# TRAFFIC NOISE MODELING AND ANALYSIS PRACTITIONERS HANDBOOK

Florida Department of Transportation
Environmental Management Office

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# INTRODUCTION

Traffic noise studies are an important aspect of any roadway improvement project, beginning with the analysis performed in the PD&E phase and continuing into the design phase. The Florida Department of Transportation (FDOT) has prepared this Traffic Noise Modeling and Analysis Practitioners Handbook to assist analysts in the prediction of existing and future traffic noise levels and the evaluation of the effectiveness of noise barriers while providing consistent, predictable, and repeatable noise studies. The contents of this handbook provide a compilation of practical approaches and examples which are to be applied in conducting traffic noise impact evaluations on the State Highway System (SHS).

The Federal Highway Administration (FHWA) Traffic Noise Model (TNM) Version 2.5 or later is the required software used to predict traffic noise levels and evaluate the effectiveness of noise barriers.[1] When analysis is required, all traffic noise analyses, traffic noise level assessments, and evaluations of potential mitigation effectiveness shall be performed using the TNM software.

Part 2, Chapter 17 (Noise) of the FDOT Project Development and Environment (PD&E) Manual constitutes the official traffic noise policy of the FDOT for the purpose of meeting the requirements of Title 23 Code of Federal Regulations (CFR) Part 772 "Procedures for Abatement of Highway Traffic Noise and Construction Noise."

This Handbook is designed for use by FDOT staff and its consultants that perform or review noise studies. It is expected that the users of this document are trained (or working under the guidance of someone who is trained) in the modeling and analysis of traffic noise impacts and abatement using the TNM. This Handbook is not to be considered the sole resource for conducting traffic noise studies using the TNM, but rather as a tool for producing consistent, predictable, and repeatable traffic noise studies. In addition to this Handbook, the analyst is also expected to follow the guidance provided in the documents text shown in the reference section of this document.

This document is divided into four sections. Section 1 provides information and guidance for "pre-modeling" activities including data collection, land use/field reviews, and sound level monitoring. Section 2 provides information and guidance for the computer modeling and analysis of traffic noise including the evaluation of abatement alternatives. Section 3 provides guidance for the documentation of both modeling input and results. Section 4 provides guidance for information regarding public involvement as it relates to traffic noise studies.

The FDOT has developed the State-Wide Acceleration and Transformation (SWAT) process to accelerate project delivery process for projects. The SWAT process also allows for an overlap of PD&E activities and Design activities to streamline delivery of projects.

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[1] For additional information regarding the TNM, analysts are referred to *Traffic Noise Model: Frequently Asked Questions (FAQ's) at: http://www.fhwa.dot.gov/environment/noise/traffic_noise_model/tnm_faqs/faq00.cfm*

Noise studies for SWAT projects must still follow the requirements of 23 CFR 772 and Part 2, Chapter 17 of the FDOT PD&E Manual. The major difference is that only one NSR may be prepared since the PD&E phase of the project may provide up to 60% roadway design plans, allowing for a detailed analysis to be completed, and allowing for noise abatement commitments to be made at that time. Consult with the District Noise Specialist to determine the appropriate approach for noise studies on SWAT projects.

# 1.0 PRE-MODELING ACTIVITIES

This section provides information and guidance for activities that take place prior to undertaking computer modeling.

## 1.1 Noise Methodology Meeting

Prior to performing the project traffic noise analysis, a methodology meeting should be held with the District Noise Specialist. This meeting establishes an agreed upon methodology and provides for sharing of necessary information and direction for the noise analysis (i.e., modeling parameters, developed lands, undeveloped lands, special land uses, available survey data, field measurement locations for model validation, etc.). Any required noise-specific public involvement efforts and expectations should also be discussed. A set of project aerials, photos of project specific issues such as outdoor advertising, community specific issues (such as existing development signage), and available typical sections should be available at the meeting. A formal agenda should be prepared outlining the methodology to be followed as well as any project-specific issues that will be addressed during the meeting and the methodology meeting will be documented with meeting minutes that become part of the official project file.

## 1.2 Data Collection: Traffic Data

The project traffic used for traffic data in the TNM will be developed in accordance with FDOT Project Traffic Forecasting Procedure, Topic 525-030-120 and the Project Traffic Forecasting Handbook (latest version). All preparers of traffic data used in the TNM shall ensure that the latest FDOT procedures are followed. A sample traffic data form is included in **Appendix A**. Traffic data should be in a format similar to the example form in Appendix A and be provided in the Noise Study Report (NSR) or design phase NSR Addendum. Traffic forecasts are developed during the PD&E study of a project. The resulting traffic data is typically reported in a Traffic Report.

In some cases, traffic data will need to be obtained for both the roadway which improvements are proposed and other major/minor roadways (cross streets) in the project area that influence traffic noise levels at nearby receptors. For example, if there are noise sensitive receptors for a widening project in close proximity to an interchange for an interstate or other limited access facility, traffic data will have to be prepared for the cross street because vehicular traffic on both roadways may contribute to the total noise level at the receptors, and one or the other roadway could cause abatement measures to be ineffective. Information for any roadways that may influence the results of the TNM should be provided by the traffic engineer/planner preparing the project traffic forecasts. Required data should be properly vetted during the project’s scoping efforts or during contract negotiations to ensure that all sources of potential noise impacts are included within the traffic data development stages for the project. This would include any and all potential noise sensitive receptors that are in close proximity to the project and shall include arterial roadways, collector-distributor (CD) roads, frontage roads, and other roadways.

As stipulated in the FDOT Noise Policy (Part 2, Chapter 17, Section 17-4.2 of the PD&E Manual), to ensure that "worst case" traffic noise conditions are used in the analysis, the following traffic volume and speed conditions shall be applied:

- For roadways (interstate mainline, CD roads, frontage roads, arterial roads, etc.), the traffic volumes will represent one of the following:
  - The directional planning analysis hour Level-of-Service (LOS) "C" peak hour, peak direction volume as specified by the most recent FDOT Quality/Level of Service Handbook Tables for Project Traffic volumes operating less than LOS C.
  - The Project Traffic peak hour directional demand volume if the facility operates at LOS A, B or C.
- The LOS "C" peak direction hourly volume for project specific conditions shall be determined from Table 7, 8 or 9 (as appropriate) of the current FDOT Quality/LOS Handbook Tables[2]. Of note, the same LOS C volume shall be applied to both directions of travel to ensure the highest noise generating conditions are represented. For interchange ramps, the traffic volume is the peak hour demand volume for the specific ramp being analyzed, even if the demand volumes represent a LOS greater than LOS C (e.g., LOS D, E or F).
- The vehicle speed to be used in the TNM is the posted speed for existing/no-build conditions, and the proposed posted speed for the future build condition. If the proposed posted speed is unknown, then the design speed is to be used. The motor vehicle speed used for ramps will be the posted speed and that speed is applied along the entire ramp unless modified by the flow condition (e.g., the speed along a loop ramp may vary from the time a vehicle leaves the mainline until it reaches the end of the ramp).

If FDOT Quality/LOS Handbook LOS C threshold directional volumes are used in the analysis (i.e., LOS C volumes are lower than project traffic volumes), the analyst should proceed to Step 3 below to obtain the volumes for each of the five vehicle types to be input into the TNM.

If project traffic peak hour demand volumes are to be used, the analyst should proceed to Step 2 below unless Directional Demand Hourly Volumes (DDHV) are provided in the project traffic report.

Occasionally, demand traffic data may be provided in the form of an Annual Average Daily Traffic (AADT) volume. In this case, the analyst will proceed with the following process, beginning with Step 1. AADT volumes are reduced to demand hourly volumes (DHV) as follows (Skip Step 1 if FDOT Quality/LOS Handbook LOS directional hourly volumes are to be used):

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[2] The FDOT LOS Tables can be accessed at: http://www.dot.state.fl.us/planning/systems/programs/sm/los/pdfs/fdot%202012%20generalized%20service%20volume%20tables.pdf

1. DHV = AADT volume x K(standard)

    - Example: AADT of 50,000 vehicles x K (standard) of 9% (or 0.09) = 50,000 x 0.09 = 4,500.

2. Directional Demand Hourly Volumes (DDHV) are calculated using the Directional Factor (D) to obtain the peak and non-peak directional volumes. As an example, if the D factor is 55% on a bi-directional roadway or one-way pair (a pair of parallel, usually one-way streets that carry opposite directions of the same signed route or major traffic flow), the directional volumes are calculated as follows:

    - Example: 4,500 x 55% = 2,475 vehicles for peak direction, which leaves a balance of 2,025 vehicles (or DHV * (1 – D)) for the non-peak direction demand hourly volume.

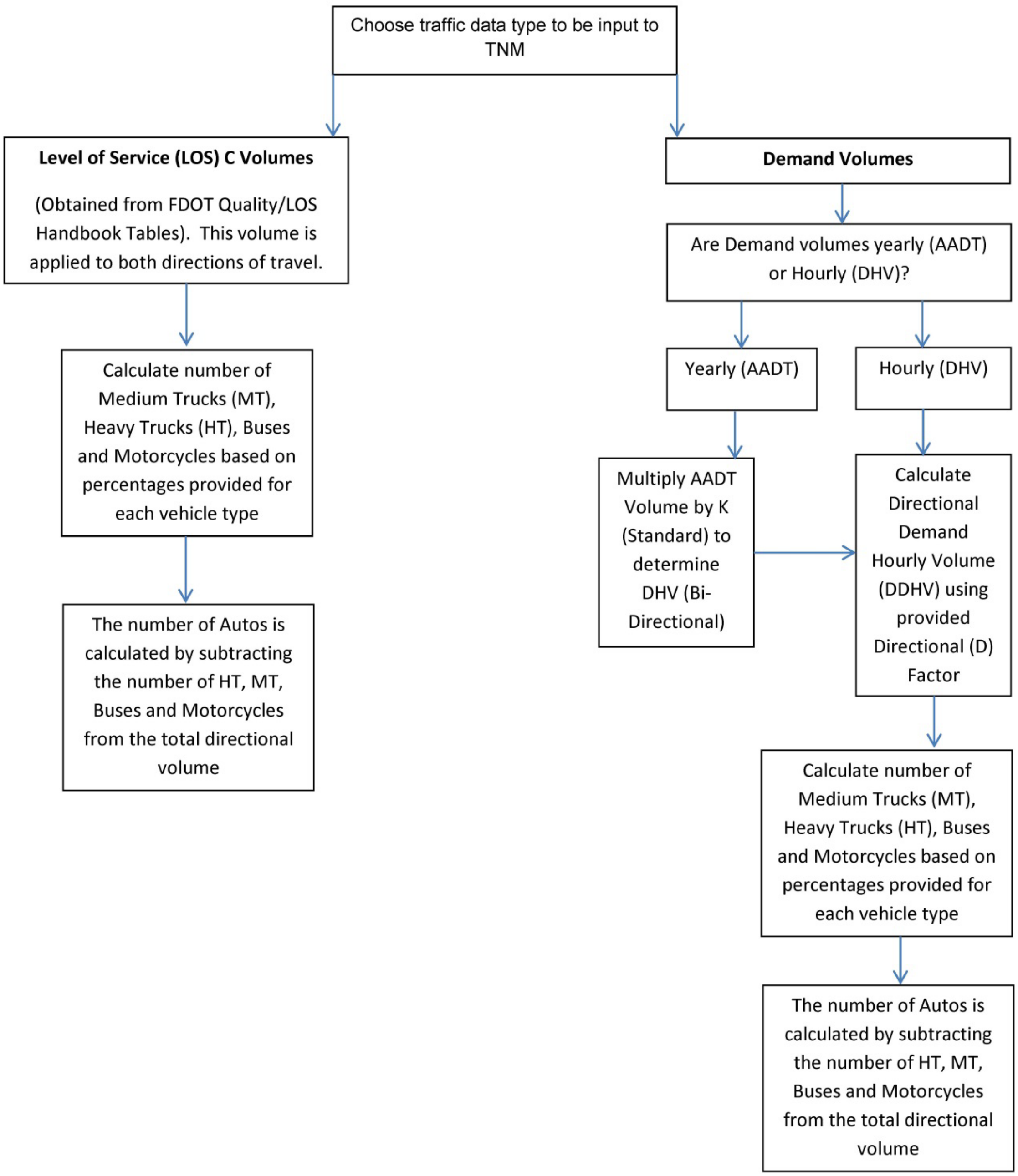
3. The number of heavy trucks (HT), medium trucks (MT), buses, and motorcycles used in the TNM is obtained by applying the respective percentages for those vehicle types to the calculated directional demand hourly volume (rounding up to the nearest whole number) for the peak hour.

