METHODOLOGY TO EVALUATE HIGHWAY TRAFFIC NOISE AT SPECIAL LAND USES

Florida Department of Transportation

Office of Environmental Management

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ACRONYMS

BER	Benefited Equivalent Residence
CNE	Common Noise Environment
dB(A)	A-weighted Decibel
DNSR	Design Noise Study Report
EAFHU	Exterior Area of Frequent Human Use
ER	Equivalent Residence
FDOT	Florida Department of Transportation
FHWA	Federal Highway Administration
NAC	Noise Abatement Criteria
NRDG	Noise Reduction Design Goal
NSR	Noise Study Report
OEM	Office of Environmental Management
PD&E	Project Development and Environment
SLU	Special Land Use
TNM	Traffic Noise Model

1. Introduction

The Florida Department of Transportation (FDOT) is responsible for providing policy and guidance related to environmental noise impacts on transportation projects, in accordance with Part 2, Chapter 18 of the Project Development and Environment (PD&E) Manual (*Highway Traffic Noise)*, and other local, state, and federal rules and regulations.

The FDOT's guidance on how to assess special land uses (SLUs) (i.e., non-residential noise sensitive sites) in Florida for highway traffic noise, *A Method to Determine Reasonableness and Feasibility of Noise Abatement at Special Land Use Locations (FL-ER-65-97)*, was first published in 1997 and updated in 2009. Since 2009, changes in federal regulations have occurred and limitations in the methodology have been identified. Additionally, potential improvements to the methodology have been suggested by highway traffic noise specialists around the state. Therefore, an update to the methodology used to assess highway traffic noise for SLUs has been completed.

The purpose of this document is to provide an overview of the limitations of the 2009 FDOT SLU Methodology update, provide an outline of other states' methodologies to evaluate SLUs, and to update the methodology that FDOT uses to evaluate SLUs.

2. Methodology Developed in 1997

FDOT's 1997 SLU Methodology was developed in several "phases." The first phase that was implemented was a survey that assessed the then-current state policies concerning SLUs. A survey was mailed to representatives from each state Department of Transportation (DOT) to inquire whether any formal state policies concerning SLUs existed. Follow-up telephone calls were made to non-responding state DOTs. Where additional insight was needed for specific problems, additional surveys were mailed to other groups and individuals. The results of the survey indicated that no states had a formal policy for SLUs, and the majority of states had difficulty in determining the reasonableness of noise abatement for SLUs. Many states responded that they evaluated SLUs on a case-by-case basis.

Furthermore, the survey asked the state DOTs to rank what they thought were the most important factors when determining feasibility and reasonableness. The majority of state DOTs responded that cost was the most important factor, followed by approaching/exceeding the Noise Abatement Criteria (NAC).

The survey also asked state DOTs to suggest a methodology to determine reasonableness at SLUs. Using the survey responses as a basis, a complex SLU Reasonable/Feasible Matrix was developed to determine if noise abatement was reasonable/feasible at an SLU. Upon review, concerns with complexity were identified. As a result, a simplified *Reasonability Matrix* and a separate *Feasibility Flowchart* were developed.

The feasibility flowchart assessed if, for sites developed before the Date of Public Knowledge, 1) the SLU is used during peak traffic conditions, 2) the NAC is approached or exceeded or if there is a substantial increase, 3) a 5 decibel (dB[A]) insertion loss can be achieved from abatement, and 4) the property owners

desire abatement, then the barrier is considered feasible and the analyst should proceed to the Reasonableness Matrix.

To assess reasonableness, an SLU "abatement cost factor" was identified and a *Reasonableness Matrix* was developed. The only changes made to the original 1997 document in 2009 were to update the reasonable cost factor from $30,000 per residence to $42,000 per residence and to update the Census data for Florida to reflect the 2000 Census.

The SLU "abatement cost factor" (see **Equation 1**) was developed by extrapolating the residential "abatement cost factor" and included the following steps:

1. Use the 2009 FDOT accepted barrier cost per residence ($42,000/benefited receptor).
2. Assume residences are used 24 hours/day.
3. Determine the average frontage of a residence (100 ft; 30.5m).
4. Determine the average height of a noise barrier statewide (14 ft; 4.3m).
5. Use the average frontage of a residence and barrier height to determine the area of a hypothetical barrier per residence frontage.
6. Determine the state average number of people per dwelling unit.
7. Use these data to determine a criteria barrier cost per hour of usage and area of barrier.

The above factors were translated into a methodology for evaluating SLUs that accounts for the threshold of $42,000 per benefitted receptor and translated that calculation to apply to a non-residential receptor based on person-hours-of-use in the following equation:

$$\frac{\$42k}{residence} x \frac{residence}{2.46\ persons} x \frac{usage}{24\ hours} x\ (14ft. x\ 100\ ft.) =\ \$995{,}935/\text{person hour/ft2}$$

Equation 1 2009 SLU Criteria Abatement Cost Factor

The cost of abatement is considered reasonable if the calculated "abatement cost factor" is below the "criteria abatement cost factor" of the above equation ($995,935/person-hour/ft^2). To assist in this determination, a Reasonableness Worksheet was developed, shown in **Table 1**. The user enters various details (highlighted in yellow), and the worksheet automatically calculates if the barrier is considered cost-effective and reasonable for a particular SLU.

Table 1 Special Land Use Worksheet: Reasonableness Determination

Item	Criteria	Input/Result
1	Enter length of proposed noise barrier (ft.)	
2	Enter height of proposed noise barrier (ft.)	
3	Multiply item 1 by item 2	
4	Enter the average amount of time that a person stays at the site per visit (hours)	
5	Enter the average number of people that use this site per day that will receive at least a 5 dB(A) benefit from abatement at the site	
6	Multiply item 4 by item 5	
7	Divide item 3 by item 6	
8	Multiply item 7 by $42,000	
9	Does item 8 exceed the "abatement cost factor" of: English Units = $995,935/person-hour/ft^2 or SI Units = $92,647/person-hour/m^2	
10	If item 9 is no, abatement is reasonable	
11	If item 9 is yes, abatement is not reasonable	

Developed by Wayson, MacDonald and Lindeman, 1997; Updated by Environmental Science Associates, Inc. 2009
Note: Yellow highlighted rows are filled in by the user. Grey rows are auto-calculated within the spreadsheet.

2.1. Limitations of 1997/2009 Methodology

2.1.1. Update to Federal Regulations

As previously mentioned, Florida's guidance on how to assess SLUs for highway traffic noise was developed in 1997 and updated in 2009. Since its development, changes to Title 23, Code of Federal Regulations, Part 772 (23 CFR 772*), Procedures for Abatement of Highway Traffic Noise and Construction Noise* have occurred. Specifically, the NAC and corresponding Activity Categories changed in 2010 such that land uses and their respective dB(A) thresholds were recategorized and additional exterior land use criteria and types were added (see **Table 2**).[1,2,3,4] As the current methodology is written, it references the previous Activity Categories for each land use type.

[1] Major changes to the noise regulations were made on July 13, 2010, with an effective date of July 13, 2011.
[2] Additional exterior and interior land use criteria and types which were added include: amphitheaters, auditorium, campgrounds, cemeteries, day care centers, medical facilities, public meeting rooms, Public/nonprofit institutional structures, radio studios, recording studios, Section 4(f) sites, TV Studios, Trails/trail crossings, offices, and restaurants/bars. Additional interior land use criteria which were added include: day care centers, medical facilities, public/nonprofit institutional structures, radio studios, recording studios, and TV Studios.
[3] The exterior criteria for hotels and motels changed from 66 dB(A) to 71 dB(A).
[4] The interior criteria for residences, motels, and hotels was removed.

Table 2 Federal Highway Administration Noise Abatement Criteria

Activity Category	Activity Leq(h)[a]		Evaluation Location		Description of Activity Category	
	Pre-2010	2010	Pre-2010	2010	Pre-2010	2010
A	57		Exterior		Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose.	
B	67		Exterior		Picnic areas, recreation areas, playgrounds, active sports areas, parks, residences, motels, hotels, schools, churches, libraries and hospitals	Residential.
C	72	67	Exterior		Developed lands, properties or activities not included in Categories A or B above.	Active sports areas, **amphitheaters**, **auditoriums**, **campgrounds**, **cemeteries**, **day care centers**, hospitals, libraries, **medical facilities**, parks, picnic areas, places of worship, playgrounds, **public meeting rooms**, **public or nonprofit institutional structures**, **radio studios**, **recording studios**, recreation areas, **Section 4(f) sites**, schools, **television studios**, **trails**, and trail crossings.
D	N/A	52	N/A	Interior	Undeveloped lands.	Auditoriums, **day care centers**, hospitals, libraries, **medical facilities**, places of worship, public meeting rooms, **public or nonprofit institutional structures**, **radio studios**, **recording studios**, schools, and **television studios**.
E	52	72	Interior	Exterior	*Residences, motels, hotels,* public meeting rooms, schools, churches, libraries. Hospitals, and auditoriums.	Hotels, motels, **offices**, **restaurants/bars**, and other developed lands, properties or activities not included in A – D or F.
F	N/A	------	N/A	------	N/A	Agriculture, airports, bus yards, emergency services, industrial, logging, maintenance facilities, manufacturing, mining, rail yards, retail facilities, shipyards, utilities (water resources, water treatment, electrical), and warehousing.
G		------		------		Undeveloped lands that are not permitted.

[a] Federal Highway Administration criteria.

Note: Bolded land uses represent newly added land use. Italicized represent removed land uses (respective to evaluation location). Source: 23 CFR Part 772, Procedures for Abatement of Highway Traffic Noise and Construction Noise, Federal Highway Administration, 2010; US Environmental Protection Agency, Office of Noise Abatement and Control, Highway Noise Impact, May 1977.

