Appendix D. Background Information on Acoustics

BACKGROUND INFORMATION ON ACOUSTICS

Sound Terminology

Sound travels through the air as waves of minute air pressure fluctuations caused by some type of vibration. In general, sound waves travel away from the sound source as an expanding spherical surface. The energy contained in a sound wave is consequently spread over an increasing area as it travels away from the source. This results in a decrease in loudness at greater distances from the sound source. The following terms are commonly used in acoustics.

Decibel

Sound-level meters measure the pressure fluctuations caused by sound waves. Because of the ability of the human ear to respond to a wide dynamic range of sound pressure fluctuations, loudness is measured in terms of decibels (dB) on a logarithmic scale. This results in a scale that measures pressure fluctuations in a convenient notation and corresponds to our auditory perception of increasing loudness.

A-Weighted Decibels

Most sounds consist of a broad range of sound frequencies. Because the human ear is not equally sensitive to all frequencies, several frequency-weighting schemes have been used to develop composite decibel scales that approximate the way the human ear responds to sound levels. The "A-weighted" decibel scale (dBA) is the most widely used for this purpose. Typical A-weighted sound levels for various types of sound sources are summarized in Figure 1.

Equivalent Sound Level

Time-varying sound levels are often described in terms of an equivalent constant decibel level. Equivalent sound levels (L_{eq}) are used to develop single-value descriptions of average sound exposure over various periods of time. Such average sound exposure values often include additional weighting factors for annoyance potential attributable to time of day or other considerations. The L_{eq} data used for these average sound exposure descriptors are generally based on A-weighted sound-level measurements.

Day-Night Average Sound Level

Average sound exposure over a 24-hour period is often presented as a day-night average sound level (L_{dn}). L_{dn} values are calculated from hourly L_{eq} values, with the L_{eq} values for the

nighttime period (10:00 p.m.-7:00 a.m.) increased by 10 dB to reflect the greater disturbance potential from nighttime noises.

Community Noise Equivalent Level

The community noise equivalent level (CNEL) is also used to characterize average sound levels over a 24-hour period, with weighting factors included for evening and nighttime sound levels. L_{eq} values for the evening period (7:00 p.m.-10:00 p.m.) are increased by 5 dB, while L_{eq} values for the nighttime period (10:00 p.m.-7:00 a.m.) are increased by 10 dB. For given set of sound measurements, the CNEL value will usually be about 1 dB higher than the L_{dn} value. In practice, CNEL and L_{dn} are often used interchangeably.

Percentile-Exceeded, Maximum, and Minimum Sound Level

The sound level exceeded during a given percentage of a measurement period is the percentile-exceeded sound level (L_x). Examples include L_{10}, L_{50}, and L_{90}. L_{10} is the A-weighted sound level that is exceeded 10% of the measurement period, L_{50} is the level exceeded 50% of the period, and so on. L_{50} is the median sound level measured during the measurement period. $L_{90,}$ the sound level exceeded 90% of the time, excludes high localized sound levels produced by nearby sources such as single car passages or bird chirps. L_{90} is often used to represent the background sound level. L_{50} is also used to provide a less conservative assessment of the background sound level.

The maximum sound level (L_{max}) and the minimum sound level (L_{min}) are the maximum and minimum sound levels respectively, measured during the measurement period. When a sound meter is set to the "slow" response setting as is typical for most community noise measurements, the Lmax and Lmin values are the maximum and minimum levels measured over a one second period.

Ambient Sound

Ambient sound is the all-encompassing sound associated with a given community site, usually being a composite of sounds from many sources, near and far, with no particular sound being dominant.

Equivalencies between Various Sound Descriptors

The L_{dn} value at a site calculated from a set of measurements taken over a given 24-hour period will be slightly lower than the CNEL value calculated over the same period. Except in situations where unusually high evening sound levels occur, the CNEL value will be within 1.5 dB of the L_{dn} value for the same set of sound measurements.

Sound Source	Sound Level (dBA)*	Response
Carrier deck jet operation	140	
Civil defense siren (at 100 feet)	130	Painfully loud
Jet takeoff (at 200 feet)	120	Threshold of feeling and pain
Riveting machine (at 1 foot) Rock music concert	110	
Pile driver (at 50 feet) Ambulance siren (at 100 feet)	100	Very loud
Heavy truck (at 50 feet)	90	
Pneumatic drill (at 50 feet) Freight train cars (at 50 feet)	80	
Garbage disposal in home		
Freight train cars (at 100 feet) Freeway traffic (at 50 feet) Vacuum cleaner (at 10 feet)	70	Moderately loud
Air conditioning unit (at 20 feet)	60	
Speech in normal voice (at 15 feet)	50	
Residence-typical movement of people, no TV or radio	40	Quiet
Soft whisper (at 5 feet)	30	
Recording studio	20	
	10	
	0	Threshold of hearing

* Typical A-weighted sound levels in decibels. "A" weighting approximates the frequency response of the human ear.

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Figure 1

Weighted Sound Levels and Human Response

The relationship between peak hourly L_{eq} values and associated L_{dn} values depends on the distribution of traffic over the entire day. There is no precise way to convert a peak hourly L_{eq} value to an L_{dn} value. However, in urban areas near heavy traffic, the peak hourly L_{eq} value is typically 2-4 dB lower than the daily L_{dn} value. In less heavily developed areas, the peak hourly L_{eq} is often equal to the daily L_{dn} value. For rural areas with little nighttime traffic, the peak hourly L_{eq} value will often be 3-4 dB greater than the daily L_{dn} value.

Working with Decibel Values

The nature of the decibel scale is such that the individual sound levels for different sound sources cannot be added directly to give the combined sound level of these sources. Two sound sources producing equal sound levels at a given location will produce a composite sound level that is 3 dB greater than either sound alone. When two sound sources differ by 10 dB, the composite sound level will be only 0.4 dB greater than the louder source alone.

