# Noise Impact Assessment
## Alexco Keno Hill Mining Corp.
## Keno Hill Silver District Operations
## Yukon Territory

**Rev 1**

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## Executive Summary

Patching Associates Acoustical Engineering Ltd. was retained by the Yukon Environmental and Socio-Economic Assessment Board (YESAB) to evaluate and predict the noise level from the existing and proposed Alexco Keno Hill Silver District Operations to be located around the Keno City, 354 km north of Whitehorse, Yukon. Alexco Keno Hill Mining Corp (AKHM) currently operates the Bellekeno mine and Keno District Mill, and proposes to strengthen its operation by incorporating production of Lucky Queen and Onek ore deposits in the Keno Hill Silver District.

The study was conducted in order to:

- Assess the sound data of typical equipment that are currently existing and proposed for AKHM mining operations, which include Bellekeno, Lucky Queen, Onek, the mill operations and the associated trucking activity and traffic noise;
- Predict the noise level from the existing and proposed facilities during mining and mill operations at the potentially most affected receiver locations.

The sound power levels emitted from the existing and proposed facilities were determined through the use of field measurements and theoretical calculations. These values were then used to model the installation and the surrounding area to determine the expected noise level at the Keno City residences and nearby area. The modeling was performed using the CadnaA noise-modeling package.

The following tables summarise the predicted noise levels based on the daytime and nighttime normal operations of the project in the Keno City district mining area.

**Summary of Predicted Noise Levels Generated by AKHM Current Mining Operations under Downwind Conditions (Daytime)**

| Residence | Predicted Facility Noise Levels Day-Time (dBA) | Measured Ambient Sound Levels (dBA) | Predicted Noise Levels Day-Time plus Ambient Sound Levels (dBA) |
|---|---|---|---|
| **R01** | 29 | 39 | **39** |
| **R02** | 30 | 35 | **36** |
| **R03** | 30 | 27 | **32** |
| **R04** | 31 | 34 | **36** |
| **R05** | 31 | 32 | **34** |

**Summary of Predicted Noise Levels Generated by AKHM Current Mining Operations under Downwind Conditions (Nighttime)**

| Residence | Predicted Facility Noise Levels Night-Time (dBA) | Measured Ambient Sound Levels (dBA) | Predicted Noise Levels Night-Time plus Ambient Sound Levels (dBA) |
|---|---|---|---|
| **R01** | 19 | 38 | **38** |
| **R02** | 15 | 28 | **28** |
| **R03** | 23 | 26 | **28** |
| **R04** | 24 | 30 | **31** |
| **R05** | 13 | -- | **--** |

## Summary of Predicted Noise Levels Generated by AKHM Current and Proposed Mining Operations under Downwind Conditions (Daytime)

--(Onek Sign Post Portal Option and Proposed North Bypass Road)

| Residence | Predicted Facility Noise Levels Day-Time (dBA) | Measured Ambient Sound Levels (dBA) | Predicted Noise Levels Day-Time plus Ambient Sound Levels (dBA) |
|---|---|---|---|
| **R01** | 29 | 39 | **39 (0)*** |
| **R02** | 30 | 35 | **36 (0)** |
| **R03** | 32 | 27 | **33 (1)** |
| **R04** | 35 | 34 | **38 (2)** |
| **R05** | 32 | 32 | **35 (1)** |

* The number in bracket is the predicted noise level increase based on current noise level

## Summary of Predicted Noise Levels Generated by AKHM Current and Proposed Mining Operations under Downwind Conditions (Nighttime)

--(Onek Sign Post Portal Option and Proposed North Bypass Road)

| Residence | Predicted Facility Noise Levels Night-Time (dBA) | Measured Ambient Sound Levels (dBA) | Predicted Noise Levels Night-Time plus Ambient Sound Levels (dBA) |
|---|---|---|---|
| **R01** | 20 | 38 | **38 (0)** |
| **R02** | 17 | 28 | **28 (0)** |
| **R03** | 25 | 26 | **28 (0)** |
| **R04** | 30 | 30 | **33 (2)** |
| **R05** | 23 | -- | **--** |

* The number in bracket is the predicted noise level increase based on current noise level

## Summary of Predicted Noise Levels Generated by AKHM Current and Proposed Mining Operations under Downwind Conditions (Daytime)

--(Onek 990 Portal Option and Proposed Keno City Bypass Road)

| Residence | Predicted Facility Noise Levels Day-Time (dBA) | Measured Ambient Sound Levels (dBA) | Predicted Noise Levels Day-Time plus Ambient Sound Levels (dBA) |
|---|---|---|---|
| **R01** | 30 | 39 | **39 (0)*** |
| **R02** | 30 | 35 | **36 (0)** |
| **R03** | 31 | 27 | **32 (0)** |
| **R04** | 32 | 34 | **36 (0)** |
| **R05** | 31 | 32 | **35 (1)** |

* The number in bracket is the predicted noise level increase based on current noise level

**Summary of Predicted Noise Levels Generated by AKHM Current and Proposed Mining Operations under Downwind Conditions (Nighttime)**

--(Onek 990 Portal Option and Proposed Keno City Bypass Road)

| Residence | Predicted Facility Noise Levels Night-Time (dBA) | Measured Ambient Sound Levels (dBA) | Predicted Noise Levels Night-Time plus Ambient Sound Levels (dBA) |
|---|---|---|---|
| **R01** | 21 | 38 | **38 (0)** |
| **R02** | 18 | 28 | **28 (0)** |
| **R03** | 24 | 26 | **28 (0)** |
| **R04** | 27 | 30 | **32 (1)** |
| **R05** | 19 | -- | **--** |

* The number in bracket is the predicted noise level increase based on current noise level

The results of this assessment indicate that the AKHM current with proposed future mining and mill operations is expected to have minor noise level increase under downwind conditions compared with current situation. This assumed all of the equipment running simultaneously and proposed noise control measures AKHM will implement in the Onek Sign Post portal site. Both the current and future mining operations will have only minor noise impacts on the Keno City residences. The most impacted residence assessed R04, which is also the closest residence to Onek portal site, will have 3-4 dBA increase of sound level based on measured ambient sound pressure level and 2 dBA increase based on current noise level. The total noise level with the current and /or future facility is low.

The proposed Onek 990 portal and Keno City bypass road will have less noise emission and almost the same noise emission with or without the surface transfer from 990 portal site to the mill.

# Table of Contents

# Introduction and Scope-of-Work

Patching Associates Acoustical Engineering Ltd. was retained by the Yukon Environmental and Socio-Economic Assessment Board to evaluate and predict the noise level from the existing and proposed Alexco Keno Hill Silver District Operations to be located around the Keno City, 354 km north of Whitehorse, Yukon. Alexco Keno Hill Mining Corp (AKHM) currently operates the Bellekeno mine and Keno District Mill and proposes to strengthen its operation by incorporating production of Lucky Queen and Onek ore deposits in the Keno Hill Silver District.

The study was conducted in order to:

- Assess the sound data of typical equipment that are currently existing and proposed for AKHM mining operations, which include Bellekeno, Lucky Queen, Onek, the mill operations and the associated trucking activity and traffic noise;
- Predict the noise level from the existing and proposed facilities during mining and mill operations at the potentially most affected receiver locations.

# Noise Criteria

## Relative noise Level Increase

A variety of sources in natural, industrial, and community settings generate sound/noise. In general, noise is defined as unwanted sound. Hearing damage is the most serious effect of noise, but the nuisance of particular sound characteristics may diminish the quality of life for those affected by the noise.

Research into the human perception of changes in sound level indicates the following:

- A 3-dB change is just perceptible,
- A 5-dB change is clearly perceptible, and
- A 10-dB change is perceived as being twice or half as loud.

A doubling or halving of acoustic energy will change the resulting sound level by 3 dB, which corresponds to a change that is just perceptible. In practice, this means that a doubling of traffic volume on a roadway, doubling the number of people in a stadium, or doubling the number of wind turbines in a wind farm will, as a general rule, only result in a 3 dB, or just perceptible, increase in noise.

In order to facilitate design and discuss the potential impact for this project and in recognition of the suburban (semirural) nature of the immediate area near the existing and proposed mining operation, all the typical equipment for the current and future mining operations need to be considered, which include Bellekeno, Lucky Queen, Onek, the mill operations and the associated trucking activity and traffic noise. The sound level increase from current mining operations will be quantified to evaluate

the noise impact to the Keno City residents. The total sound level experienced in the Keno City residential area will be mining facility level combined with measured ambient noise level. The future mining operations should not cause significant noise level increase.