2.1.2. Non-Residential Evaluation Separation

Using the 2009 methodology, the evaluation of noise barriers for impacted special land uses (i.e., non-residential) is different than for impacted residential receptors. Noise barriers for SLUs are currently evaluated following procedures documented in *A Method to Determine Reasonableness and Feasibility of Noise Abatement at Special Use Locations* (FDOT 2009). Because methodologies for evaluating SLUs and residences are independent and include separate metrics (e.g., SLUs incorporate usage factors), there is no uniform way of evaluating abatement for adjacent impacted residences and an SLU together. For example, suppose that several impacted residences are adjacent to an impacted SLU (such as a school or a park). In this instance, separate noise abatement evaluations are required: one for residential properties and one for the SLU. Neither of the two land uses may be eligible for noise abatement on its own merit, but combined, the noise barrier might meet FDOT criteria.

Typically, these scenarios are addressed on a case-by-case basis, and coordination with the FDOT is necessary. Identifying the usage of an SLU is an important aspect of determining whether noise abatement for an SLU is cost-effective.

2.1.3. Time-Consuming

Using the 2009 methodology, once impacts are identified at an SLU, the SLU undergoes a barrier analysis, even if it is a rarely-used, isolated land use. The analysis involves a grid of receptors be developed to identify the area of the SLU that is benefitted. The evaluation of noise abatement can take a considerable amount of work, especially if the SLU area is large. Over the years, it has been found that SLUs are often ineligible for noise abatement in the form of a noise barrier due to the difficulty in meeting SLU usage criteria.

2.1.4. Noise Reduction Design Goal Application

Of importance, the 2009 guidance does not explicitly state how to apply the required Noise Reduction Design Goal (NRDG) of a 7 dB(A) reduction to SLUs. For example, a noise analyst is left to determine whether the NRDG should apply to the original receptors evaluated to identify impacts, or if it should be applied to a receptor from the grid of receptors that was evaluated to determine insertion loss.

2.1.5. Template

The 2009 guidance document does not provide an example of an SLU noise barrier table which could be included in a Noise Study Report (NSR) or Design Noise Study Report (DNSR). As a result, NSRs and DNSRs can inconsistently present various information about the noise barrier evaluation.

3. Development of 2024 Methodology

3.1. Previous Methodology Limitations Addressed

This updated methodology accounts for regulation changes to 23 CFR Part 772. Revised activity categories and land use types have been referenced in the guidance document. This updated methodology also accounts for changes to the FDOT PD&E Manual (July 31, 2024) since the 2009 update. Additionally, this updated methodology can evaluate adjacent impacted residences and SLUs together to determine if noise abatement is feasible and reasonable. An "Equivalent Receptor" (ER) methodology, where an SLU is equated to a number of "residential receptors," was identified as the preferred method as it allows for a reasonable analysis to be made for impacted SLUs in conjunction with impacted residences.

The 2024 methodology also allows for a "Preliminary Usage Screening." This screening tool was developed to reduce the level of effort for evaluating noise abatement for impacted and isolated low-usage SLUs that would not qualify for noise abatement. Additionally, during Design and Design-Build phase projects, the viewpoints of SLU property owners may be solicited before the analysis begins in order to decrease the amount of time spent on the analysis. If an SLU property owner does not desire a noise barrier, the analysis can be terminated.

The updated methodology also includes explicit guidance on how to apply the NRDG. Step-by-step instructions on how to evaluate single-receptor and multiple-receptor SLU evaluations, and how to meet regulatory requirements for reasonableness are described.

In an effort to encourage consistency, the 2024 methodology document also contains an example template of an SLU noise barrier evaluation table that could be provided in an NSR/DNSR. This table is provided as example guidance, giving authority to the FDOT District(s) to discern what to provide in an NSR/DNSR on a case-by-case basis, if needed.

In summary, the 2024 methodology makes changes to the methodology presented in *A Method to Determine Reasonableness and Feasibility of Noise Abatement at Special Land Use Locations* (FDOT, updated 2009), including:

- Accounting for the change in the NAC in 23 CFR 772.
- The development of an "equivalent residential receptor" based on the SLU usage that allows for the combined noise abatement evaluation of both impacted residences and SLUs together (if they are adjacent).
- A preliminary screening process has been developed which reduces the level of effort for evaluating noise abatement for impacted low-usage SLUs that historically would not qualify for noise abatement.
- Explicit guidance on how to apply the NRDG has been provided.
- For consistency, the guidance document provides an example of an SLU noise barrier evaluation table that could be provided in an NSR/DNSR.

3.2. SLU Methodology by State

23 CFR 772 identifies how highway traffic noise should be evaluated. However, the regulations give authority to each state to define certain thresholds and methodologies. Specifically, 23 CFR 772 does not specify how to evaluate noise abatement for SLUs. As a result, each state has a different way of evaluating SLUs.

In an effort to categorize how each state evaluates SLUs, a matrix was compiled (**Table 3**) which documents various aspects of an SLU methodology. Only a few states have a stand-alone SLU guidance document, with most states only having a brief description of a general methodology in a larger guidance document. Many states (84%), not including Florida, utilize an "equivalent receptor" type methodology. In this type of methodology, an SLU receptor is weighted to reflect its "residential receptor equivalent." This methodology allows for both residential and SLU impacts to be evaluated together.

As shown in **Table 3**, various factors may be considered for calculating how an SLU is evaluated. Similar to Florida, 49% of states consider the person-usage of an SLU, which can be important for identifying reasonableness in terms of cost. Many states (43%), not including Florida, also consider a linear frontage or area of the SLU to equate to an equivalent receptor. In this fashion, the size, frontage, and/or person-usage of an SLU can determine the weight of an SLU receptor. Thus, the impacted SLU can be evaluated in conjunction with nearby impacted residential receptors, and the composite number of "equivalent receptors" can thus be used to determine the reasonableness of a single noise wall serving the combined residential and non-residential land uses.

A smaller number of states (11%) have a simple methodology, where a single worst-case receptor is identified for an SLU and is equated to a single residence. Although this methodology allows for the combined analysis of an impacted SLU and impacted residences, the methodology makes it nearly impossible for noise abatement to be found feasible and reasonable for an SLU unless there are also adjacent impacted residences.

It should be noted that some states do not have explicit guidance on how to evaluate SLUs. This has led to inconsistencies in application within those states.

Table 3 Summary Matrix of SLU Methodology by State

State	Stand-alone SLU Guidance Document Developed[1]	SLU Methodology Specified	Simple Single Receptor Methodology[2]	Multiple Receptor Methodology[3]	Equivalent Receptor Methodology	Grid of Receptors Evaluated	Considers Person-Usage of SLU	Considers Linear Frontage of SLU	Considers Area of SLU
Alabama		X	X						
Alaska		X		X	X				X
Arizona		X		X	X		X		X
Arkansas			X	X					
California			X	X					
Colorado		X		X	X				
Connecticut		X			X		X		
Delaware	No public information available on SLU.								
Florida	X	X		X		X	X		X
Georgia				X	X				
Hawaii		X			X				X
Idaho		X			X			X	
Illinois		X		X	X				
Indiana		X			X		X		
Iowa	No public information available on SLU.								
Kansas									
Kentucky		X			X		X		
Louisiana				X					
Maine		X			X			X	
Maryland	X	X			X		X	X	
Massachusetts	No public information available on SLU.								

[1] "Specific SLU Guidance Document Developed" may include Appendices.

[2] "Simple Single Receptor Methodology" implies that a single receptor is identified for an SLU, and the receptor is worth a single residence.

[3] "Multiple Receptor Methodology" implies that a receptor is placed at each area of "frequent human use" within an SLU (e.g., Receptors at a park are placed at a baseball field, a playground, a basketball court, and a picnic table).

Table 3 (Cont.) Summary Matrix of SLU Methodology by State									
State	**Stand-alone SLU Guidance Document Developed[1]**	**SLU Methodology Specified**	**Simple Single Receptor Methodology[2]**	**Multiple Receptor Methodology[3]**	**Equivalent Receptor Methodology**	**Grid of Receptors Evaluated**	**Considers Person-Usage of SLU**	**Considers Linear Frontage of SLU**	**Considers Area of SLU**
Michigan	X	X			X	X			X
Minnesota		X						X	
Mississippi	No public information available on SLU.								
Missouri					X			X	
Montana		X			X		X		X
Nebraska		X		X	X	X	X	X	X
Nevada		X			X	X	X	X	X
New Hampshire		X			X			X	
New Jersey		X			X			X	
New Mexico		X		X	X			X	X
New York		X		X	X				X
North Carolina					X		X		
North Dakota		X		X	X				X
Ohio		X			X		X		
Oklahoma	X	X		X		X	X		X
Oregon	X	X		X		X	X		X
Pennsylvania	X	X			X	X	X		X
Rhode Island	No public information available on SLU.								

[1] "Specific SLU Guidance Document Developed" may include Appendices.

[2] "Simple Single Receptor Methodology" implies that a single receptor is identified for an SLU, and the receptor is worth a single residence.

[3] "Multiple Receptor Methodology" implies that a receptor is placed at each area of "frequent human use" within an SLU (e.g., Receptors at a park are placed at a baseball field, a playground, a basketball court, and a picnic table).

Table 3 (Cont.) Summary Matrix of SLU Methodology by State									
State	**Stand-alone SLU Guidance Document Developed[1]**	**SLU Methodology Specified**	**Simple Single Receptor Methodology[2]**	**Multiple Receptor Methodology[3]**	**Equivalent Receptor Methodology**	**Grid of Receptors Evaluated**	**Considers Person-Usage of SLU**	**Considers Linear Frontage of SLU**	**Considers Area of SLU**
South Carolina		X			X	X	X	X	
South Dakota	No public information available on SLU.								
Tennessee					X				X
Texas		X		X	X	X		X	X
Utah								X	
Vermont		X			X			X	
Virginia	X	X		X	X		X	X	
Washington					X	X	X		
West Virginia						X	X		
Wisconsin			X						
Wyoming	No public information available on SLU.								

[1] "Specific SLU Guidance Document Developed" may include Appendices.

[2] "Simple Single Receptor Methodology" implies that a single receptor is identified for an SLU, and the receptor is worth a single residence.

[3] "Multiple Receptor Methodology" implies that a receptor is placed at each area of "frequent human use" within an SLU (e.g., Receptors at a park are placed at a baseball field, a playground, a basketball court, and a picnic table).