Most people have difficulty distinguishing the louder of two sound sources if they differ by less than 1.5-2.0 dB. Research into the human perception of changes in sound level indicates the following:

- a 3-dB change is just perceptible,
- a 5-dB change is clearly perceptible, and
- a 10-dB change is perceived as being twice or half as loud.

A doubling or halving of acoustic energy will change the resulting sound level by 3 dB, which corresponds to a change that is just perceptible. In practice, this means that a doubling of traffic volume on a roadway, doubling the number of people in a stadium, or doubling the number of wind turbines in a wind farm will, as a general rule, only result in a 3-dB, or just perceptible, increase in noise.

Outdoor Sound Propagation

There are a number of factors that affect how sound propagates outdoors. These factors, described by Hoover and Keith (1996), are summarized below.

Distance Attenuation

As a general rule, sound from localized or point sound sources spreads out as it travels away from the source and the sound level drops at a rate of 6 dB per doubling of distance. If the sound source is long in one dimension, such as traffic on a highway or a long train, the sound source is considered to be a line source. As a general rule, the sound level from a line source will drop off at

a rate of 3 dB per doubling of distance. If the intervening ground between the line source and the receptor is acoustically "soft" (e.g., ground vegetation, scattered trees, clumps of bushes), an attenuation rate of 4.5 dB per doubling of distance is generally used.

Attenuation from Barriers

Any solid structure such as a berm, wall, or building that blocks the line of sight between a source and receiver serves as a sound barrier and will result in additional sound attenuation. The amount of additional attenuation is a function of the difference between the length of the sound path over the barrier and the length of the direct line of sight path. Thus, the sound attenuation of a barrier between a source and a receiver that are very far apart will be much less than the attenuation that would result if either the source or the receiver is very close to the barrier.

Molecular Absorption

Air absorbs sound energy as a function of the temperature, humidity of the air, and frequency of the sound. Additional sound attenuation on the order of 1 to 2 dB per 1,000 feet can occur.

Anomalous Excess Attenuation

Large-scale effects of wind speed, wind direction, and thermal gradients in the air can cause large differences in sound transmission over large distances. These effects when combined result in anomalous excess attenuation, which can be applied to long-term sound-level estimates. Additional sound attenuation on the order of about 1 dB per 1,000 feet can occur.

Other Atmospheric Effects

Short-term atmospheric effects relating to wind and temperature gradients can cause bending of sound waves and can influence changes in sound levels at large distances. These effects can either increase or decrease sound levels depending on the orientation of the source and receptor and the nature of the wind and temperature gradient. Because these effects are normally short-term, it is generally not practical to include them in sound propagation calculations. Understanding these effects, however, can help explain variations that occur between calculated and measured sound levels.

Guidelines for Interpreting Sound Levels

Various federal, state, and local agencies have developed guidelines for evaluating land use compatibility under different sound-level ranges. The following is a summary of federal and state guidelines.

Federal Agency Guidelines

The federal Noise Control Act of 1972 (Public Law 92-574) established a requirement that all federal agencies administer their programs to promote an environment free of noise that jeopardizes public health or welfare. The U.S. Environmental Protection Agency (EPA) was given the responsibility for:

- providing information to the public regarding identifiable effects of noise on public health or welfare,
- publishing information on the levels of environmental noise that will protect the public health and welfare with an adequate margin of safety,
- coordinating federal research and activities related to noise control, and
- establishing federal noise emission standards for selected products distributed in interstate commerce.

The federal Noise Control Act also directed that all federal agencies comply with applicable federal, state, interstate, and local noise control regulations.

Although EPA was given major public information and federal agency coordination roles, each federal agency retains authority to adopt noise regulations pertaining to agency programs. EPA can require other federal agencies to justify their noise regulations in terms of the federal Noise Control Act policy requirements. The Occupational Safety and Health Administration retains primary authority for setting workplace noise exposure standards. The Federal Aviation Administration retains primary jurisdiction over aircraft noise standards, and the Federal Highway Administration (FHWA) retains primary jurisdiction over highway noise standards.

In 1974, in response to the requirements of the federal Noise Control Act, EPA identified indoor and outdoor noise limits to protect public health and welfare (communication disruption, sleep disturbance, and hearing damage). Outdoor L_{dn} limits of 55 dB and indoor L_{dn} limits of 45 dB are identified as desirable to protect against speech interference and sleep disturbance for residential, educational, and healthcare areas. Sound-level criteria to protect against hearing damage in commercial and industrial areas are identified as 24-hour L_{eq} values of 70 dB (both outdoors and indoors).

The FHWA has adopted criteria for evaluating noise impacts associated with federally funded highway projects and for determining whether these impacts are sufficient to justify funding noise mitigation actions (23 CFR 772). The FHWA noise abatement criteria are based on peak hourly L_{eq} sound levels, not L_{dn} or 24-hour L_{eq} values. The peak 1-hour L_{eq} criteria for residential, educational, and healthcare facilities are 67 dB outdoors and 52 dB indoors. The peak 1-hour L_{eq} criterion for commercial and industrial areas is 72 dB (outdoors).

The U.S. Department of Housing and Urban Development has established guidelines for evaluating noise impacts on residential projects seeking financial support under various grant programs (44 FR 135:40860-40866, January 23, 1979). Sites are generally considered acceptable for residential use if they are exposed to outdoor L_{dn} values of 65 dB or less. Sites are considered "normally unacceptable" if they are exposed to outdoor L_{dn} values of 65-75 dB. Sites are considered unacceptable if they are exposed to outdoor L_{dn} values above 75 dB.

State Agency Guidelines

In 1987, the California Department of Health Services published guidelines for the noise elements of local general plans. These guidelines include a sound level/land use compatibility chart that categorizes various outdoor L_{dn} ranges into up to four compatibility categories (normally acceptable, conditionally acceptable, normally unacceptable, and clearly unacceptable) by land use. For many land uses, the chart shows overlapping L_{dn} ranges for two or more compatibility categories.

