F – SOUND LEVEL ACOUSTICAL ANALYSIS

OVERVIEW

The Orcutt Community Plan identifies the performance requirements for projects located at the proposed OASIS site, and sets the limits of acoustic impacts to 65 Db during facility operation. We conducted a project specific sound level analysis of the project to determine any impacts from the project from amplified sound sources to neighboring properties. As there is no dedicated stage proposed or a predetermined location for amplified sound proposed, programmed, or desired by OASIS, the report was developed assuming the most restrictive location based on proximity to the neighboring residents of the SouthPoint Development.

Additionally, the sound study assumes our property line to the north as the measure for the 65Db sound level limit. Pease note figure 11 of the sound study the sound levels at the property lines of the nearest residences are closer to 61 Db which meets the requirements of the community plans. The property immediately to the north is an open space buffer and is zoned as open space.

OASIS will adjust the location of the speaker as noted in Figure 12 of the sound level study in lieu of the optional wall scenario.

Sound Level Assessment for
Proposed Oasis Meeting Center
Old Town Orcutt, CA

prepared for
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Table of Contents

List of Figures

List of Tables

Sound Level Assessment for

Proposed OASIS Meeting Center
Old Town Orcutt, CA

1.0 Description

This is a report on the sound level assessment for the proposed Oasis Meeting Center. The report is intended to define all off-site and on-site noise impacts associated with the proposed project. The following topics are presented in this report:

- A description of the study area, project site, and proposed project.
- A description of the regulatory setting, including guidelines and standards.
- An evaluation of the existing noise environment.
- An assessment of potential short-term construction-related noise and vibration impacts.
- An assessment of future potential noise and vibration impacts.
- Information on fundamentals of noise and vibration.

2.0 Location

The general vicinity of the site is in northern Santa Barbara County, south of the city of Santa Maria. The vicinity of the site is shown in "Figure 2. Site Vicinity." on page 14.

There are potential sensitive residential receptors at second floor level, located across Clark Avenue to the south and toward the west. The distance to the potential nearest sensitive residential receptor is separated by elevated terrain and distance from potential noise sources at the proposed project.

3.0 Regulatory Setting

The proposed project will be located in the unincorporated town of Orcutt, in northern Santa Barbara County. Noise regulations are addressed by federal, state, and local government agencies, discussed below. Local policies are generally adaptations of federal and state guidelines, adjusted to prevailing local condition, contained in the Orcutt Community Plan.

3.1 Federal Regulation

The adverse impact of noise was officially recognized by the federal government in the Noise Control Act of 1972, which serves three purposes:

(a) Promulgating noise emission standards for interstate commerce.

(b) Assisting state and local abatement efforts.

(c) Promoting noise education and research.

The Department of Transportation (DOT) assumed a significant role in noise control. The Federal Aviation Administration (FAA) regulates noise of aircraft and airports. Surface transportation system noise is regulated by the Federal Transit Administration (FTA). Freeways that are part of the interstate highway system are regulated by the Federal Highway Administration (FHWA).

3.2 State Regulation

California Department of Health Services Office of Noise Control (ONC) was instrumental in developing regulatory tools to control and abate noise for use by local agencies.

One significant model, which is shown in “Figure 1. State Regulatory Matrix” on page 6, depicts land use compatibility for community noise environments, which allows the local jurisdiction to clearly delineate compatibility of sensitive uses with various incremental levels of noise.

Title 24, Chapter 1, Article 4 of the California Administrative Code (California Noise Insulation Standards) requires noise insulation in new hotels, motels, apartment houses, and dwellings (other than single-family detached housing) that provides an annual average noise level of no more than 45 dBA CNEL. When such structures are located within a 60 dBA CNEL (or greater) noise contour, an acoustical analysis is required to ensure that interior levels do not exceed the 45 dBA CNEL annual threshold. In addition, Title 21, Chapter 6, Article 1 of the California Administrative Code requires that all habitable rooms shall have an interior CNEL of 45 dBA or less due to aircraft noise.

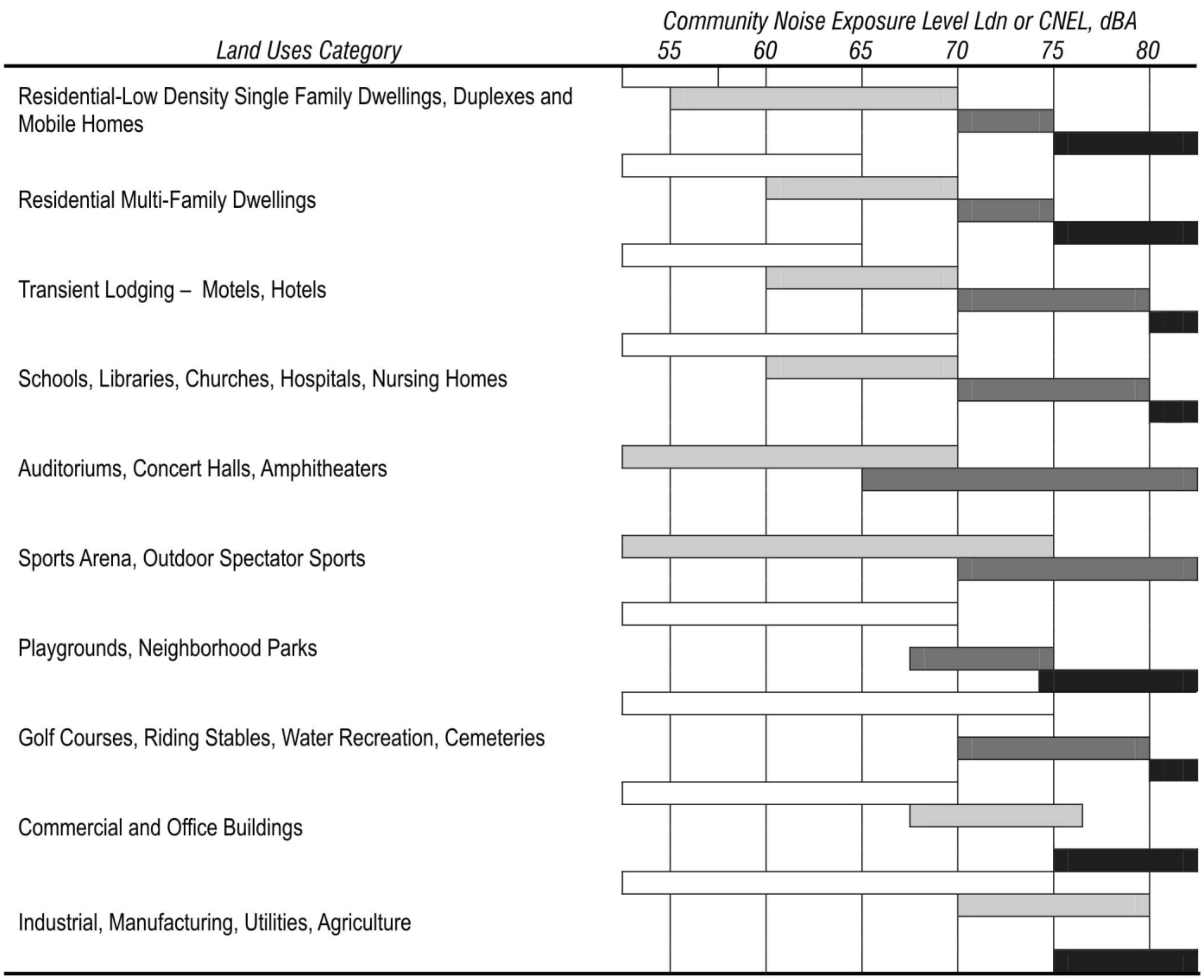
Government Code Section 65302 mandates that the legislative body of each county and city in California adopt a noise element as part of its comprehensive general plan. The local noise element must recognize the land use compatibility guidelines published by the State Department of Health Services. The guidelines rank noise land use compatibility in terms of normally acceptable, conditionally acceptable, normally unacceptable, and clearly unacceptable.

3.3 Local Regulation

The County of Santa Barbara Comprehensive Plan, the Environmental Thresholds and Guidelines Manual, the Santa Barbara County Code, and the Orcutt Community Plan establish the following applicable conclusions, recommendations, standards, policies, and regulations regarding potential noise and vibration impacts.

Figure 1. State Regulatory Matrix

The matrix from which local guidelines evolve for Land Uses Category and Community Noise Exposure Level (Ldn or CNEL) dBA.



Explanatory Notes

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.

Conditionally Acceptable:
New construction or development should be undertaken only after a detailed analysis of the noise reduction requirements is made and needed noise insulation features included in the design. Conventional construction, but with closed windows and fresh air supply system or air conditioning will normally suffice. Outdoor environment will seem noisy.

Normally Unacceptable:
New construction or development should generally be discouraged. If new construction or development does proceed, a detailed analysis of the noise reduction requirements must be made with needed noise insulation features included in the design. Outdoor areas must be shielded.

Clearly Unacceptable:
New construction or development should generally not be undertaken. Construction cost to make the indoor environment acceptable would be prohibitive and the outdoor environment would not be usable.

3.4 County of Santa Barbara Comprehensive Plan

The Noise Element of the County of Santa Barbara Comprehensive Plan provides the conclusions, recommendations, and strategies necessary to ensure an appropriately quiet and pleasurable environment for the residents, employees, and visitors in the County's unincorporated areas. Since the regulation of transportation noise sources such as roadway and aircraft primarily fall under either State or federal jurisdiction, local jurisdictions will generally use land use and planning decisions to limit locations or volumes of such transportation noise sources, to avoid development within noise impact zones, or to shield impacted receivers or sensitive receptors.

Conclusions and Recommendations in the Noise Element: The maximum exterior noise exposure compatible with noise sensitive uses should be 65 dBA Day-Night Average Sound Level unless noise mitigation features are included in project designs. The relevant noise-sensitive land use in this instance is residential, including single and multifamily dwellings, as well as transient lodging, including hotels, motels, and similar uses.

Noise-sensitive uses proposed in areas where the Day-Night Average Sound Level is 65 dBA or more should be designed so that interior noise levels attributable to exterior sources do not exceed 45 dBA Ldn when doors and windows are closed. An analysis of the noise insulation effectiveness of proposed construction should be required, showing that the building design and construction specifications are adequate to meet the prescribed interior noise standard.

