U.S. Department
of Transportation

Federal Highway
Administration

Highway Traffic Noise:
Analysis and Abatement Guidance

December 2011

FHWA-HEP-10-025

Original June 2010 and revised December 2010

Determining Existing Noise Levels *24*
Traffic Noise Impacts *24*
Impact Determination *25*
Substantial Increase *25*
Noise Abatement Criteria (NAC) *25*
Activity Category A 27
Activity Category B 27
Activity Category C 28
Examples on Determining Cost-Reasonableness of Non-residential Land Uses. 28
Activity Category D 28
Activity Category E 29
Activity Category F 29
Activity Category G 29
Receiver Locations for Highway Traffic Noise Analyses *30*
Exterior Areas of Frequent Human Use 30
Predicting Interior Noise Levels 30
Table 6: Building Noise Reduction Factors 30
NOISE REDUCTION DUE TO EXTERIOR OF THE STRUCTURE 30
FHWA PUBLICATION *FHWA-DP-45-1R, SOUND PROCEDURES FOR MEASURING HIGHWAY NOISE: FINAL REPORT* PROVIDES PROCEDURES TO MEASURE BUILDING NOISE REDUCTIONS. 31
Study Area 31
Existing Highway Traffic Noise Measurements 31
Model Validation 31
Model Calibration 32
Prediction of Future Highway Traffic Noise Levels for Study Alternatives *32*
772.13 ANALYSIS OF NOISE ABATEMENT 33
Table 7: Relationship Between Decibel, Energy, and Loudness 36
Noise Abatement Documentation: *36*
Determining Feasible and Reasonable Highway Traffic Noise Abatement *37*
Reasonableness is based on three required criteria, but may be influenced by consideration of optional criteria. The criteria used for determining reasonableness indicates a broad consideration of conditions that apply in a given location..Determining Benefited Receptors *38*
Feasibility *38*
Acoustic Feasibility 38
Reasonableness *38*
Viewpoint of Affected Residents and Property Owners 38
Allowable Cost of Highway Traffic Noise Abatement 38
Example of Regional Cost Differences 39
Noise Reduction Design Goal 39
Determining Receptors 39
Optional Reasonabless Factors 39
Date of Development 40
Length of Time Receivers Have Been Exposed to Highway Traffic Noise Impacts 40
Exposure to Higher Absolute Highway Traffic Noise Levels 40
Changes Between Existing and Future Build Conditions 40
Mixed Zoning Development 41
Noise Compatible Planning 41
Abatement Measure Reporting *41*
Third Party Participation *41*

Shadow Effect of Noise Barrier 57
Public Perception 57
Receiver Locations for Noise Barrier Design 58
Design Considerations 58
Visual Impact 59
Graffiti 59
Reflection of Noise from a Noise Barrier 60
Noise Barrier Structural and Safety Design Criteria 60
TRAFFIC MANAGEMENT 61
ALTERATION OF HORIZONTAL AND VERTICAL ALIGNMENTS 61
ACQUISITION OF PROPERTY RIGHTS FOR NOISE BARRIER OR BUFFER ZONES 61
NOISE INSULATION 62
VISUAL SCREENING 62
Vegetation *62*
Figure 3: Vegetation 62
Privacy Fencing *63*
Flexibility in Decision Making *63*
APPENDIX D: FEASIBILITY AND REASONABLENESS WORKSHEET EXAMPLE 64
REASONS FOR DECISION: 64
APPENDIX E: TYPE II PROGRAM EXAMPLES 66
MASSACHUSETTS 66
OHIO 66
TENNESSEE 66
TEXAS 66
APPENDIX F: DETERMINING THE REASONABLE COST OF ABATEMENT 67
APPENDIX G: HIGHWAY TRAFFIC-INDUCED VIBRATION 75

Source Control

The Noise Control Act of 1972 authorizes the U.S. Environmental Protection Agency (EPA) to establish noise regulations to control major sources of noise, including transportation vehicles and construction equipment. Additionally, this legislation requires EPA to issue noise emission standards for motor vehicles used in interstate commerce (vehicles used to transport commodities across State boundaries) and requires the Federal Motor Carrier Safety Administration (FMCSA) to enforce these noise emission standards. The EPA established regulations, which set emission level standards for newly manufactured medium and heavy trucks with a gross vehicle weight rating (GVWR) greater than 10,000 pounds and capable of operating on a highway or street. Table 1 shows the maximum noise emission levels allowed by the EPA noise regulations for these vehicles.

Table 1: Maximum Noise Emission Levels as Required by EPA for Newly Manufactured Trucks with GVWR Over 10,000 Pounds

Effective Date	Maximum Noise Level 50 Feet from Centerline of Travel*
January 1, 1988	80 dB(A)
* Using the Society of Automotive Engineers, Inc. (SAE), test procedure for acceleration under 35 mph	

The Federal government also has authority to regulate noise emission levels for existing (in use) medium and heavy trucks with a GVWR of more than 10,000 pounds that are engaged in interstate commerce. Table 2 shows the EPA emission level standards for in use medium and heavy trucks engaged in interstate commerce. The FMCSA enforces these standards. State or local governments have regulatory authority over all other vehicles.

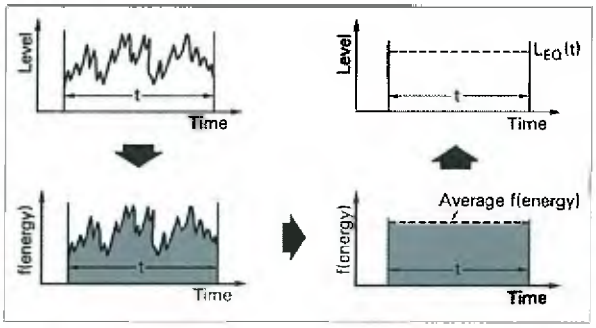
Table 2: Maximum Noise Emission Levels as Required by EPA for In Use Medium and Heavy Trucks with GVWR Over 10,000 Pounds Engaged in Interstate Commerce

Effective Date	Speed	Maximum Noise Level 50 Feet from Centerline of Travel
January 8, 1986	< 35 mph	83 dB(A)
	> 35 mph	87 dB(A)
	Stationary	85 dB(A)

abbreviated dB(A).

In addition to noise varying in frequency, noise intensity fluctuates with time. The most common descriptor of environmental noise in the United States of America is the equivalent (energy average) sound level. The equivalent sound level is the steady state, A-weighted sound level which contains the same amount of acoustic energy as the actual time varying, A-weighted sound level over a specified period of time (see Figure 1). If the time period is one hour, the descriptor is the hourly equivalent sound level, $L_{eq}(h)$, which is widely used by highway agencies as a descriptor of highway traffic noise. An additional descriptor, which is sometimes used, is the L_{10}. This is simply the A-weighted sound level that is exceeded 10 percent of the time.

Figure 1: Conceptualizing Equivalent Sound Level, LEQ



Decibel Addition

As mentioned above, decibels are logarithmic units and are not added arithmetically. Table 3 provides general procedures for decibel addition. This table shows that the sound pressure level from two equal sources is 3 dB greater than the sound pressure level of just one source. So, two trucks producing 90 dB each combine to produce 93 dB, not 180 dB. In other words, a doubling of the noise source produces only a 3 dB increase in the sound pressure level. Studies have shown that this increase is barely perceptible by the human ear.

Table 3: Rules for Combining Sound Levels by "Decibel Addition"

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 dB

*For noise levels known or desired to an accuracy or ±1 decibel (acceptable for traffic noise analyses)

Decibel Changes, Loudness, and Energy Loss

Most observers perceive an increase or decrease of 10 dB in the sound pressure level as doubling or halving of the sound. For example, 70 dB will sound twice as loud as 60 dB. Table 4 shows the relationship between decibel changes and the corresponding relative loudness, as well as the actual loss in energy that occurs with each change.

highway traffic noise. Any condition (such as a steep incline) that causes heavy laboring of motor vehicle engines will also increase highway traffic noise levels. Additionally, other, more complicated factors affect the loudness of highway traffic noise. For example, as a person moves away from a highway, distance, terrain, vegetation, and natural and manmade obstacles reduce highway traffic noise levels. Highway traffic noise is not usually a serious problem for people who live more than 500 feet from heavily traveled freeways or more than 100 to 200 feet from lightly traveled roads. In quiet settings, however, such as rural areas, people notice highway traffic noise over greater distances. Pavement type can also affect noise generated at the tire/pavement interface.

FHWA HIGHWAY TRAFFIC NOISE REGULATION

The following discussion will address those requirements and point out the most important issues related to the requirements. Each section of 23 CFR 772 follows with a discussion of that section. Some sections are self explanatory and need only a sentence or two of discussion. Other, more complicated sections will have greater discussion. The regulation specifies the requirements highway agencies must meet when using Federal-aid funds for highway projects.

772.1 Purpose

PURPOSE. To provide procedures for noise studies and noise abatement measures to help protect the public health, welfare and livability, to supply noise abatement criteria, and to establish requirements for information to be given to local officials for use in the planning and design of highways approved pursuant to Title 23, United States Code (U.S.C.).

Protection of the public health and welfare is an important responsibility that FHWA helps to accomplish during the planning and design of a highway project. The U.S. Congress has directed FHWA to develop noise standards with passage of the 1970 Federal-Aid Highway Act. Concerned citizens and States encouraged Congress to provide this protection.

772.3 Noise Standards

NOISE STANDARDS. The highway traffic noise prediction requirements, noise analyses, noise abatement criteria, and requirements for informing local officials 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 to be in conformance with the Federal Highway Administration (FHWA) noise standards.