4. Methodology to Evaluate Special Land Uses

This 2024 methodology replaces *A Method to Determine Reasonableness and Feasibility of Noise Abatement at Special Land Use Locations* (FL-ER-65-97, updated 7/22/2009) and updates FDOT's process used to identify traffic noise levels, impacts, and evaluate noise abatement for SLUs. SLUs are non-residential noise sensitive sites that are listed in FHWA's NAC Activity Categories A, C, D, and E. The methodology to evaluate SLUs is comprised of seven steps, as shown in **Figure 1** and **Figure 2**.

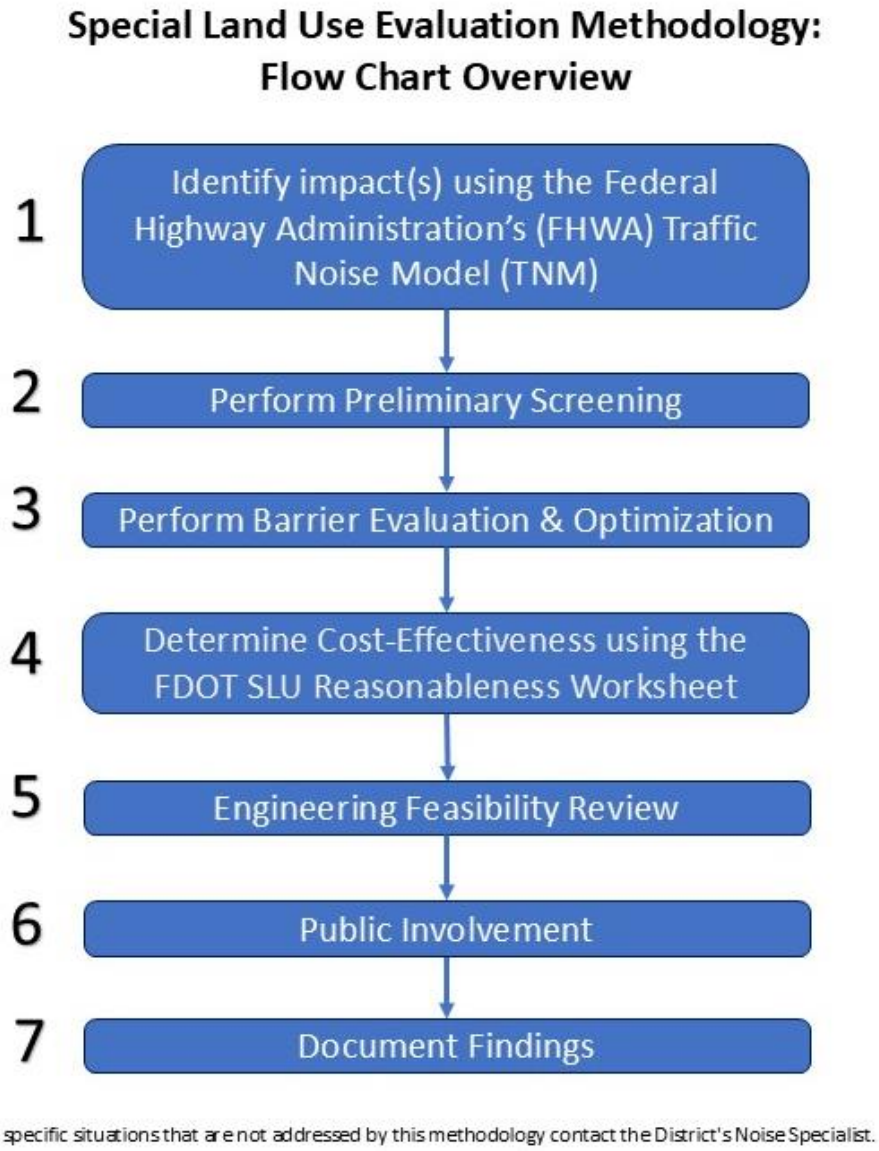

Figure 1 Special Land Use Evaluation Methodology: Process Overview

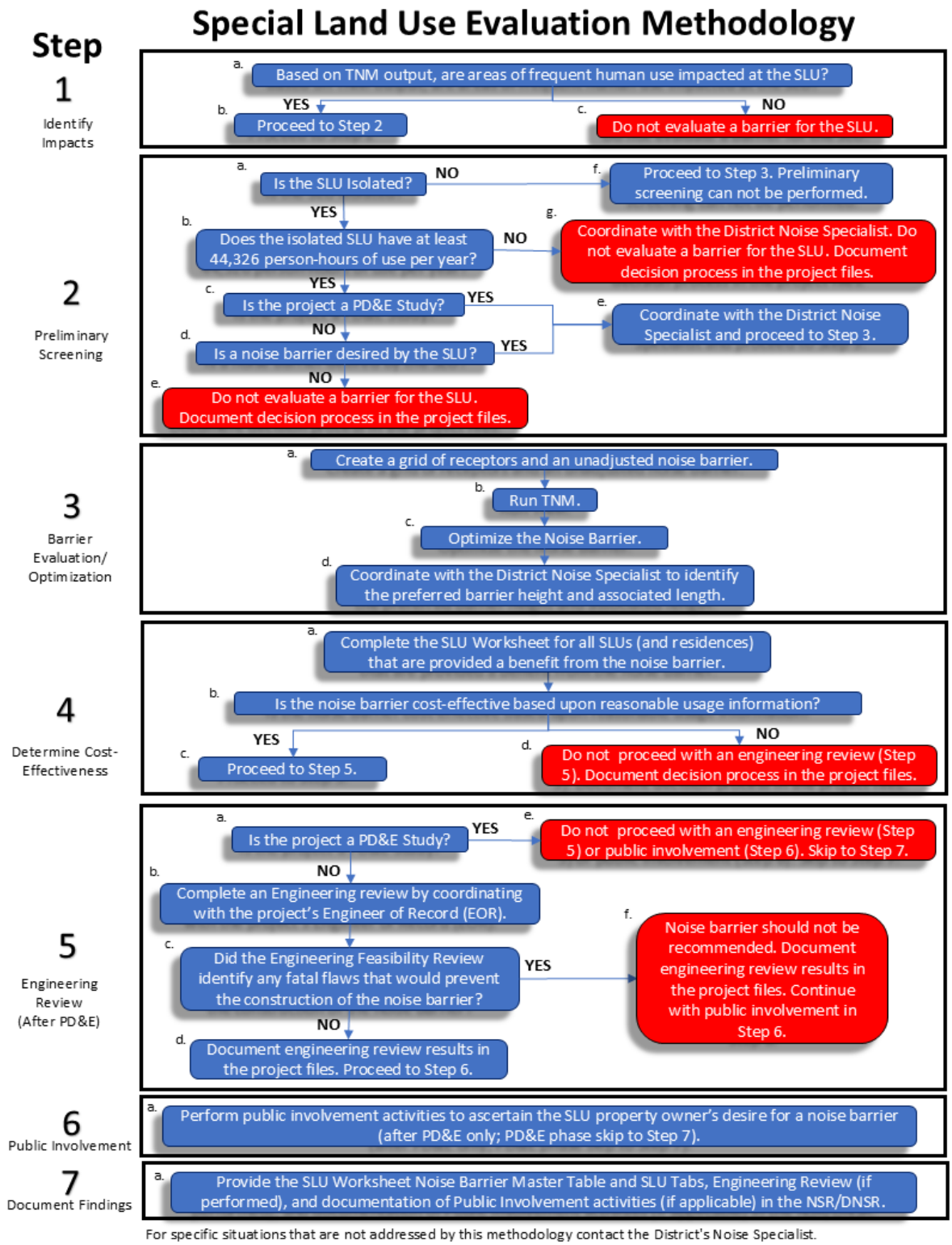

Figure 2 Special Land Use Methodology Flowchart

4.1. Step 1: Identify Impacts

In order to initiate an evaluation of noise abatement from highway traffic noise for SLUs, the future build predicted noise levels with the proposed project must be identified to determine if the NAC would be met or exceeded. For PD&E phase noise studies, the existing noise levels must also be identified to determine if a substantial increase in noise would occur. These tasks should be done following procedures listed in 23 CFR 772 and the latest versions of the FDOT PD&E Manual, Chapter 18 (*Highway Traffic Noise*) and *Traffic Noise Modeling and Analysis Practitioners Handbook*. This process is represented in **Figure 3**.

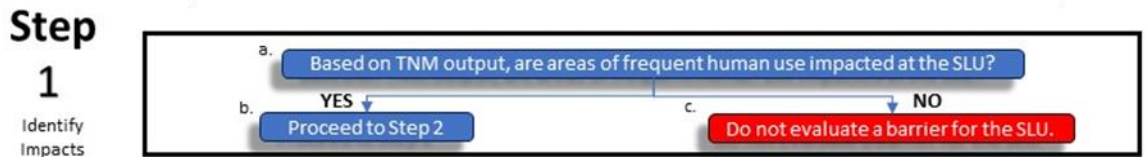

Figure 3 Step 1: Identify Impacts

4.1.1. Receptor Placement

Receptors should be placed at areas of frequent human use as described in Part 2, Chapter 18 of the PD&E Manual (*Highway Traffic Noise)*, the FDOT's *Traffic Noise Modeling and Analysis Practitioner's Handbook* (December 2018), and 23 CFR Part 772. Receptor placement at some SLUs may require a discussion with the District during the Methodology Meeting that should be conducted at the beginning of the noise evaluation.

For Activity Category A, C, and E, receptors should be placed at all exterior areas of frequent human use (EAFHU). There are three types of receptor placement for EAFHU areas at SLUs. They are presented in

Table 4**.** Note that an SLU may have more than one receptor placement type if multiple types of SLU usages are present at the SLU (e.g., a park with a playground and a trail). Receptors should not be placed at areas that are not considered frequently used (e.g., parking lots, transition areas from parking lots to frequently used areas, ponds, expanses of land/forest with no obvious frequent use areas). For example, a park may have multiple areas of EAFHU which are separated by an area of non-frequent human use (i.e., a pond or forested area).

