Noise Monitoring Services
Sound and Vibration Measurement, Testing & Consulting

Construction Noise and Vibration Analysis Report and Mitigation Plan

for the

Mixed Use Development at 24601 Hawthorne Boulevard in Torrance

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Introduction

This report details the construction noise and vibration study performed for the proposed mixed-use project at 24601 Hawthorne Boulevard in Torrance. The proposed development will consist of two new buildings with a total floor area of 18,340 sq. ft. The project will include 11 apartments, common open spaces, a commercial building and a parking area. The study was performed to assess the noise and vibration impacts during construction and the mitigation measures needed to achieve compliance with the City's requirements. This report provides the City of Torrance noise requirements; the existing noise and vibration levels at the site; an assessment of the sound and vibration levels during construction; and the mitigation measures required to achieve compliance with the noise and vibration limits.

The location of the project site is shown in Figure 1. The site is bounded on the north by a gas station; on the east by Hawthorne Boulevard; on the south side by Via Valmonte; and on the west by single family homes. Additional nearby residential properties are located south of Via Valmonte and east of Hawthorne Boulevard.

Figure 1 Project site location

Fundamentals of Sound

Sound may be thought of as mechanical energy of a vibrating object transmitted by pressure waves through a medium to the human ear. The medium of main concern for environmental noise is air. Noise is most simply defined as unwanted sound.

In its most basic form a sound can be described by its frequency and its amplitude. As a sound wave propagates past a point in the air it causes the air to alternate from a state of compression to a of rarefaction. The number of times per second that the wave passes from a state of maximum compression through a state of rarefaction and back to a state of maximum compression is the frequency. The amplitude describes the maximum pressure disturbance caused by the wave; that is, the difference between the “resting” pressure in the air when no sound is present and the pressure during the state of maximum compression or rarefaction caused by the sound wave.

Frequency is expressed in cycles per second, or Hertz (Hz). High frequencies are sometimes more conveniently expressed in units of kilohertz (kHz) or thousands of Hertz. The extreme range of frequencies that can be heard by the healthiest human ear spans from 16 to 20 Hz on the low end to about 20,000 Hz on the high end. Frequencies are heard as the pitch or tone of sound. High frequencies produce high produce low-pitched sounds. Very-low frequency airborne sound of sufficient amplitude may be felt before it can be heard, and can be confused with ground-borne vibration.

For any given frequency, an increase in amplitude correlates to an increase in loudness and a decrease in amplitude correlates to a decrease in loudness. The measurement and description of amplitude is discussed further in the following section.

Noise Descriptors

The following sections describe the noise descriptors that will be used throughout this study:

Decibels

The magnitude of a sound is typically described in term to the root-mean-square (rms) pressure of a sound wave and can be measured in units called microPascals (µPa). However, expressing sound pressure levels in terms of µPa would be very cumbersome since it would require a very wide range of numbers. For this reason, sound pressure levels are stated in terms of decibels, abbreviated dB. The decibel is a logarithmic unit that describes the ratio of the actual sound pressure to a reference pressure (20 µPa is the standard reference pressure level for acoustical measurements in air). Specifically, a sound pressure level, in decibels, is calculated as follows:

$$SPL = 20\log\left(\frac{X}{20\mu\text{Pa}}\right)$$

where *X* is the actual sound pressure and 20 µPa is the reference pressure.

Since decibels are logarithmic units, sound pressure levels cannot be added or subtracted by ordinary arithmetic means. For example, if one automobile produces a sound pressure level of 70 dB when it passes an observer, two cars passing simultaneously would not produce 140 dB. In fact, they would combine to produce 73 dB.

A-Weighting

While sound pressure level defines the amplitude of a sound, this alone is not a reliable indicator of loudness. Human perception of loudness depends on the characteristics of the human ear. In particular, the frequency or pitch of a sound has a substantial effect on how humans will respond. Human hearing is limited not only to the range of audible frequencies, but also in the way it perceives sound pressure levels within that range. In general, the healthy human ear is most sensitive to sounds between 1,000 Hz and 5,000 Hz, and perceives both higher and lower frequency sounds of the same magnitude as being less loud. In order to better relate noise to the frequency response of the human ear, a frequency adjust (or “weight”) the sound level measured by a sound level meter. The resulting sound pressure level is expressed in A-weighted decibels or dBA. When people make relative judgements of the loudness or annoyance of most ordinary everyday sounds, their judgments correlate well with the A-weighted sound levels of those sounds. A range of noise levels associated with common indoor and outdoor activities is shown in Figures 2 and 3.