The Noise Element stipulates that noise level limits, applicable to new noise sources, should be incorporated into all commercial and industrial zoning districts and into conditional use permit requirements.

3.5 Environmental Thresholds and Guidelines Manual

The County of Santa Barbara Environmental Thresholds and Guidelines Manual provides the following thresholds of significance for assisting in the determination of significant noise impacts. The thresholds are intended to be used with flexibility, as each project must be viewed in its specific circumstances. A proposed development that would generate noise levels in excess of 65 dBA CNEL and could affect sensitive receptors would generally be presumed to have a significant impact.

Outdoor living areas of noise sensitive uses that are subject to noise levels in excess of 65 dBA CNEL would generally be presumed to be significantly impacted by ambient noise. A significant impact would also generally occur where interior noise levels cannot be reduced to 45 dBA CNEL or less.

A project will generally have a significant effect on the environment if it will increase substantially the ambient noise levels for noise-sensitive receptors adjoining areas. This may generally be presumed when ambient noise levels affecting sensitive receptors are increased to 65 dBA CNEL or more.

Noise from grading and construction activity within 1,600 feet of sensitive receptors, including schools, residential development, commercial lodging facilities, hospitals or care facilities, would generally result in a potentially significant impact. To mitigate this impact, construction within 1,600 feet of sensitive receptors shall be limited to weekdays between the hours of 8 AM to 5 PM only. Noise attenuation barriers and muffling of grading equipment may also be required. Construction equipment generating noise levels above 95 dBA may require additional mitigation.

3.6 Santa Barbara County Code

The Santa Barbara County Code establishes the following noise regulation that is relevant to the proposed project:

> “Each permittee shall conduct and carry out work permitted hereunder in such manner as to avoid unnecessary inconvenience and annoyance to the general public and occupants of neighboring property. The permittee shall take appropriate measures to reduce to the fullest extent practicable in the performance of the work, noise, dust and unsightly debris. During the hours of 10:00 P.M. to 7:00 A.M., the permittee shall not use, except with the express written permission of the commissioner or in case of an emergency as herein otherwise provided, any tool, appliance or equipment producing noise of sufficient volume to disturb the sleep or repose of occupants of the neighboring property.

Nighttime Noise Restriction establishes limits for noise within the unincorporated area of the County of Santa Barbara during the following periods of time:

> The night and following morning of any Sunday, Monday, Tuesday, Wednesday, or Thursday between the hours of 10:00 P.M. of such day and 7:00 A.M. the following morning; or,
>
> The morning hours after midnight of any Friday or Saturday, between twelve midnight, following such day, and 7:00 A.M. the following morning. Within such time periods, and for the purposes of this chapter, a loud and unreasonable sound shall include any sound created by means prohibited above which is clearly discernible at a distance of one hundred feet from the property line of the property upon which it is broadcast or which is at any level of sound in excess of sixty decibels at the edge of the property line of the property upon which the sound is broadcast, as such sound would be measured on a sound measuring instrument meeting American National Standard Institute’s Standard SI.4-1971 (or more recent revision thereof) for Type 1 or Type 2 sound level meters or an instrument and the associated recording and analyzing equipment which provide equivalent data. Enforcement of a violation under this chapter shall not require the use of a sound level meter.

4.0 Existing Sound Level

To ascertain the existing sound levels at and adjacent to the project site, field monitoring was conducted between for a 24-hour period during Friday, June 3. Sound levels external to the site are dominated by transportation noise from Clark Avenue to the south, with some noise from Foxenwood Lane / Route 17 to the east of the site. The nearest public airport is Santa Maria Airport, which is located approximately 2.3 miles northwest of the project site. The project site falls outside the 65 dBA noise contour for the airport, and therefore the airport is not considered a significant source of ambient noise on the project site, however weather data from the airport was used to confirm conditions during the sound level measurement.

Sound level monitoring was performed using a Larson Davis Model 820, Type 1 integrating sound level meter. The Larson Davis meter was programmed in A-weighted "slow" mode to record the sound pressure level at Leq = 10-second intervals. The sound level meter and microphone was mounted approximately five feet above the ground and equipped with a windscreen during all measurements. "9.0 Measurements, Calculations and Modeling" on page 31 for further details on sound level measurement and protocol. Weather data was collected periodically at the measurement locations and also correlated with weather conditions at Santa Maria Airport.

The sound level monitoring location was selected in order to measure the existing noise sources impacting the vicinity of the project site and to provide a baseline for any potential noise impacts that may be created by construction, development and operation of the proposed project. The measurement locations are shown in "Figure 4. Measurement Location." on page 16.

The existing sound level measurement was conducted on a typical workday commute time period. Recorded sound level data consist of average Leq 1 hour sound levels, dBA.

Results of the measurement are shown in "Figure 7. Sound Level Measurements." on page 18.

From the measured data, existing hourly LEQ values were calculated. For an explanation of technical definitions, see "7.0 APPENDIX A: Glossary of Acoustical Terms" on page 9.

5.0 Future Sound Levels

5.1 Short Term Construction Noise

With reference to potential short-term construction noise, Section 4.3.2, the County of Santa Barbara Environmental Thresholds and Guidelines Manual provides the following thresholds of significance for assisting in the determination of significant noise impacts. The thresholds are intended to be used with flexibility, as each project must be viewed in its specific circumstances:

> "Noise from grading and construction activity within 1,600 feet of sensitive receptors, including schools, residential development, commercial lodging facilities, hospitals or care facilities, would generally result in a potentially significant impact. To mitigate this impact, construction within 1,600 feet of sensitive receptors shall be limited to weekdays between the hours of 8 AM to 5 PM only. Noise attenuation barriers and muffling of grading equipment may also be required. Construction equipment generating noise levels above 95 dBA may require additional mitigation."

According to the Environmental Thresholds and Guidelines Manual, noise sensitive land uses include residential uses, such as those to the north and to the west of the site. Therefore, the residences to the north, with habitable spaces located approximately 320 feet north of the project site are considered a noise-sensitive use. The Orcutt Community Plan states that interior noise-sensitive uses (e.g., residential habitable spaces) shall be protected to minimize significant noise impacts.

Short-term noise impacts could potentially occur during project construction activities from either the noise impacts created from the transport of workers and movement of construction materials to and from the project site, or from the noise generated on-site during demolition and ground clearing activities; excavation, grading, and similar ground-disturbing activities; and construction activities.

Construction noise levels vary significantly based upon the size and topographical features of the active construction zone, duration of the workday, and types of equipment employed, as indicated in "Table 3. Construction Equipment Vibration Levels" on page 27. A typical eight-hour construction day may generate 84 dBA CNEL at a distance of 50 feet from the noise source. Typical operating cycles may involve a short period of full power operation followed by a longer period at lower power settings. Although there would be potential for a relatively high single-event noise exposure, resulting in potential short-term intermittent annoyances, the effect on long-term ambient noise levels would be nominal when averaged over a longer period. As shown by the ambient noise level measurements in "Table 1. Existing Sound Level Measurements" on page 10, maximum noise levels in project vicinity are already up to 82 dBA Lmax.

Project construction is anticipated to utilize a mix of construction equipment on the project site, including tractors for excavation and grading activities, backhoes for trenching, earth rollers for compaction, and asphalt rollers for paving. The closest noise-sensitive use to the Project site is more than 300 feet distant, to the west and north of the project site.

The Federal Highway Administration (FHWA) Roadway Construction Model (RCNM Version 1.1), allows the preliminary prediction of construction noise levels for a variety of construction operations based on a compilation of empirical data and the application of acoustical propagation formulas.

Potential noise impacts at boundaries of the site were modeled to understand the potential effect. "Table 1. Construction Equipment Noise Levels" on page 11 shows the calculated noise levels at 150 feet for typical items of equipment to be utilized on the project site. The results of modeling show that the average (Leq) noise level of the backhoe, paver, and roller are less than 60 dBA. The tractor will generate a noise level of 64 dBA Leq, below the 65 dBA standard for sensitive receptors.

Table 1. Construction Equipment Noise Levels

Equipment	*calculated dBA at 150 feet from source*	
	Lmax	Leq
Backhoe	62	58
Paver	61	57
Roller	65	57
Tractor	69	64
Total	69	65
Source: FHWA Roadway Construction Model, RCNM ver. 1.1, 2012		

5.2 Short Term Construction Vibration

Potential construction vibration from the project would be a localized event and is typically only perceptible to a receptor that is in close proximity to the vibration source. As an example, the potential vibration from worst-case construction equipment, a small bulldozer: is: PPV at 100 feet = 0.0004 inches / second. This vibration level is far below the Federal Transit Administration Significant Impact guideline maximum of 0.2 inches / second.

A vibration impact would be generally considered significant if it involves any construction-related or operations-related impacts in excess of 78 VdB at sensitive receptors. The construction and operations-related vibration impacts have been analyzed separately below. Construction activities can produce vibration that may be felt by adjacent uses. The construction of the proposed project would not require the use of equipment such as pile drivers, which are known to generate substantial construction vibration levels. The project site is relatively small—approximately 0.68 acre—and will not utilize many pieces of construction equipment. The primary source of vibration during project construction would likely be from a bulldozer (tractor), which would generate 0.089 inch per second PPV at 25 feet with an approximate vibration level of 87 VdB.

The closest residential receptors to the project site are located to the west and to the north of the boundary of the project site, approximately 300+ feet from the center of the site. It is anticipated that vibration levels generated by a bulldozer operating on the periphery of the area of disturbance during project construction and experienced at the nearest off-site structure will be approximately 65 VdB, which is below the acceptable threshold of 78 VdB for residential (sensitive) uses during the day.

The County of Santa Barbara does not have any specific provisions regarding vibration that would be applicable to the project site as currently zoned; nonetheless, the increase in off-site vibration generated by on-site construction activities would represent only a nominal increase whose impact would not be considered significant. Therefore, impacts associated with construction vibration would be considered less than significant.