The noise element guidelines chart identifies the normally acceptable range for low-density residential uses as less than 60 dB and the conditionally acceptable range as 55-70 dB. The normally acceptable range for high-density residential uses is identified as L_{dn} values below 65 dB, and the conditionally acceptable range is identified as 60-70 dB. For educational and medical facilities, L_{dn} values below 70 dB are considered normally acceptable and L_{dn} values of 60-70 dB are considered conditionally acceptable. For office and commercial land uses, L_{dn} values below 70 dB are considered normally acceptable and L_{dn} values of 67.5-77.5 are categorized as conditionally acceptable.

These overlapping L_{dn} ranges are intended to indicate that local conditions (existing sound levels and community attitudes toward dominant sound sources) should be considered in evaluating land use compatibility at specific locations.

The California Department of Housing and Community Development has adopted noise insulation performance standards for new hotels, motels, and dwellings other than detached single-family structures (24 CCR T25-28). These standards require that "interior CNELs with windows closed, attributable to exterior sources, shall not exceed an annual CNEL of 45 dB in any habitable room".

The California Department of Transportation uses the FHWA criteria as the basis for evaluating noise impacts from highway projects.

Reference

Hoover, R. M., and R. H. Keith. 1996. Noise control for buildings and manufacturing plants. Hoover and Keith, Inc. Houston, TX.

Results of the Noise Modeling Conducted for the Land Use Map Alternatives

Table 1 Traffic Noise Levels for Alternative 2

East-West Roadway	Segment	Ldn Noise Level at 100 Feet	Distance to Noise Contour		
			70 Ldn	65 Ldn	60 Ldn
1st Street	A St to F St	61.6	28	60	129
2nd Street	3rd St to Pole Line Rd	62.8	33	71	154
	Pole Line Rd to Mace Blvd	64.4	42	91	197
	West of Mace Blvd	65.2	48	104	223
5th Street	B St to J St	65.2	48	104	224
	J St to Pole Line Rd	63.9	39	85	183
	Pole Line Rd TO Juniper Pt	64.2	41	89	191
	Juniper Pt to Pena	62.9	33	72	155
	East of Pena	60.3	23	49	105
8th Street	Sycamore Ln to F St	59.5	20	43	92
	F St to J St	60.1	22	47	102
	J St to L St	59.4	20	42	92
	L St to Pole Line Rd	58.6	17	38	81
	East of Pole Line Rd	55.6	11	23	51
14th Street	Oak Ave to F St	55.6	11	24	51
Arlington Boulevard	Lake Blvd to Russell Blvd	58.7	18	38	82
Chiles Road	Cowell Blvd to Mace Blvd	58.8	18	39	83
	Mace Blvd to infill	62.6	32	70	150
	infill to PG&E	62.6	32	70	150
	PG&E to Webster Ramps	62.6	32	70	150
County Road 31	West of Lake Blvd	66.7	60	130	280
County Road 32A	E. of Mace Blvd.	63.6	37	81	174
Covell Boulevard	Lake Blvd to Shasta Dr	66.7	60	129	278
	Denali to Shasta Dr	68	75	161	346
	Shasta Dr to County Rd 101 A	67	67	143	309
	County Rd 101 A to Sycamore Ln	67.1	65	139	300
	Sycamore Ln to Pole Line Rd (overxing)	66.7	60	129	279

	Pole Line Rd to Alhambra Dr	68.0	74	160	344
	Alhambra Dr to Alhambra Dr	64.9	45	98	211
Cowell Boulevard	Research Park Dr to Pole Line	64.0	40	85	183
	Pole Line Rd to Chiles Rd	62.1	30	64	138
	Chiles Rd to Mace Blvd	60.3	23	49	105
	East of Mace Blvd.	55.5	11	23	50
Hutchison Drive	State Route 113 to La Rue Rd	62.7	32	70	150
I-80	East of Webster	82.1	642	1383	2979
	Webster to Mace	81.8	607	1308	2819
	Mace Blvd to Olive Dr	81.7	603	1298	2797
	Olive Dr to Richards Blvd	81.6	589	1269	2734
	Richards Blvd to SR 113	81.9	620	1336	2877
	West of SR 113	81.6	597	1287	2772
Lillard Drive	Pole Line Rd to Drummond	59.5	20	43	93
	East of Drummond Ave	52.5	7	15	32
Old Davis Road	West of A St	61.4	27	58	125
Russell Boulevard	West of Lake Blvd	59.7	21	44	95
	Lake Blvd to Arlington Rd	63.7	38	82	178
	Arlington Rd to SR 113	65.7	52	112	241
	SR 113 to Anderson Rd	65.7	51	111	238
	Anderson Rd to Oak Ave	66.0	54	116	250
	Oak Ave to B St	66.2	56	120	259
Anderson Road	F St to Catalina Dr	54.1	9	19	41
	Catalina Dr to Covell Blvd	56.0	12	25	54
	Covell Blvd to Valdora Dr	60.7	24	52	112
	Valdora Dr to 8th St	60.0	21	46	100
	8th St to Russell Blvd	60.6	24	51	110
B Street	14th St to 8th St	57.6	15	32	69
	8th St to Russell Blvd	58.7	18	38	82
	Russell Blvd to 1st St	61.6	28	59	128
California Avenue	So. of Russell Blvd.	57.5	15	32	68
Catalina Drive	Grande Ave to Covell Blvd	51	6	12	27
F Street	Grande Ave to Covell Blvd	61.0	25	54	116

