Railroad Noise & Vibration Assessment

Yankee Hill Road Property Residential Development

Rocklin, California

BAC Job # 2018-004

Prepared For:

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Introduction

The proposed Yankee Hill Road Property Residential Development (project) is located west of Old Yankee Hill Road at the intersection of the eastbound and westbound Union Pacific Railroad (UPRR) tracks in Rocklin, CA. The project area and site plan are shown on Figures 1 and 2, respectively.

Due to the proximity of the UPRR tracks to the project site Bollard Acoustical Consultants, Inc. (BAC) was retained by the project applicant to prepare this noise and vibration assessment. Specifically, the purposes of this assessment are to quantify noise and vibration generated from adjacent railroad operations, and to compare those levels against the applicable City of Rocklin standards for acceptable noise and vibration exposure.

Noise & Vibration Fundamentals

Noise

Noise is often described as unwanted sound. Sound is defined as any pressure variation in air that the human ear can detect. If the pressure variations occur frequently enough (at least 20 times per second), they can be heard, and thus are called sound. Measuring sound directly in terms of pressure would require a very large and awkward range of numbers. To avoid this, the decibel scale was devised. The decibel scale allows a million-fold increase in pressure to be expressed as 120 dB. Another useful aspect of the decibel scale is that changes in levels (dB) correspond closely to human perception of relative loudness. Appendix A contains definitions of Acoustical Terminology. Figure 3 shows common noise levels associated with various sources.

The perceived loudness of sounds is dependent upon many factors, including sound pressure level and frequency content. However, within the usual range of environmental noise levels, perception of loudness is relatively predictable, and can be approximated by weighing the frequency response of a sound level meter by means of the standardized A-weighing network. There is a strong correlation between A-weighted sound levels (expressed as dBA) and community response to noise. For this reason, the A-weighted sound level has become the standard tool of environmental noise assessment. All noise levels reported in this section are in terms of A-weighted levels in decibels.

Community noise is commonly described in terms of the “ambient” noise level, which is defined as the all-encompassing noise level associated with a given noise environment. A common statistical tool to measure the ambient noise level is the average, or equivalent, sound level (L_{eq}) over a given time period (usually one hour). The L_{eq} is the foundation of the Day-Night Average Level noise descriptor, L_{dn}, and shows very good correlation with community response to noise. The Day-Night Average Level (L_{dn}) is based upon the average noise level over a 24-hour day, with a +10 decibel weighing applied to noise occurring during nighttime (10:00 p.m. to 7:00 a.m.) hours. The nighttime penalty is based upon the assumption that people react to nighttime noise exposures as though they were twice as loud as daytime exposures. Because L_{dn} represents a

24-hour average, it tends to disguise short-term variations in the noise environment. L_{dn}-based noise standards are commonly used to assess noise impacts associated with traffic, railroad and aircraft noise sources.

A single noise event is an individual distinct loud activity, such as a train passage, or any other brief and discrete noise-generating activity. Because most noise policies applicable to transportation noise sources are typically specified in terms of 24-hour-averaged descriptors, such as L_{dn} or CNEL, the potential for annoyance or sleep disturbance associated with individual loud events can be masked by the averaging process.

Extensive studies have been conducted regarding the effects of single-event noise on sleep disturbance, with the Sound Exposure Level (SEL) metric being a common metric used for such assessments. SEL represents the entire sound energy of a given single-event normalized into a one-second period regardless of event duration. As a result, the single-number SEL metric contains information pertaining to both event duration and intensity. Another descriptor utilized to assess single-event noise is the maximum, or L_{max}, noise level associated with the event. A problem with utilizing L_{max} to assess singe events is that the duration of the event is not considered.

There is currently no national consensus regarding the appropriateness of SEL criteria as a supplement or replacement for cumulative noise level metrics such as L_{dn} and CNEL. Nonetheless, because SEL describes a receiver's total noise exposure from a single impulsive event, SEL is often used to characterize noise from individual brief loud events.

Due to the wide variation in test subjects' reactions to noises of various levels (some test subjects were awakened by indoor SEL values of 50 dB, whereas others slept through indoor SEL values exceeding 80 dB), no universal criterion has been developed for environmental noise assessments.

Figure 1
Yankee Hill Estates Project Location
Rocklin, California

: Project Boundary

: Railroad Noise Measurement Sites

: Railroad Vibration Measurement Sites

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Scale (feet)
0 200 400

Figure 2
Yankee Hill Estates Project Site Plan & Railroad Noise Contours
Rocklin California

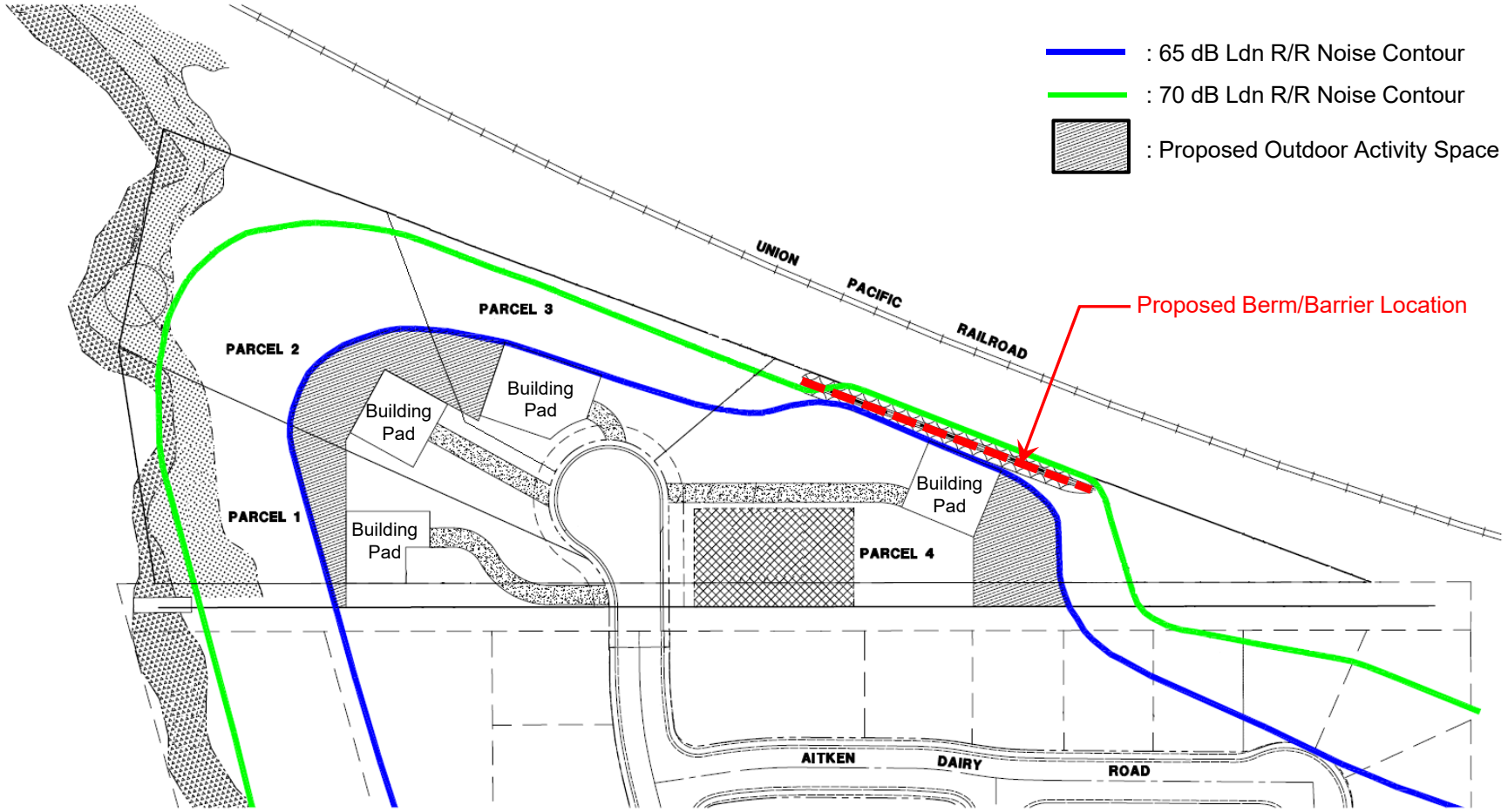

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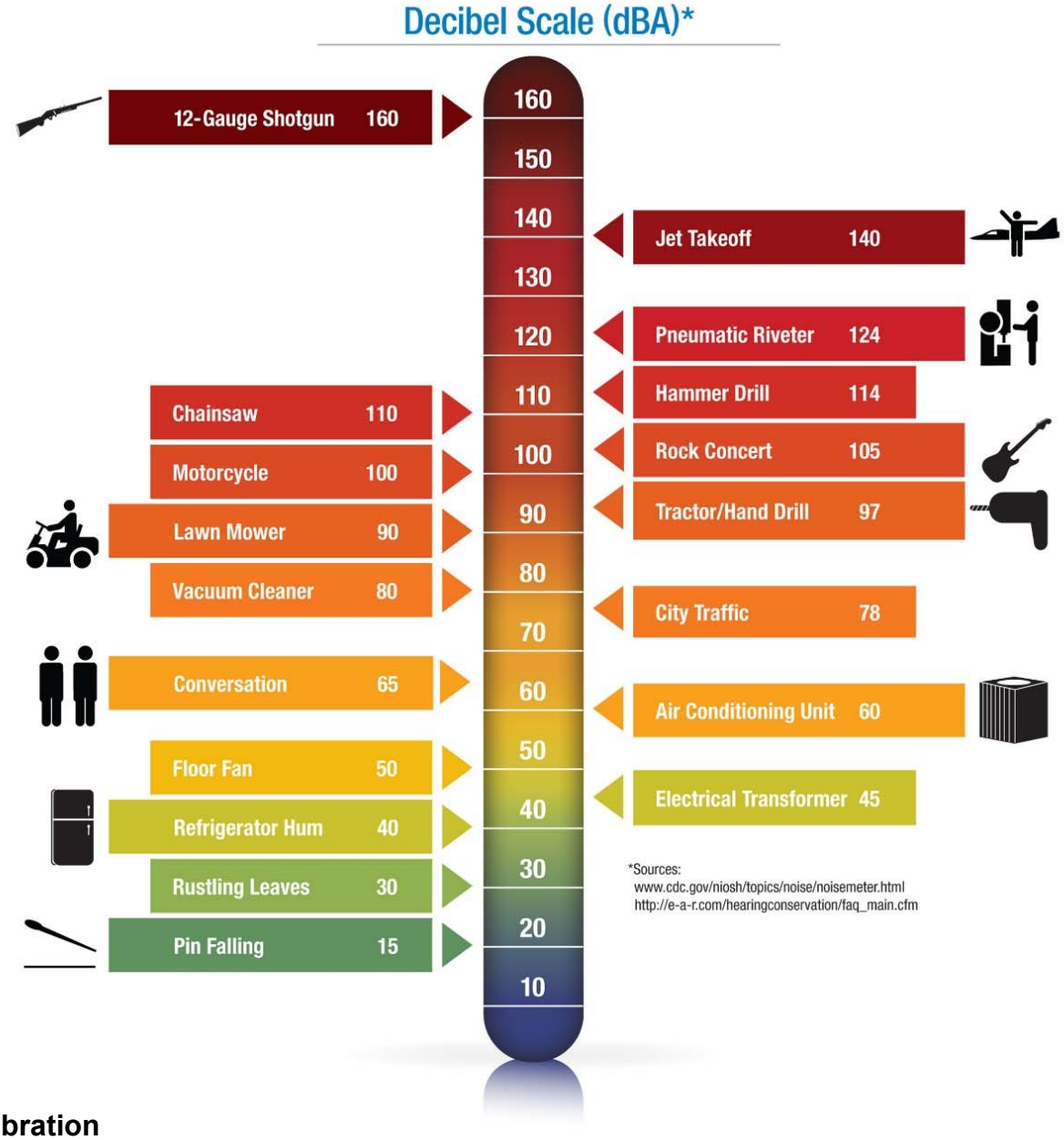
Figure 3
Noise Levels Associated with Common Noise Sources



Vibration

According to the Federal Transit Administration Noise and Vibration Impact Assessment Guidelines (FTA-VA-90-06), ground-borne vibration can be a serious concern for nearby neighbors of a transit system route or maintenance facility, causing buildings to shake and rumbling sounds to be heard. In contrast to airborne noise, ground-borne vibration is not a common environmental problem. It is unusual for vibration from sources such as buses and trucks to be perceptible, even in locations close to major roads.

Train wheels rolling on rails create vibration energy that is transmitted through the track support system into the ground, creating vibration waves that propagate through the various soil and rock strata to the foundations of nearby buildings. The vibration propagates from the foundation throughout the remainder of the building structure. The maximum vibration amplitudes of the floors and walls of a building often will be at the resonance frequencies of various components of the building.

Vibration can be described in terms of acceleration, velocity, or displacement. A common practice is to monitor vibration measures in terms of peak particle velocities (inches/second) or RMS velocity in terms of VdB.