This section makes 23 CFR 772 in its entirety the FHWA highway traffic noise standard. The standard is required by 23 U.S.C. 109(i). Some people mistake the highway traffic noise abatement criteria for the FHWA standard. Early on, FHWA did not want to be restricted to specific highway traffic noise levels that are unachievable in many highway projects. The standard developed by FHWA best serves the public in terms of protection and reasonable cost.

772.5 Definitions

Benefited Receptor. **The recipient of an abatement measure that receives a noise reduction at or above the minimum threshold of 5 dB(A), but not to exceed the highway agency's reasonableness design goal.**

Statement of Likelihood. **A statement provided in the environmental clearance document based on the feasibility and reasonableness analysis completed at the time the environmental document is being approved.**

Substantial Construction. **The granting of a building permit, prior to right-of-way acquisition or construction approval for the highway.**

Substantial noise increase. **One of two types of highway traffic noise impacts. For a Type I project, an increase in noise levels of 5 to 15 dB(A) in the design year over the existing noise level.**

Traffic Noise Impacts. **Design year build condition noise levels that approach or exceed the NAC listed in Table 1 for the future build condition; or design year build condition noise levels that create a substantial noise increase over existing noise levels.**

Type I Project.

(1) The construction of a highway on new location; or,

(2) The physical alteration of an existing highway where there is either:

(i) Substantial Horizontal Alteration. A project that halves the distance between the traffic noise source and the closest receptor between the existing condition to the future build condition; or,

(ii) Substantial Vertical Alteration. A project that removes shielding therefore exposing the line-of-sight between the receptor and the traffic noise source. This is done by either altering the vertical alignment of the highway or by altering the topography between the highway traffic noise source and the receptor; or,

(3) The addition of a through-traffic lane(s). This includes the addition of a through-traffic lane that functions as a HOV lane, High-Occupancy Toll (HOT) lane, bus lane, or truck climbing lane; or,

(4) The addition of an auxiliary lane, except for when the auxiliary lane is a turn lane; or,

(5) The addition or relocation of interchange lanes or ramps added to a quadrant to complete an existing partial interchange; or,

(6) Restriping existing pavement for the purpose of adding a through-traffic lane or an auxiliary lane; or,

(7) The addition of a new or substantial alteration of a weigh station, rest stop, ride-share lot or toll plaza.

(8) If a project is determined to be a Type I project per § 772.5 then the entire project area as defined in the environmental document is a Type I project.

Type II Project. **A Federal or Federal-aid highway project for noise abatement on an existing highway. For a Type II project to be eligible for Federal-aid funding, the highway agency must develop and implement a Type II program in accordance with section 772.7(e).**

Type III Project. **A Federal or Federal-aid highway project that does not meet the classifications of a Type I or Type II project. Type III projects do not require a noise analysis.**

The addition of an auxiliary lane is also a Type I project, unless the auxiliary lane is a turn lane. Highway agencies should take a broad approach to defining turn lanes when considering projects with auxiliary lanes. Generally, consideration for auxiliary lanes on local roads should be limited to those that could be used as a through lane (including bus or truck lanes) rather than lanes used for parking, speed change, turning or storage for turning weaving. For interstates, limit consideration to auxiliary lanes between two closely spaced interchanges to accommodate weaving traffic and auxiliary lanes carried through one or more interchanges.

The addition of bus or truck climbing lanes to existing highways can create significant changes in alignment and/or add through-traffic lanes, and is therefore classified as a Type I project.

The addition of a new through lane requires analysis on both sides of the highway whether the new lane(s) are all in one direction of travel or in both directions. New through lanes result in added capacity, more traffic and usually, more traffic noise.

Similarly, the addition of high-occupancy vehicle (HOV) lanes or high occupancy toll (HOT) lanes to highways are also Type I projects, whether added in the median or on the outside of the existing highway, since they add through-traffic lanes. Highway traffic noise analysis is required for both sides of the highway even HOV or HOT lanes added to one side of the highway. Frequently, HOV or HOT projects cause little or no change in the existing or future noise environment. However, highway traffic noise impacts may occur, since existing noise levels may already approach or exceed noise abatement criteria. In these instances, the highway agency must consider and implement abatement if feasible and reasonable.

New lanes also occur due to restriping projects. In this case, the pavement width may remain the same, but the project designates an additional traffic lane(s) by restriping the existing pavement.

No Change between Existing and Future Highway Traffic Noise Levels

A commonly held viewpoint is that a highway traffic noise analyses is not necessary for projects that do not change the noise environment - that is, no change in the noise levels from those that exist today or no change in the noise levels from those that will exist in the future if no project is implemented (e.g., 70 dB(A) existing and 70 dB(A) in the future, with or without the project). However, the FHWA highway traffic noise regulations were developed to specifically address the improvement of situations where existing highway traffic noise levels are already high (i.e., a highway traffic noise impact already exists). Thus, highway traffic noise analyses are required for all Type I projects, even when there is no change in the surrounding noise environment. A parallel occurs with highway projects that upgrade or improve substandard safety features even though the overall goal of the project is not specifically safety-related. A project with any Type I work is a Type I project, and a highway traffic noise analysis is required for the entire project, as defined in the project's environmental document.

Weigh Stations, Rest Stops and Toll Plazas

Expansion or new construction of weigh stations, rest stops and toll plazas require analysis as Type I projects. They require special attention and consideration for determining existing and future noise levels. These land uses include a mix of stationary and mobile sources. Noise analysts should develop a methodology in coordination with the highway agency noise coordinator to determine existing and future noise levels at these locations.

Type II Project Requirements

The FHWA highway traffic noise regulations limits funding participation of Type II highway traffic noise abatement measures for projects approved before November 28, 1995, or projects proposed along lands where land development or substantial construction predated the highway. In addition, FHWA will not approve highway traffic noise abatement measures at locations where such measures were previously determined not to be feasible and reasonable for a Type I project.

When considering abatement measures for Type II projects, the "date of the existence of development" along the highway is often mixed. Some development will predate the existence of any highway and some development will have occurred after the original highway was constructed. If a highway agency elects to implement Type II projects, the highway agency and the FHWA Division Office should jointly establish appropriate procedures to determine ways to address locations with different dates of development.

Type II projects that utilize Federal funding in whole or part must satisfy 23 CFR 772 and NEPA requirements. Normally, a Type II project will qualify as a Categorical Exclusion, unless other environmental impacts are identified that require additional investigation. Despite the level of documentation, a Type II project requires the same level of analyses and documentation as is required for a Type I project.

Developing a Type II Program

The highway traffic noise regulation provides highway agencies with considerable flexibility for designing their own Type II highway traffic noise abatement program, including the very important task of individual project prioritization. The regulation requires that the overall highway traffic noise abatement benefits outweigh the overall adverse social, economic, and environmental (SEE) effects and the costs of the highway traffic noise abatement measures. This determination relies on good judgment by highway agencies, rather than prescriptive Federal procedures since the individual States are in the best position to make these determinations on a local basis.

These procedures consider factors related to the land development. Factors to consider include:

1. The amount of development that predates the existence of any highway;
2. The amount of development that occurred after the construction of a highway but prior to the existence of Federal requirements related to highway traffic noise; and
3. The amount of development that predates a major change in the character of a highway, e.g., the highway has changed from a low-speed, local street to a high-speed freeway. The highway agency should utilize the "date of the existence of development" procedures when approving abatement measures for Type II projects. Federal could prorate participation in proportion to the amount of pre-existing development.

A highway agency voluntarily requesting Federal-aid participation for eligible Type II projects is required to perform a highway traffic noise analysis of sufficient scope to:

1. Identify that a highway traffic noise impact exists,
2. Demonstrate that the proposed highway traffic noise abatement measures will reduce the highway traffic noise impact, and

16. Local noise ordinances,
17. Feasibility of abating the highway traffic noise with traffic control measures.

These factors are not in any order, but indicate that highway agencies should base implementation of a Type II program upon a wide range of varying considerations.

Please see Appendix E for Type II program examples.

Type III Projects

Type III projects describe any project that does not fulfill the criteria of a Type I or Type II project. Generally, the list of projects described in 23 CFR 771.117(c) and (d) comprise the list of Type III projects, with some exceptions; as discussed below, where the project clearly meets the definition of a Type I or Type II project.

771.117(c)(6) The installation of noise barriers or alterations to existing publicly owned buildings to provide for noise reduction.

771.117(c)(12) Improvements to existing rest areas and truck weigh stations.

Improvements to existing rest areas and truck weigh stations that involve increased capacity for overnight parking, relocation of parking facilities closer to noise sensitive land uses or other changes in the configuration of the facility that would meet the description of a Type I project.

771.117(c)(13) Ridesharing activities

Construction or expansion of an existing ride-share lot and access roads to a ride-share lot are a Type I project.

771.117 (d)(1) Modernization of a highway by resurfacing, restoration, rehabilitation, reconstruction, adding shoulders, or adding auxiliary lanes (e.g., parking, weaving, turning, climbing).

Construction of auxiliary lanes other than turn lanes are a Type I project per the definition of a Type I project provided in 772.5.

771.117 (d)(3) Bridge rehabilitation, reconstruction or replacement or the construction of grade separation to replace existing at-grade railroad crossings.

Construction of a grade separation to replace existing at-grade railroad crossings is a Type I project because it results in either a new highway on new alignment or a significant change in the vertical alignment of an existing highway. In some cases, the grade separation project results in an overall benefit to the noise environment due to reduced requirements to sound train horns at grade separated crossings. Highway agencies may consider this benefit in the noise analysis. Bridge replacements may result in a Type I project if the bridge is realigned or is substantially different from the existing bridge.

771.117 (d)(5) Construction of new truck weigh stations or rest areas.

Construction of new truck weigh stations or rest areas is a Type I project per the definition of a Type I project provided in 772.5.

