Appendix E: Noise and Vibration Assessment

FIRE STATION 25 & BOREL PARK PROJECT NOISE AND VIBRATION ASSESSMENT

San Mateo, California

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Prepared for:

Julie Wright
David J. Powers & Associates, Inc.
1871 The Alameda, Suite 200,
San José, CA 95126

Prepared by:

Manasi Biwalkar

ILLINGWORTH & RODKIN, INC.
Acoustics • Air Quality
1 Willowbrook Court, Suite 120
Petaluma, CA 94954
(707) 794-0400

I&R Project: 18-074

INTRODUCTION

The City of San Mateo plans to construct a fire station and a neighborhood park on the east side of Shafter Street, between Barneson Avenue and Borel Avenue, in central San Mateo. The proposed fire station would replace the existing Fire Station 25, located at 545 Barneson Avenue, approximately 0.2 miles northwest of the proposed fire station. The new fire station would be 4,950 square feet (sf) and located on a 17,864 sf parcel at the south end of the site. The new neighborhood park would be constructed on a 50,000 sf parcel of the remaining portion of the site. The new park would include two playgrounds, lawn areas, sitting areas, and pathways. No off-street parking, restrooms or BBQ area would be provided.

This report summarizes the assessment of noise and vibration levels at nearby sensitive residential land uses during temporary construction activities or as a result of the on-going operation of the fire station. Best management practices are recommended to reduce the effects of the proposed fire station project on nearby sensitive residential land uses.

SETTING

Fundamentals of Environmental Noise

Noise may be defined as unwanted sound. Noise is usually objectionable because it is disturbing or annoying. The objectionable nature of sound could be caused by its *pitch* or its *loudness*. *Pitch* is the height or depth of a tone or sound, depending on the relative rapidity (*frequency*) of the vibrations by which it is produced. Higher pitched signals sound louder to humans than sounds with a lower pitch. *Loudness* is intensity of sound waves combined with the reception characteristics of the ear. Intensity may be compared with the height of an ocean wave in that it is a measure of the amplitude of the sound wave.

In addition to the concepts of pitch and loudness, there are several noise measurement scales which are used to describe noise in a particular location. A *decibel (dB)* is a unit of measurement which indicates the relative amplitude of a sound. The zero on the decibel scale is based on the lowest sound level that the healthy, unimpaired human ear can detect. Sound levels in decibels are calculated on a logarithmic basis. An increase of 10 decibels represents a ten-fold increase in acoustic energy, while 20 decibels is 100 times more intense, 30 decibels is 1,000 times more intense, etc. There is a relationship between the subjective noisiness or loudness of a sound and its intensity. Each 10 decibel increase in sound level is perceived as approximately a doubling of loudness over a fairly wide range of intensities. Technical terms are defined in Table 1.

There are several methods of characterizing sound. The most common in California is the *A-weighted sound level (dBA).* This scale gives greater weight to the frequencies of sound to which the human ear is most sensitive. Representative outdoor and indoor noise levels in units of dBA are shown in Table 2. Because sound levels can vary markedly over a short period of time, a method for describing either the average character of the sound or the statistical behavior of the variations must be utilized. Most commonly, environmental sounds are described in terms of an average level that has the same acoustical energy as the summation of all the time-varying events.

This *energy-equivalent sound/noise descriptor* is called L_{eq}. The most common averaging period is hourly, but L_{eq} can describe any series of noise events of arbitrary duration.

The scientific instrument used to measure noise is the *sound level meter*. Sound level meters can accurately measure environmental noise levels to within about plus or minus 1 dBA. Various computer models are used to predict environmental noise levels from sources, such as roadways and airports. The accuracy of the predicted models depends upon the distance the receptor is from the noise source. Close to the noise source, the models are accurate to within about plus or minus 1 to 2 dBA.

Since the sensitivity to noise increases during the evening and at night -- because excessive noise interferes with the ability to sleep -- 24-hour descriptors have been developed that incorporate artificial noise penalties added to quiet-time noise events. The *Community Noise Equivalent Level* (*CNEL*) is a measure of the cumulative noise exposure in a community, with a 5 dB penalty added to evening (7:00 p.m. - 10:00 p.m.) and a 10 dB addition to nocturnal (10:00 p.m. - 7:00 a.m.) noise levels. The *Day/Night Average Sound Level* (L_{dn}) is essentially the same as CNEL, with the exception that the evening time period is dropped and all occurrences during this three-hour period are grouped into the daytime period.

Effects of Noise

Sleep and Speech Interference

The thresholds for speech interference indoors are about 45 dBA if the noise is steady and above 55 dBA if the noise is fluctuating. Outdoors the thresholds are about 15 dBA higher. Steady noises of sufficient intensity (above 35 dBA) and fluctuating noise levels above about 45 dBA have been shown to affect sleep. Interior residential standards for multi-family dwellings are set by the State of California at 45 dBA L_{dn}. Typically, the highest steady traffic noise level during the daytime is about equal to the L_{dn} and nighttime levels are 10 dBA lower. The standard is designed for sleep and speech protection and most jurisdictions apply the same criterion for all residential uses. Typical structural attenuation is 12-17 dBA with open windows. With closed windows in good condition, the noise attenuation factor is around 20 dBA for an older structure and 25 dBA for a newer dwelling. Sleep and speech interference is therefore possible when exterior noise levels are about 57-62 dBA L_{dn} with open windows and 65-70 dBA L_{dn} if the windows are closed. Levels of 55-60 dBA are common along collector streets and secondary arterials, while 65-70 dBA is a typical value for a primary/major arterial. Levels of 75-80 dBA are normal noise levels at the first row of development outside a freeway right-of-way. In order to achieve an acceptable interior noise environment, bedrooms facing secondary roadways need to be able to have their windows closed, those facing major roadways and freeways typically need special glass windows.

Annoyance

Attitude surveys are used for measuring the annoyance felt in a community for noises intruding into homes or affecting outdoor activity areas. In these surveys, it was determined that the causes for annoyance include interference with speech, radio and television, house vibrations, and interference with sleep and rest. The L_{dn} as a measure of noise has been found to provide a valid correlation of noise level and the percentage of people annoyed. People have been asked to judge the annoyance caused by aircraft noise and ground transportation noise. There continues to be disagreement about the relative annoyance of these different sources. When measuring the percentage of the population highly annoyed, the threshold for ground vehicle noise is about 50 dBA L_{dn}. At a L_{dn} of about 60 dBA, approximately 12 percent of the population is highly annoyed. When the L_{dn} increases to 70 dBA, the percentage of the population highly annoyed increases to about 25-30 percent of the population. There is, therefore, an increase of about 2 percent per dBA between a L_{dn} of 60-70 dBA. Between a L_{dn} of 70-80 dBA, each decibel increase increases by about 3 percent the percentage of the population highly annoyed. People appear to respond more adversely to aircraft noise. When the L_{dn} is 60 dBA, approximately 30-35 percent of the population is believed to be highly annoyed. Each decibel increase to 70 dBA adds about 3 percentage points to the number of people highly annoyed. Above 70 dBA, each decibel increase results in about a 4 percent increase in the percentage of the population highly annoyed.

Fundamentals of Ground-borne Vibration

Ground vibration consists of rapidly fluctuating motions or waves with an average motion of zero. Several different methods are typically used to quantify vibration amplitude. One method is the Peak Particle Velocity (PPV). The PPV is defined as the maximum instantaneous positive or negative peak of the vibration wave. In this report, a PPV descriptor with units of mm/sec or in/sec is used to evaluate construction generated vibration for building damage and human complaints. Table 3 displays the reactions of people and the effects on buildings that continuous vibration levels produce. The annoyance levels shown in Table 3 should be interpreted with care since vibration may be found to be annoying at much lower levels than those shown, depending on the level of activity or the sensitivity of the individual. To sensitive individuals, vibrations approaching the threshold of perception can be annoying. Low-level vibrations frequently cause irritating secondary vibration, such as a slight rattling of windows, doors, or stacked dishes. The rattling sound can give rise to exaggerated vibration complaints, even though there is very little risk of actual structural damage.

