Guidelines for Analysis and Abatement of Roadway Traffic Noise

TxDOT Environmental Affairs Division
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I. Introduction

This document contains the Texas Department of Transportation (TxDOT) guidance on roadway traffic noise analysis and abatement for Federal projects authorized under 23 USC. This guidance describes TxDOT's implementation of the requirements of the Federal Highway Administration (FHWA) Noise Standard at 23 Code of Federal Regulations (CFR) Part 772. This guidance was developed by TxDOT and reviewed and concurred with by the Federal Highway Administration (FHWA).

FHWA issued a final amended noise regulation on July 13, 2010. The amended rule requires all State DOT's to revise and update their State noise policies. This document updates the 1997 TX DOT guidelines. Key changes to the guidelines include:

- Providing clarification of documentation requirements for roadway traffic noise impacts within technical reports and environmental documents.
- Providing added flexibility on defining parameters for feasible and reasonable noise abatement.
- Incorporating a noise reduction design goal of 7 dB(A) as a required reasonableness criterion.
- Reorganizing the noise abatement criterion (See Table 6) to more appropriately group land uses by impact criteria and to distinguish between interior and exterior evaluation areas.

1.1 Purpose

The purpose of this document is to provide updated guidelines for performing traffic noise analyses on TxDOT roadway projects. It includes a discussion of the fundamentals of sound and traffic noise, the traffic noise analysis process and associated documentation.

FHWA published a final rule updating 23 CFR 772, on July 13, 2010. This final rulemaking required TxDOT to revise its current noise policy (July 1997) to address the requirements of the final rule. The revised TxDOT noise policy will become effective July 13, 2011. Any project that has not yet completed the NEPA approval process (CE determination, FONSI or ROD) before July 13, 2011, must meet the requirements of the amended final rule and revised TxDOT policy. Any traffic noise analysis and proposed abatement, final design analysis, or noise workshop for a NEPA document completed after July 13, 2011 must comply with the new rule for 23 CFR 772 and the revised TxDOT Guidelines for Analysis and Abatement of Roadway Traffic Noise, dated April13, 2011 (See Appendix A).

1.2 Background

The National Environmental Policy Act (NEPA) of 1969 provides broad authority and responsibility for evaluating and mitigating adverse environmental effects, including roadway traffic noise. NEPA directs the federal government to use all practical means and measures to promote the general welfare and foster a healthy environment.

The federal legislation that specifically involves abatement of roadway traffic noise is the Federal Aid Highway Act of 1970. This law mandates FHWA to develop noise standards for mitigating roadway traffic noise and requires promulgation of traffic noise-level criteria for various land use activities.

The FHWA regulations for highway traffic and construction noise analysis and abatement during the planning and design of federally aided highway projects are contained in 23 CFR 772.

In June 1995, FHWA reissued existing guidance on highway traffic noise analyses in a consolidated document entitled "Highway Traffic Noise Analysis and Abatement Policy and Guidance." The 1995 FHWA document was replaced by a new noise guidance document, available at the FHWA Noise Website.

TxDOT models traffic noise not only on highways, but on urban arterials, city streets, and county roads. Given this and public input, TxDOT has changed the term "highway" to "roadway" in this document.

1.3. References

1. FHWA Highway Traffic Noise: Analysis and Abatement Guidance
2. Title 43, Texas Administrative Code, Chapter 2, "Environmental Policy", December 2006.
3. Title 23, Code of Federal Regulations, Part 772 (23 CFR 772), "Procedures for Abatement of Highway Traffic Noise and Construction Noise".

1.4 Applicability

These guidelines apply to all federal, federal-aid and state funded Type I roadway projects authorized under Title 23, United States Code and applies to any roadway project or multi-modal project that requires FHWA approval regardless of funding sources.

Type I Project:

- The construction of a highway on new location; or,
- The physical alteration of an existing highway where there is either:
  - 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,
  - 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,
  - 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,
  - The addition of an auxiliary lane, except for when the auxiliary lane is a turn lane; or,
  - The addition or relocation of interchange lanes or ramps added to a quadrant to complete an existing partial interchange; or,
  - Restriping existing pavement for the purpose of adding a through-traffic lane or an auxiliary lane; or,
  - The addition of a new or substantial alteration of a weigh station, rest stop, ride-share facility, or toll plaza.

If any portion of a project is determined to meet the definition of a Type I project, then the entire project analyzed 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, TxDOT must develop and implement a Type II program in accordance with section 772.7(e). The development and implementation of Type II projects are not mandatory requirements of Federal law or regulation. TxDOT does not participate in a Type II (retrofit) program.

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.

1.5 Scope Limitations

These guidelines apply to Type I TxDOT roadway projects regardless of funding sources.

A detailed discussion of the FHWA approved traffic noise modeling (TNM) software is beyond the scope of this document.

Although a traffic noise analysis may include preliminary dimensions and locations of noise barriers, a detailed discussion of noise barrier design specifications and construction techniques is also beyond the scope of this document.

1.6 Compliance

Compliance with FHWA's 23 CFR 772 is a prerequisite for granting federal-aid highway funds or FHWA approvals for construction or reconstruction of a roadway.

These guidelines were developed in accordance with FHWA's 23 CFR 772 and the Highway Traffic Noise: Analysis and Abatement Guidance.

1.7 Responsibilities

TxDOT's Environmental Affairs Division (ENV):

- Develop and publish TxDOT's "Guidelines for Analysis and Abatement of Roadway Traffic Noise", and provide changes/updates, as necessary.
- Provide example traffic noise analysis documentation to TxDOT District Environmental Coordinators.
- Review, evaluate, and approve traffic noise analyses and any associated noise abatement proposals.
- Submit noise abatement proposals to FHWA for approval.
- Conduct training in traffic noise analysis and associated computer modeling.
- Provide guidance and assistance, as necessary.
- Maintain a comprehensive statewide noise barrier inventory of all constructed noise barriers or other abatement measures and provide triennial updates as required by 23
- CFR 772. In addition, this regulation requires TxDOT to reevaluate the cost reasonableness criteria every five years, (see FHWA Highway Traffic Noise Analysis and Abatement Guidance, Appendix F: Determining the Reasonable Cost of Abatement).
- Publish and maintain an informative noise barrier brochure.
- Develop and publish a comprehensive user's manual for the FHWA approved traffic noise modeling software.

