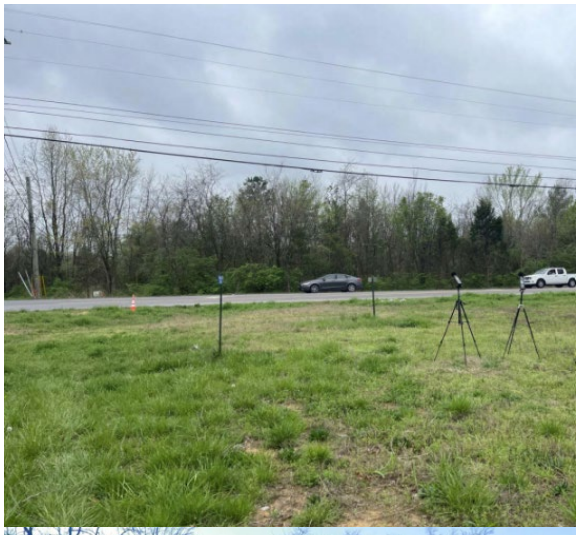

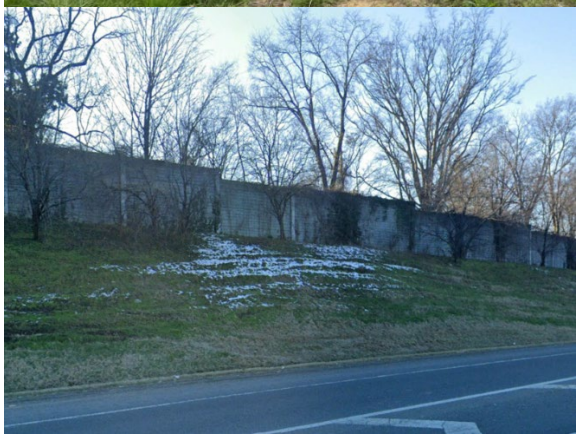

Tennessee Department of Transportation

Environmental Division

Guidance on Highway Traffic Noise Abatement

Issued by the Environmental Division,
Air & Noise Unit

October 2025

RESPONSIBLE OFFICE: Environmental Division

AUTHORITY: This guidance is authorized under the powers granted by the Commissioner of the Tennessee Department of Transportation (TDOT) in T.C.A. 4-3-2303 Et. Seq.

This guidance also complies with the requirements of the Federal Highway Administration (FHWA) regulations for the identification of highway traffic noise impacts contained in 23 CFR, Chapter I, Subchapter H, Part 772, "Procedures for Abatement of Highway Traffic Noise and Construction Noise" July 13, 2010.

If any portion of this guidance conflicts with applicable state or federal laws or regulations, that portion shall be considered void. The remainder of this guidance shall not be affected thereby and shall remain in full force and effect.

This guidance has been reviewed and approved by FHWA.

PURPOSE: This guidance describes TDOT's program to implement 23 CFR Part 772. Where 23 CFR 772 and FHWA allows state highway agencies flexibility in implementing the procedures, this guidance describes TDOT's approach to implementation.

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SECTION 1.0- DEFINITIONS (23 CFR 772.5) & QUALIFICATIONS:

1.1 DEFINITIONS:

Abatement - Measures used to reduce traffic noise levels. The use of quieter pavements and the planting of vegetation are not acceptable federal-aid noise abatement measures for federal projects.

Approach - As used in 23 CFR 772.11(e), one-hour equivalent sound levels [L_{Aeq}(h)] that are one decibel or less below the levels shown in Table 2 of this guidance.

Benefited Receptor - The recipient of an abatement measure that receives a noise reduction at or above the minimum threshold of 5 dBA regardless of whether or not the receptor is "impacted."

Common Noise Environment - A group of receptors within the same Activity Category in Table 1 that are exposed to similar noise sources and levels, traffic volumes, traffic mix and speed; and topographic features. Generally, common noise environments occur between two secondary noise sources such as interchanges, intersections, or cross-roads.

Date of Public Knowledge - The date of approval of the first Categorical Exclusion (CE), the Finding of No Significant Impact (FONSI), or the Record of Decision (ROD), as defined in 23 CFR 771.

Decibel (dB) - A measure used to express the relative level of a sound in comparison with a standard reference level. For traffic noise purposes, the A-weighted scale, which closely approximates the frequency response of the human ear to typical environmental sound levels, is used. The A-weighted sound level in decibels has the unit dB(A).

Design Year - The future year used to estimate the probable traffic volume for which a highway is designed, often 20 years into the future.

Existing Noise Level - The worst noise hour resulting from the combination of natural and mechanical sources and human activity usually present in a particular area.

Feasibility – One of two criteria (see reasonableness) used to evaluate a noise abatement measure. The combination of acoustical and engineering factors considered in the evaluation of a noise abatement measure (23 CFR). Deals with engineering considerations and the ability to achieve a 5 dB noise reduction.

First-Row Receptors - Receptors directly adjacent to the highway, at nearly the same elevation, with no intervening developed lands. Receptors with intervening developed parcels separating the receptor parcel from abutting the roadway right-of-way are generally considered second row or greater.

Frequent Human Use – an activity that results in prolonged humane exposure to traffic noise regularly over the course of a year at a specific location.

Future Noise Level - The predicted worst one-hour equivalent sound level in dBA in the design year.

Impacted Receptor - A receptor that has a traffic noise impact.

L_{10} - The sound level that is exceeded 10 percent of the time (the 90th percentile) for the period under consideration, with $L_{10}(h)$ being the hourly value of L_{10}.

L_{eq} - The equivalent steady-state sound level which in a stated period of time contains the same acoustic energy as the time-varying sound level during the same time period, with $L_{eq}(h)$ being the hourly value of L_{eq}.

L_{Aeq} - the A-weighted equivalent steady-state sound level that in a stated period of time contains the same acoustic energy as the time-varying sound level during the same time period.

$L_{Aeq}(h)$ - the hourly value of L_{Aeq}.

Multifamily Dwelling - A residential structure containing more than one residence. Each residence in a multifamily dwelling shall be counted as one receptor when determining impacted and benefited receptors.

The National Environmental Policy Act (NEPA)- Environmental law that requires federal agencies to assess the environmental effects of their proposed actions prior to making decisions.

Noise Abatement Criteria (NAC) - The Noise Abatement Criteria shown in Table 1 of this Guidance.

Noise Barrier - A physical obstruction that is constructed between the highway noise source and the noise sensitive receptor(s) that lowers the noise level, including standalone noise walls, noise berms (earth or other material) and combination berm/wall systems.

Noise Measurement Field Guide (FHWA-HEP-18-066)- The Federal Highway Field Guide provides a series of checklists and steps for the proper development, planning, preparation, and execution of a noise measurement effort for many of the measurement methodologies in the noise measurement handbook.

Noise Measurement Handbook (FHWA-HEP-18-065) - The Federal Highway Administrations handbook that provides best-practice guidance on recognizing which measurement methodologies and related considerations, terminology, and measurement instrumentation related to highway traffic noise, example report documentation for measurements and supporting material for various methodologies.

Noise Reduction Design Goal – The predicted minimum noise level reduction provided by the noise abatement measure. TDOT's noise reduction design goal is 7 dB(A) and must be achieved at 60% or more of the first-row benefited receptors or the abatement measure is not reasonable.

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.

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.

Reasonableness - One of two criteria (see "feasibility") used to evaluate a noise abatement measure. Reasonableness weighs the amount of required noise barrier area against the benefits that would be provided by the barrier.

Receptor - A discrete or representative location of a noise sensitive area(s) for any of the land uses listed in Table 2.

Residence - Either a single-family residence or each dwelling unit in a multi-family dwelling.

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.

Traffic Noise Impacts - Impacts that occur when the predicted design year traffic noise levels for the Build Alternative(s) approach or exceed the NAC or when the predicted design year traffic noise levels for the Build Alternative(s) substantially exceed the existing noise levels.

Type I Project - A project shall be considered Type I if it meets any of the following conditions:

- The construction of a highway at new location
- 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
    - **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
- The addition of a through-traffic lane(s). This includes the addition of lanes used as High-Occupancy Vehicle (HOV) lanes, High- Occupancy Toll (HOT) lanes, bus lanes or truck climbing lanes
- The addition of an auxiliary lane, expect when planned as a turn lane.
- The 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

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 voluntary federal or federal-aid highway project for noise abatement on an existing highway. TDOT does not participate in this program.

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

APPLICATION: This guidance applies to all federal or federal-aid highway projects authorized under Title 23, United States Code and does not cover non-federal aid projects. Therefore, this guidance applies to any highway project or multimodal project that:

- Requires FHWA approval regardless of funding sources
- Is funded with Federal-aid highway funds.

To obtain FHWA approval, the highway agency is required to develop guidance on highway traffic noise abatement in conformance with this regulation and shall apply these uniformly and consistently statewide.

This guidance applies to all federally funded Type I projects unless the regulation specifically indicates that a section only applies to Type II or Type III projects.

1.2 QUALIFICATIONS NECESSARY TO CONDUCT NOISE STUDIES:

Only individuals (TDOT or consultant) qualified in the field of highway traffic noise analysis shall conduct highway traffic noise studies for TDOT projects or local government projects that will utilize federal or state funding. The individual must meet minimum qualifications:

- Documented experience in conducing highway traffic noise analyses for transportation projects in accordance with 23 CFR 772
- Familiarity with TDOT's Noise Guidance
- Documented experience conducting noise measurements in accordance with FHWA-HEP-18-065 (Noise Measurement Handbook)
- Successful completion of the following formal training before conducting work on TDOT noise studies:
    - Highway Traffic Noise Analysis Training
    - FHWA Traffic Noise Model (TNM) Training
- Additional Training available through the National Highway Institute Learning Portal

TDOT may request that analysts provide documentation of the above training before or during the conduct of the noise study. TDOT may also request documentation of other noise studies that the analyst has completed.

SECTION 2.0- ANALYSIS

The primary goal of conducting noise studies is to ensure that the information derived and related conclusions are accurate and pertinent to the decision-making process.

To facilitate this goal, noise studies should accurately identify all noise-sensitive land uses that are predicted to be impacted under each Build Alternative in the design year and properly assess the potential for noise abatement measures to mitigate the predicted impacts.

The analysis procedure described below provides the basic framework for conducting a highway traffic noise study in Tennessee. More detailed technical guidance is provided in the TDOT Noise Procedures. Analysts should use both this guidance and the detailed procedures described in the Noise Procedures when conducting highway traffic noise studies.

2.1 ANALYSIS LOCATIONS

Traffic noise analysis will be performed within the project limits for developed lands containing noise-sensitive land uses in Categories A through E in Table 1 and for undeveloped land where development is permitted.

Developed lands include Activity Category A, B, C, and E land uses with exterior areas of frequent human use, as well as qualifying Category D land use.

The receivers chosen for modeling will be outdoor areas where frequent human use occurs and are not constrained by property lines. These outdoor areas could be patios, decks, balconies, common grounds areas or other appropriate locations.

2.2 DETERMINATION OF EXISTING NOISE LEVELS

The determination of existing noise levels will be made utilizing field measurement of actual sound levels and/or the prediction of existing sound levels.

The procedure used in determining existing noise levels should be consistent with the methods outlined in the Noise Procedures that consider the type of project (i.e., widening or new alignment) and facility; the extent, level of detail and accuracy of the data available to complete noise modeling for existing conditions; the number of expected impacts; the potential need for evaluation of noise abatement measures; and the effect on the decision-making process.

2.2.1 NOISE MEASUREMENTS

Noise measurements will be conducted at a representative number of noise-sensitive land uses that are likely to be affected by the project. Unless specifically approved by TDOT, field measurements will be taken at locations that are representative of outdoor areas of frequent human use.

Noise measurements should be conducted in accordance with the Noise Measurement Handbook and Field Guide.

2.3 DETERMINATION OF FUTURE NOISE LEVELS

Future noise levels will be determined for the design year for the No-Build and All-Build Alternatives under detailed study in the National Environmental Policy Act (NEPA) process. All analyses must use the FHWA Traffic Noise Model (TNM) version 2.5, which is described in *"FHWA Traffic Noise Model,"* Report No. FHWA-PD-96-010, including all applicable revisions.

TNM noise modeling shall be conducted in accordance with the procedures outlined in the TDOT Noise Procedures located in Appendix B of this document.

Design year sound levels must be predicted for the worst-noise hour, which would normally occur when the highest traffic volume can travel at the highest possible speed.

Traffic projections developed for the project typically include traffic volumes for the design hour, which is often representative of Level of Service (LOS) C operating conditions. These design hour volumes (DHV) should be used for the noise analysis since they represent the highest number of vehicles expected to travel on the roadway network in a given hour.

Average pavement type must be used for prediction of design year noise levels.

2.4 DETERMINATION OF TRAFFIC NOISE IMPACT

Traffic noise impacts may occur when design year build condition noise levels approach or exceed the NAC (Table 2) located in Appendix A for the future build condition; or design year build condition noise levels that create a substantial noise increase over existing noise levels.

2.4.1 SUBSTANTIAL NOISE INCREASE

A highway noise increase of 5 to 15 dB (A) in the design year over existing noise levels signifies an impact for a Type I project as shown in Table 2.

2.4.2 NOISE ABATEMENT CRITERIA

When the future noise levels approach, equal or exceed the FHWA's noise abatement criteria shown in Table 1.

