities and heavy mine equipment operations. Monitoring locations for noise and vibration can be found in Figures 1-2 and 1-3 respectively. Noise measurements were collected on October 5 through 6, 2011 at three locations and the vibration measurements were collected from November 1 to November 4, 2011 at five locations. There are no critical receptors in the immediate vicinity of the mine and, with the exception of several hunting cabins, no residences within a mile of the mine. The predominant land use is silviculture, with recreational activities such as hunting and snowmobiling.

The most sensitive areas to noise and vibration typically include residential lands, hospitals, schools, parks, and churches. The closest sensitive receptors to the mill site are residences located less than a quarter mile south and west of the mill site boundary. As stated above, there are no sensitive areas located near the mine site.

TABLE 1-1

NOISE MONITORING LOCATIONS INCLUDED IN THE BASELINE NOISE STUDY

Site	UTM Coordinates – Zone 16T		Monitoring Dates	Sample Type
	North	East		
Mill Site				
Site 1	5149562.5	429363.9	10/05/11	15 minute minimum daytime/nighttime
Site 2	5149209.9	430384.5	10/05/11	15 minute minimum daytime/nighttime
Site 3	5148623.0	430034.8	10/05/11	15 minute minimum daytime/nighttime
Site 4	5147728.5	431049.8	10/05/11	15 minute minimum daytime/nighttime
24 Hour Site – N	5149314.2	431364.5	10/04/11 – 10/05/11	24-hour
24 Hour Site – S	5147621.3	431351.0	10/05/11 – 10/06/11	24-hour
24 Hour Site – W	5148792.5	430324.3	10/04/11 – 10/05/11	24-hour
Mine Site				
North	5177813.2	432263.8	10/06/11	During blasting
South	5177240.2	432320.1	10/06/11	During blasting
West	5177368.4	432131.6	10/05/11 –10/06/11	During blasting

2.0 STANDARDS OR GUIDELINES

2.1 Noise

Sound propagation involves three principal components: a noise source, a person or a group of people, and the transmission path. While two of these components, the noise source and the transmission path, are easily quantified (i.e., by direct measurements or through predictive calculations), the effect of noise on humans is the most difficult to determine due to the varying responses to the same or similar noise patterns. The perception of sound (noise) by humans is subjective from individual to individual and, like odor and taste, it is difficult to predict a response from one particular individual to another.

Noise resulting from industrial activities can impact the health and welfare of both workers and the general public. The level of impact is related to the magnitude of noise, which is referred to as sound pressure level (SPL) and measured in units called decibels (dB). Decibels are calculated as a logarithmic function of the measured SPL in air to a reference effective pressure, which is considered the hearing threshold.

To account for the effect of how the human ear perceives sound, the measured SPLs are adjusted for frequency. This adjustment is referred to as A-weighting (dBA), which approximates the response of the human ear to low-frequency [i.e., below 1,000 hertz (Hz)] and high-frequency (i.e., above 10,000 Hz) SPLs.

2.1.1 Noise Guidelines

Under the Clean Air Act, the U.S. Environmental Protection Agency (EPA) administrator established the Office of Noise Abatement and Control (ONAC) to carry out investigations and studies on noise and its effect on the public health and welfare. Through ONAC, the EPA coordinated all Federal noise control activities, but in 1981 the Administration concluded that noise issues were best handled at the state and local level. There are no federal, state, or local standards that are applicable to the Project; however, the EPA has developed noise levels requisite to protect public health and welfare against hearing loss, annoyance, and activity interference. These noise levels are contained in the EPA document "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety." One of the purposes of this document was to provide a basis for state and local governments' judgments in setting standards. The document identifies a 24-hour exposure level of 70 dBA as the level of environmental noise that will prevent any measurable hearing loss over a lifetime. Likewise, levels of 55 dBA outdoors and 45 dBA indoors are identified as preventing activity interference and annoyance. These levels of noise are considered those that will permit spoken conversation and other activities such as sleeping, working and recreation, which are part of the daily human condition (EPA, 1974).

The U.S. Department of Housing and Urban Development (HUD) has promulgated noise criteria and standards “to protect citizens against excessive noise in their communities and places of residence.” These criteria relate to short-term and day-night average SPLs.

The equivalent sound pressure level (L_{eq}) is the equivalent constant SPL that would be equal in sound energy to the varying SPL over the same time period. The day-night average sound level (L_{dn}) is the 24-hour average SPL calculated with a 10 dBA “penalty” added to nighttime hours (10 p.m. to 7 a.m.). This is done because residential land uses are more sensitive to nighttime noise impacts. The equation for L_{dn} is:

$$L_{dn} = 10\log\frac{15\times10^{\frac{L_d}{10}} + 9\times10^{\frac{L_n+10}{10}}}{24}$$

where: L_d = daytime L_{eq} for the period 0700 to 2200 hours
L_n = nighttime L_{eq} for the period 2200 to 0700 hours

The EPA recommends an outdoor L_{dn} of 55 dBA for residential and farming areas. For industrial areas, an L_{eq} of 70 dBA is suggested. The HUD recommended goal for exterior noise levels is not to exceed an L_{dn} of 55 dBA. However, the HUD standard for exterior noise is 65 dBA measured as L_{dn}.

Both the City of Marquette and the Township of Marquette have noise nuisance ordinances that may be applied to the Project, but neither have specified sound level limits for sensitive receptors.

2.2 Vibration

While offsite vibrations can be generated by heavy construction and stationary machinery, vehicles, and excavation, the expected most significant offsite vibration impacts will be from blasting. Most of the energy from blasting is consumed to fracture or displace rock. However, some of the energy from the blast can travel outward through the surrounding geologic materials as ground vibration as well as through the air.

While ground vibration is an elastic effect, one must also consider the plastic or non-elastic effect produced locally by each detonation when assessing the effects on the bedrock strata and local water wells. The detonation of an explosive produces a very rapid and dramatic increase in volume due to the conversion of the explosive from a solid to a gaseous state. When this occurs within the confines of a borehole it has the following effects:

- The bedrock in the area immediately adjacent to the explosive product is crushed.
- As the energy from the detonation radiates outward from the borehole, the bedrock between the borehole and quarried face becomes fragmented and is displaced while there is minimal fracturing of the bedrock behind the borehole.

- Energy not used in the fracturing and displacement of the bedrock dissipates in the form of ground vibrations, sound, and airblast. This energy attenuates rapidly from the blast site due to geometric spreading and natural damping.
- The intensity of ground vibrations, which is an elastic effect measured as peak particle velocity (PPV), is defined as the speed of excitation of particles within the ground resulting from vibratory motion. For the purposes of this report, peak particle velocity is measured in millimeters per second (mm/s).

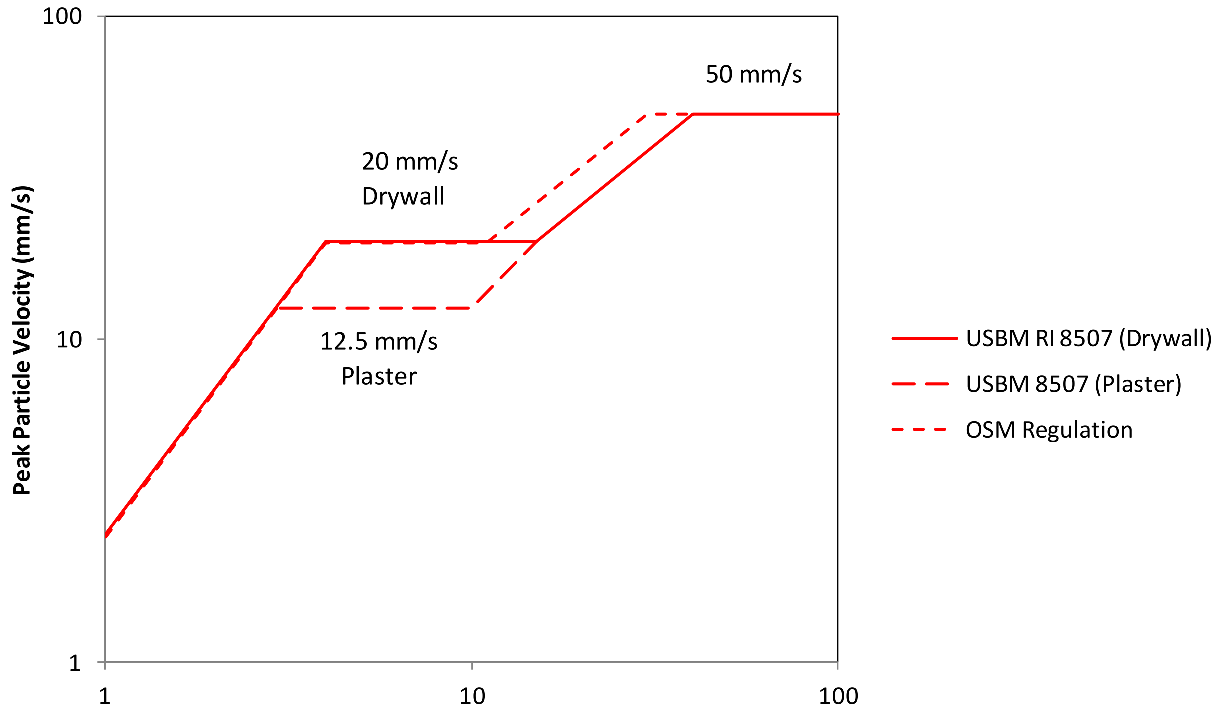
Air concussion, or air vibrations, is a pressure wave traveling through the air produced by the direct action of the explosive on air or the indirect action of a confining material subjected to explosive loading. Air vibrations from surface blasting operations consist primarily of acoustic energy below 20 Hz, where human hearing is less acute (Siskind et al., 1980), while noise is that portion of the spectrum of the air vibration lying within the audible range from 20 to 20,000 Hz. It is the lower frequency component (below 20 Hz) of air concussion, which is less audible, that is of interest as it is often the source of secondary rattling and shaking within a structure. For the purposes of this report, air vibration is measured as decibels in the Linear or Unweighted mode (dBL). This differs from noise (above 20 Hz), which is measured in dBA.

Human response to vibration is difficult to measure and to quantify. In addition to the amplitude and frequency of the vibrations that can act on humans, there are other factors that must be considered, including the direction of the vibration, the activities of the human beings, and whether the vibration is steady, impulsive, or intermittent (Beranek, 1988). Ground vibration intensity is typically measured as PPV, commonly in units of mm/s. Particle velocities of less than 1 mm/s can be perceptible to people and may result in complaints. Impacts to buildings are unlikely to occur until velocities reach values in the range of 10 to 50 mm/s and above, depending on the building construction and vibration frequency (Rosenthal and Morlock, 1987). Ground vibration may also cause harm to burrowing and subterranean animals.

2.2.1 Ground and Air Vibration Limits

Ground vibration guidelines or regulations typically established for blasting sites to prevent damage to adjacent facilities or structures generally range from 12.5 mm/s to 50 mm/s, depending on the dominant frequency of the ground vibration (Siskind and Stagg, 2000). Exceeding these levels does not in itself imply that damage would or has occurred, but only increases the potential that damage might occur. Ground vibration limits for stronger materials, such as concrete, may be set as high as 150 to 200 mm/s, while peak ground vibration levels of 300 to 600 mm/s are required to create micro-cracks or open existing discontinuities in bedrock (Keil et al., 1977). While the ground vibration velocity is considered the best indicator of the damage potential from ground vibrations, the frequency of the vibration must also be considered. Figure 2-1 shows frequency based safe level blasting criteria produced by the U.S. Bureau of Mines (USBM), which are based on comprehensive studies carried out over a 40-year period (Siskind et al., 1980). The curve was developed by David Siskind of the USBM in 1980. Another modified curve was adopted by the Office of Surface Mining (OSM) Reclamation and Enforcement in 1983 (between

11 and 30 Hz). The results of these studies are used by many U.S. jurisdictions to define blasting limit values.



Source: Siskind and Stagg (2000)

Figure 2-1: U.S. Bureau of Mines Safe Blasting Ground Vibration Criteria

Many regulatory agencies have found the limits shown in Figure 2-1 lacking in a simple method of determining compliance (Siskind, 2005). In order to include the frequency in the ground vibration limits, most regulatory bodies, including the OSM, generally use simple but workable distance dependent PPV criteria (Siskind, 2005):

- 32 mm/s (1.25 in/s) for 0 to 91 meters (300 feet)
- 25.4 mm/s (1.0 in/s) for 92 meters to 1,524 meters (301 to 5,000 feet)
- 19 mm/s (0.75 in/s) for greater than 1,524 meters (5,000 feet)

Although there are federal rules regarding the airblast from surface coal mining, most states have no specified limits for airblast (Siskind, 2005).

3.0 MEASUREMENT PROCEDURES AND METHODOLOGY

3.1 Noise

Noise was measured using a sound level meter that was set to the slow response mode to obtain consistent, integrated, A-weighted SPLs using measurement techniques set forth by the American National Standards Institute (ANSI) S12.9-1993/Part 3, 1993. Concurrent one-third octave band frequencies were also measured at all sites. The octave band data from each monitoring site were measured and stored during each monitoring period.

Integrated SPL data consisting of the following noise parameters were collected at each location:

- L_{eq} – The sound pressure level averaged over the measurement period; this parameter is the continuous steady sound pressure level that would have the same total acoustic energy as the real fluctuating noise over the same time period.
- L_{max} – The maximum sound pressure level for the sampling period.
- L_{min} – The minimum sound pressure level for the sampling period.
- L_n – The sound pressure levels that were exceeded n percent of the time during the sampling period. For example, L_{90} is the level exceeded 90 percent of the time.
- L_{dn} – The 24-hour average SPL calculated with a 10 dBA "penalty" added to nighttime hours (10 p.m. to 7 a.m.).

The SPL data were analyzed in both dB and dBA. The higher the decibel value, the louder the sound. The SPL averages were calculated using the following formula:

$$\text{Average SPL} = 10\,\text{Log}\,\frac{\sum_{i=1}^{N} 10^{(SPL_i/10)}}{N}$$

where: N = number of observations, and

SPL_i = individual SPL in data set.