TxDOT District offices:

- Perform traffic noise analyses according to the latest TxDOT Guidelines for Analysis and Abatement of Roadway Traffic Noise.
- Submit traffic noise analyses/noise abatement proposals to ENV for approval.
- Review and evaluate all traffic noise analyses performed by consultants before submitting to ENV.
- Ensure all personnel responsible for conducting traffic noise analyses receive initial and recurring training in the proper use and application of these guidelines, traffic noise modeling software, and sound meters.
- Conduct noise workshops to inform the public about a noise abatement proposal and/or to solicit public viewpoints regarding a noise abatement proposal, as necessary.
- Maintain a comprehensive noise barrier database and provide triennial updates to ENV, as required by FHWA.
- Provide useful information to local officials on noise levels from roadway projects to assist them in noise-compatible land use planning. Inform them of the ineligibility for federally funded noise abatement for new developments that are permitted after the date of public knowledge for Type I projects.

Consultants under contract to perform traffic noise analyses for TxDOT:

- Conduct traffic noise analyses according to the latest TxDOT Guidelines for Analysis and Abatement of Roadway Traffic Noise.
- Obtain/use the latest FHWA approved traffic noise modeling software and associated training.

2.0 Explanation of Terms and List of Acronyms

2.1 Terms

23 CFR 772 - Title 23, Code of Federal Regulations, Part 772 "Procedures for Abatement of Highway Traffic Noise and Construction Noise": FHWA regulations for highway traffic noise analysis and abatement during the planning and design of federally aided highway projects.

Abatement - Any positive action taken to reduce the impact of roadway traffic noise

Abatement Measures - At a minimum, noise abatement in the form of a noise barrier shall be considered. Other noise abatement measures that can be **considered** are;

- Traffic management
- Alteration of horizontal and vertical alignments
- Acquisition of real property to serve as a buffer zone
- Insulation of NAC Category D structures (see Table 6.)

Absolute Criterion - One of two criteria (see "Relative Criterion") used to determine when a noise impact occurs. Under this criterion, a noise impact occurs when the **predicted** noise level approaches, equals or exceeds the FHWA Noise Abatement Criteria.

Activity Category - Categories of land use adjacent to a roadway project.

Approach - One (1) dB(A) below the FHWA Noise Abatement Criteria (see "Absolute Criterion").

Attenuation - Reduction or lowering of the level of sound or noise.

Automobiles - Vehicles with two axles and four wheels designed primarily for transporting passengers and or cargo (includes light trucks). Generally, the gross weight is less than 10,000 lbs.

Average Daily Traffic (ADT) - The average 24-hour traffic count (vehicles per day). Typically, the total amount of traffic during a stated period (normally one year) divided by the number of days in that period. The ADT is only used as the basis for determining the "Design Hourly Volume" (DHV). The DHV is used to model a "worst case" scenario in design year traffic noise levels.

A-Weighting dB(A) - An adjustment in sound meters and traffic noise modeling software to ensure sound levels are measured/calculated in a manner that approximates the sounds that can be heard by the human ear. This is accomplished by suppressing the low and very high frequencies that cannot be heard by the human ear.

Benefitted Receptor - The recipient of an abatement measure that receives a noise reduction at or above the minimum threshold of 5 dB(A), regardless of whether or not the receptor was "impacted." The total number of benefitted receptors is used to evaluate the cost effectiveness of an abatement measure (see "Reasonable").

Categorical Exclusion (CE) - Document prepared for a project that involves actions that would result in no significant environmental impacts. Specifically, these actions would not induce significant impacts to planned growth or land use for the area; would not require the relocation of significant numbers of people; would not have a significant impact on any natural, cultural, recreational, or historic resource; would not involve significant air, **noise** or water quality impacts; would not have significant impacts on traffic patterns; or would not otherwise, either individually or cumulatively, have any significant environmental impact.

Common Noise Environment - A group of receptors within the same Noise Abatement Criteria (NAC) activity that are exposed to similar noise sources and levels; traffic volumes, traffic mix, and speed; and topographic features.

Contour (noise) - The location of a specific noise level relative to the source.

Cost/Benefitted Receptor - The cost for a single family residence which is benefitted by at least a 5 dB(A) reduction in design year traffic noise and shall not exceed $25,000 per benefitted receptor.

Cost Effectiveness - See "Reasonable."

Date of Public Knowledge - The date of approval of the Categorical Exclusion (CE), the issuance of the Finding of No Significant Impact (FONSI), or the Record of Decision (ROD) for a Type I roadway project - when FHWA and TxDOT are no longer responsible for providing noise abatement for new development adjacent to a proposed roadway project.

Decibel (dB) - The basic unit for measuring sound pressure levels.

Design Hourly Volume (DHV) - The traffic count (vehicles per hour) determined by applying the "K-factor" to the "Average Daily Traffic." The DHV is used to model a "worst case" scenario in design year noise levels. DHV is the 30th highest hourly volume for the design year.

Design Year - The year used as a basis for calculating predicted (future) noise levels - normally 20 years from the current (existing) year.

Diffraction - The bending of sound waves around an obstacle (over or around a noise barrier) and results in a corresponding "attenuation" of the sound level.

Environmental Assessment (EA) - Document prepared for a project when the significance of environmental impacts is not clearly exhibited. The assessment may result in either a Finding of No Significant Impact (FONSI) or elevated to an Environmental Impact Statement.

Environmental Impact Statement (EIS) - Document prepared for a project when significant impacts are evident or identified in an Environmental Assessment.

Existing Noise Level - The level of traffic noise measured or modeled at a receptor for the current (existing) pre-construction roadway project.

Feasible – The determination of whether it is possible to build an abatement measure given site constraints and whether the abatement measure provides a minimum reduction in noise levels.

Feasibility is limited by:

- Topography,
- Access requirements for driveways, ramps, etc.,
- The presence of local cross streets, or
- Are other noise sources in the area (e.g. aircraft, rail, commercial and industrial noise sources)?
- Addressing the project purpose
- Drainage
- Utilities
- Maintenance
- Noise reduction

A noise abatement measure is **NOT FEASIBLE** unless the measure achieves a noise reduction of at least 5 dB(A) at greater than 50% of first row impacted receptors. Blocking the line of site between the source and receptor usually provides a 5 dB(A) noise reduction.

FONSI - Finding of No Significant Impact is one potential outcome from performing an Environmental Assessment. The other outcome is to perform an EIS.

Heavy Trucks - Vehicles with three or more axles. Generally, the gross weight is greater than 26,520 lbs.

Impact - Design year condition noise levels that approach or exceed the NAC listed in Table 6 for the future build condition; or design year build condition noise levels that create a substantial noise increase over existing noise levels.

