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Keith Jones – HQ Environmental Program, Author, Team Leader
Rudy Hendriks – HQ Environmental Program, Author, Team Member

INTRODUCTION

The Traffic Noise Analysis Protocol (hereafter referred to as the Protocol) contains Caltrans noise policies, which fulfill the highway noise analysis and abatement/mitigation requirements stemming from the following State and Federal environmental statutes:

- California Environmental Quality Act (CEQA)
- National Environmental Policy Act (NEPA)
- Title 23 United States Code of Federal Regulations, Part 772 "Procedures for Abatement of Highway Traffic Noise and Construction Noise" (23 CFR 772)
- Section 216 et seq. of the California Streets and Highways Code.

Policies, procedures and practices are provided in this Protocol for use by agencies that sponsor *new construction or reconstruction transportation projects*. The Protocol is designed to evaluate the potential traffic and construction generated noise impacts, and determines *reasonable* and *feasible* noise abatement/mitigation for the project.

Special terms used in this Protocol have been defined for implementation purposes and can be found in Section 7, Glossary.

Future versions of the Protocol will be issued, as necessary, to incorporate changes in the laws, regulations, policy, procedures, and practices pertaining to traffic and construction generated noise requirements and analysis.

The Technical Noise Supplement (hereafter referred to as TeNS) is a supplement to the Protocol, and contains Caltrans noise analysis procedures, practices, and other useful technical noise background information.

1. AFFECTED PROJECTS, REQUIREMENTS, AND ANALYSES

1.1 Affected Projects

Transportation projects affected by this Protocol are *Type I projects.* A Type I project is defined in 23 CFR 772 as follows. *A proposed Federal or Federal-aid highway project for the construction of a highway on a new location, or the physical alteration of an existing highway which significantly changes either the horizontal or vertical alignment, or increase the number of through-traffic lanes.* Section 2.1 extends this definition to State-funded highway projects and adds the FHWA interpretation of the above definition.

1.2 Federal Requirements

1.2.1 National Environmental Policy Act (NEPA)

Under NEPA, impacts and measures to mitigate adverse impacts must be identified, including the identification of impacts for which no or only partial mitigation is possible.

The FHWA regulations in Sec. 1.2.2 constitute the Federal Noise Standard. Projects complying with this Standard are also in compliance with the requirements stemming from NEPA

1.2.2 Federal Highway Administration (FHWA) Regulations

Under FHWA regulations (23 CFR 772), noise abatement must be considered for Type I projects when the project results in a *substantial noise increase* (see Section 2.4.1), or when the predicted noise levels *approach or exceed* the Noise Abatement Criteria (NAC) (see Section 2.4.2). Noise abatement measures which are *reasonable* and *feasible* and that are likely to be incorporated in the project, as well as noise impacts for which no apparent solution is available, must be identified and incorporated into the project's plans and specifications (23 CFR 772.11(e)(1) and (2)).

1.3 California Requirements

1.3.1 California Environmental Quality Act (CEQA)

Under CEQA, a *substantial noise increase* may result in a significant adverse environmental effect and, if so, must be mitigated or identified as a noise impact for which it is likely that no, or only partial abatement measures are available. Specific economic, social, environmental, legal, and technological conditions may make additional noise attenuation measures infeasible.

1.3.2 Streets and Highways Code, Section 216

If, as a result of a proposed *freeway* project, noise levels in classrooms of public or private elementary or secondary schools exceed 52 dBA, $L_{eq}(h)$ the Department shall provide noise abatement to reduce classroom noise to the

criteria or below. If the classroom noise exceeds the criteria before and after the freeway project, the Department shall provide noise abatement to reduce classroom noise to pre-project noise levels. The requirements are covered in the Streets and Highways Code, Section 216.

1.4 Analyses

1.4.1 Project Alternatives

The Protocol applies to the assessment and disclosure of potential impacts of *project alternatives* as identified within the scope of an Environmental Document as required by NEPA/CEQA. The results of the screening evaluation and further detailed studies should be incorporated into environmental documentation or used as part of a major investment study (MIS) as appropriate.

1.4.2 Timing

As part of the general environmental review process associated with all projects, project sponsors are required to evaluate if the predicted noise levels could result in traffic noise impacts (see Section 2.4), and if so, consider and implement noise abatement if *feasible* and *reasonable*. The process leading to a preliminary noise abatement decision (FHWA process) is contained in Section 2 and the results are reported in the draft environmental documentation as appropriate.

A noise impact resulting from a substantial noise increase *may* additionally be a *significant adverse environmental effect*. The additional process leading to a noise abatement or mitigation decision for a significant environmental effect (CEQA process) is described in Section 3, and is also reported in the draft environmental documentation as appropriate.

The final noise abatement/mitigation decision process, described in Section 4, occurs after the input from impacted residents and local agencies, and after consideration of social, economic, environmental, legal, and technological factors.

The *date of public knowledge* of a proposed transportation project is used to determine if noise abatement should be considered as part of the project, or if noise abatement should be the responsibility of local government agencies or private developers. The *date of public knowledge* shall be the date of approval of the final environmental decision document (e.g. a Record of Decision).

When traffic noise impacts (see Section 2.4) are predicted for undeveloped lands for which development is *planned, designed and programmed* before the date of public knowledge, noise abatement must be considered as part of the project. Development is considered *planned, designed and programmed,* on the date that a noise sensitive land-use (subdivision,

residences, schools, churches, hospitals, libraries, etc.) has received final development approval (generally considered to be the issuance of a building permit) from the local agency with jurisdiction.

1.4.3 Project Re-analysis

Project noise impacts or consideration of abatement measures may have to be re-analyzed if one of the following occurs:

a) There has been a significant change in project design concept and/or scope from that of the most recent environmental analysis, or

b) A significant period of time has passed since the most recent environmental analysis, generally considered to be 3 years between project milestones, e.g. Record of Decision to Right of Way Certification, or

c) An undeveloped land becomes *planned, designed and programmed,* after the analysis, but before the *date of public knowledge*, or

d) An undeveloped land becomes developed after the date of public knowledge (disclosure of impacts, if any, but abatement not considered).

1.4.4 Levels of Traffic Noise Analysis

All proposed projects affected by this Protocol should first be analyzed by using a screening procedure. The procedure is outlined Sec. 2.2, and detailed in TeNS Sec. N-4000.

If the project does not pass the screening procedure, a detailed analysis should be performed. The detailed analysis consists of two parts: 1) traffic noise impact analysis and, 2) preliminary noise abatement design. The procedures are outlined in Sec.'s 2.3 through 2.6, and are detailed in TeNS Sec.'s N-5000 and N-6000.

1.4.5 Construction Noise

Construction noise is only substantial in exceptional cases, such as pile driving and *crack and seat* pavement rehabilitation operations. Standard Specifications (Sections 7 and 42) and Standard Special Provisions provide limits on construction noise levels and are used as appropriate. Normally, construction noise levels should not exceed 86 dBA (L_{MAX}) at a distance of 15 m.

If construction noise on any highway project is anticipated to be a substantial problem, the following items should be examined during the project process:

a) Land-uses or activities that may be affected by noise from construction of a project.

b) Measures necessary to minimize or eliminate adverse construction noise impacts on the community that could be incorporated in the plans and specifications.

1.5 Liaison with Local Agencies

Cities and counties are required to adopt general plans of development for their communities that must include a noise element, which among other noise sources, considers the noise emanated from freeways and highways (CGC 65302). The noise element serves as a guide for establishing a pattern of land-use development to minimize the exposure of community residents to excessive noise. Caltrans encourages local agencies to establish compatible zoning that would preclude noise-sensitive land-uses adjacent to State highways. To facilitate compatible land-use decisions, Caltrans will provide local agencies with project noise studies. This may be accomplished via the Inter Governmental Review (IGR) process or by direct mailing.

In addition, some communities have established local noise ordinances to abate nuisance noise. Project contract specifications (standard or special provisions) provide that construction activities may be subject to local ordinances. Efforts should be made to determine the existence of local ordinances and to what degree they may or may not apply.

The likelihood that the area considered for noise abatement would change land-use designation within the life cycle of the project should be considered. Working with the local agency responsible for the land use designation (i.e., city or county) will determine if redevelopment of the subject area (e.g. residential to commercial) is a strong possibility. A written statement from the local agency should be obtained for documentation that redevelopment is likely. If the area is likely to be redeveloped, it may be prudent to defer construction of noise abatement until a final decision is known.

2. PRELIMINARY NOISE ABATEMENT DECISION (FHWA PROCESS)

For Type I projects traffic noise must be analyzed for all alternatives under consideration, and traffic noise impacts identified. If traffic noise impacts are identified, noise abatement must be considered, and feasible and reasonable abatement measures included in the draft environmental documentation. This preliminary noise abatement decision process is depicted in Figure 2-1. The individual components of this chart are discussed in the following subsections.

2.1 Type I Projects

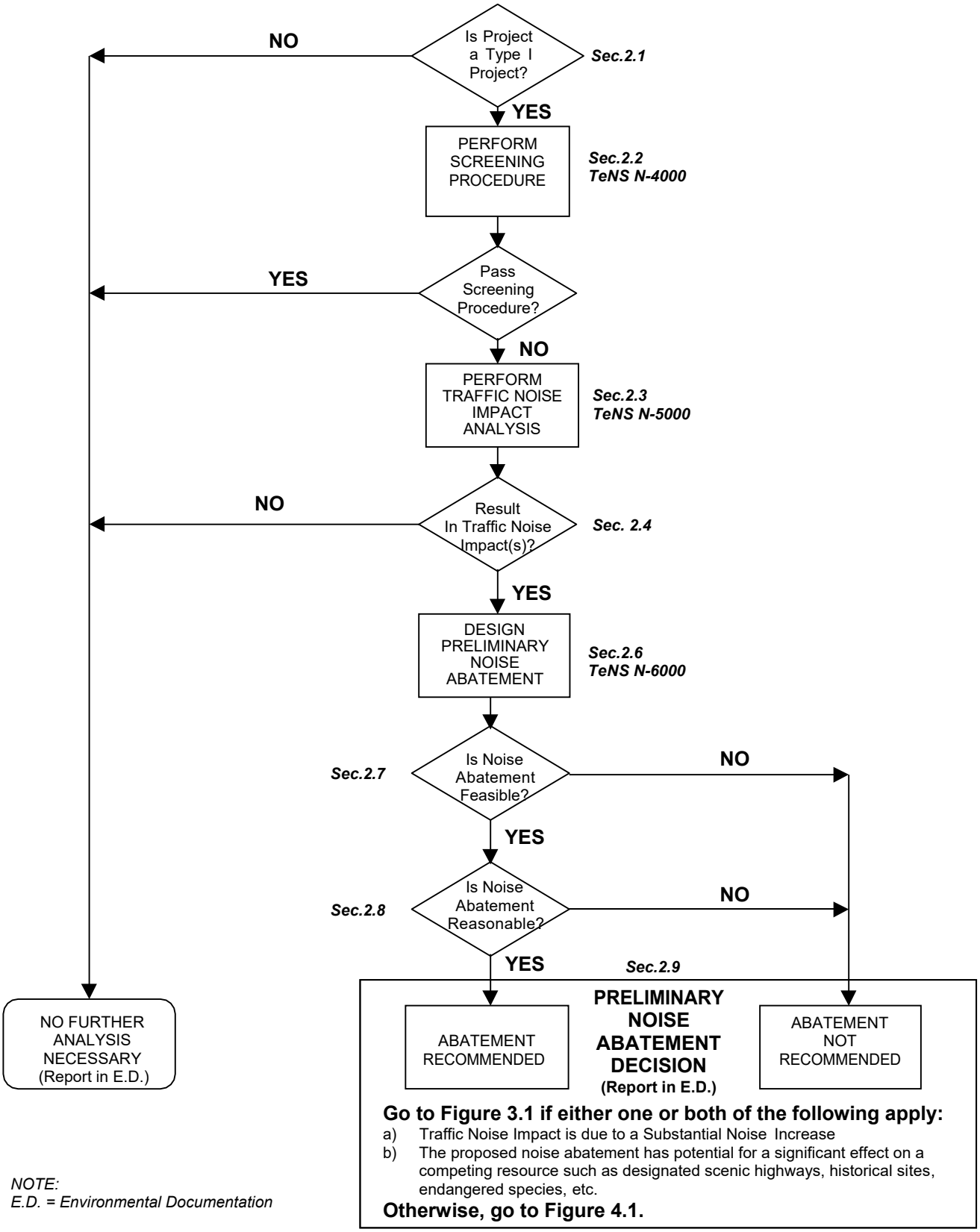
A Type I project is defined by 23 CFR 772 as follows. *A proposed Federal or Federal-aid highway project for the construction of a highway on a new location, or the physical alteration of an existing highway which significantly changes either the horizontal or vertical alignment, or increases the number of through-traffic lanes.* Caltrans extends the Type I definition in 23 CFR 772 to State highway projects without Federal funding.