5.3 Future Operations Noise Level

The operations for the proposed Meeting center have been analyzed for the contribution of traffic flow and human activities into, within, and out of the proposed project site. The planned activities will contribute some additional transient sounds on the site above ambient sound level. However, the distribution, timing and spacing of individuals and group activities on the large site is estimated to be less than three dBA increase over each one hour period, and less than three dBA increase in CNEL at the boundaries of the site. This will be a less than significant increase in impact to surrounding areas. Access to the site is provided by driveway to the entrance at the southeast corner of the site. The increase in surrounding traffic flow on Clark Avenue and Foxenwood Lane attributable to the proposed project would result in an increase in sound level less than one dBA CNEL, and is therefore judged to be a less than significant increase in daily traffic noise contribution.

In addition to traffic flow from Meeting center operations and activities, there are other potential sources of noise which are addressed below:

- Mechanical Equipment

The project may use exhaust fans, air conditioning units and refrigeration compressors. Typical air conditioning units with Variable Refrigerant Flow compressors and condensers for this type of application generate exterior noise levels of 53 dBA (within three feet) of the units. The potential noise impacts from the operation of mechanical equipment is anticipated to be less than ambient sound level at the property line, which is below the 65 dBA permitted sound level.

In order to determine the noise created by modern air conditioning units, a noise measurement was taken approximately three feet from HVAC units on a similar existing community building in Solvang. The sound level measurement was recorded at 53 dBA Leq at a distance of three feet while the HVAC unit was operational.

As there are no potentially-sensitive residential receptors within 300 feet of the planned Meeting center, impacts from noise generated by air conditioners and forced air units (ventilation fans, exhaust fans and air conditioning compressors and condensers) are considered to be below the ambient sound level at the site boundary, and therefore less than significant.

- Amplified Voice and Music

Planned outdoor events with the possibility of amplification are included in the use permit application. The use of sound amplification was studied in one fixed location near the northwest corner of the centrally-located Meeting center. The graphic exhibits for this study are shown in "Figure 10. Sound Level Contours, Amplified Sound" on page 20. A second location in the open area to the west of the Meeting center was also studied. The assumption is made that sound level near the loudspeakers used for amplification shall not exceed 88 dBA sound level.

6.0 Discussion and Conclusions

The 24-hour existing sound levels on the undeveloped site and future sound levels for the developed project are clearly shown in relation to the ambient nearby and distant traffic on Clark Avenue in relation to this project. The nearest potentially sensitive residential receptors are more than 300 feet from the center of the project and away from the potential areas for amplified music. A series of acoustic scenarios with sound level contours were modeled for the site, based on known existing ambient sound levels and based on similar-size operations for parking cars, on-site circulation and gatherings.

The acoustic scenarios are presented in the following order:

"Figure 8. Sound Level Contours, No Activity" on page 19

"Figure 9. Sound Level Contours, parking arrival / departure" on page 19

"Figure 10. Sound Level Contours, Amplified Sound" on page 20

"Figure 11. Sound Level Contours, Amplified Sound with mitigation" on page 20

"Figure 12. Speaker Location Zone" on page 21

A mitigation measure is proposed for the configuration and directionality of the amplified speaker at any location shown in the "Speaker Location Zone". An abbreviated solid noise wall, eight feet in length, shall be placed between the speaker and any potentially sensitive residential receptors. The solid noise wall shall intercept direct "line-of-sight" of the speaker from the residential use. In this manner, noise levels will not exceed 58 dBA CNEL at the boundary line nor will noise levels exceed 54 dBA CNEL at the property line of any surrounding residences.

Future sound levels from the proposed Meeting center project are compatible with surrounding residential uses because of the relative positions which allow for sound attenuation by distance separation. Noise propagation toward potential residential receptors is attenuated due to the distance and the proposed noise barrier mitigation of amplified sound.

Therefore, in our opinion this project is compatible with the General Plan Noise Element and the proposed project is in compliance with regulations governing noise and vibration.

Figure 2. Site Vicinity.

This figure shows the relationship of the site to surrounding roads and the community of Orcutt. Clark Avenue is to the south of the site and Foxenwood Lane / Route 17 is to the east of the site.

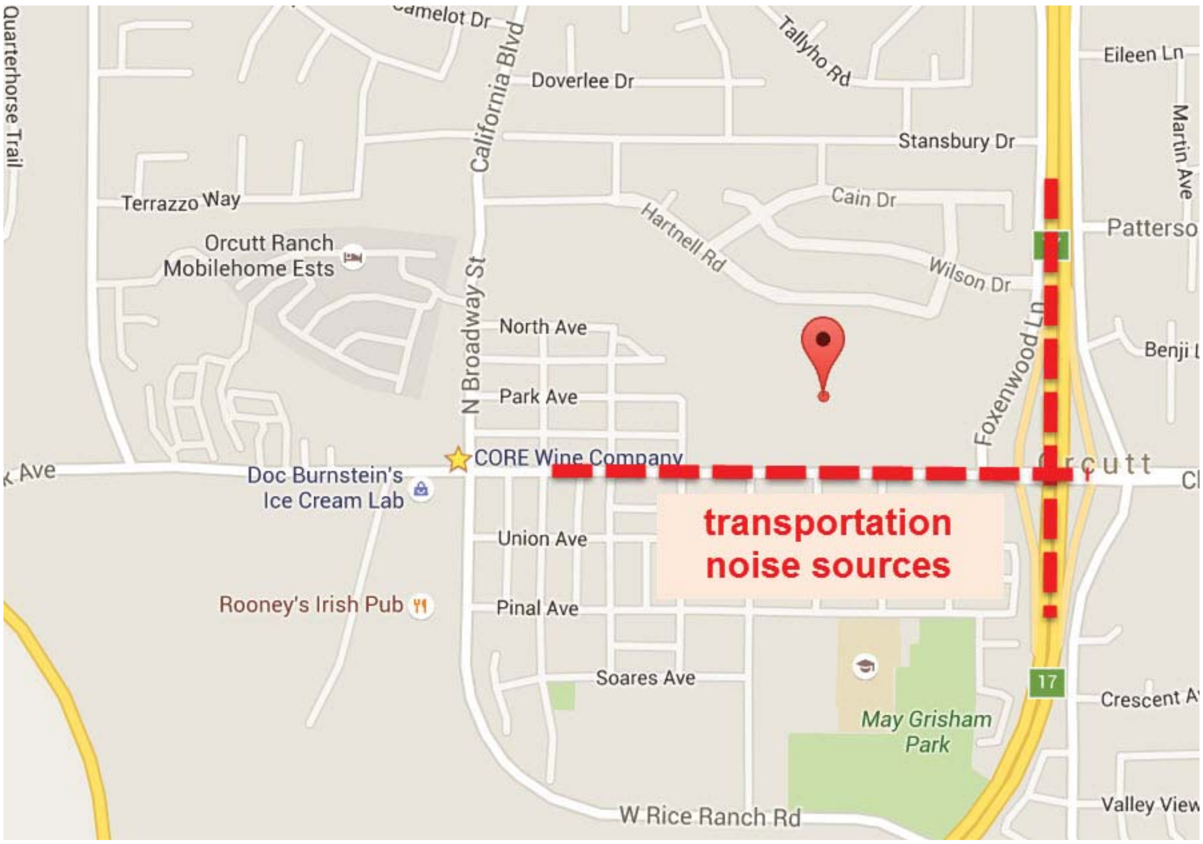


Figure 3. Site Vicinity, Airport Distance.

This figure shows the relationship of the site to Santa Maria Airport, located to the north. The airport is not considered to be a significant source of noise at the proposed site. Weather data from the airport was documented during the sound level measurement period.

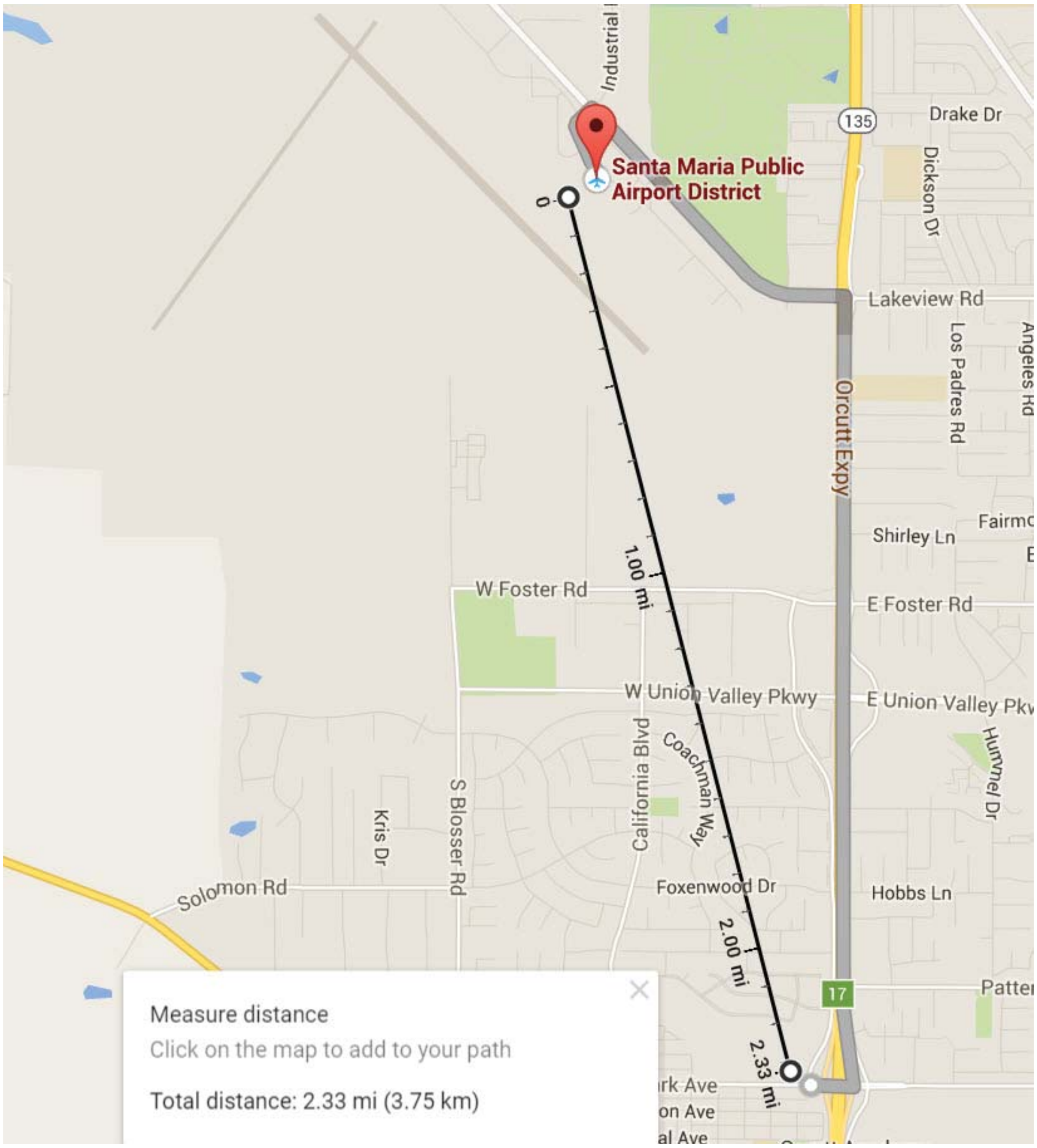


Figure 4. Measurement Location.

