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NOISE ASSESSMENT STUDY FOR THE PLANNED ATTACHED SINGLE-FAMILY DEVELOPMENT 1001 SOUTH WOLFE ROAD, SUNNYVALE

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I. Executive Summary

This report presents the results of a noise assessment study for the planned attached single-family development at 1001 South Wolfe Road in Sunnyvale, as shown on the Conceptual Site Plan, Ref. (a). The plans indicate that the project will have five attached townhouse units in one building. There will be a common open space area at the east end of the building facing South Wolfe Road and another common open space area at the northwesterly corner of the site along Maria Lane.

The noise exposure impacts to the project were evaluated against the standards of the City of Sunnyvale General Plan Noise Element, Ref. (b).

The project-generated noise impacts from project traffic will be less than significant as project traffic volumes would need to double the existing volumes on either South Wolfe Road or Maria Lane. Noise levels from project mechanical equipment could not be determined at this time as detailed equipment specifications are not yet available. However, a theoretical analysis of the mechanical equipment was performed to ensure that the mechanical equipment noise levels will remain within the limit of the City of Sunnyvale Noise Ordinance, Ref. (c). Project-generated noise impacts from construction of the project will be significant but temporary and will be minimized with the construction noise reduction methods recommended herein.

An analysis of the on-site noise measurements indicates that the noise environment is created primarily by traffic sources on Maria Lane and South Wolfe Road. There are no other significant sources of noise in the vicinity of the site.

The results of this study reveal that the noise exposure impacts to the exterior common area along South Wolfe Road will exceed the limits of the City of Sunnyvale Noise Element standards. The interior noise exposures will be within the limits of the standards. Noise mitigation measures for the exterior common area will be required. Noise mitigation measures for the project interiors will not be required.

II. Background Information on Acoustics

Noise is defined as unwanted sound. Airborne sound is a rapid fluctuation of air pressure above and below atmospheric pressure. Sound levels are usually measured and expressed in decibels (dB) with 0 dB corresponding roughly to the threshold of hearing.

Most of the sounds which we hear in our normal environment do not consist of a single frequency, but rather a broad range of frequencies. As humans do not have perfect hearing, environmental sound measuring instruments have an electrical filter built in so that the instrument's detector replicates human hearing. This filter is called the "A-weighting" network and filters out low and very high frequencies. All environmental noise is reported in terms of A-weighted decibels, notated as “dBA”. All sound levels used in this report are A-weighted unless otherwise noted. Table I on page 3 shows the typical human response and noise sources for A-weighted noise levels.

Although the A-weighted noise level may adequately indicate the level of noise at any instant in time, community noise levels vary continuously. Most environmental noise includes a mixture of noise from distant sources that create a relatively steady background noise from which no particular source is identifiable. To describe the time-varying character of environmental noise, the statistical noise descriptors, L_1, L_{10}, L_{50} and L_{90} are often used. They are the A-weighted noise levels exceeded for 1%, 10%, 50% and 90% of a stated time period. The continuous equivalent-energy level (L_{eq}) is that level of a steady state noise which has the same sound energy as a time-varying noise. It is often considered the average noise level and is used to calculate the Day-Night Levels (DNL) and the Community Noise Equivalent Level (CNEL) described below.

TABLE I

The A-Weighted Decibel Scale, Human Response, and Common Noise Sources

Noise Level, dBA	Human Response	Noise Source
120-150+	Painfully Loud	Sonic Boom (140 dBA)
100-120	Physical Discomfort	Motorcycle at 20 ft. (110 dBA) Nightclub Music (105 dBA)
70-100	Annoying	Diesel Pump at 100 ft. (95 dBA) Freight Train at 50 ft. (90 dBA) Food Blender (90 dBA) Jet Plane at 1000 ft. (85 dBA) Freeway at 50 ft. (80 dBA) Alarm Clock (80 dBA)
50-70	Intrusive	Average Traffic at 100 ft. (70 dBA) Pass. Car, 30 mph @ 25 ft. (65 dBA) Vacuum Cleaner (60 dBA) Suburban Background (55 dBA)
0-50	Quiet	Normal Conversation (50 dBA) Light Traffic at 100 ft. (45 dBA) Refrigerator (45 dBA) Desktop Computer (40 dBA) Whispering (35 dBA) Leaves Rustling (20 dBA) Threshold of Hearing (0 dBA)

In determining the daily level of environmental noise, it is important to account for the difference in response of people to daytime and nighttime noises. During the nighttime, exterior background noises are generally lower than the daytime levels. However, most household noise also decreases at night and exterior noise becomes very noticeable. Further, most people sleep at night and are very sensitive to noise intrusion. To account for human sensitivity to nighttime noise levels, the Day-Night Level (DNL) noise descriptor was developed. The DNL is also notated as L_{dn}. Either is acceptable, however, DNL is more popular worldwide. The DNL divides the 24-hour day into the daytime period of 7:00 a.m. to 10:00 p.m. and the nighttime period of 10:00 p.m. to 7:00 a.m. The nighttime noise levels are penalized by 10 dB to account for the greater sensitivity to noise at night. The Community Noise Equivalent Level (CNEL) is another 24-hour average which includes a 5 dB evening (7:00 p.m. - 10:00 p.m.) penalty and a 10 dB nighttime penalty. Both the DNL and the CNEL average the daytime, evening and nighttime noise levels over a 24-hour period to attain a single digit *noise exposure*. The proper notations for the Day-Night Level and the Community Noise Equivalent Level are dB DNL and dB CNEL, respectively, as they can only be calculated using A-weighted decibels. It is, therefore, considered redundant to notate dB(A) DNL or dB(A) CNEL.

The effects of noise on people can be listed in three general categories:

- subjective effects of annoyance, nuisance, dissatisfaction;
- interference with activities such as speech, sleep, learning, relaxing;
- physiological effects such as startling, hearing loss.

The levels associated with environmental noise, in almost every case, produce effects only in the first two categories. Workers in industrial plants, airports, etc., can experience noise in the last category. Unfortunately, there is, as yet, no completely satisfactory way to measure the subjective effects of noise, or of the corresponding reactions of annoyance and dissatisfaction. This is primarily due to the wide variation in individual thresholds of annoyance and differing individual past experiences with noise. Thus, an important way to determine a person's subjective reaction to a new noise is to compare it to the existing environment to which one has adapted, i.e., the "ambient". In general, the more a new noise exceeds the previously existing ambient noise level, the less acceptable the new noise will be judged by the receivers.

With regard to increases in A-weighted noise levels, the Environmental Protection Agency has determined the following relationships that will be helpful in understanding this report.