Sometimes, unusual projects fall outside the standard definition of a Type I project. Generally, if a project results in a new noise source, the highway agency should consider a noise analysis for the project. The regulation does not preclude highway agencies from performing a noise analysis for a project that does not strictly meet the Type I or Type II criteria, but may result in a new noise source.

guidance documents. In this case, both documents require FHWA approval following the above process.

772.9 Traffic Noise Prediction.

(a) Any analysis required by this subpart must use the FHWA Traffic Noise Model (TNM), which is described in "FHWA Traffic Noise Model" Report No. FHWA–PD–96–010, including Revision No. 1, dated April 14, 2004, or any other model determined by the FHWA to be consistent with the methodology of the FHWA TNM. These publications are incorporated by reference in accordance with section 552(a) of title 5, U.S.C. and part 51 of title 1, CFR, and are on file at the National Archives and Record Administration (NARA). For information on the availability of this material at NARA, call (202) 741–6030 or go to http://www.archives.gov/federal_register/code_of_federal_regulations/ibr_locations.html. These documents are available for copying and inspection at the Federal Highway Administration, 1200 New Jersey Avenue, SE, Washington, DC 20590, as provided in part 7 of title 49, CFR. These documents are also available on the FHWA's Traffic Noise Model Web site at the following URL: http://www.fhwa.dot.gov/environment/noise/index.htm.

(b) Average pavement type shall be used in the FHWA TNM for future noise level prediction unless a highway agency substantiates the use of a different pavement type for approval by the FHWA.

(c) Noise contour lines may be used for project alternative screening or for land use planning to comply with § 772.17, but shall not be used for determining highway traffic noise impacts.

(d) In predicting noise levels and assessing noise impacts, traffic characteristics that would yield the worst traffic noise impact for the design year shall be used.

FHWA Traffic Noise Model (FHWA TNM)

The FHWA TNM, version 2.5 (or the latest version), is required for use in all highway traffic noise analyses for Federal-aid highway projects that begin on or after May 2, 2005. The FHWA will update 23 CFR 772 as necessary to accommodate new or updated releases of the FHWA TNM. For additional information regarding the FHWA TNM, please go to http://www.fhwa.dot.gov/environment/noise/tnm/index.htm.

Average Pavement

Highway agencies must use TNM average pavement when analyzing future conditions unless there is an agreement with FHWA to use a different pavement type. States may propose use of a different pavement type for approval by coordinating with FHWA. The highway agency must demonstrate that a current TNM pavement is an acoustic match for a pavement used by the State, or provide sufficient data to FHWA to incorporate a specific pavement within the TNM.

Noise Contours

Noise contour lines are useful for screening and to provide information to local officials (772.17); however, some caution is necessary when using noise contour lines. Noise analysts usually develop the noise contours using the Noise Contour function of the FHWA TNM, or by modeling discrete receiver points and extrapolating between them. Either method can result in an inaccurate portrayal of the noise environment. When using the Noise Contour function, users must ensure the grid spacing provides a sufficient resolution to provide good results and when using discrete receivers, the user must ensure the

Category A designation.

(ii) Activity Category B. This activity category includes the exterior impact criteria for single-family and multifamily residences.

(iii) Activity Category C. This activity category includes the exterior impact criteria for a variety of land use facilities. Each highway agency shall adopt a standard practice for analyzing these land use facilities that is consistent and uniformly applied statewide.

(iv) Activity Category D. This activity category includes the interior impact criteria for certain land use facilities listed in Activity Category C that may have interior uses. A highway agency shall conduct an indoor analysis after a determination is made that exterior abatement measures will not be feasible and reasonable. An indoor analysis shall only be done after exhausting all outdoor analysis options. In situations where no exterior activities are to be affected by the traffic noise, or where the exterior activities are far from or physically shielded from the roadway in a manner that prevents an impact on exterior activities, the highway agency shall use Activity Category D as the basis of determining noise impacts. Each highway agency shall adopt a standard practice for analyzing these land use facilities that is consistent and uniformly applied statewide.

(v) Activity Category E. This activity category includes the exterior impact criteria for developed lands that are less sensitive to highway noise. Each highway agency shall adopt a standard practice for analyzing these land use facilities that is consistent and uniformly applied statewide.

(vi) Activity Category F. This activity category includes developed lands that are not sensitive to highway traffic noise. There is no impact criteria for the land use facilities in this activity category and no analysis of noise impacts is required.

(vii) Activity Category G. This activity includes undeveloped lands.

(A) A highway agency shall determine if undeveloped land is permitted for development. The milestone and its associated date for acknowledging when undeveloped land is considered permitted shall be the date of issuance of a building permit by the local jurisdiction or by the appropriate governing entity.

(B) If undeveloped land is determined to be perrmitted, then the highway agency shall assign the land to the appropriate Activity Category and analyze it in the same manner as developed lands in that Activity Category.

(C) If undeveloped land is not permitted for development by the date of public knowledge, the highway agency shall determine noise levels in accordance with 772.17(a) and document the results in the project's environmental clearance documents and noise analysis documents. Federal participation in noise abatement measures will not be considered for lands that are not permitted by the date of public knowledge.

(d) The analysis of traffic noise impacts shall include:

Impact Determination

These sound levels are to determine impacts. These are the absolute levels requiring consideration for abatement for all Activity Categories except Category F. Design highway traffic noise abatement to meet or exceed the highway agency's reasonable design goal - not to attain the noise abatement criteria.

Highway traffic noise impacts can occur below the NAC. The NAC are not the Federal standards or desirable noise levels; they are not design goals for noise barrier construction. 23 CFR 772 as a whole constitutes the standards mandated by the Federal-Aid Highway Act of 1970. Highway agencies should design traffic noise abatement to achieve the reasonableness design goal as defined in their noise policy. The NAC are absolute values which, when approached or exceeded, require the consideration of highway traffic noise abatement measures. State highway agencies may not establish minimum thresholds for consideration of noise abatement. The highway agency must consider noise abatement for projects predicted to result in highway traffic noise impacts.

A highway traffic noise impact can occur even if predicted future highway traffic noise levels are lower than existing levels, as long as the predicted future levels approach or exceed the NAC.

Substantial Increase

The 23 CFR 772 purposefully provides the highway agencies with flexibility to establish their own definition of "substantial increase." A 5dB(A) increase is a discernible increase in noise levels and a 10 dB(A) increase in noise levels is a doubling of the perceived loudness while a 15 dB(A) increase in noise levels represents more than a doubling of the loudness. Factors such as available resources, the public's attitudes toward highway traffic noise, and the absolute noise levels may influence a State's definition. Highway agencies may define a "substantial increase" to be a 5 dB(A) to 15 dB(A) increase in noise levels. A "substantial increase" may occur at any absolute noise level, i.e., there is a not a threshold below which a "substantial increase" does not occur. The FHWA will accept a uniformly and consistently applied well reasoned definition. The highway agency must define substantial increase in the State highway traffic noise policy.

Substantial increase impacts occur due to the increase in noise level and are independent of an absolute noise level. For example, a State's substantial increase criterion is 15 dBA. If the existing noise level at a receptor is 30 dBA and the design year build noise level is 45 dBA, then the receptor is impacted. There is no minimum threshold for substantial increase impacts.

In documenting any substantial increase in highway traffic noise levels in the environmental documentation for a project, take care to avoid the use of the phrase "significant increase." FHWA Technical Advisory 6640.8A discourages the use of the word "significant" in FHWA documents because it is seldom meaningful in and of itself. (http://environment.fhwa.dot.gov/projdev/impTA6640.asp) If it is used, it should be used in a manner consistent with the Council on Environmental Quality definition at 40 CFR 1508.27. Always use the phrase "substantial increase" to address this type of potential highway traffic noise impact.

Noise Abatement Criteria (NAC)

The use of subjective descriptors to describe highway traffic noise impacts is not required. Highway traffic noise impacts occur based upon the definition contained in 23 CFR 772. This definition does not contain subjective descriptors. If there are impacts, the highway agency must consider highway traffic noise abatement measures and implement them if found to be feasible and reasonable. Traffic noise

				areas, places of worship, playgrounds, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, recreation areas, Section 4(f) sites, schools, television studios, trails, and trail crossings
D	52	55	Interior	Auditoriums, day care centers, hospitals, libraries, medical facilities, places of worship, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, schools, and television studios
E\3\	72	75	Exterior	Hotels, motels, offices, restaurants/bars, and other developed lands, properties or activities not included in A-D or F.
F	--	--	--	Agriculture, airports, bus yards, emergency services, industrial, logging, maintenance facilities, manufacturing, mining, rail yards, retail facilities, shipyards, utilities (water resources, water treatment, electrical), and warehousing
G	--	--	--	Undeveloped lands that are not permitted

\1\ Either Leq(h) or L10(h) (but not both) may be used on a project.

\2\ The Leq(h) and L10(h) Activity Criteria values are for impact determination only, and are not design standards for noise abatement measures.

\3\ Includes undeveloped lands permitted for this activity category

Activity Category A

Activity Category A includes 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. Some examples of lands that have been analyzed as Activity Category A receivers include the Tomb of the Unknown Soldier, a monastery, an outdoor prayer area of a facility for nuns, and an amphitheater. The FHWA must approve a land use as Activity Category A before a noise analysis on an Activity Category A is initiated.

Activity Category A land uses are analyzed at this stricter standard even if the land use is identified within an activity category with a higher NAC.

Activity Category B

Activity Category B includes exterior criteria for residential land use. This includes single family (including mobile home parks) and multi-family residences.

When analyzing areas with multi-family dwelling units, the analyst must identify all dwelling units predicted to experience highway traffic noise impacts. This may include units above the ground level. Consider abatement for all identified highway traffic noise impacts and implement abatement that is feasible and reasonable. Multi-family dwelling units often have associated common areas for recreational or other use. The highway agency should develop a method to evaluate the number of

not feasible or reasonable.