For Category A Land Use, TDOT will submit a Proposal for Justification for Designating Land Use as Category A to the FHWA Division Office for approval prior to assigning this category.

Category B Land Use includes all single and multi-family residences. Hotels and motels that function as apartment dwellings should be treated as Category B.

If a Category C Land Use has both exterior and interior areas of frequent human use, the exterior area should be analyzed for impact as Category C. If there are no exterior areas of frequent human use or the exterior area is far from or physically shielded from the roadway in a matter that prevents an impact on the exterior areas, then the interior area should be analyzed for impact as Category D.

A Category D land use includes the interior for certain facilities list in Category C. Indoor analysis will only be conducted after a determination is made that exterior abatement measures will not be feasible or reasonable.

SECTION 3.0- EVALUATION OF NOISE ABATEMENT MEASURES

Noise abatement shall be evaluated when noise impacts are predicted in the design year for the Build Alternative(s). At a minimum, TDOT will consider noise abatement in the form of a noise barrier.

TDOT may also consider the following noise abatement measures for Type I projects on a case- by-case basis:

- traffic management measures such as traffic control devices and signing for prohibition of certain vehicle types, time-use restrictions for certain vehicle types, and exclusive lane designations
- alteration of horizontal and vertical alignments
- acquisition of property rights for construction of noise barriers
- noise insulation of Category D land uses.

3.1 MULTISTORY BUILDINGS

Each multi-level dwelling consisting of a single residential unit (e.g., two-story condo) is considered one receptor. When a residential structure contains more than one residence, each residence in a multifamily dwelling shall be counted as one receptor when determining impacted and benefited receptors. If any of the upper floor exterior balconies in multi-family dwellings are benefited as a result of a noise abatement design, then these upper floor units will be included in the reasonableness analysis.

3.2 DATE OF PUBLIC KNOWLEDGE

Federal participation in noise abatement measures will not be considered for lands that are not permitted by the date of public knowledge of the project, and TDOT will not analyze or provide noise abatement for these lands. After the date of public approval which is determined by either the date of approval of a Categorical Exclusion (CE), the Finding of No Significant Impact (FONSI), or the Record of Decision (ROD), the provisions of noise abatement becomes the responsibility of local communities or private developers.

3.3 NOISE ABATEMENT FEASIBILITY AND REASONABLENESS

Noise abatement measures must be feasible and reasonable, as defined below.

- Feasibility deals with engineering considerations and the ability to achieve a 5 dB noise reduction.
- Reasonableness compares the area of the required noise barrier and the number of benefited property owners and residents. The viewpoints of the benefited property owners and residents will be considered by TDOT in its final decision regarding reasonableness.

3.3.1 FEASIBILITY

For the noise abatement measure to be feasible it must meet the listed criteria:

- In order for the noise abatement measure to be feasible, the measure should provide a minimum of 5 dB reduction in design year highway traffic noise levels for the majority of the benefited first-row receptors.
- 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).

3.3.2 REASONABLENESS

Noise abatement will only be evaluated where noise impacts are predicted and where frequent human use occurs. Primary consideration will be given to exterior areas. Reasonableness will only be evaluated if the Feasibility criteria have been met.

3.3.2.1 NOISE REDUCTION DESIGN GOAL

The noise abatement measure shall provide at least 7 dB noise reduction at 60% or more of the first-row benefited receptors. For impacted Category D land uses, the noise abatement measure should provide a minimum 7 dB reduction in interior noise levels for the impacted areas.

3.3.2.2 CATEGORY B (RESIDENTIAL) LAND USES

For a noise abatement measure to be reasonable, the required barrier area (in square feet) per benefited residence must be less than or equal to the allowable barrier area per benefited residence for that noise abatement location.

The allowable barrier area per benefited residence for each noise abatement location is calculated using the following equation:

Allowable Area per Benefited Residence

$$Base\ Allowance + Previous\ Type\ 1\ Widening + Design\ Year\ Noise\ Levels + Noise\ Level\ Increase + Noise\ Compatible\ Planning = Total\ Allowable\ Area\ per\ Benefited\ Residence$$

The value for each allowance type should be selected based on the criteria outlined in the Table 3.

The reasonableness determination for Category B residential land uses that do not have dedicated exterior areas such as patios or balconies but do have common areas such as picnic areas, swimming pools, etc., will be evaluated in accordance with the procedures for Category C land uses described below.

3.3.2.3 Category C, Category D and Category E Land Uses

The reasonableness determination for Category C, D and E land uses requires the calculation of an equivalent number of residences based on the size, type and duration of the activity. The procedures for calculating the equivalent number of residences are contained in the noise procedures (Appendix B).

The allowable barrier area per equivalent benefited residence for each noise abatement location is calculated using the reasonableness calculation provided in the previous section.

The abatement measure will be reasonable if the required barrier area (in square feet) per equivalent benefited residence is less than or equal to the allowable barrier area per equivalent benefited residence for that noise abatement location.

3.3.2.4 Viewpoints of Benefited Property Owners and Residents

The input of the benefited property owners and residents will be solicited with formal survey by certified mail. TDOT will conclude that a community desires the construction of a noise barrier unless a majority (more than 50%) of the benefited property owners and residents indicate that they do not want the proposed noise barrier.

3.3.3 THIRD-PARTY FUNDING

Third-party funding is not allowed on a Federal or Federal-aid Type I 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 project to make functional enhancements (such as absorptive treatment, access doors, aesthetic enhancements) to a noise abatement measure already determined to be feasible and reasonable.

3.3.4 ABSORPTIVE TREATMENTS

TDOT will utilize absorptive noise barriers for all projects that involve the construction of noise barriers.

SECTION- 4.0 INFORMATION FOR LOCAL OFFICIALS

TDOT and the FHWA believe that highway traffic noise should be reduced through a program of shared responsibility. Local governments should use their power to regulate land development in such a way that noise-sensitive land uses are either prohibited from being located adjacent to a highway or that the developments are planned, designed, and constructed in such a way that noise impacts are minimized.

To minimize future traffic noise impacts on currently undeveloped lands adjacent to Type I projects, TDOT will provide local officials -with this information in the noise technical report- within whose jurisdiction the highway project is located with the following:

- Information on 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 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 2.

SECTION 5.0- CONSTRUCTION NOISE

Construction of a highway project may cause localized, short-duration noise impacts. The contractor will be bound by the *Standard Specifications* to observe any noise ordinance in effect within the project limits.

For all Type 1 project, the agency shall:

- Identify land uses or activities that may be affected by noise from construction of the project. The identification is to be performed during the project development studies.

- Determine the measures that are needed in the plans and specifications to minimize or eliminate adverse construction noise impacts to the community. This determination shall include a weighing of the benefits achieved and the overall adverse social, economic, and environmental effects and costs of the abatement measures.

- Incorporate the needed abatement measures in the plans and specifications.

Calculation of construction noise levels is usually not necessary for highway traffic noise analyses. 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.

SECTION 6.0- DOCUMENTATION OF HIGHWAY TRAFFIC NOISE ABATEMENT

TDOT will identify the following for a Type 1 project within the CE, FONSI, or ROD:

- Locations where noise impacts are predicted to occur but where noise abatement is not feasible and/or reasonable.
- A statement of likelihood for noise abatement measures that are feasible and reasonable, and which are likely to be incorporated in the project. The statement of likelihood shall include the preliminary location and physical description of noise abatement measures determined feasible and reasonable in the analysis. The statement of likelihood will 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.

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 noiseanalysis.

SECTION 7.0- ABATEMENT MEASURE REPORTING

Per 23 CFR 772, TDOT shall maintain an inventory of all constructed noise abatement measures. The inventory shall include the following parameters: type of abatement; cost (overall cost, unit cost per/sq. ft.); average height; length; area; location (State, county, city, route); year of construction; average insertion loss/noise reduction as reported by the model in the noise analysis; NAC category(s) protected; material(s) used (precast concrete, berm, block, cast in place concrete, brick, metal, wood, fiberglass, combination, plastic (transparent, opaque, other); features (absorptive, reflective, surface texture); foundation (ground mounted, on structure); and project type. The FHWA will collect this information, in accordance with OMB's Information Collection requirements.

APPENDIX A - TABLES

Table 1: Noise Abatement Criteria
[Hourly A-weighted Sound Level, decibels (dBA)]

Activity Category	$L_{Aeq}(h)$	*Evaluation Location*	*Activity Description*
A	57	Exterior	Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose.
B[(1)]	67	Exterior	Residential.
C[(1)]	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 structure, radio stations, 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 structure, radio studios, recording studios, schools, and television studios.
E[(1)]	72	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) Includes undeveloped lands permitted for this activity category.

Table 2: Substantial Noise Level Increase

Existing Noise Level (dBA) [(1)]	***Predicted Design Year Noise Level Increase (dB)*** [(2)]
42 or less	15 or more
43	14 or more
44	13 or more
45	12 or more
46	11 or more
47 or more	10 or more

(1) Worst hour noise level from the combination of natural and m human activity.
(2) Predicted design year noise level minus existing noise level.

Table 3: Reasonableness Allowances for Abatement Evaluation

Allowance Type	Criteria	Allowance in square feet
Base Allowance	Residences pre-date the highway(1) or the project is on a new alignment.	1,500
	Residences post-date the highway(2) but were constructed before September 16, 2005. (3)	750
	Residences were constructed after September 16, 2005.(3)	250
Previous Type I Widening Allowance	Residences pre-date a Type I widening project on the adjacent highway.	200
Design Year Noise Levels Allowance(4)	69 or less dBA	0
	70 – 74 dBA	100
	75 or more dBA	200
Noise Level Increase Allowance	0 – 4 dB	0
	5 – 9 dB	200
	10 or more dB	400
Noise Compatible Planning Allowance	The local government of the jurisdiction in which the project will be constructed has no policies to require that noise be considered in the land development process.	0
	The local government of the jurisdiction in which the project will be constructed has adopted official and enforceable policies to require that noise be considered as an integral component of the land development process.	100

(1) The majority (more than 50%) of residences existed before the original highway construction.
(2) The majority (more than 50%) of residences were constructed after the original highway construction.
(3) The majority (more than 50%) of residences existed before the most recent Type I project that added through traffic lanes.
(4) An average of the increases from existing noise levels to design year noise levels for the Build Alternative at the impacted first-row receivers.

Appendix B: Noise Procedures

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1.0 Introduction

Pursuant to the Federal Highway Administration (FHWA) noise regulation, *Procedures for Abatement of Highway Traffic and Construction Noise*, *23 CFR 772* (July 13, 2010), the Tennessee Department of Transportation's (TDOT's) Noise Guidance, *Guidance on Highway Traffic Noise Abatement,* provides the requirements for evaluating highway traffic noise for TDOT projects.

These noise procedures provide detailed supplemental technical guidance for conducting the required highway traffic noise studies for federal-aid highway projects per federal regulations and TDOT's Noise Guidance.

2.0 Legislation, Regulations, and Policies

2.1 NEPA

The National Environmental Policy Act of 1969 (NEPA) established a national environmental policy and created the Council on Environmental Quality (CEQ). The purpose of NEPA is to minimize or eliminate damage to the environment caused by federal actions or actions supported using federal funds. NEPA provides broad authority and responsibility for evaluating and mitigating adverse environmental effects including those resulting from highway traffic noise.

2.2 1970 Federal-Aid Highway Act

The Federal Aid Highway Act of 1970 (FAHA 1970) mandated that FHWA develop "noise standards" for identifying noise impacts and evaluating noise mitigation for federal projects. FAHA 1970 also stipulated that FHWA should not approve plans and specifications for federal projects unless the project includes adequate noise abatement measures.

2.3 FHWA Noise Regulation (23 CFR 772)

The FHWA Noise Regulation was developed in response to FAHA 1970. The Regulation has been modified over time as summarized below:

- 1973 - *Policy and Procedures Manual (PPM) 90-2.*
- 1976 - *Federal Highway Procedures Manual 7-7-3 (FHPM 773).*
- 1982 - *Procedures for Abatement of Highway Traffic Noise and Construction Noise, 23 CFR 772.*
- 1997 – *Procedures for Abatement of Highway Traffic Noise and Construction Noise, 23 CFR 772:* Revised eligibility for Type II projects.
- 2005 - *Procedures for Abatement of Highway Traffic Noise and Construction Noise, 23 CFR 772:* Revised to require FHWA's Traffic Noise Model (TNM) for highway traffic noise analyses.
- July 13, 2010 - *Procedures for Abatement of Highway Traffic Noise and Construction Noise, 23 CFR 772:* Revised to add definitions and to clarify the applicability of the regulation, certain analysis requirements, and the use of Federal funds for noise abatement measures.

The purposes of the FHWA Noise Regulation are to:

- Provide procedures for noise studies and noise abatement measures to help protect public health, welfare, and livability
- Supply noise abatement criteria (NAC)
- Establish requirements for information to be given to local officials for use in the planning and design of highways.

2.4 FHWA Guidance

On June 12, 1995, FHWA issued a memorandum requiring states to adopt written statewide noise policies. State agencies have flexibility in establishing their highway traffic noise policies and procedures. However, all policies must demonstrate "substantial compliance" with the FHWA Noise Regulation, and FHWA must review and approve all policies before they become effective.

FHWA concurrently published the document, *Highway Traffic Noise Analysis and Abatement: Policy and Guidance* (FHWA Guidance Document), to aid states in developing their policies. The FHWA Guidance Document was most recently updated in December 2011 to ensure consistency with the July 13, 2010, revision of the FHWA Noise Regulation.