Equivalent Sound Level (Leq)

Many noise sources produce levels that fluctuate over time; examples include mechanical equipment that cycles on and off, or construction work which can vary sporadically. The equivalent sound level (Leq) describes the average acoustic energy content of noise for an identified period of time, commonly 1 hour. Thus, the Leq of a time-varying noise and that of a steady noise are the same if they deliver the same acoustical energy over the duration of the exposure. For many noise sources, the Leq will vary depending on the time of day – a prime example is traffic noise which rises and falls depending on the amount of traffic on a given street or freeway.

Maximum Sound Level (Lmax)

The maximum sound level is the greatest sound level during a designated time interval or event. It is measured in decibels.

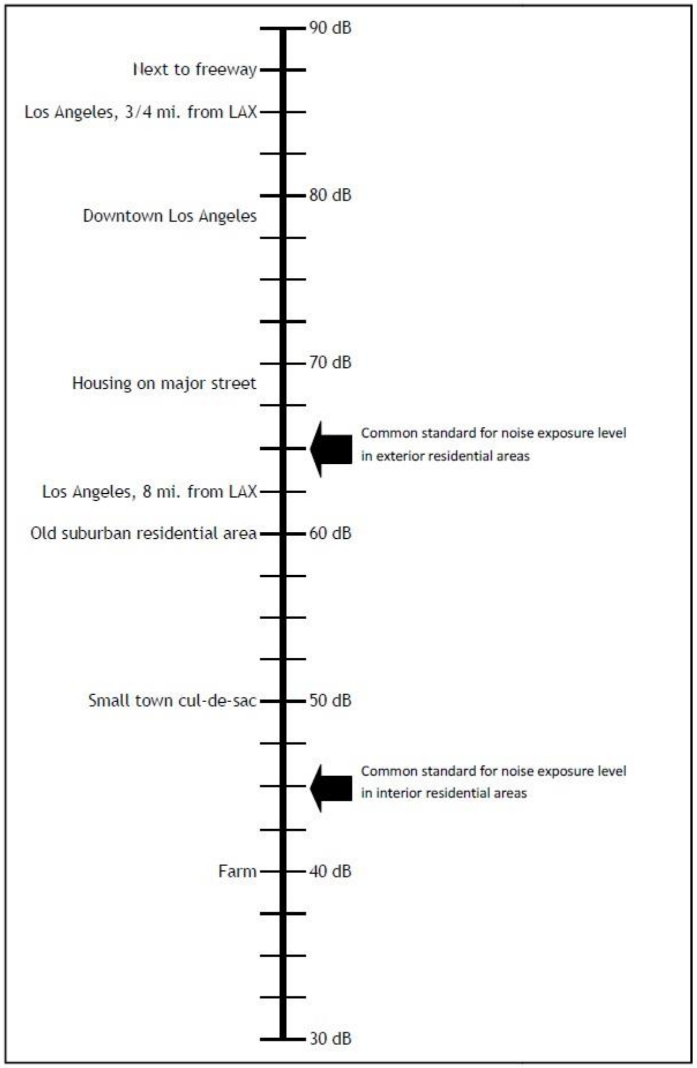


Figure 2 Common CNEL noise exposure levels at various locations

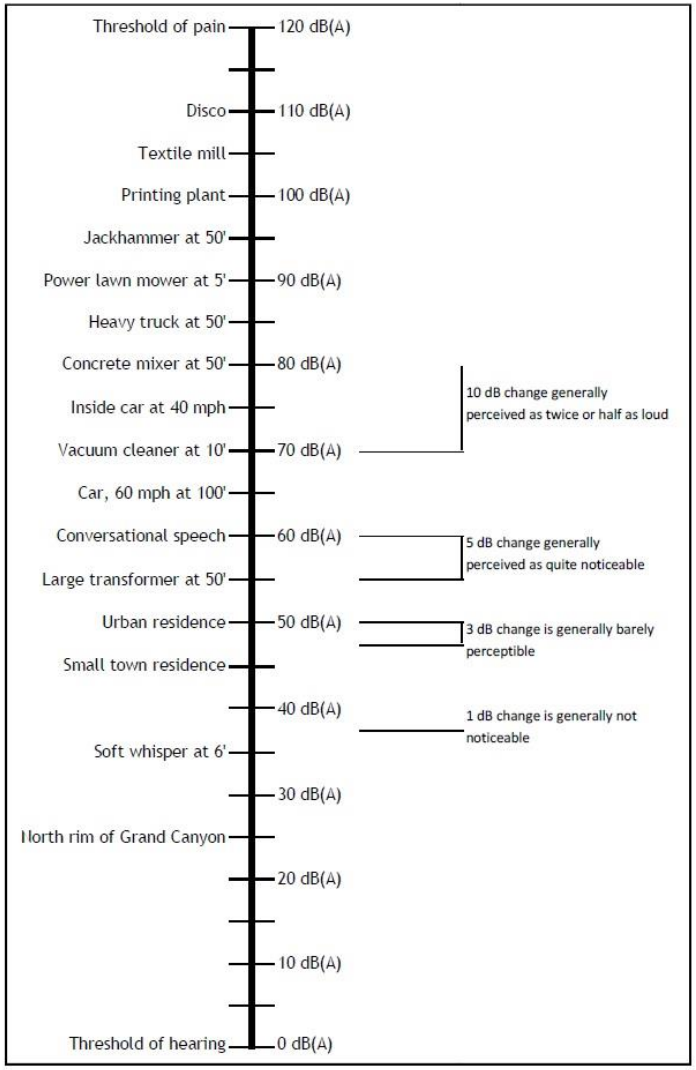


Figure 3 Common noise sources and A-weighted noise levels

Fundamentals of Ground-Borne Vibration

Vibration is acoustic energy transmitted as waves through a solid medium, such as soil or concrete. Like noise, the rate at which pressure changes occur is called the frequency of the vibration, measured in Hz. Vibration may be the form of a single pulse of acoustical energy, a series of pulses, or a continuous oscillating motion.

Ground-borne vibration is the ground motion about some equilibrium position that can be described in terms of displacement, velocity, and acceleration. It can be generated by transportation systems, construction activities, and other large mechanical systems. Vibration motion moves in the X, Y and Z axes, and this report evaluates velocity in all three axes.

The way that vibration is transmitted through the ground depends on the soil type, the presence of rock formations or man-made features and the topography between the vibration source and the receptor location. As a general rule, vibration waves tend to dissipate and reduce in magnitude with distance from the source. Also, the high frequency vibrations are generally attenuated rapidly as they travel through the ground, so that the vibration received at locations distant from the source tends to be dominated by low-frequency vibration. The frequencies of ground-borne vibration most perceptible to humans are in the range from less than 1 Hz to 100 Hz.

When ground-borne vibration arrives at a building, there is usually an initial ground-to-foundation coupling loss. However, once the vibration energy is in the building structure, it can be amplified by the resonance of the walls and floors. Occupants can perceive vibration as motion of the building elements (particularly floors) and also rattling of lightweight components, such as windows, shutters or items on shelves. At very high levels, low-frequency vibration can cause damage to buildings.