Construction activities can cause vibration that varies in intensity depending on several factors. The use of pile driving and vibratory compaction equipment typically generates the highest construction related ground-borne vibration levels. Because of the impulsive nature of such activities, the use of the PPV descriptor has been routinely used to measure and assess ground-borne vibration and almost exclusively to assess the potential of vibration to induce structural damage and the degree of annoyance for humans. The two primary concerns with construction-induced vibration, the potential to damage a structure and the potential to interfere with the enjoyment of life, are evaluated against different vibration limits. Studies have shown that the threshold of perception for average persons is in the range of 0.008 to 0.012 in/sec PPV. Human perception to vibration varies with the individual and is a function of physical setting and the type of vibration. Persons exposed to elevated ambient vibration levels, such as people in an urban environment, may tolerate a higher vibration level.

Structural damage can be classified as cosmetic only, such as minor cracking of building elements, or may threaten the integrity of the building. Safe vibration limits that can be applied to assess the potential for damaging a structure vary by researcher and there is no general consensus as to what amount of vibration may pose a threat for structural damage to the building. Construction-induced vibration that can be detrimental to the building is very rare and has only been observed in instances where the structure is at a high state of disrepair and the construction activity occurs immediately adjacent to the structure.

TABLE 1 Definition of Acoustical Terms Used in this Report

Term	Definition
Decibel, dB	A unit describing, the amplitude of sound, equal to 20 times the logarithm to the base 10 of the ratio of the pressure of the sound measured to the reference pressure. The reference pressure for air is 20 micro Pascals.
Sound Pressure Level	Sound pressure is the sound force per unit area, usually expressed in micro Pascals (or 20 micro Newtons per square meter), where 1 Pascal is the pressure resulting from a force of 1 Newton exerted over an area of 1 square meter. The sound pressure level is expressed in decibels as 20 times the logarithm to the base 10 of the ratio between the pressures exerted by the sound to a reference sound pressure (e. g., 20 micro Pascals). Sound pressure level is the quantity that is directly measured by a sound level meter.
Frequency, Hz	The number of complete pressure fluctuations per second above and below atmospheric pressure. Normal human hearing is between 20 Hz and 20,000 Hz. Infrasonic sound are below 20 Hz and Ultrasonic sounds are above 20,000 Hz.
A-Weighted Sound Level, dBA	The sound pressure level in decibels as measured on a sound level meter using the A-weighting filter network. The A-weighting filter de-emphasizes the very low and very high frequency components of the sound in a manner similar to the frequency response of the human ear and correlates well with subjective reactions to noise.
Equivalent Noise Level, L_{eq}	The average A-weighted noise level during the measurement period.
L_{max}, L_{min}	The maximum and minimum A-weighted noise level during the measurement period.
L_{01}, L_{10}, L_{50}, L_{90}	The A-weighted noise levels that are exceeded 1%, 10%, 50%, and 90% of the time during the measurement period.
Day/Night Noise Level, L_{dn} or DNL	The average A-weighted noise level during a 24-hour day, obtained after addition of 10 decibels to levels measured in the night between 10:00 p.m. and 7:00 a.m.
Community Noise Equivalent Level, CNEL	The average A-weighted noise level during a 24-hour day, obtained after addition of 5 decibels in the evening from 7:00 p.m.to 10:00 p.m. and after addition of 10 decibels to sound levels measured in the night between 10:00 p.m. and 7:00 a.m.
Ambient Noise Level	The composite of noise from all sources near and far. The normal or existing level of environmental noise at a given location.
Intrusive	That noise which intrudes over and above the existing ambient noise at a given location. The relative intrusiveness of a sound depends upon its amplitude, duration, frequency, and time of occurrence and tonal or informational content as well as the prevailing ambient noise level.

Source: Handbook of Acoustical Measurements and Noise Control, Harris, 1998.

TABLE 2 Typical Noise Levels in the Environment

Common Outdoor Activities	Noise Level (dBA)	Common Indoor Activities
	110 dBA	Rock band
Jet fly-over at 1,000 feet		
	100 dBA	
Gas lawn mower at 3 feet		
	90 dBA	
Diesel truck at 50 feet at 50 mph		Food blender at 3 feet
	80 dBA	Garbage disposal at 3 feet
Noisy urban area, daytime		
Gas lawn mower, 100 feet	70 dBA	Vacuum cleaner at 10 feet
Commercial area		Normal speech at 3 feet
Heavy traffic at 300 feet	60 dBA	
		Large business office
Quiet urban daytime	50 dBA	Dishwasher in next room
Quiet urban nighttime	40 dBA	Theater, large conference room
Quiet suburban nighttime		
	30 dBA	Library
Quiet rural nighttime		Bedroom at night, concert hall (background)
	20 dBA	
		Broadcast/recording studio
	10 dBA	
	0 dBA	

Source: Technical Noise Supplement (TeNS), California Department of Transportation, September 2013.

TABLE 3 Reactions of People and Damage to Buildings from Continuous or Frequent Intermittent Vibration Levels

Velocity Level, PPV (in/sec)	Human Reaction	Effect on Buildings
0.01	Barely perceptible	No effect
0.04	Distinctly perceptible	Vibration unlikely to cause damage of any type to any structure
0.08	Distinctly perceptible to strongly perceptible	Recommended upper level of the vibration to which ruins and ancient monuments should be subjected
0.1	Strongly perceptible	Virtually no risk of damage to normal buildings
0.3	Strongly perceptible to severe	Threshold at which there is a risk of damage to older residential dwellings such as plastered walls or ceilings
0.5	Severe - Vibrations considered unpleasant	Threshold at which there is a risk of damage to newer residential structures

Source: Transportation and Construction Vibration Guidance Manual, California Department of Transportation, September 2013.

Regulatory Background

The project site is located in the San Mateo, California. The project would be subject to noise-related regulations, plans and policies established by the State of California and the City of San Mateo.

Applicable planning documents include Appendix G of the CEQA Guidelines, San Mateo General Plan, and San Mateo Municipal Code. Regulations, plans, and policies presented within these documents form the basis of the significance criteria used to assess project impacts.

State CEQA Guidelines. CEQA contains guidelines to evaluate the significance of effects of environmental noise attributable to a proposed project. CEQA asks the following applicable questions. Would the project result in:

a) Exposure of persons to or generation of noise levels in excess of standards established in the local General Plan or Noise Ordinance, or applicable standards of other agencies?

b) Exposure of persons to or generation of excessive groundborne vibration or groundborne noise levels?

c) A substantial permanent increase in ambient noise levels in the project vicinity above levels existing without the project?

d) A substantial temporary or periodic increase in ambient noise levels in the project vicinity above levels existing without the project?

e) For a project located within an airport land use plan or, where such a plan has not been adopted within two miles of a public airport or public use airport, exposure of people residing or working in the project area to excessive noise levels?

f) For a project within the vicinity of a private airstrip, exposure of people residing or working in the project area to excessive noise levels?

Of these guidelines, items (a), (b), (c), and (d) are applicable to the proposed project. The project is not located in the vicinity of a public or private airstrip; therefore, checklist items (e) and (f) are not carried forward in this analysis.