Insertion Loss - The actual benefit (noise level reduction) derived from the construction of a noise barrier.

K-factor - Number applied to the "Average Daily Traffic" to determine the "Design Hourly Volume." The K-factor is normally 0.10 (plus or minus one percent).

L_{eq} (Equivalent Noise Level) - The equivalent steady-state sound level that, in a given time period, contains the same acoustic energy as a time-varying sound level during the same period. **L_{eq} is used for all traffic noise analyses for TxDOT roadway projects.**

Loudness - The subjective/perceived assessment of the intensity of sound.

Medium Trucks - Vehicles with two axles and six wheels. Generally, the gross weight is greater than 10,000 lbs but less than 26,520 lbs.

Mitigation - Alternative to the preferred term "abatement."

Multi-family residential - A classification of housing where multiple separate housing units for residential (i.e. non-commercial) inhabitants are contained within one building. A common form is an apartment building. Sometimes units in a multi-family residential building are condominiums, where typically the units are owned individually rather than leased from a single apartment building owner.

Noise Abatement Criteria (NAC) - Absolute sound levels, provided by FHWA, that are used to determine when a noise impact occurs (see "Absolute Criterion"). They are **not** used as a design goal for a noise abatement measure.

Noise Barrier - Typically, a solid wall-like structure located between the noise source (traffic) and the impacted receptor (frequent human activity area) to reduce noise levels. The construction of a noise barrier is one of the abatement measures that must be considered when a traffic noise analysis indicates that a roadway project would result in a noise impact.

Permitted - A definite commitment to develop land with an approved specific design of land use activities as evidenced by the issuance of a building permit.

Predicted Noise Level - The level of traffic noise modeled at a receptor in the "design year" of a proposed roadway project.

Property Owner - An individual or group of individuals that holds a title, deed, or other legal documentation of ownership of a property or a residence.

Reasonable - The combination of social, economic, and environmental factors considered in the evaluation of a noise abatement measure. A determination of reasonableness for abatement measures will include consideration of the following range of factors:

a) Cost Effectiveness

To determine cost effectiveness, the estimated cost of constructing a noise barrier will be divided among the number of benefitted receptors (those who would receive a reduction of at least 5 dB(A)). A cost of $25,000 or less per benefitted receptor (using a construction cost of $18 per square foot) is considered to be "cost effective". This cost was arrived at in a study commissioned by TxDOT by the Center for Transportation Research Research ("Report 3965-1: Validation and Cost Effectiveness Criterion for Evaluating Noise Abatement Measures", University of Texas at Austin, 1999.).

For Category C and D land use facilities, the following procedure is used to determine the equivalent number of residences to assess cost effectiveness. The land area of the Category C or D land use facility shall be divided by the representative receptor single family residential lot size development within the study area.

The number of multi-family residences (NAC category B) will be determined by a count of every impacted unit. For NAC category E receivers, the number of receptors is determined by the capacity limit of areas of frequent outdoor human use (e.g., swimming pool at hotel/motels, restaurant patio, etc.).

b) Noise reduction design goal for roadway traffic noise abatement measures.

When noise abatement measure(s) are being considered, the desired noise reduction determined from calculating the difference between future build traffic noise levels at a noise receptor with

noise abatement compared to that noise receptor without noise abatement is called the noise design goal. TxDOT has defined the noise reduction design goal as achieving a reduction in noise that is at least 7 dB(A). At least one first row receptor must achieve the noise reduction design goal.

c) Views of Benefitted Receptors

If noise abatement is determined to be feasible and cost effective, then benefitted property owners and residents will be surveyed to determine whether or not they desire noise abatement.

This survey/ballot will preferably be by prestamped/preaddressed return envelope, and will include a package of material that describes the noise barrier under consideration and the noise effects with and without the barrier. It will also describe the decision making process that TxDOT will follow to assess the survey/ballot results and make a decision on whether to build the barrier.

A noise workshop after a public hearing shall be conducted where noise impacts and abatement are discussed. Ballots cast by residents will be obtained for viewpoints, but only ballots cast by property owners will count towards determining whether a noise barrier will be constructed or not.

If the total respondents to the survey/ballot do not total a majority (50% + 1) of the benefitted receptors, then a second attempt will be made to solicit the views of those who did not respond. No third attempt is required if a majority (50% + 1) did not respond. A majority (50% + 1) of the total benefitted receptors must indicate on the survey/ballot that they want a barrier constructed for it to be considered reasonable.

All survey/ballots must be returned to TxDOT, by a due date. If a majority (50%+1) of the total benefitted receptors do not respond by the due date or do not respond after the second attempt, then TxDOT will base their decision on the survey responses they received even though a majority of responses were not received.

Generally, residential property owners prefer traffic noise barriers, while commercial property owners prefer to maintain visibility for their business from adjacent roadways. This can cause conflicts in mixed-use developments, as noise barriers may block line of sight to adjacent businesses. When a mutually satisfactory compromise cannot be reached between businesses and residences, noise barriers may be terminated at property line dividing the two areas.

Receiver/Receptor - A specific or representative location of a noise sensitive area(s), for any of the land uses as described in FHWA's Noise Abatement Criteria (NAC).

Record of Decision - A ROD issued by the Federal Highway Administration (FHWA) signals formal federal approval of an Environmental Impact Statement (EIS) concerning a proposed highway project. The ROD identifies the selected alternative.

Relative Criterion - One of two criteria (see "Absolute Criterion") used to determine when a noise impact occurs. Under this criterion, a noise impact occurs when the predicted noise level "substantially exceeds" (more than 10 dB(A)) the existing level even if it does not approach, equal or exceed the FHWA Noise Abatement Criteria.

Residence - A dwelling unit; either a single family residence or each dwelling unit in a multifamily dwelling.

Roadway - A general term denoting a public way for purposes of vehicular travel, including the entire area within the right of way.

Roadway noise - The collective sound energy emanating from motor vehicles.

Significant - Do not use this term in a traffic noise analysis - to avoid any conflict or confusion with "Finding Of No **Significant** Impact" for Environmental Assessments.

Sound - Mechanical energy produced by the movement of waves of compressed air radiating spherically from a source that can be sensed by the human ear.

Sound Meter - A device used to measure existing (actual) sound levels. Also referred to as a sound level dosimeter or analyzer.

Soundwall - Alternative to the preferred term "noise barrier."