Vibration Descriptors

Peak Particle Velocity (PPV)

The peak particle velocity (PPV) is defined as the maximum instantaneous positive or negative peak amplitude of the vibration velocity in inches per second (inch/s), and is most frequently used to describe vibration impacts to buildings. PPV is appropriate for evaluating the potential for building damage and for evaluating human response to ground-borne vibration. Tables 1 and 2 describe the typical structural and human response to ground-borne vibration levels.

Table 1 Structural Guideline Vibration Criteria

Structure and Condition	Maximum PPV (inch/s)	
	Transient Sources	**Continuous/Frequent Intermittent Sources**
Extremely Fragile historic buildings, ruins, ancient monuments	0.12	0.08
Fragile buildings	0.2	0.1
Historic and some old buildings	0.5	0.25
Older residential structure	0.5	0.3
New residential structure	1.0	0.5
Modern industrial/commercial buildings	2.0	0.5
Note: Transient sources create a single isolated vibration event. Continuous/frequent intermittent sources include impact pile drivers, vibratory pile drivers, and vibratory compaction equipment.		

Table 2 Human Guideline Vibration Criteria

Structure and Condition	Maximum PPV (inch/s)	
	Transient Sources	**Continuous/Frequent Intermittent Sources**
Barely perceptible	0.04	0.01
Distinctly perceptible	0.25	0.04
Strongly perceptible	0.9	0.10
Severe	2.0	0.4
Note: Transient sources create a single isolated vibration event. Continuous/frequent intermittent sources include impact pile drivers, vibratory pile drivers, and vibratory compaction equipment.		

Source: Above vibration criteria are provided in *Caltrans Transportation and Construction Vibration Guidance Manual (April 2020).*

City of Torrance Noise Standards

The noise and vibration study requirements for this project, provided by the City, state that the construction noise level is significant if it exceeds 75 dBA Lmax at the property line of a residential property and cannot be mitigated to be below that level.

Section 46.3.1 of the Torrance Municipal Code states that it shall be unlawful for any person within the City of Torrance to operate power construction tools, equipment, or engage in the performance of any outside construction or repair work on buildings, structures, or projects in or adjacent to a residential area involving the creation of noise beyond 50 dBA Leq as measured at property lines, except between the hours of 7:30 A.M. to 6:00 P.M. Monday through Friday and 9:00 A.M. to 5:00 P.M. on Saturdays. Construction shall be prohibited on Sundays and Holidays observed by City Hall. An exception exists between the hours of 10:00 A.M. to 4:00 P.M. for homeowners that reside at the property.