Criteria for Acceptable Noise and Vibration Exposure

City of Rocklin General Plan

The City of Rocklin General Plan Noise Element establishes 45 and 60 dB L_{dn} as being acceptable interior and exterior noise levels, respectively, for new residential uses affected by transportation noise sources. Where it is not possible to reduce noise in outdoor activity areas to 60 dB L_{dn} or less using a practical application of the best available noise reduction measures, an exterior noise level of up to 65 dB L_{dn} may be allowed provided that available exterior noise reduction measures have been implemented and interior noise levels are in compliance with the 45 dB L_{dn} standard. The intent of the interior 45 dB L_{dn} standard is to provide a suitable environment for indoor communication and sleep.

Federal Transit Administration (FTA)

Although there are no local vibration standards, U.S. Department of Transportation's Federal Transit Authority (FTA) has adopted vibration impact assessment criteria. The FTA vibration impact criteria are based on maximum overall levels for a single event, and is applicable to residential projects within 150 feet of the centerline of rail lines. This vibration impact criteria, identified in Table 8-1 of the FTA's Transit Noise and Vibration Impact Assessment (May 2006), has been reproduced in Table 1.

Table 1
Groundborne Vibration Impact Criteria

Land Use Category	Groundborne Vibration Impact Levels (VdB re 1 µinch/sec, RMS)		
	Frequent Events[1]	Occasional Events[2]	Infrequent Events[3]
Category 1: Buildings where vibration would interfere with interior operations.	65[4]	65[4]	65[4]
Category 2: Residences and buildings where people normally sleep.	72	75	80
Category 3: Institutional land uses with primarily daytime use.	75	78	83

Notes:
1 "Frequent Events" is defined as more than 70 vibration events of the same source per day. Most rapid transit projects fall into this category.
2 "Occasional Events" is defined as between 30 and 70 vibration events of the same source per day. Most commuter trunk lines have this many operations.
3 "Infrequent Events" is defined as fewer than 30 vibration events of the same kind per day. This category includes most commuter rail branch lines.
4 This criterion limit is based on levels that are acceptable for most moderately sensitive equipment such as optical microscopes. Vibration sensitive manufacturing or research will require detailed evaluation to define the acceptable vibration levels. Ensuring lower vibration levels in a building often requires special design of HVAC systems and stiffened floors.
Source: Federal Transit Administration (FTA), Transit Noise and Vibration Impact Assessment (May 2006), Table 8-1

Railroad Noise Environment

The existing ambient noise environment at the project site is primarily defined by railroad activity on the railroad tracks to the immediate south and west. To quantify existing ambient noise levels at the project site, BAC conducted long-term (24 to 96-hour) noise level surveys at four (4) locations on the project site from January 18-21, 2018. The noise level measurement locations are shown on Figure 1. The purpose of the continuous noise level surveys was to determine existing traffic and railroad noise exposure on the project site in terms of the day/night average level (L_{dn}), and to determine the typical maximum noise levels generated by train passbys.

Larson Davis Laboratories (LDL) Model 831 and 820 precision integrating sound level meters were used to conduct the noise level surveys. The meters were calibrated before use with an LDL Model CAL200 acoustical calibrator to ensure the accuracy of the measurements. The equipment used meets all pertinent specifications of the American National Standards Institute for Type 1 sound level meters (ANSI S1.4).

The sound level meters were programmed to record statistical details of brief high-noise-level events for use in identification and analysis of train passbys. A summary of the continuous noise level measurement results are shown in Table 2. Detailed results of the long-term noise level survey are shown numerically and graphically in Appendices B and C, respectively. Photographs

of the noise level measurement sites are shown in Appendix D. Due to anomalously high noise level data recorded at Site 2 which was believed to be caused by condensation in the microphone pre-amplifier, that data was not used in this assessment. It should be noted, however, that the data collected at Sites 1. 3, 4 and 5 was sufficient to evaluate railroad noise exposure at the project site.

Table 2
Summary of Long-Term Ambient Noise Monitoring Results[1]
Yankee Hill Road Property Residential Development – Rocklin, California

			Average Measured Hourly Noise Levels (dB)					
			Daytime (7 a.m. to 10 p.m.)			Nighttime (10 p.m. to 7 a.m.)		
Site	Date	L_{dn}, dB	L_{eq}	L_{50}	L_{max}	L_{eq}	L_{50}	L_{max}
Site 1 – Northwestern end of project site, approximately 60' from center of north-south railroad lines	1/18/18	79	73	51	86	72	45	82
	1/19/18	78	73	46	85	71	46	75
	1/20/18	77	65	47	72	71	44	72
	1/21/18	82	73	50	82	76	47	80
Site 2 – Western end of project site, approximately 105' from the center of north-south railroad lines	1/17/18 – 1/18/18	(Data not used due to equipment malfunction)						
Site 3 – Southwest end of project site, approximately 80' from center of north-south railroad lines	1/17/18 – 1/18/18	70	63	45	75	63	41	71
Site 4 – Southern end of project site, approximately 250' from center of east-west railroad lines	1/17/18 – 1/18/18	65	59	48	71	58	46	68
Site 5 – Southeastern end of project site, approximately 165' from center of east-west railroad lines	1/18/18	65	59	53	75	58	52	69
	1/19/18	67	62	56	78	60	58	70
	1/20/18	64	61	52	70	56	53	64
	1/21/18	70	61	52	78	64	52	76

Notes:
[1] Long-term ambient noise monitoring locations are shown on Figure 1.
Source: Bollard Acoustical Consultants, Inc. (2018)

The Table 2 data indicate that measured ambient day-night average noise levels at the project site exceeded the City of Rocklin General Plan 60 dB L_{dn} and conditionally acceptable 65 dB L_{dn} noise level standards at the noise measurement locations. Extensive analysis of the individual train passby statistics was performed to quantify the typical Sound Energy Level (SEL) per train passby for both the north-south and east-west tracks.

Ambient noise measurement Sites 1 and 4 were specifically selected to be representative of railroad noise exposure from the north-south and east-west railroad lines at the project site (respectively). Larson Davis Laboratories (LDL) Model 831 integrating sound level meters were used to conduct the noise level surveys at these sites. In addition to logging statistical data, the 831 sound level meters at Sites 1 and 4 were capable of storing audio recordings (.wav files) for subsequent playback. Those files were used to identify railroad passbys adjacent to the project site. The purpose of the noise level measurements at Sites 1 and 4 was to determine the typical sound exposure level (SEL) for railroad operations at the project site. The results of the individual train passby noise measurements are summarized in Table 3.

Table 3
Railroad Noise Measurement Results
Yankee Hill Road Property Residential Development – Rocklin, California
January 18-21, 2018

Site	Number of Total Identified Railroad Passbys[1]	Average Number of Observed Daily Railroad Passbys[2]	Mean Measured SEL, dB
Site 1 – Northwestern end of project site, approximately 60' from center of UPRR north-south line railroad lines	63	13	110
Site 4 – Southeastern end of project site, approximately 165' from center of UPRR east-west railroad lines	34	7	97

Notes:

[1] The number of total identified passbys was determined from analysis of individual single-event noise level recordings collected during the monitoring period.

[2] Average number of daily railroad passbys is based on the total number of identified passbys during the monitoring period.

Source: Bollard Acoustical Consultants, Inc. (2018)

The Table 3 data indicates that the mean SEL computed from the noise measurement results at Sites 1 and 4 were 110 and 97, respectively. When normalized to a standard distance of 100 feet from the railroad tracks, the north-south exposure was computed to be approximately 6 dB higher than the noise generation of the east-west train passbys.

To convert single-event passby noise levels (SEL) to day/night average noise levels (L_{dn}) for comparison to the City of Rocklin noise level criteria, the following formula is used:

$$L_{dn} = \overline{SEL} + 10 \log N_{eq} - 49.4, \text{ dB, where:}$$

$\overline{SEL}$ is the mean SEL of the event, N_{eq} is the sum of the number of daytime events (7 a.m. - 10 p.m.) per day plus 10 times the number of nighttime events (10 p.m. - 7 a.m.) per day, and 49.4 is 10 times the logarithm of the number of seconds per day. The results of this analysis are illustrated on Figure 2 in the form of 65 dB and 70 dB L_{dn} railroad noise level contours. The Figure 2 contour locations have been adjusted to reflect the contributions of both the north-south and the east-west lines near the southwest corner of the site, as well as the shielding provided by the proposed berm wall combination at the location indicated on Figure 2. The specific berm wall combination proposed consists of a 6-foot tall berm upon which a 6-foot tall wall would be constructed (total of 12-feet in height).

Railroad Noise Compliance Evaluation for Residential Outdoor Areas

Due to the variation in elevation of the project site, and the elevated position of the railroad tracks, the only location were a noise barrier could be effectively used for this development would be at the position shown on Figure 2 where a barrier is proposed. As a result, it is not feasible to reduce railroad noise exposure to less than 65 dB L_{dn} at the entire project site through the construction of noise barriers. The project applicant has utilized the railroad noise contour information provided in Figure 2 to design the site such that the four proposed parcels would have a portion of each parcel which is below the City's 65 dB L_{dn} noise criteria available for outdoor use. Those areas are indicated on Figure 2.

Railroad Noise Compliance Evaluation for Residential Interiors

As indicated on Figure 2, each of the proposed building pad locations are outside the 65 dB L_{dn} railroad noise contours. As a result, first-floor noise exposure would be 65 dB L_{dn} or less at the first-floor facades of each of the proposed residences. Second-floor exposure at the future residences constructed on Parcels 1-3 is also predicted to be less than 65 dB L_{dn} due to the setbacks of those proposed building pads relative to the R/R tracks. However, upper floor exposure of the future residence constructed on Parcel 4 would be higher because the proposed berm/wall combination would not shield the second-floor locations. At the elevated second-floor facades of the residence constructed on Parcel 4 railroad noise exposure is estimated to be approximately 75 dB L_{dn}.

Based on an exterior noise level of 65 dB L_{dn} at all four first-floor facades of this development and upper floors of residences proposed on Parcels 1-3, a building facade noise level reduction of approximately 20 dB would be required to reduce railroad noise exposure to 45 dB L_{dn} or less within these residences. At the elevated 2nd floor facades of a residence constructed on Parcel 4, a building façade noise reduction of at least 30 dB would be required.

Standard residential construction (stucco siding, STC-27 windows, door weather-stripping, exterior wall insulation, composition plywood roof), results in an exterior to interior noise reduction of at least 25 dB with windows closed and approximately 15 dB with windows open. Therefore, standard residential construction would be adequate to achieve compliance with the City's 45 dB standard at future residences constructed on Parcels 1-3 and at first-floor rooms of a residence constructed on Parcel 4. However, upgraded construction would be required of the upper floor façade of a residence constructed on Parcel 4. Specifically, windows with an STC rating of at least 36 would be required for the second-floor facades of the residence proposed on Parcel 4.

Although the predicted interior noise levels without window upgrades would satisfy the 45 dB L_{dn} interior noise level standard of the City of Rocklin Noise Element at Parcels 1-3 and the first-floor façade of Parcel 4, single-event noise levels resulting from nighttime railroad passages could potentially result in sleep disturbance at the future residences located within this development. As a result, BAC recommends that all bedroom windows of residences constructed on Parcels 1-3 and first-floor bedrooms of the residence constructed on Parcel 4 have a minimum sound transmission class (STC) rating of 34. This measure will reduce the potential for sleep disturbance during nighttime railroad operations.

Railroad Vibration Environment

The primary source of vibration in the project vicinity is railroad activity on the railroad tracks to the south and west of the site. To quantify existing railroad vibration levels associated with these sources, BAC conducted long-term (continuous) vibration level surveys at three (3) locations on the project site from January 17-18, 2018. The vibration level measurement locations are shown on Figure 1.

Vibration measurement Sites A and B were intended to be representative railroad passby vibration exposure at the project site from the UPRR north-south lines to the west of the development. Vibration measurement Site C was specifically selected to capture railroad passby vibration exposure from the UPRR east-west lines to the south of the project.

Larson-Davis Laboratories Model LxT precision integrating sound level meters equipped with a vibration transducer were used to complete the measurements. The results are presented graphically in Appendix E and are summarized in Table 4.

Table 4
Summary of Railroad Vibration Monitoring Results[1]
Yankee Hill Road Property Residential Development – Rocklin, California
January 17-18, 2018

Site	Number of Measured Train Passbys	Maximum Vibration Level Per Passby, VdB RMS (Average)	Highest Measured Passby Vibration Level, VdB RMS
Site A – Northwestern end of project site, approximately 60' from center of UPRR north-south line railroad tracks	15	56	63
Site B – Northern end of project site, approximately 125' from center of UPRR north-south line railroad tracks	15	60	66
Site C - Southeastern end of project site, approximately 165' from center of UPRR east-west line railroad tracks	3	52	56

Notes:
[1] Vibration measurement locations are shown on Figure 1.
Source: Bollard Acoustical Consultants, Inc. (2018)

The Table 4 data indicate that measured average railroad passby vibration levels at the project site ranged from 42-56 VdB RMS, with standard deviations ranging from 5-7 of VdB. Measured maximum vibration levels ranged from 52-66 VdB.