Table 4 Receptor Placement for SLUs

SLU Usage Type	Receptor Placement Type	Example
Concentrated Activity (e.g., restaurants/bars, basketball court, swimming pools, small playgrounds, etc.)	Receptor(s) shall be placed at the closest location to the highway right-of-way (ROW) line (e.g., where impacts are most likely to exist) and where frequent outdoor activity normally occurs. For most concentrated activities, a single receptor is sufficient to identify impacts. However, more than one receptor may be needed to fully assess the area of impact within the area of frequent human use if it is determined to be impacted (e.g., noise barrier optimization and evaluation, see **Section 4.2.1**). This category includes Activity Category D (interior) use.	
Dispersed use (golf course, park, etc.)	Receptors should be placed in a grid fashion where frequent human use occurs. See Section titled *Grid and* Linear Spacing. For golf courses, receptors should be placed at tee boxes and putting greens. Sports fields/arenas should have receptors placed at bleachers/stands and active playing fields.	
Linear use (trail)	Receptors should be placed in a linear fashion along trails or paths. Receptors shall be placed at the intersection of the ROW and the trail/path (if present) and every 50 ft. along the locations of the trail that are closest to the ROW. Receptors may need to extend up to 500 ft. from the ROW in order to determine the extent of impacts and/or benefits. Receptors do not need to be placed on portions of the trail that are within the ROW.	

For Activity Category D, receptor(s) should be placed at an interior point that would be a site of frequent human use (such as a stage, seating area, etc., following the FDOT *Traffic Noise Modeling and Analysis Practitioner's Handbook* [2018]) or at the corner of the façade of the building closest to the facility. Typically, only one receptor is sufficient for modeling interior Activity Category D land uses. However, it may be deemed necessary to evaluate more than one receptor at an interior location based on professional judgment.

Medical facilities such as hospitals or other facilities where an overnight stay may be needed should be evaluated as an Activity Category C if an EAFHU is present. If no EAFHU is present, the facility should be evaluated as an Activity Category D. However, medical facilities such as dentist offices and other facilities where an overnight stay would not be required should not be evaluated.

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 FDOT District Noise Specialist. Documentation of decisions and rationale should be provided in the NSR/DNSR.

4.1.2. Grid and Linear Spacing and Extent

For dispersed use, a grid format shall be utilized. The Noise Analyst should create a grid of receptors that covers the entire area of impact and extends far enough to capture the entire area provided a benefit[5] at the SLU. Spacing and number of the grid of receptors will vary based on the acreage of the SLU being evaluated. Table 5 provides the recommended spacing of receptors in a grid format. Note that only the area being evaluated for impacts should be considered for the acreage in Table 5 (i.e., the entire property does not have to be gridded). If impacts are identified, this grid will also be utilized in the barrier optimization process (see Section 4.3.2). If the receptor spacing in Table 5 is not utilized, the density of receptors should be specified in the NSR/DNSR and a balance between number and density should be identified such that the grid is detailed enough to support an accurate barrier optimization process.

Table 5 Recommended Receptor Spacing

SLU Area Being Evaluated	Receptor Spacing
Area 0 to 0.5 Acres	Every 25 ft.
Area Greater than 0.5 to 5 Acres	Every 50 ft.
Area Greater than 5 Acres	Every 75 ft.
Trail (linear area)	Every 50 ft.

Of note, changing the extent of an EAFHU at an SLU should not change the Equivalent Residence (ER, see **Section 4.4.1.5**) value of the benefited area at an SLU, as shown in **Figure 4**. Increasing the number of receptors (Example C) or the area evaluated (Example B) does not change the ER value of the area which is provided a benefit. The ER value is a reasonableness evaluation that incorporates the usage from both residences as well as SLUs by equating to a common denominator. Further discussion of how ER values are derived and used is provided in Section **4.4.1** .

For linear use, spacing and number of the receptors will vary based on the acreage of the SLU being evaluated. **Table 5** provides the recommended spacing of receptors along the trail/path. Note that only the area being evaluated for impacts should be considered for the acreage (i.e., the entire trail/path does not have to be analyzed).

[5] A benefit is defined as an area receiving at least 5 dB(A) of noise reduction from the analyzed noise barrier.

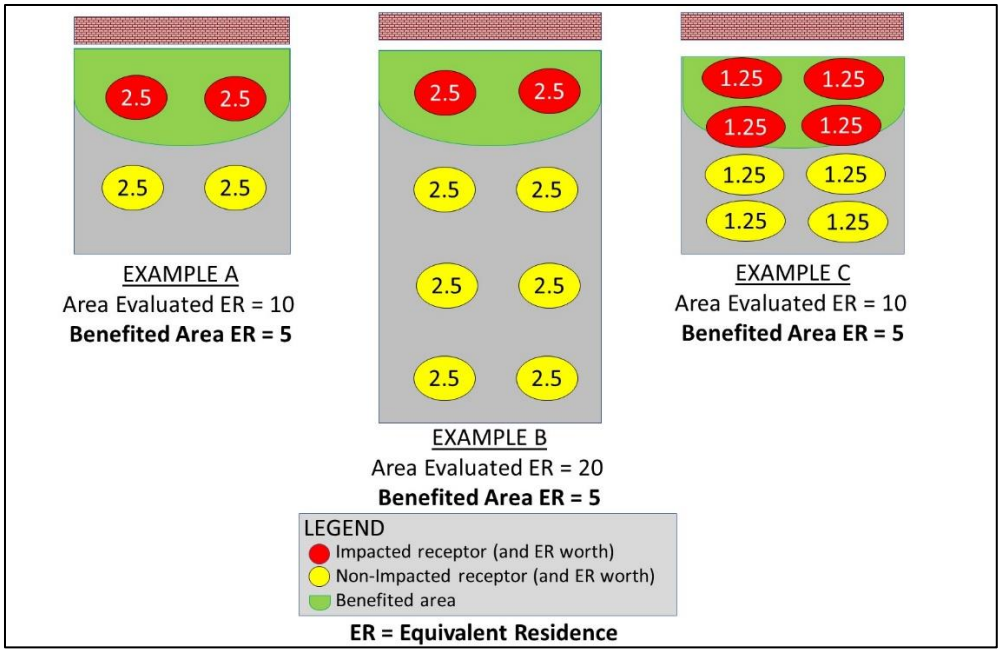

Figure 4 Grid Spacing Example

4.1.3. Grid and Linear Receptor Naming Convention

Receptors that represent an SLU should be specified with an "N" to denote a non-residential land use (e.g., N58, N109, N35, etc.). If an SLU is represented by more than one receptor, each receptor should be identified by the same numerical ID and followed with a "-" and a second numerical identifier for each unique receptor (e.g., N15-1, N15-2, N15-3, N15-4, N15-5, etc.)[6]. This nomenclature is distinct from receptors representing multi-story residences, which use an alphabetical identifier after the numerical identifier.[7] To avoid difficulty in overlapping labels for receptors in maps, a Noise Analyst may choose to identify the Common Noise Environment (CNE) number of a special land use by drawing a polygon around the property and identifying the CNE number one time on a map. A CNE is a group of receptors within the same NAC activity category that are exposed to similar noise sources and levels, traffic volumes, traffic mix, speed, and topographic features.

4.2. Step 2: Preliminary Screening

If desired, an optional preliminary screening may be applied to isolated and impacted low-usage SLUs which historically would not qualify for noise abatement, in an effort to decrease evaluation time. This may be decided on a case-by-case basis and in coordination with the FDOT District Noise Specialist. If the

[6] The receptor's full ID may contain an identifier which identifies the side of the roadway the receptor is on and the Noise Sensitive area identifier, as described in the *FDOT Traffic Modeling and analysis Practitioner's Handbook* (2018).

[7] The FDOT *Traffic Noise Modeling and Analysis Practitioner's Handbook* (2018) states, "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/DNSR should describe the convention used."

isolated SLU passes the screening analysis or does not go through a preliminary screening analysis as described below, the SLU must follow the in-depth analysis in Steps 3 through 7 described in **Sections 4.2.1** through **Section 4.7**. During Design and Design-Build phase projects, the viewpoints of SLU property owners may be solicited before the analysis begins to decrease the amount of time spent on the analysis. If an SLU property owner does not desire a noise barrier, the analysis can be terminated.

4.2.1. Step 2a: Isolation Screening

This process is only to be applied to isolated impacted SLUs. An isolated SLU is an impacted SLU that is located far enough away from other impacted SLUs and/or impacted residences such that a single noise barrier would not be a practical form of abatement for all impacted properties. Coordination with the FDOT District Noise Specialist and/or TNM modeling may be needed to determine if an SLU is considered isolated (e.g., If noise barrier panels can be eliminated in between the noise sensitive sites without a loss of benefits, the noise sensitive sites could be considered too far apart to be combined for a single noise barrier evaluation). Additionally, the **FDOT SLU Worksheet**[8] (see **Section 4.4.1**) provides a **Preliminary Screening Tab** that can be utilized for performing preliminary screening.

The following sections provide options for preliminary screening. This process is represented in **Figure 5**.

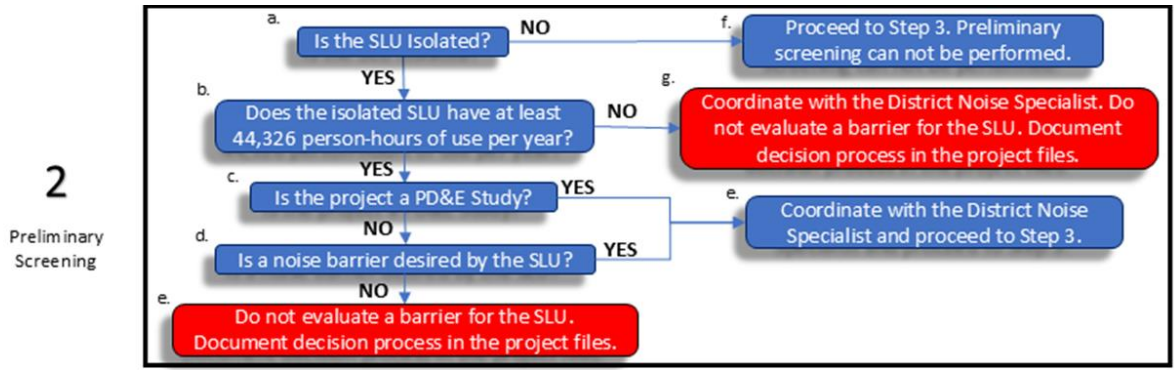

Figure 5 Step 2: Preliminary Screening

4.2.2. Step 2b: Usage Screening

An isolated impacted SLU must have enough person-hour usage to equate to at least two residences to be found feasible. To identify the number of person-hours-per-year that a single-family home in Florida has available for use, the average number of people per residence in Florida (2.53 people per residence[9]) was multiplied by the hours available for use per year (24 hours/day x 365 days/year= 8,760 hours) for a total of 22,163 person-hours available for use at each residence per year. Using these assumptions, two residences have a total of 44,326 person-hours available for use each year. Therefore, an isolated SLU

[8] The FDOT SLU Worksheet download is available on the FDOT Website.