Existing Noise and Vibration Environment

Ambient noise and vibration in the area is primarily produced by traffic on the nearby surface streets. A 24-hour ambient noise and vibration survey was performed at the site in order to determine the existing levels at the nearby properties. The locations of the measurements are provided in Figure 1. The measurements were obtained from 5:00 pm on March 4, 2020 for a period of 24-hours. Figure 4 provides the results of the ambient noise measurement and Figure 5 provides the results of the ambient vibration measurement. The noise measurement data is provided as 1-hour average sound levels and the vibration measurement data is provided as 1-minute average vibration levels over the duration of the measurement period. The range of 1-hour average noise levels and the highest vibration levels during the daytime and nighttime periods are summarized in Table 3.

Table 3 Summary of ambient noise and vibration measurement results

Time period	Range of 1-hour average (Leq) noise levels, dBA	Range of 1-hour maximum (Lmax) noise levels, dBA	Highest PPV vibration level, inch/s
Daytime (7 am to 10 pm)	53.5 to 58.3	66.6 to 82.5	0.023
Nighttime (10 pm to 7 am)	45.9 to 53.8	59.4 to 68.4	0.017

During our measurements, the ambient noise level exceeded the City's noise limit of 75 dBA Lmax during four one-hour periods between the permissible construction hours of 7 am to 6 pm. The highest measured ambient vibration levels were significantly lower than the 0.3 inch/s vibration guideline limit for older residential structures.

