EXTERIOR NOISE ANALYSIS REPORT

PALM AND HOLLISTER
SAN DIEGO, CA

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SUMMARY

This report estimates noise affecting and produced by the proposed Palm and Hollister project. The project site is located north of Palm Avenue and east of Hollister Street and the San Diego & Arizona Eastern (SD&AE) Railroad line, in the Otay Mesa-Nestor Community Plan area of the City of San Diego (City), California. The project would entail the construction of 198 residential apartments in thirteen three-story buildings and a recreation / leasing building. The outdoor recreation areas are proposed within the courtyards of Building 1 and Building 3, as well as to the north of Building 5. The primary noise sources in the project vicinity are freight & light rail operations, and roadway traffic on Interstate 5 (I-5).

Future exterior composite noise levels at the proposed project site would range from less than 60 A-weighted decibels (dBA) Community Equivalent Noise Level (CNEL) at the east façade of Building 5 to approximately 73 dBA CNEL at the west façade of the recreation / leasing building. Future exterior noise levels at all required outdoor spaces in the project would be 65 dBA CNEL or below, and would be considered "less than significant" by the City.

Because future exterior noise levels would exceed 60 dBA CNEL at some project building façades, interior noise levels in occupied areas could exceed the City of San Diego General Plan Noise Compatibility Guidelines and California Building Code (CBC) Section 1206.4 limit of 45 dBA CNEL in residences.

To avoid a potential land use impact, as a condition of project approval, an interior noise analysis would be required to be approved by the City's Building Inspection Department upon application for a building permit. This interior noise analysis must identify the sound transmission loss requirements for building façade elements (windows, walls, doors, and exterior wall assemblies) necessary to limit interior noise to 45 dBA CNEL in habitable residential rooms. Upgraded windows and/or doors with Sound Transmission Class (STC) ratings of 35 or higher may be necessary. If the interior noise limit can be achieved only with the windows closed, the building design must include mechanical ventilation that meets CBC requirements.

With the implementation of the findings of the interior noise analysis, interior noise levels would be 45 dBA CNEL or below in residences, and the project would comply with the City of San Diego General Plan Noise Compatibility Guidelines and the CBC Section 1206.4 requirement. The project would result in a less than significant interior noise impact with project features incorporated in accordance with the interior noise analysis.

Project traffic would result in a noise increase from 50 dBA CNEL to 53 dBA CNEL at some offsite land uses, and a noise increase of less than 1 dBA CNEL at all other offsite land uses. These levels and increases are considered less than significant by the City California Environmental Quality Act (CEQA) Significance Determination Thresholds.

The surrounding areas are zoned as single-family, multi-family, agricultural and industrial, with the most restrictive Municipal Code Section 59.5.401 nighttime noise limit of 42.5 dBA equivalent continuous sound level (Leq) at the property line to the south. Project operation would generate noise levels up to 36 dBA Leq at its property lines. Project-generated operational noise impacts would be less than significant.

Noise-sensitive adjacent land uses include residential (La Palma Mobile Estates) to the south, well as the Ocean View Christian Academy school to the south. Project construction would generate noise levels up to 71 dBA Leq at residential property lines. As this is below the City's construction noise limit of 75 dBA, project construction noise impacts would be less than significant.

The project site is exposed to aircraft noise levels less than 60 dBA CNEL from operations associated with the Naval Outlying Landing Field (NOLF) [Wyle 2010], the Brown Field Municipal Airport [SDALUC 2010], and the Tijuana International Airport [Landrum & Brown 2002].

The northern portion of the site is mapped within the Multiple-Habitat Planning Area (MHPA) of the Multiple Species Conservation Program Subarea Plan (MSCP). The MHPA, which is north of the project site, is already subject to noisy uses such as the trolley and vehicular use of Hollister Street that create noise. Noise generated from the use of project amenities is not expected to be excessive or long lasting, and there are no sensitive species breeding areas in the adjacent MHPA. Vehicular access to the project would be from the south and not adjacent to the MHPA. Therefore, the project is in conformance with this Land Use Adjacency Guideline [Alden Environmental, Inc. 2022].

1.0 INTRODUCTION

1.1 PURPOSE OF THE REPORT

The purpose of this report is to evaluate noise affecting and produced by the proposed Palm and Hollister project.

1.2 PROJECT LOCATION

The project site is located north of Palm Avenue and east of Hollister Street and the SD&AE Railroad line, in the Otay Mesa-Nestor Community Plan area of the City of San Diego (Figure 1).

1.3 PROJECT DESCRIPTION

The Palm & Hollister project is located on a 5.92-acre site in the Otay Mesa-Nestor Community Plan area, situated north of the Palm Avenue Trolley Station, south of the Otay Valley Regional Park, and east of Hollister Avenue. The project site has been previously graded and is undeveloped, except for a vacant residential structure and out-buildings.

Located within a Transit Priority Area, the Palm & Hollister project proposes development of multi-family housing proximate to the Palm Avenue Trolley Station. A total of 198 residential units, including eight affordable housing units, would be provided in 13 buildings. The unit mix would include one bedroom/one bath, two bedroom/two bath, and three bedroom/two bath units. Buildings would be one to three stories with tuck-under garages, as well as one-level units over carports. The main resident amenities would be provided in the western and central portions of the project site. In addition to the residential buildings and as a separate stand-alone building, residential amenities in the western portion of the project site would feature a pool, spa, fire pit, patio/bar-b-que areas, fitness center, co-working spaces, and the leasing office. An additional resident amenity area would be provided in the central portion of the project site, incorporated as an open courtyard in the center of the largest building. Situated to take advantage of views into the Otay Valley Regional Park located north of the project site, this resident amenity would feature a bar-b-que pavilion, fire table, turf area incorporating a nature playground, game courts, and sofa seating areas. A pedestrian landscaped walkway along the top of the northern slope provides views of the river valley and a continuous connection from the residential buildings to the project amenity areas. A total of 262 parking spaces would be provided as individual tuck-under garages, carports, and surface spaces.

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FIGURE 1
Vicinity Map

Approximately 5.5 acres of the 5.92-acre project site would be graded. Grading would involve approximately 15,000 cubic yards of cut and approximately 38,500 cubic yards of fill, with approximately 23,500 cubic yards of import. In addition, remedial grading would involve 67,000 cubic yards of excavation to depths of 17 feet.

Vehicular access to the project would be from the south along in the western portion of the project site via an existing access easement through property owned by the Metropolitan Transit System (MTS). Pedestrian access to the Palm Avenue Trolley Station and Palm Avenue would also be provided within the access easement.

The proposed project requires an amendment to the Otay Mesa-Nestor Community Plan to change the existing land use designation from Open Space to Residential Medium-High Density (20-35 du/nra) and a Rezone to change the existing zone from AR-1-2, RM-1-1, and RS-1-5 to RM-2-6. A Rezone requires the proposed project analyze the most intensive use permitted under the new zone. Under the proposed RM-2-6 zone, the most intensive use has been determined to be a multi-family residential development of up to 206 dwelling units. This equates to an additional eight dwelling units compared to the proposed project of 198 dwelling units.

Approximately 5.5 acres of the 5.92-acre project site would be graded. Grading would involve approximately 15,000 cubic yards of cut and approximately 38,500 cubic yards of fill, with approximately 23,000 cubic yards of import.

Vehicular access to the project would be from the south along in the western portion of the project site via an existing access easement through property owned by the Metropolitan Transit System (MTS). Pedestrian access to the Palm Avenue Trolley Station and Palm Avenue would also be provided within the access easement.

The project would require an amendment to the Otay Mesa-Nestor Community Plan to change the existing land use designation from Open Space to Residential Medium-High Density (20 - 35 du/acre) and a Rezone to change the existing zone from AR-1-2, RM-1-1, and RS-1-5 to RM-2-6. Additionally, the project proposes a Vesting Tentative Map, a Neighborhood Development Permit to allow deviations from the RM-2-6 zone.

A Rezone requires the proposed project analyze the most intensive use permitted under the new zone. Under the proposed RM-2-6 zone, the project site could be developed with up to 206 dwelling units. This equates to an additional eight dwelling units compared to the proposed project, which proposes construction of a total of 198 dwelling units.