Activity Category E
Activity Category E is the exterior criteria for, motels, hotels, offices and other developed lands not included in A-D or F. When determining the number or receivers for Activity Category E land uses, the highway agency should make this determination in the same manner that the number or receivers were determined for multi-family residences. Example: If the number of receptors for an apartment complex was determined by taking the total number of units in the building or if the determination involved the capacity limit for the pool or outdoor use area, then this philosophy should be applied to Activity Category E land uses as well.

Hotels and motels may cause some confusion when determining the appropriate land use category since all or part of some hotels and motels function as apartment buildings. The FHWA encourages highway agencies to carefully consider the context and use of hotels and motels when identifying the appropriate land use category.

Activity Category F
Activity Category F includes a number of land uses that are not sensitive to noise. No noise analysis is required for these locations.

Activity Category G
Activity Category G includes undeveloped lands. Although consideration of mitigation is not required under 23 CFR 772, the highway agency must determine and document highway traffic noise levels and provide this information to local officials. The minimum information to provide is the distance to the impact threshold of each land use category. By providing local government with the best estimate of future noise levels, the highway agency may place responsibility for noise abatement on local government and/or property owner.

A highway agency proposing to use Federal-aid highway funds for a Type II project shall perform a noise analysis in accordance with §772.11 in order to provide information needed to make the determination required by §772.13(a).

Section 772.11(d) lists the minimum requirements needed to evaluate impacts and abatement for each alternative under detailed study for the proposed highway project. The analysis should present the highway traffic noise impacts and evaluation of alternative abatement measures in a comparative format. This approach clearly identifies the potential highway traffic noise impacts and likely abatement measures associated with the various alternatives.

Section 772.11(d)(1) requires the identification of existing activities and developed lands. This identification includes not only the type (e.g., residential, commercial), but also the number or extent of activities. Some analysts overlook this quantification. Quantification of existing activities is vital to address the extent of the highway traffic noise impact on the people living near the highway project. This quantification is also important to determine the number of receptors that benefit from a proposed highway traffic noise abatement measure.

Light Frame	Ordinary Sash (closed)	20 dB
	Storm Windows	25 dB
Masonry	Single Glazed	25 dB
	Double Glazed	35 dB
*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.		

FHWA publication *FHWA-DP-45-1R, Sound Procedures for Measuring Highway Noise: Final Report* provides procedures to measure building noise reductions.

Study Area

Section 772.11(d)(4) requires the highway agency to identify all receptors impacted by a project. This approach to determining the study area provides flexibility and avoids establishing an arbitrary distance for study that may not be appropriate in all cases. Use of the model is the easiest way to determine the extent of impacts from a specific highway.

Existing Highway Traffic Noise Measurements

Existing highway traffic noise measurements are made to represent an hourly equivalent sound level, $L_{eq}(h)$. Statistical accuracy requires minimum measurements of approximately eight minutes. Most highway agencies have automated measurement equipment and typically measure 15-minute time periods to represent the $L_{eq}(h)$. This is acceptable if unusual events do not occur during the noisiest hour. Measurements along low-volume highways may require longer measurement periods (e.g., 30-60 minutes) to attain desirable statistical accuracy. If information is not available to identify the noisiest hour of the day or if there is public controversy at a specific location, 24-hour measurements may be necessary.

Use noise meters with sufficient accuracy to yield valid data for the particular project (ANSI S1.4-1983, TYPE II or better). Adopt and follow procedures to ensure measurements have consistent and supportable validity. Note traffic conditions, climatic conditions, and land uses at the time of measurement.

Model Validation

23 CFR 772.11(d)(2) requires validation to verify the accuracy of noise model runs used to predict existing noise levels for the project (This has nothing to do with validation of the FHWA TNM model, which accomplished in the TNM Validation Study).The model is validated if existing highway traffic noise levels and predicted highway traffic noise levels for the existing condition are within +/-3 dB(A).

Validation of the model requires a series of noise measurements along a project, preferably taking noise measurements within each noise sensitive area (NSA) or neighborhood along with simultaneous traffic counts and determination of vehicle speeds. In certain situations, consider multiple measurements at each location at different times and different days to account for variations in traffic. Measurements should be performed in accordance with the methodology presented in *Measurement of Highway Related Noise* FHWA-PD-96-046. Model the sites using traffic volumes and speeds collected during the measurement. If the measured and predicted highway traffic noise levels are within +/3 dB(A) for measurements taken at an NSA, then the model is considered valid and can be used to predict existing

Table 5 lists the highway traffic NAC from 23 CFR 772. Each State defines a substantial noise increase in its highway traffic noise policy based on the parameters provided in 23 CFR 772.11(f). Highway agencies must consider abatement when the noise analysis identifies future highway traffic noise impacts. Highway traffic noise analyses should recognize and consider absolute noise levels as well as substantial increases in noise levels when identifying highway traffic noise impacts and when considering highway traffic noise abatement measures.

Please see Appendix B for additional information on noise analysis documentation.

772.13 Analysis of Noise Abatement

(a) When traffic noise impacts are identified, noise abatement shall be considered and evaluated for feasibility and reasonableness. The highway agency shall determine and analyze alternative noise abatement measures to abate identified impacts by giving weight to the benefits and costs of abatement and the overall social, economic, and environmental effects by using feasible and reasonable noise abatement measures for decision-making.

(b) In abating traffic noise impacts, a highway agency shall give primary consideration to exterior areas where frequent human use occurs.

(c) If a noise impact is identified, a highway agency shall consider abatement measures. The abatement measures listed in §772.15(c) of this chapter are eligible for Federal funding.

> **(1) At a minimum, the highway agency shall consider noise abatement in the form of a noise barrier.**
>
> **(2) If a highway agency chooses to use absorptive treatments as a functional enhancement, the highway agency shall adopt a standard practice for using absorptive treatment that is consistent and uniformly applied statewide.**

(d) Examination and evaluation of feasible and reasonable noise abatement measures for reducing the traffic noise impacts. Each highway agency, with FHWA approval, shall develop feasibility and reasonableness factors.

> **(1) Feasibility:**
>
> > **(i) Achievement of at least a 5 dB(A) highway traffic noise reduction at impacted receptors. The highway agency shall define, and receive FHWA approval for, the number of receptors that must achieve this reduction for the noise abatement measure to be acoustically feasible and explain the basis for this determination; and**
> >
> > **(ii) Determination that it is possible to design and construct the noise abatement measure. Factors to consider are safety, barrier height, topography, drainage, utilities, and maintenance of the abatement measure, maintenance access to adjacent properties, and access to adjacent properties (i.e. arterial widening projects).**
>
> **(2) Reasonableness:**
>
> > **(i) Consideration of the viewpoints of the property owners and residents of the benefited receptors. The highway agency shall solicit the viewpoints of all of the**

(transparent, opaque, other); features (absorptive, reflective, surface texture); foundation (ground mounted, on structure); project type (Type I, Type II, and optional project types such as State funded, county funded, tollway/turnpike funded, other, unknown). The FHWA will collect this information, in accordance with OMB's Information Collection requirements.

(g) Before adoption of a CE, FONSI, or ROD, the highway agency shall identify:

(1) Noise abatement measures which are feasible and reasonable, and which are likely to be incorporated in the project; and

(2) Noise impacts for which no noise abatement measures are feasible and reasonable.

(3) Documentation of highway traffic noise abatement: The environmental document shall identify locations where noise impacts are predicted to occur, where noise abatement is feasible and reasonable, and locations with impacts that have no feasible or reasonable noise abatement alternative. For environmental clearance, this analysis shall be completed to the extent that design information on the alterative(s) under study in the environmental document is available at the time the environmental clearance document is completed. A statement of likelihood shall be included in the environmental document since feasibility and reasonableness determinations may change due to changes in project design after approval of the environmental document. The statement of likelihood shall include the preliminary location and physical description of noise abatement measures determined feasible and reasonable in the preliminary analysis. The statement of likelihood shall also indicate that final recommendations on the construction of an abatement measure(s) is determined during the completion of the project's final design and the public involvement processes.

(h) The FHWA will not approve project plans and specifications unless feasible and reasonable noise abatement measures are incorporated into the plans and specifications to reduce the noise impact on existing activities, developed lands, or undeveloped lands for which development is permitted.

(i) For design-build projects, the preliminary technical noise study shall document all considered and proposed noise abatement measures for inclusion in the NEPA document. Final design of design-build noise abatement measures shall be based on the preliminary noise abatement design developed in the technical noise analysis. Noise abatement measures shall be considered, developed, and constructed in accordance with this standard and in conformance with the provisions of 40 CFR 1506.5(c) and 23 CFR 636.109.

(j) Third party funding is not allowed on a Federal or Federal-aid Type I or Type II project if the noise abatement measure would require the additional funding from the third party to be considered feasible and/or reasonable. Third party funding is acceptable on a Federal or Federal-aid highway Type I or Type II project to make functional enhancements, such as absorptive treatment and access doors or aesthetic enhancements, to a noise abatement measure already determined feasible and reasonable.

(k) On a Type I or Type II projects, a highway agency has the option to cost average noise abatement among benefited receptors within common noise environments if no single common noise environment exceeds two times the highway agency's cost reasonableness criteria and

1. Description of the measure
2. Anticipated costs, problems, and disadvantages
3. Predicted design year noise reduction compared to existing levels and other factors deemed necessary to report.