FHWA and Caltrans interpretation of the above definition of Type I projects differ slightly. When there is no FHWA involvement (such as no federal funding or not on the National Highway System), "increases the number of continuous traffic lanes" refers to an increase in the basic number of continuous traffic lanes of the highway segment. The Caltrans interpretation of Type 1 Projects excludes lanes for parking, speed change, turning, storage for turning, weaving, truck climbing, and other purposes supplementary to through-traffic movement and ramp widening projects. These projects, however, are still subject to the provisions of CEQA.

FHWA has clarified their interpretation as quoted from their Protocol comments and June 1995 *Highway Traffic Noise Analysis and Abatement – Policy and Guidance*: "…a Type I project is any project that has the potential to increase noise levels at adjacent receivers. Such a project specifically creates a totally new noise source, or increases the volume or speed of traffic or moves the traffic closer to the receivers…The addition of an interchange/ramp/auxiliary lane/truck-climbing lane, etc. to an existing highway is considered to be a Type I project. A project to widen an existing ramp by a full lane-width is also considered to be a Type I project…Similarly, the addition of high-occupancy vehicle (HOV) lanes to highways are also Type I projects, whether added in the median or on the outside of the existing highway…Traffic noise analysis is required for both sides of the highway, even when HOV lanes are only added on one side of the highway…Projects unrelated to increased noise levels, such as lighting, signing, landscaping, etc., are not considered to be Type I projects."

Although a project may not comply with the definition of a Type I project, it may still be treated as a Type I project in extremely rare instances. This occurs when the project itself is expected to raise traffic noise levels from a non-approach-or-exceed level to an approach-or-exceed impact, or cause a substantial noise increase impact (see Sections 2.4.1 and 2.4.2). An example

Figure 2-1 Flow Chart of Preliminary Noise Abatement Decision



NOTE:
E.D. = Environmental Documentation

of such a situation might be side slopes that are flattened as part of a project to improve an intersection or improve sight distance.

2.2 Screening Procedure

The screening procedure is intended to determine whether a detailed analysis is necessary. If a project passes the screening procedure, further analysis is normally not necessary. In instances when a project is considered controversial or when the net effects of changes in topography and shielding are not obvious, a detailed analysis is warranted even if the screening procedure may indicate otherwise. The complete procedure is covered in TeNS, Section N-4000. Following is a summary of the screening procedure steps:

a) Determine if there are potentially impacted receivers. If there are no impacted receivers, no further analysis will be necessary.

b) Determine if the project will be along an existing alignment or realignment. If it will be on a new alignment, the screening procedure cannot be used, and a detailed analysis is required.

c) Determine if shielding (or lack thereof) of the receivers will be the same or improved after the project. If it is not, a detailed analysis is required.

d) Measure the existing worst hourly noise levels at the critical receivers. If the existing noise levels are less than 5 dBA below the applicable Noise Abatement Criterion (Table 2-1), a detailed analysis is required.

e) If the increase in noise levels after the project is 3 dBA or more above existing noise levels, a detailed analysis is required. The increase is calculated from a simple formula involving existing and future traffic, and existing and future roadway to receiver distances.

2.3 Impact Analysis

If the project fails the screening procedure, or if other conditions discussed in Section 2.2 apply, a detailed analysis must be performed. The first part of this analysis is to analyze if traffic noise impacts are predicted. The traffic noise impact analysis shall include the following for each alternative under detailed study:

a) Identify existing land use activities, developed lands, and undeveloped lands for which development is *planned, designed and programmed* (see Section 1.4.2), which may be affected by noise from the highway (TeNS Section N-5200).

b) Determine highest hourly existing noise levels (TeNS Section N-5300)

c) Predict traffic noise levels using traffic characteristics that will yield the worst hourly traffic noise impact on a regular basis for the design year and using traffic noise prediction methodology that meets the following two conditions:

1) The method is consistent with the FHWA Highway Traffic Noise Prediction Model (Report No. FHWA-RD-77-108) and,
2) The method uses California Vehicle Noise Emission Levels (Calveno) (Report No. FHWA/CA/TL-87/03).

TeNS Sections N-5400 and N-5500 discuss noise prediction procedures.

d) Determine traffic noise impacts for areas adjoining the project (Section 2.4).

2.4 Traffic Noise Impacts

When traffic noise impacts have been identified, noise abatement measures must be considered.

Traffic noise impacts occur when one or more of the following occur: 1) a substantial noise increase; 2) predicted noise levels approach or exceed Noise Abatement Criteria.

2.4.1 Substantial Noise Increase

A noise increase is substantial when the predicted noise levels with the project exceed existing noise levels by 12 dBA, $L_{eq}(h)$.

2.4.2 Approach or Exceed the Noise Abatement Criteria

A traffic noise impact will also occur when predicted noise levels with project approach within 1 dBA, or exceed the Noise Abatement Criteria (Table 2-1).

Table 2-1. Activity Categories and Noise Abatement Criteria (NAC)

Activity Category	NAC,Hourly A-Weighted Noise Level, dBA $L_{eq}(h)$	Description of Activities
A	57 Exterior	Lands on 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.
B	67 Exterior	Picnic areas, recreation areas, playgrounds, active sport areas, parks, residences, motels, hotels, schools, churches, libraries, and hospitals.
C	72 Exterior	Developed lands, properties, or activities not included in Categories A or B above.
D	--	Undeveloped lands.
E	52 Interior	Residences, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals, and auditoriums.

2.5 School Classroom Noise Impact

A noise impact may also be found if as a result of a proposed *freeway* project, noise levels exceed 52 dBA, $L_{eq}(h)$, within the interior of an existing public or private elementary, or secondary school. Refer to the provisions of the Streets and Highways Code, Section 216 for applicability. This requirement does not replace the approach or exceed NAC criterion for FHWA Activity Category E for classroom interiors (Section 2.4.2).

If a project results in an impact the Department shall provide noise abatement to reduce classroom noise to the criteria or below. If the classroom noise exceeds the criteria both before and after the freeway project, the Department shall at a minimum provide noise abatement to reduce classroom noise to pre-project noise levels.

2.6 Preliminary Noise Abatement Design

If traffic noise impacts are predicted, noise abatement measures must be evaluated and considered (see Section 5.3). Preliminary noise abatement design includes acoustical considerations such as noise barrier heights, lengths, location, material, etc. These are discussed in TeNS Section N-6000.

2.7 Noise Abatement Feasibility

Feasibility is defined as an engineering consideration. A minimum of 5-dBA-noise reduction must be achieved at the impacted receivers in order for the proposed noise abatement measure to be considered feasible. The feasibility criterion is not necessarily a noise abatement design goal (see Section 5.2). Greater noise reductions are encouraged if they can be reasonably achieved. Feasibility may be restricted by: (1) topography; (2) access requirements for driveways, ramps, etc.; (3) the presence of local cross streets, (4) other noise sources in the area, and (5) safety considerations.

2.8 Noise Abatement Reasonableness

2.8.1 General

The determination of *reasonableness* of noise abatement is more subjective than the determination of its feasibility. It implies that common sense and good judgment have been applied in arriving at a decision. There will be instances where noise abatement may be found reasonable even though it is outside the established bounds of reasonableness. The individual circumstances of each project and consideration of borderline cases should be part of the overall decision making process.

Noise abatement is only considered where noise impacts are predicted and where frequent human use occurs and a lowered noise level would be of benefit. Primary consideration will be given to exterior areas. In situations where no exterior activities are affected by the traffic noise, or where the exterior activities are far from, or physically shielded from the roadway and

therefore not impacted, the interior criterion (Category E in Table 2-1) shall be used as a basis for noise abatement consideration.

The overall reasonableness of noise abatement is determined by considering a multitude of factors including but not necessarily limited to the following:

a) Cost of the abatement
b) Absolute noise levels
c) Change in noise levels
d) Noise abatement benefits
e) Date of development along the highway
f) Life cycle of abatement measures
g) Environmental impacts of abatement construction
h) Views (opinions) of impacted residents
i) Input from the public and local agencies
j) Social, economic, environmental, legal, and technological factors

The life cycle of the noise abatement (above factor (f)) is a consideration in the preliminary reasonableness decision. It is normally not reasonable to construct a wall where planned future use would limit its useful life to less than 15 years.

Normally, noise abatement is not designed for the second floor level (Highway Design Manual Chapter 1100). However, noise abatement designed to provide 5 dBA for the second floor level without exceeding the modified allowance is within the scope of reasonableness.

The preliminary reasonableness decision is based on the above factors (a) through (f) as described in this section and the following Sections 2.8.2 and 2.8.3. The remaining factors are considered through the public input process described in Section 4. The environmental impacts of abatement construction are addressed in Section 3.