Because approximately 18 train passbys occur at the site per day the FTA vibration exposure criteria (Table 1) indicate that the numerical standard of 80 VdB for "infrequent events" (<30 events per day) would be applicable to this project. As indicated in Table 4, measured maximum vibration levels ranged from 52-66 VdB. As a result, vibration levels from railroad passbys are expected to be well below the 80 VdB FTA criteria at the nearest residences to this development and no additional consideration of vibration mitigation would be warranted. The detailed vibration monitoring results are presented graphically in Appendix E.

Conclusions and Recommendations

Portions of the Yankee Hill Road Property Residential Development are predicted to be exposed to railroad noise levels in excess of City of Rocklin General Plan exterior and interior noise standards. As a result, the noise mitigation measures cited below should be incorporated to ensure compliance with those standards.

Groundborne vibration due to freight and passenger train operations on the adjacent UPRR tracks was measured to be in compliance with the U.S. Department of Transportation's Federal Transit Authority (FTA) vibration impact assessment criteria.

1) A railroad noise barrier should be constructed as proposed at the location indicated on Figure 2. A noise barrier measuring 12-feet in height relative to Parcel 4 elevation is predicted to reduce exterior railroad noise exposure to approximately 65 dB Ldn at the proposed outdoor activity space of Parcel 4 (see shaded area of Figure 1).

2) In order to achieve compliance with the City's 45 dB L_{dn} interior noise standard, and provide additional protection against sleep disturbance during nighttime UPRR train passages, the following construction upgrades are recommended for this project:

    a. All first and second-floor bedroom windows of residences constructed on Parcels 1-3 should have a minimum Sound Transmission Class (STC) rating of 34.

    b. All first-floor bedroom windows of the residence constructed on Parcel 4 should have a minimum STC rating of 34. All other first-floor windows of the residence constructed on Parcel 4 should have a minimum STC rating of 32.

    c. All upper floor windows of the residence constructed on Parcel 4 should have a minimum STC rating of 36.

3) A suitable form of forced-air mechanical ventilation shall be provided for each residence of this development so that windows can be kept closed as desired for additional acoustical isolation.

4) Disclosure statements should be provided to all prospective residents of this development notifying of elevated noise levels during railroad passages, particularly during nighttime operations and periodic periods of warning horn usage.

These conclusions are based on the collected noise and vibration level data at the project site, on the project site plan shown in Figure 2, and on noise reduction data for standard residential dwellings and for typical STC rated window data. Deviations from the project site plan shown in Figure 2 could cause future railroad noise and vibration levels to differ from those predicted in this analysis. Bollard Acoustical Consultants, Inc. is not responsible for changed in noise levels resulting from such differences or degradation in acoustic performance of the residential construction due to poor construction practices, failure to comply with applicable building code requirements, or for failure to adhere to the minimum building practices cited in this report.

This concludes BAC's environmental noise assessment for the proposed Yankee Hill Road Property Residential Development in Rocklin, California. Please contact BAC at (916) 663-0500 or paulb@bacnoise.com with any questions regarding this assessment.

Appendix A
Acoustical Terminology

Acoustics The science of sound.

Ambient Noise The distinctive acoustical characteristics of a given space consisting of all noise sources audible at that location. In many cases, the term ambient is used to describe an existing or pre-project condition such as the setting in an environmental noise study.

Attenuation The reduction of an acoustic signal.

A-Weighting A frequency-response adjustment of a sound level meter that conditions the output signal to approximate human response.

Decibel or dB Fundamental unit of sound. A Bell is defined as the logarithm of the ratio of the sound pressure squared over the reference pressure squared. A Decibel is one-tenth of a Bell.

CNEL Community Noise Equivalent Level. Defined as the 24-hour average noise level with noise occurring during evening hours (7 - 10 p.m.) weighted by a factor of three and nighttime hours weighted by a factor of 10 prior to averaging.

Frequency The measure of the rapidity of alterations of a periodic signal, expressed in cycles per second or hertz.

IIC Impact Insulation Class (IIC): A single-number representation of a floor/ceiling partition's impact generated noise insulation performance. The field-measured version of this number is the FIIC.

L_{dn} Day/Night Average Sound Level. Similar to CNEL but with no evening weighting.

L_{eq} Equivalent or energy-averaged sound level.

L_{max} The highest root-mean-square (RMS) sound level measured over a given period of time.

Loudness A subjective term for the sensation of the magnitude of sound.

Masking The amount (or the process) by which the threshold of audibility is for one sound is raised by the presence of another (masking) sound.

Noise Unwanted sound.

Peak Noise The level corresponding to the highest (not RMS) sound pressure measured over a given period of time. This term is often confused with the "Maximum" level, which is the highest RMS level.

RT_{60} The time it takes reverberant sound to decay by 60 dB once the source has been removed.

STC Sound Transmission Class (STC): A single-number representation of a partition's noise insulation performance. This number is based on laboratory-measured, 16-band (1/3-octave) transmission loss (TL) data of the subject partition. The field-measured version of this number is the FSTC.

Appendix B-1
Yankee Hill Road Property Residential Development
Ambient Noise Monitoring Results - Site 1
Thursday, January 18, 2018

Hour	Leq	Lmax	L50	L90
0:00	74	100	46	44
1:00	78	100	46	45
2:00	46	59	45	39
3:00	74	96	39	38
4:00	76	99	42	39
5:00	48	58	47	45
6:00	58	84	49	47
7:00	79	100	52	49
8:00	53	64	53	49
9:00	50	67	49	47
10:00	74	98	51	50
11:00	67	94	51	50
12:00	52	71	51	49
13:00	65	93	50	49
14:00	71	98	51	50
15:00	77	99	49	48
16:00	52	73	50	48
17:00	53	66	51	49
18:00	74	95	52	50
19:00	53	70	51	49
20:00	74	97	49	47
21:00	77	101	48	47
22:00	47	64	47	46
23:00	50	75	46	44

Statistical Summary						
	Daytime (7 a.m. - 10 p.m.)			Nighttime (10 p.m. - 7 a.m.)		
	High	Low	Average	High	Low	Average
Leq (Average)	79	50	73	78	46	72
Lmax (Maximum)	101	64	86	100	58	82
L50 (Median)	53	48	51	49	39	45
L90 (Background)	50	47	49	47	38	43

Computed Ldn, dB	79
% Daytime Energy	66%
% Nighttime Energy	34%

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Appendix B-2
Yankee Hill Road Property Residential Development
Ambient Noise Monitoring Results - Site 1
Friday, January 19, 2018

Hour	Leq	Lmax	L50	L90
0:00	44	57	44	42
1:00	74	97	43	42
2:00	75	101	43	41
3:00	47	65	44	42
4:00	77	100	47	45
5:00	50	58	50	48
6:00	59	85	53	51
7:00	74	100	55	53
8:00	55	68	54	51
9:00	80	99	46	43
10:00	76	99	46	43
11:00	51	74	46	43
12:00	67	95	44	42
13:00	70	97	44	42
14:00	50	67	44	41
15:00	78	101	45	42
16:00	62	91	44	41
17:00	57	85	44	41
18:00	51	66	46	44
19:00	51	67	46	45
20:00	50	68	47	45
21:00	76	97	46	43
22:00	45	56	45	43
23:00	43	55	42	40

	Statistical Summary					
	Daytime (7 a.m. - 10 p.m.)			Nighttime (10 p.m. - 7 a.m.)		
	High	Low	Average	High	Low	Average
Leq (Average)	80	50	73	77	43	71
Lmax (Maximum)	101	66	85	101	55	75
L50 (Median)	55	44	46	53	42	46
L90 (Background)	53	41	44	51	40	44

Computed Ldn, dB	78
% Daytime Energy	72%
% Nighttime Energy	28%

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Appendix B-3
Yankee Hill Road Property Residential Development
Ambient Noise Monitoring Results - Site 1
Saturday, January 20, 2018

Hour	Leq	Lmax	L50	L90
0:00	45	68	42	40
1:00	75	99	44	39
2:00	41	60	39	37
3:00	39	48	38	36
4:00	77	99	44	39
5:00	43	58	43	41
6:00	74	98	47	43
7:00	51	68	50	47
8:00	58	84	51	48
9:00	76	98	47	44
10:00	46	62	43	40
11:00	49	73	45	42
12:00	53	71	46	42
13:00	48	67	43	41
14:00	49	66	45	41
15:00	49	68	43	40
16:00	50	75	43	41
17:00	47	59	45	42
18:00	55	74	49	45
19:00	50	60	49	48
20:00	59	86	51	49
21:00	54	74	53	52
22:00	52	59	52	49
23:00	50	61	49	48

	Statistical Summary					
	Daytime (7 a.m. - 10 p.m.)			Nighttime (10 p.m. - 7 a.m.)		
	High	Low	Average	High	Low	Average
Leq (Average)	76	46	65	77	39	71
Lmax (Maximum)	98	59	72	99	48	72
L50 (Median)	53	43	47	52	38	44
L90 (Background)	52	40	44	49	36	41

Computed Ldn, dB	77
% Daytime Energy	30%
% Nighttime Energy	70%

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Appendix B-4
Yankee Hill Road Property Residential Development
Ambient Noise Monitoring Results - Site 1
Sunday, January 21, 2018

Hour	Leq	Lmax	L50	L90
0:00	75	98	49	47
1:00	48	59	48	45
2:00	45	54	44	42
3:00	79	99	45	43
4:00	57	73	45	43
5:00	83	111	46	43
6:00	47	54	46	45
7:00	57	72	49	48
8:00	78	97	51	49
9:00	50	65	47	45
10:00	49	64	48	47
11:00	54	76	50	47
12:00	77	100	48	46
13:00	77	98	48	46
14:00	51	68	48	46
15:00	51	67	49	47
16:00	50	63	50	49
17:00	77	98	52	50
18:00	75	99	52	51
19:00	54	73	52	50
20:00	78	98	51	50
21:00	58	86	49	48
22:00	76	99	48	47
23:00	50	70	47	45

Statistical Summary						
	Daytime (7 a.m. - 10 p.m.)			Nighttime (10 p.m. - 7 a.m.)		
	High	Low	Average	High	Low	Average
Leq (Average)	78	49	73	83	45	76
Lmax (Maximum)	100	63	82	111	54	80
L50 (Median)	52	47	50	49	44	47
L90 (Background)	51	45	48	47	42	44

Computed Ldn, dB	82
% Daytime Energy	47%
% Nighttime Energy	53%

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Appendix B-5
Yankee Hill Road Property Residential Development
Ambient Noise Monitoring Results - Site 2
1/17/2018 - 1/18/2018

Hour	Leq	Lmax	L50	L90
12:00	58	85	42	39
13:00	64	89	43	41
14:00	45	57	44	41
15:00	46	61	45	42
16:00	50	70	45	43
17:00	95	107	81	44
18:00	81	103	47	45
19:00	89	106	49	46
20:00	98	108	95	53
21:00	99	106	97	89
22:00	100	106	99	94
23:00	101	106	100	95
0:00	98	106	95	47
1:00	99	112	60	52
2:00	88	110	58	52
3:00	95	111	60	54
4:00	95	111	61	55
5:00	86	109	59	54
6:00	91	111	59	55
7:00	83	110	60	55
8:00	82	109	58	53
9:00	88	110	57	51
10:00	71	108	55	49
11:00	67	98	57	52

	Statistical Summary					
	Daytime (7 a.m. - 10 p.m.)			Nighttime (10 p.m. - 7 a.m.)		
	High	Low	Average	High	Low	Average
Leq (Average)	100	45	93	101	86	96
Lmax (Maximum)	110	57	96	112	106	109
L50 (Median)	99	42	61	100	58	69
L90 (Background)	94	39	52	95	47	58

Computed Ldn, dB	102
% Daytime Energy	48%
% Nighttime Energy	52%

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Appendix B-5
Yankee Hill Road Property Residential Development
Ambient Noise Monitoring Results - Site 3
1/17/2018 - 1/18/2018

Hour	Leq	Lmax	L50	L90
11:00	57	75	44	42
12:00	57	83	42	39
13:00	62	88	42	40
14:00	46	61	44	42
15:00	45	59	44	42
16:00	56	78	47	43
17:00	46	65	44	42
18:00	60	86	46	45
19:00	68	89	47	45
20:00	45	54	45	41
21:00	64	88	38	36
22:00	35	48	35	34
23:00	42	55	41	36
0:00	65	90	43	41
1:00	69	88	42	41
2:00	42	48	42	37
3:00	65	86	37	35
4:00	67	90	40	37
5:00	46	56	45	43
6:00	50	74	47	44
7:00	70	89	49	47
8:00	50	58	50	46
9:00	47	61	47	45
10:00	67	88	48	46

Statistical Summary						
	Daytime (7 a.m. - 10 p.m.)			Nighttime (10 p.m. - 7 a.m.)		
	High	Low	Average	High	Low	Average
Leq (Average)	70	45	63	69	35	63
Lmax (Maximum)	89	54	75	90	48	71
L50 (Median)	50	38	45	47	35	41
L90 (Background)	47	36	43	44	34	39

Computed Ldn, dB	70
% Daytime Energy	58%
% Nighttime Energy	42%

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Appendix B-6
Yankee Hill Road Property Residential Development
Ambient Noise Monitoring Results - Site 4
1/17/2018 - 1/18/2018

