Appendix G: Noise Element Resources

I. Sound Descriptors

Sound may be described by three variables: amplitude, frequency, and time pattern.

Amplitude

Sound pressure is the amplitude or measure of the difference between atmosphere pressure (with no sound present) and total pressure (with sound present). Although there are measures of sound amplitude, sound pressure is the fundamental measure and is the basic ingredient of the various measurement descriptors.

The unit of sound pressure is the decibel (dB) scale. The decibel scale is a logarithmic, not linear scale. A logarithmic scale is used because the range of sound intensities is so great that it is convenient to compress the scale to encompass all the sounds that need to be measured. The human ear has a wide range of responses to sound amplitude. Sharp, painful sound is 10 million times greater in sound pressure than the least audible sound. In decibels, this 10 million to 1 ratio is simplified logarithmically to 140 dB.

Another property of the decibel scale is that the sound pressure levels of two separate sounds are not directly (arithmetically) additive. For example, if a sound of 70 dB is added to another sound of 70 dB, the total is only a 3-decibel increase (73 dB), not a doubling to 140 dB. Furthermore, if two sounds are of different levels, the lower level adds less to the higher as this difference increases. If the difference is as much as 10 dB, the lower level adds almost nothing to the higher level. In other words, adding a 60-decibel sound to a 70-decibel sound only increases the total sound pressure level by less than 0.5-decibel.

Frequency

The rate at which a sound source vibrates, or makes the air vibrate, determines frequency. The unit of time is usually one second and the term “Hertz” (Hz) is used to designate the number of cycles per second.

The human ear and that of most animals has a wide range of responses. Humans can identify sounds with frequencies from about 16 Hz to 20,000 Hz. Because pure tones are relatively rare in life situations, most sounds consist of a complex mixture of multiple frequencies.

Time Pattern

Sound may be described in terms of its pattern of time and level: continuity, fluctuation, impulsiveness, intermittency. Continuous sounds are those produced for relatively long periods at a constant level, such as the ringing of a telephone or aircraft take-offs and landings. Impulse noises are sounds that are produced in an extremely short span of time, such as a pistol shot or a hand clap. Fluctuating sounds vary in level over time, such as the loudness of traffic sounds at a busy intersection.

II. Noise Measurement

Noise measurements are made in accordance with existing standards and regulations. Sound is measured by a sound level meter (SLM), which is a device that can give the measured sound pressure level (SPL). The County Noise Control Ordinance specifies that an SLM needs to satisfy the requirements pertinent for type S2A meters, in accordance with the American National Standards Institutes (ANSI) specifications or the most recent revision (1985 ANSI S1.4A).

In accordance with the County Noise Control Ordinance, noise measurements in the field are made utilizing a SLM set at A-weighting scale on the “slow mode” meter response, except for impulsive noise (in which case, the SLM is set on “fast mode”). In general, the noise level is measured 4 to 5 feet above the ground, and 10 feet or more from the nearest reflective surface (i.e., walls), where possible.

The following are the basic measurements of noise:

Ambient Noise

Ambient noise is the composite of noise from all sources near and far. In this context, the ambient noise level constitutes the normal or existing level of environmental noise at a given location.

Community Noise Equivalent Level (CNEL)

CNEL is the average equivalent A-weighted sound level during a 24-hour day that is obtained after the addition of 5 decibels to sound levels in the evening, from 7 p.m. to 10 p.m., and after the addition of 10 decibels to sound levels in the evening, from 10 p.m. to 7 a.m. The CNEL metric isused by the California Aeronautics Code for the evaluation of noise impacts at airports. Local compliance with state airport standard requires that community noise levels be expressed in CNEL.

Decibel, dB

A unit measurement describing the amplitude of sound, equal to 20 times the logarithm to the base of 10, or the ratio of the pressure of the sound measured to the reference pressure, which are 20 micropascals.

Impulsive Noise

Impulsive noise is noise from impacts or explosions (e.g., from a pile driver), punch press or gunshot. The County Noise Control Ordinance defines impulsive noise as a sound of short duration that is usually less than one second and of high intensity, with an abrupt onset and rapid decay.

Intrusive Noise

Intrusive noise refers to the noise that intrudes over and above the existing ambient noise at a given location. The relative intrusiveness of a sound depends upon its amplitude, duration, frequency, time of occurrence, tonal or informational content,and the prevailing noise level.

Leq

Leq is the equivalent energy level. The sound level corresponding to a steady state sound level that contains the same total energy as a time varying signal over a given sample period. Leq is typically computed over 1, 8 and 24-hour sample periods.

Day-Night Average Level (Ldn)

Ldn is the average equivalent A-weighted sound level during a 24-hour day that is obtained after the addition of 10 decibels to sound levels in the evening, after 10 p.m. and before 7 a.m. The Ldn represents a simplification of the CNEL measure.

Noise Contours

Noise contours are lines drawn about a noise source that indicates equal levels of noise exposure.

Pure Tone

Pure tone is a sound that is made up of only one frequency. The County Noise Control Ordinance defines pure tone noise as any sound that can be judged as audible as a single pitch or a set of single pitches.

Statistical Values

Statistical values are statistical methods used to account for the variance in noise levels throughout a given measurement period. L(%) is a way of expressing the noise level that is exceeded for a percentage of time in a given measurement period. For example, the County uses the L50 as a statistical value. Thirty minutes is 50 percent of 60 minutes, so the L50 is the noise level that is equal to or exceeded for 30 minutes in a 60 minute measuring period.