2.8.2 Preliminary Reasonableness Determination for Residential Areas in Activity Category B

The preliminary decision of providing noise abatement for exteriors of residential areas in activity category B (see Table 2-1) is made from a single dollar value, a reasonable allowance per *benefited residence* (see Section 7, *Glossary*) that embodies five reasonableness factors. If the abatement can be constructed for that amount, the preliminary reasonableness decision will be to provide abatement

The preliminary reasonableness determination of providing noise abatement for exteriors of residential areas in activity category B (see Table 2-1) begins with a $15,000 base allowance per benefited residence. The 1998 base year allowance is based on a noise barrier cost of $\$151/m^2$ ($\$14/ft^2$), which includes costs of the wall, footings, traffic control, drainage, modifying or adding planting, miscellaneous items and a 10% contingency. A wall length of 30.5 m (100 ft) and a height of 3.05 m (10 ft) is assumed to cover the average residence. This wall height normally provides a 5 dBA noise

reduction and breaks the line of sight between a 3.5 m (11.5 ft) high truck exhaust stack and a 1.5 m (5 ft) high receiver at the first tier of residences, as required by the Highway Design Manual, Chapter 1100.

The $15,000 base allowance may be updated every two years using the Construction Cost Index as calculated by the Office of the Office Engineer, and rounded to the nearest one thousand dollars.

The base cost per benefited residence will be adjusted by the five *reasonableness factors* explained in the following pages. The terms used in these reasonableness factors are explained in Section 7 Glossary.

For each noise abatement facility (noise barrier) location the base allowance of $15,000 (1998) per benefited residence is adjusted by the following *reasonableness factors*. The final result will be the reasonable allowance per residence for the noise abatement facility, taking into consideration the following five reasonableness factors:

1) **Absolute Noise Levels**. These are predicted future noise levels (with project, but without noise abatement) at the *critical design receiver(s)*. If the absolute noise levels are:

69 dBA or less:	**add**	**$2,000**
70-74 dBA:	**add**	**$4,000**
75-78 dBA:	**add**	**$6,000**
More than 78 dBA:	**add**	**$8,000**

(Choose one only)

2) **"Build" VS Existing Noise Levels**. This is the increase in noise levels of the future predicted (with project) over existing noise levels at the *critical design receivers*. If the increase is:

Less than 3 dBA:	**add**	**$0**
3-7 dBA:	**add**	**$2,000**
8-11 dBA:	**add**	**$4,000**
12 dBA or more:	**add**	**$6,000**

(Choose one only)

3) **Achievable Noise Reduction**. This is the noise reduction (e.g. noise barrier insertion loss) provided by the noise abatement at the *critical design receivers*. If the noise reduction is:

Less than 6 dBA:	**add**	**$0**
6-8 dBA:	**add**	**$2,000**
9-11 dBA:	**add**	**$4,000**
12 dBA or more:	**add**	**$6,000**

(Choose one only)

4) **New Construction, or Predate 1978**. If the project is new highway construction, or if the majority of *benefited residences* (more than 50%) were in existence before January 1, 1978 for a highway reconstruction.

If:	
YES on either one:	**add $10,000**
If NO on both:	**add $ 0**
(Choose one only)	

5) **Total Noise Abatement Allowance VS Project Cost**. The final reasonableness factor, based on the ratio of the total allowance ($\mathbf{A_T}$) for noise abatement versus the cost of the project without noise abatement ($\mathbf{C_P}$) may result in a modified reasonable allowance ($\mathbf{A_m}$). $\mathbf{A_T}$ is calculated from the base cost plus adjustments (1) through (4) (**A**) for each abatement facility (e.g. noise barrier) location (**i**), multiplied by the number of benefited residences (**N**) for each location (**i**) and summed for all locations (**n**) and is expressed mathematically as:

$$A_T = \left(\sum_{i=1}^{n} N_i A_i\right)$$

and represents the total allowance ($\mathbf{A_T}$) for noise abatement on the project.

If the ($\mathbf{A_T}$) is no more than 50% of the estimated project cost ($\mathbf{C_P}$), the reasonable allowance per residence is $\mathbf{A_i}$, and no further modification is necessary. This condition is expressed as:

$$A_T - \left(0.5C_p\right) \le 0 \qquad \text{(No modification necessary)}$$

If the total allowance for noise abatement exceeds 50% of the cost of the project, the above expression is greater than 0. The positive result is the total allowance excess ($\mathbf{E_T}$) and is expressed as:

$$E_T = A_T - \left(0.5C_p\right) > 0 \qquad \text{(Modification necessary)}$$

If there is an excess allowance as described above, the reasonable allowance per residence at each noise abatement location is reduced as follows:

$$A_{m_i} = A_i - \frac{\left(\frac{N_i A_i}{A_T}\right)\left(E_T\right)}{N_i}$$

The modified reasonable allowance per benefited residence for each noise abatement location ($\mathbf{A_{m_i}}$) is a dollar value that always is greater than zero. This final dollar value embodies five reasonableness factors and is the basis for the preliminary noise abatement decision at that location. $\mathbf{A_{m_i}}$ should therefore not be construed as *one cost effectiveness factor* to be weighed with other factors in the preliminary abatement decision. The initial base allowance of $15,000 complies with the FHWA minimum cost effectiveness requirement.

The estimated actual cost per residence of the proposed noise abatement for a location should be at or below the modified (if necessary) reasonable allowance per residence for the noise abatement to be reasonable for that location. The cost calculations of the noise abatement should include all items appropriate and necessary for the construction of the noise abatement facility (e.g. noise barrier), such as traffic control, drainage modification, retaining walls, etc.

The reasonable allowance (modified or unmodified) as discussed in this section is calculated independently from the estimated cost per benefited residence discussed in the previous paragraph. The reasonable allowance should be used for comparative purposes only and is considered the maximum amount that should reasonably be spent on noise abatement. It should not be construed as a spending goal. If the estimated cost of the noise abatement per benefited residence turns out to be below the reasonable allowance per benefited residence and the noise abatement goals (Section 5.2) will be met, no attempt should be made to increase spending for noise abatement to the maximum of the reasonable allowance.

An example of the modified reasonable allowance calculation on the basis of the above reasonableness factors (1) through (5), and suggested worksheets is shown in Appendix B.

2.8.3 Preliminary Reasonableness Determination For Non-Residential Areas in Activity Category B, and Other Activity Categories

a) For schools, churches, hospitals, hotels, motels, and other potentially noise sensitive buildings in land use category B (Table 2-1), the concepts of reasonableness determination for residences (Section 2.8.2) may be applied. The same base allowance ($15,000), adjustments and modifications explained in Section 2.8.2 will be used in the determination of reasonableness, except that instead of residential units *30.5 m (100 ft) frontage* units are used. This method ensures the same consideration of the severity of impacts as used in residential areas.

b) For parks, recreational and picnic areas in land use category B (Table 2-1), only the areas of frequent human use will be considered for noise abatement. These areas will be treated the same as under (a) in this section with the same frontage units calculated for frontages of impacted

areas of frequent human use and where a lowered noise level would be of benefit. This method preserves the same consideration of severity of impacts as in a) and Section 2.8.2.

c) Lands on which serenity and quiet are of extraordinary significance (Category A, Table 2-1) are rare, and reasonableness of noise abatement should be determined on a case-by-case basis.

In addition to the cost, factors that must be considered are:

- Importance with respect to public need
- Importance of the serene and quiet qualities with respect to the area's intended purpose
- Frequency of human use

d) Noise abatement is normally not considered reasonable for commercial areas.

e) Noise abatement is not considered reasonable for parking lots. These facilities are intended for transient use only.

f) Reasonableness of noise abatement for residence interiors (Category E, Table 2-1) should be considered using the same factors as in Section 2.8.2, using exterior noise levels to determine the adjustment for absolute noise levels. For interiors of schools, churches, hospitals and other potentially sensitive buildings, the same factors as in (a) should be used to arrive at a preliminary reasonableness decision.

2.9 Preliminary Noise Abatement Decision and Reporting

After completing the preliminary noise abatement decision process depicted in flowchart 2.1, a decision is made based on the findings determined during the process. There are three possible outcomes:

a) If the project is exempt from analysis per Section 2.1, or if there are no traffic noise impacts predicted, no further analysis is necessary. Report in the project's environmental documentation that no traffic noise impacts are predicted.

b) If traffic noise impacts are predicted and the proposed noise abatement is feasible *and* reasonable, abatement will be recommended. The preliminary decision is reported in the applicable environmental documentation with the following cautionary note:

Based on the studies so far accomplished, Caltrans intends to incorporate noise abatement measures in the form of (a) barrier(s) at: _____, with respective lengths and average heights of: _____ Calculations based on preliminary design data indicate that the barrier(s) will reduce noise levels by 5 to

___ dBA for_____ residences at a cost of:_____ If during final design conditions have substantially changed, noise barriers might not be provided. The final decision of the noise barriers will be made upon completion of the project design and the public involvement processes.

c) If traffic noise impacts are predicted, but the proposed noise abatement is *not feasible* or *reasonable*, noise abatement will not be recommended.

Report that traffic noise impacts exist for which no apparent solutions are available, the reasons why, and that the impacts will not cause a significant adverse environmental effect.

The process in Section 4 finalizes the preliminary decision. Procedures covered in Section 3 must first be followed before reporting the preliminary decision, if the potential exists for a significant adverse environmental impact due to either one or both of the following:

- Traffic noise impacts predicted in either (b) or (c) are due to substantial noise increases.
- The proposed noise abatement in (b) has a potential for a significant effect on a competing resource such as designated scenic highways, scenic vistas, historical sites, endangered species, etc.

Modifications:

Section 2.8.2 of the Traffic Noise Analysis Protocol deals with the preliminary reasonableness determination for residential areas. A reasonable allowance is calculated by starting with a base cost allowance, then adding dollars for other specific reasonableness factors. In the Protocol (October 98') the base allowance per benefited is listed as $15,000 based on 1998 dollars. The Protocol also sates that the cost may be updated every two years using the Construction Cost Index (CCI) as calculated by the Office of Office Engineer, and rounded to the nearest one-thousand dollars. According to the new figures released by the Office of the Engineer, in 2000 there was a 13.7% increase to the CCI, therefore the new base cost allowance is $15,000 x 1.137= $17,000. For the price index released by the Office of Engineer, click here.

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3. PRELIMINARY NOISE ABATEMENT/MITIGATION DECISION (CEQA PROCESS)

This decision process examines whether the project or proposed abatement measures result in a significant adverse environmental effect. Either one or both of the following trigger this process:

- Traffic noise impacts predicted are due to substantial noise increases.
- Proposed noise abatement has a potential for a significant effect on a competing resource such as a designated scenic highway, a historical site, an endangered species, etc.

Figure 3.1 shows both situations entering the flowchart. The process addresses requirements under the California Environmental Quality Act (CEQA).

3.1 Traffic Noise Impact Due To A Substantial Noise Increase

If the predicted traffic noise levels after the proposed project are expected to result in a substantial noise increase over the existing noise levels there is a potential for the proposed project to cause a significant adverse environmental effect due to noise. This will be evaluated in Section 3.2.

3.2 Does Project Result In A Significant Adverse Environmental Effect Due To Noise?

To determine if the substantial noise increase is a significant adverse environmental effect, consideration must be given to the context and intensity of the substantial noise increase. Context refers to the project setting and uniqueness, or sensitive nature of the noise receiver(s). Intensity refers to the project induced substantial noise increase, i.e. the increase over the "no-build" condition; it also refers to the number of residential units affected and to the absolute noise levels.