FHWA also developed a list of Frequently Asked Questions (FAQs) to provide additional guidance for implementing the FHWA Noise Regulation on as well as several "Highway Traffic Noise Resources."

2.5 TDOT's Noise Guidance

TDOT's Noise Guidance was developed per the FHWA Noise Regulation and Guidance Document. TDOT's Noise Guidance outlines TDOT's process for making decisions on highway traffic noise abatement to justify the expenditure of public funds most cost-effectively when addressing the total needs of the state's highway system. TDOT's Noise Guidance, is available on TDOT's Environmental Division website.

These noise procedures incorporate additional guidance provided in FHWA's FAQs and Traffic Noise Resources that are available on FHWA's website.

3.0 Qualifications Necessary to Conduct Noise Studies

Only individuals (TDOT or consultant staff) qualified in the field of highway traffic noise analysis shall conduct highway traffic noise studies for TDOT projects or local projects that utilize federal or state funding.

To be qualified, the person performing the analysis must have 1) demonstrated experience in conducting highway traffic noise analyses for transportation projects per the FHWA Noise Regulation, 2) familiarity with TDOT's Noise Guidance, and 3) demonstrated experience conducting noise measurements per FHWA-HEP-18-065, the *"Noise Measurement Handbook."*

Qualified individuals must have successfully completed the following formal training before conducting work on TDOT noise studies:

- Highway Traffic Noise Analysis Training
- TNM Training

TDOT may request documentation of training before or during the conduct of a noise study. TDOT may also request documentation of other noise studies completed by the analyst.

4.0 Definitions

The following definitions are used in these Procedures.

Abatement - measures used to reduce traffic noise levels. The use of quieter pavements and the planting of vegetation are not acceptable Federal-aid noise abatement measures for Federal projects.

Ambient Noise - all-encompassing sound that is associated with a given environment.

Approach - as used in 23 CFR 772.5(g), one-hour equivalent sound levels [L_{eq}(1h)] that are one decibel or less below the levels shown in Table 2.

Attenuation - reduction of the level of sound or noise.

Average Daily Traffic (ADT) - the average number of vehicles passing a specific point in a 24-hour period (given in vehicles per day).

A-Weighted Sound Level (dBA) - the sound level in decibels measured with a frequency weighing network corresponding to the A-scale. The A-scale tends to suppress lower frequencies (i.e. below 1,000 Hz) and best approximates the sound as heard by the human ear.

Benefited Receptor - the recipient of an abatement measure that receives a noise reduction at or above the minimum threshold of 5 dBA regardless of whether the receptor is "impacted."

Common Noise Environment - a group of receptors within the same Activity Category in Table 2 that are exposed to similar noise sources and levels; traffic volumes, traffic mix and speed; and topographic features. Generally, common noise environments occur between two secondary noise sources such as interchanges, intersections, or cross-roads.

Date of Public Knowledge - the date of approval of the first Categorical Exclusion (CE), the Finding of No Significant Impact (FONSI), or the Record of Decision (ROD), as defined in 23 CFR 771.

Decibel (dB) – a measure used to express the relative level of a sound in comparison with a standard reference level. For traffic noise purposes, the A-weighted scale, which closely approximates the frequency response of the human ear to typical environmental sound levels, is used. The A-weighted sound level in decibels has the unit *dBA*.

Design Year - the future year used to estimate the probable traffic volume for which a highway is designed, typically 20 years into the future.

Design Hour Volume (DHV) - the DHV is typically the thirtieth highest hourly traffic volume for the design year, commonly twenty years from the time of construction. The DHV is given in units of vehicles per hour.

Existing Noise Level - the existing worst one-hour equivalent sound level, in dBA, resulting from the natural and mechanical sources and human activity present in a particular area.

Feasibility - one of two criteria (also see "reasonableness") used to evaluate a noise abatement measure. Feasibility deals with engineering considerations and the ability to achieve a 5 dB noise reduction at the majority (>50%) of first-row receptors.

First-Row - receptors directly adjacent to the highway with no intervening developed lands.

Frequent Human Use - an activity that results in prolonged human exposure to traffic noise regularly over the course of a year at a specific location.

Future Noise Level - the predicted worst one-hour equivalent sound level, in dBA, in the design year.

Impacted Receptor - a receptor that has a traffic noise impact.

Insertion Loss - the reduction in $L_{eq}(1h)$ at a location after a noise barrier is constructed.

K- Factor - a percentage applied to the Average Daily Traffic (ADT) to determine the Design Hour Volume (DHV).

L_{Aeq} - the A-weighted equivalent steady-state sound level that, in a stated time period, contains the same acoustic energy as the time-varying sound level during the same time period.

$L_{Aeq}(h)$ - the hourly value of L_{Aeq}.

L_{eq} - The equivalent steady-state sound level which in a stated period of time contains the same acoustic energy as the time-varying sound level during the same time period, with Leq(h) being the hourly value of Leq.

Multifamily Dwelling - a residential structure containing more than one residence. Each residence in a multifamily dwelling shall be counted as one receptor when determining impacted and benefited receptors.

The National Environmental Policy Act (NEPA)- Environmental law that requires federal agencies to assess the environmental effects of their proposed actions prior to making decisions.

Noise - unwanted sound.

Noise Abatement Criteria (NAC) - the Noise Abatement Criteria shown in Table 2 of these Procedures.

Noise Barrier - a physical obstruction that is constructed between the highway noise source and the noise-sensitive receptor(s) that lowers the noise level, including stand-alone noise walls, noise berms (earth or other material), and combination berm/wall systems.

Noise Reduction Design Goal – the predicted minimum noise level reduction provided by the noise abatement measure. TDOT's noise reduction design goal is 7 dB and must be achieved at 60% or more of the first-row benefited receptors or the abatement measure is not reasonable.

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.

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

Reasonableness - one of two criteria (also see "feasibility") used to evaluate a noise abatement measure. Reasonableness weighs the amount of required noise barrier area against the benefits that would be provided by the barrier.

Receptor - a discrete or representative location of a noise-sensitive area(s) for any of the land uses listed in Table 2.

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

Shielding - any man-made or natural structure or barrier that provides an auditory barrier between a receptor and a roadway (e.g.,, the top of a cut or an intervening hill).

Sound Level Meter - a device used to measure sound levels. A sound level meter is also called a sound level analyzer or dosimeter.

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 Noise Increase – an increase in existing noise levels as defined in Table 1 of these Procedures.

Substantial Noise Reduction - a minimum reduction in traffic noise levels of at least 7 dB at the majority of impacted first-row receptors.

Traffic Noise Impacts - impacts that occur when the predicted design year traffic noise levels for the Build Alternative(s) approach or exceed the NAC, or when the predicted design year traffic noise levels for the Build Alternative(s) substantially exceed the existing noise levels.

Type I Project - a Federal or Federal-aid highway project shall be considered Type I if it meets one of the following conditions:

(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 High-Occupancy Vehicle (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 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. TDOT does not participate in this 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.

Worst Noise Hour - a one-hour period during the day that represents the peak noise hour.

5.0 Traffic Noise Terminology

Traffic noise levels are expressed in terms of the hourly, A-weighted equivalent sound level in decibels (dBA). A *sound level* represents the level of the rapid air pressure fluctuations caused by sources, such as traffic, that are heard as noise. A *decibel* is a unit that relates the sound pressure of a noise to the faintest sound the young human ear can hear. The A-weighting refers to the amplification or attenuation of the different frequencies of the sound (subjectively, the pitch) to correspond to the way the human ear "hears" these frequencies. Generally, when the sound level exceeds the mid-60 dBA range, outdoor conversation in normal tones at a distance of three feet becomes difficult. A 9-10 dB increase in sound level is typically judged by the listener to be twice as loud as the original sound while a 9-10 dB reduction is judged to be half as loud. Doubling the number of sources (i.e., vehicles) will increase the hourly equivalent sound level by approximately 3 dB, which is usually the smallest change in hourly equivalent A-weighted sound levels that people can detect without specifically listening for the change.

Because most environmental noise fluctuates from moment to moment, it is standard practice to condense data into a single level called the equivalent sound level (L_{eq}). The L_{eq} is a steady sound level that would contain the same amount of sound energy as the actual time-varying sound evaluated over the same time period. The L_{eq} averages the louder and quieter moments but gives much more weight to the louder moments in the averaging. For traffic noise assessment purposes, L_{eq} is typically evaluated over the worst one-hour period and is defined as $L_{eq}(1h)$.

The term insertion loss (IL) is used to describe the reduction in L_{eq}(1h) at a location after a noise barrier is constructed. For example, if the L_{eq}(1h) at a residence before a barrier is constructed is 75 dBA and the L_{eq}(1h) after a barrier constructed is 65 dBA, then the insertion loss would be 10 dB.

6.0 Noise Study Requirements

Per the FHWA Noise Regulation and TDOT's Noise Guidance, noise studies must be conducted for Type I projects.

6.1 Type I Projects

Type I projects are proposed Federal or Federal-aid highway projects that increase capacity, construct a highway on new location, or physically alters an existing highway in a manner that significantly changes either the horizontal or vertical alignment.

Per the definition in Section 4.0, a project that halves the distance between the traffic noise source and the closest receptor is a Type I project. Halving the distance would increase the noise level at an adjacent receptor by approximately 3 dB.

When assessing whether a project will halve the distance between the noise source and a receptor, the measured distance should be the smallest distance between the modeled receiver and the center of the nearest travel lane.

Although the function of an auxiliary lane differs depending on the type of facility, an auxiliary lane should classify the project as Type I if the auxiliary lane is 2,500 feet (762 meters) or longer (FHWA FAQ C2).

A detailed noise analysis is required for a federal-aid highway Type I project. Noise analyses are not required for projects that are state-funded or Type III regardless of the level of NEPA document.

6.1.1 Noise Screening for Type I Projects

Some Type I projects may not create noise impacts. These might include widening projects on low and medium volume roads, and projects where noise-sensitive land uses are at distances where impacts would not be expected. In these cases, a noise screening analysis should be completed to determine if a detailed noise study is needed.

New alignment projects and other Type I projects that might create impacts due to a *substantial increase* in noise levels require a detailed noise study.

The noise screening steps include:

- Determine if noise-sensitive land uses exist in the project area. If noise-sensitive land uses do not exist, then a noise study is not needed.
- If noise-sensitive land uses exist but it is uncertain if they will be impacted, simplified TNM modeling should be completed to identify the distance to the 66 dBA contour. The TNM model

should represent an at-grade condition with an array of receivers and utilize the proposed cross-section design year traffic projections.

If the predicted noise levels are below the NAC for the identified noise-sensitive land use(s), then a detailed noise study is not needed. A detailed noise study is needed if noise impacts are predicted.

The noise screening analysis should involve a review of project plans as well as aerial photography from web-based mapping sites such as Google Maps, web-based city or county GIS sites, or data from the State of Tennessee Real Estate Assessment Data website. A site visit may be required to establish if any recent development has occurred. The municipal planning or codes department should also be contacted to determine if any building permits have been issued in the project area.

The results of the screening analysis and the conclusion that a detailed noise study is not needed should be summarized in the environmental document along with discussions of information for local officials and construction noise per Sections 7.14 and 7.13 of these Procedures.

7.0 Noise Study Methodology and Procedures

The primary goal of conducting noise studies is to ensure that the results and related conclusions are accurate and pertinent to the decision-making process.

To facilitate this goal, noise studies should 1) accurately identify all noise-sensitive land uses that are predicted to be impacted under each Build Alternative in the design year, and 2) properly assess noise abatement measures for impacted land uses.

This section provides the detailed framework for conducting a highway traffic noise study in Tennessee. Noise studies should include the following tasks:

- Identification of noise-sensitive land uses: Identification of existing land uses in the project area that are sensitive to highway traffic noise;
- Determination of existing noise levels: Measurement and/or prediction of existing worst-hour sound levels at noise-sensitive land uses to characterize the existing noise environment in the project area;
- Determination of future noise levels: Prediction of design year worst-hour noise levels for the Build Alternatives;
- Determination of traffic noise impacts: Determination of traffic noise impacts based on the increase in existing noise levels and predicted design year noise levels;
- Noise abatement evaluation: Evaluation of noise abatement measures for noise-sensitive land uses predicted to be impacted by the project;
- Discussion of construction noise;
- Provision of information for local officials;
- Discussion of meteorological effects on noise levels

Each of these steps and all analysis results should be thoroughly documented in a Noise Technical Report for the project. Each of these analysis steps is discussed in detail below following a discussion of TDOT's criteria for determining noise impacts.

7.1 Criteria for Determining Impacts

Traffic noise impacts occur if 1) the predicted noise level in the design year with the project approaches or exceeds the NAC, or 2) if the project causes a *substantial increase* in existing noise levels.

7.1.1 Substantial Increase

TDOT's criteria to define a substantial noise increase are shown in Table 1.

.

7.1.2 Noise Abatement Criteria (NAC)

Highway traffic noise impacts also occur when the design year noise levels approach, equal, or exceed the FHWA's NAC shown in Table 2. TDOT's Noise Guidance defines "approach" as one decibel below the NAC.