The noise monitoring equipment used during the study included:

- Larson Davis Model 824 and 831 Precision Integrating Sound Level Meters with Real Time Frequency Analyzer
- Larson Davis Model PRM902 Microphone Preamplifier
- Larson Davis Model 2560 Prepolarized ½-inch Condenser Microphone
- Windscreen, tripod, and various cables
- Larson Davis Model CAL200 Sound Level Calibrator, 94/114 dB at 1,000 Hz

Monitoring was conducted using the sound level meter mounted on a tripod at a minimum height of 1.5 meters (5 feet) above grade. A windscreen was used since measurements were taken outdoors. The microphone was positioned so that a random incidence response was achieved. The sound level meter and octave band analyzer were calibrated immediately prior to and just after each sampling period using the CAL200 to provide a quality control check of the sound level meter's operation during monitoring.

The operator recorded detailed field notes during monitoring that included major noise sources in the area. The Larson Davis sound level meters comply with Type I - Precision requirements set forth for sound level meters and for one-third octave filters. Calibration reports for the Larson Davis Sound Level Meters can be found in Appendix A.

3.2 Vibrations

Development blasting started in September 2011 and had progressed to approximately 60 meters at the time of this study. A series of five seismographs was deployed to measure the resulting ground vibration from blasting activities at the mine site. The monitoring locations are shown Figure 1-3.

Two of the most important variables that affect the PPV from a blast are the distance from the source (seismic waves attenuate with distance) and the maximum explosive charge weight per delay period. The most common method of normalizing these two factors is by means of plotting the scaled distance (distance divided by the square root of the charge weight per delay) against the PPV. A similar method is used for the overpressure monitoring but with the scaled distance equal to the distance divided by the cube root of the charge weight per delay. The ground and air vibrations were monitored at appropriate stand-off distances from the blast that provided a significant range of distance between the blast and the monitoring locations (i.e. from 186 meters to greater than 1,300 meters). The array of five seismographs recorded the vibrations from each blast. The stand-off distance and recorded vibration levels were used with the blast parameters provided by the mine to provide initial estimates of the ground and air vibration attenuation models.

The ground and air vibration measurements were collected using the following equipment:

- Instantel Vibration and Overpressure Monitor (blasting seismograph)
- Instantel Standard Triaxial Geophone
- Instantel Overpressure Microphone

The seismographs were capable of monitoring PPV in the transverse, vertical, and longitudinal planes and were calibrated within one calendar year of their use. The instruments complied with the "Performance Specifications for Blasting Seismographs" that have been published by the International Society of Explosives Engineers (ISEE). The operation of the seismograph shall comply with the recommended practices as outlined in the ISEE's "ISEE Field Practice Guidelines for Blasting Seismographs". These ISEE-issued documents are considered industry standards for blast vibration monitoring. A copy of each document is attached in Appendix B.

Vibrations were recorded with triaxial geophones that have a range of up to 254 mm/s and a frequency response of 2 to 250 Hz. Airblast overpressure was recorded with linear microphones, which had a range of 88 to 148 dBL and a frequency response of 2 to 250 Hz. The geophones were buried in the ground (as outlined in the ISEE Field Practice Guidelines) while the microphones were mounted on the stands supplied with the instrument for that purpose.

Specific instrument and blast locations were established using a Garmin GPS electronic navigation aid (NAVAID) to determine accurate distances between the blast and receptors.

4.0 MILL SITE BASELINE ENVIRONMENT AND RESULTS

Noise levels in the area of the mill are variable, impacted mainly by roadway noise, airplane traffic, wind noise, and sounds of nature. Table 4-1 shows a summary for the data collected at the 24-hour and daytime/nighttime monitoring locations. The L_{eq} ranged from a low of 33.1 dBA at Site 2 during the nighttime to a maximum of 58.5 dBA at Site 3 during the daytime. The 24-hour locations had an L_{eq} range from a low of 38.8 dBA at the West site to a maximum of 50.2 dBA at the North site.

The sound level that is exceeded 90 percent of the time (L_{90}) is commonly used when comparing noise monitoring results between locations. This excludes most transient and intermittent noise sources, such as traffic noise, birds chirping, etc., which may vary from site to site. The L_{90} ranged from a low of 31 dBA during the daytime at Sites 3, 4, and 5 to a high of 50 dBA at Site 7 during the nighttime.

4.1 Daytime/Nighttime Mill Site Noise Results

4.1.1 Monitoring Site 1

Sound level results recorded at Site 1 are presented in Table 4-1. Moderate traffic, birds, and construction noise were sources of noise observed during the daytime monitoring study. During the nighttime monitoring study, light traffic on US 41 and State Road 95 were observed as sources of noise. The closest receptors to this monitoring location were commercial receptors located near the busy intersection.

Measurements were taken on October 5th, 2011. It was found that sound pressure levels were elevated during the daytime with an L_{eq} of 58.3 dBA compared to an L_{eq} of 49.4 dBA at night.

The monitoring setup is shown in Photograph 4-1.

Photograph 4-1: Noise Monitoring Site 1 – Northwest of Project at intersection of US 41 and State Road 95

4.1.2 Monitoring Site 2

Sound level results recorded at Site 2 are presented in Table 4-1. Distant traffic along with construction noise from heavy equipment operations were sources observed during the noise monitoring study.

Sound levels at this site were greater during the day than at night due to increased noise from heavy equipment, with an L_{eq} of 47.8 dBA during the day and an L_{eq} of 33.1 dBA at night.

The monitoring setup is shown in Photograph 4-2.

Photograph 4-2: Noise Monitoring Site 2 – Northwest of the mill site

4.1.3 Monitoring Site 3

Sound level results recorded at Site 3 are presented in Table 4-1. Distant traffic and heavy equipment operation were sources observed during the noise monitoring study.

Sound pressure levels during the daytime were at a L_{eq} of 58.5 dBA compared to at night when the L_{eq} was 48.8 dBA on October 5th. The L_{max} for both day and night was much greater at this location than it was at the other 3 day/night noise monitoring locations; however, the L_{90} values are much closer in value to the other monitoring locations, showing the influence of loud transient noises from local traffic.

The monitoring setup is shown in Photograph 4-3.

Photograph 4-3: Noise Monitoring Site 3 – East of the Project site just off of County Road 601

4.1.4 Monitoring Site 4

Sound level results recorded at Site 4 are presented in Table 4-1. Distant heavy traffic, light traffic on County Road 601, and distant heavy equipment operation were sources observed during the noise monitoring study.

At the Site 4 noise monitoring location, the daytime L_{eq} was 45.5 dBA while the nighttime L_{eq} was 37.6 dBA.

The monitoring setup is shown in Photograph 4-4.

Photograph 4-4: Noise Monitoring Site 4 – South of the Project site. County Road 601 is out of view to the left (west) of this location.

4.1.5 24-hour Site – North

Sound level results recorded at the 24-hour north site are presented in Table 4-1 and Figure 4-1. Distant highway traffic, heavy equipment operation, light on-site traffic, and sounds of nature were sources observed during the noise monitoring study.

At the 24-hour north site the L_{eq} was 50.2 dBA, while the L_{min} and L_{max} were 17.4 dBA and 69.4 dBA, respectively.

The monitoring setup is shown in Photograph 4-5.

Photograph 4-5: Noise Monitoring 24-hour site – North near the northern property boundary

4.1.6 24-hour Site – South

Sound level results recorded at the 24-hour south site are presented in Table 4-1 and Figure 4-2. Wind and sounds of nature (insects and birds) along with periodic heavy equipment operations were sources observed during the noise monitoring study.

Sound pressure levels for the south site were a L_{eq} of 43.9 dBA, with an L_{min} and L_{max} of 17.4 dBA and 76.4 dBA, respectively.

The monitoring setup is shown in Photograph 4-6.

Photograph 4-6: Noise Monitoring 24-hour site – South, near the southern mill property boundary

4.1.7 24-hour Site – West

Sound level results recorded at the 24-hour west site are presented in Table 4-1 and Figure 4-3. Sounds of nature, light traffic on the tailings pit access road, and distant heavy equipment operation were sources observed during the noise monitoring study.

Sound pressure levels for the west site were at a L_{eq} of 38.8 dBA, with an L_{min} and L_{max} of 16.9 dBA and 79.4 dBA, respectively.

The monitoring setup is shown in Photograph 4-7.

Photograph 4-7: Noise Monitoring 24-hour site – West, near the western mill property boundary

4.2 Mill Site Noise Conclusion

As shown in the results, the noise levels in the area of the mill site are variable and typical of rural forested areas. The daytime noise levels are typically elevated and the major noise sources included wind noise, local and highway traffic, and typical sounds of nature.

The sound level that is exceeded 90 percent of the time (L_{90}) is commonly used when comparing noise monitoring results between locations. This excludes most transient and intermittent noise sources, such as traffic noise, airplane noise, birds chirping, etc. The L_{90} is better used to compare measurements between sites where transient noises may vary greatly. At the off-site short-term monitoring locations the daytime L_{90} results ranged from a minimum of 36.0 dBA at Site 4 to a maximum of 51.5 dBA at Site 1. This difference is due to the increased daytime traffic at the intersection of US 41 and State Road 95. The nighttime L_{90} showed a more constant noise level and ranged from a low of 27.4 dBA at Site 1 to a high of 34.0 dBA at Site 3.

The 24-hour data from the on-site monitoring locations show higher noise levels to the south and north of the mill site than to the west. This is likely due to the proximity of local traffic corridors, County Road 601 to the south and US 41 to the north. The L_{90} values ranged from a low of 19.4 dBA at the south site to 25.3 dBA at the north site. This 6-dBA range also shows the influence of transient noise impacts around the mill site and a more consistent noise level when these transient noise sources are removed.

Outdoor conversation typically experiences mild annoyance when noise levels are above 55 dBA; levels above 62 dBA are considered significant interference (EPA, 1974). The monitoring suggests that noise levels in the area of the mill are well below these levels. The EPA also recommends an L_{dn} of 55 dBA (55 dBA during the daytime and 45 dBA during the nighttime). As the 24-hour Figures 4-1, 4-2, and 4-3 illustrate, with the exception of early morning (around 6 a.m.) traffic noise at the North Site, the recorded L_{90} values comply with the EPA guideline.

5.0 MINE SITE BLASTING NOISE MEASUREMENTS AND RESULTS

At the mine site, noise measurements were collected during a mine portal blast that occurred at 2:18 pm on October 6, 2011, and heavy mine equipment operations. The blast was approximately 7 seconds in duration. The heavy equipment operated during the daytime only. Monitoring locations can be found in Figure 1-2. Noise measurements were collected at three locations for varying time periods with the single portal blast included in all measurements.

5.1 Mine Site Noise Results

5.1.1 Mine Site North

Sound level results recorded at the Mine Site North are presented in Table 5-1 and Figure 5-1. This site was located along the western fence line near the gate at the northwest corner of the fence line. Heavy equipment operations associated with the mine and the portal blast were the main sources observed during the 2-hour measurement. The overall L_{eq} and L_{90} during the monitoring period were 45.5 dBA and 35.7 dBA, respectively. The 1-minute interval collected during the single portal blast had an overall L_{eq} of 56.8 dBA and an L_{max} of 73.4 dBA.

5.1.2 Mine Site South

Sound level results recorded at the Mine Site South are presented in Table 5-1 and Figure 5-2. This site was located south off the mine portal across Triple A road approximately 186 feet from the mine fence line. Heavy equipment operations associated with the mine, traffic along Triple A Road, and the portal blast were the main sources observed during the 7-hour measurement. The overall L_{eq} and L_{90} were 48.3 dBA and 37.4 dBA, respectively, during the monitoring period. The 1-minute interval collected during the single portal blast had an overall L_{eq} of 56.7 dBA and an L_{max} of 79.8 dBA.

5.1.3 Mine Site West

Sound level results recorded at the Mine Site West are presented in Table 5-1 and Figure 5-3. This site was located along the west of the mine portal approximately 138 feet from the fence line. Heavy equipment operations associated with the mine and the portal blast were the main sources observed during the 23-hour measurement. The overall L_{eq} and L_{90} during the monitoring period were 45.1 dBA and 33.8 dBA, respectively. The 1-minute interval collected during the single portal blast had an overall L_{eq} of 67.8 dBA and an L_{max} of 85.7 dBA.

5.2 Mine Site Noise Conclusion

As shown in the results, the noise levels in the area of the mine site are variable and typical of rural forested areas. The 24-hour measurement to the west of the mine indicates that daytime noise levels are typically elevated and include transient noise sources from mining operations, local traffic, and typical sounds of nature. The results also show increased noise levels during the brief blasting period. The overall average sound levels were rather constant with an L_{eq} range from 45.1 dBA at the West Site to

48.3 at the South Site. The south site had additional noise sources of traffic along Triple A road. During the blasting period the maximum instantaneous sound level (L_{max}) ranged from 73.4 dBA at the north site to 85.7 dBA at the west site.

The sound level that is exceeded 90 percent of the time (L_{90}) is commonly used when comparing noise monitoring results between locations. This excludes most transient and intermittent noise sources, such as traffic noise, airplane noise, birds chirping, etc. The L_{90} is better used to compare measurements between sites where transient noises may vary greatly. At the three monitoring locations, the overall L_{90} results ranged from a low of 33.8 dBA at the west site to a maximum of 37.4 dBA at the south site. The overall difference is less than 4 dBA and shows a constant noise level in the area of the mine in the absence of transient noise sources.

Outdoor conversation typically experiences mild annoyance when noise levels are above 55 dBA; levels above 62 dBA are considered significant interference (EPA, 1974). The monitoring suggests that the overall noise levels in the area of the mine are well below these levels. The EPA also recommends an L_{dn} of 55 dBA (55 dBA during the daytime and 45 dBA during the nighttime). Figures 5-1, 5-2, and 5-3 indicate that, with the exception of an elevated early nighttime (10 p.m. to 11 p.m.,) the recorded L_{90} values comply with the EPA guideline. These elevated nighttime measurements at the West Site were collected well after mine operations had ceased for the day were most likely caused by a period of high winds that tapered off after 11 p.m.