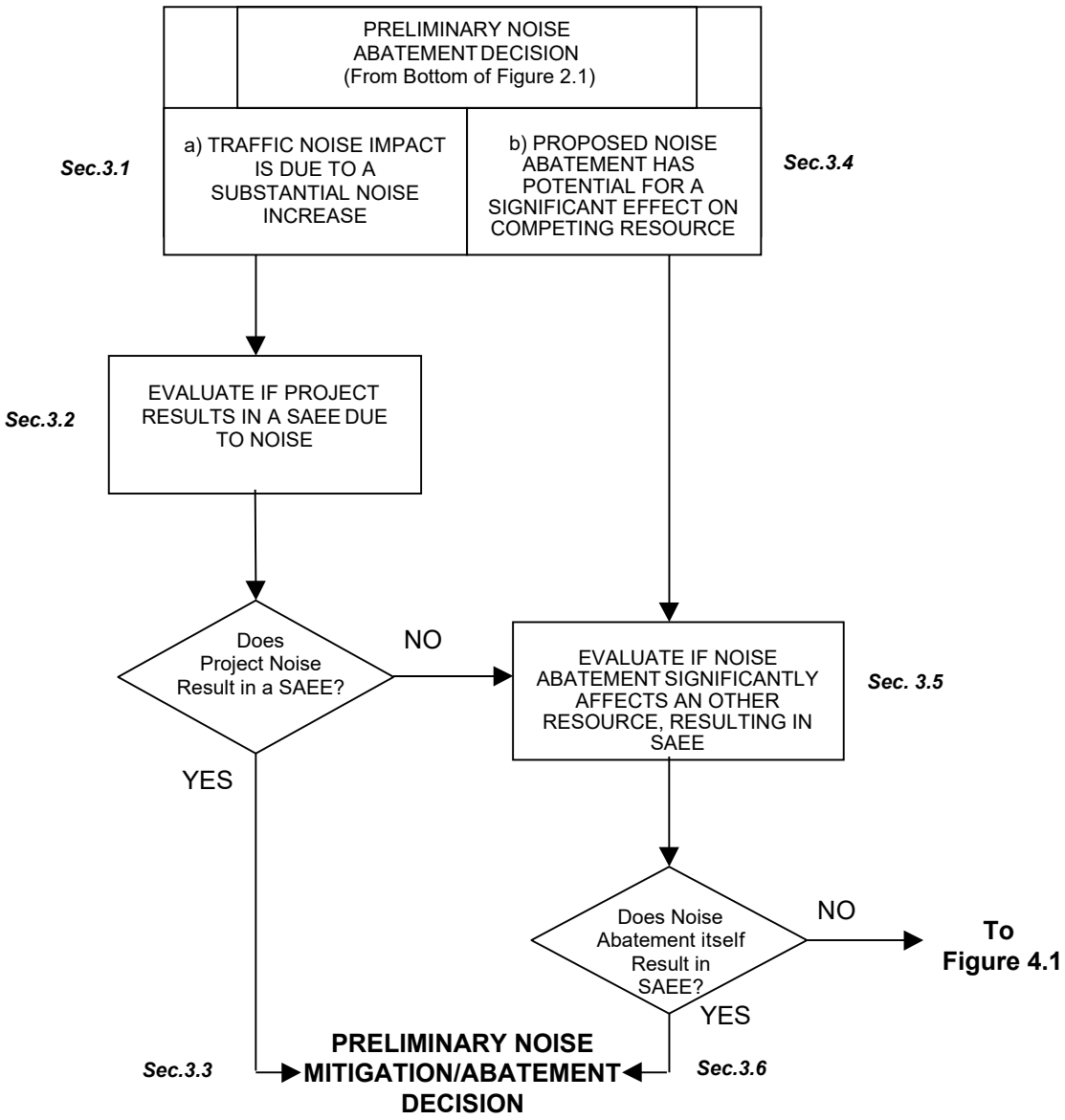
3.2.1 Project Results In A Significant Adverse Environmental Effect Due To Noise

If the project-generated substantial noise increase is expected to cause a significant adverse environmental effect the procedures in Section 3.3 must be followed.

3.2.2 Project Does Not Result In A Significant Adverse Environmental Effect Due To Noise

If the project-generated substantial noise increase does not cause a significant adverse environmental effect go to Section 3.5.

Figure 3-1 Flow Chart of Preliminary Noise Mitigation/Abatement Decision



NOTE:
E.D. = Environmental Documentation

SAEE= Significant Adverse Environmental Effect

3.3 Preliminary Noise Mitigation Decision And Development Of An Overall Mitigation Plan

The traffic noise impact caused by the project is expected to be a significant adverse environmental effect, and mitigation must be considered under CEQA requirements. It must be further evaluated whether the proposed noise mitigation itself will result in a significant adverse environmental effect.

3.3.1 Noise Mitigation Does Not Result in Significant Adverse Environmental Effect

If the noise mitigation *is not* expected to cause a significant adverse environmental effect, report in the Draft Environmental Document that noise mitigation will be a condition of project approval. Include likely noise mitigation measures, general location and dimensions (height and length), noise reduction, and cost of the noise mitigation facility (e.g. noise barrier). Also identify significant adverse noise effects for which it is likely that no, or only partial mitigation measures are available, including specific economic, social, environmental, legal, and technological conditions which make infeasible additional noise mitigation measures. Go to Section 4 for the final mitigation decision.

3.3.2 Noise Mitigation Results in a Significant Adverse Environmental Effect

If the noise mitigation *is* expected to result in a significant adverse environmental effect (such as by causing a visual intrusion on a scenic highway, blocking resident's views, adverse effects on historical sites, etc.), an overall mitigation plan must be developed. The plan should include consideration of competing environmental resources. To accomplish this, sufficient information regarding the physical characteristics, benefits, and detriments of the proposed mitigation is necessary so that it can be balanced against the affected resource(s). Go to Section 4 for the final mitigation decision.

3.4 The Proposed Noise Abatement Has Potential For A Significant Effect On Competing Resource(s)

In Section 2.9 it was determined that, although the project-generated noise increase was not substantial, the proposed noise abatement has a potential for a significant effect on a competing resource such as designated scenic highways, scenic vistas, historical sites, endangered species, etc.

3.5 Does Noise Abatement Significantly Affect Another Resource, Resulting In A Significant Adverse Environmental Effect?

If the project-generated noise does not cause a significant adverse environmental effect and proposed noise abatement may negatively affect one or more competing resources such as designated scenic highways, scenic vistas, historical sites, endangered species, the abatement itself may cause a significant adverse environmental effect.

As was the case with the substantial noise increase (Section 3.2), the significance of the effect must be evaluated in terms of the context and intensity. In this case, the context of the noise abatement (e.g. noise barrier) refers to how it blends in with the environment (e.g. visual blight in a scenic area), whether it blocks the views of residents as well as those of the motorists (scenic highway), etc. The intensity refers to the amount of resource users are affected and the extent of the detrimental affects of the abatement (such as shadows, redirecting airflow, changes in microclimate and temperature, or other environmental effects).

3.5.1 Noise Abatement Does Not Result in a Significant Adverse Environmental Effect

If the proposed noise abatement itself does not affect any other resources go to Section 4.

3.5.2 Noise Abatement Results in a Significant Adverse Environmental Effect

If the noise abatement *is* expected to result in a significant adverse environmental effect (such as by causing a visual intrusion on a scenic highway, blocking resident's views, adverse effects on historical sites, and changes in microclimate etc.), go to Section 3.6.

3.6 Preliminary Noise Abatement Decision And Development Of An Overall Mitigation Plan

An overall mitigation plan must be developed and reported in the Environmental Document (see Sec. 3.3.1 and 3.3.2 for reporting requirements). The plan should include consideration of competing environmental resources. To accomplish this, sufficient information regarding the physical characteristics, benefits, and detriments of the proposed mitigation is necessary so that it can be balanced against the affected resource(s). Go to Section 4 for the final abatement decision.

4. FINAL NOISE ABATEMENT/MITIGATION DECISION (FHWA AND CEQA PROCESS)

The flow chart in Figure 4-1 shows the process of reporting the preliminary noise abatement/mitigation decision and soliciting public input, including the views of impacted residents, local agencies, social, economic, environmental, legal, and technological factors. The preliminary decision and the public input process form the basis for the final noise abatement/mitigation decision.

4.1 Environmental Documentation

The appropriate environmental documentation (e.g. Draft Environmental Impact Statement, Draft Negative Declaration etc.) serves as a vehicle to circulate the preliminary noise abatement/mitigation decision. If noise abatement/mitigation is proposed the design is based on preliminary project alignments and profiles, which may be subject to change. The document should report that the physical characteristics of the abatement/mitigation (e.g. length, height, location and material of noise barrier) are preliminary and should be accompanied with a statement such as the following:

> *If pertinent parameters change substantially during the final project design, the preliminary noise abatement/mitigation design may be changed or eliminated from the final project design. A final decision of the construction of the noise abatement/mitigation will be made upon completion of the project design.*

If the project will have a significant adverse environmental effect due to noise, the proposed noise abatement measure is called *noise mitigation.* Otherwise, it should be referred to as *noise abatement*.