   Notably, if the percentage of automobiles is not provided by a traffic engineer, it is calculated by subtracting the number of HT, MT, buses and motorcycles from the total directional volume being used.

   - Example: Assuming HT, MT, bus, and motorcycle peak hour factors of 3%, 2%, 1%, and 0.5%, respectively, and a Directional Design Hourly Volume of 2,475, the number of automobiles, HT, MT, buses and motorcycles in the peak direction of travel would be 2,314, 74, 50, 25 and 12, respectively.

The flowchart in **Figure 1** illustrates the process described above.

**Figure 1: Traffic Data Flowchart**



## 1.3 Data Collection

### 1.3.1 Elevation Data

The "Z" coordinate input to the TNM establishes the elevation of the modeled objects. It is important to use the most accurate elevation data available for all components of the modeling input, especially for roadways, receptors, and barriers (existing and proposed). In order of preference, the following is a list of acceptable sources of elevation data:

1. For receptor points, project specific survey data (i.e., spot elevations). The number will vary depending on the length/scope of the project;

2. Cross sections from roadway design plans;

3. Digital terrain model (DTM);

4. LIDAR (L**i**ght Detection and Ranging), an aerial method of mapping and survey;

5. As built plans for the existing roadway; and

6. United States Geological Survey (USGS) quadrangle maps.

### 1.3.2 Roadway Data

The FDOT provides the plans necessary to obtain horizontal roadway alignment data for existing roadways, and the proposed improvements for existing roadway or new alignments. This data shall be obtained for all roadways to be included in the analysis. For a PD&E study, an accurate survey may not be available for a proposed roadway alignment/alternative. In such case, the analyst should consult with the District Noise Specialist or District Project Manager to determine the source of elevation data to be used in the TNM. In most cases, as-built roadway plans (or the best available data) are appropriate for use.

During the design phase of a project, vertical alignment data for a roadway is obtained from the project's design plans. Vertical alignment data for cross streets may have to be obtained from other sources (such as those listed in Section 1.3) if insufficient coverage is available in a project's plan set.

For projects with a new alignment, the District Noise Specialist should be consulted to determine the best available data to use in the analysis.

The source for the horizontal and vertical roadway alignment data that are used in the modeling efforts shall be documented in the NSR or NSR Addendum for the project.

### 1.3.3 Receptor Data

Elevation data for the receptors is as critical as that for the roadway. However, this data typically cannot be obtained from roadway plans since the receptors in the analysis are outside the right-of-way.

The United States Geological Survey (USGS) is a common source for elevation data, with the data being available on topographic (topo) maps on the USGS website. The USGS website provides a "National Map Viewer"[3] which is a Geographic Information System (GIS) based interface containing various datasets. One of the available tools of this GIS provides spot elevations for nearly any location within the United States.

LIDAR and DTM are other sources of elevation data. Both may be available in a GIS based format from the Florida Geographic Data Library (FGDL).[4]

In the case of planned and permitted developments, it may be possible to obtain elevation data from the site plan. Site plans can be requested from the permitting agency or obtained directly from the site developer.

Regardless of the source of elevation data, it is important to recognize the vertical datum that is being used for the project, to ensure its consistency with the sources of elevation data used for TNM input objects. There are two types of vertical datum commonly used; the National Geodetic Vertical Datum of 1929 (NGVD 29) and the North American Vertical Datum of 1988 (NAVD 88). The vertical datum being used on a project is documented in the roadway plans, or available from the FDOT if plans have not been prepared. The source(s) of elevation data should be referenced in the NSR or NSR Addendum.

### 1.3.4 Other Input Items

Elevation data, including the height and bottom (ground) elevation of existing privacy walls and/or earth berms or are planned to be placed between a roadway and noise sensitive sites are required, as these features may have an acoustic effect on predicted noise levels. For this reason, all existing walls and earth berms should be surveyed if possible, for use as input into the TNM. It is also important to note the material used to construct existing privacy walls. Open-weave walls, open-board fences, wooden privacy fences, chain link fences, and similar walls are typically not dense enough to provide meaningful noise level attenuation, and are not included in a traffic noise analysis.

## 1.4 Field Reviews

Regardless of the size, scope, or general nature of a project, land use and field reviews of the project area are an essential part of an analysis. The size and scope of a project determines the number of field reviews to be performed, with a minimum of two preferred.

The primary goal of the field review is to identify existing land uses adjacent to the project corridor for which there are noise abatement criteria. These properties are included in the modeling/analysis.

While technology (Google Earth, etc.) makes it simple to perform a "desktop" review of the project area, there are some land uses that cannot be identified without a field visit. One example would be the

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[3] The National Map Viewer can be accessed at: http://viewer.nationalmap.gov/viewer/

[4] The Florida Geographic Data Library can be accessed at: http://www.fgdl.org

number of dwelling units in a multi-family building, or a duplex that from an aerial photograph appears to be a single-family residence when in fact it contains more than one dwelling unit.

When conducting the field review for a project, it is important to note the "exterior area of frequent human use" for multi-family (MF) buildings (e.g., apartments and condominiums). When an evaluation includes Activity Category "D" sites (the interiors of schools, libraries, places of worship, etc.), it is also important to note the construction material used for the buildings (wood frame, masonry, etc.).

In the absence of exterior areas of frequent human use, this information will be used to determine the sound level reduction factor that should be applied to the modeling results to predict interior traffic noise levels (for those Activity Categories for which an interior criteria apply). Additional information regarding sound level reduction factors to be used can be found in the FHWA's "Highway Traffic Noise: Analysis and Abatement Guidance"[5] document.

Another goal of the field review is to note any potential conflicts that could arise in areas of potential noise abatement. For engineering issues, conflicts should be further verified/discussed with the engineers developing the conceptual or final design.

These include utilities (both overhead and sub-surface), drainage features, access requirements (driveways, cross streets, etc.), outdoor advertising, or any other factors that may impact the placement or routine construction of a noise barrier.

The earlier in the process that these types of potential conflicts are identified, the less likely they are to create an issue later in the project. The FDOT will provide detailed utility data to the extent practical and called for in the project scope.

It is also important to note any signs of new development or zoning changes on undeveloped lands. Local government property records should be reviewed to ensure that new building permits have not been issued for undeveloped lands. A review of property records is needed during the design phase to ensure no new building permits were issued prior to the Date of Public Knowledge, but after the PD&E noise study was completed.

At least one, if not more, additional land use review(s) should be conducted throughout the life of the project to verify if any land use changes have occurred, and also to review potential noise abatement locations for conflicts as detailed above.

### 1.5 Determining Existing Noise Levels

Noise measurements are taken in the project study area to determine existing noise levels for projects on new alignment (in this case existing traffic noise levels cannot be modeled using the TNM). A combination of measurements and modeling is performed to validate the TNM for use on a project, where an existing roadway is being improved. Regardless of the intent, all measurements shall be

[5] The FHWA's Highway Traffic Noise Analysis and Abatement Guidance document can be found at: http://www.fhwa.dot.gov/environment/noise/regulations_and_guidance/analysis_and_abatement_guidance/revguidance.pdf

conducted in accordance with the requirements detailed in FHWA's publication "Measurement of Highway Related Noise" (MHRN)[6] and the applicable sections of the FDOT Noise Policy (Part 2, Chapter 17 of the FDOT PD&E Manual). An example noise level measurement data sheet is provided in **Appendix B**.

### 1.5.1 Equipment

A sound level meter (SLM) plays a key part in model validation since the results of the monitoring efforts are used to validate the TNM and/or determine existing noise levels. It is important to use equipment that is accurate and well maintained. At a minimum, the SLM shall be calibrated following the suggested frequency recommended by its' manufacturer. The calibrator emits a pure tone that matches the calibration requirement of the SLM manufacturer. Additional information regarding the noise level measurement equipment is available in the MHRN document.

All noise level readings shall be taken using the "A" weighting scale and on the "slow" response setting. The SLM shall be mounted so that the microphone is oriented in the direction of the traffic noise source consistent with the manufacturer's recommendations.

The microphone shall be located five feet above ground level or five feet above the base level of the noise sensitive receptor of interest. A windscreen designed for use on the SLM shall be used at all times during the field measurement period.

Prior to the field measurement period, the SLM shall be calibrated and the results noted on the field data sheet. The SLM shall also be calibrated at the end of the field measurement period. If the difference between the two calibrations is greater than one dB, the measurement period shall be repeated.

### 1.5.2 Validation Site Selection and Data

The required number of validation sites is project specific and shall be coordinated with the District Noise Specialist. If practical and possible, validation sites should coincide with potentially impacted locations. Residential communities are of particular interest, especially communities that have expressed traffic noise concerns. Additionally, validation sites shall be selected in an area that is representative of free-flow conditions (i.e., there are no traffic control devices such as traffic signals or stop signs nearby). Monitoring shall be performed for a minimum of 30 minutes (3 repetitions of 10 minutes each) at each selected monitoring site.