The location of Existing Sound Level measurement is shown on this plan as X station.

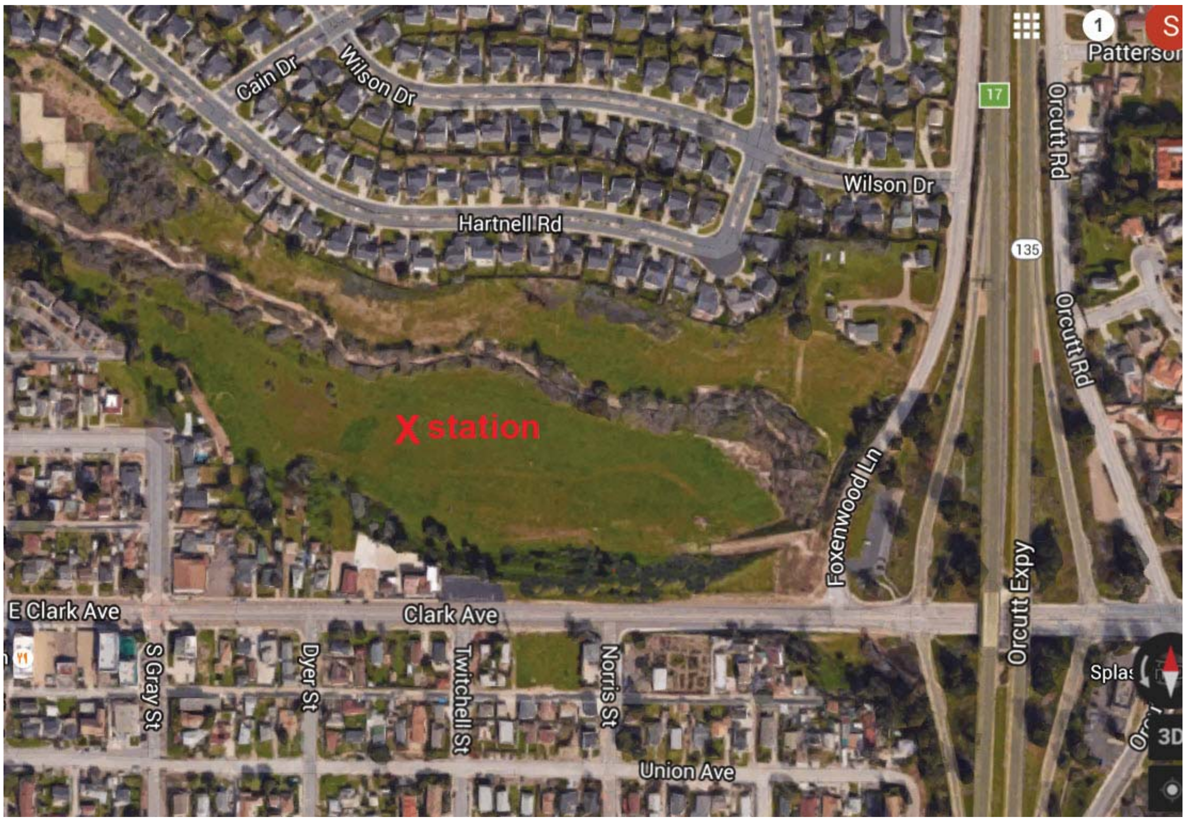


Figure 5. Site Layout.

The layout of the major components of the proposed project are shown below, in relation to nearby streets and terrain.

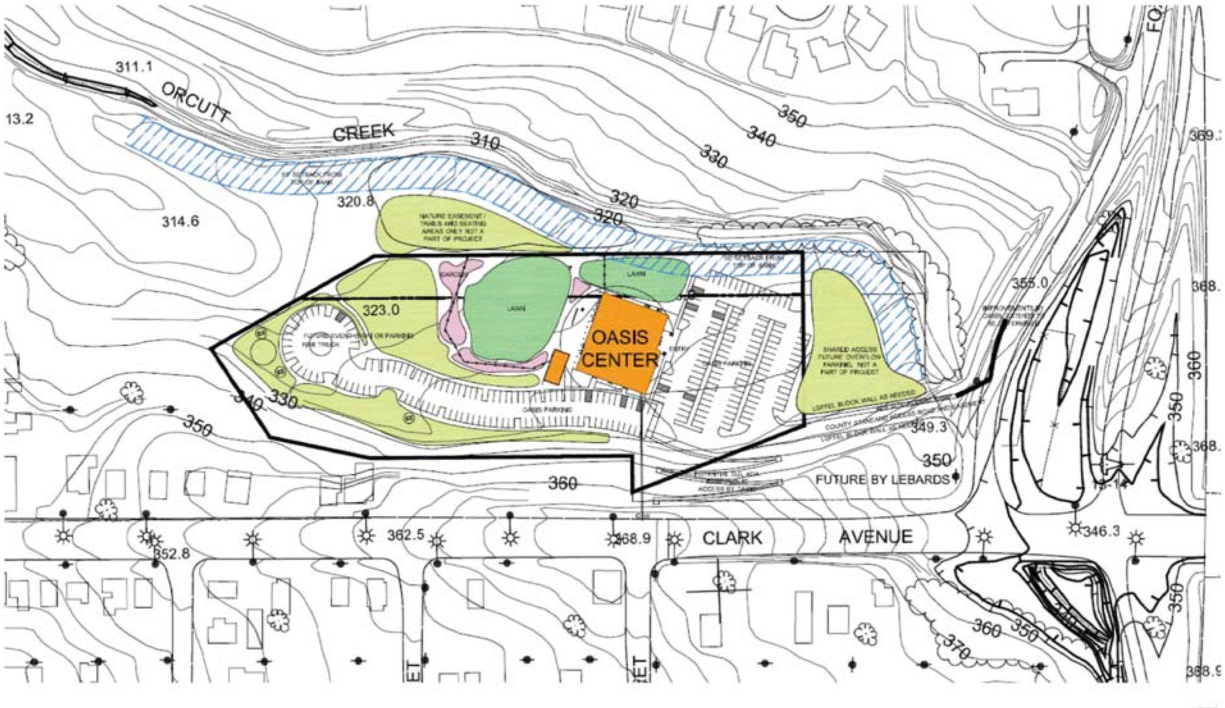


Figure 6. Site Section

The location of Existing Sound Level measurement is shown in this site section. Line-of-sight and elevation profile is also shown.

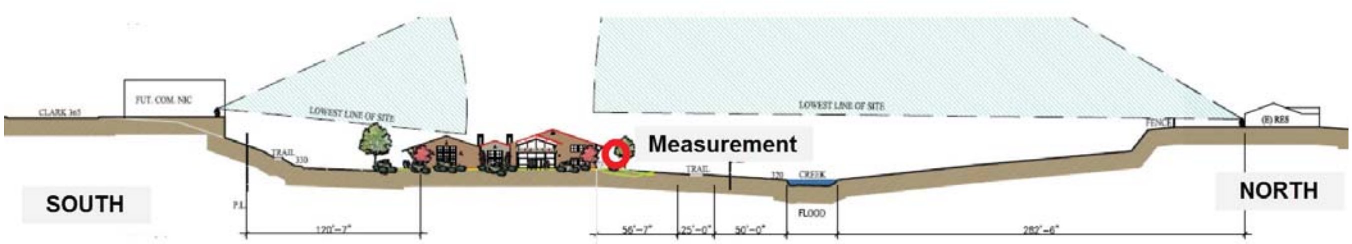


Figure 7. Sound Level Measurements.

The hourly averages (Leq = 1 hr.) of sound level measurements. Overall 24-hour CNEL is 52 dBA.

See Appendix for explanation of terms.

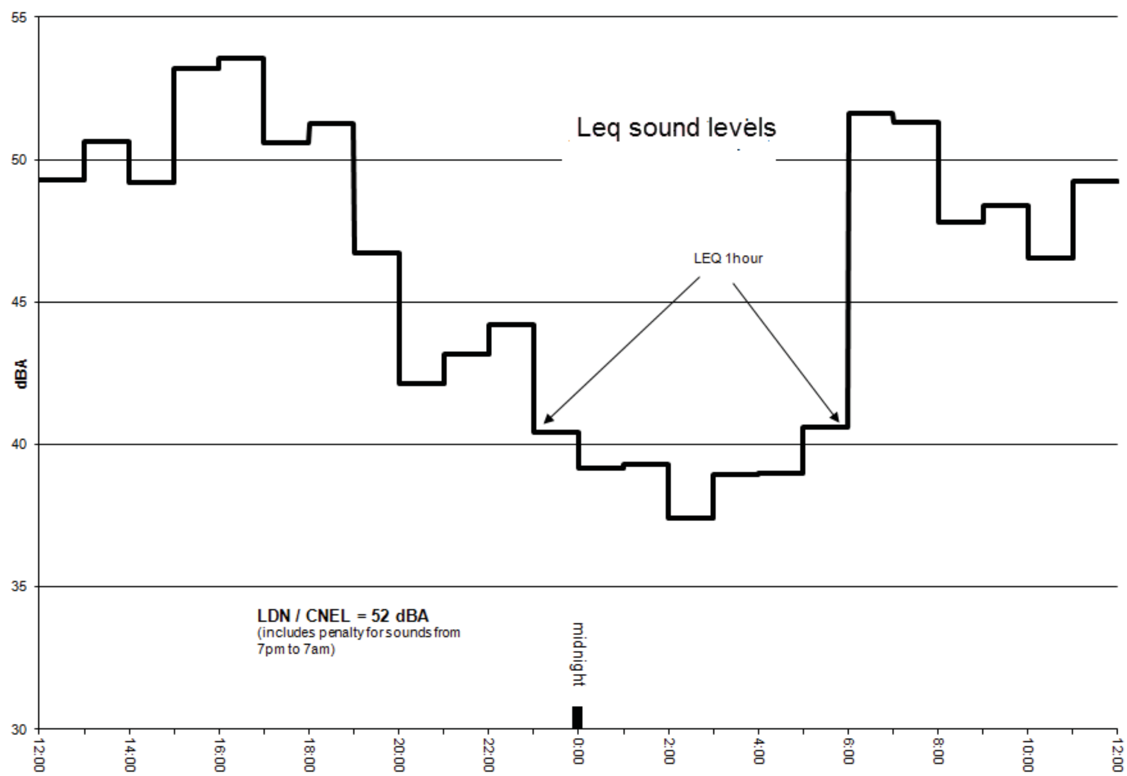


Figure 8. Sound Level Contours, No Activity

The site plan with sound level contours, CNEL = dBA, showing the effect of traffic noise alone from Clark Avenue to the south, no other significant activity on site.