6.0 MINE SITE VIBRATION MEASUREMENTS AND RESULTS

6.1 Blast Parameters

Three blasts were included in this study and the parameters provided by the mine staff are as follows:

- Blast Type — Development Round
- Hole Diameter — 44.5 mm
- Collar Length — 0.6 meters
- Explosive Name — Orica Magnafrac (cartridge explosive)
- Cartridge Diameter — 38 mm
- Explosive per Hole — 3.9 to 4.4 kg (toe blast 2.9 kg)
- Explosive per Delay Period — 14.7 to 44 kg

6.1.1 Monitoring Summary

The data from the recorded events are summarized in Table 6-1.

Table 6-1: Summary of Blast Vibration Monitoring Results

Date	Time (hh:mm)	Max. Charge (kg/delay)	Site	Dist. (m)	SD ($m/kg^{0.5}$)	PVV		OP (dBL)
						(mm/s)	(Hz)	
1-Nov-11	13:58	35.3	1	186	31.3	1.65	19	125
			2	508	85.5	0.19	21	118
			3	760	127.9	0.49	12	91.5
			4	1360	228.9	0.13	10	111
			5	287	48.3	0.25	30	110
2-Nov-11	13:36	14.7	1	186	48.5	1.78	14	130
			2	508	132.5	0.16	12	113
			3	760	198.2	0.33	13	94
			4	1360	354.7	0.13	17	91.5
			5	287	74.9	0.16	14	105
4-Nov-11	9:24	44.1	1	186	41.4	2.29	>100	132
			2	508	76.5	0.29	85	121
			3	760	114.4	0.29	15	110
			4	1360	204.8	0.16	13	112
			5	287	43.2	0.48	24	118

Note: The mine contractor will be transitioning to the use of pumped bulk emulsion from cartridge explosive.

6.1.2 Attenuation Characteristics

The rate at which ground vibrations attenuate or decrease with increased distance from a blast source depends on a variety of conditions, including the type and condition of the bedrock being blasted, depth and composition of the earth covering deposits (soil), and the general topography. Air vibration effects are less affected by these factors, being more influenced by the prevailing weather conditions at the time of the blast. Additionally, underground blast air vibrations will diminish as the development for the ramp and infrastructure continues.

Site specific Scaled Distance plots are commonly used as a blast design tool since peak vibration levels can be reasonably predicted at specified distances from a blast site.

The following relationships were established from the blast monitoring results.

6.1.3 Ground Vibrations

The ground vibration attenuation characteristics established for the Project mine are presented in Figure 6-1 as a plot of the peak particle velocity against the Scaled Distance. Scaled Distance is defined as:

$$Scaled\ Distance\ (SD) = \frac{D}{\sqrt{W}}$$

where D = distance (meters) between the blast and receptor

W = maximum weight of explosive (kg) detonated per delay period

As seen in Figure 6-1, the collection of points defining the rate of decay for the ground vibrations exhibits a degree of scatter that is inherent in all Scaled Distance plots. Factors responsible for these variations include the geologic conditions of the bedrock (type and structure), different wave types, errors in blast initiation timing, differences between types of explosives, degree of confinement, and differences in blast efficiencies. Figure 6-1 provides a plot of the blast vibration monitoring conducted during the period from November 1 to 4, 2011. It also displays the 95-percent confidence lines for this data.

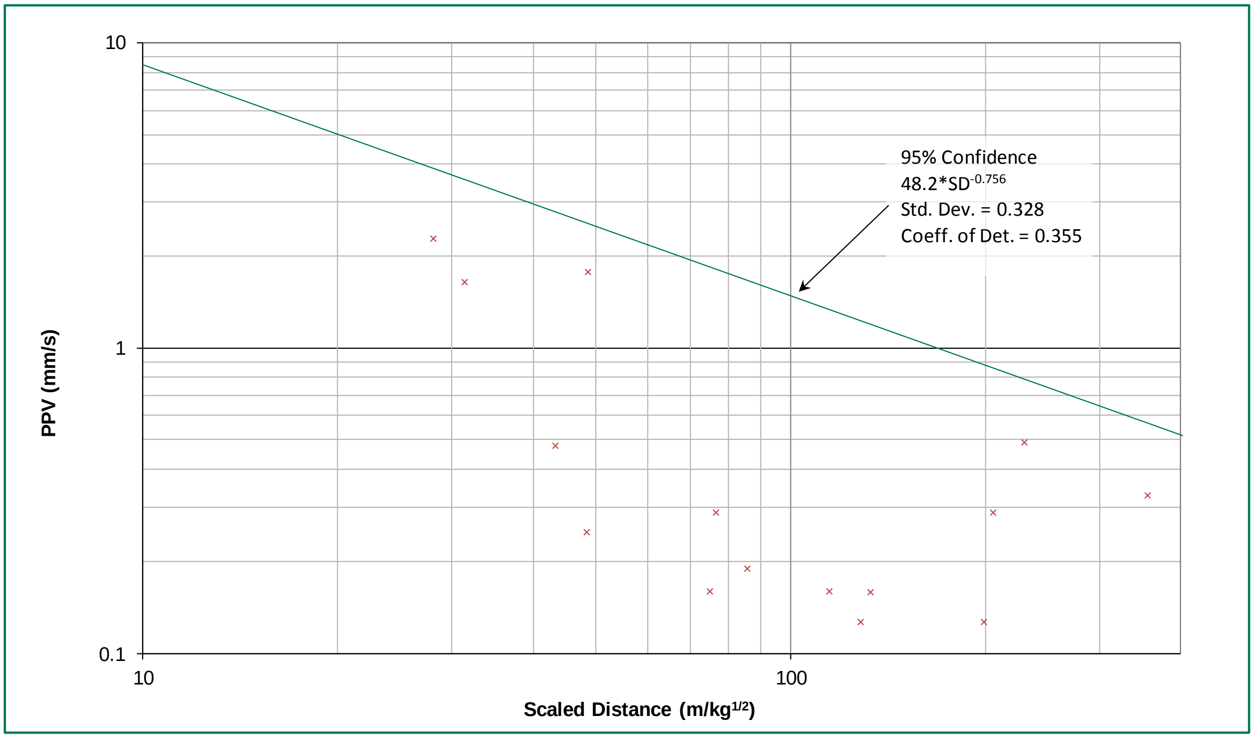


Figure 6-1: PPV versus Scaled Distance for Blasts Monitored from November 1 to 4, 2011

The equation for the 95-percent regression line developed in Figure 6-1 can be expressed as:

$$PPV = 91.7\left(\frac{D}{\sqrt{W}}\right)^{-0.961}$$

Where: PPV is the Peak Particle Velocity (mm/sec)

D is the distance between the charge and the point of measurement (meters)

W is the effective mass charge per delay (kg)

This represents the estimated 95-percent confidence line, which provides a means to predict the maximum vibration for a given explosive charge weight per delay and given distance from the source to the target location. The purpose of this equation is not so much to predict what a given vibration level would be at a particular location for a given blast, but to indicate the probability that the peak vibration would fall below the level indicated by the equation for a given distance and maximum explosive weight. The equation is therefore a useful blast design tool in establishing maximum explosive charge weights per delay for various distances from a blast site for a given maximum ground vibration level. The collection of additional monitoring data would enable the refinement of the ground vibration model.

6.1.4 Air Vibrations

Cube root scaling was used in establishing the air vibration decay characteristics as given in the following relationship, where D and W are defined as previously described:

$$Scaled\ Distance\ (SD) = \frac{D}{\sqrt[3]{W}}$$

Air vibration attenuation plots typically exhibit considerably more scatter and have a typically poorer correlation than that seen with the ground vibration results. This is primarily due to variable weather conditions during each blast, which are entirely independent of the blasting operations. Other factors influencing air vibration distribution from a blast include the length of collar, type of stemming material used, differences in explosive types, and variations in burden distance. Underground blasting is even more complex because the vibrations are channeled by the rock walls of the ramp and infrastructure.

Figure 6-2 provides a plot of the blast vibration monitoring conducted during the period from November 1 to 4, 2011. It also displays the 95-percent confidence lines for this data.

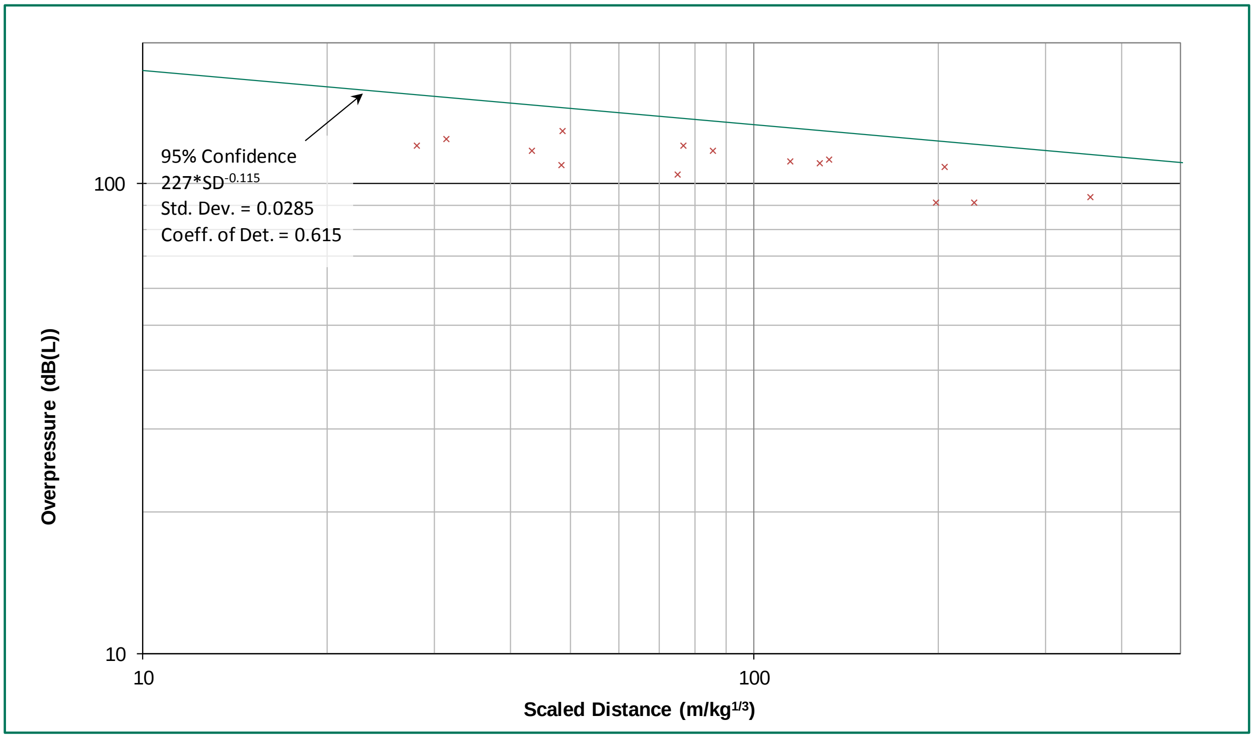


Figure 6-2: Airblast Overpressure versus Scaled Distance for Blasts Monitored from November 1 to 4, 2011

The equation for the 95-percent regression line developed in Figure 4 can be expressed as:

$$APL = 215\left(\frac{D}{\sqrt[3]{W}}\right)^{-0.101}$$

Where: APL is the Air Pressure Level (dBL)
D is the distance between the charge and the point of measurement (meters)
W is the effective mass charge per delay (kg)

The variability in the plot due to weather influences suggests that it is less reliable as a tool for guiding blast design.

6.1.5 Estimated Vibrations

Golder understands that the nearest residential structure to the mine operation is located approximately 1,600 meters (1 mile) beyond the perimeter fence of the mine structure. Based on the 95-percent regression equations given in Figures 6-1 and 6-2, and the current blast parameters, the maximum estimated ground and air vibration levels at that structure are 0.47 mm/s PPV and 116 dBL airblast.

The estimated PPV is well below damage thresholds and regulatory limits. The airblast estimate is well below damage thresholds. It is also likely to underestimate the attenuating effect of the local forest.

Figure 6-3 shows the estimated maximum PPV for various explosive loads using the attenuation characteristics established in this study.

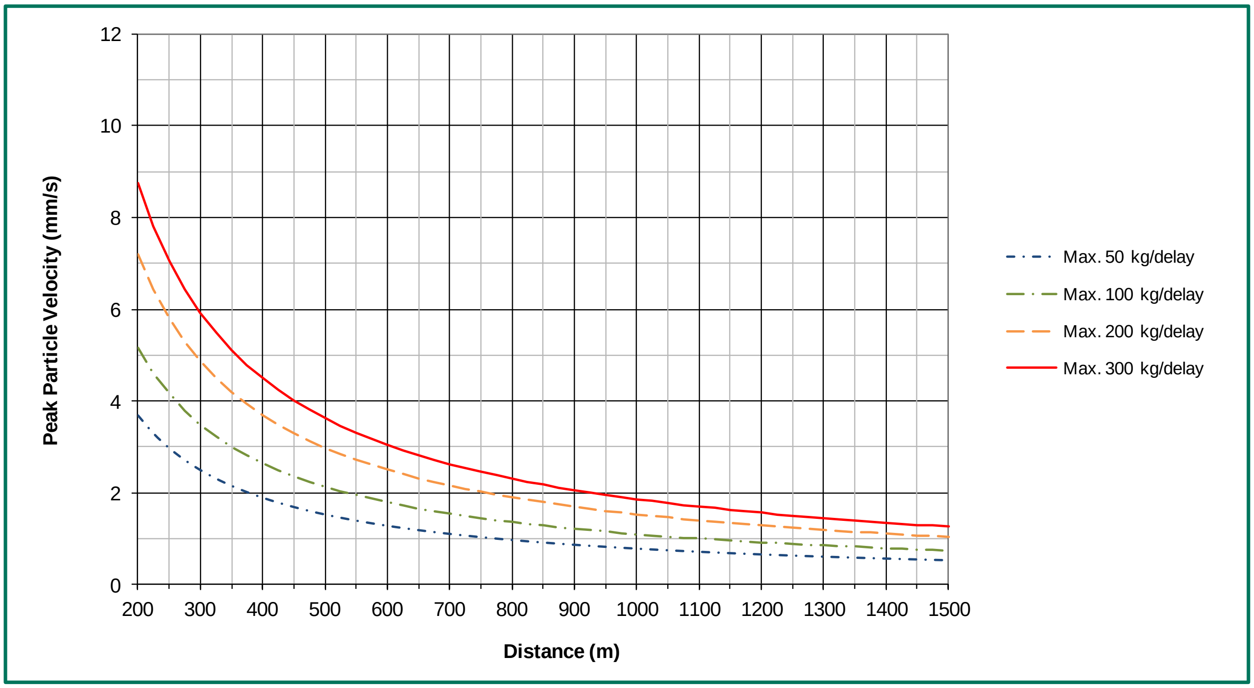


Figure 6-3: Estimated PPV versus Distance from Blasts for Various Explosive Loads

7.0 REFERENCES

American National Standards Institute (ANSI). S12.9-1993 (Part 3) (1993 and Revised 1998). Quantities and Procedures for Description and Measurement of Environmental Sound – Part 3: Short-Term Measurements with an Observer Present.