- Except in carefully controlled laboratory experiments, a change of 1 dB cannot be perceived.
- Outside of the laboratory, a 3 dB change is considered a just-perceptible difference.
- A change in level of at least 5 dB is required before any noticeable change in community response would be expected.
- A 10 dB change is subjectively heard as approximately a doubling in loudness, and would almost certainly cause an adverse change in community response.

The adding or subtracting of sound levels is not simply arithmetic. The sound levels, in decibels, must be converted to Bels, the anti-logs of which are then calculated. The manipulation is then performed (arithmetic addition or subtraction), the logarithm of the sum or difference is calculated. The final number is then multiplied by 10 to convert Bels to decibels. The formula for adding decibels is as follows:

$$\text{Sum} = 10\log(10^{SL/10} + 10^{SL/10}) \qquad \text{where, SL is the Sound Level in decibels.}$$

For example, 60 dB + 60 dB = 63 dB, and 60 dB + 50 dB = 60 dB. Two sound sources of the same level are barely noisier than just one of the sources by itself. When one source is 10 dB higher than the other, the less noisy source does not add to the noisier source.

III. Noise Standards

A. City of Sunnyvale General Plan

The noise assessment results presented in the findings were evaluated against the standards of the City of Sunnyvale Noise Element, which utilizes the Day-Night Level (DNL) descriptor. The Noise Element standards specify a limit of 60 dB DNL for multi-family residential exteriors. Policy SN-8.7 of the Noise Element states,

"Supplement Figure 6-5, " 'State of California Noise Guidelines for Land Use Planning' for residential uses by attempting to achieve an outdoor L_{dn} of no greater than 60 dBA for common recreational areas, backyards, patios and medium and large-size balconies. These guidelines should not apply where the noise source is railroad or an airport. If the noise source is a railroad, then an L_{dn} of no greater than 70 dBA should be achieved in common areas, backyards, patios and medium and large balconies. If the noise source is from aircraft, then preventing new residential uses within areas of high L_{dn} from aircraft noise is recommended".

A limit of 45 dB DNL is specified for interior living spaces. However, when the source is a railroad or aircraft and the exterior noise exposure is 55 dB DNL or more, Policy SN-8.3 states,

"Attempt to achieve a maximum instantaneous noise level of 50 dBA in bedrooms and 55 dBA in other areas of residential units exposed to trains or aircraft noise, when the exterior L_{dn} exceeds 55 dBA".

This site is not exposed to railroad or aircraft noise.

B. City of Sunnyvale Noise Ordinance

The City of Sunnyvale Municipal Code Section 19.42.030 – Noise or Sound Level (Text Amended August 8, 2023) Paragraph (a) states:

Section 19.42.030. Noise or sound level. (a) Residential Noise Limits

(1) Operational noise shall not exceed 50 dBA during nighttime or 60 dBA during daytime hours at any point on the property line of the adjacent single family or duplex uses.

(2) Operational noise shall not exceed 55 dBA during nighttime or 65 dBA during daytime hours on the primary useable open space of multi-family uses.

(3) Operational noise shall not exceed 60 dBA during nighttime or 70 dBA during daytime hours on the primary useable open space of residential uses located along major transportation corridors (freeways, expressways, arterials, and rail lines) or mixed-use residential properties.

The definition of "Major Transportation Corridor" is below (emphasis added):

"Major Transportation Corridor" means a large roadway or rail line that contributes a significant amount of noise and air pollution to the ambient environment. Large roadways include freeways (Interstate 280, State Route (SR) 85, SR 237, and U.S. Highway 101); expressways (Central Expressway and Lawrence Expressway); Class I arterials (Caribbean Drive, El Camino Real (SR 82), Java Drive, Mathilda Avenue, N. Fair Oaks Avenue, N. Wolfe Road, and Sunnyvale-Saratoga Road); and Class II arterials (Arques Avenue, E. Remington Drive, Evelyn Avenue, Fremont Avenue, Homestead Road, Mary Avenue, S. Fair Oaks Avenue, S. Sunnyvale Avenue, and S. Wolfe Road). Any future large roadways not listed in this definition that are identified in the General Plan as freeways, expressways, Class I arterials, or Class II arterials are also major transportation corridors.

IV. Acoustical Setting

A. Site, Traffic and Project Descriptions

The planned project site is located at 1001 South Wolfe Road in Sunnyvale. The 0.85 acre site is relatively flat and at-grade with the surrounding roadways and land uses. The site is currently occupied by a single-family structure with a detached garage. Surrounding land uses include single-family attached residential adjacent to the south, single-family residential adjacent to the west, multi-family residential across Maria Lane to the north and multi-family residential across South Wolfe Road to the east.

The primary existing sources of noise at the site are traffic on Maria Lane and South Wolfe Road. Recent traffic volume data are not available from the City of Sunnyvale. However, traffic counts from 2011 indicate that the traffic volume on South Wolfe Road was 19,060 vehicles ADT, Ref. (d). Although the normal convention for the City of Sunnyvale is a traffic volume growth rate of 1% per year, Ref. (e), the traffic noise data indicate that the South Wolfe Road traffic volume is currently similar to the past traffic counts. Thus, adding 1 decibel to the noise data for South Wolfe Road is a conservative approach.

The planned project includes construction of five three-story attached single-family homes (townhouses) is one building. Two common open space areas will be provided. Ingress and egress to the site will be by way of a private driveway off of Maria Lane. The Conceptual Site Plan is shown on Figure 1 on page 9.

FIGURE 1 – Site Plan

V. Existing Noise Environment

A. Existing Noise Levels

To determine the existing noise environment at the site, continuous recordings of the sound levels were made at a location 78 ft. from the centerline of South Wolfe Road, corresponding to the setback of the building from the roadway. The measurement location is shown on Figure 2, below.