4.2 Public Input Process

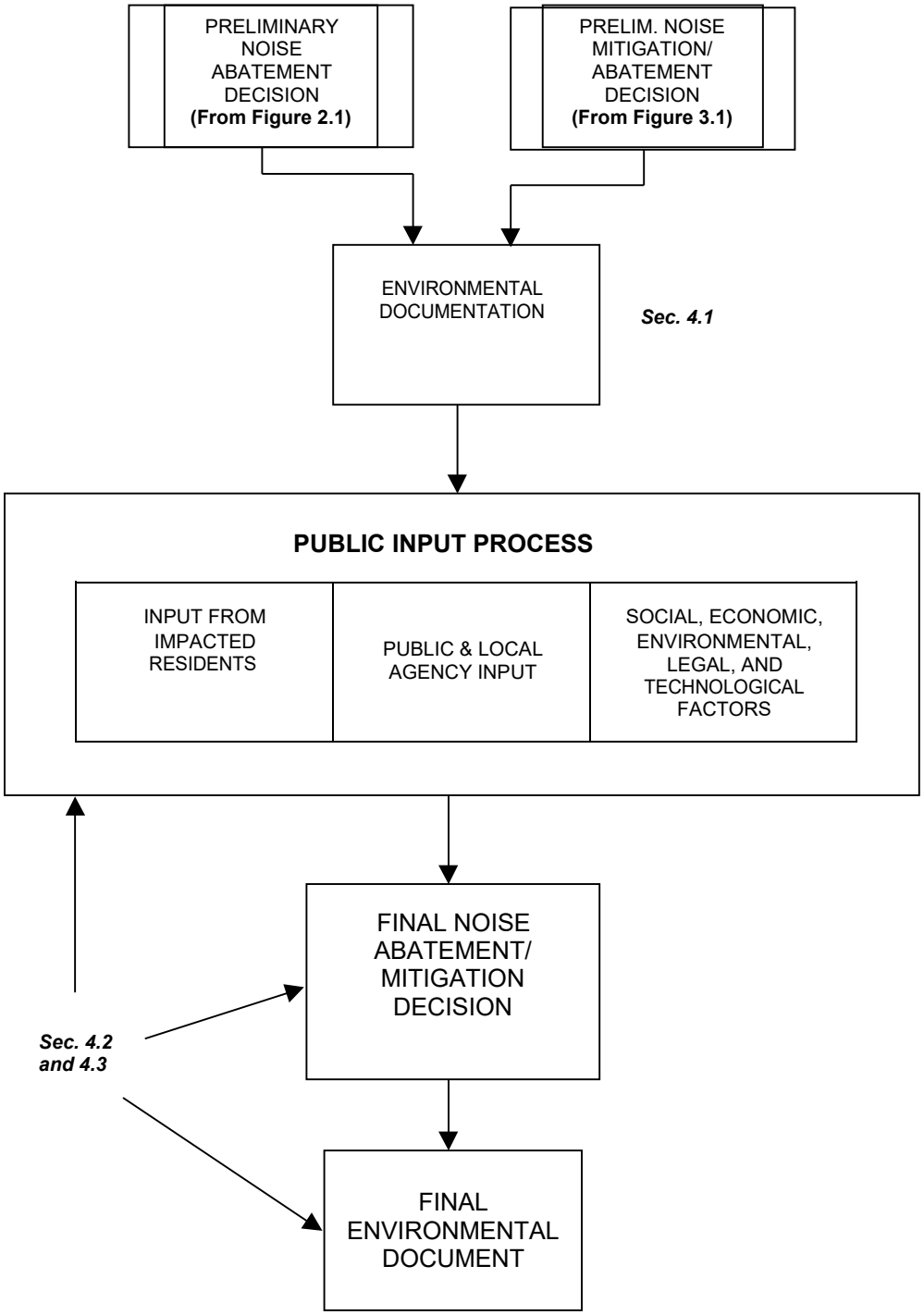
Views (i.e. opinions) of the impacted residents will be a major consideration in reaching a final decision on the reasonableness of abatement measures to be provided. The opinions of these residents should be obtained through public hearings, community meetings or other means as appropriate. Use of visual simulations to show impacts created by barriers is recommended.

Public hearings and community meetings also serve as a vehicle for other public input, such as views of motorists, other members of the community, and local agencies. The latter must be consulted on newly approved developments, *planned, designed and programmed* (see Section 1.4.2).

4.3 Final Noise Abatement Decision And Final Environmental Document

The final noise abatement decision is a product of public input as well as the preliminary noise abatement decision. It is a component of the project's overall environmental decision making process.

Figure 4-1 Flow Chart of Noise Abatement/Mitigation Decision



Although the Draft Environmental Document serves as a starting point in the final noise abatement decision, the decision maker has an obligation to balance a variety of public objectives. These include specific economic, environmental, social, legal, and technological factors as well as other public opinions and the views of the impacted residents.

If noise abatement is proposed, consideration must be given to the opinions of the adjacent resident owners, such as whether they favor the construction of the proposed noise abatement facilities, materials to be used, final appearance, etc. In the case of rental or leased property, the owners' opinion are superior to that of the residents.

Noise abatement will not be provided if 50% or more of the affected residents do not want it. The opinions of those affected residents should also be considered regarding the heights of proposed noise barriers. If the majority of those residents object to a proposed height, the barrier may be constructed at lower height under certain conditions. The affected residents should be informed of the proposed height of the noise barrier determined necessary by noise analysis. If they request a lower noise barrier, the shorter height may be constructed if it still will reduce the noise by a minimum of 5 dBA. The final abatement decision is reflected in the Final Environmental Document.

If the reported preliminary abatement/mitigation design changes after approval of the Final Environmental Document, a project reanalysis may be necessary (Section 1.4.3).

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5. NOISE ABATEMENT

5.1 Noise Abatement Objectives

The objectives of noise abatement are shown in the Highway Design Manual, Chapter 1100, Highway Traffic Noise Abatement, Index 1101.2 (see Appendix A).

5.2 Noise Abatement Design Goals

a) If a traffic noise impact *is not* found to be a *significant adverse environmental effect*, the project sponsor shall identify and implement all *reasonable* and *feasible* noise abatement measures. These noise abatement measures are considered project features. The abatement must provide a substantial noise reduction, defined as a minimum of 5 dBA for the impacted receivers. Greater noise reductions are encouraged as long as they can be achieved under the reasonableness guidelines covered in Section 2.8. If a noise barrier is designed, the end locations of the barrier should be influenced only by the impacted receivers, and not by any potentially benefited receivers (defined in Section 7, *Glossary*) flanking the barrier. The Noise Abatement Criteria in Section 2.4.2, Table 2-1 should not be used as design goals for noise abatement.

b) If a traffic noise impact *is* found to be a *significant adverse environmental effect* the project sponsor shall identify and implement all abatement measures to reduce the noise increase below the threshold level of *significance.* These are considered *mitigation* measures and are the *conditions of project approval*. If these measures are insufficient to eliminate the *significance,* the project sponsor shall implement all measures that would lessen the *significance*, and make a finding that specific economic, environmental, legal, social or technological factors make additional project alternatives or mitigation measures infeasible.

5.3 Noise Abatement Measures

Noise abatement measures may include, but are not limited to:

a) *Avoiding the project impact* by using design alternatives that result in lessening the noise effect, such as altering horizontal and vertical alignments to avoid a noise impact.

b) *Constructing noise barriers* (sound walls and earth berms).

c) *Acquiring property* or interest to serve as a buffer zone to preempt development which would be adversely impacted by traffic noise. An example would be a small set-back from a highway in cut, which would significantly increase the shielding effect by the top of cut.

d) Using *Traffic Management Measures* that are consistent with State Statutes regarding the regulation of traffic control devices, vehicle types, time use restrictions, modified speed limits, etc.

e) *Insulating and/or air-conditioning* public use or nonprofit institutional structures.

5.4 Ultimate Location

Noise barriers should be constructed at the ultimate location to accommodate a full standard facility or approved permanent nonstandard facility, meeting the transportation concept for the number of lanes, when reasonable or feasible. A noise barrier is normally not constructed where planned future construction would limit its useful life to less than 15 years. If the route concept indicates the freeway will be widened, and the noise barriers are currently to be constructed adjacent to the shoulder, the design should provide for salvage in the future.

5.5 Noise Abatement Outside the Right of Way

Noise abatement facilities are normally constructed within the State highway right of way. However, under certain topographical and geometric configurations it may be more practical and effective to construct the noise barrier outside the right of way on private property.

This policy regarding the possibility of constructing noise barriers outside the right of way applies to all State highway projects regardless of funding for those projects. When it is determined that noise abatement should be considered for properties adjacent to the freeway, and when it is found to be more reasonable and feasible to construct a noise barrier for that abatement outside the State highway right of way, such construction may be implemented under the following conditions.

For a proposed barrier location outside of the State highway right of way, a permanent easement must be secured for all (100%) of the affected properties to construct and maintain the barrier. On a federally funded project, the FHWA will hold Caltrans responsible for structural maintenance of the barriers. The acquisition of this permanent easement is part of the "reasonableness" (reasonable allowance per residence) determination for the abatement. If the noise abatement is determined not to be reasonable, the property owner may donate the permanent easement by signing a waiver of just compensation. Because noise abatement is a consideration and not a requirement, requesting donation of a permanent easement from the property owner, when noise abatement is determined not to be reasonable, is not a violation of the Uniform Act.

Additionally, all (100%) of the affected property owners must be supportive of the proposed noise attenuation (barrier), the location and the materials to be used for construction.

Each affected property owner must enter into a contract with Caltrans which specifies that they:

- Agree to allow Caltrans personnel, representatives and contractors to enter upon their property for purposes of constructing the noise barrier and all other related work.
- Agree to allow Caltrans personnel and representatives to enter upon their property with appropriate prior notification for the purpose of periodic inspection or structural repair of the barrier.
- Agree to accept aesthetic maintenance responsibility of their respective portion of the noise barrier upon its completion, and that the barrier's initial aesthetic qualities will be perpetuated.
- Agree not to remove the noise barrier without full consent of all other affected property owners and Caltrans.
- Agree that the contract provisions will be a permanent burden upon the property involved. The District Right of Way Branch will determine specific wording which, as a minimum, should include these provisions:

  "The term of this contract shall be a burden which runs with the land, and shall inure and be binding upon the successors, assigns or transferees of the property owner."

  "The undersigned knowingly waives the right to just compensation." (When appropriate).

All parties to the contract must agree to record the document in the official records of the appropriate County Recorder's office.

5.6 Unusual and Extraordinary Abatement

Unusual and extraordinary noise abatement strategies such as providing noise insulation of residential units are rarely employed. Noise insulation will not normally be provided in private residential dwellings, and may be provided only when severe traffic noise impacts are anticipated and normal abatement measures are physically not feasible or are economically unreasonable. When considering extraordinary abatement measures, it must be demonstrated that the affected activities experience traffic noise impacts to a far greater degree than other similar activities adjacent to highway facilities; i.e., private residential dwelling units will have after-project exterior noise levels of 75 dBA, $L_{eq}(h)$, or more, or the project causes a noise level increase of 30 dBA or more over predicted noise levels if no project was constructed. Noise insulation proposed in accordance with these criteria, on a Federal-aid project, is subject to approval of the FHWA on a case by case basis. When noise abatement is provided for public or private properties in line with this policy, an agreement must be entered into with the owner of the subject property which specifies that Caltrans is not responsible for any future costs of operating and/or maintaining the noise abatement improvements; i.e., air conditioning, caulking, etc.

5.7 Aesthetics Elements of Noise Abatement Features

Use of plants as aesthetic components of noise barriers should be considered. The objective is to reduce life cycle costs of the improvements. Plantings should be used to combat graffiti and enhance public acceptance.

When landscaping will eventually screen a substantial portion of the sound wall, only a minimal aesthetic treatment of the barrier is justified. Standard aesthetic treatments can be found in the Bridge Standard Plans.

When plants or aesthetic features are integral elements of the abatement feature, they will be considered part of the barrier for reasonableness consideration.

Where plants are to be used as a cover or appliqué for aesthetics and graffiti control, or where aesthetic treatments are considered, the District should involve the local community, which has a strong interest in protecting the community's image, and seek participative involvement in protecting the plants or aesthetic treatment from vandalism.

Planting as an element or component of a noise barrier is not subject to the funding limitations for Standard Highway Planting.

5.8 Value Analysis and Life-Cycle Cost Analysis

Value Analysis (VA) studies should be considered for all noise barriers. The VA studies should consider that the basic aim is to achieve satisfactory noise reduction. Specific considerations are:

a) Are there non-barrier alternatives?
b) Can part or all of the noise reduction be achieved using an earth mound (berm)?
c) Are there materials or systems that would be acceptable at this location that have not been tried previously?
d) Can relocating the wall eliminate the need for a safety shape barrier?
e) Is the barrier located so that future maintenance costs will be minimized?
f) Can the cost for aesthetic treatments be reduced or eliminated by judicious use of planting?
g) Is the barrier designed for the ultimate route concept?