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Siskind, D.E., 2005. *Vibrations from Blasting*, International Society of Explosives Engineers, 120 pp.

TABLES

Table 4-1. Baseline Ambient Sound Pressure Levels for Kennecott Eagle Mill, October 2011

Site	Date	Time	Sound Levels (dBA)					Observations
			Min	Max	L_{90}	L_{eq}	L_{dn}	
1: Northwest of the mill near intersection of 41 and 95	5-Oct-11	Day	44.1	68.8	51.5	58.3		Moderate traffic; birds; construction noise
	5-Oct-11	Night	22.9	67.2	27.4	49.4	49.6	Light traffic on 41 and 95
2. Clearing approximately 0.75 miles northwest of the mill site	5-Oct-11	Day	40.0	54.2	44.0	47.8		Distant traffic; Heavy equipment operation with reverse alarms
	5-Oct-11	Night	28.5	45.7	29.5	33.1	42.8	Wind; distant traffic on 41 and 95
3: On County Road 601 approximately 0.4 miles east of 95	5-Oct-11	Day	33.2	77.9	36.4	58.5		Local and distant traffic and heavy equipment operation;sounds of nature
	5-Oct-11	Night	32.9	72.1	34.0	48.8	40.8	Wind; distant dog, very light traffic
4: On County Road 601 approximately 0.25 miles due south of the mill	5-Oct-11	Day	34.4	63.9	36.0	45.4		Local and distant traffic; distant heavy equipmentoperation, sounds of nature
	5-Oct-11	Night	31.3	46.0	33.9	37.6	40.7	Wind; distant dog
24-hour site - North: Approximately 0.75 miles north of the mill near 41.	4-5 Oct 2011	24-hour	17.4	69.4	25.3	50.2	54.9	Highway traffic in distance, sounds of nature, light on-site traffic, distant heavy equipment operation
24-hour site - West: On a ridge near the fence-line.	4-5 Oct 2011	24-hour	16.9	79.4	22.3	38.8	38.5	Sounds of nature; light pit traffic; distant heavy equipment operation
24-hour site - South: On unnamed street approximately 0.4 miles south of the mill	5-6 Oct 2011	24-hour	16.7	76.4	19.4	43.9	44.5	Wind; insects; birds; very distant construction

Source: Golder Associates Inc, 2011.

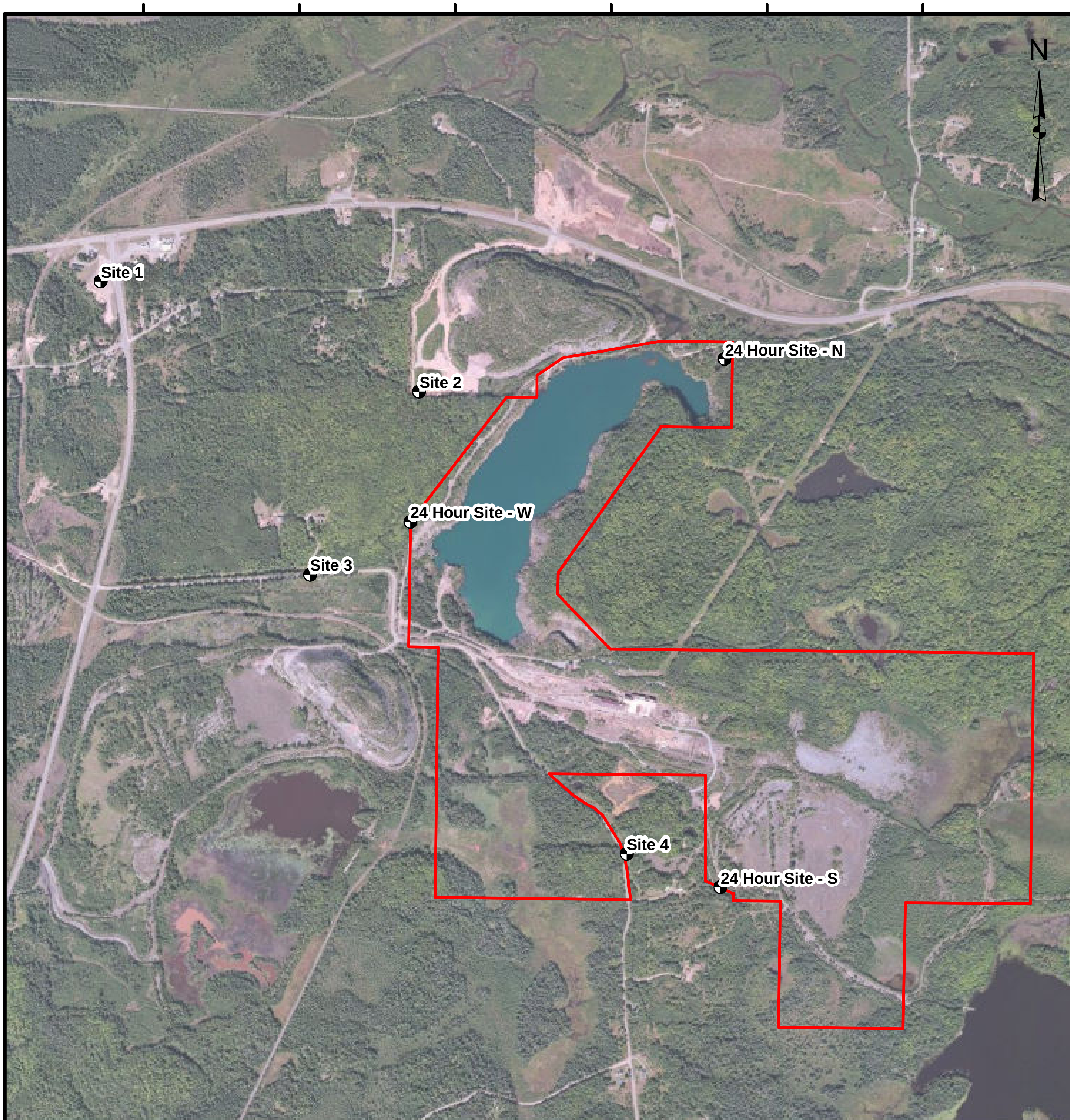
Table 5-1. Ambient Sound Pressure Levels for Kennecott Eagle Mine, October 2011

Site	Date	Time	Sound Levels (dBA)				Observations
			Min	Max	L_{90}	Leq	
Mine Site North	6-Oct-11	2-Hour	32.4	72.3	35.7	45.5	Heavy equipment operation; nearby traffic
Blast Noise 1 minute interval [a]		1 Minute	35.0	73.4	37.3	56.8	
Mine Site South - Blast	6-Oct-11	7-Hour	33.6	86.6	37.4	48.3	Sounds from mine and equipment operation; birds and other nature sounds
Blast Noise 1 minute interval [a]		1 Minute	40.2	79.8	48.7	56.7	
Mine Site West - Blast	5-6 Oct 2011	24-Hour	29.7	87.4	33.8	45.1	Heavy equipment near mine shaft; light traffic on access road
Blast Noise 1 minute interval [a]		1 Minute	35.5	87.4	NA	67.9	

Source: Golder Associates Inc, 2011.

[a] Blast noise is included in the overall site measurements.

FIGURES



1,500 0 1,500 Feet

LEGEND

- Noise Monitoring Locations
- Project Boundary

REFERENCES

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Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 16

REV.	DATE	DES	REVISION DESCRIPTION	GIS	CHK	RVW

PROJECT

KENNECOTT EAGLE
NOISE & VIBRATION STUDY

TITLE

MILL SITE
NOISE MONITORING LOCATIONS

Golder Associates
Gainesville, Florida

PROJECT No.		113-87635	FILE No.	11387635_A001
DESIGN	GBM	2/14/2012	SCALE: AS SHOWN	REV. 0
GIS	NRL	2/15/2012	**FIGURE 1-1**	
CHECK	XXX	8/13/2008		
REVIEW	XXX	8/13/2008		

Map Document: TB-PS-A.mxt / Modified 3/15/2010 5:11:02 PM / Plotted 3/16/2010 3:12:54 PM by rlamar

Map Document: TB-PS-A.mxt / Modified 3/15/2010 5:11:02 PM / Plotted 3/16/2010 3:12:54 PM by rlamar

LEGEND

- Portal Entrance
- Noise Monitoring Locations
- Fence Line

250 0 250
Meters

REFERENCES

Bing imagery supplied by Microsoft® Virtual Earth Bing Map™ license under ESRI Inc.
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Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 16

REV.	DATE	DES	REVISION DESCRIPTION	GIS	CHK	RVW

PROJECT

KENNECOTT EAGLE
NOISE & VIBRATION STUDY

TITLE

MINE SITE
NOISE MONITORING LOCATIONS

Golder Associates
Gainesville, Florida

PROJECT No.		113-87635	FILE No. 11387635_A002	
DESIGN	GBM	2/6/2012	SCALE: AS SHOWN	REV. 0
GIS	NRL	2/14/2012	**FIGURE 1-2**	
CHECK	XXX	8/13/2008		
REVIEW	XXX	8/13/2008		

LEGEND

- Seismograph Locations
- Portal Entrance
- Blast Location
- Fence Line

250 0 250 Meters

REV.	DATE	DES	REVISION DESCRIPTION	GIS	CHK	RVW

PROJECT

KENNECOTT EAGLE
NOISE & VIBRATION STUDY

TITLE

MINE SITE SEISMOGRAPH LOCATIONS

Golder Associates
Gainesville, Florida

PROJECT No.		113-87635
DESIGN	GBM	2/6/2012
GIS	NRL	2/14/2012
CHECK	XXX	8/13/2008
REVIEW	XXX	8/13/2008

FILE No. 11387635_A002
SCALE: AS SHOWN REV. 0

FIGURE 1-3

REFERENCES

Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 16

Map Document: TB-PS-A.mxt / Modified 3/15/2010 5:11:02 PM / Plotted 3/16/2010 3:12:54 PM by rlamar

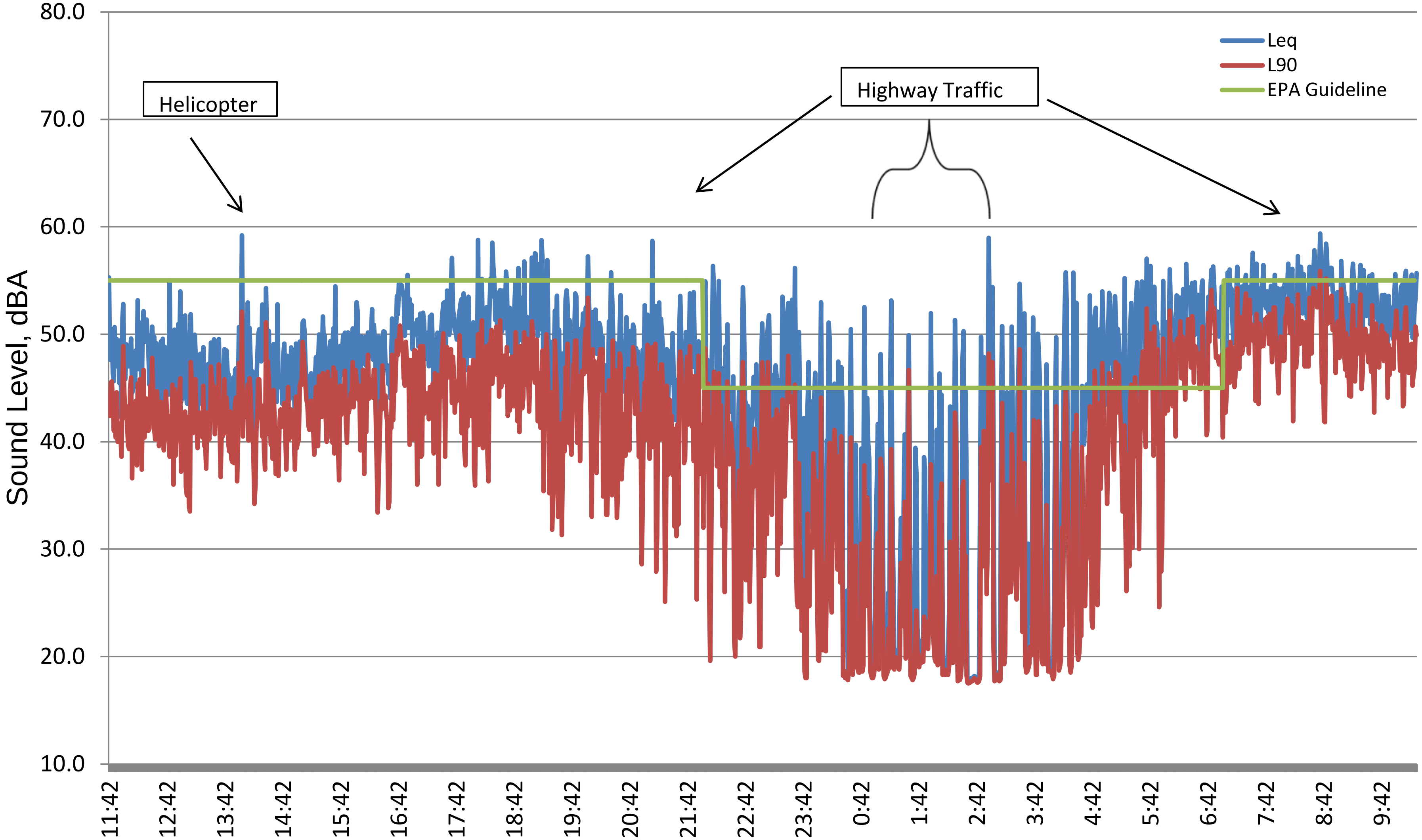

Figure 4-1. 24-hour North Mill Site One Minute Interval Baseline Sound Pressure Levels, October 4 to 5, 2011

Y:\Projects\2011\113-87635 KEMC\Noise Rpt\Final\Figs\Figure 4-1.docx

Source: Golder, 2011.