S**tatement of Likelihood** - Statement provided in the environmental clearance document based on the feasibility and reasonableness analysis completed at the time the environmental document is being approved. 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 abatement measure(s) is determined during the completion of the project's final design and the public involvement processes.

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

Substantial Noise Increase - When the predicted noise level exceeds the existing level by *more than 10 dB(A)* (see "Relative Criterion").

Substantial Noise Reduction - is defined as a reduction in noise levels of at least 7 dB(A) at impacted receptors, and is independent of the NAC, The **goal** is to achieve a substantial noise reduction at all first row receptors. At least one first row receptor must achieve a substantial noise reduction to be reasonable.

Substantial Horizontal Alteration - A proposed project halves the distance between the traffic noise source and the closest receptor between the existing condition to the future build condition.

Substantial Vertical Alteration - An increase of one or more levels (overpass/underpass) proposed 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 roadway or by altering the topography between the roadway traffic noise source and the receptor.

Third Party Funding – is not allowed on federal or federal aid Type I projects 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 federal or federal aid Type I projects to make functional enhancements such as absorptive treatment and access doors or aesthetic enhancement, to a noise abatement measure already determined reasonable and feasible.

Through-Traffic Lane(s) - includes the addition of a general purpose lane, toll lane, managed lane, High Occupancy Vehicle (HOV) lane, High Occupancy Toll (HOT) lane, bus lane, or truck climbing lane; or, the addition of an auxiliary lane **except** for when the auxiliary lane is a turn lane, addition or relocation of interchange lanes or ramps added to a quadrant to complete an existing partial interchange. Restriping existing pavement for the purpose of adding a through-traffic lane or an auxiliary lane. The addition of a new or substantial alteration of a weigh station, rest stop, ride-share lot, or toll plaza.

Traffic Noise Model (TNM) - FHWA's required traffic noise modeling software.

Type I Project:

- is the construction of a highway on new location; or,
- The physical alteration of an existing highway where there is either:
  - 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,
  - 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,
  - 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,
  - The addition of an auxiliary lane, except for when the auxiliary lane is a turn lane; or,
  - The addition or relocation of interchange lanes or ramps added to a quadrant to complete an existing partial interchange; or,
  - Restriping existing pavement for the purpose of adding a through-traffic lane or an auxiliary lane; or,
  - The addition of a new or substantial alteration of a weigh station, rest stop, ride-share lot, or toll plaza.

If a project is determined to be a Type I project under this definition 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, TxDOT must develop and implement a Type II program in accordance with section 772.7(e). The development and implementation of Type II projects are not mandatory requirements of Federal law or regulation. TxDOT does not participate in a Type II (retrofit) program.

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.

2.2 Acronyms

23 CFR 772	Title 23, Code of Federal Regulations, Part 772
ANSI	American National Standards Institute
ADT	Average Daily Traffic
CE	Categorical Exclusion
dB	Decibel
dB(A)	A-weighted decibel
DHV	Design Hourly Volume
EPA	U. S. Environmental Protection Agency
EA	Environmental Assessment
EIS	Environmental Impact Statement
ENV	Environmental Affairs Division
FHWA	Federal Highway Administration
FONSI	Finding of No Significant Impact
HOT	High Occupancy Toll
HOV	High Occupancy Vehicle
HZ	Hertz
Leq	Equivalent Noise Level
NAC	Noise Abatement Criteria
NEPA	National Environmental Policy Act
NHS	National Highway System
PFC	Porous Friction Course
ROD	Record of Decision
TAC	Texas Administrative Code
TNM	Traffic Noise Model
TPP	Transportation Planning and Programming Division
TxDOT	Texas Department of Transportation

3.0 Fundamentals of Sound and Traffic Noise

3.1 Sound

Sound can be defined as mechanical energy produced by the movement of waves of compressed air radiating spherically from a source that can be sensed by the human ear. Or, simply stated, sound is what we hear. Although sounds are perceived differently from one person to another, they can be precisely measured.

3.1.1 Decibel

Sound spans a large dynamic range and any associated calculations in units of pressure involve cumbersome astronomical numbers. Therefore, in order to simplify the process, the strength of sound is commonly measured on a relative scale of sound pressure levels expressed in decibels or "dB."

Because the decibel is a simple representation of a much larger value, it is considered as a logarithmic (based on powers of 10) rather than a linear function. Consequently, sound levels cannot be added by ordinary arithmetic means. Representative examples of decibel addition are shown in **Table 1**. From this table it can be seen that doubling a noise source produces only a 3 dB increase in the sound pressure level.

Table 1
Decibel Addition*

Decibel Addition			
Difference Between Two Sources	**For Example**	**Add to the Higher Level**	**Resultant Sound Level****
0 dB	60 and 60 dB	3 dB	63 dB
1 dB	60 and 61 dB		64 dB
2 dB	60 and 62 dB	2 dB	64 dB
3 dB	60 and 63 dB		65 dB
4-9 dB	60 and 65 dB	1 dB	66 dB
10 dB or more	60 and 70 dB	0 dB	70 dB

* This table only represents approximations of the logarithmic function of decibel addition.
** Accurate within 1 dB

3.1.2 A-weighted Levels

Sound is composed of a wide range of frequencies measured in Hertz (Hz). Adult humans respond to sounds ranging from 20-20,000 Hz or, roughly, from the lowest note of a pipe organ to the highest note of a violin.

Traffic sounds normally range from 100-4,000 Hz. Because the human ear does not hear all frequencies, an adjustment is made to the high and low frequency to approximate the average human response to traffic sounds. These adjusted sound levels are referred to as "A-weighted levels" and expressed as "dB(A)."

3.1.3 Equivalent Sound Level (L_{eq})

Roadway traffic sounds are never constant. Sound levels vary in frequency and their intensity fluctuates over time. Therefore, an equivalent sound level, expressed as "L_{eq}", is used to represent a single number to describe varying traffic sound levels averaged over time.

More specifically, Leq is the equivalent steady-state sound level that, in a given time period, contains the same acoustic energy as a time-varying sound level during the same period. Leq is used for all traffic noise analyses of TxDOT roadway projects.

3.1.4 Sources

The primary sources of roadway traffic sounds are the tires, engine and exhaust of the various types of vehicles present.

The level of traffic sounds generally depends on the overall number, type and speed of the vehicles (especially trucks), pavement type and the distance between the source (traffic) and the receptor (human). Any condition (such as a steep incline) that causes heavy laboring of a vehicle's engine would also affect the overall level of traffic sounds.