Validation studies require the collection of accurate field data for the locations where field measurements are obtained. One way to obtain the location of the SLM is to use a global positioning system (GPS) unit that has an accuracy of 0.5 meters or better. If using a GPS unit isn't practical, aerial photography or a set of plans for the project can be used to establish the location of the validation site. A measuring wheel or measuring tape can be used to obtain the distance from the edge of pavement of

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[6] http://www.fhwa.dot.gov/environment/noise/measurement/measure.cfm

the roadway and at least two other points (an intersecting street, drainage feature, power pole, building corner, etc.).

Analysts also locate and identify features that may influence the measured noise levels, including ditches, berms, privacy walls, canals, streets, parking lots, buildings, billboards, etc. The location and any details of these features are to be noted on the site sketch or plan set. Taking photographs of the site is recommended.

If the pavement condition does not reflect an average pavement type, one of the alternative pavement types that more accurately reflects the actual pavement condition may be applied. ***Note – Use of this alternative pavement type in the TNM is only applicable to validation efforts and the prediction of existing traffic noise levels, and is not to be used for the prediction of future traffic noise impacts, and must be approved by the District Noise Specialist.*** While in the field, note if the roadway is an urban curb and gutter configuration or if it has paved shoulders and grass swales. The dimensions of all of these features, including traffic safety devices such as "Jersey" barriers at the shoulder or in the median, and the height above the roadway shall also be obtained. Analysts should not rely on the construction plans to provide all of the information regarding site details, geometry, etc. for the modeling effort.

Since the TNM cannot account for noise other than traffic, analysts must be certain that traffic noise is the dominant noise source. Activities such as lawn mowing, children playing, air conditioning units, and aircraft flyovers can dominate the background noise levels to an extent that the traffic source is relegated to a lesser impact. If this is the case, the noise level monitoring equipment should be relocated to a more suitable site. During each measurement period, the sources of the sounds other than those resulting from traffic on a roadway are noted on field measurement data sheets.

### 1.5.3 Meteorological Data

While the meteorological data (other than the default values for relative humidity, temperature, and wind) are not used in TNM, it is important to note the actual field conditions prior to and during the field measurements. This will document the appropriateness of the weather conditions for taking field measurements. Temperature and humidity can affect the sensitivity of SLM's and may result in the SLM not recording the noise accurately or, in some cases, not at all. To ensure that this does not happen, it is important to know and adhere to the manufacturer's operating conditions for the SLM and calibrator in use. The temperature and humidity can easily be determined by the use of a hand-held or mounted thermometer and hygrometer. The wind speed and direction can also be determined through the use of a hand held or mounted anemometer and compass. If the observed wind speed exceeds the recommended limits in the MHRN document, measurements shall be suspended until conditions improve or postponed until a later date. Rain and/or wet roads could result in higher noise and shall be avoided during monitoring.

### 1.5.4 Traffic Counts and Classification

Obtaining traffic data in the field is the key to successful model validation. At a minimum, analysts must separate traffic counts by direction and vehicle type consistent with the FHWA/TNM vehicle classification system for use in traffic noise studies (shown in **Table 1**).

**Table 1: Vehicle Classification for Traffic Noise Studies**

| | Autos | Medium Trucks (MT) | Heavy Trucks (HT) | Buses | Motorcycles |
|---|---|---|---|---|---|
| **Description** | 2 axles and 4 tires | 2 axles and 6 tires, and designed to haul cargo | Cargo vehicles with 3 or more axles | All vehicles designed to carry more than 9 passengers | All vehicles having 2 or 3 tires with an open-air driver and/or passenger compartment |
| **Examples** | Passenger cars, pick-up trucks | Large pickup with dual rear tires, delivery vans, local moving vans, dump trucks, service trucks, motor-homes | Tractor-trailer units, including dual rear tire pickups pulling a trailer, large motor-homes with 3 axles, large dump trucks | Local and long distance buses, hotel/airport vans, school buses | Harley Davidson, Honda Gold Wing, Yamaha and other makes of motorcycles |

Source: FHA Report FWHA-PD-96-046 – Measurement of Highway-Related Noise, May 1996.

### 1.5.5 Traffic Speeds

Since traffic noise levels are, in part, speed dependent, every effort should be made to accurately depict the traffic speed for each vehicle type during the measurement period. Traffic speeds are best obtained through the use of a hand-held radar gun or similar device. Some roadways may have higher or lower volumes of one vehicle class versus another, and it is very important to obtain the speed of each vehicle class, especially the low volume variety, which are most often buses and motorcycles. Capturing speeds for as many vehicles in each vehicle class is recommended. The overall goal of measuring traffic speeds is not to get the fastest speeds, but rather an accurate representation of the speeds for all vehicle types observed during each measurement period.

## 1.6 TNM Validation

This section describes the process that shall be used to validate noise levels obtained in the field. The primary purpose of the field measurements are to determine if traffic is the primary noise source in the area and to validate the computer model using the conditions observed in the field. As required by the FHWA (23 CFR 772.11(d)) (2) and the FDOT Noise Policy (PD&E Manual Part 2, Chapter 17, Section 17-5.2), field measured traffic noise levels must be compared to the predicted results under the same conditions. To do this with a consistent degree of accuracy, the information gathered in the field during the time of the sound level measurements is key.

Since the TNM predicts traffic noise levels that represent steady-state noise for a period of one hour, field samples that are collected for periods of less than one hour must be converted so they reflect an hourly condition. For example, if the monitoring is conducted for 10 minutes and during that 10 minutes 100 autos, four medium trucks, 10 heavy trucks, zero buses and one motorcycle were counted, each value shall be multiplied by six to obtain hourly values (if the measurement period was 15 minutes, the volumes shall be multiplied by four). The measured speeds would be applied to all vehicle types based on the average readings taken for each vehicle type. If no speed was recorded for a particular vehicle type, the analyst should use the average speed of all other vehicle types during that measurement period.

For the purpose of model validation, the actual pavement type may be used in the TNM as long as the pavement type is verified by FDOT.

Next input any barriers, building rows, terrain lines, or ground zones that existed at the measurement site. Privacy walls are to be included in the modeling if the density of the construction material is enough (a minimum density of 4 pounds per square foot) to provide reasonable noise attenuation. See FHWA's *Noise Barrier Design Handbook* for further discussion on noise transmission loss. Open-weave walls, open-board fences, wooden fences, chain link fences, and similar privacy structures shall not be included in the modeling effort since they may have little or no noise reduction impact on the measured noise levels. The District Noise Specialist shall be consulted for any questions regarding features to be included in the TNM.

TNM results shall be reviewed for consistency with the field measured data. If the results are within the accepted FHWA and FDOT limit of +/- 3 dB(A), the validation effort will be considered complete. If this is not the case, then the modeled results must be reviewed in detail to determine if a site feature was not correctly accounted for within the modeling input, or if sources of sound other than motor vehicle traffic during the measurement period had too great an influence. If the difference between the measured and modeled noise cannot be reconciled, the measurement period (or site if all measurement periods fail) cannot be used for the purpose of validating the model. If validation measurements were not obtained at any other site, the field measurements must be repeated until at least one measurement period is validated. If the results indicate that the measured noise levels are higher than those predicted by the TNM, an explanation should be provided as to why the measured levels were higher (i.e., other sound sources were present during the monitoring that cannot be accounted for using the TNM).

The results of the model validation effort shall be documented in the appropriate NSR or NSR Addendum. Documentation shall include a table within the report that shows the field measured value, the modeled value, and the difference between the two. Copies of the field measurement data sheets must be provided in the appendix of an NSR. The location of each validation site shall also be illustrated on the same plan sheets/aerials as the modeled receptors.

# 2.0 TNM Modeling & Analysis Guidelines

This section provides guidance for the TNM input that is typically used in the analysis of FDOT projects. Specific questions or concerns not addressed here should be directed to the appropriate District Noise Specialist.

Quality assurance (QA) and quality control (QC) are essential to ensure a high quality report with consistent, predictable, and repeatable results. A checklist provides assurance that the QA/QC review efforts have occurred. An example modeling QC checklist is provided in **Appendix C.**

## 2.1 File Naming Conventions and File Information

This section provides guidance for setting up a TNM file using a logical naming convention and the type of information to be included in the model run, roadway, and receptor and barrier identification. The FHWA *Traffic Noise Model User's Guide* recognizes that use of the term "File" is a misnomer. The term "File" is used for consistency with most window-based programs. A TNM run is saved in a subdirectory (i.e. folder) and the logical naming convention is applied to the folders. Sharing a TNM run with someone else requires that you transfer the entire folder.

The names of input files should be simple, short, and descriptive (significant extensions may cause the TNM file to be deemed inaccessible). Due to limitations on the total number of characters in a file name, input files should also not be saved inside a long string of folders. The file name should be descriptive enough to clearly let the user know what project and scenario is being evaluated. Standardizing the naming of input files will make it easier for an analyst (and others that might need to use a TNM file) to locate and open each file as needed. The following provides example input file names for a project on US 27 for which the existing, future no-build, future build, and abatement scenarios are being evaluated:

- US27EX (i.e., existing)
- US27NB (i.e., no-build)
- US27B (i.e., build)
- US 27BAR1 (i.e., barrier 1)

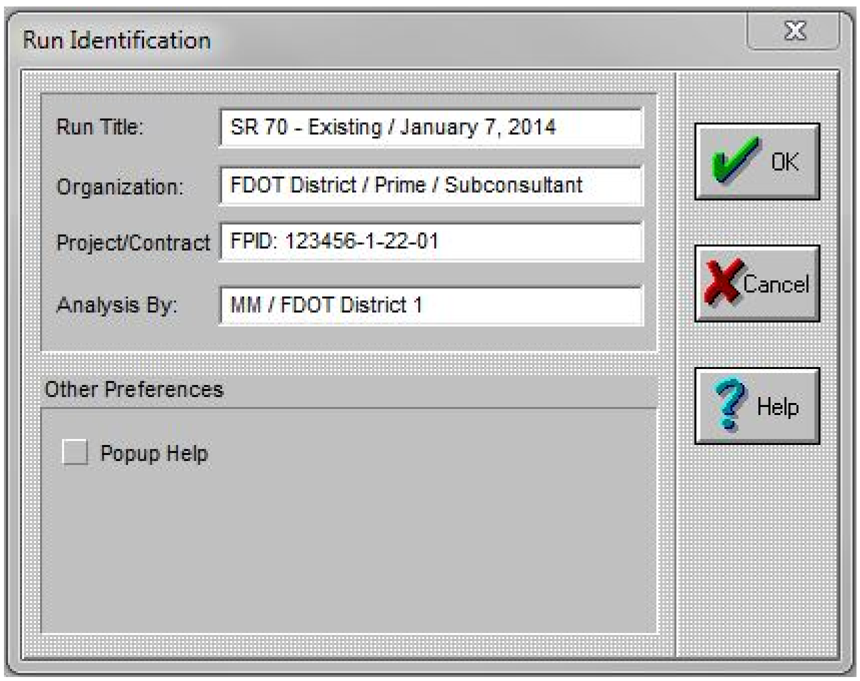
### 2.1.1 Run Identification Input

Analysts shall use the TNM's run identification input to document additional information about the project and scenario being evaluated. Run titles should essentially mirror the input file name. For example, if the input file name is "US27EX", the run title would be "US 27 – Existing". If a project is divided into segments, the project segment being evaluated shall also be identified (e.g., US 27 – Existing - Elden to Pace). If a project is segmented for other reasons, such as the typical section, the segment identification can also be included in the title (e.g., US 27 – Existing - Segment 1). Where segment numbers are used the limits of each segment shall be defined in the NSR. If stationing is available, analysts could also use the beginning and end station for each segment.