Golder Associates

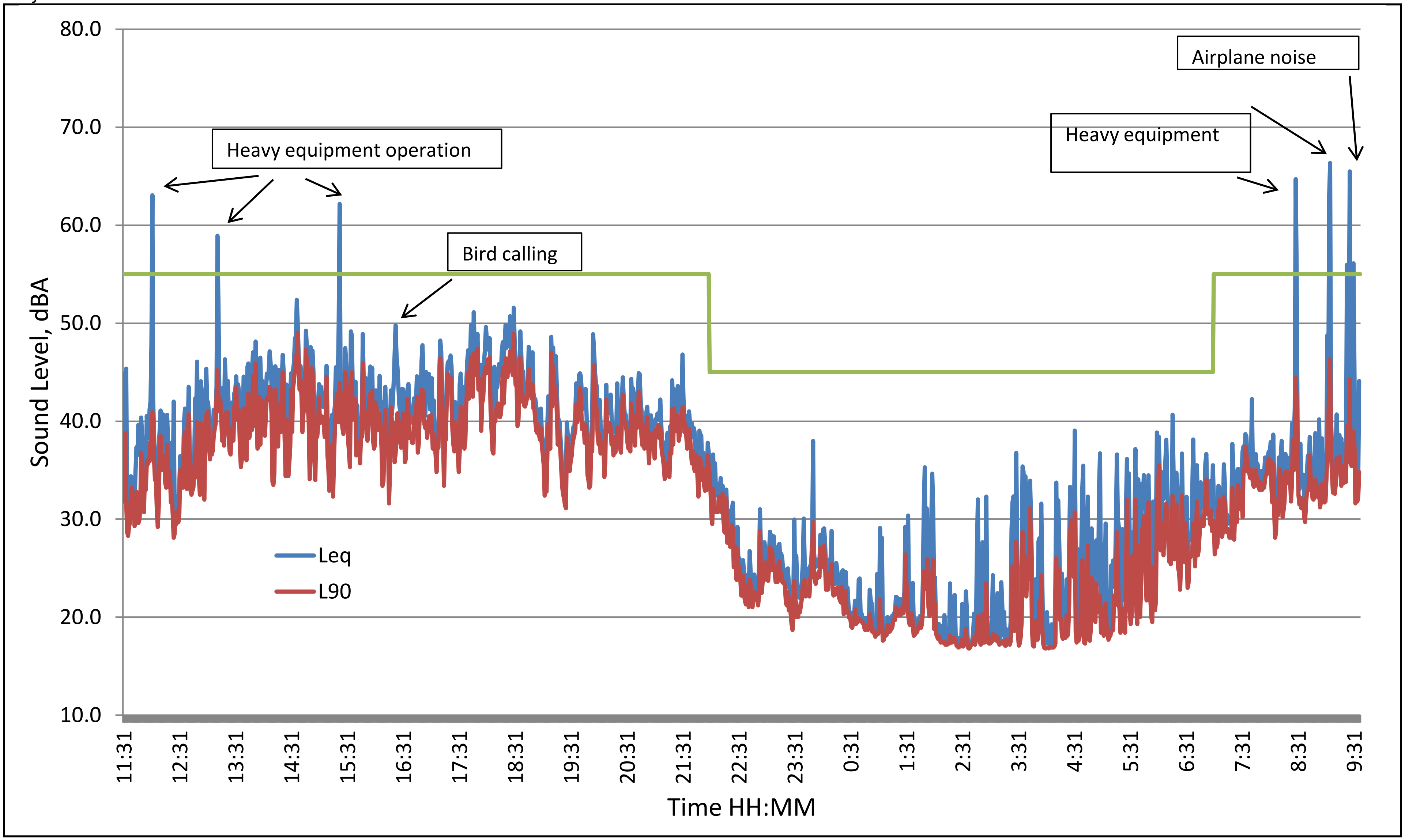

Figure 4-2. 24-hour South Mill Site One Minute Interval Baseline Sound Pressure Levels, October 5 to 6, 2011

Y:\Projects\2011\113-87635 KEMC\Noise Rpt\Final\Figs\Figure 4-2.docx

Source: Golder, 2011.

Golder Associates

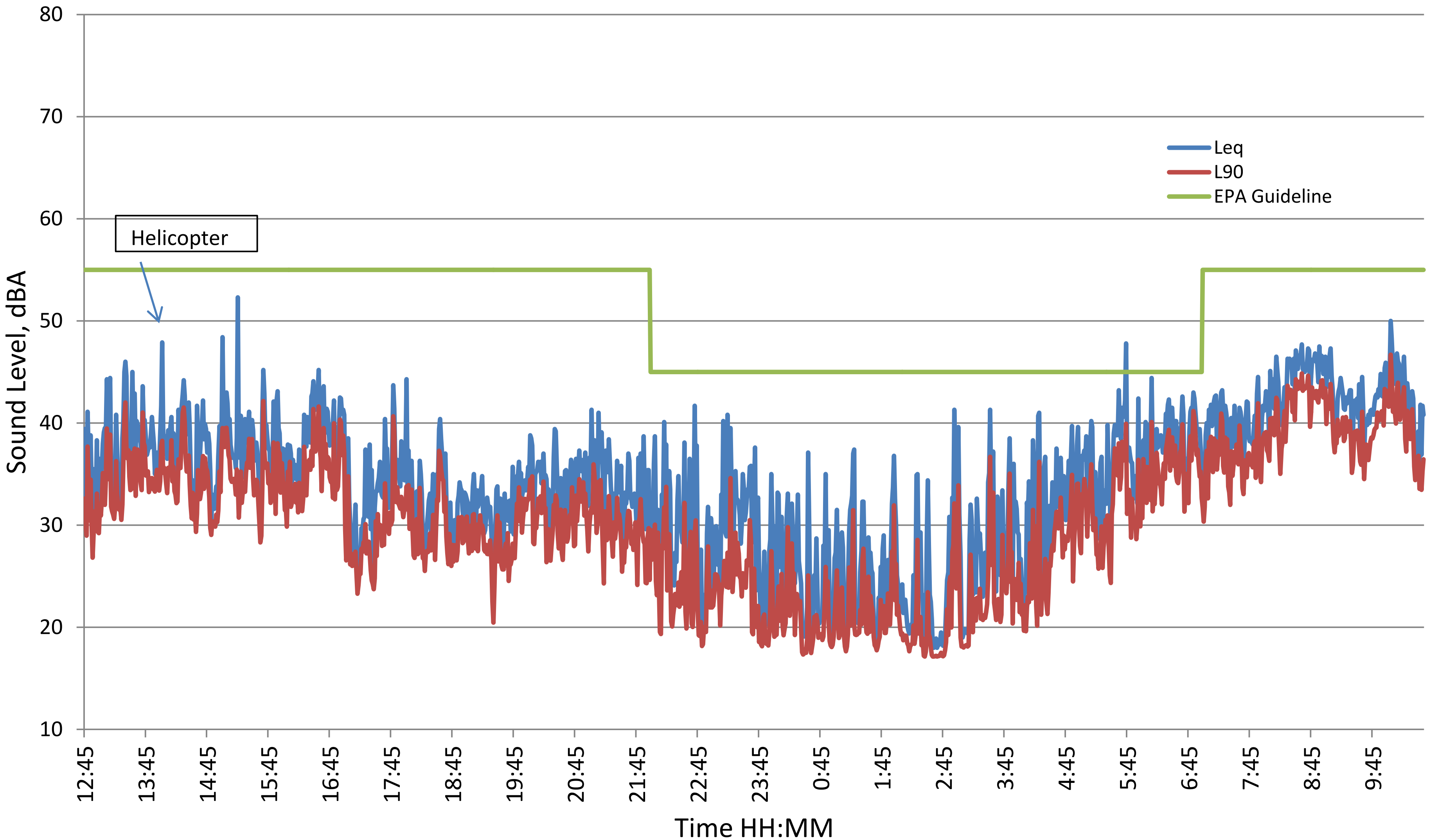

Figure 4-3. 24-hour West Mill Site One Minute Interval Baseline Sound Pressure Levels, October 4 to 5, 2011

Y:\Projects\2011\113-87635 KEMC\Noise Rpt\Final\Figs\Figure 4-3.docx

Source: Golder, 2011.

Golder Associates

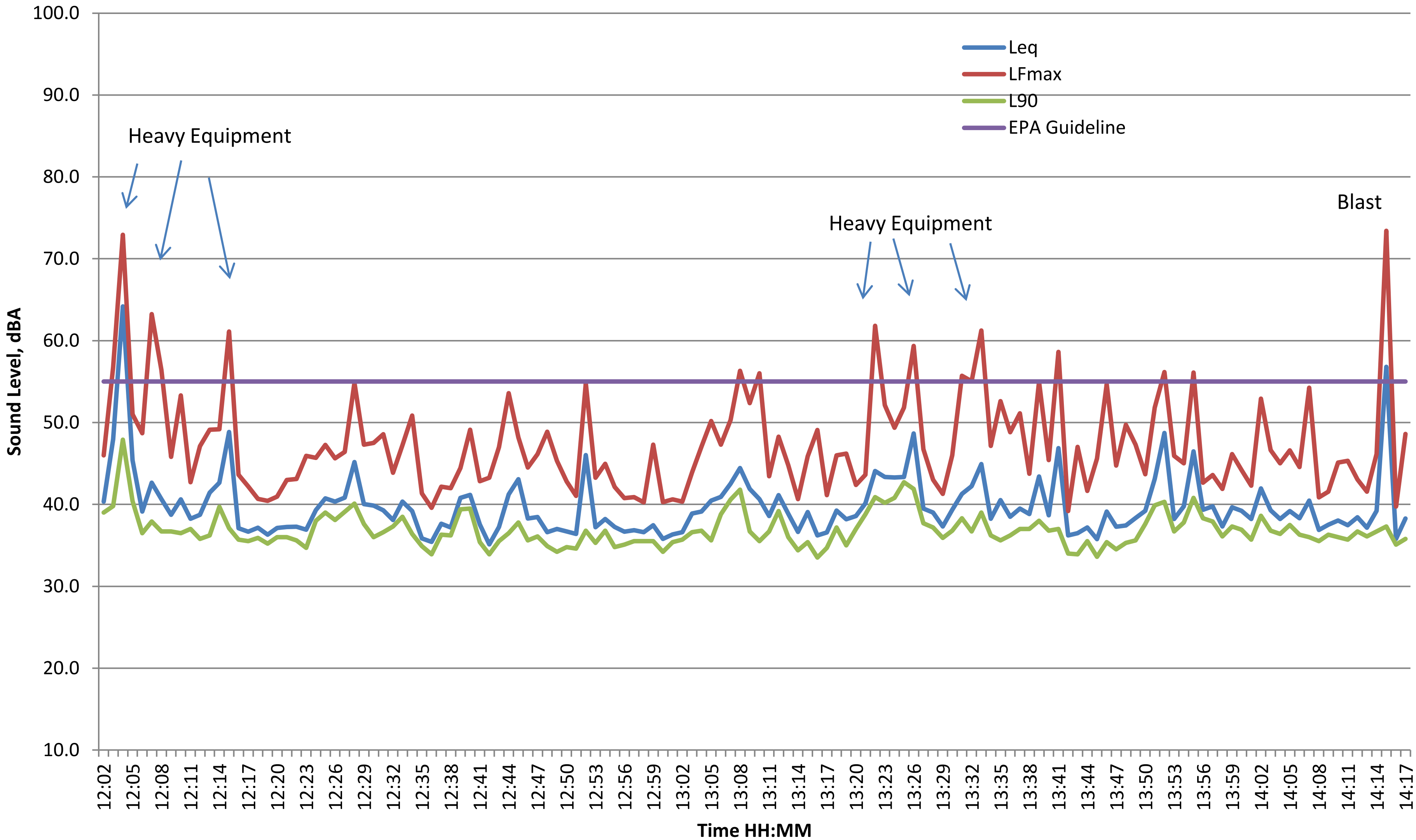

Figure 5-1. North Mine Site One Minute Interval Baseline Sound Pressure Levels, October 6, 2011

Y:\Projects\2011\113-87635 KEMC\Noise Rpt\Final\Figs\Figure 5-1.docx

Source: Golder, 2011.

