

Noise Barrier Acceptance Criteria: Evaluation Tools

Publication No. FHWA-HEP-16-016

September 2013, updated November 2015



U.S. Department of Transportation
Federal Highway Administration

Foreword

The purpose of this report is to document the development of two tools to evaluate the effects of policy changes on the feasibility and reasonableness of noise abatement for the factors described in the Federal Highway Administration (FHWA) noise regulation in Title 23 CFR Part 772 as implemented in the individual state highway agency (SHA) noise policies. These tools allow a user to evaluate different combinations of factors to determine the effects of policy changes. The report specifically addresses the requirements of Tasks 3.6 through 3.8 of the FHWA Task Order No. DTFH61-D-00028-T12-002, *23 CFR 772 Streamlining, Analysis, and Outreach* and Task 3 of the FHWA Task Order No. DTFH61-D-00028-0005, *23 CFR 772 Streamlining, Analysis, and Outreach, Phase II*.

CONTENT SUMMARY

This report is comprised of the following four chapters:

- Chapter 1 contains the introduction.
- Chapter 2 describes the Noise Abatement Feasibility and Reasonableness Analysis Tool (NAFRAT) in detail and presents step-by-side instructions for its use.
- Chapter 3 describes the Noise Abatement Reasonableness Sensitivity Analysis Tool (NARSAT).
- Chapter 4 concludes the report.

INTERESTED AUDIENCE

This report was prepared for and reviewed by FHWA and the project's Technical Working Group (TWG), first as a draft report and then as an interim report. It addresses comments received from FHWA and the TWG during the review process. The intended audience includes analysts and policy-makers within FHWA and state highway agencies (SHAs) who specialize in highway traffic noise and National Environmental Policy Act (NEPA) implementation policies, processes, and procedures.

PREVIOUS PRINTINGS

This is the second printing of this report and includes a new Section 2.1.3.

PUBLICATION STATUS

The initial report was the second of two *Final Task 3 Deliverable Documents* under Task Order No. DTFH61-D-00028-T12-002. This updated report is the second of two *Final Task 3 Deliverable Documents* under Task Order No. DTFH61-D-00028-0005.

Notice

This document is disseminated under the sponsorship of the U.S. Department of Transportation in the interest of information exchange. The U.S. Government assumes no liability for the use of the information contained in this document.

The U.S. Government does not endorse products or manufacturers. Trademarks or manufacturers' names appear in this report only because they are considered essential to the objective of the document.

Quality Assurance Statement

The Federal Highway Administration (FHWA) provides high-quality information to serve Government, industry, and the public in a manner that promotes public understanding. Standards and policies are used to ensure and maximize the quality, objectivity, utility, and integrity of its information. FHWA periodically reviews quality issues and adjusts its programs and processes to ensure continuous quality improvement.

1. Report No. FHWA-*****	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle Noise Barrier Acceptance Criteria: Evaluation Tools		5. Report Date : September 2013, updated August 2015	
		6. Performing Organization Code:	
7. Author(s): William Bowlby, PhD, PE, Rennie Williamson and Geoffrey Pratt, PE, Bowlby & Associates, Inc.; Kenneth Kaliski, PE, RSG Inc.		8. Performing Organization Report No.	
9. Performing Organization Name and Address RSG Inc., White River Junction VT Bowlby & Associates, Inc., Franklin TN Environmental Acoustics, Lemoyne PA		10. Work Unit No. (TRAI5)	
		11. Contract or Grant No. DTFH61-11-D-00028-T12-002 and DTFH61-11-D-00028-0005	
12. Sponsoring Agency Name and Address U.S. Department of Transportation Federal Highway Administration Office of Planning, Environment and Realty Washington, DC 20590		13. Type of Report and Period Covered Guidelines	
		14. Sponsoring Agency Code HEPN	
15. Supplementary Notes			
16. Abstract: This report describes two tools for evaluating the effects on noise abatement decisions caused by changes to the feasibility and reasonableness criteria in state highway agency (SHA) noise policies developed under the FHWA noise regulation in 23 CFR 772. The Noise Abatement Feasibility and Reasonableness Analysis Tool (NAFRAT) uses results from noise barrier designs created with the FHWA Traffic Noise Model Version 2.5. Results are built-in for two designs for each of four actual highway projects or may be user-entered. The analyst may test abatement decisions for one or more designs for a single project against one or more sets of policy criteria or multiple projects' designs against one or more sets of criteria, including the criterion on the consideration of viewpoints of property owners and residents. The Noise Abatement Reasonableness Sensitivity Analysis Tool (NARSAT) is based on series of 108 cases derived from hypothetical scenarios involving: one, two, and three rows of receptors; three different receptor densities; two different setbacks from the barrier to the first row of receptors; and six different barrier heights. The tools were utilized for research documented in a companion report.			
17. Key Words: FHWA noise regulation, 23 CFR 772, noise barrier, noise abatement, feasibility, reasonableness, viewpoints	18. Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22161.		
19. Security Classification (of this report) Unclassified	20. Security Classification (of this page) Unclassified	21. No of Pages *****	22. Price

