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The manual is divided into three sections. The first is devoted to the fundamentals of sound, how it relates to traffic noise, and how it is measured and analyzed. Section II presents the FHWA procedure for predicting highway traffic noise and the attenuation provided by barriers. Section III covers the California Department of Transportation noise program required by California law. This refers to the School Noise Law and the noise element of the General Plan used by local agencies for land use planning.

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FOREWORD

This manual is designed to provide guidance and procedures for the California Department of Transportation and other organizations involved in noise activities as related to the highway transportation system. The procedures discussed cover the requirements of all Federal and California State laws.

Purposes of this manual are to:

- Provide a reference and training manual.
- Promote uniformity in performing noise studies and reporting results.
- Detail elements of a noise study and report.
- Outline the overall Caltrans responsibilities.
- Provide a quick reference for the applicable laws, regulations, guidelines and procedures.

Most of Caltrans activities in the noise area involve performing a project study. The objectives or purposes of the study are as follows:

1. Define the noise envrionment and assess any impact on receivers due to a proposed improvement to the transportation system. Determine the appropriate mitigation if necessary and feasible.

2. Determine the noise impact of receivers on existing highways and the mitigation if necessary and feasible.

[illegible]

This manual provides the information to allow project study personnel to perform a noise study to meet selected objectives. Steps to follow involve becoming familiar with:

- Legal requirements
- Fundamental concepts of noise
- Measuring noise and analyzing data
- Predicting noise
- Mitigating noise
- Writing the report

The manual is divided into three basic sections as follows:

Section I Fundamental of the Physics of Sound and Sound Measurements

This section discusses the noise concepts and how it applies to people, vehicles and highway traffic.

Section II FHWA Noise Prediction Model, Barrier Design Procedures, Construction Noise and Noise Reports

This section discusses the FHWA requirements and procedures for performing the complete study, writing the report and the legal references.

Section III California Department of Transportation Requirements and Policies

This section discusses things that apply only to California and Caltrans involvement. Various legal references are presented.

The laws and regulations which apply to Transportation Noise are discussed in Section II (Federal) and Section III (State).

Organization

Policies and procedures related to noise are developed by the following Caltrans Headquarters Offices in Sacramento.

Office of Planning and Design:

° Responsible for policies and procedures related to project development, including noise reports. The Community Noise Program, HB311, and the School Noise Program, HB312, are assigned to this office.

Office of Environmental Planning:

° Responsible for policies and procedures related to preparing, reviewing and processing Environmental Impact Statements (EIS), Environmental Impact Reports (EIR), Findings of No Significant Impact (FONSI), and Negative Declarations (ND).

Office of Structures and Design:

° Responsible for developing structural design criteria, standard plans, and special provisions.

° Provides architectural assistance to the Districts.

° Responsible for designing sound walls not covered by standard plans.

Office of Transportation Laboratory:

° Responsible for providing consultation and advisory services in environmental noise matters.

° Develop methods and techniques for investigating, evaluating and reporting of environmental noise impact.

° Provides a centralized capability to do the more complex and difficult studies by maintaining a staff of experts and state of the art equipment.

- Provides review and training services to ensure that District noise studies are of uniform high quality.
- Conduct research which will anticipate and provide solutions to the needs and problems of Caltrans during highway planning, design, construction, operation and maintenance.
- Evaluates implemented research.
- Develops, modifies and maintains computer programs to facilitate project studies.
- Performs Quality Assurance Tests on District's noise instrumentation and procedures.

[illegible]

SECTION I

SECTION I

FUNDAMENTALS OF THE
PHYSICS OF SOUND AND
SOUND MEASUREMENTS

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CONVERSION FACTORS

English to Metric System (SI) of Measurement

Quanity	English unit	Multiply by	To get metric equivalent
Length	inches (in)or(")	25.40	millimetres (mm)
		.02540	metres (m)
	feet (ft)or(')	.3048	metres (m)
	miles (mi)	1.609	kilometres (km)
Area	square inches (in^2)	6.432×10^{-4}	square metres (m^2)
	square feet (ft^2)	.09290	square metres (m^2)
	acres	.4047	hectares (ha)
Volume	gallons (gal)	3.785	litres (l)
	cubic feet (ft^3)	.02832	cubic metres (m^3)
	cubic yards (yd^3)	.7646	cubic metres (m^3)
Volume/Time (Flow)	cubic feet per second (ft^3/s)	28.317	litres per second (l/s)
	gallons per minute (gal/min)	.06309	litres per second (l/s)
Mass	pounds (lb)	.4536	kilograms (kg)
Velocity	miles per hour(mph)	.4470	metres per second (m/s)
	feet per second(fps)	.3048	metres per second (m/s)
Acceleration	feet per second squared (ft/s^2)	.3048	metres per second squared (m/s^2)
	acceleration due to force of gravity(G)	9.807	metres per second squared (m/s^2)
Weight Density	pounds per cubic (lb/ft^3)	16.02	kilograms per cubic metre (kg/m^2)
Force	pounds (lbs)	4.448	newtons(N)
	kips (1000 lbs)	4448	newtons (N)
Thermal Energy	British thermal unit (BTU)	1055	joules (J)
Mechanical Energy	foot-pounds(ft-lb)	1.356	joules (J)
	foot-kips (ft-k)	1356	joules (J)
Bending Moment or Torque	inch-pounds(ft-lbs)	.1130	newton-metres (Nm)
	foot-pounds(ft-lbs)	1.356	newton-metres (Nm)
Pressure	pounds per square inch (psi)	6895	pascals (Pa)
	pounds per square foot (psf)	47.88	pascals (Pa)
Stress Intensity	kips per square inch square root inch ($ksi\sqrt{in}$)	1.0988	mega pascals $\sqrt{metre}$ ($MPa\sqrt{m}$)
	pounds per square inch square root inch ($psi\sqrt{in}$)	1.0988	kilo pascals $\sqrt{metre}$ ($KPa\sqrt{m}$)
Plane Angle	degrees (°)	0.0175	radians (rad)
Temperature	degrees fahrenheit (F)	$\frac{tF - 32}{1.8} = tC$	degrees celsius (°C)

INTRODUCTION

The passage of the National Environmental Policy Act of 1969 (P.L. 91-90) and subsequent Federal and State legislation required the California Department of Transportation (Caltrans) and others to become involved in environmental analyses. Noise is one element which needs to be addressed.

Section I deals with the basic fundamentals of noise and relates it to the highway transportation system. It also includes the measurement and analysis of traffic noise.

Enough information is provided to enable a serious reader to communicate with other technically oriented personnel in highway transportation noise and with the lay person. Additional information for those who wish to extend their knowledge in acoustics may be obtained from the references listed with this section or from textbooks.

A glossary is included at the end of this Section to provide information on acoustical terms not commonly used by the lay person. Sources for obtaining noise information are also provided.

CHAPTER I-1

BASIC FUNDAMENTALS

Chapter I-1

Basic Fundamentals

I-1.1 Sound

Sound is mechanical energy transmitted by pressure waves traveling in a medium such as air. It is usually caused by a vibrating object which compresses or rarefies the air. Noise is defined as unwanted sound. This perception may differ between individuals. An example of this might be music from a rock band. These two terms, sound and noise, are often used synonymously.

The speed at which sound travels is 1128 feet per second at 70°F and an atmospheric pressure of 29.92 inches of mercury.

Acoustics is the science of sound which includes the generation, transmission and effects of sound.

I-1.2 Decibels

Sound creates pressure differentials in the air. In order to measure sound, a scale graduated in decibels (dB) was developed. Zero dB was established as the starting point. It is referenced to a pressure of 0.0002 microbar which is the weakest sound that can be detected by an average, young, alert person without any hearing impairment.

A strong sound, which might come from a source such as a jet airplane, could be 1,000,000,000 times greater than a person whispering. The large spread in sound pressures and how it is perceived by the human ear indicated that the logarithmic decibel scale was a practical system for measuring sound intensity. Logarithms compress large numbers into a more simple manageable scale.

In its simplest form, sound pressure in decibels is expressed by the term;

$$\text{Sound Pressure Level (SPL)} = 20 \log_{10}\left(\frac{P_1}{P_2}\right) \text{ dB}$$

P_1 is any sound pressure
P_2 is 0.0002 microbars, the reference pressure.

In acoustics, the word "level" (abbreviated L) is used whenever sound is expressed in decibels relative to the reference pressure. Figure I-1.1 illustrates the various sound levels for indoor and outdoor sources.

I-1.3 Addition of Decibels

Sound pressure levels are logarithmic units which cannot be added algebraically. An approximate estimate of the sum of two decibel levels can be made by using the following Table I-1.1.

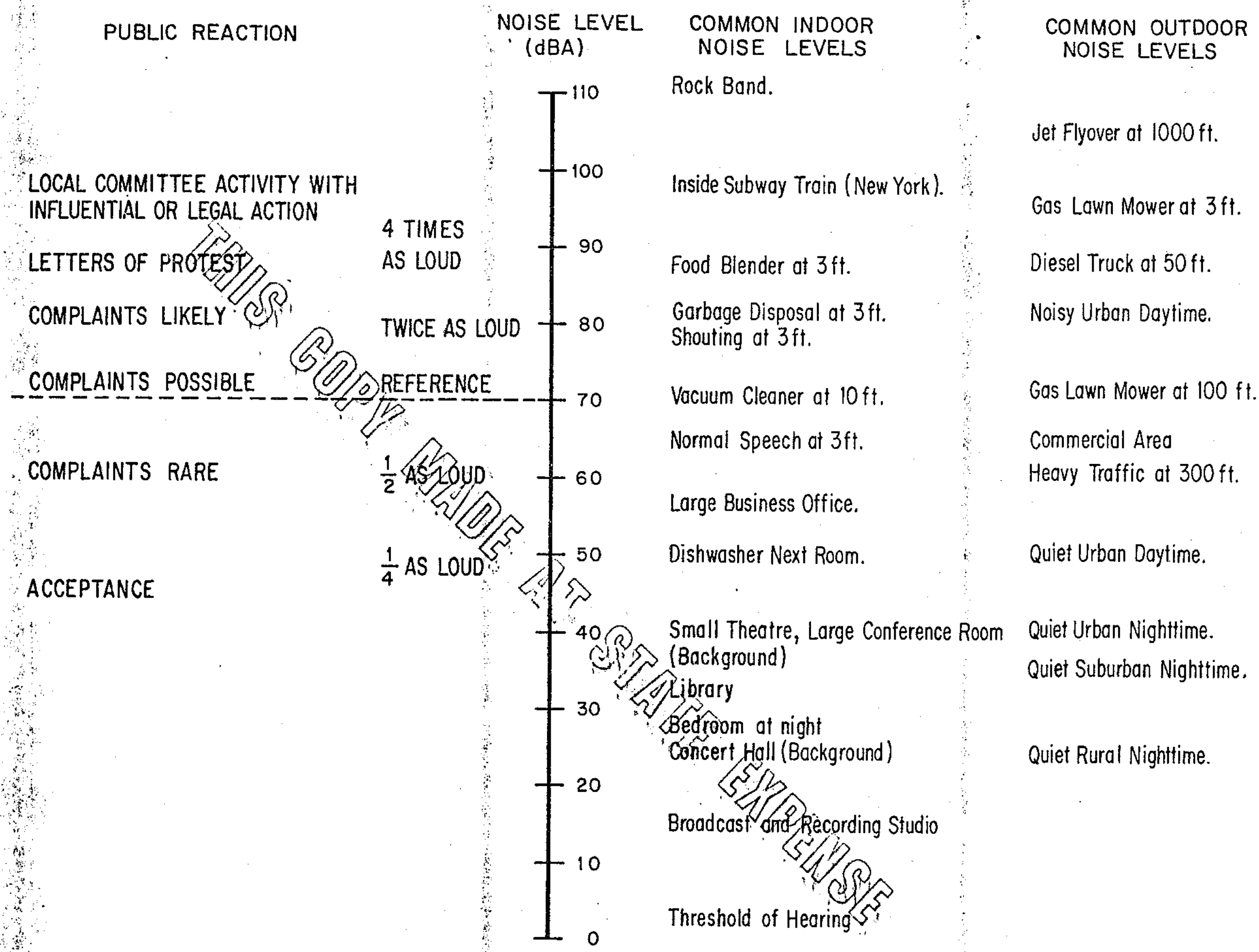
Table I-1.1

When two decibel values differ by	Add the following amount to the higher value
0 or 1 dB	3 dB
2 or 3 dB	2 dB
4 to 9 dB	1 dB
10 dB or more	0

This table provides an accuracy of ± 1 dB.

Figure I-1.1

RELATIVE SCALE OF VARIOUS NOISE SOURCES AND EFFECT ON PEOPLE



See following for examples of the use of Table I-1.1.

Problem: What is the sum of two noise sources 60 and 63 dB?

Solution: 63-60 = 3 dB
From Table I-1.1. When two decibel values differ by 2 or 3 dB, add 2 dB to the higher value:
63 + 2 = 65 dB

Figure I-1.2 shows a chart which is used to add two decibel levels. It provides an accuracy of about 0.2 dB if care is used.

Alternate Solution: 63-60 = 3 dB
From Figure I-1.2. The difference in decibels (3 dB) is located on the abscissa and a vertical line is drawn to intersect the curve. Then a horizontal line is drawn to intersect the ordinate giving a correction of about 1.8 dB which is added to the higher source
63 + 1.8 = 64.8 dB

When several decibel levels are to be added, they are arranged in increasing value and added two at a time starting with the lower values. The following example is shown using Table I-1.1.

Problem: Given sound levels of 75, 82, 68, 79 and 88. What is the total sound level?

Figure I-1.2

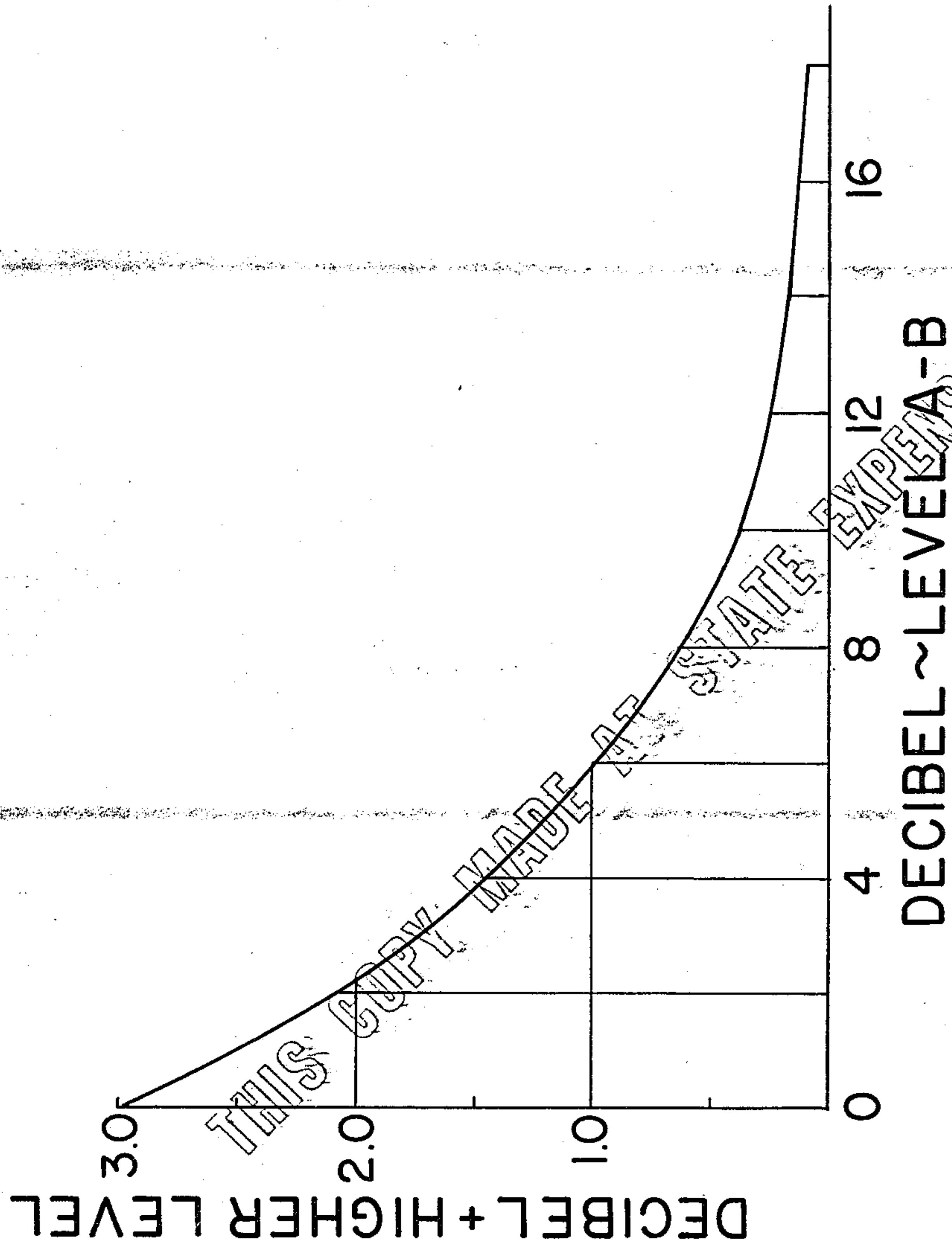
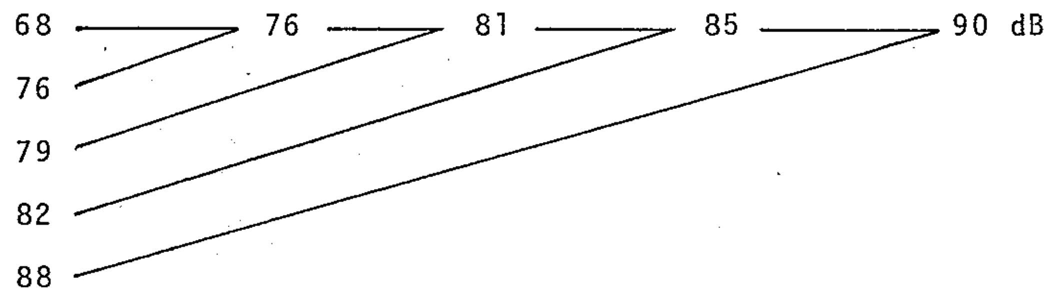


CHART FOR COMBINING SOUND LEVELS BY "DECIBEL ADDITION"

Solution:



The difference between 68 and 75 is 7. From Table I-1.1, when two decibel values differ by 4 to 9 dB, 1 dB is added to the higher value (75 + 1 = 76). The difference between 76 and 79 is 3. From Table I-1.1, when two values by 2 or 3, 2 dB is added to the higher value (79 + 2 = 81). In a like manner the other values are combined as shown in the above example.

If a calculator is available, the decibel levels are combined using the following equation:

$$SPL = 10 \log_{10}\left(10^{\frac{SPL_1}{10}} + 10^{\frac{SPL_2}{10}} + \text{-----} 10^{\frac{SPL_n}{10}}\right)$$

where SPL = Sound Pressure Level (dB)

Using the sound levels in the previous examples and substituting into the above equation, the total level is calculated as follows:

$$SPL = 10 \log_{10}\left(10^{\frac{75}{10}} + 10^{\frac{82}{10}} + 10^{\frac{68}{10}} + 10^{\frac{79}{10}} + 10^{\frac{88}{10}}\right)$$

$$SPL = 89.6$$

The 89.6 is an exact calculation. The approximate 90 decibels determined by using Table I-1.1 is very close to the calculated value.

The Table I-1.2 showing "10 log N" values is useful for determining decibel equivalents of numbers. It can be used for the following purposes.

1) Problem:
Combine four equal noise levels of 80, 80, 80 and 80 dB.

Solution:
From Table I-1.2. Under the N column, find the number closest to 4 which is 3.98. The 10 log N number opposite the 3.98 is 6.
Add the 6 to the 80 for a total 86 dB.

2) Problem:
70 dB is produced by traffic of 2,000 autos per hour. What is the level produced by traffic of 6,500 autos per hour.

Solution:
Increase in traffic is $\frac{6500}{2000} = 3.25$
From Table I-1.2. Under the N column, find the number closest to 3.25 which is 3.16 (a closer estimate may be made by interpolating). The 10 log N number opposite the 3.16 is 5. Therefore, the increase in noise level due to an increase in traffic is 70 + 5 = 75 dB.

3) Problem:
The noise level for peak hour traffic is 72 dB.
What is the noise level when the traffic is 70 percent of peak hour traffic?

Solution:
From Table I-1.2. Under the N column, find the number closest to 0.70 which is .708. The 10 log N value opposite the .708 is -1.5.
Since this is a decrease in traffic, the noise level is now 72 -1.5 = 70.5 dB.

TABLE I-1.2

DECIBEL EQUIVALENTS OF NUMBERS

N	10 log N (dB)	N	10 log N (dB)	N	10 log N (dB)
.10	-10	2.24	3.5	250	24
.112	- 9.5	2.51	4	320	25
.126	- 9	2.82	4.5	400	26
.141	- 8.5	3.16	5	500	27
.158	- 8	3.55	5.5	630	28
.178	- 7.5	3.98	6	800	29
.200	- 7	4.47	6.5	1,000	30
.224	- 6.5	5.01	7	1,250	31
.251	- 6	5.62	7.5	1,600	32
.282	- 5.5	6.31	8	2,000	33
.316	- 5	7.08	8.5	2,500	34
.355	- 4.5	7.94	9	3,200	35
.398	- 4	8.91	9.5	4,000	36
.447	- 3.5	10	10	5,000	37
.501	- 3	12	11	6,300	38
.562	- 2.5	16	12	8,000	39
.631	- 2	20	13	10,000	40
.708	- 1.5	25	14	12,500	41
.794	- 1	32	15	16,000	42
.891	- 0.5	40	16	20,000	43
1.000	0.0	50	17	25,000	44
1.12	0.5	63	18	32,000	45
1.26	1	80	19	40,000	46
1.41	1.5	100	20	50,000	47
1.58	2	125	21	63,000	48
1.78	2.5	160	22	80,000	49
2.00	3	200	23	100,000	50

Note: By simply remembering the relationship that,

10 log 1 = 0 dB
10 log 1.25 = 1 dB
10 log 1.6 = 2 dB
10 log 2 = 3 dB

the above table can be extended up or down to get "10 log" of any number desired. Note the simple sequence: for each doubling of a quantity, there is an increase of 3 dB for "10 log" of that quantity, or each time a quantity is changed by a factor of 10, there is a change of 10 dB for "10 log" of that quantity.

The above examples were presented to demonstrate the use and versatility of Table I-1.2. The decibel levels used were for illustration purposes only. If a calculator were available, any 10 log N value could be accurately determined.

I-1.4 Frequency

Sound is composed of different frequencies unless it is a pure tone. Frequency simply means cycles per second or how often the compression or rarefaction of air occurs each second. The new international unit now commonly used to describe frequency is the Hertz (Hz) which has the same meaning as cycles per second. The study of sound's frequency content is often referred to as "spectral analysis".

It is sometimes necessary to characterize sound in terms of its frequency components for the following reasons;

1) People have different hearing sensitivities and different reactions to the various frequency ranges of noise.

2) Different noise sources have differing amounts of noise across the full audio range of frequencies.

3) Engineering solutions for mitigating noise are different for high and low frequency noise.

A person with acute hearing would be able to detect frequencies from 20 to 20,000 Hz. However, everyone loses the ability to hear high frequencies (over 10,000 Hz) as they become older.

I-1.5 Octave Bands of Frequency

It is conventional practice in acoustics to separate frequencies into nine octave bands. The frequencies are shown as ranges with the geometric mean frequencies representing the range. The numbers are rounded off and are shown on the following table:

Table I-1.3

Octave Frequency Range (Hz)	Geometric Mean Frequency of Band (Hz)
22-44	31
44-88	63
88-175	125
175-350	250
350-700	500
700-1400	1000
1400-2800	2000
2800-5600	4000
5600-11,200	8000

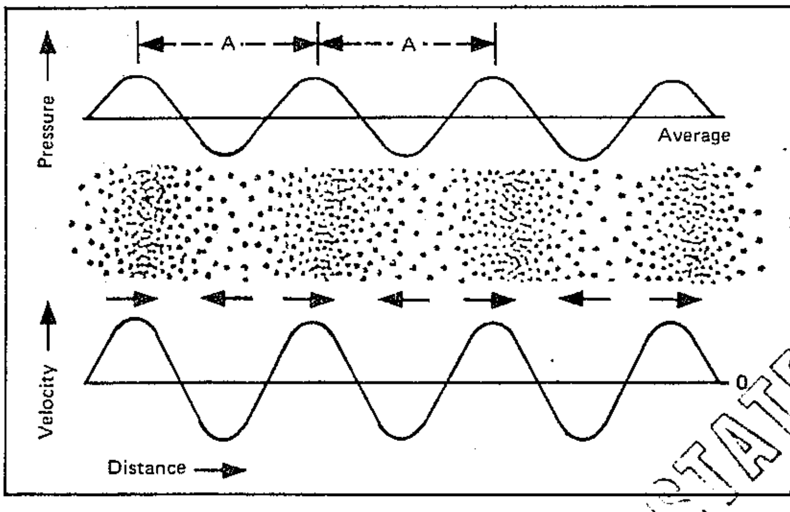
For specialized applications Table I-1.3 can be extended to cover lower or higher frequencies. It can also be broken down to smaller ranges such as one half, one third or one sixth of the ranges shown.

When a sound source includes a wide range of frequencies, the resulting value is called the "overall level". If a sound source falls in one octave frequency range it is called an "octave band level".

I-1.6 Wavelength of Sound

Wavelengths of sound are useful when considering various accoustical properties of sources, materials or sound control treatments.

Sound was defined as pressure waves caused by the compression and rarefaction of air. Frequency is how often the compression and rarefaction occur each second. Wavelength is the distance from one cycle of compression to the next cycle of compression (Sketch I-1.1).



The upper curve in the figure shows how pressure varies above and below average with distance at a given time. The lower curve shows how velocity varies, above zero (that is, molecules moving to the right) and below zero (that is, molecules moving to the left). The distance (A) between crests of both curves is the wavelength of the sound.

Sketch I-1.1

It can be calculated by

$$\lambda = \frac{c}{f}$$

λ = wavelength (feet)

c = speed of sound (1128 ft/sec)

f = frequency (cycles/sec)

The following Table I-1.4 was constructed using the above equation:

Table I-1.4

Frequency (Hz)	Wavelength (feet)
16	70
31	35
63	17.5
125	9
250	4.5
500	2.2
1000	1.1
2000	.55
4000	.27
8000	.14

A practical application of this property of soundwaves is in selecting material to mitigate noise. As an example a one inch thick acoustical tile would be ineffective for attenuating low frequency sound but would be very effective against sound 1000 Hz or higher. Another example would be a 15 foot high noise barrier which would be very effective against sound 63 Hz or higher. For noise having frequencies of say 16 Hz, the sound waves would tend to go over and around the barrier.

Vehicle noise ranges from below 63 Hz to over 8,000 Hz and tends to center around 500 to 550 Hz.

CHAPTER I-2

NOISE RECEIVER CHARACTERISTICS

Chapter I-2

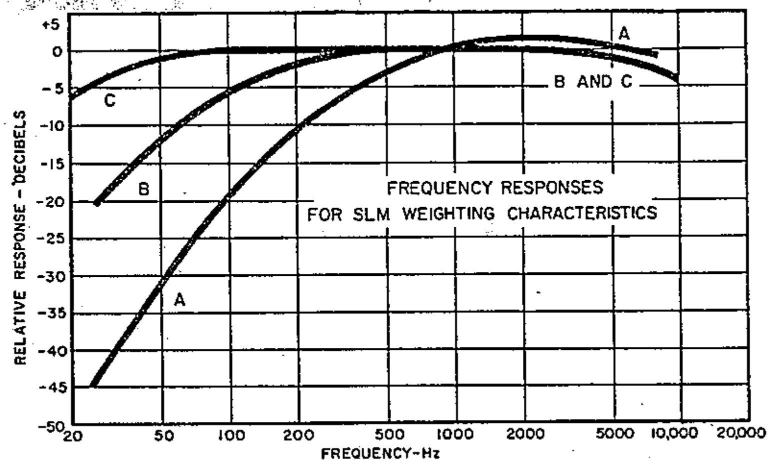
Noise Receiver Characteristics

I-2.1 A-Scale Sound Level

The normal human ear does not hear all the sound equally at all the frequencies emanating from a sound source. In addition, the apparent loudness from different sources, such as jet aircraft and automobiles, differs considerably as perceived by humans even though the overall level is the same.

Sound level meters are designed to reflect the ear's response to the various sounds. They are constructed with weighting circuits that tend to represent the frequency characteristics of the human ear for various sound intensities.

The American National Standard Institute (ANSI) established a specification (ANSI S1.4 - 1971) to which sound level meters should conform (Sketch I-2.1). The commonly identified weighting scales are the A, B, and C. Whenever these scales are used, the decibel (dB) levels are shown as dBA, dBB, or dBC.



Frequency-response characteristics in the American National Standard Specification for Sound-Level Meters, ANSI-S1.4-1971.

Sketch I-2.1

Studies have shown that when people make relative judgments of the nuisance value of noise they most often correlate with the A-scale sound levels determined by a sound level meter. The dBA scale is the standard for Caltrans' noise work.

The following Table I-2.1 illustrates the sound levels of a diesel truck at the various frequencies, the overall (dB) and A-weighted (dBA) levels.

Table I-2.1

Column 1 Octave Frequency Band (Hz)	Column 2 SPL* in Octave Band (dB)	Column 3 A-Scale Correction Term** (dB)	Column 4 Corrected Band Value*** (dB)
31	75	-39	36
63	78	-26	52
125	83	-16	67
250	84	- 9	75
500	80	- 3	77
1000	75	0	75
2000	72	+ 1	73
4000	64	+ 1	65
8000	55	- 1	54
	Overall = 88.4 dB		A-Weighted = 81.5 dBA

*SPL = Sound Pressure Level

**From Sketch I-2.1

***Column 2-3

The overall 88.4 dB and A-weighted 81.5 dBA were calculated. These values could also have been determined using Table I-1.1 and the procedure outlined in Chapter I-1.3.

For Caltrans' purposes sound levels are measured or expressed in terms of all the octave frequency bands in terms of dBA so there will be a simple one number system. The information and discussion on Table I-2.1 was presented to provide a basic understanding of the system.

I-2.2 Noise Descriptors

A number of descriptors have been devised by acousticians to rate noise on the basis of such things as annoyance, loudness, short term, long term and by statistical levels. For Caltrans' purposes the following descriptors are commonly encountered:

Descriptor	Definition
Peak Noise	The highest noise level emitted from a source.
L_{10}, L_{50}, L_{90}, etc.	Statistical descriptor. L_{10} 80 dBA means the sound level of 80 decibels on the A-scale is exceeded ten percent of the time. L_{50} and L_{90} mean levels are exceeded 50 and 90 percent of the time, respectively.
L_{eq} (sound level equivalent)	The equivalent steady state sound level in a stated period of time that would contain the same acoustical energy as the time-varying sound level during the same period.
L_{dn} (sound level, day, night)	The 24-hour L_{eq} with the day (d) period from 0700 to 2200 hours. The night (n) period is from 2200 to 0700 hours. A penalty of 10 dBA is added to n because this is normally the sleeping time.
CNEL (community noise equivalent level)	The 24-hour L_{dn} with an additional penalty of 5 dBA from 1800 to 2200 because this is the time for things such as relaxation, TV viewing and listening and conversation.

The measurement, analysis and application of the various descriptors will be covered later in this manual.

I-2.3 Human Response to Noise

People react to noise in a variety of ways. Rock music, as an example, can be pleasant, annoying, a health hazard and can interfere with various activities. In a very general sense, Figure I-1.1 shows public reactions to various noise levels.

Human response to noise depends on various factors as follows:

1) The level or intensity, frequency distribution, and time pattern of the noise source.

Relating to traffic noise, a high level is more objectionable than a low level noise, and intermittent truck peak noise levels are more objectionable than a steady state level.

Humans have better hearing sensitivities in the high frequency region than the low. This is reflected in the A-scale (Chapter I-2.1) which de-emphasizes the low frequency sounds. Studies indicate that the annoyance or disturbance correlates with the A-scale.

The time pattern is illustrated by an automobile horn at 2:00 a.m. which is more disturbing than the same noise in traffic at 5:00 p.m.

2) The amount of background noise present before the intruding noise.

People tend to compare an intruding noise with the existing background noise. If the new noise is readily identifiable or considerably higher than the background or ambient, it usually becomes objectionable. An aircraft flying over a residential area is an example.

3) The nature of the work or living activity that is exposed to the noise source.

Highway traffic noise might not be disturbing to workers in a factory or office but the same noise might be annoying or objectionable to people sleeping at home or studying in a library.

I-2.4 Interference With Speech

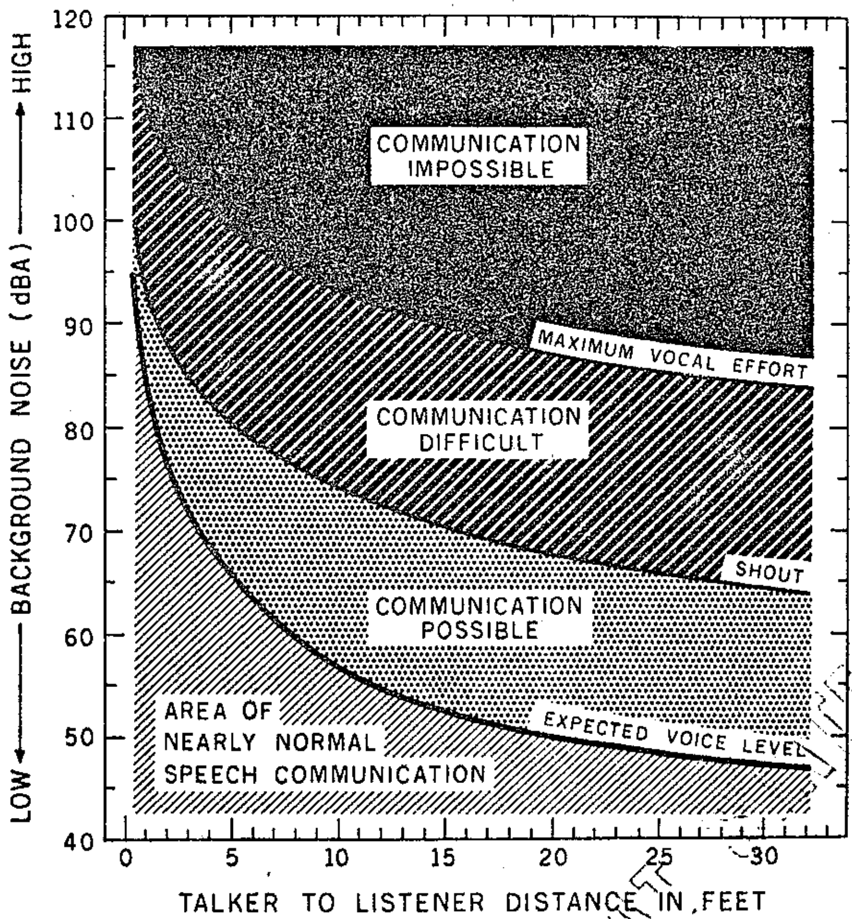
Figure I-2.1 gives an estimate of the speech communication that is possible at various noise levels and distances. As an example, if the talker to listener distance is 20 feet, normal communications can be conducted with the background level around 50 dBA. If the background level is increased to 60 dBA then the person must increase his voice level to communicate without losing intelligibility.

I-2.5 Interference With Sleep

The work of Thiessen and Olson* revealed that a tape recorded truck passage wakened more than 50 percent of the test subjects when the peak noise reached 50 dBA. However, some of the subjects did not waken when the peak reached 75 dBA.

Other studies showed more than 50 percent of the test subjects were wakened by a steady state noise of 35 dB and that a range of 35 dB in noise levels was required to waken all subjects.

*Thiessen, G. J., and Olson, N.; "Community Noise-Surface Transportation," Sound and Vibration Magazine, April 1968.



Simplified chart that shows the quality of speech communication in relation to the A-weighted sound level of noise (dBA) and the distance between the talker and the listener.

Figure I-2.1

I-2.6 Sound Level Differences

A person with acute hearing can detect an increase of about 0.5 dB in the mid frequency range. Normally, when real life sounds are heard it is possible to detect changes of 2 to 3 dB. A 5 dB change is very noticeable and a change of 10 dB is judged by most people as halving or doubling the perceived noise level. An increase of 20 dB is perceived as four times as loud.

These subjective reactions to various levels of noise were conducted under controlled laboratory conditions.

I-2.7 Noise Induced Hearing Damage

The Federal Occupations Safety and Health Act (OSHA) of 1970 established the following maximum permissible noise exposures:

Durations per day (hours)	Sound Level dBA
8	90
6	92
4	95
3	97
2	100
1	105
.5	110
.25	115

This table is intended to apply to industrial areas and workers. In addition, other requirements such as personnel audiometric tests, hearing protection and source monitoring are also required.

CHAPTER I-3

SOUND PROPAGATION FUNDAMENTALS

Chapter I-3

Sound Propagation Fundamentals

I-3.1 Sound Level Reduction Due to Distance

Sound from a point source spreads in a spherical manner away from the source. This spreading results in a sound level decrease or increase of 6 dB for each doubling or halving of distance. It is known as the "inverse square law".

The area of a sphere is increased 4 times for each doubling of the radius (distance) as illustrated by the following equation:

Area of sphere $A_1 = 4\pi R^2$

Area of sphere (double radius) $A_2 = 4\pi(2R)^2$

Example: Assume a source to receiver distance of 50 feet and a second receiver distance of 100 feet.

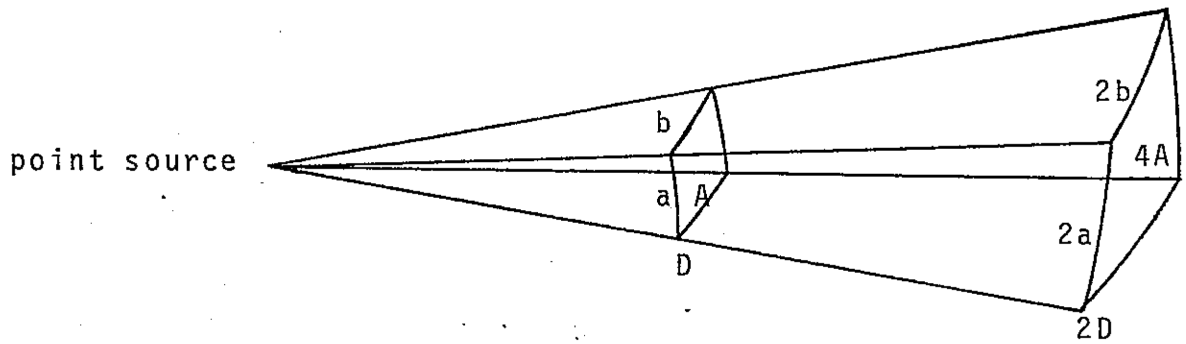
$$A_1 = 4\pi(50)^2 = 31,416$$

$$A_2 = 4\pi(100)^2 = 125,664$$

$$\frac{A_2}{A_1} = 4$$

$$10 \log 4 = 6 \text{ dBA}$$

Sketch I-3.1 shows part of a sphere and another illustration of the inverse square law for a point source.



Sketch I-3.1

Doubling the distance increases the area from A to 4A. Conversely the sound decrease due to spreading is a loss factor of 4 in intensity. Two equal noise levels produce an increase of 3 dB (Chapter I-1.3), therefore, 4 equal levels will produce two 3 dB changes, or 6 dB.

The spreading loss is affected by high frequency sound absorbed by air, which becomes significant at long distance. Table I-3.1 lists the drop-off rate of 6 dB for a point source starting at 50 feet and the additional loss due to air absorption is about 1 dBA per 1000 feet starting beyond the first 2000 feet.

The equation used to construct Table I-3.1 is described approximately by the following:

$$\text{dBA Reduction} = 20 \log \frac{D}{50} + \underbrace{\left[\frac{D-1000}{1000}\right]}_{\text{for } D>1000} + \underbrace{\left[\frac{D-2000}{1000}\right]}_{\text{for } D>2000}$$

D = distance in feet

50 = reference distance at which this table was established.

TABLE I-3.1

REDUCTION OF A-SCALE SOUND LEVEL AT VARIOUS DISTANCES FROM A VEHICULAR "POINT SOURCE", RELATIVE TO 50 FT DISTANCE, USING THE DROP-OFF RATE OF 6 dBA PER DOUBLE DISTANCE

$$\text{dBA REDUCTION} = 20 \text{ LOG } \frac{D}{50} + \left|\frac{D-1000}{1000}\right|_{\text{for } D>1000} + \left|\frac{D-2000}{1000}\right|_{\text{for } D>2000}$$

DISTANCE (ft)	REDUCTION (dBA)	DISTANCE (ft)	REDUCTION (dBA)	DISTANCE (ft)	REDUCTION (dBA)
50	0	237	13.5	1,100	27
53	0.5	251	14	1,150	27.5
56	1	266	14.5	1,210	28
60	1.5	282	15	1,270	28.5
63	2	299	15.5	1,330	29
67	2.5	316	16	1,400	29.5
71	3	335	16.5	1,470	30
75	3.5	355	17	1,540	30.5
79	4	376	17.5	1,610	31
84	4.5	398	18	1,690	31.5
89	5	422	18.5	1,770	32
94	5.5	447	19	1,850	32.5
100	6	473	19.5	1,930	33
106	6.5	500	20	2,010	33.5
112	7	531	20.5	2,090	34
119	7.5	562	21	2,170	34.5
126	8	596	21.5	2,250	35
133	8.5	631	22	2,330	35.5
141	9	668	22.5	2,420	36
150	9.5	708	23	2,510	36.5
158	10	750	23.5	2,600	37
168	10.5	794	24	2,690	37.5
178	11	841	24.5	2,780	38
188	11.5	891	25	2,870	38.5
200	12	944	25.5	2,960	39
211	12.5	1,000	26	3,050	39.5
224	13	1,050	26.5	3,140	40

Highway traffic noise on high volume highways simulates a "line source" and the drop-off rate of sound with distance approaches "cylindrical spreading". The decrease or increase for doubling or halving of distance under this condition is 3 dBA.

The area of a cylinder is increased 2 times for each doubling of the radius (distance) as illustrated by the following equation:

Area of cylinder $A_1 = L2\pi R$

Area of cylinder (double radius) $A_2 = L2\pi(2R)$

Example: Assume a source receiver distance of 50 feet and a second receiver distance of 100 feet and the line of vehicles as 500 feet long.

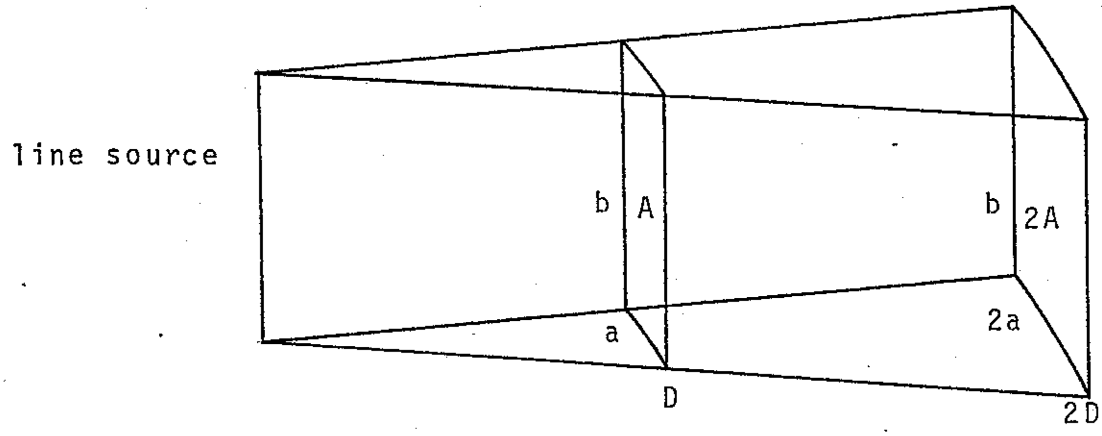
$$A_1 = 500 \times 2 \times \pi \times 50 = 157{,}080$$

$$A_2 = 500 \times 2 \times \pi \times 100 = 314{,}159$$

$$\frac{A_2}{A_1} = 2$$

$$10 \log 2 = 3 \text{ dBA}$$

Sketch I-3.2 shows part of a cylinder and an illustration of the inverse first power law for a line source.



Sketch I-3.2

Doubling the distance increases the area from A to 2A. Conversely the sound decrease due to spreading is a loss factor of 2 in intensity. Two equal noise levels produce an increase of 3 dB (Chapter I-1.3).

The additional loss due to atmospherics affects the line source similar to the point source. Table I-3.2 lists a drop-off of 3 dB for a line source.

The equation used to construct Table I-3.2 is described approximately by the following:

$$\text{DBA Reduction} = 10 \log \frac{D}{50} + \underbrace{\left[\frac{D-1000}{1000}\right]}_{\text{for } D>1000} + \underbrace{\left[\frac{D-2000}{1000}\right]}_{\text{for } D>2000}$$

Under field conditions the traffic rarely reaches an idealized line source and the propagation of traffic noise to the receiver can also be affected by ground attenuation. Therefore, a drop-off rate close to 4.5 dB may be more realistic for many conditions. Table I-3.3 is presented for the 4.5 dB drop-off rate.

TABLE I-3.2

REDUCTION OF A-SCALE SOUND LEVEL AT VARIOUS DISTANCES FROM A VEHICULAR "LINE SOURCE," RELATIVE TO 50 FT DISTANCE, USING THE DROP-OFF RATE OF 3.0 dBA PER DOUBLE DISTANCE

$$\text{dBA REDUCTION} = 10 \text{ LOG } \frac{D}{50} + \left|\frac{D-1000}{1000}\right|_{\text{for } D>1000} + \left|\frac{D-2000}{1000}\right|_{\text{for } D>2000}$$

DISTANCE (ft)	REDUCTION (dBA)	DISTANCE (ft)	REDUCTION (dBA)	DISTANCE (ft)	REDUCTION (dBA)
50	0	398	9	2,340	18.5
56	0.5	447	9.5	2,480	19
63	1	500	10	2,630	19.5
71	1.5	562	10.5	2,780	20
79	2	631	11	2,930	20.5
89	2.5	708	11.5	3,080	21
100	3	794	12	3,230	21.5
112	3.5	891	12.5	3,380	22
126	4	1,000	13	3,530	22.5
141	4.5	1,100	13.5	3,690	23
158	5	1,200	14	3,850	23.5
178	5.5	1,310	14.5	4,010	24
200	6	1,420	15	4,170	24.5
224	6.5	1,540	15.5	4,330	25
251	7	1,660	16	4,490	25.5
282	7.5	1,790	16.5	4,660	26
316	8	1,920	17	4,830	26.5
355	8.5	2,060	17.5	5,000	27
		2,200	18		

TABLE I-3.3

REDUCTION OF A-SCALE SOUND LEVEL AT VARIOUS DISTANCES FROM A VEHICULAR "LINE SOURCE," RELATIVE TO 50 FT DISTANCE, USING THE DROP-OFF RATE OF 4.5 dBA PER DOUBLE DISTANCE

$$\text{dBA REDUCTION} = 15 \log \frac{D}{50} + \left|\frac{D-1000}{1000}\right|_{\text{for } D>1000} + \left|\frac{D-2000}{1000}\right|_{\text{for } D>2000}$$

DISTANCE (ft)	REDUCTION (dBA)	DISTANCE (ft)	REDUCTION (dBA)	DISTANCE (ft)	REDUCTION (dBA)
50	0	316	12	1,670	23.5
54	0.5	339	12.5	1,770	24
58	1	367	13	1,880	24.5
63	1.5	397	13.5	2,000	25
68	2	428	14	2,090	25.5
74	2.5	463	14.5	2,190	26
80	3	499	15	2,290	26.5
86	3.5	538	15.5	2,400	27
93	4	582	16	2,500	27.5
100	4.5	629	16.5	2,610	28
108	5	676	17	2,720	28.5
117	5.5	731	17.5	2,840	29
126	6	790	18	2,960	29.5
136	6.5	847	18.5	3,080	30
147	7	922	19	3,200	30.5
158	7.5	998	19.5	3,330	31
170	8	1,070	20	3,460	31.5
184	8.5	1,140	20.5	3,590	32
199	9	1,215	21	3,730	32.5
215	9.5	1,290	21.5	3,860	33
233	10	1,380	22	3,990	33.5
251	10.5	1,470	22.5	4,130	34
270	11	1,570	23	4,270	34.5
292	11.5			4,410	35

The equation used to construct Table I-3.3 is described approximately by the following:

$$\text{dBA Reduction} = 15 \log \frac{D}{50} + \underbrace{\left[\frac{D-1000}{1000}\right]}_{\text{for } D>1000} + \underbrace{\left[\frac{D-2000}{1000}\right]}_{\text{for } D>2000}$$

The following discussion illustrates the application of the change from a point source to a line source as related to highway traffic noise. Figure I-3.1 shows a situation with a point source (1 vehicle) and the 6 dBA decrease in noise due to a doubling of distance.

Figure I-3.2 shows a hypothetical situation with a line of vehicles. The calculated noise levels indicate a drop-off rate for doubling of distance of 3.5 dBA from 50 to 100 feet, 3.1 dBA from 100 to 200 feet, 3.5 dBA from 200 to 400 feet and 3.8 dBA from 400 to 800 feet. Note that the drop-off for this "line source" starts at 3.5 dBA, decreases, then increases to 3.8 dBA.

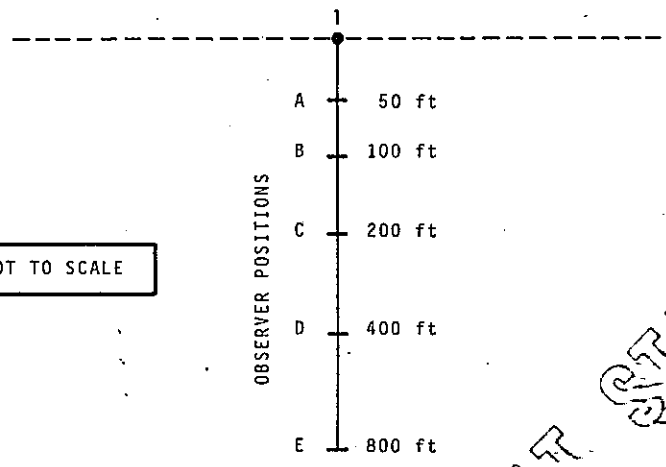
It is assumed that if the vehicles are spaced very closely together, the 3 dBA drop-off will be ultimately attained. The significance of this discussion is related to control of noise in highway design and in noise prediction which will be covered later in Section II.

I-3.2 Atmospheric Effects

Atmospheric effects seldom have any significant effect on noise levels at the relatively short distances from the highway to the adjacent residents. In some instances, short duration, intermittent or temporary atmospheric effects can be significant but these are not counted for steady-state noise control.

Figure I-3.1

CALCULATED A-SCALE SOUND LEVELS AT OBSERVER POINTS A, B, C, D, AND E FOR SOUND SOURCE AT POINT 1. SOURCE PRODUCES SOUND LEVEL OF 80 dBA AT 50 FT DISTANCE.

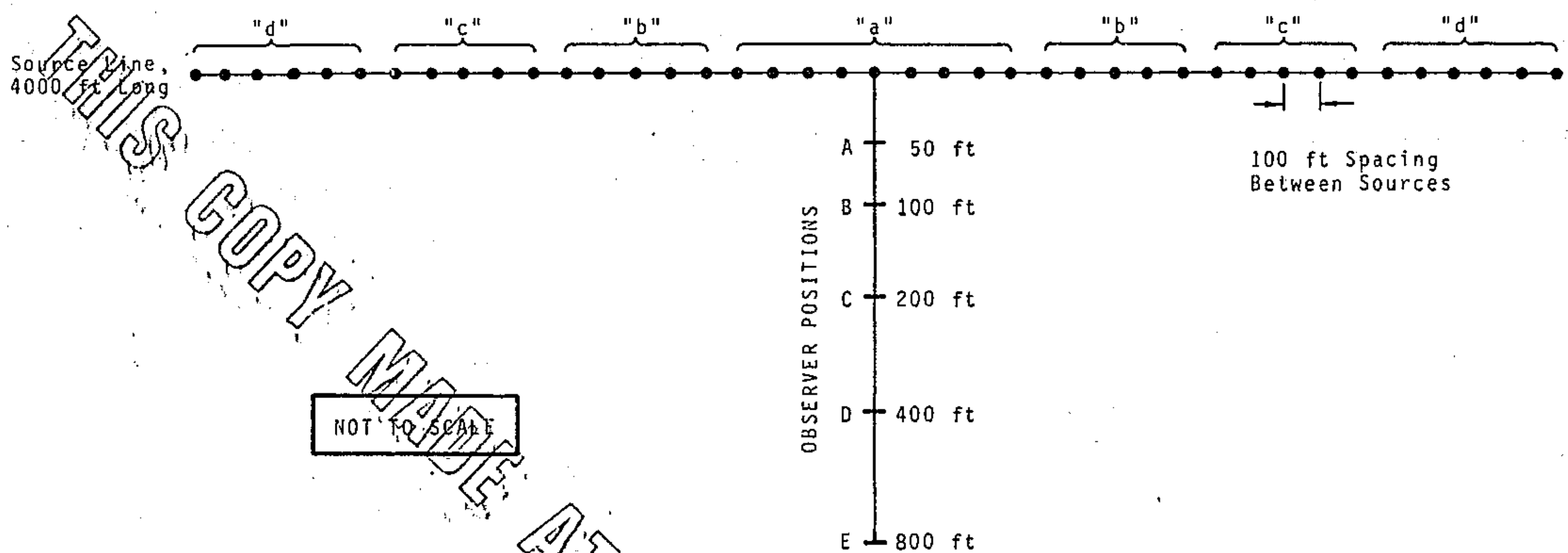


NOT TO SCALE

Point	Total Sound Level (dBA)	Difference, Drop-off Rate (dBA/DD)
A	80	
B	74	6.0
C	68	6.0
D	62	6.0
E	56	6.0

Figure I-3.2

CALCULATED A-SCALE SOUND LEVELS AT OBSERVER POINTS A, B, C, D, AND E FOR 41 SOUND SOURCES EQUALLY SPACED AT 100 FT INTERVALS ALONG A 4000-FT SOURCE LINE. EACH SOURCE PRODUCES SOUND LEVEL OF 80 dBA AT 50 FT DISTANCE.



Sound Level Contributions (dBA)

Point	Group "a" Central 9 Sources, Within 400 ft of Center	Group "b" Next 10 Sources, 500-900 ft from Center	Group "c" Next 10 Sources, 1000-1400 ft from Center	Group "d" Next 12 Sources, 1500-2000 ft from Center	Total Sound Level (dBA)	Difference, Drop-Off Rate/DD (dBA)
A	82.1	67.6	62.2	59.0	82.3	
						3.5
B	78.3	67.4	62.2	59.0	78.8	
						3.1
C	74.6	67.2	62.1	58.9	75.7	
						3.5
D	70.2	66.1	61.7	58.7	72.2	
						3.8
E	65.0	63.4	60.3	57.8	68.4	

Sound traveling with the wind is bent down to earth and sound traveling against the wind is bent upwards above the earth. Irregular, turbulent or gust wind causes fluctuations in sound transmissions.

Rain, fog, hail and snow will wet the pavement and cause an increase in tire noise. However, this may be compensated by vehicles being driven at a slower rate of speed under adverse weather conditions.

Temperature gradients can bend or reflect noise back down to earth. These usually occur at large distances (over a half mile).

Molecular absorption of sound energy at a given temperature of 60°-70°F and 60-70 percent relative humidity is shown on the following Table I-3.4.

Table I-3.4

Octave Frequency Band (Hz)	Absorption Rate (dB per 1,000 ft)
31-250	0
500	0.7
1000	1.4
2000	3.0
4000	7.7
8000	14.4

Tables I-3.1, I-3.2 and I-3.3 show the approximate corrections for molecular absorption for distances over 1,000 feet based on Table I-3.4.

I-3.3 Effects of Trees and Vegetation

Trees and shrubs usually do not provide any significant reduction in noise unless they are very high, very deep, provide no visual path and are evergreen. However, trees and vegetation have aesthetic and psychological value and can provide some attenuation.

Extensive fields of crops such as corn, wheat and other vegetation as well as freshly plowed fields can absorb sound waves near the ground. However, these may not be permanent and therefore no attenuation credit should be given in these cases.

Section II of this manual provides the conditions where attenuation due to trees, vegetation and ground conditions may be used for predicting or mitigating noise.

I-3.4 Building Noise Reductions

Buildings act as a barrier and can provide noise attenuation. Section II of this manual defines the conditions where reductions of noise due to buildings may be estimated.

Noise levels are reduced from the outside of buildings to the inside even if the window is open. A significant reduction is noted when the window is closed. The Federal Highway Program Manual (FHPM) 7-7-3 shows allowable decibel reduction from outside to inside of buildings for various conditions. This information is in Section II of this manual.

CHAPTER I-4

VEHICLE NOISE

Chapter I-4

Vehicle Noise

I-4.1 Heavy Trucks

The FHWA model for noise prediction and barrier design, adopted in July 1979, defined heavy trucks as those vehicles having three or more axles, designed to carry cargo and generally weighing 26,000 pounds or more. The "average" noise emission levels for heavy trucks are speed dependent and are defined in detail later in Section II of this manual.