Golder Associates

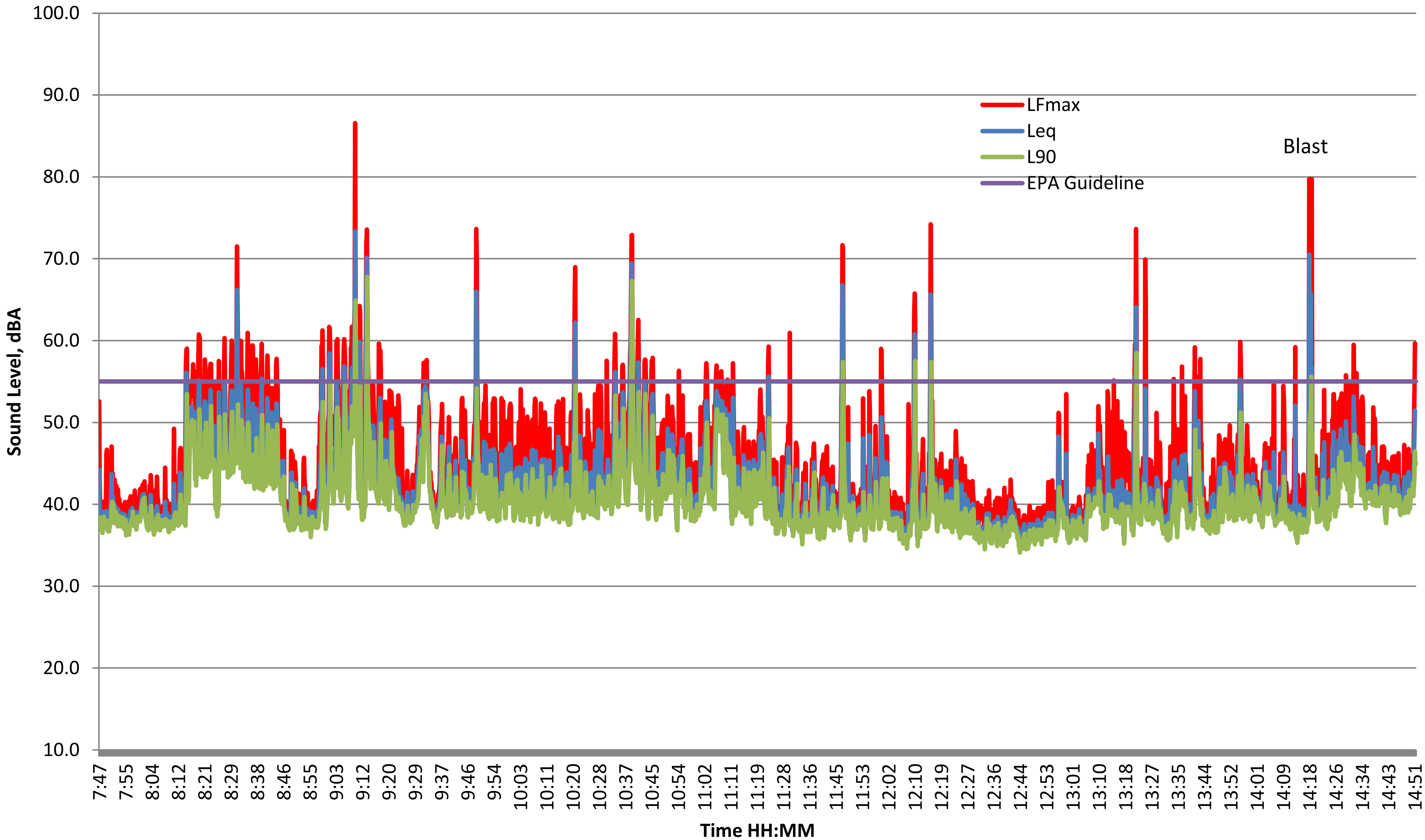

Figure 5-2. South Mine Site One Minute Interval Baseline Sound Pressure Levels, October 6, 2011

Y:\Projects\2011\113-87635 KEMC\Noise Rpt\Final\Figs\Figure 5-2.docx

Source: Golder, 2011.

Golder Associates

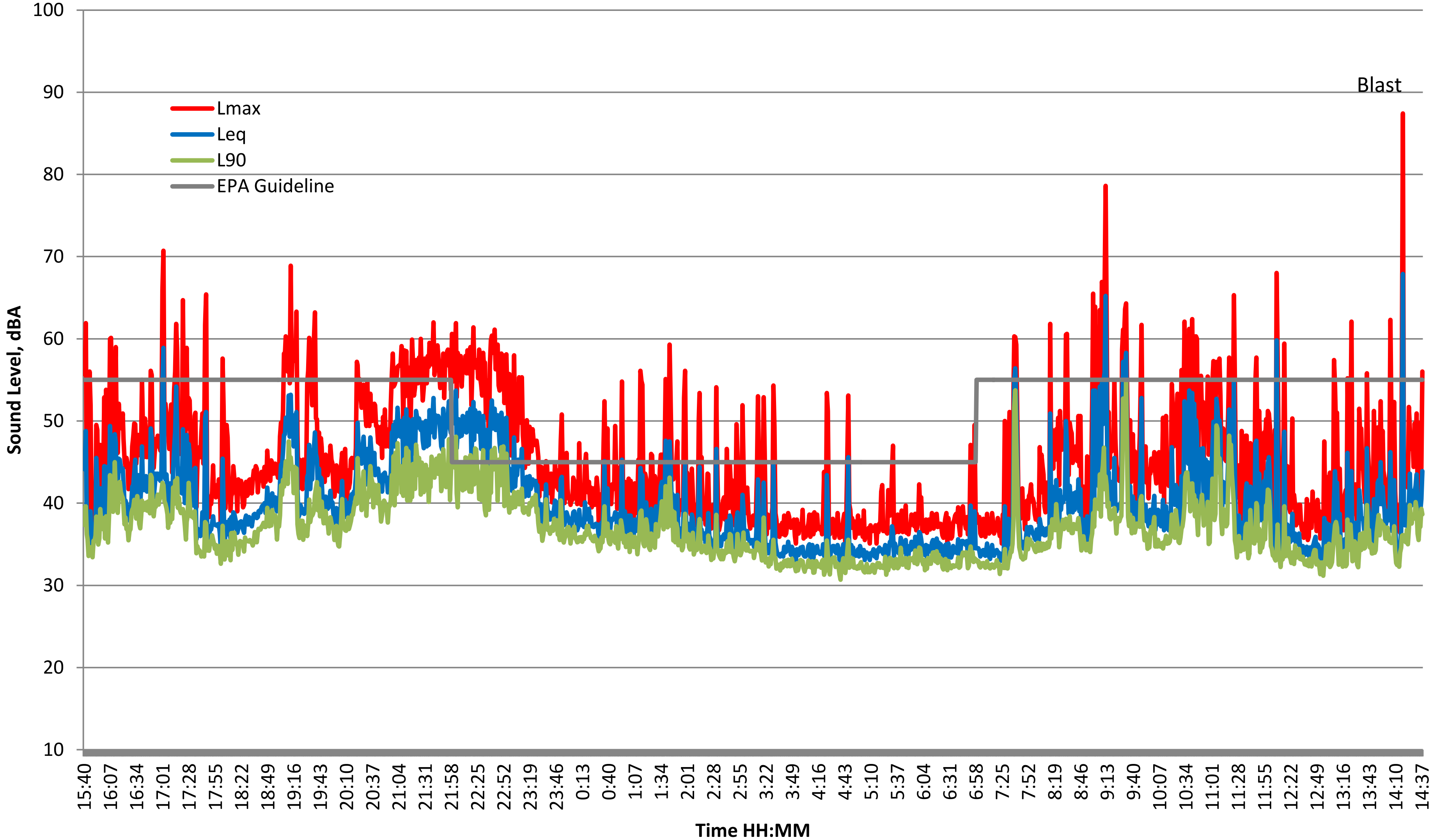

Figure 5-3. 24-Hour West Mine Site One Minute Interval Baseline Sound Pressure Levels, October 5 to 6, 2011

Y:\Projects\2011\113-87635 KEMC\Noise Rpt\Final\Figs\Figure 5-3.docx

Source: Golder, 2011.

Golder Associates

APPENDIX A

SOUND LEVEL METER CALIBRATION REPORTS

PCB PIEZOTRONICS
A PCB GROUP COMPANY

Certificate of Calibration and Conformance

Certificate Number 2011-141418

Instrument Model 824, Serial Number 3106, was calibrated on 29MAR2011. The instrument meets factory specifications per Procedure D0001.8046, IEC 61672-1:2002 Class 1; IEC 60651-2001, 60804-2000 and ANSI S1.4-1983 Type 1 1/3, 1/1 Oct. Filters; S1.11-1986 Type 1C; IEC61260-am1-2001 Class 1 .

Instrument found to be in calibration as received: NO
Date Calibrated: 29MAR2011
Calibration due: 29MAR2012

Calibration Standards Used

MANUFACTURER	MODEL	SERIAL NUMBER	INTERVAL	CAL. DUE	TRACEABILITY NO.
Larson Davis	LDSigGn/2209	0617 / 0104	12 Months	14JAN2012	2011-138543

Reference Standards are traceable to the National Institute of Standards and Technology (NIST)

Calibration Environmental Conditions

Temperature: 22 ° Centigrade

Relative Humidity: 21 %

Affirmations

This Certificate attests that this Instrument has been calibrated under the stated conditions with Measurement and Test Equipment (M&TE) Standards traceable to the U.S. National Institute of Standards and Technology (NIST). All of the Measurement Standards have been calibrated to their manufacturers' specified accuracy / uncertainty. Evidence of traceability and accuracy is on file at Provo Engineering & Manufacturing Center. An acceptable accuracy ratio between the Standard(s) and the item calibrated has been maintained. This instrument meets or exceeds the manufacturer's published specification unless noted.

This calibration complies with the requirements of ISO 17025 and ANSI Z540. The collective uncertainty of the Measurement Standard used does not exceed 25% of the applicable tolerance for each characteristic calibrated unless otherwise noted.

The results documented in this certificate relate only to the item(s) calibrated or tested. A one year calibration is recommended, however calibration interval assignment and adjustment are the responsibility of the end user. This certificate may not be reproduced, except in full, without the written approval of the issuer.

"As received" data unavailable due to unit failure.
Tested with PRM902 S/N 3275

Signed: Sean Childs

Technician: Sean Childs

PCB PIEZOTRONICS
A PCB GROUP COMPANY

Certificate of Calibration and Conformance

Certificate Number 2011-141641

Microphone Model 2560, Serial Number 3424, was calibrated on 31MAR2011. The microphone meets factory specifications per Test Procedure D0001.8167.

Instrument found to be in calibration as received: NO
Date Calibrated: 31MAR2011
Calibration due: 31MAR2012

Calibration Standards Used

MANUFACTURER	MODEL	SERIAL NUMBER	INTERVAL	CAL. DUE	TRACEABILITY NO.
Larson Davis	2559	2506	12 Months	10MAY2011	17414-1
Larson Davis	2900	0575	12 Months	18JUN2011	2010-130730
Larson Davis	PRM915	0102	12 Months	17AUG2011	2010-132962
Larson Davis	PRM902	0206	12 Months	17AUG2011	2010-132963
Larson Davis	2559	3034LF	12 Months	18AUG2011	2010-133036
Larson Davis	PRM902	0529	12 Months	08SEP2011	2010-133837
Larson Davis	PRM902	0528	12 Months	08SEP2011	2010-133838
Larson Davis	MTS1000 / 2201	1000 / 0100	12 Months	10SEP2011	SM090910
Hewlett Packard	34401A	3146A62099	12 Months	11NOV2011	4994123
Larson Davis	PRM916	0102	12 Months	23DEC2011	2010-137908
Larson Davis	CAL250	42630	12 Months	04JAN2012	2011-138110

Reference Standards are traceable to the National Institute of Standards and Technology (NIST)

Calibration Environmental Conditions

Environmental test conditions as printed on microphone calibration chart.

Affirmations

This Certificate attests that this instrument has been calibrated under the stated conditions with Measurement and Test Equipment (M&TE) Standards traceable to the U.S. National Institute of Standards and Technology (NIST). All of the Measurement Standards have been calibrated to their manufacturers' specified accuracy / uncertainty. Evidence of traceability and accuracy is on file at Provo Engineering & Manufacturing Center. An acceptable accuracy ratio between the Standard(s) and the item calibrated has been maintained. This instrument meets or exceeds the manufacturer's published specification unless noted.

This calibration complies with the requirements of ISO 17025 and ANSI Z540. The collective uncertainty of the Measurement Standard used does not exceed 25% of the applicable tolerance for each characteristic calibrated unless otherwise noted.

The results documented in this certificate relate only to the item(s) calibrated or tested. A one year calibration is recommended, however calibration interval assignment and adjustment are the responsibility of the end user. This certificate may not be reproduced, except in full, without the written approval of the issuer.

"AS RECEIVED" data is unavailable due to unit failure.

Signed: Abraham Ortega
Technician: Abraham Ortega

Provo Engineering and Manufacturing Center, 1681 West 820 North, Provo, Utah 84601
Toll Free: 888.258.3222 Telephone: 716.926.8243 Fax: 716.926.8215
ISO 9001-2000 Certified

PCB PIEZOTRONICS
A PCB GROUP COMPANY

Certificate of Calibration and Conformance

Certificate Number 2011-141413

Instrument Model PRM902, Serial Number 3275, was calibrated on 29MAR2011. The instrument meets factory specifications per Procedure D0001.8126.

Instrument found to be in calibration as received: NO
Date Calibrated: 29MAR2011
Calibration due: 29MAR2012

Calibration Standards Used

MANUFACTURER	MODEL	SERIAL NUMBER	INTERVAL	CAL. DUE	TRACEABILITY NO.
Hewlett Packard	34401A	US36033460	12 Months	19JUN2011	4816110
Larson Davis	LDSigGn/2209	0617 / 0104	12 Months	14JAN2012	2011-138543

Reference Standards are traceable to the National Institute of Standards and Technology (NIST)

Calibration Environmental Conditions

Temperature: 22 ° Centigrade

Relative Humidity: 21 %

Affirmations

This Certificate attests that this instrument has been calibrated under the stated conditions with Measurement and Test Equipment (M&TE) Standards traceable to the U.S. National Institute of Standards and Technology (NIST). All of the Measurement Standards have been calibrated to their manufacturers' specified accuracy / uncertainty. Evidence of traceability and accuracy is on file at Provo Engineering & Manufacturing Center. An acceptable accuracy ratio between the Standard(s) and the item calibrated has been maintained. This instrument meets or exceeds the manufacturer's published specification unless noted.