When identifying the organization in the run identification input, analysts shall identify either the FDOT District or company that is preparing the analysis (e.g., District One, Central Office, XYZ Consulting Company). Under the Project/Contract heading, provide the FDOT Financial Project Identification Number (FPID) or, if unavailable, the contract number. Finally, the individual performing the analysis shall be identified by their initials. This will allow any future modeling questions to be directed to the appropriate person within the FDOT or the consulting firm responsible for the modeling input.

**Figure 2** illustrates how this information would appear for an example project, assuming the analysts' name is Michelle Miller and she is an employee of the FDOT District One.

**Figure 2: Run Identification**




## 2.2 TNM INPUT

### 2.2.1 State Plane Coordinate System

The state plane coordinate system shall be used to define the X and Y coordinates of all roadways, receptors, barriers, and other features input to the TNM. The use of the state plane system allows for consistent replication of project information (unlike the use of an aerial or roadway plan sheet with a user-drawn coordinate system).

### 2.2.2 Roadway Input

#### a. General

The first input you will provide related to roadways (including ramps and roadways on structure) is the name of the roadway. Roadways should be identified consistently throughout the modeling process. Naming roadways is best done by identifying both the roadway and the direction. For example, I-95 NB could be used to identify northbound I-95. The use of stationing is recommended for segment or point identification as well.

### b. Roadway Travel Lanes and Shoulders

Consistent with the TNM Manual/FAQ guidance, individual roadway lanes should be modeled and the lanes shall overlap. The input for paved shoulders shall be such that the shoulder overlaps the travel lane adjacent to the shoulder. Both can be accomplished by inputting the X, Y, and Z coordinates of the centerline of each lane or shoulder and adding 0.2 feet to the width of the travel lane or shoulder (e.g., a travel lane with a width of 12 feet shall be input as 12.2 feet). The pavement width used shall represent either the existing or planned roadway width, depending on the scenario being evaluated.

The use of lane by lane modeling will greatly increase the model calculation or “run” time. For this reason, analysts shall use the lane by lane modeling for the roadway being evaluated but not necessarily for all roadways included in the TNM input file. For example, on an interstate widening project, analysts shall model all travel lanes on the interstate individually, and group travel lanes together for other roadways such as arterials, interchange ramps and CD roads.

As with all TNM input items, the naming convention used is important. When using lane-by-lane modeling, analysts shall identify each lane being modeled (e.g., inside, center, outside, etc.). The locations of shoulders shall also be identified (e.g., inside and outside).

Modeled roadways shall extend at least eight times the distance between the roadway and the most distant receptor, with the receptor centered along the roadway. For instance, a modeled roadway segment should extend at least 4,000 feet in either direction beyond a receptor that is located 500 feet from the center of the road.

### c. Intersecting Roadways

Model any intersecting roadway that carries a substantial volume of traffic, if this information is available, and the traffic noise from the intersecting roadway would likely influence the predicted traffic noise level at nearby noise sensitive receptors. Minor cross streets or other local roadways in the vicinity of a project usually do not require modeling.

### d. Pavement Type

The pavement type default is “average” and must be used in the prediction of future traffic noise levels. For existing noise level prediction or for model validation studies, the actual pavement type may be used, but only if the pavement type can be verified by the FDOT.

### e. Elevated Roadways

The “Z” coordinate of roadway segments is an important TNM input. If a roadway is elevated and on fill by a mechanically stabilized earth (MSE) wall or embankment section) the roadway itself becomes a barrier if it lies between a receptor and some or all of the roadway lanes being evaluated (or other roadways). This is not the case for roadway segments on structure, when sound can pass under the structure.

It is important to locate and identify all roadway segments on structure (bridge). Doing so ensures, (1) intersecting roadways will not cause a TNM-generated error message, and (2) that sound from other roadways is allowed to pass through/underneath the structure (i.e., the elevated roadway does not act like a barrier as discussed above). Please refer to the TNM User's Manual for additional information regarding the modeling of roadways on structure.

#### f. Roadway Length

Since roadways rarely run in a straight line and on a flat plane, most roadways have to be segmented to allow the accurate depiction of real-world conditions. To accomplish this, segments of varying length must be used to reflect changes in gradient or curvature. The more curvature you have, the greater number of tangent segments you will be required to input.

#### g. Roadway Medians

Paved roadway medians shall be modeled either as a zero-traffic roadway, or as a "pavement" ground zone. Regardless of the method used, the analyst shall ensure that the width is enough so that the TNM doesn't "assume" default ground type on either side of the median. If using a zero-traffic roadway, 0.2 feet can be added to the width of the median roadway input to ensure sufficient overlap (as with ensuring overlap of individually modeled roadway travel lanes and shoulders). If the roadway median ground type is something other than TNM's default ground type (i.e., lawn), then a ground zone of the appropriate type shall be modeled.

### 2.2.3 Traffic Volumes, Speeds and Flow

#### a. General

As stated in Section 1.2, when peak hour demand volumes are used in an analysis, traffic volumes are calculated for the peak and off peak directions of roadway travel. When receptors are located on both sides of the roadway of interest, the analyst should create two TNM files to represent worst-case conditions. Concurrence on the application of directional traffic splits should be obtained from the District Noise Specialist.

One TNM input file would have the peak traffic on the northbound travel lanes (off peak traffic on the southbound travel lanes), and receptors on the east side of the roadway. The second TNM input file would have the peak traffic on the southbound travel lanes, off peak traffic on the northbound lanes, and receptors on the west side of the roadway. Use of this method ensures that the "worst-case" conditions are evaluated for all receptors, regardless of which side of the roadway they are located on.

The distribution of directional traffic volumes amongst individual travel lanes depends on the circumstances surrounding the roadway. If there are no known restrictions (high occupancy vehicle (HOV) lanes, truck lanes, etc.) then the peak directional traffic is distributed evenly by the number of travel lanes being modeled. The individual lane volumes are estimated to the nearest whole number. (e.g., a calculated lane volume of 947.6 autos per lane is rounded up to 948 autos per lane).

When a roadway project involves HOV lanes or designated lanes for certain vehicle types, the analyst assigns the appropriate type and volume of vehicle to the appropriate travel lane based on predictions provided.

### b. Flow Control

Flow control allows analysts to address the impact of vehicle acceleration away from selected traffic control devices such as stop signs, toll booths, traffic signals, and on-ramp start points. The speed constraint used should be obtained from the TNM Manual. In general, 100 percent of vehicles are affected by all traffic control devices except traffic signals, which typically catch only a portion of vehicles on their red phase. The percentage of the vehicles affected to be applied is 100 percent unless a traffic study indicates otherwise.

## 2.2.4 Receptors

### a. General

Receptors should be located so that they are consistent with the guidance found in Part 2, Chapter 17, Section 17-4.3 of the PD&E Manual. Like roadways, receptor points should be labeled in a manner that is logical and consistent. Typically, alpha/numeric systems are used, starting on one side of the roadway and working south to north or west to east, consistent with the baseline of survey stations. This process is then repeated on the opposite side of the roadway as well. If a project has been segmented or there are distinct noise study areas (NSA's), an analyst may want to use a receptor identification system that includes NSA identification (e.g., letters or numbers). For example, the 23rd receptor on the west side of I-95 within the third NSA could be identified as "3-W-23". ***(Caution – ID's can clutter the aerial display so they should be as simple and brief as possible with the requirement that aerials be completely legible).***

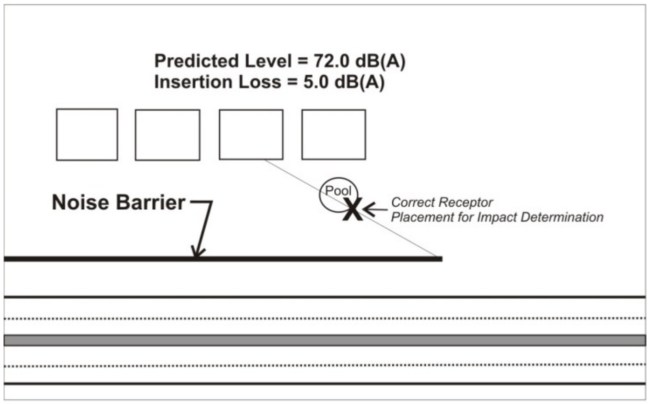
To distinguish receptors located on the first and second floors, additional letters shall be assigned to the receptor ID. In the example above, the ID's for receptors on the first and second floor would be "3-W-23A" and "3-W-23B", respectively. Regardless of the specific labeling convention that is used, the NSR or NSR Addendum should describe the convention used.

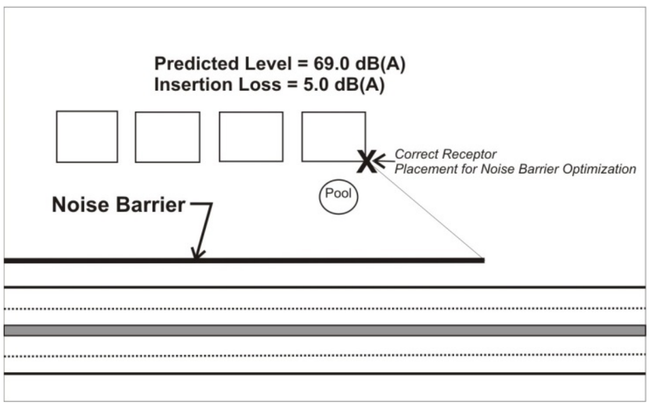
Receptor placement is important as it can determine if a property is impacted and affect the results of noise barrier analyses and barrier optimization. Analysts may have to develop two sets of receptors for the same property depending on the purpose of the modeling effort. If the purpose is to determine whether a property is impacted, the placement of the receptor should be as stipulated in Part 2, Chapter 17, Section 17-4.3 of the PD&E Manual (i.e., the area of frequent human exterior use).[7]

[7] Unless the area of frequent human use is identified elsewhere, residential receptor sites should be placed at the edge of the dwelling unit closest to the major traffic noise source or as dictated by professional judgment.