2016 California Green Building Standards Code (Cal Green Code). The State of California established exterior sound transmission control standards for new non-residential buildings as set forth in the 2016 California Green Building Standards Code (Section 5.507.4.1 and 5.507.4.2). Section 5.507 states that either the prescriptive (Section 5.507.4.1) or the performance method (Section 5.507.4.2) shall be used to determine environmental control at indoor areas. The prescriptive method is very conservative and not practical in most cases; however, the performance method can be quantitatively verified using exterior-to-interior calculations. For the purposes of this report, the performance method is utilized to determine consistency with the Cal Green Code. Both of the sections that pertain to this project are as follows:

> **5.507.4.1 Exterior noise transmission, prescriptive method.** Wall and roof-ceiling assemblies making up the building envelope that are exposed to the noise source shall meet a composite STC rating of at least 50 or a composite OITC rating of no less than 40, with exterior windows of a minimum STC of 40 or OITC of 30 when the building falls within the 65 dBA L_{dn} noise contour of a freeway or expressway, railroad, industrial source or fixed-guideway noise source, as determined by the local general plan noise element.
>
> **5.507.4.2 Performance method.** For buildings located within the 65 dBA L_{dn} noise contour of a freeway or expressway, railroad, industrial source or fixed-guideway noise source, wall and roof-ceiling assemblies making up the building envelope and exposed to the noise source shall be constructed to provide an interior noise environment attributable to exterior sources that does not exceed an hourly equivalent noise level ($L_{eq\ (1\text{-}hr)}$) of 50 dBA in occupied areas during any hour of operation.

The performance method, which establishes the acceptable interior noise level, is the method typically used when applying these standards.

City of San Mateo General Plan: The Noise Element of City of San Mateo's General Plan sets forth goals and policies regarding the control of environmental noise and protection of citizens from excessive noise exposure. The goals and policies relevant to this project are mentioned below:

Goal 1: Protect "noise sensitive" land uses from excessive noise levels.

<u>Policy N1.2: Exterior Noise Level Standard.</u> Require an acoustical analysis for new parks, play areas and multi-family common open space (intended for the use of the enjoyment of residents) that have an exterior noise level of 60 dB (L_{dn}) or above. Require an acoustical analysis that uses

peak hour L_{eq} for new parks and play areas. Require a feasibility analysis of noise reduction measures for public parks and play areas. Incorporate necessary mitigation measures into residential project design to minimize common open space noise levels. Maximum exterior noise should not exceed 67 dB (L_{dn}) for residential uses and should not exceed 65 dB (L_{eq}) during the noisiest hour for public park uses.

TABLE N-1
NOISE SENSITIVE LAND-USE COMPATIBILITY GUIDELINES FOR COMMUNITY NOISE ENVIRONMENTS[1]
Day-Night Average Sound Level (L_{dn}), Decibels

Land-Use Category	Normally Acceptable[2]	Conditionally Acceptable[3]	Normally Unacceptable[4]
Single-Family Residential	50 to 59	60 to 70	Greater than 70
Multi-Family Residential	50 to 59	60 to 70	Greater than 70
Hotels, Motels, and Other Lodging Houses	50 to 59	60 to 70	Greater than 70
Long-Term Care Facilities	50 to 59	60 to 70	Greater than 70
Hospitals	50 to 59	60 to 70	Greater than 70
Schools	50 to 59	60 to 70	Greater than 70
Multi-Family Common Open Space Intended for the Use and Enjoyment of Residents	50 to 67	--	Greater than 67

TABLE N-2
NOISE GUIDELINES FOR OUTDOOR ACTIVITIES
Average Sound Level (L_{eq}), Decibels

Land Use Category	Normally Acceptable[2]	Conditionally Acceptable[3]	Normally Unacceptable[4]
Parks, Playgrounds	50 to 65*	--	Greater than 65*

[1] These guidelines are derived from the California Department of Health Services, Guidelines for the Preparation and Content of the Noise Element of the General Plan, 2003. The State Guidelines have been modified to reflect San Mateo's preference for distinct noise compatibility categories and to better reflect local land-use and noise conditions. It is intended that these guidelines be utilized to evaluate the suitability of land-use changes only and not to determine cumulative noise impacts. Land uses other than those classified as being “noise sensitive” are exempt from these compatibility guidelines.

[2] Normally Acceptable – Specified land use is satisfactory, based upon the assumption that any buildings involved are of normal conventional construction, without any special noise insulation requirements.

[3] Conditionally Acceptable – New construction should be undertaken only after a detailed analysis of the noise reduction requirement is conducted and needed noise insulation features included in the design.

[4] Normally Unacceptable – New construction should be discouraged. If new construction or development does proceed, a detailed analysis of the noise reduction requirements must be made and needed noise insulation features included in the design.

* Average Sound Level (Leq) for peak hour.

Goal 2: Minimize unnecessary, annoying and unhealthful noise.

Policy N2.1: Noise Ordinance. Continue implementation and enforcement of City's existing noise control ordinance: (a) which prohibits noise that is annoying or injurious to neighbors of normal sensitivity, making such activity a public nuisance, and (b) restricts the hours of construction to minimize noise impact.

Policy N2.2: Minimize Noise Impact. Protect all "noise-sensitive" land uses listed in Tables N-1 and N-2 from adverse impacts caused by noise generated on-site by new developments. Incorporate necessary mitigation measures into development design to minimize noise impacts. Prohibit long-term exposure increases of 3 dB (L_{dn}) or greater at the common property line, excluding existing ambient noise levels.

"Noise-sensitive" land uses, such as residential neighborhoods, hotels, hospitals, schools, and outdoor recreation areas must be protected from new development that causes discernable increases in noise levels as a result of on-site activities. Noise generators such as machinery or parking lots must be mitigated through physical measures or operational limits.

Existing Noise Environment

The project site is located east of Shafter Street between Barneson Avenue and Borel Avenue in the City of San Mateo, California. Figure 1 shows an aerial image of the project site and surroundings. Borel Middle School is to the east of the project site. Two-story residences surround the project site on the west and north. A commercial use building is located to the southeast of the site. The project site is to the north of Highway 92. Two long-term measurements and three 10-minute short-term measurements were made from Tuesday, May 1st to Friday May 4th, 2018. The results from short-term measurements are summarized in Table 4.

Long-term noise measurement LT-1 was made across the street from 1448 Shafter Street approximately 21 feet from centerline of Shafter Street. The primary noise source at this location was the traffic noise from vehicles traveling on Shafter Street. Hourly average noise levels at this location ranged from 52 to 63 dBA L_{eq} during the day, and from 44 to 57 dBA L_{eq} at night. The day-night average noise level on both Wednesday, May 2nd, 2018 and Thursday May 3rd, 2018 was 61 dBA L_{dn}. The daily trend in noise levels at LT-1 is shown in Figures 2 and 3.

Long-term noise measurement LT-2 was made on the eastern property line of the site, along the school fence line. Hourly average noise levels at this ranged from 50 dBA at 62 dBA L_{eq} during the day, and from 42 dBA to 55 dBA L_{eq} at night. The day-night average noise level on Wednesday, May 2nd, 2018 and Thursday May 3rd, 2018 was 59 dBA L_{dn}. The daily trend in noise level at LT-2 is shown in Figures 4 and 5.