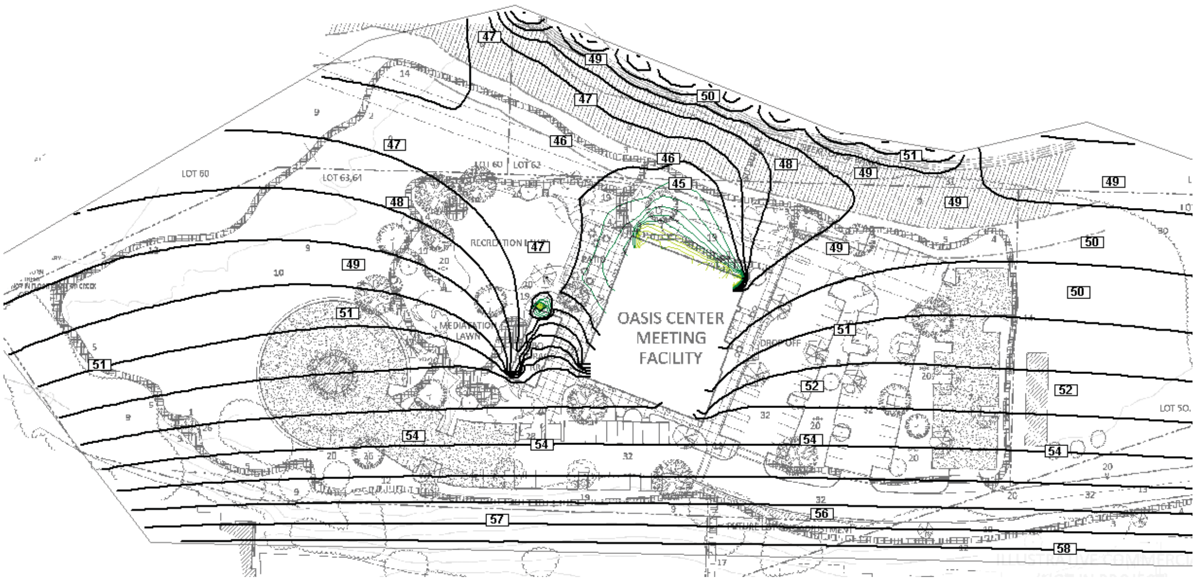


Figure 9. Sound Level Contours, parking arrival / departure

The site plan with sound level contours, CNEL = dBA, showing the effect of limited on-site activity associated with arrival and departure, voice only, no amplification.

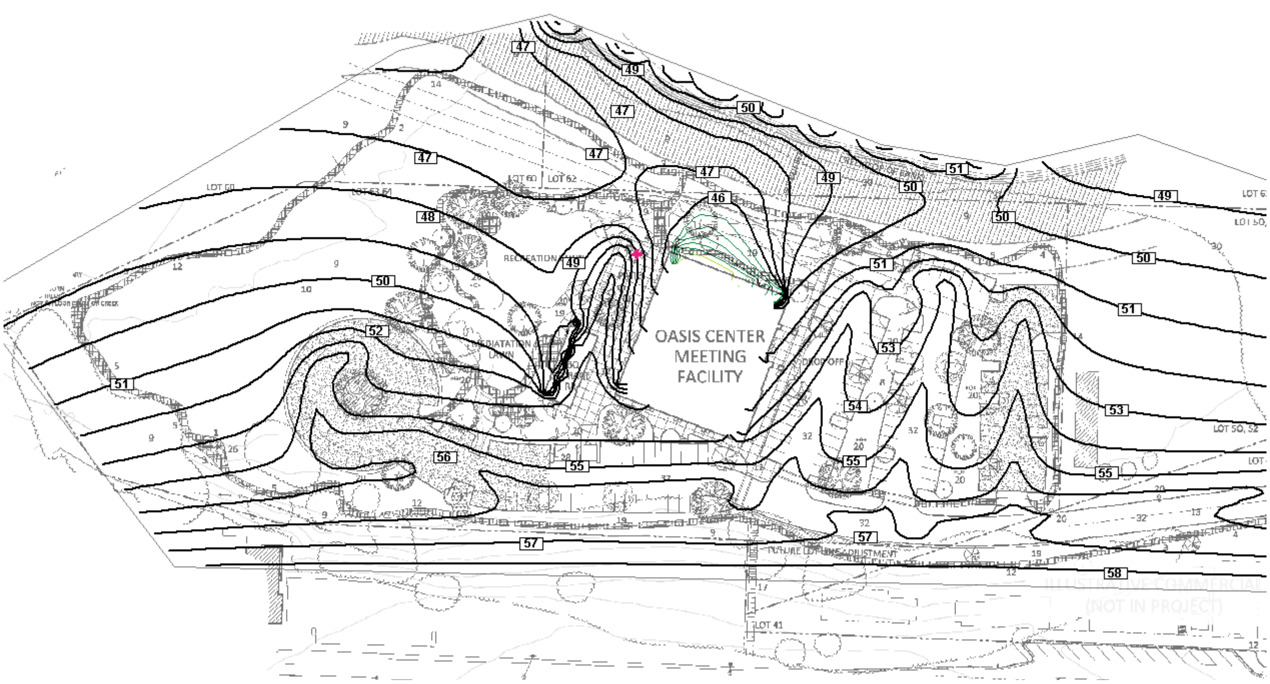


Figure 10. Sound Level Contours, Amplified Sound

The site plan with sound level contours, CNEL=dBA, showing the effect of sound propagation from unmitigated amplified sound at 88 dBA, speaker located at northwest corner patio of meeting facility.

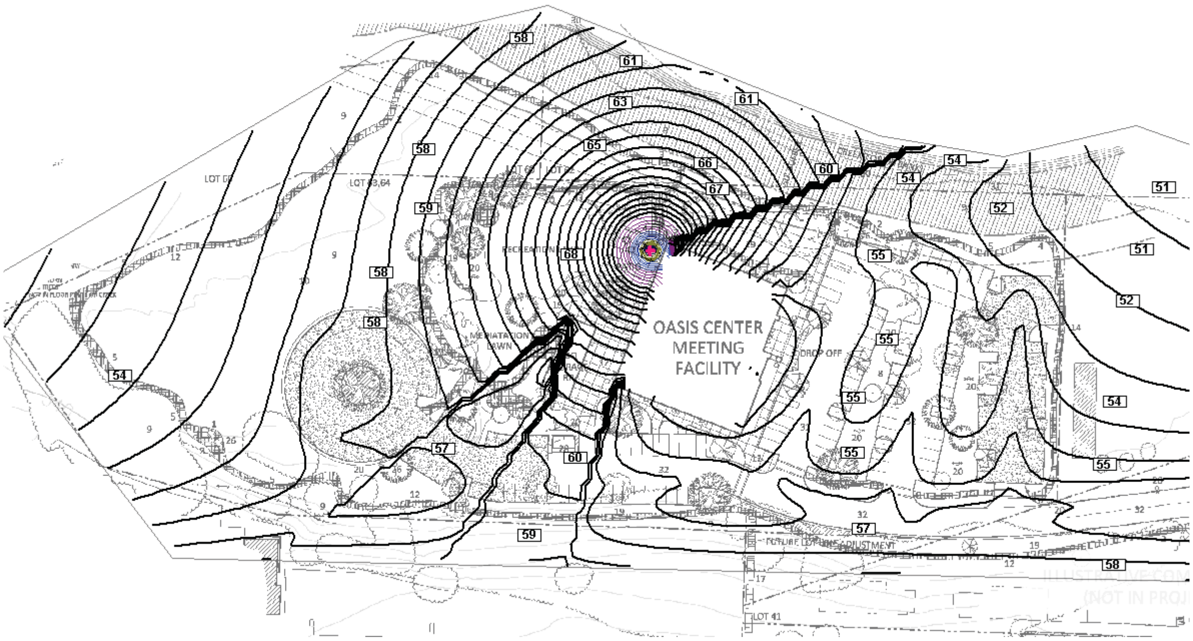


Figure 11. Sound Level Contours, Amplified Sound with mitigation

The site plan with sound level contours, CNEL=dBA, showing the effect of mitigation of 88 dBA amplified sound, speaker and backdrop wall located at northwest corner patio of meeting facility.