There are additional, more complicated factors that affect the level of traffic sounds, including elevated or depressed roadways/terrain, surface absorption.

Some of the more common factors that influence the level of traffic sounds at a receptor are outlined in **Table 2**. These cause-and-effect relationships can be used throughout the traffic noise analysis to double-check preliminary and final calculations; however, they are not to be used in the place of actual sound level measurements and/or modeling.

Table 2
Cause-and-Effect Relationships dB(A)*

Cause-and-Effect Relationships dB(A)*		
Change**	**Increase**	**Decrease**
Traffic count doubled	3	
Speed limit lowered by 5 mph		1
Depressed roadway		3-5
Elevated roadway		3-5***
Distance doubled over pavement		3
Distance doubled over grass		4
Effects are Cumulative		
Speed limit lowered by 5 mph + Distance doubled over grass		5

* These figures are approximations and are not to be used to calculate sound levels.

** Assumes that all other factors remain constant.

*** For nearby receptors - may actually increase slightly at more distant receptors because of possible reductions in shielding and/or surface absorption.

3.1.5 Loudness

The term “loudness” is used to describe the manner in which people perceive the intensity of sound.

The loudness level is based on a subjective comparison of different sounds under controlled laboratory conditions.

The human ear is a far better detector of relative (comparative) differences in sound levels than absolute levels. **Table 3** depicts the relationship between changes in sound levels and the perceived change in loudness.

Table 3
Sound Level Change vs. Loudness

Sound Level Change vs. Loudness	
Sound Level Change	**Relative Loudness**
1 dB(A)	No perceptible change
3 dB(A)	Barely perceptible change
5 dB(A)	Readily perceptible change
10 dB(A) increase	Perceived as twice as loud

3.2 Noise

Noise is commonly defined as unwanted sound. However, as indicated in the above discussion on loudness, the determination of “unwanted” is very subjective and can vary substantially from one person to another. Therefore, the Federal Highway Administration (FHWA) has established absolute and relative criteria to more objectively determine when traffic sounds reach levels that result in impacts for humans.

3.2.1 Absolute Criterion

Under this criterion, a noise impact occurs when the predicted noise level approaches, equals or exceeds the FHWA Noise Abatement Criteria (NAC) **Table 6**.

3.2.2 Relative Criterion

Under this criterion, a noise impact occurs when the **predicted** noise level “substantially exceeds” the existing level even if it does not approach, equal or exceed the NAC **Table 6.**

3.3 Sound/Noise Levels

Representative sound pressure levels (decibels) for a variety of common outdoor and indoor areas/activities are depicted in **Table 4.**

Table 4
Common Sound/Noise Levels

Common Sound/Noise Levels		
Outdoor	**dB(A)**	**Indoor**
Air horn	110	Rock/Blues Band
Jet Flyover at 1000 feet		Baby Crying
Leaf Blower	100	Subway
Gas Weed Eater		Fire Alarms
Riding Lawn Mower	90	Blender
Gas Edger		Crowded Restaurant
Police Whistle	80	Disposal at 3 feet
Air Conditioner Compressor		Shouting at 3 feet
	70	
		Normal Conversation at 3 feet
Normal Conversation at 3 feet	60	Clothes Dryer at 3 feet
Babbling Brook		Large Business Office
Quiet Urban (daytime)	50	Refrigerator
Quiet Urban (nighttime)	40	Quiet Office/Library
Wilderness	30	
	20	Recording Studio
	10	Threshold of Hearing

4.0 Traffic Noise Analysis

4.1 Planning

Comprehensive planning and coordination should be accomplished as early as possible in the project development process to ensure that comparative analyses of all transportation alternatives include serious consideration for minimizing or avoiding traffic noise impacts. This could reduce or eliminate the need for costly abatement later in the design process.

4.2 Requirements

A traffic noise analysis is required for all federal, federal-aid, and state funded Type I roadway projects**.**

4.3 Objectives

The major objectives of a traffic noise analysis are to:

- Identify areas where possible noise impacts may occur for each project alternative.
- Consider and evaluate abatement measures to mitigate these impacts.
- Propose implementation of feasible and reasonable abatement measures.
- Communicate the results to the public and local officials.

4.4 Documentation

A traffic noise analysis is designed to provide comprehensive information to the public and local government and elected officials. **TxDOT's Environmental Affairs Division shall provide to District Environmental Coordinators current examples of traffic noise analysis and abatement documentation.**

4.4.1 Public

The analysis should clearly, concisely and accurately provide individuals affected by a roadway project with a basic understanding of traffic noise fundamentals, regulatory requirements, the traffic noise analysis process, and any associated impacts/abatement.

4.4.2 Information for Local Officials

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

- Noise compatible planning concepts;

  The best estimation of the future design year noise level contours at various distances from the edge of the nearest travel lane of the highway improvement where the future noise levels "approach" the NAC (66 and 71 dBA) for undeveloped lands or properties within the project limits. The traffic noise analysis should provide government decision- makers with an important element of the overall environmental data needed for an informed selection of a project alternative and for the development of compatible land use plans.

5.0 Traffic Noise Analysis Process

5.1 Determine Need for a Traffic Noise Analysis

Noise analyses are conducted on Type I projects, as required by the FHWA Noise Standard at 23 Code of Federal Regulations (CFR) Part 772. This guidance was developed by TxDOT and reviewed and concurred with by the FHWA. If a project is not a Type I project, a noise analysis will not be conducted. Therefore, the process begins by determining if a proposed project is a Type I project. Type I projects are generally projects to construct roadways on new location, or projects for existing roadways that will substantially change its location or add a through lane.

If a project is identified as Type I, the next step is to identify the area(s) with potential for noise impacts, the associated land uses in each area, the "receptors" of noise in each area, and the applicable Noise Abatement Criteria (NAC) for each receptor identified. All impacted receptors must be identified for each reasonable alternative identified in the NEPA evaluation. Once identified, receptors are classified by land use and the appropriate Activity Category identified in the NAC (see Table 6).

FHWA regulations require that the noise analysis include undeveloped land that is permitted. TxDOT has defined permitted as undeveloped lots which have had building permits issued for construction by local authorities. If no zoning or building permit process is in place then land is considered undeveloped.

FHWA also requires TxDOT to identify the date when the public is officially notified of the adoption of the location of a proposed highway project. This date establishes the "date of public knowledge" and determines the date when the FHWA and TxDOT are no longer responsible for providing highway traffic noise abatement for new development, which occurs adjacent to the proposed highway project. TxDOT has defined this as the date that the final NEPA approval is made (approval of Categorical Exclusion, Finding of No Significant Impact or Record of Decision). FHWA and TxDOT are not responsible for providing highway traffic noise abatement for development that has been determined to be permitted (building permits have been issued) after the "date of public knowledge" (NEPA approval).