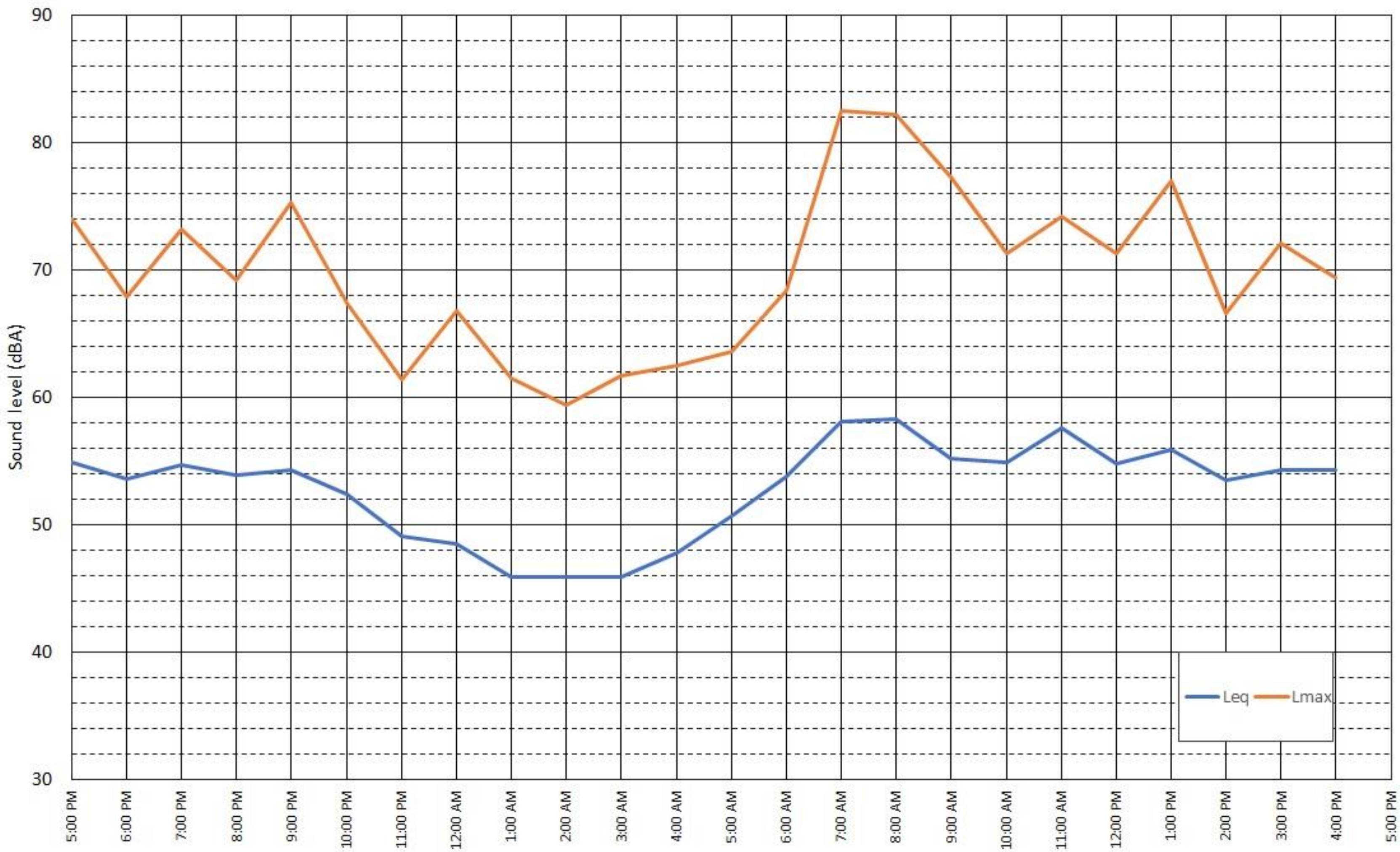


Figure 4 Measured ambient sound levels

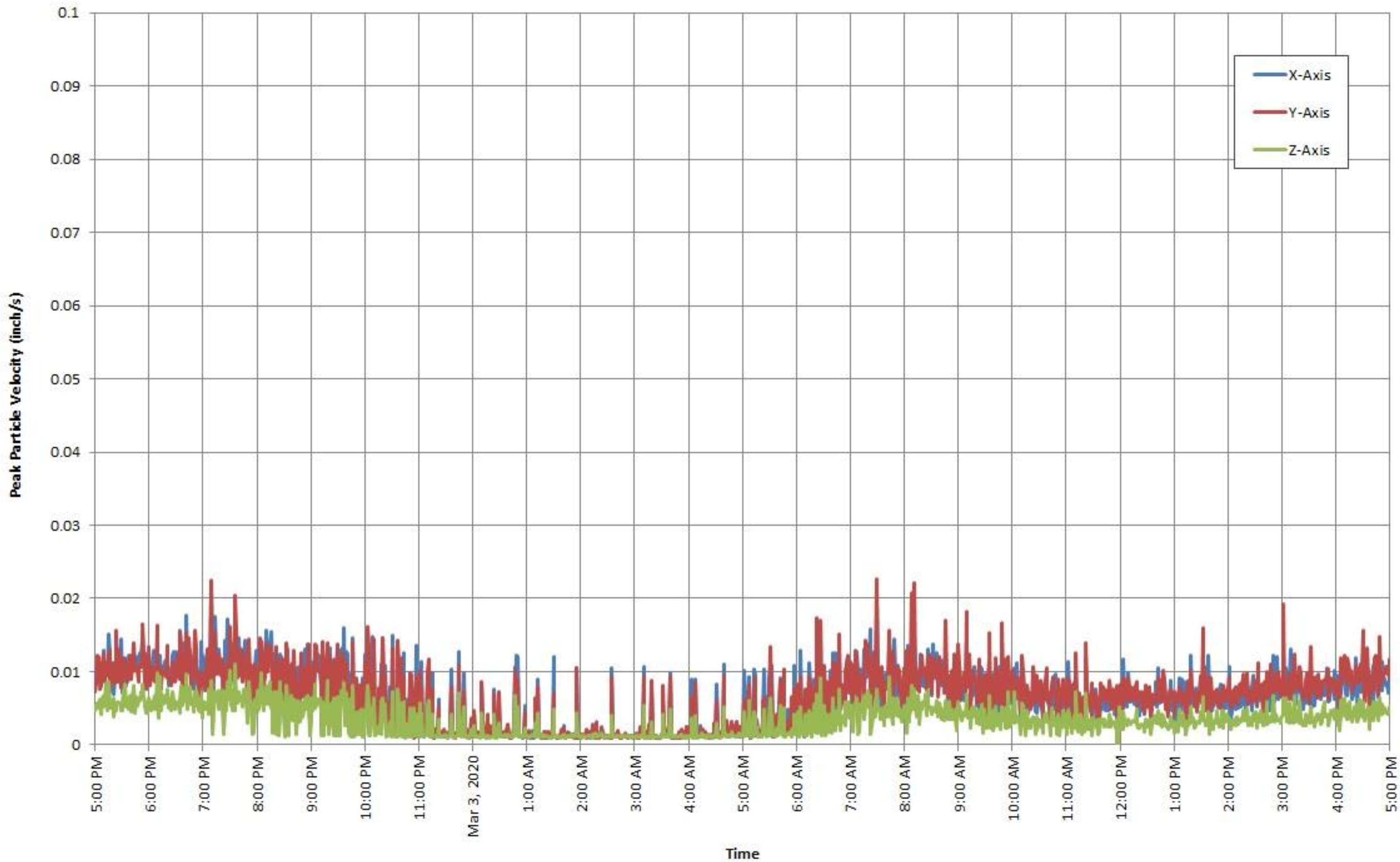


Figure 5 Measured ambient vibration levels

Construction Noise Analysis

A computer noise model of construction activities at the site was generated to estimate noise levels produced by the project during the two construction phases that will generate the highest noise levels. Noise levels during construction were predicted based on typical equipment used, estimated equipment sound levels and estimated usage factors (the percentage of time each piece of equipment is in use) in the construction of the project building. The assumed equipment that will be used for the excavation phase and the build/finish phase of construction, along with their sound levels and estimated usage factors is provided in Tables 4 and 5. It was assumed that the equipment may operate anywhere around the site and therefore the noise levels calculated as part of this analysis are the worst-case level with the equipment operating close to the property lines.