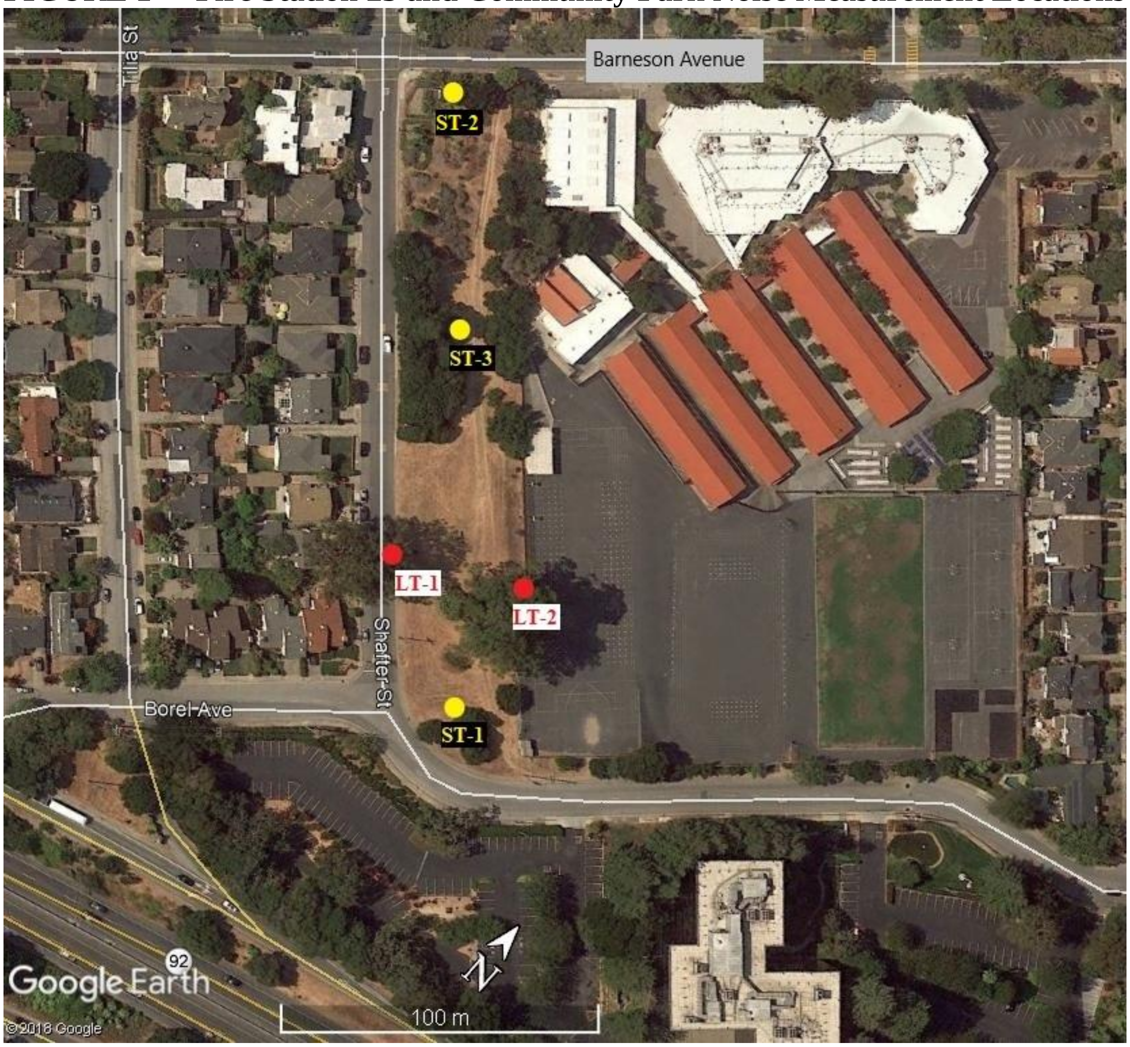
TABLE 4 Summary of Short-Term Noise Measurement Data (dBA)

Noise Measurement Location	L_{max}	$L_{(1)}$	$L_{(10)}$	$L_{(50)}$	$L_{(90)}$	L_{eq}	L_{dn}
ST-1: South end of the site, 105 feet east of Shafter Street. (5/1/2018, 12:00 p.m. - 12:10 p.m.)	63	52	60	58	54	57	

ST-2: Corner of Shafter Street and Barneson Avenue (5/4/2018, 11:40 a.m. - 11:50 a.m.)	67	62	56	51	45	53	
ST-3: Midpoint of the park. (5/4/2018, 12: 00 p.m. - 12:10 p.m.)	65	62	56	53	51	54	

Note: The L_{dn} is determined by correlating the short-term measurement with the representative long-term measurement.

FIGURE 1 Fire Station 25 and Community Park Noise Measurement Locations



Source: Google Earth, May 2017.