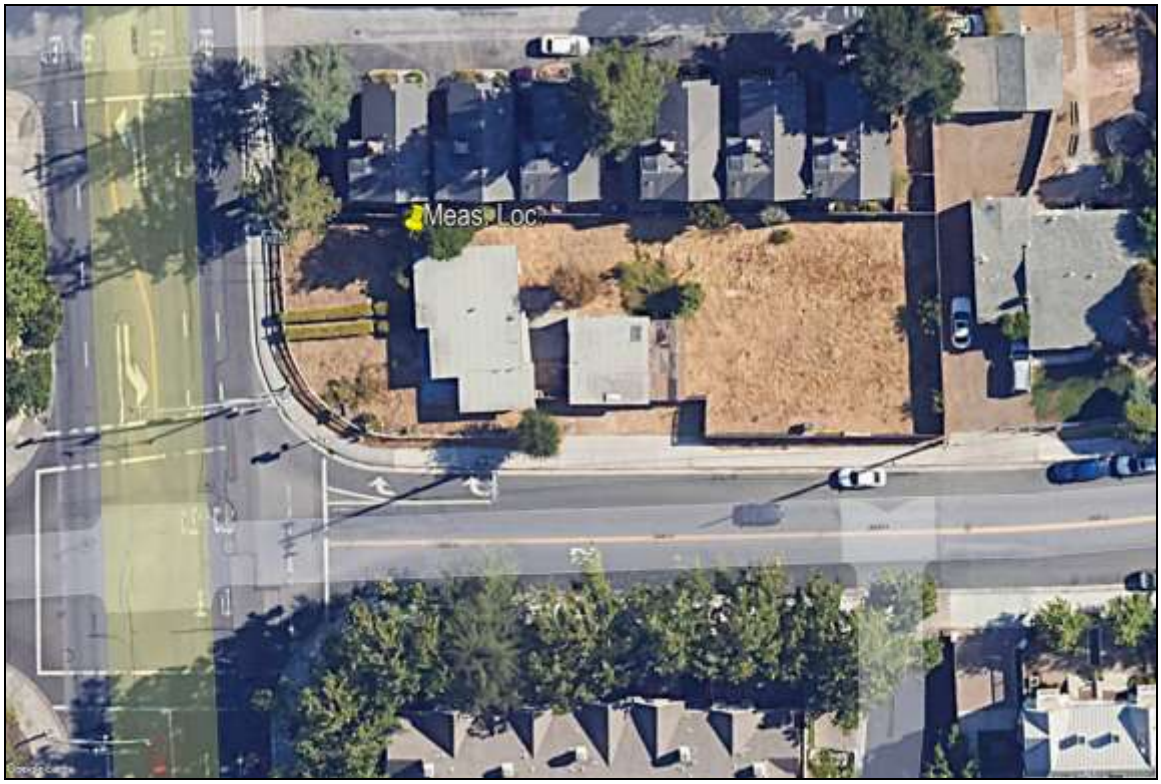


FIGURE 2 – Noise Measurement Location

The noise level measurements were made on June 10-11, 2024 for a continuous period of 24 hours at each location and included measurements during the daytime and nighttime periods of the DNL index.

The sound levels were recorded and processed using a Larson-Davis Model LxT Precision Integrating Sound Level Meter. The meter yields, by direct readout, a series of descriptors of the sound levels versus time, which include the L_1, L_{10}, L_{50}, and L_{90}, i.e., those levels that are exceeded 1%, 10%, 50%, and 90% of the time. The meters also yield the maximum and minimum levels, and the continuous equivalent-energy levels (L_{eq}), which are used to calculate the DNL. The measured L_{eq}'s are shown in the data table in Appendix C.

The L_{eq}'s at the measurement location, 78 ft. from the centerline of South Wolfe Road, ranged from 60.0 to 64.6 dBA during the daytime and from 49.2 to 58.9 dBA at night.

Traffic noise dissipates at the rate of 3 to 6 dB for each doubling of the distance from the source to the receiver. Thus, locations on the sites at greater distances from South Wolfe Road will have lower noise levels. Additional acoustical shielding will be provided by interposed buildings elements of the project.

Vehicular traffic noise contains a wide spectrum of frequency components (from 100 to 10,000 Hertz), which are associated with engine, tire, drive-train, exhaust and other sources. The frequency components are centered primarily in the 250 and 500 Hz octave bands.

B. Future Noise Levels

Future traffic volume data for South Wolfe Road were not available at the time of this study. Thus, we are estimating a future annual average traffic volume growth rate of 1% per year. Over course of 20 years, the total increase in traffic volume equates to a 22% increase in the existing traffic volume. This increase in traffic volume yields a 1 dB increase in the traffic noise levels.

VI. Noise Impacts to the Project

A. Exterior Noise Exposures

To determine the noise impacts to the project, the DNL for the survey location was calculated by decibel averaging of the L_{eq}'s as they apply to the daily time periods of the DNL index. A 10 decibel nighttime weighting factor was applied and the DNL was calculated using the formula shown in Appendix B. Adjustments were made to the measured noise levels to account for variations between the measurement locations and the building setbacks using methods established by the Highway Research Board, Ref. (f). The measured L_{eq}'s and DNL calculations are shown in the data table in Appendix C.

- The existing exterior noise exposure at the most impacted planned common open space area closest to South Wolfe Road, 53 ft. from the centerline of the road, is 67 dB DNL. Under future traffic conditions, the noise exposure is predicted to increase to 68 dB DNL. Thus, the noise exposure will be up to 8 dB in excess of the 60 dB DNL limit of the City of Sunnyvale Noise Element standards.

- The existing exterior noise exposure in the most impacted planned building setback from South Wolfe Road, 78 ft. from the centerline of the road, is 65 dB DNL. Under future traffic conditions, the noise exposure is predicted to increase to 66 dB DNL. Maria Lane traffic does not add to the noise exposures over the site.

As the exterior noise exposures will exceed the limits of the standards, noise mitigation measures for the exterior common open space will be required. The recommended measures are described in Section VIII of this report.

B. Interior Noise Exposures

To determine the interior noise exposures, a 25 dB reduction was applied to the exterior noise exposures at the building setbacks to represent the attenuation provided by a typical building shell under a closed window condition. The close window condition assumes the installation of standard dual-pane thermal insulating windows and glass doors and that full-time mechanical ventilation (per the Mechanical Code) will be provided for all living spaces allowing the residents to keep the windows closed at all times for noise control.

- The interior noise exposures in the most impacted living spaces closest to South Wolfe Road will be up to 40 and 41 dB DNL under existing and future traffic conditions, respectively. Thus the noise exposures will be within the 45 dB DNL limits of the City of Sunnyvale Noise Element standards.

The interior noise exposures in the most impacted living spaces of the project will be within the 45 dB DNL limit of the City of Sunnyvale Noise Element standards. Noise control measures for the project interiors will not be required. However, general construction measures to ensure that the building shell adequately reduces exterior noise are provided in Appendix B.

VII. Project-Generated Noise

A. Project Traffic

In order for the project traffic to be a significant noise impact, it must add 3 decibels to the existing noise environment where the existing ambient is below 60 dB DNL and 2 dB to the existing noise environment where the existing ambient is 60 dB DNL or higher. To increase the noise environment by 3 decibels, the project traffic volume must result in a doubling of the Maria Lane Average Daily Traffic (ADT) volumes. To increase the noise environment by 2 dB, the project traffic must add 43% of the existing volume to the roadway network. As this does not appear to be likely, project-generated traffic noise will be a less than significant impact to the existing noise environment in the vicinity of the project. Noise mitigation measures for project traffic will not be required.