Palm and Hollister
Exterior Noise Analysis

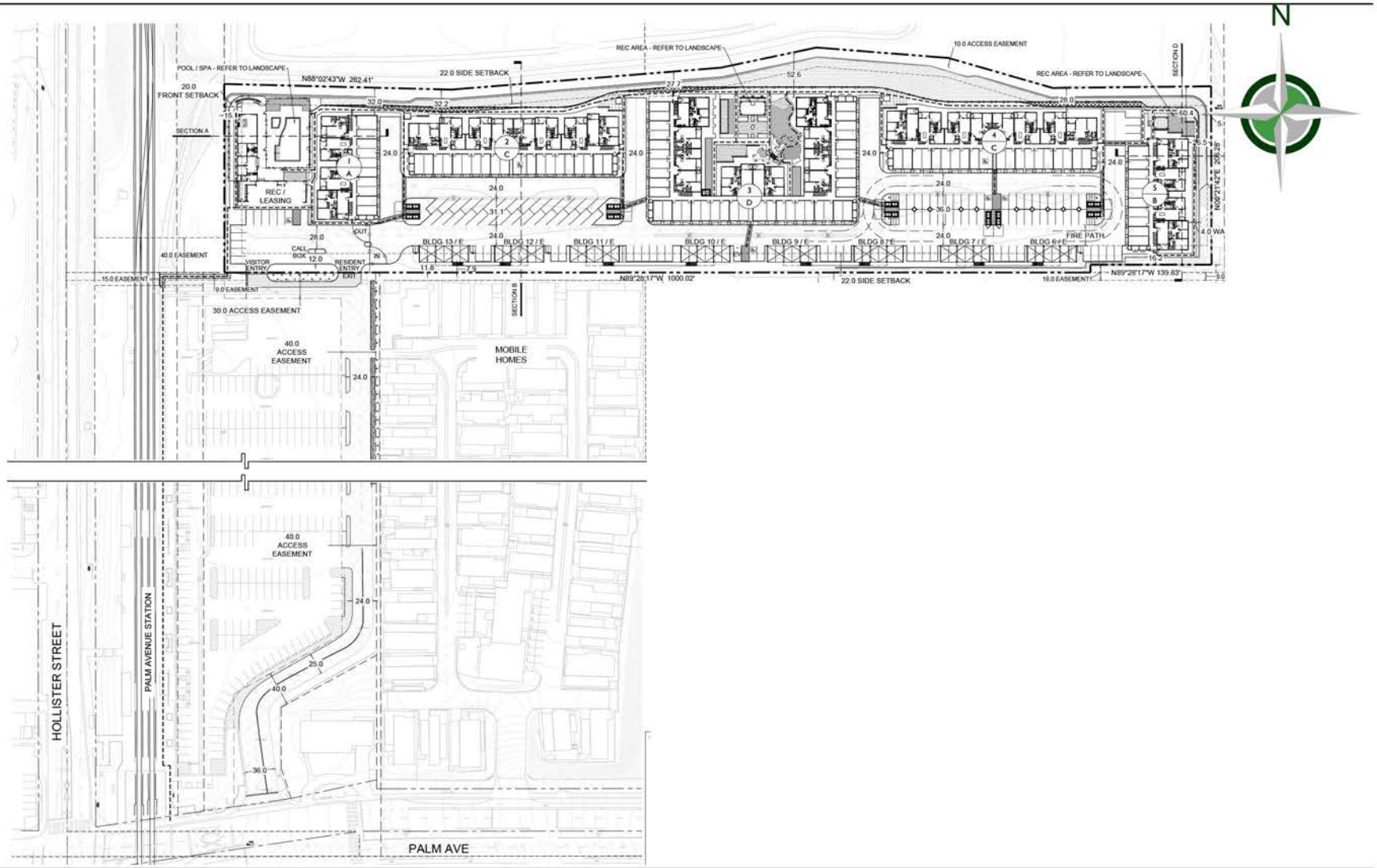

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FIGURE 2
Site Plan

1.4 NOISE BACKGROUND

Noise is generally defined as loud, unpleasant, unexpected, or undesired sound that is typically associated with human activity and that interferes with or disrupts normal activities. The human environment is characterized by a certain consistent noise level that varies by location and is termed ambient noise. Although exposure to high noise levels has been demonstrated to cause hearing loss, the principal human response to environmental noise is annoyance. The response of individuals to similar noise events is diverse and influenced by the type of noise, perceived importance of the noise and its appropriateness in the setting, time of day and type of activity during which the noise occurs, and sensitivity of the individual.

Sound is a physical phenomenon consisting of minute vibrations that travel through a medium, such as air, and are sensed by the human ear. Sound is generally characterized by several variables, including frequency and intensity. Frequency describes the sound's pitch and is measured in cycles per second, or hertz (Hz), whereas intensity describes the sound's loudness and is measured in decibels (dB). Decibels are measured using a logarithmic scale. A sound level of 0 dB is approximately the threshold of human hearing and is barely audible under extremely quiet listening conditions. Normal speech has a sound level of approximately 60 dB. Sound levels above about 120 dB begin to be felt inside the human ear as discomfort and eventually as pain at still higher levels. The minimum change in the sound level of individual events that an average human ear can detect is about 3 dB. The average person perceives a change in sound level of about 10 dB as a doubling (or halving) of the sound's loudness; this relation holds true for sounds of any loudness. Sound levels of typical noise sources and environments are provided in Table 1.

Because of the logarithmic nature of the decibel unit, sound levels cannot be added or subtracted directly and are somewhat cumbersome to handle mathematically. A simple rule is useful, however, in dealing with sound levels. If a sound's intensity is doubled, the sound level increases by 3 dB, regardless of the initial sound level. Thus, for example, 60 dB + 60 dB = 63 dB, and 80 dB + 80 dB = 83 dB.

The normal human ear can detect sounds that range in frequency from about 20 Hz to 20,000 Hz. However, all sounds in this wide range of frequencies are not heard equally well by the human ear, which is most sensitive to frequencies in the range of 1,000 Hz to 4,000 Hz. This frequency dependence can be taken into account by applying a correction to each frequency range to approximate the human ear's sensitivity within each range. This is called A-weighting and is commonly used in measurements of community environmental noise. The A-weighted sound pressure level (abbreviated as dBA) is the sound level with the "A-weighting" frequency correction. In practice, the level of a noise source is conveniently measured using a sound level meter that includes a filter corresponding to the dBA curve.

Table 1. Sound Levels of Typical Noise Sources and Noise Environments

Noise Source (at Given Distance)	Noise Environment	A-Weighted Sound Level	Human Judgment of Noise Loudness (Relative to Reference Loudness of 70 Decibels*)
Military Jet Takeoff with Afterburner (50 ft)	Carrier Flight Deck	140 Decibels	128 times as loud
Civil Defense Siren (100 ft)		130	64 times as loud
Commercial Jet Take-off (200 ft)		120	32 times as loud **Threshold of Pain**
Pile Driver (50 ft)	Rock Music Concert Inside Subway Station (New York)	110	16 times as loud
Ambulance Siren (100 ft) Newspaper Press (5 ft) Gas Lawn Mower (3 ft)		100	8 times as loud **Very Loud**
Food Blender (3 ft) Propeller Plane Flyover (1,000 ft) Diesel Truck (150 ft)	Boiler Room Printing Press Plant	90	4 times as loud
Garbage Disposal (3 ft)	Noisy Urban Daytime	80	2 times as loud
Passenger Car, 65 mph (25 ft) Living Room Stereo (15 ft) Vacuum Cleaner (10 ft)	Commercial Areas	70	Reference Loudness **Moderately Loud**
Normal Speech (5 ft) Air Conditioning Unit (100 ft)	Data Processing Center Department Store	60	1/2 as loud
Light Traffic (100 ft)	Large Business Office Quiet Urban Daytime	50	1/4 as loud
Bird Calls (distant)	Quiet Urban Nighttime	40	1/8 as loud **Quiet**
Soft Whisper (5 ft)	Library and Bedroom at Night Quiet Rural Nighttime	30	1/16 as loud
	Broadcast and Recording Studio	20	1/32 as loud **Just Audible**
		0	1/64 as loud **Threshold of Hearing**

Source: Compiled by dBF Associates, Inc.

A metric known as the Community Noise Equivalent Level (CNEL) an adjusted average A-weighted sound level for a 24-hour day. It is calculated by adding a 5-dB adjustment to sound levels during evening hours (7:00 p.m. to 10:00 p.m.) and a 10-dB adjustment to sound levels during nighttime hours (10:00 p.m. to 7:00 a.m.). These adjustments compensate for the increased sensitivity to noise during the typically quieter evening and nighttime hours. CNEL is used by the State of California and City of San Diego to evaluate land-use compatibility with regard to noise.

Another metric known as the Day-Night Average Sound Level (Ldn or DNL) is an adjusted average A-weighted sound level for a 24-hour day. It is calculated by adding a 10-dB adjustment to sound levels during nighttime hours (10:00 p.m. to 7:00 a.m.). These adjustments compensate for the increased sensitivity to noise during the typically quieter nighttime hours. DNL is generally considered interchangeable with CNEL.

Sound Transmission Class (STC) is a single-number rating of the effectiveness of a material or construction assembly to impede the transmission of airborne sound.

Sound Exposure Level (SEL) is the total sound energy of a measurement normalized to a one-second time duration.

2.0 APPLICABLE STANDARDS

2.1 FEDERAL

There are no federal standards applicable to this project.

2.2 STATE OF CALIFORNIA

California Building Code (CBC), Chapter 12: Interior Environment, Section 1206: Sound Transmission regulates noise levels in buildings with multiple habitable units [State of California 2019]. Relevant portions are reproduced below.