Hour	Leq	Lmax	L50	L90
12:00	57	79	46	44
13:00	59	80	47	45
14:00	51	66	48	47
15:00	50	59	49	48
16:00	61	82	50	48
17:00	48	61	47	46
18:00	57	80	48	47
19:00	62	82	49	48
20:00	47	53	47	45
21:00	59	78	44	44
22:00	43	49	44	43
23:00	45	51	45	44
0:00	60	82	46	45
1:00	62	80	46	45
2:00	46	50	46	45
3:00	60	79	44	43
4:00	64	81	45	44
5:00	48	58	48	46
6:00	50	65	49	47
7:00	64	82	50	49
8:00	52	64	52	50
9:00	52	67	51	49
10:00	61	80	51	50
11:00	65	75	51	50

	Statistical Summary					
	Daytime (7 a.m. - 10 p.m.)			Nighttime (10 p.m. - 7 a.m.)		
	High	Low	Average	High	Low	Average
Leq (Average)	65	43	59	64	45	58
Lmax (Maximum)	82	49	71	82	50	68
L50 (Median)	52	44	48	49	44	46
L90 (Background)	50	43	47	47	43	45

Computed Ldn, dB	65
% Daytime Energy	68%
% Nighttime Energy	32%

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Appendix B-7
Yankee Hill Road Property Residential Development
Ambient Noise Monitoring Results - Site 5
Thursday, January 18, 2018

Hour	Leq	Lmax	L50	L90
0:00	58	79	51	51
1:00	60	78	51	51
2:00	51	53	51	51
3:00	58	77	50	50
4:00	64	84	51	50
5:00	52	59	51	51
6:00	52	64	52	51
7:00	63	82	52	52
8:00	53	58	53	52
9:00	53	64	52	52
10:00	59	78	53	52
11:00	56	72	53	52
12:00	53	65	52	51
13:00	54	75	52	51
14:00	58	85	53	52
15:00	61	79	52	52
16:00	63	85	52	52
17:00	53	61	53	52
18:00	60	76	56	54
19:00	62	84	57	56
20:00	59	76	56	55
21:00	61	81	56	55
22:00	56	58	57	56
23:00	57	59	57	57

Statistical Summary						
	Daytime (7 a.m. - 10 p.m.)			Nighttime (10 p.m. - 7 a.m.)		
	High	Low	Average	High	Low	Average
Leq (Average)	63	53	59	64	51	58
Lmax (Maximum)	85	58	75	84	53	68
L50 (Median)	57	52	53	57	50	52
L90 (Background)	56	51	53	57	50	52

Computed Ldn, dB	65
% Daytime Energy	68%
% Nighttime Energy	32%

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Appendix B-8
Yankee Hill Road Property Residential Development
Ambient Noise Monitoring Results - Site 5
Friday, January 19, 2018

Hour	Leq	Lmax	L50	L90
0:00	58	59	58	58
1:00	61	77	59	58
2:00	62	81	59	59
3:00	62	86	59	59
4:00	63	79	59	59
5:00	59	60	59	59
6:00	59	69	59	59
7:00	61	79	59	59
8:00	58	63	58	57
9:00	64	78	57	57
10:00	63	81	57	56
11:00	59	77	56	56
12:00	60	84	56	55
13:00	57	78	55	55
14:00	55	64	55	55
15:00	68	86	55	55
16:00	60	83	55	55
17:00	57	79	54	54
18:00	65	85	54	54
19:00	62	84	54	54
20:00	54	63	54	54
21:00	61	79	54	54
22:00	54	61	54	53
23:00	53	59	53	53

Statistical Summary						
	Daytime (7 a.m. - 10 p.m.)			Nighttime (10 p.m. - 7 a.m.)		
	High	Low	Average	High	Low	Average
Leq (Average)	68	54	62	63	53	60
Lmax (Maximum)	86	63	78	86	59	70
L50 (Median)	59	54	56	59	53	58
L90 (Background)	59	54	55	59	53	57

Computed Ldn, dB	67
% Daytime Energy	73%
% Nighttime Energy	27%

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Appendix B-9
Yankee Hill Road Property Residential Development
Ambient Noise Monitoring Results - Site 5
Saturday, January 20, 2018

Hour	Leq	Lmax	L50	L90
0:00	53	64	53	53
1:00	60	78	53	53
2:00	53	55	53	53
3:00	53	53	53	52
4:00	61	79	53	52
5:00	53	54	53	52
6:00	58	78	53	52
7:00	53	60	53	53
8:00	64	86	53	53
9:00	60	79	52	52
10:00	52	58	52	52
11:00	55	77	52	52
12:00	52	59	52	52
13:00	52	61	52	52
14:00	64	87	52	52
15:00	69	95	52	52
16:00	52	57	52	52
17:00	53	62	52	52
18:00	66	86	53	52
19:00	53	58	53	53
20:00	54	64	53	53
21:00	53	60	53	53
22:00	53	56	53	52
23:00	53	60	53	52

	Statistical Summary					
	Daytime (7 a.m. - 10 p.m.)			Nighttime (10 p.m. - 7 a.m.)		
	High	Low	Average	High	Low	Average
Leq (Average)	69	52	61	61	53	56
Lmax (Maximum)	95	57	70	79	53	64
L50 (Median)	53	52	52	53	53	53
L90 (Background)	53	52	52	53	52	53

Computed Ldn, dB	64
% Daytime Energy	83%
% Nighttime Energy	17%

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Appendix B-10
Yankee Hill Road Property Residential Development
Ambient Noise Monitoring Results - Site 5
Sunday, January 21, 2018

Hour	Leq	Lmax	L50	L90
0:00	61	79	52	52
1:00	52	59	52	52
2:00	52	58	52	51
3:00	64	80	52	51
4:00	68	87	52	51
5:00	70	94	52	51
6:00	52	53	52	52
7:00	68	86	52	52
8:00	62	77	53	52
9:00	57	87	52	51
10:00	52	68	52	51
11:00	53	73	52	51
12:00	60	79	52	51
13:00	61	85	51	51
14:00	58	85	51	51
15:00	60	85	51	51
16:00	52	58	52	51
17:00	60	78	52	52
18:00	58	78	52	52
19:00	63	87	52	52
20:00	61	79	52	52
21:00	52	66	52	52
22:00	61	80	52	52
23:00	64	91	52	51

Statistical Summary						
	Daytime (7 a.m. - 10 p.m.)			Nighttime (10 p.m. - 7 a.m.)		
	High	Low	Average	High	Low	Average
Leq (Average)	68	52	61	70	52	64
Lmax (Maximum)	87	58	78	94	53	76
L50 (Median)	53	51	52	52	52	52
L90 (Background)	52	51	51	52	51	51

Computed Ldn, dB	70
% Daytime Energy	44%
% Nighttime Energy	56%

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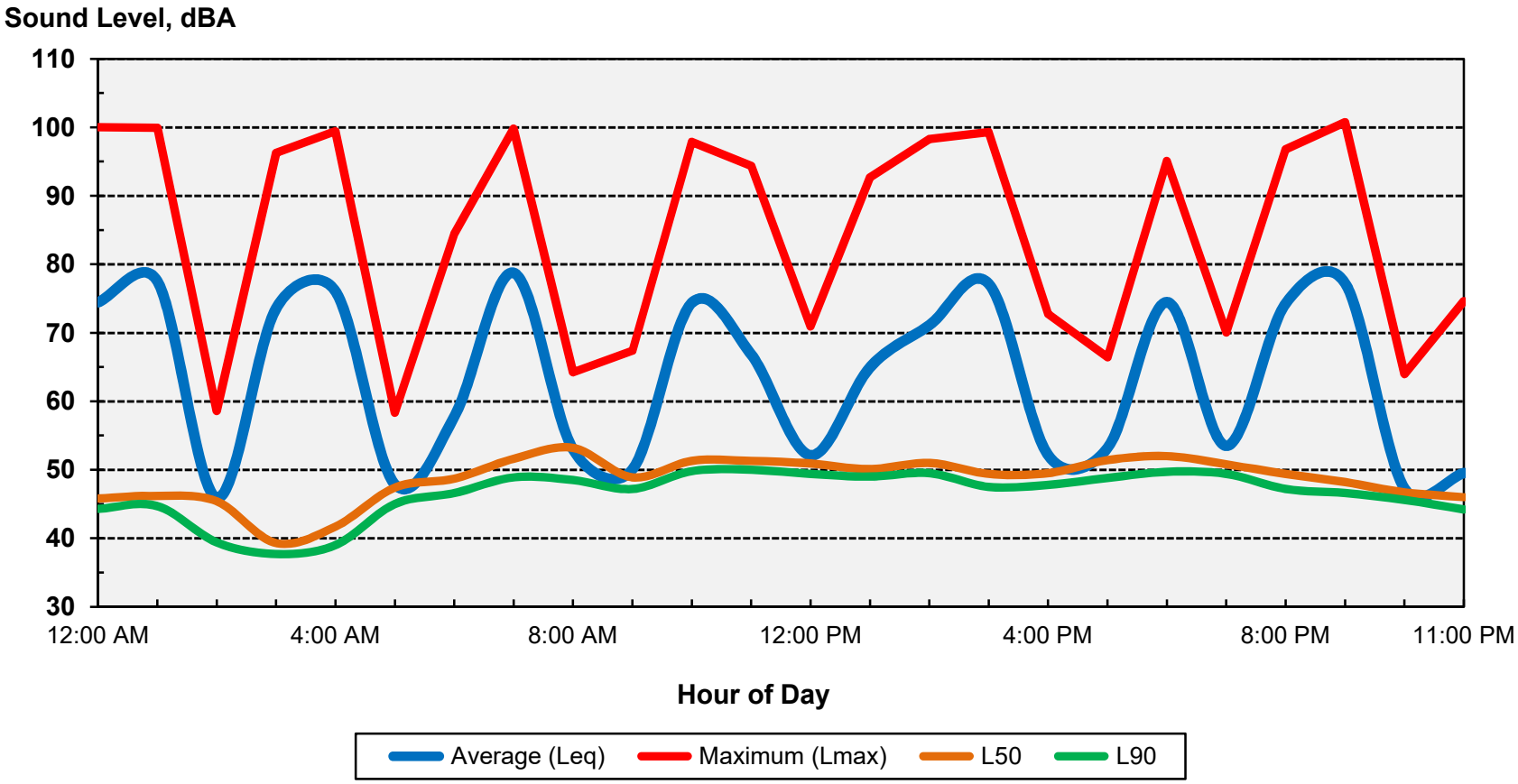
Appendix C-1
Yankee Hill Road Property Residential Development
Ambient Noise Monitoring Results - Site 1
Thursday, January 18, 2018



Ldn: 79 dB

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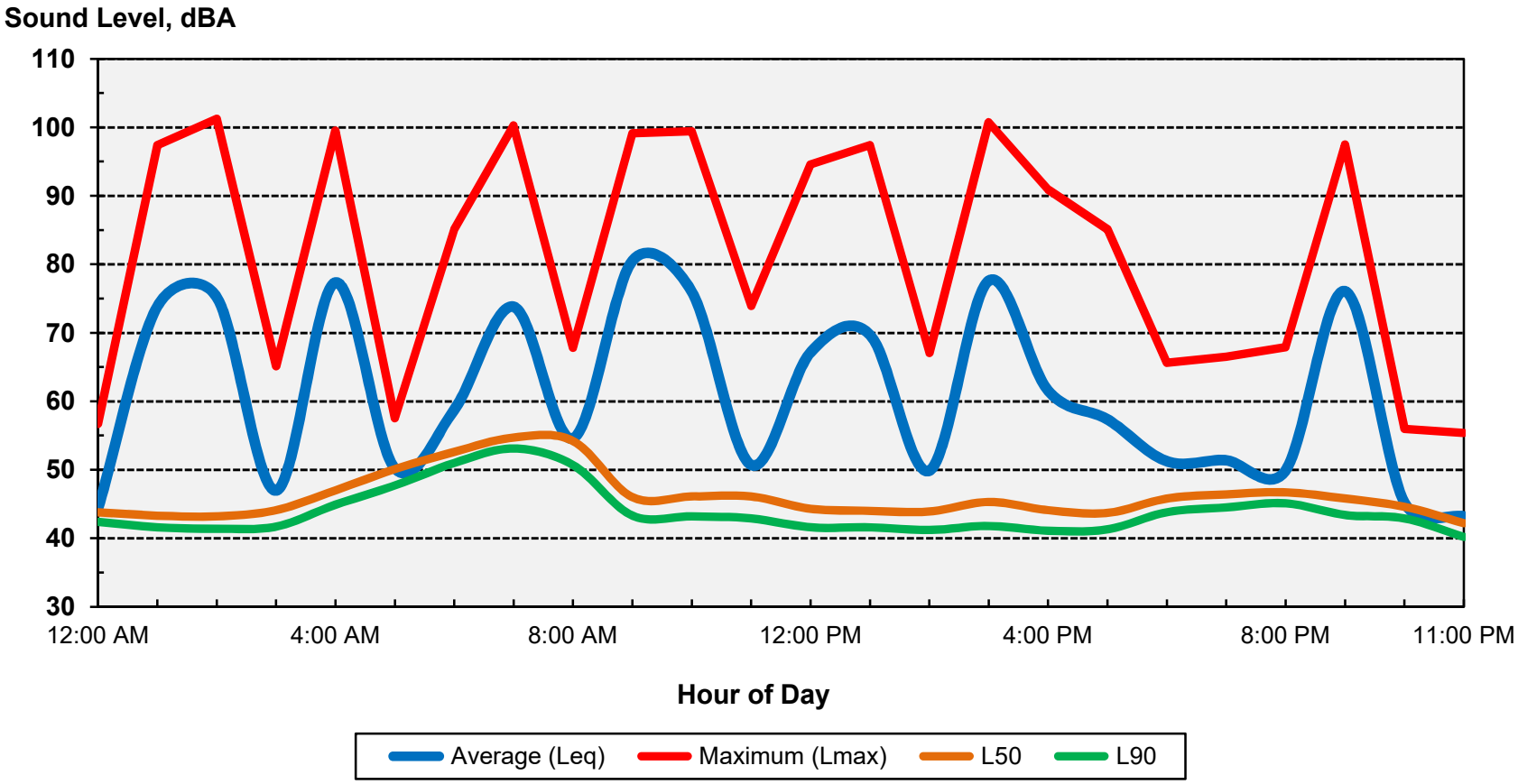
Appendix C-2
Yankee Hill Road Property Residential Development
Ambient Noise Monitoring Results - Site 1
Friday, January 19, 2018