[9] The assumption that 2.53 persons utilize the average single-family home in Florida was obtained from the Florida Census data from 2018-2022 (https://www.census.gov/quickfacts/fact/table/FL/HSD310220). It should be assumed that each single-family home is available for use 24 hours a day, 7 days a week, 365 days a year. This decision was based upon the fact that working, sleeping, and outdoor activities can be done at all hours of the day at a residence.

must have at least 44,326 person-hours of use per year in the benefited area for a noise barrier to be found a feasible form of noise abatement.

Because this is a preliminary screening and the benefited area of an SLU has not yet been identified, if the entire SLU has less than 44,326 person-hours per year, it is reasonable to assume that the benefited area of the SLU has less than 44,326 person-hours per year, and therefore the SLU is not eligible for a noise barrier. As an example, an SLU would need to be utilized by approximately 122 people for 1 hour per day for 365 days in a year to meet the required 44,326 person-hours. The **Preliminary Screening Tab** in the **FDOT SLU Worksheet** (shown in **Figure 6**) aids in this screening process.

Average Single-Family Residence in Florida - Person Hours per Year	
Average number of people in a single-family residence in Florida (US CENSUS, 2018-2022 data)	2.53
Hours a single-family residence is available for use (24 hours x 365 days)	8,760
Residential Person-Hours per Year Available for Use	22,163
Isolated SLU Person-Hours per Year	
Average number of users per day at the SLU	
Approximate daily hourly usage by each person at the SLU	
Number of Days per week the SLU is operational	
Number of weeks per year the SLU is operational	
Person-Hours per Year SLU is available for use	-
Equivalent Residence (ER)	-
Isolated SLU Eligible for Noise Barrier Evaluation?	NOT ELIGIBLE

Figure 6 Step 2: Preliminary Screening

The isolated SLU worksheet requires the SLU property owner to be contacted to inquire about usage information. Before reaching out to the SLU property owner, the Noise Analyst should coordinate with the FDOT District Noise Specialist to inform them of the intent to contact the SLU property owner. Upon contact with the SLU property owner, the Noise Analyst should explain that a noise barrier is being evaluated, but the outcome has not been determined. The Noise Analyst should fill out usage data (yellow highlighted cells).

The worksheet will automatically calculate the isolated SLU's equivalent residences and determine if the SLU is eligible for further noise abatement evaluation. If the isolated SLU is determined to not meet the minimum number of person-hours of use per day, the noise analyst should coordinate with the FDOT District Noise Specialist and inform them that the SLU was impacted but failed to pass the preliminary screening analysis.

Step 3 (**Section 4.2.1**) through Step 5 (**Section 4.5**) should not be completed for SLUs that did not pass the preliminary screening test based upon reasonable assumptions. In addition, the results and assumptions of the preliminary screening analysis should be provided in the NSR/DNSR to document why the SLU was not eligible for noise abatement.

Alternatively, if the operational hours of the SLU are known, but usage data is unavailable, the following formula (**Equation 2**) can be used to identify the minimum required person-hours in the benefited area of an SLU for a noise barrier to be considered cost-effective:

$$([\{\langle\lfloor a \times b \times \$40\rfloor \div \$64{,}000\rangle \times 22{,}163\} \div c] \div d) \div e = f$$

Where:

a = Noise Barrier height

b = Noise Barrier length

c = Number of days per week the SLU is operational

d = Number of weeks per year the SLU is operational

e = Hours per person per day a visitor is present in the benefited area of the SLU

f = Minimum person-hours required for a noise barrier to be cost reasonable

Equation 2 Minimum Usage Requirement

4.2.1. Step 2c and 2d: Viewpoint Screening (Design or Design-Build Phase only)

During a Design or Design-Build phase project, the SLU property owner(s) should be contacted to inquire about their viewpoint for or against a noise barrier if it is determined that a feasible and reasonable noise barrier can be built and after coordination with the FDOT District Noise Specialist has occurred.[10] If the SLU property owner is contacted and they desire a noise barrier, usage information should be collected as well (see **Section 4.4**).

4.3. Step 3: TNM Barrier Evaluation and Optimization

If the Preliminary Screening results indicate that a full analysis is warranted (or if the Preliminary Screening process was not applied), the following steps are required to identify the optimal noise barrier length and height for the impacted SLU. This process is represented in **Figure 7**.

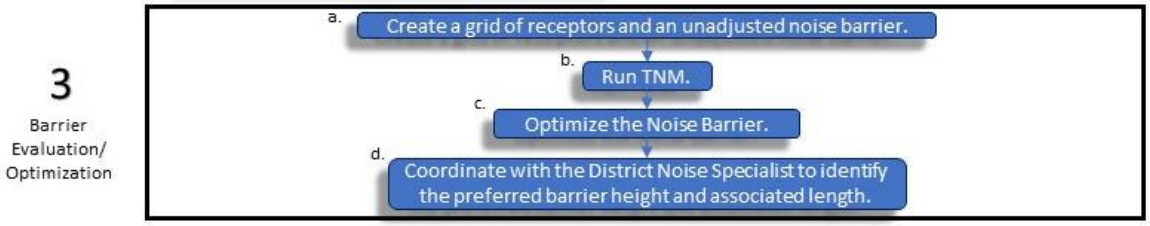

Figure 7 Step 3: Barrier Evaluation/Optimization

[10] Note that during a PD&E phase project, the SLU property owner is not typically contacted. Coordination and approval from the FDOT District Noise Specialist is required to reach out to an SLU property owner during the PD&E phase.

4.3.1. Initial Noise Barrier Length and Height

Following guidance from FDOT's *Traffic Noise Modeling & Analysis Practitioner's Handbook* (2018),

> *A noise barrier is to be input into the Traffic Noise Model (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.*

4.3.2. Noise Barrier Optimization – Acoustic Feasibility and Reasonableness

Following guidance is from FDOT's *Traffic Noise Modeling & Analysis Practitioner's Handbook* (2018),

> *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).*
>
> *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.

The District's Noise Specialist should be consulted to confirm the optimal barrier height and associated length identified.

4.4. Step 4: Determine Cost-Effectiveness – Reasonableness

Once it is determined that a noise barrier can provide a benefit to the SLU and meet the NRDG, the Noise Analyst should identify the cost-effectiveness of the barrier. This process is represented in **Figure 8.**

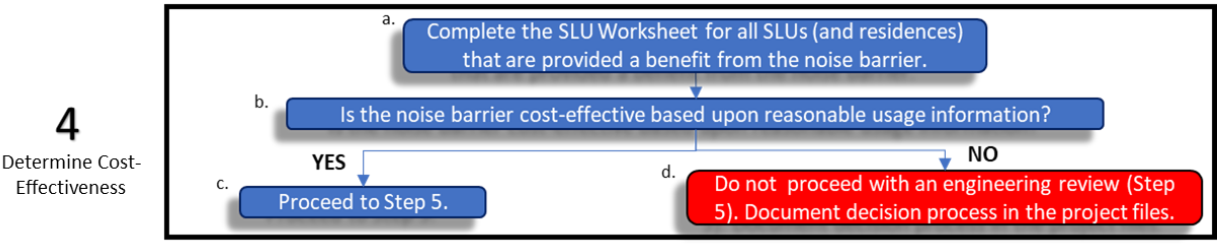

Figure 8 Step 4: Determine Cost-Effectiveness

The Noise Analyst should utilize the SLU Tabs of the **FDOT SLU Worksheet**[11] to enter usage data of the SLU, if known. Although the SLU property owner is not typically contacted during the PD&E phase of the project, the Noise Analyst could coordinate with the FDOT District Noise Specialist and receive approval to contact the SLU property owner. Upon contact with the SLU property owner, the Noise Analyst should be clear that an evaluation of noise is being performed and that the determination if a noise barrier is merited has not yet been determined. The SLU property owner should provide the operating hours/days/weeks of the facility as well as person-hour usage information for the area evaluated (i.e., the area of the SLU that was represented by receptors). All usage information should be reviewed and approved by the FDOT District Noise Specialist. If unreasonable data is provided by the SLU, discussion with the FDOT District Noise Specialist is required to identify reasonable use data before proceeding with the noise barrier analysis.

[11] The FDOT SLU Worksheet is available for download on the FDOT Website.

The usage data, along with the optimal noise barrier heights and lengths, and the number of modeled and benefited receptors are entered into the **SLU Worksheet**. The worksheet then calculates the cost per benefited residence/equivalent residence and identifies the noise barrier as either cost "reasonable" or "not reasonable" for the SLU.

If the SLU property owner is unable to be contacted or if usage information is not available, the Noise Analyst should utilize the **Noise Barrier Master Table** of the **FDOT SLU Worksheet** to identify the minimum usage required. The **Noise Barrier Master Table** enables the Noise Analyst to "back calculate" the number of required person-hours of use per day in the benefited area of an SLU for a noise barrier to be considered cost-effective.

A determination is then made as to whether the calculated minimum person-hours per day of usage is considered likely to occur at the SLU. This could be determined by the size of the SLU, number of parking spaces, number of tables, etc. If the minimum person-hours per day of usage is unlikely to occur at the SLU, the noise barrier is considered not cost effective. All usage assumptions should be documented in the project file and the NSR/DNSR.