The increase in noise exposure due to changes in traffic volume is calculated using the formula:

$\Delta dB = 10\log_{10}(V_1/V_2)$ where; V_1 = future volume or the existing + project, and V_2 = existing volume.

B. Project Mechanical Equipment

The outdoor mechanical equipment for the project has not been specified. For the planned sizes of the dwelling, air-conditioning units will typically need to provide 3-4 tons of cooling capacity. A theoretical analysis was performed which placed the air-conditioning units (condensing units or exterior heat pumps) on the roof over the third floor shafts adjacent to the laundry closet. These locations are 12 ft. from the south parapet. The roof elevation is approximately 32 ft. high. The parapet is 3 ft. high. The distance from the sound façade of the building to the south property line is 17 ft. The neighboring townhouses appear to have rear patios facing the project.

The neighboring residences are within the "major transportation corridor" of South Wolfe Road defined in the Noise Ordinance. Thus, 60 dBA is the most restrictive noise level limit for the project mechanical equipment. In order for the roof-top mechanical units to exceed 60 dBA in the rear patios of the adjacent townhouses, they must be sound rated (by the manufacturer) to be no higher than 87 dBA @ 1 meter (3.28 ft.) or an A-weighted sound power level (L*w*A) of 94 dBA. Mechanical units from foreign manufactures (Mitsubishi, Samsung, Panasonic, etc.) are usually sound rated at 1 meter. American companies, such as Carrier/Bryant, Trane, Day-Night, use the sound power rating scheme. Provided that the roof-top mechanical units chosen for the project do not exceed these sound levels, the mechanical equipment noise levels will remain within the limits of the City of Sunnyvale Noise Ordinance standards under worst-case operations of all units operating simultaneously.

C. Construction Noise and Vibration

The City of Sunnyvale Municipal Code, Ref. (c), does not contain noise or vibration limits on demolition or construction. The Municipal Code provides construction time limits to preclude noise annoyance from demolition and construction. The Municipal Code limits are described below.

City of Sunnyvale Construction Limits

16.08.030. Hours of construction—Time and noise limitations.

Construction activity shall be permitted between the hours of seven a.m. and six p.m. daily Monday through Friday. Saturday hours of operation shall be between eight a.m. and five p.m. There shall be no construction activity on Sunday or federal holidays when city offices are closed.

No loud environmentally disruptive noises, such as air compressors without mufflers, continuously running motors or generators, loud playing musical instruments, radios, etc., will be allowed where such noises may be a nuisance to adjacent residential neighborhoods.

Exceptions:

(a) Construction activity is permitted for detached single-family residential properties when the work is being performed by the owner of the property, provided no construction activity is conducted prior to seven a.m. or after seven p.m. Monday through Friday, prior to eight a.m. or after seven p.m. on Saturday and prior to nine a.m. or after six p.m. on Sunday and national holidays when city offices are closed. It is permissible for up to two persons to assist the owner of the property so long as they are not hired by the owner to perform the work. For purposes of this section, "detached single-family residential property" refers only to housing that stands completely alone with no adjoining roof, foundation or sides.

(b) As determined by the chief building official:

(1) No loud environmentally disruptive noises, such as air compressors without mufflers, continuously running motors or generators, loud playing musical instruments, radios, etc., will be allowed where such noises may be a nuisance to adjacent properties.

(2) Where emergency conditions exist, construction activity may be permitted at any hour or day of the week. Such emergencies shall be completed as rapidly as possible to prevent any disruption to other properties.

Short-term noise impacts may be created during construction of the project. Construction equipment noise levels range from 76 to 101 dBA at a 50 ft. distance from the source, and has a potential to disturb the residences adjacent to the west, north and east.

A table of construction equipment (mostly earthwork equipment, which is usually the noisiest, taken from the Federal Transit Administration Noise and Vibration Impact Assessment, Ref. (g), is provided on page 18. The noise levels for each item of equipment, not all of which will be used on this project, are reported for a standard distance of 50 ft.

None of the construction equipment used for this project will generate noise levels higher than 90 dBA at 50 ft. No extreme noise generators, such as pile driving, will be used on this project. Noise from construction equipment dissipates at the rate of 6 dB per doubling of the distance from the source to the receiver.

Since construction is carried out in several reasonably discrete phases, each will have its own mix of equipment and consequently, its own noise characteristics. Generally, the site preparation requires the use of heavy equipment such as bulldozers, loaders, graders, concrete trucks and diesel trucks. Construction of the building includes haul trucks, cranes, forklifts, pumps, air compressors and powered and manual hand tools (saws, nail guns, sprayers). Once the shell of the building is completed with the windows installed, much of the construction noise will be contained inside the building.

Table 7-1 Construction Equipment Noise Emission Levels *

Equipment	Typical Noise Level 50 ft. from Source, dBA
Air Compressor	80
Backhoe	80
Ballast Equalizer	82
Ballast Tamper	83
Compactor	82
Concrete Mixer	85
Concrete Pump	82
Concrete Vibrator	76
Crane, Derrick	88
Crane, Mobile	83
Dozer	85
Generator	82
Grader	85
Impact Wrench	85
Jack Hammer	88
Loader	80
Paver	85
Pile-driver (Impact)	101
Pile-driver (Sonic)	95
Pneumatic Tool	85
Pump	77
Rail Saw	90
Rock Drill	95
Roller	85
Saw	76
Scarifier	83
Scraper	85
Shovel	82
Spike Driver	77
Tie Cutter	84
Tie Handler	80
Tie Inserter	85
Truck	84

**This Table is copied from the FTA Transit Noise and Vibration Impact Assessment Manual, pg. 176.

Table II on page 20 provides the noise levels from demolition and construction of the project at the residences adjacent to the west, south and across Maria Lane to the north for operations that occur close to the property lines (near distance) and when operations occur at areas of the site farthest from the residences (far distance). Because demolition and construction operations are dynamic (move around the site constantly), the amount of time at one general location is approximately 40% of the total operation

The noise level values are the time adjusted noise levels extrapolated to the nearest residences. The noise levels presented in the table are typical noise levels produced by the pieces of equipment shown. However, equipment used in the field may vary slightly, depending on the sizes of engines, the contractor and their sub-contractors, age of equipment, the way tools, devices and items of equipment are utilized and many other factors that are unknown at this time and cannot be predicted with any level of accuracy. In addition, the sound levels at the property boundaries at any given time will change dramatically such that maximum noise levels may occur for very short periods of time or may occur for longer periods of time. The noise levels at the residences represent the typical, average sound levels of construction activity and operations based on the 40% usage factor. The noise exposures (dB DNL) shown assume that all equipment is in operation simultaneously.