Table 1: Substantial Noise Level Increase

Existing Noise Level (dBA) (1)	Predicted Design Year Noise Level Increase (dB) (2)
42 or less	15 or more
43	14 or more
44	13 or more
45	12 or more
46	11 or more
47 or more	10 or more

(1) Worst hour noise level from the combination of natural and mechanical sources and human activity.
(2) Predicted design year noise level minus existing noise level.

Table 2: Noise Abatement Criteria
[Hourly A-weighted Noise Level, decibels (dBA)]

Activity Category	$L_{Aeq}(h)$	Evaluation Location	Activity Description
A	57	Exterior	Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose.
B(1)	67	Exterior	Residential.
C(1)	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 structure, radio stations, 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 structure, radio studios, recording studios, schools, and television studios.
E(1)	72	Exterior	Hotels, motels, offices, restaurants/bars, RV parks, 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) Includes undeveloped lands permitted for this activity category.

The NAC are not arbitrary. The NAC are based upon noise levels associated with interference of speech communication and are a compromise between noise levels that are “desirable” and those that are achievable. The NAC should not be viewed as desirable noise levels, and they should not be used as goals for noise barrier design.

7.2 Identification of Noise-Sensitive Land Uses

The traffic noise analysis should identify all noise-sensitive land uses within the project limits. These uses include 1) developed lands containing noise-sensitive land uses and 2) undeveloped lands where noise-sensitive development is permitted.

Land uses that are sensitive to highway noise will generally be identified based on a review of project plans, web-based city or county GIS sites, and aerial photography from web-based mapping sites including Google Maps, Bing Maps, ESRI Maps, and other available mapping resources. Additional information including, but not limited to, address, construction date, and land use can be accessed through the State of Tennessee Real Estate Assessment Data website.

7.2.1 Developed Lands

Developed lands include Activity Category A, B, C, and E land uses with exterior areas of frequent human use, as well as qualifying Category D land uses.

As defined previously, frequent human use is an activity that results in prolonged human exposure to traffic noise on a regular basis over the course of a year. Land uses must meet this definition to be considered noise sensitive. Sidewalks and parking lots are not noise sensitive.

7.2.1.1 Activity Category A

TDOT should be consulted if a land use has the potential to be designated as an Activity Category A land use. If TDOT determines that the use is worthy of consideration, TDOT will prepare and submit a *"Proposal for Justification for Designating Land Use as Category A"* to the FHWA Division Office.

7.2.1.2 Activity Category B

Activity Category B land uses are residential properties including single-family homes, apartments, condominiums, townhouses, mobile homes, and assisted living facilities. Frequent human use areas at Activity Category B land uses could include yards, patios, and balconies. Each dwelling unit must be counted as one receptor. Care should be exercised to correctly identify the number of units in multi-family buildings, including duplexes and triplexes.

Residential hotels and motels that function as apartment dwellings are Category B land uses (FHWA FAQ D3).

Properties that are condemned and require a building permit before the residence can be occupied are not noise sensitive. Vacant but habitable properties are considered noise sensitive.

7.2.1.3 Activity Category C

Activity Category C land uses include 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 structure, radio stations, recording studios, recreation areas, Section 4(f) sites, schools, television studios, trails, and trail crossings.

Activity Category C land uses should be assessed to identify any areas of frequent human use. If a Category C land use has both exterior and interior areas of frequent human use, the exterior area should be analyzed for impact as Activity Category C.

Residential communities with common areas that can be used by all residents (e.g., swimming pools, playgrounds, tennis and basketball courts, and trails) should be designated as Activity Category C.

Multi-purpose lanes, sidewalks, and paths within TDOT's right-of-way are not considered to be noise sensitive and should not be included in noise studies.

Active sports areas that are inherently noisy and do not require a quiet noise environment for normal activities are Activity Category E. These might include miniature golf courses or facilities geared toward providing entertainment.

TDOT should be consulted if there is uncertainty regarding whether an area qualifies as frequent human use.

FHWA has provided additional guidance for some Activity Category C land uses:

- Rest stops or areas: The Activity Category will depend on the use of the rest stop. If the rest stop is designed and used to park vehicles, in particular heavy vehicles, then the rest stop is functioning more as a noise-generating land use and should be categorized as Activity Category F. If the rest stop is designed and used in a park-like setting, such as those along scenic routes, then the rest stop should be treated as Activity Category C land use. (FHWA FAQ D11)
- Trails and trail crossings: Trails are defined in 23 USC 206(a)(2)(A-F) of the recreational trails program and require a noise analysis. Trail crossings describe locations where trails cross surface transportation facilities. Motorized activities are noise generators and should be designated as Activity Category F. (FHWA FAQ D4.e)
- Medical facilities: The FHWA defines a medical facility as an inpatient medical facility where medical treatment and care occurs. (FHWA FAQ D4.b)
- Section 4(f) lands: The requirements of Section 4(f) are separate from the FHWA Noise Regulation but may also call for consideration of noise impacts to lands subject to Section 4(f). A noise impact does not necessarily constitute a Section 4(f) use. However, even when noise increases do not constitute a Section 4(f) use, noise impacts may still require consideration for abatement under 23 CFR 772. Abatement measures may result in additional impacts that require consideration under Section 4(f), NEPA, Section 106, or as visual impacts. Section 23 CFR 774.15 shall govern implementation of Section 4(f) includes specific discussion to aid in assessing whether noise impacts would constitute a constructive use and require a Section 4(f) evaluation. In general, a constructive use occurs when *"The projected noise level increase attributable to the project substantially interferes with the use and enjoyment of a noise-sensitive facility of a property protected by Section 4(f),"* Examples include, hearing performances at an outdoor amphitheater, sleeping in a campground, visiting a historic site where a quiet setting is related to the site's significance, enjoying an urban park where serenity and quiet are significant attributes, or viewing wildlife in an area of a refuge intended for such viewing. (FHWA FAQ D4.c)
- Section 106 lands: As with Section 4(f), the consideration of historic properties under Section 106 is a separate requirement but may be related to the assessment of noise impacts under 23 CFR 772. There is no metric for analyzing when a change in noise constitutes an effect under the regulations implementing Section 106 (36 CFR Part 800) since that will be dependent on the contributing characteristics and use of the historic resource. Some properties, such as designed or cultural landscapes where the landscape itself is the significant feature or where the setting is especially important, may be sensitive to change that can be perceived by the human ear. In such cases, FHWA considers anything above 3 dB(A) to be a change that should be considered an effect.

These cases should be assessed to determine whether it could adversely affect the contributing characteristics of the property. Other historic properties, such as historic transportation facilities, could be relatively unaffected by noise. It depends on the resource as to when noise impacts may diminish the integrity of a property's significant historic features, including a change in character of the property's setting or use [see 36 CFR 800.5(a)(1) and (2)]. Mitigation to address impacts of noise to a historic property is a separate matter from any abatement determined justified under 23 CFR 772, and as with Section 4(f) properties, the abatement measures may present additional impacts to be considered. (FHWA FAQ D4.d)

7.2.1.4 Activity Category D

Activity Category D land uses are the subset of the listed Activity Category C land uses that have a building(s) and, therefore, may or may not have an exterior frequent human use area. If there are no exterior areas of frequent human use, then the land use is Activity Category D and must be assessed for interior noise impacts. Additionally, if the exterior area is far from or physically shielded from the roadway in a manner that prevents an impact on the exterior areas, then the interior area should be evaluated for impact as an Activity Category D land use. A church playground that is shielded from the project by the building itself and not impacted is an example of this situation.

7.2.1.5 Activity Category E

Activity Category E land uses include hotels, motels, offices, restaurants/bars, recreational vehicle (RV) parks, and other developed lands, properties or activities not included in A-D, or F. Medical offices and walk-in clinics should be treated as general offices.

Activity Category E land uses should be assessed to identify any areas of frequent human use. These areas could include exterior eating areas, playgrounds, pools, or other locations where people may gather for extended periods. Active sports areas that are inherently noisy and do not require a quite noise environment for normal activities are classified as Category E. These might include facilities geared toward providing entertainment such as amusement parks and driving ranges.

Golf courses and driving ranges that are included as part of a larger commercial entertainment facility are Category E land uses.

Land uses that do not have exterior frequent human use areas are not noise sensitive and are not evaluated for impacts. Benches at the entrances of motels and hotels, and exterior restaurant waiting areas do not qualify as frequent human use areas.

TDOT should be consulted if there is uncertainty regarding whether an area qualifies as frequent human use.

7.2.1.6 Activity Category F

Activity Category F land uses include agriculture, airports, bus yards, emergency services, industrial, logging, maintenance facilities, manufacturing, mining, rail yards, retail facilities, shipyards, utilities, and warehousing. Offices, restaurants, hotels, and motels with no exterior frequent human use areas are Activity Category F.

Activity Category F uses are not noise-sensitive; however, the Noise Technical Report should include a general description of the uses.

7.2.1.7 Activity Category G

Activity Category G undeveloped lands are not noise-sensitive and should not be included in noise studies. However, they should be addressed as part of the "Information for Local Officials" section of the Noise Technical Report.

7.2.2 Permitted Development

Development is "permitted" if there is a definite commitment to develop land with an approved specific design as evidenced by the issuance of a building permit. (FHWA FAQ D8.a)

The noise study should include land uses that are permitted at the date of public knowledge for the project. The date of public knowledge is the first date that FHWA approves a project's initial environmental document (i.e., CE, FONSI, or ROD).

The municipal planning, codes, or building department should be contacted to determine if any building permits have been issued in the project area. Some municipalities provide permit information online. Municipalities that do not provide data online should be contacted directly. Generally, the planning, codes, or building department will need a list of vacant parcels to check against building permits.

7.2.3 Noise Analysis Areas

For most projects, separate areas of noise-sensitive land uses called Noise Analysis Areas (NAAs) should be identified along the project to better organize the modeling, analysis, and reporting. NAAs may not be needed when land uses are scattered.

Factors to consider in identifying NAAs include types of land uses, separation by distance or terrain features, directional traffic effects, likelihood of noise impacts, and potential for noise abatement.

NAAs may be designated using a naming or numbering system relevant to the project. If NAAs are used, the report should define and describe the NAAs and include figures showing the NAAs.

7.3 Determination of Existing Noise Levels

Existing noise levels should be determined using one of the following methods:

- Method 1: Measurement of Existing Noise Levels
- Method 2: Measurement and Prediction of Existing Noise Levels (including validation)

TDOT will consider several factors when determining the method for each project. These factors include the type of project (i.e., road widening or new alignment); facility type; the extent and level of detail of

the data available to complete noise modeling for existing conditions; the number of expected impacts; the need for evaluation of noise abatement measures; and the effect on the decision-making process.

7.3.1 Method 1: Measurement of Existing Noise Levels

Method 1 should be used for projects involving the construction of a roadway on a new alignment. This method should also be used on Type I projects when the extent, level of detail, and/or accuracy of data for existing conditions is not sufficient to support the development of an accurate noise model for existing conditions.

All measurements should be conducted per the detailed procedures outlined later in this section. Use of these procedures will ensure that the existing worst-hour noise levels at noise-sensitive uses in the project area are accurately determined and reported.

7.3.2 Method 2: Measurement and Prediction of Existing Noise Levels (including validation)

Some projects may require both noise measurements and modeling of existing conditions to facilitate validation of the TNM model. These projects might include large widening projects on existing facilities and projects where noise barriers preexist.

To ensure that project noise models are a reasonable representation of the current real-world landscape, the existing condition noise model must be validated using field-measured traffic data and noise levels, per 23 CFR 772.11(d)(2). Traffic data consists of traffic volume, mix, and speed. For each measurement location input as a receiver, the resulting modeled noise level is compared to the measured noise level.

7.3.2.1 Validation Overview

Validation is performed so that the model can be used with confidence to predict existing and design year noise levels. Chapter 4 of FHWA's Noise Measurement Handbook (FHWA-HEP-18-065) provides guidance on field measurements for validation.

To determine whether the model validates, compare modeled results to field measured noise levels. The maximum acceptable difference between the field noise measurements and the modeling results is +/-3.0 dB. If the difference is within 3.0 dB, the existing condition noise model is considered validated.

If the difference is not within +/-3.0 dB, the noise modeler should double-check model inputs, coordinates, and other variables to determine if the discrepancy can be explained. If the discrepancy can be explained, either the inputs are corrected, or the data point is removed or recollected in another field visit. After examination, if the difference still exceeds +/-3.0 dB, the reason for the difference will be adequately explained in the traffic noise technical report, and FHWA must concur with the explanation. A second measurement may be required in some instances.

For projects with a new highway on a new location, it is not generally possible to validate the existing condition noise model of the new highway location except where the new highway ties into or is very

close to an existing highway. In that case, the existing condition noise model near the existing highway may be validated near the tie-in point.

7.3.2.2 Validation Measurements

Validation measurement locations should be representative of first-row receptor locations and should not be blocked by buildings or terrain features. Two to three measurements of at least 15 minutes in length are made at each measurement location. The measurements may be consecutive or done at different times of the day. The measurements do not have to be during the worst noise hour and should not be made during periods of slow-moving traffic congestion. Validation measurements should be made during daylight hours not close to sunrise or sunset (to avoid temperature inversions) and when winds are generally calm. For measurement locations within 100 feet of the edge of the nearest travel lane, wind speed may be as high as 11 miles per hour (mph), but the speed and direction must be noted. For distances over 100 feet, validation is not recommended because of meteorological effects on sound propagation, but if needed, should be done under lower wind speed conditions. Cloudy or partly cloudy days are preferred over sunny days, especially for distances beyond 200 feet because of meteorological effects not modeled in FHWA TNM2.5.