If the purpose is to determine whether a noise abatement measure, especially a noise barrier, would benefit a property, additional receptors may be required. **Figure 3** illustrates a situation where additional receptors, for the same property, should be considered in a noise barrier evaluation. As shown, only considering abatement for the first scenario would be inappropriate since more of the property is impacted and requires abatement consideration. The second scenario depicts the correct receptor placement for the purpose of determining noise barrier effectiveness.

**Figure 3: Receptor Placement**




Assuming uniform characteristics (distance from roadway, land use, topography, etc.), it is acceptable to combine receptor points that may be located more toward the center of the frontage of the community.

Modeling of special use locations such as parks, playgrounds, trails, and non-standard sites like schools and places of worship will require extra attention to receptor placement and shall be done by applying the principles illustrated in the FDOT research report: "A Method to Determine Reasonableness and Feasibility of Noise Abatement at Special Use Locations" ("Special Use" methodology) [8].

[8] The FDOT "Special Land Use" Methodology can be found at:
http://www.dot.state.fl.us/emo/pubs/Reasonableness%20and%20feasibility%20of%20Abatements%20at%20Special%20Use%20Locations%20%20Report%20Update%20-%207-22-09%20%282%29.pdf

Due to the various types of special use locations, any questions regarding the application of this methodology to project specific conditions should be directed to the District Noise Specialist. Documentation of decisions and rationale is of extreme importance.

TNM's default receptor height is 4.92 feet above ground, and this value shall be changed to 5.0 feet. When selecting receptor sites, receptors shall be included such that all potentially impacted sites are either specifically modeled or represented. The number of receptors modeled will vary depending on the location of the receptors in proximity to one another and their distance from the roadway(s) in the TNM input.

For an arterial roadway in an urban area that has a uniform distance from the roadway to numerous noise sensitive sites, a single receptor may be used to represent the sites for the purpose of the noise impact assessment as long as the roadway and traffic characteristics are consistent within the area of concern. For roadways that vary in alignment and elevation (i.e., an urban highway that has frequent overpasses, underpasses, interchanges and ramps), numerous receptors will need to be modeled as these design features can significantly affect motor vehicle acoustics.

The Receiver "Adjustment Factors" tab provides the analyst the ability to manually adjust the predicted noise level from a roadway segment to a receiver to account for things that cannot be modeled by the TNM (such as background noise, other transportation noise sources, etc.). Analysts shall not ***use this function unless the expected change to the predicted traffic noise level is three or more dB(A) consistent with FHWA guidance*** found in Appendix A of the TNM User's Manual. If an analyst does use an adjustment factor, the feature that causes the need for an adjustment and the reasons for applying the adjustment must be fully quantified and documented prior to finalizing the TNM results.

### b. Multi-Story Receptor Height

Unless more accurate data are available, for receptors located on the second and subsequent floors of a building analysts shall add 10 feet to the "height above ground" for each additional floor evaluated above the ground floor. Application of the guidance found in Section 17-4.3 of the PD&E Manual is acceptable.

### c. Receptor Locations for Non-Residential Receptors

The following is guidance for consideration of special situations.

- For Activity Category A sites (lands on which serenity and quiet are of extraordinary significance), the receptor point(s) are to be located at a point(s) representing an area of frequent human use and at a point(s) closest to the roadway that is anticipated to generate the greatest noise impact. The FHWA must approve of the use of Activity Category A receptors. For state only funded projects, the District Noise Specialist should consult with the State Environmental Management Office (SEMO).

- Sites at Recreational Vehicle (RV) parks are to be treated as Activity Category B of the NAC. Each location within an RV park that has a "hookup" (i.e., connection for electrical, water, sewer, etc.) is treated as one (1) residential receptor.

- For Activity Category C sites, (i.e., active sport areas, amphitheaters, cemeteries, hospitals, etc.) the placement of the receptor point(s) will depend on the type of site.

    - For active sport areas, the locations of receptors need to be consistent with the guidance provided in the "Special Use" methodology. An array/grid of receptors is placed in areas of use and where impacts are expected to be predicted. If an impact is identified, the same receptor array/grid is used to determine the feasibility and cost reasonableness of abatement.

    - For amphitheaters, the outdoor seating areas and/or the performance stage are typically the primary areas of concern. The application of the "Special Use" methodology receptor array/grid as noted above is used to assess the extent of impacts and abatement.

    - For auditoriums, appropriate exterior receptor locations are placed at features that attract frequent human use (e.g., gazebos). If no exterior use areas exist, then the receptor is considered Activity Category D and is located at an interior point that would be a site of frequent human use, such as a stage, seating area, etc. As stated in the FDOT Noise Policy (Part 2, Chapter 17 of the PD&E Manual), the prediction of interior traffic noise levels will be coordinated with the District Noise Specialist. If interior levels are to be predicted, the analyst refers to Table 17.2 in the FDOT Noise Policy (Part 2, Chapter 17 of the PD&E Manual) that provides the appropriate reduction factor to be applied to the predicted exterior noise.

    - Campgrounds have receptors placed at points where camping facilities (e.g., grills, patios) are designated (regardless of whether there is an active occupant).

    - At cemeteries, receptors are placed in an array/grid and follow the same analysis procedure noted above for active sport areas.

- There are several types of Activity Category E sites for which the following guidance is provided.

    - Hotels and motels that have an outdoor pool or other gathering areas (e.g., shuffleboard court, grill, etc.) that can be considered a frequent exterior use area. These locations are modeled to identify potential impacts. Offices that have outdoor features that are a gathering area (e.g., table(s), awning(s), etc.) used by employees and others. These areas shall be considered areas of frequent human use.

- Restaurants/bars that have outdoor seating areas at which customers are served are considered noise sensitive. Receptor point(s) are placed at the point of frequent human use within these areas that is closest to the traffic noise source.

- If the outdoor frequent use area is located in an area protected by the building, the building itself is modeled as a barrier to accurately reflect the nature of the site.

- Since there are no Noise Abatement Criteria established for such properties, it is not necessary to model Activity Category F and G properties.

As previously noted, the placement of receptors for the establishment of traffic noise impacts may not be consistent with the placement of receptors for the purpose of determining the effectiveness of noise abatement efforts, especially for larger use areas like campgrounds, parks, trails, school grounds, and similar uses. In these cases, the placement of additional receptors is established following the guidance found in the “Special Use” methodology.

### 2.2.5 Noise Barriers

#### a. General

To achieve consistency in the modeling and analysis of noise barriers, it is recommended that the following step-by-step noise barrier evaluation process be adhered to. The evaluation process focuses on selecting an optimized noise barrier configuration with consideration given to barrier aesthetics. The optimization process considers the amount of noise reduction provided by a barrier, the number of impacted and benefitted receptors, and the cost reasonableness of constructing a barrier.

Prior to initiating the noise barrier modeling process, consideration is given to the grouping of impacted receptors into a single NSA depending on the proximity of receptors and the roadway characteristics. The density of residences within a community also is to be considered. When considering how to group one or more communities, groups should be defined as such that they are consistent with the FDOT Policy (Part 2, Chapter 17 of the PD&E Manual) definition of “Common Noise Environment” (a group of impacted receptors of the same NAC must benefit from the same continuous noise barrier or noise barrier system (i.e., overlapping/continuous noise barrier)).

#### b. Basic Noise Barrier Input

The title of the barrier should be descriptive enough to clearly identify whether the barrier is a berm or wall, whether it is located on or within the right-of-way (ROW) line, on or near the shoulder, on structure, or a combination of these locations. Currently, it is the FDOT’s preference to place noise barriers at or near the ROW. However, it may be necessary to consider a shoulder or structure barrier if a ROW barrier is determined to be acoustically ineffective or not cost reasonable. Chapter 32 “Noise Barriers” of Volume 1 of the FDOT Plan Preparation Manual (PPM) and the PD&E Manual are consulted to determine the current FDOT height restrictions for noise barriers on structure and if there are any safety offsets required for barriers at or near the roadway shoulder. The noise analyst shall consult with the District Noise Specialist concerning the preferred placement of noise barriers.

Within the FDOT ROW, consideration should be given to "wrapping" barrier ends at roadway intersections. Doing so may improve barrier performance by reducing the amount of sound flanking around the ends of the barrier.

If placement of a noise barrier at the ROW (or other location outside the clear zone) is not possible due to engineering constraints or other limitations, ground mounted noise barriers can also be placed within the clear zone and will require shielding by a crash-tested device.

The "Z" coordinate at the bottom of the barrier is the actual ground level and can be expected to vary along the length of the wall, sometimes dramatically. Analysts should ensure that any variation is accounted for in the TNM input file. Sources of this information are discussed in Section 1.2 of this document. A field review can help the analyst decide what level of accuracy is needed for PD&E efforts, but when noise barriers are being considered for a project's design phase, only cross sections should be used for establishing ground level along a noise barrier within the right-of-way (to an accuracy level of 1.0 foot or better).

Existing barriers (berms, noise barriers, privacy walls) shall be included in a TNM input file as a fixed barrier if the material and thickness of the barrier would provide a sound level reduction. This would include a median or shoulder barrier (e.g. a solid traffic "Jersey" barrier). Privacy walls with slatted openings or similar patterns, regardless of their composition, typically do not provide significant noise reduction to be considered in the modeling effort. If there is any question regarding the appropriateness of modeling an existing wall, consult with the District Noise Specialist to determine the appropriate input.

### c. Initial Noise Barrier Length and Height

A noise barrier is to be input into the TNM at a length that is considerably greater than what one might anticipate would be needed to maximize noise reduction so that traffic noise flanking the ends of the noise barrier is considered in the analysis. In this document, this is referred to as the "unadjusted noise barrier length". A good starting point is to have the barrier extend beyond the end/last receptor at least approximately four times the perpendicular distance between the receptor and the noise barrier. The unadjusted barrier length can also be influenced by other features, such as intersecting cross streets and driveways. In these cases, land use or geographic features may dictate the unadjusted barrier length.

When modeling noise barriers as abatement features, the unadjusted barrier length is subdivided, typically into 20-foot to 100-foot increments (with the 20-foot segments at the ends and the 100-foot segments in the middle of a barrier), so that small portions of the noise barrier at either end can be raised or lowered as needed during the optimization process.