### Transient vs. Continuous Noise ($L_{eq}$ average)

The Sound Level is a $L_{eq}$ value, which is the equivalent-continuous sound level. This index is an energy average of the varying sound levels over a specified period. The use of this index permits the description of a varying sound level environment as a single number. As the $L_{eq}$ is an "average" level, the measured sound level may exceed the criterion level for a short period, provided that the duration is limited. Transient factors such as equipment start-ups, shut-downs, back-up beeping or unstable environmental propagation may cause the sound level to fluctuate and potentially exceed the criterion level for short periods. The $L_{eq}$ value considers both the sound level and the length of time that the sound level occurs and higher level periods are acceptable as long as the duration is short. All of the sound levels discussed in this study are $L_{eq}$ sound levels and the values presented and the "average" sound level a receiver would experience from day to day, night to night, and month to month. Appendix A provides a detailed explanation of the $L_{eq}$ index.

## Project Study Area

The project study area is located around Keno City, 354 km north of Whitehorse, Yukon. The terrain cover around the facility is mainly forested. Alexco Keno Hill Mining Corp (AKHM) currently operates the Bellekeno mine and Keno District Mill and proposes to strengthen its operation by incorporating production of two new (Lucky Queen and Onek) ore deposits in the Keno Hill Silver District. These mining operations are located around the Keno City residential area. There is Lightning Creek running along the south side of the Keno City.

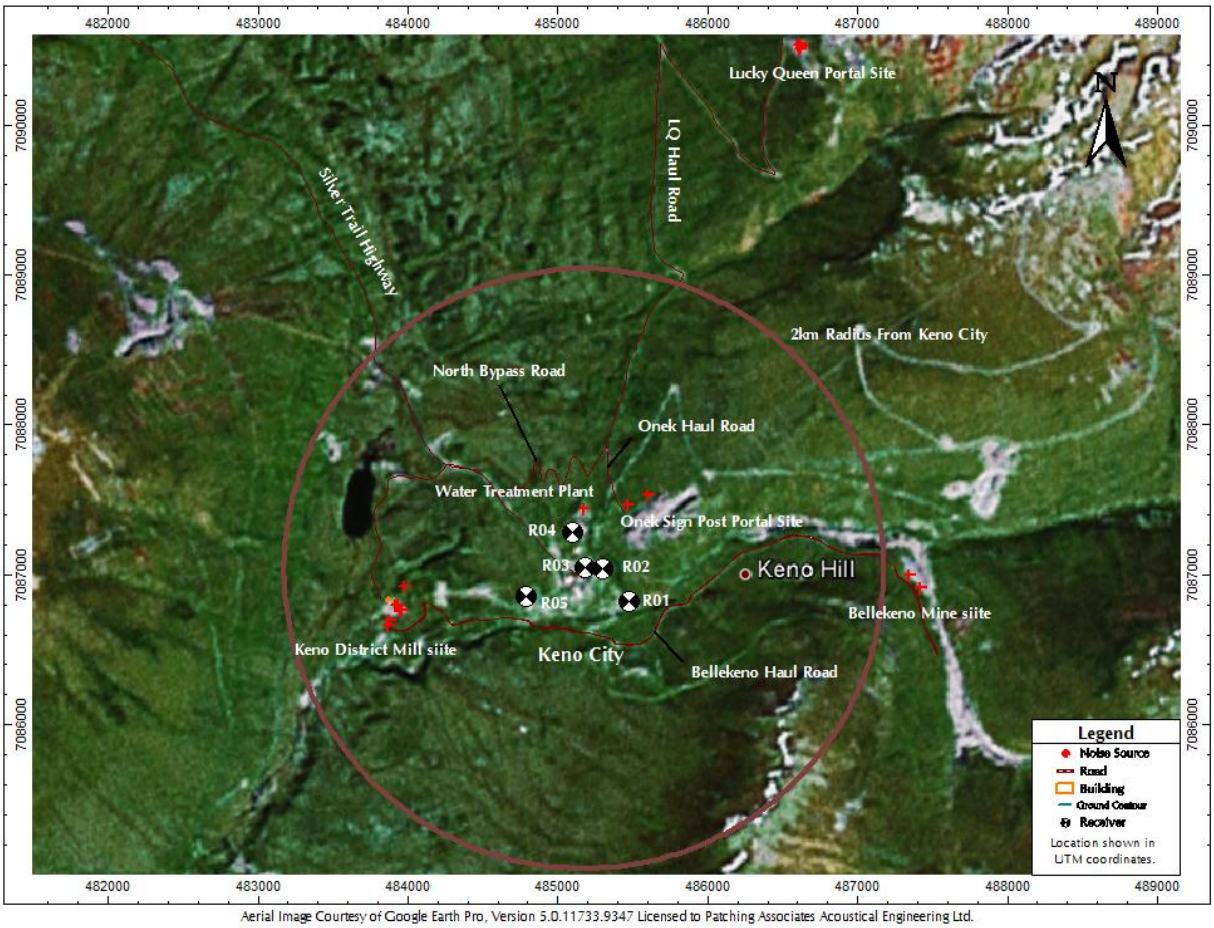
This study assesses the noise levels of the current and future facility at five receivers representing potential noise sensitive areas in the Keno City residential area, which are listed in table 1.

**Table 1 – Representative Residence Locations Assessed in the Keno City**

| Residence | GPS Location | Description |
|---|---|---|
| **R01** | N63.90827 W135.29599 | East end Residence, north side of Lightning Creek Road |
| **R02** | N63.91019 W135.29968 | Residence, east side of Sign Post Road |
| **R03** | N63.91023 W135.30205 | Town Center, north from the Snack Bar |
| **R04** | N63.91239 W135.30376 | Residence, west side of Wernecke Road, closest to the proposed Onek Sign Post portal location |
| **R05** | N63.90851 W135.30993 | Residence, about 850m east from the Mill |

Figure 1 presents an overview of the project study area.

**Figure 1: Overview of the project study area.**




Aerial Image Courtesy of Google Earth Pro, Version 5.0.11733.9347 Licensed to Patching Associates Acoustical Engineering Ltd.

## Current and Proposed Major Operations

The existing and proposed AKHM mining operations include three major operations, which are existing and proposed mine site operations, mill site operation, and transportation along haul roads. The facility equipment details are shown in Table 2.

**Table 2: Major Equipment Details**

| Equipment Description | Equipment Details |
|---|---|
| Existing and proposed Bellekeno Mine Site Facility and transportation | • Existing Sullair LS-25S compressor unit<br>• Existing fresh Air Intake<br>• Currently Total 44 round trips along Bellekeno haul road daytime (0700-1900), 30kph, which include 22 light trucks and 22 heavy trucks (ore trucks, heavy trucks and buses), no transportation nighttime<br>• Future Proposed Total 62 round trips daytime, 30kph, which include 22 light trucks and 40 heavy trucks (ore trucks, heavy trucks and buses),no transportation nighttime<br>• Noise emission from the light truck and heavy truck assumed equal to current light truck and haul truck, measured by PAAE staff between June 25th and 29th ,2012 |
| Existing and Proposed Mill site Operation | • Crusher, full load operation, currently running every other day, daytime operation<br>• Cat 930G front-end Loader Loading rock for crusher, daytime operation<br>• Mill Building, Internal equipment running day and night<br>• Dry stack tailings facility (DSTF) area (one Packer Cat CS543E and one Backhoe daytime operation)<br>• Noise emission from the above equipment measured by PAAE staff between June 25th and 29th ,2012 |
| Existing and Proposed Lucky Queen Portal Facility and Transportation | • Existing 500 kW Cummins genset<br>• Existing Gardner-Denver D800 compressor unit<br>• Existing fresh air intake<br>• Noise emission from the above equipment measured by PAAE staff between June 25th and 29th ,2012<br>• Proposed Cat 930G front-end Loader, 40% usage, daytime operation<br>• Proposed Tandem axle dump truck (12 yard truck) , 40% usage, daytime operation<br>• Proposed 15-ton underground haul truck, 40% usage, daytime operation<br>• Total 27 Round trips daytime, 40 kph, which include 6 light trucks and 21 heavy trucks (ore trucks, heavy trucks and buses), no transportation nighttime. The route will follow Wernecke road and proposed updated north bypass road. |