Ldn: 78 dB

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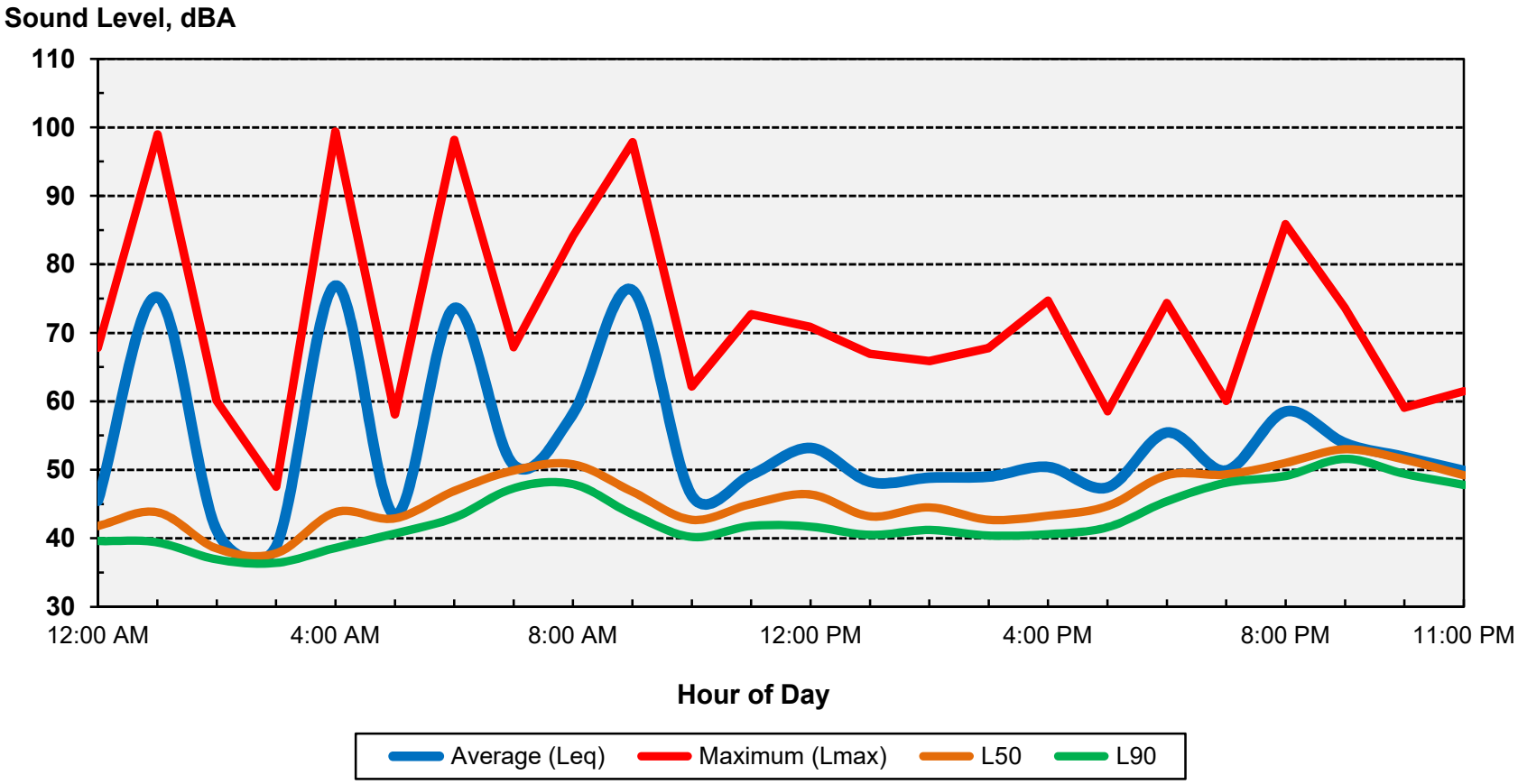
Appendix C-3
Yankee Hill Road Property Residential Development
Ambient Noise Monitoring Results - Site 1
Saturday, January 20, 2018



Ldn: 77 dB

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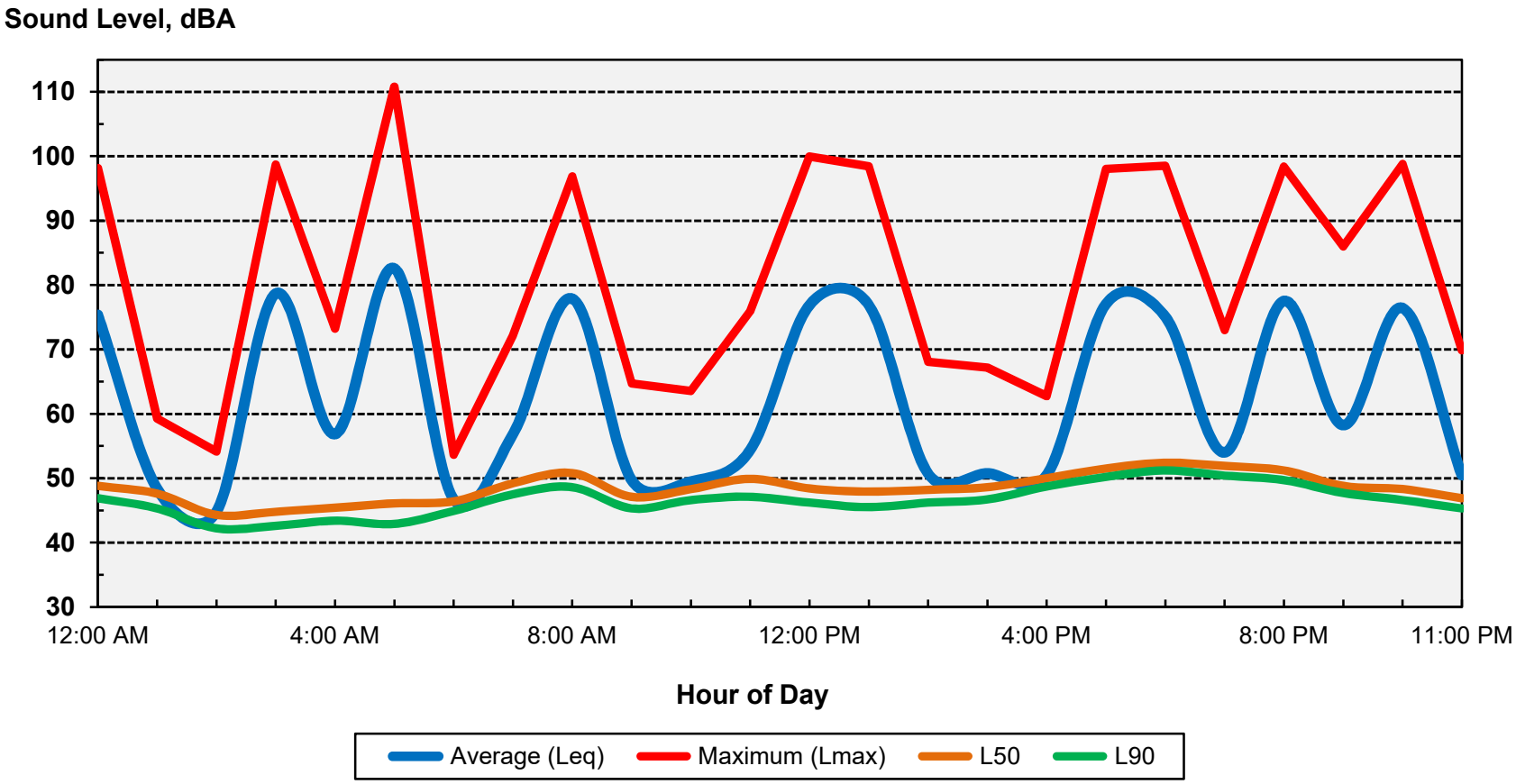
Appendix C-4
Yankee Hill Road Property Residential Development
Ambient Noise Monitoring Results - Site 1
Sunday, January 21, 2018



Ldn: 82 dB

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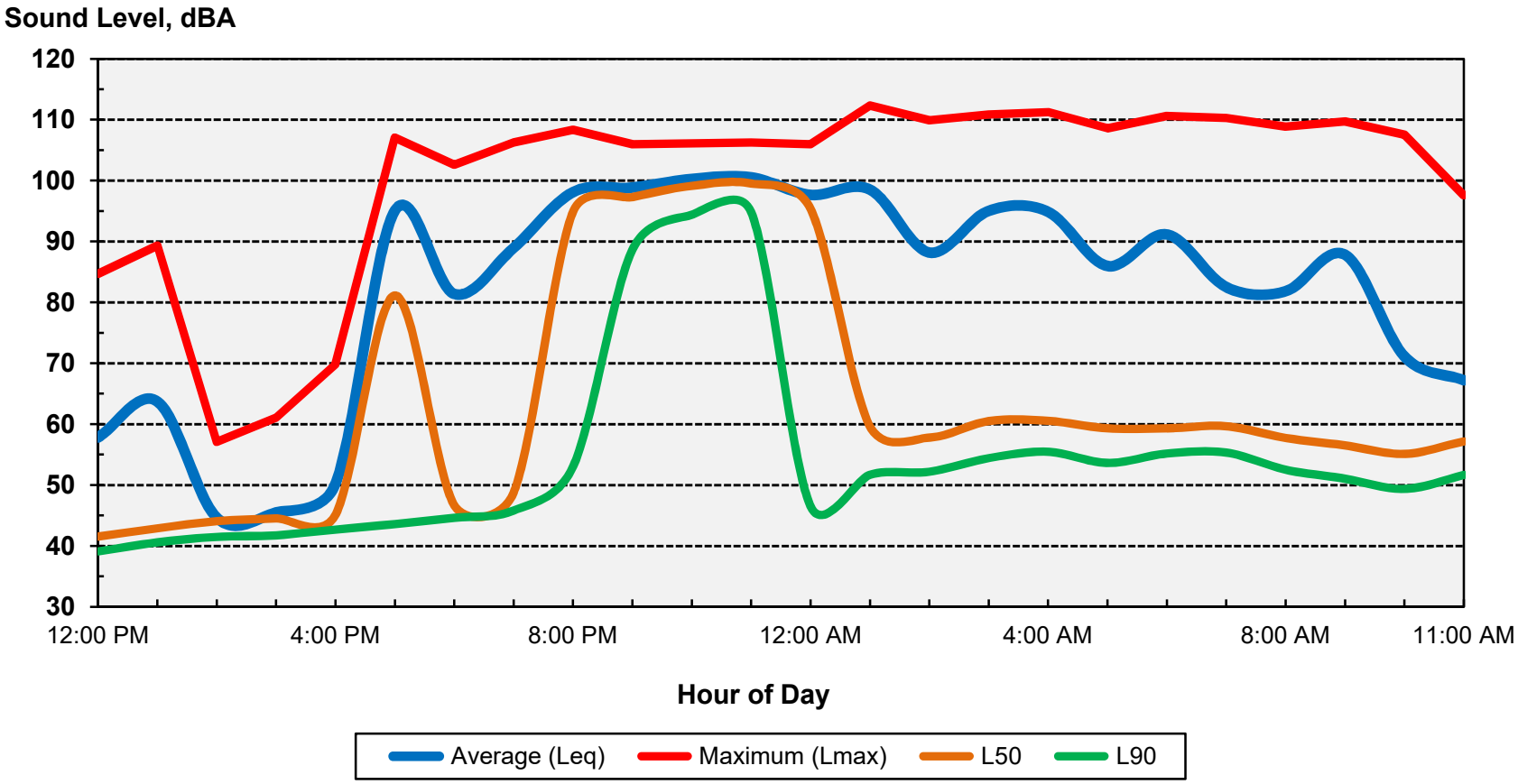
Appendix C-5
Yankee Hill Road Property Residential Development
Ambient Noise Monitoring Results - Site 2
1/17/2018 - 1/18/2018