The following measurements from the study area must be collected as part of the validation process.

- Traffic Data (field-measured):
    - Volume
    - Vehicle mix
    - Speed
    - Pavement type
- Noise Level Measurements:
    - Taken at representative locations within the study area, should reflect first-row receptors, and conduct enough to represent all affected neighborhoods (minimum 2-3 measurements per location, each greater than or equal to 15 minutes)
    - Must not be blocked by buildings or terrain
    - Not recommended beyond 100 feet from the roadway (unless necessary)
    - Avoid times of:
        - Traffic congestion
        - Sunrise or sunset (temperature inversions)
        - Windspeeds greater than or equal to 12 mph
    - Input into the noise model as receiver locations

7.3.2.3 Validation Process

Field-measured traffic data and measurement locations are to be input into the existing condition noise model. The modeled noise levels are compared to measured noise levels at each receiver. A difference of ≤ 3.0 dB is acceptable.

- If within range → Model is validated
- If difference > 3.0 dB → Further review is required

If the Model Fails Validation (>3.0 dB Difference)

- Recheck inputs:
  - Traffic data
  - Receiver coordinates
  - Pavement, terrain, barriers, geometry, etc.
- If discrepancy can be explained and corrected:
  - Adjust model inputs
  - Re-model or re-measure as needed
- If discrepancy remains unexplained:
  - Obtain TDOT and FHWA concurrence
  - Provide explanation in Traffic Noise Technical Report. It must be justified and clearly documented.
  - Possible causes:
    - Non-road noise sources
    - Unusual vehicle noise
    - Pavement conditions not modeled (tining, wear, roughness)
    - Meteorological or terrain effects
- If unresolved:
  - Consult analyst, project team, and TDOT noise specialist
  - May require second field measurement

7.4 Noise Measurements

Noise measurements should be conducted per FHWA-HEP-18-065, the *"Noise Measurement Handbook,"* using the procedures described below.

Field staff conducting noise measurements must wear high visibility safety vests and carry proper identification. Consultants conducting measurements should obtain a measurement explanation letter from TDOT before conducting field work. This letter will explain the purpose of the measurements and should be provided to residents, business owners, and/or law enforcement who inquire about the purpose of the measurements.

7.4.1 Locations

Noise measurement locations should be representative of the project area and should include exterior areas of frequent human use for Category A (if applicable) B, C, or E land uses. Selected sites should be exposed to the highest noise levels generated by the project. Long-term reference measurements may be conducted in areas that do not have frequent human use as outlined in Section 7.4.4.1.

Measurement sites should be clear of obstructions (e.g., not shielded by wooden fences) and the microphone should be located at least 10 feet (3 meters) from any reflective surfaces. If possible, selected sites should have a low likelihood of contamination by persistent, non-traffic sources (e.g., barking dogs and running HVAC units).

Interior noise measurements are not typically needed.

7.4.2 Data Sheets

TDOT's standard noise measurement data sheet should be used for all measurements. The data sheet is provided in Appendix A.

Each noise measurement data sheet should include a detailed site sketch showing appropriate distance measurements. Additionally, several photographs should be taken at each location showing the microphone relative to the study roadway and nearby area(s) of frequent human use. The following information should be noted, as applicable:

- Microphone height (if not 5 feet)
- The roadway elevation relative to the elevation of the measurement location (i.e., in cut, on fill, at-grade)
- Pavement type (asphalt or concrete) and other observable pavement information (e.g., concrete surface texture)
- Distances from the measurement location to the adjacent road and/or nearby buildings or structures
- Type of intervening ground
- Any surfaces or areas that could affect noise levels such as ponds, lakes, and parking areas
- Existing structures including residences, garages, barns, commercial and industrial buildings, noise barriers, and fences
- Significant existing terrain features such as berms, crests of hills, and drainage ditches
- Locations and density of areas of trees and/or vegetation
- A description of any non-traffic noise sources (e.g., aircraft and/or train operations, or commercial and industrial activities)
- Calibration results

- Wind speed and direction
- Temperature

Copies of the noise measurement data sheets and representative photographs should be provided in an appendix of the Noise Technical Report.

7.4.3 Equipment

Measurements should be conducted using an ANSI Type I or II sound level meter using a *slow time-averaging* setting. A windscreen shall be used and should be of a type specified by the manufacturer for the microphone. The windscreen should be clean, dry, and in good condition.

Sound level meters should be calibrated at the beginning and end of each measurement and the results should be noted on the noise measurement data sheet.

7.4.4 Time and Duration

Noise levels will vary by location and time of day depending on the proximity of noise-sensitive land uses to roads and other noise sources. Additionally, noise levels can vary with changes in meteorological conditions including shifts in wind speed and direction and changes in the vertical temperature profile.

Although long-term measurements would better characterize the existing noise environment, the collection of long-term data *at many sites* would require significant time, effort, and resources. In most cases, the additional data would not significantly change the conclusions regarding the number and locations of noise impacts and the associated need to consider noise abatement.

7.4.4.1 Long-Term Measurements

Existing noise levels should be representative of the worst noise hour. High traffic volumes at high speeds usually create the noisiest conditions. The peak traffic hour may be the worst noise hour for roadways that are not congested during that time. However, the peak traffic hour is usually not the worst noise hour for congested roadway facilities that operate at low speeds during peak traffic conditions. In most cases, the worst noise hour will occur between 6:00 am and 7:00 pm.

One or more long-term measurements (8 to 12 hours) should be conducted to identify changes in noise levels throughout the day and to aid in identifying the worst noise hour. Long-term measurements should include the morning and/or afternoon peak traffic periods.

The noise environment at long–term measurement sites should generally be dominated by traffic noise from the study roadway and should be isolated from local traffic noise sources and other sources of potential contamination.

The long–term monitor does not have to be attended during the entire measurement period. However, it is recommended that field staff return to the monitor several times during the measurement period(s) to ensure that the sound level meter is functioning properly.

The number of long-term measurements will depend on the number of alternatives and the variation in noise levels throughout the day. Long-term measurements are generally not needed to establish background noise levels in areas where no significant traffic noise sources exist, such as near new roadway alignment projects in rural areas. Short-term measurements can usually be used to establish background noise levels in these areas.

The long-term measurement data should be used to calculate noise levels for each hour of the long-term measurement period and to identify the worst noise hour. The long-term data should also be used to develop adjustments to apply to the short-term measurements to arrive at existing worst-hour noise levels at the short-term measurement sites.

7.4.4.2 Short-Term Measurements

Short-term measurements should be conducted when traffic is free-flowing and concurrently with the long-term measurements, if applicable. The short-term measurements should be adjusted to represent worst-hour noise levels during the measurement period as described above.

The duration of the short-term measurements will depend on the density of traffic on the study roadway. Noise measurements near high-volume roads can be of shorter duration than measurements near low-volume roads. General guidance for determining the minimum duration of short-term measurements is provided in Table 3.

Table 3: Short-Term Measurement Durations

Traffic Volume (vehicle/hour/lane)	Minimum Duration (minutes)
High (>1000)	15
Medium (500-1000)	20
Low (<500)	30

7.4.4.3 Time History Data

Measurement data should be recorded in one-minute intervals to allow for the removal of non-representative, intrusive events. These events should be noted in the associated one-minute period on the noise measurement data sheets. The noise level data should be thoroughly reviewed to ensure that the reported data is representative of traffic noise levels. One-minute periods that include noise from unusual or unrepresentative sources should be eliminated (e.g., intermittent lawn equipment, sirens, dogs, and/or aircraft overflights). The one-minute data and noise measurement data sheets for both the long-term and short-term sites should be included in the appendix of the Noise Technical Report.

The measurement time history data should be imported into spreadsheet tables and any measurement intervals that are contaminated - due to unrepresentative noise sources, high wind, or other factors - should be identified and eliminated. A printout of the spreadsheet table for each measurement site should be included in the noise measurement appendix of the Noise Technical Report.

7.4.5 Meteorological Conditions

Meteorological conditions can significantly affect noise levels and sound propagation. Higher noise levels will occur when the wind blows from a highway toward a community (downwind) due to the downward bending, or refraction, of the sound waves. Lower noise levels will occur when the wind blows from a community toward a highway (upwind) due to the upward bending of the sound waves.

Measurements should not be conducted when the wind speed(s) at the microphone exceeds 11 mph (5 m/s), regardless of wind direction. Wind speed should be monitored and reported on the noise measurement data sheet.

When the air above the ground is warmer than the air near the ground, a *temperature inversion* occurs that causes sound waves to bend back toward the earth and increase noise levels. Temperature inversions often occur at night when the weather is clear and the winds are calm. There is no set limit on temperature during noise measurements. However, the ambient temperature must be noted on the noise measurement data sheet. Inversions cannot be measured without sophisticated equipment. However, the analyst should note any suspected inversion based on weather conditions and field observations

7.4.6 Pavement Conditions

Noise measurements should only be conducted when road surfaces are dry. Road surfaces should also be free of extraneous material such as gravel.

Pavement type (asphalt or concrete) and condition should be noted on the noise measurement data sheets. Observations about the pavement surface, such as the density of the asphalt grading or the concrete, should also be noted.

7.5 Prediction of Noise Levels

TNM should be used to predict noise levels at the noise-sensitive land uses and measurement locations.

TNM is a complex model requiring numerous inputs and modeling assumptions. As a result, FHWA developed user guides and best practices to ensure consistency in modeling practices and enable the comparison of results.

The guidances are intended to provide supplementary information to analysts who are skilled in both traffic noise modeling and the use of TNM. TNM models should include the following:

- Existing and Build Alternative(s)
    - Existing roadways that contribute to the noise environment including ramps and intersections
    - Receivers
    - Existing noise barriers or large buildings that act as noise barriers
    - Terrain features including intervening hills, tops of cuts, and bases of fills
    - Rows of buildings that provide shielding
    - Intervening ground zones that will affect sound propagation including parking lots and bodies of water.

- Build Alternative(s)
    - Proposed roadways including ramps and intersections
    - Proposed noise barriers

All TNM runs developed for the project shall be transmitted to TDOT electronically the time any draft or final report is submitted.

7.5.1 Existing Conditions

Method 2 requires the prediction of existing worst-hour noise levels. TNM models of existing conditions should be developed and used to predict existing worst-hour noise levels at noise-sensitive land uses and to characterize the existing noise environment in the project area.

7.5.2 Build Alternative(s)

Requiring detailed and accurate modeling of the Build Alternative(s) in the design year is the best way to ensure 1) the best estimates of design year noise levels for all receptors and 2) the most accurate accounting of the impacts resulting from the project.

TNM models for all Build Alternatives should be developed and used to predict worst-hour noise levels in the design year at noise-sensitive land uses.

7.5.3 Modeling Data

7.5.3.1 Project Plans and Mapping

The survey-based project plans that will be submitted with the environmental document should be used for the noise study. These plans could include:

- Right-of-Way, or Construction Plans, including roadway profiles, cross-sections, and ground contours
- MicroStation design files, including proposed horizontal alignment and vertical profiles

The following mapping should be used in the development of the TNM models as available:

- County GIS data
- Aerial photography from Google, ESRI, or the USGS National Map

The accuracy and relevance of any datasets (e.g., aerial photography and elevation data) should be verified using other sources whenever possible.

7.5.3.2 TNM Roadways

Existing and proposed roadways should be modeled, including ramps and intersections. Local roads that either contribute to the noise environment or help define the terrain should also be modeled.

The direction of travel should be properly modeled for each TNM roadway. No more than two lanes of travel should be combined into a single TNM roadway. When cross-section data is available, every travel lane should be modeled as a separate TNM roadway.

The full width of the roadway pavement should be modeled, including travel lanes and shoulders. The widths of adjacent TNM roadways should overlap slightly and the outside edge of pavement should be modeled as close as possible to the actual edge of shoulder. Outside and inside shoulders may be modeled using a "dummy" TNM roadway with no traffic. The superelevation of the highway will be considered, and individual lanes will be modeled based on their proper elevation. If available, separate profiles will be used to determine the elevation of each travel lane (including shoulders) for roadway sections that are superelevated.

Appropriately assign all flow-control devices, including on-ramps, stop signs, traffic signals, and toll booths.

7.5.3.3 Traffic

Design year noise levels should be predicted for the worst-noise hour, which would normally occur when the highest traffic volume can travel at the highest possible speed.

Traffic projections developed for projects typically include traffic volumes for the "design hour," which is often representative of Level of Service (LOS) C operating conditions. These design hour volumes (DHVs) should be used for the noise analysis since they represent the highest number of vehicles expected to travel on the roadway network in a given hour.

The DHVs should be modeled at the planned posted speed for the Build Alternative(s), since modeling DHVs at posted speeds provides a conservative estimate of worst-hour noise levels.

Traffic projections for the project should also include truck projections. If the percentage of trucks for the design hour is not provided, then the percentage of trucks during the design hour should be assumed to be two-thirds of the projected percentage of daily trucks. The split between medium trucks and heavy trucks should be based on the traffic classification counts used for the pavement design and provided in TDOT's traffic projections report.

The Noise Technical Report should include a table summarizing the projected traffic volumes for each modeled roadway. The traffic projections should be included in an appendix of the Noise Technical Report.