TABLE III

Construction Noise Analysis

	Reference		Residences to South				Residence to West				Residences to North			
Mobile Equipment	Level, dBA	Dist., ft.	Near Dist.	Far Dist.	Avg. SL	Leq(h) 40%	Near Dist.	Far Dist.	Avg. SL	Leq(h) 40%	Near Dist.	Far Dist.	Avg. SL	Leq(h) 40%
Paving Machine	89	50	6	66	104	100	5	203	106	102	77	143	105	101
Water Truck	84	50	6	66	99	95	5	203	101	97	77	143	99	95
Compactive Rollers	85	50	6	66	100	96	5	203	102	98	77	143	100	96
Scrapers	86	50	6	66	101	97	5	203	103	99	77	143	102	98
Graders	83	50	6	66	98	94	5	203	100	96	77	143	98	94
Wheel Loader	82	50	6	66	97	93	5	203	99	95	77	143	97	93
Track Loader	85	50	6	66	100	96	5	203	102	98	77	143	100	96
Backhoe	82	50	6	66	97	93	5	203	99	95	77	143	97	93
Bulldozer	85	50	6	66	100	96	5	203	102	98	77	143	100	96
Haul Trucks	84	50	6	66	99	95	5	203	101	97	77	143	99	95
Crane	82	50	23	66	86	82	39	203	81	77	77	143	85	81
Excavator	85	50	6	66	100	96	5	203	102	98	77	143	100	96
Gas Forklift	65	15	15	66	62	58	15	203	62	58	77	143	58	54
Skid Steer	78	50	6	60	93	89	5	203	95	91	77	143	93	89
					DNL =	104			DNL =	105			DNL =	104
Stationary Equipment														
Large Air Compressor	90	50	23	60	94	90	39	203	89	85	77	143	94	90
Generator	81	50	23	60	85	81	39	203	80	76	77	143	84	80
Nail gun	84	15	23	60	78	74	39	203	73	69	77	143	76	72
Hammering	86	15	23	60	80	76	39	203	75	71	77	143	78	74
Circular Saw	74	15	23	60	68	64	39	203	63	59	77	143	64	60
Miter Saw	75	15	23	60	69	65	39	203	64	60	77	143	65	61
Portable Table Saw	78	15	23	60	72	68	39	203	67	63	77	143	69	65
Pancake Compressor	77	15	23	60	71	67	39	203	66	62	77	143	68	64
Palm Sander	71	15	23	60	65	61	39	203	60	56	77	143	61	57
Portable Tile Saw	85	15	23	60	79	75	39	203	74	70	77	143	77	73
Electric Grinder	90	15	23	60	84	80	39	203	79	75	77	143	82	78
Rotary Hammer	92	15	23	60	86	82	39	203	81	77	77	143	85	81
					DNL =	104			DNL =	106			DNL =	104

Construction activities can also produce varying amounts of ground-borne vibration, which depend on the type of equipment used and various methods. Vibration is produced by the equipment operation and the vibrational waves travel through the ground/soil that diminish over distance. It is rare that construction vibration is intense enough to cause damage to existing structures.

Ground-borne vibration is typically reported in terms of "peak particle velocity" or PPV, and sometimes reported in terms of decibels of vibration, notated as VdB, which is a level of vibration (L_v). The use of PPV is more common for construction equipment and methods.

Table VII, below, provides building damage criteria from construction vibration established by the Federal Transit Administration.

TABLE III		
Construction Vibration Damage Criteria		
Building Category	PPV (in/sec)	Approx. L_v (VdB)
I. Reinforced-concrete, steel or timber (no plaster)	0.50	102
II. Engineered concrete and masonry (no plaster)	0.30	98
III. Non-engineered timber and masonry buildings	0.20	94
IV. Buildings extremely susceptible to vibration damage	0.12	90
** RMS velocity in decibels (VdB) re: 1 micro-inch/second		

The adjacent residential buildings are larger attached single-family structures most likely on slab on grade foundations or a small single-family structure on a perimeter wall/joist foundation. These structures fall into Building Category III where the vibration limit is 0.20 in/sec PPV. There are no buildings adjacent to or near the site that would fall under Categories I, II or IV.

The contractors used for the demolition of the site and construction of the project have not yet been selected, nor has a construction schedule and list of equipment been developed. Table IV, below, provides a list of typical construction equipment, some of which will likely not be used on this project, such as pile driving. The Table shows their vibration levels at a 25 ft. reference distance, the vibration levels at the nearest building setbacks of the buildings to the west, south and east. Also shown are the distances each item of equipment must stay away from the respective adjacent structures to limit the vibration levels to no more than 0.20 in/sec at the buildings. As shown in Table II, most of the equipment will generate ground-borne vibration levels in excess of the 0.20 in/sec criterion if operated too closely to the residence to the south. Earth compacting equipment also has a possibility of generating excessive ground-borne vibration at the home adjacent to the west.

TABLE IV

Construction Equipment Vibration Levels, in/sec PPV

Dist. to Res. To South, ft.	6
Dist to Res. To West	13
Dist to Res. To North	77

EQUIPMENT d =	Reference Vibration at d, ft. 25	Vibration Level @ Res. To South	Vibration Level @ Res. To West	Vibration Level @ Res. To North	Dist for 0.2 PPV limit
Excavator	0.089	**0.8**	0.2	0.0	15
Hoe Ram	0.089	**0.8**	0.2	0.0	15
Large Bulldozer	0.089	**0.8**	0.2	0.0	15
Loaded Trucks	0.076	**0.6**	0.2	0.0	13
Jackhammer	0.035	**0.3**	0.1	0.0	8
Small Bulldozer	0.003	0.0	0.0	0.0	2
Backhoe	0.088	**0.7**	0.2	0.0	14
Compactor	0.240	**2.0**	**0.6**	0.0	28
concrete Mixer	0.080	**0.7**	0.2	0.0	14
Concrete Pump	0.080	**0.7**	0.2	0.0	14
Crane	0.008	0.1	0.0	0.0	3
Dump Truck	0.080	**0.7**	0.2	0.0	14
Front End Loader	0.088	**0.7**	0.2	0.0	14
Grader	0.088	**0.7**	0.2	0.0	14
Hydra Break Ram*	0.040	**0.3**	0.1	0.0	9
Soil Sampling Rig	0.088	**0.7**	0.2	0.0	14
Paver	0.080	**0.7**	0.2	0.0	14
Pickup Truck	0.080	**0.7**	0.2	0.0	14
Slurry Trenching	0.016	0.1	0.0	0.0	5
Tractor	0.080	**0.7**	0.2	0.0	14
Vibratory Roller (lge)	0.477	**4.1**	**1.3**	0.1	45
Vibratory Roller (sm)	0.176	**1.5**	**0.5**	0.0	23
Clam Shovel*	0.208	**1.8**	**0.6**	0.0	26
Rock Drill	0.088	**0.7**	0.2	0.0	14