Noise sources for trucks are from such things as the tires, engine, exhaust and intake system, cooling fan, transmission and muffler. The dominant noise for diesel trucks prior to 1978 has been from the exhaust system, tires and the cooling fan. It is expected that the tire and engine noise will become dominant as the Federal regulations concerning truck noise become effective. However, exhaust noise will continue to be a primary noise source from a barrier design standpoint.

Prior to 1978, diesel trucks had exhaust stacks that were as high as 13 feet, engine and cooling fan noise centered around 4 feet, and tire noise at the pavement surface. The centroid of these noise sources, commonly used for prediction and mitigation, for heavy trucks is 8 feet above the ground.

Frequency analysis of noise from the individual noise sources indicates that all except the tires generate low frequency (below 500 Hz) noise. Tire noise is predominantly above 500 Hz. Figures I-4.1 and I-4.2 illustrate a hypothetical case of the various frequency and sound levels from individual sources and the heights of the sources above the pavement.

Studies were performed by the National Bureau of Standards on noise generated by various types of truck tires on smooth concrete and "textured" asphalt. Figures I-4.3 and I-4.4 show the types of tires used and the noise levels at the different speeds.

The data indicated the pocket retread tire was the noisiest and the rib tires were the quietest. In general, the tread designs, such as the pocket retread, trap air in the cavity as the tire makes contact with the pavement. The air is compressed and pops out as the first escape route appears. The rib tire design allows the air to escape and therefore is quieter.

Grades affect truck noise and some correction is suggested for heavy trucks going uphill. This is discussed in more detail in Section II.

I-4.2 Medium Trucks

The FHWA defines medium trucks as those vehicles having two axles and six wheels designed to carry cargo and generally weighing between 10,000 and 26,000 pounds. Noise sources for these trucks are generally the same as for the heavy trucks but the exhaust is usually below the engine.

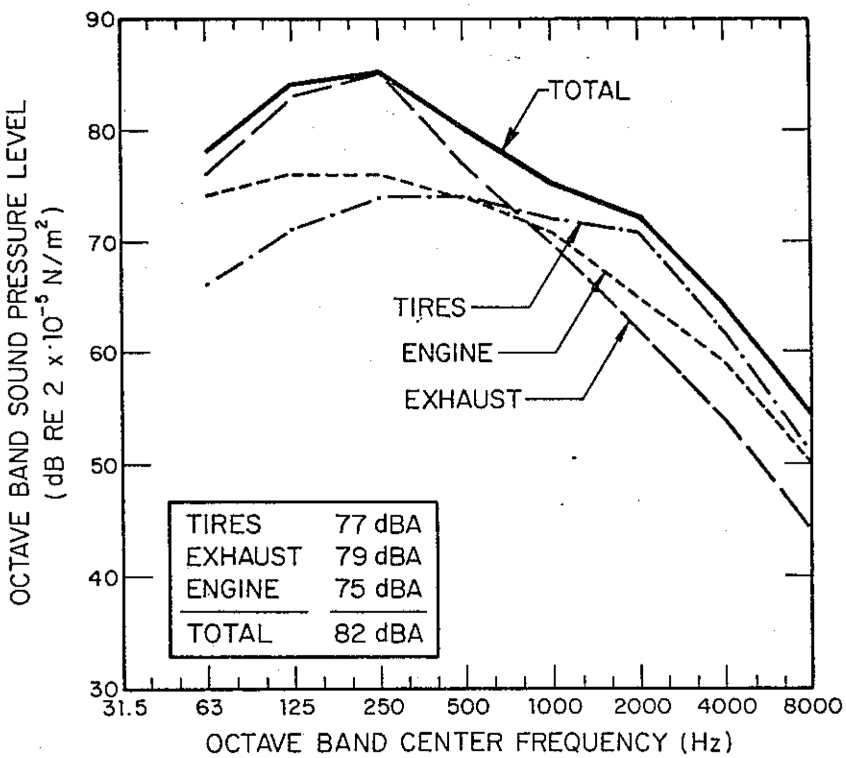


FIGURE I-4.1 HYPOTHETICAL MIXTURE OF THE THREE PRINCIPAL SOURCES OF TRUCK NOISE. NOISE LEVELS WILL VARY FOR DIFFERENT COMPONENTS IN DIFFERENT TRUCKS

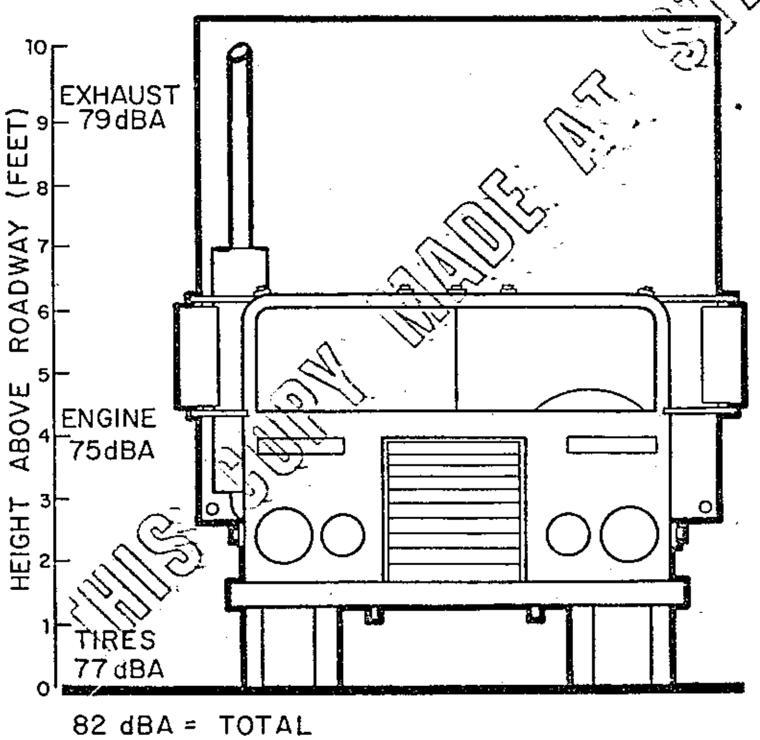


FIGURE I-4.2 REPRESENTATION OF TRUCK NOISE COMPONENTS OF FIGURE I-4.1 RELATIVE TO HEIGHT ABOVE THE ROADWAY

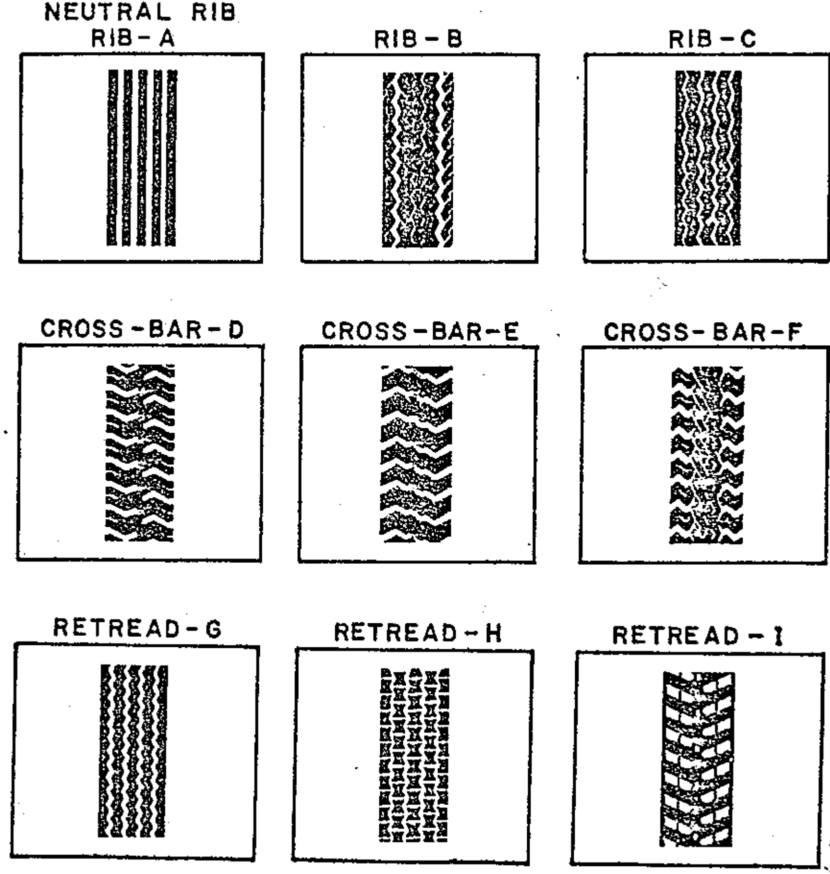


Figure I-4.3 Types of Tires for Noise Studies

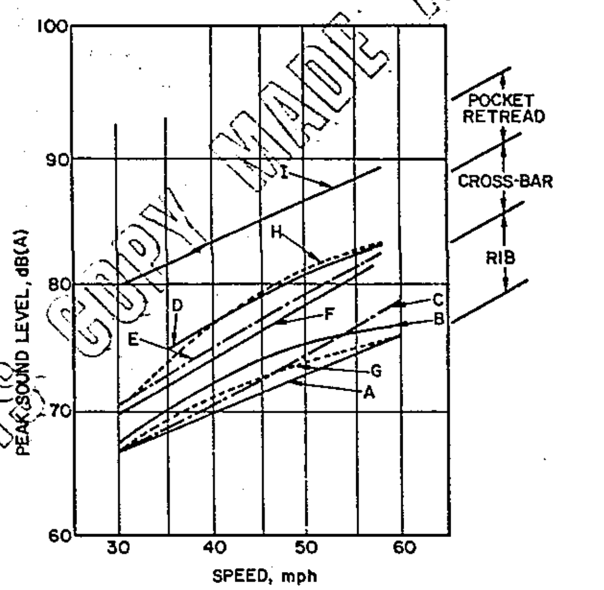


Figure I-4.4 Tire Noise on Asphalt

For prediction and mitigation purposes, the centroid of the sources is set at 2.3 feet. The "average" emission levels for this class of trucks are speed dependent and are defined later in Section II.

Studies performed on the emission level of trucks indicated the medium trucks exhibited different noise levels at the various speeds as compared to the heavy trucks. Therefore, this special category of truck was developed for noise prediction and mitigation purposes.

I-4.3 Automobiles

The FHWA defines automobiles as those vehicles having two axles and 4 tires, designed to carry 9 or less passengers and/or cargo (pickups) and generally weighing less than 10,000 pounds. Noise sources for automobiles are generally the same as for the trucks but high frequency tire noise predominates. Therefore, the centroid of the noise sources for prediction and mitigation purposes is set at the pavement surface. Automobile noise is speed dependent and is defined later in Section II.

Automobile noise is about 15 dBA less than heavy truck noise. However, automobile noise is an important source because there are so many of them.

Pavement surfaces affect tire noise and hence auto noise but this variable is so difficult to quantify that no adjustment in noise level is made due to pavement type. Also, predictions for noise levels used in environmental reports are projected about 20 years into the future and no accurate estimate of pavement type or condition can be made.

Field test results from a FHWA study indicated open graded asphaltic friction courses generally produces slightly lower noise levels than asphalt coated dense graded surfaces, portland cement concrete, or chip seals. A 1973 Plymouth station wagon using various tires was used as the test vehicle.

CHAPTER I-5

SOUND MEASUREMENTS
AND
INSTRUMENTATION

Chapter I-5

Sound Measurements and Instrumentation

I-5.1 Sound Level Meters

All sound level meters (SLM) used by the California Department of Transportation (Caltrans) shall be Type I or II as defined in the American National Standard Institute (ANSI) specification S1.4-1971. The Type I has a nominal accuracy of about ± 1 dBA at 1K Hz and the Type II about ± 2 dBA at 1K Hz.

A tripod is recommended for the SLM because it allows the operator to stand away from the meter and leaves his hands free for note taking.

I-5.2 Calibrator

A calibrator is a standardized noise source for conducting an overall systems check and calibration of the SLM. Each manufacturer of a SLM has a calibrator designed specifically for an individual microphone. Mismatched calibrators can result in errors or damage to the microphone. Calibration should be performed using a 1000 Hz signal.

Calibrator output is affected by changes in atmospheric pressure. Manufacturers provide correction curves for calibrator use at other than standard atmospheric pressures.

I-5.3 High Impedance Headphone

It is suggested that a high impedance headphone be used to listen for such things as wind and internal or popping noise due to a wet microphone.

I-5.4 Windscreens

Windscreens are generally of spherical or cylindrical shape and made of formed polyvinyl, open-celled polyurethane or a silk covered grid. The screen fits over the microphone and helps to protect as well as minimize wind noise.

Measurements can be made in winds up to 12 mph with a windscreen. It should always be used when making field measurements.

I-5.5 Graphic Level Recorder

A graphic level recorder facilitates noise measurements by providing a trace of the noise level on graph paper for a permanent record that can be analyzed at a later date. The data can be reduced manually and calculations performed to obtain descriptors such as peak, L_{10} and L_{eq}.

I-5.6 Alternative Sound Measuring Instruments

Sound level distribution analyzers (noise classifier types) are often used for monitoring highway or community noise. They are especially useful for long term measurements. One disadvantage is that they sample all noise and are not able to eliminate airplanes or barking dogs when traffic noise is the only interest.

The distribution analyzers provide a mechanical and electrical means for obtaining a large sample which can be converted manually or by computer to descriptors such as L_{10} and L_{eq}. There are also fully automatic instruments that provide hard copies of the test data as well as calculate such things as peak, L_{10} and L_{eq} values.

I-5.7 Accessory Equipment

Sometimes, a wind speed indicator accurate to ± 10% at 12 mph and a sling psychrometer for measuring humidity and temperature may be desired. Microphone operation may be affected when relative humidity is not between 10 and 90%. Other items such as a stopwatch with sweep second hand, data sheets and spare batteries may be helpful.

<u>Caution</u>: The operator should be familiar with and always have a copy of the manufacturers instructions with each sound measuring instrument.

I-5.8 Quality Assurance

All instrumentation used for noise measurements should be checked periodically and calibrated. Permanent records showing this work should be maintained.

The procedures for performing the calibration are shown in Appendix D.

I-5.9 Suggestions for Noise Measurement

1. Check batteries and calibrate the SLM before each use.

2. Make measurements during "noisiest" traffic periods when possible.

3. Use the SLM's A-weighting network.

4. Remeasure ambient noise several days later as a check (same time of day at same location).

5. Avoid measurements in high winds, rain or high humidity.

6. Make outdoor ambient measurements at <u>upper</u> floors.

7. Keep microphones covered at all times (using protective cap or windscreen). Never touch the diaphragm.

8. Always use a windscreen during outdoor measurements.

9. Orient the microphone according to manufacturer's instructions.

10. State all noise levels in terms of a descriptor and weighting factor (e.g., L_{eq} = 72 dBA).

11. Always carry spare batteries for the SLM and calibrator; spare pen and paper for the graphic level recorder.

12. Treat all noise measuring instruments as delicate electronic equipment.

13. Document all noise measurements with complete information as to location, time, personnel, instruments used, etc.

CHAPTER I-6

FIELD MEASUREMENTS AND ANALYSIS

Chapter I-6

Field Measurement and Analysis

I-6.1 Selection of Sampling Time

Design noise levels in the Federal Highway Program Manual (FHPM) 7-7-3 (Appendix IIB) are based in part on the design (peak) hourly traffic volume. Sound measurements should therefore be made near or at the design hourly traffic volume. However, the period with the highest sound levels may not occur at the design hourly volume. This condition may occur when traffic volumes are lower but the truck percentage is greater.

If measurements are made during off-peak traffic, mathematically adjust the sound level (L_{eq}) so that the highest (peak hour) sound levels are reported based on peak traffic data. The calculations to perform this adjustment are explained in Section II because familarity with the prediction model is necessary.

Measurements are very rarely made for a full one-hour period, but "samples" are taken to represent this period.

I-6.2 Measurement Location (Ambient and Traffic Noise)

Sound level measurements are usually made so that they are representative of the receiver(s) involved in an activity. An example is noise measurements in the back yard of a residence. The fence line is not appropriate but the patio, in the middle of the backyard or around a barbecue pit, could be representative.

It is difficult to establish a precise location for measurements in a picnic or recreation area and in school playgrounds. Judgement has to be exercised to assure that such sites are representative.

The sound level meter microphone should be kept at least 4 feet away from buildings or structures.

I-6.3 L_{eq} Determination by the Manual Check-off Method

The sampling program described below provides the procedure for determining the equivalent sound level (L_{eq}). Figure I-6-1 shows an example worksheet for recording noise data.

a) All information required on the worksheet should be entered. The column to the left is divided into fifty 1-decibel increments, marked in five sets of 0-9. Enter the appropriate 10 decibel intervals in front of each "0", increasing from bottom to top. Keep in mind the expected range of noise levels to be measured (Figure I-6.2).

b) The SLM microphone is set about 5 feet above the ground. It needs to be set on a tripod and located not less than 4 feet from any reflecting surface. There may be instances where measurements are made at heights other than 5 feet (i.e., upper story of residence). This information should always be noted on the worksheet.

c) Generally, the meter is set at "slow" response. However, if impulsive or peak noise values are needed, fast response may be preferable. Judgement should be exercised as to which response to use. Always use the "A" weighting network.

TRANSPORTATION LABORATORY
NOISE SECTION

District ____ Co. ____________ Rte. ____________ P.M. ____________

Test By ________________ Date ______ Time ______ Wind Speed ______

SLM Mfg.______ Serial No.____ Calibrator Mfg.______ Serial No.______

Site Sketch

Traffic	Count	Speed
Autos		
Medium Trk	____	____
Heavy Trk	____	____

Comment ____

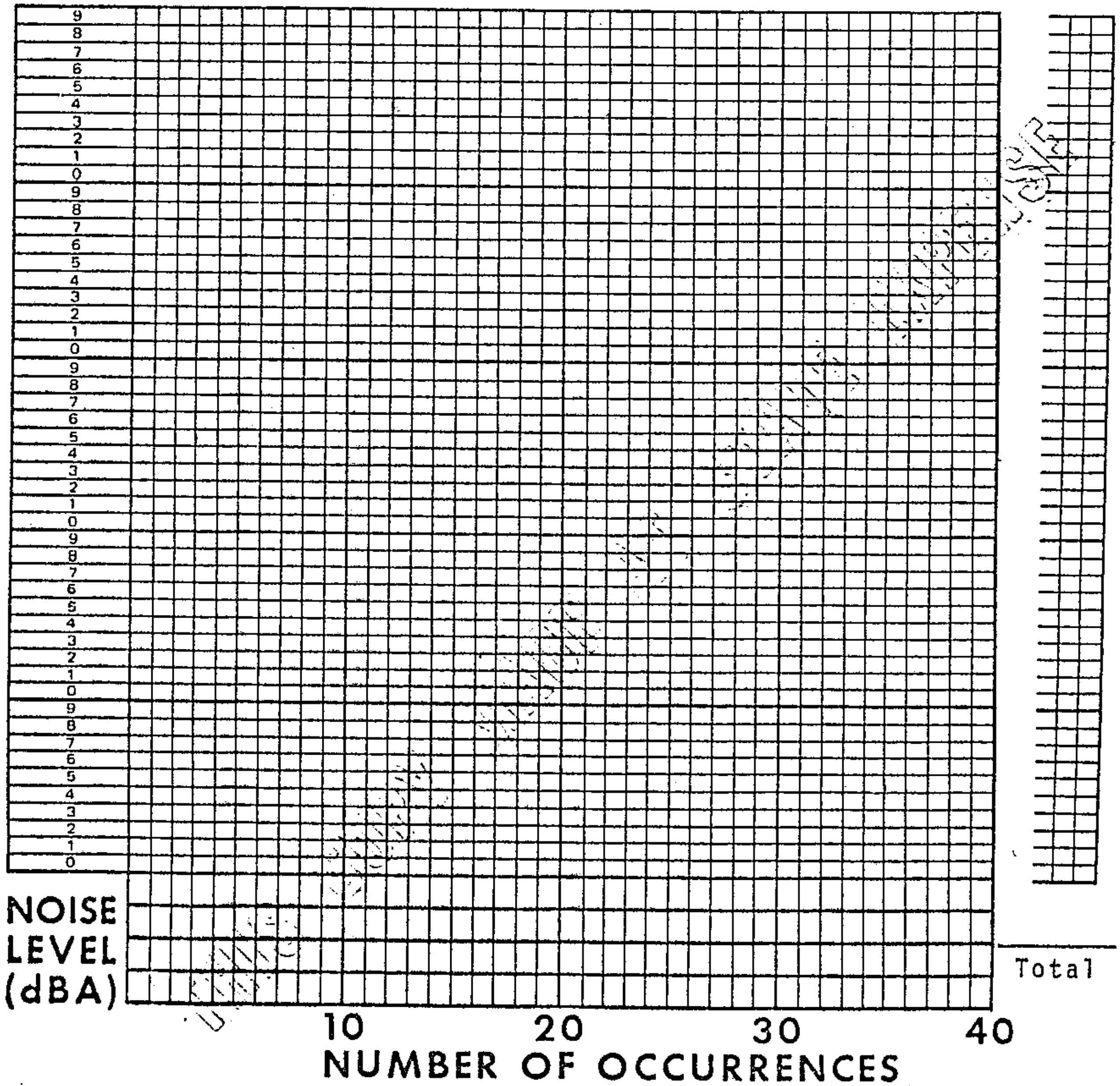


Figure I-6.1 Sample Sound Level Measurement Data Sheet

CALIFORNIA DEPARTMENT OF TRANSPORTATION
TRANSPORTATION LABORATORY
NOISE SECTION

District ____ Co. __________ Rte. __________ P.M. __________

Test By __________ Date ______ Time ______ Wind Speed ____

SLM Mfg. ______ Serial No. ____ Calibrator Mfg. ______ Serial No. ______

Site Sketch

Traffic	Count	Speed
Autos	____	____
Medium Trk	____	____
Heavy Trk	____	____

Comment ____

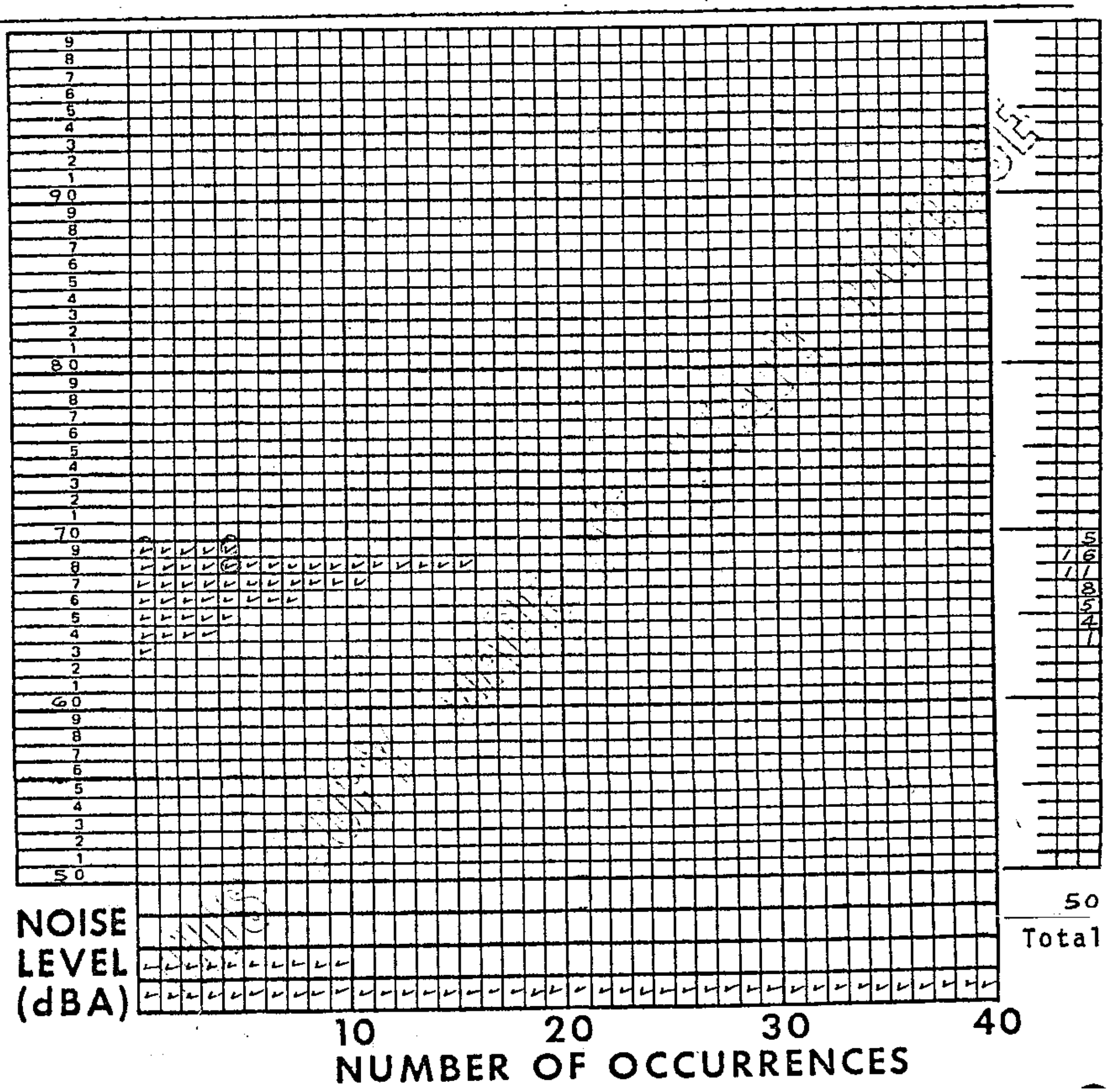


Figure I-6.2 Sample Sound Level Measurement Data Sheet

d) Calibrate the SLM according to the manufacturer's instructions.

e) Read the SLM every ten seconds (this is an instantaneous reading at 10 seconds) and place a check mark in the appropriate decibel level box and also a check mark along the bottom row to keep track of the number of measurements recorded (Figure I-6.2).

A method of identifying any unrepresentative sound sources which may influence the measurements is to use a letter code for different sources. Instead of a check mark on the work sheet, a letter corresponding to a particular source causing that sound level is used (i.e., A-airplane, J-jet, D-dog, etc.). Usually, these extraneous sound sources are not included in the data collection or analysis process unless they are a normal part of the noise environment of interest.

f) After fifty measurements, a validity test is performed to determine if an adequate sample has been taken to represent the peak hour traffic noise at a 95 percent confidence level. If the criterion is met, the measurement program is complete. Otherwise, another fifty measurements are taken and a test is applied to the one hundred measurements.

The following validity test is based upon a 95 percent confidence interval (Table I-6.1) and was originally developed for use in L_{10} determination.

Table I-6.1

95 PERCENT CONFIDENCE TEST SAMPLE TABLE FOR L_{10}

Total No. of Samples	Upper Error Limit	L_{10}	Lower Error Limit	Allowable Skewing
50	1st Sample	5th Sample	10th Sample	None
100	4th Sample	10th Sample	16th Sample	One
150	7th Sample	15th Sample	23rd Sample	One
200	11th Sample	20th Sample	29th Sample	One
250	15th Sample	25th Sample	35th Sample	One
300	19th Sample	30th Sample	41st Sample	One
350	24th Sample	35th Sample	46th Sample	One
400	28th Sample	40th Sample	52nd Sample	One

Note: The 95% confidence is met if the Upper and Lower Error Limits are within 3 dBA of the L_{10} Level.

Count down from the top of the data sheet (from left to right) and circle the data samples given in Table I-6.1. For example, after 50 samples have been recorded, the 1st, 5th, and 10th samples are circled. These samples constitute the L_{10} flanked by the upper and lower error limits. If the 1st and 10th samples are each within 3 dB of the 5th sample, the measurement program is complete. Otherwise, an additional 50 samples must be observed and the validity test is repeated. An example is given in Figure I-6.2. The criterion is met in this example.

If 100 or more samples have been taken, a process called "skewing" is allowed. By this process, the two outer test samples (the error limits) can be shifted by one sample (not one window), both in the same direction (Table I-6.1).

For example, if the criterion is not met after 100 samples by testing the 4th, 10th and 16th samples, the criterion can be tested with the 3rd, 10th and 15th samples or the 5th, 10th and 17th samples. Although this skewing procedure will not change the L_{10} value - nor will it change the number of samples between the upper and lower error limits - it can sometimes provide the necessary accuracy without requiring further sampling. However, if the criterion is still not met after skewing, then another 50 samples must be taken, and so on.

g) The Equivalent Sound Level, L_{eq}, is defined as:

$$L_{eq} = 10 \log_{10} [\frac{1}{n} \sum_{i=1}^{n} 10^{(L_i/10)}]$$

where L_i is an A-weighted sound level measured in decibels.

The L_{eq} can be evaluated after the L_{10} validity criterion is met using the data collected on Figure I-6.2 and the computational worksheet shown in Figure I-6.3, as follows:

CALIFORNIA DEPARTMENT OF TRANSPORTATION
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NOISE SECTION

District ____ Co. ____________ Rte. ____________ P.M. ________

Calc. By ____________________ Date ____________

Comment ____

____

SOUND LEVEL dB (A)	COUNT (B)		RELATIVE SOUND ENERGY (C)		RELATIVE TOTAL SOUND ENERGY (D)
100		x	100,000	=	
99		x	79,400	=	
98		x	63,100	=	
97		x	50,100	=	
96		x	39,800	=	
95		x	31,600	=	
94		x	25,100	=	
93		x	20,000	=	
92		x	15,900	=	
91		x	12,600	=	
90		x	10,000	=	
89		x	7,940	=	
88		x	6,310	=	
87		x	5,010	=	
86		x	3,980	=	
85		x	3,160	=	
84		x	2,510	=	
83		x	2,000	=	
82		x	1,590	=	
81		x	1,260	=	
80		x	1,000	=	
79		x	794	=	
78		x	631	=	
77		x	501	=	
76		x	398	=	
75		x	316	=	
74		x	251	=	
73		x	200	=	
72		x	159	=	
71		x	126	=	
70		x	100	=	
69	5	x	79.4	=	397
68	16	x	63.1	=	1010
67	11	x	50.1	=	551
66	8	x	39.8	=	318
65	5	x	31.6	=	158
64	4	x	25.1	=	100
63	1	x	20.0	=	20
62		x	15.9	=	
61		x	12.6	=	
60		x	10.0	=	
59		x	7.94	=	
58		x	6.31	=	
57		x	5.01	=	
56		x	3.98	=	
55		x	3.16	=	
54		x	2.51	=	
53		x	2.00	=	
52		x	1.59	=	
51		x	1.26	=	
50		x	1.00	=	
49		x	.794	=	
48		x	.631	=	
47		x	.501	=	
46		x	.398	=	
45		x	.316	=	
44		x	.251	=	
43		x	.200	=	
42		x	.159	=	
41		x	.126	=	
40		x	.100	=	
	Σ= 50				Σ= 2554

Example

1. Sum B 50
2. Sum D 2554
3. Sum D/B 51
4. Leq 67

Leq is determined by finding the closest value for Sum D/B in Column C and reading the Sound Level in Column A

Figure I-6.3 Leq Computation Worksheet

STEP	PROCEDURE
1	Enter number of checks per sound level in Column B.
2	Multiply the counts in Column B by the relative sound energy factor in Column C and enter the result in Column D.
3	Add all values in Column B to determine Sum B (50), add all values in Column D to determine Sum D (2554), and divide Sum D by Sum B (2554/50 = 51).
4	Locate the value (51) in Column C that is approximately equal to Sum D/Sum B. The corresponding value in Column A is equal to L_{eq}.

The relative sound energies in Column C were derived by taking the antilog of SPL/10 and multiplying the results by 10^{-5} to keep the values manageably small.

h) Remember that the measured L_{eq} is the L_{eq} for the measurement time period only. For example, if 100 samples were taken before the criterion was met, then the noise was sampled over 1000 seconds (approximately 17 minutes). The L_{eq} pertains to that 17-minute period only. For this reason, it may be desirable to collect further samples, to extend the total time period. The accuracy depends only upon the number of samples taken. Therefore, if it is desired to sample over a longer time period, the sample interval may be changed to 20 or 30 seconds, to save work. In this manner, a smaller number of samples will be spread uniformly over a longer time period, that might more realistically be said to typify the measurement site.

i) In the example shown in Figure I-6.3, the L_{eq} is 67.

Another way to calculate the L_{eq} is shown on Figure 6.4. The same set of raw data on Figure I-6.3 is transferred to Figure I-6.4, Column A (sound level) and B (count). The 10 log N and dB sum addition calculations were covered in Chapter 1. Calculations can also be performed using a calculator.

FIGURE I-6.4

L_{eq} DETERMINATIONS FROM SOUND LEVEL MEASUREMENTS

$$L_{eq}(h) = 10 \log \frac{1}{N_t} \sum_{i=1}^{N_t} n_i \, 10^{L_i/10}$$

N_t = total no. of samples taken

n_i = no. of samples in a particular window

L_i = the middle value of the particular window

Tabular Simplification

A	B	C	D	E
MEASURED SOUND LEVEL L	NO. OF OCCURRENCES (N)	10 LOG N	L+10 LOG N	dB SUM (dB ADDITION)
69	5	6.99	76	63
68	16	12.04	80	70
67	11	10.41	77	72
66	8	9.03	75	75
65	5	6.99	72	76
64	4	6.02	70	77
63	1	0	63	80

dB addition: 63 + 70 → 71; 71 + 72 → 75; 75 + 75 → 78; 78 + 76 → 80; 80 + 77 → 82; 82 + 80 → 84

$$L_{eq}(h) = \text{dB Sum} - 10 \log N_t$$

$= 84 - 17$

$= 67$

I-6.4 Day-Night Sound Level Calculations

Day-night sound levels can be obtained for each hour of the 24 hours and then energy-averaged.

Hourly Sound Level Measurements

Example: To determine L_{dn} from hourly measurements (Table I-6.2).

1. For daytime (0700-2200), determine the number of hours represented by each daytime equivalent sound level (L_{eq}) and enter this value in Column B of Figure I-6.5.

2. For nighttime (2200-0700), determine the number of hours represented by each nighttime equivalent sound level plus 10 dB (L_{eq}+10) and enter this value in Column B of Figure I-6.5.

3. For each sound level band Figure I-6.5, Column A, multiply the number of hours in Column B by the corresponding value in Column C. Enter the result in Column D.

4. Add all the values in Figure I-6.5, Column D to obtain the Sum D. Divide Sum D by 24. Locate the value of Sum D/24 in Column C and note the corresponding sound level in Column A. This is the day-night sound level L_{dn}.

Table I-6.2

EXAMPLE: 24-HOUR SURVEY FOR L_{dn} DETERMINATION

Time of Day	Hourly L_{eq}
0700-0800	62
0800-0900	64
0900-1000	62
1000-1100	62
1100-1200	58
1200-1300	56
1300-1400	54
1400-1500	54
1500-1600	58
1600-1700	66
1700-1800	66
1800-1900	62
1900-2000	60
2000-2100	58
2100-2200	56
2200-2300	54*
2300-2400	52*
2400-0100	52*
0100-0200	50*
0200-0300	48*
0300-0400	48*
0400-0500	48*
0500-0600	48*
0600-0700	48*

Hourly L_{eq} A	No. of Hours B Day	Night
66	2	0
64	1	1
62	4	2
60	1	1
58	3	5
56	2	0
54	2	0
	15	9

*10-decibel penalties are added to these nighttime values

CALIFORNIA DEPARTMENT OF TRANSPORTATION
TRANSPORTATION LABORATORY
NOISE SECTION

District ___ Co. ______________ Rte. __________ P.M. ________

Calc. By ______________ Date __________

Comment ______________________________

EXAMPLE

SOUND LEVEL dB (A)	COUNT (B) Day	Night		RELATIVE SOUND ENERGY (C)		RELATIVE TOTAL SOUND ENERGY (D)
100			x	100,000	=	
99			x	79,400	=	
98			x	63,100	=	
97			x	50,100	=	
96			x	39,800	=	
95			x	31,600	=	
94			x	25,100	=	
93			x	20,000	=	
92			x	15,900	=	
91			x	12,600	=	
90			x	10,000	=	
89			x	7,940	=	
88			x	6,310	=	
87			x	5,010	=	
86			x	3,980	=	
85			x	3,160	=	
84			x	2,510	=	
83			x	2,000	=	
82			x	1,590	=	
81			x	1,260	=	
80			x	1,000	=	
79			x	794	=	
78			x	631	=	
77			x	501	=	
76			x	398	=	
75			x	316	=	
74			x	251	=	
73			x	200	=	
72			x	159	=	
71			x	126	=	
70			x	100	=	
69			x	79.4	=	
68			x	63.1	=	
67			x	50.1	=	
66	II		x	39.8	=	80
65			x	31.6	=	
64	I	I	x	25.1	=	50
63			x	20.0	=	
62	IIII	II	x	15.9	=	95
61			x	12.6	=	
60	I	I	x	10.0	=	20
59			x	7.94	=	
58	III	卌	x	6.31	=	50
57			x	5.01	=	
56	II		x	3.98	=	8
55			x	3.16	=	
54	II		x	2.51	=	5
53			x	2.00	=	
52			x	1.59	=	
51			x	1.26	=	
50			x	1.00	=	
49			x	.794	=	
48			x	.631	=	
47			x	.501	=	
46			x	.398	=	
45			x	.316	=	
44			x	.251	=	
43			x	.200	=	
42			x	.159	=	
41			x	.126	=	
40			x	.100	=	

Σ= 24 Σ= 308

*10 dB penalty added to nighttime values

1. Sum B 24
2. Sum D 308
3. Sum D/B 12.8
4. Leq 61 = L_{dn}

Leq is determined by finding the closest value for Sum D/B in Column C and reading the Sound Level in Column A

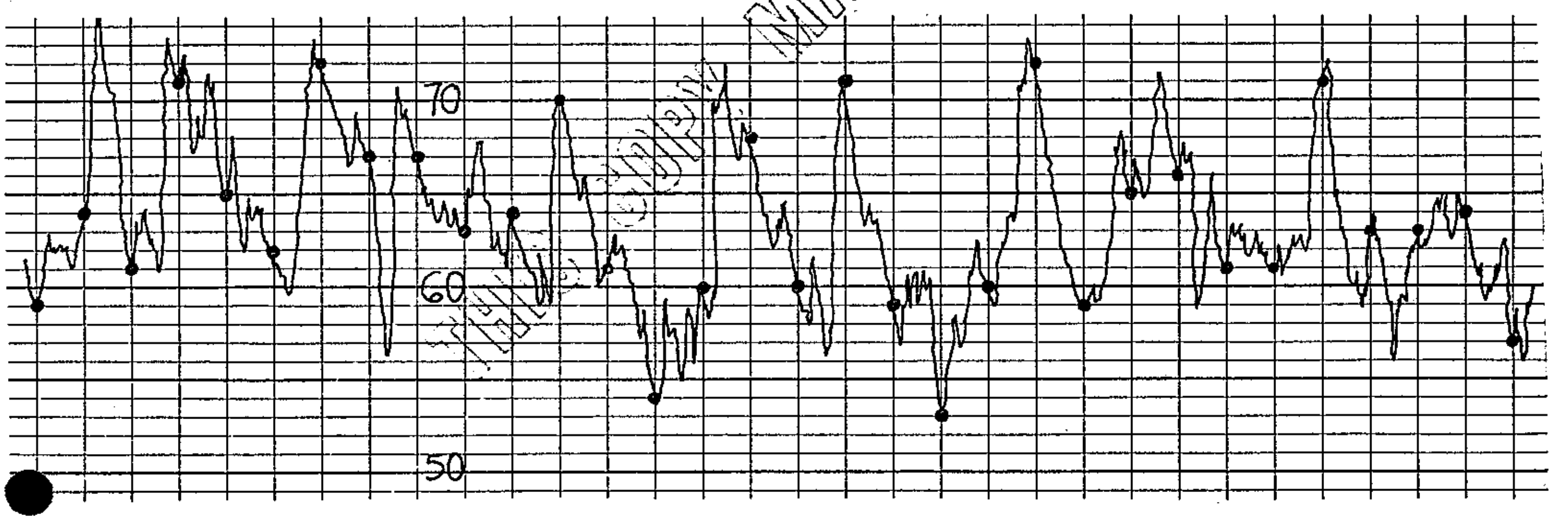
Figure I-6.5 Leq Computation Worksheet

I-6.5 L_{eq} Determination Using A Graphic Level Recorder

To determine L_{eq} from a continuous graphic record of sound pressure level (SPL) versus time (Sketch I-6.1), pick points at absolutely regular time intervals along the plot. The closer together the points are picked, the more accurate and repeatable the L_{eq} determination will be.

For the sake of convenience and consistency, a time interval should be chosen which coincides with the preprinted vertical lines on the graph paper. The time interval represented by these lines will vary depending on which paper speed setting is being used. Where the lines are not provided, they should be constructed on the graph paper with attention to accuracy.

The SPL values picked from the graphic record can be interpreted using the same methods employed in the check-off method discussed previously. For simplicity these SPL's can first be transferred to the FHWA "Sound Level Measurement Data Sheet" (Figure I-6.6) thereby arranging the data for ease of analysis. The L_{eq} Computation Work Sheet (Figure I-6.7) is then used to determine the L_{eq}. The example does not show the application of the accuracy test due to the limited data.



Sketch I-6.1 EXAMPLE

CALIFORNIA DEPARTMENT OF TRANSPORTATION
TRANSPORTATION LABORATORY
NOISE SECTION

District ____ Co. __________ Rte. __________ P.M. __________

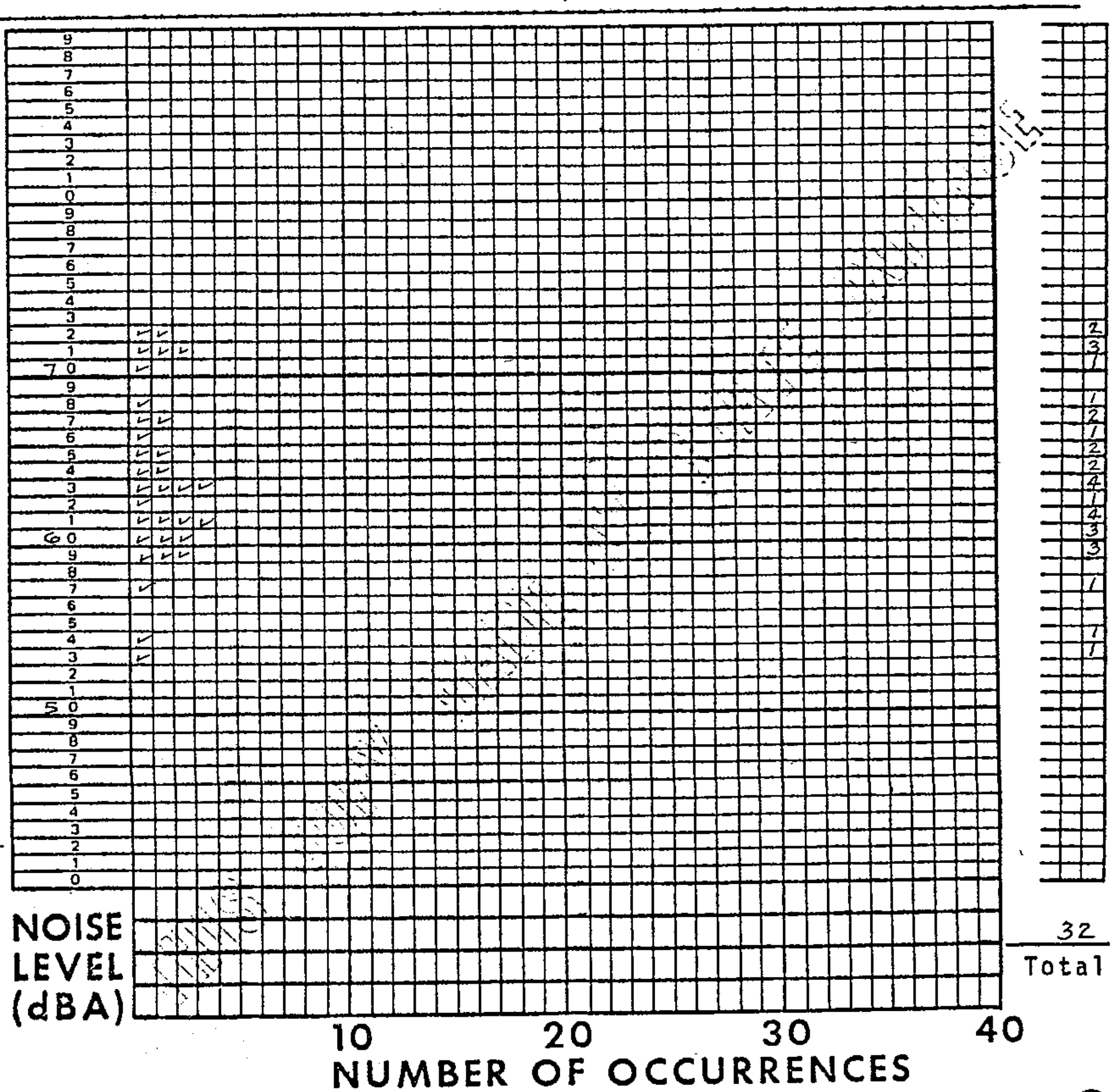
Test By ______________ Date ______ Time _____ Wind Speed ______

SLM Mfg. _____ Serial No. _____ Calibrator Mfg. _____ Serial No. _____

Site Sketch

Traffic	Count	Speed
Autos		
Medium Trk		
Heavy Trk		

Comment ____



Example

Figure I-6.6 Sample Sound Level Measurement Data Sheet

CALIFORNIA DEPARTMENT OF TRANSPORTATION
TRANSPORTATION LABORATORY
NOISE SECTION

District ____ Co. ____________ Rte. ____________ P.M. ________

Calc. By ____________________ Date ____________

Comment ____

SOUND LEVEL dB (A)	COUNT (B)		RELATIVE SOUND ENERGY (C)		RELATIVE TOTAL SOUND ENERGY (D)
100		x	100,000	=	
99		x	79,400	=	
98		x	63,100	=	
97		x	50,100	=	
96		x	39,800	=	
95		x	31,600	=	
94		x	25,100	=	
93		x	20,000	=	
92		x	15,900	=	
91		x	12,600	=	
90		x	10,000	=	
89		x	7,940	=	
88		x	6,310	=	
87		x	5,010	=	
86		x	3,980	=	
85		x	3,160	=	
84		x	2,510	=	
83		x	2,000	=	
82		x	1,590	=	
81		x	1,260	=	
80		x	1,000	=	
79		x	794	=	
78		x	631	=	
77		x	501	=	
76		x	398	=	
75		x	316	=	
74		x	251	=	
73		x	200	=	
72	2	x	159	=	318
71	3	x	126	=	378
70	1	x	100	=	100
69		x	79.4	=	
68	1	x	63.1	=	63.1
67	2	x	50.1	=	100.2
66	1	x	39.8	=	39.8
65	2	x	31.6	=	63.2
64	2	x	25.1	=	50.2
63	4	x	20.0	=	80.0
62	1	x	15.9	=	15.9
61	4	x	12.6	=	50.4
60	3	x	10.0	=	30.0
59	3	x	7.94	=	23.8
58		x	6.31	=	
57	1	x	5.01	=	5.0
56		x	3.98	=	
55		x	3.16	=	
54	1	x	2.51	=	2.5
53	1	x	2.00	=	2
52		x	1.59	=	
51		x	1.26	=	
50		x	1.00	=	
49		x	.794	=	
48		x	.631	=	
47		x	.501	=	
46		x	.398	=	
45		x	.316	=	
44		x	.251	=	
43		x	.200	=	
42		x	.159	=	
41		x	.126	=	
40		x	.100	=	
	Σ= 32				Σ= 1322.0

Example

1. Sum B 32
2. Sum D 1322.0
3. Sum D/B 41.3
4. Leq 66

Leq is determined by finding the closest value for Sum D/B in Column C and reading the Sound Level in Column A

Figure I-6.7 Leq Computation Worksheet

When graphic level noise measurements are being made in the field, it is not practical to apply an accuracy criterion to determine if an adequate sample has been taken. Therefore, as a guide, graphic level recordings should be taken for at least 8.5 minutes under heavy traffic conditions, at least 17 minutes under medium traffic conditions and at least 25 minutes under low traffic conditions. When in doubt about traffic conditions, recordings should be made for the longer time periods.

I-6.6 L_{eq} Determination Using the Environmental Noise Classifier

L_{eq} can readily be determined from the data collected by the B&K Environmental Noise Classifier (Models 166 and 166/S45). Ideally, the instrument would be allowed to accumulate noise level data for the entire time period for which an L_{eq} value is desired. In the case of highway noise, this would be for the entire "peak traffic" hour. If measuring for the entire hour is not practical, caution should be exercised in using shorter measurement periods to establish the 1-hour L_{eq}.

As a guide, classifier recordings should be taken for at least 8.5 minutes under heavy traffic conditions, at least 17 minutes under medium traffic conditions, and at least 25 minutes under low traffic conditions. When in doubt about traffic conditions, recordings should be made for the longer time periods.

L_{eq} is determined from Noise Classifier data via the general expression:

$$L_{eq} = 10 \log_{10} \frac{\text{Sum of energies for each of the measured SPL's}}{\text{Total number of measurements made } (N_t)}$$

which becomes ...

$$L_{eq} = 10 \log_{10} \left(\frac{10^{\frac{SPL_1}{10}} + 10^{\frac{SPL_2}{10}} + 10^{\frac{SPL_3}{10}} \ldots + 10^{\frac{SPL_{N_t}}{10}}}{N_t} \right)$$

or ...

$$L_{eq} = 10 \log \frac{1}{N_t} \sum_{i=1}^{N_t} n_i \, 10^{L_i/10}$$

where:

n_i = no. of samples in a particular window

L_i = the middle value of the particular window

Noise classifier may also be interpreted using the "Tabular Simplification" worksheet as shown on Figures I-6.8 and I-6.9.

The window values shown on Figure I-6.8 are the lower limit for the window.

i.e.: The lower limit for the first window is 45. It covers the range between 45 and 46. The middle value is 45.5 dBA.
The lower limit for the second window is 47. It covers the range between 47 and 49. The middle value is 48 dBA.
The lower limit for the third window is 50. It covers the range between 50 and 51. The middle value is 50.5 dBA.

Successive middle values should be calculated for each window and recorded on Figure I-6.9 (Column A). The corresponding number of occurrences are recorded on Column B and then calculations are performed to determine L_{eq}.

CALIFORNIA DEPARTMENT OF TRANSPORTATION
TRANSPORTATION LABORATORY
NOISE SECTION

District ____ Co. ________ Rte. ________ P.M. ________
Test By ________ Date ______ Time ______ Wind Speed ______

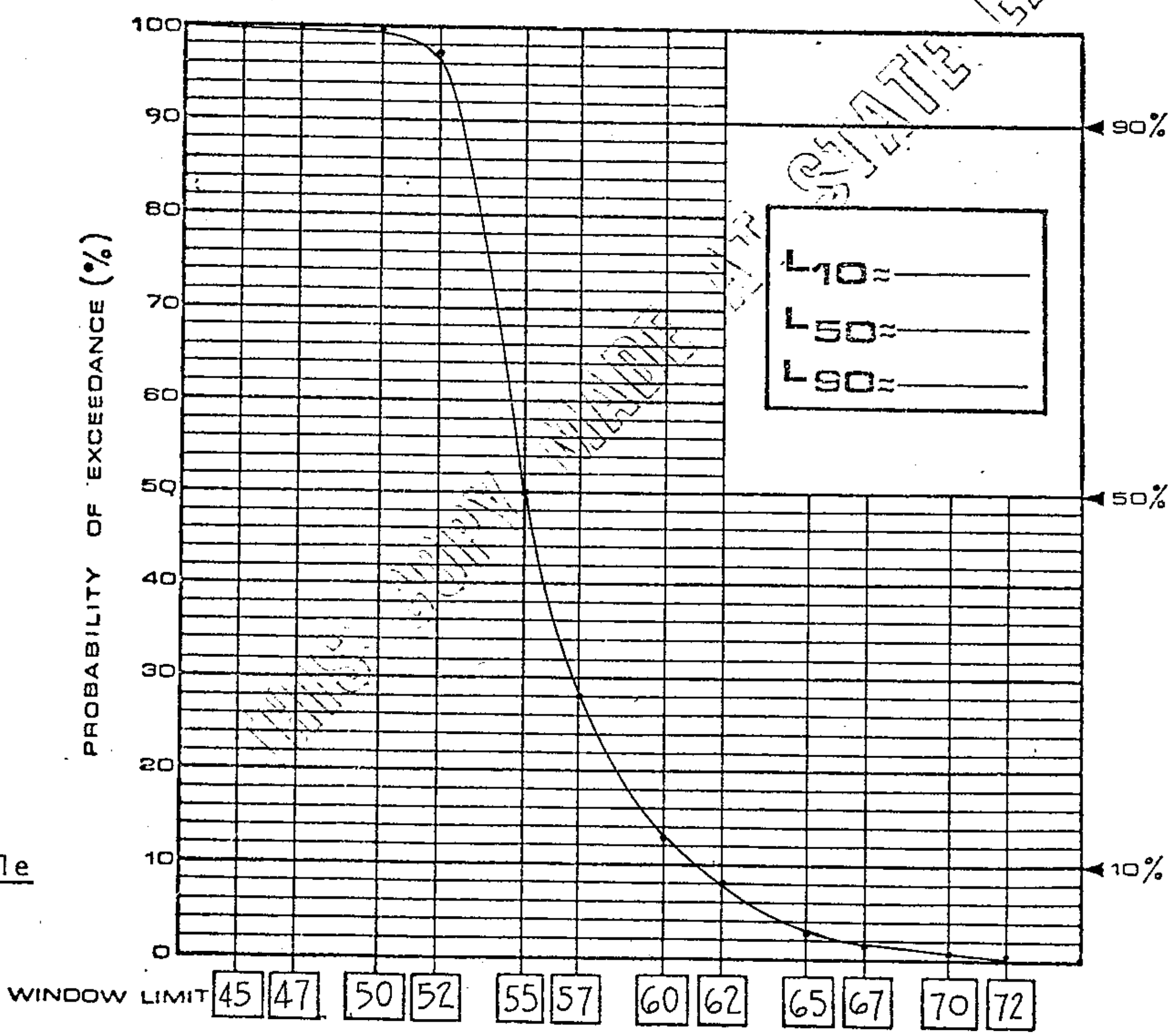
LOWER LIMIT	45	47	50	52
READING	0	3	10	61
% OF TOTAL	0	2	6.7	40.7
PROB OF EXC(%)	99.4	99.4	99.4	90.7

LOWER LIMIT	55	57	60	62
READING	33	23	7	8
% OF TOTAL	22	15.3	4.7	5.3
PROB OF EXC(%)	50.0	28.0	12.7	8.0

TOTAL TIME

LOWER LIMIT	65	67	70	72
READING	2	1	1	0
% OF TOTAL	1.3	.7	.7	0
PROB OF EXC(%)	2.7	1.4	.7	0

START HERE



Example

Figure I-6.9

L_{eq} DETERMINATIONS FROM SOUND LEVEL MEASUREMENTS

$$L_{eq}(h) = 10 \log \frac{1}{N_t} \sum_{i=1}^{N_t} n_i \, 10^{L_i/10}$$

N_t = total no. of samples taken

n_i = no. of samples in a particular window

L_i = the middle value of the particular window

Tabular Simplification

A	B	C	D	E
MEASURED SOUND LEVEL L	NO. OF OCCURRENCES (N)	10 LOG N	L+10 LOG N	dB SUM (dB ADDITION)
48	3	4.77	52.8	79.5
50.5	10	10.00	60.5	
53	61	17.85	70.9	
55.5	33	15.19	70.7	
58	23	13.62	71.6	
60.5	7	8.45	69.0	
63	8	9.03	72.0	
65.5	2	3.01	68.5	
68	1	0	68.0	
70.5	1	0	70.5	
	$N_t = 142$	$21.7 = 10 \log N_t$		

$$L_{eq}(h) = \text{dB Sum} - 10 \log N_t$$

$$= 79.5 - 21.7$$

$$= 58$$

I-6.7 Computer Analyses of Graphic Level Recorder Data

The L_{eq} is a calculated value requiring a tedious time consuming manual calculation using data from either the FHWA check-off procedure, the graphic level recorder or the environmental noise classifier.

A computer program (Program Name 5; ENV; ENVSYS; L Calc) on the TENET Time-Share System is available for calculating L_{eq} from the check-off procedure or the Environmental Noise Classifier.

For graphic level recordings, the Transportation Laboratory uses a digitizer pen and computer program to interpret the graphic data and print out results for direct inclusion in noise reports. It is more accurate and faster than the manual method.

Figures I-6.10 and I-6.11 show the information required for analysis and Figure I-6.12 shows an example computer printout.