As soon as it is determined that a traffic noise analysis will be required for a highway project, a request for existing and predicted traffic data should be submitted in writing to TxDOT's Transportation Planning and Programming Division (TPP). If this information is obtained from a source other than TxDOT/TPP, such as a Metropolitan Planning Organization or city planning staff, it should be provided to TxDOT/TPP for review and approval.

NOTE: Use Design Volume (DNV), not Average Daily Traffic (ADT) to model traffic noise levels.

- **Existing Traffic:** This should reflect the traffic data for the current (existing) year and roadways. This data may be collected on-site.
- **Predicted Traffic:** This should reflect traffic data for the design year. The design year is normally 20 years from the current/existing year.
- **Speed Limits:** Normally, the posted speed limit is used to determine noise levels. However, the average operating speed may be used if it is determined to be **consistently higher** than the posted speed limit.

5.2 Determination of Existing Noise Levels

Determining existing noise levels is started by measuring the noise at each receptor or representative set of receptors (for very large numbers of receptors). These measurements must be taken at a time of day that reflects the loudest hourly highway traffic noise levels occurring on a regular basis under normal traffic conditions, (Level of Service C). It is possible that the period with the loudest sound levels is not at the peak traffic hour, but instead, during some period when traffic volumes are lower but the truck mix or vehicle speeds are higher. Measurement should be in units of decibel Leq (dBA).

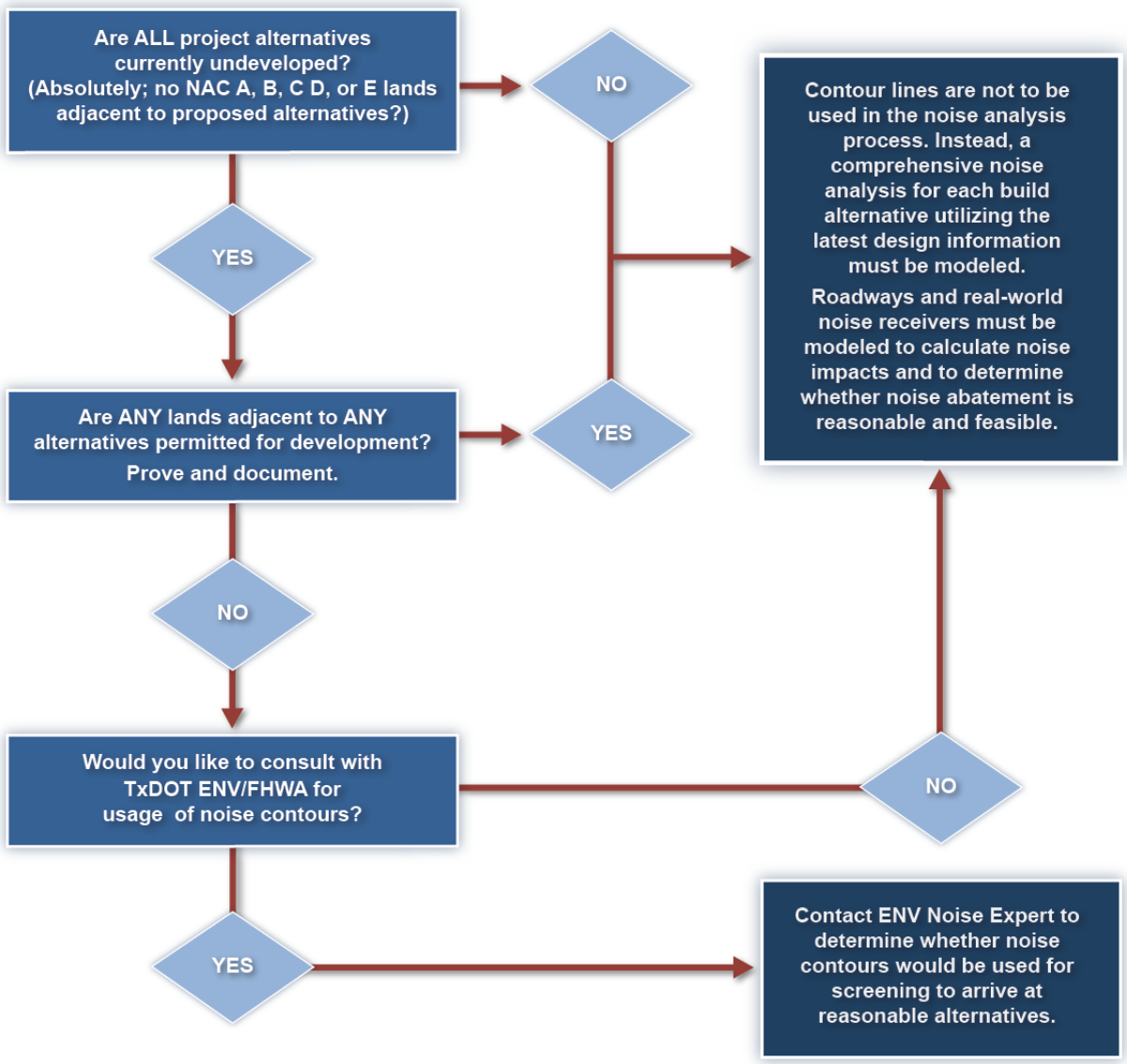
Receptors should be located at a location where frequent human activity occurs. This may be a yard, patio, or other area of frequent use depending on the particular location. The choice of receptor location must be documented for later verification, if needed. Noise meter measurements must be taken to determine existing noise levels for proposed roadways on new alignments where there is currently no roadway. For existing locations, if on-site noise meter measurements are not possible, then estimates must be made according to the FHWA Traffic Noise Model (FHWA TNM). The most current version of the FHWA TNM computer model must be used in the noise analysis, and if appropriate should be validated with noise measurements taken at noise receptors. For receptors that are determined to be NAC category D, refer to Table 5 to determine interior noise reduction factors.

5.3 Prediction of Future Noise Levels

Predicted noise levels should be derived according to the most current version of FHWA TNM. Input data such as future traffic volumes, traffic speed, and percent of vehicle types should reflect the traffic characteristics which yield the loudest hourly traffic noise levels on a regular basis under normal conditions. The period with the loudest traffic noise levels may not be at the peak traffic hour which traffic is moving at slower speeds. For receptors that are determined to be NAC category D, refer to Table 5 to determine interior noise reduction factors. Noise analyses are conducted for all alternatives under detailed study.