During PD&E and unless there are significant increases/decreases in ground elevation, noise barriers are typically modeled at constant heights from 8 feet in two-foot increments to the maximum height of 22 feet. If, at these heights, the cost of a noise barrier is close to, but exceeds the cost reasonableness criteria, the incremental height of the barrier is reduced by one foot.

## d. Noise Barrier Optimization

A final recommendation for a noise barrier should be for a barrier that benefits the most impacted receptors (i.e., at least a 5 dB(A) reduction) while achieving the noise reduction design goal of 7 dB(A) for at least one impacted receptor) and the cost of the barrier is at or below the cost reasonable limit. The noise barrier optimization should maximize the noise level reduction while maintaining a cost per benefited receptor at or below the reasonable limit. It is important to note that analysts should not "stop" optimizing a barrier once the noise reduction design goal is achieved or a benefit is provided to impacted receptors (i.e., do not just design the barrier to meet the minimum noise reduction criteria).

Noise reduction results for the unadjusted barrier length at a particular height are reviewed to determine which impacted receptors would benefit from a noise barrier at that particular height. Impacted receptors that cannot be provided at least a 5 dB(A) reduction at a particular height for the unadjusted barrier length are dropped from consideration when evaluating that particular height. The height for the 20-foot to 100-foot segments at either end of the noise barrier should be lowered to zero feet while evaluating the amount of noise reduction achieved to maintain the same number of impacted and benefited receptors as the unadjusted barrier length for that particular height, while also achieving the noise reduction design goal. In other words, at each evaluated barrier height, the length of the barrier should be optimized such that only those impacted receptors benefiting from the barrier are considered. The objective of this process is to achieve noise reduction requirements while also minimizing excess barrier length and thus reducing the overall cost (and the cost per benefited receptor) of the noise barrier. Although benefiting the maximum amount of impacted receptors is preferable, receptors that require excessive amounts of barrier length to be benefited may be dropped from consideration if the result is a cost reasonable noise barrier for other impacted receptors that are benefited.

In the design phase analysis, the barrier length and height that maximizes the number of impacted receptors that can be benefited at a cost below the reasonable limit should be identified. For this barrier configuration, the barrier length that will maximize the number of receptors that are provided the noise reduction design goal (7 dB(A)) while maintaining cost reasonableness should also be determined. This assists the District Noise Specialist in determining a recommended barrier configuration that maximizes noise reduction while still considering cost.

When optimizing a noise barrier, consideration should be given to minimizing the number of "steps" along the top of the noise barrier due to fluctuations in the ground elevation at the base of the noise barrier. If "steps" along the top profile of the noise barrier are necessary due to changing ground elevations, every attempt should be made to minimize the size of the steps to 0.5 feet or less. It is also important to report the noise barrier height as the "height above finished grade" so that a portion of the bottom panels of the noise barrier are not buried, which may result in a lower overall noise barrier height than what was recommended.

## e. Noise Barrier Results and Recommendations

The optimal results for all noise barrier heights are tabulated and reported in a table similar to the example shown in **Table 2**. This provides sufficient information to estimate approximate noise barrier costs for a project (part of programming a project for the design phase) and assists the Department in their evaluation of a recommended noise barrier configuration in the final design phase. Final recommendations regarding noise barrier height and length should be based on the number of impacted and benefited receptors, the cost per benefited receptor, the number of impacted receptors within a noise reduction range, and the average noise reduction provided (i.e., a combination of these factors).

As shown in the example in **Table 2**, a noise barrier would need to be a minimum of 10 feet in height to benefit at least one of the impacted receptors (i.e., reduce traffic noise levels at least 5 dB(A)) and also achieve the noise reduction design goal for at least one receptor (i.e., a reduction in traffic noise of at least 7 dB(A)). Three of the 23 impacted receptors could not be provided at least a 5 dB(A) reduction at any barrier height or length. The maximum number of impacted receptors that could be provided a reduction of 5 dB(A), with at least a 7 dB(A) reduction at one receptor, is 20. However, none of these configurations (heights of 18, 20, and 22 feet) are cost reasonable. The maximum number of impacted receptors that could be provided a reduction of 5 dB(A), with at least a 7 dB(A) reduction at one receptor, while remaining cost reasonable is 19, with two non-impacted receptors also benefited. Therefore, a 16-foot high and 1,805 foot long noise barrier is the most cost effective recommendation.

**Table 2: Noise Barrier Analysis Results**

| Barrier Height (feet) | Barrier Length (feet) | Number of Impacted Receptors | Noise Reduction at Impacted Receptors[1] (dB(A)) | | | Number of Benefited Receptors[2] | | | Average Reduction for Benefited Receptors (dB(A))[1] | Total Estimated Cost[3] | Cost per Benefited Receptor[4] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 5 -5.9 dB(A) | 6 – 6.9 dB(A) | ≥ 7 dB(A) | Impacted | Not Impacted | Total | | | |
| 8 | NA[5] | 23 | 2 | 0 | 0 | NA[5] | NA[5] | NA[5] | NA[5] | NA[5] | NA[5] |
| 10 | 1,605 | | 6 | 2 | 2 | 10 | 1 | 11 | 6.5 | $481,500 | $43,772 |
| 12 | 1,705 | | 4 | 4 | 4 | 12 | 1 | 13 | 6.8 | $613,800 | $47,215 |
| 14 | 1,705 | | 5 | 5 | 6 | 16 | 2 | 18 | 7.0 | $716,100 | $39,783 |
| 16 | 1,805 | | 4 | 7 | 8 | 19 | 2 | 21 | 7.8 | $866,400 | $41,257 |
| 18 | 1,805 | | 2 | 8 | 10 | 20 | 2 | 22 | 8.0 | $974,700 | $44,305 |
| 20 | 1,905 | | 0 | 6 | 14 | 20 | 3 | 23 | 8.5 | $1,143,000 | $49,696 |
| 22 | 1,905 | | 0 | 5 | 15 | 20 | 3 | 23 | 9.0 | $1,257,300 | $54,665 |

[1] Receptors with a predicted noise level of 66 dB(A) or greater.

[2] Receptors with a predicted reduction of five dB(A) or more are considered benefited.

[3] Based on a unit cost of $30 per square foot.

[4] FDOT cost reasonable criterion is $42,000 per benefited receptor.

[5] 7 dB(A) reduction not achieved at any receptor.

Once an optimal barrier height and length have been chosen (during the design phase), a thorough engineering feasibility review of the barrier should be conducted by the FDOT consistent with Sections 17-6.1.2 through 17-6.1.8 of Part 2, Chapter 17 of the PD&E Manual and Chapter 32 of the FDOT PPM to ensure the recommended barrier can be constructed as planned, or if further refinements are necessary before proceeding with the noise barrier specific public involvement.

#### f. Parallel Noise Barriers

A parallel barrier situation rarely occurs. Should this be the case, the determination of how to model this condition will be determined by the width to height ratio, which is the ratio of the separation between two parallel barriers (W), their average height ($H_{AVG}$), and the amount of insertion loss degradation. As a rule, if the W / $H_{AVG}$ ratio is 10:1 or more, the insertion loss degradation is negligible and the modeling of the parallel barrier condition is not required. If the ratio is less than 10:1, contact the District Noise Specialist for guidance on how to model this condition. Further information on modeling parallel noise barriers is provided in the TNM User's Manual.

### 2.2.6 Building Rows

If a large building or series of buildings exist between a roadway and modeled noise sensitive sites, analysts shall include the building(s) as building rows in the TNM input file. The average height of the building row and the percentage of the row that provides noise reduction to receptors behind the row is a necessary part of the input. The maximum percentage of coverage allowed by TNM for a building row is 80%. ***If a row of buildings occupies more than 80% of the entire length of the row, then model the building row as a barrier.***

In some cases, such as where a building is a large apartment or office building, it is best to model those structures as barriers. The name of the building row should reflect the nature of the row and its relative location if warranted. If data regarding the height of a structure is not readily available, assume 10 feet for each story of a building or mobile home, 12 feet for a single-story home, and 22 feet for a two-story building. For each additional floor of a building or residence, add 10 feet. The z-coordinate of a building row shall always be the ground elevation at the face of the building.

### 2.2.7 Terrain Lines

A terrain line should be used in areas where topographic features alter the propagation path for traffic noise. For example, terrain lines shall be used to define the bottom of the slope for roadways on fill/embankment, and also for roadways constructed on mechanically stabilized earth (MSE) or retaining walls. If a particular roadway segment is on fill/embankment or MSE wall, and a terrain line is not used to represent the bottom of the slope or the bottom of the MSE wall, TNM will assume the ground line extends from the roadway edge out to the next closest object, which may be a receptor, which would be an inaccurate representation of the conditions. The use and modeling of terrain lines should follow the guidance provided in the TNM/FAQ. ***Remember to use care in the placement and application of terrain lines since they may have a significant impact on the predicted noise and model run times.***

### 2.2.8 Ground Zones

Ground zones are used when there is a large area of ground that is different than the default ground type used in the project setup information. With the exception of dry ponds that are designed to hold runoff and will not contain water all the time, all water features shall be included in the TNM input file if they are located between the roadway and modeled receptors.

### 2.2.9 Tree Zones

FHWA guidance contained in the TNM User's Manual suggests that for tree zones to be included in an input file they should consist of long, wide regions of heavy, non-deciduous woods and undergrowth, not just individual trees or a row of trees. The vegetation must be sufficiently dense to completely block the view along the propagation path. Since this condition is rarely possible, tree zones shall not be used in a TNM input file unless otherwise directed by the District Noise Specialist.

### 2.2.10 Noise Contours

Noise contours (i.e., areas of traffic noise impacts) are generalized and cannot be used to determine traffic noise impacts. Noise contours are used as a tool to assess the potential impacts of a variety of corridors or alignment alternatives. They are also used as a land use planning tool when they are provided to local government consistent with 23 CFR 772.17. In this case, the contours aid in future noise impact reduction as part of a local government's planning and zoning efforts.

The TNM contouring program shall not be used to develop noise contours. Instead, contours shall be developed by using a receptor grid, the roadway's typical section and approved traffic data. The resultant impact zone is determined by using the edge of pavement of the roadway as the reference point.

# 3.0 NOISE STUDY DOCUMENTATION

This section discusses the requirements for documenting the analyses that have been conducted for a project including the validation of the TNM, the assessment of impacts, barrier analysis, and any noise contour analysis. Example NSR outlines for both PD&E studies and design-phase reevaluations are provided in **Appendix D**.