Weighted Level

Weighted level is the sound level in decibels as measured on a sound level meter using the A-weighting filter network. This filter de-emphasizes the very low and very high frequency components of the sound in a manner similar to the response of the human ear, which gives a good correlation with subjective reactions to noise.

III. Federal Guidelines

Table G.1: Federal Guidelines for Acceptable Environmental Noise Levels

Authority and SpecifiedSound Levels (dBA)	Criteria Objectives
EPA Levels Document (1974)	
55 dBA Ldn outdoors	For the protection of public health and welfare with an adequate margin of safety.
45 dBA Ldn indoors	
Federal Inter-Agency Committee on Noise (FICON)	

65 dBA Ldn outdoors	Generally compatible for residential development.
>65 – 75 dBA	Residential use discouraged.
HUD	
65 dBA Ldn outdoors	Acceptable for housing without special acoustical consideration.
>65 – 75 dBA Ldn outdoors	Normally unacceptable, but acceptable with acoustical sound isolation.
>75 dBA Ldn outdoors	Unacceptable, but acceptable with acoustical isolation and the existence of overriding benefits.
FHWA	
57 dBA Ldn (1H) 60 dBA Ldn (1h) outdoors	Activity category "A": Lands on which serenity and quiet are of extraordinary significance.
67 dBA Ldn (1h) 70 dBA Ldn (1h) outdoors	Activity category "B": Picnic areas, recreation areas, residences, motels, schools, churches, libraries, and hospitals.
72 dBA Ldn (1h) 75 dBA Ldn (1h) outdoors	Activity category "C": Developed lands not in Categories "A" and "B" above.
52 dBA Ldn (1h) outdoors	Residences, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals and auditoriums.
FAA	
65 dBA Ldn outdoors	Compatible for residential, public and commercial uses.
>65 – 70 dBA Ldn outdoors	Compatible for commercial building uses. Compatible for public building use with 25 dBA building envelope aircraft noise reduction (NR). Not compatible for residential, but interior acceptable with 25 dBA building envelope NR.
>70 – 75 dBA Ldn outdoors	Compatible for commercial building use with 25 dBA building envelope NR. Compatible for public building use with 30 dBA building

	envelope aircraft noise reduction (NR). Not compatible for residential, but interior acceptable with 30 dBA building envelope NR.
>75 – 80 dBA Ldn outdoors	Compatible for commercial building use with 30 dBA building envelope NR. Not compatible for public building use. Not compatible for residential, but interior acceptable with 35 dBA building envelope NR.
>80 dBA Ldn outdoors	Not acceptable for commercial, public, or residential use buildings.

IV. Noise Barriers

Noise barriers include any man-made or natural feature that blocks or diminishes sound in its path from the source to the receiver, with concrete block walls and earthen berms being the more common kinds of man-made construction. A noise barrier reduces sound levels by breaking the direct line of sight between the noise source and the receiver. Effectiveness of noise mitigation barriers is primarily a function of height, the location in relation to the sound source and, to a lesser degree, the shape of the edge of the barrier. Since walls have a finite height, sound energy reaches the receptor by bending (diffraction) over the top of any barrier at a reduced intensity. An analysis based on application of the FHWA TNM "Look-up Tables"[14] demonstrates the effectiveness of noise barriers of varying heights at controlling noise from a sample of traffic, consisting of 1,000 automobiles traveling at 60 mph with the receptor at a distance of 100 meters (340 feet). The difference between a "no barrier" scenario and one with a 2 meter-high (6.5 feet) barrier results in an auditory noticeable condition, a decrease of approximately 7 dBA. The noise insertion loss resulting from the installation of a 3-meter high (9.8 feet) barrier is even more dramatic, lowering ambient noise levels by 12 dBA.

Also, the precise location of barriers between the sound source and the receptor plays a pivotal role in sound attenuation. Studies cited by Caltrans indicate that the bestresults to minimize noise are obtained when the noise barrier is either close to either the sound source or to the receptor. Finally, the shape of barriers has an additional, substantial effect on noise attenuation and sound propagation. Most traffic noise prediction models factor in smooth edges on the noise barriers. However, research has shown that increased noise attenuation can be achieved with jagged edges on the noise barriers to create greater diffraction of the sound path. Results to date show "significant improvement (3-8 dB) for a barrier with a random edge profile compared to one of the same average height with a straight edge."[15]

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[14] FHWA. Traffic Noise Model, 1998.

[15] "Noise Barriers with Random Edge Profiles", Acoustical Society of America's 129th Meeting, May – June 1995; see "Jagged-edge Noise Barriers" in ICA/ASA 98' Lay Language Papers, June 1998.

Noise barriers (sound walls) are the most widely used method of mitigating noise from traffic. Caltrans characterizes noise barriers as the most reasonable noise abatement option available to the State to reduce highway and freeway noise.[16] This is due to barrier insertion being very effective in reducing noise sources that are close to the ground. Also, established land use patterns often pose constraints at the site of many proposed mitigation measures. In other words, there is no available land for any other mitigation technique other than a noise barrier. Thus, construction of noise barriers is limited to those situations where other alternatives, such as open space, do not exist due to the lack of available land or space. Overall, public reaction to highway noise barriers appears to be generally positive, although some residents have argued that aesthetics or view protection values are often sacrificed. In this regard, it should be noted that Caltrans has discovered that vegetation as a factor in noise attenuation does not appear to be significant, and it takes either a considerable depth of plant material or a considerable density of it for any substantial attenuation of sound.

[16] Technical Noise Supplement, Caltrans, October 1998, Section N-6000.