* Transient vibration levels

The ground-borne vibration levels from construction equipment are within the 0.20 in./sec. PPV limit at distances ranging from 2 ft. to 15 ft. from the heavy equipment location. The equipment that could generate excessive vibration levels are those that excite the ground by striking it. Some of these are very large pieces of equipment and will likely not be used on the project. Smaller equipment, such small bulldozers/skid steers (Bobcats) may be used up to the property lines for excavation and other necessary earth work

VIII. Recommendations

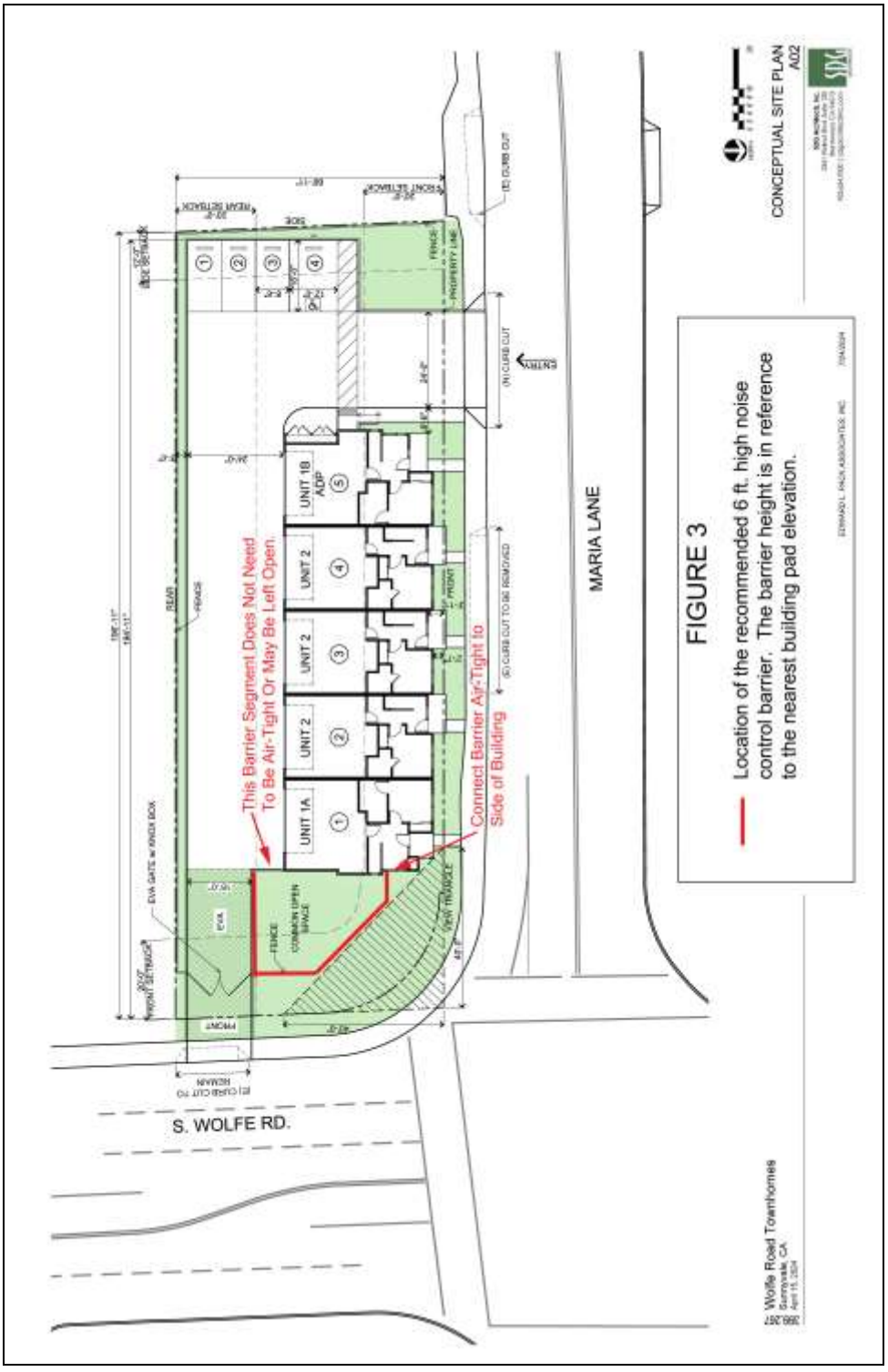
A. Exterior Noise Control

To achieve compliance with the 60 dB DNL limit of the City of Sunnyvale Noise Element, the following noise control barrier will be required.

- Construct a 6 ft. high acoustically-effective barrier along the outer perimeter of the common open space at the east end of the building facing South Wolfe Road. Connect the barrier air-tight to the side of the building. The return segment at the southeasterly corner of Unit 1 may be left open or may be any type of fence with a gate, as desired.

- The barrier height is in reference to the nearest **building pad** elevation.

- Please see Figure 3 for the location of the recommended noise control barrier.


CONCEPTUAL SITE PLAN
A02
FIGURE 3
Location of the recommended 6 ft. high noise control barrier. The barrier height is in reference to the nearest building pad elevation.
This Barrier Segment Does Not Need To Be Air-Tight Or May Be Left Open.
Connect Barrier Air-Tight to Side of Building
MARIA LANE
S. WOLFE RD.
UNIT 1A
UNIT 2
UNIT 2
UNIT 2
UNIT 1B ADP
Wolfe Road Townhomes

To achieve an acoustically-effective barrier it must be constructed air-tight, i.e., without cracks, gaps or other openings, and must provide for long-term durability. Barriers can be constructed of masonry, wood, stucco, concrete, earth berm or a combination thereof and must have a minimum surface weight of 4.0 lbs. per sq. ft. for the railroad noise barrier and 2.5 lbs. per sq. ft. for the vehicular traffic noise barrier. If wood construction is used, homogeneous sheet materials are preferable to conventional wood fencing, as the latter has a tendency to warp and form openings with age. However, high quality air-tight tongue-and-groove, board and batten or shiplap construction can be used. All connections with posts, pilasters and the building shells must be sealed air-tight. No openings are permitted between the upper barrier components and the ground.

The implementation of the above recommended measures will reduce the noise exposures in the common open space to 60 dB DNL or lower for compliance with the City of Sunnyvale Noise Element.