Table 4 Assumed construction equipment in use during excavation phase

Equipment	Quantity	Unmitigated Lmax sound pressure level at 50 feet (dBA)	Use factor (%)
Air compressor	1	78	10
Backhoe	1	78	4
Dozer	1	82	8
Loader	1	79	8
Pump	1	81	4
Rock drill	1	81	1
Shovel	1	82	2
Truck	1	76	40

Table 5 Assumed construction equipment in use during build phase

Equipment	Quantity	Unmitigated Lmax sound pressure level at 50 feet (dBA)	Use factor (%)
Concrete mixer	1	79	8
Crane	1	81	10
Pneumatic tools	1	85	10
Electric saw	2	78	10

Our analysis indicates that the unmitigated maximum noise levels at the nearest residential property line will be up to 91 dBA during the excavation phase and up to 94 dBA during the build phase. The maximum construction noise level is will therefore exceed the City's 75 dBA noise limit by 19 dBA. Noise mitigation will be required that reduces the construction activity noise level by at least 19 dBA at the nearest residential property line. The unmitigated maximum noise levels at the residences south of Via Valmonte and east of Hawthorne Boulevard would be below 75 dBA Lmax and therefore no mitigation is required to reduce noise levels at these properties. Figures 6 and 7 provide noise contour maps of the modelled construction phases.