Ldn: 102 dB

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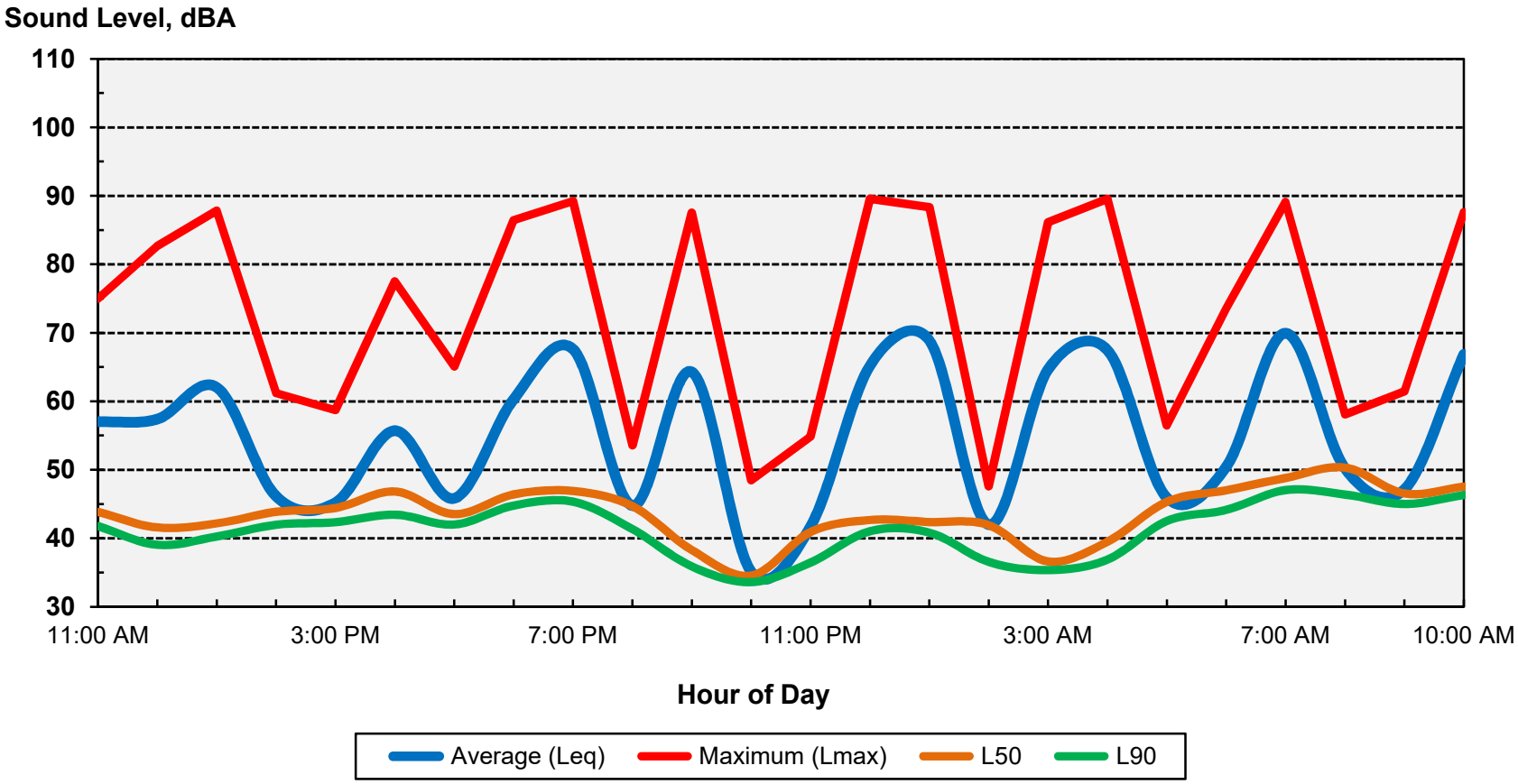
Appendix C-5
Yankee Hill Road Property Residential Development
Ambient Noise Monitoring Results - Site 3
1/17/2018 - 1/18/2018



Ldn: 70 dB

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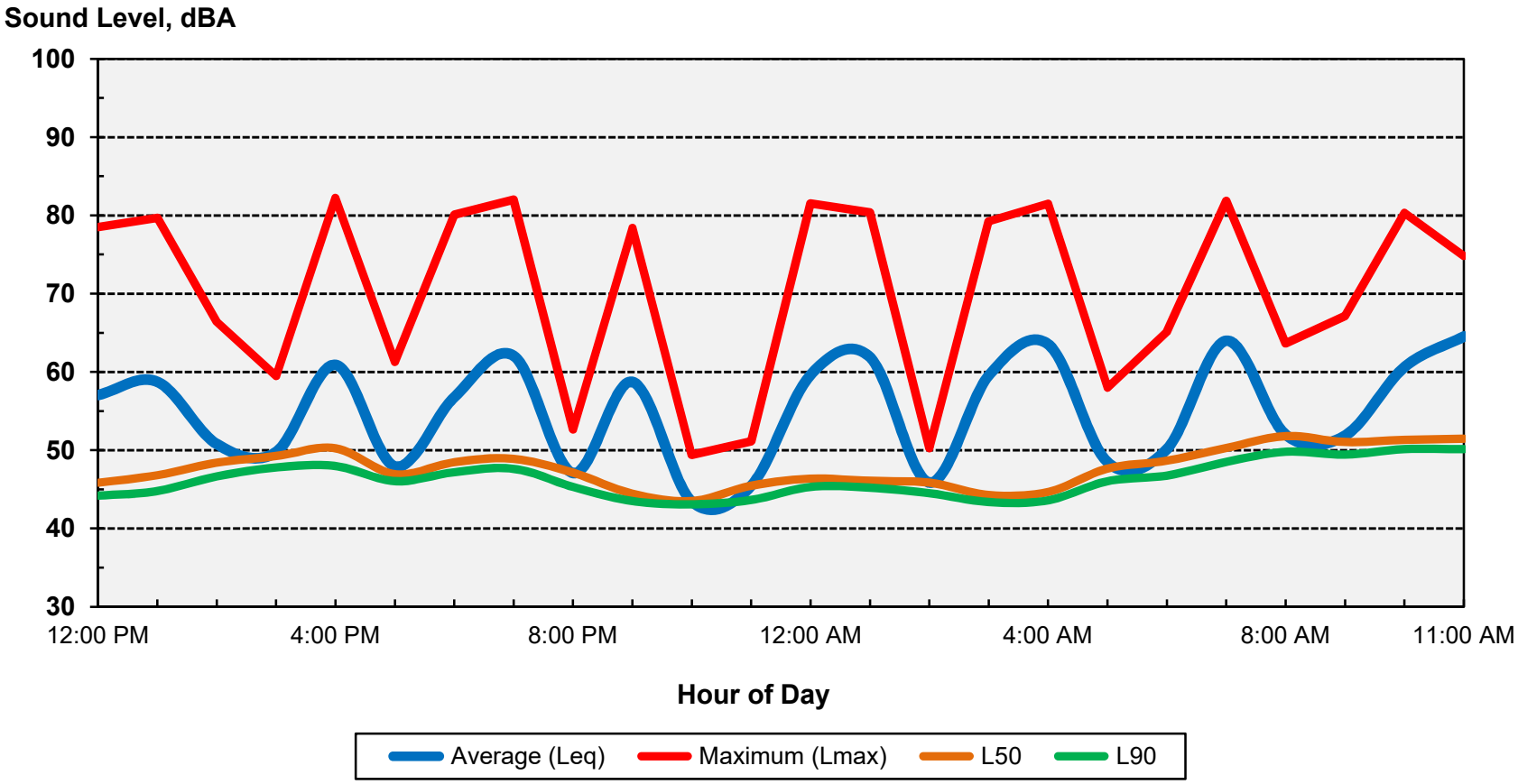
Appendix C-6
Yankee Hill Road Property Residential Development
Ambient Noise Monitoring Results - Site 4
1/17/2018 - 1/18/2018



Ldn: 65 dB

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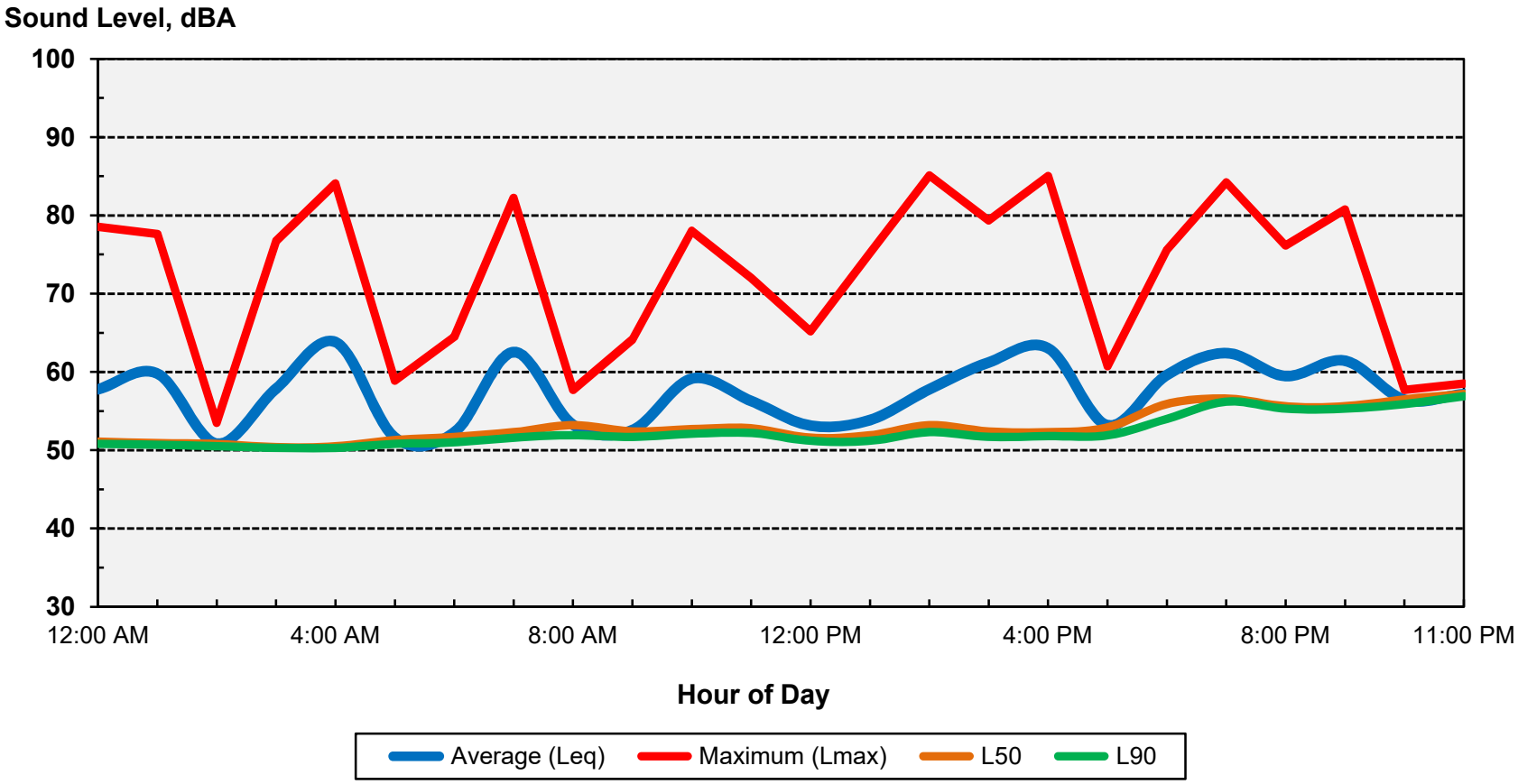
Appendix C-7
Yankee Hill Road Property Residential Development
Ambient Noise Monitoring Results - Site 5
Thursday, January 18, 2018