> 1206.4 Allowable interior noise levels. Interior noise levels attributable to exterior sources shall not exceed 45 dB in any habitable room. The noise metric shall be either the day-night average sound level (Ldn) or the community noise equivalent level (CNEL), consistent with the noise element of the local general plan.

2.3 LOCAL

2.3.1 City of San Diego General Plan

The City of San Diego requires new projects to meet noise level standards as established in the Noise Element of the General Plan [City of San Diego 2008, Amended 2015: Policy NE-A.4]. These standards are shown in Table NE-3: Land Use – Noise Compatibility Guidelines (Table 2 of this report).

Noise-sensitive land uses include, but are not necessarily limited to residential uses, hospitals, nursing facilities, intermediate care facilities, child educational facilities, libraries, museums, and child care facilities.

Noise-sensitive land uses in the project vicinity include the homes in the La Palma Mobile Estates development, one single-family residence, and the Ocean View Christian Academy (Midway Baptist School) to the south, and single-family residences across Hollister Street to the northwest and southwest.

The project would consist of multi-family residential uses. In the Residential – Multiple Units land use category, noise levels up to 60 dBA CNEL are considered Compatible with outdoor use areas; noise levels up to 70 dBA CNEL are considered Conditionally Compatible. The building structure must attenuate exterior noise in occupied areas to 45 dBA CNEL or below.

Table 2. City of San Diego Land Use – Noise Compatibility Guidelines

Land Use Category	Exterior Noise Exposure (dBA CNEL)				
	60	65	70	75	
Parks and Recreational					
Parks, Active and Passive Recreation					
Outdoor Spectator Sports, Golf Courses; Water Recreational Facilities; Indoor Recreation Facilities					
Agricultural					
Crop Raising & Farming; Community Gardens, Aquaculture, Dairies; Horticulture Nurseries & Greenhouses; Animal Raising, Maintain & Keeping; Commercial Stables					
Residential					
Single Dwelling Units; Mobile Homes		45			
Multiple Dwelling Units **For uses affected by aircraft noise, refer to Policies NE-D.2. & NE-D.3.*		45	45*		
Institutional					
Hospitals; Nursing Facilities; Intermediate Care Facilities; Kindergarten through Grade 12Educational Facilities; Libraries; Museums; Child Care Facilities		45			
Other Educational Facilities including Vocational/Trade Schools and Colleges and Universities		45	45		
Cemeteries					
Retail Sales					
Building Supplies/Equipment; Food, Beverages & Groceries; Pets & Pet Supplies; Sundries Pharmaceutical, & Convenience Sales; Wearing Apparel & Accessories			50	50	
Commercial Services					
Building Services; Business Support; Eating & Drinking; Financial Institutions; Maintenance & Repair; Personal Services; Assembly & Entertainment (includes public and religious assembly); Radio & Television Studios; Golf Course Support			50	50	
Visitor Accommodations		45	45	45	
Offices					
Business & Professional; Government; Medical, Dental & Health Practitioner; Regional & Corporate Headquarters			50	50	
Vehicle and Vehicular Equipment Sales and Services Use					
Commercial or Personal Vehicle Repair & Maintenance; Commercial or Personal Vehicle Sales & Rentals; Vehicle Equipment & Supplies Sales & Rentals; Vehicle Parking					
Wholesale, Distribution, Storage Use Category					
Equipment & Materials Storage Yards; Moving & Storage Facilities; Warehouse; Wholesale Distribution					
Industrial					
Heavy Manufacturing; Light Manufacturing; Marine Industry; Trucking & Transportation Terminals; Mining & Extractive Industries					
Research & Development				50	

	Compatible	**Indoor Uses**	Standard construction methods should attenuate exterior noise to an acceptable indoor noise level. Refer to Section I.
		Outdoor Uses	Activities associated with the land use may be carried out.
45, 50	**Conditionally Compatible**	**Indoor Uses**	Building structure must attenuate exterior noise to the indoor noise level indicated by the number (45 or 50) for occupied areas. Refer to Section I.
		Outdoor Uses	Feasible noise mitigation techniques should be analyzed and incorporated t make the outdoor activities acceptable. Refer to Section I.
	Incompatible	**Indoor Uses**	New construction should not be undertaken.
		Outdoor Uses	Severe noise interference makes outdoor activities unacceptable.

2.3.2 City of San Diego CEQA Significance Thresholds

The City California Environmental Quality Act (CEQA) Significance Determination Thresholds [City of San Diego 2022] addresses traffic noise, as specified in Table K-2: Traffic Noise Significance Thresholds (dB(A) CNEL). Relevant portions are reproduced in Table 3 below.

Table 3. City of San Diego Traffic Noise Significance Thresholds (dBA CNEL)

Structure or Proposed Use that would be impacted by Traffic Noise	Interior Space	Exterior Useable Space †
Single-family detached	45 dB	65 dB
Multi-family, schools, libraries, hospitals, day care, hotels, motels, parks, convalescent homes	Development Services Department (DSD) ensures 45 dB pursuant to Title 24	65 dB
Offices, Churches, Business, Professional Uses	n/a	70 dB
Commercial, Retail, Industrial, Outdoor Spectator Sports Uses	n/a	75 dB

† If a project is currently at or exceeds the significance thresholds for traffic noise described above and the project would result in less than a 3 dB increase, then the impact is not considered significant.

The CEQA Significance Determination Thresholds also identify that construction noise that exceeds 75 dBA Leq at a sensitive receptor, or that would occur between 7 p.m. to 7 a.m. or on holidays would be considered significant. Additionally, construction noise that would substantially interfere with normal business communications or affect sensitive receptors may be significant.

2.3.3 City Municipal Code

2.3.3.1 Operational Noise

Operational noise within the City is governed by Municipal Code Section 59.5.401: Sound Level Limits.

> It shall be unlawful for any person to cause noise by any means to the extent that the one–hour average sound level exceeds the applicable limit given in the following table, at any location in the City of San Diego on or beyond the boundaries of the property on which the noise is produced. The noise subject to these limits is that part of the total noise at the specified location that is due solely to the action of said person.

TABLE OF APPLICABLE LIMITS

Land Use	Time of Day	One-Hour Average Sound Level (decibels)
1. Single Family Residential	7 a.m. to 7 p.m. 7 p.m. to 10 p.m. 10 p.m. to 7 a.m.	50 45 40
2. Multi-Family Residential (up to a maximum density of 1/2000)	7 a.m. to 7 p.m. 7 p.m. to 10 p.m. 10 p.m. to 7 a.m.	55 50 45
3. All other Residential	7 a.m. to 7 p.m. 7 p.m. to 10 p.m. 10 p.m. to 7 a.m.	60 55 50
4. Commercial	7 a.m. to 7 p.m. 7 p.m. to 10 p.m. 10 p.m. to 7 a.m.	65 60 60
5. Industrial or Agricultural	any time	75

The sound level limit at a location on a boundary between two zoning districts is the arithmetic mean of the respective limits for the two districts. Permissible construction noise level limits shall be governed by Section 59.5.0404 of this article.
…
(Amended 9-11-1989 by O-17337 N.S.)
(Amended 11-28-2005 by O-19446 N.S.; effective 2-9-2006.)

Note that the table refers to land use, not zoning, notwithstanding the term in the text following.

The project site would include multi-family residences, and would have a density higher than one unit per 2,000 square feet of lot area. Surrounding land uses include agricultural land, a school sports field, a parking lot, vacant land, a single-family residence, and a mobile home park with a density lower than one unit per 2,000 square feet of lot area. Noise limits for "all other residential" uses were considered applicable to the school land use.

At the south project property line shared with the mobile home park, the operational sound level limits would be:

- 57.5 dBA Leq during daytime hours (7:00 a.m. to 7:00 p.m.),
- 52.5 dBA Leq during evening hours (7:00 p.m. to 10:00 p.m.), and
- 47.5 dBA Leq during nighttime hours (10:00 p.m. to 7:00 a.m.).

At the south project property line shared with the single-family residence, the operational sound level limits would be:

- 55 dBA Leq during daytime hours (7:00 a.m. to 7:00 p.m.),
- 50 dBA Leq during evening hours (7:00 p.m. to 10:00 p.m.), and
- 45 dBA Leq during nighttime hours (10:00 p.m. to 7:00 a.m.).

At the south project property line shared with the school, the operational sound level limits would be:

- 60 dBA Leq during daytime hours (7:00 a.m. to 7:00 p.m.),
- 55 dBA Leq during evening hours (7:00 p.m. to 10:00 p.m.), and
- 50 dBA Leq during nighttime hours (10:00 p.m. to 7:00 a.m.).

2.3.3.2 Construction Noise

Construction noise within the City is governed by Municipal Code Section 59.5.0404: Construction Noise.