7.5.3.4 TNM Receivers

TNM receivers should be used to represent Activity Category B, C, D, and E land uses use as well as FHWA-approved Activity Category A land uses. TNM receivers should also be used to represent Activity Category G undeveloped land where development is permitted. Receivers should also be modeled at all noise measurement sites.

Properties that will be taken for the project should be identified. For environmental studies, noise-sensitive land uses that are shown as being taken for the project should be modeled using TNM receivers designated as "takes" and with zero assigned dwelling units. One exception is if the land use is within the proposed roadway (i.e., receivers cannot be within the roadway width). The predicted noise levels should

not be reported, but the Noise Technical Report should provide a general description of the properties to be taken. The locations of takes can change during the design process, so including them in the TNM models will help facilitate future environmental reevaluations.

7.5.3.4.1 Number of Receivers

The number of modeled TNM receivers for a project should be adequate to facilitate an accurate count of the number of impacts that will result from each Build Alternative. An analysis should be completed at the beginning of the modeling process to identify the distance within which receivers should be modeled. The 64 dBA contour is first determined using the noise screening process described previously for Type I projects. The distance within which impacts might occur will often be much greater for new alignment projects, particularly those in quiet areas. For a new alignment project, the 55 dBA contour is first determined using the noise screening process described previously for Type I projects.

If noise barriers are being evaluated, enough receivers should be modeled to ensure an accurate count of the number of benefits.

A table that indicates the number of residences being modeled by each receiver should be included in the Noise Technical Report.

7.5.3.4.2 Receiver Elevations

Receiver elevations should closely approximate actual ground elevations. The elevation datum should be Mean Sea Level (most recent North American Vertical Datum or National Geodetic Vertical Datum). If a different datum is used, then a discussion of the datum should be included in the Noise Technical Report.

Elevation data for most of the state can be found in multiple formats at the STS-GIS Services from the Tennessee Department of Finance and Administration. Municipal GIS departments and tax assessors may also have online mapping that includes contours. The USGS National Map also has elevation data. Google Earth elevations should not be used for TNM receivers.

7.5.3.4.3 Receiver Heights

Most receivers should be modeled using a height of 5 feet (1.5 m) above the ground. For multi-story residential facilities with upper-floor balconies, an additional 10 feet should be added to the receiver height for each subsequent floor (e.g., receiver height for the 3rd floor would be 25 feet). The heights of other frequent human use areas in multi-story buildings should be estimated using judgment available information.

7.5.3.4.4 Receiver Names

Receivers should be named using the property name and/or address. Address information can be obtained at the Tennessee Property Viewer, the Tennessee Property Data Home Page from the Comptroller of the Treasury, or various county GIS and tax assessor websites.

7.5.3.4.5 Category B Land Uses

Receivers should represent frequent human use areas of the property that are oriented toward the project roadway. Therefore, receivers may need to represent front-yard locations. Receivers should be modeled at the ground elevation approximately 10 feet from the point of the residence closest to the roadway.

Single-family residences and townhouses may have elevated decks. Receivers at these locations can be included for informational purposes. However, noise abatement will not be designed for these locations.

Upper story locations in multi-family buildings including apartments and condominiums should be modeled to identify impacts and benefits. Noise abatement might be designed for these locations as discussed in Section 7.7.4.

Apartment or condominium complexes may have shared common areas of frequent human use, such as swimming pools, playgrounds, tennis courts, or basketball courts. Each of these common areas should be modeled per the guidance provided below for Activity Category C land uses.

A single receiver can represent more than one residential unit if the units would be expected to have comparable existing and design year noise levels. Residential units modeled by a single receiver should have similar elevations, distances from the roadway, and intervening shielding. Residences at the boundaries of a neighborhood should each be modeled by a single receiver to accurately determine the noise barrier length.

7.5.3.4.6 Category C Land Uses

Receivers should be located at frequent human use areas of the Category C land uses listed in Table 2 and as discussed in Section 7.2.1.3.

Active Sports Areas

Receivers should be placed at locations where people would congregate and locations where communication between coaches, referees, and/or players would occur. For baseball and softball fields, receivers should be placed at the dugouts, home plate, pitcher's mound, and bases. For soccer and lacrosse fields, receivers should be placed at the sidelines, midfield, and goals. For football fields, receivers should be placed at the sidelines and each 30-yard line. For basketball and tennis courts, receivers should be located at the baseline locations closest to the roadway.

Receivers should also be placed at formal seating areas and bleachers. For bleachers, receivers should be located at midlevel near the center and ends of the bleacher section on each side of the field. For small bleachers, one receiver near the center of the section is acceptable. Receiver heights will need to be estimated based on available information.

Receivers for golf courses should be placed at the tee boxes and greens. Receivers for driving ranges should be placed at a subset of tee boxes.

Amphitheaters

Receivers should be placed on the stage and at representative locations throughout the seating area, including bleachers.

Campgrounds
For developed campgrounds, receivers should be placed at cabins and campsites with picnic tables, electrical hook-ups, and/or fire pits. Campsites that are close together can be grouped into one TNM receiver. TDOT should be consulted to identify receivers for dispersed camping areas.

Playgrounds and Swimming Pools
If the playground is small, a single receiver should be placed at the playground apparatus that is closest to the roadway. For larger playgrounds, place additional receivers at each cluster of playground equipment.

For small swimming pools, a single receiver should be placed on the pool deck at the location closest to the roadway. For large public and community swimming pools, place additional receivers on the deck along each side of the pool.

Places of Worship and Day Care Centers
Receivers should be placed at any playground, picnic area, or pavilion. If the frequent human use area is far - or physically shielded - from the roadway in a manner that prevents an impact, then the facility is an Activity Category D land use. Receiver placement for Activity Category D land uses is discussed in the following section.

Parks and Recreation Areas
Areas of frequent human use within parks should be modeled per the guidance above. Additional receivers may also be needed at popular landmarks (e.g., statues, fountains, and commemorative symbols/plaques).

Miscellaneous Areas
At least one receiver should be modeled at each distinct sitting/eating area, such as a picnic shelter, gazebo, cluster of benches, or seating areas at dog parks. More receivers may be needed to account for additional seating clusters within a larger area.

7.5.3.4.7 Category D Land Uses

Receivers for Category D land uses should be modeled at the closest building edge facing the highway. Interior noise levels should be estimated by applying a Building Noise Reduction Factor to the predicted exterior noise level per the FHWA Guidance Document. The first step in FHWA's procedure involves identifying and documenting the type of building construction. The second step is determining whether the building would normally operate under "closed windows" conditions. The appropriate noise reduction from Table 4 is then applied to the predicted exterior noise level to arrive at the predicted interior noise level. This level should be compared to the NAC for Activity Category D land uses to determine if interior impacts are predicted.

Table 4: Building Noise Reduction Factors

Building Type	Window Condition	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
** 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.*		

Source: FHWA's "*Highway Traffic Noise Analysis and Abatement: Policy and Guidance.*"

7.5.3.4.8 Category E Land Uses

Receivers should be modeled at exterior frequent human use areas of Category E land uses such as exterior restaurant seating areas, swimming pools, RV parks, or playgrounds. The guidance provided above for Activity Category C receiver placement should be applied.

Land uses that would normally qualify as Activity Category E but have been designated as Section 4(f) properties (e.g., a restaurant at a historic site) should be analyzed as an Activity Category C land use.

7.5.3.5 TNM Barriers

Existing noise barriers, noise barriers that are being evaluated as abatement measures, and any structures that function like noise barriers - such as median barriers, parapet walls, and large buildings - should be modeled.

7.5.3.5.1 Median Barriers and Parapet Walls

If the future typical cross-section shows that a median barrier will be constructed, the median barrier shall be modeled in TNM at the proposed location(s) and height(s). Parapet walls should be modeled at the existing or proposed location(s) and height(s) so that the shielding from the parapet wall is included in the no-abatement noise levels.

7.5.3.5.2 Buildings

Large buildings (e.g., apartments, retail) should be modeled as fixed height noise barriers with at least four segments to represent the sides of the building. The shielding provided single-family residences should generally be modeled using building rows as discussed below. Modeling scattered or isolated residences using a fixed height barrier may sometimes be needed if the building is shielding a nearby receiver.

7.5.3.5.3 Existing Noise Barriers

Noise barriers that were constructed to abate noise should be modeled as fixed height noise barriers. Existing noise barriers should be evaluated per Section 7.9 (Consideration of Existing Noise Barriers in a Type I Noise Analysis) of these procedures.

7.5.3.5.4 Privacy Fences

Privacy fences that are constructed with materials that would be expected to reduce noise levels should be modeled in TNM. These types of fences could include solid cinder block or brick walls.

Wooden privacy fences are not typically constructed to mitigate noise and should not be modeled as noise barriers.

7.5.3.6 TNM Building Rows

Multiple small buildings, such as rows of houses, that act as multiple small barriers with gaps should be modeled using TNM building rows. Per FHWA guidance, if the building blockage is less than 20%, the building row should not be modeled. The maximum building percentage is 80%. If the blockage is greater than 80%, the row of buildings should be modeled using a fixed-height barrier.

7.5.3.7 TNM Terrain Lines

TNM terrain lines should be used to define the terrain between TNM roadways and receivers and should be modeled where terrain breaks the line-of-sight or reduces excess ground attenuation. TNM terrain lines could include:

- The top of cut for a depressed roadway
- The bottom of deep drainage ditches
- The edge of fill for roadways on fill
- Ridges of intervening hills
- Lines of constant elevation of an intervening hill

7.5.3.8 TNM Ground Zones

“Lawn” should generally be specified as the default ground type for TDOT projects. Any large areas of ground type that differ from the default - and would be expected to affect sound propagation - should be modeled using TNM ground zones. Ground zones might include parking lots, large ponds, and lakes.

7.5.3.9 TNM Tree Zones

Tree zones should not be modeled on TDOT projects unless they meet FHWA’s definition, which states that tree zones should consist of long, wide regions of heavy, non-deciduous woods and undergrowth, not just individual trees, or several rows of trees. The vegetation also must be sufficiently dense to completely block the view along the sound propagation path. This requires dense undergrowth as well as dense tree-top foliage. Tree zones should not be modeled unless they have this vegetative density and TDOT concurs.

7.5.3.10 TNM Contours

TNM contours should be utilized for screening and land-use planning activities.

7.5.4 Review of Noise Levels

The predicted design year noise levels for the Build Alternative(s) should be thoroughly reviewed to assess whether the predicted noise levels at each receiver are realistic given the analyst's knowledge and understanding of the traffic noise source, the path between the source and the receiver, and the characteristics of the intervening ground.

The predicted design year noise levels at the measurement locations should be compared to existing worst-hour noise levels to assess whether the predicted change in noise level due to the project is in line with expectations.

If the predicted change in noise levels due to the project is significantly higher or lower than the expected change, then the analyst should thoroughly review the modeling for the Build Alternative to ensure that the TNM model accurately represents the design year conditions. For example, a predicted 6 dB increase in the noise level would not be expected if the traffic did not double, and the roadway did not move closer to the receiver.

7.6 Determination of Traffic Noise Impacts

Traffic noise impacts for each Build Alternative should be identified per TDOT's Noise Guidance. Impacts are only associated with the Build Alternative(s) so an impact analysis should not be conducted for the No-Build Alternative.

Each receptor should be identified as *not impacted*, *impacted based on the NAC, impacted based on a substantial increase in noise levels*, or *impacted based on both the NAC and a substantial increase in noise levels*. The information should be presented in a table in the Noise Technical Report.

The total number of impacts by Land Use Category resulting from each Build Alternative should be determined and summarized in a table in the Noise Technical Report. TDOT should be consulted if an Activity Category D land use is predicted to be impacted.

If traffic noise impacts are not predicted for the Build Alternative(s) in the design year, the analysis is considered complete and noise abatement measures should not be evaluated. This determination should be stated in the Noise Technical Report.

7.7 Evaluation of Noise Abatement Measures

Noise abatement should be evaluated when noise impacts are predicted in the design year for the Build Alternative(s). At a minimum, TDOT will consider noise abatement in the form of a noise barrier, since barriers are usually the best available abatement measure to reduce sound levels for impacted land uses.

Earth berms are similar to noise barriers and are sometimes considered to be more aesthetically pleasing than noise barriers. However, berms require significant right-of-way that is typically not available. For example, the needed width for a 15-foot-high berm constructed at a 2:1 slope with a top width of five feet is 65 feet plus additional width for drainage. Berms are usually not feasible where the road is in cut or on-fill and may also be difficult to maintain. As a result, earth berms are not feasible for most projects.

However, berms may be evaluated in lieu of - or in combination with - noise barriers on a case-by-case basis.

TDOT may also consider the following noise abatement measures for Type I projects: (1) traffic management measures (e.g., traffic control devices and signing for the prohibition of certain vehicle types, time-use restrictions for certain vehicle types, and exclusive lane designations); (2) alteration of horizontal and vertical alignments; (3) acquisition of property rights (either in fee or lesser interest) for construction of noise barriers; and (4) noise insulation of Category D land uses.

These measures are discussed in greater detail below. The feasibility and reasonableness of these alternative abatement measures will be assessed on a case-by-case basis.

7.7.1 Traffic Management Measures

Truck prohibitions and reducing speed limits can sometimes reduce noise levels. However, a 20 mile-per-hour reduction in speed is necessary for a readily noticeable (5 dB) decrease in noise levels. This noise level reduction would not be substantial. Therefore, speed reductions are not acoustically feasible for most projects.