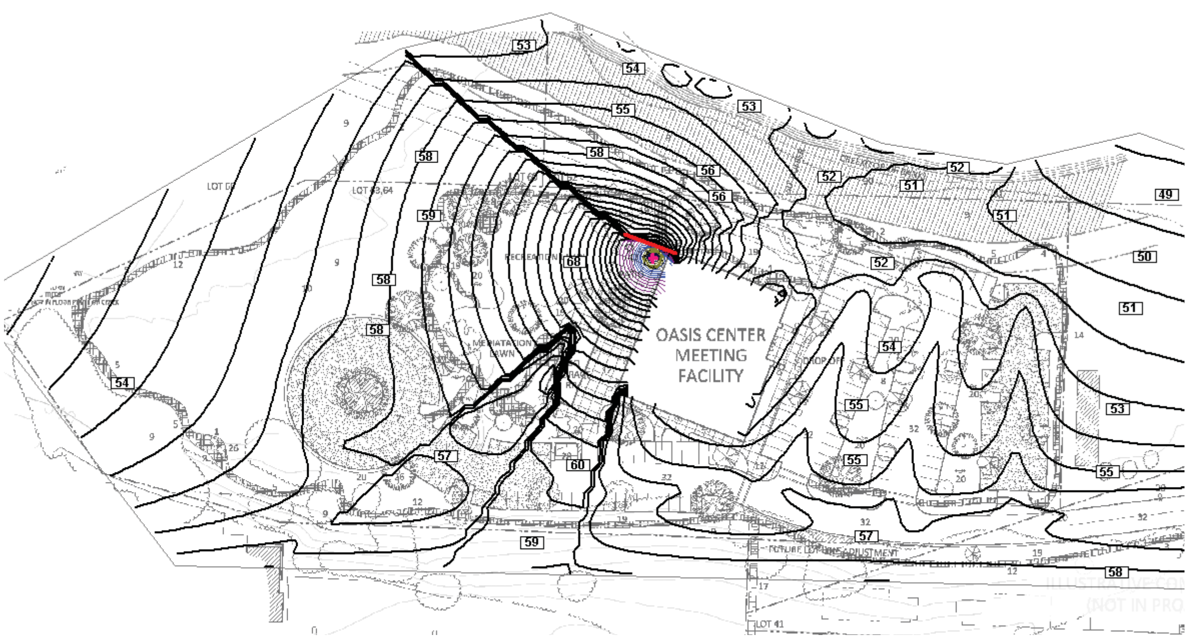


Figure 12. Speaker Location Zone

The site plan with proposed zone for speaker location. Requires mitigated loudspeaker arrangement with sound barrier behind speaker to protect neighboring residential receptors from "line-of-sight" sound propagation. Sound level at speaker shall not exceed 88 dBA.

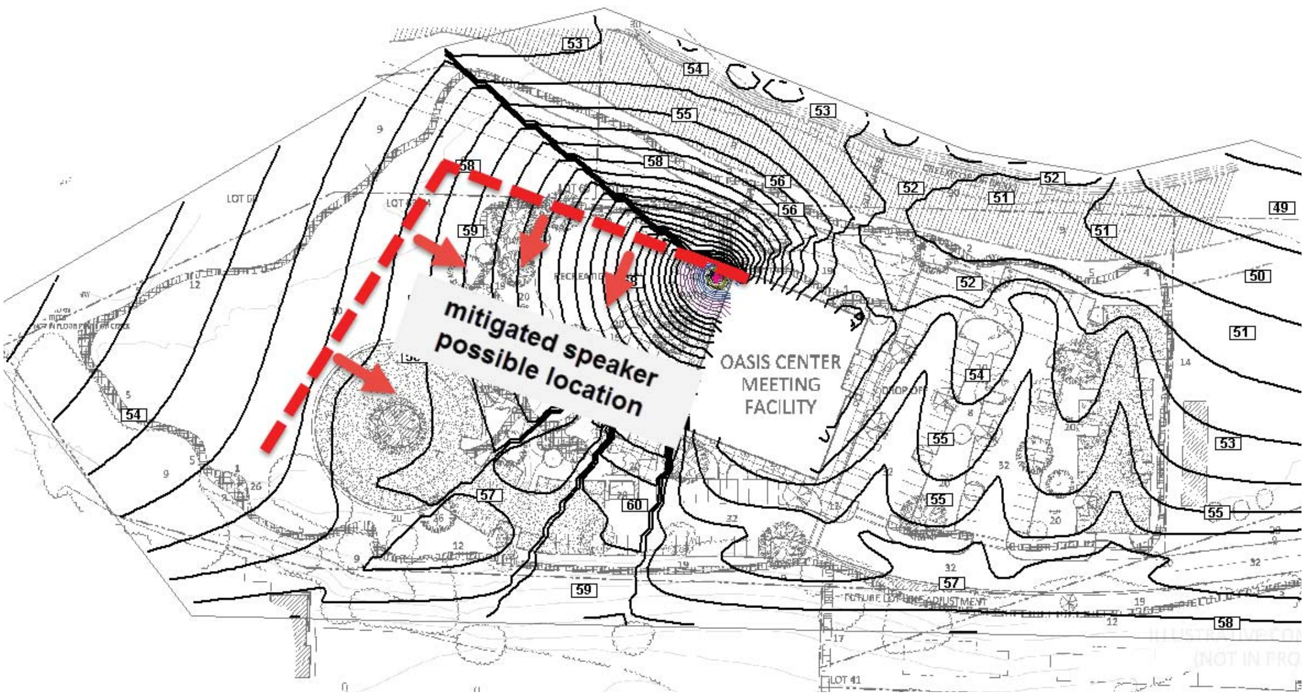


Figure 13. Amplified Sound Mitigation

Example configuration of solid noise barrier, top of barrier is one foot higher than top of speaker, and is 8 feet long. Noise barrier is located on the residential side of the speaker to prevent "line-of-sight" noise propagation. In this case the noise barrier is shown as laminated glass, however any solid material may be used.

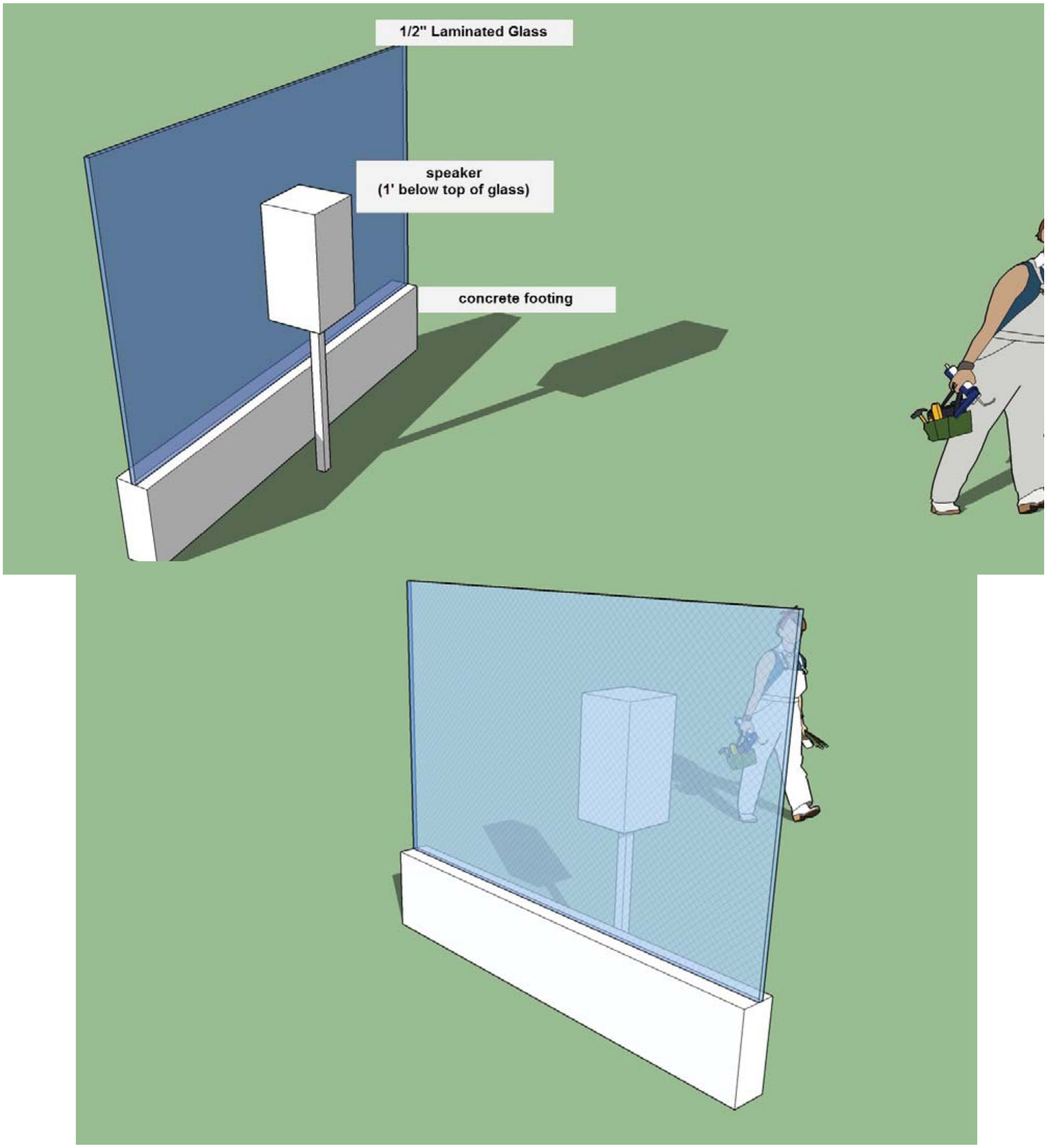
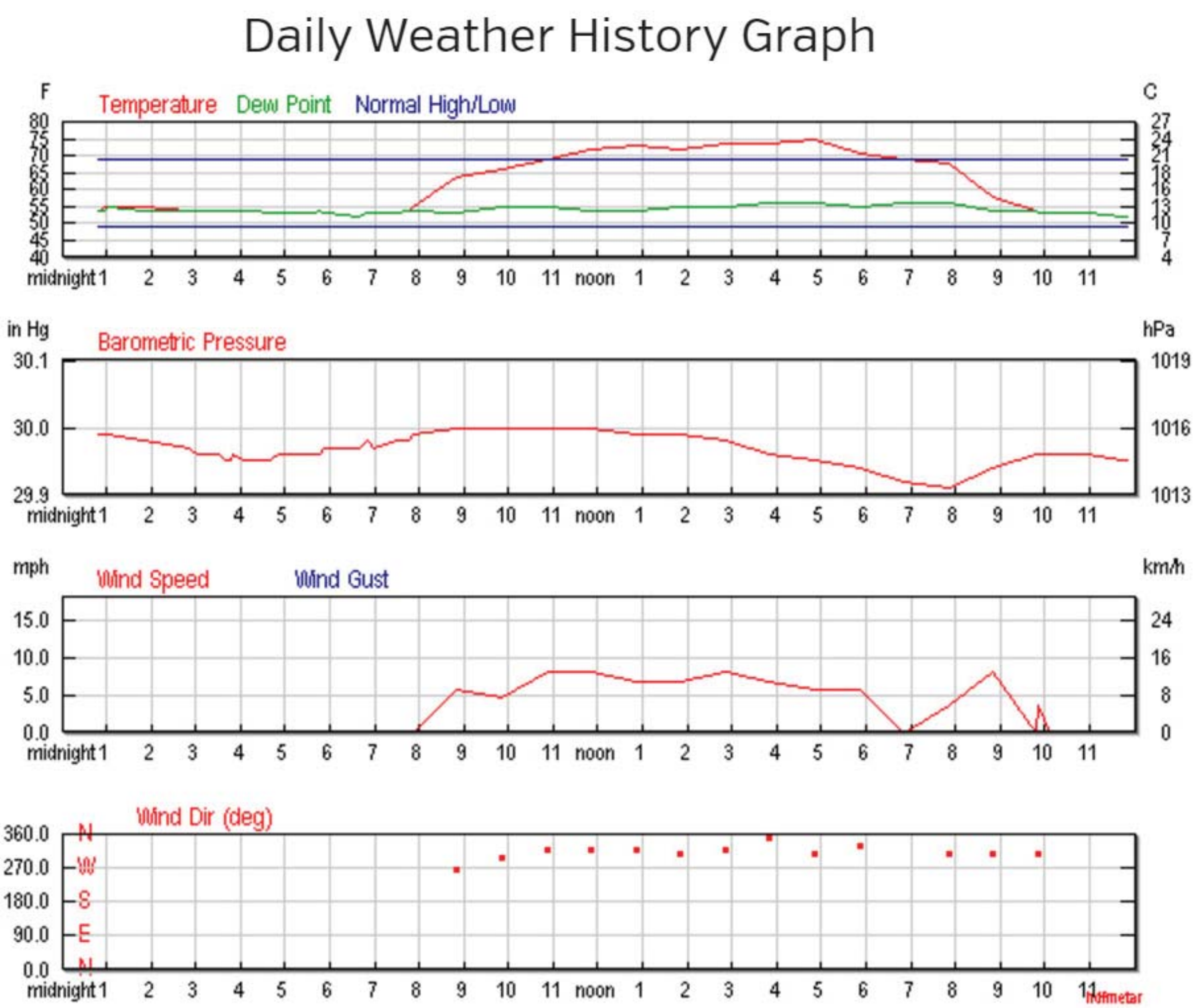