FIGURE 2   Daily Trend in Noise Levels at LT-1

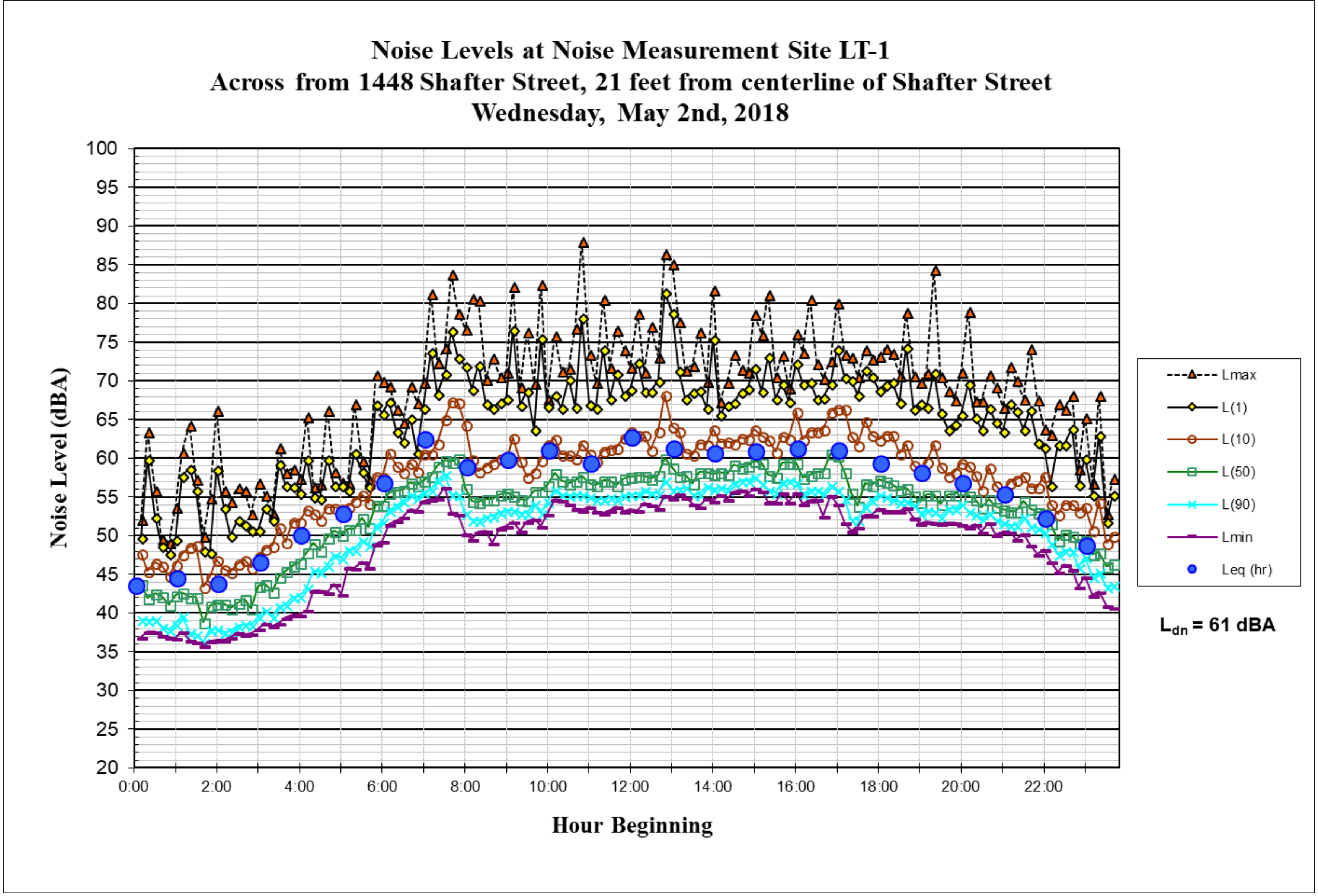


FIGURE 3 Daily Trend in Noise Levels at LT-1

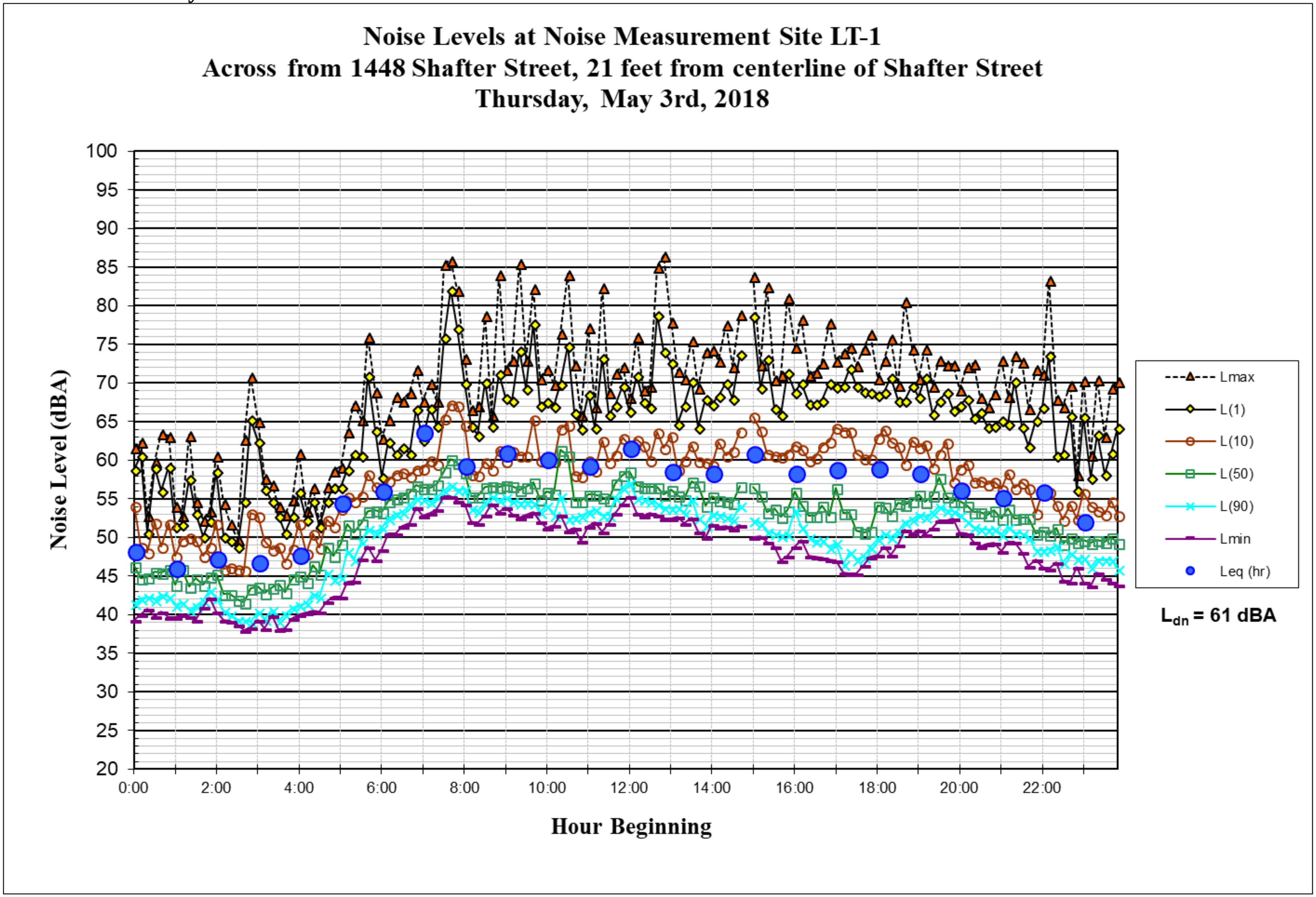


FIGURE 4 Daily Trend in Noise Levels at LT-2

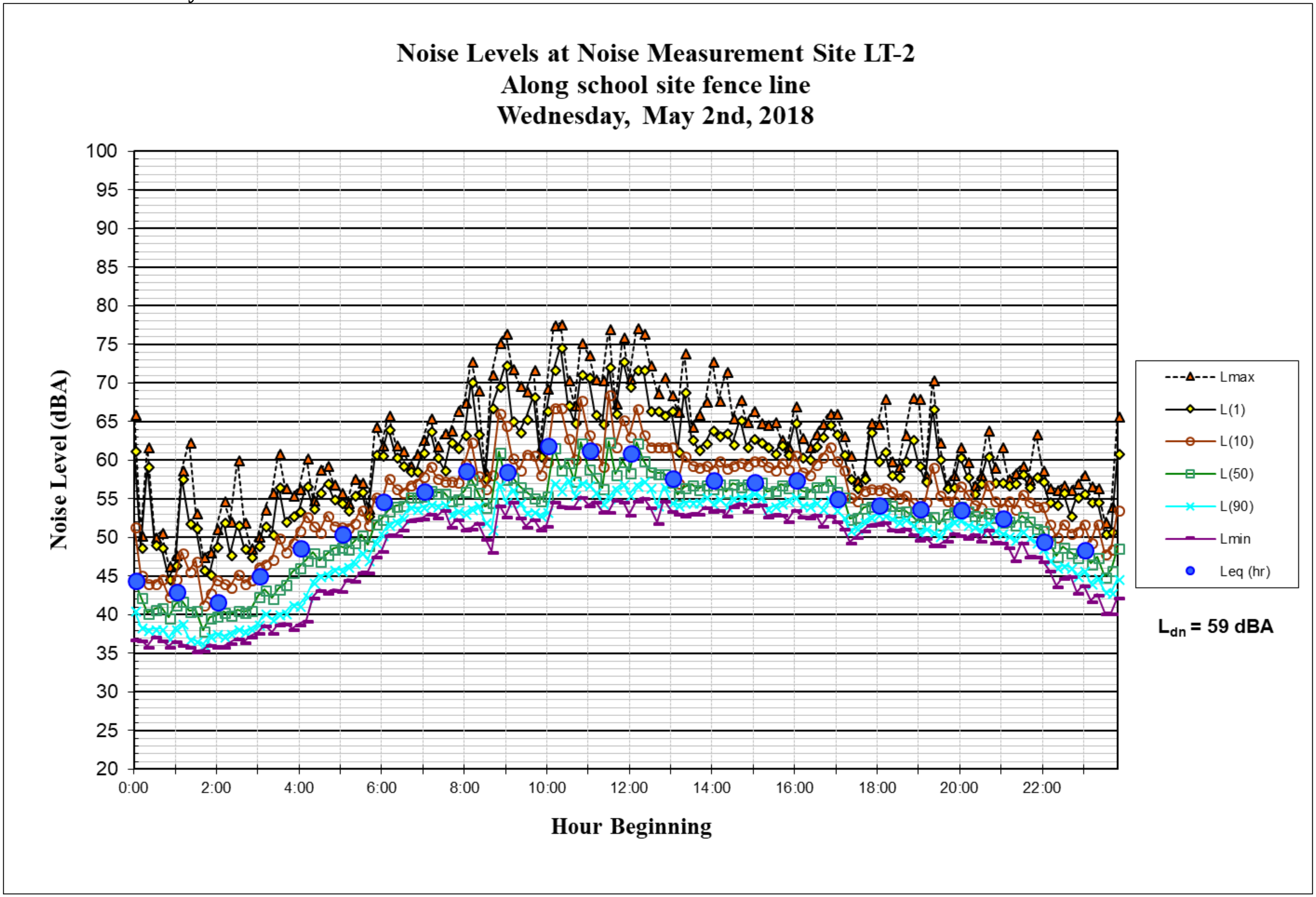
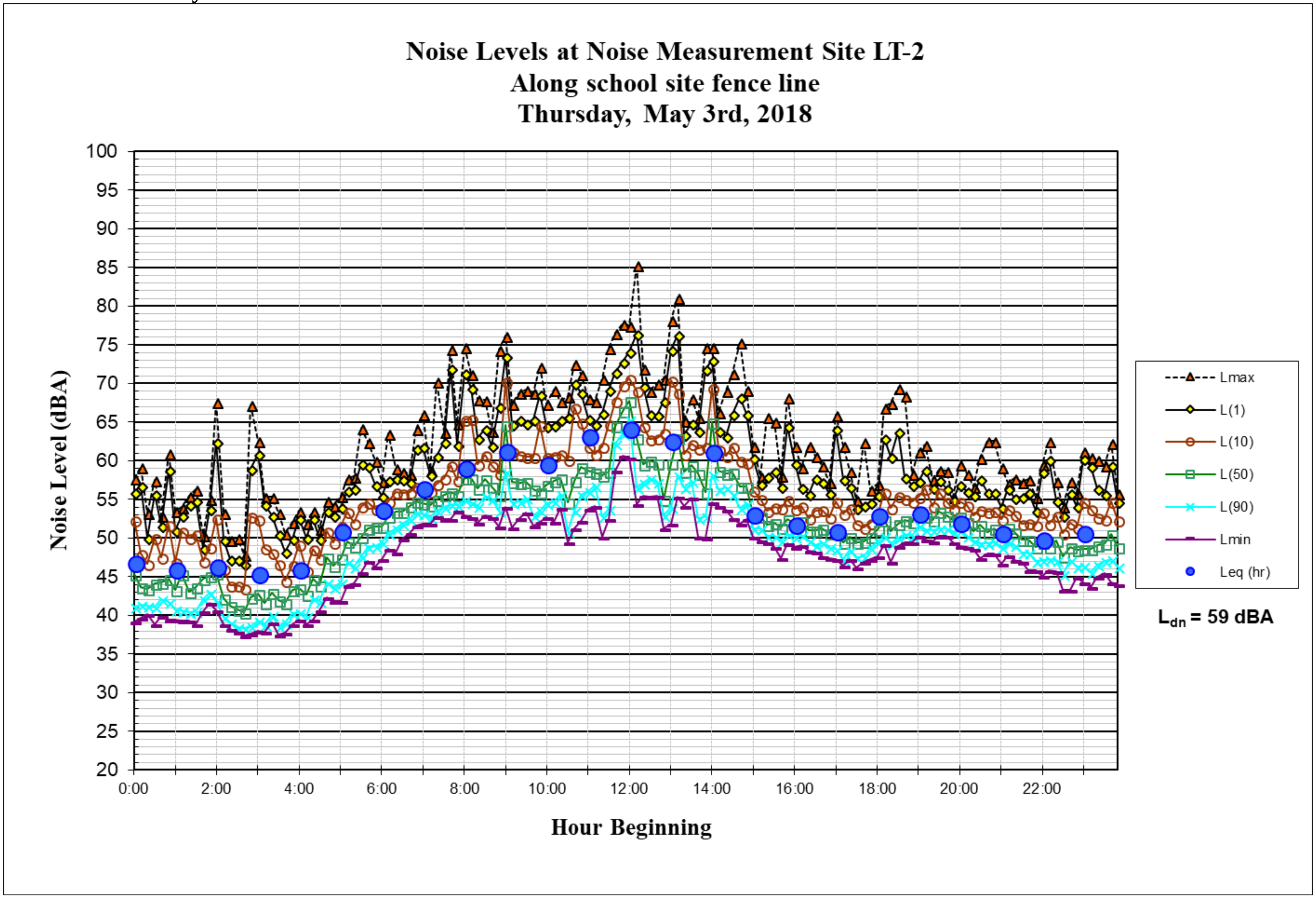