> It shall be unlawful for any person, between the hours of 7:00 p.m. of any day and 7:00 a.m. of the following day, or on legal holidays as specified in Section 21.04 of the San Diego Municipal Code, with exception of Columbus Day and Washington's Birthday, or on Sundays, to erect, construct, demolish, excavate for, alter or repair any building or structure in such a manner as to create disturbing, excessive or offensive noise unless a permit has been applied for and granted beforehand by the Noise Abatement and Control Administrator. In granting such permit, the Administrator shall consider whether the construction noise in the vicinity of the proposed work site would be less objectionable at night than during the daytime because of different population densities or different neighboring activities; whether obstruction and interference with traffic particularly on streets of major importance, would be less objectionable at night than during the daytime; whether the type of work to be performed emits noises at such a low level as to not cause significant disturbances in the vicinity of the work site; the character and nature of the neighborhood of the proposed work site; whether great economic hardship would occur if the work were spread over a longer time; whether proposed night work is in the general public interest; and he shall prescribe such conditions, working times, types of construction equipment to be used, and permissible noise levels as he deems to be required in the public interest.

Except as provided in subsection C. hereof, it shall be unlawful for any person, including The City of San Diego, to conduct any construction activity so as to cause, at or beyond the property lines of any property zoned residential, an average sound level greater than 75 decibels during the 12-hour period from 7:00 a.m. to 7:00 p.m.

The provisions of subsection B. of this section shall not apply to construction equipment used in connection with emergency work, provided the Administrator is notified within 48 hours after commencement of work.

(Amended 1-3-1984 by O-16100 N.S.)

2.3.3.3 Refuse Vehicles and Parking Lot Sweepers

Refuse vehicle and parking lot sweeper noise within the City is governed by Municipal Code Section 59.5.0406: Refuse Vehicles and Parking Lot Sweepers.

No person shall operate or permit to be operated a refuse compacting, processing, or collection vehicle between the hours of 7:00 p.m. to 6:00 a.m. or a parking lot sweeper between the hours of 7:00 p.m. to 7:00 a.m. in any residential area unless a permit has been applied for and granted by the Administrator.

("Refuse Vehicles" added 9-18-1973 by O-11122 N.S.; amended 9-22-1976 by O-11916 N.S.)
(Amended 6-9-2010 by O-19960 N.S.; effective 7-9-2010.)

2.3.4 Airport Land Use Compatibility Plans

The project site is within the Airport Influence Area of the Naval Outlying Landing Field (NOLF) Imperial Beach (FAA LID / IATA code: NRS). Other nearby airports are the Brown Field Municipal Airport (FAA LID: SDM) and the Tijuana International Airport (IATA code: TIJ).

2.3.5 Multiple Species Conservation Program Multi-Habitat Planning Area Land Use Adjacency Guidelines

The City's Multiple Species Conservation Program Subarea Plan (MSCP) was adopted by the City in March 1997 [City of San Diego 1997]. Multiple-Habitat Planning Area (MHPA) lands are large blocks of native habitat that have the ability to support a diversity of plant and animal life and, therefore, have been included within the City's MSCP for conservation. The MHPA also delineates core biological resource areas and corridors targeted for conservation as these lands have been determined to provide the necessary habitat quality, quantity, and connectivity to sustain the unique biodiversity of the San Diego region. The northern portion of the site is

mapped within the MHPA. Development adjacent to the MHPA must ensure that indirect impacts to the MHPA are minimized. Section 1.4.3 of the City's Subarea Plan outlines the requirements to address indirect effects related to drainage and toxics, lighting, noise, public access, invasive plant species, brush management, and grading/land development. Because the project includes development adjacent to the MHPA, conformance with the adjacency guidelines would be required [Alden Environmental, Inc. 2023].

3.0 EXISTING NOISE ENVIRONMENT

The project site is located approximately 1,000 feet north of Palm Avenue, east of Hollister Street, in the Palm City neighborhood of the City of San Diego, California. The project site consists of one property, which is currently developed with a single-family residence.

Adjacent uses include agricultural land to the north and east; a transit parking lot, mobile home park, single-family residence, and school sports field to the south; single-family residences across Hollister Street to the northwest and southwest; and commercial and vacant land to the west beyond the rail line and Hollister Street.

The primary noise sources affecting the project site are rail operations on the SD&AE Railroad line and roadway traffic on I-5.

3.1 RAIL

The project site is adjacent to the SD&AE Railroad line on the east. The northbound and southbound tracks are approximately 85 feet and 99 feet from the western project property line, respectively.

3.1.1 Freight Rail

In a 24-hour period, there would be up to two freight trains in each direction, during nighttime hours, with one locomotive and 30 cars, at up to 40 miles per hour (mph) [Kimley-Horn and Associates 2009; SANDAG 2010].

Freight train noise levels were estimated using the noise prediction methodology in the Federal Transit Authority (FTA) Transit Noise and Vibration Impact Assessment manual [FTA 2006]. Noise levels from freight train movements would range from below 60 dBA CNEL at the eastern façade of Building 5 to approximately 63 dBA CNEL at the western façade of the recreation / leasing building (Appendix A).

The FTA manual does not address train horn noise. Freight train horn noise levels were estimated using the rail horn noise model developed by the Federal Railroad Administration [FRA 2020]. Noise levels from freight train horns would range from below 60 dBA CNEL at the eastern façade of Building 5 to approximately 72 dBA CNEL at the western façade of the recreation / leasing building (Appendix A).

3.1.2 Light Rail

The project site is approximately 500 feet north of the Palm Avenue Station of the San Diego Metropolitan Transit System [MTS] Blue Line, which carries San Diego Trolley light rail traffic. The existing average San Diego Trolley volume near the project site is 95 daytime trolleys & 26 nighttime trolleys (northbound), and 94 daytime trolleys & 23 nighttime trolleys (southbound) [MTS 2022].

Each trolley generates an average SEL of approximately 81 dBA at 100 feet, based on measurements conducted during the site visit. Accordingly, each trolley generates an hourly Leq of approximately 45 dBA at 100 feet. At an hourly average volume of approximately 13 / 6 daytime / nighttime trolleys, the hourly total trolley noise levels are approximately 56 / 53 dBA Leq at 100 feet. The corresponding noise level is 60 dBA Ldn (CNEL) at 100 feet. The western façade of the recreation / leasing building is approximately 105 feet from the centerline of both tracks.

Noise levels from light rail traffic would range from below 60 dBA CNEL / DNL at the eastern façade of Building 5 to approximately 60 dBA CNEL / DNL at the western façade of the recreation / leasing building.

3.2 ROADWAY

I-5 is a two-way eight-lane Freeway roadway with a speed limit of 65 mph. The centerline of I-5 is approximately 1,250 feet west of the western project property line. The existing (year 2017) ADT volume on I-5 is 140,000 vehicles between Coronado Avenue and California State Route (SR) 75 [Caltrans 2020a]. The year 1983 vehicle mix on I-5 north of SR 75 was 2.1% medium trucks and 1.6% heavy trucks; this was considered to be generally accurate at the time of this report, based on qualitative observations. I-5 is approximately on grade with the project site.

3.3 AIRCRAFT

The project site is exposed to aircraft noise levels less than 60 dBA CNEL from operations associated with the NOLF [Wyle 2010], the Brown Field Municipal Airport [SDALUC 2010], and the Tijuana International Airport [Landrum & Brown 2002]. However, noise associated with aircraft operations may be periodically audible on the project site or within the project building. As the project is located outside of any 60 dBA CNEL airport noise level contour per the aforementioned documents, aircraft noise does not warrant further discussion herein.

3.4 SOUND LEVEL MEASUREMENTS

Short-term sound level measurements were conducted on Wednesday, January 5, 2022 to quantify the existing onsite acoustical environment. Multiple spot measurements were also conducted to quantify noise levels from trolley passbys alone.

The San Diego Unified School District and Ocean View Christian Academy were in session. The South Bay Union School District was not in session.

A RION NL-31 American National Standards Institute (ANSI) Type 1 Integrating Sound Level Meter was used as the data-collection device. The meter was mounted to a tripod roughly five feet above ground to simulate the average height of the human ear. The sound level meter was calibrated before and after the measurement periods.