TRANSPORTATION LABORATORY
Enviro-Chemical Branch
NOISE SECTION

GRAPHIC RECORDER DATA SHEET

The following information is necessary for strip charts submitted to TransLab for computer analysis:

1. District: ________
2. County: ________________
3. Route: ________________
4. Post mile: ________________
5. Date of measurement: ____________
6. Submitted by: ________________
7. Beginning time of measurement: ______________
8. Ending time of measurement: __________________
9. Field data by: __________________________
10. Branch: ________________________________
11. Field measurement location: __________________

Figure I-6.10

Graphic Level Recording (strip chart)

Note: The following items should be marked on the strip chart:

A) Sound pressure level corresponding to each 10 dB line

B) Starting & ending points of strip chart recording

Writing speed should be: 3 or 10"/sec on GenRad 1521
100 mm/sec on B&K 2306

Paper speed should be: 1/5"/min on GenRad 1521
1 mm/sec on B&K 2306

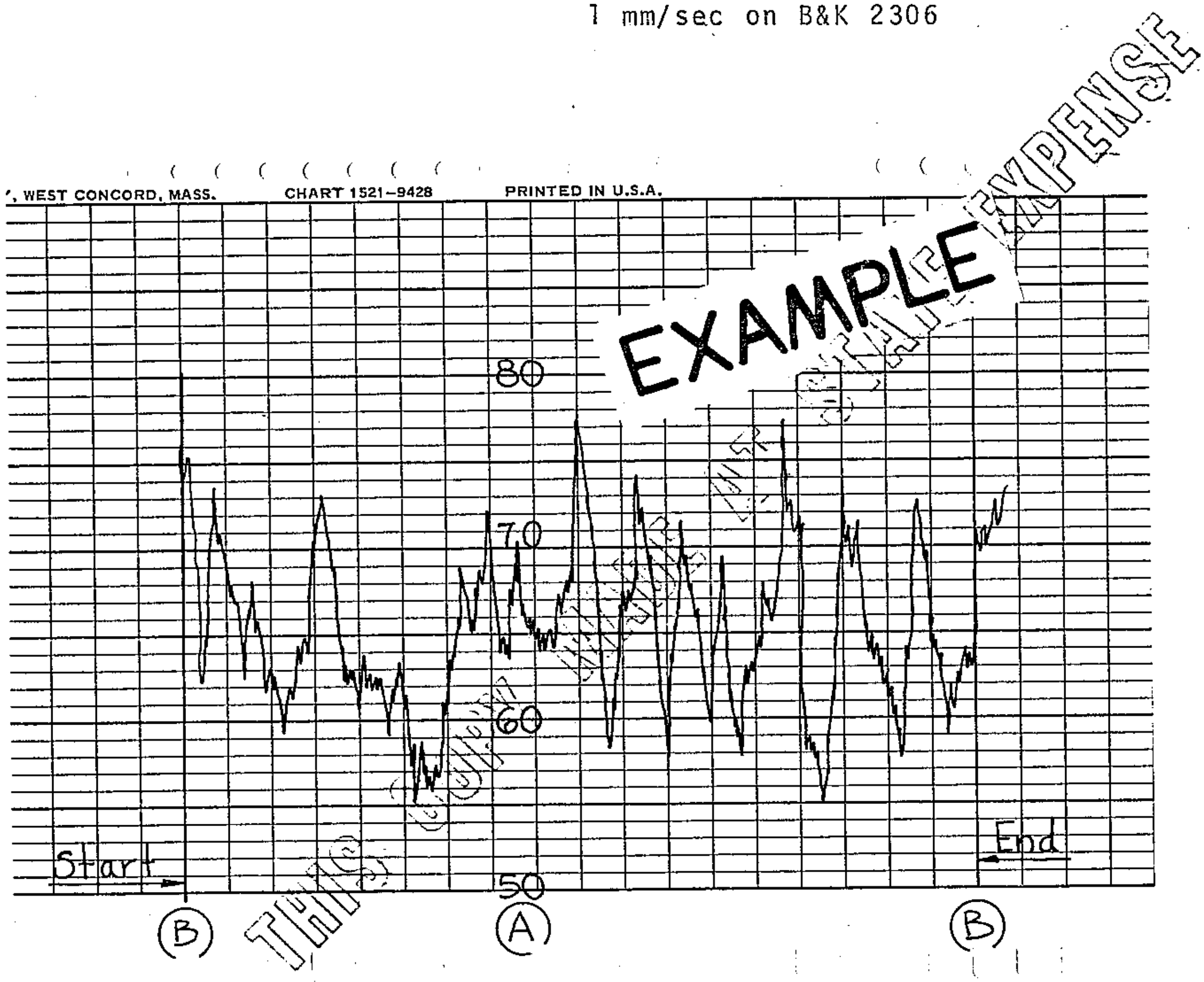


Figure I-6.11

L_{eq} Computer Printout From Graphic Level Recorder

DIST.:03
CO.: YOLO
RTE.: I-80
P.M.: ?
BRANCH: ENVIRO-CHEMICAL
FIELD MEASUREMENT LOCATION: ONE MILE WEST OF YOLO CAUSEWAY

MEASUREMENT DATE: 4-19-78
MEASUREMENT TIME:1200 TO 1220
SUBMITTED BY: R. SMITH
FIELD DATA BY: R.SMITH

L(EQ)= 76.6 DBA
L(10)= 81.8
L(50)= 68.0
STANDARD DEVIATION= 8.4

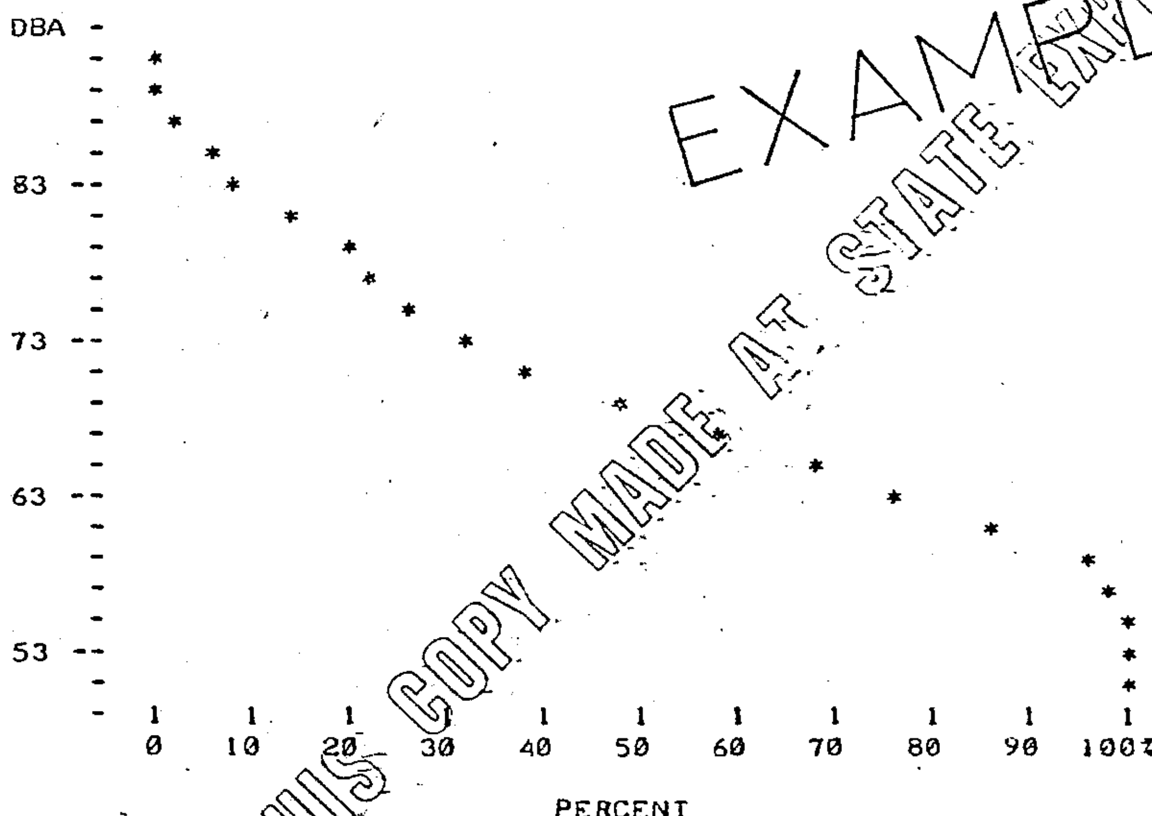


Figure I-6.12

APPENDIX IA

GLOSSARY

Glossary

The terms and definitions in this glossary are either used in this manual or are of interest and commonly used by people involved in environmental noise.

A-Weighted Sound Level (dBA) - A number representing the sound level which contains a wide range of frequencies weighted in a manner representative of the ear's response.

Absorption - A property of materials that reduces the amount of sound energy that is reflected. It is an entirely different process from that of transmission loss through a material.

Absorption Coefficient - A measure of the sound absorbing ability of a surface. The values range from about 0.01 for marble slate to 1.00 for a 100 percent absorbent material. One type of such a coefficient is referred to as a Noise Reduction Coefficient (NRC).

Acoustics - The science of sound including the generation, transmission, and effects of sound waves, both audible and inaudible.

Airborne Sound - Sound that reaches the point of interest by propagation through air.

Ambient Noise Level - That sound level that exists at any instant regardless of source.

Anechoic Room - A room whose boundaries have been designed to absorb nearly all of the sound incident on them, thereby affording a test room essentially free from reflected sound.

Articulation Index (AI) - A numerically calculated measure of the intelligibility of transmitted or processed speech. It takes into account the limitations of the transmission path and background noise. The AI ranges from 0 to 1.0. Speech intelligibility is low if the AI is 0.1 and high if 0.6.

Audio Frequency - Audible sine wave of sound between 20 and 20,000 Hz.

Aural - Pertaining to the ear or hearing.

Audiogram - A graph showing hearing loss as a function of frequency.

Audiometer - An instrument for measuring hearing sensitivity or hearing loss.

Background Noise - The total of all noise in a system or situation, independent of the presence of the desired sound.

Baffle - A shielding structure or series of partitions used to increase the effective length of the external transmission path between two points in an acoustic system.

Band - A segment of the frequency spectrum.

Band Center Frequency - The designated (geometric) mean frequency of a band of noise.

Band Pressure Level - The pressure level for the sound contained within a specified frequency band.

Broadband Noise - Noise with components over a wide range of frequencies.

C-Weighted Sound Level (dBC) - A number representing the sound level which contains a wide range of frequencies which are linear from 70 to 4000 Hz, but below and above these limits, frequencies are slightly discriminated against.

Coincidence Effect - When the wavelength of the bending wave in a panel coincides with the length of an incident sound wave at the angle at which it strikes the panel. When the coincidence effect occurs, the Transmission loss for the panel is greatly reduced.

Community Noise Equivalent Level (CNEL) - A scale that takes into account all the A-weighted acoustical energy from a source during 24 hours and weights the evening (7 to 10 p.m.) events 5 dBA and night (10 p.m. to 6 a.m.) events 10 dBA.

Cylindrical Divergence - The condition of propagation of cylindrical waves that accounts for the regular decrease in intensity of a cylindrical wave at progressively greater distance from the source. This decrease is 3 decibels with each doubling of distance.

Cycles Per Second (cps) - A measure of frequency numerically equivalent to Hertz.

Damage Risk Criterion - Noise levels above which permanent hearing loss of at least a specified amount is likely to be sustained by a person.

Decibel (dB) - A unit of measurement on a logarithmic scale which describes the magnitude of a particular quantity of sound pressure or power with respect to a standard reference value.

Diffuse Sound Field - The presence of many reflected waves (echoes) in a room having a very small amount of sound absorption.

Doppler Effect - The apparent upward shift in frequency of a sound as a noise source approaches and the apparent downward shift when the noise source recedes.

Electro-acoustics - The science and technology of transforming sound waves into currents in electrical circuits (and vice versa) by means of microphones, loudspeakers, and electronic amplifiers and filters.

Filter - A device that transmits certain frequency components of the signal (sound or electrical) incident upon it and rejects other frequencies.

Free Sound Field (Free Field) - A sound field in which the effects of obstacles or boundaries on sound propagated in that field are negligible.

Frequency - The number of times per second that the sine wave of sound repeats itself, or that the sine wave of a vibrating object repeats itself - now expressed in Hertz (Hz), formerly in cycles per second (cps).

Fundamental Frequency - The frequency with which a periodic function reproduces itself, sometimes called the first harmonic.

Gaussian Distribution (or Normal Distribution) - a term used in statistics to describe the extent and the frequency of deviations or errors. The outstanding characteristics are a tendency to a maximum number of occurrences at or near the center or mean point, the progressive decrease of frequency of occurrence with distance from the center, and the symmetry of distribution on either side of the center. In respect of random noise, each fluctuation of amplitude is an occurrence, whether above or below the mean level; the peak value of each fluctuation is the error and the distribution of errors with time is Gaussian.

Gradient - A variation of the local speed of sound with height above ground or other measure of distance causing refraction of sound. It is most commonly caused by rising or falling temperature with altitude or by differences in wind speed.

Harmonic - A sinusoidal (pure-tone) component whose frequency is a whole-number multiple of the fundamental of the wave. If a component has a frequency twice that of the fundamental it is called the second harmonic.

Learing Disability - An actual or presumed inability, due to hearing impairment, to remain employed at full wages.

Hearing Handicap - The disadvantage imposed by a hearing impairment sufficient to affect one's efficiency in the situation of everyday living.

Hearing Impairment - A deviation or change for the worse in either hearing structure or function, usually outside the normal range; see hearing loss.

Hearing Loss - The amount by which a person's hearing is worse than some selected norm.

Hearing Loss for Speech - The difference in decibels between the speech levels at which the "average normal" ear and a defective ear, respectively, reach the same intelligibility, often arbitrarily set at 50 percent.

Hertz - Unit of measurement of frequency, numerically equal to cycles per second.

Impact - A word used to express the extent or severity of an environmental problem.

Infrasonic - A frequency below the audible sound spectrum (in general, lower than 20 Hz).

Inverse Square Law - That acoustical situation where the mean square sound pressure decreases in inverse proportion to the square of the distance from the source. This amounts to a decrease of 6 decibels with each doubling of distance from a point source.

L_{dn} - Sound level, day, night. This is a 24 hour L_{eq} with the daytime level from 0700 to 2200 hours and the nighttime level from 2200 to 0700 hours. A 10 dB penalty is added to the nighttime period.

L_{eq} - The equivalent steady state sound level which in a stated period of time would contain the same acoustical energy as time-varying sound level during the same period.

L_{10} - The sound level exceeded 10 percent of the time. Corresponds to peaks of noise in the time history of environmental noise.

L_{50} - The sound level exceeded 50 percent of the time. Corresponds to the average level of noise.

Level - The value of an acoustical quantity in decibels.

Loudness - The judgement of intensity of a sound by a human being.

Masking - The action of bringing one sound (audible when heard alone) to inaudibility or to unintelligibility by the introduction of another sound.

Medium - A substance carrying a sound wave.

Microbar - A microbar (μbar) is a unit of pressure equal to 1 dyne per square centimeter (10 μbar = 1 pascal).

Microphone - An electro-acoustic transducer that responds to sound waves and delivers essentially equivalent electrical waves.

Noise - Any sound that is undesireable because it interferes with speech and hearing, or is intense enough to damage hearing, or is otherwise annoying (unwanted sound).

Noise Reduction Coefficient (NRC) -The average of a material's absorption coefficients for frequencies 250, 500, 1000 and 2000 Hz.

Octave - The interval between two sounds having a basic frequency ratio of two.

Octave Band - All of the components in a sound spectrum whose frequencies are between two sine wave components separated by an octave.

Octave Band Sound Pressure Level - The integrated sound pressure level of only those sine wave components in a specified octave band for a noise or sound having a wide spectrum.

Pascal - A pascal (Pa) is a unit of pressure equal to 1 newton per square meter (1 pascal = 10 microbar).

Peak Sound Pressure - The maximum instantaneous sound pressure for a transient or impulsive sound of short duration or in a specified time interval for a sound of long duration.

Pink Noise - Noise where the level decreases with increasing frequency to yield constant energy per octave band width.

Presbycusis - The decline in hearing acuity that normally occurs as a person grows older.

Pure Tone - A sound wave whose waveform is that of a sine wave.

Random Incidence - If an object is in a diffuse sound field, the sound waves that comprise the sound field are said to strike the object from all angles of incidence at random.

Random Noise - An oscillation whose instantaneous magnitude is not specified for any given instant of time. It can be described in a statistical sense by probability distribution functions giving the fraction of the total time that the magnitude of the noise lies within a specified range.

Rate of Decay - Rate of decay is the time rate at which the sound-pressure level (or other stated characteristic, such as a vibration level) decreases at a given point and at a given time after the source is turned off. The commonly used unit is decibels per second.

Refraction - The bending of a sound wave from its original path, either because it is passing from one medium to another or because (in air) of a temperature or wind gradient in the medium.

Residual Noise Level - The noise that exists at a point as a result of the combination of many distant sources, individually indistinguishable. In statistical terms, it is the level that exists 90 percent of the time. (Acousticians should note it means the same level to which they have customarily applied the term "ambient.")

Resonance - The relatively large amplitude of vibration produced when the frequency of some source of sound or vibration "matches" or synchronizes with the natural frequency of vibration of some object, component, or system.

Resonator - A resonator is a device that resounds or vibrates in sympathy with some source of sound or vibration.

Reverberant Field - The region in a room where the reflected sound dominates, as opposed to the region close to the noise source where the direct sound dominates.

Reverberation - The persistence of sound in an enclosed space, as a result of multiple reflections, after the sound source has stopped.

Reverberation Room - A room having a long reverberation time, especially designed to make the sound field inside it as diffuse (homogeneous) as possible. Also called a live room.

Reverberation Time (RT) - The reverberation time of a room is the time taken for the sound energy (or sound intensity) to decrease to one-millionth of its steady-state value when the source of sound energy is suddenly interrupted. (This corresponds to a drop of 60 dB in sound pressure level.) It is a measure of the persistence of an impulsive sound in a room and of the amount of acoustical absorption present inside the room.

Room Constant - The room constant is equal to (a) the product of the average absorption coefficient of the room and the total internal area of the room, divided by (b) the quantity one minus the average absorption coefficient.

Root-Mean-Square (RMS) - The root-mean square value of a quantity that is varying as a function of time is obtained by squaring the function at each instant, obtaining the average of the squared values over the interval of interest, and taking the square root of this average. For a sine wave, multiply the RMS value by $\sqrt{2}$, or about 1.43, to get the peak value of the wave. The RMS value, also called the effective value of the sound pressure, is the best measure of ordinary continuous sound, but the peak value is necessary for assessment of impulse noises.

Shielding - The attenuation of a sound by placing walls, buildings, or other barriers between a sound source and the receiver.

Sine-Wave - A sound wave, audible as a pure tone, in which the sound pressure is a sinusoidal function of time.

Sound - The compression and rarefaction of the air.

Sound Insulation - (1) The use of structures and materials designed to reduce the transmission of sound from one room or area to another or from the exterior to the interior of a building. (2) The degree by which sound transmission is reduced by means of sound insulating structures and materials.

Sound Level (Noise Level) - The weighted sound pressure level obtained by use of a sound level meter having a standard frequency-filter for attenuating part of the sound spectrum.

Sound Level Meter - An instrument, comprising a microphone, an amplifier, an output display, and frequency-weighting networks, that is used for the measurement of noise and sound levels in a specified manner.

Sound Power - The total amount of energy radiated into the atmosphere per unit time by a source of sound.

Sound Power Level - The level of sound power, averaged over a period of time, the reference being 10^{-12} watts.

Sound Pressure - (1) The minute fluctuations in atmospheric pressure that accompany the passage of a sound wave; the pressure fluctuations on the tympanic membrane are transmitted to the inner ear and give rise to the sensation of audible sound. (2) For a steady sound, the value of the sound pressure averaged over a period of time.

(3) Sound pressure is usually measured (a) in dynes per square centimeter (dyn/cm^2), or (b) in newtons per square meter (N/m^2). $1\ N/m^2 = 10\ dyn/cm^2 = 10^{-5}$ times the atmospheric pressure.

Sound Pressure Level - The root-mean-square value of the pressure fluctuations above and below atmospheric pressure due to a sound wave; expressed in decibels based on a reference pressure of 0.0002 microbars (2×10^{-5} newtons per square meter).

Sound Shadow - The acoustical equivalent of a light shadow. A sound shadow is often partial because of diffraction effects.

Sound Transmission Class (STC) - The preferred single figure rating system designed to give an estimate of the sound insulation properties of a partition or a rank ordering of a series of partitions. It is intended for use primarily when speech and office noise constitute the principal noise problem.

Sound Transmission Coefficient - The fraction of incident sound energy transmitted through a structural configuration.

Sound Transmission Loss (Transmission Loss (TL)) - A measure of sound insulation provided by a structural configuration. Expressed in decibels, it is 10 times the logarithm to the base 10 of the reciprocal of the sound transmission coefficient of the configuration.

Spectrum - The description of a sound wave's resolution into components, each of different frequency and (usually) different amplitude and phase.

Speed (Velocity) of Sound in Air - The speed of sound in air is 344 m/sec or 1128 ft/sec at 70°F and an atmospheric pressure of 29.92 inches of mercury.

Spherical Divergence - Spherical divergence is the condition of propagation of spherical waves that relates to the regular decrease in intensity of a spherical sound wave at progressively greater distances from the source. Under this condition the sound-pressure level decreases 6 decibels with each doubling of distance from the source. See also cylindrical divergence.

Spherical Wave - A sound wave in which the surfaces of constant phase are concentric spheres. A small (point) source radiating into an open space produces a free sound field of spherical waves.

Standard - (1) A prescribed method of measuring acoustical quantities. Standards in this sense are promulgated by professional and scientific societies like ANSI, SAE, ISO, ETC., as well as by other groups. (2) In the sense used in Federal environmental statutes, a standard is a specific statement of permitted environmental conditions.

Steady-State Sounds - Sounds whose average characteristics remain constant in time. An example of a steady-state sound is an air conditioning unit.

Structureborne Sound - Sound that reaches the point of interest, over at least part of its path, by vibration of a solid structure.

Temporary Threshold Shift (TTS) - A temporary impairment of hearing capability as indicated by an increase in the threshold of audibility. By definition, the ear recovers after a given period of time. Sufficient exposures to noise of sufficient intensity, from which the ear never completely recovers, will lead to a permanent threshold shift (PTS), which constitutes hearing loss. See hearing loss, threshold shift, threshold of audibility.

Third-Octave Band - A frequency band whose cutoff frequencies have a ratio of 2 to the one-third power, which is approximately 1.26. The cutoff frequencies of 891 Hz and 1112 Hz define a third-octave band in common use. See also band center frequency.

Threshold of Audibility (Threshold of Detectability) - The minimum sound-pressure level at which a person can hear a specified sound for a specified fraction of trials.

Threshold Shift - An increase in a hearing threshold level that results from exposure to noise.

Transducer - A device capable of being actuated by waves from one or more transmission systems or media and supplying related waves to one or more other transmission systems or media. Examples are microphones, and loudspeakers.

Waveform - A presentation of some feature of a sound wave, e.g., the sound pressure, as a graph showing the moment-by-moment variation of sound pressure with time.

Wavefront - An imaginary surface of a sound wave on its way through the atmosphere. At all points on the wavefront, the wave is of equal amplitude and phase.

Wavelength - For a periodic wave (such as sound in air), the perpendicular distance between analogous points on any two successive waves. The wavelength of sound in air or in water is inversely proportional to the frequency of the sound. Thus, the lower the frequency, the longer the wavelength.

White Noise - Noise whose energy is uniform over a wide range of frequencies, being analogous in spectrum characteristics to white light. White noise has a "hissing" sound. See also broadband noise.

Ultrasonic - Pertaining to sound frequencies above the audible sound spectrum (in general, higher than 20,000 Hz).

APPENDIX IB

WHERE TO FIND HELP
WITH NOISE PROBLEMS

Where To Find Help With

Noise Problems

Following are addresses and telephone numbers of agencies, groups and organizations that can help to answer questions about noise problems.

Acoustical Society of America
335 East 45th Street
New York, NY 10017
(212) 661-9404

Institute of Noise Control Engineering
P.O. Box 3206, Arlington Branch
Poughkeepsie, NY 12603
(914) 462-6719

National Council of Acoustical Consultants, Inc.
8811 Colesville Rd., Suite 225
Silver Spring, MD 20910
(301) 587-0233

National Institute for Occupational Safety and Health
U.S. Dept. of Health, Education and Welfare
Parklawn Building
5600 Fishers Lane
Rockville, MD 20852
(301) 443-1530

National Safety Council
444 North Michigan Avenue
Chicago, ILL 60611
(312) 527-4800

California Dept. of Health
Office of Noise Control
2151 Berkeley Way
Berkeley, CA
(415) 843-7900

California Highway Patrol
2555 First Ave.
Sacramento, CA 95804
(916) 445-1865

Transportation Laboratory
5900 Folsom Blvd.
Sacramento CA 95819
(916) 739-2413

Noise Control Products & Materials Association
410 North Michigan Avenue
Chicago, IL 60611
(312) 326-1646

Occupational Safety and Health Administration
U. S. Dept. of Labor
14th St. & Constitution Ave., N.W.
Washington, DC 20210
(202) 523-5224

Occupational Safety and Health Review Commission
1825 K Street, N.W.
Washington, DC 20006
(202) 634-7960

U. S. Dept. of Transportation
Federal Highway Administration
Bureau of Motor Carrier Safety
400 Seventh Street, S.W.
Washington, DC 20590
(202) 426-4000

U. S. Environmental Protection Agency
401 M Street, S.W.
Washington DC 20460
(202) 655-4000

U.S. Environmental Protection Agency
100 California Street
San Francisco, CA
(415) 556-4606

California Division of Aeronautics
1120 N Street
Sacramento, CA
(916) 322-3090

Center for a Quiet Environment
University of California
Richmond Field Station, Bldg 167
1301 So. 46th Street
Richmond, CA 94804
(415) 231-9463

The National Association of
Noise Control Officials
P.O. Box 2618
Fort Walton Beach, FL 32549
(904) 243-8129

U.S. Dept. of Transportation
Federal Highway Administration
Office of Environmental Policy
400 7th Street, S.W.
Washington, DC 20590
(202) 426-4836

APPENDIX IC

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REFERENCES

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3. NCHRP Report 117 "Highway Noise, A Design Guide for Highway Engineers", 1971.

4. NCHRP Report 144 "A Field Evaluation of Traffic Noise Reduction Measures", 1973.

5. "Manual for Highway Noise Prediction", Report No. DOT-TSC-FHWA-72-1, March 1972.

6. "Manual for Highway Noise Prediction", Report No. DOT-TSC-FHWA-72-2, March 1972.

7. "Noise Barrier Design Handbook", FHWA - RD-76-58, February 1976.

8. "Highway Noise Barrier Selection, Design and Construction Experiences", Implementation Package FHWA 76-8, 1975.

9. "Highway Construction Noise, Measurement, Prediction and Mitigation", Special Report FHWA Bulletin, May 2, 1977.

10. "Insulation of Buildings Against Highway Noise", FHWA - TS-77-02.

11. NCHRP Report 173 "Highway Noise Generation and Control", 1976.

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13. "FHWA Highway Traffic Noise Prediction Method", Research Report FHWA-RD-77-108, July 1978.

14. "Highway Construction Noise", Report of 1977 Symposium FHWA-TS-77-211.

15. "Sound Procedures for Measuring Highway Noise", Interim Report, FHWA-DP-45-1, May 1978.

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21. "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare With an Adequate Margin of Safety", Environment Protection Agency, March 1974.

22. "Effects of Noise on People", Environmental Protection Agency, December 31, 1971.

23. "A Guide to Visual Quality in Noise Barrier Design", FHWA, Implementation Package 77-12, December 1976.

Publications 1, 5, 6, 7, 8, 9, 10, 13, 14, 15, 16, 17, 18, 19, 20, 23, available from:
National Technical Information Service
Springfield, Virginia 22161

Publications 2, 3, 4, 11, and 12 are available from:
Highway Research Board
National Academy of Sciences
2101 Constitution Avenue
Washington, D.C. 20418

Publications 21 and 22 are available from:
U.S. Environmental Protection Agency
Office of Noise Abatement and Control
Washington, D.C. 20460

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2. "Sound Emanation From Highways", January 1963, presented at ITTE Los Angeles.

3. "Appearance and Noise Study, North Side of Interstate Route 580 Between Lakeshore Avenue and Park Boulevard in Oakland", March 1966, 19605-762550-39579.

4. "Traffic Noise Study Adjacent to 04-SF-82(280) Near San Jose Avenue Undercrossing", December 1966, 19605-762550-36406.

5. "Traffic Noise Study - Route 2, City of Beverly Hills and West Los Angeles Areas", October 1969, No. 36460.

6. "Can Noise Radiation From Highways Be Reduced by Design", January 1968, No. 636316-1, Highway Research Board Paper.

7. "Traffic Noise Near Highways, Testing and Evaluation", January 1973, No. 6316-2-72-43, Highway Research Board Paper.

8. "Traffic Noise Near Highways" January 1976, No. 6316-3-76-07.

9. "Feasible Noise Limits For Construction and Maintenance Equipment and Study of Noise Reduction Methods", July 1977, No. 7083-77-18.

10. "Evaluation of Noise Barrier Reflection, 04-SCl-101-30.7", January 1978, No. 7278-78-02.

11. "Noise Measurement and Quality Assurance", March 1979, No. FHWA-CA-TL-79-06.

12. "Survey of Barrier Materials", Presented at Conference on Highway Traffic Noise Mitigation (FHWA), Los Angeles, California, December 1978.

APPENDIX ID

QUALITY ASSURANCE PROGRAM FOR THE
CALIFORNIA DEPARTMENT OF TRANSPORTATION
(NOISE)

[illegible]

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I. Introduction

This Quality Assurance Program (QAP) is designed to provide relatively simple procedures for administration, training, equipment calibration, operator certification and documentation. The purpose of the QAP is to assure valid data.

Calibration of instruments is intended to detect serious malfunctions or deficiencies and establish a record of immediate and long term stability. No attempt is made to "type test" sound level meters for full compliance with ANSI S1.4-1971 specifications.

II. Objectives

1) To establish uniformity in the noise testing program within Caltrans.

2) To insure the reliability and validity of noise data for environmental and legal activities.

3) To insure that standard methodology and techniques are followed without shortcuts or other variations.

4) To maintain a staff of trained personnel.

5) To carry out a program of instrument calibration that is traceable to the National Bureau of Standards.

III. Administration

The Office of Transportation Laboratory (TransLab) of the California Department of Transportation (Caltrans) will be responsible for preparing, updating, administering and carrying out the Quality Assurance Program (QAP) on a statewide basis.

TransLab will perform the following functions:

1) Provide a coordinator to make periodic field reviews of the District's noise programs, instrument calibrations and operator audit of procedures. Reports will be prepared.

2) Provide instruction and assistance on such things as equipment maintenance, field calibrations, and noise measurements.

3) Provide formal training courses.

4) Disseminate information on changes in policy and procedures.

5) Assist in purchasing proper equipment.

6) Prepare or revise California test methods under certain circumstances where it may be more advantageous than following national standards.

7) Assist the Districts in finding and correcting problems in noise measurement.

Each district has the ultimate responsibility for maintaining their equipment, periodic calibrations, following proper procedures, and having trained personnel capable of producing reliable test data.

Each District will be responsible for the following specific functions:

1) Obtaining calibrations of instruments so they will be traceable to the National Bureau of Standards. TransLab can perform this function.

2) In-house calibration of instruments according to established procedures.

3) Maintaining instruments (repairs are generally made by manufacturer).

4) Keeping permanent records of <u>all</u> instrument calibrations and repairs in bound volumes. All records will have a 5 year retention period. Some documents such as backup worksheets, certificates and manufacturers repair records are kept in a binder or file.

5) Maintaining a record of each SLM sensitivity calibration in a bound notebook to be kept with each SLM. If a SLM is calibrated a number of times in the field, each calibration time, date and any adjustment should be noted.

6) Selecting, training and certifying personnel for noise measurement work. TransLab will assist the District or perform these functions.

7) Keeping a current list of qualified operators.

IV. Standards Maintained by TransLab

A. TransLab Standard Microphones (2 ea) equivalent to Western Electric 640A Standard Microphone

Two Laboratory Standard Microphones (B&K 4160) which are equivalent to the Western Electric 640A will serve as the California Department of Transportation (Caltrans) Standards for acoustic measurements. These TransLab Standard Microphones will alternately be sent to the National Bureau of Standards (NBS) every six months for calibration until a history of stable performance has been established (about 2 years). Then the NBS calibration interval can be extended to one year. These TransLab Standard Microphones will be kept at the Transportation Laboratory where they will be used in conjunction with B&K 2607 Measuring Amplifiers (designated as the TransLab Standard Sound Level Meters) to calibrate the TransLab "working standard" microphone.

B. TransLab Standard Sound Level Meters (SLM) (2 ea)

TransLab will designate one B&K 2607 Measuring Amplifier as the "TransLab Standard SLM" and a second B&K 2607 SLM as the "Working Standard SLM". It is on the latter instrument that all testing of District microphones and calibrators will be done. The TransLab Standard SLM will be used only in a "bench calibration" capacity and will never be subjected to the rigors of field use.

The following performance characteristics of these two instruments will be checked prior to District visits and at least every three months in accordance with Section VI below:

1. A-weighted frequency response to a constant amplitude AC voltage input signal at each of the 9 octave band frequencies from 31.5 through 10,000 Hz.

2. Step attenuator deviation from a true 10 dB increment at 250, 500, and 1,000 Hz.

3. Linearity of the SLM meter dial (i.e., meter response to 1 dB changes in input voltage) at 250, 500 and 1,000 Hz.

4. Internal circuit noise of the SLM.

C. Working Standard Microphone (1 ea)

One B&K 4134 microphone will be calibrated via comparison with the TransLab Standard Microphone using the B&K 4220 Pistonphone (Section V). This microphone will be designated as the TransLab "working standard microphone" and will be used on the TransLab working standard sound level meter to calibrate the District's calibrators and to characterize the output of the TransLab Genrad 1562-A "slave" calibrator driven externally by a Hewlett-Packard 3311A Function Generator.

D. Working Standard Sound Level Meter (1 ea)

One B&K 2607 measuring amplifier will be designated as the TransLab "working standard sound level meter" and will be calibrated by comparison with the "TransLab Standard SLM" (Section V).

E. Pistonphones (B&K 4220) (2 ea)

These instruments will be kept at TransLab as "transfer" calibration standards. Their output will be defined on the TransLab Standard Microphone and used to calibrate the working standard SLM.

F. Standard Frequency Counter (1 ea)

TransLab will designate a Hewlett-Packard 5306A Multimeter/Counter as the "Standard Frequency Counter". Accuracy of the counter will be checked annually using tuning forks of certified frequencies, and will be sent for manufacturer's calibration every two years.

G. Standard Voltmeter (1 ea)

TransLab will designate a Fluke 8030A Multimeter (digital TRMS) as the "Standard Voltmeter". This instrument will be factory calibrated (traceable to NBS) on an annual basis.

H. Standard Attenuator Set (1 ea)

TransLab will designate a Hewlett Packard 350B Attenuator Set as the "Standard Attenuator Set". The accuracy of its step attenuators in providing true 10 dB and 1 dB changes in attenuation will be checked by using the Standard Voltmeter to determine the voltage ratios corresponding to the attenuation changes.

V. Calibration of Working Standard Microphone and SLM

The Working Standard Microphone (WSM) to be used in the calibration of District equipment will be a B&K 4134, a 1/2 inch condenser-type microphone. It will be used with the B&K 2607 measuring amplifier (this is the working standard SLM). This instrument allows calibration with respect to the pre-defined sensitivity of the microphone one chooses to use on it. This means that the system can be calibrated in the field without the use of acoustical-type calibrators and their attendant error. One simply adjusts the input sensitivity of the B&K 2607 to provide the specified sensitivity (mv/Pa i.e., mv/94 dB), readable on its meter scale.

The sensitivity to be specified for the WSM will be determined by "comparison" with B&K 4160 Laboratory Standard Microphone (LSM) whose sensitivity is defined semi-annually by the National Bureau of Standards. This comparison technique is outlined below:

1. Connect the LSM to the Laboratory Standard SLM by means of a B&K 2619 preamp.

2. Set the SLM controls as follows:

Input Attenuator ...	0.1
Output Attenuator ...	X1
Weighting	C
Gain Control	Cal.
Meter Function	RMS, Lin
Averaging Time	Fast
Input	Preamp

3. Install the SA0056 meter scale on the SLM.

4. Activate the SLM's "50 mv RMS Ref." signal.

5. Adjust the SLM's "Preamp. Input Sens." screw to provide the LSM sensitivity reading on the lower (red) meter scale. (This LSM sensitivity will be determined semi-annually by NBS.)

6. Deactivate the "50 mv RMS Ref." signal.

7. Adjust the SLM Input Attenuator to establish the zero point on the meter scale as 120 dB.

8. Mount the B&K 4220 Pistonphone on the LSM and read the meter response. This is the <u>true</u> output of the Pistonphone.

9. Connect the WSM to the Working Standard SLM using a B&K 2619 preamp.

10. Install the SA 0057 meter scale.

11. Set SLM controls as in Step 2, except Input Attenuator must be set at "1V".

12. Mount the Pistonphone on the WSM and adjust the "Preamp. Input Sens." to provide a meter reading equal to the true Pistonphone output level determined in Step 8.

13. Reactivate the "50 mv RMS Ref" signal.

14. Reset the Input and Output Attenuator to "0.1V" and "S1", respectively.

15. Read and record the sensitivity of the WSM indicated on the lower (red) meter scale.

These working standards can now be taken to the District Offices, where, prior to their use, the sensitivity of the WSM (determined) must be set on the Working Standard SLM, thereby establishing a "true reading" system.

VI. <u>Calibration and Testing of Districts' Equipment</u>

A. General

Each of Caltrans' eleven District Offices will be visited at least <u>once a year</u> by TransLab personnel. During this visit, the District's noise measuring equipment will be calibrated and subjected to tests that will verify its compliance with operational tolerances. Although the equipment will not be tested for compliance with <u>all</u> aspects of the ANSI S1.4-1971 "Specification for Sound Level Meters", enough tests will be run to disclose major deficiences in the equipments' performance. Tests to be performed are described below:

B. District Equipment Tests Performed by TransLab (Record all data on Figure D2, D3, & D4.)

1. <u>Calibrator Sound Pressure Level</u> (SPL) will be determined for each of its frequency settings by measurement on the Working Standard SLM. The District's calibrator will be labeled as to its exact SPL at each frequency setting (if it is a multi-frequency calibrator). If the Calibrator's actual output level varies from its nominal specified output level by 0.5 dB or more, the internal potentiometers will be adjusted to provide the specified nominal output.

2. Calibrator Frequency settings (where applicable) shall be verified to be accurate within ±5%[1] by mounting the calibrator on the TransLab Working Standard SLM and measuring the frequency of the SLM output signal using the Standard Frequency Counter.

(Items 3, 4, and 5 may provide an electro-acoustical check of the SLM-microphone combination or simply an electrical check of just the SLM (w/o microphone) behavior. In the former, an acoustical signal is input through a Genrad 1562 "slave" calibrator from a H.P. 3311A Function Generator. The output level of the "slave" calibrator as related to frequency will be characterized on the Laboratory Standard Microphone. This comprehensive method checks both microphone and meter behavior.

If only an electrical check of the SLM circuitry is desired, the microphone will be removed and sinusoidal electrical signals of various frequencies will be input through a shielded "dummy" microphone of equal impedance arrangement.

The Caltrans calibration program will use the electro-acoustical method as a primary check. The electrical check will only be used in Item 8 or to determine whether suspected problems are microphone or SLM based.)

---

[1]Accuracy limit is from National Institute for Occupational Safety and Health (NIOSH) sound level meter certification criteria (Federal Register 10/8/76).

3. Linearity of the SLM meter scale's graduations will be checked using a Hewlett Packard 350 B Attenuator Set. With the input signal amplitude adjusted to produce full scale meter deflection, the signal will be attenuated 5 dB at a time. The resulting change in meter scale indication will be observed. Permissible total error for any 5 dB meter scale segment will be 0.4 dB. This test will be performed at the 250 Hz, 500 Hz, and 1,000 Hz frequencies.

4. The SLM's 10 dB step attenuator accuracy will also be checked using the Hewlett-Packard 350 B Attenuator Set. 119 dB input signals of 250, 500, and 1,000 Hz will be reduced by true 10 dB increments to provide signals as low as 59 dB. After the SLM attenuator has been switched to accommodate each signal, the resulting change in meter response and SLM output voltage shall be 10 ± 0.5 dB.

The maximum net cumulative error allowed at any point on the SLM's step attenuator will be ±1.0 dB for an SLM adjusted to read "true" at its 110 dB attenuator setting.

The exact procedure for determining SLM attenuator accuracy is outlined below:

a. Arrange equipment as shown in Figure D1. SLM should be set on "A-weighting".

b. Set SLM attenuator at "110" and attenuator box HP350B at "0" (both dials).

c. Adjust function generator output to provide a SLM reading of "+9" (119.0 dB) at 250 Hz. Record the SLM output voltage.

d. Switch attenuator box dial to "10".

e. Switch the SLM attenuator to "100".

f. Note the new reading on the SLM scale and new output voltage.

g. Determine algebraic difference between the known change in signal provided by the attenuator box and the change (both scale and SLM output) provided by switching the SLM attenuator. Difference should be no greater than 0.5 dB.

h. Reset the SLM needle to exactly "+9".

i. Switch attenuator box dial to "20".

j. Switch SLM attenuator to "90".

k. Repeat Step 7.

l. Repeat this procedure for attenuator box settings "30" through "60" (SLM attenuator settings "80" through "50").

m. Repeat the entire procedure using 500 Hz and 1000 Hz signals.

n. In evaluating the SLM attenuator accuracy, the following criteria will apply:

1. the change in attenuation provided by each change of the SLM attenuator should be 10 ± 0.5 dB.

2. The cumulative error resulting from any series of SLM attenuator changes should not exceed $\pm$ 1.0 dB.

5. The <u>A-weighted frequency response</u> of the SLM (with microphone) will be checked for compliance with ANSI S1.4-1971 using the electro-acoustical method. Response will be measured at each octave band frequency from 63 Hz through 8,000 Hz using a 90 dB (@ 1000 Hz) input signal. Allowable deviation from the A-weighted responses at each frequency will be those specified in ANSI S1.4-1971 for Type 2 SLM's. If the A-weighted response to the acoustical input does <u>not</u> meet the ANSI criteria, the microphone will be removed and the SLM will be checked using electrical input as described above. In this case, the A-weighted response should be within the limits established for SLM electrical weighting (Table D1).

The exact procedure for determining the SLM A-Weighting accuracy is outlined below:

a. Use "slave" calibrator setup shown in Figure D1.

b. Mount "slave" calibrator on SLM to be tested. Set SLM to provide "A-weighting".

c. Set HP 350B Attenuator Set on "30".

d. With the signal generator frequency control set at 1000 Hz, adjust its output amplitude to read "+10" when the SLM step attenuator is set on "80".

e. Adjust the signal generator's frequency control to provide signals at all the octave band center frequencies from 63 Hz through 8000 Hz. Record each SLM reponse relative to the "+10", 1000 Hz response in Step 3. (Example: A SLM reading of "+6.5" would mean a "-3.5" relative response.)

f. For those frequencies that produce a SLM reading off the lower end of the meter scale, the HP 350B Attenuator Set should be switched in 10 dB steps to bring the SLM needle back into scale range. These reductions in attenuation via the Attenuator Set must be included in the relative response determination. Example: At 125 Hz the SLM needle falls below the scale range. Switching the Attenuator Set to the "10" setting (from "30") produces an on-scale SLM reading of "+6". The total relative response would be (-20) + (-4) or -24 dB.

6. The internal (electrical) "noise" of the SLM will be checked by replacing its regular microphone with a short-circuited "dummy" (equal impedance) microphone. Under this condition the meter shall indicate less than 30 dB on the A-weighting scale.

7. The SLM output voltage signals will be checked at the same time that tests are run for scale linearity and 10 dB step attenuator accuracy (items 3 and 4 above). Accuracy will be measured by connecting a graphic level recorder (GLR) to the SLM output and observing the GLR deflection resulting from the changes in the "slave" calibrators' input to the SLM. If no GLR is available, output voltage accuracy will be determined via output voltage ratios using the Standard Voltmeter. In either

case the SLM output voltages must correspond to the 10 dB changes in acoustical input within ± 0.5 dB. Output linearity error must be less than 0.4 dB for any 5 dB segment of the meter scale.

8. <u>GLR response</u> accuracy will be measured as described in Item 7 or may be determined by putting electrical signals from the HP 350B Attenuator Set directly into the GLR. Tolerances for the GLR response will be the same as those in Item 7.

9. <u>GLR "overshoot, undershoot, and creep"</u> will be checked by effecting a sudden 20 dB change in input signal and observing the immediate amount of GLR pen travel at the fastest writing speed seting. Overshoot/undershoot of 1.0 dB or less will be considered acceptable, but every attempt will be made to eliminate or minimize it where instrument adjustments are provided. No creep will be permitted.

10. <u>GLR chart speed stability</u> will be checked for stability by determining it at two different segments of a continuous running period. The chart speeds determined for these two segments must be within 10% of each other. This test must be made at (1) the chart speed setting normally used during routine use (1.5 in./min) and at (2) the fastest speed setting offered on the GLR.

11. <u>GLR writing speeds</u> will be determined by suddenly applying and removing an input signal that will cause full-scale pen deflection. This should be done with the chart advancing at its fastest speed (actual speed determined in Step 10). From the slopes of the resulting

traces (both rise and fall) the writing speeds (inches/sec) can be determined. This test will be run for the writing speeds commonly used in Caltrans field measurement (3 or 10 inches/sec for Genrad GLR's). An actual writing speed between 3 and 10 inches/sec must be obtainable at one of the settings. Other settings will be tested as necessary. Rise and fall speed must be equal.

C. Supplementary Equipment Tests to be Performed by District Personnel.

1. The following items should be checked prior to each use or at least once per month:

a. battery condition
b. general operability of both SLM and calibrator
c. SLM calibration @ 1000 Hz

2. The items mentioned in C.1. above should also be checked during field use at the following times:

a. immediately <u>before and after</u> each measuring period
b. upon installation of new batteries
c. upon changing instrument operator
d. after instrument has been transported or subjected to any rough handling
e. whenever operator suspects calibration to have drifted.

3. With reference to item 2-a above, the "before" and "after" calibration response levels should be recorded on the noise data documents for the particular measuring period. Also, this information should be recorded on a running record of SLM "drift" (Figure D5) to be kept with each SLM.

4. The larger Districts, which use noise measuring equipment on a regular basis, should send their calibrators to TransLab for calibration at least once between the annual visits by TransLab personnel. This requirement can be waived in those districts that have more than one calibrator. In these instances, interim accuracy can be verified using comparison methods.

VII. Certification Program for Noise Measurement Personnel

A. Training

Each Caltrans district is responsible for maintaining trained personnel capable of performing noise measurements and studies.

TransLab presents a 32-hour noise training course upon request from the Districts. All district noise measurement personnel should have completed this course.

Supplementary training through academic classes, equipment manufacturers' seminars, FHWA courses and various reading materials is also encouraged.

B. Annual Audit of Procedures

District personnel responsible for making noise measurements will be examined and reviewed annually as to their ability to determine the L_{eq} value for a tape recording of traffic noise. This L_{eq} determination will be made using two different methods:

1. the manual check-off method using the FHWA "Ambient Noise Survey Data Sheet" and SLM only

2. the graphic method using a GLR connected to the SLM output.

Operators will be expected to use those methods taught and acceptable to TransLab and FHWA.

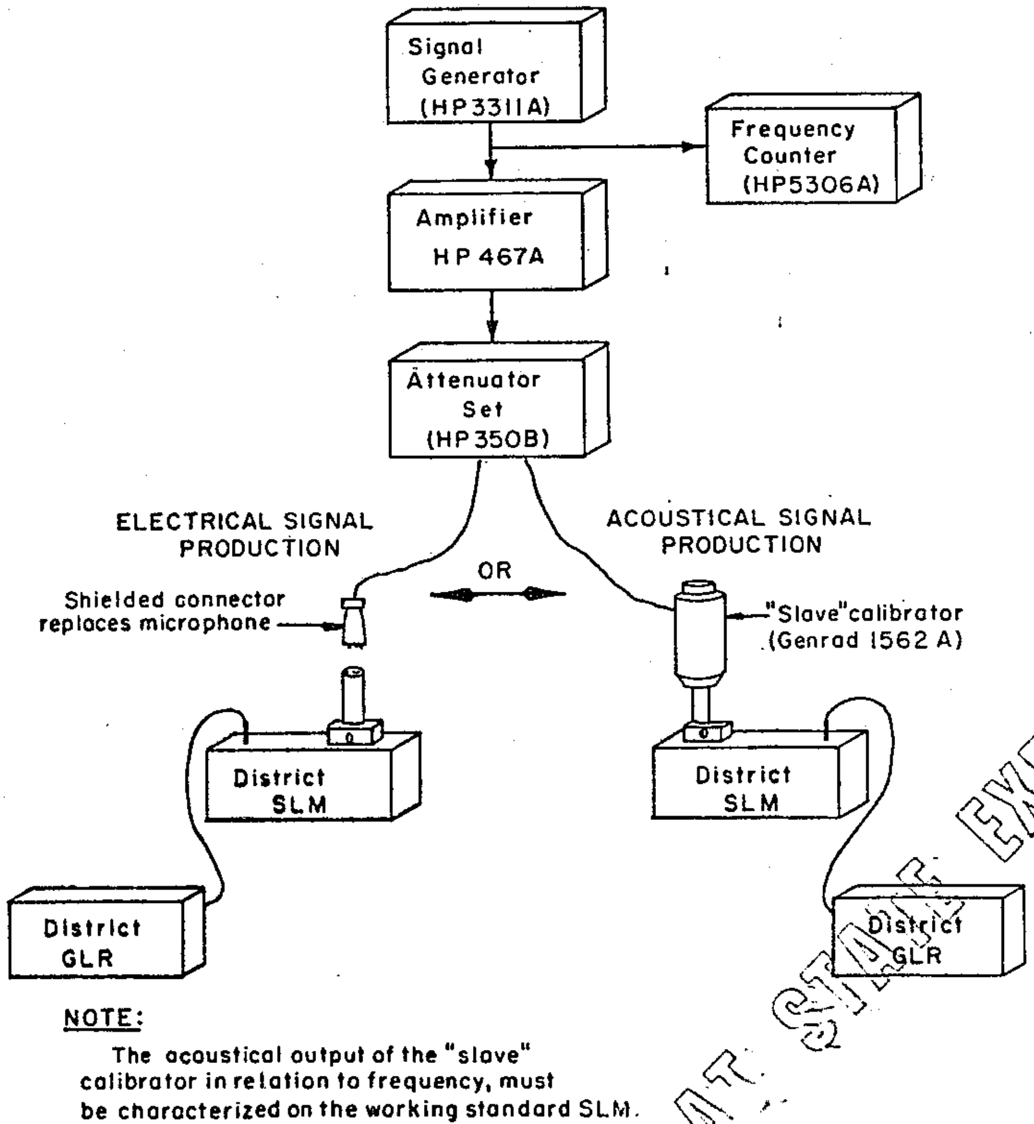
These tests will determine operators' ability to use both the SLM and the GLR, as well as their ability to interpret the measurement data and make an accurate L_{eq} determination. L_{eq} values within ± 1dB of the known mean L_{eq} for the test tape will be considered acceptable.

If the operator being tested does not meet the above criteria on the first testing, a single retest will be allowed with the operator using a different SLM. A minimum of two operators must interpret <u>any</u> run of the test tape for this testing to be valid.

Upon completion of operator performance testing in each District, a certificate (Figure D6) will be presented listing all certified personnel.

Frequency (Hz)	Electrical A-Weighting (dBA)	
100	-19.8	-18.1
400	-5.4	-4.2
1000	-0.4	+0.4
2000	+0.7	+1.8
5000	-0.5	+1.5
8000	-2.1	-0.1

Table D1 A-Weighting Electrical Tolerances (i.e., w/o Microphone) for Type 2 SLM's(11)



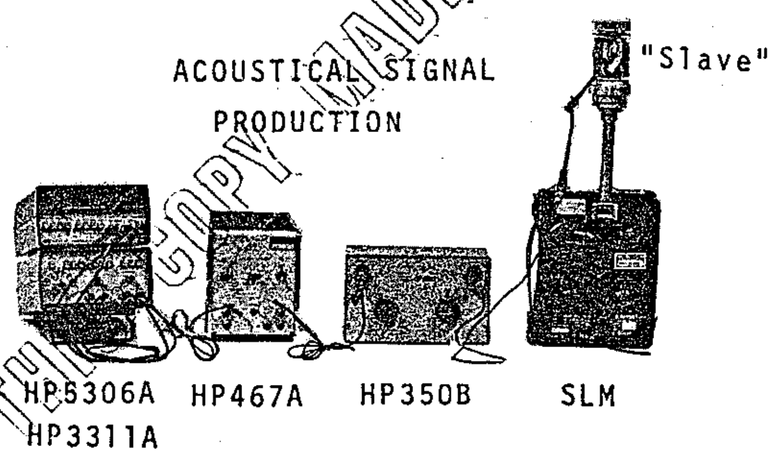


Figure D1, EQUIPMENT SET-UP FOR GENERATING ACOUSTICAL AND ELECTRICAL SIGNALS

California Department of Transportation

TRANSPORTATION LABORATORY
Enviro-Chemical Branch
NOISE SECTION

RECORD OF CALIBRATOR CALIBRATION

DISTRICT ______________________ CALIBRATOR TYPE ______________________

Responsible Person ______________________ SERIAL NUMBER ______________________

Phone ______________________

CALIBRATOR OUTPUT **

DATE	Before Calibration					After Calibration*					Tested By	Remarks
	125	250	500	1000	2000	125	250	500	1000	2000		

*Calibrator ouput must ultimately be within ±0.5 dB at any output frequency. Adjustment of a calibrator's output potentiometer(s) will only be made when this criterion is not met.

**For each date, upper figure is measured frequency (H_2), lower figure is level (dB).

TL-746 (Orig. 12/78)

Figure D2. Documentation Form For Calibrator Calibration

CALIFORNIA DEPARTMENT OF TRANSPORTATION
TRANSPORTATION LABORATORY
Enviro-Chemical Branch
NOISE SECTION

CALIBRATION WORKSHEET
FOR
SOUND LEVEL METERS(SLM)
AND
GRAPHIC LEVEL RECORDERS(GLR)

District ______________________ SLM TYPE ______________________

Responsible Person ______________________ SLM S/N ______________________

Phone ______________________ GLR TYPE ______________________

Microphone S/N ______________________ GLR S/N ______________________

Tests By ______________________ Where Performed ______________________ Date ______________________

Phone ______________________

SLM A-Weighting Network

Frequency (H_z)	⊛ 1	Actual (dBA)
8000	-20.3 ±6.5	
4000	-20.3 $^{+5.5}_{-4.5}$	
2000	-8.6 ±3.0	
1000	0 ref.	
500	-1.0 ±2.0	
250	-8.8 ±2.5	
125	-24.0 ±2.5	
63	-42.5 ±3.0	

SLM 10 dB Step Attenuator

Step	SLM Scale 250	500	1000	SLM Output 250	500	1000
110 → 100						
100 → 90						
90 → 80						
80 → 70						
70 → 60						
60 → 50						
Cumulative Net Error	a	b	c	a	b	c

⊛ .The SLM attenuator must attenuate 10.0 ±0.5dB each step
.The Cumulative Net Error should not exceed ±1.0dB
a.Algebraic sum of step errors -0.2 corr.factor
b. " " " " " +0.1 " "
c. " " " " " +0.1 " "

Internal Noise (dBA)

⊛	Actual
≤30	

GLR Checks	⊛	Actual
1. Chart Speed($\frac{in}{min}$) Maximum	N/A	
2. Writing Speed($\frac{in}{sec}$)	3 → 10	
3. Response to 10dB change in input(dB)	±0.5	
4. Response to 5dB change in input(dB)	±0.4	
5. Creep	None allowed	
6. Overshoot (+dB) Undershoot(-dB)	±0.5	

SLM 1dB Linearity

Scale Segment	⊛ Permitted Cumulative Error (dB)	SLM Scale 250	500	1000	SLM Output 250	500	1000
+10 → +5	0.4						
+ 5 → 0	0.4						
0 → -5	0.4						

REMARKS: ______________________

⊛ Performance guidelines for CALTRANS equipment
1. These values are an algebraic sum of slave calibrator frequency response and A-weighting per ANSI S1.4-1971

TL-745 (Orig.12/78)

Figure D3. Calibration Worksheet

California Department of Transportation

TRANSPORTATION LABORATORY
Enviro-Chemical Branch
NOISE SECTION
(916)444-4886

District ____________ Date ______________

CERTIFICATE OF CONFORMANCE

Lab Std. Mic. No. __________
Lab Std. SLM No. __________
Working Std. Mic. No. __________
Working Std. SLM No. __________
Pistonphone No. __________

This is to certify that the equipment listed below has been tested and calibrated to Caltrans Performance standards using instruments whose calibration is traceable to the National Bureau of Standards.

Make	Model No.	Serial No.

____
Earl C. Shirley, Chief
Enviro-Chemical Branch

TL-747 (Orig. 12/78)

Figure D4. Calibration Certificate

California Department of Transportation
TRANSPORTATION LABORATORY
Enviro-Chemical Branch

NOISE SECTION

RECORD
OF
SLM CALIBRATION DRIFT

DISTRICT ______________________ CALIBRATOR TYPE ______________________

Responsible Person ______________________ SERIAL NUMBER ______________________

Phone ______________________ SLM TYPE ______________________

SERIAL NUMBER ______________________

DATE	TIME OF DAY	CALIBRATOR OUTPUT @ 1000 Hz (dB)	INITIAL SLM RESPONSE (dBA)	CHECKED BY	REMARKS

NOTE: This form will be in a bound volume that will always be kept with the SLM.