B. Mechanical Equipment

The outdoor mechanical systems for the project have not yet been determined. To ensure that the combined noise level of all equipment operating simultaneously at night remains within the limits of the 60 dBA nighttime noise standard of the City of Sunnyvale Municipal Code, the mechanical units shall be sound rated no higher than:

87 dBA @ 1 meter (3.28 ft.) or,
94 dBA L*w*A.

C. Construction Noise and Vibration Control

Control of the demolition/construction phase noise at the site can be accomplished by using quiet or "new technology" equipment. The greatest potential for noise abatement of current equipment should be the quieting of exhaust noises by use of improved mufflers. It is recommended that all internal combustion engines used at the project site be equipped with a type of muffler recommended by the vehicle manufacturer. In addition, all equipment should be in good mechanical condition so as to minimize noise created by faulty or poorly maintained engine, drive-train and other components.

As additional noise reduction benefits can be achieved by appropriate selection of equipment utilized for various operations, subject to equipment availability and cost considerations, the following recommendations for minimizing impacts on the surrounding area are offered:

OPERATIONAL AND SITUATIONAL CONTROLS

- Schedule construction operations that comply with the limits of the City of Sunnyvale Municipal Code.
- Construction Hours = Per City Requirements, 7:00 AM – 6:00 PM Monday-Friday, and 8:00 AM – 5:00 PM Saturdays. No work is permitted on Sundays or holidays.
- No material deliveries are allowed on Sundays or Federal Holidays.
- Minimize material movement along the east and south sides of the site.
- Keep mobile equipment (haul trucks, concrete trucks, etc.) off of local streets near residences as much as possible.

- Utilize temporary power service from the utility company in lieu of generators wherever possible.

- Keep vehicle paths graded smooth as rough roads and paths can cause significant noise and vibration from trucks (particularly empty trucks) rolling over rough surfaces. Loud bangs and ground-borne vibration can occur.

INTERIOR WORK

- For interior work, the windows of the interior spaces facing neighboring residences where work is being performed shall be kept closed while work is proceeding.

- Noise generating equipment indoors should be located within the building to utilize building elements as noise screens.

EQUIPMENT

- Place long-term stationary equipment as far away from the residential areas as possible.

- Due to the close proximity of the project to adjacent uses, sound level limits on equipment at the property lines will not be feasible. This is common with urban in-fill projects.

- Circular saws, miter/chop saws and radial arm saws shall be screened from view by any and all residences using an air-tight screen material of at least 2.0 lbs./sq. ft. surface weight, such as ¾" plywood.

- Music shall not be audible off site.

- Earth Removal: Use scrapers as much as possible for earth removal, rather than the noisier loaders and hauling trucks.

- Building Construction: Power saws should be shielded or enclosed where practical to decrease noise emissions. Nail guns should be used where possible as they are less noisy than manual hammering.

- Generators and Compressors: Use generators and compressor that are housed in acoustical enclosures rather than weather enclosures or none at all.

- Backfilling: Use a backhoe for backfilling, as it is less costly and quieter than either dozers or loaders.

- Ground Preparation: Use a motor grader rather than a bulldozer for final grading. Wheeled heavy equipment is less noisy than track equipment. Utilize wheeled equipment rather than track equipment whenever possible.

- Portable generators, compressors and pumps shall have manufacturer's acoustical enclosures whenever possible.

- Use electrically powered tools rather than pneumatic tools whenever possible.

- The greatest potential for noise abatement of current equipment should be the quieting of exhaust noises by use of improved mufflers.

- It is recommended that all internal combustion engines used at the project site be equipped with a type of muffler recommended by the vehicle manufacturer.

- All equipment should be in good mechanical condition so as to minimize noise created by faulty or poorly maintained engines, drive-trains and other components. Worn, loose or unbalanced parts or components shall be maintained or replaced to minimize noise and vibration.

NOISE COMPLAINT MANAGEMENT

- Provide a noise disturbance coordinator with a phone line and voicemail/answering machine. Post signs around the site with the necessary information. The officer shall be available at all times during construction hours via both telephone and email. Signs shall be posted at site entries. A sample is shown below.

NOISE COMPLAINTS

FOR CONCERNS REGARDING CONSTRUCTION NOISE PLEASE CONTACT:

John Doe
JohnDoe@ConstructionCo.com
OPERATIONS MANAGEMENT ENGINEER
CALL CENTER: (111) 111-1111

- Notify, in writing, all residents within 200 ft. of the project perimeter and adjacent commercial uses of construction. The notification shall contain the name, phone number and email address of the noise complaint officer. A flyer may be placed at the doors of the residences.

- A log of all complaints shall be maintained. The logs shall contain the name and address of the complainant, the date and time of the complaint, the nature/description of the noise source, a description of the remediation attempt or the reason remediation could not be attempted.

IX. Conclusions

In conclusion, the exterior noise exposures at project common open space the project will exceed the limits of the City of Sunnyvale Noise Element standards. Noise reduction measures will be required. Project-generated noise from mechanical equipment is not expected to exceed the limits of the City of Sunnyvale Municipal Code. Noise and vibration from construction be significant but temporary and will be minimized with the noise and vibration controls recommended in this study.

This report presents the results of a noise assessment study for the planned attached single-family development at 1001 South Wolfe Road in Sunnyvale. The study findings for existing conditions are based on field measurements and other data and are correct to the best of our knowledge. Future noise projections are based on estimates made by Edward L. Pack Associates, Inc. from information provided by the City of Sunnyvale. However, significant deviations in the predicted traffic volumes, motor vehicle technology, noise regulations or other future changes beyond our control may produce long-range noise results different from our estimates.

Report Prepared By:

EDWARD L. PACK ASSOC., INC.

Jeffrey K. Pack
President

APPENDIX A

References

(a) Conceptual Site Plan, Wolfe Road Townhouses, by SDG Architects, April 15, 2024

(b) Noise Element of the General Plan, Chapter 6, "Safety and Noise", City of Sunnyvale, July, 2011

(c) City of Sunnyvale Municipal Code, Sections 19.42.030 Noise or Sound Level, 19.54.050 Operation and Maintenance Standards, 16.08.030 Hours of Construction – Time and Noise Limitations

(d) City Count Map, City of Sunnyvale, https://www.arcgis.com/apps/mapviewer/index.html?layers=b2221d1a82064970b0ab9caf536562a6

(e) Information on Future Traffic Volume Growth Rates Provided by Mr. Jack Witthaus, City of Sunnyvale Transportation Planning Department, by Telephone to Edward L. Pack Associates, Inc., June 6, 2012

(f) Highway Research Board, "Highway Noise - A Design Guide for Highway Engineers", Report 117, 1971

(g) United States Federal Transit Administration, Transit Noise and Vibration Impact Assessment Manual, Federal Transit Administration, Report No. 0123, by John A. Volpe National Transportation Systems Center, September 2018

APPENDIX B

Noise Standards, Terminology, Instrumentation and General Building Shell Controls,

1. Noise Standards

A. City of Sunnyvale Noise Element Standards

The noise criteria for residential uses in the City of Sunnyvale are specified in the Noise Element of the General Plan, Chapter 6, "Safety and Noise", as approved by the City Council, July, 2011. These standards include the following:

- Attempt to achieve an outdoor limit of 60 dB DNL for common recreation areas, backyards, patios, and useable balconies. This standard does not apply where the noise source is a railroad or airport.