Ldn: 65 dB

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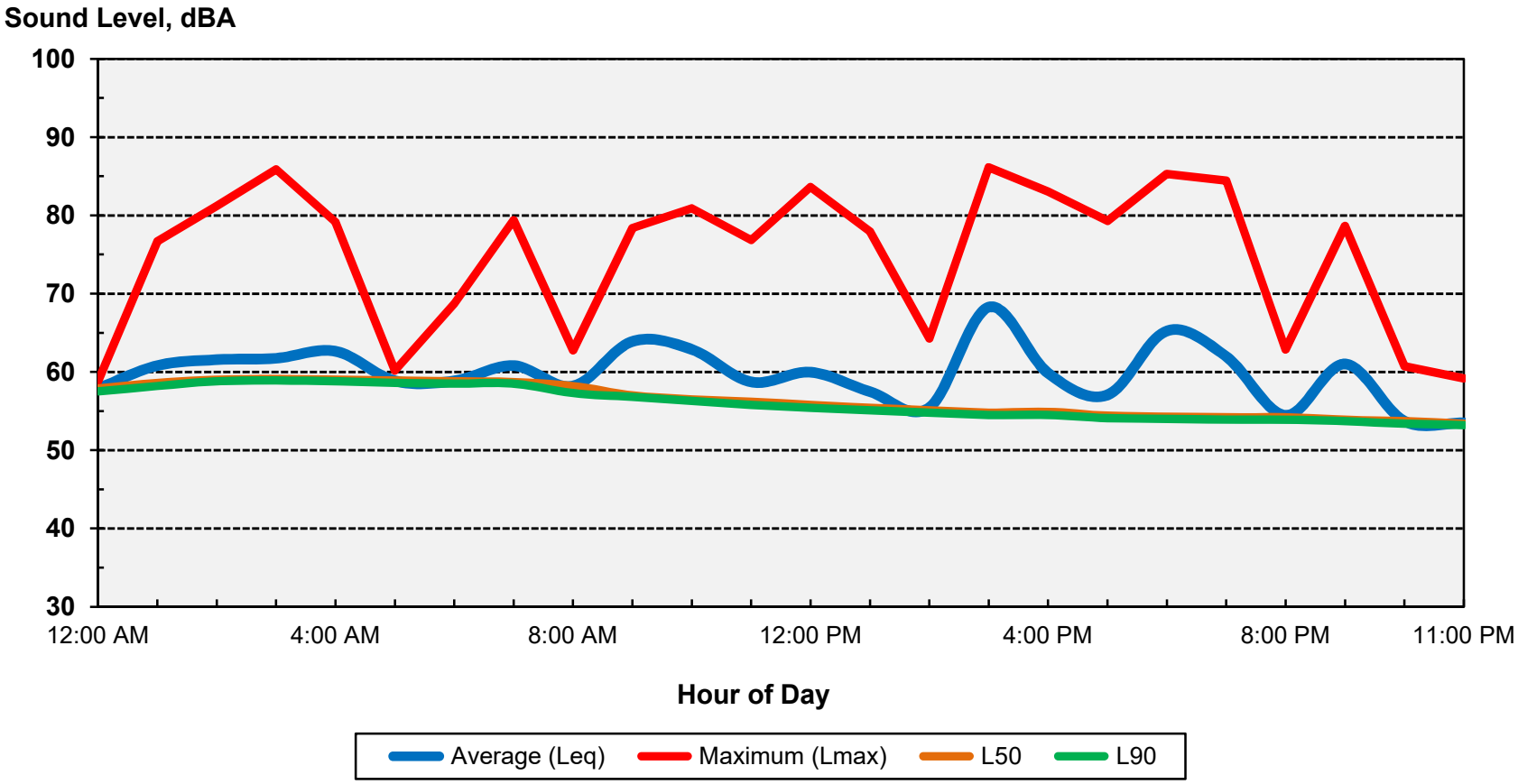
Appendix C-8
Yankee Hill Road Property Residential Development
Ambient Noise Monitoring Results - Site 5
Friday, January 19, 2018



Ldn: 67 dB

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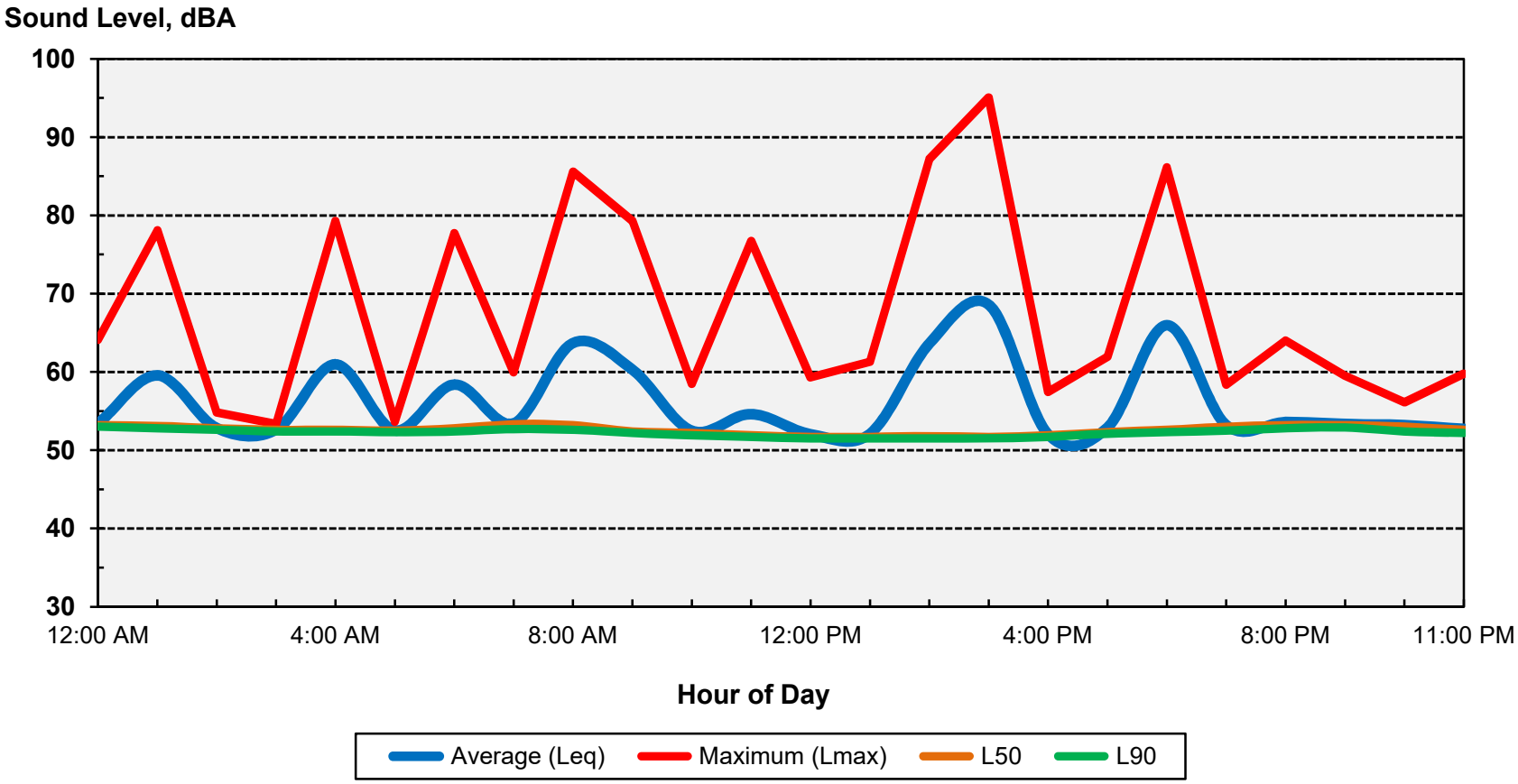
Appendix C-9
Yankee Hill Road Property Residential Development
Ambient Noise Monitoring Results - Site 5
Saturday, January 20, 2018



Ldn: 64 dB

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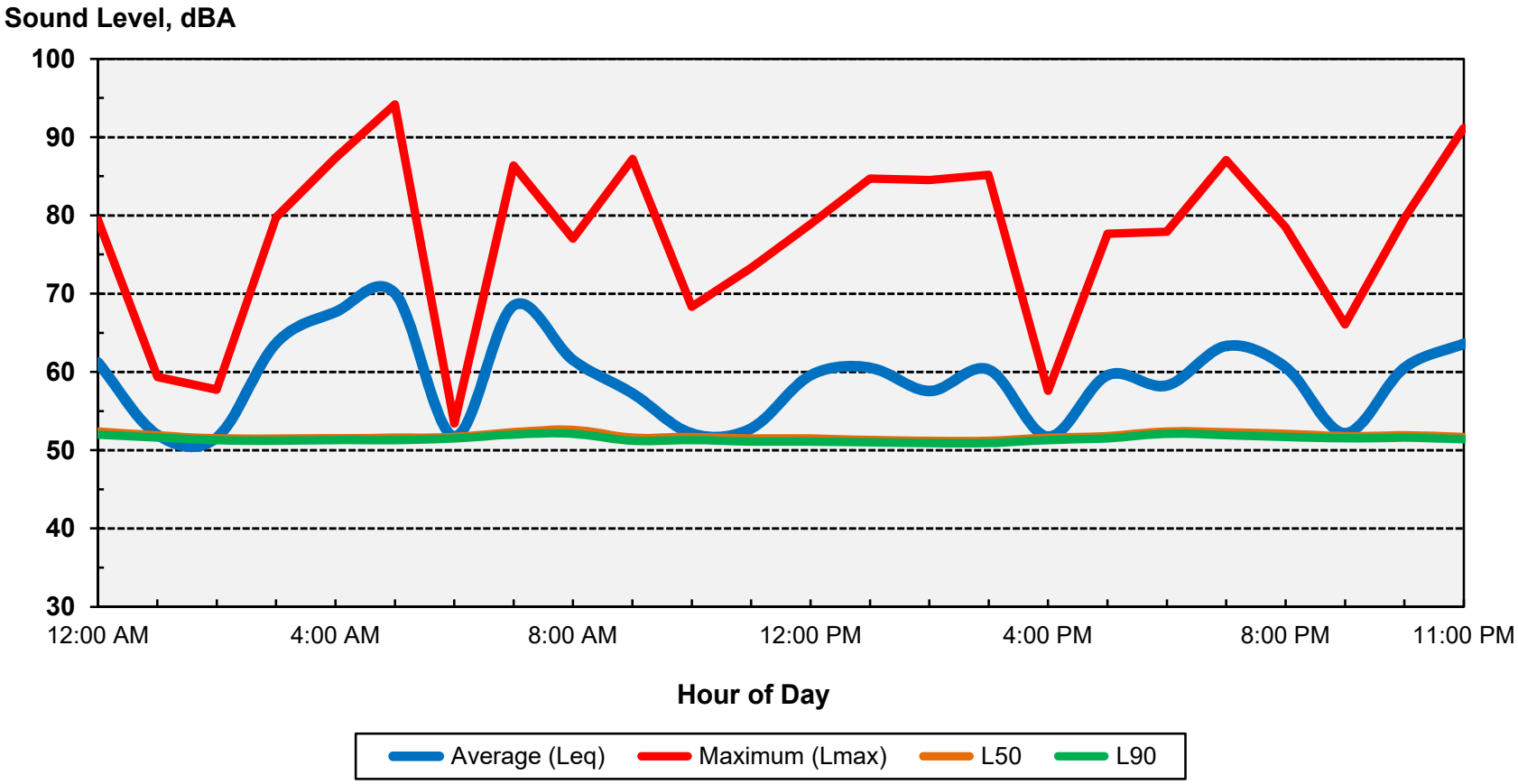
Appendix C-10
Yankee Hill Road Property Residential Development
Ambient Noise Monitoring Results - Site 5
Sunday, January 21, 2018



Ldn: 70 dB

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Notes:

Left: Long-term noise measurement Site 1, facing northwest towards UPRR north-south line tracks
Right: Long-term noise measurement Site 1, facing southwest towards UPRR north south line tracks

Yankee Hill Road Property
Residential Development
Rocklin, California

Project Site Photos

Appendix D-1

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Notes:

Left: Long-term noise measurement Site 2, facing southwest towards UPRR north-south line tracks
Right: Long-term noise measurement Site 2, facing southeast towards PG&E natural gas facility

Yankee Hill Road Property
Residential Development
Rocklin, California

Project Site Photos

Appendix D-2

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Notes:

Left: Long-term noise measurement Site 3, facing northeast
Right: Long-term noise measurement Site 3, facing southwest towards UPRR north-south line tracks

Yankee Hill Road Property
Residential Development
Rocklin, California

Project Site Photos

Appendix D-3

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Notes:

Left: Long-term noise measurement Site 4, facing northeast
Right: Long-term noise measurement Site 4, facing southwest

Yankee Hill Road Property
Residential Development
Rocklin, California

Project Site Photos

Appendix D-4

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Notes:

Shown: Long-term noise measurement Site 5, facing south towards UPRR east-west line tracks

Yankee Hill Road Property
Residential Development
Rocklin, California

Project Site Photos

Appendix D-5

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Notes:

Left: Vibration measurement Site A
Right: Vibration measurement Site A, facing southwest towards UPRR east-west line tracks

Yankee Hill Road Property
Residential Development
Rocklin, California

Project Site Photos

Appendix D-6

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Notes:

Left: Vibration measurement Site B
Right: Vibration measurement Site B, facing east

Yankee Hill Road Property
Residential Development
Rocklin, California

Project Site Photos

Appendix D-7

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Notes:

Shown: Vibration measurement Site C, facing south towards UPRR east-west line tracks