These are only a few of the questions, which an innovative VA team should consider.

Project files for any project that incorporates a noise barrier should include the justification and background for the design type or the options allowed.

Beyond the basic questions addressed in a VA study, a Life-Cycle Cost Analysis should be conducted for the types of noise barriers considered. A number of factors are involved in planning, designing, constructing and maintaining noise barriers. Because some of these are difficult to evaluate, a list of them should

be used to test barriers being studied and to justify the material type selected. The analysis may be different for a given design type depending on whether it is nearer the traveled way or the right of way line. Life-cycle costs include all associated costs, such as planting, landscape maintenance and irrigation costs.

The Value Analysis and Life-Cycle Cost Analysis should be conducted before any presentations of noise abatement options to the public, and should be the basis for the alternatives presented.

5.9 Noise Abatement Design Criteria and Considerations

Design criteria for noise abatement facilities are covered in detail in Appendix A, which contains the Caltrans Highway Design Manual, Chapter 1100, *Noise Abatement*.

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6. REFERENCES

1. TeNS - *Technical Noise Supplement, Caltrans, Environmental Program, Noise, Air Quality, and Hazardous Waste Management Office, October 1998*
2. NEPA - *National Environmental Policy Act of 1969; 42 US Code, sections 4321 - 4370.*
3. CEQA - *California Environmental Quality Act of 1970; Public Resources Code Division 13, sections 21000 - 21177.*
4. 23 CFR 772 - Title 23, *United States Code of Federal Regulations, Part 772.*
5. HDM 1100 - *Caltrans Highway Design Manual, Chapter 1100, "Highway Traffic Noise Abatement", 5th Edition, July 1, 1995.*
6. CGC 65302 - *California Government Code Section 65302.*
7. FHWA -RD-77-108 - *FHWA Highway Traffic Noise Prediction Model, Federal Highway Administration, Office of Research, Office of Environmental Policy, December 1978.*
8. FHWA/CA/TL-87/03 - *California Vehicle Noise Emission Levels (Final Report), Caltrans, Office of Transportation Laboratory, January 1987.*
9. *Highway Traffic Noise Analysis and Abatement – Policy and Guidance, Federal Highway Administration, Office of Environment and Planning, Noise and Air Quality Branch, Washington, D.C., June 1995.*

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GLOSSARY

Benefited residence - A dwelling unit expected to receive a noise reduction of at least 5 dBA from the proposed noise abatement measure. A multi-story residence counts as one benefited residence even if the proposed noise abatement provides 5 dBA for the exterior (e.g. balconies) of two or more floors. The definition is primarily used in the determination of noise abatement reasonableness (Sec's 2.8.2 and 2.8.3).

Critical design receiver(s) - Depending on the context in which it is used, the design receiver(s) that is (are) impacted and for which the absolute noise levels, build vs. existing noise levels, or achievable noise reduction will be at a maximum where noise abatement is considered. The definition is primarily used in the determination of noise abatement reasonableness (Sec's 2.8.2 and 2.8.3).

Date of public knowledge - The date that a project is approved, i.e. approval of the final environmental documentation is completed (e.g. Record of Decision).

dBA, dB(A) - Unit of sound pressure level in decibels on the "A-weighted" Scale.

Design receiver - Any receiver used in the noise impact analysis, and /or noise abatement design. Normally, a design receiver represents several or more locations judged to receive approximately the same predicted noise levels, the same build vs. existing noise levels, and/or the same achievable noise reduction where noise abatement (e.g. sound wall) is considered.

Existing noise level(s) – The noise, resulting from the natural and mechanical sources and human activity, considered normally present in a particular area.

FHWA Type I Project - A proposed Federal or Federal-aid highway project for the construction of a highway on a new location, or the physical alteration of an existing highway which significantly changes either the horizontal or vertical alignment, or increases the number of through-traffic lanes. Caltrans extends this Type 1 definition to State highway projects without Federal funding.

Impacted receivers - Receivers that will receive a traffic noise impact (Section 2.4).

$L_{eq}(h)$ - The equivalent steady-state sound level that, in a specific hour, contains the same acoustic energy as a time-varying sound level during the same hour.

Noise Abatement – Noise attenuation provided for non-significant adverse environmental effects due to noise.

Noise Mitigation – Noise attenuation provided for significant adverse environmental effects due to noise.

Planned, designed and programmed - A noise sensitive land-use (subdivision, residences, schools, churches, hospitals, libraries, etc.) is considered planned, design and programmed when it has received final development approval (generally the issuance of a building permit) from the local agency with jurisdiction.

Predicted noise level(s) – Future noise levels, resulting from the natural and mechanical sources and human activity, considered being usually present in a particular area, including the project.

Receivers - Locations selected for determining traffic noise impacts. These locations should represent areas where frequent human use occurs, or is likely to occur in the foreseeable future (e.g. vacant property for which development plans have received final approval).

School Classroom Noise Impact – Occurs when a *freeway* project causes interior noise levels of an existing public or private elementary or secondary school to exceed $L_{eq}(h)$ 52 dBA (See Section 2.5 of this Protocol and Streets and Highways Code, Section 216).

Traffic Noise Impact - Impact that occurs at a receiver when one or both of the following takes place:

1) The predicted noise level *substantially* exceeds (Section 2.4.1) the existing noise level.

2) The predicted noise level with the project *approaches or exceeds* (Section 2.4.2) the Noise Abatement Criteria (NAC).

APPENDIX A – DESIGN CRITERIA (HIGHWAY DESIGN MANUAL CHAPTER 1100)

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Highway Design Manual

CHAPTER 1100
HIGHWAY TRAFFIC NOISE ABATEMENT

Topic 1101 - General Requirements

1101.1 - Introduction

The abatement of highway traffic noise is a design consideration that is required by State and Federal Statutes and regulations and by Caltrans policy. This chapter provides design standards relating to the location, height and length of noise barriers and includes discussion on alternative designs, maintenance and emergency access considerations and aesthetics of noise barriers. Procedures and policies on minimum attenuation, design goals, assessing noise impacts, noise abatement criteria levels, priorities, reasonableness and feasibility, and cost-effectiveness are contained in the Traffic Noise Analysis Protocol and the Technical Noise Supplement.

1101.2 Objective

The objectives are: for new construction or reconstruction of highways, to limit the intrusion of highway noise into adjacent areas; on existing freeways to limit the noise intrusion to achievable levels within practical and financial limitations; and to limit the noise to the levels specified by statute for qualifying schools adjacent to freeways. To achieve these objectives the Department supports the following four approaches to alleviate traffic noise impacts:

(1) *Reduction at the Source*. Reduction of traffic noise at the source is the most effective control. Therefore, Caltrans encourages and supports legislation to require reduction in motor vehicle noise as advances in the state-of-the-art of motor vehicle engineering permit.

(2) *Encouraging Compatible Adjacent Land Use*. Caltrans encourages those who plan and develop land and local governments controlling development or planning land use near known highway locations to exercise their powers and responsibility to minimize the effect of highway vehicle noise through appropriate land use control. 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.

(3) *Noise Abatement*. Caltrans will attempt to locate, design, construct, and operate State highways to minimize the intrusion of traffic noise into adjacent areas. When this is not possible, noise impacts may be attenuated by the construction of noise barriers.

(4) Noise Abatement by Others. An increasing number of requests are being made to Caltrans by owners or developers to attenuate noise reaching adjacent properties for which the State's mitigation priority is low or nonexistent. 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 State's right of way. The State shall assume NO review authority or responsibility of any kind for the structural integrity or the effectiveness of the sound attenuation of walls constructed by others outside of the State's right of way. Where it is determined to be necessary to permit others to construct a sound barrier within the State's right of way, the general policy is that the design will meet Caltrans geometric, structural, and safety standards as established in this and other manuals and that the effects of the barrier on operation, maintenance and aesthetics of the highway will be more beneficial than detrimental.

1101.3 Terminology

The terms "noise barrier" and "sound wall" are often used interchangeably. Technically, a "noise barrier" may be any feature which blocks, prevents or diminishes the transmission of noise. An earth berm could serve this purpose. A large building could serve as a noise barrier to shield receptors further from the noise source. A dense growth of vegetation, if it were wide enough and dense enough, would be a noise barrier. A "sound wall" is a particular type of noise barrier. It is a wall, which may be constructed of concrete panels, masonry blocks, wood boards or panels, or a variety of other materials.

1101.4 Procedures for Assessing Noise Impacts

Highway traffic noise impacts are identified in the project noise study report and are listed in the environmental document. The procedures for assessing noise impacts for new highway construction or reconstruction projects, retrofit projects (Community Noise Abatement Program - HB311) along existing freeways, and School Noise Abatement Projects (HB312), are included in Title 23, United States Code of Federal Regulations Part 772, the Project Development Procedures Manual, and Section 216 of the Streets and Highways Code.

1101.5 Prioritizing Construction of Retrofit Noise Barriers

Legal requirements and procedures for prioritizing the construction of noise attenuation barriers are provided in Section 215.5 of the Streets and Highway Code.

Highway Design Manual

CHAPTER 1100
HIGHWAY TRAFFIC NOISE ABATEMENT

Topic 1102 – Design Criteria

1102.1 General

This section covers the noise barrier location, various design aspects such as height and length of noise barriers, alternative designs, maintenance considerations, and aesthetic considerations. Various types of Caltrans standard noise barrier designs are referenced. Noise level criteria and barrier design procedures, from the acoustical standpoint, are included in the Caltrans Traffic Noise Analysis Protocol and Technical Noise Supplement.

1102.2 Noise Barrier Location

(1) Lateral Clearances. **Minimum lateral clearance to noise barriers shall be as provided in Topic 309.1, Horizontal Clearances, of this manual, but shall not be less than 3 m.** Lateral clearances greater than the minimums should be used whenever feasible. Where terrain permits, the most desirable location for a noise barrier from a safety perspective is just inside the right of way or, alternatively, 10 m or more from the traveled way.

When lateral clearance is 4.5 m or less, the noise barrier shall be placed on a safety shape concrete barrier. Guardrail or safety shape barrier protection should be considered when the noise barrier is located between 4.5 m and 9 m from the edge of the traveled way.

When the noise barrier is placed closer than 5 m from the traveled way, Traffic Operations should be consulted early in the design. Signs (overhead and ground mounted) and other poles and standards for lighting, Transportation Management items, call boxes, etc. should be detailed for mounting on the wall, incorporated into the wall foundation and possibly recessed into the surface of the wall.

(2) Sight Distance Requirements. The stopping sight distance is of prime importance for noise barriers located on the edge of shoulder along the inside of a curve. Horizontal clearances, which reduce the stopping sight distance should be avoided. Noise barriers within gore areas should begin or end at least 60 m from the theoretical curb nose location.

(3) Ultimate Location. Noise barriers should be constructed at the ultimate location for the facility as discussed in the Project Development Procedures Manual.