TL-750 (Orig. 2/79)

Figure D5. Record Of SLM Calibration Drift

California Department of Transportation
TRANSPORTATION LABORATORY
Enviro-Chemical Branch
NOISE SECTION
(916)444-4886

District____________ Date________________

PERFORMANCE CERTIFICATE

FOR

NOISE MEASUREMENT PERSONNEL

This is to certify that the individuals listed below have been audited for proper performance of procedures used in Caltrans noise measurement work.

________________________________ ________________________________
________________________________ ________________________________
________________________________ ________________________________
________________________________ ________________________________
________________________________ ________________________________
________________________________ ________________________________
________________________________ ________________________________
________________________________ ________________________________

____
Earl C. Shirley, Chief
Enviro-Chemical Branch

TL-749 (Orig.2/79)

Figure D6. Operator Qualification Certificate

APPENDIX IE

SECTION I
PROBLEMS

SECTION I

PROBLEMS

1. Determine the sum of the following sound levels by "decibel addition" to an accuracy of ± 1 dB:

a. 86 dB	b. 81 dB	c. 90 dB
89 dB	81 dB	76 dB
72 dB	81 dB	78 dB
77 dB		80 dB
Ans. _____ dB	_____ dB	_____ dB

2. Suppose the noise level from one noise source (assume a "point source") is 56 dB at a certain distance away. Now, suppose that 16 of those same noise sources were turned on at the same location as the first source. What noise level would you expect at the same distance away?

   Ans. _____ dB

3. Suppose highway traffic produces a noise level of 64 dB at a certain position from the road for a traffic flow of 2000 vehicles per hour. What noise level could be expected for the various rates of flow listed below, assuming the same general type of traffic?

   Ans. 5000 vehicles per hour _________ dB

   1800 vehicles per hour _________ dB

   600 vehicles per hour _________ dB

4. Suppose the octave band sound pressure levels of a truck are as listed below. Find the overall sound level (± 1 dB accuracy is adequate).

Octave Frequency Band (Hz)	Sound Pressure Level (dB)
31	74
63	90
125	89
250	84
500	82
1000	80
2000	74
4000	72
8000	65

Ans. _____ dB overall, _____ dBA

5. Find the A-scale sound level for the truck in problem 4 (± 1 dB accuracy is adequate).

6. Suppose a single automobile produces a sound level of 65 dBA at 50 ft distance. What would its sound level be at the following distances, assuming good sound propagating atmospheric conditions?

at 200 ft Ans. _____ dBA

at 500 ft _____ dBA

at 1000 ft _____ dBA

at 2000 ft _____ dBA

7. Suppose the noise level of a passing truck is found to be 80 dBA when measured at a distance of 100 ft. What would be the A-scale sound level of that truck at 50 ft distance?

Ans. _____ dBA

8. Suppose the sound level of a bus is found to be 76 dBA at 160 ft distance. What would be its A-scale sound level at 800 ft distance?

Ans. ______ dBA

9. A continuous flow of traffic is found to produce an average noise level of 80 dBA at the reference 50 ft distance. For a drop-off rate of 4.5 dBA/DD, what average A-scale sound level would be expected at 800 ft distance? What sound level would be expected for a 3 dBA/DD drop-off rate?

Ans. ______ dBA for 4.5 dBA/DD

______ dBA for 3 dBA/DD

10. Suppose the average noise level produced at a 400 ft distance from an existing highway is about 72 dBA. The highway now handles about 1200 vehicles per hour. Following a proposed improvement program, it is expected that the highway traffic will increase to 3200 vehicles per hour. Assuming 3 dBA drop-off per double distance, at what distance from the improved highway will the 72 dBA level apply.

Ans. ______ ft

11. A large number of residences located at 250 ft distance along an existing highway now receive average nighttime noise levels of 68 dBA. Future traffic is expected to quadruple the present traffic. The present neighbors are already unhappy with the 68 dBA noise levels. The future noise will expose still more people to 68 dBA or higher. If nothing is done about the increased

noise, how far from the road will the 68 dBA levels be heard for the increased traffic conditions, assuming 3 dBA/DD drop-off and assuming that the houses are far enough apart that they do not provide any appreciable barrier effect.

Ans. ______ ft

12. The Occupational Safety Health Act (OSHA) establishes a maximum permissable exposure in hours to various sound levels. What duration per day in hours is permissable for a sound level of 90 dBA?

Ans. _____ hours

SECTION II

SECTION II

FHWA NOISE PREDICTION MODEL,
BARRIER DESIGN PROCEDURES,
CONSTRUCTION NOISE AND NOISE REPORTS

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LIST OF FIGURES

INTRODUCTION

This section covers the procedure for performing the technical work, a discussion on special situations, mitigation measures, performing, and reporting the results.

Chapter II-1 covers the procedures for noise prediction and barrier design. The manual entitled "FHWA Traffic Noise Prediction Model" is a separate manual.

A discussion and some suggestions on how to handle special situations are given in Chapter II-2.

Construction noise is addressed in Chapter II-3 because it is a FHWA requirement as outlined in FHPM 773.

Chapter II-4 provides instructions on the use of computers for assisting in the prediction of noise and the design of noise barriers.

Mitigation measures by barriers and other means are discussed in Chapter II-5.

Chapter II-6 provides an overview of the steps which may be followed in performing a noise study.

Chapter II-7 outlines the writing of the Noise Report and Chapter II-8 shows a Reviewer Checklist for completeness of Noise Reports.

[illegible]

CHAPTER II-1

FHWA TRAFFIC
NOISE PREDICTION MODEL

Chapter II-1

FHWA Highway Traffic Noise Prediction Method

This chapter is the Manual entitled "FHWA Highway Traffic Noise Prediction Model", Report No. FHWA-RD-77-108, December 1978.

It is the procedure to be used for Caltrans projects after December 31, 1979, for predicting highway noise and designing noise barriers.

An abstract from the publication is shown below:

This report presents the FHWA method for predicting noise generated by constant speed highway traffic. The report is intended to be a users' manual as well as a reference document detailing the development, use, and limitations of the prediction method. In the main body of the report, the prediction procedure is presented in a step-by-step fashion and includes numerous example problems designed to highlight important concepts and features. For those interested in the theoretical development of the model, an extremely detailed derivation is presented in the appendices. The basis of the model is the equivalent sound level, L_{eq}, although an adjustment for conversion to L_{10} is provided. The method incorporates three classes of vehicles--automobiles, medium trucks, and heavy trucks. Adjustments for absorptive ground covers and finite length barriers are also included. Certain special topics such as nonuniform highway sites and determination of equivalent day-night levels, L_{dn}, are also included.

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National Technical Information Service
Springfield, Virginia 22161

CHAPTER II-2

SPECIAL SITUATIONS

Chapter II-2

Special Situations

Note: Metric measurements are used in this chapter because some parts of this chapter are tied to the FHWA manual which is in metric.

The manual entitled "FHWA Highway Traffic Noise Prediction Model" (FHWA-RD-77-108) does not always provide procedures for predicting traffic noise under certain conditions. These may be things such as vehicle speeds below 50 Km per hour, stop and go traffic, vehicles not representative of the Reference Emission Levels, traffic in metropolitan areas near tall buildings, and very small distances from source to receiver.

When special conditions are encountered, it is recommended that field measurements be made whenever possible. The reported noise levels should then be carefully defined so that the reader will understand the conditions under which measurements were made.

In those situations where new construction is involved, similar existing situations should be found for taking field measurements.

In those cases where measurements are not available, the suggestions offered in this section for some situations may be considered. No backup data or procedures are available and the user must exercise caution when using these suggestions.

The methodology for predicting future noise levels under these special situations is not available.

II-2.1 Vehicle speeds Below 50 Km per Hour

A) For automobiles: Use a constant Reference Energy Mean Emission Level of 62 dBA.

B) For medium trucks: Use a constant reference Energy Mean Emission Level of 74 dBA.

C) For heavy trucks: Use a Reference Energy Mean Emission Level which goes from 80 dBA at 50 Km/h to 87 dBA at 40 Km/h. Use a constant 87 dBA at speeds below 40 Km/h.

II-2.2 Stop and Go Traffic

This condition occurs when signal lights control traffic on highways. It does not refer to traffic situations where highways become overloaded. In this latter case, the noise level usually does not represent the worst condition.

It is recommended that field measurements be made in these cases. Similar situations in terms of traffic and terrain should be selected.

II-2.3 Vehicles Not Representative of Reference Emission Levels

An example for this situation could be a highway with low traffic volume carrying a large number of buses or delivery trucks. In this type situation, field noise measurements are made of these kinds of vehicles and converted to energy mean emission levels for use in the FHWA Highway Traffic Noise Prediction Model.

The detailed procedures for performing the work are in the manual entitled "Determination of Reference Mean Emission Levels" FHWA-OEP/HEV-78-1, July 1978.

This publication is available from:

National Technical Information Service
Springfield, Virginia 22161

II-2.4 Traffic in Metropolitan Areas Near Tall Buildings

A combination of factors such as multiple reflections, upper floors, shielding, side streets, traffic signals and short source-receiver distances make it extremely difficult to obtain an estimate of the noise levels through prediction procedures.

It is recommended that field measurements be made in these cases. Representative sites should be selected for the sensitive receptors that may be impacted. Measurement conditions and locations should be carefully described in the noise report and related to the problem.

II-2.5 Small Source to Receiver Distances

Field measurements are recommended for these situations. Small distances are defined as less than 15 meters.

Several examples are discussed in the FHWA Highway Traffic Noise Prediction Manual, FHWA-RD-108 (p. 89) which is referenced as Chapter II-1 of this Manual.

CHAPTER II-3

CONSTRUCTION NOISE

Chapter II-3

Construction Noise

II-3.1 Introduction

FHWA has a legislative mandate to act to reduce or, if possible, to eliminate adverse environmental effects of highway construction noise. FHPM 7-7-3 requires that land uses and activities which may be affected by construction noise be identified during project development. It also requires determination of the measures needed in the plans and specifications to minimize or eliminate construction noise impacts.

II-3.2 Estimating Construction Site Noise

The noise produced at construction sites originates from sources of varying intensity and nature. These variables are best described by identifying the different phases of a project and relating it to various land uses and activities. In general, these construction phases can be listed as:

- Mobilization -- Moving equipment on to a project and setting up offices and an equipment storage and maintenance area.

- Clearing and Grubbing -- May require the demolition and removal of existing structures by jackhammers, explosives, hand tools, loaders, dozers and trucks to remove debris.

- Earthwork -- Dozers, graders, earthmovers and trucks are the main noise sources.

- Structure Construction -- Backhoe, cranes, dozers, trucks and compaction equipment are required to prepare sites for drainage and utility facilities. Pile driving may be used for structure foundations. Carpentry work for form construction.

- Structural Section -- Concrete, asphalt and aggregate plants, trucks, concrete mixer trucks, pavers, loaders, compactors.

- Finishing -- Cleanup, landscaping and moving out are the primary consideration. Little noise is associated with this phase.

Once the phases are identified, construction schedules can be estimated, equipment can be identified, noise levels of the equipment can be obtained from the manufacturers, usage factors applied and noise levels can be predicted. L_{eq} is an appropriate descriptor for construction noise except when a pile driver or other impact equipment is involved. Figure II-3.1 provides a worksheet for predicting construction noise.

II-3.3 Mitigation

No specific guidelines are available for assessing construction noise impact. However, various local ordinances, FHPM 7-7-3 and other state and Federal regulations may provide guidance (references).

The California Standard Specifications (1978), Section 7-1.01N, Section 42-1.02, Section 42-2.02 and Standard

Special Provisions Section 5-1, may be referenced in the plans and specifications when they apply to minimize or eliminate construction noise.

Figure II-3.2 illustrates other mitigation measures that can be utilized to minimize impact. Barriers should be constructed first on those projects where they are part of the highway improvement contract.

II-3.4 Construction Noise Monitoring

A noise survey of the community should be made prior to construction. Measurement sites are located with regard to land use and activity. They should be representative of the receptor that might be impacted.

A subsequent noise survey during construction provides an in-progress means of assessing impact due to construction noise. It also allows monitoring to check for specification compliance and to evaluate predictions and mitigation measures.

A PHASE	B EQUIPMENT	C EMISSION LEVELS (dBA)	D DISTANCE FROM EQUIPMENT TO OBSERVER	E EQUIPMENT $L_{eq}(h)$ AT RECEPTOR (dBA)	F OVERALL $L_{eq}(h)$ AT RECEPTOR FOR EACH PHASE (dBA)
Mobilization					
Clearing and Grubbing					
Earthwork					
Structure Construction					
Structural Section					
Finishing					

Figure II-3.1

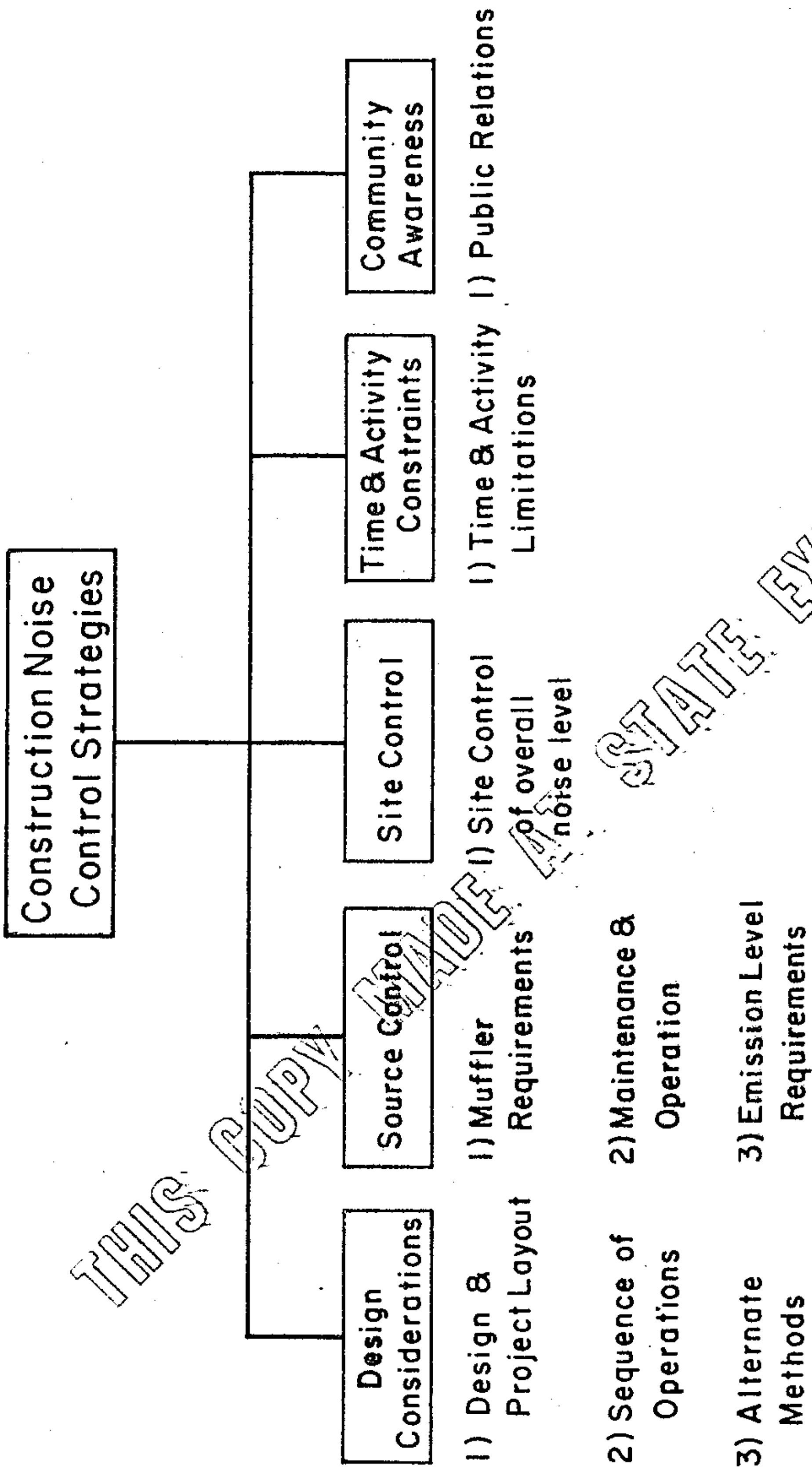

Construction Noise Control Strategies
Design Considerations
Source Control
Site Control
Time & Activity Constraints
Community Awareness
1) Design & Project Layout
2) Sequence of Operations
3) Alternate Methods
1) Muffler Requirements
2) Maintenance & Operation
3) Emission Level Requirements
1) Site Control of overall noise level
1) Time & Activity Limitations
1) Public Relations

Figure II-3.2

CHAPTER II-4

COMPUTER PROGRAMS
FOR THE
FHWA NOISE PREDICTION MODEL

Chapter II-4

Computer Programs for the FHWA Noise Prediction Model

The FHWA has developed two computer programs to facilitate the calculations necessary to predict highway traffic noise and to design barriers to mitigate noise.

One is called Simplified Noise Analysis Program (SNAP 1) which is the FHWA Level 1 program for simple roadway - receiver geometrics. It is on the TENET System, written in BASIC language and instructions for its use are in this chapter. The user should supplement these instructions by reading the publication entitled "Users Manual: FHWA Highway Traffic Noise Prediction Model, SNAP 1.0," Report No. FHWA-RD-78-139; January 1979.

The second FHWA program is called STAMINA and it is the Level II program for complex roadway receiver geometrics. This program could not be placed on the TENET System because of insufficient capacity. It is placed on the Teale Data System Computer and is available for District use. Instructions for its use are in Chapter II-4.4.

II-4.1 Instructions for Using SNAP 1.0 Program (Program Name is "5;ENV;SOUND 2A")

Use the worksheet (Figure II-4.1) for SNAP 1.0.

Figure II-4.1

CALIFORNIA DEPARTMENT OF TRANSPORTATION

TRANSPORTATION LABORATORY

WORKSHEET FOR SNAP1.0
FHWA HIGHWAY NOISE PREDICTION MODEL

1	Is there a barrier(1=yes,2=no)	
2	No. of lane groups	

District		By		W.O. no.	
County		Date		Page	
Route		Reviewed by		Data file name	
P.M.		Date			

ROADWAY GEOMETRY

		1	2	3	4	5	6	7	8	9	10	11	12
3	Leftend X coordinate, XL/l												
4	Rightend X coordinate, XL/r												
5	Leftend Y coordinate, YL/l												
6	Rightend Y coordinate, YL/r												
7	Leftend Z coordinate, ZL/l												
8	Rightend Z coordinate, ZL/r												
9	No. of lanes in lane group												
10	Speed (mph)												
11	Auto volume/hour												
12	Medium truck volume/hour												
13	Heavy truck volume/hour												
14	Heavy truck grade adjustment (dBA)												
15	Dropoff rate (3 or 4.5 dBA)												

RECEIVER GEOMETRY

16	Receiver (description)						
17	Receiver X, Y, Z, coordinates						

BARRIER GEOMETRY

18	Barrier epsilon (0=wall, 1=berm)												
19	Leftend X coordinate, XB/l												
20	Rightend X coordinate, XB/r												
21	Leftend Y coordinate, YB/l												
22	Rightend Y coordinate, YB/r												
23	Leftend Z coordinate, ZB/l												
24	Rightend Z coordinate, ZB/r												

KEY

X,Y	- Horiz. controls
Z	- Vert. control
B	- Barrier
L	- Lane
r	- right
l	- left

HEAVY TRUCK

Grade adjustment	
Gradient	Adjust
<2	0
3 to 4	+2
5 to 6	+3
>7	+5

REMARKS

Note: Coordinates refer to center line of lane nearest to receiver in each group.

II-4.2 Input Options

The program may be used with or without a previously created file. The program will ask: "Enter Filename or NONE?"

a) If the user enters a filename, (Problems 1 & 2) the computer will ask if the filename is new. If "N" (no) is input, the computer will assume that the file was previously created, in the same format as the answers on the worksheet (multiple answers separated by commas). If the user answers the question "Is this a new file (Y/N)?" with "Y" (yes), a file will be created by the program at the time the input questions are answered, and will be given the filename entered on the previous line.

b) If the user enters "NONE", the input data for the program will have to be entered at that time by answering questions asked by the computer in the same order as on the worksheet (Problems 3 & 4).

II-4.3 Multiple Answers

When data is input at the time the program is run and multiple answers to a question are all the same, only one answer needs to be entered. When in the above instance the input data is stored in a new file, the program will enter the same multiple answers in that file. For example, if coordinates for three lane groups are entered and the left end 2-coordinates are the same for all, (e.g., 9 feet, worksheet question 7), the user may answer the question by entering one 9 only. However, if the data is stored by the program, line 7 in the new file will read: 9,9,9.

II-4.4 Changing Data

Regardless of which of the previously discussed imput options are used, (input from old file, input data stored in new file, or input data not stored) the program will provide an opportunity for the user to see the input data and make line by line changes if necessary, before and after running the program (sample problems 1, 2, 3, 4). If a previously created input file is used, data changes will be stored in the old file.

The program can be repeated with the same or a different set of data, whether data set is in a file or not. The above flexibility in changing inputs allows the user to run noise predictions for various wall heights and receivers.

II-4.5 Criterion for Parallelism

The criterion for problems including barriers is set at ± 1° in the program. This means that all lanes have to be parallel with the barrier within 1°, horizontally and vertically. For a "no-barrier" situation, this criterion is set at 90°.

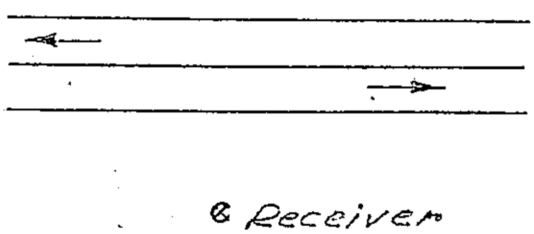
II-4.6 Equivalent Lanes vs. Individual Lanes

For the purposes of this program the highway lanes are categorized into lane groups which are defined as one lane or a composite of more than one lane treated as one set of calculations by the computer. Figure II-4.2 illustrates some roadway configurations and their respective lane groups.

FIGURE II-4.2 - EXAMPLES OF LANE GROUPS

The number of lane groups is recorded on line 2 of the worksheet. This corresponds to the column number 1 thru 12. i.e.: If there are 4 lane groups, then there will be 4 columns of data

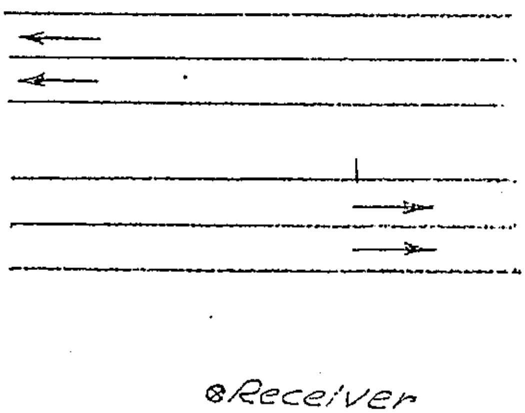
Infinite 2 lane highway



If the equivalent lane distance is used, there is 1 lane group.

If each lane is treated as separate noise sources, there are 2 lane groups.

Infinite 4 lane highway

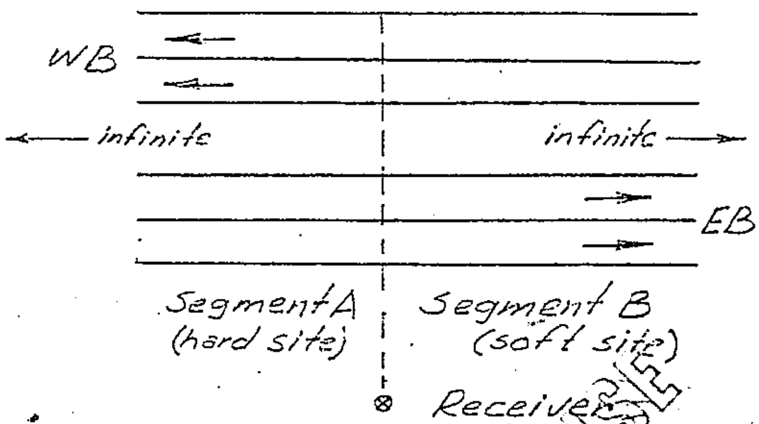


If equivalent lane distance is used for 4 lanes, there is 1 lane group.

If equivalent lane distance is used for the two EB and two WB lanes there are 2 lane groups.

If each lane is treated as separate noise sources, there are 4 lane groups.

4 Lane Highway with 2 segments



If equivalent lane distance is used for 4 lanes, there are 2 lane groups (1 group in Segment A and 1 group in Segment B).

If equivalent lane distance is used for the two EB and two WB lanes, there are 4 lane groups (2 groups in Segment A and 2 groups in Segment B).

If each lane is treated as separate noise sources, there are 8 lane groups, (4 groups in Segment A and 4 groups in Segment B).

FHWA manual 77-108 describes these situations as a segment and equivalent lane.

a) Equivalent Lanes. Each lane group is described by the coordinates of each end of the centerline of the lane nearest the receiver (worksheet questions 3-8) and the number of lanes in each lanegroup (worksheet question 9). The program then assumes all lane centerlines in each lane group to be 12 feet apart.

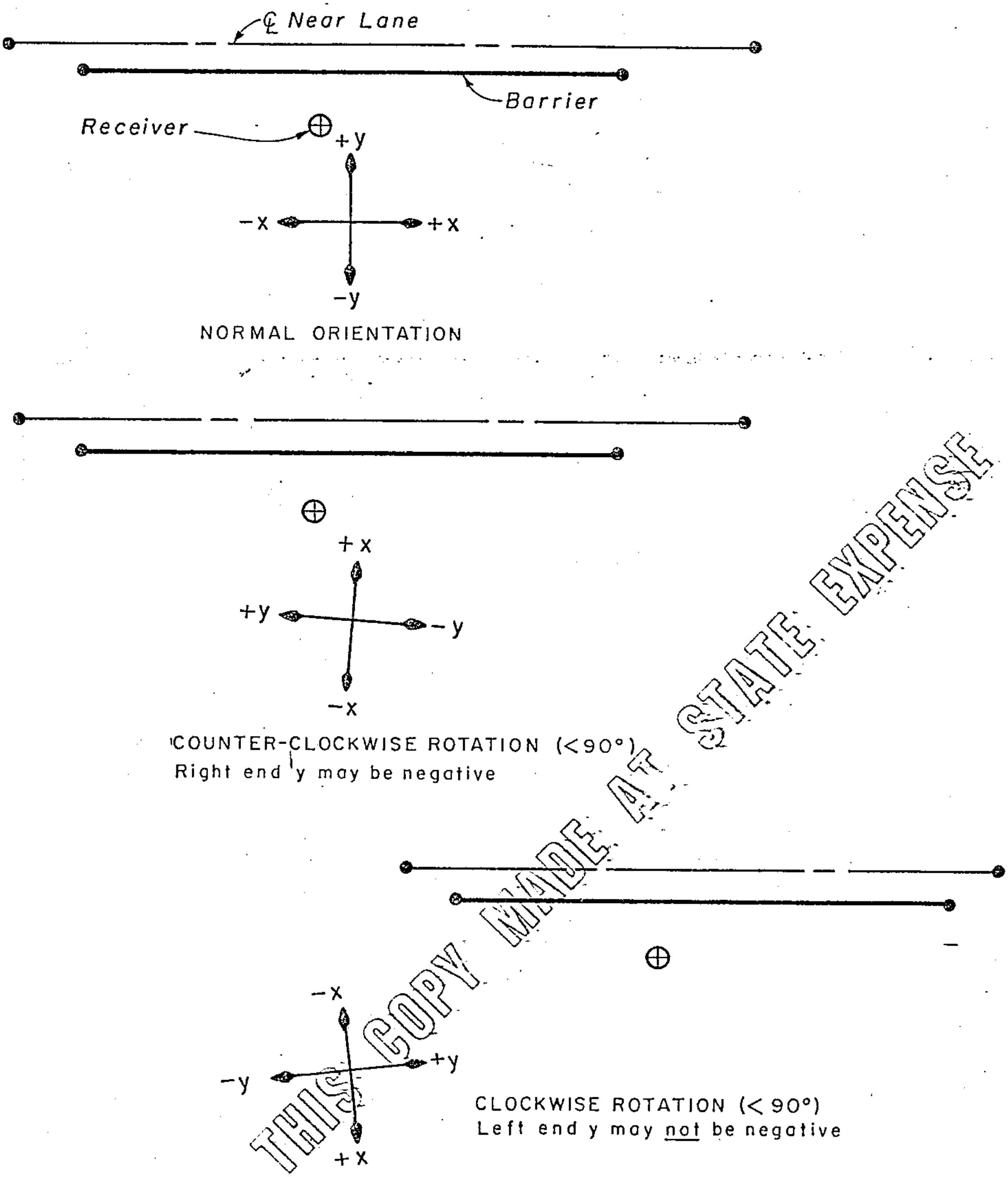
b) Individual Lanes. If lane-by-lane data is available, these inputs can be entered by treating each lane as a separate lane group of 1 lane. The equivalent lane distance then becomes the actual lane distance.

Sample problem 3 shows both the equivalent lane and lane-by-lane methods. In deciding which method to follow, the user should consult FHWA manuaul 77-108 and CALTRANS Noise Manual. The final decision, however, is dictated by the availability of detailed traffic information and use of sound engineering judgment.

II-4.7 Limits of X, Y Axis Rotation

Normally, the simplest way to orient a coordinate system relative to the roadway, barrier and receiver, is to make the x-axis parallel to the roadway and barrier and to place the receiver either at the origin or somewhere between the origin and the barrier (or roadway).

Figure II-4.3 shows the limits permitted x, y rotations, indicating the normal situation, counter-clockwise and



LIMITS OF PERMITTED ROTATIONS OF X AND Y AXES

FIGURE II-4.3

clockwise rotations of less than 90°. Note that within these limits, the left-end y coordinate may never be negative. The right-end y coordinate, however, may be positive or negative.

II-4.8 Infinite vs. Finite Roadways

Although there never is a truly infinite roadway in real life, there are situations where, for practical purposes, a roadway may be considered infinite. The FHWA highway Traffic Noise Prediction Model (Manual FHWA-RD-77-108) shows that for a hard site, a roadway segment of 161° will produce noise levels that are within 0.5 dBA from noise levels produced by an "infinite roadway. The 161° segment translates into 12 times the distance from receiver to the centerline of the lane considered (12D measured along the roadway, 6D left and 6D right). A segment of 170°, or 30D (15D left and 15D right) results in noise levels of only 0.1 dBA less than those of an infinite roadway. Coordinates for the end points of an "infinite" roadway should therefore be chosen to reflect at least the 6D left and right from the receiver (measured along the roadway). Any large negative and positive x-coordinate will suffice. The program is capable of handling values up to 10^8.

II-4.9 Sample Problems and Computer Runs

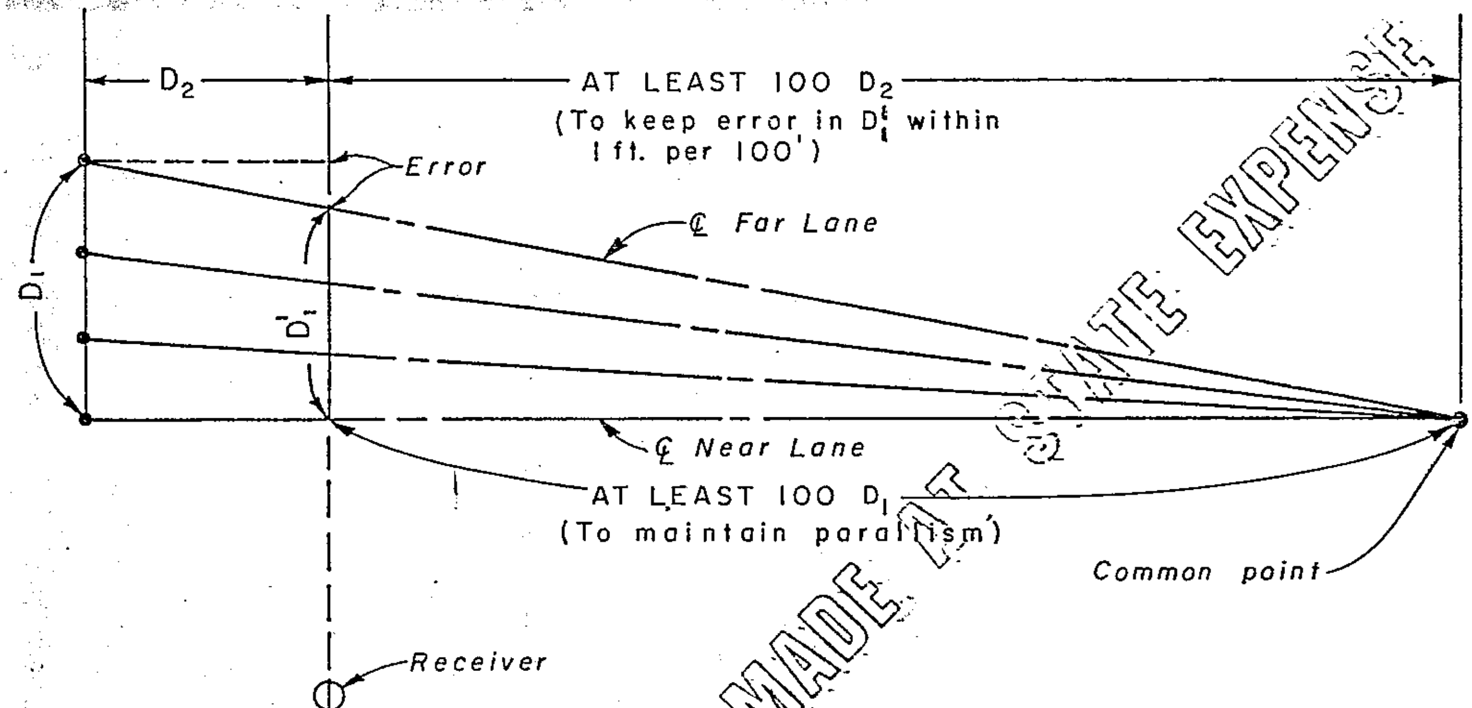
The following examples illustrate some applications of the "5; ENV; SOUND 2A" program. The problems shown do not necessarily depict "real world" situations. They are intended to point out some of the most important capabilities and limitations of the program.

Problem 1 shows a rotation of the x & y axes relative to the roadway and barrier. This rotation from the normal orientation is within the limits of permitted rotations depicted in Figure II-4.3. Note that the right end coordinates are the same for both lane groups. This is permitted as long as the roadways are sufficiently long in one direction of the receiver (in order not to violate the criterion of parallelism for barrier problems) and short in the opposite direction (in order not to introduce an error in the location of the lanes and barrier). As a rule of thumb the ratio between long and short "legs" of the roadway should be at least 100:1 and the far end of the lanes at least 100x the distance between the nearest and far lane, before a common terminus may be used (see Sketch II-4.1).

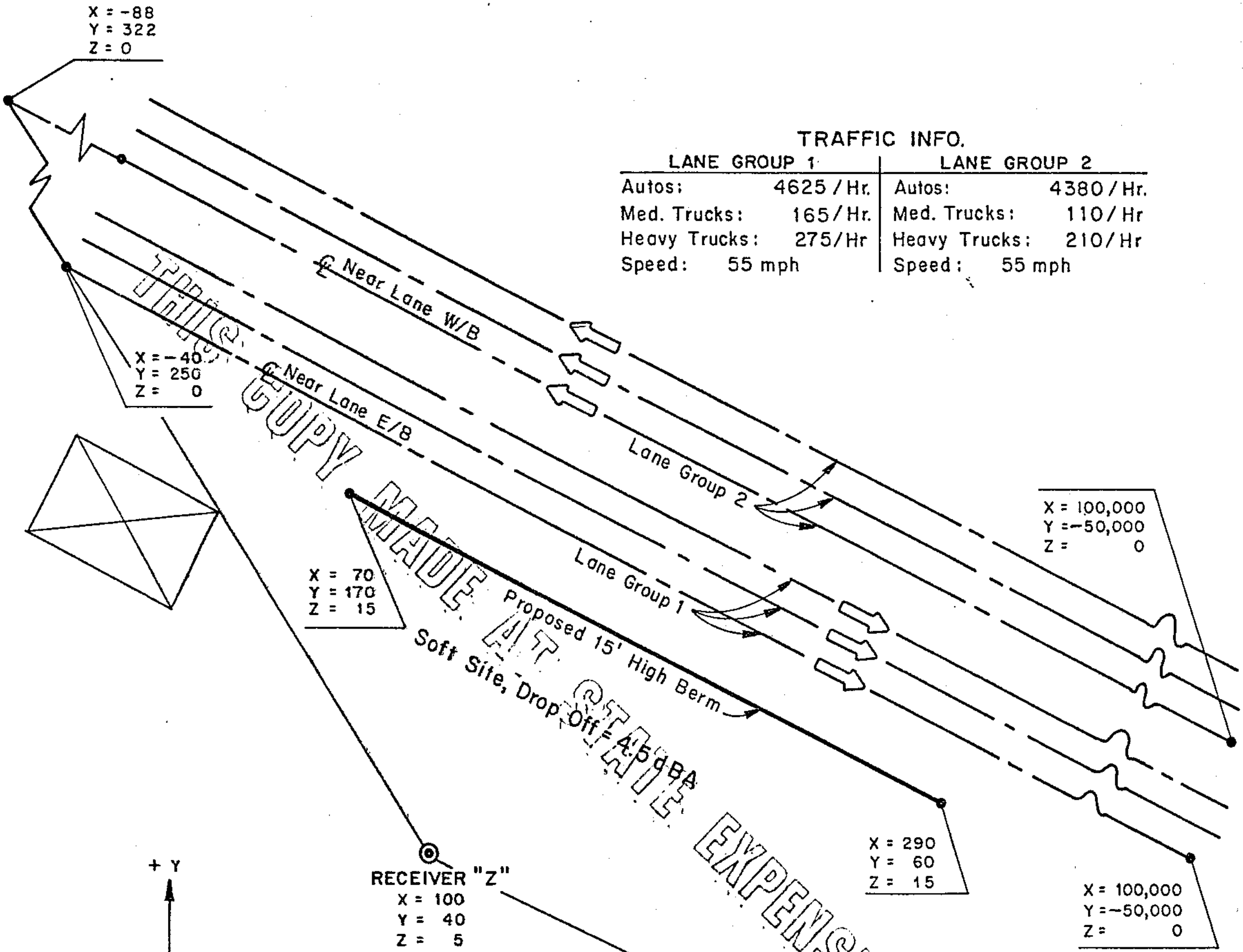
Problem 2 illustrates a curved roadway without a barrier. The roadway is divided into 4 straightline segments to approximate the curbed and tangent portions of the roadway. The 4 segments are then treated as 4 nonparallel lane groups. For this reason, the program will not solve this type of problem if a barrier is included. The criterion of parallelism is 90° for a nonbarrier problem and 1° with a barrier. If barrier calculations are desired for a curved roadway, each segment will have to be run separately, and the results combined by decibel addition. (Not part of this program).

Problem 3 indicates 2 methods of inputting roadway geometry and traffic data:

A. Lane by lane
B. Two equivalent lanes


D2
AT LEAST 100 D2
(To keep error in D1' within
1 ft. per 100')
Error
℄ Far Lane
D1
D1'
℄ Near Lane
AT LEAST 100 D1
(To maintain parallism)
Common point
Receiver

SKETCH II-4.1



SAMPLE PROBLEM NO. 1

SCALE: 1" = 50'

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WORKSHEET FOR SNAP1.0
FHWA HIGHWAY NOISE PREDICTION MODEL

1	Is there a barrier(1=yes,2=no)	1
2	No. of lane groups	2

District	19	By	R. HENDRIKS	W.O. no.	123456
County	SACRAMENTO	Date	12/5/79	Page	1
Route	9999	Reviewed by		Data file name	"PROB1"
P.M.	6.0	Date			

ROADWAY GEOMETRY

		1	2	3	4	5	6	7	8	9	10	11	12
3	Leftend X coordinate, XL/1	-40	-88										
4	Rightend X coordinate, XL/r	100,000	100,000										
5	Leftend Y coordinate, YL/1	250	322										
6	Rightend Y coordinate, YL/r	-50,000	-50,000										
7	Leftend Z coordinate, ZL/1	0	0										
8	Rightend Z coordinate, ZL/r	0	0										
9	No. of lanes in lane group	3	3										
10	Speed (mph)	55	55										
11	Auto volume/hour	4625	4390										
12	Medium truck volume/hour	465	110										
13	Heavy truck volume/hour	275	210										
14	Heavy truck grade adjustment (dBA)	0	0										
15	Dropoff rate (3 or 4.5 dBA)	4.5	4.5										

RECEIVER GEOMETRY

		1	2	3	4	5
16	Receiver (description)	RECEIVER 2				
17	Receiver X, Y, Z, coordinates	100, 40, 5				

BARRIER GEOMETRY

		1	2	3	4	5	6	7	8	9	10	11	12
18	Barrier epsilon (0=wall, 1=berm)	1											
19	Leftend X coordinate, XB/1	20											
20	Rightend X coordinate, XB/r	290											
21	Leftend Y coordinate, YB/1	170											
22	Rightend Y coordinate, YB/r	60											
23	Leftend Z coordinate, ZB/1	15											
24	Rightend Z coordinate, ZB/r	15											

KEY

X,Y	- Horiz. controls
Z	- Vert. control
B	- Barrier
L	- Lane
r	- right
1	- left

HEAVY TRUCK

Grade adjustment	
Gradient	Adjust
<2	0
3 to 4	+2
5 to 6	+3
>7	+5

REMARKS SAMPLE PROBLEM 1

Note: Coordinates refer to center line of lane nearest to receiver in each group.

```
1 COPY PROB1 TO TEL TEXT
2
-40,-88
100000,100000
250,322
-50000,-50000
0
0,0
3,3
55,55
4625,4380
165,110
275,210
0,0
4.5,4.5
RECEIVER Z
100,40,5
1
70
290
170
60
15
15
-
```

* * * PROGRAM '5;ENV;SOUND2A' * * *

FHWA NOISE PREDICTION MODEL
(SNAP 1.0)

SAMPLE PROBLEM 1

Enter filename or NONE?PROB1

Is this a new file(Y/N)?N

Do you want to look at the data(Y/N)?Y

Fast view(Y/N)?Y

1.	1	
2.	2	
3.	-40	-88
4.	100000	100000
5.	250	322
6.	-50000	-50000
7.	0	0
8.	0	0
9.	3	3
10.	55	55
11.	4625	4380
12.	165	110
13.	275	210
14.	0	0
15.	4.5	4.5
16.	RECEIVER Z	
17.	100	40
18.	1	
19.	70	
20.	290	
21.	170	
22.	60	
23.	15	
24.	15	

Change data(Y/N)?N

Run(Y/N)?Y

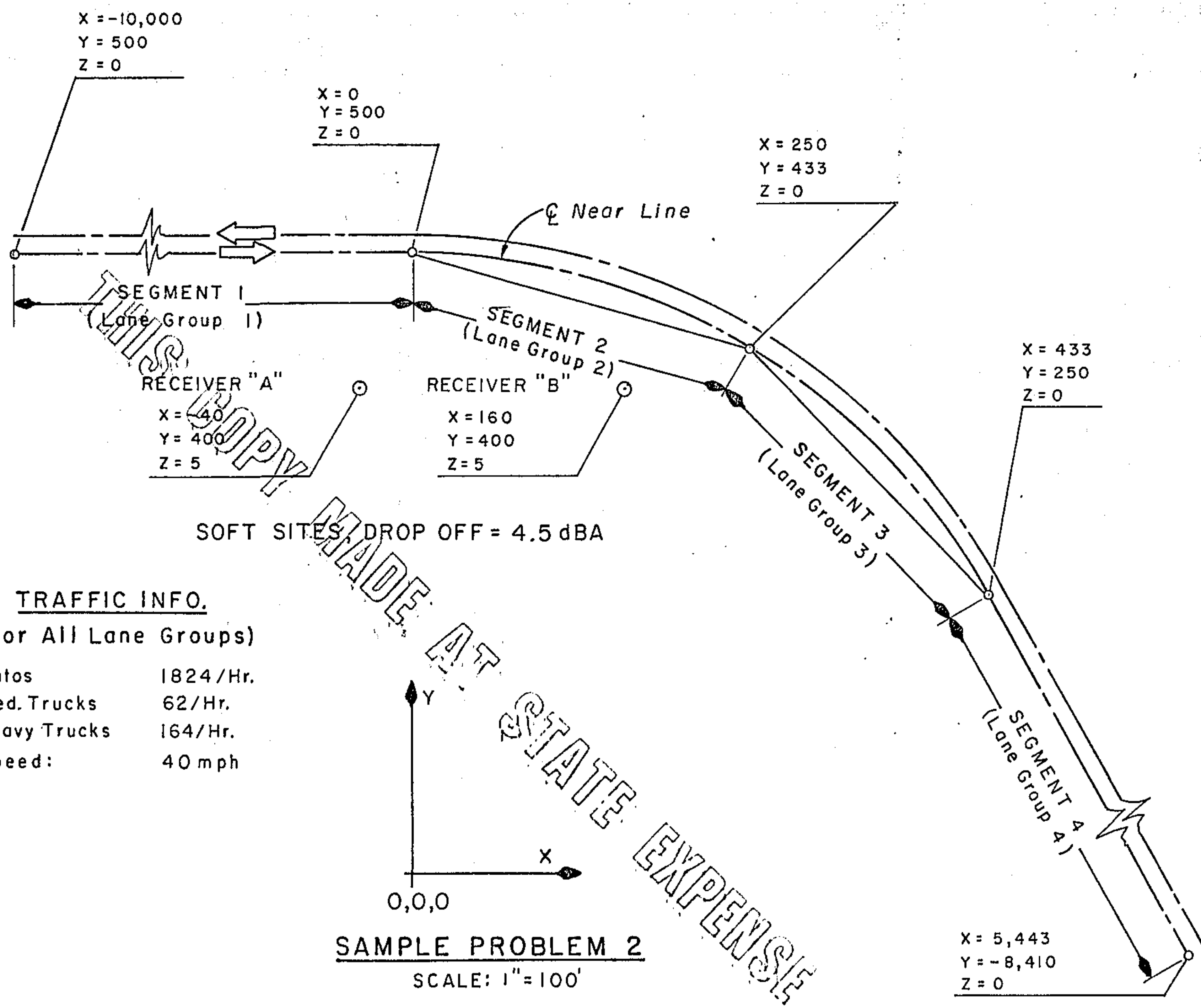
RECEIVER Z

```
TOTAL LEQ WITHOUT BARRIER= 74.2 dBA
TOTAL LEQ WITH BARRIER    = 68.9 dBA

LEQ FROM LEFT UNSHIELDED SEGMENT = 65.3 dBA
LEQ FROM RIGHT UNSHIELDED SEGMENT= 65.5 dBA
LEQ FROM MIDDLE SHIELDED SEGMENT = 58.8 dBA
```

```
Run again with the same data(Y/N)?N

Run the program from the beginning(Y/N)?N
1=RERUN ,2=BACK TO SYSTEM ,3=STOP      ?3
```



SOFT SITES, DROP OFF = 4.5 dBA

TRAFFIC INFO.
(For All Lane Groups)

Autos	1824/Hr.
Med. Trucks	62/Hr.
Heavy Trucks	164/Hr.
Speed:	40 mph

SAMPLE PROBLEM 2

SCALE: 1" = 100'

CALIFORNIA DEPARTMENT OF TRANSPORTATION

TRANSPORTATION LABORATORY

WORKSHEET FOR SNAP1.0
FHWA HIGHWAY NOISE PREDICTION MODEL

1	Is there a barrier(1=yes,2=no)	2
2	No. of lane groups	4

District	19	By	R HENDRIKS
County	SACRAMENTO	Date	12/5/79
Route	9998	Reviewed by	
P.M.	9.8	Date	

W.O. no.	234567
Page	1
Data file name	PROB 2

ROADWAY GEOMETRY

		1	2	3	4	5	6	7	8	9	10	11	12
3	Leftend X coordinate, XL/1	-10,000	0	250	433								
4	Rightend X coordinate, XL/r	0	250	433	5,433								
5	Leftend Y coordinate, YL/1	500	500	433	250								
6	Rightend Y coordinate, YL/r	500	433	250	-8,410								
7	Leftend Z coordinate, ZL/1	0	0	0	0								
8	Rightend Z coordinate, ZL/r	0	0	0	0								
9	No. of lanes in lane group	2	2	2	2								
10	Speed (mph)	40	40	40	40								
11	Auto volume/hour	1824	1824	1824	1824								
12	Medium truck volume/hour	62	62	62	62								
13	Heavy truck volume/hour	164	164	164	164								
14	Heavy truck grade adjustment (dBA)	0	0	0	0								
15	Dropoff rate (3 or 4.5 dBA)	4.5	4.5	4.5	4.5								

RECEIVER GEOMETRY

		1	2	3	4	5	6
16	Receiver (description)	REC. A	REC. B				
17	Receiver X, Y, Z, coordinates	-40,400,5	160,400,5				

BARRIER GEOMETRY

		1	2	3	4	5	6	7	8	9	10	11	12
18	Barrier epsilon (0=wall, 1=berm)												
19	Leftend X coordinate, XB/1												
20	Rightend X coordinate, XB/r												
21	Leftend Y coordinate, YB/1												
22	Rightend Y coordinate, YB/r												
23	Leftend Z coordinate, ZB/1												
24	Rightend Z coordinate, ZB/r												

KEY

X,Y	- Horiz. controls
Z	- Vert. control
B	- Barrier
L	- Lane
r	- right
l	- left

HEAVY TRUCK

Grade adjustment	
Gradient	Adjust
<2	0
3 to 4	+2
5 to 6	+3
>7	+5

REMARKS SAMPLE PROBLEM 2
CURVED ROADWAY, NO BARRIER

Note : Coordinates refer to center line of lane nearest to receiver in each group.
This program can be used with lane by lane data, by assuming each lane to be a separate group.

```
 COPY PROB2 TO TEL TEXT
2
4
-10000,0,250,433
0,250,433,5433
500,500,433,250
500,433,250,-8410
0,0,0,0
0,0,0,0
2,2,2,2
40,40,40,40
1824,1824,1824,1824
62,62,62,62
164,164,164,164
0,0,0,0
4.5,4.5,4.5,4.5
PROBLEM 2 RECEIVER A
-40,400,5
-
```

* * * PROGRAM '5;ENV;SOUND2A' * * *

FHWA NOISE PREDICTION MODEL
(SNAP 1.0)

Enter filename or NONE?PROB2

Is this a new file(Y/N)?N

Do you want to look at the data(Y/N)?Y

Fast view(Y/N)?Y

1.	2			
2.	4			
3.	-10000	0	250	433
4.	0	250	433	5433
5.	500	500	433	250
6.	500	433	250	-8410
7.	0	0	0	0
8.	0	0	0	0
9.	2	2	2	2
10.	40	40	40	40
11.	1824	1824	1824	1824
12.	62	62	62	62
13.	164	164	164	164
14.	0	0	0	0
15.	4.5	4.5	4.5	4.5
16.	PROBLEM 2 RECEIVER A			
17.	-40	400	5	

Change data(Y/N)?N

Run(Y/N)?Y

PROBLEM 2 RECEIVER A

TOTAL LEQ WITHOUT BARRIER= 69.3 dBA

Run again with the same data(Y/N)?Y

Do you want to look at the data(Y/N)?N

Change data(Y/N)?Y

Which line?16

16. Receiver (Description) ?PROBLEM 2 RECEIVER B

Change data(Y/N)?Y

Which line?17

17. Receiver X,Y,Z Coordinates ?160,400,5

Change data(Y/N)?N

Run(Y/N)?Y

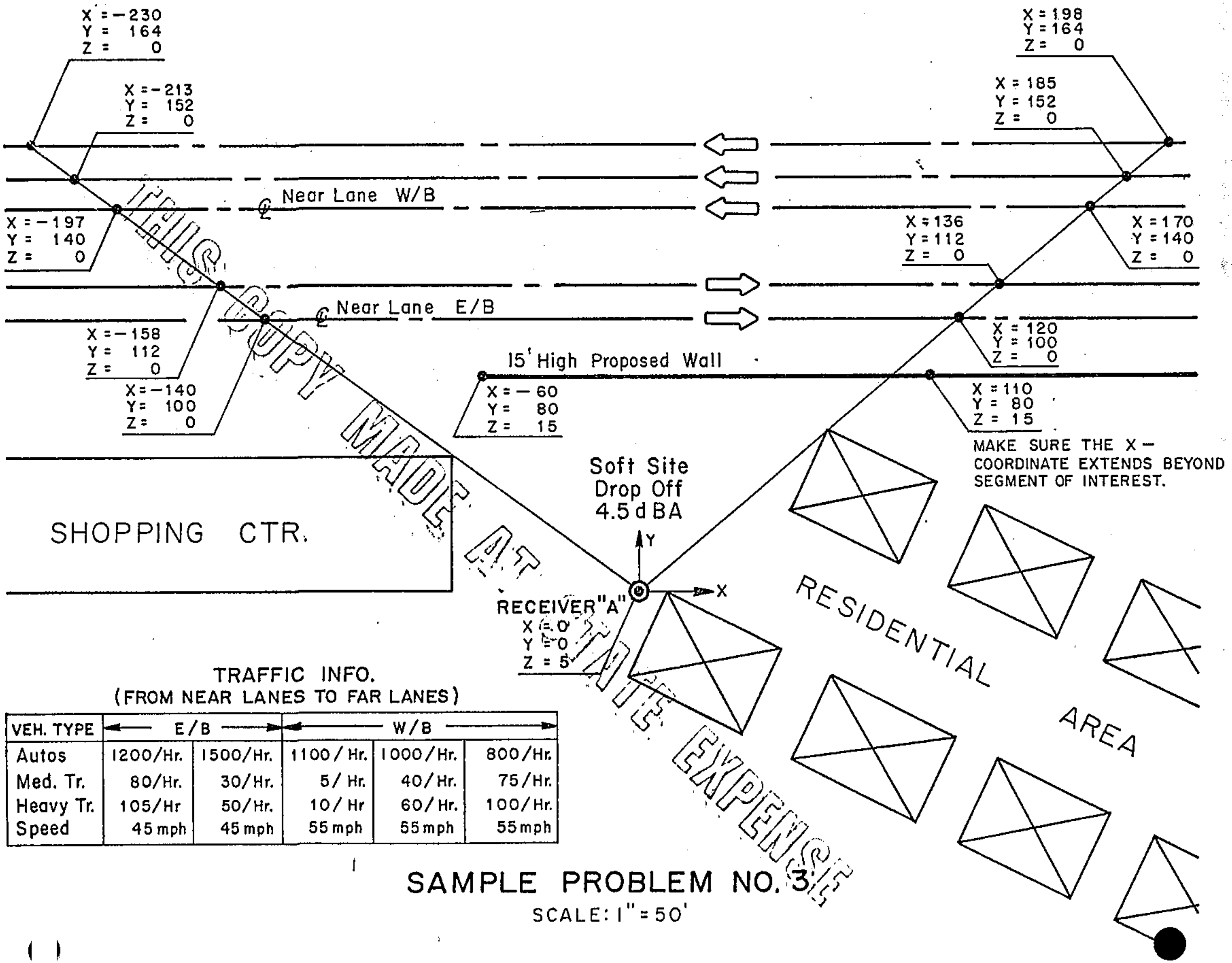
```
TOTAL LEQ WITHOUT BARRIER= 72.7 dBA




Run again with the same data(Y/N)?N




     Run the program from the beginning(Y/N)?N
1=RERUN ,2=BACK TO SYSTEM ,3=STOP       ?3
```



TRAFFIC INFO.
(FROM NEAR LANES TO FAR LANES)

VEH. TYPE	E/B		W/B		
Autos	1200/Hr.	1500/Hr.	1100/Hr.	1000/Hr.	800/Hr.
Med. Tr.	80/Hr.	30/Hr.	5/Hr.	40/Hr.	75/Hr.
Heavy Tr.	105/Hr	50/Hr.	10/Hr	60/Hr.	100/Hr.
Speed	45 mph	45 mph	55 mph	55 mph	55 mph

SAMPLE PROBLEM NO. 3
SCALE: 1" = 50'

CALIFORNIA DEPARTMENT OF TRANSPORTATION

TRANSPORTATION LABORATORY

WORKSHEET FOR SNAP1.0
FHWA HIGHWAY NOISE PREDICTION MODEL

1	Is there a barrier(1=yes,2=no)	1
2	No. of lane groups	5

District	19	By	R. HENDRIKS	W.O. no.	345678
County	SACRAMENTO	Date	12/5/79	Page	1
Route	9997	Reviewed by		Data file name	NONE
P.M.	9.7	Date			

ROADWAY GEOMETRY

		1	2	3	4	5	6	7	8	9	10	11	12
3	Leftend X coordinate, XL/l	-140	-158	-197	-213	-230							
4	Rightend X coordinate, XL/r	120	136	170	185	198							
5	Leftend Y coordinate, YL/l	100	112	140	152	164							
6	Rightend Y coordinate, YL/r	100	112	140	152	164							
7	Leftend Z coordinate, ZL/l	0	0	0	0	0							
8	Rightend Z coordinate, ZL/r	0	0	0	0	0							
9	No. of lanes in lane group	1	1	1	1	1							
10	Speed (mph)	45	45	55	55	55							
11	Auto volume/hour	1200	1500	1100	1000	800							
12	Medium truck volume/hour	80	30	5	40	75							
13	Heavy truck volume/hour	105	50	10	60	100							
14	Heavy truck grade adjustment (dBA)	0	0	0	0	0							
15	Dropoff rate (3 or 4.5 dBA)	4.5	4.5	4.5	4.5	4.5							

RECEIVER GEOMETRY

16	Receiver (description)	RECEIVER A						
17	Receiver X, Y, Z, coordinates	0,0,5						

BARRIER GEOMETRY

		1	2	3	4	5	6	7	8	9	10	11	12
18	Barrier epsilon (0=wall, 1=berm)	0											
19	Leftend X coordinate, XB/l	-60											
20	Rightend X coordinate, XB/r	110											
21	Leftend Y coordinate, YB/l	80											
22	Rightend Y coordinate, YB/r	80											
23	Leftend Z coordinate, ZB/l	15											
24	Rightend Z coordinate, ZB/r	15											

KEY

X,Y	- Horiz. controls
Z	- Vert. control
B	- Barrier
L	- Lane
r	- right
l	- left

HEAVY TRUCK

Grade adjustment	
Gradient	Adjust
<2	0
3 to 4	+2
5 to 6	+3
>7	+5

REMARKS SAMPLE PROBLEM NO. 3A
LANE-BY-LANE INPUT

Note : Coordinates refer to center line of lane nearest to receiver in each group.
This program can be used with lane by lane data, by assuming each lane to be a separate group.