Section 13 ties the highway traffic noise regulation to the NEPA requirements. The choice of the word "likely" was deliberate. If a decision maker is to make an informed decision and make the public aware of the impacts, the State must make its intentions known. If the State later decides abatement is unwarranted, the decision should have strong support. Sates should qualify the meaning of "likely," to avoid confusion when noise abatement is determined unwarranted. When a project involves consideration of more than one barrier, the State should include a statement of "likelihood" for each barrier in the environmental document. Example Statement of Likelihood

Based on the studies thus far accomplished, the State intends to install highway traffic noise abatement measures in the form of a barrier at _____. These preliminary indications of likely abatement measures are based upon preliminary design for a barrier cost of $_____ that will reduce the noise level by ___ dB(A) for ___ residences. If it subsequently develops during final design that these conditions have substantially changed, the abatement measures might not be provided. A final decision regarding installation of the abatement measure(s) will be made upon completion of the project's final design and the public involvement processes.

The viewpoints of the impacted residents and property owners should be a major consideration in determining the reasonableness of highway traffic noise abatement measures for proposed highway construction projects. These viewpoints should be determined and addressed during the environmental phase of project development. The will and desires of the public should be an important factor in dealing with the overall problems of highway traffic noise. Highway agencies should incorporate highway traffic noise consideration in their on-going activities for public involvement in the highway program, i.e., and reexamine the residents' views on the desirability and acceptability of abatement periodically during project development.

The key words in the statement of likelihood are feasible and reasonable. Feasibility deals primarily with engineering considerations (e.g., can a barrier be built given the topography of the location; can a substantial noise reduction be achieved given certain access, drainage, safety, or maintenance requirements; are other predominating noise sources present in the area, etc.). Reasonableness is a more subjective criterion than feasibility. It implies that the highway agency applied common sense and good judgment in arriving at a decision. Reasonableness should be based on a number of factors -- not just one criterion. For a detailed explanation of feasibility and reasonableness of abatement, see the discussions in Section IV: Highway Traffic Noise Analysis and Documentation.

Determining Feasible and Reasonable Highway Traffic Noise Abatement

Feasibility deals primarily with engineering considerations (e.g., can a barrier be built given the topography of the location; can a substantial noise reduction be achieved given certain access, drainage, safety, or maintenance requirements; are other noise sources present in the area, etc.). Address safety, maintenance, and drainage concerns for highway traffic noise abatement measures during preliminary and final project design. These issues should be part of the feasibility determination and can usually be resolved through use of good design practices.

that must be considered. Each highway agency is required to incorporate a cost index in their highway traffic noise policy. Most highway agencies typically determine reasonable cost by using either a cost/receiver or cost/receiver/dB(A) reduction index. Recently, some States started using a maximum square footage per benefitted residence.

Some highway agencies may choose to implement a tiered approach to cost reasonableness based on regional cost differences within the State. This approach conforms to the regulation. However, the ratio of the unit cost of abatement and the reasonable cost per residence must remain the same statewide.

Example of Regional Cost Differences

In one part of a State, the unit cost for noise barrier construction is $15 per square foot and the allowable cost per benefitting residence is $20,000. In another part of the State with higher construction and materials cost, the unit cost for noise barrier construction is $30 per square foot. The allowable cost per benefiting residence in the more expensive location is $40,000 since the unit cost in the more expensive are is double the unit cost in other areas of the State.

Highway agencies must ensure that the reasonable cost of abatement is justified based on actual construction costs and clearly communicate all reasonableness criteria to the public.

Appendix F provides information on using construction costs to help determine the reasonable cost of abatement.

Noise Reduction Design Goal

The objective of noise abatement is not to reduce predicted noise levels to the noise abatement criteria. The goal of noise abatement is to provide a substantial reduction in noise level as defined by the design goal. A predicted noise level of 69 dB(A) for a Category B activity (see Table 5) should not be reduced to the noise abatement criterion of 67 dB(A). 23 CFR 772.13(d)(2)(iii) introduces the requirement for highway agencies to identify a design goal of at 7-10 dBA to encourage design and construction of effective noise abatement measures. The highway agency will establish the design goal within their noise policy. The noise abatement measure must meet or exceed the highway agency design goal to achieve this reasonableness criterion. Choosing a decibel reduction between 7 and 10 defines the design goal, however; actual noise reductions can exceed the design goal.

Determining Receptors

Receivers are discrete points within a noise model that represent noise sensitive land uses. An individual receiver may represent multiple receptors. The highway agency highway traffic noise policy should clearly delineate the method used to count receptors in the noise analysis. The number of receptors should include all dwelling units, e.g., owner-occupied, rental units, mobile homes, etc. Count each unit in a multifamily building as one receptor. The highway agency highway traffic noise policy must also delineate how receptor units are determined for special land uses, such as parks, recreation areas, cemeteries, etc.

Optional Reasonabless Factors

In addition to the required reasonableness factors listed in §§772.13(d)(2)(i), (ii) and (iii), a highway agency has the option to also include the following reasonableness factors: date of development, length of time receivers have been exposed to highway traffic noise impacts, exposure to higher absolute highway traffic noise levels, changes between existing and future build conditions, percentage of mixed zoning development, and use of noise compatible planning concepts by the local government. Since the

Mixed Zoning Development
It is acceptable to give less consideration for abatement to areas of mixed zoning or development and to areas where existing local plans call for zoning changes to a less noise sensitive use.

Noise Compatible Planning
It is acceptable to give added weight to areas that demonstrate implementation of efforts to prevent incompatible growth and development along highways.

Abatement Measure Reporting
The requirements of 772.13(f) replace the triennial noise abatement inventory. Information collected is largely the same, but the language in the regulation allows for reporting of abatement measures other than noise barriers. The New York and Ohio Departments of Transportation developed noise barrier inventory management systems to accommodate the reporting requirements and to assist with identifying noise barrier maintenance needs. FHWA recommends that highway agencies develop protocols for the collection and reporting of this information to ensure they provide accurate and useable data.

Third Party Participation
To comply with environmental justice requirements, when a noise barrier's cost is higher than the highway agency's cost allowance, it is not acceptable to allow a third party to contribute funds to make up the difference. A third party may contribute funds to make functional or aesthetic enhancements to a noise barrier already determined to be feasible and reasonable.

A highway agency may consider local participation for Type II projects if the noise abatement measure is feasible and reasonable without consideration for the local participation amount. For example, a state highway agency may require a local match of 20% of the cost of the Type II project. This amount may go toward paying for the project, but not to offset costs of abatement that exceed the cost reasonableness criterion in the state noise policy. The feasibility and reasonableness determination is performed independently of the local contribution.

772.15 Federal Participation
(a) Type I and Type II projects. Federal funds may be used for noise abatement measures when:

(1) Traffic noise impacts have been identified; and

(2) Abatement measures have been determined to be feasible and reasonable pursuant to §772.13(d) of this chapter.

(b) For Type II projects.

(1) No funds made available out of the Highway Trust Fund may be used to construct Type II noise barriers, as defined by this regulation, if such noise barriers were not part of a project approved by the FHWA before the November 28, 1995.

(2) Federal funds are available for Type II noise barriers along lands that were developed or were under substantial construction before approval of the acquisition of the rights-of-ways for, or construction of, the existing highway.

(3) FHWA will not approve noise abatement measures for locations where such measures were previously determined not to be feasible and reasonable for a Type I project.

Funding

The participating share for the highway traffic noise mitigation measure is the same as that for the system on which the project is located. Although most highway traffic noise abatement occurs along Interstate highways, highway agencyies may use Federal funds for abatement measures along other types of highways, if highway traffic noise impacts exist and the project meets the criteria in 772.15(a).

Property owners cannot receive Federal funds as monetary compensation in lieu of noise abatement. It is the highway agency's responsibility to ensure that Federal funds are properly used.

Appendix C provides additional information about eligible abatement measures.

772.17 Information for local officials

(a) To minimize future traffic noise impacts on currently undeveloped lands of Type I projects, a highway agency shall inform local officials within whose jurisdiction the highway project is located of:

> **(1) Noise compatible planning concepts;**
>
> **(2) The best estimation of the future design year noise levels at various distances from the edge of the nearest travel lane of the highway improvement where the future noise levels meet the highway agency's definition of "approach" for undeveloped lands or properties within the project limits. At a minimum, identify the distance to the exterior noise abatement criteria in Table 1;**
>
> **(3) Non-eligibility for Federal-aid participation for a Type II project as described in §772.15(b).**

(b) If a highway agency chooses to participate in a Type II noise program or to use the date of development as one of the factors in determining the reasonableness of a Type I noise abatement measure, the highway agency shall have a statewide outreach program to inform local officials and the public of the items in §772.17(a)(1)- (3).

Noise Compatible Planning

Highway traffic noise is a program of shared responsibility. The FHWA encourages State and local governments to practice noise compatible land planning and control near highways. Local governments may use their power to regulate land development to prohibit noise-sensitive land uses adjacent to a highway, or require developers to plan, design, and construct projects that minimize highway traffic noise impacts on adjacent developments.

The prevention of future impacts is one of the most important parts of highway traffic noise control. New development and highways can be compatible. But, local government officials need to know what highway traffic noise levels to expect from a highway and what techniques they can use to prevent future impacts. Highway agencies can inform local officials by including a table of future noise levels at specific locations or a figure of distances to typical noise levels along the roadway. Encourage local officials to make this such information available for disclosure in real estate transactions. Make local officials aware of the eligibility requirements for Federal-aid participation in Type II projects.

effects and costs of the abatement measures.

(c) Incorporate the needed abatement measures in the plans and specifications.

The impact of construction noise does not appear to be serious in most instances. Consider the following items to ensure adequate consideration of potential construction noise impacts during highway project development:

Construction Noise Analysis

Calculation of construction noise levels is usually not necessary for highway traffic noise analyses. The decision to develop a detail construction noise analysis usually results from combination of factors including the scale and scope of the project along with public concern about construction noise. In some cases, the decision to complete a construction noise analysis may occur after construction begins resulting from public complaints. It is best to anticipate public concerns so the project plans, specification and estimates include consideration for construction noise abatement where necessary.