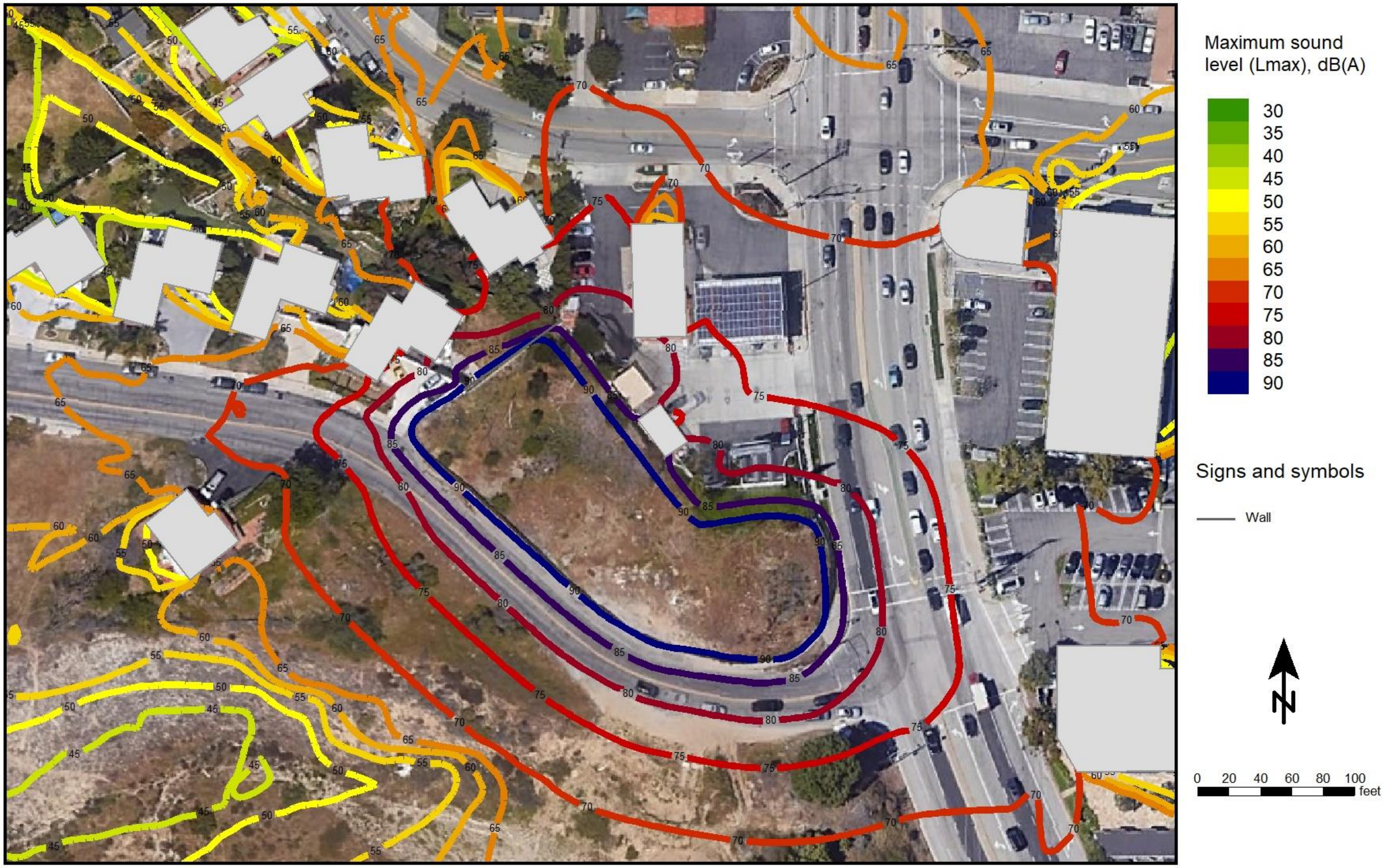
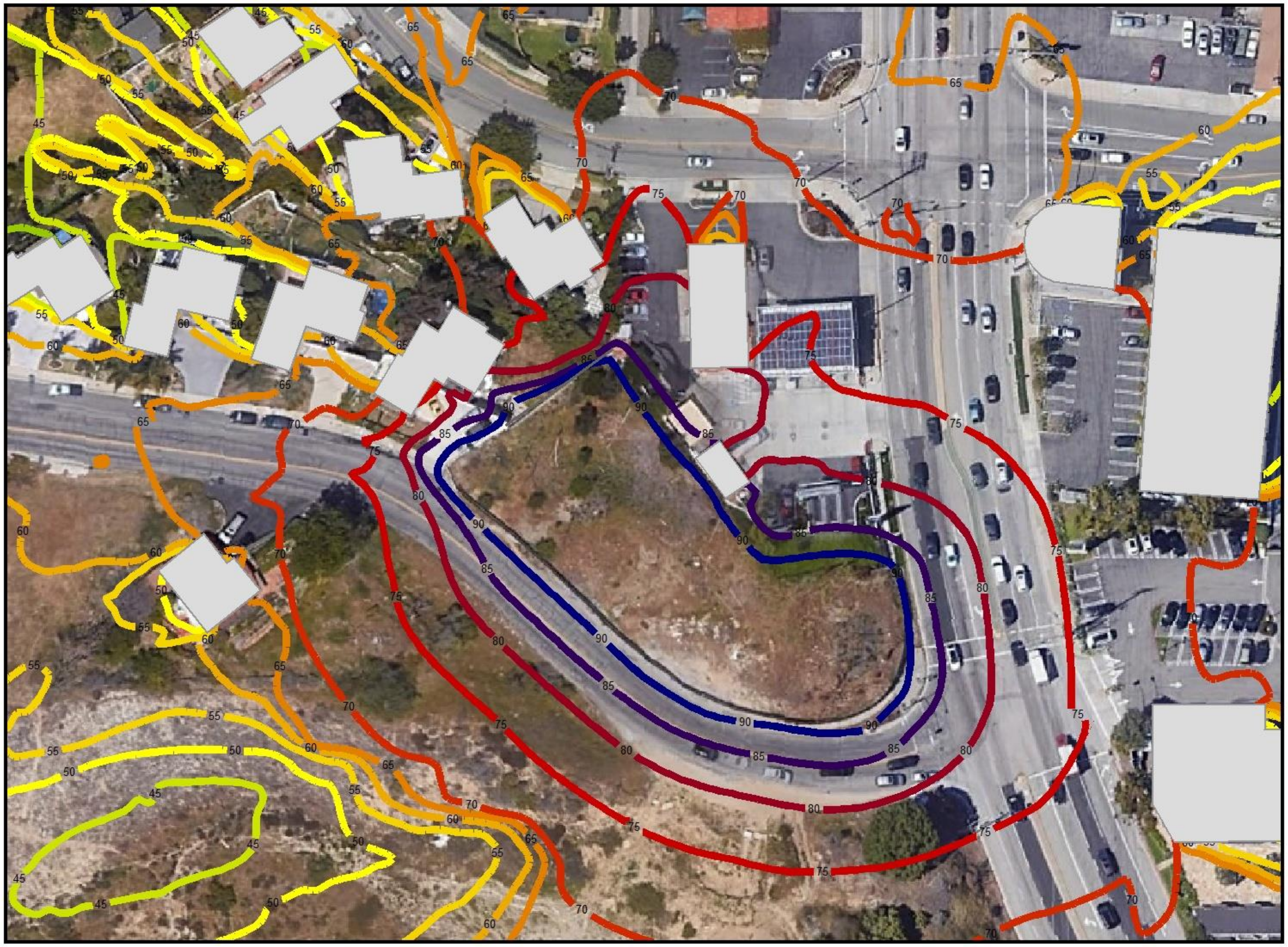


Figure 6 Unmitigated excavation phase noise contour map



Maximum sound level (Lmax), dB(A)

30
35
40
45
50
55
60
65
70
75
80
85
90

Signs and symbols

Wall

N

0 20 40 60 80 100 feet

Figure 7 Unmitigated build phase noise contour map

The noise modeling was performed using SoundPlan version 7.3, which takes into account the sound levels, frequency spectra and locations of the noise sources, and the effects on noise of the terrain, buildings and barriers.