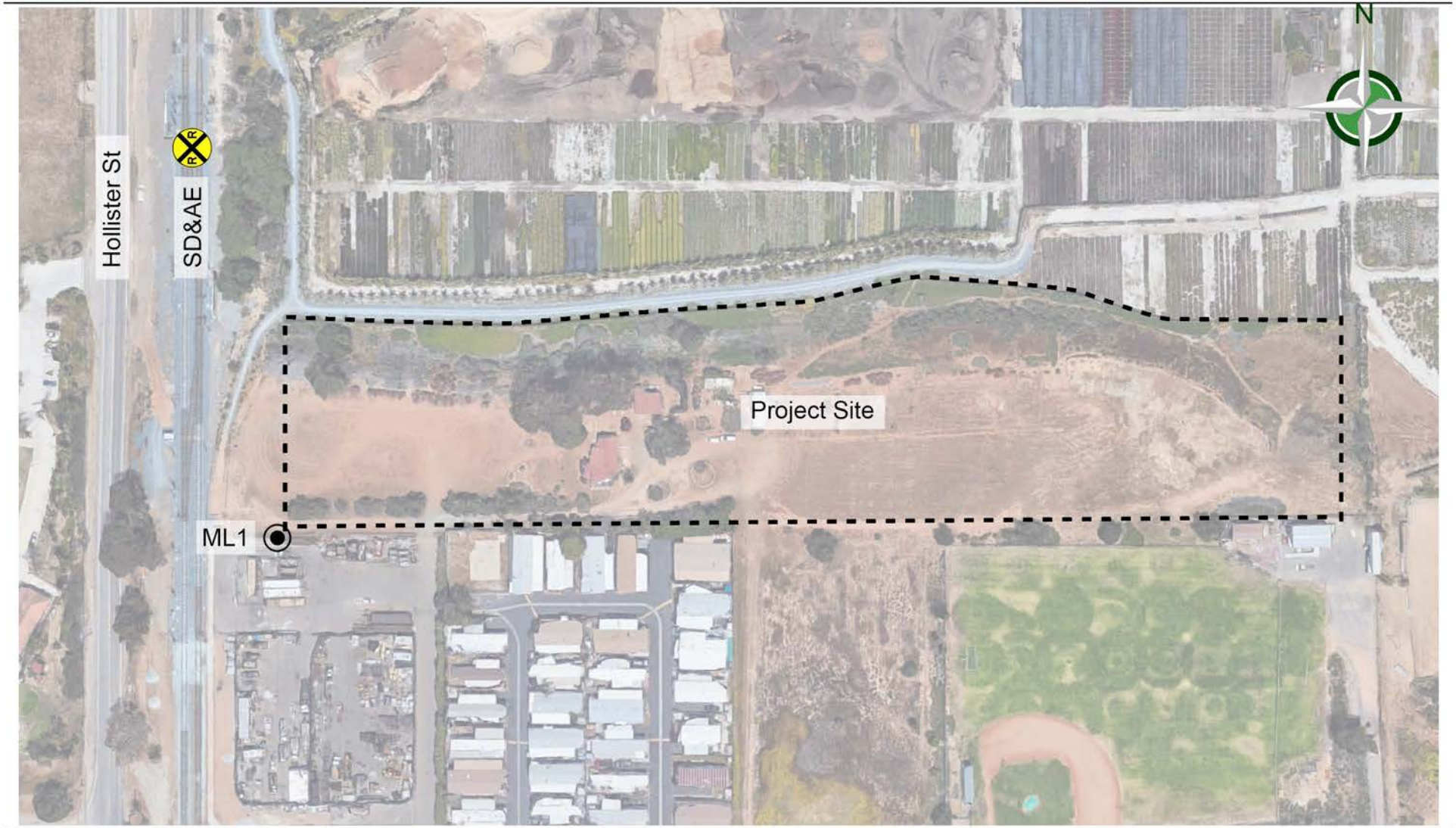
The measurement results are summarized in Table 4 and correspond to the location depicted on Figure 3. A review of the table shows that the measured sound level was approximately 60 dBA Leq. The primary noise sources observed during the site visit were vehicular roadway traffic and light rail traffic.

Table 4. Sound Level Measurements (dBA)

Measurement Location	Date / Time	Leq	Lmin	Lmax	L10	L50	L90
ML1: ~100 feet from rail centerline ~1,250 feet from I-5 centerline	2022-01-05 10:10 – 10:25	60.4	52.1	74.1	60.0	57.6	54.2

Research demonstrates that the maximum hourly noise level from freeways can be estimated by adding 1-2 dBA to the measured freeway noise level during any daytime period [LoVerde, Dong, & Rawlings 2014 (Appendix B)]. Therefore, the maximum existing hourly I-5 noise level at the project building could be as high as approximately 62 dBA Leq.

During the site visit, two southbound trolleys and one northbound trolley were measured at ML1. The sound exposure level (SEL) of the passbys were 80.9 dBA (northbound), 81.6 (southbound), and 84.2 (simultaneous northbound and southbound).



dBF Associates, Inc.

FIGURE 3
Sound Level Measurement Locations

4.0 POTENTIAL NOISE IMPACTS

4.1 NOISE AFFECTING THE PROJECT SITE

The future noise environment is primarily a result of rail operations and roadway traffic.

Freight train and light rail traffic projections are not available. As such, the existing rail noise environment is considered applicable to describe the future rail noise environment.

The peak hour traffic noise level was considered equivalent to the CNEL [24 CFR §51.106]. The future (year 2050) ADT on I-5 is projected to be approximately 128,700 (63,600 northbound + 65,100 southbound) north of SR 75 [SANDAG 2020b]. The existing speed limit (65 mph) and vehicle mix (96.5% cars, 2.1% medium trucks, and 1.6% heavy trucks) are expected to remain constant. Because the future traffic volume on I-5 is projected to be lower than the existing volume, the existing freeway noise environment is considered applicable to describe the future freeway noise environment.

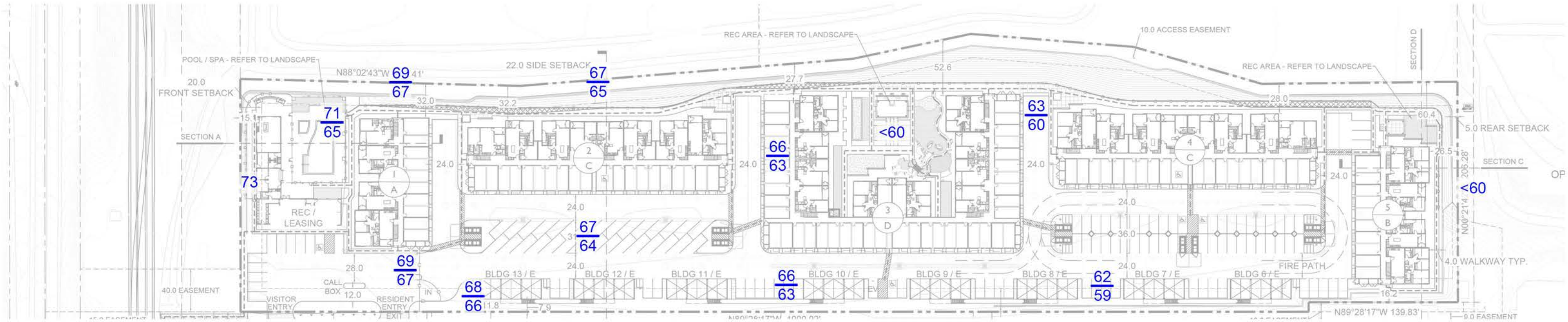
Future exterior composite noise levels at the proposed project site would range from below 60 dBA CNEL at the eastern façade of Building 5 to approximately 73 dBA CNEL at the western façade of the recreation / leasing building, as shown on Figure 4.

The project includes the following common outdoor usable areas: a pool / spa recreation / leasing building courtyard, a recreation area in the Building 3 courtyard, and a recreation area north of Building 5. Future exterior composite noise levels would be 65 dBA CNEL or below at all common outdoor recreational spaces in the project.

In the Residential – Multiple Units land use category, per the Noise Element, noise levels up to 60 dBA CNEL are considered Compatible with outdoor use areas; noise levels between 60-70 dBA CNEL are considered Conditionally Compatible.

At multi-family residential land uses, per the CEQA Significance Determination Thresholds, traffic noise levels up to 65 dBA CNEL are less than significant.

Future exterior composite noise levels at all required outdoor spaces in the project would be 65 dBA CNEL or lower, and would be considered Conditionally Compatible and less than significant by the City.



$\frac{XX}{YY}$ = $\frac{\text{UPPER FLOOR}}{\text{GROUND FLOOR}}$

4.2 PROJECT-GENERATED TRAFFIC

The proposed project would generate vehicular traffic, primarily on the MTS access road and Palm Avenue [Michael Baker International 2023].

The Federal Highway Administration (FHWA) Traffic Noise Model (TNM) version 2.5 was used to estimate traffic noise levels. A default ground type of "pavement" was used in the model.

The project would add 82 cars to the existing a.m. peak-hour volume of 36 cars on the MTS access road. This would increase the noise level at the nearest La Palma Mobile Estates homes (approximately 20 feet from the centerline) from approximately 50 dBA CNEL to approximately 55 dBA CNEL.

The project would add 69 cars to the existing p.m. peak-hour volume of 1,207 cars on Palm Avenue west of the MTS access road. This would increase the noise level at adjacent land uses by less than 1 dBA CNEL. The project would generate fewer absolute and relative trips along all other roadway segments [Michael Baker International 2023].

These levels and increases are considered less than significant by the City CEQA Significance Determination Thresholds.

4.3 PROJECT OPERATION

The residential project buildings would have rooftop HVAC units, as shown on the architecture plans (Summa Architecture 2022). There would be one unit per residence. It was assumed that the recreation / leasing building would have ten units. The unit sizes are not currently specified; however, it was assumed that 3-ton units would be used. A typical 3-ton HVAC condenser produces a sound power level of approximately 77 dBA [Carrier].