Noise contours shall be used as an aid to future planning, but their usage for project alternative screening to arrive at reasonable alternatives is limited. The following flowchart explains circumstances when noise contours may be useful in the project alternative screening process. In no circumstances shall noise contours be used for determining highway traffic noise impacts or the feasibility and reasonableness of noise

Utilization of contour lines for alternatives screening



5.4 Identification of Impacted Receptors

Traffic noise receptors are identified as "impacted" under either of two conditions:

- The predicted noise levels approach (TxDOT defines as 1 dBA) or exceed the NAC (see Table 6); or
- The predicted traffic noise levels substantially exceed the existing noise levels (TxDOT defines this as 10 dBA).

The next step is to compare the predicted noise levels for each project alternative under detailed study with the NAC and existing noise levels.

23 CFR 772 requires noise levels at undeveloped land be reported to local officials to facilitate noise compatible land use planning. TxDOT will also inform the officials that new development that is

permitted after the date of public knowledge will not be considered for federally funded noise abatement, unless a future Type I project is proposed.

5.5 Consideration of Abatement

If traffic noise impacts are projected to occur at a receptor, TxDOT must consider measures to mitigate/abate the traffic noise impacts. Once traffic noise impacted receptors have been identified, an assessment must be conducted to evaluate how to abate the noise impacts and determine whether the abatement is both "reasonable" and "feasible".

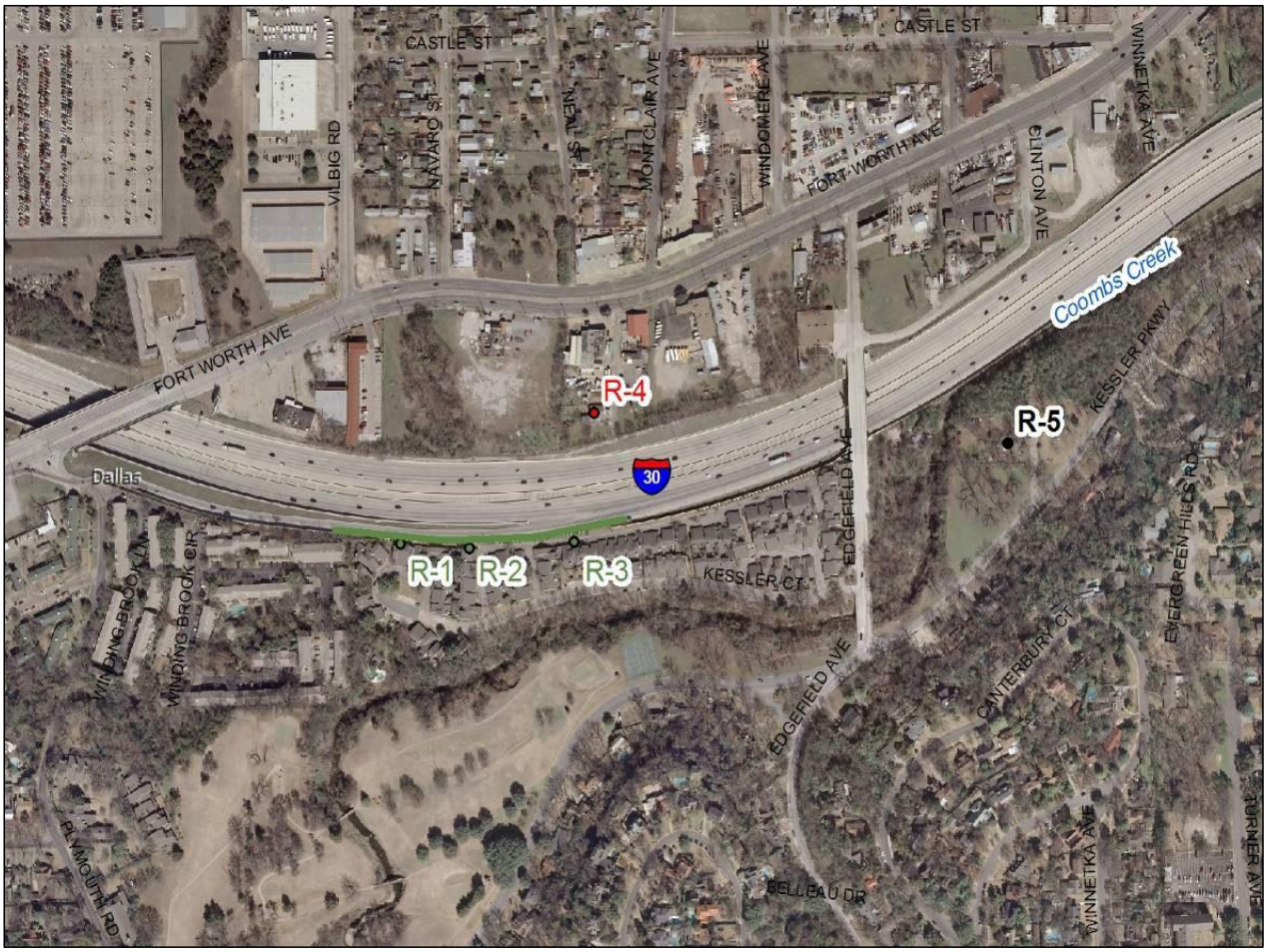
If noise levels at a receptor indicate a noise impact, then noise abatement must be evaluated. The goal of abatement is to provide a substantial reduction of at least seven (7) dB(A) in the design year for first row receptors. The resulting noise level may or may not be at or below the NAC levels.

Traffic noise abatement measures can be in many forms and may include traffic control measures, alteration of vertical or horizontal alignment, acquisition of buffering land, noise insulation of NAC category D, and/or construction of traffic noise barriers. Due to limitations on TxDOT's ability to acquire right-of-way for mitigation or to mitigate sites off of State Right-of-Way, the most common form of abatement is the construction of noise barriers. Other forms of abatement will be evaluated on a case-by-case basis. TxDOT will choose the most feasible and reasonable form of abatement. Noise abatement measures will be evaluated using FHWA TNM to determine their effect on noise levels. All noise abatement incorporated into a Type I project must be feasible and reasonable (see Section II, A. Terms). The final NEPA evaluation will include a summary of this analysis and must include commitments to incorporate any reasonable and feasible noise abatement into the project.