4.4.1. SLU Worksheet

The **FDOT SLU Worksheet** can be utilized to assist with the assessment of whether a noise barrier is a feasible and reasonable form of abatement for an impacted area that has one or more SLUs[12] or an impacted SLU(s) adjacent to an impacted residential area. The **SLU Worksheet** can also be used to "back-into" or "back-calculate" the minimum person-hours required for a noise barrier to be cost-effective A separate **SLU Worksheet** should be filled out for each noise barrier/noise barrier system. The **SLU Worksheet** should only contain SLUs for which the barrier/barrier system is being evaluated. If multiple barriers/barrier systems are evaluated in a project, multiple **SLU Worksheets** should be utilized. The **SLU Worksheet** has three main components: the **Preliminary Screening** (discussed in **Section 4.2**), the **Noise Barrier Master Table** (shown in

Figure 9), and the **SLU Tabs** (shown in

[12] Note that the FDOT SLU Worksheet does not assist with the optimization of the noise barrier in TNM. Optimization must be performed separately. The resulting optimized heights/lengths should be documented in the SLU Worksheet.

Figure 10**;** ex. SLU #1, SLU #2, etc.). The **Noise Barrier Master Table** identifies the noise barrier details and summarizes important metrics for determining if a noise barrier/noise barrier system is feasible and/or reasonable which are based upon data in the **SLU Tabs**. The **SLU Tabs** identify usage data of each SLU for which the noise barrier/noise barrier system is being evaluated. All SLUs that receive a benefit from the noise barrier/noise barrier system should have a corresponding **SLU Tab** filled out. However, if the noise barrier is feasible and reasonable for an adjacent residential area, and the SLU would receive a benefit from the barrier, usage of the SLU is not required for determining cost reasonableness (although still required during the Design Phase when community input is solicited), as the residential area already

qualifies for a noise barrier. The Noise Analyst should fill out all applicable data and insert the completed **Noise Barrier Master Table** into the report. Further discussion of feasibility and reasonableness factors is included in **Section 4.4.1.6** and **Section 4.4.1.7**.

The **FDOT SLU Worksheet** can be completed by taking the following Steps:

1) **STEP 1 -** Click on the **Noise Barrier Master Table tab**. Fill out the yellow highlighted cells: Project name, FPID, SLU name(s), SLU description(s), and Barrier Height and Length combinations evaluated. For each height/length evaluated, fill in the approximate barrier stationing extent (and/or XY coordinates), the number of residences provided a benefit (if any), and the Average and Maximum reduction received at any receptor evaluated for the noise barrier (including residences and SLUs).
2) **STEP 2 -** For each SLU evaluated, fill out the yellow highlighted cells in an **SLU Tab**. This includes the SLU name, SLU description, NAC Activity Category assigned, average number of users per day in the area evaluated at the SLU, approximate daily hourly usage by each person in the area evaluated at the SLU, number of days per week and weeks per year the SLU is operational, the number of receptors evaluated at the SLU, the number of receptors benefited, and the number of receptors that are both impacted and benefited.
3) **STEP 3 -** If an SLU's usage is unknown, **Columns T** and **U** of the **Noise Barrier Master Table** can be used as a "Back-in" calculation to identify the minimum usage required for the noise barrier to be cost-effective. These columns identify the minimum Benefited Equivalent Residences (BER) (or residences) and the minimum person-hours per day that are required for a noise barrier to be cost-effective, respectively.
4) **STEP 4 -** Once all SLUs being evaluated have an **SLU tab** with all relevant information filled out, the **Noise Barrier Master Table** summarizes data from each of the **SLU Tabs** and will auto-populate. The Noise Barrier Master Table can be copied into the report.

ALL YELLOW HIGHLIGHTED CELLS SHOULD BE FILLED IN BY THE NOISE ANALYST.

Note: Barrier Height/Length and # of residences benefited should be completed in "Noise Barrier Master Table" Tab first. Then, details of each SLU should be entered in the yellow cells in the SLU tabs. The noise barrier height/length is auto-populated into the SLU Tabs.

Project	
FPID	
SLU Name(s)	
SLU Descripti	

Table 1 - Noise Barrier Evaluation

				Cost per sq. ft.	$40		Residences		SLUs		Residences + SLUs		Cost-Effectiveness Criteria ($/per benefit):			$64,000	"BACK-IN" Calculation [1]	
Barrier Scenario ID	Barrier Location	Barrier Height	Barrier Length [1]	Barrier Total Cost [2]		Approximate Barrier Stationing Extent [3]	Impacted and Benefited	Total Benefited	Impacted and Benefited Equivalent Residences (BER)	Total Benefited Equivalent Residences	Combined Impacted and Benefited Residences and Equivalent Residences [4]	Combined Benefited Residences and Equivalent Residences	Average Reduction [(dB(A)]	Maximum Reduction [(dB(A)] [5]	Cost per Benefited Residence/ Equivalent Residence	Cost-Effective & Reasonable?	Minimum BERs (or residences) are required to be cost-effective?	Minimum Person-hours per day are required in the benefited area to be cost-effective?
1	ROW			$	-				0.0	0.0	0.0	0.0				NOT REASONABLE	0.0	-
	Shoulder																	
	Structure																	
2	ROW			$	-				0.0	0.0	0.0	0.0				NOT REASONABLE	0.0	-
	Shoulder																	
	Structure																	
3	ROW			$	-				0.0	0.0	0.0	0.0				NOT REASONABLE	0.0	-
	Shoulder																	
	Structure																	
4	ROW			$	-				0.0	0.0	0.0	0.0				NOT REASONABLE	0.0	-
	Shoulder																	
	Structure																	
5	ROW			$	-				0.0	0.0	0.0	0.0				NOT REASONABLE	0.0	-
	Shoulder																	
	Structure																	
6	ROW			$	-				0.0	0.0	0.0	0.0				NOT REASONABLE	0.0	-
	Shoulder																	
	Structure																	
7	ROW			$	-				0.0	0.0	0.0	0.0				NOT REASONABLE	0.0	-
	Shoulder																	
	Structure																	
8	ROW			$	-				0.0	0.0	0.0	0.0				NOT REASONABLE	0.0	-
	Shoulder																	
	Structure																	

[1]Barrier length refers to the total length at the ROW, Shoulder, or on Structure.

[2]Assumes $40 per square foot.

[3] Alternatively, XY coordinates may be provided.

[4]If the total impacted and benefited residences and equivalent residences is less than 2, the noise barrier is not considered feasible.

[5]Maximum Reduction refers to the maximum reduction at any receptor (residential or SLU) evaluated for the noise barrier. If 7 dB(A) or greater, the Noise Reduction Design Goal (NRDG) is met and the barrier is acoustically reasonable.

[1]Only to be utilized when an SLU does not know usage data. This column can be used to identify the minimum usage the SLU needs to have in order to make the noise barrier cost-effective.

Figure 9 SLU Worksheet: Noise Barrier Master Table

	SLU NAME							
	SLU DESCRIPTION							
	NAC							
	SLU Equivalent Residence (ER) Identification							
	Step	**Sub-Step**	**Description**					**Value**
	Average Single-Family Residence in Florida - Person Hours per Year							
	A1	a	Average number of people in a single-family residence in Florida (US CENSUS, 2018-2022 data)					2.53
		b	Hours a single-family residence is available for use (24 hours x 365 days)					8,760
		c	**Residential Person-Hours per Year Available for Use**					22,163
	SLU Person Hours per Year							
	A2	a	Average number of users per day *in the area evaluated* at the SLU					
		b	Approximate daily hourly usage by each person *in the area evaluated* at the SLU					
		c	Number of days per week the SLU is operational					
		d	Number of weeks per year the SLU is operational					
		e	**Person-Hours per Year Available for Use at the SLU**					-
	SLU Area Evaluated Equivalent Residence (ER)							
	A3	a	**Equivalent Residence (ER)**					-
	SLU Receptor Equivalent Residence (ER)							
	A4	a	Identify the number of receptors evaluated at the SLU					
		b	Individual Receptor Equivalent Residence (i.e., each receptor point evaluated is worth...)					0
	SLU Weighted Residential Vote Value							
	A5	a	Barrier ID Selected					
		b	Number of votes Assigned to SLU in Barrier Voting Process (if applicable)					#N/A
	Barrier Evaluation for SLU #1							
	Barrier ID	**Barrier Location**	**Barrier Height**	**Barrier Length**	**Number of Impacted and Benefited Receptors at SLU #1**	**Total Number of Benefited Receptors at SLU #1**	**Impacted BER**	**Total BER**
	1	ROW	-	-			0.00	0.00
		Shoulder	-	-				
		Structure	-	-				
	2	ROW	-	-			0.00	0.00
		Shoulder	-	-				
		Structure	-	-				
	3	ROW	-	-			0.00	0.00
		Shoulder	-	-				
		Structure	-	-				
	4	ROW	-	-			0.00	0.00
		Shoulder	-	-				
		Structure	-	-				
	5	ROW	-	-			0.00	0.00
		Shoulder	-	-				
		Structure	-	-				
	6	ROW	-	-			0.00	0.00
		Shoulder	-	-				
		Structure	-	-				
	7	ROW	-	-			0.00	0.00
		Shoulder	-	-				
		Structure	-	-				
	8	ROW	-	-			0.00	0.00
		Shoulder	-	-				
		Structure	-	-				
	Note: Yellow highlighted cells are to be filled out by Noise Analyst/District Noise Specialist. Grey cells have embedded formulas.							

Figure 10 SLU Worksheet: SLU Tabs

4.4.1.1. Noise Barrier Details

For each noise barrier height evaluated, the location (ROW, shoulder, or structure), height and length of the noise barrier should be filled in **Columns D, E, and F** of the **Noise Barrier Master Table**. If a noise barrier system (i.e., more than a single noise barrier; e.g., an overlapping right-of-way and shoulder or structure noise barrier that accommodates an overpass) is evaluated, the location of each segment and associated length should be identified (ex., 1,000 ft. ROW, 500 ft. shoulder, and 400 ft. structure). The resulting auto-calculation, shown in **Column G,** is the cost of the proposed noise barrier using the current FDOT cost estimate of $40 per square foot. This cost-per-square-foot can be adjusted in **cell G9.** The noise barrier's approximate stationing extent (or XY coordinates) can also be provided in **Column H**, if desired.