The Datakustik Cadna/A industrial noise prediction model was used to estimate operational noise levels. It was assumed that the units could operate continuously.

The project would produce operational noise levels up to approximately 42 dBA Leq at the property lines of the residences and school to the south, and below 30 dBA Leq at the single-family residences across Hollister Street to the northwest and southwest. All other adjacent land uses are not noise-sensitive. There are no other noise-sensitive receptors in the project area.

Project operation would not exceed the property line sound levels allowed by the City of San Diego Municipal Code. Project operation noise impacts would be less than significant.

4.4 PROJECT CONSTRUCTION

The primary noise source from project construction would be from site preparation. Remedial grading would require the use of heavy equipment such as bulldozers, loaders, and scrapers. No blasting would be necessary. Haul trucks would be used to import fill to the project site. The project proponent estimates that 1,469 truck loads would be needed for the 23,500 cubic yards of import, over 60 work days, for an average of 24.5 trucks per day. The remedial grading quantity is 67,000 cubic yards.

During construction, the project would generate six trucks per hour (three inbound & three outbound) on the MTS access road. This would cause a noise level of approximately 59 dBA CNEL at the nearest La Palma Mobile Estates homes. All other potentially-affected land uses would be further from the trucks and would experience lower noise levels.

Noise from demolition would also require the use of heavy equipment such as backhoes and excavators. However, for demolition, fewer pieces of equipment would be needed at any given time, and the activity would be further from project property lines. Noise levels would be lower than during grading.

Construction of the project would generate a short-term temporary increase in noise in the project area. The increase in noise level would be primarily experienced close to the noise source. The magnitude of the impact would depend on the type of construction activity, noise level generated by various pieces of construction equipment, duration of the construction phase, acoustical shielding and distance between the noise source and receiver.

Construction activity and delivery of construction materials and equipment would be limited to between 7:00 a.m. and 7:00 p.m., except on Sundays or holidays.

This project would implement conventional construction techniques and equipment. Standard equipment such as scrapers, graders, backhoes, loaders, tractors, cranes, and miscellaneous trucks would be used for construction of most project facilities. Sound levels of typical construction equipment range from approximately 65–95 dBA at 50 feet from the source (U.S. Environmental Protection Agency [U.S. EPA] 1971). Worst-case noise levels are typically associated with grading. Noise sources associated with grading of the proposed project, and associated noise levels, are shown in Table 5.

Table 5. Grading Noise Source Levels

Noise Source	Noise Level	Number
Bulldozer	86 dBA at 10 meters	1
Scraper	82 dBA at 10 meters	1
Backhoe	69 dBA at 10 meters	1
Water Truck	81 dBA at 10 meters	1
Roller	84 dBA at 10 meters	1

Source: DEFRA 2005

The Datakustik Cadna/A industrial noise prediction model was used to estimate construction noise levels. It was assumed that up to five pieces of equipment at any given time would operate continuously within the grading area boundary. No correction was applied for downtime associated with equipment maintenance, breaks, or similar situations.

The closest occupied residential properties are in the La Palma Mobile Estates located adjacent to the project site on the south. Construction of the project would produce noise levels up to approximately 71 dBA Leq (12 hours) at the property lines of the residences.

Construction would occur during the days and hours proscribed by the City of San Diego Municipal Code. Construction noise levels at residential property lines would not exceed the 75 dBA Leq (12 hour) sound level allowed by the City of San Diego Municipal Code. Project construction noise impacts would be less than significant.

Construction noise could be audible at the school and its baseball field, the nursery, and the golf driving range. However, there are no noise significance thresholds for these land uses.

4.5 MSCP MHPA LUAG

The project could generate noise affecting the MHPA.

The MHPA, which is north of the project site, is already subject to noisy uses such as the trolley and vehicular use of Hollister Street that create noise. The project primarily involves residential housing, which is not an excessively noisy use. The project would also include a bar-b-que pavilion, fire table, turf area incorporating a nature playground, game courts, sofa seating areas, and a pedestrian landscaped walkway along the top of the northern slope connecting the residential buildings to these amenities, which would be situated to take advantage of views of Otay Valley Regional Park to the north. Noise generated from the use of these amenities is not expected to be excessive or long lasting, and there are no sensitive species breeding areas in the adjacent MHPA (the MHPA to the north consists of agricultural and developed land associated with the Terra Bella Nursery). Vehicular access to the project would be from the south and not adjacent to the MHPA. Therefore, the project is in conformance with this Land Use Adjacency Guideline [Alden Environmental 2023].

4.6 MOST INTENSIVE USE

If the site were developed with its most intensive use, eight dwelling units would be added.

These units would be located within the same footprint as the proposed project, by modifying unit size, adding an additional level or partial level to some buildings, or constructing the units in areas currently designated for parking, etc. The conclusions about noise affecting the project site would not change.

The project-generated traffic would increase by roughly 4%. This would increase project-generated traffic noise by approximately 0.2 dBA. The conclusions about project-generated traffic noise would not change.

Eight HVAC units would be added, within the same footprint. This could increase property line noise levels by roughly 1 dBA. The conclusions about project operation noise would not change.

The eight additional units would not affect construction noise levels. The conclusions about project construction noise would not change.

The eight additional units would not change the project's conformance to the MHPA LUAG.

5.0 FINDINGS AND MITIGATION

5.1 EXTERIOR LAND USE – NOISE COMPATIBILITY

Future exterior composite noise levels at all required outdoor spaces in the project would be considered Conditionally Compatible and less than significant by the City.

5.2 PROJECT-GENERATED NOISE

The project would not cause traffic, operational, or construction noise impacts beyond the City thresholds, and project-generated noise impacts would be less than significant. No mitigation is required.

5.3 INTERIOR LAND USE – NOISE COMPATIBILITY

Because future exterior composite noise levels would exceed 60 dBA CNEL at some project building façades, interior noise levels in occupied areas could exceed the City of San Diego General Plan Noise Compatibility Guidelines and CBC Section 1206.4 requirement of 45 dBA CNEL in residences.

To avoid a potential land use impact, as a condition of project approval, an interior noise analysis would be required to be approved by the City's Building Inspection Department upon application for a building permit. This interior noise analysis must identify the sound transmission loss requirements for building façade elements (windows, walls, doors, and exterior wall assemblies) necessary to limit interior noise to 45 dBA CNEL in habitable residential rooms.

Upgraded windows and/or doors with Sound Transmission Class (STC) ratings of 35 or higher may be necessary. If the interior noise limit can be achieved only with the windows closed, the building design must include mechanical ventilation that meets CBC requirements.

With the implementation of the findings of the interior noise analysis, interior noise levels would be 45 dBA CNEL or below in residences, and the project would comply with the City of San Diego General Plan Noise Compatibility Guidelines and the CBC Section 1206.4 requirement.

The project would result in a less than significant interior noise impact with project features incorporated in accordance with the interior noise analysis.

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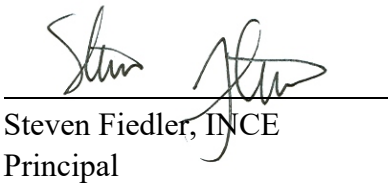
7.0 LIST OF PREPARERS



Steven Fiedler, INCE
Principal

APPENDICES

APPENDIX A

RAIL NOISE CALCULATIONS

Noise Model Based on Federal Transit Adminstration General Transit Noise Assessment
Developed for Chicago Create Project

Case: Palm City Transit Neighborhood

RESULTS			
Noise Source	**Ldn (dB)**	**Leq - daytime (dB)**	**Leq - nighttime (dB)**
All Sources	65	38	59
Source 1	57	35	51
Source 2	60	18	54
Source 3	56	34	50
Source 4	59	17	53
Source 5	0	0	0
Source 6	0	0	0
Source 7	0	0	0
Source 8	0	0	0

Enter noise receiver land use category below.

LAND USE CATEGORY	
Noise receiver land use category (1, 2 or 3)	2

Enter data for up to 8 noise sources below - see reference list for source numbers.