Figure 14. Average Weather Conditions

Sound measurement and sound propagation can be influenced by the wind speed and wind direction. The data graphed below represent average conditions at SMX, Santa Maria Public Airport, for June 3, 2016. During the time of measurement over a 24 hour period, wind speed was less than 10 mph from the southeast, and therefore had a less than significant impact on the measurement accuracy.



7.0 Sound and Vibration Fundamentals

7.1 Terminology / Noise Descriptors

Noise is most often defined as unwanted sound. Although sound can be easily and objectively measured, the perception of noise and the physical, subjective response to sound complicate the analysis of its impact on people. People judge the relative magnitude of sound sensation in subjective terms such as “noisiness” or “loudness.”

The following are brief definitions of terminology used in this report:

- Sound. A disturbance created by a vibrating object, which, when transmitted by pressure waves through a medium such as air, is capable of being detected by a receiving mechanism, such as the human ear or a microphone.
- Noise. Sound that is loud, unpleasant, unexpected, or otherwise undesirable.
- Decibel (“dB”). A unitless measure of sound on a logarithmic scale.
- A-Weighted Decibel (“dBA”). An overall frequency-weighted sound level in decibels that approximates the frequency response of the human ear.
- Equivalent Continuous Noise Level (“Leq”). The mean of the noise level averaged over the measurement period, regarded as an average level.
- Day-Night Level (“Ldn”). The energy average of the A-weighted sound levels occurring during a 24-hour period, with 10 dB added to the sound levels occurring during the period from 10:00 PM to 7:00 AM.
- Community Noise Equivalent Level (“CNEL”). The energy average of the A-weighted sound levels occurring during a 24-hour period with 5 dB added to the levels occurring during the period from 7:00 PM to 10:00 PM and 10 dB added to the sound levels occurring during the period from 10:00 PM to 7:00 AM.

Note that Ldn and CNEL values rarely differ by more than 1 dB. As a matter of practice, Ldn and CNEL values are considered to be equivalent and are treated as such in this assessment.

7.2 Characteristics of Sound

When an object vibrates, it radiates part of its energy as acoustical pressure in the form of a sound wave. Sound can be described in terms of amplitude (loudness), frequency (pitch), or duration (time). The human hearing system is not equally sensitive to sound at all frequencies. Therefore, to approximate this human, frequency-dependent response, the A-weighted filter system is used to adjust measured soundlevels. The normal range of human hearing extends from approximately 0 dBA to 140 dBA.Unlike linear units such as inches or pounds, decibels are measured on a logarithmic scale, representingpoints on a sharply rising curve. Because of the physical characteristics of noise transmission and of noiseperception, the relative loudness of sound does not closely match the actual amounts of sound energy.

"Table 3." below presents the subjective effect of changes in sound pressure levels.

Table 2. Decibel Changes

Decibel Changes, Loudness, Energy Loss		
Sound level change	***Relative Loudness***	***Acoustic Energy Loss***
0 dBA	Reference	0%
-3 dBA	Barely Perceptible Change	50%
-5 dBA	Readily Perceptible Change	67%
-10 dBA	Half as Loud	90%
-20 dBA	1/4 as Loud	99%
-30 dBA	1/8 as Loud	99.9%
Source: Highway Traffic Noise Analysis and Abatement Policy and Guidance, U.S. Department of Transportation, Federal Highway Administration, Office of Environment and Planning, Noise and Air Quality Branch, June 1995.		

Sound levels are generated from a source and their decibel level decreases as the distance from that source increases. Sound dissipates exponentially with distance from the noise source. This phenomenon is known as spreading loss. Generally, sound levels from a point source will decrease by 6.0 dBA for each doubling of distance. Sound levels for a highway line source vary differently with distance because sound pressure waves propagate along the line and overlap at the point of measurement. A closely spaced, continuous line of vehicles along a roadway becomes a line source and produces a 3.0 dBA decrease in sound level for each doubling of distance. However, experimental evidence has shown that where sound from a highway propagates close to "soft" ground (e.g., plowed farmland, grass, crops, etc.), a more suitable drop-off rate to use is not 3.0 dBA but rather 4.5 dBA per distance doubling (FHWA 2010).

When sound is measured for distinct time intervals, the statistical distribution of the overall sound level during that period can be obtained. The Leq is the most common parameter associated with such measurements. The Leq metric is a single-number noise descriptor that represents the average sound level over a given period of time. For example, the L50 noise level is the level that is exceeded 50 percent of the time. This level is also the level that is exceeded 30 minutes in an hour. Similarly, the L02, L08 and L25 values are the noise levels that are exceeded 2, 8, and 25 percent of the time or 1, 5, and 15 minutes per hour. Other values typically noted during a noise survey are the Lmin and Lmax. These values represent the minimum and maximum root-mean-square noise levels obtained over the measurement period.

Because community receptors are more sensitive to unwanted noise intrusion during the evening and at night, State law requires that, for planning purposes, an artificial dB increment be added to quiet-time noise levels in a 24-hour noise descriptor called the CNEL or Ldn. This increment is incorporated in the calculation of CNEL or Ldn, described earlier.

7.3 Characteristics of Vibration

Vibration is an oscillatory motion through a solid medium in which the motion's amplitude can be described in terms of displacement, velocity, or acceleration. Vibration is normally associated with activities such as railroads or vibration-intensive stationary sources, but can also be associated with construction equipment such as jackhammers, pile drivers, and hydraulic hammers. Vibration displacement is the distance that a point on a surface moves away from its original static position. The instantaneous speed that a point on a surface moves is described as the velocity and the rate of change of the speed is described as the acceleration. Each of these descriptors can be used to correlate vibration to building damage, and acceptable equipment vibration levels.

During construction of a development project, the operation of construction equipment can cause groundborne vibration. During the operational phase of a project, receptors may experience annoyance due to noise generated from vibration of a structure or items within a structure. This type of vibration is best measured in velocity and acceleration.

The three main wave types of concern in the propagation of groundborne vibrations are surface or Rayleigh waves, compression or P-waves, and shear or S-waves.

- Surface or Rayleigh waves travel along the ground surface. They carry most of their energy along an expanding cylindrical wave front, similar to the ripples produced by throwing a rock into a lake. The particle motion is more or less perpendicular to the direction of propagation (known as retrograde elliptical).

- Compression or P-waves are body waves that carry their energy along an expanding spherical wave front. The particle motion in these waves is longitudinal, in a push-pull motion. P-waves are analogous to airborne sound waves.

- Shear or S-waves are also body waves, carrying their energy along an expanding spherical wave front. Unlike P-waves, however, the particle motion is transverse, or perpendicular to the direction of propagation.

The peak particle velocity ("PPV") or the root mean square ("RMS") velocity is usually used to describe vibration amplitudes. PPV is defined as the maximum instantaneous peak of the vibration signal and RMS is defined as the square root of the average of the squared amplitude of the signal. PPV is more appropriate for evaluating potential building damage.

The units for PPV velocity is normally inches per second (in/sec). Often, vibration is presented and discussed in dB units in order to compress the range of numbers required to describe the vibration. In this study, all PPV and RMS velocity levels are in in/sec and all vibration levels are in dB relative to one microinch per second (abbreviated as VdB). Typically, groundborne vibration generated by human activities attenuates rapidly with distance from the source of the vibration. Even the more persistent Rayleigh waves decrease relatively quickly as they move away from the source of the vibration. Human-made vibration problems are, therefore, usually confined to short distances (500 feet or less) from the source.