	Covell Blvd to 14 St	61.0	25	54	116
	14th St to 8th St	60.6	24	51	110
	8th St to 5th St	59.0	18	40	86
	5th St to 1st St	59.8	21	45	97
Howard Way	So. of Russell Blvd.	61.1	25	55	118
J Street	Covell Blvd to 8th St	55.2	10	22	48
	8th St to 3rd St	53.4	8	17	36
L Street	County Rd 102/Ple Line to Covell	61	23	50	108
	Covell Blvd to 8th St	59	19	41	89
	8th St to 5th St	60	21	45	98
	5St to 2nd St	60	21	46	99
Lake Boulevard	No. of Covell Blvd	59.1	19	41	88
	Covell Blvd to Arlington Blvd	60.3	23	49	105
	Arlington Blvd to Russell	55.0	10	22	46
Mace Boulevard	Covell Blvd to 2nd St	68.6	81	174	376
	2nd St to Chiles Rd	69.1	86	186	401
	Chiles Rd to Cowell Blvd	63.6	38	81	174
	Cowell Blvd to Montgomery Rd	59.5	20	43	93
Oak Avenue	Covell Blvd to 14th St	57.4	14	31	67
	14th St to Eighth St	54.0	9	19	40
	Eighth St to Russell Blvd	53.3	8	17	36
Pole Line Road	No. of Covell Blvd	68.7	82	178	383
	Covell Blvd to Loyola	61.6	28	60	129
	Loyola to 8th	60.9	25	53	115
	8th St to 5th St	60.9	25	53	115
	5th St to Cowell Blvd	62.3	30	66	141
Richards Boulevard	E St to East Olive Dr	66.8	61	132	283
State Route 113	I-80 to Hutchison Dr	78.3	357	769	1657
	Hutchison Dr to Russell Blvd	77.8	332	715	1541
	Russell Blvd to Covell Blvd	77.6	320	690	1488
	No. of Covell Blvd	76.3	261	563	1212
Sycamore Lane	No. of Covell Blvd	60.1	22	47	102
	Covell Blvd to Russell Blvd	57.2	14	30	65

Table 2 Traffic Noise Levels for Alternative 3

Roadway	Segment	Ldn Noise Level at 100 Feet	Distance to Noise Contour		
			70 Ldn	65 Ldn	60 Ldn
1st Street	A St to F St	62	28	61	132
2nd Street	3rd St to Pole Line Rd	63	32	70	150
	Pole Line Rd to Mace Blvd	64	42	89	193
	West of Mace Blvd	65.2	48	103	221
5th Street	B St to J St	65	46	98	211
	J St to Pole Line Rd	64	37	81	174
	Pole Line Rd TO Juniper Pt	64	39	84	181
	Juniper Pt to Pena	62	31	68	146
	East of Pena	60	20	44	94
8th Street	Sycamore Ln to F St	59	20	42	92
	F St to J St	59	20	43	92
	J St to L St	58	17	37	79
	L St to Pole Line Rd	58	17	37	79
	East of Pole Line Rd	55	11	23	49
14th Street	Oak Ave to F St	56	11	24	51
Arlington Boulevard	Lake Blvd to Russell Blvd	59	17	38	81
Chiles Road	Cowell Blvd to Mace Blvd	59	19	40	87
	Mace Blvd to infill	62	31	68	146
	infill to PG&E	62	31	68	146
	PG&E to Webster Ramps	62	31	68	146
County Road 31	West of Lake Blvd	67	59	127	274
County Road 32A	E. of Mace Blvd.	63	35	75	162
Covell Boulevard	Lake Blvd to Denali	67	59	128	276
	Denali to Shasta Dr	68	74	159	343
	Shasta Dr to County Rd 101 A	67	66	142	306
	County Rd 101 A to Sycamore Ln	67	63	136	294

Table 2 Traffic Noise Levels for Alternative 3

	Sycamore Ln to Pole Line Rd (overxing)	67	60	129	278
	Pole Line Rd to Alhambra Dr	68	69	149	322
	Alhambra Dr to Alhambra Dr	65	45	96	207
Cowell Boulevard	Research Park Dr to Pole Line	64	39	84	182
	Pole Line Rd to Chiles Rd	62	30	65	139
	Chiles Rd to Mace Blvd	60	22	47	101
	East of Mace Blvd.	55	11	23	50
Hutchison Drive	State Route 113 to La Rue Rd	63	32	69	148
I-80	East of Webster	82	636	1370	2952
	Webster to Mace	82	604	1302	2805
	Mace Blvd to Olive Dr	82	601	1294	2789
	Olive Dr to Richards Blvd	82	587	1265	2726
	Richards Blvd to SR 113	82	611	1316	2835
	West of SR 113	82	594	1280	2758
Lillard Drive	Pole Line Rd to Drummond	59	20	42	91
	East of Drummond Ave	52	7	14	31
Old Davis Road	West of A St	61	26	56	120
Russell Boulevard	West of Lake Blvd	60	20	43	93
	Lake Blvd to Arlington Rd	64	38	81	175
	Arlington Rd to SR 113	66	51	111	239
	SR 113 to Anderson Rd	66	51	110	236
	Anderson Rd to Oak Ave	66	53	114	245
	Oak Ave to B St	66	55	119	256
Anderson Road	F St to Catalina Dr	54	9	19	40
	Catalina Dr to Covell Blvd	56	12	25	54
	Covell Blvd to Valdora Dr	61	23	50	108
	Valdora Dr to 8th St	60	21	45	98
	8th St to Russell Blvd	61	24	52	112
B Street	14th St to 8th St	57	14	31	66

Table 2 Traffic Noise Levels for Alternative 3

	8th St to Russell Blvd	59	18	39	84
	Russell Blvd to 1st St	62	28	60	129
California Avenue	So. of Russell Blvd.	58	15	32	70
Catalina Drive	Grande Ave to Covell Blvd	52	6	13	28
F Street	Grande Ave to Covell Blvd	61	24	53	114
	Covell Blvd to 14 St	61	23	50	108
	14th St to 8th St	60	22	48	103
	8th St to 5th St	59	19	40	86
	5th St to 1st St	60	22	47	101
Howard Way	So. of Russell Blvd.	61	25	54	116
J Street	Covell Blvd to 8th St	55	10	22	48
	8th St to 3rd St	52	6	13	29
L Street	County Rd 102/Ple Line to Covell	58	16	35	75
	Covell Blvd to 8th St	59	19	40	87
	8th St to 5th St	59	19	41	89
	5St to 2nd St	60	20	43	94
Lake Boulevard	No. of Covell Blvd	59	18	40	85
	Covell Blvd to Arlington Blvd	60	22	48	104
	Arlington Blvd to Russell	55	10	21	46
Mace Boulevard	Covell Blvd to 2nd St	68	78	167	360
	2nd St to Chiles Rd	69	84	181	389
	Chiles Rd to Cowell Blvd	63	36	79	169
	Cowell Blvd to Montgomery Rd	59	20	43	92
Oak Avenue	Covell Blvd to 14th St	57	14	30	65
	14th St to Eighth St	54	9	19	41
	Eighth St to Russell Blvd	52	6	13	29
Pole Line Road	No. of Covell Blvd	68	76	163	352
	Covell Blvd to Loyola	61	24	51	110