CALIFORNIA DEPARTMENT OF TRANSPORTATION

TRANSPORTATION LABORATORY

WORKSHEET FOR SNAP1.0
FHWA HIGHWAY NOISE PREDICTION MODEL

1	Is there a barrier(1=yes,2=no)	1
2	No. of lane groups	2

District	19	By	R.HENDRICKS.	W.O. no.	345678
County	SACRAMENTO	Date	12/5/79	Page	2
Route	9997	Reviewed by		Data file name	NONE
P.M.	9.7	Date			

ROADWAY GEOMETRY

		1	2	3	4	5	6	7	8	9	10	11	12
3	Leftend X coordinate, XL/l	-140	-197										
4	Rightend X coordinate, XL/r	120	170										
5	Leftend Y coordinate, YL/l	100	140										
6	Rightend Y coordinate, YL/r	100	140										
7	Leftend Z coordinate, ZL/l	0	0										
8	Rightend Z coordinate, ZL/r	0	0										
9	No. of lanes in lane group	2	3										
10	Speed (mph)	45	55										
11	Auto volume/hour	2200	2900										
12	Medium truck volume/hour	110	120										
13	Heavy truck volume/hour	155	170										
14	Heavy truck grade adjustment (dBA)	0	0										
15	Dropoff rate (3 or 4.5 dBA)	4.5	4.5										

RECEIVER GEOMETRY

		1	2	3	4	5	6	7	8	9	10	11	12
16	Receiver (description)	RECEIVER A											
17	Receiver X, Y, Z, coordinates	0,0,5											

BARRIER GEOMETRY

		1	2	3	4	5	6	7	8	9	10	11	12
18	Barrier option (0=wall, 1=berm)	0											
19	Leftend X coordinate, XB/l	-60											
20	Rightend X coordinate, XB/r	110											
21	Leftend Y coordinate, YB/l	80											
22	Rightend Y coordinate, YB/r	80											
23	Leftend Z coordinate, ZB/l	15											
24	Rightend Z coordinate, ZB/r	15											

KEY

X,Y	- Horiz. controls
Z	- Vert. control
B	- Barrier
L	- Lane
r	- right
l	- left

HEAVY TRUCK

Grade adjustment	
Gradient	Adjust
<2	0
3 to 4	+2
5 to 6	+3
>7	+5

REMARKS SAMPLE PROBLEM NO.3B
TWO EQUIVALENT LANES
(ONE LANE GROUP OF 2 LANES & ONE LANE GROUP
OF 3 LANES)

Note Coordinates refer to center line of lane nearest to receiver in each group.

* * * PROGRAM '5ENVSOUND2A' * * *

FHWA NOISE PREDICTION MODEL
(SNAP 1.0)

```
Enter filename or NONE?NONE

INPUT: All Distances should be in Feet.
       Separate Multiple Answers with Commas or spaces.
```

SAMPLE PROBLEM NO.3A
LANE-BY-LANE INPUTS

```
 1. Is There a Barrier
     (1=yes , 2=no)              ?1

 2. No. of Lane Groups           ?5


         ROADWAY GEOMETRY

 3. Leftend  X coordinate        ?-140,-158,-197,-213,-230

 4. Rightend X coordinate        ?120,136,170,185,198

 5. Leftend  Y coordinate        ?100,112,140,152,164

 6. Rightend Y coordinate        ?100,112,140,152,164

 7. Leftend  Z coordinate        ?0

 8. Rightend Z coordinate        ?0

 9. No. of lanes in lane group   ?1

10. Speed (mph)                  ?45,45,55,55,55

11. Auto volume/hr               ?1200,1500,1100,1000,800

12. Medium truck volume/hr       ?80,30,5,40,75

13. Heavy truck volume/hr        ?105,50,10,60,100

14. Heavy Truck Sound-Level
```

Adjustment Parameter ?0

15. Dropoff rate(3 or 4.5 dBA) ?4.5

RECEIVER GEOMETRY

16. Receiver (Description) ?RECEIVER A

17. Receiver X,Y,Z Coordinates ?0,0,5

BARRIER GEOMETRY

18. Epsilon for Barrier
(0=Wall , 1=Berm) ?0

19. Leftend X coordinate ?-60

20. Rightend X coordinate ?110

21. Leftend Y coordinate ?80

22. Rightend Y coordinate ?80

23. Leftend Z coordinate ?15

24. Rightend Z coordinate ?15

Change data(Y/N)?N

Run(Y/N)?Y

RECEIVER A

TOTAL LEQ WITHOUT BARRIER= 71.8 dBA
TOTAL LEQ WITH BARRIER = 65.0 dBA

LEQ FROM LEFT UNSHIELDED SEGMENT = 63.7 dBA
LEQ FROM RIGHT UNSHIELDED SEGMENT= .0 dBA
LEQ FROM MIDDLE SHIELDED SEGMENT = 59.0 dBA

Run again with the same data(Y/N)?N

Run the program from the beginning(Y/N)?Y

FHWA NOISE PREDICTION MODEL
(SNAP 1.0)

Enter filename or NONE?NONE

INPUT: All Distances should be in Feet.
Separate Multiple Answers with Commas or spaces.

SAMPLE PROBLEM NO.3B

2 EQUIVALENT LANES (ONE LANE GROUP OF 2 LANES
& ONE LANE GROUP OF 3 LANES)

1. Is There a Barrier
(1=yes , 2=no) ?1

2. No. of Lane Groups ?2

ROADWAY GEOMETRY

3. Leftend X coordinate ?-140,-197

4. Rightend X coordinate ?120,170

5. Leftend Y coordinate ?100,140

6. Rightend Y coordinate ?100,140

7. Leftend Z coordinate ?0

8. Rightend Z coordinate ?0

9. No. of lanes in lane group ?2,3

10. Speed (mph) ?45,55

11. Auto volume/hr ?2700,2900

12. Medium truck volume/hr ?110,120

13. Heavy truck volume/hr ?155,170

14. Heavy Truck Sound-Level Adjustment Parameter ?0

15. Dropoff rate(3 or 4.5 dBA) ?4.5

RECEIVER GEOMETRY

16. Receiver (Description) ?RECEIVER A

17. Receiver X,Y,Z Coordinates ?0,0,5

BARRIER GEOMETRY

18. Epsilon for Barrier (0=Wall , 1=Berm) ?0

19. Leftend X coordinate ?-60

20. Rightend X coordinate ?110

21. Leftend Y coordinate ?80

22. Rightend Y coordinate ?80

23. Leftend Z coordinate ?15

24. Rightend Z coordinate ?15

Change data(Y/N)?N

Run(Y/N)?Y

RECEIVER A

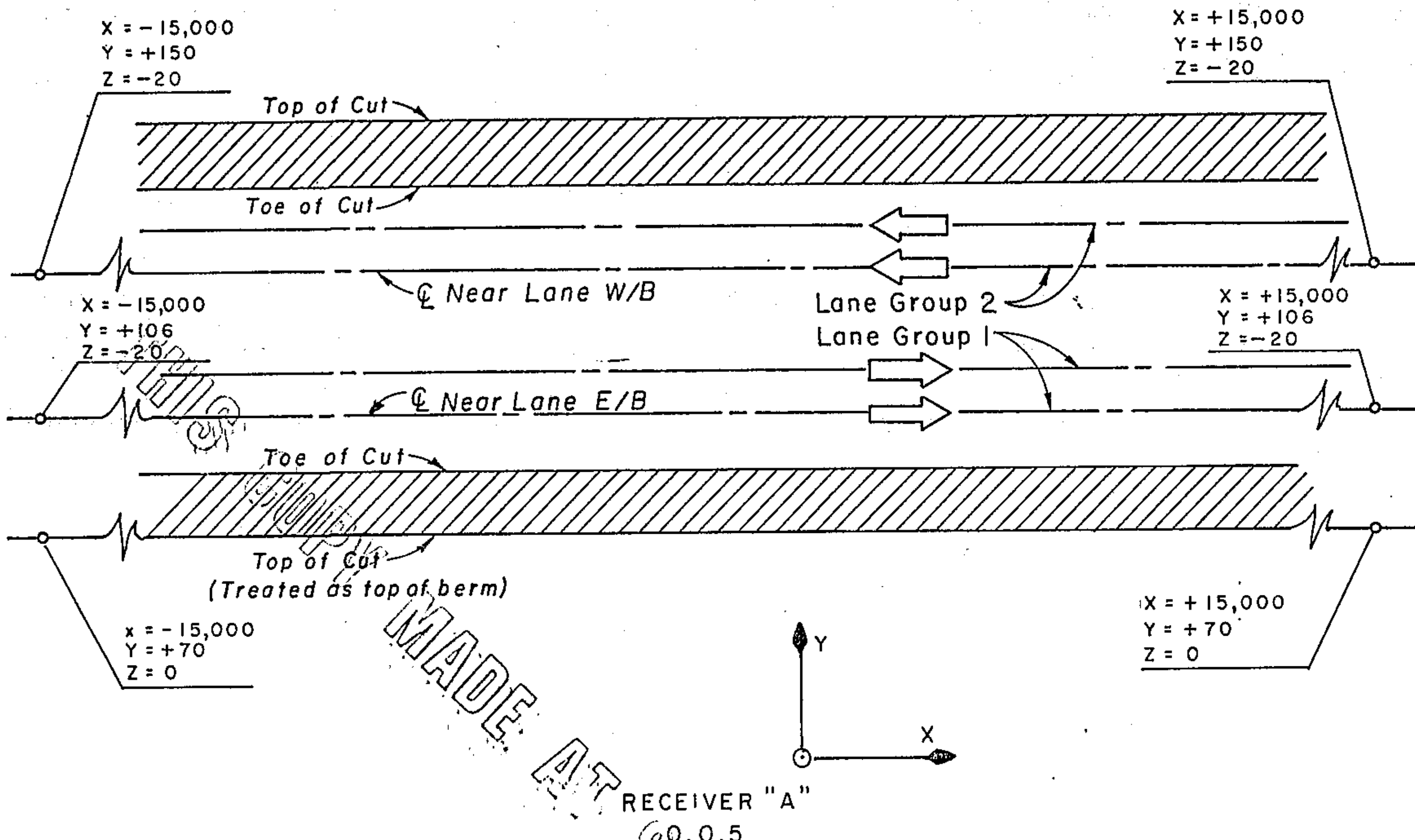
TOTAL LEQ WITHOUT BARRIER= 71.7 dBA

```
TOTAL LEQ WITH BARRIER   = 64.7 dBA

     LEQ FROM LEFT UNSHIELDED SEGMENT = 63.3 dBA
     LEQ FROM RIGHT UNSHIELDED SEGMENT=    .0 dBA
     LEQ FROM MIDDLE SHIELDED SEGMENT = 59.0 dBA

     Run again with the same data(Y/N)?N

     Run the program from the beginning(Y/N)?N
1=RERUN ,2=BACK TO SYSTEM ,3=STOP      ?3
```



HARD SITE DROP OFF 3.0 dBA

TRAFFIC INFO.

VEH. TYPE	E/B	W/B
Autos	2700/Hr.	2300/Hr.
Med. Tr.	50/ Hr.	40/Hr.
Heavy Tr.	110/ Hr.	90/Hr.
Speed	55/mph	55/mph

SCALE: 1" = 50'

SAMPLE PROBLEM NO. 4

(Simple cut, line of sight between receiver and all lanes broken)

CALIFORNIA DEPARTMENT OF TRANSPORTATION

TRANSPORTATION LABORATORY

WORKSHEET FOR SNAP1.0
FHWA HIGHWAY NOISE PREDICTION MODEL

1	Is there a barrier(1=yes,2=no)	1
2	No. of lane groups	2

District	19	By	R. HENDRIKS	W.O. no.	456789
County	SACRAMENTO	Date	12/5/79	Page	1
Route	9996	Reviewed by		Data file name	NONE
P.M.	9.6	Date			

ROADWAY GEOMETRY

		1	2	3	4	5	6	7	8	9	10	11	12
3	Leftend X coordinate, XL/l	-15,000	-15000										
4	Rightend X coordinate, XL/r	+15,000	+15,000										
5	Leftend Y coordinate, YL/l	+106	+150										
6	Rightend Y coordinate, YL/r	+106	+150										
7	Leftend Z coordinate, ZL/l	-20	-20										
8	Rightend Z coordinate, ZL/r	-20	-20										
9	No. of lanes in lane group	2	2										
10	Speed (mph)	55	55										
11	Auto volume/hour	2700	2300										
12	Medium truck volume/hour	50	40										
13	Heavy truck volume/hour	110	90										
14	Heavy truck grade adjustment (dBA)	0	0										
15	Dropoff rate (3 or 4.5 dBA)	3	3										

RECEIVER GEOMETRY

		1	2	3	4	5	6
16	Receiver (description)	70' S. OF TOP CUT					
17	Receiver X, Y, Z, coordinates	0, 0, 5					

BARRIER GEOMETRY

		1	2	3	4	5	6	7	8	9	10	11	12
18	Barrier epsilon (0=wall, 1=berm)	1											
19	Leftend X coordinate, XB/l	-15,000											
20	Rightend X coordinate, XB/r	+15,000											
21	Leftend Y coordinate, YB/l	+20											
22	Rightend Y coordinate, YB/r	+20											
23	Leftend Z coordinate, ZB/l	0											
24	Rightend Z coordinate, ZB/r	0											

KEY

X,Y	- Horiz. controls
Z	- Vert. control
B	- Barrier
L	- Lane
r	- right
l	- left

HEAVY TRUCK

Grade adjustment	
Gradient	Adjust
<2	0
3 to 4	+2
5 to 6	+3
>7	+5

REMARKS SAMPLE PROBLEM NO. 4.
SIMPLE CUT.

Note : Coordinates refer to center line of lane nearest to receiver in each group.
This program can be used with lane by lane data, by assuming each lane to be a separate group.

* * * PROGRAM '5;ENV;SOUND2A' * * *

FHWA NOISE PREDICTION MODEL
(SNAP 1.0)

Enter filename or NONE?NONE

INPUT: All Distances should be in Feet.
Separate Multiple Answers with Commas or spaces.

1. Is There a Barrier
   (1=yes , 2=no) ?1

2. No. of Lane Groups ?2

ROADWAY GEOMETRY

3. Leftend X coordinate ?-15000

4. Rightend X coordinate ?15000

5. Leftend Y coordinate ?106,150

6. Rightend Y coordinate ?106,150

7. Leftend Z coordinate ?-20

8. Rightend Z coordinate ?-20

9. No. of lanes in lane group ?2

10. Speed (mph) ?55

11. Auto volume/hr ?2700,2300

12. Medium truck volume/hr ?50,40

13. Heavy truck volume/hr ?110,90

15. Dropoff rate(3 or 4.5 dBA) ?3

RECEIVER GEOMETRY

16. Receiver (Description) ?RECEIVER 70 FEET SOUTH OF TOP CUT

17. Receiver X,Y,Z Coordinates ?0,0,5

BARRIER GEOMETRY

18. Epsilon for Barrier
(0=Wall , 1=Berm) ?1

19. Leftend X coordinate ?-15000

20. Rightend X coordinate ?15000

21. Leftend Y coordinate ?70

22. Rightend Y coordinate ?70

23. Leftend Z coordinate ?0

24. Rightend Z coordinate ?0

Change data(Y/N)?N

Run(Y/N)?Y

RECEIVER 70 FEET SOUTH OF TOP CUT

TOTAL LEQ WITHOUT BARRIER= 75.5 dBA

TOTAL LEQ WITH BARRIER = 63.8 dBA

LEQ FROM LEFT UNSHIELDED SEGMENT = .0 dBA
LEQ FROM RIGHT UNSHIELDED SEGMENT= .0 dBA
LEQ FROM MIDDLE SHIELDED SEGMENT = 63.8 dBA

For the lane-by-lane method each lane is considered a separate lane group of 1 lane. For the equivalent lane method, the 2 E/B lanes are grouped together as one lane group of 2 lanes (described by the centerline of near lane), and the 3 W/B lanes are combined as one lane group of 3 lanes, described by the centerline of near lane. In this instance the difference between the two methods is 0.3 dBA with the barrier and 0.1 dBA without.

Problem 4 shows an infinite cut section where the top of cut breaks the line of sight between the receiver and all lanes. The top of cut acts as a barrier and should be treated as such when running the program. As with any barrier problem, this program can only handle lanes parallel to the top of cut (horizontally and vertically). Any parallel cut section should be handled as a barrier, whether the cut shields all lanes completely or not.

The four above problems show some of the capabilities and limitations of "SOUND 2A". Some of these limitations will be eliminated by the Level II program when it becomes operational. Other problems, such as double line of sight breaks need special treatment and good ole' engineering judgment. For further questions, call Rudy Hendriks (ATSS 497-2475) or Dick Wood (ATSS 497-2472).

II-4.10

INSTRUCTION FOR

LEVEL II PROGRAM

"STAMINA"

TO BE INCLUDED LATER

II-4.11

TRANSPORTATION LABORATORY

COMPUTER PROGRAM LISTING

II-4.11 Listing of Computer Programs for Noise

TRANSPORTATION LABORATORY
Enviro-Chemical Branch

NOISE SECTION

Noise Studies - Rudy Hendriks ATSS 497-2475
Computer Applications - Dick Wood ATSS 497-2472

TO CALCULATE	SYSTEM	PROGRAM NAME	DATA REQUIRED	REFERENCE	REMARKS
L_{10}, L_{50} Barrier Design	TENET	5;ENV;ENVSYS Sound1	Traffic, roadway, path and observer characteristics	NCHRP 117/144	Traffic Noise Prediction & Barrier Design; Program simple to operate
L_{10}, L_{50}, L_{eq} Barrier Design	IBM 370 (TEALE)	TMBBN144 (TransLab)	Traffic, roadway, path and observer characteristics	NCHRP 117/144	Traffic Noise Prediction & Barrier Design; Prediction program, Batch Jobs- same as Sound1 -fairly simple
L_{10}, L_{50}, L_{eq}	TENET	5;ENV;ENVSYS LCALC	List of sampled noise data and number of occurrences	TransLab	Field measured traffic noise level will calculate data from watch & clipboard, noise classifier
L_{dn}	TENET	5;ENV;ENVSYS LDNCALC	Daytime and nighttime L_{eq}	TransLab	Field measured traffic noise level or predicted traffic noise level Daytime 0700-2200 hrs Nighttime 2200-0700 hrs
Barrier Design (based on peak)	TENET	5;ENV;ENVSYS NOISEBAR	Source level, barrier CHARACTERISTICS	Rettinger TM Calif. 702A	Barrier design; noise diffraction program based on Fresnel integrals for Calif. School noise only
Barrier Design (based on L_{eq})	TENET	5;ENV; Sound2A	Traffic, roadway, path and observer characteristics	FHWA-RD-78-139	Traffic Noise Prediction & Barrier Design; Program simple to operate
Barrier Design (based on L_{eq})	IBM 370 (TEALE)	TMENV LVL2M	Traffic, roadway, path and observer characteristics	FHWA-RD-78-138	Traffic Noise Prediction and Barrier Design

CHAPTER II-5

MITIGATION OF HIGHWAY NOISE

Chapter II-5

Mitigation of Highway Noise

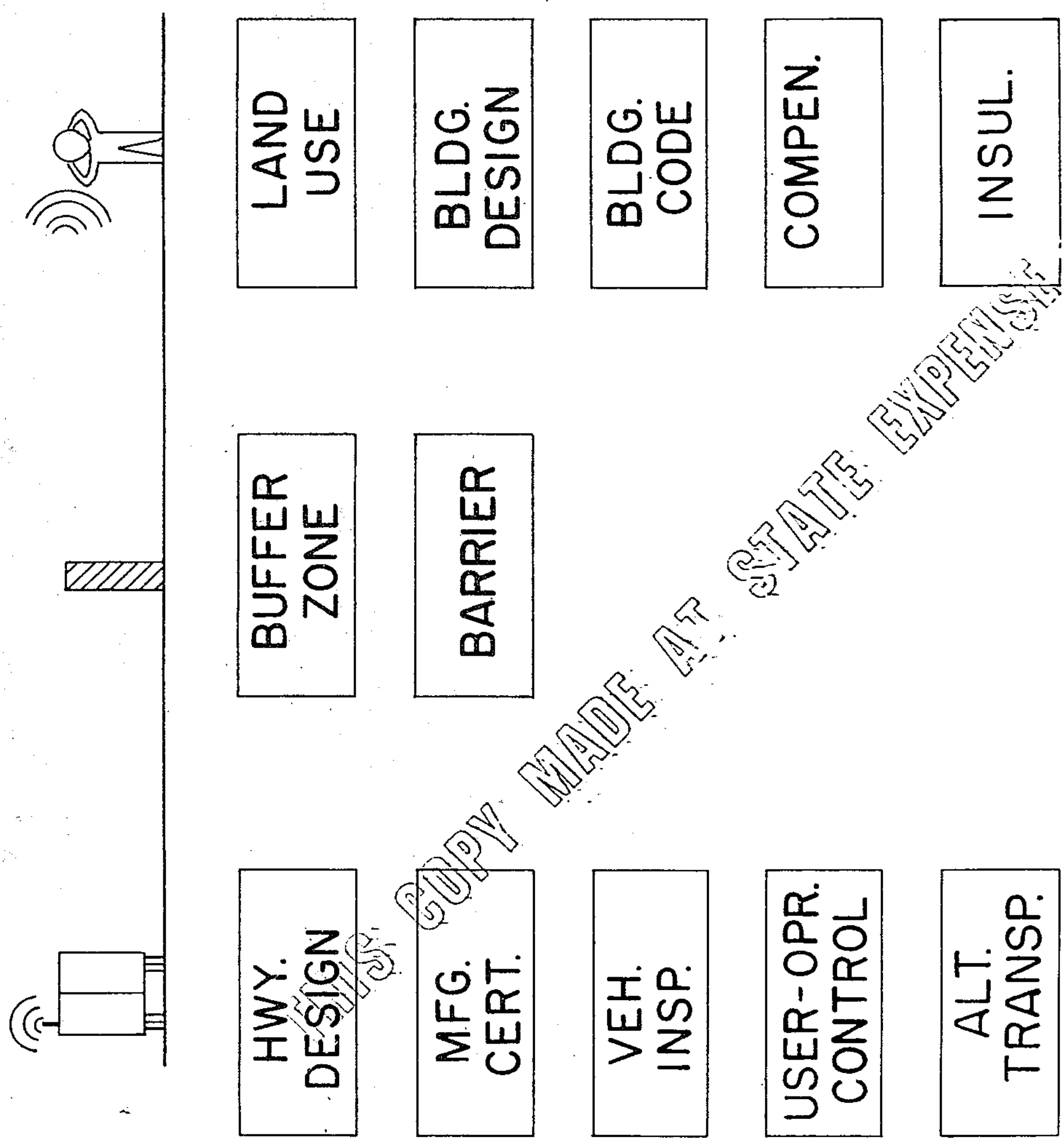
This chapter discusses various mitigation measures which can minimize or eliminate highway noise. Most of these items are beyond the scope of the Department of Transportation but are sometimes covered in noise reports.

Figure II-5.1 shows a schematic of the noise source and receiver. The mitigation measures to quiet the source are listed below the source. Those measures to protect the receiver are listed below the receiver. A third way is to increase the distance or interrupt the noise path.

A brief description of each mitigation measure is covered in Section II-5.1.

Section II-5.2 is devoted to a brief discussion on barriers because it is a significant part of Caltrans program to minimize effect of traffic noise.

Figure II-5.1



LAND USE
BLDG. DESIGN
BLDG. CODE
COMPEN.
INSUL.
BUFFER ZONE
BARRIER
HWY. DESIGN
MFG. CERT.
VEH. INSP.
USER-OPR. CONTROL
ALT. TRANSP.

II-5.1 MITIGATION OF HIGHWAY NOISE (Figure II-5.1)

Highway Design - Consider things such as grade, alignment, type of surfacing, cut or fill.

Manufacturers Certification - Under EPA jurisdiction where trucks manufactured for sale in interstate commerce meet certain noise levels. California also has a vehicle code which regulates noise levels of new vehicles.

Vehicle Inspection - California Highway Patrol enforces about 12 vehicle codes related to operation, mufflers, etc.

User Operator Control - Educate operators in vehicle maintenance, reroute traffic, set speed limits and night restrictions.

Alternate Transportation - Bicycle

Buffer Zone - Purchase additional R/W or use wide medians.

Barriers - Artificial or Natural.

Land Use - Control through zoning regulations is exercised by cities and counties so noise sensitive receptors are not constructed near highways.

Building Design - California Administrative Code Title 25. New construction must meet CNEL of 45 dBA (interior). Commercial buildings may be regulated by local codes.

Building Codes - Local ordinance requiring builders to meet an interior noise level of CNEL 45 dBA. Certain jurisdictions also regulate exterior levels and apply maximum dBA level criteria.

Compensation - Paying damages for noise levels from highway which exceeds a specified limit.

Insulation - Adding insulation to existing homes which reduces interior noise and provides a secondary benefit of energy savings.

II-5.2 Noise Barrier

The effectiveness of a barrier is a function of how much it extends above the line of sight between the source and the receiver. It must also be of sufficient length to minimize flanking noise around the ends of the barrier. The noise that goes through the wall (transmission loss) is negligible if the material weighs at least four pounds per square foot.

Aesthetics is an important consideration in construction of barriers. Appendix 1C, References, Items 7 and 23 provides FHWA manuals to help incorporate aesthetics into the design of barriers. Landscaping is an integral part of the highway where sufficient right of way is available.

Noise that reflects off noise walls and median barriers to receptors on the opposite side of the highway, has been perceived as a problem by some people. The noise source is doubled if the vehicle is very close to the barrier. If all the noise were reflected, this situation would result in a 3 dBA increase. This does not occur because the vehicle itself blocks some of the noise and some decrease results from the increased distance sound travels to the wall and back to the receiver.

There may be special situations where parallel barriers are constructed on both sides of the highway where multiple reflections can occur. This may result in degrading barrier performance by more than 3 dBA on either side of the highway if the barriers are situated at a certain elevation. This situation can be corrected by using sound absorbing material on the face of the barrier or by tilting the barriers about 5 degrees off of vertical, sloping away from traffic.*

*Menge, C. W.; "Sloped Barriers For Highway Noise Control," Internoise 78 Conference; San Francisco, Calif.; May 1978.

CHAPTER II-6

ELEMENTS OF A HIGHWAY NOISE STUDY

Chapter II-6

Elements of a Highway Noise Study

II-6.1 Planning the Study

Noise studies generally fall into two major categories. The first case (Type I Projects) includes construction or reconstruction of a section of highway. This may involve a new alignment, adding a lane, or replacing a structure. The second case (Type II Projects) involves retrofitting noise barriers to existing highways (Community Noise Program). A noise report is required in both situations.

An outline of the study plan might involve the following elements:

- Preliminary Planning
- Coordination
- Field Investigation
- Land Use
- Community Involvement
- Noise Report

Specific requirements for the study are shown in FHPM 7-7-3.

Figure 6.1 shows a flow diagram for project development. In general, the various elements are covered for both cases. This section does not go beyond the Noise Report.

II-6.2 Preliminary Planning

The resources needed and available are placed in proper perspective. Time, money, manpower, and equipment deadlines and schedules are planned. Maps are obtained and project objectives are established. These might be to determine ambient sound levels and potential or actual impact to various sensitive receptors. Traffic data are obtained and a preliminary estimate can be made of the potential impacts upon sensitive activity.

II-6.3 Coordination

Various organizations such as local officials, other state agencies, landscape, environmental, traffic, maintenance, and structures may become a part of the study team or be made aware that the noise study is being performed. This coordination is important because it may affect the planning for improvement of the total transportation system. The study team should hold preliminary meetings early in the planning stage. Appendix II-B, FHPM 7-7-3, Paragraph 10, Policies for coordination with Local Officials, provides the supplementary information needed by the study team. Caltrans requirement for a Citizen Aesthetic Advisor is covered in Appendix III-L.

II-6.4 Field Investigation

A field review is made for project familiarization and to study feasibility, general location of facility, landscape and utilities considerations for possible mitigation purposes. Sites for measurements are located so that they are representative of the sensitive receptors or activities that might be impacted. Traffic counts are made at the same time as noise measurements.

As part of the field investigations, noise levels are determined for the present, future, no-build and build situations projected 10 to 20 years. Mitigation measures are considered and preliminary barrier designs are developed. Construction noise analysis is performed and mitigation measures proposed for the project.

II-6.5 Adjacent Land Use

Certain land uses are synonymous with human activity. Potential impact is determined as part of the study. FHPM 7-7-3, paragraph 8 (Appendix H) provides design guideline activities which allows the study team to assess impact. The investigators should be especially aware of things such as parks, schools, churches, hospitals, residences, motels, hotels, public meeting rooms and other areas where human activities occur.

II-6.6 Community Involvement

Public meetings are held to obtain citizen input into the project.

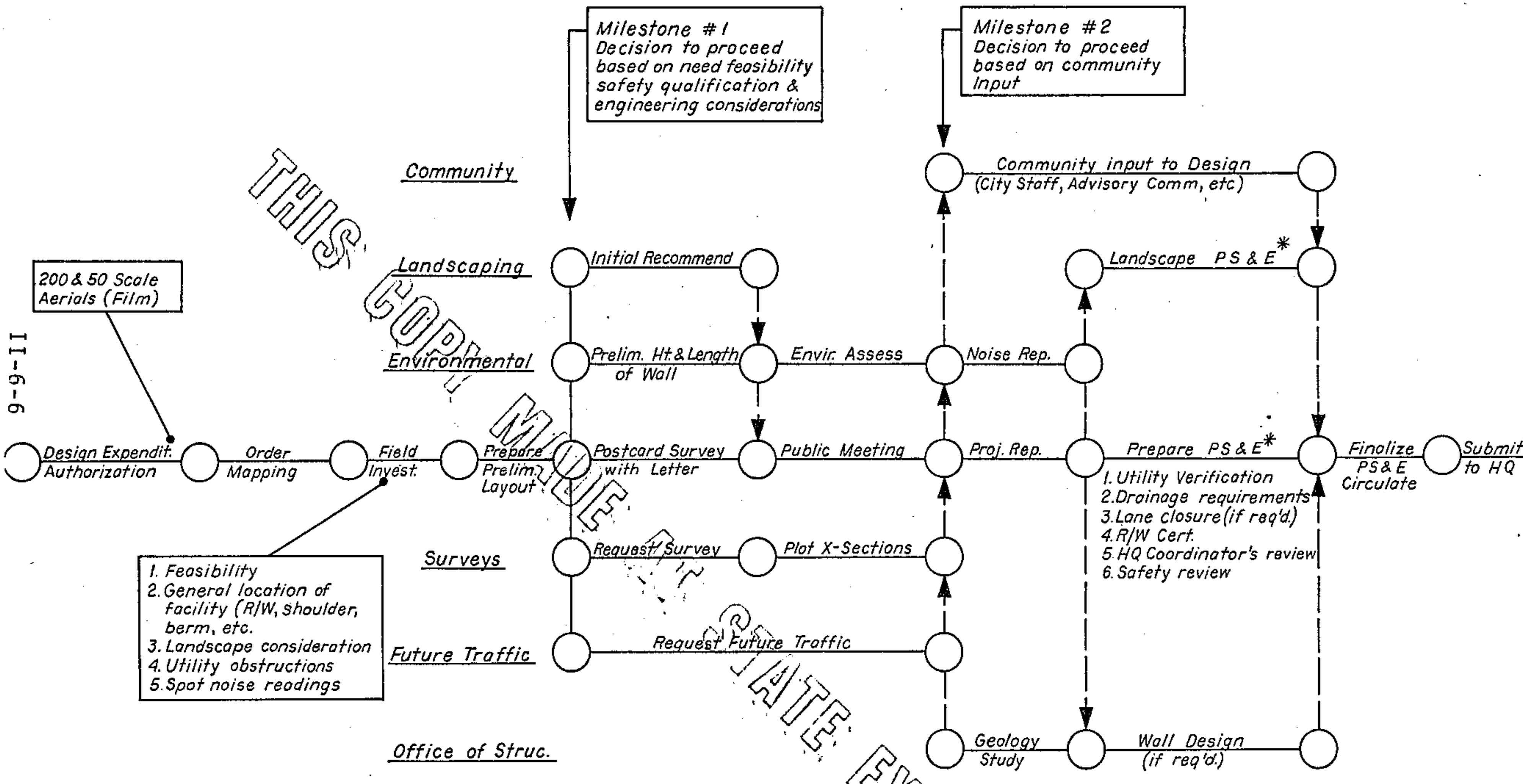
For the community noise program, a preliminary letter or postcard survey may be used. If the citizens indicate they do not want barriers, no further project development is necessary. If the response is positive, project development proceeds and public hearings are held to complete the study.

Community input is not a one time involvement but should be continuous throughout a barrier project.

II-6.7 Noise Study Report

Approval of the noise study and project reports by FHWA results in preparation of the final design, plans, specifications and estimates to construct the project.

The requirements for federally participating projects are covered in FHPM 7-7-3. Section 7C (Appendix IIC) of the manual shows the requirements for a Noise Study Report.



* Plans, Specifications and Estimates.

GENERAL PROGRESS SCHEDULE FOR NOISE BARRIER PROJECTS

District 04

FIGURE II-6.1

CHAPTER II-7

CONSIDERATIONS
FOR A
NOISE STUDY REPORT

Chapter II-7

Noise Study Report

This chapter is a discussion of the contents of technical environmental reports. Its purpose is to provide guidance to the writer in preparation of the Noise Study Report.

The initial Noise Study Report is the basis for the Project Report for noise barrier projects. The Noise Study Report along with a transmittal letter constitutes the Project Report.

A final Noise Study Report is required by FHPM 7-7-3 to be submitted with the PS&E. The report is short and outlines any changes occurring during the design stage and verifies that the noise mitigation measures are adequate to accomplish the project objectives. It also outlines any exceptions to federal guidelines or standards.

NOISE STUDY REPORT

Content and format for various technical environmental reports are very similar. Certain functions have to be performed by the report regardless of whether the study involves air quality, water quality, noise, or environmental resources such as energy.

The primary function of an environmental document is that of communication. Impact information has to be presented to two basically different groups of people, the technical and the non-technical. The report must communicate equally with both groups. In the non-technical sense, information must be in a form suitable for presentation at a public hearing, for use by executives and lay groups in decision making, and for incorporation into an EIS. From a technical standpoint, the document must fully support the EIS and must satisfy the needs of the technical reviewer, who wishes to assess the validity of the study and its compliance with environmental law.

To satisfy these two levels of need, the report is written in two parts. The technical part is written first, the first part is then rewritten to summarize, in nontechnical language, the more important findings of the study. This summary can be presented, depending on the study objectives, in a form suitable for incorporation in an EIS.

In a Noise Study Report, particularly in the summary, the values reported should reflect the accuracy of the analysis. Reporting fractional decibel values is never warranted.

A report may involve a broad category (planning, design, construction, or operation and maintenance). The functions to be served by a report will vary widely depending on the objectives defined in the study phase. A relatively complete study might serve several of the following functions:

1) To describe existing ambient noise as a baseline against which future changes can be evaluated.

2) To provide traffic noise data, any impacts, and mitigation information for input to the environmental impact statement.

3) To provide planners with noise information which will enable logical trade-off analyses in system planning, mode selection, and corridor location.

4) To provide designers with noise information which will enable logical trade-off analyses in geometric design, volume and flow alternatives, and materials used for barriers.

5) To provide information on construction noise and methods for mitigation.

6) To provide noise information which specifically addresses noise sensitive receptors such as schools, hospitals, churches, residence, etc.

Considering the various functions of a relatively comprehensive report, the following outline presents a basic and flexible format in which to present a noise study. The process must be executed for each alternative proposed including the "No Build".

II-7.1 INTRODUCTION

The introduction should be a short narrative statement describing the existing situation, the need for the proposed improvement, and the location and extent of the various alternatives in sufficient detail to provide the reader with a mental picture of the work to be done. The project description must give the reader some indication as to the background of the project, including public concerns, so that the reader fully understands the context and the transportation system into which the project fits.

Some items of consideration are as follows:

A. Project Description
   1. Location (maps)
   2. Proposed improvement

B. Scope of Analysis
   1. Time period

C. Highway Noise Fundamentals
   1. Reference to informative literature
   2. Definitions (dBA, L_{eq}, etc.)

II-7.2 CONCLUSIONS OR SUMMARY

The conclusions are presented early in the report. This allows the person who does not desire to dig through the detail to read the project description and the conclusions and thus obtain a cursory knowledge of the project. In the conclusions, the first thing to be discussed should be answers to the questions for the environmental impact statement. Secondly, the findings, as they apply to the following headings, (a) potential problems in planning (b) design mitigation and possible enhancement, and (c) construction control, should be presented briefly. The final portion of the conclusions should present the written and tabular data summaries covering the above items. These can be interspersed with graphic data presentations.

In this manner, the conclusions, in conjunction with the project description, enable the layman to understand the impact of noise, provide the EIS writer with some basic answers to the noise aspects of the questions he needs to answer, and provide transportation engineers, in the planning, design, construction, and maintenance areas, with warning flags marking areas which need further consideration.

II-7.3 Existing Noise Environment

The background discussion provides information on the project in terms of its noise setting. It shows measurement data related to the sensitive receptors. It also provides a "memory freshener" for study review in the future.

Some items of consideration are as follows:

A. Description of the study area (maps)
   1. Show measurement sites (maps)
   2. Show sensitive receptors (maps)

B. Tabulation and discussion of ambient measurement data
   1. Show and discuss ambient conditions
      a. On new alignment
      b. For improvement of existing route
      c. Combination of the two

C. Traffic Data (ambient)

D. Ambient Noise Contours

II-7.4 Predicted Noise From Proposed Improvement.

A description of the analytical approach is necessary for the technical reviewer. Reference should be made to the procedure acceptable to the FHWA. This provides an indication of the technical adequacy of the document. The approach should be discussed in sufficient detail to allow review of the important steps and show continuity in the analysis.

Some items of consideration are as follows:

A. Summary of Predicted Traffic Data (peak hour traffic, speed, percent autos, medium and heavy trucks).

B. Maps showing predicted noise level vs. distance to sensitive receptors and measurement sites (this may be shown as part of III D).

   1. from main lines
   2. from ramps and feeder roads

C. Noise control from barriers

   1. Cuts
   2. Fills
   3. Vegetation
   4. Trees
   5. Structures & Buildings
   6. Noise control expected from normal design features

D. Noise Contours - predicted post-construction

II-7.5 Impact Assessment

The anticipated beneficial and adverse noise impact of the various alternatives should be discussed. (1) Noise impact is broadly defined as being significant when it will substantially exceed the existing noise levels; (2) when it will exceed the FHWA design guidelines; (3) when it is decreased by a build option but will still exceed the guidelines.

Some items of consideration are:

A. Compare predicted with ambient (measured)

B. Compare predicted and ambient with Design Criteria (FHPM 7-7-3) on a build and no build basis

C. Discuss Impacts

1. Impacts may occur even though the Design Criteria are not exceeded. As an example, the present ambient level may be 50 dBA and the future predicted level may be 60 dBA which is below the FHWA Design Criteria but it has doubled the perceived noise level.

2. Discuss and show extent of impact and numbers and types of activities affected

3. Extent of impact in decibels

D. Identify Special Problem Areas

1. Present a site plan with general land use superimposed over the predicted noise level contours or this may be identified in general terms.

E. Mention adverse effects from construction of barriers such as reducing open space and view, creating a shadow zone and blocking air circulation.

II-7.6 Special Noise Problems

This part identifies items which may create problems requiring special attention. Items for consideration are:

A. Special noise sensitive locations

B. Ratio of outside to inside noise in sensitive buildings (hospitals, churches, schools, etc.)

C. Special needs for lower design standards

D. Detailed noise reduction design analysis

E. Special Problems in urban areas

F. Construction Noise

II-7.7 Mitigation - Enhancement

This section serves as input to the project design. It describes not only the permanent measures but also those temporary measures which can be foreseen as desirable during the construction process and which should be encompassed by the project design.

Items for consideration are:

A. Discussion of size and types of noise reduction treatment required. (Barriers, cuts, fills, vegetation, building insulation, etc.)

B. Discussion of feasible designs and approximate benefits to be gained. Make mention of future noise levels which may be lower than present ambient if this is the case.

C. Discussion of impact situations where fully adequate noise reduction treatments are not feasible. (Request exception from FHWA).

D. Construction of barriers as a first item during the construction project.

E. Use of Standard Specifications and Special Provisions to minimize noise impact.

II-7.8 Bibliography

In this section the sources of the historical data used in the report and sources for statements that were made should be listed for the benefit of the reader.

II-7.9 Appendices

The detailed data and procedures are usually placed in this part of the report. Information of this type is usually not of interest to the average reviewer.

Items of consideration are as follows:

A. Noise Measurement Procedures, Data, Instrumentation System, Calibrations, Quality Assurance Systems.

B. Tabulations of Traffic Data and Analysis Used

C. Discussion of Prediction Methodology and Sample Calculations

D. Noise Reduction Methodology and Sample Design Calculations

E. Special Problem Analysis and Computations

Note: Data from II-7.3, II-7.4, II-7.5, II-7.6, and II-7.7 should be displayed in a table and simply transferred to the EIS. An example table is on the following page (Figure II-7.1).

RECOMMENDATIONS

Recommendations would not be written for inclusion in an EIS. This section might be written to summarize information presented as an input to the various phases of a project and serves to identify opportunities for abatement of noise. For studies not concerned with an EIS input, the section might provide recommendations as to a preferred alternative action from a noise standpoint.

RECEPTOR	NO BUILD		BUILD		FHWA
	EXIST 1976	PREDICTED 1996	PREDICTED 1996	PREDICTED W/WALL 1996	GUIDLINE Leq
SCHOOL	60	54	56	51	52
RESIDENCE	65	72	74	64	67

Figure II-7.1

CHAPTER II-8

REVIEWER'S CHECKLIST
FOR
NOISE STUDY REPORTS
AND
NOISE PART OF EIS AND EIR

Chapter II-8

Reviewer's Checklist for Noise Reports and Noise Part of EIS and EIR

General

Environmental Noise Reports, Environmental Impact Statements (EIS) Environmental Impact Reports (EIR) and Negative Declarations are communication documents. They are intended to fully disclose any adverse impacts, mitigation measures or enhancement of the environment due to construction of a transportation facility.

Substance of the information conveyed rather than the length or detail of the statement should be stressed. Ideally, the Noise Report is a combination technical document containing details and a summary which can be lifted and used in the EIS or EIR. The summary should be easily understood by a layman. Enough information should be provided so that the readers can reach the same conclusions based on the data presented.

A "Noise Review Checklist" (Figure II-8.1) is provided as an aid to reviewers. To use the check list, the reviewer should check the appropriate Yes, No, Not Applicable column for each item listed. If there are any comments concerning a particular item, a reference number is noted on the "Comment No." column (Figure II-8.1) and is also repeated on the "Amplification of Comments" (Figure II-8.2) with the reviewers discussion. Normally a check in the Yes or Not Applicable column would not require a comment but may be offered to improve the report. A check in the No column would always have comments.

Figure II-8.1

Noise Report Review Checklist

District ___ Co. ___________ Rte. ___________ PM ___________ W.O. ___________

Reviewed By ________________ Date ___________

Item	Covered In Report: Yes	Covered In Report: No	Covered In Report: Not Applicable	Comment No.
1. Project Description				
a. Proposed improvement				
b. Alternatives				
c. Anticipated benefits				
d. Maps				
e. Scope of analysis (objectives)				
f. Time period				
g. Highway noise fundamentals				
h. Reference to informative literature				
i. Definition				
2. Background				
a. Applicable laws, regulations, codes, etc.				
b. Population affected				
c. Public attitudes				
3. Conclusions or Summary				
a. Environmental setting/project				
b. Impacts				
c. Mitigation				
d. Enhancements				
e. Potential problems (design, construction, maintenance)				

Figure II-8.1

Noise Report Review Checklist

District ___ Co. __________ Rte. __________ PM _________ W.O. _________

Reviewed By _______________ Date __________

Item	Covered In Report: Yes	No	Not Applicable	Comment No.
4. Existing Noise Environment				
a. Map of study area (show all alternatives)				
b. Measurement sites identified				
c. Sensitive receptors identified				
d. Ambient conditions				
e. Traffic data				
f. Noise contours				
g. Current traffic data				
5. Predicted Noise				
a. Predicted traffic data (how obtained)				
b. Predicted noise levels				
c. Methodology for predicting noise				
d. Prediction affected by cuts				
e. Prediction affected by fills				
f. Prediction affected by vegetation				
g. Prediction affected by trees				
h. Prediction affected by structures				
i. Prediction affected by barriers				
j. Prediction affected by highway design				
k. Predicted noise level contours				

Figure II-8.1

Noise Report Review Checklist

District ___ Co. __________ Rte. __________ PM __________ W.O. __________

Reviewed By ______________ Date __________

Item	Covered In Report: Yes	No	Not Appli-cable	Comment No.
6. Impact Assessment				
a. Positive or negative impact				
b. Compare ambient, predicted and Design Criteria				
c. Number, extent and types of activities affected				
d. Special problem areas				
e. Land use site plan				
f. Adverse effects of barriers				
7. Special Situations				
a. Schools (Section 216, Streets and Highways Code)				
b. Hospitals, churches, etc.				
c. Special needs for lower standards				
d. Inside-outside measurements (sensitive receptors)				
e. Detailed mitigation analysis				
f. Special problems in urban areas				
g. Construction noise impact and mitigation				

Figure II-8.1

Noise Report Review Checklist

District ___ Co. __________ Rte. __________ PM __________ W.O. __________

Reviewed By _______________ Date __________

Item	Covered In Report: Yes	No	Not Appli-cable	Comment No.
8. Mitigation - Enhancement				
a. Benefits from barriers				
b. By highway design (cuts, fills, vegetation, etc.)				
c. Heights and length of barriers (for design guidance)				
d. By traffic controls				
e. Build barriers first on construction projects				
f. Use of Standard Specs and Special Provisions				
g. Any impacts from mitigation efforts				
h. Exception request where mitigation is not feasible				
i. Cost estimates				
9. Bibliography				
10. Appendices				
a. Measurement procedures and systems				
b. Noise level data				
c. Graphic level recordings				
d. Quality assurance				
e. Traffic data and how derived				
f. Prediction methodology				
g. Barrier design methodology				
h. Special problem analysis				

Figure II-8.1

Noise Report Review Checklist

District ___ Co. __________ Rte. __________ PM __________ W.O. __________

Reviewed By _______________ Date __________

Item	Covered In Report: Yes	No	Not Applicable	Comment No.
10. Appendices (Continued)				
i. Identify study personnel				
j. Identify public contract/ coordination				
k. Public input (phone calls, letters, petitions)				
l. Location where report is available				
11. Recommendations				
a. Do not include in EIS or EIR				
b. Might provide for other reports				
12. Suitability EIS, EIR Vs Technical Report				
a. Language (lay or technical)				
b. Simple, clear charts and tables				
c. Conciseness				

Figure II-8.2

AMPLIFICATION OF COMMENTS

Comment No.	Comment

REFERENCES

1. FHPM 7-7-1, December 30, 1974
Process Guidelines (For the Development of Environmental Action Plans)

2. FHPM 7-7-2, January 2, 1976
Environmental Impact and Related Statements

3. FHPM 7-7-3, May 14, 1976
Procedures For Abatement of Highway Traffic Noise and Construction Noise

4. Environmental Handbook
Caltrans' Office of Environmental Planning

5. Preparation of Environmental Impact and 4(f) Statements
FHWA Training Manual

6. California Streets and Highways Code Section 216

APPENDIX IIA

References for Section II

The References listed in Section I are applicable to both sections I and II. A supplementary list for Section II is shown on the next page.

REFERENCES

1. Barry, T. M. and Reagon, J. A.: "FHWA Highway Traffic Noise Prediction Model", U.S. Department of Transportation, Federal Highway Adminsitration, Report No. FHWA-RD-77-108, July 1978.

2. Rudder, F. F., Jr. and Cheung, P.: "User's Manual FHWA Level 2 Highway Traffic Noise Prediction Model", U.S. Department of Transportation, Federal Highway Administration, Report No. FHWA-RD-78-138, July 1978.

3. Ma, Y.Y. and Rudder, F. F., Jr.: "Statistical Analysis of FHWA Traffic Noise Data", U.S. Department of Transportation, Federal Highway Administration, Report No. FHWA-RD-78-64, July 1978.

4. Gordon, C. G., et.al.: "Highway Noise, A Design Guide for Engineers", Highway Research Board, National Academy of Sciences, Report NCHRP 117, 1971.

5. Kugler, B. A., et.al.: "Highway Noise, A Design Guide for Prediction and Control, Highway Research Board, National Academy of Sciences, Report NCHRP 174, 1976.

6. Simpson, M. A.: "Noise Barrier Attenuation: Field Experience", U.S. Department of Transportation, Federal Highway Administration, Report No. FHWA-RD-76-54, February 1976.

7. Anon.; "Proposed Motorcycle Noise Emission Regulations: Background Document", U.S. Environmental Protection Agency Office of Noise Abatement and Control, Report No. EPA 550/9-77-203, November 1977.

8. Rudder, Jr., F. F. and Lam, D. F., "Users Manual: FHWA Highway Traffic Noise Prediction Model", SNAP 1.0, Report No. FHWA-RD-78-139", January 1979.

9. Rudder, Jr., F. F., Lam, D. F. and Cheung, P., "Users Manual: FHWA Level 2 Highway Traffic Noise Prediction Model", STAMINIA 1.0, Report No. FHWA-RD-78-138", May 1979.

APPENDIX IIB

FEDERAL LAWS AND REGULATIONS

Appendix IIB

Federal Laws and Regulations

The following are various laws and regulations that directly and indirectly apply to Caltrans activities.

1. Public Law 91-190; National Environmental Policy Act of 1969; January 1, 1970

This Act specifies the Environmental Protection Agency as the Federal Agency responsible for administering the act and establishing standards for environmental quality. It declares national policy for harmony between man and his environment. An Environmental Impact Statement (EIS) is required for all Federal projects.

2. Federal Air Highway Act of 1970

This Act requires the Secretary of the U.S. Department of Transportation (USDOT) to promulgate guidelines designed to assure that possible adverse environmental (air, noise, water) effects relating to any proposed project on any Federal Air System have been fully considered. It also required the USDOT to establish noise standards.

3. Public Law 92-574; Noise Control Act of 1972; October 27, 1972

A national policy to promote an environment for all Americans free from noise that might jeopardize their health and welfare. The primary Federal responsibility is for noise source emission control while the states and other political subdivisions retain rights to establish and enforce controls through licensing, operation, and restrictions on use or movement.

4. Public Law 93-87; Federal Aid Highway Act of 1973; August 13, 1973

This Act required promulation of Noise Level Standards by the Secretary of Transportation.

5. Department of Transportation, Federal Highway Administration; Interstate Motor Carrier Noise Emission Standards; September 12, 1975

The Bureau of Motor Carrier Safety establishes measurement procedures and methodologies for determining whether commercial motor vehicles conform to the Interstate Motor Carrier Noise Emission Standards of the Environmental Protection Agency.

6. Department of Labor; Occupational Safety and Health Administration (OSHA), Occupational Noise Exposure; October 24, 1971

Established maximum permissible noise exposure level for employees. It also requires employer to take certain actions when permissible levels are exceeded.

7. Environmental Protection Agency; Noise Emission Standards for Transportation Equipment, Medium and Heavy Trucks; April 13, 1976

Established maximum emission levels for the years 1978, 1982 and 1985 as 83 dBA, 80 dBA and (reserved) for trucks with a gross vehicle weight rating greater or equal to 10,000 pounds.

8. Environmental Protection Agency; Portable Air Compressors, Noise Emission Standards; January 14, 1976

Establishes an emission level of 76 dBA at 7 meters. Establishes maximum average sound levels of 76 dBA at 7 meters. These regulations become effective January and July, 1978 depending on the size of the unit.

9. Environmental Protection Agency; Railroad Noise Emission Standards; January 14, 1976

Establishes limits for stationary and operation under moving conditions for locomotives manufactured after December 1976 and 1979.

10. Federal Highway Administration; Federal Highway Program Manual (FHPM) 7-7-3; May 14, 1976

Establishes noise standards related to highway noise, acceptable descriptors and methodologies for predicting noise and requires some general steps concerning construction noise. FHPM 7-7-3 is printed in Appendix H since it is one of the most important documents for highway projects related to noise.

11. Environmental Protection Agency; Mandated (5/28/77) and Proposed in Federal Register (1978)

    1. Wheel and Track Loader Regulations
    2. Wheel and Track Dozer Regulations
    3. Truck Transport Refrigeration Units Regulations
    4. Truck Mounted Solid Waste Compactor Regulations
    5. Motorcycle Regulations
    6. Bus Regulations
    7. Pavement Breaker and Rock Drills Regulations

APPENDIX IIC

FEDERAL HIGHWAY PROGRAM MANUAL

Volume 7
Chapter 7
Section 3

U. S. DEPARTMENT OF TRANSPORTATION

FEDERAL HIGHWAY ADMINISTRATION

FEDERAL-AID HIGHWAY PROGRAM MANUAL

VOLUME	7	RIGHT-OF-WAY AND ENVIRONMENT
CHAPTER	7	ENVIRONMENT
SECTION	3	PROCEDURES FOR ABATEMENT OF HIGHWAY TRAFFIC NOISE AND CONSTRUCTION NOISE

Transmittal 192
May 14, 1976
HEV-21

1. PURPOSE

To promulgate:

a. policies and procedures for noise studies and noise abatement measures,

b. design noise levels, and

c. requirements for coordination with local officials for use in the planning and design of highways approved pursuant to Title 23, United States Code.

2. AUTHORITY

23 U.S.C. 109(h), 109(i), and 42 U.S.C. 4331, 4332.

*Regulatory material is italicized.

3. NOISE STANDARDS

The highway traffic noise studies, noise abatement procedures, coordination requirements, and design noise levels in this directive constitute the noise standards mandated by 23 U.S.C. 109(i). All highway projects which are developed in conformance with this directive shall be deemed in conformance with the FHWA noise standards.