1102.3 Noise Barrier Heights

(1) Minimum Height. Noise barriers should have a minimum height of 1.8 m (measured from the top of the barrier to the top of the foundation).

(2) Maximum Height. Noise barriers should not exceed 4.3 m in height (measured from the pavement surface at the face of the safety-shape barrier) when located 4.5 m or less from the edge of the traveled way, and should not exceed 5.0 m in height above the ground line when located more than 4.5 m from the traveled way.

(3) Truck Exhaust Intercept. Current FHWA noise barrier design procedures result in noise barrier heights, which often do not intercept noise, emitted from the exhaust stack of trucks. For design purposes, the noise barrier should intercept the line of sight from the exhaust stack of a truck to the receptor. The truck stack height is assumed to be 3.5 m above the pavement. The receptor is assumed to be 1.5 m above the ground and located 1.5 m from the living unit nearest the roadway. If this location is not representative of potential outdoor activities, then another appropriate location should be justified in the noise study report.

(4) Two-story Development. The noise barrier should not be designed to shield the second story of two-story residences unless it provides attenuation for a substantial number of residences at a reasonable increase in cost. If the noise barrier is extended in height to provide second story attenuation, this attenuation is to be at least 5 decibels.

(5) Parallel Noise Barriers. Frequently, noise barriers are constructed to shield noise receivers on both sides of a highway. These are referred to as parallel barriers. If the barrier surfaces are hard, relatively smooth, and non porous, such as concrete or masonry surfaces, the barriers can reflect noise back and forth between the barriers, decreasing their effectiveness. As a result of research performed by Caltrans and others, reflective parallel barriers should have a width-to-height ratio (W:H) of at least 10:1 to avoid a risk of perceptible reduction in performance of both noise barriers. The width is the distance between the two barriers, and the height is the average height of both barriers with reference to the roadway elevation. For example, two parallel barriers, one 3 m the other 4 m high, should be separated by at least 35 m to avoid a noticeable degradation in performance. A perceptible, or noticeable decrease in performance is defined as a reduction of 3 dBA or more in barrier attenuation.

1102.4 Noise Barrier Length

(1) General. Careful attention should be given to the length of a noise barrier to assure that it provides adequate attenuation for the end dwelling. The Caltrans

Environmental Handbook provides guidance on determining how far beyond the end dwelling a noise barrier should be extended. When

appropriate, consideration should be given to terminating the noise barrier with a section of the barrier perpendicular to the freeway. This could reduce the overall barrier length, but may require an easement or acquisition from the property owner to permit construction of the noise barrier off the right of way.

(2) Gap Closures. In some cases, short gaps may exist between areas qualifying for a noise barrier. The closure of these gaps should be considered on a project by project basis and be justified in the Project Report.

(3) Local Street Connections. At on- and off-ramp connections to local streets, the Department's responsibility for noise abatement should be limited to areas where the traffic noise level from the State highway is the predominant noise source.

(4) Barrier Overlaps. When the noise barrier has overlapping sections, such as when concealing an access opening, the walls must be overlapped a minimum of 2.5 to 3 times the offset distance in order to maintain the integrity of the sound attenuation.

1102.5 Alternative Noise Barrier Designs

(1) General. Every noise barrier that is constructed as a part of new highway construction or reconstruction, or along freeways as a part of the Community and School Noise Abatement Programs, requires at least two alternative designs included in the contract plans. Selection of the most cost-effective and aesthetically pleasing designs should include an analysis of their life-cycle costs. The Traffic Noise Analysis Protocol discusses cost analysis of noise barriers.

Standard sheets for noise barriers (sound walls) developed by the Office of Structure Design have been furnished to the Districts. These standard designs include the following materials:

- Masonry block.
- Precast concrete panel (with post or mounted on safety shaped barrier).
- Wood (post and plank or framed plywood).
- Metal (ribbed steel).
- Composite beam (Styrofoam and wire mesh core with stucco exterior).
- Other design alternatives may be considered provided they meet the structural and noise attenuation criteria. Questions regarding the approval status of various designs or products should be directed to the Headquarters Noise Abatement Design Standards Engineer in the Office of Project Planning and Design.

Project Files for each noise barrier project should include the justification and background for the design type or the options allowed on each project.

(2) Design Procedures. The plans for alternative noise barriers are to be prepared using the standard sound wall sheets and the appropriate Standard Special Provisions. As a minimum, the sound wall plans are to show the horizontal alignment, the wall profile made up of a top elevation line and a bottom elevation line, the applicable standard sound wall detail sheets, and aesthetic features sheet. The top elevation line is defined as the profile line of the minimum wall height required for the design insertion loss, and the bottom elevation line is defined as the finished grade ground line. If a concrete safety-shape barrier is involved, the top of barrier is to be designated as the bottom elevation line of the sound wall. For alternative sound walls not on a barrier, the footing design does not have to be detailed on the plans. If a barrier is required, the pile layout should be detailed for only one of the alternative designs. Although this method does not require the detailing of one complete sound wall alternative, it does not remove the necessity to solve drainage, utility, foundation, or any other problems, which are unique to each project.

(3) Pay Quantities. The pay item for alternative sound walls without a barrier is square meter of sound wall and is measured between the top elevation line and the bottom elevation line. The square meter cost includes all types of supports (footings, piles and pile caps).

If the sound wall is on a barrier the sound wall pay item is measured from top elevation line to top of barrier, and the supporting piles or footings and barrier will be separate pay items.

The aesthetic features affect the amount of footing for the masonry block design, and these features must be shown clearly on the plans. The "Typical Sections" sheet is the recommended location to show the aesthetic treatment.

Refer to the Standard Special Provisions for more information on measurement and pay quantities.

(4) Shop Plans. The Special Provisions should require the successful bidder to submit two sets of shop plans of the selected alternate for approval. These shop drawings must show pile spacing, pile lengths, expansion joints location, and aesthetic treatment.

(*5) Preliminary Site Data*. In using the "Top Line/Bottom Line" concept, it is important that the preliminary site data be as complete as possible. To eliminate or minimize construction change orders the following guidelines are suggested.

- Provide accurate ground line profiles.
- Select only approved design alternative sound wall types.
- Provide adequate foundation investigation.
- Locate overhead and underground utilities.

- Review drainage and show any modifications on the plans.
- Determine and specify architectural treatment.
- Determine the need for special design, and coordinate with the Office of Structures Design during the early stages of design.

1102.6 Noise Barrier Aesthetics

(1) General. A landscaped earth berm or a combination wall and berm tend to minimize the apparent noise barrier height and are probably the most aesthetically acceptable alternative, but unfortunately these alternatives are not suitable for many sites due to limited space.

Some moderate additional cost to enhance the noise barrier's aesthetic quality is usually warranted. However, elaborate or costly individualized designs, which significantly increase the cost of the noise barrier should be avoided. Sound walls should not be designed with abrupt beginnings or ends. Generally, the ends of the sound wall should be tapered or stepped if the height of the sound wall exceeds 2 m. The District Landscape Architect should be consulted regarding the design of tapers or stepped ends, aesthetic treatment and landscaping for noise barriers.

(2) Standard Aesthetic Treatment. Only the standard aesthetic treatments for the various alternative materials developed by the Division of Structures should be used. A description of the different types of aesthetic treatments developed is included in the "Instructions for Using the Standard Aesthetics Features Sheets" which are available from the Aesthetics and Models unit of the Division of Structures.

(3) Nonstandard Aesthetic Treatment. When a nonstandard aesthetic treatment is proposed for noise barriers, the Headquarters Traffic Liaison should be consulted.

(4) Planting of Noise Barriers. The use of plants in conjunction with noise barriers can help to combat graffiti and enhance public acceptance of the noise barrier. When landscaping is to be placed adjacent to the sound wall that will eventually screen a substantial portion of the wall, only a minimal aesthetic treatment is justified.

Index 902.3 of this manual and the Traffic Noise Analysis Protocol contain additional information on the planting of noise barriers.

1102.7 Maintenance Consideration in Noise Barrier Design

(1) General. Noise barriers placed within the area between the shoulder and right of way line complicate the ongoing maintenance operations. When there is a substantial distance behind the noise barriers and in front of the right of way line, special consideration is required. If the adjoining land is occupied with streets, roads, parks, or other large parcels, an effort should be made during

the right of way negotiations to have the abutting property owners maintain the area. In this case, the chain link fence at the right of way line would not be required. Maintenance by others may not be practical if a number of small individual properties abut the noise barrier.

(2) Access Requirements. Access to the backside of the noise barrier must be provided if the area is to be maintained by Caltrans. In subdivided areas, access can be via local streets, when available. If access is not available via local streets, access gates or openings are essential at intervals along the noise barrier. Access may be provided via offsets in the barrier. Offset barriers must be overlapped a minimum of 2.5 to 3 times the offset distance in order to maintain the integrity of the sound attenuation of the main barrier. Location of the access openings must be coordinated with the District maintenance office.

(3) Noise Barrier Material. The alternative materials selected for the noise barrier should be appropriate for the environment in which it is placed. For walls that are located at or near the edge of shoulder, the portion of the noise barrier located above the safety-shape concrete barrier should be capable of withstanding the force of an occasional vehicle, which may ride up above the top of the safety barrier. At this location, concrete block, cast-in-place concrete, or precast concrete panels are the recommended alternative sound wall materials. In locations, which are susceptible to fires, use of wood noise barriers should be avoided.

1102.8 Emergency Access Considerations in Noise Barrier Design

(1) General. In addition to access gates being constructed in noise barriers to satisfy the Department's maintenance needs, they may also be constructed to provide a means to access the freeway in the event of a catastrophic event which makes the freeway impassable for emergency vehicles. These gates are not intended to be used as an alternate means of emergency access to adjacent neighborhoods. Access to those areas should be planned and provided for from local streets and roads. Small openings may also be provided in the noise barrier, which would allow a fire hose to be passed through it. Local emergency response agencies should be contacted early in the design process to determine the need for emergency access gates and fire hose openings.

(2) Emergency Access Gate Requirements. Access gates in noise barriers should be kept to a minimum and should be at least 300 m apart. Locations of access should be coordinated with the District Maintenance office. Only one opening should be provided at locations where there is a need for access openings to serve both the emergency response agency and Caltrans maintenance. Design of gates should comply with the sound wall details developed by the Office of Structures Design.

(3) Fire Hose Access Openings. When there is no other means of providing fire protection to the freeway, small openings for fire hoses may be provided. Fire hose access should be located as close as possible to the fire hydrants on the local street system. Where possible, fire hose access should be combined with

emergency or maintenance access openings. Design of fire hose openings should be requested from the Office of Structures Design.

1102.9 Drainage Openings in Noise Barrier

Drainage through noise barriers is sometimes required for various site conditions. Depending on the size and spacing, small, unshielded openings at ground level can be provided in the barriers to allow drainage and not defeat the noise attenuation of the barrier. The following sizes of unshielded openings at ground level are allowed for this purpose:

(a) Openings of 200 mm x 200 mm or smaller, if the openings are spaced at least 3 m on center.