Table 2 Traffic Noise Levels for Alternative 3

	Loyola to 8th	61	24	52	113
	8th St to 5th St	61	25	53	115
	5th St to Cowell Blvd	62	29	63	136
Richards Boulevard	E St to East Olive Dr	67	59	127	274
State Route 113	I-80 to Hutchison Dr	78	345	743	1601
	Hutchison Dr to Russell Blvd	78	324	698	1505
	Russell Blvd to Covell Blvd	77	314	677	1458
	No. of Covell Blvd	76	258	556	1199
Sycamore Lane	No. of Covell Blvd	60	22	47	101
	Covell Blvd to Russell Blvd	57	14	30	65

Table 3 Modeled Traffic Noise Levels for Alternative 4

East-West Roadway	Segment	Ldn Noise Level at 100 Feet	Distance to Noise Contour		
			70 Ldn	65 Ldn	60 Ldn
1st Street	A St to F St	62	29	62	134
2nd Street	3rd St to Pole Line Rd	63	34	73	157
	Pole Line Rd to Mace Blvd	65	44	95	204
	West of Mace Blvd	67	61	132	284
5th Street	B St to J St	65	47	102	220
	J St to Pole Line Rd	64	40	86	186
	Pole Line Rd TO Juniper Pt	64	41	89	191
	Juniper Pt to Pena	63	34	72	156
	East of Pena	60	20	44	94
8th Street	Sycamore Ln to F St	60	21	46	100
	F St to J St	60	22	48	103
	J St to L St	60	20	43	93
	L St to Pole Line Rd	59	18	38	82
	East of Pole Line Rd	56	11	24	51
14th Street	Oak Ave to F St	56	11	24	52
Arlington Boulevard	Lake Blvd to Russell Blvd	61	24	51	109
Chiles Road	Cowell Blvd to Mace Blvd	59	19	40	86
	Mace Blvd to infill	62	29	63	136
	infill to PG&E	62	29	63	136
	PG&E to Webster Ramps	62	29	63	136
County Road 31	West of Lake Blvd	68	69	148	318
County Road 32A	E. of Mace Blvd.	65	43	94	202
Covell Boulevard	Lake Blvd to Denali	68	70	150	323
	Denali to Shasta Dr	69	82	177	381
	Shasta Dr to County Rd 101 A	68	73	158	340
	County Rd 101 A to Sycamore Ln	68	69	149	320

Table 3 Modeled Traffic Noise Levels for Alternative 4

East-West Roadway	Segment	Ldn Noise Level at 100 Feet	Distance to Noise Contour		
			70 Ldn	65 Ldn	60 Ldn
	Sycamore Ln to Pole Line Rd (overxing)	67	63	135	291
	Pole Line Rd to Alhambra Dr	68	75	161	347
	Alhambra Dr to Alhambra Dr	65	45	97	209
Cowell Boulevard	Research Park Dr to Pole Line	64	39	84	182
	Pole Line Rd to Chiles Rd	62	30	65	139
	Chiles Rd to Mace Blvd	61	24	51	109
	East of Mace Blvd.	56	11	23	51
Hutchison Drive	State Route 113 to La Rue Rd	63	33	72	155
I-80	East of Webster	82	652	1404	3024
	Webster to Mace	82	616	1327	2860
	Mace Blvd to Olive Dr	82	614	1324	2851
	Olive Dr to Richards Blvd	82	600	1292	2783
	Richards Blvd to SR 113	82	629	1356	2921
	West of SR 113	82	605	1304	2809
Lillard Drive	Pole Line Rd to Drummond	60	21	45	97
	East of Drummond Ave	52	7	14	31
Old Davis Road	West of A St	62	27	59	126
Russell Boulevard	West of Lake Blvd	61	24	51	110
	Lake Blvd to Arlington Rd	64	40	87	187
	Arlington Rd to SR 113	66	57	123	264
	SR 113 to Anderson Rd	66	54	116	251
	Anderson Rd to Oak Ave	66	55	118	254
	Oak Ave to B St	66	56	120	259

Table 3 Modeled Traffic Noise Levels for Alternative 4

East-West Roadway	Segment	Ldn Noise Level at 100 Feet	Distance to Noise Contour		
			70 Ldn	65 Ldn	60 Ldn
Anderson Road	F St to Catalina Dr	55	9	20	43
	Catalina Dr to Covell Blvd	56	12	27	57
	Covell Blvd to Valdora Dr	61	24	52	111
	Valdora Dr to 8th St	60	21	45	97
	8th St to Russell Blvd	61	24	52	112
B Street	14th St to 8th St	58	16	34	72
	8th St to Russell Blvd	59	19	40	87
	Russell Blvd to 1st St	62	29	62	134
California Avenue	So. of Russell Blvd.	58	15	33	70
Catalina Drive	Grande Ave to Covell Blvd	51	6	12	27
F Street	Grande Ave to Covell Blvd	61	26	56	120
	Covell Blvd to 14 St	61	25	53	115
	14th St to 8th St	60	23	50	108
	8th St to 5th St	59	18	39	85
	5th St to 1st St	60	21	45	97
Howard Way	So. of Russell Blvd.	61	25	53	115
J Street	Covell Blvd to 8th St	55	10	22	48
	8th St to 3rd St	54	9	20	43
L Street	County Rd 102/Ple Line to Covell	61	24	53	114
	Covell Blvd to 8th St	59	20	43	92
	8th St to 5th St	60	21	46	99
	5St to 2nd St	60	20	44	94
Lake Boulevard	No. of Covell Blvd	67	66	141	304
	Covell Blvd to Arlington Blvd	62	29	62	133
	Arlington Blvd to Russell	55	10	22	47