4. DEFINITIONS (as used in this directive)

a. *Buffer Zone - lands, properties, and parcels (or portions thereof) adjacent to a highway acquired either in fee or a lesser interest for the purpose of preempting development which would be adversely impacted by traffic noise and for other noise abatement purposes.*

b. *Control of Access - the condition where the right of owners or occupants of abutting land or other persons to access, light, air, or view in connection with a highway is fully or partially controlled by public authority.*

(1) *Full control of access means that the authority to control access is exercised to give preference to through traffic by providing access connections with selected public roads only and by prohibiting crossings at grade or direct private driveway connections.*

(2) *Partial control of access means that the authority to control access is exercised to give preference to through traffic except that, in addition to access connections with selected public roads, there may be some crossings at grade and some private driveway connections.*

(3) *Uncontrolled access means that the authority having jurisdiction over a highway, street, or road does not limit the number of points of ingress or egress except through the exercise of control over the placement and the geometrics of connections as necessary for the safety of the traveling public.*

c. *Date of Public Knowledge of a Proposed Highway Project - the date that the highway agency officially notifies the public of the adoption of the location of a proposed highway project.*

d. *<u>Design Noise Levels</u> - the noise levels established by this directive for various activities or land uses which represent the upper limit of acceptable traffic noise level conditions. These levels are used to determine the degree of impact of traffic noise on human activities.*

e. *<u>Design Year</u> - the future year used to estimate the probable traffic volume for which a highway is designed. A time 10 to 20 years from the start of construction is usually used.*

f. *<u>Existing Noise Levels</u> - the noise, made up of all the natural and manmade noises, considered to be usually present (unique noise events may be excluded) within a particular area's acoustical environment.*

g. *<u>Highway Section</u> - a finite length of highway proposed for development between logical termini (population centers, major traffic generators, major crossroads, etc.) as normally included in a location study or multiyear highway improvement program.*

h. $\underline{L_{10}}$ *- the sound level that is exceeded 10 percent of the time (the 90th percentile) for the period under consideration. This value is an indicator of both the magnitude and frequency of occurrence of the loudest noise events.*

i. $\underline{L_{10}(h)}$ *- the hourly value of* L_{10}.

j. $\underline{L_{90}}$ *- the sound level that is exceeded 90 percent of the time (the 10th percentile) for the period under consideration.*

k. $\underline{L_{eq}}$ *- the equivalent steady state sound level which in a stated period of time would contain the same acoustic energy as the time-varying sound level during the same time period.*

l. $\underline{L_{eq}(h)}$ *- the hourly value of* L_{eq}.

m. *<u>Level of Service C</u> - traffic conditions (used and described in the Highway Capacity Manual - Highway Research Board, Special Report 87, 1965) where speed and maneuverability are closely controlled by high volumes, and where drivers are restricted in their freedom to select speed, change lanes, or pass.*

n. *Location Approval* - *the approval which establishes the general location for a highway section based upon a location study report (in accordance with FHPM 7-7-5) or the adoption of a final environmental impact statement or negative declaration (where the highway agency has implemented paragraph 11b(7) and (8) of the Process Guidelines--FHPM 7-7-1).*

o. *Metropolitan Planning Organization* - *the organization, designated by the Governor, as being responsible, together with the State, for carrying out the provisions of 23 U.S.C. 134, as required by 23 U.S.C. 104(f)(3), and capable of meeting the requirements of 49 U.S.C. 1603(a).*

p. *Noise Level* - *the sound level obtained through use of A-weighting characteristics specified by the American National Standards Institute (ANSI) Standard S1.4-1971. The unit of measure is the decibel (dB), commonly referred to as dBA when A-weighting is used.*

q. *Noise Standards* - *the highway traffic noise studies, noise abatement procedures, coordination requirements, and design noise levels in this directive.*

r. *Operating Speed* - *the highest overall speed at which a driver can travel on a given highway under favorable weather conditions and under prevailing traffic conditions, without at any time exceeding the safe speed as determined by the design speed on a section-by-section basis.*

s. *Partial Noise Abatement Measures* - *measures taken to reduce the noise impact but not to a level below the design noise levels.*

t. *Project Development* - *actions described in State action plans developed pursuant to FHPM 7-7-1 (Process Guidelines), and specific studies, surveys, coordination, reviews, approvals, and other activities and steps normally engaged in to determine the location, to perform the design, and to prepare the plans, specifications and estimates for a highway project.*

u. *Traffic Noise Impacts* - *impacts which occur when the predicted traffic noise levels approach or exceed the design noise levels, or when the predicted traffic noise levels substantially exceed the existing noise levels.*

v. *Truck* - *any motor vehicle (including buses) having a gross vehicle weight greater than 10,000 pounds.*

w. *<u>Type IA Project</u> - a proposed Federal or Federal-aid highway project for construction or reconstruction of a section of highway (or portion thereof) which has either partial or full control of access and for which the highway location is approved after July 1, 1972, or the authorization to advertise for bids for the major grade and drain elements is given after July 1, 1976. Projects unrelated to traffic noise such as lighting, signing, landscaping, safety, etc., are not considered construction or reconstruction of a highway section.*

x. *<u>Type IB Project</u> - a proposed Federal or Federal-aid highway project for construction or reconstruction of a section of highway (or portion thereof) on which the access is uncontrolled and for which the highway location is approved after July 1, 1972, or authorization to advertise for bids for the major grade and drain elements is given after July 1, 1976.*

y. *<u>Type II Project</u> - a proposed Federal or Federal-aid highway project for noise abatement on an existing highway (located on a Federal-aid system) which does not include construction or reconstruction of a highway section (or portion thereof).*

z. *<u>Undeveloped Lands</u> - those tracts of land or portions thereof which do not contain improvements or activities devoted to frequent human habitation or use (including low density recreational use), and for which such improvements or activities are unplanned and not programed.*

5. <u>RETROACTIVITY</u>

The requirements of this directive are not retroactive. Approval actions taken prior to the effective date of this directive, in conformance with Policy and Procedure Memorandums 90-2 dated April 26, 1972, subject: Interim Noise Standards and Procedures for Implementing Section 109(i) Title 23, U.S.C., and February 8, 1973, Subject: Noise Standards and Procedures; and FHPM 7-7-3-1 dated February 20, 1974, shall remain in effect.

6. <u>APPLICABILITY</u>

a. *Type IA Projects (Partial and full control of access) - all requirements of this directive (FHPM 7-7-3) apply to all Type IA projects unless it is specifically indicated that a paragraph applies only to Type II projects.*

b. Type IB Projects (Uncontrolled access) - all requirements of this directive (FHPM 7-7-3), with the exception of paragraphs 7b(6) and 9, apply to all IB projects unless it is specifically indicated that a paragraph applies only to Type II projects.

c. Type II Projects (Specifically for noise abatement) - the development and implementation of Type II projects are not mandatory requirements of 23 U.S.C. 109(i) and are therefore not requirements of this directive. When Type II projects are proposed for Federal-aid highway fund participation (at the option of the highway agency) the provisions of paragraphs 7d, e, 12a, c, d, e, and 13 of this directive shall apply.

d. Type IA, IB, and II Projects - the plans and specifications for Type IA, IB, and II projects shall not be approved by FHWA unless:

(1) the noise study report has been concurred in by FHWA, and

(2) the project has been developed in accordance with the requirements of this directive.

e. Type IA Projects - in addition to the requirements of paragraph 6d, the plans and specifications for Type IA projects shall not be approved by FHWA unless:

(1) noise abatement measures are incorporated to attain reductions to or below the design noise levels for those activities and land uses where predicted noise levels exceed the design noise levels in Figure 3-1, or

(2) partial noise abatement measures are incorporated, where feasible, and exceptions to the design noise levels have been approved by FHWA where the design noise levels cannot be reasonably achieved.

f. Type IB Projects - in addition to the requirements of paragraph 6d, the plans and specifications for Type IB projects shall not be approved by FHWA unless the noise abatement measures identified as feasible (as determined by the analysis in paragraph 7b(5)) have been incorporated in the plans and specifications for Type IB projects.

7. ANALYSIS OF TRAFFIC NOISE IMPACTS AND ABATEMENT MEASURES

a. *In type IA and IB project development, the highway agency shall determine and analyze expected traffic noise impacts and determine the overall benefits which can be achieved by noise abatement measures to mitigate these impacts, giving weight to any adverse social, economic, and environmental effects. The level of analysis may vary from simple calculations for rural and low volume highways to extensive analysis for high volume controlled access highways in urban areas.*

b. *The traffic noise analysis shall be conducted in the following manner:*

(1) *Identify existing activities or land uses which may be affected by noise from the highway section.*

(2) *Predict the traffic noise levels for each alternative under detailed study (including the "do nothing" alternative). Steps 3 through 6 of the traffic noise analysis may be eliminated if it is analytically determined (in accordance with steps 1 and 2) that activities or developed land uses are not sufficiently close to the proposed highway improvement to be adversely affected by traffic noise.*

(3) *Measure the existing noise levels for existing activities or developed land uses. Measurements may not be necessary where it is clear that the existing levels are predominantly from the highway being improved and can be satisfactorily estimated using approved noise prediction methods. The purpose of this noise level information is to quantify the existing acoustic environment and to provide a base for assessing the impact of noise level increases. The descriptors (L_{eq} or L_{10}) used to quantify these measurements shall be consistent with the descriptors used for the predicted levels and the design noise levels in Figure 3-1. Measurement systems shall, as a minimum, meet the requirements for Type 2 instruments as specified in ANSI Standard S1.4-1971.*

(4) Compare the predicted traffic noise levels for each alternative under detailed study with the existing noise levels and with the design noise levels in Figure 3-1. This comparison shall also include predicted traffic noise levels for the "do nothing" alternative in the design year. Such information shall be used primarily to describe the noise impact of proposed highway improvements in contrast with noise levels likely to be reached in the same area if no highway improvement is undertaken. Noise impacts can be expected when the predicted traffic noise levels (for the design year) approach or exceed the design noise levels in Figure 3-1, or when the predicted traffic noise levels are substantially higher than the existing noise levels. The comparison between predicted traffic noise levels for the proposed action and the "do nothing" alternative (for the design year) may be used in the consideration of exceptions to the design noise levels.

(5) Examine and evaluate alternative noise abatement measures for reducing or eliminating the noise impact on existing activities; developed lands; and undeveloped lands for which development is planned, designed and programed. This examination shall include a thorough consideration of traffic management measures (e.g., prohibition of certain vehicle types, time use restrictions for certain vehicle types, modified speed limits, exclusive lane designations, traffic control devices or combinations of such measures). Federal law requires a determination that noise abatement measures needed to implement the noise standards have been incorporated into project plans and specifications before they are approved. Because decisions on noise abatement are prerequisites to determining environmental impacts, and because these impacts influence decisions on adoption of a highway location, it is important that a preliminary determination be made. Before adoption of a highway location, the highway agency shall identify:

(a) noise abatement measures which are likely to be incorporated in the project, and

(b) noise impacts for which no apparent solution is available.

(6) *Identify for Type IA projects those lengths of highway (separately for each side of the highway) and those individual land uses where noise abatement measures appear impracticable or not prudent and which may qualify under the exception procedures (paragraph 9a and b).*

c. *Upon completion of the noise analysis for Type IA or IB projects, the highway agency shall prepare a noise study report for FHWA concurrence.*

(1) *The noise study report shall include the following:*

(a) *detailed noise analysis and evaluation information (paragraph 7b),*

(b) *proposed noise abatement measures including descriptive information which portrays their design details, anticipated effectiveness in relation to the design noise levels (paragraph 8) and/or existing noise levels and estimated costs and benefits,*

(c) *requests for exceptions to the design noise levels and supporting information as required and outlined in paragraph 9 (Type IA projects only),*

(d) *discussion of construction noise analysis information, as required in paragraph 13, including proposed contract provisions to minimize or eliminate adverse construction noise impacts, and*

(e) *discussion and documentation of coordination with local officials as required in paragraph 10.*

(2) *The noise study report may be in preparation throughout the project development process but shall be concluded prior to approval of the plans and specifications. Preliminary versions of the report shall be prepared as necessary for environmental statements and for input to decisions on selecting a highway location. Depending on the scope and timeliness of a complete noise report, various sections of the report such as noise impact evaluations, proposed noise abatement measures, noise exception requests, etc., may be processed separately and included in the final report.*

(3) *FHWA concurrence in the noise study report shall constitute its approval of all requested exceptions to the design noise levels contained therein and approval of proposed abatement measures contained therein.*

d. *Highway agencies proposing to use Federal-aid highway funds for Type II projects shall perform a noise analysis similar to that described in paragraph 7b and shall prepare a noise report with recommendations. This noise report shall indicate and describe the noise impacts that have been identified for these type projects. The design noise levels in Figure 3-1 are a suitable yardstick for this determination.*

e. *In requesting Federal construction funding for a Type II project, the highway agency shall indicate the nature of the proposed Type II project and the relative priority with other potential Type II projects in the State. Some of the suggested factors which may be considered in the development of this relative priority are:*

(1) *applicable State law,*

(2) *type of development to be protected,*

(3) *magnitude of the traffic noise impact,*

(4) *cost - benefits,*

(5) *population density of the affected area,*

(6) *day-night use of the property,*

(7) *feasibility and practicability of noise abatement at the site,*

(8) *availability of funds,*

(9) *existing noise levels,*

(10) *achievable noise reduction,*

(11) *intrusiveness of highway noise (L_{10} - L_{90}),*

(12) *public's attitude,*

(13) *local governments' efforts to control land use adjacent to the highway,*

(14) *date of construction of adjoining development,*

(15) increase in traffic noise since the development was constructed,

(16) local noise ordinances,

(17) feasibility of abating the noise with traffic control measures.

8. DESIGN NOISE LEVELS.*

a. The design noise levels in Figure 3-1 represent a balancing of that which may be desirable and that which may be achievable. Consequently, noise impacts can occur even though the design noise levels are achieved. The design noise levels for Categories A, B, C, and E should be viewed as maximum values, recognizing that in many cases, the achievement of lower noise levels would result in even greater benefits to the community. Every reasonable effort shall be taken to achieve substantial noise reductions when predicted noise levels exceed these design noise levels. However, any significant reduction in the existing or predicted noise level will be a benefit, and partial noise abatement measures shall be included in the project development where they are consistent with overall social, economic, and environmental considerations. On the other hand, the adverse social, economic, and environmental effects of providing abatement measures may be too high. For each case where the circumstances warrant, this directive provides for FHWA approval of exceptions to the design noise levels for Type IA projects. Exceptions are not required for Type IB and Type II projects.

b. The design noise levels are to be applied to:

(1) those undeveloped lands for which development is planned, designed, and programed on the date of public knowledge of the highway project,

(2) those activities and land uses in existence on the date of public knowledge of the highway project,

(3) areas which have regular human use and in which a lowered noise level would be of benefit. Such areas would not normally include service stations, junkyards, industrial areas, railroad yards, parking lots, storage

DESIGN NOISE LEVEL/ACTIVITY RELATIONSHIPS 1/

Activity Category	Design Noise Levels - dBA 2/ $L_{eq}(h)$	$L_{10}(h)$	Description of Activity Category
A 3/	57 (Exterior)	60 (Exterior)	Tracts of land in which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose. Such areas could include amphitheaters, particular parks or portions of parks, open spaces, or historic districts which are dedicated or recognized by appropriate local officials for activities requiring special qualities of serenity and quiet.
B 3/	67 (Exterior)	70 (Exterior)	Picnic areas, recreation areas, playgrounds, active sports areas, and parks which are not included in Category A and residences, motels, hotels, public meeting rooms, schools, churches, libraries, and hospitals.
C	72 (Exterior)	75 (Exterior)	Developed lands, properties or activities not included in Categories A or B above.
D	--	--	For requirements on undeveloped lands see paragraphs 11a and c.
E 4/	52 (Interior)	55 (Interior)	Residences, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals, and auditoriums.

1/ See Paragraph 8 for method of application.
2/ Either L_{10} or L_{eq} (but not both) design noise levels may be used on a project.
3/ Parks in Categories A and B include all such lands (public or private) which are actually used as parks as well as those public lands officially set aside or designated by a governmental agency as parks on the date of public knowledge of the proposed highway project.
4/ See Paragraphs 8c, d, and e for method of application.

yards, and the unused open space portions of other developments and facilities. Design noise levels should, however, be applied to those parks and recreational areas or portions thereof where serenity and quiet are considered essential even though such areas may not be subject to frequent human use, and

(4) those places within the sphere of human activity (at approximately ear-level height) where activities actually occur. The values do not apply to an entire tract upon which an activity is based, but only to that portion on which such activity normally occurs.

c. The interior design noise levels in Category E apply to:

(1) indoor activities for those parcels where no exterior noise sensitive land use or activity is identified, and

(2) those situations where the exterior activities on a tract are either remote from the highway or shielded in some manner so that the exterior activities will not be significantly affected by the noise, but the interior activities will.

d. The interior design noise levels in Category E may be considered as a basis for noise insulation of public use institutional structures in special situations when, in the judgment of the highway agency and concurred in by the FHWA, such consideration is in the best public interest.

e. Interior noise level predictions may be computed by subtracting from the predicted exterior levels the noise reduction factors for the building in question. If field measurements of these noise reduction factors are obtained, (or if the factors are calculated from detailed acoustical analyses) the measured (or calculated) values shall be used.

(1) In the absence of such calculations or field measurements, the noise reduction factors may be obtained from the following table:

Building Type	*Window Condition*	*Noise Reduction Due to Exterior of the Structure*
All	*Open*	*10 dB*
Light Frame	*Ordinary Sash (closed)*	*20*
	Storm Windows	*25*
Masonry	*Single Glazed*	*25*
Masonry	*Double Glazed*	*35*

(2) *The windows shall be considered open unless there is firm knowledge that the windows are in fact kept closed almost every day of the year.*

(3) *Situations where open window periods do not coincide with a high traffic noise level may qualify as a closed window condition. In such instances, the optional noise prediction procedures in paragraph 14c shall be used.*

9. PROCEDURE FOR REQUESTING EXCEPTIONS TO THE ACHIEVEMENT OF THE DESIGN NOISE LEVELS FOR TYPE IA HIGHWAY PROJECTS

a. *There may be situations along Type Ia highway projects where the predicted noise levels exceed the design noise levels and the adverse social, economic, and environmental effects of noise abatement measures are considered to exceed the abatement benefits. If this condition is expected to occur, the noise analysis shall include evaluations of adverse effects and the benefits of full and partial reductions of the predicted noise levels.*

b. *The highway agency may request an exception to the achievement of the specified design noise levels for Type IA projects where it can be demonstrated that the adverse effects exceed the overall benefits. To request an exception, the highway agency shall provide in the noise study report required by paragraph 7c the results of the following:*

(1) *Identification of the individual noise sensitive activities or groups of activities (including the number of persons affected) along the sections of highway which are*

subjected to existing traffic noise levels, or are expected to be subjected to future traffic noise levels, in excess of design levels.

(2) *An examination of the overall benefits and adverse effects of partial noise abatement measures.*

(3) *A weighing of the overall benefits which can be achieved by the noise abatement measures against any adverse effects and other conflicting values such as economic reasonableness, air quality, highway safety, adjacent neighborhood desires about esthetic impact (and other desires), or other similar values. Such weighing shall establish that measures for reduction of noise levels to more desirable levels for that particular activity, land use, or groups of activities are not in the best overall public interest. A principal factor in this weighing shall be the concern for public health, public welfare, and the quality of life. These decisions must ultimately be based upon case-by-case determinations. However, every effort shall be made to obtain detailed information on the costs, benefits, and effects involved to assure that final decisions utilize a systematic and factually based assessment.*

(4) *Recommendations for incorporation in the project plans and specifications of the partial noise abatement measures determined to have benefits consistent with adverse effects.*

c. *Exception approvals shall not be granted without a showing that all reasonable options for noise reduction (excluding measures provided by paragraph 12e) have been explored and that the partial noise abatement measures recommended provide the greatest attainable noise reductions consistent with the overall public interest.*

d. *In most cases, exceptions will be approved when the predicted traffic noise level from the highway project is less than the existing noise level (originating from sources other than the highway being improved or replaced) for the activity or land use in question. In these instances, there should be a reasonable expectation that the noise from the other sources will not be significantly reduced in the future.*

10. POLICIES FOR COORDINATION WITH LOCAL OFFICIALS

Pursuant to this directive, FHPM 7-7-1 (Process Guidelines), and FHPM 7-7-5 (Public Hearing and Location/Design Approval) highway agencies have the responsibility for taking measures that are prudent and feasible to assure that the location and design of highways are compatible with existing and planned land uses. Local governments have responsibility for land development control and zoning. Highway agencies can be of considerable assistance to local officials in promoting compatibility between land development and highways. Therefore, for each Type IA and IB project, highway agencies shall cooperate with metropolitan planning organizations and with local officials (within whose jurisdiction the highway project is located) by furnishing:

a. approximate generalized future noise levels (for various distances from the highway improvement) for both developed and undeveloped lands or properties in the immediate vicinity of the project,

b. information that may be useful to local communities to protect future land development from becoming incompatible with anticipated highway noise levels, and

c. the FHWA policy regarding land use development or changes which are initiated after issuance of this directive (as described in paragraph 12c(2)).

11. NOISE ABATEMENT MEASURES FOR LANDS WHICH ARE UNDEVELOPED ON THE DATE OF PUBLIC KNOWLEDGE OF THE PROPOSED HIGHWAY PROJECT

a. Noise abatement measures are not required for lands which are undeveloped on the date of public knowledge of the proposed highway project (except as provided in paragraph 11b).

b. For lands which are undeveloped on the date of public knowledge of the highway project, the highway agency should treat the activity or land use as developed land in the following situations:

(1) the development was planned, designed, and programed before the highway studies and there is firm evidence that the development has been only temporarily delayed, or

(2) *the development is planned, designed, and programed during the highway project planning and design; there is a very high probability of the development being constructed; and the developer has considered the noise impacts to the extent reasonable and practicable.*

c. *A highway agency may request Federal-aid participation in the cost of providing noise abatement measures for undeveloped lands along Type IA and IB projects when the noise analysis demonstrates a need in the following situations:*

(1) *development occurs between the date of public knowledge of the proposed highway project and the actual construction of the project, or*

(2) *the probability of development occurring within a few years is very high and a strong case can be made in favor of providing noise abatement measures as part of the highway project based on consideration of need, expected long term benefits to the public interest, and the difficulty and increased cost of later incorporating abatement measures into either the highway or the development.*

12. FEDERAL PARTICIPATION

a. *General. Federal funds may be used for noise abatement measures in those situations where:*

(1) *a traffic noise impact has been identified,*

(2) *the noise abatement measures will reduce the noise impact, and*

(3) *the overall noise abatement benefits are determined to outweigh the overall adverse social, economic, and environmental effects of the noise abatement measures.*

b. *Type IA and IB Projects. The following noise abatement measures may be incorporated in Type IA and IB projects to reduce highway-generated noise impacts and the costs of such measures may be included in Federal-aid participating project costs:*

(1) *traffic management measures (e.g., traffic control devices and signing for prohibition of certain vehicle types, time use restrictions for certain vehicle types, modified speed limits, and exclusive lane designations),*

(2) *alterations of horizontal and vertical alignments,*

(3) *acquisition of property rights (either in fee or lesser interest) for installation or construction of noise abatement barriers or devices,*

(4) *installation or construction of noise barriers or devices (including landscaping for esthetic purposes) whether within or outside the highway right-of-way, and*

(5) *acquisition of real property or interests therein (predominantly unimproved property) to serve as a buffer zone to preempt development which would be adversely impacted by traffic noise and for other noise abatement purposes. Acquisition of a few improved parcels may be included in such buffer zone acquisitions to provide a uniform treatment. In authorizing any buffer zone acquisition, consideration shall be given to the needs and desires of the community, the demonstrated efforts of the community to implement effective land use control for compatibility, and the overall public interest. It is preferred that buffer zone acquisition be performed in conjunction with local zoning, land use controls, or other local government controls imposed or exercised in accordance with a comprehensive plan. Buffer zones shall be obtained by acquisition of the least real property interest practicable that is sufficient to prevent incompatible uses of adversely impacted lands while permitting uses compatible with the highway environment (e.g., negative easements that restrict grantors' use). In certain cases it may be necessary to acquire additional right-of-way in fee simple with the intent to dispose of excess interests in a manner compatible with the highway environment. Proposals of this kind shall be submitted to FHWA for prior approval. Any conveyance of excess right-of-way shall be in accordance with paragraph 7c of FHPM 7-4-2.*

c. *Type II Projects*

(1) *The Federal share for noise abatement measures on Type II projects shall be the same as that for the Federal-aid system on which the project is located. For Type II projects on the*

Interstate System (including completed sections), the Federal share shall be from Federal-aid Interstate funds.

(2) *For Type II projects, noise abatement measures will not normally be approved for those activities and land uses which come into existence after the effective date of this directive. However, noise abatement measures may be employed to protect activities and land uses which come into existence after the effective date provided local authorities have taken measures to exercise land use control over the remaining undeveloped lands adjacent to highways in the local jurisdiction to prevent further development of incompatible activities.*

(3) *The following noise abatement measures may be incorporated in Type II projects to reduce highway-generated noise impacts and the costs of such measures may be included in Federal-aid participating project costs:*

(a) *acquisition of property rights (either in fee or lesser interest) for installation or construction of noise abatement barriers or devices,*

(b) *installation or construction of noise barriers or devices (including landscaping for esthetic purposes) whether within or outside the highway right-of-way, and*

(c) *traffic management measures (e.g., traffic control devices and signing for prohibition of certain vehicle types, time use restrictions for certain vehicle types, modified speed limits, exclusive land designations, traffic control devices, or combinations of such measures).*

d. *Noise Insulation. In some specific cases, there may be compelling reasons to consider measures to noise insulate structures. Situations of this kind may be considered on a case-by-case basis for Type IA, IB, and II projects when they involve such public use or nonprofit institutional structures as schools, churches, libraries, hospitals, and auditoriums. Proposals of this type, together with the State's recommendation, shall be submitted to FHWA for prior approval action.*

e. *Other Abatement Measures.* *There may be situations where:*

(1) *especially severe traffic noise impacts exist or are expected, and*

(2) *the abatement measures listed above are physically infeasible or economically unreasonable.*

f. *In these instances, noise abatement measures other than those listed in paragraph 12b-d may be proposed for Types IA, IB, and II projects by the State highway agency, and approved by the Regional Federal Highway Administrator on a case-by-case basis when the conditions of paragraph 12a have been met.*

13. CONSTRUCTION NOISE. *The following general steps are to be performed for all Type IA, IB, and II projects after the effective date of this directive.*

a. *Identify land uses or activities which may be affected by noise from construction of the highway. The identification is to be performed during the project development studies.*

b. *Determine the measures which are needed in the contract plans and specifications to minimize or eliminate adverse construction noise impacts to the community. This determination shall include a weighing of the benefits achieved and the overall adverse social, economic and environmental effects of the abatement measures.*

c. *Incorporate the needed abatement measures in the contract plans and specifications.*

14. TRAFFIC NOISE LEVEL PREDICTION METHODS

a. *Any traffic noise prediction method is approved for use in any noise analysis required by this directive if it meets the following two conditions.*

(1) *The methodology is consistent with the methodology in the FHWA Highway Traffic Noise Prediction Model (Report No. FHWA-RD-77-108).*

(2) *The prediction method uses noise emission levels obtained from one of the following:*

(a) *Attachment 1, National Reference Energy Mean Emission Levels as a Function of Speed.*

(b) *Report No. FHWA-OEP/HEV-78-1, Determination of Reference Energy Mean Emission Levels.*

b. *In predicting noise levels and assessing noise impacts, the following traffic characteristics shall be used.*

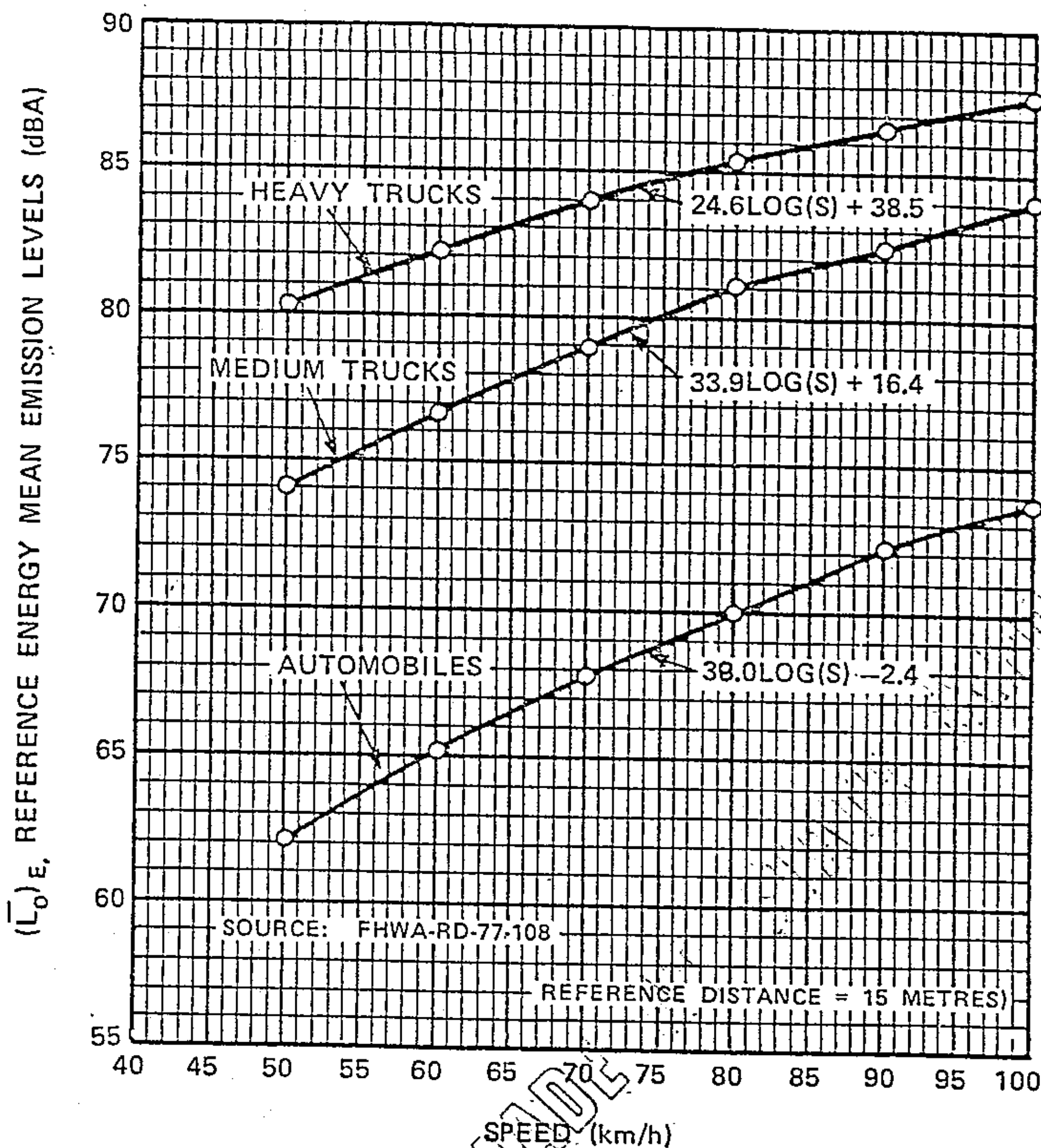
(1) *Automotive volume - the future volume (reduced for truck traffic) obtained from the lesser of the design hourly volume or the maximum volume which can be handled under traffic level of service C conditions. For automobiles, level of service C is considered to be the combination of speed and volume which creates the worst noise conditions. The average day for the design year may be used for those highway sections where the design hourly volume or the level of service C condition is not anticipated to occur on a regular basis during the design year.*

(2) *Speed - the operating speed which corresponds with the design year traffic volume selected in paragraph 14b(1) and the truck traffic predicted from paragraph 14b(3). The operating speed must be consistent with the volume used.*

(3) *Truck volume - the design hourly truck volume shall be used for those cases where either the design hourly volume or level of service C was used for the automobile volume. Where the average hourly volume for the highest 3 hours on an average day was used for automobile traffic, comparable truck volumes should be used.*

c. *As an alternative to paragraph 14b, the highway agency may select traffic characteristics to correspond with the critical times of day and night which will create the most adverse traffic noise impacts upon the nearby activities and land uses. When such alternative traffic characteristics are used, a thorough discussion of such alternative characteristics shall be included in the noise study report.*

d. *Traffic noise prediction methods approved pursuant to paragraph 14 of FHPM 7-7-3 dated May 14, 1976, remain approved until December 31, 1979. Any noise analysis performed after December 31, 1979, must comply with the requirements of paragraph 14a.*



LEGEND:

1. AUTOMOBILES: ALL VEHICLES WITH TWO AXLES AND FOUR WHEELS.
2. MEDIUM TRUCKS: ALL VEHICLES WITH TWO AXLES AND SIX WHEELS.
3. HEAVY TRUCKS: ALL VEHICLES WITH THREE OR MORE AXLES.

National Reference Energy Mean Emission Levels as a Function of Speed

APPENDIX IID

FEDERAL HIGHWAY PROGRAM MANUAL

Volume 7
Chapter 7
Section 2

APPENDIX IID

This Appendix provides some additional background information to the person writing the noise portion of the EIS. The items listed are requirements for the EIS.

FLOW CHART REFERENCE

PROBABLE IMPACTS (Noise)

F.H.P.M. 7-7-2 REQUIREMENT

Paragraph 19.i.

2.e. Noise Impacts

If significant factor, discuss possible noise problems, summarize noise analysis. Include:

1. numbers and types of affected activities,
2. extent of impact (in decibles),
3. likelihood that abatement measures reduce impacts,
4. noise abatement measures likely to be incorporated,
5. noise problems with no available solution ,
6. construction impacts.

COMMENTS

The E.I.S. should contain the following to properly address the noise impact of a project:

1. General reference to informative literature covering the fundamentals of noise, definitions, measurement, impact assessment and abatement, (ie., "Fundamentals and Abatement of Highway Traffic Noise, Volume I" can be obtained through NTIS).

2. Brief presentation of existing noise levels presented in tabular form or on a general corridor site map. Sufficient measurements should be shown and correlated to site numbers to quantify the existing noise environment throughout the new corridor. If three or four alternates are under study, then measurements should represent the actual existing noise environment for all the alternates being considered.

3. Predicted future noise levels. A brief description of the traffic characteristics should be given (ie., DHV, percentage trucks and speed). Predicted levels may be shown on a general site map as noise level contours or the future noise levels may be presented in tabular form. If presented in tabular form, the site numbers should correspond with the measured site numbers.

4. Define impact. Basically there are two general definitions of impact: (a) when the predicted future noise level exceed the FHWA design noise level, and (b) when the predicted future noise level is substantially greater than the existing measured noise level.

5. Identify the land use types that will be impacted by noise. The identification can be accomplished by presenting a general land use site plan and superimposing the predicted noise level contours onto it, or the land uses may be identified in general terms that correspond to the above mentioned site numbers. Tabular displays of data are often effective. Whatever presentation method is used, the statement should clearly indicate the numbers and types of noise sensitive land uses impacted under both definitions of impact.

FLOW CHART REFERENCE Probable Impacts (continued) (Noise)	COMMENTS
F.H.P.M. 7-7-2 REQUIREMENT Paragraph 19.i.2.e. (cont.)	6. Present noise abatement measures which will likely be incorporated into the project that would reduce the number of impacted people. 7. Present in tabular form, information on the numbers and types of land uses that will remain impacted even after the proposed mitigation measures are taken. 8. Discuss in general terms the coordination efforts made between the State highway agency and the local officials and/or local planning agency to control future noise sensitive land development adjacent to the highway. 9. Address in general terms the effect of construction noise and possible ways to mitigate it. The State highway agency should present their intended solutions for the mitigation of construction noise. 10. Reference the Noise Study Report as a comprehensive engineering report that (a) is attached as an appendix or (b) may be studied at a designated location, or (c) may be obtained at a designated location.

SECTION III

SECTION III

CALIFORNIA DEPARTMENT OF TRANSPORTATION REQUIREMENTS AND POLICIES

TABLE OF CONTENTS

INTRODUCTION

This section covers the procedure for complying with two specific California State laws and other State and Agency codes, policies and guidelines.

Chapter III-1 describes the procedures for performing studies to evaluate the peak noise from trucks that intrudes into school classrooms. A possible mitigation measure using a barrier is presented in those cases where peak noise level exceeds the statutory limit of 50 dBA.

Chapter III-2 describes the method for development of noise contours along State highways for city and county use in their general plan.

The appendices provide information on the various State laws, codes, policies and guidelines.

CHAPTER III-1

CALIFORNIA TEST 703
METHOD FOR MEASURING, PREDICTING, AND MITIGATING PEAK HIGHWAY TRAFFIC NOISE

STATE OF CALIFORNIA—BUSINESS AND TRANSPORTATION AGENCY

DEPARTMENT OF TRANSPORTATION
DIVISION OF CONSTRUCTION
Office of Transportation Laboratory
P. O. Box 19128
Sacramento, California 95819
(916) 444-4800

California Test 703
1978

METHOD FOR MEASURING, PREDICTING, AND MITIGATING PEAK HIGHWAY TRAFFIC NOISE

A. SCOPE (GENERAL DISCUSSION)

This method provides procedures for measuring highway traffic noise using a sound level meter (SLM) with and without a graphic level recorder (GLR). A graph is included for predicting peak truck noise and a nomograph solution for designing noise barriers to attenuate peak truck noise.

The principal application of this method is for compliance with Section 216 of the California Streets and Highways Code which establishes 50 dBA as the peak noise limit in primary or secondary school classrooms.

This method is not applicable to measuring, predicting or mitigating noise where descriptors such as L_{10} or L_{eq} are used.

A Sound Level meter measures the intensity level of sound in decibels (dB). Sound intensity in highway work is measured on the A-weighting scale and is denoted as dBA. The A-scale is used because it more nearly parallels humans' frequency response to the measured noise than to other scales (B,C,D).

The procedures using a SLM with and without a GLR are described for measuring peak traffic noise. Both methods use the same SLM and have the same inherent accuracy. Using the SLM without the GLR permits the operator a greater degree of freedom in reaching difficult locations. It also permits conversing with an assistant when necessary without including this noise as part of the record.

The SLM used with the GLR provides a chart which becomes a permanent record for later analysis or verification, but may restrict mobility in the field because an AC power source is required for some units. The operator must also identify the source of noise peaks on the chart (airplanes, dog barking, etc.) so that unrelated sources are not counted as highway noise. A wider dynamic range with the SLM and GLR system eliminates the last minute changing of the decibel range switch, as must often be done when using the SLM by itself.

This method is divided into two parts.

Part I. Measuring Peak Highway Traffic Noise.

Part II. Predicting and Mitigating Peak Highway Traffic Noise.

PART I MEASURING PEAK HIGHWAY TRAFFIC NOISE

A. APPARATUS FOR SLM MEASUREMENTS

1. SLM meeting American National Standard Institute Specifications; (ANSI) S 1.4-1971, Type I or II.
2. Sound Level Calibrator designed for the SLM.
3. Supporting stand or tripod (a tripod and adaptor may be obtained for the SLM at a camera supply store).
4. A windscreen (a porous sphere that covers the microphone to reduce wind turbulance without reducing the sound signal).
5. A high impedance earphone to detect wind noise or other false non-acoustic signals.
6. Note pad and pencil.

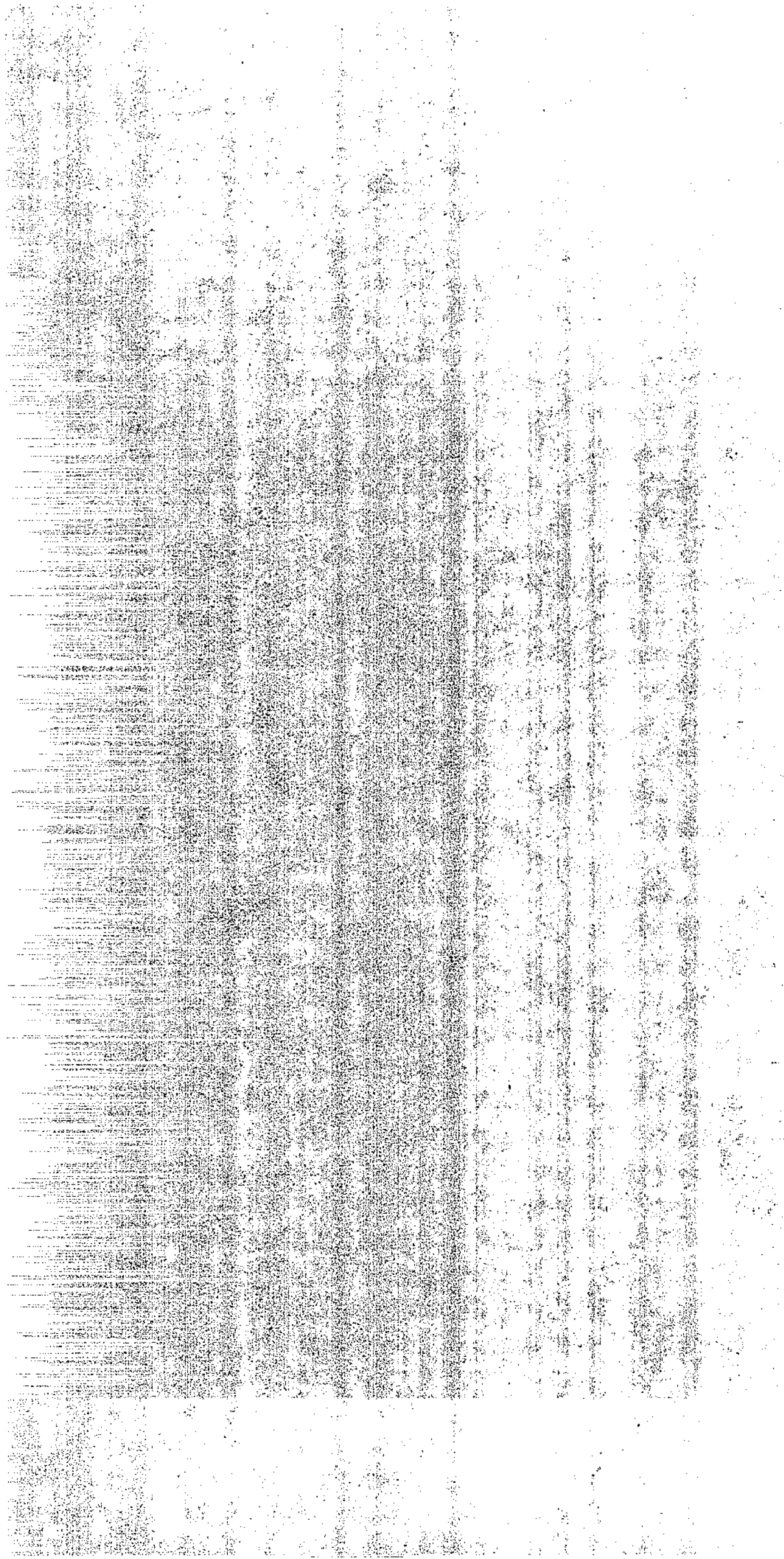
B. APPARATUS FOR SLM AND GLR MEASUREMENTS

1. All items listed in Part IA "Apparatus for SLM Measurements".
2. A GLR designed for use with the SLM.
3. For non-battery powered recorders; a power inverter, 12 volts DC to 110/120 volts, 60 Hz AC rated at 75 to 100 watts with adaptor cord and connectors to auto or truck battery.

   Examples: ATR—Model 12T-RME
   Terado—Model 50-127
   CDE—Model 12 B-8 or equal
4. A 12 foot (3.7 meters) AC extension cord to connect the inverter to the GLR.
5. Cable: 30 feet (9.1 meters) of RG/62U (or RG 59/U) coaxial cable with appropriate fittings to connect the SLM to the GLR.

C. PRELIMINARY PREPARATIONS BEFORE LEAVING THE OFFICE

1. Test the batteries for the SLM, Calibrator and GLR using a battery tester or following the manufacturers instructions using the instrument.
2. Check the operation and calibrate the SLM acoustically using the calibrator and manufacturers instructions.



straight line between the source and the receiver (i.e. line of sight). A is the distance from the source to a point perpendicular to the top of the barrier. B is the distance from the receiver to the same point. H is the optical height of the barrier. The optical height is the perpendicular distance from the line of sight to the top of the barrier. If the line of sight passes over the top of the barrier, the optical height is negative. The optical height is zero when the noise source is just visible from the receiver. These dimensions are illustrated in Figure 2.

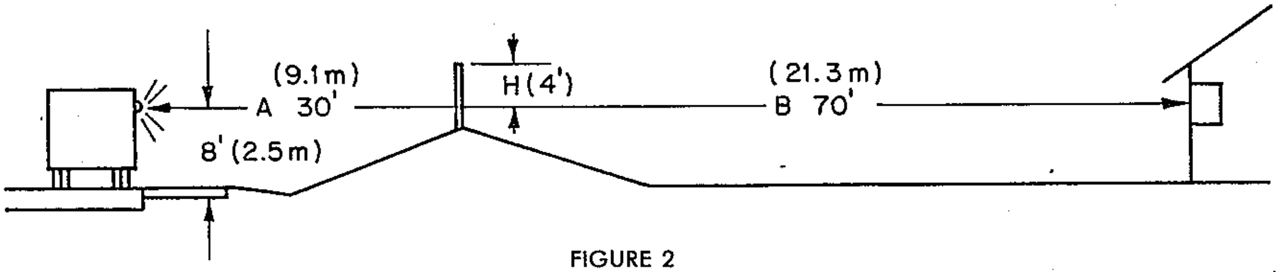


FIGURE 2

E. USE OF THE NOMOGRAPH

The "Determine V/H factor" nomograph (Figure 5) is entered first. The dimensions A and B are located on their respective lines and a straight line is drawn between them. In the example (Figure 2) distance A is 30 feet (9.1m) and distance B is 70 feet (21.3m). The V/H factor is then 0.195. H is positive so the next step is to enter the "Determine Sound Level Reduction" nomograph (Figure 6). The V/H factor is located on its line and the height H is located on its proper line ($H>O$). A straight line drawn between these points intersects the SLR line at 12.3. The sound level reduction of the example barrier is 12.3 dBA. If the line of sight between the noise source and the noise receiver had passed over the top of the barrier then H would have been negative and the $H<O$ line would have been used.

F. DETERMINING EXPECTED PEAK SOUND LEVELS

In the example, Figure 2, the receiver is located 100 feet (30.5m.) from the noise source so the maximum peak noise level expected from a legal truck will be 84 dBA. The sound level reduction determined from the nomograph is subtracted from this value. The example sound level reduction was 12.3 dBA, so the projected maximum peak noise level will be 71.7 dBA at the shielded receiver.

G. DETERMINING HEIGHT OF BARRIER

Figures 5 and 6 can be used to determine the height of a barrier for a given peak noise and distances A and B. As an example, if the conditions are as shown in Figure 2 and a required reduction in noise level is 10 dBA, the H value is 2.4 (Figure 6).

REFERENCES

American National Standard Institute (ANSI) Specifications 1.4—1971

California Streets and Highways Code; Section 216; Control of Freeway Noise in School Classrooms; September 17, 1970.

Beaton, J. L., Bourget, L.; Traffic Noise Near Highways, Testing and Evaluation; California Department of Transportation, Transportation Laboratory; Research Report No. CA-HY-MR-6316-2-72-42.

End of Text (7 pgs) on Calif. 703

Department of Transportation
Division of Construction
Office of Transportation Laboratory

California Test 703

SCHOOL NOISE STUDY

District________ CO__________ Rte ____________ P.M.________________

Name of School ____

Address________________________________ City______________ Zip_____

Contact Person_____________________ Title________________ Phone_____

_____________________ " ________________ " _____

Field Noise Measurements By____________________________ Date_______

		ID. No.	Date of Last Calib.
SLM Model & Type			
Calibrator Model			
GLR Model			

SLM Calibration(__dBA at _____ Hz) Before_______ After____________

Remarks____

____

SUMMARY OF FIELD MEASUREMENTS

Room No.	Room Used For	Measuring Time		Inside Meas. Peak dBA				Outside Meas.
				Window Closed		Window Open		
		Begin	End	No. >50	Max.	No. >50	Max.	

FIGURE 3

CHART FOR USE OF THE NOISE NOMOGRAPH
CALIFORNIA NOISE LIMIT FOR VEHICLES OVER 6,000 LBS.
SECTION 23130 OF THE VEHICLE CODE (1972)

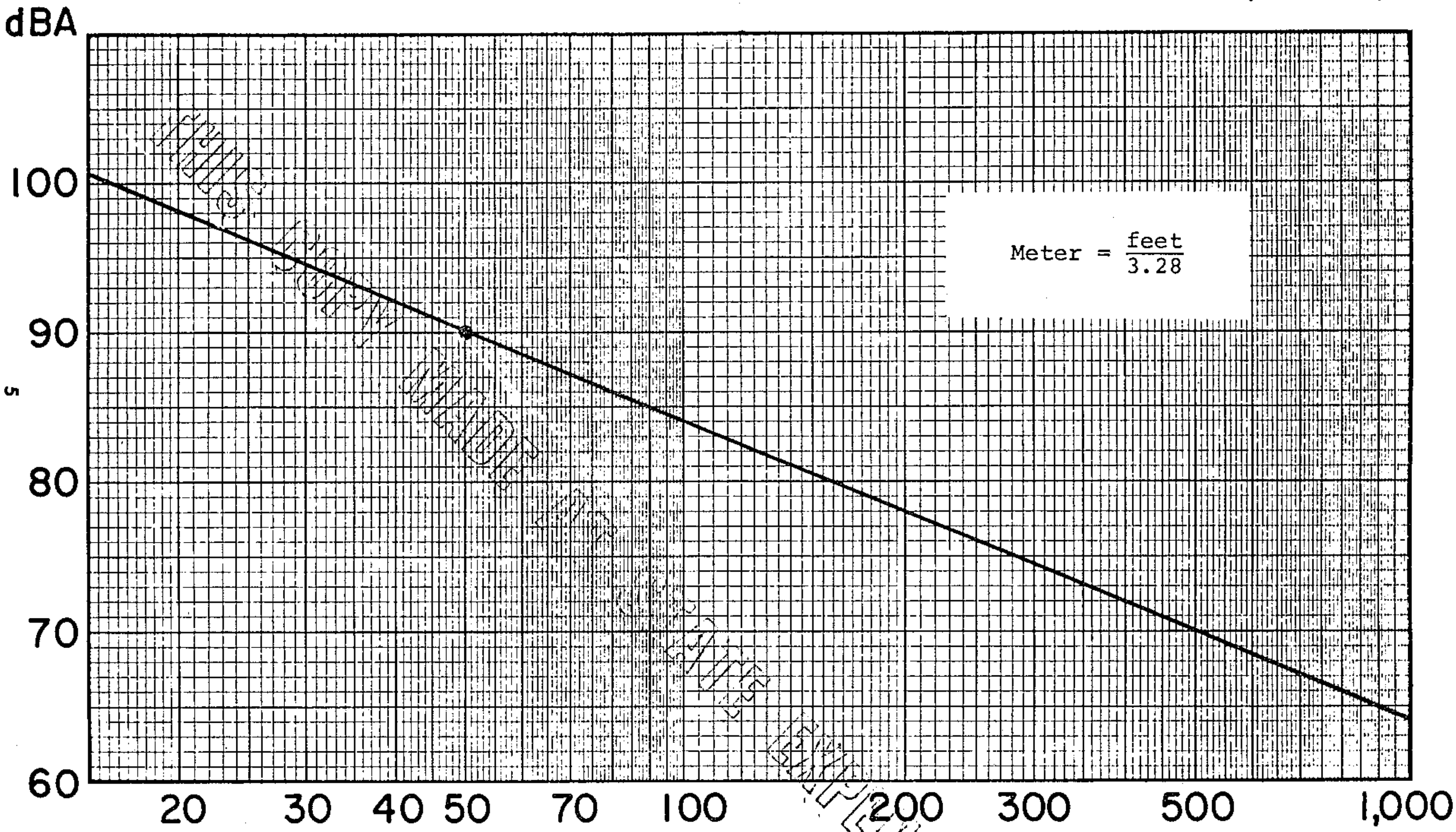


FIGURE 4

NOISE BARRIER ATTENUATION NOMOGRAPH

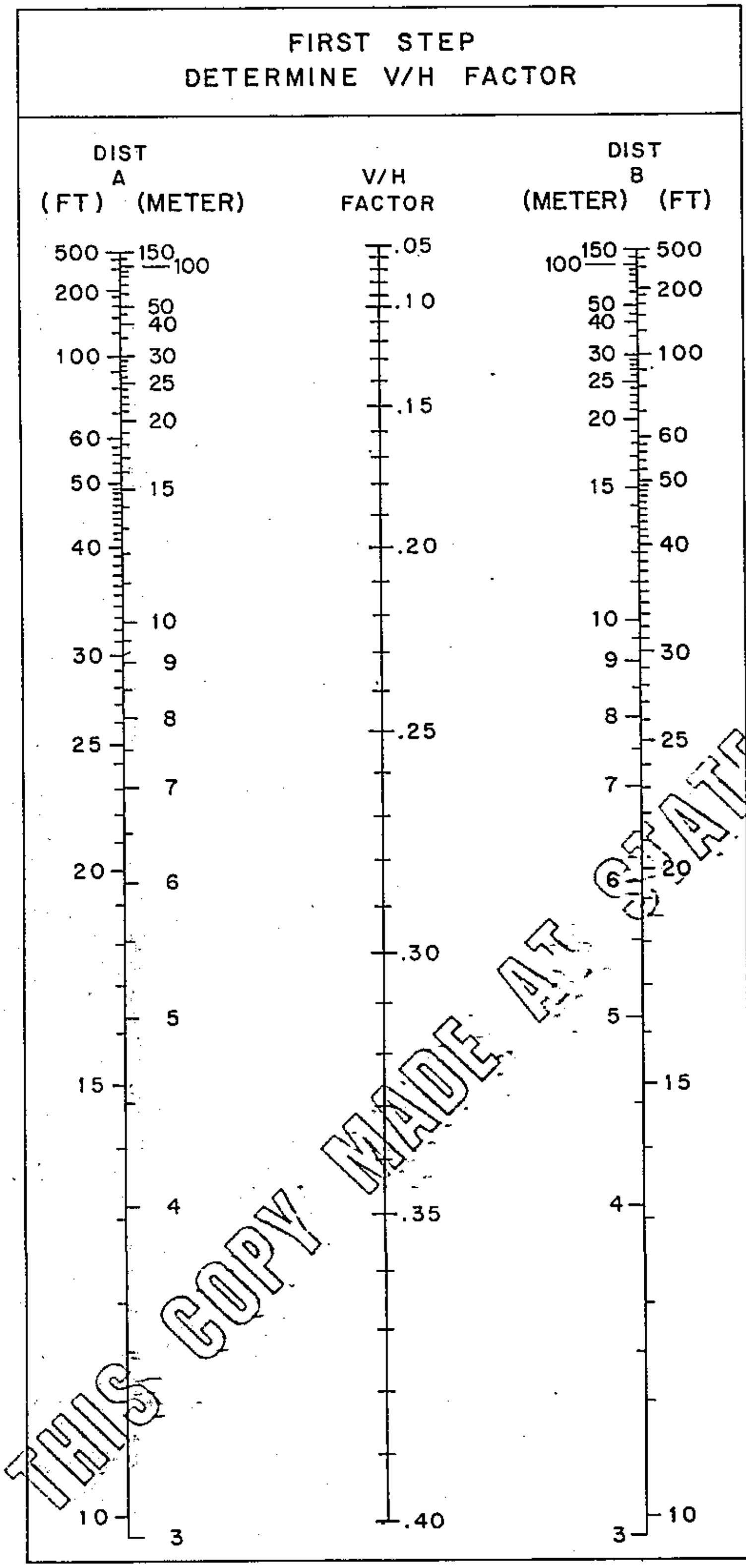


FIGURE 5

NOISE BARRIER ATTENUATION NOMOGRAPH

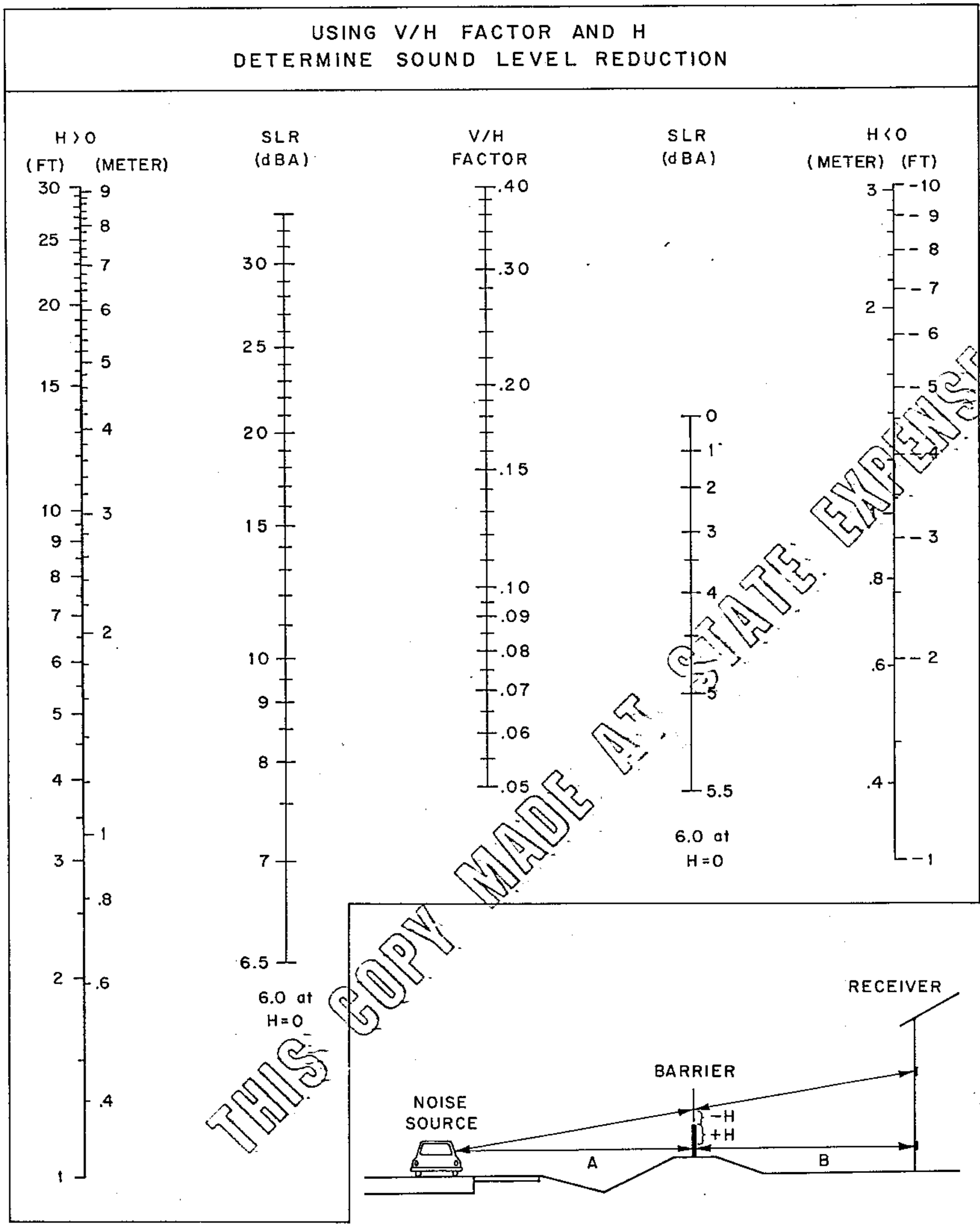
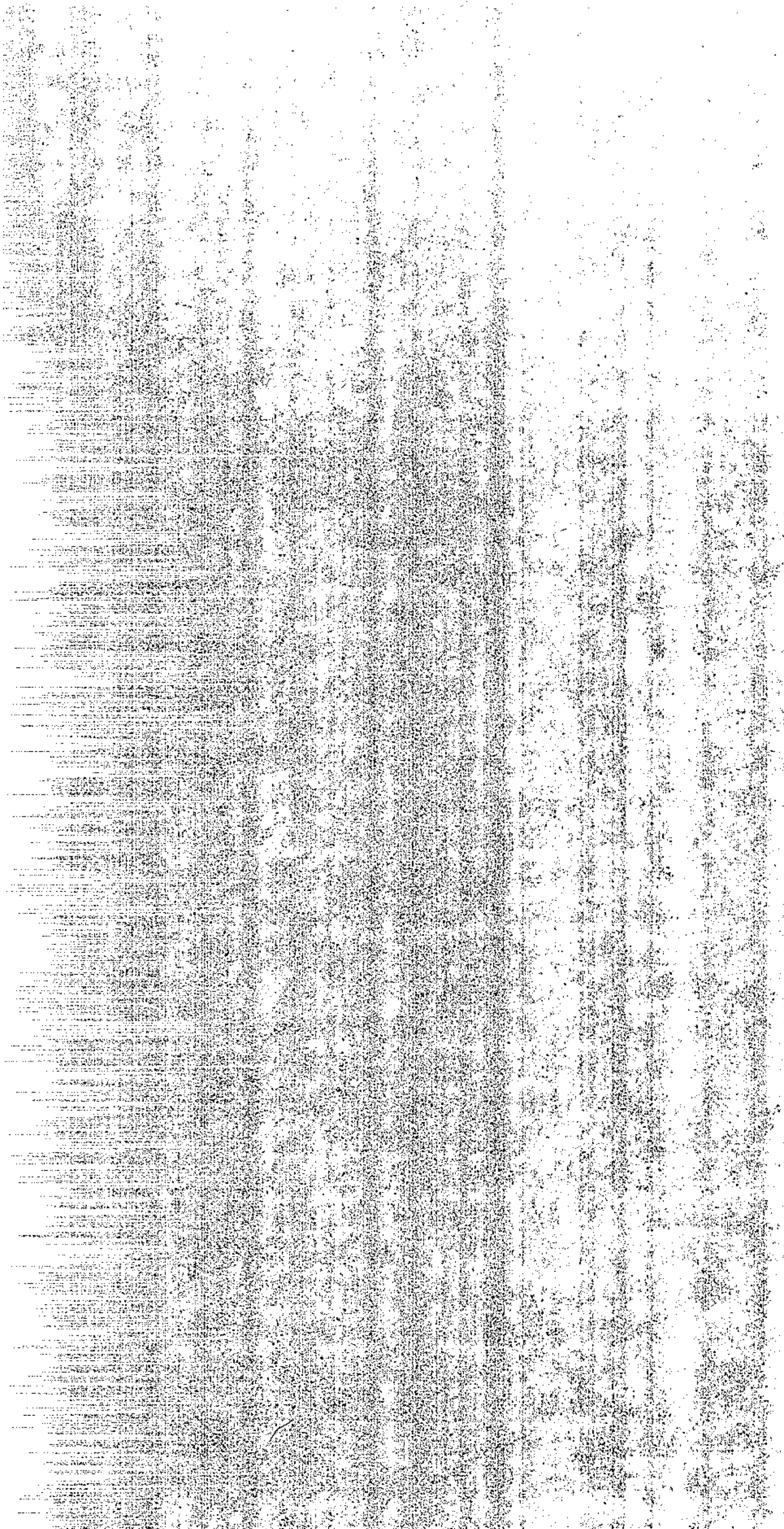


FIGURE 6



CHAPTER III-2

NOISE CONTOURS FOR
CITY AND COUNTY GENERAL PLAN

(916) 444-4886

November 10, 1976

District Directors of Transportation 01-11

Noise Level Information for City and County General Plan

The purpose of this memorandum is to provide guidelines to be followed by the Districts when responding to local agency requests for noise levels as required by SB 860.