NOISE SOURCE PARAMETERS								
Parameter	**Source 1**		**Source 2**		**Source 3**		**Source 4**	
Source Num.	Freight Locomotive	9	Freight Cars	10	Freight Locomotive	9	Freight Cars	10
Distance (source to receiver)	distance (ft)	85	distance (ft)	85	distance (ft)	99	distance (ft)	99
Daytime Hours	speed (mph)		speed (mph)		speed (mph)		speed (mph)	
(7 AM - 10 PM)	trains/hour		trains/hour		trains/hour		trains/hour	
	locos/train		length of cars (ft) / train		locos/train		length of cars (ft) / train	
Nighttime Hours	speed (mph)	40	speed (mph)	40	speed (mph)	40	speed (mph)	40
(10 PM - 7 AM)	trains/hour	0.222	trains/hour	0.222	trains/hour	0.222	trains/hour	0.222
	locos/train	1	length of cars (ft) / train	2040	locos/train	1	length of cars (ft) / train	2040
Wheel Flats?			% of cars w/ wheel flats	100.00%			% of cars w/ wheel flats	100.00%
Jointed Track?	Y/N	N	Y/N	N	Y/N	N	Y/N	N
Embedded Track?	Y/N	N	Y/N	N	Y/N	N	Y/N	N
Aerial Structure?	Y/N	N	Y/N	N	Y/N	N	Y/N	N
Barrier Present?	Y/N	N	Y/N	N	Y/N	N	Y/N	N
Intervening Rows of of Buildings	number of rows	0	number of rows	0	number of rows	0	number of rows	0

FRA Grade Crossing Noise Model

User Input	
Noise Situation (Pick from List)	1
Horn Lmax (dBA) @ 100 feet	104
Horn Location on Locomotive(Pick from List)	1
Non Train Noise Environment (pick from list)	3
Shielding (Pick from List)	6
Length of Impact Area (pick from list)	1
Existing Train Speed (mph)	40
Future Train Speed (mph)	40
Number of Existing Trains in one Direction	2
Number of Future Trains in one Direction	2
Existing Number of Day Trains (7 am to 10 p.m.)	0
Future Number of Day Trains (7 am to 10 p.m.)	0
Existing Number of Night Trains (10 p.m. to 7 am)	2
Future Number of Night Trains (10 p.m. to 7 am)	2
Existing Average Number of Cars	30
Future Average Number of Cars	30
Existing Average Number of Locomotives	1
Future Average Number of Locomotives	1

Noise Situation	
Horns Existing and Future	1
Horns in Future Only	2
No Horns Existing and Future	3

Horn Location on Locomotive			
National Average (50% front, 50% middle)			1
All Front Mounted			2
All Middle Mounted			3
User Defined	80	% front mounted horns	4

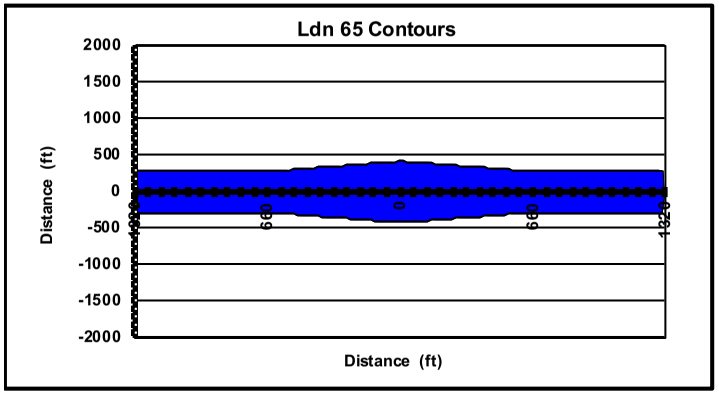
Non Train Noise Environment			
Urban			1
Suburban			2
Rural			3
User Defined Ldn =	0	dBA	4

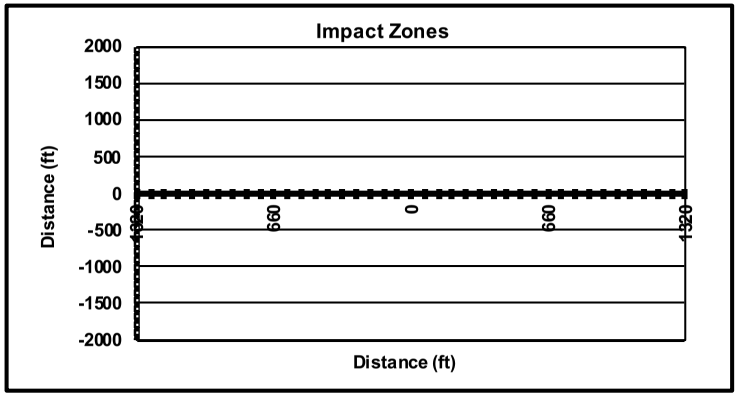
Shielding	
Dense Urban	1
Light Urban	2
Dense Suburban	3
Light Suburban	4
Rural	5
No Shielding	6

Length of Impact Area	
1/4 mile	1
20 seconds	2
15 seconds	3

Ldn 65 Contours Numeric Output (in feet)	
Existing 65 Ldn Contour at X-ing	418
Future 65 Ldn Contour at X-ing	418
Existing 65 Ldn Contour at 1/2 zone length	280
Future 65 Ldn Contour at 1/2 zone length	280
Zone Length	1320
1/2 Zone Length	660

Impact Zones Numeric Output (in feet)	
Impact Distance at X-ing	0
Severe Impact Distance at X-ing	0
Impact Distance at 1/2 zone length	0
Severe Impact Distance at 1/2 zone length	0
Zone Length	1320
1/2 Zone Length	660





APPENDIX B

LOVERDE, et. al. RESEARCH PAPER

Fort Lauderdale, Florida
NOISE-CON 2014
2014 September 8-10

Noise prediction of traffic on freeways and arterials from measured sound data

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ABSTRACT

Evaluation and mitigation of noise from exterior noise sources is common as a building design criterion, and has long been part of federal and California building design requirements for residential housing. Criterion is included in LEED building design standards for school and healthcare facilities, and will be included for all buildings types in LEED version 4. These criteria require that the noise level be quantified precisely, but do not provide a method for defining the noise level given the normal variations in exterior sound level that occur. This paper analyzes long term traffic noise measurement data to develop statistically meaningful definitions of exterior noise from vehicular sources. Methods for predicting the noise level using data from relatively short measurement periods are evaluated, and minimum survey requirements to determine specific exterior noise parameters are suggested.

1. INTRODUCTION

Traffic noise is a common noise source impacting all building types and has been the subject of considerable study. Previous measurement surveys[1,2] have primarily examined the spatial variations, variations in vehicle type or speed, or variations during a single day. Long-term measurement programs to document the day-to-day variations in level have been performed[3], have been focused on average or 24-hour hour metrics, which are normally used for residential noise criteria. However recent criteria have required evaluation of the loudest instead of the average level. Evaluating the maximum level requires a different level of type of analysis than have previously been documented.

2. BUILDING CODES AND REGULATIONS

A. Daily metrics

Noise from transportation sources has long been a part of codes and guidelines for residential projects, and the noise level has been evaluated in terms of daily metrics such as L_{dn} and CNEL (or L_{den}). The U.S. Department of Housing and Urban Development defines an acceptable acoustical environment in terms of L_{dn}[4]. In California, the state building code[5], as well as the General Plans of many municipalities, similarly defines noise level requirements in terms of CNEL or L_{dn}.

B. Hourly metrics

Recently there have been an increased number of design requirements and guidelines for non-residential projects, many associated with green building guidelines. The California Green Building Standards require that the interior noise level "does not exceed an hourly equivalent noise level (Leq-1Hr) of 50 dBA in occupied areas during any hour of operation."[6] This applies to most non-residential projects.

Green building guidelines for schools, such as the California Collaborative for High Performance Schools, reference ANSI S12.60. The requirements for noise from exterior sources are defined in terms of "the noisiest continuous one-hour period during times when learning activities take place."[7] LEED v4 BD+C: Schools "requires mitigation for high-noise sites (peak-hour Leq above 60 dBA during school hours)".

C. Daily Average vs. Maximum Hour

While criteria for residential projects has historically been in terms of 24-hour averaged metrics, recent requirements for commercial and school projects is framed in terms of the loudest hourly Leq during the period of operation. However, none of the criteria documents provide or describe any procedures or guidance regarding how the "loudest hour" should be defined, given the day-to-day variations in noise level. Even if given a large data set encompassing the full range of variation, which level does the acoustician define to be "typical"?

Further, while it is straightforward to determine the loudest hour of any measurement period, how would one know that the loudest hour of the day, or the loudest day of the week, had been captured? What about longer term variations with the school year or the seasons? How much information regarding variations can the designer be expected to obtain?

Currently, acousticians faced with these questions have simply measured over a single day and used the loudest hour to perform calculations. In our view, there has been insufficient consideration of the variation of the sound level, and whether the measurement constitutes adequate sampling to have confidence that the reported sound level is accurate.

3. MEASUREMENT PROGRAM

In order to begin to address these questions and clarify procedure, we performed long-term noise surveys of roadways, with an aim to determine not just the level but the temporal distribution of levels. Based on the measured variation in noise level, hour-to-hour and day-to-day, a reasonable definition of the "loudest hour" can be extracted. Finally, we wish to determine the minimum length of measurement required determine the loudest hour to the desired accuracy.

A. Long term traffic noise survey

Measurements were performed on several arterial roadways and freeways. The results from one arterial are presented here. The arterial in questions is a 4-lane road with a wide median and a 40 mile per hour speed limit. A microphone was mounted to the rooftop of a building at the façade facing the street. This location had unobstructed exposure to all four lanes in both directions at an approximate elevation of 20 feet. A Bruel & Kjaer type 2260 sound level meter logged the noise level at high time resolution from February 11 through March 14, 2014.