Table 3 Modeled Traffic Noise Levels for Alternative 4

East-West Roadway	Segment	Ldn Noise Level at 100 Feet	Distance to Noise Contour		
			70 Ldn	65 Ldn	60 Ldn
Mace Boulevard	Covell Blvd to 2nd St	69	85	183	394
	2nd St to Chiles Rd	69	91	196	423
	Chiles Rd to Cowell Blvd	64	40	86	184
	Cowell Blvd to Montgomery Rd	60	20	44	94
Oak Avenue	Covell Blvd to 14th St	57	14	31	67
	14th St to Eighth St	54	9	18	40
	Eighth St to Russell Blvd	54	9	19	41
Pole Line Road	No. of Covell Blvd	69	84	181	389
	Covell Blvd to Loyola	62	28	60	129
	Loyola to 8th	61	25	53	115
	8th St to 5th St	61	25	53	115
	5th St to Cowell Blvd	62	31	66	142
Richards Boulevard	E St to East Olive Dr	67	62	133	286
State Route 113	I-80 to Hutchison Dr	79	369	795	1712
	Hutchison Dr to Russell Blvd	78	344	742	1598
	Russell Blvd to Covell Blvd	78	324	697	1502
	No. of Covell Blvd	77	273	589	1269
Sycamore Lane	No. of Covell Blvd	60	22	48	103
	Covell Blvd to Russell Blvd	57	14	30	64

Table 4. Modeled Traffic Noise Levels for Alternative 5

East-West Roadway	Segment	Ldn Noise Level at 100 Feet	Distance to Noise Contour		
			70 Ldn	65 Ldn	60 Ldn
1st Street	A St to F St	62	29	62	134
2nd Street	3rd St to Pole Line Rd	63	34	74	160
	Pole Line Rd to Mace Blvd	65	45	97	209
	West of Mace Blvd	67	62	133	287
5th Street	B St to J St	65	48	102	221
	J St to Pole Line Rd	64	40	86	185
	Pole Line Rd TO Juniper Pt	64	41	88	190
	Juniper Pt to Pena	63	33	71	154
	East of Pena	59	20	42	91
8th Street	Sycamore Ln to F St	60	21	46	99
	F St to J St	60	22	48	103
	J St to L St	59	20	43	92
	L St to Pole Line Rd	59	17	38	81
	East of Pole Line Rd	56	11	23	50
14th Street	Oak Ave to F St	56	11	24	53
Arlington Boulevard	Lake Blvd to Russell Blvd	59	19	41	88
Chiles Road	Cowell Blvd to Mace Blvd	59	19	42	90
	Mace Blvd to infill	66	58	126	271
	infill to PG&E	65	45	98	211
	PG&E to Webster Ramps	64	43	92	198
County Road 31	West of Lake Blvd	67	64	139	299
County Road 32A	E. of Mace Blvd.	65	46	100	215
Covell Boulevard	Lake Blvd to Denali	67	62	134	288

Table 4. Modeled Traffic Noise Levels for Alternative 5

East-West Roadway	Segment	Ldn Noise Level at 100 Feet	Distance to Noise Contour		
			70 Ldn	65 Ldn	60 Ldn
	Denali to Shasta Dr	68	77	165	356
	Shasta Dr to County Rd 101 A	68	70	151	326
	County Rd 101 A to Sycamore Ln	67	67	145	313
	Sycamore Ln to Pole Line Rd (overxing)	67	62	134	288
	Pole Line Rd to Alhambra Dr	68	76	163	351
	Alhambra Dr to Alhambra Dr	65	47	102	219
Cowell Boulevard	Research Park Dr to Pole Line	64	40	86	186
	Pole Line Rd to Chiles Rd	62	31	68	146
	Chiles Rd to Mace Blvd	61	25	54	117
	East of Mace Blvd.	57	15	31	68
Hutchison Drive	State Route 113 to La Rue Rd	63	34	72	156
I-80	East of Webster	82	649	1397	3011
	Webster to Mace	82	619	1333	2871
	Mace Blvd to Olive Dr	82	620	1335	2877
	Olive Dr to Richards Blvd	82	604	1302	2805
	Richards Blvd to SR 113	82	631	1360	2931
	West of SR 113	82	606	1307	2815
Lillard Drive	Pole Line Rd to Drummond	60	21	45	97
	East of Drummond Ave	52	6	14	30
Old Davis Road	West of A St	62	27	59	128
Russell Boulevard	West of Lake Blvd	60	22	48	102
	Lake Blvd to Arlington Rd	64	40	85	183
	Arlington Rd to SR 113	66	54	116	249

Table 4. Modeled Traffic Noise Levels for Alternative 5

East-West Roadway	Segment	Ldn Noise Level at 100 Feet	Distance to Noise Contour		
			70 Ldn	65 Ldn	60 Ldn
	SR 113 to Anderson Rd	66	53	114	247
	Anderson Rd to Oak Ave	66	55	118	255
	Oak Ave to B St	66	56	122	262
Anderson Road	F St to Catalina Dr	54	9	19	41
	Catalina Dr to Covell Blvd	56	12	26	55
	Covell Blvd to Valdora Dr	61	24	53	114
	Valdora Dr to 8th St	60	22	47	101
	8th St to Russell Blvd	61	24	52	111
B Street	14th St to 8th St	58	15	33	71
	8th St to Russell Blvd	59	18	39	84
	Russell Blvd to 1st St	62	29	62	134
California Avenue	So. of Russell Blvd.	58	15	33	71
Catalina Drive	Grande Ave to Covell Blvd	51	6	12	27
F Street	Grande Ave to Covell Blvd	61	26	56	121
	Covell Blvd to 14 St	61	25	54	116
	14th St to 8th St	61	23	51	109
	8th St to 5th St	59	18	40	86
	5th St to 1st St	60	21	45	97
Howard Way	So. of Russell Blvd.	61	25	53	115
J Street	Covell Blvd to 8th St	55	10	22	48
	8th St to 3rd St	54	9	20	43
L Street	County Rd 102/Ple Line to Covell	61	25	53	114