The following discussion assumes that a roadway project would result in a noise impact and that a noise barrier is being proposed as a feasible and reasonable abatement measure.

Initial proposal: Provide sufficient information in the environmental document to verify that a proposed noise barrier is both feasible and reasonable, including (as a minimum):

- Noise barrier proposal table with location and dimensions including exhibits; using the latest aerial photographs or satellite imaging, exhibits must clearly show all modeled receptors. Impacted receptors shall be identified with a **RED font**. Receptors benefitting from a proposed noise barrier shall be identified by a **GREEN font**. Non- impacted receptors shall be identified by a **BLACK** font. Location of proposed noise barrier(s) shall be identified by a **GREEN** line. In addition, all modeled receptors shall have a white background (mask/halo), see following example. If needed, bright **GREEN** may be used. (See example on following page).
- Number of benefitted receptors.
- Total cost and cost for each benefitted receptor.



6.0 Public Involvement

Property owners and residents (first row receptors) who are adjacent to proposed noise barriers will be contacted early in project development and given an opportunity to provide input on their desire to have a barrier. After public hearings, a traffic noise workshop will also be conducted to discuss the results of noise studies and solicit input from the public on barriers to be included in the final design. If a barrier is to be constructed, adjacent property owners will be given options to the esthetic treatment of the barrier facing away from the roadway. TxDOT will select the color and texture of the barrier surface facing the roadway. Barriers proposed early in project development may change due to other revisions to the project scope or alignment. If a barrier's status (reasonableness and/or feasibleness) changes, additional notification will be made to affected property owners to discuss the changes.

7.0 Construction Noise Documentation

It is difficult to predict levels of construction noise at a particular receptor or group of receptors. 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 receptors 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. TxDOT contractors and developers shall comply with local construction noise ordinances.

8.0 Information for Local Officials

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

- Noise compatible planning concepts;
- 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 “approach” the NAC (66 and 71 dBA) for undeveloped lands or properties within the project limits. The traffic noise analysis should provide government decision-makers with an important element of the overall environmental data needed for an informed selection of a project alternative and for the development of compatible land use plans.
- Date of Public Knowledge - This date establishes the "date of public knowledge" and determines the date when the FHWA and highway agencies are no longer responsible for providing highway traffic noise abatement for new development which occurs adjacent to the proposed highway project. The "date of public knowledge" cannot precede the date of approval of the Categorical Exclusion (CE), the Finding of No Significant Impact (FONSI), or the Record of Decision (ROD).

The FHWA and TxDOT are not responsible for providing highway traffic noise abatement for development permitted after the “date of public knowledge”. However, for Type I project, the FHWA and TxDOT are responsible for analyzing and documenting the existing and future levels on these lands. TxDOT should make local governments aware of these results.

9.0 Documentation of Traffic Noise Analysis

NOTE: Each topic to be addressed in the documentation of a traffic analysis is included in the examples of recommended text at: http://crossroads/org/env/Guidance/Traffic/default.htm

File Name	Description
Example 1	Analysis Not Required
Example 2	Typical Analysis -- No Impact
Example 3	Typical Analysis -- Impact with No Feasible & Reasonable Abatement
Example 4	Typical Analysis -- Impact with Feasible & Reasonable Abatement
Example 5	Atypical Analysis – All Undeveloped Land
Example 6	Combined Analysis -- Developed (no impact) and Undeveloped Land
Example 7	Analysis Reevaluation
Example 8	Atypical Analysis – NAC F – All Retail or Industrial Development and Undeveloped
Example 9	Atypical Analysis – NAC F – All Retail

NOTE: Do not include technical data, such as TNM .dat, .dxf or design/.dgn files in the documentation of a traffic noise analysis. However, this information should be maintained on file for future reference as necessary.

Table 5
Interior Noise Reduction Factors

Interior Noise Reduction Factors		
Building Type	**Window Condition**	**Noise Reduction**
All	Open	10 dB
Light frame	Ordinary sash (closed)	20 dB
	Storm windows	25 dB
Masonry	Single glazed	25 dB
	Double glazed	35 dB

Table 6
Noise Abatement Criteria

Noise Abatement Criteria		
Activity Category	**FHWA (dB(A) Leq)**	**Description of Land Use Activity Areas**
A	57 (exterior)	Lands on which serenity and quiet are of extra-ordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose.
B	67 (exterior)	Residential
C	67 (exterior)	Active sport areas, amphitheaters, auditoriums, campgrounds, cemeteries, day care centers, hospitals, libraries, medical facilities, parks, picnic 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 (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	72 (exterior)	Hotels, motels, offices, restaurants/bars, and other developed lands, properties, or activities not included in A-D or F.
F	--	Agricultural, 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.

Appendix A

Texas Department of Transportation

MEMORANDUM

TO: District Engineers
Division/Office Directors
Regional Office

DATE: November 15, 2010

From: Dianna F. Noble, P.E.

SUBJECT: Guidance for Highway Traffic Noise Analysis and Abatement

The Federal Highway Administration (FHWA) published a final rule updating 23 CFR 772 on July 13, 2010. The final rulemaking requires the Texas Department of Transportation (TxDOT) to revise its current noise policy in accordance with the rule, and will become effective on July 13, 2011. The purpose of this memorandum is to provide guidance for highway traffic noise in the state of Texas due to the upcoming requirements.

Any traffic noise analysis and proposed abatement, final design analysis or noise workshop held prior to July 13, 2011, must comply in accordance to the current TxDOT Guidelines for Analysis and Abatement of Highway Traffic Noise, dated July 1997. For noise purposes only, final design refers to the approved schematic for public involvement.

Any traffic noise analysis and proposed abatement, final design analysis or noise workshop completed after July 13, 2011, must comply with the new rule for 23 CFR 772 (attached) and the revised TxDOT Guidelines for Analysis and Abatement of Highway Noise Traffic Guidelines. These Guidelines are currently being updated and will be sent out to the urban districts and RECs for review in mid-November.

Please provide this information to your consultants. Contact Jenise Walton, Supervisor of the Human Environmental Branch, at (512) 416-2763, or Jenise.Walton@txdot.gov if you have any questions.

Attachment

cc: Administration
District Environmental Coordinators
District TP&Ds
Regional Environmental Coordinators

Appendix B

The following table shows the revision history for this guidance document.

Revision History	
Effective Date Month, Year	**Reason for and Description of Change**
March 2011	23 CFR 772 Final Rule and Revision of Noise Policy