Construction operations generally include a wide range of activities that can generate groundborne vibration. In general, blasting and demolition of structures generate the highest vibrations. Vibratory compactors or rollers, pile drivers, and pavement breakers can generate perceptible amounts of vibration at distances within 200 feet of the vibration sources. Heavy trucks can also generate groundborne vibrations, which vary depending on vehicle type, weight, and pavement conditions. Potholes, pavement joints, discontinuities, differential settlement of pavement, etc., all increase the vibration levels from vehicles passing over a road surface. Construction vibration is normally of greater concern than vibration of normal traffic on streets and freeways with smooth pavement conditions. Trains generate substantial quantities of vibration due to the mass and momentum of their engines, vibration transmission from steel wheels to steel track, and heavy loads.

Table 3. Construction Equipment Vibration Levels

Equipment	Peak Particle Velocity (inches/second) at 25 feet	Approximate Vibration Level (L_V) at 25 feet
Pile driver (impact)	1.518 (upper range) 0.644 (typical)	112 104
Pile driver (sonic)	0.734 upper range 0.170 typical	105 93
Clam shovel drop (slurry wall)	0.202	94
Hydromill (slurry wall)	0.008 in soil 0.017 in rock	66 75
Vibratory Roller	0.210	94
Hoe Ram	0.089	87
Large bulldozer	0.089	87
Caisson drill	0.089	87
Loaded trucks	0.076	86
Jackhammer	0.035	79
Small bulldozer	0.003	58
Source: Transit Noise and Vibration Impact Assessment, Federal Transit Administration, May 2006.		

8.0 Appendix: Glossary of Acoustical Terms

A-Weighted Sound Level (dBA)

The sound pressure level in decibels as measured on a sound level meter using the internationally standardized A-weighting filter or as computed from sound spectral data to which A-weighting adjustments have been made. A-weighting de-emphasizes the low and very high frequency components of the sound in a manner similar to the response of the average human ear. A-weighted sound levels correlate well with subjective reactions of people to noise and are universally used for community noise evaluations.

Airborne Sound

Sound that travels through the air, differentiated from structure-borne sound.

Ambient Sound Level

The prevailing general sound level existing at a location or in a space, which usually consists of a composite of sounds from many sources near and far. The ambient level is typically defined by the Leq level.

Background Sound Level

The underlying, ever-present lower level noise that remains in the absence of intrusive or intermittent sounds. Distant sources, such as traffic, typically make up the background. The background level is generally defined by the L90 percentile noise level.

Community Noise Equivalent Level (CNEL)

The Leq of the A-weighted noise level over a 24-hour period with a 5 dB penalty applied to noise levels between 7 p.m. and 10 p.m. and a 10 dB penalty applied to noise levels between 10 p.m. and 7 a.m.

Day-Night Sound Level (Ldn)

The Leq of the A-weighted noise level over a 24-hour period with a 10 dB penalty applied to noise levels between 10 p.m. and 7 a.m.

Decibel (dB)

The decibel is a measure on a logarithmic scale of the magnitude of a particular quantity (such as sound pressure, sound power, sound intensity) with respect to a reference quantity.

DBA or dB(A)

A-weighted sound level. The ear does not respond equally to all frequencies, but is less sensitive at low and high frequencies than it is at medium or speech range frequencies. Thus, to obtain a single number representing the sound level of a noise containing a wide range of frequencies in a manner representative of the ear's response, it is necessary to reduce the effects of the low and high frequencies with respect to the medium frequencies. The resultant sound level is said to be A-weighted, and the units are dBA. The A-weighted sound level is also called the noise level.

Energy Equivalent Level (LEQ)

Because sound levels can vary markedly in intensity over a short period of time, some method for describing either the average character of the sound or the statistical behavior of the variations must be utilized. Most commonly, one describes ambient sounds 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 LEQ. In this report, an hourly period is used.

Field Sound Transmission Class (FSTC)

A single number rating similar to STC, except that the transmission loss values used to derive the FSTC are measured in the field. All sound transmitted from the source room to the receiving room is assumed to be through the separating wall or floor-ceiling assembly.

Outdoor-Indoor Transmission Class (OITC)

A single number classification, specified by the American Society for Testing and Materials (ASTM E 1332 issued 1994), that establishes the A-weighted sound level reduction provided by building facade components (walls, doors, windows, and combinations thereof), based upon a reference sound spectra that is an average of typical air, road, and rail transportation sources. The OITC is the preferred rating when exterior facade components are exposed to a noise environment dominated by transportation sources.

Percentile Sound Level, Ln

The noise level exceeded during *n* percent of the measurement period, where *n* is a number between 0 and 100 (e.g., L10 or L90)

Sound Transmission Class (STC)

STC is a single number rating, specified by the American Society for Testing and Materials, which can be used to measure the sound insulation properties for comparing the sound transmission capability, in decibels, of interior building partitions for noise sources such as speech, radio, and television. It is used extensively for rating sound insulation characteristics of building materials and products.

Structure-Borne Sound

Sound propagating through building structure. Rapidly fluctuating elastic waves in gypsum board, joists, studs, etc.

Sound Exposure Level (SEL)

SEL is the sound exposure level, defined as a single number rating indicating the total energy of a discrete noise-generating event (e.g., an aircraft flyover) compressed into a 1-

second time duration. This level is handy as a consistent rating method that may be combined with other SEL and Leq readings to provide a complete noise scenario for measurements and predictions. However, care must be taken in the use of these values since they may be misleading because their numeric value is higher than any sound level which existed during the measurement period.

Subjective Loudness Level

In addition to precision measurement of sound level changes, there is a subjective characteristic which describes how most people respond to sound:

•A change in sound level of 3 dBA is *barely perceptible* by most listeners.

•A change in level of 6 dBA is *clearly perceptible*.

•A change of 10 dBA is perceived by most people as being *twice* (or *half*) as loud.

9.0 Measurements, Calculations and Modeling

9.1 Wind Measurement

Sound level measurements become less reliable when average wind speed is greater than 11 m.p.h. at the measurement site. Therefore, wind speed and direction were measured periodically at the measurement site and the results are correlated with wind data from a nearby established weather station. A Larson Davis WS 001 windscreen is used as wind protection for all microphones and is left in place at all times.

Wind speed and direction were noted throughout the measurement period and compared with data from the nearby National Weather Service weather station at Santa Maria Airport. A Davis Turbo Wind meter was used to measure wind speed at the measurement site to cross-check wind speeds at the airport. The Turbo Wind meter is a high performance wind speed indicator with exceptional accuracy.

9.2 Precision of Sound Level Meters.

The American National Standards Institute (ANSI) specifies several types of sound level meters according to their precision. Types 1,2, and 3 are referred to as “precision,” “general purpose,” and “survey” meters, respectively. Most measurements carefully taken with a type 1 sound level meter will have an error not exceeding 1 dB. The corresponding error for a type 2 sound level meter is about 2 dB.

The sound level meters used for measurements shown in this report are Larson-Davis Laboratories Model 820, and Norsonic Model 140. These sound level meters meet all requirements of ANSI s1.4, IEC 651 for Type 1 accuracy and include the following features: 110 dB dynamic range for error free measurements. Measures FAST, SLOW, Unweighted PEAK, Weighted PEAK, Impulse, Leq, LDOD, LOSHA, Dose, Time Weighted Average, SEL, Lmax, Lmin, Ldn. Time history sampling periods from 32 samples per second up to one sample every 255 seconds.

Field calibration of each sound level meter with an external Type 1 calibrator is accomplished before and after all field measurements. Laboratory calibration accuracy of the all instruments can be traced to the U.S. National Institute of Science and Technology standard.

9.3 Sound Level Measurement Method

The accepted method for conducting sound level measurements is described in detail by the American Society for Testing and Materials (ASTM) in their E 1014 “Measurement of Outdoor A-Weighted Sound Levels”publication and the CalTrans Traffic Noise Analysis Protocol. The procedures and standards in those documents are met or exceeded for sound level measurements shown in this report. The standards of ASTM E 1014 are exceeded by using Type 1 sound level meters for all measurements in this report instead of the less accurate Type 2 meters. Therefore, the precision of the measurements in this report is likely to be better than +/- 2 dB as stated in ASTM E1014. Particular and specific local sound sources are identified by listening to synchronous audio recordings of peak sound level events.

Caltrans Noise Measurement Guidelines: Caltrans makes available general guidelines for taking into account environmental elements in noise measurements. The following is an excerpt from their guidelines. The Traffic Noise Analysis Protocol contains Caltrans noise policies, which fulfill the highway noise analysis and abatement/mitigation requirements stemming from the following State and Federal environmental statutes:

- California Environmental Quality Act (CEQA)
- National Environmental Policy Act (NEPA)
- Title 23 United States Code of Federal Regulations, Part 772 “Procedures for Abatement of Highway Traffi c Noise and Construction Noise” (23 CFR 772)
- Section 216 et seq. of the California Streets and Highways Code

Noise Contour Modeling

Noise contours incorporating the measured sound level values were generated for this assessment using an acoustical modeling program that is in conformance with the TNM 2.5 algorithms, and which was developed to predict hourly Leq values for free-flowing traffic conditions. This computer modeling tool is an internationally accepted acoustical modeling software program, used by many acoustics and noise control professional offices in the U.S. and abroad. The software has been validated by comparison with actual values in many different settings. The program has a high level of reliability and follows methods specified by the International Standards Organization in their ISO 9613-2 standard, “Acoustics – Attenuation of sound during propagation outdoors, Part 2: General Method of Calculation.” The standard states that, “this part of ISO 9613 specifies an engineering method for calculating the attenuation of sound during propagation outdoors in order to predict the levels of environmental noise at a distance from a variety of sources. The method predicts the equivalent continuous A-weighted sound pressure level under meteorological conditions favorable to propagation from sources of known sound emissions. These conditions are for downwind propagation under a well-developed moderate ground-based temperature inversion, such as commonly occurs at night.”

The computer modeling software takes into account source sound power levels, surface reflection and absorption, atmospheric absorption, geometric divergence, meteorological conditions, walls, barriers, berms, and terrain variations. The software uses a calculated grid of receivers covering the project site, from which it generates accurate sound level contour maps.

10.0 References

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