Background

Section 65302 of the Government Code was amended by the Legislature (SB 860) to become effective on January 1, 1976. The amended Section requires the noise element of the cities and counties General Plan to be presented in terms of noise contours using new noise descriptors identified as community noise equivalent level (CNEL) or day-night average level (L_{dn}).

Responsibility for providing the noise contours was prescribed in Senate Bill 860 as follows:

> "The State, local or private agency responsible for the construction, maintenance, or operations of those transportation, industrial, or other commercial facilities specified in paragraph 2 of this subdivision shall provide to the local agency producing the general plan, specific data relating to current and projected levels of activity and a detailed methodology for the development of noise contours given this supplied data, or they shall provide noise contours as specified in the foregoing statements."

The Office of Noise Control (ONC) of the Department of Health is mandated under SB 860 to provide guidelines for the preparation of the noise element of the General Plan. They have expressed an opinion that Caltrans could best serve the needs of the various communities conducting noise studies and satisfy the intent of SB 860 by preparing CNEL or L_{dn} noise contours for the roadways under their control rather than providing data and methodology.

The ONC also stated that the noise element should be updated every 5 years, and at that time, the forecasted noise exposure be projected an additional 5 years.

Implementation

1) The L_{dn} noise descriptor shall be used by the Districts when developing noise contour maps.

2) Local agencies shall be given the option of receiving current and projected traffic data and a detailed methodology (attached) for the development of noise contours using this supplied data or receiving noise contour maps developed by the Districts according to these guidelines.

3) Noise levels shall be shown as contours on a strip map. The contours shall be shown in increments of 5 dBA and shall continue down to 60 dBA. Although desirable, it is not necessary to have buildings shown on the map.

4) A scale map of 1" = 1000' or larger scale shall be used. The larger scale maps (down to 1" = 500') may be desirable, where sensitive facilities may be affected.

5) Variations due to buildings, barriers or other structures outside the highway right of way shall not be included.

6) Variations due to local traffic or noise from other sources emanating from outside the right of way shall not be included.

7) The L_{dn} value near highways with ADT over 30,000 may be obtained by subtracting 3 dBA from the L_{10} value obtained for the peak traffic hour.

8) Present and projected traffic data and worksheets for developing the noise contours shall be supplied with the strip maps to the requesting local agency.

9) Most of the noise levels needed to develop the required noise contours can be obtained from traffic counts and the attached procedure. Supplemental noise measurements may be needed in some instances, such as at locations

where a noise barrier has been constructed within the highway right of way.

10) In many cases, cities and counties will need to modify the noise contours to show the influence of other noise sources adjacent to the State Highway. Local agencies will also be developing noise contours adjacent to local major arterials. They may be provided copies of this memorandum and whatever instructions are necessary.

The attached "Estimation of Community Noise Exposure in Terms of Day-Night Average Level Noise Contours" by the Office of Noise Control dated May 1975, has been verified for traffic volumes over 20,000 ADT. For traffic under 20,000 ADT, some refinement to the procedure needs to be made. Future modifications will be transmitted to the Districts.

Development and submission of the required information to the local agencies is included in the HD-21 program and should be done under EA 600200 drawn against the Districts' 908 General Ledger allotment.

It is requested that the Districts submit an estimate of this activity's funding and man-year needs for the balance of the 1976-77 fiscal year. Please submit this information as soon as possible to the Office of Highway Planning and Research, Attention Mr. C. A. Pivetti. Future required effort must be included in HD-2/GL908 one and five year work programs.

Local agencies are required to update their general plan every five years. Considering that some planning agencies completed their noise element as early as 1974 and others have not even started, it appears that the Districts will have a continuing program for this activity. Manpower needs for this activity should be included in the Districts' annual P&OE budget request.

Mas Hatano(ATSS 432-4886) or Walt Whitnack(ATSS 485-6780) may be contacted if further information is required for developing contour maps.

C. E. FORBES
Chief Engineer

Attachment

MMH:bd

cc: WRGreen-Planning & Design
AELowe-Office of Noise Control(DOH)
ACEstep - Office of Local Assistance
JRGordon- Environmental Planning
CAPivetti-Planning and Research
Translab

III-2.1 ESTIMATION OF NOISE EXPOSURE FROM HIGHWAY TRAFFIC

Two highway traffic noise nomograms have been developed which provide an estimate of the L_{dn} noise exposure value at a defined distance from the roadway given typical vehicle flow volumes expressed in terms of an average ADT (Average Daily Traffic Flow Volume). These nomograms have been prepared for the general categories of highways defined as "High Speed Highways and Freeways" and "Low Speed Arterials" (typically 35 MPH). For each case, a generalized day-night split in vehicle flow volume of 87 percent day and 13 percent night has been assumed. Additionally, nominal day and night heavy truck percentages of 4 percent for arterials and 10 percent for freeways have been assumed. General 2 and 4 lane road configurations have been assumed for arterial highways while 6 to 8 lanes have been assumed for freeways. Both nomograms are also based upon the roadway being the same elevation as the sideline terrain.

From these basic nomograms are derived a nominal L_{dn} noise exposure value at the site location. The flow parameters upon which the nomograms have been formulated are typical. However, to cover a broad variety of traffic flow situations, additional adjustments are provided to account for variations in day/night traffic flow percentage, variations in heavy truck flow percentage, vehicle speed, number of traffic lanes and relative elevation or depression of the roadway with respect to the sideline terrain.

The following procedure yields the L_{dn} noise exposure value at the site given the above described traffic flow descriptions. In the event certain flow data is not available or a rough estimate of the noise exposure is desired, the procedure may be stopped after Step 3, which yields a nominal L_{dn} value given a number of assumptions concerning typical flow parameters. The entire 9-step sequence should be followed whenever possible to insure the most accurate assessment of the noise exposure and fairness to all concerned.

This procedure has been experimentally verified for traffic flow volumes of over 20,000 ADT. For flows under 20,000 vehicles per day, the following general rules of thumb should be followed:

Low Speed Highways:	L_{dn} = 65 dB within 100 feet of the roadway. 60 dB or less beyond 100 feet.
High Speed Highways:	L_{dn} = 70 dB within 100 feet of the roadway. L_{dn} = 65 dB between 100 and 200 feet from the roadway. 60 dB or less beyond 200 feet.

A highway noise exposure computation worksheet has been provided in Figure III-2.1 to facilitate this analysis.

Instruction for use of the traffic nomograms are as follows:

<u>Step 1</u>: Determine the following typical traffic flow parameters and enter on the work sheet:

- ADT (Total typical flow in both directions for 24 hours).
- Typical % of ADT flowing during daytime hours (7 AM - 10 PM).

- Percent usage by heavy trucks for day and night.
- Number of traffic lanes.
- Average Vehicle Speed.
- Elevation or depression of the roadway with respect to the sideline terrain.
- Distance to the site measured from the center line of the closest traffic lane.

Step 2: Determine general category of roadway under consideration as either "low speed arterial" or "high speed highway or freeway" and use Figure III-2.2 or III-2.3 respectively.

Step 3: Determine the intercept point for the horizontal line drawn through the ADT in thousands on the left axis of Figure III-2.2 or III-2.3 (as determined in Step 1) and a vertical line through the distance (measured from the centerline of the closest traffic lane) to the investigation site. Interpolate linearly between L_{dn} contour curves to determine the nominal on-site noise exposure.

If the traffic flow parameters determined in Step 1 do not correspond to those for which the nomograms were developed (summarized in Figure III-2.2 and III-2.3 under "Traffic Flow Parameters"), proceed with Steps 4 through 9 which account for variations in the assumed traffic flow parameters.

Step 4: The nomographs utilized in Step 3 incorporated an 87/13 day night % split in traffic flow. If the observed day night split differs from this, Figure III-2.4 should be used. Enter the left axis at the daytime flow percentage and read across until the curve is intersected. The correction (+ or -) to the nominal values appears directly below. Enter this value on the work sheet.

Step 5: Heavy Truck % Adjustments. If the day and night time heavy truck % is not constant and 4% and 10% for low and high speed highways respectively as assumed, Figures III-2.5 and III-2.6 should be used. Enter the bottom horizontal scale at the daytime heavy truck % and read vertically until the line corresponding to the nighttime heavy truck % is intersected. Read the correction to the nominal L_{dn} in dB on the vertical axis directly left of the intercept point. Enter this adjustment (+ or -) on the work sheet.

Step 6: Vehicle Speed Adjustment. (Low Speed Only). The nomogram in Figure III-2.2 was developed assuming 35 mph average vehicle speeds. For vehicle speeds up to 45 mph, enter a speed adjustment factor of + 2 dB on the work sheet. (For higher speeds, use Figure III-2.3; High Speed Highways.)

Step 7: Number of Traffic Lanes.

a. Low Speed: For low speed highways, only 2-4 lane configurations are treated. If 6-8 lane low speed situations exist, enter an adjustment factor of -1 dB on the work sheet.

b. <u>High Speed</u>: The nomogram in Figure III-2.2 has been derived for 6-8 lane roadway configurations. For 2-4 lane high speed roadways, enter an adjustment of + 2 dB on the work sheet.

<u>Step 8</u>: <u>Relative Highway Elevation</u>. The nomograms in Figure III-2.2 and III-2.3 were developed for highway surfaces at the same elevation as the sideline terrain. Hence, for such level roadways, there is no correction. For elevated highways (typically 30 feet), the adjustment varies with distance away from the road; providing up to 6 dB shielding at 100 feet and diminishing to 0 dB beyond 300 feet. For depressed roadway configurations, a 6 dB reduction in level is assumed at all distances from the roadway beyond 100 feet. The decibel adjustment for the particular roadway configuration under investigation may be determined from the work sheet and entered in the appropriate spot.

<u>Step 9</u>: <u>Adjusted L_{dn} Exposure Value</u>. The adjusted on-site noise exposure value may now be determined by summing the adjustment factors determined in Steps 4 through 8 and adding this correction to the nominal L_{dn} determined in Step 3.

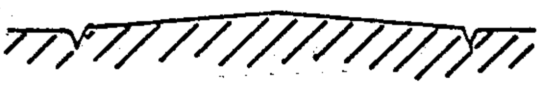
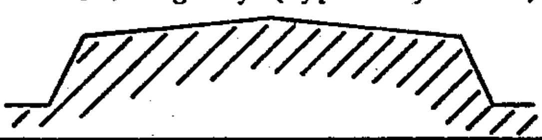
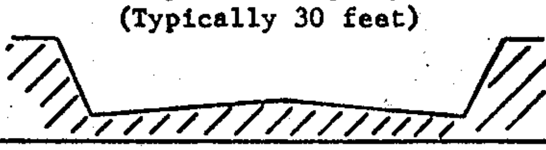
FIGURE III-2.1 HIGHWAY TRAFFIC NOISE WORKSHEET

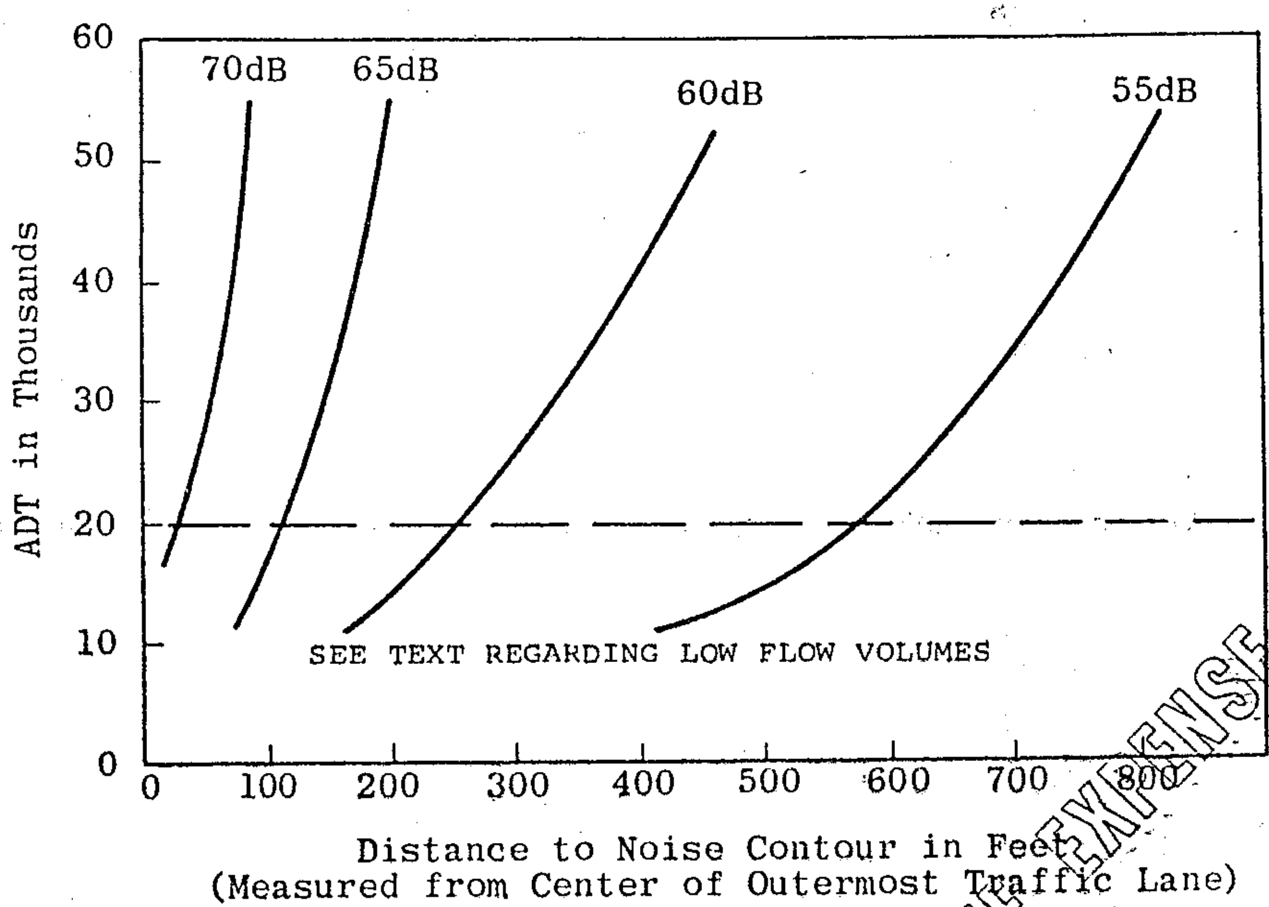
Step 1. Traffic Flow Data

ADT	: ________	Vehicles/24 hours
Daytime % of Traffic Flow	: ________	Vehicles/Daytime
Daytime % of Heavy Duty Truck Flow	: ________	Trucks/Day
Nighttime % of Heavy Duty Truck Flow	: ________	Trucks/Night
Average Vehicle Speed	: ________	MPH
Number of Traffic Lanes	: ________	Lanes
Highway Elevation Relative to Sideline Terrain	: ________	Feet
Distance to Site (Measured from Center Line of Closest Traffic Lane)	: ________	Feet

	Low Speed	High Speed
Step 2. General Highway Classification		
• Low Speed 35 - 45 mph	Figure III-2.2	
• High Speed 55 + mph		Figure III-2.3
Step 3. Nominal L_{dn} corresponding to ADT in Step 1 at specified distance.		
Step 4. Adjustment for Daytime % of traffic flow: Use Figure III-2.4 if other than 87%.		
Step 5. Adjustment for Variation in Day/Night Heavy Truck Volume %		
• Low Speed: If not constant 4%, use Figure III-2.5		
• High Speed: If not constant 10%, use Figure III-2.6		

FIGURE III-2.1 HIGHWAY TRAFFIC NOISE WORKSHEET (Continued)

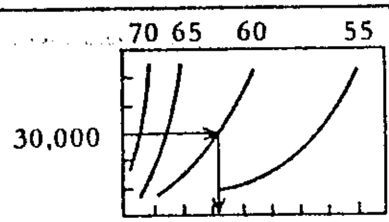
		Low Speed	High Speed
Step 6. Adjustment for Vehicle Speed - Low Speed Only 35 mph Average Speed: Add 0 dB 45 mph Average Speed: Add + 2 dB			
Step 7. Number of Traffic Lanes			
6-8 Lanes (Low Speed) : - 1 dB			
2-4 Lanes (High Speed): + 2 dB			
Step 8. Correction For Relative Highway Elevation			
Highway Configuration	Noise Exposure Adjustment at Specific Distance		
Highway at Grade 			
Elev. Highway (Typically 30 ft) 	-6 @ 100' -2 @ 200' 0 > 300'		
Depressed Highway (Typically 30 feet) 	-6 > 100'		
Step 9. Adjusted L_{dn} Contour Value at Site Location			



L_{dn} Noise Contours for Low Speed Arterials

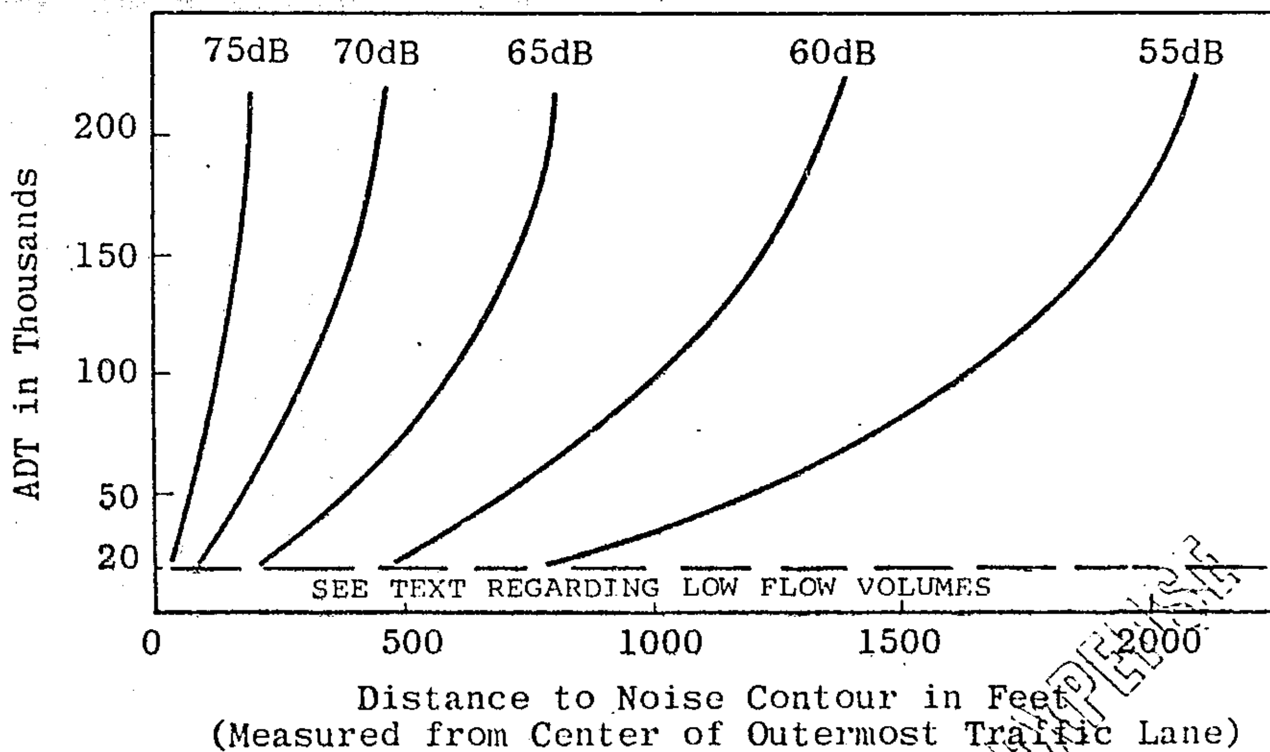
Traffic Flow Parameters	
Day Night Split:	87% - 13%
Percent Heavy Trucks:	4%
Typical Speeds:	35-45 mph
Roadway Configuration:	2 or 4 lanes

Example



ADT = 30,000
yields:
60dB at 330 feet

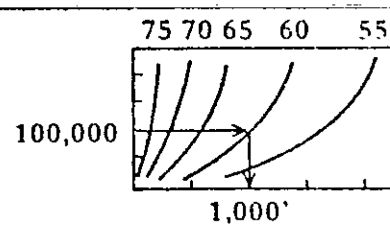
Figure III-2.2 TRAFFIC NOISE NOMOGRAM FOR LOW SPEED ARTERIALS.



L_{dn} Noise Contours for High Speed Highways and Freeways

Traffic Flow Parameters	
Day Night Split:	87% - 13%
Percent Heavy Trucks:	10%
Typical Speeds:	55-65 mph
Roadway Configuration:	6 to 8 lanes

Example



ADT = 100,000
yields:
60dB at 1,000 feet

Figure III-2.3 TRAFFIC NOISE NOMOGRAM FOR HIGH SPEED HIGHWAYS AND FREEWAYS.

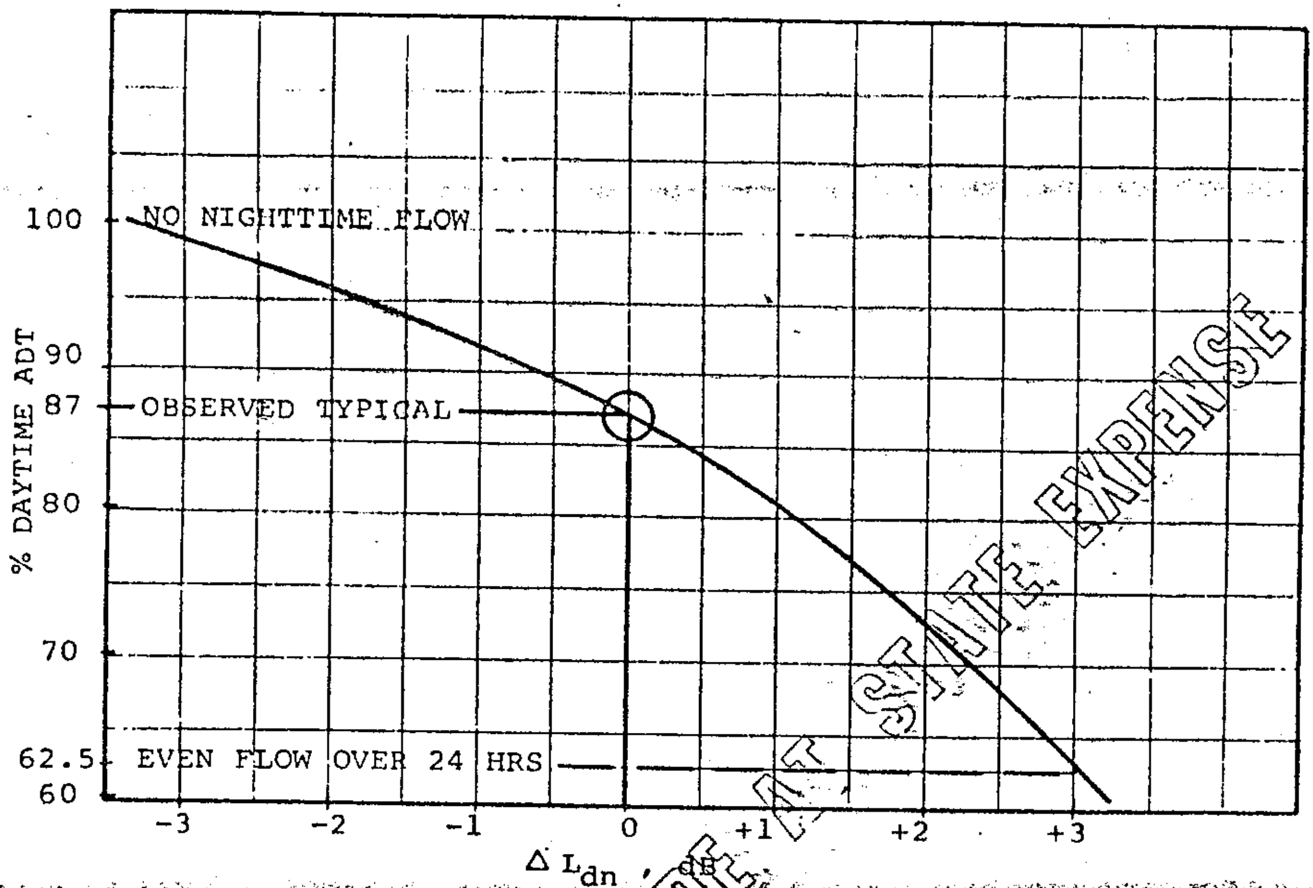


FIGURE III-2.4
ADJUSTMENTS FOR VARIATION IN DAY/NIGHT FLOW DISTRIBUTION

FIGURE III-2.5

ADJUSTMENT FOR VARIATION IN DAY AND NIGHT HEAVY TRUCK PERCENTAGE - LOW SPEED HIGHWAYS

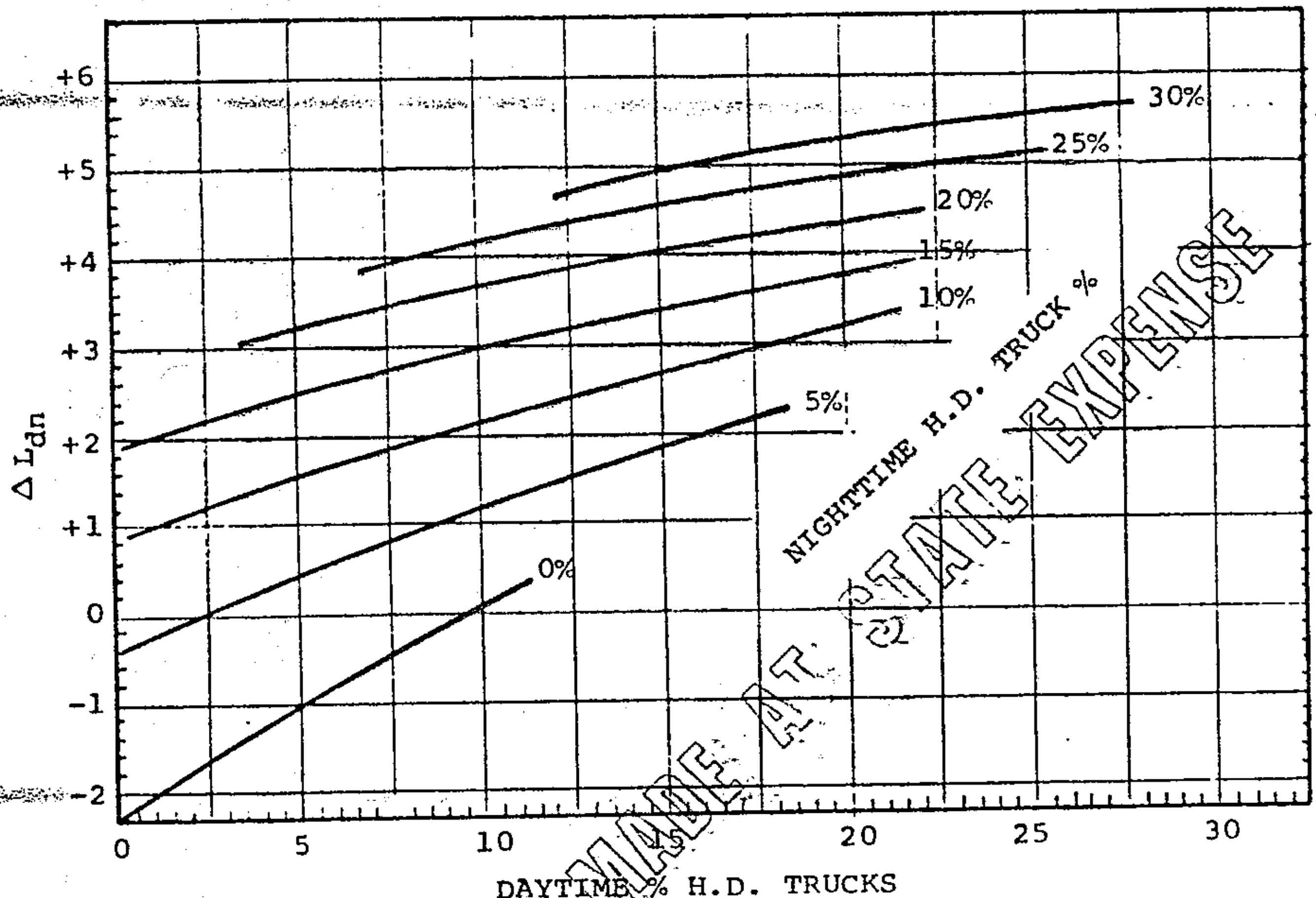
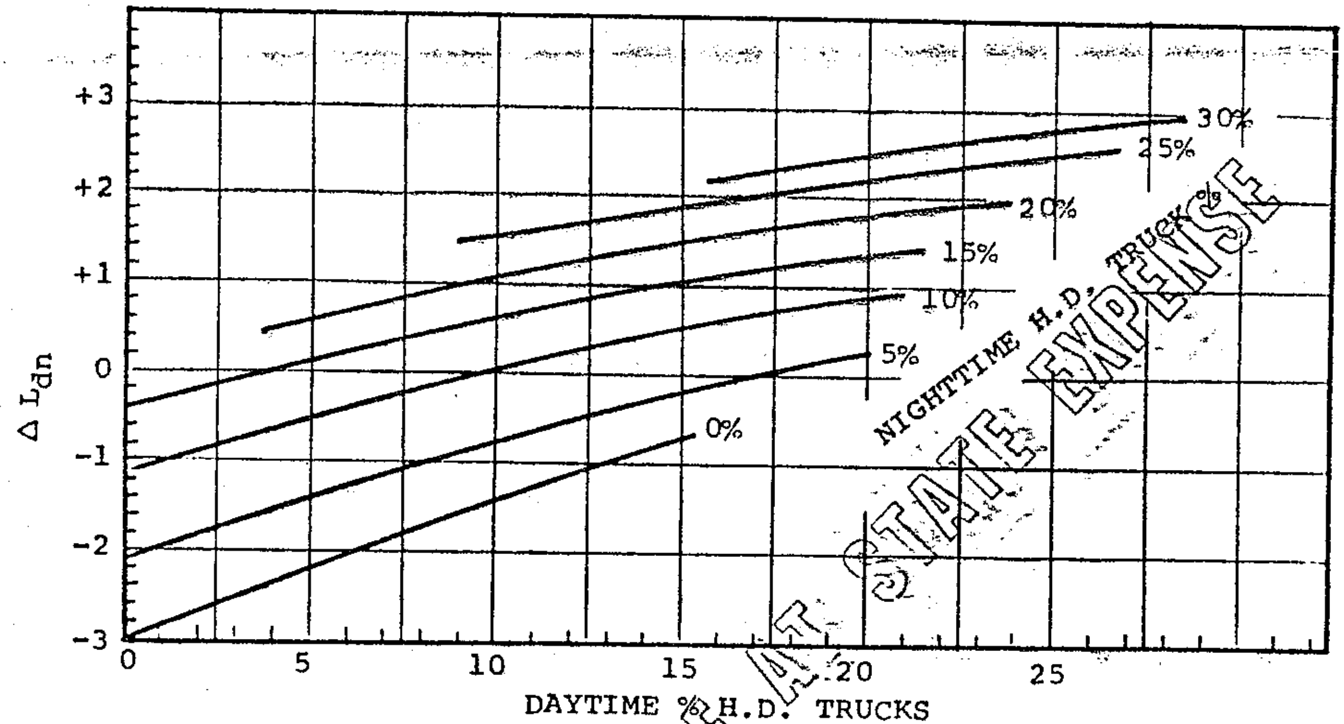


FIGURE III-2.6

ADJUSTMENT FOR VARIATION IN DAY AND NIGHT
HEAVY TRUCK PERCENTAGE - HIGH SPEED HIGHWAYS



III-2.2 EXAMPLE PROBLEM ON NOISE CONTOURS (HIGH SPEED HIGHWAY)

a) Step 1

Record the Traffic Flow Data on Figure III-2.1a.

b) Step 2

General Highway Classification is High Speed since the data in Step 1 shows average vehicle speed of 55 mph.

c) Step 3

Using Figure III-2.3a with an ADT of 100,000 and distance of 500 feet, the L_{dn} is about 67 dBA. Record this data on Figure III-2.1a.

d) Step 4

Using Figure III-2.4a with a % daytime ADT of 80%, the L_{dn} adjustment of + 1.1 is determined. Record this data on Figure III-2.1a.

e) Step 5

Using Figure III-2.6a with a daytime % H.D. Trucks of 15%, the truck volume adjustment is -0.3 dBA.

f) Steps 6 & 7, do not apply for this example.

g) Step 8

Since this is a depressed highway, 6 dBA is subtracted because the cut section is greater than 100 ft to the receiver. Record this data on Figure III-2.1a.

h) Step 9

Sum up the values in Steps 3, 4, 5 and 9. The calculated value is L_{dn} 61.8 which is recorded on Figure III-2.1a.

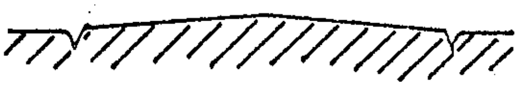
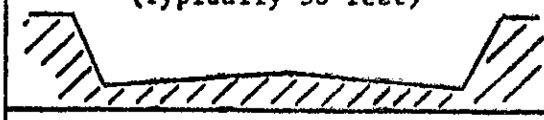
FIGURE III-2.6a HIGHWAY TRAFFIC NOISE WORKSHEET

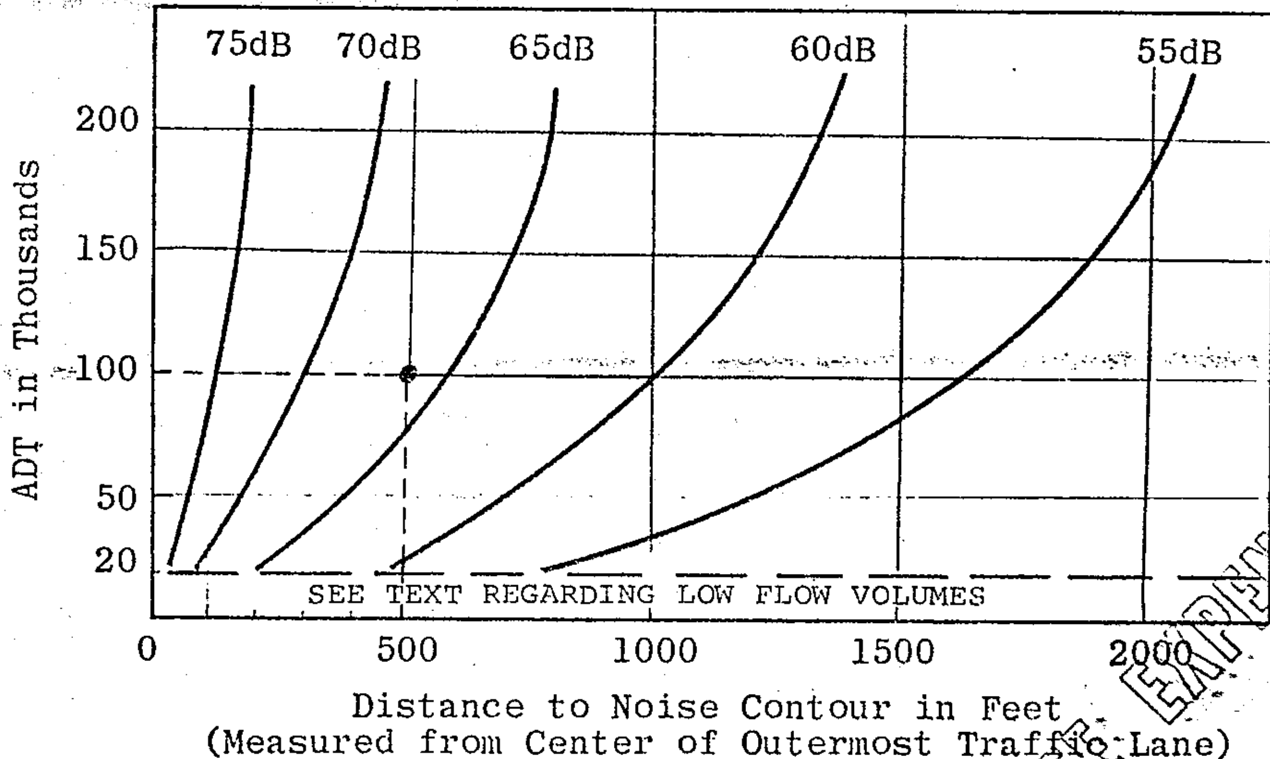
Step 1. Traffic Flow Data

ADT	:	100,000	Vehicles/24 hours
Daytime % of Traffic Flow	:	80 %	Vehicles/Daytime
Daytime % of Heavy Duty Truck Flow	:	15 %	Trucks/Day
Nighttime % of Heavy Duty Truck Flow	:	5 %	Trucks/Night
Average Vehicle Speed	:	55	MPH
Number of Traffic Lanes	:	8	Lanes
Highway Elevation Relative to Sideline Terrain	:	-30	Feet
Distance to Site (Measured from Center Line of Closest Traffic Lane)	:	500	Feet

	Low Speed	High Speed
Step 2. General Highway Classification • Low Speed 35 - 45 mph	Figure III-2.2a	
• High Speed 55 + mph		Figure III-2.3a
Step 3. Nominal L_{dn} corresponding to ADT in Step 1 at specified distance.		67.0
Step 4. Adjustment for Daytime % of traffic flow: Use Figure III-2.4a if other than 87%.		+1.1
Step 5. Adjustment for Variation in Day/Night Heavy Truck Volume %		
• Low Speed: If not constant 4%, use Figure III-2.5		
• High Speed: If not constant 10%, use Figure III-2.6a		-0.3

FIGURE III 2.6a HIGHWAY TRAFFIC NOISE WORKSHEET (Continued)

		Low Speed	High Speed
Step 6. Adjustment for Vehicle Speed - Low Speed Only 35 mph Average Speed: Add 0 dB 45 mph Average Speed: Add + 2 dB			
Step 7. Number of Traffic Lanes			
6-8 Lanes (Low Speed): - 1 dB			
2-4 Lanes (High Speed): + 2 dB			
Step 8. Correction For Relative Highway Elevation			
Highway Configuration	Noise Exposure Adjustment at Specific Distance		
Highway at Grade 			
Elev. Highway (Typically 30 ft) 	-6 @ 100' -2 @ 200' 0 > 300'		
Depressed Highway (Typically 30 feet) 	-6 > 100'		-6.0
Step 9. Adjusted L_{dn} Contour Value at Site Location			61.8
Step 10. Required Dwelling Isolation		45 dB	45 dB



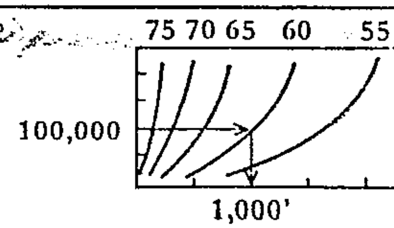
L_{dn} Noise Contours for High Speed Highways and Freeways		
Traffic Flow Parameters		Example
Day Night Split:	87% - 13%	 ADT = 100,000 yields: 60dB at 1,000 feet
Percent Heavy Trucks:	10%	
Typical Speeds:	55-65 mph	
Roadway Configuration:	6 to 8 lanes	

FIGURE III-2.3a TRAFFIC NOISE NOMOGRAM FOR HIGH SPEED HIGHWAYS AND FREEWAYS.

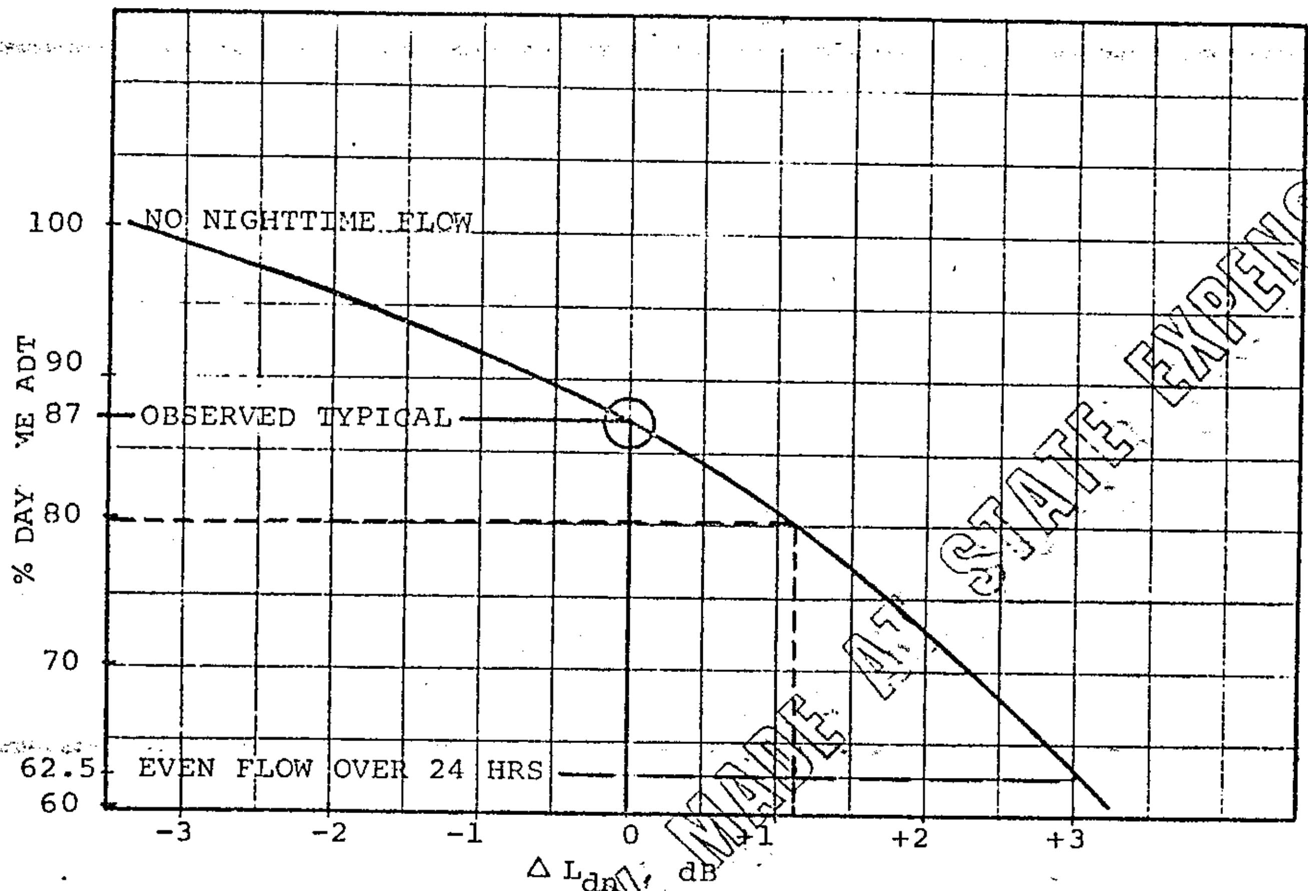
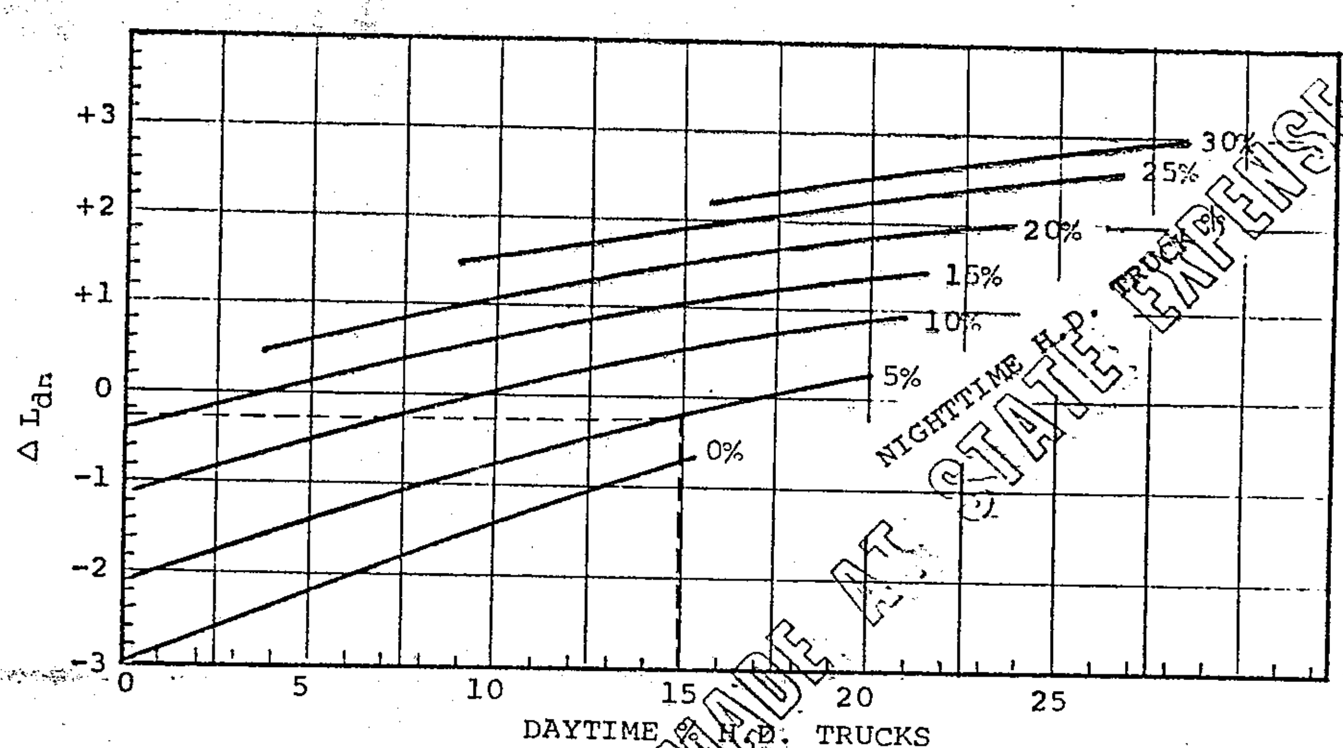


FIGURE III-2.4a
ADJUSTMENTS FOR VARIATION IN DAY/NIGHT FLOW DISTRIBUTION

FIGURE III-2.6a

ADJUSTMENT FOR VARIATION IN DAY AND NIGHT
HEAVY TRUCK PERCENTAGE - HIGH SPEED HIGHWAYS



REFERENCES

FOR

SECTION III

REFERENCES

1. California Standard Specifications; January 1978
   Section 7-1.01N, Sound Control Requirements
   Section 42-1.02, Construction
   Section 42-2.02, Construction

2. Environmental Handbook; Department of Transportation; Office of Environmental Planning.

3. Project Development Procedure, Department of Transportation; Office of Planning and Design.

APPENDIX IIIA

CALIFORNIA LAWS, CODES
AND
CALTRANS DIRECTIVES

APPENDIX IIIA

California Laws, Codes and Caltrans Directives That are of Interest to Transportation Engineers

1. Environmental Quality Act of 1970; Public Resources Code; Division 13; Environmental Quality

This act requires environmental impact reports to be written for highway projects. It sets policy and defines the duties of the various state agencies.

2. California Streets and Highways Code; Section 216; Control of Freeway Noise in School Classrooms; September 17, 1970

This section requires that Caltrans abate noise to 50 dBA peak or less when the noise from freeways exceeds 50 dBA in schools. (Appendix IIIB shows the entire Section 216.)

3. California Vehicle Code (As of September 1978)

23130	Vehicle Noise Limits
23130.5	Vehicle Noise Limits: 35 mph or less speed zone
27150	Mufflers
27150.1	Sale of Exhaust Systems
27150.2	Regulations Concerning Exhaust Systems
27150.3	Study of Exhaust Systems
27150.4	Filing of Regulations with Legislature
27150.5	Sale of Non Complying Exhaust System
27150.6	Federal Assistance
27150.7	Dismissal of Prosecution
27150.8	Motorcycle Exhaust System

27151	Modification of Exhaust System
27152	Exhaust Pipes
27200	Vehicle Registration and Sale Prohibitions
27201	Pre 1970 Motorcycle Limit
27202	Motorcycle Limit
27204, 204.5, 27205, 27206, 27207,	Reference to 27200
38365	Muffler and Exhaust Systems
38370	Noise Limits

4. California Administrative Code Title 25; Article 4; Noise Insulation Standards; February 22, 1974

Sets interior noise levels at CNEL 45 dBA for new construction of commercial or multifamily residential units.

5. Department of Transportation Policy and Procedure No. P74-47; Freeway Traffic Noise Reduction; July 24, 1974

This directive outlines Caltrans policy and responsibilities related to transportation noise (Appendix IIIC).

6. Department of Transportation Memo from John F. Maloney; Policy on Traffic Generated Noise; September 12, 1974

Contains further details to Item 5 (Appendix IIID).

7. Senate Bill 860; Section 65302 of the Government Code; Noise Element of the General Plan; September 28, 1975

Requires Caltrans to provide cities and counties with a noise contour map along state highways.

8. Department of Transportation Memo from Carl Forbes; Noise Level Information for City and County General Plan; November 10, 1976

Caltrans implementation of Item 7 (III-2).

9. Department of Transportation Memo from Carl Forbes; Legal Involvement in Environmental Process; June 24, 1976

Requires Caltrans legal department to assist in environmental projects and activities (Appendix IIIE).

10. Department of Transportation Policy and Procedure; No. P77-40; Sound Barriers; October 7, 1977

Provides policy on requests from others to construct a sound barrier on State right of way and encourages coordination from those constructing such facilities near the right of way (Appendix IIIF).

11. Department of Transportation Memo from W. R. Green; Priority for Community Noise Program; May 31, 1978

Discusses present practice for determining C-1 and C-2 categories. Request input for modifying policy (Appendix IIIG).

12. Department of Transportation Memo from W. R. Green; Priority for Community Noise Abatement; October 3, 1978

Provides additional discussion on Item 11 (Appendix IIIH).

13. Department of Transportation Memo from C. E. Forbes; New FHWA Highway Traffic Noise Prediction Model; November 2, 1978

Provides instructions on implementation of New FHWA Prediction Model (Appendix IIII).

14. Department of Transportation Memo from Phil Raine; 1980 STIP Priority Setting Phase; March 1, 1979 HB311 - Community Noise Attenuation, HB312 - School Noise Attenuation.

Prioritizes projects for the two programs (Appendix IIIJ), supplements Appendix IIIG and IIIH.

15. California Streets and Highways Code; Section 2155; Priority System For Noise Barriers; January 1, 1979

This section requires Caltrans to develop and implement a system of priorities for ranking the need for installation of noise attenuation barriers in California. It also provides reimbursement of costs incurred by city or county when barriers are constructed by them under certain conditions.

Refer to Appendix IIIG, IIIH and IIIJ.

APPENDIX IIIB

SECTION 216
OF THE
CALIFORNIA STREETS AND HIGHWAYS CODE
CONTROL OF FREEWAY NOISE IN SCHOOL CLASSROOMS

Control of Freeway Noise in School Classrooms

216. The noise level produced by the traffic on, or by the construction of, a state freeway shall be measured in the classrooms, libraries, multipurpose rooms, and spaces used for pupil personnel services of a public or private elementary or secondary school if the classrooms, libraries, multipurpose rooms, or spaces used for pupil personnel services were constructed prior to the award of the initial construction contract for the freeway route and prior to January 1, 1974, or were constructed after December 31, 1973, and were constructed prior to the issuance of a statement of present and projected noise levels of the freeway route by the department pursuant to subdivision (g) of Section 65302 of the Government Code, and are being used for the purpose for which they were constructed.

Such measurements shall be made at appropriate times during regular school hours and shall not include noise from sources that exceed the maximum permitted by law.

If the noise level produced from the freeway traffic, or the construction of the freeway, exceeds 50 decibels on the "A" scale, the department shall undertake a noise abatement program in any such classroom, library, multipurpose room, or space used for pupil personnel services to reduce the freeway traffic noise level therein to 50 or fewer decibels on the "A" scale by, but not limited to, installing acoustical materials, eliminating windows, installing air conditioning, or constructing sound baffle structures.

If the department determines that the construction of the freeway will result in a noise level exceeding 50 decibels on the "A" scale, the department shall complete the temporary or permanent noise abatement program prior to commencing such construction, or as soon as practicable thereafter.

If it becomes necessary to convert such classrooms, libraries, multipurpose rooms, or spaces used for pupil personnel services to other school-related purposes because the freeway traffic noise level therein exceeds 50 decibels on the "A" scale, the department shall pay the cost of such conversions.

If the noise level generated from sources within and without the classrooms, libraries, multipurpose rooms, or spaces used for pupil personnel services exceeds 50 decibels on the "A" scale prior to construction of the freeway and the noise from the freeway, or the construction thereof, also exceeds 50 decibels on the "A" scale, the department shall be required to undertake such a noise abatement program that will reduce the noise to its preconstruction level.