**Table 2 (Cont.): Major Equipment Details**

| Equipment Description | Equipment Details |
|---|---|
| Proposed Onek Facility and Transportation –– Sign Post Portal | • Proposed 200 Hp electric driven Ingersoll Rand R150IU rotary screw compressor, housed in sound dampening enclosure, assumed open area less than 1.5%<br>• Proposed ventilation fan, 30 Hp, 36" Diameter, assumed 1274rpm, less than 12000 fpm tip speed. There will be inlet and exhaust sound dampeners, will decrease noise by about 10 dBA<br>• Proposed Cat 930G front-end Loader, 40% acoustical usage, daytime operation<br>• Proposed Tandem axle dump truck (12 yard truck) , 40% acoustical usage, daytime operation<br>• Proposed 15-ton underground haul truck, 40% acoustical usage, daytime operation<br>• Total 37 Round trips daytime, 40 kph, which include 6 light trucks and 31 heavy trucks (ore trucks, heavy trucks and buses), no transportation nighttime<br>• A 80m long x 4m high x 5m wide sound berm will be constructed along the west side of Sign Post Portal Pad to deflect noise, or an equivalent sound curtain will be installed. The route will cross the Sign Post Road and Wernecke Road, and follow the proposed updated north bypass road. |
| Proposed Water Treatment Plant | • 5Hp water pump, assumed 3600 RPM<br>• 3 Hp compressor, assumed 1800 RPM<br>• Both equipment run continuously, housed in insulated sea cans, assumed open area less than 1.5%. |
| Proposed Onek Facility and Surface Transportation –990 Portal | • Proposed compressor, ventilation fan, Cat 930G front-end Loader, Tandem axle dump truck (12 yard truck) , 15-ton underground haul truck, keep the same running situation as Sign Post portal option.<br>• Total 37 Round trips daytime, 40 kph, which include 6 light trucks and 31 heavy trucks (ore trucks, heavy trucks and buses), no transportation nighttime<br>• The haul route will be developed from Onek 990 Portal, crossing Lightning Creek Road and the Onek Access Bridge across Lightning Creek to the Bellekeno Haul Road. |

**Table 2 (Cont.): Major Equipment Details (990 Portal Option)**

| Equipment Description | Equipment Details |
|---|---|
| Proposed Onek Facility and Underground Transportation –990 Portal | • Proposed compressor, ventilation fan, Cat 930G front-end Loader, Tandem axle dump truck (12 yard truck) , 15-ton underground haul truck, keep the same running situation as Sign Post portal option.<br>• Total 37 Round trips daytime, 40 kph, which include 6 light trucks and 31 heavy trucks (ore trucks, heavy trucks and buses), no transportation nighttime<br>• Ore haul trucks will transport ore directly from underground to mill (no surface ore transfer) |

## Proposed Operations Schedule

AKHM will run the mining and mill operations with the equipment shown in table 1. There will be no loader and truck operation at the portal site and no transportation during the nighttime (1900-0700).

The background noise levels for the Keno City residential area will vary considerably depending on location and local activities. Mining project operations will be in addition to the normal fluctuations in background noise levels. Relative humidity, temperature, temperature inversions, the number and varied noise sources are some of the factors that affect sound level and sound propagation.

## Method

The distance to the residences and facility physical layout information were obtained from the YESAB, satellite photos and field reconnaissance performed by Patching Associates Acoustical Engineering Ltd. staff. Sound power levels were determined for all of the major noise sources at the existing and proposed facility. Sound propagation calculations were then undertaken to determine the sound pressure level that will exist at the most impacted residences from the mining and mill facility. All calculations were undertaken in octave bands.

The octave band sound power level for each source that will exist at the facility was obtained or calculated field measurements, from manufacturer's data, acoustical reference literature or previous studies. The results of the sound propagation calculations were compared to the recommended permissible sound level to determine if the current and future facility will cause higher noise level to the Keno City residential area.

## Sound Power Level Calculations

Octave band sound power levels were calculated for all of the major noise sources that are present at the current and future facility. These octave band sound power levels and the source of the data are presented in Table 3.

**Table 3 – Source Octave Band Sound Power Levels**

| Source Description | Data Source | Linear Octave Band Centre Frequency (dB, ref 1 pW) | | | | | | | | | Total (dBA) | Total (dBC) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 31.5 | 63 | 125 | 250 | 500 | 1k | 2k | 4k | 8k | | |
| Bellekeno Mine Fresh Air Intake | Field Measurements | 86 | 92 | 98 | 103 | 110 | 110 | 102 | 97 | 83 | **112** | **114** |
| Mill Crusher in full operation | Field Measurements | 118 | 113 | 111 | 110 | 110 | 107 | 105 | 98 | 89 | **112** | **120** |
| Lucky Queen Portal Genset Exhaust | Field Measurements | 107 | 113 | 118 | 112 | 112 | 105 | 101 | 87 | 71 | **112** | **120** |
| Lucky Queen Portal Genset wall | Field Measurements | 109 | 114 | 119 | 114 | 108 | 103 | 99 | 90 | 87 | **110** | **121** |
| Lucky Queen Portal Genset Open Door | Field Measurements | 107 | 107 | 111 | 111 | 107 | 105 | 103 | 95 | 86 | **110** | **116** |
| Mill DSTF Track Excavator | Field Measurements | 131 | 108 | 116 | 107 | 105 | 105 | 95 | 96 | 88 | **109** | **128** |
| Lucky Queen Portal Genset Exhaust Muffler | Field Measurements | 104 | 106 | 111 | 110 | 109 | 100 | 98 | 86 | 71 | **109** | **116** |
| Bellekeno Mine Compressor Unit | Field Measurements | 90 | 90 | 105 | 107 | 105 | 105 | 98 | 90 | 83 | **108** | **112** |
| Lucky Queen Portal Air Inlet | Field Measurements | 79 | 94 | 87 | 92 | 103 | 104 | 101 | 95 | 85 | **108** | **108** |
| Lucky Queen Portal Genset Air Outlet | Field Measurements | 96 | 102 | 108 | 107 | 104 | 102 | 100 | 92 | 83 | **107** | **112** |
| Lucky Queen Portal Compressor Wall | Field Measurements | 98 | 107 | 106 | 105 | 102 | 99 | 101 | 93 | 87 | **106** | **112** |

## Table 3 (Cont.) – Source Octave Band Sound Power Levels

| Source Description | Data Source | Linear Octave Band Centre Frequency (dB, ref 1 pW) | | | | | | | | | Total (dBA) | Total (dBC) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 31.5 | 63 | 125 | 250 | 500 | 1k | 2k | 4k | 8k | | |
| Lucky Queen Portal Compressor Open Door | Field Measurements | 86 | 97 | 93 | 96 | 94 | 98 | 99 | 93 | 88 | **103** | **104** |
| Mill DSTF Packer | Field Measurements | 129 | 113 | 105 | 100 | 100 | 99 | 95 | 87 | 81 | **103** | **126** |
| Lucky Queen Portal Gen doors closed | Field Measurements | 95 | 106 | 110 | 103 | 99 | 96 | 93 | 88 | 80 | **102** | **112** |
| Bellekeno Haul Volvo Truck | Field Measurements | 103 | 101 | 99 | 100 | 96 | 95 | 93 | 87 | 80 | **100** | **107** |
| Mill Cat 930G Wheel Loader | Field Measurements | 106 | 110 | 99 | 92 | 95 | 98 | 91 | 79 | 8 | **100** | **111** |
| Mill Building wall | Field Measurements | 111 | 111 | 104 | 98 | 93 | 94 | 5 | 5 | 5 | **97** | **113** |
| Onek Comp Bldg. Open Area (Doors Closed) | Theoretical | 85 | 83 | 87 | 87 | 89 | 90 | 91 | 87 | 80 | **96** | **97** |
| Onek Portal Haul Truck | Field Measurements | 99 | 97 | 95 | 96 | 92 | 91 | 89 | 83 | 76 | **96** | **103** |
| Onek Dump Truck | Field Measurements | 99 | 97 | 95 | 96 | 92 | 91 | 89 | 83 | 76 | **96** | **103** |
| LQ Portal Haul Truck | Field Measurements | 99 | 97 | 95 | 96 | 92 | 91 | 89 | 83 | 76 | **96** | **103** |
| LQ Dump Truck | Field Measurements | 99 | 97 | 95 | 96 | 92 | 91 | 89 | 83 | 76 | **96** | **103** |
| Onek Fan Package | Theoretical | 101 | 102 | 101 | 98 | 93 | 90 | 83 | 79 | 73 | **96** | **106** |
| Onek Cat 930G Wheel Loader | Field Measurements | 102 | 106 | 95 | 88 | 91 | 94 | 87 | 75 | 4 | **96** | **107** |
| LQ Cat 930G Wheel Loader | Field Measurements | 102 | 106 | 95 | 88 | 91 | 94 | 87 | 75 | 4 | **96** | **107** |
| Mill Air Bag Exhaust | Field Measurements | 91 | 98 | 88 | 88 | 89 | 88 | 88 | 89 | 88 | **95** | **100** |
| Mill South Open Door | Field Measurements | 96 | 92 | 86 | 82 | 81 | 85 | 83 | 82 | 76 | **90** | **97** |
| Mill Bldg Open Doors | Field Measurements | 94 | 87 | 84 | 83 | 83 | 81 | 84 | 82 | 73 | **89** | **94** |
| Onek Comp Bldg. Wall | Field Measurements | 103 | 95 | 93 | 90 | 90 | 77 | 77 | 67 | 59 | **89** | **102** |
| Light truck | Field Measurements | 92 | 92 | 91 | 87 | 84 | 81 | 80 | 70 | 5 | **87** | **96** |
| East End Bldg | Field Measurements | 104 | 97 | 89 | 84 | 84 | 79 | 74 | 5 | 5 | **85** | **102** |
| Mill Bldg Louvers | Field Measurements | 85 | 84 | 81 | 80 | 76 | 77 | 76 | 72 | 65 | **82** | **89** |