The data was reduced to hourly intervals synced to the clock for this analysis. The weekends were significantly quieter than the weekdays, and the weekends were excluded from the analysis. The hourly Leq's for all weekdays are shown in Figure 1. The dashed lines show February 18, which was the Presidents Day holiday, and had slightly reduced noise levels. The dotted line shows a day when work crews were conducting tree trimming on the street. Although

this was not a traffic source and this day was excluded from the data for this analysis, it bears considering what effect such an event might have on an unmanned measurement.

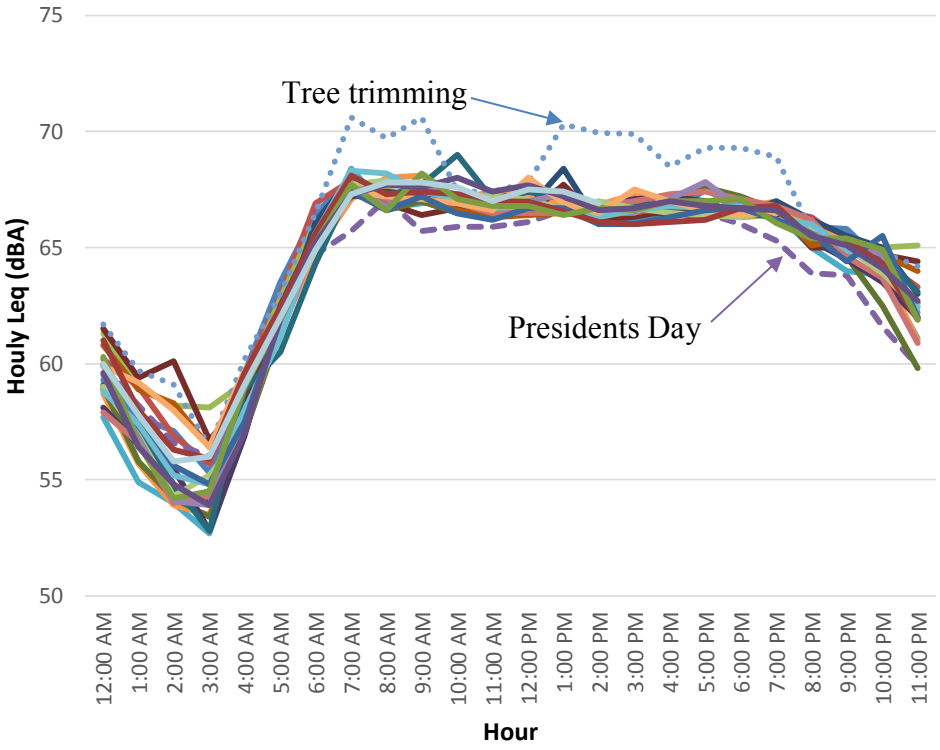

Figure 1. Hourly Leq's for all days measured.

B. Analysis

During the daytime hours (from 7:00 AM to 7:00 PM), there is very little variation in level, both day-to-day and from hour-to-hour within a day for a free flowing arterial. In fact, over the 22 weekdays in the measurement period, the daytime hourly Leq ranged from 66–69 dBA. Because the spread in the data was so small, we analyzed the data at a resolution of a tenth of a dB in order to reduce rounding errors. The average hourly Leq was 67.0 dBA, and the standard deviation was 0.5 dB.

It is the authors' opinion that the "maximum" level of a distribution, assuming that it is approximately normal, should be defined as 2 standard deviations above the mean. This is an arbitrary but common convention in many branches of science and engineering, corresponding to approximate 95 percent confidence interval about the mean. It is the 97.5 percentile of the distribution. For the measured data, 2 standard deviations are 1.0 dB and the "loudest hour" is therefore defined to be 68.0 dBA. (Note that the mean and maximum values have tenth-dB resolution and are not rounded. It is coincidence that they happened to end up on zero tenths.)

4. REQUIRED LENGTH OF MEASUREMENT

We have determined that the "true" average hourly level is 67 dBA and the loudest hourly level is 68 dBA. Given the month-long measurement period, we are confident that these values

accurately encompass the normal daily variation in level. (Seasonal variations may remain.) For a typical project, the measurement period will be much shorter. How long does the measurement period need to be to ensure an accurate result?

A. Monte Carlo Method

Monte Carlo method is ideal for this analysis. We use a random number generator to randomly select a start hour from the data set. From the start hour, we calculate the average noise level (Leq) that would be achieved after measuring for n hours, so that n is the length of the measurement. For each n, we repeat for at least 1000 trials and plot the results. The distribution of the results gives the probability of measuring that level after a measurement that is n hours long. The process is repeated with different values of n. Representative results are shown in Figure 2.

Figure 2 shows that the mean of the distribution is the same as the mean of the measurement data, as expected. Also as expected, the distribution narrows (variation become smaller) as the measurement time increases. However, the narrowing "levels off" and there is no further improvement after 4 or 5 hours. Measuring for 8 hours or 12 hours (the entire daytime) would not yield a more accurate measurement (compared to the monthly average) than the level measured after 5 hours.

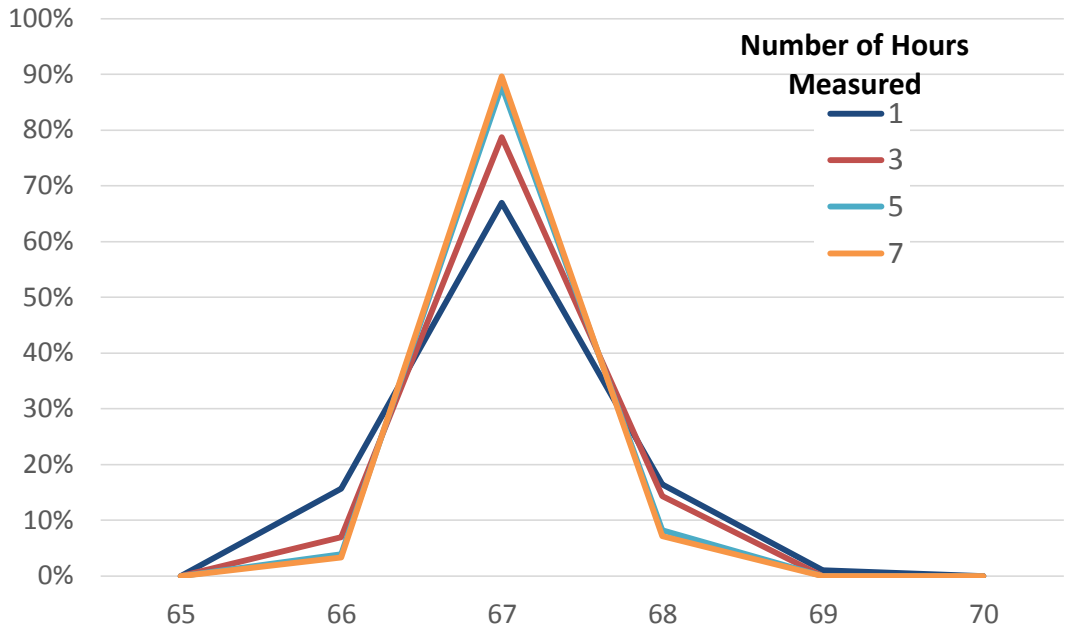

Figure 2. Results of Monte Carlo analysis with n=1, 3, 5, 7 hours.

B. Length of Measurement Predictions

Given the above information, we can evaluate methods for determining the level of the loudest hour for an actual project on this or a similar roadway. While acoustical overdesign should be avoided, a slightly conservative estimate is appropriate. It is important to avoid underestimating the measured level, which could lead to interior levels that exceed the criteria. For this roadway, the loudest hour is 68 dBA, and a level of 69 dBA would be acceptable. However, the measurement method should not result in a level below 68 dBA.

For this roadway, a one-hour measurement will usually result in a level of 67 dBA, so adding 1 dB would result in the correct loudest hour. However, 16 percent of the time this

estimate will be too low. Measuring for 2 hours would reduce this to 10 percent of the time, and a 4 hour measurement would reduce this to 4 percent. A better method may be to add 2 dB to the measured level. This would be too high 17 percent of the time, but will prevent erring on the low side.

5. CONCLUSIONS

The method described is intended to optimize measurement times while minimizing risk. This is accomplished by understanding the temporal behavior of the source. For arterial roadways similar to the free flowing one in this study, the loudest levels are in the daytime hours from 7:00 AM to 7:00 PM. There is remarkably little variation in noise level, both hour-to-hour and day-to-day. Following common science and engineering practice, we define the "loudest hour" as 2 standard deviations above the mean (97.5 percentile).

It is possible to accurately estimate the "true" long-term maximum hourly level to within +1/-0 dB with short term measurements. For this roadway, the method would be to add 1 or 2 dB to the measured value, depending on the length of the measurement and how conservative a result is desired.

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