FIGURE 5 Daily Trend in Noise Levels at LT-2



NOISE CONSISTENCY ANALYSIS – NOISE AND LAND USE COMPATIBILITY

Noise and Land Use Compatibility Thresholds

A significant noise impact would be identified if the project would expose persons to or generate noise levels that would exceed applicable noise standards presented in the General Plan or Municipal Code.

- For non-residential land uses, the Cal Green Code requires interior noise levels to be maintained at 50 dBA $L_{eq(1\text{-}hr)}$ or less during hours of operation in noise sensitive spaces such as offices.

- The San Mateo General Plan requires that exterior noise should not exceed 65 dBA (L_{eq}) during the noisiest hour for public park uses.

Future Noise Environment

The future exterior environment at the project site would primarily result from local traffic on Shafter Street and Borel Avenue. Based on noise measurements conducted at the site, the hourly average daytime noise levels at the site would range from 42 to 64 dBA L_{eq}, depending on the time of day and proximity to Shaffer Street and Highway 92. Exterior noise levels throughout the site would be considered compatible with City's noisiest hour criteria for public parks of 65 dBA L_{eq}.

Some interior areas on level one and level two of the Fire Station would be designed as office spaces and dorms. The Cal Green Building Code requires interior noise levels to be maintained at 50 dBA $L_{eq(1\text{-}hr)}$ or less during hours of operation in rooms sensitive to noise. A review of hourly average exterior noise levels measured at the site indicates that exterior levels typically range from 56 to 64 dBA dBA $L_{eq(1\text{-}hr)}$. Standard construction with windows open provides approximately 15 dBA of noise reduction in interior spaces. As a result, interior hourly average noise levels from exterior environmental noise sources would typically be 41 to 49 dBA $L_{eq(1\text{-}hr)}$. Noise levels are compatible with the proposed use and would not result in a significant impact.

NOISE IMPACTS AND MITIGATION MEASURES

Significance Criteria

The following criteria was used to evaluate the significance of environmental noise resulting from the project:

- **Groundborne Vibration from Construction:** A significant impact would be identified if the construction of the project would expose persons to excessive vibration levels. Groundborne vibration levels exceeding 0.3 in/sec PPV would have the potential to result in cosmetic damage to normal buildings (see Table 3).

- **Permanent Noise Increases:** A significant impact would be identified if traffic generated by the project or project improvements/operations would substantially increase noise levels at sensitive receivers in the vicinity. The City of San Mateo defines a substantial increase to occur if the noise level increase is 3 dBA L_{dn} or greater where the future noise level exceeds the compatibility threshold.

- **<u>Mechanical & Operational Noise:</u>** A significant impact would be identified if equipment used or operational routines conducted by the project exceed San Mateo City's allowable noise limit thresholds at sensitive receptors.

- **<u>Construction Noise:</u>** A significant noise impact would be identified if construction-related noise would temporarily increase ambient noise levels at sensitive receptors. At commercial uses, hourly average noise levels exceeding 70 dBA $L_{eq,}$ and the ambient by at least 5 dBA L_{eq}, for a period of more than one year would constitute a significant temporary noise increase. At residential and school uses in the project vicinity, hourly average noise levels exceeding 60 dBA $L_{eq,}$ and the ambient by at least 5 dBA L_{eq}, for a period of more than one year would constitute a significant temporary noise increase. Industrial land uses are not considered noise-sensitive and would not be subject to temporary construction noise regulations.

Impact 1: **Exposure to Excessive Ground-borne Vibration due to Construction.** Existing structures in the vicinity of the would not be exposed to excessive vibration from project construction. **This is a less-than-significant impact.**

The construction of the project may generate perceptible vibration when heavy equipment or impact tools (e.g. jackhammers, hoe rams) are used. Construction activities would include demolition, site preparation, grading and excavation, trenching, building (exterior), interior/ architectural coating and paving. Pile driving is not anticipated for construction of the building foundation.

To avoid structural damage, the California Department of Transportation recommends a vibration limit of 0.5 in/sec PPV for buildings that are structurally sound and designed to modern engineering standards, which typically consist of buildings constructed since the 1990s. A conservative vibration limit of 0.3 in/sec PPV has been used for buildings that are found to be structurally sound but where structural damage is a major concern (see Table 3). For historical buildings or buildings that are documented to be structurally weakened, a conservative limit of 0.08 in/sec PPV is often used to provide the highest level of protection. This analysis assumes that buildings adjoining the site were constructed prior to the 1990s and are structurally sound. Therefore, ground-borne vibration levels exceeding the conservative 0.3 in/sec PPV limit would have the potential to result in a significant vibration impact.

Table 5 presents typical vibration levels that could be expected from construction equipment at distances of 25 feet and 60 feet. Construction activities, such as drilling, the use of jackhammers, rock drills and other high-power or vibratory tools, and rolling stock equipment (tracked vehicles, compactors, etc.) may also potentially generate substantial vibration in the immediate vicinity. Erection of the building structure is not anticipated to be a source of substantial vibration with the exception of sporadic events such as dropping of heavy objects, which should be avoided to the extent possible. Pile driving is not anticipated as a method of construction.