**Table 3 (Cont.) – Source Octave Band Sound Power Levels**

| Source Description | Data Source | Linear Octave Band Centre Frequency (dB, ref 1 pW) | | | | | | | | | Total (dBA) | Total (dBC) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 31.5 | 63 | 125 | 250 | 500 | 1k | 2k | 4k | 8k | | |
| WTP Facility Bldg. Open Area (Doors Closed) | Theoretical | 68 | 66 | 70 | 71 | 72 | 73 | 74 | 70 | 63 | **79** | **80** |
| WTP Facility Bldg. Wall | Theoretical | 86 | 79 | 76 | 73 | 72 | 60 | 60 | 49 | 42 | **72** | **85** |
| Bellekeno Proposed Total Daytime (12h),1m | Field Measurements/ Theoretical | 52 | 50 | 49 | 49 | 45 | 44 | 42 | 36 | 28 | **49** | **56** |
| Onek Proposed Total Daytime (12h),1m | Field Measurements/ Theoretical | 50 | 49 | 47 | 48 | 43 | 42 | 40 | 35 | 27 | **47** | **54** |
| Bellekeno Current Total Daytime (12h),1m | Field Measurements/ Theoretical | 50 | 48 | 47 | 46 | 42 | 41 | 39 | 34 | 26 | **46** | **54** |
| LQ Proposed Total Daytime (12h),1m | Field Measurements/ Theoretical | 48 | 47 | 45 | 46 | 42 | 41 | 39 | 33 | 26 | **46** | **53** |

## Sound Propagation Calculations

The sound propagation calculations were undertaken using the noise modeling software package CadnaA by Datakustik. CadnaA bases its calculation algorithms on ISO 9613 and the ground cover was modeled as mixed ground between the operations and residential areas, with consideration of some deciduous trees in the area. Octave-band sound power level information was used for the major noise sources for the proposed project. The frequency dependency of sound propagation calculations such as ground absorption, air absorption and elevation relative to the sound source, and barrier effects are considered in the model. The weather condition modeled was 10º C temperature and 80% relative humidity; the temperature and humidity values are conditions with a minimum value of air absorption, and so constitute a "worst case" condition. The CadnaA model calculates the contribution level of each noise source at each receiver location in octave bands as well as the overall dBA level.

## Modeling Results

The objective of this study was to predict the noise level from the existing and proposed mining and mill operations at the potentially most affected receiver locations. The predictions based on the CadnaA model for this facility are summarized in Tables 4-9 along with the PSL.

**Table 4 - Summary of Predicted Noise Levels Generated by AKHM Current Mining Operations under Downwind Conditions (Daytime)**

| Residence | Predicted Facility Noise Levels Day-Time (dBA) | Measured Ambient Sound Levels (dBA) | Predicted Noise Levels Day-Time plus Ambient Sound Levels (dBA) |
|---|---|---|---|
| **R01** | 29 | 39 | **39** |
| **R02** | 30 | 35 | **36** |
| **R03** | 30 | 27 | **32** |
| **R04** | 31 | 34 | **36** |
| **R05** | 31 | 32 | **34** |

**Table 5 - Summary of Predicted Noise Levels Generated by AKHM Current Mining Operations under Downwind Conditions (Nighttime)**

| Residence | Predicted Facility Noise Levels Night-Time (dBA) | Measured Ambient Sound Levels (dBA) | Predicted Noise Levels Night-Time plus Ambient Sound Levels (dBA) |
|---|---|---|---|
| **R01** | 19 | 38 | **38** |
| **R02** | 15 | 28 | **28** |
| **R03** | 23 | 26 | **28** |
| **R04** | 24 | 30 | **31** |
| **R05** | 13 | -- | **--** |

**Table 6 - Summary of Predicted Noise Levels Generated by AKHM Current and Proposed Mining Operations under Downwind Conditions (Daytime)**

--(Onek Sign Post Portal Option and Proposed North Bypass Road)

| Residence | Predicted Facility Noise Levels Day-Time (dBA) | Measured Ambient Sound Levels (dBA) | Predicted Noise Levels Day-Time plus Ambient Sound Levels (dBA) |
|---|---|---|---|
| **R01** | 29 | 39 | **39 (0)*** |
| **R02** | 30 | 35 | **36 (0)** |
| **R03** | 32 | 27 | **33 (1)** |
| **R04** | 35 | 34 | **38 (2)** |
| **R05** | 32 | 32 | **35 (1)** |

* The number in bracket is the predicted noise level increase based on current noise level

**Table 7 - Summary of Predicted Noise Levels Generated by AKHM Current and Proposed Mining Operations under Downwind Conditions (Nighttime)**

--(Onek Sign Post Portal Option and Proposed North Bypass Road)

| Residence | Predicted Facility Noise Levels Night-Time (dBA) | Measured Ambient Sound Levels (dBA) | Predicted Noise Levels Night-Time plus Ambient Sound Levels (dBA) |
|---|---|---|---|
| **R01** | 20 | 38 | **38 (0)** |
| **R02** | 17 | 28 | **28 (0)** |
| **R03** | 25 | 26 | **28 (0)** |
| **R04** | 30 | 30 | **33 (2)** |
| **R05** | 23 | -- | **--** |

* The number in bracket is the predicted noise level increase based on current noise level

**Table 8 - Summary of Predicted Noise Levels Generated by AKHM Current and Proposed Mining Operations under Downwind Conditions (Daytime)**

--(Onek 990 Portal Option and Proposed Keno City Bypass Road)

| Residence | Predicted Facility Noise Levels Day-Time (dBA) | Measured Ambient Sound Levels (dBA) | Predicted Noise Levels Day-Time plus Ambient Sound Levels (dBA) |
|---|---|---|---|
| **R01** | 30 | 39 | **39 (0)*** |
| **R02** | 30 | 35 | **36 (0)** |
| **R03** | 31 | 27 | **32 (0)** |
| **R04** | 32 | 34 | **36 (0)** |
| **R05** | 31 | 32 | **35 (1)** |

* The number in bracket is the predicted noise level increase based on current noise level

**Table 9 - Summary of Predicted Noise Levels Generated by AKHM Current and Proposed Mining Operations under Downwind Conditions (Nighttime)**

--(Onek 990 Portal Option and Proposed Keno City Bypass Road)

| Residence | Predicted Facility Noise Levels Night-Time (dBA) | Measured Ambient Sound Levels (dBA) | Predicted Noise Levels Night-Time plus Ambient Sound Levels (dBA) |
|---|---|---|---|
| **R01** | 21 | 38 | **38 (0)** |
| **R02** | 18 | 28 | **28 (0)** |
| **R03** | 24 | 26 | **28 (0)** |
| **R04** | 27 | 30 | **32 (1)** |
| **R05** | 19 | -- | **--** |

* The number in bracket is the predicted noise level increase based on current noise level

The results of this assessment indicate that the AKHM existing and proposed facilities during mining and mill operations is expected to have minor noise level increase under downwind conditions. This assumed the equipment running simultaneously and proposed noise control measures AKHM will implement in the Onek Sign Post portal site. Both the current and future