This calibration complies with the requirements of ISO 17025 and ANSI Z540. The collective uncertainty of the Measurement Standard used does not exceed 25% of the applicable tolerance for each characteristic calibrated unless otherwise noted.

The results documented in this certificate relate only to the item(s) calibrated or tested. A one year calibration is recommended, however calibration interval assignment and adjustment are the responsibility of the end user. This certificate may not be reproduced, except in full, without the written approval of the issuer.

"As received" data unavailable due to unit failure.

Signed: Sean Childs
Technician: Sean Childs

Provo Engineering and Manufacturing Center, 1681 West 820 North, Provo, Utah 84601
Toll Free: 888.258.3222 Telephone: 716.926.8243 Fax: 716.926.8215
ISO 9001-2000 Certified

PCB PIEZOTRONICS
A PCB GROUP COMPANY

Certificate of Calibration and Conformance

Certificate Number 2011-141047

Instrument Model CAL200, Serial Number 4318, was calibrated on 18MAR2011. The instrument meets factory specifications per Procedure D0001.8190.

Instrument found to be in calibration as received: YES
Date Calibrated: 18MAR2011
Calibration due: 18MAR2012

Calibration Standards Used

MANUFACTURER	MODEL	SERIAL NUMBER	INTERVAL	CAL. DUE	TRACEABILITY NO.
Larson Davis	2900	0661	12 Months	02APR2011	2010-128279
Larson Davis	2559	2506	12 Months	10MAY2011	17414-1
Hewlett Packard	34401A	3146A10352	12 Months	12AUG2011	4877885
Larson Davis	PRM915	0112	12 Months	09SEP2011	2010-133976
Larson Davis	PRM902	0480	12 Months	09SEP2011	2010-133975
Larson Davis	MTS1000/2201	0111	12 Months	09SEP2011	SM090910
PCB	1502B02FJ15PSIA	1342	12 Months	06DEC2011	3374488329

Reference Standards are traceable to the National Institute of Standards and Technology (NIST)

Calibration Environmental Conditions

Environmental test conditions as shown on calibration report.

Affirmations

This Certificate attests that this instrument has been calibrated under the stated conditions with Measurement and Test Equipment (M&TE) Standards traceable to the U.S. National Institute of Standards and Technology (NIST). All of the Measurement Standards have been calibrated to their manufacturers' specified accuracy / uncertainty. Evidence of traceability and accuracy is on file at Provo Engineering & Manufacturing Center. An acceptable accuracy ratio between the Standard(s) and the item calibrated has been maintained. This instrument meets or exceeds the manufacturer's published specification unless noted.

This calibration complies with the requirements of ISO 17025 and ANSI Z540. The collective uncertainty of the Measurement Standard used does not exceed 25% of the applicable tolerance for each characteristic calibrated unless otherwise noted.

The results documented in this certificate relate only to the item(s) calibrated or tested. A one year calibration is recommended, however calibration interval assignment and adjustment are the responsibility of the end user. This certificate may not be reproduced, except in full, without the written approval of the issuer.

Before: 113.96 dB, 93.97 dB, 1000.2 Hz @ sea level.
After: Refer to Certificate of Measured Output.

Signed: Scott Montgomery
Technician: Scott Montgomery

Provo Engineering and Manufacturing Center, 1681 West 820 North, Provo, Utah 84601
Toll Free: 888.258.3222 Telephone: 716.926.8243 Fax: 716.926.8215
ISO 9001-2000 Certified

PCB PIEZOTRONICS
A PCB GROUP COMPANY

Certificate of Calibration and Conformance

Certificate Number 2011-145350

Instrument Model 831, Serial Number 0001314, was calibrated on 23JUN2011. The instrument meets factory specifications per Procedure D0001.8310, ANSI S1.4-1983 (R 2006) Type 1; S1.4A-1985 ; S1.43-1997 Type 1; S1.11-2004 Octave Band Class 0; S1.25-1991; IEC 61672-2002 Class 1; 60651-2001 Type 1; 60804-2000 Type 1; 61260-2001 Class 0; 61252-2002.

Instrument found to be in calibration as received: YES
Date Calibrated: 23JUN2011
Calibration due: 23JUN2012

Calibration Standards Used

MANUFACTURER	MODEL	SERIAL NUMBER	INTERVAL	CAL. DUE	TRACEABILITY NO.
Stanford Research Systems	DS360	61889	12 Months	01FEB2012	61889-020111

Reference Standards are traceable to the National Institute of Standards and Technology (NIST)

Calibration Environmental Conditions

Temperature: 23 ° Centigrade

Relative Humidity: 39 %

Affirmations

This Certificate attests that this instrument has been calibrated under the stated conditions with Measurement and Test Equipment (M&TE) Standards traceable to the U.S. National Institute of Standards and Technology (NIST). All of the Measurement Standards have been calibrated to their manufacturers' specified accuracy / uncertainty. Evidence of traceability and accuracy is on file at Provo Engineering & Manufacturing Center. An acceptable accuracy ratio between the Standard(s) and the item calibrated has been maintained. This instrument meets or exceeds the manufacturer's published specification unless noted.

This calibration complies with the requirements of ISO 17025 and ANSI Z540. The collective uncertainty of the Measurement Standard used does not exceed 25% of the applicable tolerance for each characteristic calibrated unless otherwise noted.

The results documented in this certificate relate only to the item(s) calibrated or tested. A one year calibration is recommended, however calibration interval assignment and adjustment are the responsibility of the end user. This certificate may not be reproduced, except in full, without the written approval of the issuer.

"AS RECEIVED" data same as shipped data.
Tested with PRM831-0480

Signed: Ron Harris
Technician: Ron Harris

Provo Engineering and Manufacturing Center, 1681 West 820 North, Provo, Utah 84601
Toll Free: 888.258.3222 Telephone: 716.926.8243 Fax: 716.926.8215
ISO 9001-2008 Certified

PCB PIEZOTRONICS
A PCB GROUP COMPANY

Certificate of Calibration and Conformance

Certificate Number 2011-145344

Instrument Model PRM831, Serial Number 0480, was calibrated on 23JUN2011. The instrument meets factory specifications per Procedure D0001.8167.

Instrument found to be in calibration as received: YES
Date Calibrated: 23JUN2011
Calibration due: 23JUN2012

Calibration Standards Used

MANUFACTURER	MODEL	SERIAL NUMBER	INTERVAL	CAL. DUE	TRACEABILITY NO.
Hewlett Packard	34401A	MY41044529	12 Months	26JAN2012	5056765
Larson Davis	LDSigGn/2209	0277 / 0109	12 Months	21MAR2012	2011-141059

Reference Standards are traceable to the National Institute of Standards and Technology (NIST)

Calibration Environmental Conditions

Temperature: 23 ° Centigrade

Relative Humidity: 39 %

Affirmations

This Certificate attests that this instrument has been calibrated under the stated conditions with Measurement and Test Equipment (M&TE) Standards traceable to the U.S. National Institute of Standards and Technology (NIST). All of the Measurement Standards have been calibrated to their manufacturers' specified accuracy / uncertainty. Evidence of traceability and accuracy is on file at Provo Engineering & Manufacturing Center. An acceptable accuracy ratio between the Standard(s) and the item calibrated has been maintained. This instrument meets or exceeds the manufacturer's published specification unless noted.

This calibration complies with the requirements of ISO 17025 and ANSI Z540. The collective uncertainty of the Measurement Standard used does not exceed 25% of the applicable tolerance for each characteristic calibrated unless otherwise noted.

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Technician: Ron Harris

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PCB PIEZOTRONICS
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Certificate of Calibration and Conformance

Certificate Number 2011-145423

Microphone Model 377B02, Serial Number 109933, was calibrated on 27JUN2011. The microphone meets factory specifications per Test Procedure D0001.8167.

Instrument found to be in calibration as received: YES
Date Calibrated: 27JUN2011
Calibration due: 27JUN2012

Calibration Standards Used

MANUFACTURER	MODEL	SERIAL NUMBER	INTERVAL	CAL. DUE	TRACEABILITY NO.
Larson Davis	PRM915	0102	12 Months	17AUG2011	2010-132962
Larson Davis	PRM902	0206	12 Months	17AUG2011	2010-132963
Larson Davis	2559	3034LF	12 Months	18AUG2011	2010-133036
Larson Davis	PRM902	0529	12 Months	08SEP2011	2010-133837
Larson Davis	PRM902	0528	12 Months	08SEP2011	2010-133838
Larson Davis	MTS1000 / 2201	1000 / 0100	12 Months	10SEP2011	SM090910
Hewlett Packard	34401A	3146A62099	12 Months	11NOV2011	4994123
Larson Davis	2559	2504	12 Months	29NOV2011	17865-1
Larson Davis	PRM916	0102	12 Months	23DEC2011	2010-137908
Larson Davis	CAL250	42630	12 Months	04JAN2012	2011-138110
Larson Davis	2900	0575	12 Months	14JUN2012	2011-144882

Reference Standards are traceable to the National Institute of Standards and Technology (NIST)

Calibration Environmental Conditions

Environmental test conditions as printed on microphone calibration chart.

Affirmations

This Certificate attests that this instrument has been calibrated under the stated conditions with Measurement and Test Equipment (M&TE) Standards traceable to the U.S. National Institute of Standards and Technology (NIST). All of the Measurement Standards have been calibrated to their manufacturers' specified accuracy / uncertainty. Evidence of traceability and accuracy is on file at Provo Engineering & Manufacturing Center. An acceptable accuracy ratio between the Standard(s) and the item calibrated has been maintained. This instrument meets or exceeds the manufacturer's published specification unless noted.

This calibration complies with the requirements of ISO 17025 and ANSI Z540. The collective uncertainty of the Measurement Standard used does not exceed 25% of the applicable tolerance for each characteristic calibrated unless otherwise noted.

The results documented in this certificate relate only to the item(s) calibrated or tested. A one year calibration is recommended, however calibration interval assignment and adjustment are the responsibility of the end user. This certificate may not be reproduced, except in full, without the written approval of the issuer.

"AS RECEIVED" data is the same as shipped data.

Signed: Abraham Ortega
Technician: Abraham Ortega

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Toll Free: 888.258.3222 Telephone: 716.926.8243 Fax: 716.926.8215
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PCB PIEZOTRONICS
A PCB GROUP COMPANY

Certificate of Calibration and Conformance

Certificate Number 2011-145518

Instrument Model CAL200, Serial Number 5636, was calibrated on 28JUN2011. The instrument meets factory specifications per Procedure D0001.8190.

Instrument found to be in calibration as received: YES
Date Calibrated: 28JUN2011
Calibration due: 28JUN2012

Calibration Standards Used

MANUFACTURER	MODEL	SERIAL NUMBER	INTERVAL	CAL. DUE	TRACEABILITY NO.
Hewlett Packard	34401A	3146A10352	12 Months	12AUG2011	4877885
Larson Davis	PRM915	0112	12 Months	09SEP2011	2010-133976
Larson Davis	PRM902	0480	12 Months	09SEP2011	2010-133975
Larson Davis	MTS1000/2201	0111	12 Months	09SEP2011	SM090910
Larson Davis	2559	2504	12 Months	29NOV2011	17865-1
PCB	1502B02FJ15PSIA	1342	12 Months	06DEC2011	3374488329
Larson Davis	2900	0661	12 Months	05APR2012	2011-141857

Reference Standards are traceable to the National Institute of Standards and Technology (NIST)

Calibration Environmental Conditions

Environmental test conditions as shown on calibration report.

Affirmations

This Certificate attests that this instrument has been calibrated under the stated conditions with Measurement and Test Equipment (M&TE) Standards traceable to the U.S. National Institute of Standards and Technology (NIST). All of the Measurement Standards have been calibrated to their manufacturers' specified accuracy / uncertainty. Evidence of traceability and accuracy is on file at Provo Engineering & Manufacturing Center. An acceptable accuracy ratio between the Standard(s) and the item calibrated has been maintained. This instrument meets or exceeds the manufacturer's published specification unless noted.

This calibration complies with the requirements of ISO 17025 and ANSI Z540. The collective uncertainty of the Measurement Standard used does not exceed 25% of the applicable tolerance for each characteristic calibrated unless otherwise noted.

The results documented in this certificate relate only to the item(s) calibrated or tested. A one year calibration is recommended, however calibration interval assignment and adjustment are the responsibility of the end user. This certificate may not be reproduced, except in full, without the written approval of the issuer.

Before: 114.07 dB, 94.06 dB, 1000.3 Hz @ sea level.
After: Refer to Certificate of Measured Output.

Signed: Scott Montgomery
Technician: Scott Montgomery

Provo Engineering and Manufacturing Center, 1681 West 820 North, Provo, Utah 84601
Toll Free: 888.258.3222 Telephone: 716.926.8243 Fax: 716.926.8215
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APPENDIX B

FIELD PRACTICE GUIDELINES FOR BLASTING SEISMOGRAPHS
2009 EDITION

PERFORMANCE SPECIFICATIONS FOR BLASTING SEISMOGRAPHS

GENERAL SPECIFICATIONS

Ground Vibrations Measurement:

Frequency range……………….	2 to 250 Hz, within zero to -3 dB of an ideal flat response
Accuracy………………………..	±5 pct or ±0.02 in/sec (0.5 mm/sec), whichever is larger, between 4 and 125 Hz
Phase response…………………	See Level #2
Cross-talk response……………	See Level #2
Density of transducer jug…….	<150 lbs/ft^3 (should be reported for user consideration)

Airblast Measurement:

Frequency range…………….….	2 to 250 Hz flat, -3 dB at 2 Hz ±1dB
Accuracy……………………….	±10 pct or ±1 dB, whichever is larger, between 4 and 125 Hz.

General Requirements:

Digital sampling………………..	1000 samples/sec or greater, per channel
Operating temperature………..	10 to 120^{0}F (-12 to 49^{0}C)

Measurement Practices:

Specified in a separate specification: Seismograph Field Practice Guidelines

SPECIFIC USER NEEDS

Some requirements are specific to a user, an application, or a regional need. General Specifications listed above are to be considered minimums. Additional requirements can be requested by a customer, such as, use under arctic-type conditions requiring good performance at low temperatures or extended frequency ranges such as might be of concern for close-in construction blasting.