TABLE 5 Vibration Source Levels for Construction Equipment

Equipment		PPV at 25 ft. (in/sec)	Approximate L_v at 25 ft. (VdB)	Calculated PPVat 60 ft. (VdB)[1]
Clam shovel drop		0.202	94	0.077
Hydromill (slurry wall)	in soil	0.008	66	0.003
	in rock	0.017	75	0.006
Vibratory Roller		0.210	94	0.080
Hoe Ram		0.089	87	0.034
Large bulldozer		0.089	87	0.034
Caisson drilling		0.089	87	0.034
Loaded trucks		0.076	86	0.029
Jackhammer		0.035	79	0.013
Small bulldozer		0.003	58	0.001

Source: Transit Noise and Vibration Impact Assessment, United States Department of Transportation, Office of Planning and Environment, Federal Transit Administration, May 2006.

[1]These levels calculated assuming normal propagation conditions, using a standard equations of *PPVeqmt-PPVref * (25/D) 1.5*, from FTA, May 2006.

Construction of the Fire Station and Community Park would be staggered. The construction of the Fire Station would require approximately 16 months, anticipated to start in July 2019 and conclude in November 2020. Construction of Borel Park would require approximately 6 months of construction, starting in December 2020. The nearest buildings to project construction are residential structures located about 60 feet to the west of the project site and Borel Middle School building 300 feet from the construction of Fire Station. At these distances, construction related vibration levels from all sources are calculated to be below 0.3 in/sec PPV impact threshold (see Table 5). Vibration levels would be lower at structures located further from construction. This is a **less-than-significant impact**.

Mitigation Measures: None Required.

Impact 2: Project-Generated Traffic Noise. The proposed project would not result in a permanent traffic noise level increase at noise-sensitive land uses in the project vicinity. **This is a less-than-significant impact.**

A significant impact would occur if the permanent noise level increase due to project-generated traffic was 3 dBA L_{dn} or greater at noise-sensitive receptors for existing levels exceeding 60 dBA L_{dn} or was 5 dBA L_{dn} or greater for existing levels at or below 60 dBA L_{dn} . For reference, a 3 dBA L_{dn} noise increase would be expected if the project would double existing traffic volumes along a roadway and a 5 dBA L_{dn} noise increase would be expected if the project would triple existing traffic volumes along a roadway.

The only anticipated increase in traffic would result from the vehicles of the six Fire Station staff. Six additional vehicles on the existing roadway network would not make a measurable contribution to traffic noise levels on the surrounding roadway network. No new parking areas other than the existing on-street parking would be provided for Borel Park. The proposed improvements to the park are not anticipated to generate measurable new trips, and therefore would not result in an increase in traffic noise levels. This is a **less-than-significant** impact.

Mitigation Measures: **None required.**

Impact 3: **Mechanical Equipment Noise & Operational Noise.** The proposed project would not generate noise levels in excess of the City's standards for fixed sources of noise. **This is a less-than-significant impact.**

Mechanical Equipment Noise

The evaluation of potential temporary increases in ambient noise levels from project operation considers the testing and maintenance of the proposed emergency generator at the new fire station. The emergency generator would allow the Fire Station to reliably provide emergency services to the community in the event of a power outage. Operation of this equipment during an emergency would be exempt from City noise limits. The Borel Park is not anticipated to require any mechanical equipment.

A 250-gallon diesel backup generator would be located in an enclosure southeast of the fire-house building. It is not anticipated to be operational continuously. As part of routine maintenance, the back-up emergency generator would be tested frequently. It is advised that the generator testing be conducted between the hours of 8:00 a.m. and 6:00 p.m. Monday through Friday, for a duration of approximately 30 minutes. As per the San Mateo Municipal Code, emergency equipment are exempt from the quantitative noise limits contained in the code. This is **less-than-significant** impact.

Fire Apparatus Noise

Noise generating activities associated with the operation of the proposed fire station would include the sounds of vehicle engines, as emergency vehicles leave and return to the station, the testing of engines and equipment during the morning and weekly testing routines, the intermittent testing and operation of the emergency generator, and increased traffic to and from the site.

The primary noise source associated with the normal daily activity at the fire station is the noise generated by the fire apparatus responding to emergencies as they exit and return to the station. Most emergency responses occur during the daytime hours when people are up and active although, of course, an emergency call can occur at any time during the day or night. Each call would include the sound of the trucks exiting the station during emergencies and returning to the station after responding to the call. Sometimes ancillary equipment is checked and tested after returning to the station. Emergency calls at night could result in sleep disturbance at nearby residences.

The station will house one emergency response vehicle that would be started every morning during commute hour for the mandatory check. Minimal diagnostic maintenance would also occur during the morning check and would consist of such activities as pulling the engine out, tilting the cab, checking fluids, running the pump and emergency lights, and an air brake test.

Noise measurements conducted at similar fire stations during the morning equipment checkout and weekly maintenance of equipment indicate that maximum noise levels at a distance of 50 feet from the activity can reach 80 to 85 dBA. Noise levels ranging 79 to 84 dBA would be expected at the nearest existing residences located immediately west of the project site and approximately 60 feet from the fire station. Noise from the morning check and weekly maintenance would have the potential to elevate daytime traffic noise levels at residences to the west of the site along Shafter Street. Noise levels would exceed existing ambient noise levels at the nearest residences while operational. However, the operational time is not anticipated to substantially increase the day-night equivalent level.

The City of San Mateo Municipal Code also specifically exempts, "Any mechanical device, apparatus, or equipment used, related to, or connected with emergency machinery, vehicle, work, or warning alarm or bell, provided the sounding of any bell or alarm on any building or motor vehicle shall terminate its operation within thirty minutes in any hour of its being activated." This is **less-than-significant** impact.

Mitigation Measures: None required.

Impact 4: Substantial Temporary Noise Increase due to Construction. Existing noise-sensitive land uses would be exposed to construction noise levels in excess of the significance thresholds for a period of more than one year. **This is a potentially significant impact** which could be reduced to a less than significant impact by implementation of best construction management practices.

Noise impacts resulting from construction depend upon the noise generated by various pieces of construction equipment, the timing and duration of noise-generating activities, and the distance between construction noise sources and noise-sensitive areas. Construction noise impacts primarily result when construction activities occur during noise-sensitive times of the day (e.g., early morning, evening, or nighttime hours), the construction occurs in areas immediately adjoining noise-sensitive land uses, or when construction lasts over extended periods of time. The Fire Station building is anticipated to be constructed occur over an approximate period of 16 months. Construction of Borel Park would begin after the Fire Station building is completed and is anticipated to take approximately six months. Noise would be generated only during a portion of the Fire Station construction period, as interior construction activities would not be anticipated to generate substantial noise. Construction of Borel Park would include phases such as grading, trenching and paving which do not incorporate use of heavy construction equipment.

As discussed in the Fundamentals section of this report, thresholds for speech interference indoors is 45 dBA. Assuming a 15 dBA exterior-to-interior reduction for standard residential construction and a 25 dBA exterior-to-interior reduction for standard commercial construction, this would correlate to an exterior threshold of 60 dBA L_{eq} at residential land uses and 70 dBA L_{eq} at commercial land uses. Additionally, temporary construction would be annoying to surrounding land uses if the ambient noise environment increased by at least 5 dBA L_{eq} for an extended period of time. Therefore, the temporary construction noise impact would be considered significant if project construction activities exceeded 60 dBA L_{eq} at nearby residences or school uses or exceeded 70 dBA L_{eq} at nearby commercial land uses and exceeded the ambient noise environment by 5 dBA L_{eq} or more for a period longer than one year.

Construction activities for individual projects are typically carried out in stages. During each stage of construction, there would be a different mix of equipment operating, and noise levels would vary by stage and vary within stages, based on the amount of equipment in operation and the location at which the equipment is operating. Typical construction noise levels at a distance of 50 feet are shown in Tables 6 and 7. Table 6 shows the average noise level ranges, by construction phase, and Table 7 shows the maximum noise level ranges for different construction equipment. Most demolition and construction noise falls within the range of 80 to 90 dBA at a distance of 50 feet from the site.