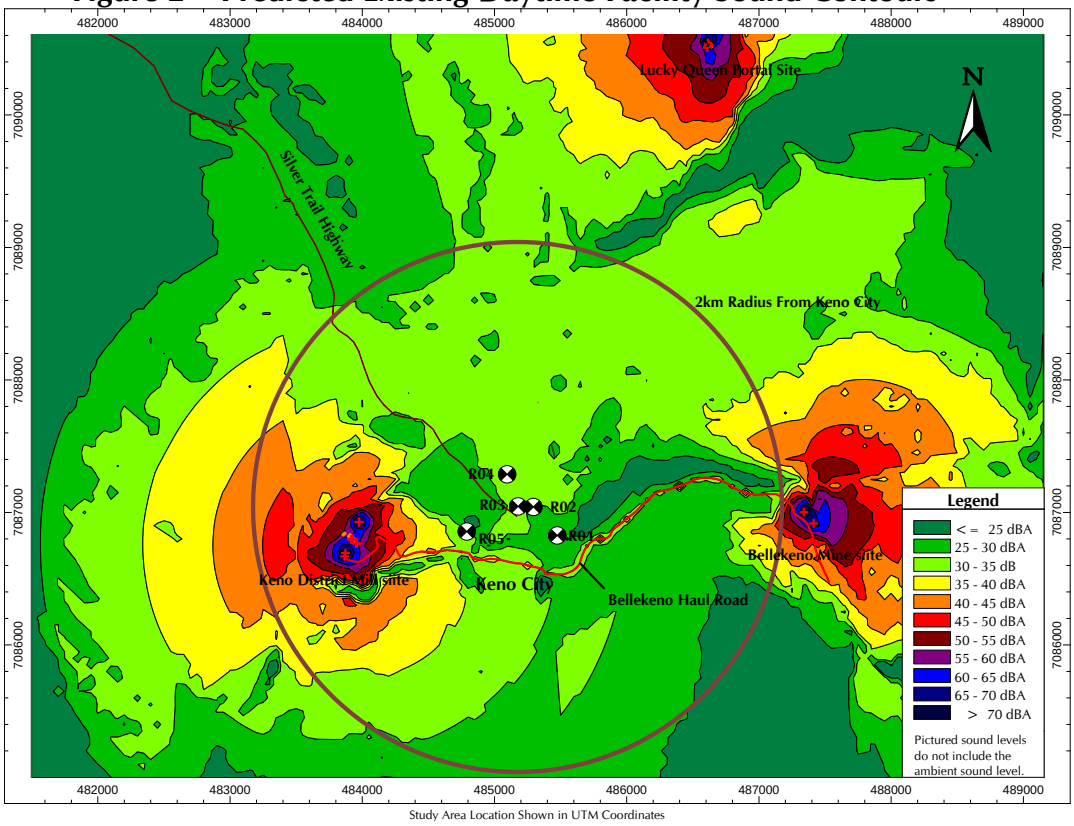
mining operations will have only minor noise impacts on the Keno City residences. The most impacted residence assessed, R4, which is also the closest residence to Onek portal site, will have 3-4 dBA increase of sound level based on measured ambient sound pressure level and 2 dBA increase based on current noise level. The total noise level with the current and /or future facility is low.

The proposed Onek 990 portal and Keno City bypass road will have less noise emission and almost the same noise emission with or without the surface transfer from 990 portal site to the mill.

During the field diagnosis study on the mill facility, the working Cat 930G Wheel Loader, STF Packer and DSTF Track Excavator were fitted with back up beepers, which contribute a high frequency noise signal. Even though the beeper noise didn't cause annoyance for the community due to the short duration of the beeper's signals and the significant distance from the residential area, considering that more similar equipment will be used on Lucky Queeen and Onek mining operation, broadband alarms are recommended to be an effective option to reduce potential noise complaints from the community.

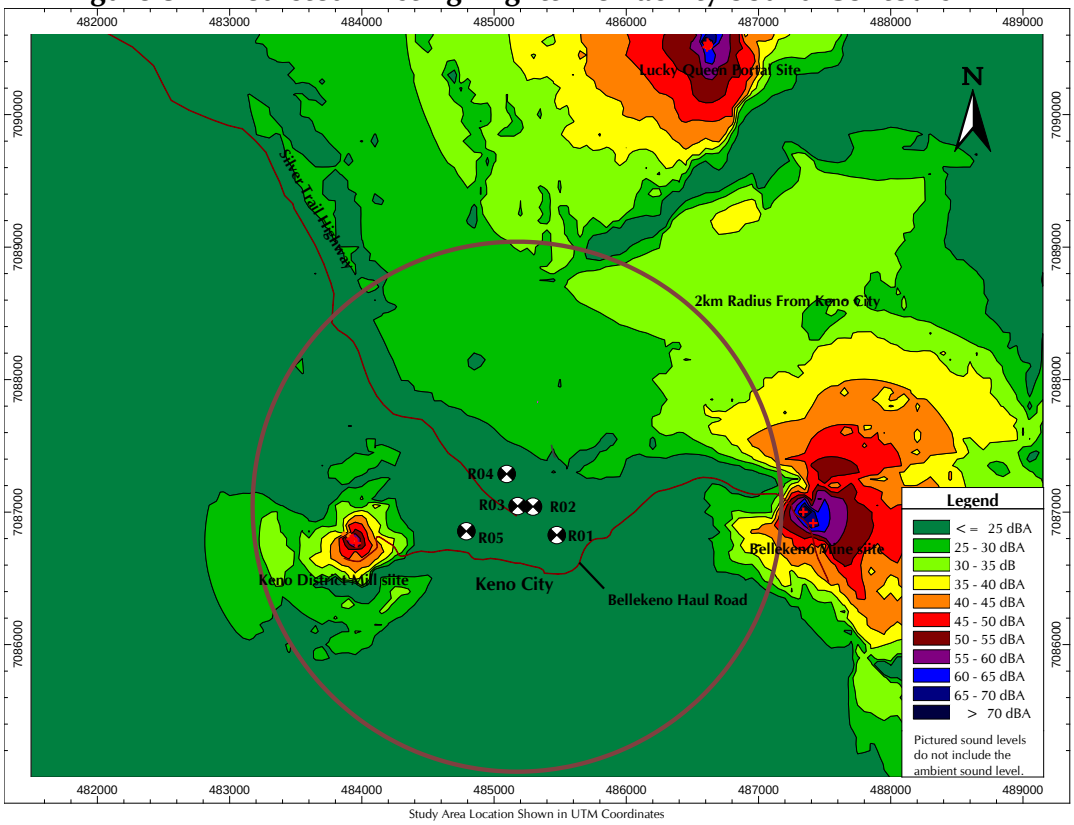
Figures 2 and 7 show the predicted sound levels for the area during mining and mill operations. The labeled sound levels are the predicted sound levels from only the facility (ambient sound level is not included). The scales on the figures are the Universal Transverse Mercator (UTM) coordinates in zone 11U.