Yankee Hill Road Property
Residential Development
Rocklin, California

Project Site Photos

Appendix D-8

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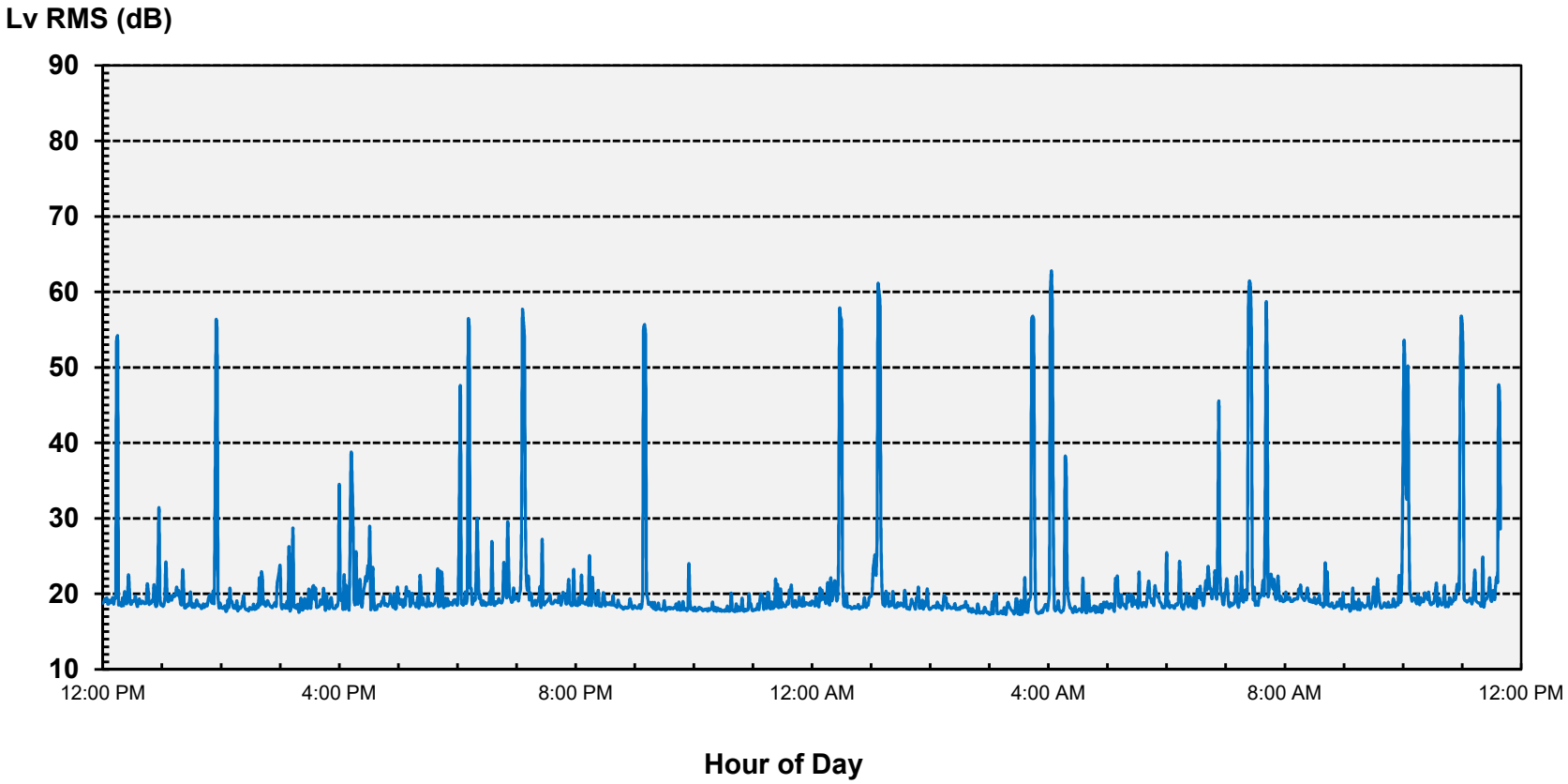
Appendix E-1
Yankee Hill Road Property Residential Development
Long-Term Vibration Measurement Results - Site A
January 17-18, 2018



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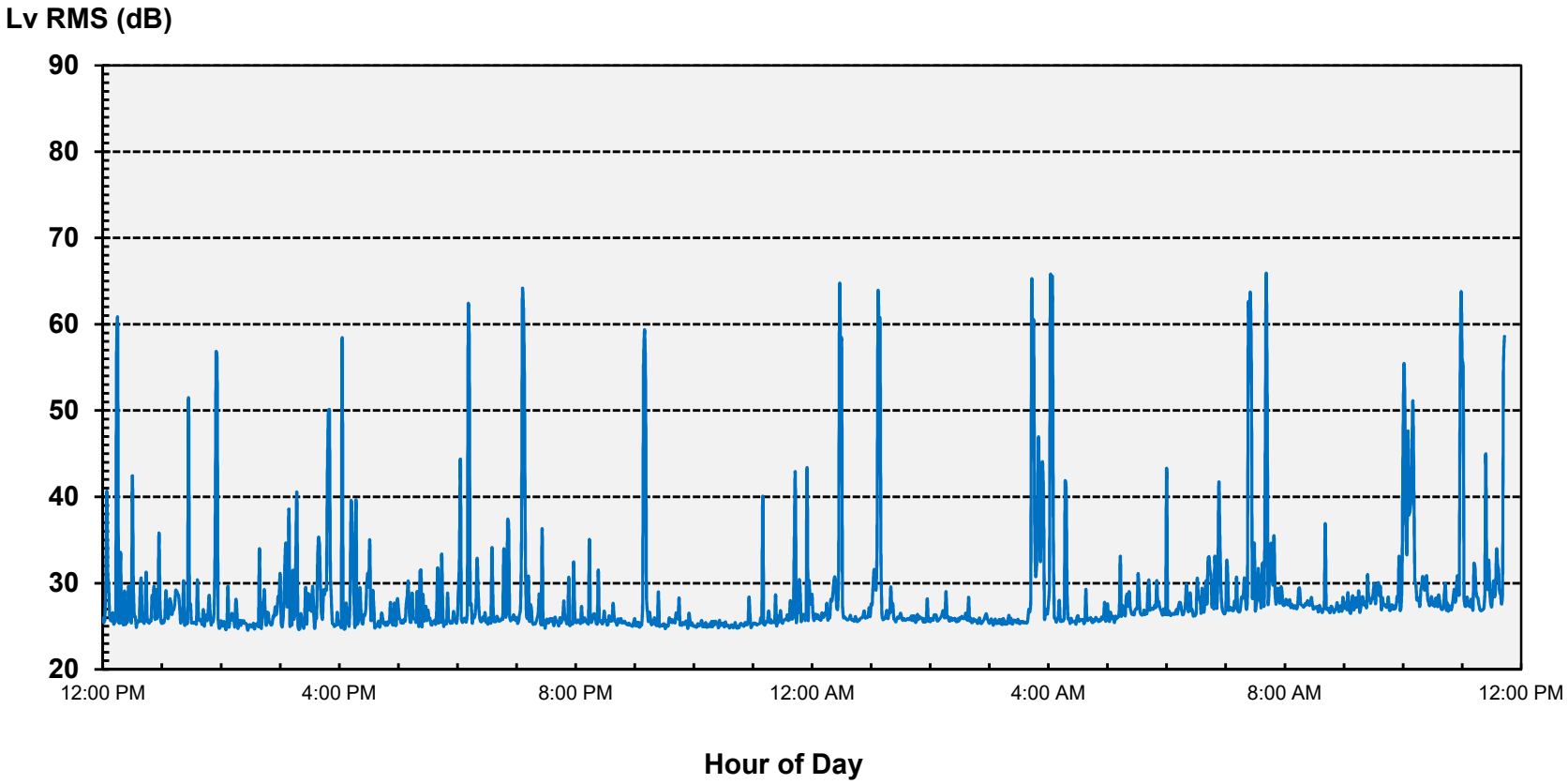
Appendix E-2
Yankee Hill Road Property Residential Development
Long-Term Vibration Measurement Results - Site B
January 17-18, 2018



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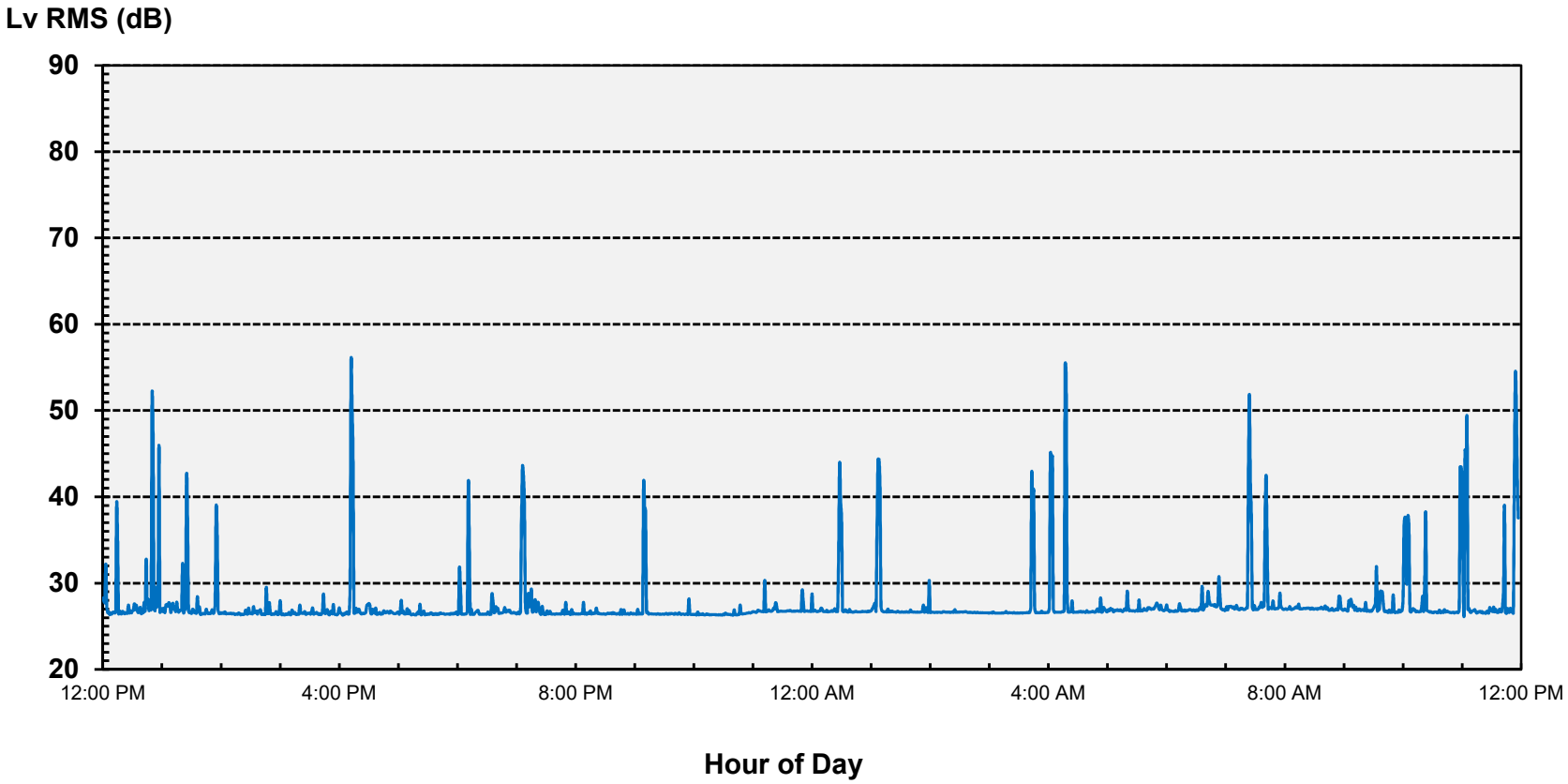
Appendix E-3
Yankee Hill Road Property Residential Development
Long-Term Vibration Measurement Results - Site C
January 17-18, 2018



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Appendix A
Acoustical Terminology

Acoustics The science of sound.

Ambient Noise The distinctive acoustical characteristics of a given space consisting of all noise sources audible at that location. In many cases, the term ambient is used to describe an existing or pre-project condition such as the setting in an environmental noise study.

Attenuation The reduction of an acoustic signal.

A-Weighting A frequency-response adjustment of a sound level meter that conditions the output signal to approximate human response.

Decibel or dB Fundamental unit of sound. A Bell is defined as the logarithm of the ratio of the sound pressure squared over the reference pressure squared. A Decibel is one-tenth of a Bell.

CNEL Community Noise Equivalent Level. Defined as the 24-hour average noise level with noise occurring during evening hours (7 - 10 p.m.) weighted by a factor of three and nighttime hours weighted by a factor of 10 prior to averaging.

Frequency The measure of the rapidity of alterations of a periodic signal, expressed in cycles per second or hertz.

IIC Impact Insulation Class (IIC): A single-number representation of a floor/ceiling partition's impact generated noise insulation performance. The field-measured version of this number is the FIIC.

L_{dn} Day/Night Average Sound Level. Similar to CNEL but with no evening weighting.

L_{eq} Equivalent or energy-averaged sound level.

L_{max} The highest root-mean-square (RMS) sound level measured over a given period of time.

Loudness A subjective term for the sensation of the magnitude of sound.

Masking The amount (or the process) by which the threshold of audibility is for one sound is raised by the presence of another (masking) sound.

Noise Unwanted sound.

Peak Noise The level corresponding to the highest (not RMS) sound pressure measured over a given period of time. This term is often confused with the "Maximum" level, which is the highest RMS level.

RT_{60} The time it takes reverberant sound to decay by 60 dB once the source has been removed.

STC Sound Transmission Class (STC): A single-number representation of a partition's noise insulation performance. This number is based on laboratory-measured, 16-band (1/3-octave) transmission loss (TL) data of the subject partition. The field-measured version of this number is the FSTC.