TABLE 6 Typical Ranges of Construction Noise Levels at 50 Feet, L_{eq} (dBA)

	Domestic Housing		**Office Building, Hotel, Hospital, School, Public Works**		**Industrial Parking Garage, Religious Amusement & Recreations, Store, Service Station**		**Public Works Roads & Highways, Sewers, and Trenches**	
	I	**II**	**I**	**II**	**I**	**II**	**I**	**II**
Ground Clearing	83	83	84	84	84	83	84	84
Excavation	88	75	89	79	89	71	88	78
Foundations	81	81	78	78	77	77	88	88
Erection	81	65	87	75	84	72	79	78
Finishing	88	72	89	75	89	74	84	84
I - All pertinent equipment present at site. **II** - Minimum required equipment present at site.								

♦ Source: U.S.E.P.A., Legal Compilation on Noise, Vol. 1, p. 2-104, 1973.

TABLE 7 Construction Equipment 50-foot Noise Emission Limits

Equipment Category	L_{max} Level (dBA)1,2	Impact/Continuous
Arc Welder	73	Continuous
Auger Drill Rig	85	Continuous
Backhoe	80	Continuous
Bar Bender	80	Continuous
Boring Jack Power Unit	80	Continuous
Chain Saw	85	Continuous
Compressor[3]	70	Continuous
Compressor (other)	80	Continuous
Concrete Mixer	85	Continuous
Concrete Pump	82	Continuous
Concrete Saw	90	Continuous
Concrete Vibrator	80	Continuous
Crane	85	Continuous
Dozer	85	Continuous
Excavator	85	Continuous
Front End Loader	80	Continuous
Generator	82	Continuous
Generator (25 KVA or less)	70	Continuous
Gradall	85	Continuous
Grader	85	Continuous
Grinder Saw	85	Continuous
Horizontal Boring Hydro Jack	80	Continuous
Hydra Break Ram	90	Impact
Impact Pile Driver	105	Impact
Insitu Soil Sampling Rig	84	Continuous
Jackhammer	85	Impact
Mounted Impact Hammer (hoe ram)	90	Impact
Paver	85	Continuous
Pneumatic Tools	85	Continuous
Pumps	77	Continuous
Rock Drill	85	Continuous
Scraper	85	Continuous
Slurry Trenching Machine	82	Continuous
Soil Mix Drill Rig	80	Continuous
Street Sweeper	80	Continuous
Tractor	84	Continuous
Truck (dump, delivery)	84	Continuous
Vacuum Excavator Truck (vac-truck)	85	Continuous
Vibratory Compactor	80	Continuous
Vibratory Pile Driver	95	Continuous
All other equipment with engines larger than 5 HP	85	Continuous

Notes:

1 Measured at 50 feet from the construction equipment, with a “slow” (1 sec.) time constant.

2 Noise limits apply to total noise emitted from equipment and associated components operating at full power while engaged in its intended operation.

3 Portable Air Compressor rated at 75 cfm or greater and that operates at greater than 50 psi.

Source: Mitigation of Nighttime Construction Noise, Vibrations and Other Nuisances, National Cooperative Highway Research Program, 1999.

Construction activities would include demolition, site preparation, grading and excavation, trenching, building (exterior), interior/ architectural coating and paving. Pile driving, which has the highest potential of generating noise impacts, is not anticipated. Hourly average noise levels due to construction activities during busy construction periods outdoors would typically range from about 75 to 87 dBA L_{eq} at a distance of 50 feet. Construction-generated noise levels drop off at a rate of about 6 dBA per doubling of the distance between the source and receptor.

The closest residences are located about 60 feet to the west of the site. The closest Borel Middle School buildings are 300 feet from Fire Station site and as close as 50 feet from the Borel Park site. The existing school playground adjacent to the Fire Station site is anticipated to be under construction for a new gymnasium building during construction for the Fire Station and Park site. Therefore, Fire Station construction is not anticipated to adversely affect outdoor areas of the school.

During the construction of the Fire Station, exterior noise levels at the residence closest to the site (on Shafter Street and Borel Avenue) would range from 74 to 86 dBA L_{eq} at a distance of 60 feet. All other residences and the school buildings would be further from the Fire Station site where most of the heavy construction equipment would be used. Construction noise at the two residences, within a distance of 200 feet from the Fire Station site, would be exposed to construction noise levels above 70 dBA L_{eq} during heavy construction periods. The noise levels would also exceed ambient noise environment by at least 5 dBA L_{eq} occasionally during periods of heavy construction over a period greater than 12 months. This is a **potentially significant impact**. During the construction of Borel Park, the closest school building would be exposed to noise levels of up to 84 dBA L_{eq} at 50 feet from the construction equipment. Construction of Borel Park would not require heavy construction equipment and would be completed in six months from commencement. This would not result in a significant impact.
The Borel Middle School adjacent to the project site plans to construct a gymnasium building close to the proposed Fire Station. The construction schedules of the Fire Station and Borel School gymnasium might be coordinated so as to share excavated soil from the other project. This would further reduce the number of hauling trucks required during construction and in turn reduce the construction noise impact. In addition, reasonable regulation of hours of construction, regulation of heavy equipment are necessary to protect the health and safety of persons, promote the general welfare of the community, and maintain the quality of life. The following construction best management practices would reduce construction noise levels emanating from the site and minimize disruption and annoyance at existing noise-sensitive receptors in the project vicinity.

Construction Best Management Practices

Develop a construction noise control plan, including, but not limited to, the following available controls:

- Construct temporary noise barriers, where feasible, to screen stationary noise-generating equipment. Temporary noise barrier fences would provide a 5 dBA noise reduction if the noise barrier interrupts the line-of-sight between the noise source and receiver and if the barrier is constructed in a manner that eliminates any cracks or gaps.

- Equip all internal combustion engine-driven equipment with intake and exhaust mufflers that are in good condition and appropriate for the equipment.

- Unnecessary idling of internal combustion engines should be strictly prohibited.

- Locate stationary noise-generating equipment, such as air compressors or portable power generators, as far as possible from sensitive receptors. If they must be located near receptors, adequate muffling (with enclosures where feasible and appropriate) shall be used reduce noise levels at the adjacent sensitive receptors. Any enclosure openings or venting shall face away from sensitive receptors.

- Utilize "quiet" air compressors and other stationary noise sources where technology exists.

- Construction staging areas shall be established at locations that will create the greatest distance between the construction-related noise sources and noise-sensitive receptors nearest the project site during all project construction.

- A temporary noise control blanket barrier could be erected, if necessary, along building facades facing construction sites. This mitigation would only be necessary if conflicts occurred which were irresolvable by proper scheduling. Noise control blanket barriers can be rented and quickly erected.

- Locate material stockpiles, as well as maintenance/equipment staging and parking areas, as far as feasible from residential and school receptors.

- Control noise from construction workers' radios to a point where they are not audible at existing residences bordering the project site.

- The contractor shall prepare a detailed construction plan identifying the schedule for major noise-generating construction activities. The construction plan shall identify a procedure for coordination with adjacent residential land uses so that construction activities can be scheduled to minimize noise disturbance.

- Designate a "disturbance coordinator" who would be responsible for responding to any complaints about construction noise. The disturbance coordinator will determine the cause of the noise complaint (e.g., bad muffler, etc.) and will require that reasonable measures be implemented to correct the problem. Conspicuously post a telephone number for the disturbance coordinator at the construction site and include in it the notice sent to neighbors regarding the construction schedule.

Implementation of the above best management practices would reduce construction noise levels emanating from the site, limit construction hours, and minimize disruption and annoyance. With the implementation of these measures and recognizing that noise generated by construction activities would occur over a temporary period, the impact would be **less-than-significant**.

Mitigation Measures: **None Required.**