Other performance capabilities related to specific needs are:

1. Dynamic range (smallest to highest usable measurement)
2. Resolution
3. Trigger levels and options (vibration, airblast or both)
4. Recording duration (per event)
5. Memory or record capacity (number of events)
6. Nature of display and recording (hard copy, LCD, downloading, etc.)
7. Mounting options (transducer attitude, orientation, etc.)

International Society of Explosives Engineers
Blast Vibrations and Seismograph Section
30325 Bainbridge Road • Cleveland, Ohio 44139-2295
Tel: 440-349-4400 • Fax: 440-349-3788 www.isee.org

ISEE
Field Practice Guidelines For Blasting Seismographs
2009 Edition

International Society of Explosives Engineers
30325 Bainbridge Road
Cleveland, OH 44139

Published by
International Society of Explosives Engineers
30325 Bainbridge Road
Cleveland, Ohio USA 44139-2295
http://www.isee.org

International Society of Explosives Engineers - Standards Committee Members*
Chairman, Kenneth K Eltschlager, US Office of Surface Mining Reclamation and Enforcement
Douglas Bartley, DBA Consulting
Steven DelloRusso, Simpson Gumpertz & Heger Inc.
Alastair Grogan, Davey Bickford Canada, Inc.
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Douglas Rudenko, Vibra-Tech Engineers, Inc.
Mark Svinkin, Vibraconsult
Robert Turnbull, Instantel
Randall Wheeler, White Industrial Seismology
Board Liaison, John Wiegand, Vibronics, Inc.

**This list represents the membership at the time the Committee was balloted on the final text of this edition. Since that time, changes in the membership may have occurred. A key to classifications is found at the back of the document.*

Committee Scope: This Committee shall have primary responsibility for documents on the manufacture, transportation, storage, and use of explosives and related materials. This Committee does not have responsibility for documents on consumer and display fireworks, model and high power rockets and motors, and pyrotechnic special effects.

ISEE Field Practice Guidelines For Blasting Seismographs

International Society of Explosives Engineers
30325 Bainbridge Road
Cleveland, OH 44139

International Society of Explosives Engineers

ISEE Field Practice Guidelines
For
Blasting Seismographs
2009 Edition

This edition of *ISEE Field Practice Guidelines for Blasting Seismographs* was revised by the ISEE Standards Committee on February 4, 2008 and supersedes all previous editions. It was approved by the Society's Board of Directors in its role of Secretariat of the Standards at its February 5, 2009 meeting.

Origin and Development of
ISEE Field Practice Guidelines for Blasting Seismographs

In 1994, questions were raised about the accuracy, reproducibility and defensibility of data from blasting seismographs. To address this issue, the International Society of Explosives Engineers (ISEE) established a Seismograph Standards Subcommittee at its annual conference held in February 1995. The committee was comprised of seismograph manufacturers, researchers, regulatory personnel and seismograph users.

In 1997, the Committee became the Blast Vibrations and Seismograph Section. The Guidelines were drafted and approved by the Section in December of 1999. The Section completed two standards in the year 2000: 1) ISEE Field Practice Guidelines for Blasting Seismographs; and 2) Performance Specifications for Blasting Seismographs.

In 2002, the Society established the ISEE Standards Committee. A review of the ISEE Field Practice Guidelines and the Performance Specifications for Blasting Seismographs fell within the scope of the Committee. Work began on a review of the Field Practice Guidelines in January of 2006 and was completed in February of 2008 with this edition.

One of the goals of the ISEE Standards Committee is to develop uniform and technically appropriate standards for blasting seismographs. The intent is to improve accuracy and consistency in ground and air vibration measurements. Blasting seismograph performance is affected by how the blasting seismograph is built and how it is placed in the field.

The ISEE Standards Committee takes on the role of keeping the standards up to date. These standards can be obtained by contacting the International Society of Explosives Engineers located at 30325 Bainbridge Road, Cleveland, Ohio 44139 or by visiting our website at www.isee.org.

Table of Contents

Disclaimer: These field practice recommendations are intended to serve as general guidelines, and cannot describe all types of field conditions. It is incumbent on the operator to evaluate these conditions and to obtain good coupling between monitoring instrument and the surface to be monitored. In all cases, the operator should describe the field conditions and setup procedures in the permanent record of each blast.

Preface: Blasting seismographs are used to establish compliance with Federal, state and local regulations and evaluate explosive performance. Laws and regulations have been established to prevent damage to property and injury to people. The disposition of the rules is strongly dependant on the accuracy of ground vibration and air overpressure data. In terms of explosive performance the same holds true. One goal of the ISEE Standards Committee is to ensure consistent recording of ground vibrations and air overpressure between all blasting seismographs.

Part I. General Guidelines

Blasting seismographs are deployed in the field to record the levels of blast-induced ground vibration and air overpressure. Accuracy of the recordings is essential. These guidelines define the user's responsibilities when deploying blasting seismographs in the field and assume that the blasting seismographs conform to the ISEE "Performance Specifications for Blasting Seismographs".

1. Read the instruction manual and be familiar with the operation of the instrument. Every seismograph comes with an instruction manual. Users are responsible for reading the appropriate sections and understanding the proper operation of the instrument before monitoring a blast.

2. Seismograph calibration. Annual calibration of the seismograph is recommended.

3. Keep proper blasting seismograph records. A user's log should note: the user's name, date, time, place and other pertinent data.

4. Document the location of the seismograph. This includes the name of the structure and where the seismograph was placed on the property relative to the structure. Any person should be able to locate and identify the exact monitoring location at a future date.

5. Know and record the distance to the blast. The horizontal distance from the seismograph to the blast should be known to at least two significant digits. For example, a blast within 1000 meters or feet would be measured to the nearest tens of meters or feet respectively and a blast within 10,000 meters or feet would be measured to the nearest hundreds of feet or meters respectively. Where elevation changes exceed 2.5h:1v, slant distances or true distance should be used.

6. Record the blast. When seismographs are deployed in the field, the time spent deploying the unit justifies recording an event. As practical, set the trigger levels low enough to record each blast.

7. Record the full time history waveform. Summary or single peak value recording options available on many seismographs should not be used for monitoring blast-generated vibrations. Operating modes that report peak velocities over a specified time interval are not recommended when recording blast-induced vibrations.

8. Set the sampling rate. The blasting seismograph should be programmed to record the entire blast event in enough detail to accurately reproduce the vibration trace. In general the sample rate should be at least 1000 samples per second.

9. Know the data processing time of the seismograph. Some units take up to 5 minutes to process and print data. If another blast occurs within this time the second blast may be missed.

10. Know the memory or record capacity of the seismograph. Enough memory must be available to store the event. The full waveform should be saved for future reference in either digital or analog form.

11. Know the nature of the report that is required. For example, provide a hard copy in the field, keep digital data as a permanent record or both. If an event is to be printed in the field, a printer with paper is needed.

12. Allow ample time for proper setup of the seismograph. Many errors occur when seismographs are hurriedly set-up. Generally, more than 15 minutes for set-up should be allowed from the time the user arrives at the monitoring location until the blast.

13. Know the temperature. Seismographs have varying manufacturer specified operating temperatures.

14. Secure cables. Suspended or freely moving cables from the wind or other extraneous sources can produce false triggers due to microphonics.

Part II. Ground Vibration Monitoring

Placement and coupling of the vibration sensor are the two most important factors to ensure accurate ground vibration recordings.

A. Sensor Placement

The sensor should be placed on or in the ground on the side of the structure towards the blast. A structure can be a house, pipeline, telephone pole, etc. Measurements on driveways, walkways, and slabs are to be avoided where possible.

1. Location relative to the structure. Sensor placement should ensure that the data obtained adequately represents the ground-borne vibration levels received at the structure. The sensor should be placed within 3.05 meters (10 feet) of the structure or less than 10% of the distance from the blast, whichever is less.

2. Soil density evaluation. The soil should be undisturbed or compacted fill. Loose fill material, unconsolidated soils, flower-bed mulch or other unusual mediums may have an adverse influence on the recording accuracy.

3. The sensor must be nearly level.

4. The longitudinal channel should be pointing directly at the blast and the bearing should be recorded.

5. Where access to a structure and/or property is not available, the sensor should be placed closer to the blast in undisturbed soil.

B. Sensor coupling

If the acceleration exceeds 1.96 m/s^2 (0.2 g), decoupling of the sensor may occur. Depending on the anticipated acceleration levels spiking, burial, or sandbagging of the geophone to the ground may be appropriate.

1. If the acceleration is expected to be:
    - a. less than 1.96 m/s^2 (0.2 g), no burial or attachment is necessary
    - b. between 1.96 m/s^2 (0.2 g), and 9.81 m/s^2 (1.0 g), burial or attachment is preferred. Spiking may be acceptable.
    - c. greater than 9.81 m/s^2 (1.0 g) , burial or firm attachment is required (RI 8506).

The following table exemplifies the particle velocities and frequencies where accelerations are 1.96 m/s^2 (0.2 g) and 9.81 m/s^2 (1.0 g).

Frequency, Hz	4	10	15	20	25	30	40	50	100	200
Particle Velocity mm/s (in/s) at 1.96 m/s^2 (0.2 g)	78.0 (3.07)	31.2 (1.23)	20.8 (0.82)	15.6 (0.61)	12.5 (0.49)	10.4 (0.41)	7.8 (0.31)	6.2 (0.25)	3.1 (0.12)	1.6 (0.06)
Particle Velocity mm/s (in/s) at 9.81 m/s^2 (1.0 g)	390 (15.4)	156 (6.14)	104 (4.10)	78.0 (3.07)	62.4 (2.46)	52.0 (2.05)	39.0 (1.54)	31.2 (1.23)	15.6 (0.61)	7.8 (0.31)

2. Burial or attachment methods.
    - a. The preferred burial method is excavating a hole that is no less than three times the height of the sensor (ANSI S2.47), spiking the sensor to the bottom of the hole, and firmly compacting soil around and over the sensor.
    - b. Attachment to bedrock is achieved by bolting, clamping or adhering the sensor to the rock surface.
    - c. The sensor may be attached to the foundation of the structure if it is located within +/- 0.305 meters (1-foot) of ground level (RI 8969). This should only be used if burial, spiking or sandbagging is not practical.

3. Other sensor placement methods.
    - a. Shallow burial is anything less than described at 2a above.
    - b. Spiking entails removing the sod, with minimal disturbance of the soil and firmly pressing the sensor with the attached spike(s) into the ground.

c. Sand bagging requires removing the sod with minimal disturbance to the soil and placing the sensor on the bare spot with a sand bag over top. Sand bags should be large and loosely filled with about 4.55 kilograms (10 pounds) of sand. When placed over the sensor the sandbag profile should be as low and wide as possible with a maximum amount of firm contact with the ground.

d. A combination of both spiking and sandbagging gives even greater assurance that good coupling is obtained.

C. Programming considerations

Site conditions dictate certain actions when programming the seismograph.

1. Ground vibration trigger level. The trigger level should be programmed low enough to trigger the unit from blast vibrations and high enough to minimize the occurrence of false events. The level should be slightly above the expected background vibrations for the area. A good starting level is 1.3 mm/s (0.05 in/s).

2. Dynamic range and resolution. If the seismograph is not equipped with an auto-range function, the user should estimate the expected vibration level and set the appropriate range. The resolution of the printed waveform should allow verification of whether or not the event was a blast.

3. Recording duration - Set the record time for 2 seconds longer than the blast duration plus 1 second for each 335 meters (1100 feet) from the blast.

Part III Air Overpressure Monitoring

Placement of the microphone relative to the structure is the most important factor.

A. Microphone placement

The microphone should be placed along the side of the structure, nearest the blast.

1. The microphone should be mounted near the geophone with the manufacturer's wind screen attached.

2. The microphone may be placed at any height above the ground. (ISEE 2005)

3. If practical, the microphone should not be shielded from the blast by nearby buildings, vehicles or other large barriers. If such shielding cannot be avoided, the horizontal distance between the microphone and shielding object should be greater than the height of the shielding object above the microphone.

4. If placed too close to a structure, the airblast may reflect from the house surface and record higher amplitudes. Structure response noise may also be recorded. Reflection can be minimized by placing the microphone near a corner of the structure. (RI 8508)

5. The orientation of the microphone is not critical for air overpressure frequencies below 1,000 Hz (RI 8508).

B. Programming considerations

Site conditions dictate certain actions when programming the seismograph to record air overpressure.

1. Trigger level. When only an air overpressure measurement is desired, the trigger level should be low enough to trigger the unit from the air overpressure and high enough to minimize the occurrence of false events. The level should be slightly above the expected background noise for the area. A good starting level is 20 Pa (0.20 millibars or 120 dB).

2. Recording duration. When only recording air overpressure, set the recording time for at least 2 seconds more than the blast duration. When ground vibrations and air overpressure measurements are desired on the same record, follow the guidelines for ground vibration programming (Part II C.3).

References:

1. American National Standards Institute, Vibration of Buildings – Guidelines for the Measurement of Vibrations and Evaluation of Their Effects on Buildings. ANSI S2.47-1990, R1997.

2. Eltschlager, K. K., Wheeler, R. M. Microphone Height Effects on Blast-Induced Air Overpressure Measurements, 31st Annual Conference on Explosives and Blasting Technique, International Society of Explosives Engineers, 2005.

3. International Society of Explosives Engineers, ISEE Performance Specifications for Blasting Seismographs, 2000.

4. Siskind, D. E., Stagg, M. S., Kopp, J. W., Dowding, C. H. Structure Response and Damage by Ground Vibration From Mine Blasting. US Bureau of Mines Report of Investigations RI 8507, 1980.

5. Siskind, D. E., Stagg, M. S. Blast Vibration Measurements Near and On Structure Foundations, US Bureau of Mines Report of Investigations RI 8969, 1985.

6. Stachura, V. J., Siskind, D. E., Engler, A. J., Airblast Instrumentation and Measurement for Surface Mine Blasting, US Bureau of Mines Report of Investigations RI 8508, 1981.

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