Construction Vibration Analysis

Vibration due to construction activities was estimated based on typical construction equipment peak particle velocity vibration levels. Construction equipment vibration data at a distance of 25 feet from the equipment is provided by the Caltrans Transportation and Construction Vibration Guidance Manual (April 2020). The distance that vibration-producing construction equipment must maintain from adjacent structures to minimize the possibility of structural damage is provided in Table 6. The distances are based on a vibration velocity limit of 0.3 inch/s. This is a conservative vibration limit for older residential structures as provided by Caltrans.

Table 6 Typical construction equipment vibration levels and required distances to structures

Equipment	Peak particle velocity vibration level at 25 ft. (inch/s)	Required distance from equipment to structures to comply with 0.3 inch/s limit (ft.)
Backhoe	0.076	8
Dozer	0.089	9
Loader	0.076	8
Rock drill	0.035	4
Truck	0.076	8
Crane	0.076	8
Pneumatic tools	0.035	4

In addition to the equipment above, an analysis was performed to assess the impact of pile driving activities. Based on an assumed peak particle velocity of 0.65 inch/s at a distance of 25 ft, vibratory or impact pile driving poses a risk of structural damage if it occurs within approximately 50 ft of a structure. It is understood that no pile driving is planned at the site during construction of the project. However, this report provides recommendations to reduce vibration in the event that sheet pile installation is necessary.

Noise and Vibration Mitigation Plan

The following recommendations are provided to comply with the City of Torrance noise limits, and to minimize vibration impacts at nearby structures:

1. Construction activities, services or repair of equipment, and job-site deliveries shall not occur before 7:30 am or after 6 pm Monday through Friday, before 9 am or after 5 pm on Saturdays, or anytime on Sundays or holidays observed by City Hall.

2. Heavy construction equipment such as pile drivers, mechanical shovels, derricks, hoists, pneumatic hammers, compressors or similar devices shall not be operated at any time, within or adjacent to a residential area, without first obtaining from the Community Development Director permission to do so. Such request for permission shall include a list and type of equipment to be used, the requested hours and locations of its use, and the applicant shall be required to show that the selection of equipment and construction techniques has been based on minimization of noise within the limitations of such equipment as is commercially available or combinations of such equipment and auxiliary sound barriers.

3. A temporary noise barrier at least 12 feet in height shall be erected at the locations shown in Figure 8 and shall remain in place during construction activities. The barrier shall have a Sound Transmission Class (STC) rating of at least 26 and a Noise Reduction Coefficient (NRC) of at least 0.70. There should be no gaps in the barrier. Suitable products include Echo Noise Control STC-26 temporary noise barriers or Pacific Sound Control 'Noise Soaker' barriers.

4. Heavy equipment including backhoes, loaders, dozers, rock drills, cranes and jackhammers should not be used within 10 feet of an existing structure. If equipment of this type is planned for use within this distance of a structure, alternative construction methods that minimize vibration should be employed wherever feasible.

5. During pile driving operations performed within 100 feet of an existing structure (including sheet pile installation and removal), vibration monitoring shall be performed. The monitoring equipment shall utilize a tri-axial geophone measuring peak particle velocity, which shall be located at the nearest structure to the pile driving operation. The vibration level due to pile installation or removal shall not exceed 0.3 inch/s in any axis at any existing structure. The vibration monitor shall be capable of providing an immediate warning to onsite personnel in the event of a vibration limit exceedance. If the vibration level exceeds this limit, the activity shall stop and mitigation measures shall be applied to bring the operation into compliance. Vibration mitigation measures may include reducing the vibration amplitude of the pile driver.

Figure 8 Required temporary noise barrier locations

Conclusion

This report provides an analysis of the noise and vibration levels associated with the construction of the proposed mixed-use project at 24601 Hawthorne Boulevard in Torrance. With the implementation of the noise and vibration mitigation measures contained in this report, the project will comply with the City's noise level requirement of 75 dBA Lmax. With the implementation of the vibration mitigation measures in this report, the potential for damage to nearby structures due to construction activities will be minimized.

References

1. Mixed-Use Development Site Plan, Ashai Design. June 19, 2019.

2. Caltrans Transportation and Construction Vibration Guidance Manual (April 2020)