- Enforce the California Code of Regulations, Title 24 noise standard of 45 dB DNL multi-family for interiors. This standard shall also be applied to single-family interiors.

- When the noise source is a railroad, 70 dB DNL is acceptable for exteriors. Attempt to achieve maximum instantaneous noise levels (L_{max}) of 50 dBA for bedrooms and 55 dBA for other living spaces when the noise source is a railroad or aircraft and the exterior DNL exceeds 55 dB.

2. Terminology

A. Statistical Noise Levels

Due to the fluctuating character of urban traffic noise, statistical procedures are needed to provide an adequate description of the environment. A series of statistical descriptors have been developed which represent the noise levels exceeded a given percentage of the time. These descriptors are obtained by direct readout of the Sound Level Meters and Noise Analyzers. Some of the statistical levels used to describe community noise are defined as follows:

L_1 - A noise level exceeded for 1% of the time.

L_{10} - A noise level exceeded for 10% of the time, considered to be an "intrusive" level.

L_{50} - The noise level exceeded 50% of the time representing an "average" sound level.

L_{90} - The noise level exceeded 90 % of the time, designated as a "background" noise level.

L_{eq} - The continuous equivalent-energy level is that level of a steady-state noise having the same sound energy as a given time-varying noise. The L_{eq} represents the decibel level of the time-averaged value of sound energy or sound pressure squared and is used to calculate the DNL and CNEL.

B. Day-Night Level (DNL)

Noise levels utilized in the standards are described in terms of the Day-Night Level (DNL). The DNL rating is determined by the cumulative noise exposures occurring over a 24-hour day in terms of A-Weighted sound energy. The 24-hour day is divided into two subperiods for the DNL index, i.e., the daytime period from 7:00 a.m. to 10:00 p.m., and the nighttime period from 10:00 p.m. to 7:00 a.m. A 10 dB weighting factor is applied (added) to the noise levels occurring during the nighttime period to account for the greater sensitivity of people to noise during these hours. The DNL is calculated from the measured L_{eq} in accordance with the following mathematical formula:

$$DNL = 10\log_{10}\left[\left(\left(\sum(10^{Leq(7AM\text{-}10PM)})\right)+\left(\sum(10^{Leq(10PM\text{-}7AM)}+10)\right)\right)/24\right]$$

C. A-Weighted Sound Level

The decibel measure of the sound level utilizing the "A" weighted network of a sound level meter is referred to as "dBA". The "A" weighting is the accepted standard weighting system used when noise is measured and recorded for the purpose of determining total noise levels and conducting statistical analyses of the environment so that the output correlates well with the response of the human ear.

3. Instrumentation

The on-site field measurement data were acquired by the use of one or more of the precision acoustical instruments shown below. The acoustical instrumentation provides a direct readout of the L exceedance statistical levels including the equivalent-energy level (L_{eq}). Input to the meters was provided by a microphone extended to a height of 5 ft. above the ground. The meter conforms to ANSI S1.4 for Type 1 instruments and IEC 61672-1:2002 for Class 1 instruments. The "A" weighting network and the "Fast" response setting of the meter were used in conformance with the applicable ISO and IEC standards. All instrumentation was acoustically calibrated before and after field tests to assure accuracy.

Larson Davis LDL 812 Precision Integrating Sound Level Meter
Larson Davis Lxt Precision Integrating Sound Level Meter
Larson Davis 831 Precision Integrating Sound Level Meter

4. Building Shell Controls

The following additional precautionary measures are required to assure the greatest potential for exterior-to-interior noise attenuation by the recommended mitigation measures. These measures apply at those units where closed windows are required:

- Unshielded entry doors having a direct or side orientation toward the primary noise source must be 1-5/8" or 1-3/4" thick, insulated metal or solid-core wood construction with effective weather seals around the full perimeter. Mail slots should not be used in these doors or in the wall of a living space, as a significant noise leakage can occur through them.

- If any penetrations in the building shell are required for vents, piping, conduit, etc., sound leakage around these penetrations can be controlled by sealing all cracks and clearance spaces with a non-hardening caulking compound.

- Ventilation openings shall not compromise the acoustical integrity of the building shell.

- Spray-in or expandable foams are not acceptable as acoustical sealant or as sound absorptive material in walls and ceilings.

- Ventilation openings connecting the exterior of the building to interior spaces should face away from any major noise source and the duct connecting the exterior vent to the interior grille should have at least two 90° turns.

APPENDIX C

Noise Measurement Data and Calculation Tables

DNL CALCULATIONS

CLIENT: SAMIR SHARMA
FILE: 56-017
PROJECT: 5-UNIT TOWNHOMES
DATE: 6/10-11/2024
SOURCE: SOUTH WOLFE ROAD

LOCATION 1	S. Wolfe Rd.			
Dist. To Source	78 ft.			
TIME	Leq	10^Leq/10		
7:00 AM	63.8	2388916.7		
8:00 AM	64.6	2867952.8		
9:00 AM	64.3	2670133.7		
10:00 AM	62.0	1570344.7		
11:00 AM	62.2	1673693.8		
12:00 PM	61.8	1520750.6		
1:00 PM	62.6	1817937.7		
2:00 PM	60.4	1104424.4		
3:00 PM	61.5	1412290.4		
4:00 PM	63.0	1987009.8		
5:00 PM	63.5	2236675.6		
6:00 PM	63.1	2028462.6		
7:00 PM	64.1	2569064.5		
8:00 PM	62.1	1620384.2		
9:00 PM	60.0	995426.0	SUM=	28463467.4
10:00 PM	58.9	769376.6	Ld=	74.5
11:00 PM	55.9	391720.2		
12:00 AM	53.8	238257.7		
1:00 AM	53.8	237160.3		
2:00 AM	49.8	95528.3		
3:00 AM	49.2	82796.1		
4:00 AM	54.3	267370.2		
5:00 AM	58.3	679707.4		
6:00 AM	60.7	1167648.2	SUM=	3929565.1
			Ln=	65.9
	Daytime Level=	74.5		
	Nighttime Level=	75.9		
	DNL=	**65**		
	24-Hour Leq=	61.3		