## 3.1 Validation Analyses

The efforts used to validate the TNM are documented in the project files in both hard copy and electronic format. For the efforts related to model validation, analysts include the following information in the files and within the appendices of the appropriate report (NSR or NSR Addendum):

- A listing of all measurement equipment used, and the results of the field calibrations;
- A listing of all traffic data (volume, speed, and classification) obtained and a source of the data;
- A table summarizing the measured and predicted sound level differences for each validation site;
- The TNM files used in the validation effort placed on a CD with the appropriate Read Me file.

## 3.2 Impact Assessment

The following items are included in the NSR or NSR Addendum to support the analyses that were conducted to ascertain the impact of traffic noise within the project corridor:

- A table or appendix documenting traffic volumes, classification, and speeds used in the analyses for existing, future no-build, and future build conditions that were modeled;
- For a PD&E study, a table showing the predicted modeling results for existing, future no-build, and future build conditions. This table may be included in the body of the text (as a summary table if desired) or as an appendix to the report depending upon the number of receptors that were modeled. For a project's design phase, tables should be provided for the future design year build condition only unless otherwise directed by the District Noise Specialist;
- Typical sections of both existing and future roadways that were modeled;
- A plan view or aerial overlay that shows the validation measurement sites, the modeled receptors, potentially feasible/cost reasonable noise barriers (in the PD&E phase), recommended noise barriers (in the design phase), and any related information. Cross streets, neighborhoods of interest and key cultural features (e.g., schools, places of worship) as referenced in the text shall also be identified.

## 3.3 Noise Barrier Analyses

To document efforts related to the noise barrier evaluation, the following are included in the NSR or NSR Addendum as appropriate:

- A table showing the overall benefits and related costs of various barrier options considered (see Table 2 in Section 2.2.5);
- Figures or aerials that illustrate the location of all modeled noise sensitive receptors, noise monitoring locations (if applicable), and noise barriers considered as being potentially feasible and cost reasonable if the study is prepared during PD&E, or the final recommended barriers if the study is prepared in a project's design phase; and
- In the appendix, all TNM input files on a CD with the appropriate Read Me file that describes what area of a project is evaluated in each input file and the naming convention that was used.

## 3.4 Statement of Likelihood

During a PD&E study, the FDOT commits to construct noise barriers contingent upon their being determined feasible, cost reasonable and supported by the adjacent community/communities during a project's design phase when detailed engineering data is available. Consistent with the requirements of 23 CFR Part 772, NSR's produced during the PD&E study must contain a "Statement of Likelihood". A sample statement is provided in the FDOT Noise Policy (Part 2, Chapter 17, Section 8-5 of the PD&E Manual).

For those locations where noise barriers were determined not to be potentially feasible and reasonable, it is also important to explain why this is the case (i.e. too many cross streets or driveway openings, residences are located too far from the roadway to be benefited, etc.).

## 3.5 Noise Contour Analyses for Local Officials

Noise contours shall be documented in the NSR in the form of a table and/or figure consistent with the guidance found in Part 2, Chapter 17, Section 17-8.4 of the PD&E Manual. On completion of a PD&E Study, the District office shall transmit the NSR with the contour information to the appropriate local officials for use in future land use planning. A statement is included in the NSR documenting this transmittal.

## 3.6 Construction Noise and Vibration

At a minimum, land uses or activities that have the potential to be affected by construction noise and/or vibration are noted and included in the NSR or NSR Addendum. Table 17.3 in Part 2, Chapter 17 of the FDOT PD&E Manual provides a partial listing of land uses that have the potential to be affected by construction noise and/or vibration.

If noise sensitive land uses adjacent to the project corridor are identified as having the potential to be affected by construction noise and/or vibration, the FHWA desires that additional information (other than referring to the FDOT “Standard Specifications for Road and Bridge Construction”) be provided in the NSR or NSR Addendum, including potential abatement measures (such as alternative construction methods, temporary noise barriers, equipment shielding, etc.) to be considered.

## 3.7 Public Involvement

Public involvement is an important aspect of any transportation improvement project. Any public involvement activities that take place as part of the project should be documented in the NSR or NSR Addendum. At a minimum, the NSR shall describe the nature of the events that took place (workshop or hearing, date, location, time, etc.) and note whether any traffic noise related issues were raised by the public that were related to the project in question. If written comments are received regarding noise or vibration issues, they should be included as an appendix to the NSR or NSR Addendum.

As discussed in the following section, the details of noise barrier specific public involvement with individual communities should be documented, including an appendix containing copies of materials sent to property owners when gathering a community consensus regarding potential noise abatement options.

# 4.0 NOISE SPECIFIC PUBLIC INVOLVEMENT

## 4.1 PD&E Study Public Involvement

Public involvement during a PD&E study typically contains two major events; a public workshop (sometimes also referred to as an "alternatives public workshop"), and a public hearing for the project. At the public workshop, the noise analyst should discuss noise sensitive sites within the project corridor. The discussion should include description of the analysis procedures and the potential for traffic noise impacts utilizing generalized noise contours.

At the public hearing for the project, the noise analyst should be prepared to discuss site specific results of the noise study, including the location of impacted receptors and the potential for further noise abatement consideration during the design phase, if applicable. A draft NSR should be available at the public hearing.

## 4.2 Noise Barrier Specific Public Involvement in the Design Phase

Prior to initiating noise barrier related public involvement during the design phase, the optimal barrier length and height should be established and any engineering/constructability issues should be identified and resolved.

Noise barrier specific public involvement includes informational meetings and written surveys to affected property owners and tenants. Additionally, door-to-door and telephone solicitations are necessary if insufficient responses are received from a written survey. As stipulated in the PD&E Manual, it is the FDOT's desire to obtain a response for or against a noise barrier from the majority of the benefitted property owners and tenants that respond to the survey.

The following provides examples of the type of written correspondence prepared by the FDOT and provided to property owners and tenants in connection with a noise barrier survey:

- Notification Letter: The notification letter alerts the property owner(s)/tenants of the FDOT's intent and also informs them that further information is forthcoming. This letter is mailed using regular (non-certified) mail services. The letters are mailed to the address of the property of interest and to the property owner's address, if different than the property of interest. Property ownership information can be obtained from the property appraiser's office/website for the county in which the project is located. If a noise barrier specific informational meeting is being held; date, time, and location details are also provided in this letter.

- Noise Barrier Survey Package: This package should include a certified letter from the FDOT describing the roadway improvement project and the noise barrier(s) of interest, an exhibit illustrating the proposed location of a barrier(s), information regarding the advantages and disadvantages of noise barriers, color and texture options (if applicable), and a noise barrier survey form. The address of the property being surveyed and the registered property owner's name(s) should be shown on this form. It is recommended that each survey be individually numbered for easier tracking once they are returned.

Copies of all design-phase traffic noise related public involvement materials should be provided as an Appendix in the NSR Addendum to properly document survey efforts.

# 5.0 CONCLUSIONS

From the beginning of the noise study, close coordination between the analyst, the District Noise Specialist and both the consultant and FDOT project managers is of paramount importance. All decisions made regarding the methodology used in the analysis should be discussed and clarified with the District Noise Specialist prior to implementation and properly documented in the project file.

Data collection and the generation of TNM input will have a direct influence on the results and recommendations produced at the conclusion of the study. Field reviews during the course of the study can provide assurance that project conditions are being accurately represented in the TNM. Noise barriers being considered for inclusion in the roadway construction plans should be thoroughly reviewed for any engineering or geographic constraints that may preclude their construction.

The methodology, results and recommendations of the noise study should be clearly documented in the NSR or NSR Addendum for the project. Doing so ensures the reader (whether technical or layperson) will have a clear understanding of the approach and outcome of the noise study.

Public involvement is vital to any transportation improvement project. Traffic noise concerns raised by the public should be documented in the NSR or NSR Addendum as appropriate. Noise barrier specific public involvement is important because it can determine whether or not a noise barrier will be constructed as part of the project. Clearly conveying the results of the noise study and the advantages and disadvantages of noise barriers can aid in the public's decision making process.

Following the requirements stated in 23 CFR Part 772, the FDOT Noise Policy (Part 2 Chapter 17 of the PD&E Manual), and the contents of this handbook will result in consistent, predictable and repeatable traffic noise studies statewide.

# 6.0 REFERENCES


**FHWA Regulation and Guidance**

1. Procedures for Abatement of Highway Traffic Noise and Construction Noise. 23 CFR Part 772. Federal Highway Administration. Final Rule; Published in the Federal Register July 13, 2010; Pages 39820 – 39839.

   http://www.gpo.gov/fdsys/pkg/FR-2010-07-13/html/2010-15848.htm

2. Highway Traffic Noise: Analysis and Abatement Guidance. Federal Highway Administration. June 2010 (Revised December 2010); 76 pages.

   http://www.fhwa.dot.gov/environment/noise/regulations_and_guidance/analysis_and_abatement_guidance/

3. FHWA Traffic Noise Model Technical Manual. Federal Highway Administration. Final Report, February 1998; FHWA-PD-96-010; 157 pages.

   http://www.fhwa.dot.gov/environment/noise/traffic_noise_model/tnm_v25/tech_manual/index.cfm

4. FHWA Traffic Noise Model Version 1.0 User's Manual. Federal Highway Administration. Final Report, January 1998; FHWA-PD-96-009; 171 pages.

   http://www.fhwa.dot.gov/environment/noise/traffic_noise_model/old_versions/tnm_version_10/users_guide/index.cfm

5. FHWA Traffic Noise Model User's Guide (Version 2.0 Addendum). Federal Highway Administration. Final Report, May 2002; HW266/H2008; 37pages.

   http://www.fhwa.dot.gov/environment/noise/traffic_noise_model/old_versions/tnm_version_20/tnm20cover.cfm

6. FHWA Traffic Noise Model User's Guide (Version 2.5 Addendum). Federal Highway Administration. Final Report, April 2004; HW-66/AS036; 36pages.

   http://www.fhwa.dot.gov/environment/noise/traffic_noise_model/tnm_v25/users_manual/index.cfm

7. Traffic Noise Model: Frequently Asked Questions FAQs. Federal Highway Administration Website.

   http://www.fhwa.dot.gov/environment/noise/traffic_noise_model/tnm_faqs/faq00.cfm

8. Measurement of Highway-Related Noise. Federal Highway Administration. Final Report, May 1996; FHWA-PD-96-046; 206 pages.

http://www.fhwa.dot.gov/environment/noise/measurement/measure.cfm

9. FHWA Construction Noise Handbook. Federal Highway Administration. Final Report, August 2006; FHWA-HEP-06-015; 185 pages.

http://www.fhwa.dot.gov/environment/noise/construction_noise/handbook/

**FDOT Statute, Policy and Guidance**

1. Florida Statute 335.17: State Highway Construction; Means of Noise Abatement. 2013 Florida Statutes, Title XXVI, Chapter 335, Section 17.