4.4.1.2. Adjacent Benefited Residences

Although a noise barrier is optimized and designed for impacted residences and SLUs, the SLU Worksheet (and therefore cost-effectiveness calculation) should include all residences and SLUs that would receive a benefit from the noise barrier. This methodology allows the combined evaluation of both Activity Category B as well as Activity Category A, C, D, and E together for a single noise barrier system that would potentially provide a benefit to all land use types evaluated. Impacted and benefited residences should be noted in **Column I** of the **Noise Barrier Master Table**. Benefited residences should be noted in **Column J**. These metrics aid in evaluating feasibility factors (see **Section 4.4.1.6**).

4.4.1.3. Independent Analyses

If a noise barrier evaluated for a combined impacted SLU and an adjacent impacted residential area is not acoustically feasible and reasonable, then no additional analysis is required. However, if the barrier is acoustically feasible and reasonable, but not cost reasonable, then a barrier should be evaluated for both the SLU and the residential area independently to determine if a noise barrier for either the SLU or the residential area would be feasible and reasonable on its own merit.

4.4.1.4. Residential Person-Hours Per Year

Step A1 of the **SLU Tab** outlines usage assumptions about the average single-family residence in Florida. To identify the number of person-hours-per-year that a single-family home in Florida has available for use, the average number of people per residence in Florida (2.53 people per residence[9]) was multiplied by the hours available for use per year (24 hours/day x 365 days/year= 8,760 hours) for a total of 22,163 person-hours available for use at each residence.

4.4.1.5. SLU Equivalent Residence

Step A2 of the **SLU Tab** identifies the person-hours per year available for use at the SLU. The Noise Analyst should fill out usage data in Steps A2a through A2d (**Column I, rows 11-14** of the **SLU Tab**). The worksheet will auto-calculate the Person-Hours per year that are available for use at the SLU, as well as the Equivalent Residences (ER; i.e., number of residences that the area evaluated at the SLU can be equated to, based upon hourly usage).

Step A3 of the **SLU Tab** is an auto-calculation to equate an SLU area to an ER. The ER facilitates a collective cost-effectiveness evaluation that incorporates the usage from both residences as well as SLUs by equating to a common denominator. The ER can be identified by dividing the SLU person-hours per year available for use by the residential person-hours per year available for use. To calculate the ER, refer to the formula in **Equation 3**.

$$[(a \times b \times c \times d) \div e\,] = \mathrm{ER}$$

Where:
a = Average number of users per day in the area evaluated at the SLU
b = Approximate daily hourly usage by each person in the area evaluated at the SLU
c = Number of days per week the SLU is operational
d = Number of weeks per year the SLU is operational
e = Residential Person-Hours per year available for use (22,163 person-hours)
ER = Equivalent Residence

Equation 3 ER Equation

Step A4 of the **SLU Tab** requires the Noise Analyst to input the number of receptors evaluated at the SLU (**Column I, row 19** of the **SLU Tab**). This includes single, gridded, and linear placed receptors. The worksheet will auto-calculate how many residences each receptor is worth to facilitate the calculation of the SLU's BER.

In the **Barrier Evaluation** section of the SLU Tab, the number of impacted and benefited receptors (**Column F, rows 25-48** of the **SLU Tab**) and the total number of benefited receptors (**Column G, rows 25-48** of the **SLU Tab**) should be filled out by the Noise Analyst. These metrics enable the calculation of the percentage of receptors that are benefited to identify the impacted BER and the total BER. The worksheet will auto-calculate the impacted BER and total BER. To calculate the BER, refer to the formula in **Equation 4**.

$$[(a \times b \times c \times d) \div e\,] \times (f \div g) = \mathrm{BER}$$

Where:
a = Average number of users per day in the area evaluated at the SLU
b = Approximate daily hourly usage by each person in the area evaluated at the SLU
c = Number of days per week the SLU is operational
d = Number of weeks per year the SLU is operational
e = Residential Person-Hours per year available for use (22,163 person-hours)
f = Number of benefited receptors evaluated at the SLU
g = Total number of receptors evaluated at the SLU
BER = Benefited Equivalent Residence

Equation 4 BER Equation

4.4.1.6. Feasibility Factors

The Noise Analyst should identify the total number of impacted and benefited residences (**Column I** of the **Noise Barrier Master Table**) and the total number of benefited residences (**Column J**). **Column M** adds the number of impacted and benefited residences and ERs. A noise barrier must provide a benefit to at least two (2) impacted residences[13] and/or ERs. If a noise barrier does not provide a benefit to at least two impacted residences and/or ERs, the noise barrier is not considered a feasible form of noise abatement.

4.4.1.7. Reasonableness Factors

4.4.1.7.1. Noise Reduction Design Goal

The Noise Analyst should identify the maximum reduction that any receptor (residential or SLU) receives from the noise barrier (**Column P** of the **Noise Barrier Master Table**), which identifies whether the noise barrier has met the NRDG. If this value is at or over 7 dB(A), the NRDG has been met. If the maximum reduction is below 7 dB(A), the noise barrier has not met the NRDG, and the impacted noise sensitive sites do not qualify for a noise barrier.

4.4.1.7.2. Cost-Effectiveness

Column Q of the **Noise Barrier Master Table** of the SLU Worksheet is an auto-calculation of the cost per benefited residence and/or BER. This step divides the cost of the proposed noise barrier by the total number of SLU BERs and benefited residences. The worksheet then determines if the cost per benefited residence (and/or BER) is less than the current FDOT threshold of $64,000. Note that this criterion can be adjusted in cell **R9** of the **Noise Barrier Master Table**. If the cost per benefited residence (and/or BER) is less than $64,000, the proposed noise barrier is considered cost-effective and, therefore, reasonable, and the **Noise Barrier Master Table** and **SLU Tab** should be provided in the NSR/DNSR.

If the cost per benefited residence (and/or BER) is greater than $64,000, the proposed noise barrier is considered not cost reasonable, the analysis is complete, and the **Noise Barrier Master Table** and **SLU Tab** should be provided in the NSR/DNSR.

If an SLU's usage is unknown, **Columns T** and **U** ("Minimum BERs [or residences] required to be cost-effective?" and "Minimum Person-hours per day required to be cost-effective", respectively) can be used to identify the minimum usage required for the noise barrier to be cost-effective (commonly referred to as the “back-in” calculation method). This follows the formula previously outlined in **Equation 2**.

4.4.1.7.3. SLU Weighted Residential Vote Value

After a noise barrier is determined to be reasonable, the benefited SLU and residential property owners will be solicited for their desire for or against a noise barrier during the project’s design phase (see **Section 4.6**). The number of residential votes that an SLU is equivalent to is the total BER rounded up if it is at or above 2.1 (e.g., a total BER of 2.3 should be rounded up to 3 residences, but a total BER of 2.09 should be

[13] Consistent with the FDOT PD&E Manual, Chapter 18, Section 18.2.3.2.1

rounded down to 2). Because the Residential Vote Value varies per barrier selected, the Barrier ID should be identified in Step A5a (**Column I, row 22** of the **SLU Tab)**. Once the barrier is identified, the Residential Vote Value is auto-calculated in Step A5b (**Column I**) of each **SLU Tab**.

4.5. Step 5: Engineering Feasibility Review (After PD&E Phase)

An engineering review is typically not performed in the PD&E phase of a project. During the Design phase (or Design-Build), once an optimal barrier height and length have been chosen, a thorough engineering feasibility review of the barrier should be conducted. The Noise Analyst should provide a form (see **Figure 11** for an example) with the proposed noise barrier details to the Engineer of Record (EOR), who in turn addresses and documents the following potential engineering constraints:

- Design/constructability
- Drainage
- Utilities
- Safety
- Maintenance
- ROW Acquisition
- Legal
- Outdoor advertising

Noise Barrier Engineering Review Form

123456-1 Widen Florida Avenue from Miami Rd. to Western Rd. (MP 1.0 to 4.0)

Hillsborough County, Florida

Noise Barrier #:_____

Date Provided: _____

Date Reviewed: _____

Reviewed By: _____

Topic	Details
Location	ROW
Length	5,000
Height	22
Estimated Cost (@ $30/ sq. ft.)	$3,300,00
Design/Constructability Issues	
Drainage Issues	
Utility Issues	
Safety Issues	
Maintenance Issues	
ROW Acquisition Issues	
Legal Issues	
Outdoor Advertising Issues	
Are any of the above issues severe enough so that a noise barrier cannot be constructed at this location? If so, please explain in detail.	

Figure 11 Sample Noise Barrier Engineering Review Form

Additionally, the EOR should make a final determination if the noise barrier can be constructed as proposed, or if modifications are needed. The form should be returned to the Noise Analyst and then provided in the appendix of the DNSR. If modifications to the noise barrier are needed, the Noise Analyst may need to re-model based on the required changes, in order to verify that the noise barrier meets acoustic and cost requirements.

Approval of the engineering feasibility review shall be received by the FDOT, consistent with Part 2, Chapter 18 of the PD&E Manual (*Highway Traffic Noise)* and 23 CFR Part 772 and the FDOT Design Manual 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. This process is represented in **Figure 12**.