FHWA generally does not allow restrictions of truck-trailer combinations on facilities in the National Network for large trucks, except under very special circumstances and where comparable parallel facilities are available. The National Network includes most of the Interstate Highway System in Tennessee. Therefore, truck restrictions are not possible for projects involving Interstates or other routes where comparable alternative routes do not exist. Truck restrictions could be evaluated if the restriction would not conflict with the designated use of the roadway and where such restrictions would not cause increased delay or travel times to the motoring public.

7.7.2 Alteration of Horizontal and Vertical Alignment

For projects that involve the widening of an existing facility, the modification of the horizontal and vertical alignment is generally not a feasible mitigation strategy. However, TDOT might consider the modification of the horizontal and vertical alignment for new alignment projects.

7.7.3 Noise Insulation of Category D Land Uses

Noise insulation might be possible to mitigate predicted interior impacts of NAC D land uses. Measures might include installation of new windows; sealing windows, cracks, and other openings; and the installation of air-conditioning. However, post-installation maintenance and operational costs for noise insulation are not eligible for Federal-aid funding.

7.7.4 Multistory Buildings

For multiple-story, single-family houses and multi-family dwellings, noise abatement will be designed to protect the exterior ground-floor receptors. In cases where the exterior balconies of multi-family buildings are elevated above the ground but are still below the grade of the roadway, noise abatement will generally be designed to protect those elevated areas.

7.7.5 Date of Public Knowledge

Federal participation in noise abatement measures will not be considered for lands that are not permitted by the date of public knowledge of the project, and TDOT will not analyze or provide noise abatement for these lands. After the date of public knowledge, the provision of noise abatement becomes the responsibility of local communities or private developers.

7.7.6 Trees/Vegetation

The planting of trees/vegetation is not considered as a noise abatement measure because vegetation and trees could not be constructed within the right-of-way at the depth and density required to provide a substantial noise reduction. Additionally, the planting of vegetation is not an acceptable noise abatement measure for Federal projects.

7.7.7 Alternative Pavements

FHWA's document *"Guidance on Pavement as a Noise Abatement Measure"* (FHWA-HEP-16-015) states the following:

> *"Pavement is sometimes mentioned as a factor in traffic noise. While it is true that noise levels do vary with changes in pavements and tires, it is not clear that these variations are substantial when compared to the noise from exhausts and engines, especially when there are a large number of trucks on the highway. Additional research is needed to determine to what extent different types of pavements and tires contribute to traffic noise.*
>
> *It is very difficult to forecast pavement surface condition into the future. Unless definite knowledge is available on the pavement type and condition and its noise generating characteristics, no adjustments should be made for pavement type in the prediction of highway traffic noise levels. Studies have shown open-graded asphalt pavement can initially produce a benefit of 2-4 dBA reduction in noise levels. However, within a short time period (approximately 6-12 months), any noise reduction benefit is lost when the voids fill up and the aggregate becomes polished. The use of specific pavement types or surface textures must not be considered as a noise abatement measure."*

Therefore, alternative pavement types cannot be used as a noise abatement measure.

7.8 Noise Barrier Design

Noise abatement will only be assessed where noise impacts are predicted and where frequent human use occurs. Primary consideration will be given to exterior areas. TNM should be used to evaluate noise barriers to reduce noise levels at impacted land uses.

7.8.1 Noise Reduction Design Goal

The noise abatement measure shall provide at least 7 dB noise reduction at 60% or more of the first-row benefited receptors. For impacted Category D land uses, the noise abatement measure should provide a

minimum 7 dB reduction in interior noise levels for the impacted areas. If a reduction of 7 dB at 60% or more of first-row benefited receptors cannot be met, the abatement measure is notreasonable.

When the noise reduction design goal can be achieved, additional efforts may be made to obtain up to a 10 dB noise reduction at impacted first-row receptors.

7.8.2 Barrier Location

Acoustically, the most effective noise barriers are usually located close to the source (i.e., at/near the highway shoulder) or close to the receptor (i.e., at/near the right-of-way). The analyst should exercise judgment in determining the most effective location for a barrier. Additionally, in areas where a road transitions from cut to fill, and vice versa, the barrier may need to transition from a location near the road to a location near the right-of-way.

Some situations may require an analysis of more than one barrier location and may require coordination with TDOT's Design Division.

7.8.3 Barrier Heights

Barrier heights will vary depending on traffic volumes and mixes, the characteristics of the intervening ground, and the location of the road relative to the impacted receptors (i.e., cut or fill). Barrier heights between 10 and 20 feet are typical. Barrier heights above 20 feet will generally only be constructed in areas where the barrier location is transitioning from a location at/near the shoulder to a location at/near the right-of-way, or vice versa.

TNM should typically be run with an input height of 16 feet, a perturbation increment of 2 feet, and with 4 perturbations up and down.

7.9 Noise Barrier Feasibility and Reasonableness

Noise abatement measures must be *feasible* and *reasonable*, as defined below. *Feasibility* deals with engineering considerations and the ability to achieve a 5 dB noise reduction. *Reasonableness* weighs the amount of required noise barrier area against the benefits that would be provided by the barrier. The viewpoints of the benefited property owners and residents will be considered by TDOT in its final decision regarding reasonableness.

7.9.1 Feasibility

To be feasible, a noise abatement measure should provide a minimum of 5 dB reduction in design year noise levels for the majority of the impacted first-row receptors. This is called *acoustic feasibility*. Barriers that are predicted to provide a minimum of 5 dB IL at the majority of impacted first-row receptors should be identified as *acoustically feasible*.
The noise barrier must also be feasible from an engineering standpoint. *Engineering feasibility* may also be affected by: (1) topography; (2) access and utility requirements; (3) drainage; (4) safety and maintenance considerations; (5) the presence of local cross streets; (6) noise from other sources in the area such as local roads, trains, aircraft, factories; (7) and excessive height of barrier needed to reach the

reduction goal. The extent to which these issues can be assessed will depend on the project development process.

A preliminary qualitative assessment should be completed to identify any potential major design, construction, maintenance, or safety factors associated with the construction of noise barriers. The Noise Technical Report should include a summary of potential feasibility issues.

TDOT Structures and Design Divisions will assess feasibility issues during the design process for noise barriers that are determined to be acoustically feasible and reasonable. Issues associated with drainage, sight distance, clear zone, and utilities can sometimes be addressed during the design process without affecting the feasibility and reasonableness of the noise barrier. In some cases, design constraints may affect the feasibility.

Feasibility alone does not dictate whether a noise barrier will be built. Each noise barrier must also be "reasonable" per TDOT's Noise Guidance. Reasonableness will only be evaluated if the Feasibility criteria have been met.

7.9.2 Reasonableness

For a noise barrier to be *reasonable*, the following three conditions must be met:

1. TDOT's noise reduction design goal must be achieved.
2. The required noise barrier area per benefited residence must be less than or equal to the allowable area per benefited residence.
3. The benefited residents and/or property owners must support the construction of the noise barrier.

7.9.2.1 Noise Reduction Design Goal

The designed noise barrier should be evaluated to ensure that it also meets TDOT's noise reduction design goal to provide 7 dB noise reduction for 60% or more of the benefited receptors. For impacted Category D land uses, the noise abatement measure should provide a minimum 7 dB reduction in interior noise levels for the impacted areas. If a reduction of 7 dB at 60% or more of first-row benefited receptors cannot be met, the abatement measure is not reasonable.

7.9.2.2 Cost-Effectiveness

For a noise abatement measure to be reasonable, the required barrier area (in square feet) per benefited residence must be less than or equal to the allowable barrier area per benefited residence. Noise abatement will generally not be considered *reasonable* for isolated residences due to the quantity of abatement versus the benefits provided.

The calculated area per benefited residence is the estimated area of the barrier divided by the number of benefited residences. The number of benefited residences in each NAA is determined by counting all the residences that would receive at least 5 dB of insertion loss due to the construction of the barrier regardless of whether or not the residence is predicted to be impacted. An equivalent number of benefited residences must also be determined for all Activity Category C, D, and E receptors that are

benefited by the measure using the process in Section 7.9.2.8. Only the portions of the receptor area that are benefited should be included (e.g., only include the parts of a playground that are benefited).

The allowable barrier area per benefited residence for each noise abatement location is calculated using the following equation:

	Base Allowance	_____
+	Previous Type I Widening Allowance	_____
+	Design Year Noise Levels Allowance	_____
+	Noise Level Increase Allowance	_____
+	Noise Compatible Planning Allowance	_____
=	**Total Allowable Area per Benefited Residence**	_____

The value for each allowance type should be selected based on the criteria outlined in Table 5.

Table 5: Reasonableness Allowances

Allowance Type	Criteria	Allowance in square feet
Base Allowance	Land uses pre-date the highway[1] or the project is on a new alignment.	1,500
	Land uses post-date the adjacent highway[2] but were constructed before September 16, 2005. [3]	750
	Residences were constructed after September 16, 2005.[3]	250
Previous Type I Widening Allowance[4]	Residences pre-date a Type I widening project on the adjacent highway.	200
Design Year Noise Levels Allowance[5]	69 or less dBA	0
	70 – 74 dBA	100
	75 or more dBA	200
Noise Level Increase Allowance[6][7]	0 – 4 dB	0
	5 – 9 dB	200
	10 or more dB	400
Noise Compatible Planning Allowance	The local government of the jurisdiction in which the project will be constructed has no policies to require that noise be considered in the land development process.	0
	The local government of the jurisdiction in which the project will be constructed has adopted official and enforceable policies to require that noise be considered as an integral component of the land development process.	100

(1) The majority (more than 50%) of impacted residences existed before the original highway construction.
(2) The majority (more than 50%) of impacted residences were constructed after the original highway construction.
(3) TDOT's previous noise Guidance, became effective on September 16, 2005. FHWA's approval of this policy was contingent upon TDOT's completion of a public outreach program to 1) notify local jurisdictions of the changes in TDOT's new Noise Guidance, and 2) encourage them to consider noise compatible land use planning when noise sensitive land uses are proposed adjacent to TDOT's highways. As a result, development that occurs after this date receives less consideration in the reasonableness analysis.
(4) The majority (more than 50%) of impacted residences existed before the most recent Type I project that added through traffic lanes.
(5) Applies to Activity Category B, C, and D land uses. No allowance for Activity Category E land uses. Based on an average of the impacted first–row receivers' levels (design year noise levels for Type I projects)
(6) An average of the increases from existing noise levels to design year noise levels for the Build Alternative at the impacted first-row receivers.

A table summarizing the results of the noise barrier reasonableness analysis should be provided in the Noise Technical Report and environmental document. The table should include a description of the area protected by the barrier(s), barrier length(s), average height(s), estimated barrier area(s), number of benefited residences, calculated area per benefited residence, allowable area per benefited residence, and whether the barrier is reasonable.

Section 772.17(b) of the FHWA Noise Regulation. (July 13, 2010) states that 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 (1) Noise compatible planning concepts, (2) The best estimation of the future design year noise levels for undeveloped lands or properties within the project limits, and (3) Non-eligibility for Federal-aid participation for Type II projects.

Since TDOT has demonstrated compliance with Section 772.17(b) of the FHWA Noise Regulation. (July 13, 2010), the date of development is a factor in determining the Base Allowance for the reasonableness analysis as described below.

7.9.2.3 Base Allowance

If the project is located on a new alignment, then each impacted area along the new alignment should be assigned New Alignment Allowance of 1,500 square feet.

If the project involves an existing road, then a development date analysis must be completed to determine the build dates of the impacted residences or other noise-sensitive land uses. The development date analysis involves first, determining the date of original highway construction; second, determining the construction dates of the impacted receptors; and third, determining whether the majority of impacted residences 1) predated the highway, 2) postdated the highway but were constructed before September 16, 2005, or 3) were constructed after September 16, 2005. The applicable base allowance is determined based on the results of the development date analysis.

The construction dates for most of Tennessee highways can be obtained from TDOT's TRIMs database. If the road construction date is not available, a determination as to whether a land use(s) predated the highway might be possible by reviewing historical mapping, GIS data, and property assessment data. TDOT should be consulted if a determination cannot be made using these available sources of information.

The construction dates for impacted receptors can usually be obtained from the County Property Assessor or the Tennessee Property Data Home Page.

A table summarizing the results of the development date analysis should be included in the Noise Technical Report and detailed results should be provided in an appendix.

7.9.2.4 Previous Type I Widening Allowance

Areas where the majority (more than 50%) of impacted residences existed before the most recent Type I project that added through traffic lanes should be assigned a Previous Type I Widening Allowance of 200 square feet.

7.9.2.5 Design Year Noise Levels Allowance

Areas with Activity Category B, C, and D land uses can receive a Design Year Noise Levels Allowance. Activity Category E land uses do not qualify for a Design Year Noise Levels Allowance. The Design Year Noise Levels Allowance is based on an average of the impacted first–row receptors' levels. NAAs with Activity Category B, C, and D land uses with average predicted future noise levels of 75 dBA or higher should be assigned a Noise Levels Allowance of 200 square feet. Areas with average predicted future noise levels between 70 and 74 dBA should be assigned a Noise Levels Allowance of 100 square feet.

Areas with average predicted future noise levels of 69 dBA or lower should not be assigned a Design Year Noise Levels Allowance.