Table 4. Modeled Traffic Noise Levels for Alternative 5

East-West Roadway	Segment	Ldn Noise Level at 100 Feet	Distance to Noise Contour		
			70 Ldn	65 Ldn	60 Ldn
	Covell Blvd to 8th St	59	20	42	91
	8th St to 5th St	60	21	46	99
	5St to 2nd St	60	21	44	96
Lake Boulevard	No. of Covell Blvd	60	20	43	93
	Covell Blvd to Arlington Blvd	61	24	52	111
	Arlington Blvd to Russell	55	10	22	46
Mace Boulevard	Covell Blvd to 2nd St	69	84	180	388
	2nd St to Chiles Rd	69	92	199	429
	Chiles Rd to Cowell Blvd	64	38	82	176
	Cowell Blvd to Montgomery Rd	60	20	43	94
Oak Avenue	Covell Blvd to 14th St	57	15	31	68
	14th St to Eighth St	54	9	18	40
	Eighth St to Russell Blvd	54	8	17	37
Pole Line Road	No. of Covell Blvd	69	84	180	388
	Covell Blvd to Loyola	62	28	61	131
	Loyola to 8th	61	25	53	115
	8th St to 5th St	61	25	54	116
	5th St to Cowell Blvd	62	31	66	143
Richards Boulevard	E St to East Olive Dr	67	62	135	290
State Route 113	I-80 to Hutchison Dr	79	369	795	1712
	Hutchison Dr to Russell Blvd	78	342	737	1589
	Russell Blvd to Covell Blvd	78	329	709	1527
	No. of Covell Blvd	76	271	584	1258

Table 4. Modeled Traffic Noise Levels for Alternative 5

East-West Roadway	Segment	Ldn Noise Level at 100 Feet	Distance to Noise Contour		
			70 Ldn	65 Ldn	60 Ldn
Sycamore Lane	No. of Covell Blvd	60	22	48	103
	Covell Blvd to Russell Blvd	57	14	30	65

Table 5 Comparison of Modeled Traffic Noise Results

Roadways	Segment	Most Sensitive Adjacent Land Use*	Ldn at 100 Feet From Roadway Centerline								
			Existing Conditions	Build-Out of Existing	Build-Out minus Existing	Reduced Build-Out of GP	Reduced Build-Out minus Existing	Alt. 4	Alt. 4 minus Existing	Alt. 5	Alt. 5 minus Existing
1st Street	A St to F St	Residential	61	62	1	62	1	62	1	62	1
2nd Street	3rd St to Pole Line Rd	Residential	57	63	6	63	6	63	6	63	6
	Pole Line Rd to Mace Blvd	Plan Dev.	59	64	5	64	5	65	6	65	6
	West of Mace Blvd	Commercial	59	65	6	65	6	67	8	67	8
5th Street	B St to J St	Residential	62	65	3	65	3	65	3	65	3
	J St to Pole Line Rd	Residential	61	64	3	64	3	64	3	64	3
	Pole Line Rd TO Juniper Pt	Residential	59	64	5	64	5	64	5	64	5
	Juniper Pt to Pena	Residential	59	63	4	62	3	63	4	63	4
	East of Pena	Residential	56	60	4	60	4	60	4	59	3
8th Street	Sycamore Ln to F St	Residential	57	59	2	59	2	60	3	60	3
	F St to J St	Residential	58	60	2	59	1	60	2	60	2
	J St to L St	Residential	57	59	2	58	1	60	3	59	2
	L St to Pole Line Rd	Residential	58	59	1	58	0	59	1	59	1
	East of Pole Line Rd	Residential	55	56	1	55	0	56	1	56	1
14th Street	Oak Ave to F St	Residential	55	56	1	56	1	56	1	56	1

Table 5 Comparison of Modeled Traffic Noise Results

Arlington Boulevard	Lake Blvd to Russell Blvd	Residential	58	59	1	59	1	61	3	59	1
Chiles Road	Cowell Blvd to Mace Blvd	Residential	58	59	1	59	1	59	1	59	1
	Mace Blvd to infill	Commercial	57	63	6	62	5	62	5	66	9
	infill to PG&E	N/A	57	63	6	62	5	62	5	65	8
	PG&E to Webster Ramps	N/A	55	63	8	62	7	62	7	64	9
County Road 31	West of Lake Blvd	Residential	65	67	2	67	2	68	3	67	2
County Road 32A	E. of Mace Blvd.	N/A	56	64	8	63	7	65	9	65	9
Covell Boulevard	Lake Blvd to Shasta Dr	Residential	65	67	2	67	2	68	3	67	2
	Denali to Shasta Dr	Residential	65	68	3	68	3	69	4	68	3
	Shasta Dr to County Rd 101 A	Hospital	65	67	2	67	2	68	3	68	3
	County Rd 101 A to Sycamore Ln	Residential	65	67	2	67	2	68	3	67	2
	Sycamore Ln to Pole Line Rd (overxing)	Residential	65	67	2	67	2	67	2	67	2
	Pole Line Rd to Alhambra Dr	Residential	66	68	2	68	2	68	2	68	2
	Alhambra Dr to Alhambra Dr	Residential	64	65	1	65	1	65	1	65	1
Cowell Boulevard	Research Park Dr to Pole Line	Residential	62	64	2	64	2	64	2	64	2
	Pole Line Rd to Chiles Rd	Residential	60	62	2	62	2	62	2	62	2