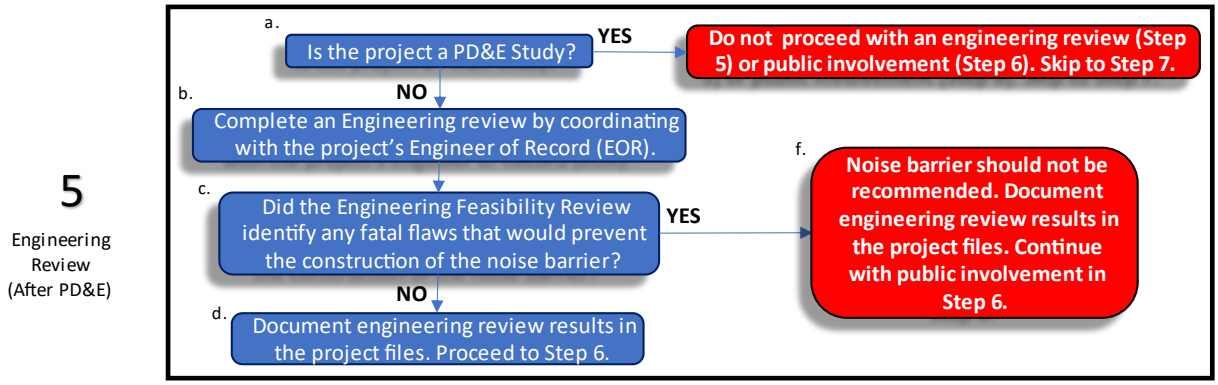

Figure 12 Step 5: Engineering Review

4.6. Step 6: Public Involvement

Public involvement should occur throughout the lifecycle of a project. The Public Involvement process as it pertains to SLUs is represented in **Figure 12**.

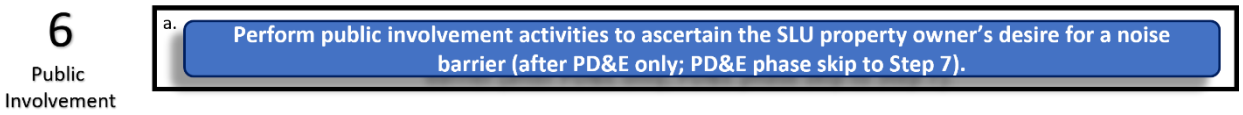

Figure 13 Step 6: Public Involvement

Several public involvement tasks related to a noise barrier are performed, including:

1. Public Information Meetings
2. Public Hearings
3. Identifying the number of users and hours of use at an SLU by coordinating with the SLU owner
4. Determining the SLU's support for/opposition to a noise barrier.

All engineering conflicts must be resolved before an SLU property owner is solicited for their desire for/opposition to a noise barrier.

Following guidance from FDOT's *Traffic Noise Modeling & Analysis Practitioner's Handbook* (December 2018),

> *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* [renamed DNSR]*. 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* [renamed DNSR]*.*
>
> *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.*

4.6.1. PD&E Study Public Involvement

Following guidance from FDOT's *Traffic Noise Modeling & Analysis Practitioner's Handbook* (December 2018),

> *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.*

4.6.2. Design Phase Public Involvement

Following guidance from FDOT's *Traffic Noise Modeling & Analysis Practitioner's Handbook (December 2018)*,

> *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 benefited 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 [renamed DNSR] *to properly document survey efforts.*

It is important to note that the viewpoints of the property owner will be considered as having the greatest weight in the decision as to whether FDOT will provide noise abatement. While the viewpoint of the non-owner resident will be considered, their viewpoint will carry less weight, consistent with the formula shown in **Table 6**.

Table 6 Viewpoint Weighting Factors

Property Type	Owner Occupies Property	Owner Does Not Occupy Property	
		Owner	Renter
Single-Family	100%	90%	10%
Multi-Family (duplex, apartments, condominiums)*			
Mobile Home Park*		80%	20%
Offices, Businesses			

* The weighting factor is for each unit (mobile home, apartments, condominiums), not for the entire mobile home park, apartment complex, or condominium building.
Source: FDOT, Part 2, Chapter 18 of the PD&E Manual (Highway Traffic Noise) and 23 CFR Part 772, Table 18-1 (2020).

Consistent with Part 2, Chapter 18 of the PD&E Manual (Highway Traffic Noise), in the event that some benefited SLU property owners and residents desire noise abatement and others do not, further assessment may be necessary in order to determine what impact, if any, this will have on the feasibility and reasonableness as well as the social impacts. Consultation with FDOT's Office of Environmental Management (OEM) may be needed. Documentation of noise abatement measures developed during the

final design should include letters, public hearing transcripts, and survey results, indicating that the benefited property owners or residents were afforded an opportunity to provide input.

4.7. Step 7: Document Findings

The documentation of the SLU analysis process is represented in **Figure 124**.

Figure 14 Step 7: Document Findings

In addition to the guidance provided in Part 2, Chapter 18 of the PD&E Manual (*Highway Traffic Noise)*, the noise barrier evaluation results must be documented in the NSR/DNSR. A table documenting the noise barrier types, heights, lengths, locations, benefited residences and equivalent residences, maximum noise reduction, and cost must be completed and provided in the NSR/DNSR. The **Noise Barrier Master Table** serves this purpose. An example table is provided in **Table 7**.Additionally, a summary table of all proposed barriers should be included (see example table in **Table 8**). Additionally, all completed **SLU Tab(s)** from the **SLU Worksheet** should be provided in the NSR/DNSR.

Table 7 Noise Barrier Evaluation for [INSERT SLU NAMES] (EXAMPLE)

Barrier Scenario	Barrier Location	Barrier Height (ft.)	Barrier Length[1] (ft.)	Barrier Total Cost[2] ($)	Approximate Barrier XY Extent (Stationing)	Residences		Special Land Uses		Combined Total Impacted and Benefited Residences and Equivalent Residences[3]	Combined Total Benefited Residences and Equivalent Residences	Average Reduction [(dB(A)]	Maximum Reduction [(dB(A)][4]	Cost per Benefited Residence/ Equivalent Residence ($)	Cost-Effective?
						Impacted and Benefited	Total Benefited	Impacted and Benefited Equivalent Residences	Total Benefited Equivalent Residences						
1	Shoulder	8	2,700	$928,000		15	19	1	1	16	20	7.5	9	$46,400	Yes
	Structure	8	200												
2	Shoulder	10	2,700	$1,144,000		15	20	1	1	16	21	8.0	10	$54,476	Yes
	Structure	8	200												
3	Shoulder	12	2,700	$1,360,000		15	21	1	1	16	22	8.5	11	$61,818	Yes
	Structure	8	200												
4	Shoulder	14	2,600	$1,520,000		15	22	1	1	16	23	9.0	12	$66,087	No
	Structure	8	200												

[1]Barrier length refers to the total length at the ROW, Shoulder, or on Structure. Length indicated does not include the length of any required taper in height at a shoulder noise barrier termination.
[2]Assumes $40 per square foot.
[3]If total Impacted BER is less than 2, the noise barrier is not considered feasible.
[4]Maximum Reduction refers to the maximum reduction at any receptor (residential or SLU) evaluated for the noise barrier. If 7 dB(A) or greater, the Noise Reduction Design Goal (NRDG) is met.

Table 8 Feasible and Reasonable Noise Barriers (EXAMPLE)

Barrier ID	Common Noise Environments	Barrier Location	Barrier Height (ft.)	Barrier Length[1] (ft.)	Barrier Total Cost[2] ($)	Approximate Barrier XY Extent (Stationing)	Residences		SLUs		Total Impacted and Benefited Residences and Equivalent Residences[3]	Total Benefited Residences and Equivalent Residences	Cost per Benefited Residence/ Equivalent Residence ($)	Cost-Effective?
							Impacted & Benefited Residences	Benefited Residences	Impacted & Benefited SLUs (ER)	Benefited SLUs (ER)				
1	ABC Neighborhood, ABC Daycare	ROW	22	2,102	$2,068,640		36	36	1	1	37	37	$55,909	Yes
		Shoulder	8	684										
2	XYZ Neighborhood, XYZ School	Shoulder	14	1,573	$944,880		20	25	1	1	26	26	$36,342	Yes
		Structure	8	200										
3	ABC Park, DEF Neighborhood	ROW	22	3,475	$3,058,000		120	130	1	1	121	131	$23,342	Yes
Totals	------	------	------	------	$6,071,520	------	176	191	3	3	184	194	------	------

[1]Barrier length refers to the total length at the ROW, Shoulder, or on Structure. Length indicated does not include the length of any required taper in height at a shoulder noise barrier termination.

[2]Assumes $40 per square foot.

[3]If total Impacted BER is less than 2, the noise barrier is not considered feasible.

5. Conclusions

The FDOT's guidance on how to assess SLUs in Florida for highway traffic noise, *A Method to Determine Reasonableness and Feasibility of Noise Abatement at Special Land Use Locations*, was developed in 1997 and updated in 2009. Since the 2009 update, changes in federal regulations have occurred and limitations have been identified. Additionally, potential improvements to the methodology have been suggested by highway traffic noise specialists around the state. Therefore, this 2024 methodology document provides updated guidance on how to assess traffic noise for SLUs and replaces *A Method to Determine Reasonableness and Feasibility of Noise Abatement at Special Land Use Locations* (FL-ER-65-97). An Equivalent Receptor methodology has been provided which allows for the combined evaluation of both residential and non-residential noise sensitive land uses. The methodology follows the current 23 CFR Part 772 regulation and Part 2, Chapter 18 of the PD&E Manual (*Highway Traffic Noise)*.

In circumstances not outlined by this guidance document, Noise Analysts should coordinate with the District Noise Specialist and the FDOT OEM.

References

23 CFR Part 772, *"Procedures for Abatement of Highway Traffic Noise and Construction Noise"*, Federal Register, Vol. 75, No. 133, Tuesday, July 13, 2010; pages 39834-39839.

FDOT, "A Method to Determine Reasonableness and Feasibility of Noise Abatement at Special Use Locations", FL-ER-65-97, updated July 2009. 64 pages.

FDOT, *"Highway Traffic Noise"*, Part 2, Chapter 18. Project Development and Environment Manual, FDOT, Tallahassee, July 31, 2024.

FDOT, "FDOT Traffic Noise Modeling & Analysis Practitioners Handbook", December 31, 2018. https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/environment/pubs/final-practitioners-handbook---december-2018-version.pdf?sfvrsn=95bb91d6_2

Federal Highway Administration, Report FHWA-HEP-10-025, *"Highway Traffic Noise: Analysis and Abatement Guidance"*, December 2011; 75 pages.