7.9.2.6 Noise Level Increase Allowance

The Noise Level Increase Allowance is based on an average of the change between existing noise levels and future noise levels for the Build Alternative(s) at the impacted first–row receptors.

Areas where the predicted change is 10 dB or more should be assigned a Noise Level Increase Allowance of 400 square feet. Areas where the predicted change is between 5 and 9 dB should be assigned a Noise Level Increase Allowance of 200 square feet. Areas where the predicted change is 4 dB or less should not be assigned a Noise Level Increase Allowance.

7.9.2.7 Noise Compatible Planning Allowance

TDOT's Noise Guidance, states the following:

> *"TDOT and the FHWA believe that highway traffic noise should be reduced through a program of shared responsibility. Local governments should use their power to regulate land development in such a way that noise-sensitive land uses are either prohibited from being located adjacent to a highway or that the developments are planned, designed, and constructed in such a way that noise impacts are minimized."*

Local governments that have adopted official and enforceable policies to require that noise be considered as an integral component of the land development process will be assigned Noise Compatible Planning Allowance of 100 square feet.

7.9.2.8 Non-Residential Receptor Equivalency

The reasonableness determination for Category C, D and E land uses requires the calculation of an equivalent number of residences based on the size, type and duration of the activity.

The allowable barrier area per equivalent benefited residence for each noise abatement location is determined using the reasonableness calculation provided in the previous section.

The abatement measure will be reasonable if the required barrier area (in square feet) per equivalent benefited residence is less than or equal to the allowable barrier area per equivalent benefited residence for that noise abatement location.

The number of equivalent residences is determined using the following formula:

$$\text{Equivalent Residences} = \frac{\text{Number of Users}}{\text{(Number of People Per Residence}} \times \text{Usage}$$

Where:
Number of Users= Average number of users during usage time
Number of People Per Residence= 2.5 (Tennessee Average from census)

Usage= (Hours used per day/24 hours) x (Days used per year/365 days)

The Number of users, Hours Used Per Day, and Days Used Per Year should be determined by evaluating the characteristics of the individual use.

Variables that might be included in assessing the Number of users could include the maximum capacity of the use or the number of parking spaces provided. If maximum capacities are used, these capacitates should be multiplied by a Typical user Factor to arrive at the average number of users during usage times. Guidance for calculating the Number of Users for swimming pools and playgrounds in provided in Table 6.

Table 6: Number of Users Calculation for Playground and Swimming Pools

Land Use	Number of Users	Maximum Users	Typical Use Factor
Swimming Pool	Maximum Users X Typical User Factor	Area (sq. ft) / 10 (sq. ft) (1)	10% to 50% (2)
Playground		Area (sq. ft) / 50 (sq. ft)(3)	10% to 75% (4)

(1) Maximum occupancy based on Davidson County and Hamilton County swimming pool regulations that require 10 ft^2 of swimming pool area (deck areas excluded) per person.
(2) The typical number of users would be significantly less than the maximum number of users
(3) Based on the Tennessee licensure regulations for playgrounds requiring 50 ft^2.
(4) School playgrounds that are used throughout the day (i.e. schools) would have higher Typical user Factors than playgrounds at other facilities (i.e. churches, libraries, etc)

7.5.3.4.6
Active sports areas and dog parks are inherently noisy, and a quiet noise environment is not important for normal activities. Therefore, these areas are equivalent to one residence.

Parks will typically be comprised of several individual use areas including active sports areas, swimming pools, playgrounds, picnic areas. The equivalent residences for each of these individual uses should be calculated and added to get the total number of equivalent residences for the park.

7.9.2.9 Viewpoints of Benefited Property Owners and Residents

Per TDOT's Noise Guidance, the viewpoints of benefited property owners and residents will be considered in making final noise abatement decisions. TDOT will solicit input through formal questionnaires. FHWA has indicated that the solicitation of viewpoints should occur following approval of the final noise abatement design (FHWA FAQ G8).

Experience on past projects has indicated that residents have supported TDOT's proposed noise barriers. However, there may be instances where benefited residents or property owners oppose the construction of noise barriers for various reasons, including blockage of views, the loss of sunlight due to the shadow created by a noise barrier, and isolation effects.

TDOT will conduct a certified mail survey to solicit the viewpoints of the benefited residents and/or property owners that would be protected by the barrier(s). If a majority of benefited residents/property owners oppose the construction of a noise barrier, then the barrier is not reasonable and will not be included in the project plans. The determination will be made based on the total responses received.

Responses from residents or owners of properties that are predicted to be impacted as well as benefited will be counted as two responses. Responses from residents or owners of properties that are predicted to be benefited but not impacted will be counted as one response.

TDOT will conclude that a community desires the construction of a noise barrier unless a majority (more than 50%) of the impacted property owners and residents that respond indicate that they do not want the proposed noise barrier. If TDOT receives no responses, TDOT will move forward with the construction of the noise barrier.

7.10 Type I Projects with Existing Noise Barriers

Type I projects may include existing noise barriers that were constructed for a previous project. FHWA's guidance document *"Consideration of Existing Noise Barrier in a Type I Noise Analysis"* (FHWA-HEP-15-021) will govern the noise evaluation process for TDOT Type I projects that involve existing abatement measures.

Existing noise barriers will be evaluated to determine if they meet 1) TDOT's current acoustic feasibility criteria, 2) TDOT's Noise Reduction Design Goal, and 3) whether or not existing barriers are beyond average life. TNM should be used to calculate the noise levels without the barrier as well as the insertion loss for the land uses protected by the noise barrier. The insertion losses should then be used to determine if the noise barrier meets TDOT's criteria.

If an existing noise barrier does not meet TDOT's Noise Reduction Design Goal, the barrier may need to be modified or the entire noise barrier may need to be replaced.

7.11 Statement of Likelihood

A statement of likelihood should be included in the CE, FONSI, or ROD for all abatement measures that are determined to be feasible and reasonable. The statement of likelihood should include the preliminary location and physical description of all likely noise abatement measures and should indicate that final decisions regarding the construction of abatement measures will be made during the final design process for the project.

7.12 Third-Party Funding

Third-party funding is not allowed on a Federal or Federal-aid Type I 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 project to make functional enhancements (such as absorptive treatment, access doors, aesthetic enhancements) to a noise abatement measure already determined to be feasible and reasonable.

7.13 Construction Noise

Construction noise should be addressed in the Noise Technical Report and in the environmental document for the project. Most projects will not require modeling or any form of construction-related noise analysis. In most cases, construction noise may be adequately addressed through a narrative discussion that includes a statement indicating that construction procedures will be governed by the current TDOT's *Standard Specifications for Road and Bridge Construction* and local noise ordinances.

Large projects in urban or populated areas or controversial projects may require assessment of construction noise and construction noise mitigation.

7.14 Information for Local Officials

To minimize future traffic noise impacts on currently undeveloped lands adjacent to Type I projects, TDOT will provide local officials of the jurisdiction where the highway project is located with the following:

1. Information on noise compatible planning concepts;
2. The best estimation of the design year noise levels on the undeveloped lands along the project at various distances from the edge of the nearest travel lane of the highway improvement; and

This information should be included in the "Information for Local Officials" section of the Noise Technical Report and environmental document.

7.14.1 Noise Compatible Planning

TDOT encourages local governments with jurisdiction over undeveloped lands, as well as potential developers of these lands, to practice noise compatibility planning to avoid future noise impacts. The following language is included in TDOT's Noise Guidance:

> *"TDOT and the FHWA believe that highway traffic noise should be reduced through a program of shared responsibility. Local governments should use their power to regulate land development in such a way that noise-sensitive land uses are either prohibited from being located adjacent to a highway or that the developments are planned, designed, and constructed in such a way that noise impacts are minimized."*

TDOT's Noise Guidance states that:

> *"Federal participation in noise abatement measures will not be considered for lands that are not permitted by the date of public knowledge of the project and TDOT will not analyze or provide noise abatement for these lands. After the date of public knowledge, provision of noise abatement becomes the responsibility of local communities or private developers."*

FHWA has developed guidance documents on noise compatible land use planning:

- *The Audible Landscape: A Manual for Highway Noise and Land Use*, FHWA, November 1974.
- *Entering the Quiet Zone: Noise Compatibility Land Use Planning*, FHWA, May 2002.

7.14.2 Design Year Noise Levels

The Noise Technical Report and the environmental document should include a brief discussion of the locations and types of undeveloped lands within the project area. TNM should be used to predict design year noise levels at various distances from the proposed centerline of the near lane for these undeveloped areas. The analysis should be done for an at-grade condition without any shielding.

8.0 Reporting

8.1 Noise Technical Report

The results of the detailed noise analysis should be documented in a Noise Technical Report with a logical sequence and language that adequately describes the noise analysis procedures. Tables and figures should be used to convey the study results and ensure the report is easily understandable for both technical reviewers and lay-people.

TDOT has developed templates for the preparation of Noise Technical Reports to ensure consistency between project studies. These templates should be used on all TDOT projects and will be provided upon request.

The Noise Technical Report should contain the following sections as applicable:

1.0 Executive Summary
1.0 Introduction 1
2.0 Legislation, Regulations, and Policies 1
2.1 NEPA 1
2.2 1970 Federal-Aid Highway Act 1
2.3 FHWA Noise Regulation (23 CFR 772) 1
2.4 FHWA Guidance 2
2.5 TDOT's Noise Guidance 2
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Appendices (as applicable):

- Cover Sheet of Project Plans and Typical Cross-Section(s)
- Noise Measurement Data Sheets and Photographs, including the minute-by-minute time history data from the spreadsheet for each measurement site
- Traffic Projections
- TNM Plan Views and Modeling Checklist(s)
- Design Year Noise Levels and Impacts, Build Alternative(s)
- Development Date Analysis
- Noise Barrier Analysis Results

The cover should include TDOT's project name, PIN, state project number, and the type of plans used for the study.

All TNM runs developed for the project shall be transmitted to TDOT electronically with the submission of a draft or final report.

9.0 Final Noise Abatement Decisions

Conditions can change during the project design process. These changes may affect the preliminary noise abatement determinations in the environmental document. Such changes could include modifications to the proposed cross-sections, shifting the alignment, and changing roadway or ramp grades. Final decisions regarding the construction of noise barriers will be made during the final design process.

9.1 Final Noise Barrier Design

Final noise barrier designs will be developed once right-of-way plans have been completed and the design issues discussed below are better understood. The final barrier designs will be incorporated into the preliminary construction roadway design plans.

9.1.1 Right-of-Way

Right-of-way needs, including access rights (air, light, view, ingress/egress), easement for construction and/or maintenance, and additional land must be considered as part of the feasibility of noise barrier construction.

Isolated pockets of land between noise barriers and access control fences and private fencing should be avoided if possible. Such areas collect litter and are difficult to access and maintain. In many cases, the noise barriers will serve to control access so that a control of access fence may not be required, particularly in locations where the noise barrier is constructed at/near the right-of-way.

9.1.2 Safety

Safety factors including maintaining an adequate clear zone and sight distance are critical factors in determining whether a particular abatement scheme is viable.

9.1.3 Accessibility

Noise abatement measures should not affect ingress or egress from adjacent properties. Accessibility is considered in determining if the abatement measure is feasible and should be reviewed during final design.

9.1.4 Drainage

Drainage is an important consideration in locating and designing a noise barrier. Directing water along, under, or away from a noise barrier can be expensive and cause construction and maintenance problems.

9.1.5 Utilities

The location of overhead and underground utilities can affect the location and design of noise barriers. In some cases, utilities may have to be relocated so that a noise barrier can be constructed.

9.1.6 Ultimate Location

Noise abatement measures should be constructed to accommodate any planned widening of the facility. A noise abatement measure will not normally be constructed where the implementation of future projects would limit its useful life to less than 20 years. If noise abatement measures will be constructed at a shoulder location along a project where future widening is anticipated, then the project design should provide for salvage in the future.

9.1.7 Noise Absorptive Treatment

Noise reflections between parallel, reflective noise barriers can degrade the predicted effectiveness of the noise barriers. The amount of degradation is highly dependent on geometrics, and degradations can vary significantly from location to location behind the same noise barrier. TDOT will specify that the barriers shall be absorptive.

9.1.8 Aesthetics

TDOT will solicit the viewpoints of the residents and/or owners of the impacted properties when determining the aesthetic texture and color of the community side of the noise barrier. TDOT will select the aesthetic texture and color of the highway-side of the noise barrier.

9.1.9 Maintainability

Noise barriers must be maintained after construction including removing or covering any graffiti that appears on both the roadside and community side of noise barriers. Maintenance could be hampered if

the noise barrier is constructed at a location that is difficult for maintenance crews to access. Therefore maintenance crews must be able to access barrier locations.

10.0Construction Noise

As discussed previously, transportation projects will result in intermittent and temporary noise above existing ambient noise levels due to construction activities. The noise levels resulting from construction activities will be a function of the types of equipment utilized, the duration of the activities, and the distances between construction activities and nearby land uses.

One key to effectively addressing construction noise effects is proactive communication with the community. Residents and other affected property owners should be notified in advance of construction activities that will generate high noise levels, including blasting and pile driving. Measures contained in TDOT's Standard Specifications and local noise ordinances should apply to most projects. In addition to those measures, the following measures may be incorporated:

- Inform the public in advance regarding construction activities that might generate particularly high noise levels.
- Noise barriers that are included in the design plans should be constructed as early in project construction as practical.