(b) Openings of 200 mm x 400 mm or smaller, if the openings are spaced at least 6 m on center, and the noise receiver is at least 3 m from the nearest opening.

The location and size of drainage openings need to be designed based on the hydraulics of the area. The designer should also take into consideration possible erosion problems that may occur at the drainage openings.

Where drainage requirements dictate openings that do not conform to the above limitations, shielding of the opening will be necessary to uphold the noise attenuation of the barrier. Shield design must consider the hydraulic characteristics of the site. When shields are determined to be necessary, consultation with the District Hydraulics Unit and the OPPD Coordinator and Environmental Engineering staff is recommended.

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APPENDIX B – SUGGESTED WORKSHEETS, AND EXAMPLES OF CALCULATING REASONABLE ALLOWANCES PER RESIDENCE

WORKSHEET "A" FOR CALCULATING REASONABLE ALLOWANCE PER RESIDENCE

PROJECT: Co. Rte. PM. EA:	**PROJECT LOCATION:**		**Page of**
NOISE BARRIER I.D. & LOCATION:			
PROJECT ENGINEER:			**Date:**
Base Allowance (1998 Dollars) Update for year 2____			**$ 15,000 _____**
1) Absolute Noise Levels (Choose One)		**Check**	
69 dBA or less:	**Add $ 2,000**		
70-74 dBA:	**Add $ 4,000**		
75-78 dBA:	**Add $ 6,000**		
More than 78 dBA:	**Add $ 8,000**		
2) "Build" VS Existing Noise Levels (Choose One)		**Check**	
Less than 3 dBA:	**Add $ 0**		
3-7 dBA:	**Add $ 2,000**		
8-11 dBA:	**Add $ 4,000**		
12 dBA or more:	**Add $ 6,000**		
3) Achievable Noise Reduction (Choose One)		**Check**	
Less than 6 dBA:	**Add $ 0**		
6-8 dBA:	**Add $ 2,000**		
9-11 dBA:	**Add $ 4,000**		
12 dBA or more:	**Add $ 6,000**		
4) Either New Construction Or Pre-date 1978? (Choose Yes or No)		**Check**	
YES on either one:	**Add $10,000**		
NO on both:	**Add $ 0**		
Unmodified Reasonable Allowance Per Residence			
Continued on Worksheet B			

WORKSHEET "B" FOR CALCULATING REASONABLE ALLOWANCE PER RESIDENCE

PROJECT: Co. : _____ Rte: _____ PM: _____ EA: PROJECT ENGINEER:	PROJECT DESCRIPTION AND LOCATION:	Page ___ of ___ Date: _____

NOISE BARRIER I.D. (From Worksheet A)	REASONABLE ALLOWANCE PER BENEFITED RESIDENCE, A_i (Worksheet A) (a)	NO. OF BENEFITTED RESIDENCES N_i (b)	REASONABLE ALLOWANCE PER NOISE BARRIER (A_i x N_i) (c) (c =a x b)	FRACTION OF TOTAL REASONABLE ALLOWANCE (A_i x N_i)/ A_T (d) (d =c/box 1)	REDUCTION OF REASONABLE ALLOWANCE PER NOISE BARRIER (e) (e =d x box 3)	REDUCTION OF REASONABLE ALLOWANCE PER BENEFITED RESIDENCE (f) (f =e/b)	MODIFIED REASONABLE ALLOWANCE PER BENEFITED RESIDENCE (A_{m_i}) (g) (g =a – f)

TOTAL REASONABLE ALLOWANCE FOR ABATEMENT (A_T)	(Box1)
ESTIMATED PROJECT COST x 0.5	(Box2)
SUBTRACT BOX 2 FROM BOX 1 • If result is zero or less, STOP. Use the reasonable allowances per residence in column (a) above. • If result is greater than zero, the amount is TOTAL ALLOWANCE EXCESS (E_T); continue with columns (d) through (g).	(Box3)

EXAMPLE

WORKSHEET "A" FOR CALCULATING REASONABLE ALLOWANCE PER RESIDENCE

PROJECT:Sim-999-9.9 **EA: 654321**	**PROJECT LOCATION:** **Between Gilster Street & Jones Avenue**		**Page 1 of 4**
NOISE BARRIER I.D. & LOCATION: SW-1			
PROJECT ENGINEER: Hendriks			**Date: 10/20/98**
Base Allowance (1998 Dollars) **Update for year 2____**			**$ 15,000**
1) Absolute Noise Levels (Choose One)		**Check**	
69 dBA or less:	**Add $ 2,000**		
70-74 dBA:	**Add $ 4,000**		
75-78 dBA:	**Add $ 6,000**	✓	**$ 6,000**
More than 78 dBA:	**Add $ 8,000**		
2) "Build" VS Existing Noise Levels (Choose One)		**Check**	
Less than 3 dBA:	**Add $ 0**	✓	**$ 0**
3-7 dBA:	**Add $ 2,000**		
8-11 dBA:	**Add $ 4,000**		
12 dBA or more:	**Add $ 6,000**		
3) Achievable Noise Reduction (Choose One)		**Check**	
Less than 6 dBA:	**Add $ 0**		
6-8 dBA:	**Add $ 2,000**	✓	**$ 2,000**
9-11 dBA:	**Add $ 4,000**		
12 dBA or more:	**Add $ 6,000**		
4) Either New Construction Or Pre-date 1978? (Choose Yes or No)		**Check**	
YES on either one:	**Add $10,000**	✓	**$ 10,000**
NO on both:	**Add $ 0**		
Unmodified Reasonable Allowance Per Residence			**$ 33,000**
Continued on Worksheet B			

EXAMPLE

WORKSHEET "A" FOR CALCULATING REASONABLE ALLOWANCE PER RESIDENCE

PROJECT: SIM-999-10.4 **EA: 654321**	**PROJECT LOCATION:** **Between Gilster Street & Jones Avenue**		**Page 2 of 4**
NOISE BARRIER I.D. & LOCATION: SW-2			
PROJECT ENGINEER: Hendriks			**Date: 10/20/98**
Base Allowance (1998 Dollars) **Update for year 2____**			**$ 15,000** **_____**
1) Absolute Noise Levels (Choose One)		**Check**	
69 dBA or less:	**Add $ 2,000**		
70-74 dBA:	**Add $ 4,000**	✓	**$ 4,000**
75-78 dBA:	**Add $ 6,000**		
More than 78 dBA:	**Add $ 8,000**		
2) "Build" VS Existing Noise Levels (Choose One)		**Check**	
Less than 3 dBA:	**Add $ 0**	✓	**$ 0**
3-7 dBA:	**Add $ 2,000**		
8-11 dBA:	**Add $ 4,000**		
12 dBA or more:	**Add $ 6,000**		
3) Achievable Noise Reduction (Choose One)		**Check**	
Less than 6 dBA:	**Add $ 0**		
6-8 dBA:	**Add $ 2,000**	✓	**$ 2,000**
9-11 dBA:	**Add $ 4,000**		
12 dBA or more:	**Add $ 6,000**		
4) Either New Construction Or Pre-date 1978? (Choose Yes or No)		**Check**	
YES on either one:	**Add $10,000**		
NO on both:	**Add $ 0**	✓	**$ 0**
Unmodified Reasonable Allowance Per Residence			**$ 21,000**
Continued on Worksheet B			

EXAMPLE

WORKSHEET "A" FOR CALCULATING REASONABLE ALLOWANCE PER RESIDENCE

PROJECT: Sim-999-11.2 **EA: 654321**	**PROJECT LOCATION:** **Between Gilster Street & Jones Avenue**		**Page 3 of 4**
NOISE BARRIER I.D. & LOCATION: SW-3			
PROJECT ENGINEER: Hendriks			**Date: 10/20/98**
Base Allowance (1998 Dollars) **Update for year 2____**			**$ 15,000** **_____**
1) Absolute Noise Levels (Choose One)		**Check**	
69 dBA or less:	**Add $ 2,000**		
70-74 dBA:	**Add $ 4,000**		
75-78 dBA:	**Add $ 6,000**		
More than 78 dBA:	**Add $ 8,000**	✓	**$ 8,000**
2) "Build" VS Existing Noise Levels (Choose One)		**Check**	
Less than 3 dBA:	**Add $ 0**	✓	**$ 0**
3-7 dBA:	**Add $ 2,000**		
8-11 dBA:	**Add $ 4,000**		
12 dBA or more:	**Add $ 6,000**		
3) Achievable Noise Reduction (Choose One)		**Check**	
Less than 6 dBA:	**Add $ 0**		
6-8 dBA:	**Add $ 2,000**	✓	**$ 2,000**
9-11 dBA:	**Add $ 4,000**		
12 dBA or more:	**Add $ 6,000**		
4) Either New Construction Or Pre-date 1978? (Choose Yes or No)		**Check**	
YES on either one:	**Add $10,000**	✓	**$ 10,000**
NO on both:	**Add $ 0**		
Unmodified Reasonable Allowance Per Residence			**$ 35,000**
Continued on Worksheet B			

EXAMPLE

WORKSHEET "B" FOR CALCULATING REASONABLE ALLOWANCE PER RESIDENCE

PROJECT: Co. : Sim Rte: 999 PM: 9.5/12.0 EA: 654321 PROJECT ENGINEER: Hendriks	PROJECT DESCRIPTION AND LOCATION: Outside widening between Gilster Street & Jones Avenue	Page 4 of 4 Date: 10/20/98

NOISE BARRIER I.D. (From Worksheet A)	REASONABLE ALLOWANCE PER BENEFITED RESIDENCE, A_i (Worksheet A) (a)	NO. OF BENEFITTED RESIDENCES N_i (b)	REASONABLE ALLOWANCE PER NOISE BARRIER (A_i x N_i) (c) (c =a x b)	FRACTION OF TOTAL REASONABLE ALLOWANCE (A_i x N_i)/ A_T (d) (d =c/box 1)	REDUCTION OF REASONABLE ALLOWANCE PER NOISE BARRIER (e) (e =d x box 3)	REDUCTION OF REASONABLE ALLOWANCE PER BENEFITED RESIDENCE (f) (f =e/b)	MODIFIED REASONABLE ALLOWANCE PER BENEFITED RESIDENCE (A_{m_i}) (g) (g =a – f)
SW-1	$ 33,000	23	$ 759,000	0.341	$ 112,189	$ 4,878	$ 28,122
SW-2	$ 21,000	15	$ 315,000	0.141	$ 46,389	$ 3,093	$ 17,907
SW-3	$ 35,000	33	$ 1,155,000	0.518	$ 170,422	$ 5164	$ 29,836

TOTAL REASONABLE ALLOWANCE FOR ABATEMENT (A_T)	(Box1) $ 2,229,000
ESTIMATED PROJECT COST x 0.5	(Box2) $ 1,900,000
SUBTRACT BOX 2 FROM BOX 1 • If result is zero or less, STOP. Use the reasonable allowances per residence in column (a) above. • If result is greater than zero, the amount is TOTAL ALLOWANCE EXCESS (E_T); continue with columns (d) through (g).	(Box3) $ 329,000