Roadway Construction Noise Model

If the highway agency anticipates a construction noise impact at a particular sensitive receiver, they have the option to use the FHWA Roadway Construction Noise Model (FHWA RCNM). This model uses the database for the construction noise prediction spreadsheet developed for the Central Artery/Tunnel Project in Boston, Massachusetts (CA/T Project). The CA/T Project is the largest urban construction project ever conducted in the United States and has the most comprehensive noise control specification ever developed in the United States. RCNM incorporates the CA/T Project's noise limit criteria and extensive construction equipment noise database that allows the user to modify parameters to their needs. Users can activate and analyze multiple pieces of equipment simultaneously and define multiple receptor locations including land-use type and baseline noise levels. The FHWA RCNM calculates sound level results for multiple metrics.

The FHWA RCNM has two main uses:

1. To easily predict noise emission from construction equipment;
2. To determine a construction work plan's compliance with noise limits.

Users may quickly create a variety of construction work scenarios and determine the impact of changing construction equipment and adding/removing the effects of shielding due to noise mitigation devices such as barriers. The user provides receptor information (description, land use and baseline sound levels) and equipment information (by choosing from the default list or adding new equipment). Find additional information regarding the FHWA RCNM at http://www.trafficnoisemodel.org/main.html.

Construction Noise Impacts

For the majority of highway projects, highway agencies may address potential impacts of highway construction noise in a general manner in the noise analysis; noting the temporary nature of the impacts. The analysis should indicate the anticipated types of construction and noise levels associated with these activities from information available in existing literature and present this information in the noise analysis.

Construction Noise Abatement Measures

Highway traffic noise analyses should identify measures to mitigate potential highway construction noise impacts using a common-sense approach. Highway agencies may incorporate low-cost, easy-to-

Appendix A: HIGHWAY TRAFFIC NOISE ANALYSIS PROCESS

There is no one size fits all approach to the level of analysis necessary for various levels of environmental documents. One project may result in significant impacts on the natural environment, have no noise impacts and require an EIS, while another project processed as a CE may not have any significant impacts, but has numerous noise impacts. Various approaches to NEPA among States with programmatic agreements with the FHWA may also result in similar projects processed as different environmental documents in different States. The information below is a general guide to the level of documentation needed, but State approaches may vary.

Highway Traffic Noise Analysis

The level of detail and effort for the highway traffic noise analysis required for each alternative of a proposed project should be commensurate with the type of project and the impacts and/or issues with which it is associated. 23 CFR 772.11 and .13 provide the general content of a highway traffic noise analysis.

The major objectives of a highway traffic noise study for new highway construction or a highway improvement are:

1. To identify areas of potential highway traffic noise impact for each study alternative;
2. To determine existing noise levels;
3. To predict future noise levels and identify impacts;
4. To evaluate abatement measures for these impacts
5. To compare the various study alternatives based on predicted highway traffic noise impacts and the associated social, economic and environmental effects of abatement.

Highway traffic noise studies provide information primarily to government decision makers and the lay public. For the government decision maker, the study should provide a portion of the data needed for the informed selection of a satisfactory project alternative and appropriate abatement measures. For the lay public, the study should provide discussion of potential impacts in any areas of concern to the public.

Identifying Activity Categories and Applicable NAC of Adjacent Land Uses

The first step in the highway traffic noise study is to determine the activity category and applicable NAC for all land uses adjacent to each project alternative. Select representative locations for all activity categories to determine existing and future noise levels.

Determine status of undeveloped lands. Consider permitted land as developed for the purposes of the noise analysis. Assign the appropriate activity category to the permitted land and assess highway traffic noise impacts accordingly.

Determination of Existing Highway Traffic Noise Levels

Establish existing highway traffic noise levels by field measurements for all developed and permitted land uses and activities. Field measurements are preferred because existing noise levels are usually a composite of environmental noise sources and highway traffic noise prediction models are applicable only to noise originating from a specific source. If it is clear that existing noise levels at locations of interest are predominantly due to a highway, calculate existing noise levels using the FHWA Traffic

highway agency's noise policy, environmental documents and noise analysis documents.

Identification and Consideration of Highway Traffic Noise Abatement

The next step in the highway traffic noise analysis is comparison of the various study alternatives based on predicted highway traffic noise impacts and the associated social, economic and environmental effects of abatement.

It is FHWA's policy to ensure that projects incorporate all feasible and reasonable abatement measures to minimize highway traffic noise impacts to the extent practicable. Highway agencies must fulfill this commitment to minimize highway traffic noise impacts through prudent application of FHWA's highway traffic noise regulation and the State noise policy.

23 CFR 772.13(g) requires that "...before adoption of a final environmental impact statement or finding of no significant impact, the highway agency shall identify highway traffic noise abatement measures which are feasible and reasonable and which are likely to be incorporated in the project...." This is frequently the most difficult part of the highway traffic noise analysis for a proposed highway project. Highway agency decision makers often ask, "What does feasible and reasonable mean? How should we determine feasibility and reasonableness?" The following discussion assists in answering these questions.

Feasibility and Reasonableness Determination and Worksheet

Each highway agency should develop its own factors under both the feasibility and reasonableness criteria. Keeping in mind that the following are required factors:

1. Feasibility: At least a 5 dB(A) highway traffic noise reduction is achieved at the majority of the impacted receivers.
2. Reasonableness: Point of view of benefitting property owners and residents
3. Reasonableness: Allowable cost of highway traffic noise abatement
4. Reasonableness: Meets or exceeds the reasonable design goal

The report must provide thorough documentation of the feasibility and reasonableness analysis. Each highway agency should develop a worksheet to evaluate feasibility and reasonableness. Please see Appendix D for an example feasibility and reasonableness worksheet.

Construction Noise Analyses

The highway agency must address consideration of construction noise in the environmental document. A construction noise documentation example is in Appendix B – Highway Traffic Noise Reporting.

Coordination with Local Governments

The final part of the highway traffic noise analysis is coordination with local officials whose jurisdictions are affected. The primary purpose of this coordination is to promote compatibility between land development and highways.

The highway agency should also coordinate with the local governments when the local governments are opposed to the recommended noise abatement that was determined to be feasible and reasonable. This coordination should determine if the local government's reasons for the opposition are justified, such as for safety reasons. The local governments cannot arbitrarily veto and/or restrict the length or height of the mitigation measure that was determined to be feasible and reasonable based on an unjustified reason

Appendix B: Highway Traffic Noise Reporting

Noise Analysis Documentation

The final product of a highway traffic noise study should be a clear, concise written discussion of the study. This report gives the reader a detailed description of all the elements of the analysis done for the study including information on noise fundamentals and regulatory requirements. Additionally, the environmental document for Type I projects, i.e., Categorical Exclusion (CE), Environmental Assessment/Finding of No Significant Impact (EA/FONSI), Environmental Impact Statement (EIS), should contain a brief summary of the important points found in the highway traffic noise study report. The project development records should fully document the highway traffic noise analysis level-of-effort, strategies considered, adjacent resident's views on the desirability and acceptability of abatement, and a final decision on the feasibility and reasonableness of abatement.

Section 772.11(a) is the major requirement to prepare a highway traffic noise analyses on all Type I projects. However, these requirements include evaluation of noise reduction benefits, abatement cost, and SEE effects. This evaluation requires a balancing by the highway agency of benefits and disbenefits. Section 772.13 covers noise reduction benefits and abatement cost. The public involvement process strongly influences balancing noise abatement and the SEE effects of the mitigation. The people who live next to the highway project can best evaluate if the abatement benefits will outweigh the SEE effects. The highway agencies should not do this evaluation without public involvement.

It is also important to remember that noise abatement consideration should be an inherent project consideration incorporated and considered in the total project development decision. A noise analysis is required for all Type I and Type II projects regardless of their classification (i.e. controlled access, uncontrolled-access roads).

A simplified example of noise analysis documentation follows. A complete noise analysis should clearly describe each alternative under study and detail the adjacent land uses. Accurately labeled aerial photography and aerial photography with project alternative overlays also help readers visualize the project and gain a better understanding of the context and intensity of the proposed project. The noise analysis should include the following information. Examples of some of the sections follow. The order or format is not required, but the following provides a representation of the information needed in a highway traffic noise study.

Noise Analysis Contents

Section[1]	Include Discussion Of:
1. Executive Summary	Concise project description, noise impacts, abatement considerations, commitments
2. Project History and Background Information	Project planning, detailed project description, purpose and need, ancillary improvements, characteristics of noise

[1] NHI Noise Course Lesson 11 Noise Study Documentation

sound propagation over moderate distances.

Field staff collected noise measurements with an ABC Model 123 portable integrating sound level meter set to collect the A-weighted Leq at a slow response time. During the measurement, field staff noted ambient noise sources and counted local traffic. The duration of each measurement period was between 20 and 35 minutes.

Future Noise Environment Documentation Example

The noise analysis includes prediction of 2025 noise levels at each receiver for each of the seven alternatives under consideration using the FHWA TNM. This model uses the number and type of vehicles on the planned roadway, their speeds, and the physical characteristics of the road, e.g., curves, hills, depressed, elevated, etc. Preliminary alignment and roadway elevation characteristics were available for use in this noise analysis. The models included existing natural or man-made barriers, but did not assume inclusion of any noise abatement measures. The model uses traffic volumes obtained from the Metropolitan Council Regional Traffic Assignment Model. The noise predictions made in this report are highway related noise predictions for the traffic conditions during the design year. For this analysis, the peak hour volumes and corresponding speeds for trucks and automobiles result in the noisiest conditions. During all other periods, the noise levels will be less than indicated in this report.