## Figure 2 – Predicted Existing Daytime Facility Sound Contours



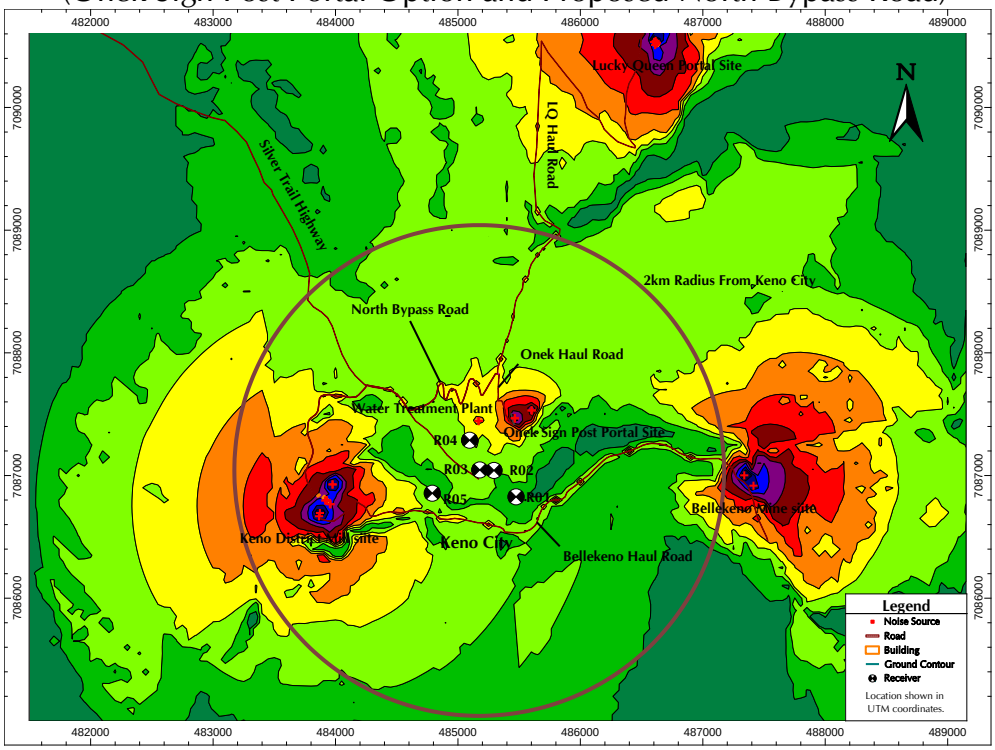

Study Area Location Shown in UTM Coordinates

## Figure 3 – Predicted Existing Nighttime Facility Sound Contours



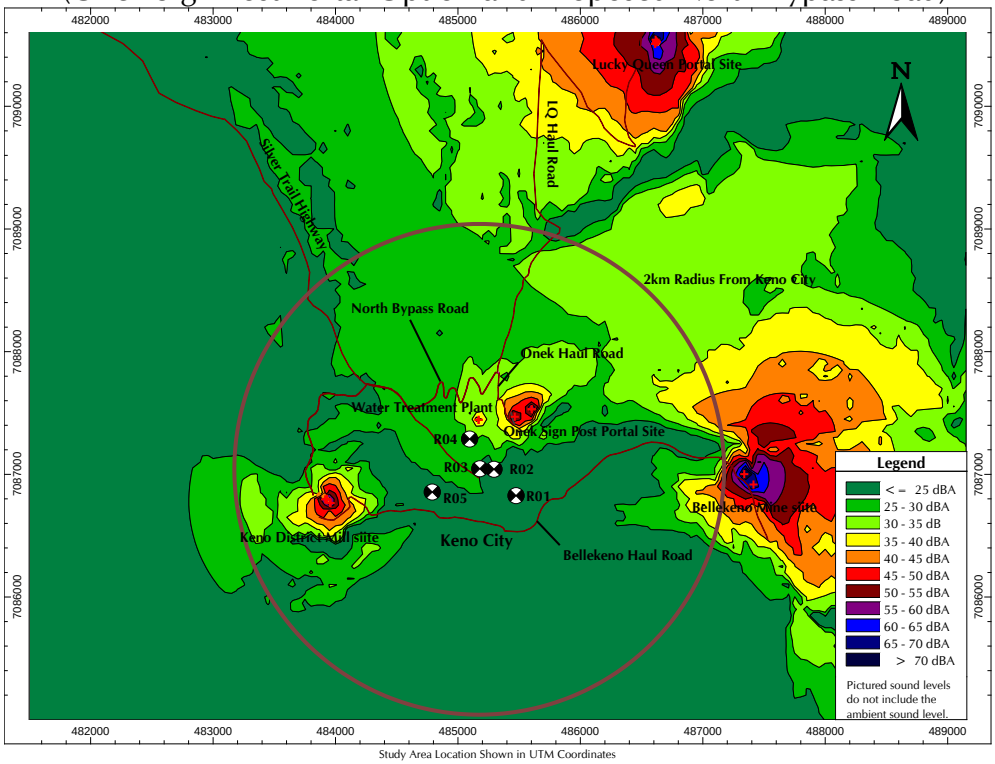

Study Area Location Shown in UTM Coordinates

**Figure 4 – Predicted Existing and Proposed Daytime Facility Sound Contours**
–(Onek Sign Post Portal Option and Proposed North Bypass Road)




Aerial Image Courtesy of Google Earth Pro, Version 5.0.11733.9347 Licensed to Patching Associates Acoustical Engineering Ltd.

**Figure 5 – Predicted Existing and Proposed Nighttime Facility Sound Contours**
–(Onek Sign Post Portal Option and Proposed North Bypass Road)




Study Area Location Shown in UTM Coordinates

**Figure 6 – Predicted Existing and Proposed Daytime Facility Sound Contours**
--(Onek 990 Portal Option and Proposed Keno City Bypass Road)

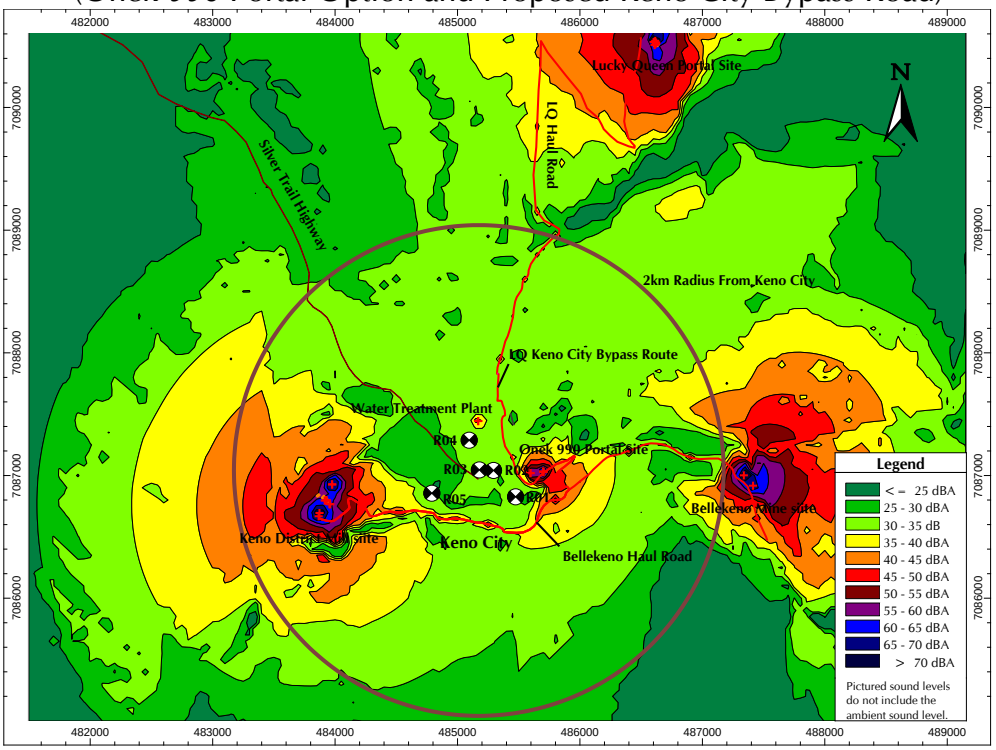
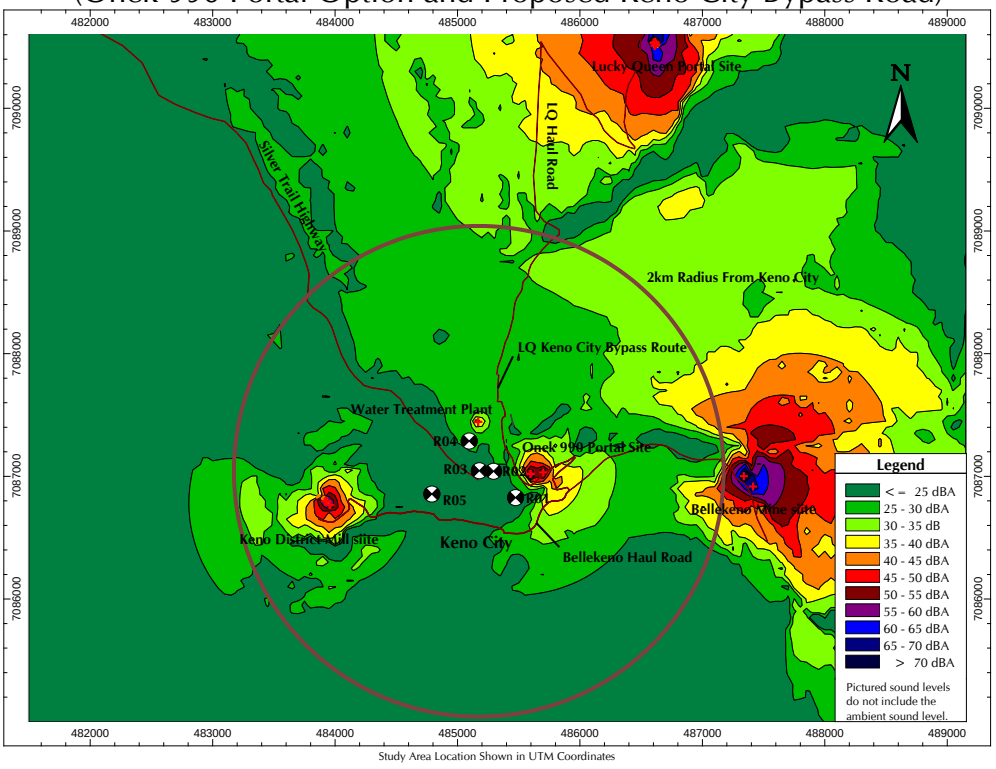