http://www.flsenate.gov/Laws/Statutes/2013/335.17

2. Noise. Florida Department of Transportation Project Development and Environment Manual, Part 2, Chapter 17. May 24, 2011; 40 pages.

http://www.dot.state.fl.us/emo/pubs/pdeman/pdeman1.shtm

3. Noise Barriers. Florida Department of Transportation Plans Preparation Manual, Volume 1, Chapter 32. July 2013; 18 pages.

http://www.dot.state.fl.us/rddesign/PPMManual/2013PPM.shtm

4. A Method to Determine Reasonableness and Feasibility of Noise Abatement at Special Use Locations. Florida Department of Transportation Environmental Research Report FL-ER-65-97; Updated July 22, 2009; 64 pages.

http://www.fhwa.dot.gov/environment/noise/noise_barriers/abatement/reasonableness/

5. Florida Department of Transportation Standard Specifications for Road and Bridge Construction; 2011; 996 pages.

http://www.dot.state.fl.us/specificationsoffice/Specs.shtm

6. 2013 FDOT Quality/Level of Service Handbook; http://www.dot.state.fl.us/planning/systems/programs/sm/los/pdfs/fdot%202012%20generalized%20service%20volume%20tables.pdf

# APPENDIX A

## Example Noise Study Traffic Data Form

## TRAFFIC DATA FOR NOISE STUDIES

**Federal Aid Number(s):** ____________________

**FPID Number(s):** ____________________

**State/Federal Route No.:** ____________________

**Road Name:** ____________________

**Project Description:** ____________________

**Segment Description:** ____________________

**Section Number:** ____________________

**Mile Post To/From:** ____________________

| **Existing Facility:** | | | | |
|---|---|---|---|---|
| | | D = | | % |
| | | T24 = | | % of 24 Hour Volume |
| **Year:** | | Tpeak = | | % of Design Hour Volume |
| | | MT = | | % of Design Hour Volume |
| **LOS C Peak Hour Directional Volume:** | | HT = | | % of Design Hour Volume |
| **Demand Peak Hour Volume:** | | B = | | % of Design Hour Volume |
| **Posted Speed:** | | MC = | | % of Design Hour Volume |

| **No Build Alternative (Design Year):** | | | | |
|---|---|---|---|---|
| | | D = | | % |
| | | T24 = | | % of 24 Hour Volume |
| **Year:** | | Tpeak = | | % of Design Hour Volume |
| | | MT = | | % of Design Hour Volume |
| **LOS C Peak Hour Directional Volume:** | | HT = | | % of Design Hour Volume |
| **Demand Peak Hour Volume:** | | B = | | % of Design Hour Volume |
| **Posted Speed:** | | MC = | | % of Design Hour Volume |

| **Build Alternative (Design Year):** | | | | |
|---|---|---|---|---|
| | | D = | | % |
| | | T24 = | | % of 24 Hour Volume |
| **Year:** | | Tpeak = | | % of Design Hour Volume |
| | | MT = | | % of Design Hour Volume |
| **LOS C Peak Hour Directional Volume:** | | HT = | | % of Design Hour Volume |
| **Demand Peak Hour Volume:** | | B = | | % of Design Hour Volume |
| **Posted Speed:** | | MC = | | % of Design Hour Volume |

I certify that the above information is accurate and appropriate for use with the traffic noise analysis.

Prepared By: ____________________ Date: __________

Print Name Signature

I have reviewed and concur that the above information is appropriate for use with the traffic noise analysis.

FDOT Reviewer: ____________________ Date: __________

Print Name Signature

# APPENDIX B

## Example Noise Measurement Data Sheet

Site/Run #:

# Noise Measurement Data Sheet

**Date:** ______________________ **Measurement Taken By:** ______________________

**Project:** ______________________

**Site ID:** ______________________

**Weather Conditions:** Clear: Partly Cloudy: Cloudy: Other:

Temperature: Start: End: (°F)

Wind Direction: Start: End:

Wind Speed (Start): Min: Max: Average: (mph)

Wind Speed (End): Min: Max: Average: (mph)

Humidity: Start: End: (%)

**Equipment Data**

Sound Level Meter: Serial Number:

Date of Last Traceable Calibration:

Calibration: Start: End: Difference:

Battery: Start: End:

Weighting Scale: Response:

Calibrator: Serial Number:

**Results:** Leq:
in dB(A)

Major Noise Sources:

Background Noise Sources:

Other Notes/Observations:

Observed Traffic Data Site Sketch on Reverse Side

**Observed Traffic Data** Site #: Run #:

| Vehicle Types | | | | | | |
|---|---|---|---|---|---|---|
| | Volume | Speed | Volume | Speed | Volume | Speed |
| Auto | | | | | | |
| Medium Truck | | | | | | |
| Heavy Truck | | | | | | |
| Bus | | | | | | |
| Motorcycle | | | | | | |

**Site Sketch**

# APPENDIX C

## Example TNM Input File QC Checklist

**TRAFFIC NOISE MODEL (TNM) INPUT FILE CHECK LIST**

**Project Name and Limits:**
**County:**
**FPID Number:**
**FDOT District:**
**Analyst/Organization:**

**PROJECT ALTERNATIVE**

- ☐ Existing Conditions (Year ____)
- ☐ No Build Conditions (Design Year ____)
- ☐ Build Alternative (Design Year ____) Location: ______________________________

**TNM INPUT**

File Name: __________________________

- ☐ Run Identification Correct
- ☐ Units in file - English or Metric
- ☐ Pavement type – Average & Default Ground Type – Lawn
- ☐ Traffic volumes & posted speeds match Noise Study Report & Approved Traffic Volumes
- ☐ Roadway and Ground Zones named correctly
- ☐ Receiver heights (5 ft.), Criteria (66 dBA), and Substantial Increase (15 dBA)
- ☐ All noise sensitive areas/sites represented
- ☐ Tree Zone heights and locations correct
- ☐ Building Row heights and locations correct
- ☐ Terrain Line heights and limits correct
- ☐ Ground Zone designations and limits correct
- ☐ Roadway width, elevations, and directions correct
- ☐ Ground elevations at proposed barrier locations and receivers correct
- ☐ Input file includes all appropriate Roadways, Ground Zones, Existing barriers/berms, Tree Zones, Bridges, and Building Rows
- ☐ Cross section data along roadway verified using skew view in TNM
- ☐ TNM print outs checked for missing data and data consistent within each category

Name of Reviewer: __________________________

Date of Review: _____________________________

# APPENDIX D

## Example Noise Study Report Outlines

## EXAMPLE PD&E NOISE STUDY REPORT (NSR) TABLE OF CONTENTS

**EXECUTIVE SUMMARY**

**TABLE OF CONTENTS**

List of Tables
List of Figures
List of Appendices

**1.0 INTRODUCTION**

1.1 Project Description (includes Project Location Map)
1.2 Proposed Improvements (includes conceptual typical section(s))

**2.0 METHODOLOGY** (opening paragraph references regulation, policy and TNM version)

2.1 Noise Metrics
2.2 Traffic Data
2.3 Noise Abatement Criteria (includes general discussion and application specific to the project)
2.4 Noise Abatement Measures (General Discussion)
2.4.1 Traffic Management
2.4.2 Alignment Modifications
2.4.3 Buffer Zones (includes noise contours and intended application of contours
2.4.4 Noise Barriers (includes discussion of minimum reduction requirements and cost reasonable limit)

**3.0 TRAFFIC NOISE ANALYSIS**

3.1 Model Validation
3.2 Existing Noise Levels (documents noise monitoring to establish existing noise levels; usually only included for new alignment projects)
3.3 Predicted Noise Levels and Abatement Analysis (includes discussion of impacts and noise barrier analysis with each noise sensitive area (including special land use locations and Activity Category D receptors impacted by interior noise) addressed as a separate report section).

**4.0 CONCLUSIONS** (includes Statement of Likelihood)

**5.0 CONSTRUCTION NOISE AND VIBRATION**

**6.0 COMMUNITY COORDINATION** (documents any public comments specific to traffic noise, transmittal of the Noise Study Report to local officials and references noise contours discussed above)

**7.0 REFERENCES**

**APPENDICES**

**Appendix A** **Traffic Data**
**Appendix B** **Predicted Noise Levels**
**Appendix C** **Aerials** (showing receptor points)
**Appendix D** **TNM Modeling Files and PDF of the NSR** (on disc, including “Read Me” file)

**EXAMPLE DESIGN NOISE STUDY REPORT (NSR) ADDENDUM TABLE OF CONTENTS**

**EXECUTIVE SUMMARY**

**TABLE OF CONTENTS**

List of Tables
List of Figures
List of Appendices

**1.0 INTRODUCTION**

1.1 Project Description (includes Project Location Map)
1.2 Summary of PD&E Results and Commitments
1.3 Design Improvements (includes comparison to PD&E conceptual design and design typical section(s))

**2.0 METHODOLOGY** (opening paragraph references regulation, policy and TNM version)

2.1 Noise Metrics
2.1.1.1 Traffic Data
2.2 Noise Abatement Criteria (includes general discussion and application specific to the project; includes discussion that the PD&E noise analysis determined no substantial increase)
2.3 Noise Abatement Measures (General discussion identifying noise barriers as only viable abatement measure based on PD&E noise study; includes discussion of minimum reduction requirements and cost reasonable limit)

**3.0 TRAFFIC NOISE ANALYSIS**

3.1 Model Validation (Only if validation update from PD&E noise study is needed)
3.2 Predicted Noise Levels and Abatement Analysis (includes discussion of impacts and noise barrier analysis with each noise sensitive area addressed as a separate report section; includes selection of recommended noise barrier length and height)
3.3 Engineering Feasibility Review (includes discussion on noise barrier modifications to resolve construction conflicts

**4.0 Outdoor Advertising** (if applicable, discusses conflicts with outdoor advertising, resolution of conflicts and fulfillment of FDOT responsibilities in accordance with F.S. 479.25)

**5.0 CONCLUSIONS** (includes discussion on fulfillment of PD&E commitments and tabulates specifics for each recommended noise barrier to be included in the design plans and constructed with the project)

**6.0 CONSTRUCTION NOISE AND VIBRATION**

**7.0 COMMUNITY COORDINATION** (includes results of noise barrier survey specific to each noise barrier or noise barrier system)

**8.0 REFERENCES**

**APPENDICES**

**Appendix A** **Traffic Data**
**Appendix B** **Predicted Noise Levels**
**Appendix C** **Aerials** (showing receptor points and noise barriers to be included in design plans)
**Appendix D** **Noise Barrier Survey Package**
**Appendix E** **TNM Modeling Files and PDF of the NSR Addendum** (on disc, including “Read Me” file)