Traffic Noise Impact Documentation Example

The traffic noise analysis for the proposed actions predicts greatest noise impacts to occur at residential sites near the proposed loop location. Table No. 7 shows the result of this analysis. The average increase at the selected sites is +12 dB(A). The largest increases (up to +25 dB(A)) occur at rural residences close to the proposed highway.

For the preferred Alternate 3, 52 single family residences, 12 multiple family residences and 2 places of worship approach or exceed the noise abatement criteria. Fifty-two single family residences, 28 multiple family residences, 2 businesses, and 2 places of worship will experience a substantial increase in existing noise levels.

Consideration of Abatement Documentation Example

The most likely method available to reduce noise levels and alleviate noise impacts from Airport Drive is incorporation of noise abatement measures into the highway design. Since the alignment and grade of Airport Drive are established, noise barriers beside the roadway are the most acceptable means of noise abatement.

. . . The first proposed barrier location is along Airport Drive at the East Avenue-Fair Oaks apartment complex. The proposed barrier is located 12 feet from the edge of Airport Drive, is about 1,770 feet long, and runs from a point about 150 feet north of the edge of Niners Road at the Airport Drive intersection to about 70 feet north of the northernmost apartment building. A barrier 10 feet above grade level provides 9-11 dB reduction in the noise levels at the nearest building, first floor elevation (5 feet above ground). This reduces the predicted exterior Leq noise levels near these buildings from 73-74 dB to 62-65 dB and achieves the 7 d(BA) reasonableness design goal.

. . . The cost of noise barriers depends directly on the material used to build it. Depending upon material selection, barrier costs including installation may be as little as $15 per lineal foot or as great as $75 per lineal foot. A wooden barriers erected along Airport Drive at the apartments

truncating measured or modeled noise levels. Reporting noise levels to the tenth of a decibel may imply a false sense of accuracy and precision. Use caution in presenting material as this approach may result in presenting contradictory information to the public since the TNM reports noise levels to the tenth of a decibel. If a highway agency implements reporting of noise levels to the whole decibel, the highway agency should develop custom output tables from TNM for inclusion in noise analysis reports that round or truncate the results per the highway agency's noise policy.

Construction Noise Documentation

It is difficult to predict levels of construction noise at a particular receiver or group of receivers. Heavy machinery, the major source of noise in construction, is constantly moving in unpredictable patterns. Daily construction normally occurs during daylight hours when people tolerate occasional loud noises. The duration for individual receivers should be short; therefore, there are no anticipated disruptions of normal activities. However, the project plans and specifications include provisions requiring the contractor to make every reasonable effort to minimize construction noise through abatement measures such as work-hour controls and maintenance of muffler systems.

For additional information on construction noise, please refer to the FHWA Construction Noise Handbook (FHWA-HEP-06-015) and the Roadway Construction Noise Model (RCNM). Both are located at http://www.fhwa.dot.gov/environment/noise/cnstr_ns.htm.

Coordination with Local Officials

This section documents the coordination process with local officials. The highway agency provides the specific information given to local officials to satisfy 23 CFR 772.17, notably, the best estimate of future noise levels on undeveloped land adjacent to the project within their jurisdiction and noise compatible planning strategies.

Table 8: Barrier Attenuation

Reduction in Sound Level	Reduction in Acoustic Energy	Difficulty To Obtain Reduction
5 dB(A)	70%	Simple
10 dB(A)	90%	Attainable
15 dB(A)	97%	Very Difficult
20 dB(A)	99%	Nearly Impossible

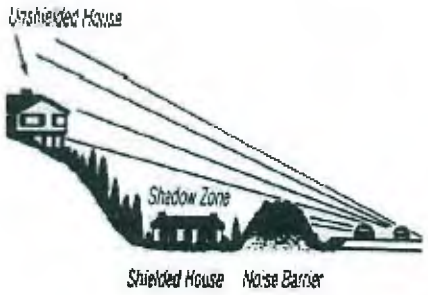
Noise Barrier Material Types

There are no Federal requirements or FHWA regulations related to the selection of material types in the construction of highway traffic noise barriers. Individual highway agencies select the material types to use when building their barriers. Highway agencies normally make this selection based on a number of factors such as aesthetics, durability, maintenance, cost, public comments, etc. The FHWA does not specify the type of material to use for noise barrier construction, but the material type chosen must meet State specifications approved by the FHWA. The material chosen should be rigid and of sufficient density (approximately 4 pounds/square foot minimum) to provide a k loss of 20 dB(A) greater than the expected reduction in the noise diffracted over the top of the barrier.

Shadow Zone

Noise barriers and earthen berms create a shadow zone. The vertical nature of a noise barrier or earthen berm causes an area of decreased sound energy on the non-highway side due to diffraction, reflection and transmission loss. Receivers that are located in the shadow zone (see Figure 2), will benefit the most from the noise barrier or earth berm.

Figure 2: Noise Barrier Shadow Zone



Shadow Effect of Noise Barrier

The noise barrier protects the shielded house, but leaves the unshielded house unprotected.

Public Perception

Overall, public reaction to noise barriers appears to be positive. There is, however, a wide diversity of

when compared to a roadway configuration with a wide right-of-way and variations in horizontal and vertical alignments. In the former case, the roadway designer is limited in the options of visual design to minor differences in form, surface treatment, and landscaping. In the latter case, the designer has the opportunity employ a range of design alternatives to develop a visually pleasing and effective barrier.

From both a visual and a safety standpoint, noise barriers should not begin or end abruptly. There are several alternatives to achieve a gradual transition from the ground plane to the desired barrier height. One concept is to begin or terminate the barrier in an earth berm or mound. Other possibilities include adding a slope to the top of the barrier, curving the barrier in a transition form, stepping the barrier down in height, or terminating the barrier in a vegetative planter. The concept of terminating the barrier in a vegetative planter in areas where climatic conditions are conducive to continued vegetative growth.

Visual Impact

A major consideration in the design of a noise barrier is the visual impact on the adjoining land use. An important concern is the scale relationship between the barrier and activities along the roadway right-of-way. A tall barrier near a low-scale single-family detached residential area could have a severe adverse visual effect. In addition, a tall barrier placed close to residences could create detrimental shadows. One solution to the potential problem of scale relationship is to provide staggered horizontal elements to a noise barrier to reduce the visual impact through introduction of landscaping in the foreground. This can also allow for additional sunlight and air movement in the residential area. In general, it is desirable to locate a noise barrier approximately four times its height from residences and to provide landscaping near the barrier to avoid visual dominance.

Carefully consider the visual character of noise barriers in relationship to the environment. The barriers should reflect the character of their surroundings as much as possible. Where strong architectural elements of adjoining activities occur in close proximity to barrier locations, consider the relationship of material, surface texture, and color in the barrier design. In other areas, particularly those near roadway structures or other transportation elements, it may be desirable that proposed noise barriers have a strong visual relationship, either physically or by design concept, to the roadway elements.

Preserve aesthetic views and scenic vistas to the extent possible. However, the highway agency cannot reject feasible and reasonable noise barrier based on visual impacts without justification. Local governments cannot arbitrarily veto and/or restrict the length or height of an abatement measure determined feasible and reasonable based on visual quality concerns. In this case, the FHWA will not authorize the Federal-aid project unless the recommended noise abatement is included in the project design, plans and specifications.

In general, a successful design approach for noise barriers is to utilize a consistent color and surface treatment, with landscaping elements used to soften foreground views of the barrier. It is usually desirable to avoid excessive detail, which tends to increase the visual dominance of the barrier and may provide a distraction for motorists.

Graffiti

Graffiti on noise barriers can be a potential problem. A possible solution to this problem is applying an anti-graffiti coating or using materials. Landscaping and plantings near barriers can discourage graffiti as well as to add visual quality.

There are several safety considerations to keep in mind when designing a noise barrier. The designer must consider the effect on site distance for drivers. There AASHTO Green Book provides design requirements for Stopping Sight Distance (SSD) Decision Sight Distance (DSD), and the Horizontal Sightline Offset (HSO).

Designers must also consider the safety of the traveling public and those on adjacent properties when considering possible vehicle impacts with noise barriers. Several States use specially designed noise barriers on bridges to guard against dislodging of the barrier onto roads below the bridge. Another factor to consider is the presence of a noise barrier within the clear zone and the need for safety barriers in these circumstances.

Traffic Management

Controlling traffic can sometimes reduce highway traffic noise problems. Possible ways to achieve this are:

1. Prohibiting trucks from certain streets and roads,
2. Permitting trucks to use certain streets and roads only during daylight hours,
3. Timing traffic lights to achieve smooth traffic flow and to eliminate the need for frequent acceleration and deceleration,
4. Reducing speed limits reduces highway traffic noise levels; however, an approximate reduction of 20 mph is necessary for a readily perceptible decrease in noise levels.

Alteration of Horizontal and Vertical Alignments

A change in the horizontal or vertical alignment of the highway may reduce noise levels at noise sensitive receivers. Suppressing the highway's vertical alignment to create a natural berm between the highway and receivers or shifting the highway's horizontal alignment away from noise sensitive receivers and closer to less sensitive receivers are two methods to accomplish this measure. Usually, this approach is limited to use on projects on new alignment as a means of avoiding impacts rather than as an abatement measure. It is may be very expensive to alter the alignment of a highway to reduce noise levels.

Acquisition of Property Rights for Noise Barrier or Buffer Zones

The highway agency may acquire property rights to allow for the construction of a noise barrier. Include the cost of property purchased by the highway agency in the barrier's reasonableness determination. Buffer zones can only be used in Type I projects. The potential use of buffer zones applies to predominantly unimproved property; not to purchase homes or developed property to create a noise buffer zone. Highway agencies may purchase unimproved property to preclude future highway traffic noise impacts.