**Figure 7 – Predicted Existing and Proposed Nighttime Facility Sound Contours**
--(Onek 990 Portal Option and Proposed Keno City Bypass Road)



## Source Order Rankings

Based on the CadnaA model, the sound sources can be ranked by the sound levels at the receivers. The source order ranking for the daytime and nighttime scenarios are shown in Tables 10 and 13 for conditions with a wind from the operational areas to the most impacted residence from the current and proposed facility, which is residence R04 located about 384 meters from the proposed Onek Sign Post Portal facility.

**Table 8 – Source Order Ranking for Current and Proposed Mining and Mill Operations**

– Onek Sign Post Portal, Receiver R04, Downwind Condition (Daytime)

| Source | Levels (dBA) |
|---|---|
| Crusher in full operation | 29 |
| Onek Cat 930G Wheel Loader | 26 |
| Onek Portal Haul Truck | 26 |
| Onek Dump Truck | 26 |
| Onek Fan Package | 26 |
| Mill DSTF Track Excavator | 25 |
| WTP Facility Bldg. Open Area (Doors Closed) | 22 |
| Onek Comp Bldg. Open Area (Doors Closed) | 21 |
| Lucky Queen Portal Genset Exhaust | 19 |
| Mill DSTF Packer | 18 |
| Lucky Queen Portal Gen wall | 18 |
| Onek Comp Bldg. Wall | 17 |
| Mill Cat 930G Wheel Loader | 16 |
| Lucky Queen Portal Genset Exhaust Muffler | 15 |
| Lucky Queen Portal Genset Air Outlet | 14 |
| WTP Facility Bldg. Wall | 14 |
| Mill Building wall | 13 |
| Lucky Queen Portal Air Inlet | 12 |
| Onek Sign Post Haul Route | 9 |
| Lucky Queen Portal Gen doors closed | 9 |
| LQ Haul Route | 8 |
| Lucky Queen Portal Compressor Wall | 7 |
| Bellekeno Haul Road | 6 |
| Mill Air Bag Exhaust | 5 |
| Mill East End Bldg | 0 |
| Lucky Queen Portal Genset Open Door | 0 |
| LQ Portal Haul Truck | 0 |
| LQ Dump Truck | 0 |
| LQ Cat 930G Wheel Loader | -1 |
| Lucky Queen Portal Compressor Open Door | -1 |
| Bellekeno Mine Fresh Air Intake | -1 |
| Bellekeno Mine Compressor Unit | -1 |
| Mill Bldg Open Doors | -4 |
| Mill Bldg Louvers | -9 |
| Mill South Open Door | -15 |
| **Total Facility Sound Level** | **35** |
| Average Ambient Level | 34 |
| **Total Facility Plus Ambient** | **38** |

**Table 9 – Source Order Ranking for Current and Proposed Mining and Mill Operations**

– Onek Sign Post Portal, Receiver R04, Downwind Condition (Nighttime)

| Source | Levels (dBA) |
|---|---|
| Onek Fan Package | 26 |
| WTP Facility Bldg. Open Area (Doors Closed) | 22 |
| Onek Comp Bldg. Open Area (Doors Closed) | 21 |
| Lucky Queen Portal Genset Exhaust | 19 |
| Lucky Queen Portal Gen wall | 18 |
| Onek Comp Bldg. Wall | 17 |
| Lucky Queen Portal Genset Exhaust Muffler | 15 |
| Lucky Queen Portal Genset Air Outlet | 14 |
| WTP Facility Bldg. Wall | 14 |
| Mill Building wall | 13 |
| Lucky Queen Portal Air Inlet | 12 |
| Lucky Queen Portal Gen doors closed | 9 |
| Lucky Queen Portal Compressor Wall | 7 |
| Mill Air Bag Exhaust | 5 |
| Mill East End Bldg | 0 |
| Lucky Queen Portal Genset Open Door | 0 |
| Lucky Queen Portal Compressor Open Door | -1 |
| Bellekeno Mine Fresh Air Intake | -1 |
| Bellekeno Mine Compressor Unit | -1 |
| Mill Bldg Open Doors | -4 |
| Mill Bldg Louvers | -9 |
| Mill South Open Door | -15 |
| **Total Facility Sound Level** | **30** |
| Average Ambient Level | 30 |
| **Total Facility Plus Ambient** | **33** |

**Table 10 – Source Order Ranking for Current and Proposed Mining and Mill Operations**

– Onek 990 Portal, Receiver R04, Downwind Condition (Daytime)

| Source | Levels (dBA) |
|---|---|
| Crusher in full operation | 29 |
| Mill DSTF Track Excavator | 25 |
| WTP Facility Bldg. Open Area (Doors Closed) | 22 |
| Lucky Queen Portal Genset Exhaust | 19 |
| Mill DSTF Packer | 18 |
| Lucky Queen Portal Gen wall | 18 |
| Mill Cat 930G Wheel Loader | 16 |
| Lucky Queen Portal Genset Exhaust Muffler | 15 |
| Lucky Queen Portal Genset Air Outlet | 14 |
| Onek Comp Bldg. Wall | 14 |
| WTP Facility Bldg. Wall | 14 |
| Mill Building wall | 13 |
| Lucky Queen Portal Air Inlet | 12 |
| Onek Comp Bldg. Open Area (Doors Closed) | 11 |
| LQ Keno City Bypass Route | 11 |
| Lucky Queen Portal Gen doors closed | 9 |
| Lucky Queen Portal Compressor Wall | 7 |
| Bellekeno Haul Road | 6 |
| Mill Air Bag Exhaust | 5 |
| Onek 990 Route | 5 |
| Onek Fan Package | 4 |
| Onek Cat 930G Wheel Loader | 3 |
| Onek Portal Haul Truck | 3 |
| Onek Dump Truck | 3 |
| Mill East End Bldg | 0 |
| Lucky Queen Portal Genset Open Door | 0 |
| LQ Portal Haul Truck | 0 |
| LQ Dump Truck | 0 |
| LQ Cat 930G Wheel Loader | -1 |
| Lucky Queen Portal Compressor Open Door | -1 |
| Bellekeno Mine Fresh Air Intake | -1 |
| Bellekeno Mine Compressor Unit | -1 |
| Mill Bldg Open Doors | -4 |
| Mill Bldg Louvers | -9 |
| Mill South Open Door | -15 |
| **Total Facility Sound Level** | **32** |
| Average Ambient Level | 34 |
| **Total Facility Plus Ambient** | **36** |

**Table 11 – Source Order Ranking for Current and Proposed Mining and Mill Operations – Onek 990 Portal, Receiver R04, Downwind Condition (Nighttime)**

| Source | Levels (dBA) |
|---|---|
| WTP Facility Bldg. Open Area (Doors Closed) | 22 |
| Lucky Queen Portal Genset Exhaust | 19 |
| Lucky Queen Portal Gen wall | 18 |
| Lucky Queen Portal Genset Exhaust Muffler | 15 |
| Lucky Queen Portal Genset Air Outlet | 14 |
| Onek Comp Bldg. Wall | 14 |
| WTP Facility Bldg. Wall | 14 |
| Mill Building wall | 13 |
| Lucky Queen Portal Air Inlet | 12 |
| Onek Comp Bldg. Open Area (Doors Closed) | 11 |
| Lucky Queen Portal Gen doors closed | 9 |
| Lucky Queen Portal Compressor Wall | 7 |
| Mill Air Bag Exhaust | 5 |
| Onek Fan Package | 4 |
| Mill East End Bldg | 0 |
| Lucky Queen Portal Genset Open Door | 0 |
| Lucky Queen Portal Compressor Open Door | -1 |
| Bellekeno Mine Fresh Air Intake | -1 |
| Bellekeno Mine Compressor Unit | -1 |
| Mill Bldg Open Doors | -4 |
| Mill Bldg Louvers | -9 |
| Mill South Open Door | -15 |
| **Total Facility Sound Level** | **27** |
| Average Ambient Level | 30 |
| **Total Facility Plus Ambient** | **32** |

## Conclusion

The results of this assessment indicate that the AKHM current with proposed future mining and mill operations is expected to have minor noise level increase under downwind conditions compared with current situation. This assumed all of the equipment running simultaneously and proposed noise control measures AKHM will implement in the Onek Sign Post portal site. Both the current and future mining operations will have only minor noise impacts on the Keno City residences. The most impacted residence assessed R04, which is also the closest residence to Onek portal site, will have 3-4 dBA increase of sound level based on measured ambient sound pressure level and 2 dBA increase based on current noise level. The total noise level with the current and /or future facility is low.