Priority for noise abatement programs shall be given to those public and private elementary and secondary classrooms, libraries, multipurpose rooms, and spaces used for pupil personnel services constructed in conformance with Article 4 (commencing with Section 15451), Chapter 2, Division 11 of the Education Code.

As used in this section, the "A" scale means the "A" weighting described in Section 3.1 of the American National Standard Specification for sound level meters, S1.4-1971, approved April 27, 1971, and published by the American National Standards Institute.

The department shall submit to the Legislature, on or before Feburary 1 of each year, an annual report on its program for the implementation of this section.

Definition

216.1. As used in Section 216, "spaces used for pupil personnel services" means rooms that are used primarily for counseling, testing, or similar type services involving the presence of pupils.

Santa Teresita Parish School

216.2. The department shall undertake a noise abatement program pursuant to Section 216 at the Santa Teresita Parish School near Route 10 in the City of Los Angeles, notwithstanding the fact that the school was constructed after the initial construction contract for Route 10 was let.

This section shall not be construed to affect the eligibility of any other school for a noise abatement program of the department.

Soto Street School

216.3. The department shall undertake a noise abatement program pursuant to Section 216 at the Soto Street School of the Los Angeles City Unified School District, notwithstanding the fact that the traffic noise level in the front portior of the school is produced by traffic on a city street.

APPENDIX IIIC

CALTRANS POLICY AND PROCEDURE

ON

FREEWAY TRAFFIC NOISE REDUCTION

APPENDIX IIIC

POLICY & PROCEDURE
Freeway Traffic Noise Reduction

No. P74-47
7/24/74

I. PURPOSE:

This directive outlines the basic policy and responsibilities of the Department in dealing with noise generated by motor vehicles on State freeways.

II. POLICY:

It is the objective of the Department of Transportation to reduce freeway traffic noise to specified standards on new construction and to achievable levels within practical and financial limits on existing freeways. Policies in support of this Departmental objective are described below in terms of the three approaches to alleviation of traffic noise problems -- reducing the motor vehicle noise source, encouraging compatible adjacent uses, and decreasing the noise reaching adjacent areas.

A. Reduction at the Source

Reduction of traffic noise at the source is the most effective control; therefore, the Department encourages and supports legislation to require reduction in motor vehicle noise as advances in the state of the art of motor vehicle engineering permit.

B. Encouraging Compatible Adjacent Use

The Department encourages those who plan and develop land and the local governments controlling development or planning land use near known freeway locations to exercise their powers and responsibility to minimize the effect of vehicle noise and to locate land uses appropriately. For example, cities and counties have the power to control development by the adoption of land use plans and zoning, subdivision, building and housing regulations.

C. Noise Attenuation

The Department of Transportation will locate, design, construct, and operate freeways to minimize the traffic noise reaching adjacent areas.

III. PROCEDURE:

A. Reduction at the Source

Existing State law requires progressively lower allowable noise levels for new vehicles through 1987. As motor vehicle engineering advances are made these vehicle noise emission laws should be updated to further reduce vehicle noise to achievable levels.

Further, the Department encourages and supports local, State, and Federal agencies in the effective enforcement of existing vehicle noise laws. It is effective enforcement that gives meaning to adopted vehicle noise laws and ordinances.

The Department will work with the appropriate Federal agencies in the implementation of the Federal Noise Act of 1972 (PL 92-574).

Cities and counties should adopt a noise ordinance which includes reference to vehicle noise and should pursue a vehicle noise law enforcement program.

B. Encouraging Compatible Adjacent Use

Vehicle noise attenuation is a shared responsibility; therefore, mitigation measures by the Department will be taken in relation to the assumption of local responsibilities by the respective cities and counties. These local actions would include, but not be limited to:

- An adopted transportation noise element in the community general plan (as required by Section 65302(g), California Government Code).
- Subdivision regulations which provide for proper site design and building location where noise sensitive uses must locate in proximity to freeways.
- Zoning regulations which separate noise sensitive land uses from proximity to freeways and locate land uses compatible with traffic noise adjacent to freeways.
- Building construction requirements for sound proofing buildings from exterior noise.

C. Noise Attenuation

1. Freeway Mitigation Measures

The Department will take the following actions, within practical and financial limits:

a. During the route location study phase, the Department will endeavor to protect adjacent noise sensitive buildings and land uses by appropriate means of location and design, such as depressing of the freeway or construction of noise barriers.

b. For existing freeways (including freeways under construction and adopted freeway routes on which construction has not started), the Department will develop a program of appropriate measures to mitigate the effects of traffic noise upon noise sensitive developments and land uses. The program will be based on factual data, objective criteria, and a system of priorities for action. A major criterion in determing priorities will be local action as listed in III, B to assume responsibility for planning and regulating land uses and buildings adjacent to freeways so as to reduce the effect of traffic noise.

In those areas where adjacent noise sensitive developments came into existence after commencement of construction of a now existing freeway, the local action listed in III. B. will be considered a requirement before the Department would consider remedial measures.

2. <u>Research and Study of Noise Pollution</u>

The Department will perform and encourage research to reduce the noise generated by motor vehicles.

The Department will continue research on noise barrier design and the development of improved noise reduction techniques. The Department also will study the impact of vehicle noise on individuals and the environment, and make other studies dealing with freeway noise. This activity will be coordinated with other public and private research and development on noise reduction.

3. <u>Noise Abatement for Schools</u>

The Department will undertake noise abatement measures in accordance with Section 216 of the Streets and Highways Code.

4. <u>Technical Assistance</u>

The Department will provide to cities and counties the sound level information relating to traffic on State highways that these local units need for the preparation of the transportation noise element of their general plan as required by Section 65302(g) of the California Government Code.

The Department will advise and assist in analyzing freeway traffic noise relating to land use, building, and housing regulation within its area of expertise.

IV. ACTION REQUIRED:

A. The Legislative Affairs Unit shall:

1. Review, analyze, and recommend departmental positions on State and federal legislation which requires reduced motor vehicle noise emissions.

2. Introduce and support legislation which will aid and implement departmental policies on motor vehicle noise control.

B. The Division of Transportation Planning shall:

1. Prepare and issue guidelines for systems planning and corridor studies that would achieve motor vehicle noise levels that are compatible with existing and planned adjacent land uses.

2. Provide noise control consulting services to the Districts for systems planning and corridor studies.

C. The Division of Highways shall:

1. Pursuant to III.C. 1, develop and provide to the Districts a program, within practical and financial limits, to reduce the effects of motor vehicle noise upon noise sensitive developments and land uses adjacent to freeways, including existing freeways, freeways under construction, and adopted freeway routes where construction has not started.

2. Conduct an active program of research on noise problems, including but not limited to noise reducing devices and possible noise limits for motor vehicles, noise reduction barriers, and the impact of freeway noise on people.

3. Provide noise control consulting services to Districts for project development.

D. The Transportation Districts and Toll Bridge Administration shall:

1. Carry out the statewide program to reduce the effects of motor vehicle noise generated by freeway traffic.

2. Assist local agencies and transportation planning agencies to incorporate noise control measures in systems planning and corridor studies.

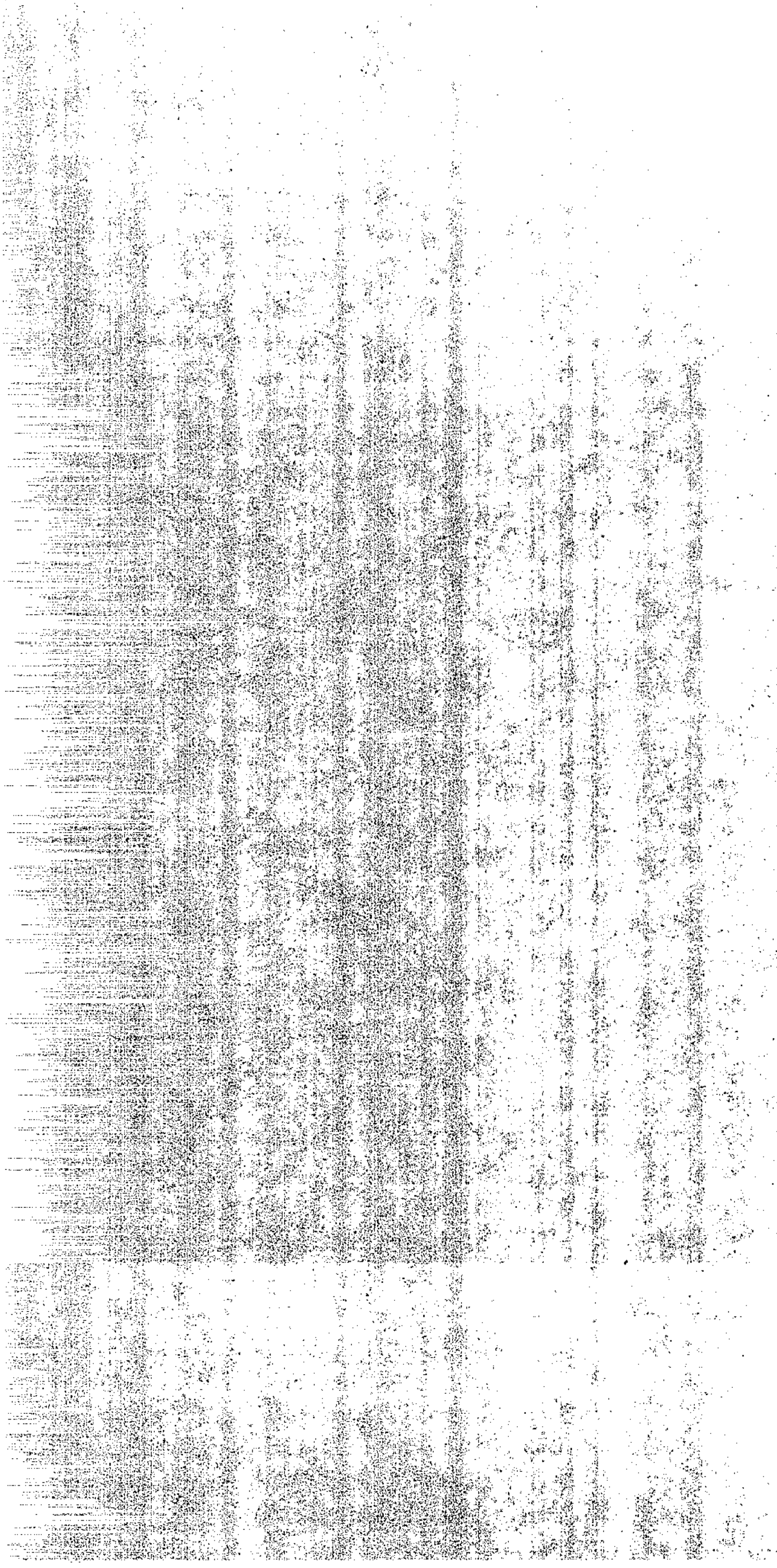
3. Work with local units of government to encourage the use of control measures that will alleviate the effect of motor vehicle noise on land adjacent to freeways.

4. Provide cities and counties with the noise level information required by California Government Code Section 65302(g) for those cities and counties to prepare the transportation noise elements of their general plans.

5. Undertake noise abatement programs for elementary and secondary schools as required by Section 216, Streets and Highways Code.

APPENDIX IIID

CALTRANS POLICY MEMO
ON
TRAFFIC GENERATED
FREEWAY NOISE



Memorandum

To : All District Directors of Transportation

Date: September 12, 1974

File :

From : DEPARTMENT OF TRANSPORTATION
Director's Office

Subject: Policy on Traffic Generated Freeway Noise

Policy and Procedure No. 74-47 dated July 24, 1974 states basic Departmental policy on traffic-generated freeway noise. This letter contains further details and implementing instructions.

The basic policy liberalizes and extends noise reduction measures to be taken on existing and planned freeways. These measures are, in some cases, contingent on local governments regulating future development near freeways to be compatible with the freeway environment.

Local governments' promotion and regulation of future development which is compatible with the Department's future projects or existing facilities must be a cooperative effort on everyone's part. The actions which we will expect local governments to accomplish are detailed in Sections II-B and III-B of P 74-47.

We, in turn, should take positive steps to inform local governments of what they can expect from the Department. To this end, the Districts shall:

1. Inform local governments of Departmental policy by sending copies of P 74-47 and this letter, together with appropriate explanation. Include a statement that there will be further consultation with CSAC and the League of Cities regarding criteria for the priorities stated under Sec. C.

2. Continue the practice of reviewing and commenting on proposed subdivision plans, local project EIR's, etc., pointing out possible noise impacts and the effect of Departmental policy.

3. Continue to furnish information to local planning agencies to assist them in preparing the noise element of general plans per Sec. 65302(g) of the California Government Code.

4. Advise and assist in analyzing freeway traffic noise relating to land use, building, and housing regulations within our area of expertise.

Departmental development of freeway projects can be divided into three categories: (A) route studies prior to route adoption; (B) new construction on routes already adopted or reconstruction of existing freeways; and (C) noise attenuation projects on existing freeways.

A. Route Studies prior to route adoption: Section III-C 1-a of P 74-47 states the basic policy which conforms to existing policy and Federal and State laws and regulations.

B. New construction on routes already adopted, or reconstruction of existing freeways.

1. Residences and other noise sensitive development in existence or under construction as of the date of notification of local governments of Departmental policy, as previously stated, will be protected similar to A without protection being conditioned on adoption of local ordinances, regulations, etc.

2. Protection of development which begins after notification of local governments of Departmental policy will be conditioned on adoption of proper ordinances, regulations, building codes, etc.

   Where these local actions are taken, the Department will undertake whatever design steps or modifications are feasible and required for further attenuation of noise impact. Federal noise level standards or lower would be a goal for achievement, but would not be mandatory. If proper local control has been achieved, required Departmental effort should be minimal.

   Where local responsibilities are not fulfilled, special justification for Departmental financial obligation must be submitted for approval to DOH Project Development Branch.

3. There may be cases where local responsibilities have been fulfilled per Sec. III-B of P 74-47, but excessive noise impact from a freeway construction project will still remain. The Department will take whatever steps may be feasible, consistent with cost-effectiveness and traffic safety, to reduce the remaining impact. However, development in this category should be discouraged as not being compatible development through the District's review and comment on subdivision plans and EIR's.

C. Noise attenuation on existing freeways. A new element of the HB-36 Program will be recommended as a part of the 1975-76 fiscal year budget, and will continue as an on-going program. Basic to this on-going program will be an inventory of locations where noise-sensitive development is exposed to freeway noise levels in excess of Federal standards. Work on this inventory should begin immediately and should be basically completed so that a logical selection of projects, and a funding level, can be made for the 1976-77 F.Y. budget. Include in this inventory any projects which were identified for the cost estimate developed for the 1975-76 F.Y. budget. This inventory will be used to develop annual District targets for the on-going HB-36 program. It is anticipated that funding of this program will be modest, and therefore a systematic approach to setting of priorities is important.

The following interim priorities are established:

1. Noise sensitive development which existed or was under construction prior to route adoption. Projects for noise protection in this first priority will not be conditioned on local enactment of ordinances, etc.. At the expected level of funding, it will probably be a number of years before completion of all projects in this category.

   a. Within this category, first priority is given to development which is exposed to the highest noise levels.

   b. There will undoubtedly be many areas exposed to about the same noise levels. To set priorities within these comparable areas, use the following approach:

      $$\frac{\text{Achievable reduction}^{*} \times \text{number of living units}}{\text{Cost}}$$

      * Achievable L_{10} noise level reduction, expressed in dBA, based on measurements of existing noise levels, and interpreted as instructed in "Instructions on Noise Studies" dated June 19, 1974.

* Sec. C projects on Interstate routes may be eligible for Federal participation in engineering, R/W, and construction costs under the provisions of Sec. 114 of the 1973 F.A. Highway Act.

- Attenuation measures may consist of the most appropriate and cost-effective construction methods whether inside or outside the R/W, including barriers or treatment of structures. Measures such as purchase of noise easements or buying and/or re-selling of homes will not be used. PPM 90-2 noise levels are a desirable goal to be achieved but are not mandatory.

- Local financial participation in Section C projects is encouraged. Local funds should be considered to reduce the denominator of the formula in C-1b for the purpose of setting priorities.

- Policies previously established regarding other forms of cooperation with local agencies are continued where appropriate. These include granting of permits for local projects on State R/W and maintaining features constructed by others, all subject to proper controls.

- There will undoubtedly be cases where structures post-dating route adoption are intermixed with those pre-dating route adoption. As a general rule, no distinction should be made and all considered as warranting protection. Judgment will have to be used in deciding what length of gap to close, under this general rule.

2. Development occurring after route adoption but before initial freeway construction, and

3. Development occurring after initial freeway construction.

Since it is anticipated that it will be a considerable length of time before any projects in Categories 2 or 3 are undertaken, detailed guidelines will not be established at this time. It can be stated, however, that local enactment of proper ordinances etc. will be an important factor in setting priorities within these categories.

The following applies to all noise attenuation features constructed and/or maintained by the Department.

Environmental laws and Federal and State policies and regulations all treat noise attenuation as one aspect of achieving environmental compatibility with governmental actions. It is to be considered within the overall environment, and other elements may sometimes overrule noise mitigation. Within this philosophy, Departmental actions and projects must be considered in terms of cost, effectiveness, and possible undesirable results such as reduced safety, geometric standards, or aesthetics. It is recognized that decisions will sometimes have to be made that consideration of these other elements overrules the desirability of noise attenuation.

Original Signed By J. F. Maloney

JOHN F. MALONEY
Deputy Director
for Operations

NOTE: The formula for establishing priorities in this memo has been changed and is now shown as Section 215.5 of the California Streets and Highways Code (Appendix IIIK).

[illegible]

APPENDIX IIIE

CALTRANS POLICY MEMO
ON
LEGAL PARTICIPATION

State of California — Business and Transportation Agency

Memorandum

: ALL DISTRICT DIRECTORS

Date: June 24, 1976

File :

From : DEPARTMENT OF TRANSPORTATION
Chief Engineer's Office

Subject:

The integration of the many procedural requirements of the environmental process into all of our activities is a complex task. Because of these procedural complexities, lawsuits charging noncompliance with the environmental requirements have been used to successfully delay or stop Departmental activities. These actions, when brought, are disruptive and costly. They have usually occurred after the Department has expended considerable time and money on the project.

The Department desires to assure itself that the procedures followed on all of its activities are legally adequate. In order to reduce our exposure to litigation concerning noncompliance with the environmental laws, I have asked the Legal Division to become more involved in the Department's environmental process. The Legal Division has agreed to provide a greater degree of participation in the environmental process and will be assigning a specific attorney for each district.

The attorney will be available for assistance on specific projects as well as to advise the district on overall environmental activities. It is my intention to utilize the Legal Division as a resource to be introduced early into the activities involving CEQA and/or NEPA, and not to be used only to perform formal legal review. In this way the special knowledge and experience of the attorney can be used to the fullest in the environmental review procedure.

You will be contacted in the near future by Mr. Jim Gordon to arrange a meeting with you, your Deputies, and the district's environmental attorney. The purpose of this meeting will be to discuss various concerns, areas of involvement, means of contact, and so forth. It is anticipated that the environmental attorney will meet periodically with the district's Environmental Branch, and other branches as appropriate. Among other things, these meetings will discuss the status of existing activities, proposed new activities, provide advice on unusual or unique proposals, and to keep the districts abreast as to the current developments of the law.

I want to reemphasize the purpose of the environmental attorney is not intended to be strictly that of a reviewer of the environmental process, but rather to provide counsel to the district for all activities through all stages of the environmental process. In this way we can minimize our exposure to environmental litigation at that critical point just prior to construction so that there will be no costly delays or disruptions to our activities.

C. E. FORBES
Chief Engineer

APPENDIX IIIF

CALTRANS POLICY AND PROCEDURE
ON
SOUND BARRIERS

CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DAS-MA-4

policy & procedure

TITLE: Sound Barrier Construction by Others Within or Near State Highway Right of Way	APPROVED BY: [signature]
NO. P77-40	DATE ISSUED 10/7/77
PAGE 1 OF 9	
SUBJECT AREA: Sound Barriers	ISSUING UNIT: Office of Planning and Design
SUPERSEDES: None	DISTRIBUTION: Divisions and Districts/through Branch Chiefs

I. PURPOSE

To set forth a policy on handling requests from others for authority to construct a sound barrier within the right of way, and to encourage coordination where appropriate with those constructing such facilities near the right of way.

II. BACKGROUND

Some Districts are receiving requests from others for authority to construct sound barriers within the right of way. Such installations may be the most feasible or least expensive way for owners or developers to attenuate noise reaching adjacent properties for which the State's mitigation priority is low or nonexistent. At the same time, depending on its location and design, the effect of the barrier on the operation, maintenance or aesthetics of the highway may be more detrimental than beneficial. Thus, it appears desirable to provide guidance on appropriate action when such construction is proposed by others.

III. POLICY

A. <u>The general policy is that all feasible steps must be taken in the design of the adjacent development to attenuate noise, so as not to require encroachment on the right of way</u>.

B. Where it is determined to be appropriate to permit others to construct a sound barrier within the right of way, the general policy is that:

1. <u>Neither sight distance nor any other applicable geometric or safety standards are to be reduced below standard to accommodate noise barriers</u>.

2. The State shall assume ownership and maintenance responsibility for any facility built within the right of way.

3. Sound barriers are not considered to be longitudinal encroachments.

4. Proposals for sound wall construction within the right of way by others should be initiated and justified by others.

C. When others propose to construct a sound wall near, but outside the right of way line, it is frequently appropriate for the State to coordinate with the builder in such regards as:

1. Authorizing grading work under permit within the right of way to facilitate the construction of the wall on a better line and grade, which may provide mutual benefits from the functional and aesthetic points of view.

2. Negotiating arrangements whereby the State's fence can be omitted or removed, if the wall will suffice for access control.

D. The State shall assume <u>no</u> review authority or responsibility of any kind for the structural integrity or the effectiveness of the sound attenuation of walls constructed <u>outside</u> the right of way. It should be made clear to all concerned that any comments on these matters by State personnel in response to questions are informal opinions, and that all responsibility for the wall continues to rest with others. (However, in special cases, the State may, by a specific agreement, contract to provide design or other services, if authorized under the "Work For Others" policy).

IV. <u>PROCEDURE</u>

A. Requests from others for authority to construct sound barriers within the right of way should be considered on an individual case-by-case basis. Among the matters to be addressed are:

1. Alternative methods by which the objectionable noise may be attenuated.

2. Type and acoustical effectiveness of sound barrier proposed.

3. Location of sound barrier.

4. Advantages and disadvantages to State highway users.

5. Advantages and disadvantages to the adjacent community.

Considerations, criteria, and standards relative to the above items are discussed in more detail in the attached appendix. Similar criteria apply to the selection of the type and location of sound barriers on projects originated and administered by the State. Only when the District is satisfied that encroachment is the only practical solution should the proposal be pursued further. In this respect, a moderate increase in cost to the developer to avoid encroachment should not be the sole reason for permitting encroachment.

B. If it is concluded that it is proper to permit the sound barrier to be built within the right of way, the minimal State responsibility is to perform sufficient additional review and inspection to reach a judgment that:

   1. The design is appropriate, effective, adequate, aesthetically pleasing and safe, all factors considered, including future maintenance considerations and costs.

   2. Construction is performed in a safe and satisfactory manner.

C. Beyond that, questions to be decided include:

   1. Whether it is appropriate from the priority standpoint and other considerations to advance the construction of any adjacent wall which is a State obligation, in order to combine it and the other party's wall into one contract for continuity, public relations benefits, etc.

   2. Which party will design the facility and undertake the necessary environmental processing. Although there is much to be said in favor of the Department performing these functions for installations located within the right of way, the District will not always have this option under the present manpower situation. However, walls designed by others for installation on State right of way shall be reviewed and approved for structural adequacy by the Office of Structures Design.

   3. Which party will prepare and administer the contract. Again, manpower considerations will play a part in the decision. However, generally, the State will administer

any such contract within the right of way if the District deems this necessary for safety reasons, such as when the wall is to be located near moving traffic, or when construction operations may interfere with traffic. In other cases, at the District's option, it may be acceptable for others to administer the work, unless protection of landscaping or other considerations make this inadvisable.

3. The payment to the State. Normally, the State will be paid for all its administrative and engineering costs when it performs design work for, or administers a sound barrier contract. However, State participation in such costs may be appropriate in a few cases where there are offsetting benefits to the State, such as when:

   a. A wall eliminates the need for a fence.

   b. A wall with a built-in safety shape barrier reduces the hazard of running off the road.

   c. A mound benefits highway users in terms of safety and aesthetics.

V. ACTIONS REQUIRED

In accordance with the policies, procedures, and criteria set forth herein:

A. Review and process requests from others for authority to construct sound barriers within the right of way.

B. Coordinate, where appropriate, with those who propose to build sound barriers just outside the right of way.

C. For highways that have been Federally funded, obtain FHWA concurrence for any sound wall construction within the right of way, or that affects access control.

- APPENDIX -

MISCELLANEOUS CONSIDERATIONS, CRITERIA, AND STANDARDS

I. ALTERNATIVE METHODS OF NOISE ATTENUATION FOR DEVELOPMENT ADJACENT TO STATE HIGHWAY RIGHT OF WAY*

A. Provide buffer zones by developing immediately adjacent to the highway:

1. Landscaped open areas. (For the most part, the degree of attenuation varies directly with the depth of the property rather than the amount of landscaping.)

2. Property uses not sensitive to noise.

B. Reorient tract, streets, buildings, etc., to increase the distance to properties, and minimize the number which are on a direct line of sight from the source of the sound:

1. Construct local street between highway and adjacent properties.

2. Minimize or eliminate openings on highway side of buildings.

3. Place buildings on highway side of lots, and connect buildings with walls to shield garden areas from noise.

C. Install air conditioning and acoustical insulation.

D. Build walls or mounds outside the right of way.

E. With due consideration for potential drainage, maintenance, or other problems, issue permit for grading in right of way to facilitate construction of walls oustide right of way. (When this is done, it is often desirable to negotiate arrangements whereby the State's access control fence can be omitted or removed, if the wall will suffice for this purpose.

* Further data on this subject are contained in:

- "The Audible Landscape", November 1974; an FHWA Manual prepared by Urban Systems Research and Engineering, Inc., Cambridge, Mass.

- "Quiet City Report", prepared by the Quiet City Committee Los Angeles County Division, League of California Cities.

Where the estimated value of the fence does not exceed the estimated cost of its removal, others may be permitted to remove the fence and salvage the materials. The State will benefit from not having to maintain the fence, and from not having to tolerate the unsightly conditions that can develop between a fence and a wall. A wall which replaces a fence may be placed just inside the right of way line or just outside the line. In the latter case, provisions should be made to insure that no gap exists between either end of the wall and the start of the State's fence. Also, rights should be obtained to erect temporary fences, if necessary, to close any holes in the wall that may come into being in the future, in the event the owner does not undertake immediate repairs.)

II. TYPE OF SOUND BARRIER

Basically, sound barriers include earth mounds, walls, or a combination thereof. Earth mounds are often safer and more aesthetic, and may be the least expensive solution, depending on the height required and the availability of right of way. More detailed information on types of sound barriers is available in W. R. Green's memorandum of April 15, 1974 on "Sound Wall Design", FHPM 7-7-3, and U.S. Department of Transportation Implementation Package 76-8, "Highway Noise Barrier Selection, Design and Construction Experiences".

III. LOCATION OF SOUND BARRIER

A. The general policy is that all feasible steps must be taken in the design of the adjacent development to attenuate noise so as not to require encroachment on the right of way*. (See Section I). Only when the District is satisfied that encroachment is the only practical solution will it be considered. In this respect, a moderate increase in cost to the developer to avoid encroachment should not be the sole reason for permitting encroachment.

B. Where it is determined to be permissible to locate a sound barrier inside rather than outside the right of way, first preference shall be given to placing it just inside the right of way line, unless another location has advantages which are clearly superior.

In establishing the location of a sound barrier, factors to be considered are compatibility with, and ease of maintenance of, existing or future State-constructed facilities, such as:

1. Roadway improvements.

* An exception to this policy is a case in which it is considered advantageous to locate the wall just inside the right of way line to eliminate the need for a fence.

2. Landscaping and irrigation facilities.
3. Drainage facilities.
4. Other noise attenuation facilities.

Compatibility with other noise attenuation facilities does not necessarily mean identity of design. Facilities that harmonize aesthetically as to design and cross sectional location, and achieve similar degrees of attenuation will suffice.

C. Possible locations for sound barriers within the right of way (in generally decreasing order of desirability, except as noted) are:

1. Just inside the right of way line.
2. Thirty feet or more from the edge of pavement.
3. Sixteen to twenty-nine feet from the edge of pavement, provided walls are shielded by guardrail placed at least three feet closer to the pavement. (See Qualifying Notes D.-2. and D.-3. below.)
4. Fifteen feet from the edge of pavement, provided walls include a safety-shape barrier.

D. Qualifying notes:

1. Mounds at any of the above locations are generally preferable to walls. (It is not possible, of course, to provide full height mounds unless the location is far enough away from the pavement.)
2. If the base of a wall is located on a cut slope steeper than 4:1 at a point four feet or more above the shoulder hinge point, guardrail is not required since few vehicles will reach the wall.
3. In some cases, where the severity of an accident would be reduced if a vehicle were to collide with guardrailing rather than to run down a slope, it may be better to locate a wall at the top of an embankment rather than farther out. As indicated above, at least minimum clearances and protective barriers should be provided. The general policy is that neither sight distance nor any other applicable geometric or safety standards are to be reduced below standard to accommodate sound barriers.

any such contract within the right of way if the District deems this necessary for safety reasons, such as when the wall is to be located near moving traffic, or when construction operations may interfere with traffic. In other cases, at the District's option, it may be acceptable for others to administer the work, unless protection of landscaping or other considerations make this inadvisable.

3. The payment to the State. Normally, the State will be paid for all its administrative and engineering costs when it performs design work for, or administers a sound barrier contract. However, State participation in such costs may be appropriate in a few cases where there are offsetting benefits to the State, such as when:

   a. A wall eliminates the need for a fence.

   b. A wall with a built-in safety shape barrier reduces the hazard of running off the road.

   c. A mound benefits highway users in terms of safety and aesthetics.

V. ACTIONS REQUIRED

In accordance with the policies, procedures, and criteria set forth herein:

A. Review and process requests from others for authority to construct sound barriers within the right of way.

B. Coordinate, where appropriate, with those who propose to build sound barriers just outside the right of way.

C. For highways that have been Federally funded, obtain FHWA concurrence for any sound wall construction within the right of way, or that affects access control.

V. ADVANTAGES AND DISADVANTAGES TO COMMUNITY

A. Some Possible Advantages:

1. Sound walls help to shield occupants of adjacent properties from noise and other pollutants generated on highways.

2. Sound walls may protect people and property from injury or damage by vehicles which run off the road.

3. Sound walls may reduce a property's exposure to excessive noise sufficiently to make it eligible for a Federal mortgage financing guarantee when it otherwise would not have been eligible.

B. Some Possible Disadvantages:

1. Sound walls may interrupt the passage of air, view, and light for properties adjacent to freeways.

2. Sound walls may detract aesthetically from the overall visual impression of a neighborhood.

3. Sound walls may lead to neighborhood dissension in that there may not be a unanimity of opinion as to their desirability.

APPENDIX IIIG

CALTRANS POLICY MEMO
ON
PRIORITY FOR NOISE PROGRAMS

State of California APPENDIX IIIG Business and Transportation Agency

Memorandum

To : ALL DEPUTY DISTRICT DIRECTORS
PROJECT DEVELOPMENT

Date: May 31, 1978

File :

From : **DEPARTMENT OF TRANSPORTATION**
Division of Project Development - Office of Planning and Design

Subject:

Mr. Maloney's letter of September 12, 1974 provided implementation instructions for traffic-generated freeway noise. Category C was established for noise attenuation along existing freeways with the first consideration to be given to noise-sensitive development which existed or was under construction prior to freeway route adoption. In many cases, a number of years have now passed since the original route adoption date, and there have been considerable transfers of property ownerships.

A question has been raised as to whether transfer of original ownership since the time of route adoption should be a determining factor in establishing priorities for community noise attenuation. Should a C-1 category project be changed to C-3 if all or a substantial portion of the present owners purchased their homes after construction of the freeway?

Our present practice of disregarding property transfers has been working satisfactorily. We have had one instance where a budgeted project was later determined to be C-2 category in lieu of C-1 with some resulting embarrassment. The District Photogrammetry Coordinator should always be consulted for closest available photography at time of route adoption to provide a starting base for determination of C-1 categories.

Consideration of property ownership changes would require added research of county ownership changes and possibly develop additional gaps in sound wall proposals. Greater judgment would have to be used in establishing wall limits and existing priorities could be subject to considerable change.

Please furnish comments or suggestions by June 30 regarding the equity and whether the purchase date of property should be considered in establishing category level and priorities for HB 311 community noise attenuation projects.

We also plan to incorporate P&P 74-47 and Mr. Maloney's letter of September 12, 1974, with appropriate updating, into the Design Manual in the near future. Please furnish comments on other suggested changes.

W. R. GREEN
Chief, Office of Planning and Design

FLJ:vc

cc: RGAdams
HLKagan
GAHill
FLJackson
Central File
Planning & Design File

APPENDIX IIIH

CALTRANS POLICY MEMO
ON
PRIORITY FOR COMMUNITY NOISE ABATEMENT

[illegible]

State of California APPENDIX IIIH Business and Transportation Agency

Memorandum

To : ALL DEPUTY DIRECTORS
Project Development

Date: October 3, 1978

File :

Telephone: ATSS ( )
( )

From : DEPARTMENT OF TRANSPORTATION - Division of Project Development
Office of Planning and Design

Subject: Priorities for Community Noise Abatement

By memorandum dated May 31, 1978, comments were requested regarding our current practice of establishing priorities for HB-311 community noise attenuation projects as set forth in Mr. Maloney's letter of September 12, 1974. Your responses were very interesting and included excellent comments.

Three Districts supported dropping C-1 category projects to C-3 if all or a substantial portion of the present owners had purchased their home after freeway construction. One District felt the freeway construction date should not be a determining factor, and that priorities should be based upon economic, effectiveness, and severity factors. The remaining Districts favored retention of the present practice.

After considerable deliberation, it was decided to retain our current practice for the time being. Supporting factors including the following:

1. The present method has been widely publicized and accepted by the Legislature, local agencies, and many individuals.

2. Owner expectations have been generated based on present program commitments.

3. The practice gives first priority to impacted improvements in existence prior to freeway route adoption and construction.

4. Consideration of changing ownerships and rental properties would introduce many sound wall gaps.

5. Continual property ownership updating would be a burden and changing priorities would hamper continuity of plan preparation.

6. The Crain and Associates consultant contract will be evaluating how priorities should be established.

All Deputy Directors
Page 2
October 3, 1978

Comments received regarding other suggested changes are appreciated and will be considered for inclusion in development of Design Manual instructions for traffic noise abatement.

Original Signed W. R. Green

W. R. GREEN
Chief, Office of Planning and Design

FJ:dlt

cc: NEAndersen
RGAdams
HLKagan
FLJackson
Central Files
Planning and Design Files

APPENDIX IIII

CALTRANS POLICY MEMO
ON
NEW FHWA HIGHWAY TRAFFIC
NOISE PREDICTION MODEL

State of California — Business and Transportation Agency

Memorandum

To : District Director of Transportation

Attn:
Environmental Planning Branch
Project Development Branch

Date: November 2, 1978

File :

From : DEPARTMENT OF TRANSPORTATION
Chief Engineer's Office

Subject: New FHWA Highway Traffic Noise Prediction Model

This memo formalizes the adoption by Caltrans of the new Federal Highway Traffic Noise Prediction Model as reported in the publication FHWA-RD-77-108. FHPM 7-7-3 dated May 14, 1976, defined and introduced design noise levels in terms of L_{eq}. FHWA-RD-77-108 now provides the procedures for using the L_{eq} noise descriptor and should be distributed by FHWA about December 1978.

The new FHWA procedures will be available in four forms as follows:

1. Nomograph Methods -- To be used for estimating or screening purposes only.
2. Manual Method ----- Can be used for simple sites on minor projects and the data reported when there is clearly no impact. The report should state that the Manual Method was used.
3. Level I Computer --- This method will be suitable for evaluating simple sites. The report should state that the Level I computer method was used.
4. Level II Computer Method --- This method will be suitable for evaluating complex sites. The report should state that the Level II computer method was used.

Whenever barriers need to be designed for a project, the Level I or II Computer Method shall be used.

After Dec. 31, 1979, the procedures in 77-108 shall be used for noise studies on all new projects involving federal or state funds except where specific state laws such as the California Streets and Highways Code, Section 216 (School Noise), or California Government Code, Section 65302 (General Plan), would apply.

Prior to July 1, 1979, the Districts may select the option of completing all ongoing projects using the L_{10} descriptor or may reevaluate using the new L_{eq} method. Some advantages of the new model as compared to the NCHRP 117/144 and TSC models are:

- The new model is easier to calibrate
- The new model is more accurate and does not tend to over-predict as do the older models
- The new model will be more accurate for predicting noise on roads with low traffic volumes
- The new model has incorporated findings from recent studies on barriers and allows additional attenuation for berms.

<u>Background Information</u>

The FHWA presented a two-day orientation program to acquaint State and FHWA personnel with the new FHWA noise prediction method. This was held in Las Vegas, Nevada on March 16 and 17, 1978, with two Caltrans' engineers attending.

Subsequent to the FHWA orientation, TransLab scheduled seven training seminars to familiarize Caltrans' personnel with the new prediction model. The first seminar was held in June and the last was completed on September 29, 1978. Additional seminars will be scheduled as needed.

The FHWA Manual 77-108 which was scheduled for publication in April, 1978, was rescheduled for August, 1978, and we anticipate distribution to the districts around December 1978. We expect to receive the Level I and II computer programs from FHWA and have them fully operational before July 1, 1979. Instructions for their use will be transmitted to the Districts at a later date.

Authority for implementation of the new FHWA Traffic Noise Prediction Model was published in the Federal Register, Vol. 43, No. 193, Wednesday, October 4, 1978. It is reprinted here for ease of reference.

"772.25 Traffic noise level prediction methods.

(a) Any traffic noise prediction method is approved for use in any noise analysis required by this part if it meets the following two conditions:

(1) The methodology is consistent with the methodology in the FHWA Highway Traffic Noise Prediction Model. (Report No. FHWA-RD-77-108).

(2) The prediction method uses noise emission levels obtained from one of the following:

(i) Federal-Aid Highway Program Manual, Volume 7, Chapter 7, Section 3, Attachment 1 (National Reference Energy Mean Emission Levels as a Function of Speed).

(ii) Report No. FHWA-OEP/HEV-78-1. Determination of Reference Energy Mean Emission Levels.

(b) In predicting noise levels and assessing noise impacts the following traffic characteristics shall be used:

(1) Automotive volume.- The Future volume (reduced for truck traffic) obtained from the lesser of the design hourly volume or the maximum volume which can be handled under traffic level of service C conditions. For automobiles, level of service C is considered to be the combination of speed and volume which creates the worst noise conditions. The average hourly volume for the highest 3 hours on an average day for the design year may be used for those highway sections where the design hourly volume or the level of service C condition is not anticipated to occur on a regular basis during the design year.

(2) Speed. - The operating speed which corresponds with the design year traffic volume selected in paragraph(b)(1) of this section and the truck traffic predicted from paragraph (b)(3) of this section. The operating speed must be consistent with the volume used.

(3) Truck volume.- The design hourly truck volume shall be used for those cases where either the design hourly volume or level of service C was used for the automobile volume. Where the average hourly volume for the highest 3 hours on an average day was used for automobile traffic, comparable truck volumes should be used.

(c) An alternative to paragraph(b) of this section, the highway agency may select traffic characteristics to correspond with the critical times of day and night which will create the most adverse traffic noise impacts upon the nearby activities and land uses. When such alternative traffic characteristics are used, a thorough discussion of such alternative characteristics shall be included in the noise study report.

(d) Traffic noise prediction methods approved pursuant to prior requirements of this part (41 FR 16936. Apr. 23,1976) remain approved until July 1, 1979. Any noise analysis performed after July 1, 1979, must comply with the requirements of paragraph (a) of this section."

If there are any questions concerning this memo, please call Mas Hatano (ATSS 432-4886) or Walt Whitnack (ATSS 485-6780).

ORIGINAL SIGNED BY

C. E. FORBES
Chief Highway Engineer

MH:bd

cc: Wayne Branch FHWA- Sacramento
Herb Gregory FHWA- San Francisco
W. R. Green Hq. Planning & Design
N. A. Andersen TransLab
E. C. Shirley TransLab

APPENDIX IIIJ

PRIORITIZING COMMUNITY AND
SCHOOL NOISE PROGRAM PROJECTS

APPENDIX IIIJ

Prioritizing Community and School Noise Program Projects

This is an excerpt taken from the Memo from Phil Raine on the 1980 STIP - Priority Setting Phase, March 1, 1979.

This is a supplement to Appendices IIID and IIIH.

HB311 - COMMUNITY NOISE ATTENUATION
(Program Advisor: Fred Jackson ATSS 8-485-2800)

Prioritize community noise projects in those areas developed prior to freeway route adoption (Category C-1)

Within this category, first priority is to be given to projects with the highest noise index (N.I.) calculated by the following formula:

$$\text{Noise Index} = \frac{\text{dbA reduction} \times (\text{dbA level} - 70)^2 \times \text{dwelling units}}{\text{Cost (\$1,000)}}$$

The number of dwelling units used in the formula should be limited to the first row of dwelling units adjacent to the freeway. The dbA reduction should be the average achievable reduction at the first row of dwelling units To assist the Program Advisor in developing a statewide priority list, please provide the noise index for each identified project. Input the Noise Index on the place provided under Special Priority Index Number in Section V of these instructions.

HB312 - SCHOOL NOISE ATTENUATION
(Program Advisor: Fred Jackson ATSS 8-485-2800)

<u>School Noise Abatement Projects</u>

First priority should be given to schools receiving the highest average noise levels.

School noise project priorities may be modified for the following reasons:

1. Coordinate with community noise project requiring sound wall.

2. Interest shown by school district and ability of school district to deliver plans if work is done on school.

3. Desires of school district to incorporate other features in project (at its expense) which may cause delay in project in order for school district to secure financing.

4. In case of school districts which have more than one school in program, the school districts are allowed to establish the priorities for their schools.

To assist the Program Advisor in developing a statewide priority list, please provide the following information:

a. Average peak noise level within the eligible classrooms (windows open).

b. Reason a project is not listed in accordance with the established priority system if applicable.

APPENDIX IIIK

SECTION 215.5
OF THE
CALIFORNIA STREETS AND HIGHWAYS CODE
PRIORITY SYSTEM FOR NOISE BARRIERS

Priority System for Noise Barriers

215.5. (a) The department shall develop and implement a system of priorities for ranking the need for installation of noise attenuation barriers along freeways in the California freeway and expressway system. The priority system shall include as criteria the existing and future intensity of sound generated by the freeway.

(b) When all freeways have been ranked in priority order, the department shall, consistent with available funding, recommend in the 6-year plan, and in succeeding 6-year plans, a program of construction of noise attenuation barriers beginning with the highest priority.

(c) Should any city or county construct a sound attenuation barrier along a freeway using public funds prior to the time that such barrier reaches a high enough priority for state funding, then, when the funding priority is reached, the department shall reinburse the city or county without interest for the cost of such construction when constructed, but the reimbursement may not exceed the cost of the department to construct such barriers. Reimbursement shall be made only if the city or county constructs the sound attenuation barrier to the standards approved by department, follows bidding and contracting procedures approved by the department, and the project is approved by the California Transportation Commission.

APPENDIX IIIL

AESTHETIC REVIEW OF CALTRANS' PROJECTS
AESTHETICS OF SOUND WALL DESIGN
REVISIONS TO PROJECT DEVELOPMENT PROCEDURES MANUAL

State of California

Business and Transportation Agency

Memorandum

To : ALL DISTRICT DIRECTORS OF TRANSPORTATION

Date: March 28, 1977

File : 801-D

From : DEPARTMENT OF TRANSPORTATION
Chief Engineer's Office

Subject: Aesthetic Review of Caltrans' Projects

This letter supersedes my letter of February 22, 1977. This letter makes two primary revisions to the previous letter. The first revision is to redefine project applicability to generally limit the review to major projects having a construction cost over $200,000. There are important exceptions, however. The second revision is the deletion of the discussion on completed projects on designated scenic highways. It was decided to delete this discussion because of the small number of possible projects. Any projects in this category will be handled on an individual basis by the Office of Office Engineer.

PURPOSE

As you know, the Director is concerned about the effect of Caltrans' projects on the aesthetics of the project area. To assure that due consideration has been given to the aesthetic effects of our projects, the Director has requested the establishment of a procedure to appropriately involve local citizens as aesthetic advisors in the project development process.

APPLICABILITY

As a result, the following consultation/review procedure will apply to all future and on-going projects.

1. Projects that will normally be reviewed are major construction projects (over $200,000 construction cost) unless they are contained essentially within the existing right-of-way and do not substantially alter visual appearances. Examples of exceptions are pavement reconstruction, resurfacing, pavement grooving, guardrailing, earthquake restrainers, bridge deck restoration, etc.

2. Minor construction projects (under $200,000 construction cost) will normally not be reviewed. Review will be required, however, when these projects involve significant impacts to aesthetic values such as removal of trees, landscaping alterations, channel changes, bridge replacement, etc.

3. New or major modifications to Land and Building projects are also to be reviewed when the public's view is impacted.

4. In all cases, input is desired on any project, regardless of size or type, that is likely to generate aesthetic concerns by the public.

<u>PROCEDURE</u>

<u>Advisor Selection Process</u>

Designated Scenic Highways - The advisor for projects on the Designated Scenic Highway System shall be the Scenic Highway Advisory Committee member assigned to the District.

At the present time, there are only four members on the Scenic Highway Advisory Committee. We expect the three vacancies to be filled shortly. In the meantime, we will only make assignments of Advisory Committee members to some of the Districts and will make the other assignments when we know where the three new members live. See the attached list for those assignments.

Those Districts which have projects in the planning or design stage on Designated Scenic Highways and which are not assigned an Advisory Committee member now, should contact either Irv Denny, Executive Secretary of the Scenic Highway Advisory Committee, ATSS 485-9451, or Ron Lemmon, State Scenic Highway Coordinator, ATSS 485-9288, to arrange for a review of the project. Those Districts which are starting new projects on designated Scenic Highways should contact Irv or Ron, when the Project Development Team is being formed, to discuss the availability of an Advisory Committee member for assignment to the team.

<u>All Other Highways</u> -- The advisor for all other projects will be a citizen advisor selected from a panel of citizen advisors established for each District. The advisors shall be co-selected by the District Director and the Scenic Highway Advisory Committee member

from available interested local citizens. The panel members should be chosen so as to represent the various geographic areas of the District. The number of people in each group will vary according to the number of projects to be reviewed annually and the available time of the members.

The Scenic Advisory Committee member will act as a coordinator and advisor to the panel. Assignment of projects to the individual citizen advisors will be made by the District Director. The citizen advisor selected would normally be the person living the closest to the project site, thus assuring input from the person most familiar with the scenic values in the locality.

A citizen advisor will be consulted on Designated Scenic Highway projects in the event the Scenic Highway Advisory Committee member is not available for timely review.

<u>Consultation/Review Process</u>

<u>New Projects</u> -- Whenever a new project is started by the District, an advisor will be invited to be a member of the Project Development Team. This will also include participation on informal teams established for Category 4B and 5 projects.

<u>Pipeline Projects</u> -- For projects already partially through the project development process, the advisor should be briefed on the status of the project and given an opportunity to comment on the aesthetic considerations of the Project Development Team to that point. The advisor would then be retained as a team member until the project is completed.

<u>Documentation</u> -- Throughout the development of a project, the advisor will be consulted whenever decisions are to be made which will have aesthetic effects. Comments and recommendations of the advisor will be recorded and included with the other documents in the project files for consideration in arriving at the decisions being made.

Any project changes proposed as a result of these reviews, which affect agreements previously reached with local officials, should be discussed with those officials before implementation to avoid infringement on local government prerogatives or responsibilities.

Summaries of actions to date and conclusions reached will be included in the Project Report, Project Approval Report, and PS&E Report.

<u>Comment Resolution</u> -- Any recommendation made by an advisor, which the advisor believes has not been given adequate consideration by th Project Development Team, shall be referred by the team to the District Director for resolution. If the advisor still believes the recommendation has not been adequately considered, the District Director shall refer the matter to the Scenic Highway Advisory Committee for its review. The Committee may recommend

reconsideration by the District Director or may refer the matter to the Director of Transportation for resolution.

ACTION REQUIRED

These procedures should be implemented as quickly as possible. Projects will not be approved for advertising until the required consultations have been successfully completed.

These provisions will be incorporated into future revisions to the Project Development Procedures Manual.

C. E. FORBES
Chief Engineer

Attachment

NEA/RGL/RDL:dlt
bcc: District Scenic Highway Coordinators
Scenic Highway Advisory Committee
WRGreen
ENKress
IVDenny - Local Assistance
RDLemmon - Local Assistance
RGLutz
Andersen's Pend
Chief Engineer's Files
Director's X-Ref.
Director's Files
Planning and Design Files
DPengilly
CPSweet
JRGordon
All OPD Coordinators
HHeckeroth
JKozak
GLRussell

State of California — Business and Transportation Agency

Memorandum

To : ALL DISTRICT DIRECTORS OF TRANSPORTATION

Date: October 28, 1977

File : 801 C 1
xx (803 C)

From : **DEPARTMENT OF TRANSPORTATION**
Chief Engineer's Office

Subject: Aesthetics of Sound Wall Design

The 1977 Six-Year Highway Program includes funding of approximately $106 million for community traffic noise abatement along existing California freeways. Additional major funds will also be spent for the same purpose in conjunction with new freeway construction. Sound walls represent a permanent freeway fixture and should be designed to be architecturally attractive, both in the context of the freeway environment and compatibility with the adjacent community.

Two steps are under way in HQ to upgrade the aesthetic treatment of noise walls.

1. Architectural variations for the standard concrete block wall plans, to produce aesthetically pleasing patterns and variations, will be developed and incorporated in the Standard Plans under the direction of R.C. Cassano, Chief of the Office of Structures Design.

2. Alternative standard plans utilizing methods and materials other than concrete blocks will also be developed by Structures Design. This will give districts a wide choice of aesthetically pleasing standard designs.

   Availability of these standard plans does not preclude the use of special architectural treatment that may be developed in cooperation with local officials or community groups for a particular site.

The Districts have a considerable reservoir of assistance available to assure that these structures are as compatible as possible with both highway and adjoining community environments. This includes:

- District or HQ Landscape Architects.
- Office of Structures Design Architectural Specialists.
- Local Citizen Aesthetic Advisor.
- District Art Coordinator.
- References: Design Bulletin dated April 15, 1974
  FHWA Implementation Package 76-8

SURNAME

IIIL-6

All District Directors of
Transportation
Page Two
October 28, 1977

Full use should be made of this talent and expertise early in the project development process. If some of the above are not members of the PD Team, they should be consulted by the team.

Since these structures will become a permanent feature of the adjoining community, a strong community/citizen involvement program should obviously be undertaken during project development.

Coordination of design and scheduling of noise walls and landscaping is required. Desirably, wall construction should precede or be concurrent with landscaping. There are pros and cons to separate wall and landscape contracts, or combined contracts, which should be considered by the District. Design of landscaping should be compatible with a noise wall and vice versa.

Any structures that are designed in the District without local architectural review, either in-house or from the resources listed above, are to be submitted to Office of Structures Design for such a review prior to finalizing plans.

ORIGINAL SIGNED BY
C. E. FORBES
Chief Engineer

WRGreen:bg
cc: JRGordon
BCassano
FLJackson
WWhitnack
BLudlow
JRupp
GFung
RGAdams
WRGreen

OPD Coordinators
OPD Geometricians
Director's Office
Chief Engineer
Director's X-Ref file
Planning & Design files
EKress

State of California

Business and Transportation Agency

Memorandum

To : ALL DISTRICT DIRECTORS

Date: August 13, 1979

File :

Telephone: ATSS (485-) 3446

( )

From : DEPARTMENT OF TRANSPORTATION
Division of Project Development

Subject: Revision to Project Development Procedures Manual

Effective immediately all Project Development teams (formal or informal), on projects involving the construction of sound barriers, shall include a Bridge Architect or a Landscape Architect. It will be this team member's responsibility to help assure that sound barriers are architecturally attractive, both in the context of the freeway environment and compatability with the adjacent community. This is an extension of the direction given by the Chief Engineer in a memo dated October 28, 1977. If an architect is not available in the District, call John Ritner of Structures Design on ATSS 485-2138 or Ed Kress of Landscape Architecture on ATSS 485-3102 for assistance.

Please see that all PDPM holders and District Landscape Architects get a copy of this memo. This revision is being incorporated into a general revision to the PDPM which should be out in August 1979.

R. G. ADAMS, Chief
Division of Project Development

RGL:ag
cc:
RCassano
JRitner
OPD Coordinators
OPD Geometricians
WRGreen
JGordon
WAmes
WWhitnack
RHBennett
WDBethell
KHintzman

RGLutz
Chief Engineer
RGAdams
Planning & Design File

APPENDIX IIIM

DESIGN INFORMATION BULLETIN NO. 65 -
NOISE BARRIERS

State of California

Business and Transportation Agency

Memorandum

To : District Directors

Date: February 21, 1980

File :

From : **DEPARTMENT OF TRANSPORTATION**
Division of Project Development - Office of Planning and Design

Subject: Design Information Bulletin No. 56 - Noise Barriers

The purpose of this Design Bulletin is to establish guidelines for noise barriers constructed as a part of freeway construction or reconstruction and the community noise abatement program (HB 311) for existing freeways. Not all aspects of noise barrier design are covered by this bulletin. For areas not covered, or in any area where there are special problems, the Districts should consult with the Headquarters Planning and Design Coordinators.

The Federal Highway Administration Program Manual, Volume 7, Chapter 7, Section 3(FHPM 7-7-3) specifies a design L_{10} level of 70 dBA (67 dBA Leq) for exterior noise levels in residential areas (activity Category B). However, FHPM 7-7-3 implies that noise mitigation should be included in new construction or reconstruction when the predicted traffic noise levels substantially exceed the existing traffic noise levels even though the predicted levels are below the design levels. FHPM 7-7-3 doesn't define the term "substantial" and in order to provide a uniform approach, the Districts should propose noise mitigation on all construction and reconstruction projects when the predicted design year traffic noise level will increase by 10 dBA over the ambient level and the design year traffic noise level equals or exceeds an L_{10} level of 65 dBA (62 dBA Leq).

The design noise levels in Figure 3-1 of FHPM 7-7-3 represent a balancing of what may be desirable and that which is achievable. For new construction, reconstruction, and community noise abatement projects every effort should be made to achieve the maximum reduction of noise levels within reason. The design levels of FHPM 7-7-3 should not automatically be considered the lower limit of attenuation. On the other hand, achievement of these levels may have adverse social, economic, and environmental effects and under these circumstances partial noise abatement measures should be considered.

Any major reconstruction where the resulting noise level will exceed the design levels prescribed in FHPM 7-7-3 (even though lower than the preconstruction level) should include consideration of noise mitigation. This would be limited to areas where the adjacent development occurred prior to November 1, 1974. Exceptions to providing noise mitigation would be allowed for valid reasons. Noise mitigation is usually not required for low-cost traffic capacity improvement projects such as restriping for use of shoulder as an auxiliary lane, as the additional cost of mitigation can make the project not viable. In most cases, the noise increase for this type of project is only 1 to 2 dBA, which is not perceptible. This type of project should be discussed with the FHWA Area Engineer early in the project development stage to determine if an exception request is necessary. Many of these low-cost projects are considered temporal and noise mitigation, if required, should be included with ultimate construction. If the low-cost project is permanent, the noise mitigation may be included in the community noise abatement program with programming in accordance with the established priority system.

Noise barriers should have a minimum height of 6 feet and should achieve a minimum attenuation of 6 dBA. No maximum height limitation is proposed as our review of proposed noise barrier projects indicates that the Districts are attempting to keep wall heights as low as possible for cost and aesthetic reasons. Generally, wall heights to date have not exceeded 16 feet.

Current design procedures result in noise barrier heights which do not intercept noise emitted from the exhaust from trucks. This can create a problem in that the wall blocks out automobile noise but results in a more intrusive noise level as the trucks pass by. In order to avoid this situation, barrier heights should be designed to intercept the exhaust stack of trucks. Measurements of truck exhaust stack heights by District 07 at a brake inspection station indicated that 90% of the exhaust stack heights were under 12.5 feet. For design purposes, a 12.5-foot height is recommended. If local conditions do not appear to fit this exhaust stack height, the District may make its own measurements.

In general, the noise barrier height should not be designed to shield the second story of two-story residents as there usually isn't any outdoor living activity at that level. However, attenuation of the second story can be considered if it can be done at very little additional cost and there is a relatively large number of two-story homes involved. In some cases, the design of the noise barrier to shield the first floor from truck exhaust stacks will also provide some attenuation for the second floor. Each location should be examined on an individual basis.

On ramp connections to local streets, the question arises as to where the responsibility of noise mitigation ends for the State and begins for the local agencies. Because of the many possible variables, the determination of this responsibility will have to be done on an individual basis. As a general rule, the State's responsibility for noise mitigation should be limited to areas where the influence of the traffic noise level from the freeway or freeway ramps is the predominant noise source which causes the total noise level to exceed the design standards.

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END OF TEXT