Buffer zones are undeveloped, open spaces that border a highway (as defined by this policy). Buffer zones occur when a highway agency purchases land or development rights, in addition to the normal right-of-way, to prohibit construction of future dwellings close to the highway. This prevents the possibility of exposing new dwellings to an excessive noise level from nearby highway traffic. An additional benefit of buffer zones is that they often improve the roadside appearance. However, because of the tremendous amount of needed land and because in many cases dwellings already border existing roads, creating buffer zones is often not possible. The intention of this provision is for purchase of

Privacy Fencing

Privacy fencing provides a visual screen between the source and receptor, but is unlikely to provide a discernible reduction in noise levels. Like vegetation, this screening may provide psychological relief, but not highway traffic noise abatement.

Flexibility in Decision Making

The basis for the Federal-aid highway program is a strong State-Federal partnership. At the core of that partnership is a philosophy of trust and flexibility, and a belief that the States are in the best position to make investment decisions on the needs and priorities of their citizens. The FHWA highway traffic noise regulations give highway agencies flexibility to determine the feasibility and reasonableness of highway traffic noise abatement; balancing the benefits of highway traffic noise abatement against the overall adverse social, economic and environmental effects and costs of the highway traffic noise abatement measures. The highway agency must base its determination on the interest of the overall public good, keeping in mind all the elements of the highway program (need, funding, environmental impacts, public involvement, etc.).

One of the most difficult parts of traffic noise analysis is determining the reasonableness and feasibility of abatement. This discussion has addressed the details of determining the reasonableness and feasibility of noise abatement.

Good program management supports the need for highway traffic noise abatement decision-making policies. Abatement decision-making must not be arbitrary and capricious. The reasoning for decisions should be available and supportable. Objective, quantifiable decision making criteria can aid in promoting better public understanding and acceptance of decisions.

Inclusion of a wide range of reasonableness criteria provides greater flexibility in abatement decision-making. Such flexibility is essential to allow for consideration of special circumstances in individual cases. Highway agencies should not rigidly apply their policies.

Appendix F: Determining the Reasonable Cost of Abatement

23 CFR 772.13(d)(2)(ii) requires highway agencies to determine the basis for the reasonable cost of abatement on actual construction costs. One way to determine the reasonable cost of abatement to evaluate the actual unit costs of recently constructed noise barriers in the State and identifying a range of unit costs. This information, coupled with data on the range of costs per residence of constructed noise barriers or in some cases, the square footage of noise barrier per residence will help guide the highway agency to develop the cost reasonableness criteria for the State. The regulation requires reevaluation of the cost reasonableness criteria at a minimum of every five years. States may choose to incorporate an inflation adjustment based on historical or projected trends. One benefit of using the maximum square feet per benefited residence approach is that this value remains constant. Actual costs may increase, but the highway agency guards against stepping away from perceived commitments to provide noise abatement due to escalating costs.

It may be difficult to get a grasp of the actual constructed cost of noise abatement. There are costs associated with a project that a line item in project bid tabulations does not capture. Each highway agency should determine what expenses to include in noise abatement cost valuations. It is valid to simply look at the bid cost of post and panels, but it is equally valid to include other items directly related to providing noise abatement such as design, purchase of right-of-way, maintenance of traffic, deployment costs, clearing and grubbing, grading, reseeding and mulching, cost of safety barriers and any other project costs related to the constructed noise abatement measure. The examples below do not provide all possible cost categories for States to consider, but are illustrative of possible items to include in the cost estimate.

Standalone noise abatement projects, such as Type II projects, can help identify the full unit cost of noise abatement. In a Type II project, the entire project is usually about construction of noise abatement, usually in the form of a noise barrier. The project includes all the associated costs of design and construction, making it pretty easy to divide the total project cost by the square footage of constructed noise barrier to find the unit cost of the project.

The following tables follow an option for project cost projections. Determining project construction cost is the starting point to identifying future costs. Users could also apply these tables at the program level or for future projects help get a better idea of whether a project that is cost reasonable today, will remain cost reasonable years from now given the projection of cost increases predicted to occur between design and construction.

Highway agencies may identify a typical unit cost for noise abatement and identify other features that are project specific. For example, several items shown in the tables below, such as foundations, clearing and grubbing, reseeding, drilled shafts, grading and the barriers, are typical for most projects. Other expenditures, such as purchase of right-of-way, installation of safety barriers and utility relocations are specific to some projects. The noise barrier input function in the TNM provides users with the ability to establish a cost per square foot of wall area, which could include all the typical costs, plus an additional value based on the length of the barrier, which could include atypical costs. This approach avoids assuming the worst case scenario for all projects, but allows highway agencies to account for additional expenses that occur with some projects.

NOTE: The values in the table are illustrative and do not necessarily reflect actual costs.

Noise Barrier Construction Project - Detailed Program
Table
C1.1 Program Item Cost Calculations ($)

	Item	Unit	Unit Cost ($)	Number of Units	Total Cost ($)
1.1	Right of Way				
1.1a	Purchase Strip right-of-way	sf		50,000.0	
	Total	acre	10,000.0	1.1	11,478.4
1.2	Clearing and Grubbing				
1.2a	Cut existing vegetation	sf	1.50		75,000.0
1.2b	Remove existing vegetation	sf	1.00		50,000.0
1.2c	Smooth disturbed soil	sf	1.00		50,000.0
	Total	sf	3.5	50,000.0	175,000.0
1.3	Road and Access	cf			
1.3a	Grade access road	cf	5.0	5,000.0	25,000.0
	Total		5.0	5,000.0	25,000.0
1.4	Grading				
1.4a	Cut	cf	5.00	3,000.0	15,000.0
1.4b	Fill	cf	5.00	5,000.0	25,000.0
	Total	cf	5.00	8,000.0	40,000.0
1.5	Noise Barrier <10'	sf	7.25	5,400.0	39,150.0
1.6	Noise Barrier 10-16'	sf	7.30	38,460.0	280,758.0
1.7	Noise Barrier > 16'	sf	7.35	12,000.0	88,200.0
	Total		7.31	55,860.0	408,108.0
1.8	Foundations (see table below)				
1.8a	Structural Steel	lf	3.50	100,000.0	350,000.0
1.8b	Concrete	cy	100.00	650.0	65,000.0
1.8c	Soil Borings	unit	25.00	1,000.0	25,000.0
	Total	unit	1,760.00	250.0	440,000.0
1.9	Seeding and Mulching				
1.9a	Type 4a grass seed mixture	sf	0.15	50,000.0	7,500.0
	Straw mulch	sf	0.07	50,000.0	3,500.0
	Total		0.11	100,000.0	11,000.00
1.10	Landscaping	sf			
1.10a	4" Deciduous trees	unit	175.00	225.0	39,375.0
1.10b	5' Conifers	unit	100.00	175.0	17,500.0
1.10c	#2 Deciduous shrubs	unit	350.00	18.8	6,562.5
1.10d	Daylilies	unit	1,275.00	10.0	12,750.0
1.10e	Landscape mulch (see table below)	cy	5.75	1,388.9	7,986.1
	Total				84,173.6
1.11	Drilled Shafts	unit	100.00	250.0	25,000.0
	Equipment Rental				
	Total	unit	100.00	250.0	25,000.0

Input Values

Table C2 gives the opportunity to capture some costs that are not captured in the previous tables. Physical contingencies represent an extra amount to account for changes in project quantities or other added expenses directly related to changes in a particular program element.

Table C4 give the distribution of cost in constant prices across the life of the project.

Table C5 Distribution of Cost, In Current Prices ($)

	Item	2005	2006	2007	2008	2009	2010	Total
	Inflation Rate		4.0%	4.0%	4.0%	4.0%	4.0%	
	Price Index	1.000	1.040	1.082	1.125	1.170	1.217	
	Design	0.0	46,180.5	48,027.7	0.0	0.0	0.0	94,208.27
	Supervision	0.0	0.0	4,116.7	17,125.3	17,810.3	4,630.7	43,683.01
	Right of Way	3,013.1	6,267.2	3,259.0	0.0	0.0	0.0	12,539.26
	Clearing and Grubbing	0.0	0.0	198,744.0	0.0	0.0	0.0	198,744.00
	Road and Access	0.0	0.0	28,392.0	0.0	0.0	0.0	28,392.00
	Grading	0.0	0.0	22,713.6	23,622.1	0.0	0.0	46,335.74
	Noise Barrier	0.0	0.0	0.0	120,504.8	250,650.0	130,338.0	501,492.88
	Foundations	0.0	0.0	0.0	259,843.6	270,237.3	0.0	530,080.91
	Seeding and Mulching	0.0	0.0	0.0	0.0	0.0	14,052.3	14,052.34
	Landscaping	0.0	0.0	0.0	0.0	0.0	107,530.6	107,530.57
	Drilled Shafts	0.0	0.0	0.0	14,763.8	15,354.4	0.0	30,118.23
	Total	3,013.1	52,447.7	305,253.0	435,859.7	554,052.1	256,551.6	1,607,177.21

Input Values

Table C5 provides the opportunity to account for inflation across the life of the project. This information carries into Table C6 as the project financial contingencies.

Appendix G: Highway Traffic-Induced Vibration

There are no Federal requirements directed specifically to highway traffic induced vibration. All studies the highway agencies have done to assess the impact of operational traffic induced vibrations have shown that both measured and predicted vibration levels are less than any known criteria for structural damage to buildings. In fact, normal living activities (e.g., closing doors, walking across floors, operating appliances) within a building have been shown to create greater levels of vibration than highway traffic. Address vibration concerns on a case-by-case basis as deemed appropriate in the noise analysis or in a standalone vibration analysis report.