Table 5 Comparison of Modeled Traffic Noise Results

	Chiles Rd to Mace Blvd	Residential	58	60	2	60	2	61	3	61	3
	East of Mace Blvd.	Residential	51	56	5	55	4	56	5	57	6
Hutchison Drive	State Route 113 to La Rue Rd	N/A	62	63	1	63	1	63	1	63	1
I-80	East of Webster	N/A	81	82	1	82	1	82	1	82	1
	Webster to Mace	N/A	81	82	1	82	1	82	1	82	1
	Mace Blvd to Olive Dr	Residential	81	82	1	82	1	82	1	82	1
	Olive Dr to Richards Blvd	Plan Dev.	81	82	1	82	1	82	1	82	1
	Richards Blvd to SR 113	Plan Dev.	81	82	1	82	1	82	1	82	1
	West of SR 113	N/A	81	82	1	82	1	82	1	82	1
Lillard Drive	Pole Line Rd to Drummond	Residential	58	60	2	59	1	60	2	60	2
	East of Drummond Ave	Residential	52	52	0	52	0	52	0	52	0
Old Davis Road	West of A St	N/A	58	61	3	61	3	62	4	62	4
Russell Boulevard	West of Lake Blvd	Residential	56	60	4	60	4	61	5	60	4
	Lake Blvd to Arlington Rd	Residential	62	64	2	64	2	64	2	64	2
	Arlington Rd to SR 113	Residential	65	66	1	66	1	66	1	66	1
	SR 113 to Anderson Rd	Residential	64	66	2	66	2	66	2	66	2
	Anderson Rd to Oak Ave	Residential	65	66	1	66	1	66	1	66	1
	Oak Ave to B St	Residential	65	66	1	66	1	66	1	66	1

Table 5 Comparison of Modeled Traffic Noise Results

Anderson Road	F St to Catalina Dr	Residential	53	54	1	54	1	55	2	54	1
	Catalina Dr to Covell Blvd	Residential	56	56	0	56	0	56	0	56	0
	Covell Blvd to Valdora Dr	Residential	60	61	1	61	1	61	1	61	1
	Valdora Dr to 8th St	Residential	60	60	0	60	0	60	0	60	0
	8th St to Russell Blvd	Residential	60	61	1	61	1	61	1	61	1
B Street	14th St to 8th St	Residential	55	58	3	57	2	58	3	58	3
	8th St to Russell Blvd	Residential	57	59	2	59	2	59	2	59	2
	Russell Blvd to 1st St	Residential	60	62	2	62	2	62	2	62	2
California Avenue	So. of Russell Blvd.	Educational	58	57	-1	58	0	58	0	58	0
Catalina Drive	Grande Ave to Covell Blvd	Residential	52	51	-1	52	0	51	-1	51	-1
F Street	Grande Ave to Covell Blvd	Residential	59	61	2	61	2	61	2	61	2
	Covell Blvd to 14 St	Residential	60	61	1	61	1	61	1	61	1
	14th St to 8th St	Residential	59	61	2	60	1	60	1	61	2
	8th St to 5th St	Residential	59	59	0	59	0	59	0	59	0
	5th St to 1st St	Residential	59	60	1	60	1	60	1	60	1
Howard Way	So. of Russell Blvd.	Educational	61	61	0	61	0	61	0	61	0
J Street	Covell Blvd to 8th St	Residential	55	55	0	55	0	55	0	55	0
	8th St to 3rd St	Residential	48	53	5	52	4	54	6	54	6
L Street	County Rd 102/Ple	Residential	N/A	61	N/A	58	N/A	61	N/A	61	N/A

Table 5 Comparison of Modeled Traffic Noise Results

	Line to Covell										
	Covell Blvd to 8th St	Residential	N/A	59	N/A	59	N/A	59	N/A	59	N/A
	8th St to 5th St	Residential	N/A	60	N/A	59	N/A	60	N/A	60	N/A
	5St to 2nd St	Residential	N/A	60	N/A	60	N/A	60	N/A	60	N/A
Lake Boulevard	No. of Covell Blvd	Agricultural	56	59	3	59	3	67	11	60	4
	Covell Blvd to Arlington Blvd	Residential	60	60	0	60	0	62	2	61	1
	Arlington Blvd to Russell	Residential	55	55	0	55	0	55	0	55	0
Mace Boulevard	Covell Blvd to 2nd St	Plan Dev.	66	69	3	68	2	69	3	69	3
	2nd St to Chiles Rd	Commercial	67	69	2	69	2	69	2	69	2
	Chiles Rd to Cowell Blvd	Residential	63	64	1	63	0	64	1	64	1
	Cowell Blvd to Montgomery Rd	Residential	59	60	1	59	0	60	1	60	1
Oak Avenue	Covell Blvd to 14th St	Residential	57	57	0	57	0	57	0	57	0
	14th St to Eighth St	Residential	54	54	0	54	0	54	0	54	0
	Eighth St to Russell Blvd	Residential	52	53	1	52	0	54	2	54	2
Pole Line Road	No. of Covell Blvd	Residential	67	69	2	68	1	69	2	69	2
	Covell Blvd to Loyola	Residential	59	62	3	61	2	62	3	62	3
	Loyola to 8th	Residential	59	61	2	61	2	61	2	61	2
	8th St to 5th St	Residential	60	61	1	61	1	61	1	61	1
	5th St to Cowell Blvd	Residential	60	62	2	62	2	62	2	62	2
Richards Boulevard	E St to East Olive Dr	Plan Dev.	66	67	1	67	1	67	1	67	1

Table 5 Comparison of Modeled Traffic Noise Results

State Route 113	I-80 to Hutchison Dr	N/A	77	78	1	78	1	79	2	79	2
	Hutchison Dr to Russell Blvd	N/A	76	78	2	78	2	78	2	78	2
	Russell Blvd to Covell Blvd	Residential	76	78	2	77	1	78	2	78	2
	No. of Covell Blvd	Residential	75	76	1	76	1	77	2	76	1
Sycamore Lane	No. of Covell Blvd	Residential	60	60	0	60	0	60	0	60	0
	Covell Blvd to Russell Blvd	Residential	57	57	0	57	0	57	0	57	0

*As indicated on the City of Davis Zoning District Map
Plan Dev. - Plan Development
N/A - Not Available