The proposed Onek 990 portal and Keno City bypass road will have less noise emission and almost the same noise emission with or without the surface transfer from 990 portal site to the mill.

# APPENDIX A

## Explanation of Technical Details Regarding Sound Measurement and Analysis

# Technical Details

Sound is the phenomena of vibrations transmitted through air, or other medium such as water or a building structure. The range of pressure amplitudes, intensities, and frequencies of the sound energy is very wide, and many specialized fields have developed using different ranges of these variables, such as room acoustics and medical ultrasound.

Due to the wide range of intensities, which are perceived as sound, standard engineering units become inconvenient. Sound levels are commonly measured on a logarithmic scale, with the level (in decibels, or dB) being proportional to ten times the common logarithm of the sound energy or intensity. Normal human hearing covers a range of about twelve to fourteen orders of magnitude in energy, from the threshold of hearing to the threshold of pain. On the decibel scale, the threshold of hearing is set as zero, written as 0 dB, while the threshold of pain varies between 120 to 140 dB. The most usual measure of sound is the sound pressure level (SPL), with 0 dB SPL set at $2.0 \times 10^{-5}$ N/m$^2$ (also written 20 $\mu$Pa), which corresponds to a sound intensity of $10^{-12}$ Watts/m$^2$ (or 1 picoWatt/m$^2$, written 1 pW/m$^2$).

Normal human hearing spans a frequency range from about 20 Hertz (Hz, or cycles per second) to about 20,000 Hz (written 20 KHz). However, the sensitivity of human hearing is not the same at all frequencies. To accommodate the variation in sensitivity, various frequency-weighting scales have been developed. The most common is the A-weighting scale, which is based on the sensitivity of human hearing at moderate levels; this scale reflects the low sensitivity to sounds of very high or very low frequencies. Sound levels measured on the A-weighted scale are written in A-weighted decibels, commonly shown as dBA or dB(A).

When sound is measured using the A-weighting scale, the reading is often called the "Noise level", to confirm that human sensitivity and reactions are being addressed. A table of some common noise sources and their associated noise levels are shown in Table A1.

When the A-weighting scale is not used, the measurement is said to have a "linear" weighting, or to be unweighted, and may be called a "linear" level. As the linear reading is an accurate measurement of the physical (sound) pressure, the term "Sound Pressure Level", or SPL, is usually (but not universally) reserved for unweighted measurements.

Noise is usually defined as "unwanted sound", which indicates that it is not just the physical sound that is important, but also the human reaction to the sound that leads to the perception of sound as noise. It implies a judgment of the quality or quantity of sound experienced. As a human reaction to sound is involved, noise levels are usually given in A-weighted decibels (dBA). An alternate definition of noise is "sound made by somebody else", which emphasizes that the ability to control the level of the sound alters the perception of noise.

Table B1- Noise Levels of Familiar Sources

| Source Or Environment | Noise Level (dBA) |
|---|---|
| High Pressure Steam Venting To Atmosphere (3m) | 121 |
| Steam Boiler (2m) | 90-95 |
| Drilling Rig (10m) | 80-90 |
| Pneumatic Drill (15m) | 85 |
| Pump Jack (10m) | 68-72 |
| Truck (15m) | 65-70 |
| Business Office | 65 |
| Conversational Speech (1m) | 60 |
| Light Auto Traffic (30m) | 50 |
| Living Room | 40 |
| Library | 35 |
| Soft Whisper (5m) | 20-35 |

The single number A-weighted level is often inadequate for engineering purposes, although it does supply a good estimate of people's reaction to a noise environment. As noise sources, control measures, and materials differ in the frequency dependence of their noise responses or production, sound is measured with a narrower frequency bandwidth; the specific methodology varies with the application. For most work, the acoustic frequency range is divided into frequency bands where the center frequency of each band is twice the frequency of the next lower band; these are called "Octave" bands, as their frequency relation is called an "Octave" in music, where the field of acoustics has its roots. For more detailed work, the octave bands, and certain standard octave and 1/3 octave bands have been specified by international agreements.

Where the noise at the receiver is steady, it is easy to assess the noise level. However, both the production of noise at the source and the transmission of noise can vary with time; most noise levels are not constant, either because of the motion of the noise source (as in traffic noise), because the noise source itself varies, or because the transmission of sound to the receiver location is not steady as over long distances. This is almost always the case for environmental noise studies. Several single number descriptors have been developed and are used to assess noise in these conditions.

The most common is the measurement of the "equivalent continuous" sound level, or $L_{eq}$, which is the level of a hypothetical source of a constant level which would give the same total sound energy as is measured during the sampling period. This is the "energy" average noise level. Typical sampling periods are one hour, nighttime (9 hours) or one day (24 hours); the sampling period used must be reported when using this unit.

The greatest value of the $L_{eq}$ is that the contributions of different sources to the total noise level can be assessed, or in a case where a new noise source is to be added to a proposed environment, the total noise level from new and old sources can be easily calculated. It is also sensitive to short term high noise levels.

Statistical noise levels are sometimes used to assess an unsteady noise environment. They indicate the levels that are exceeded a fixed percentage of the measurement time period measured. For example, the 10%-ile level, written $L_{10}$, is the levels exceeded 10% of the time; this level is a good measure of frequent noisy occurrences such as steady road traffic. The 90% level, $L_{90}$, is the level exceeded 90% of the time, and is the background level, or noise floor. A steady noise source will modify the background level, while an intermittent noise source such as road or rail traffic will affect the short-term levels only.

One disadvantage with the $L_{eq}$ measure, when used alone, is that nearby loud sources (e.g. dogs barking, or birds singing) can confuse the assessment of the situation when it is the noise from a distant plant that is the concern. For this reason, the equivalent level and the statistical levels can be used together to better understand the noise environment. One such indication is the difference between the $L_{eq}$ and the $L_{90}$ levels. A large difference between the $L_{eq}$ and $L_{90}$, greater than 10 dB, indicates the intrusion of short-term noise events on the general background level. A small difference, less than 5 dB, indicates a very steady noise environment. If the $L_{eq}$ value exceeds the $L_{10}$ value this indicates the presence of significant short-term loud events.

For most noise measurement, instruments are adjusted so that the time response of the instrument is similar to the response of the human ear; this is the "Fast" setting. Measurement with the "Fast" setting therefore assesses the sound environment according to the way humans would hear it and react to it. Where the noise level varies substantially and an average level is wanted without the complexity of and $L_{eq}$ or statistical measurement, the "Slow" setting is used on the sound level meter. The "Slow" setting is also typically used in industrial settings where hearing damage is a concern. Where the noise level changes very rapidly, for example due to impacts or detonations, the "Fast" and "Slow" settings do not respond quickly enough to assess the maximum levels, and the "Impulse" meter setting us used.

The Sound Power Level (abbreviated $L_w$, SWL or PWL) is the decibel equivalent of the total energy emitted from a source in the form of noise. The reference level for the sound power is $10^{-12}$ Watts, or 1 picoWatt (abbreviated pW). The sound power level is given by:

$$L_w, \text{SWL, PWL} = 10 \times \log_{10} (\text{Emitted Power} / 1\ \text{pW})\ \text{dB}$$

Therefore, a source emitting 1 Watt of power in the form of sound would have a sound power level of 120 dB. Sound power levels can be expressed in terms of frequency bands, an overall linear-weighted level or A-weighted, as is the case for sound pressure levels. However, sound power levels are inherent to the source of noise, whereas the sound pressure level is dependent on the source, but also on the distance from the source and other environmental factors.