LIST OF ABBREVIATIONS AND ACRONYMS

% 1R, %1	- Percentage of first-row (impacted or benefited) receptors (see P1)
% ALL, %A	- Percentage of all (impacted or benefited) receptors (see PA)
%	- Percentage
#	- Number (integer)
# 1R	- Number of first-row
# All	- Number of all (impacted or benefited) receptors
#NA	- Not Applicable (due to missing criteria)
#/%	- Number or Percent
\$	- Cost (in dollars)
1R	- First-row
APBR	- Area per benefited receptor
APBR calc	- Calculated APBR
Ben, BR	- Benefited receptor
CE	- Cost effectiveness
CFR	- Code of Federal Regulations
CPBR	- Cost per benefited receptor
Crit	- Criterion
dB	- Decibel
dB(A), dBA	- Decibel unit for A-weighted sound level
DU	- Dwelling unit
Feas	- Feasibility
FHWA	- Federal Highway Administration
FHWA TNM	- FHWA Traffic Noise Model Version 2.5
L_{eq}	- Equivalent sound level in dB(A)

N	- Number of receptors
NAFRAT	- Noise Abatement Feasibility and Reasonableness Analysis Tool
NARSAT	- Noise Abatement Reasonableness Sensitivity Analysis Tool
NEPA	- National Environmental Policy Act
NR	- Noise reduction
NRDG	- Noise reduction design goal
P1	- Percentage of first-row (impacted or benefited) receptors (see % 1R)
PA	- Percentage of all (impacted or benefited) receptors (see % ALL)
Reas	- Reasonable by...
Reas?	- Overall reasonableness decision
SHA	- State highway agency
SF	- Square foot (feet)
TNM	- FHWA Traffic Noise Model Version 2.5
TWG	- Technical Working Group
UC	- Unit cost

TABLE OF CONTENTS

CHAPTER 1. INTRODUCTION 4

CHAPTER 2. THE NOISE ABATEMENT FEASIBILITY AND REASONABLENESS ANALYSIS TOOL (NAFRAT) 7

2.1 SUMMARY WORKSHEET 8

2.1.1 Feasibility Results Table..... 8

2.1.2 Reasonableness Results Table (NRDG and APBR)..... 12

2.1.3 Reasonableness Results Table (Viewpoints Criterion)..... 19

2.1.4 Combined Feasibility and Reasonableness Results Table: One project applied to many sample policies 24

2.2 SAMPLE POLICIES WORKSHEET 27

2.3 INDIVIDUAL CASE WORKSHEETS 28

2.4 STEP-BY-STEP INSTRUCTIONS FOR USE OF NAFRAT 34

CHAPTER 3. THE NOISE ABATEMENT REASONABLENESS SENSITIVITY ANALYSIS TOOL (NARSAT)..... 38

3.1 MODELED CASES AND REASONABLENESS FACTORS 38

3.1.1 Modeled Scenarios and Cases 38

3.1.2 Factors Studied..... 41

3.2 LAYOUT OF THE FACTORS AND CASES IN THE TOOL..... 42

3.3 STEP-BY-STEP INSTRUCTIONS FOR TOOL USE 47

CHAPTER 4. CONCLUSION 49

4.1 NAFRAT 49

4.2 NARSAT 51

LIST OF FIGURES

Figure 1. Feasibility Results table..... 8

Figure 2. Feasibility Results table: case identification. 9

Figure 3. Feasibility Results table: feasibility factors..... 10

Figure 4. Feasibility Results table: feasibility results. 11

Figure 5. Example help text. 12

Figure 6. Reasonableness Results table (NRDG and APBR)..... 13

Figure 7. Reasonableness Results table: case identification..... 14

Figure 8. Reasonableness Results table: reasonableness factors..... 15

Figure 9. APBR calculator. 16

Figure 10. Reasonableness Results table: reasonableness results. 17

Figure 11. FHWA TNM Barrier Descriptions Table highlighting location of Area in sq ft (SF) for a particular barrier design. 18

Figure 12. Reasonableness Results table (Viewpoints)..... 20

Figure 13. Reasonableness Results table: Viewpoints Factors. 20

Figure 14. Reasonableness Results table: Viewpoints Factors (vote weighting)..... 21

Figure 15. Reasonableness Results table: Viewpoints Results..... 23

Figure 16. Section of an individual project worksheet showing only the eligible voters..... 24

Figure 17. Screenshot showing a portion of the Combined Feasibility & Reasonableness Results table..... 26

Figure 18. Screenshot showing the summary portion of the Combined Feasibility & Reasonableness Results table. 27

Figure 19. Screenshot showing a portion of the Sample Policies worksheet. 27

Figure 20. Portion of an individual case worksheet..... 28

Figure 21. FHWA TNM Plan View of a portion of a model of a study area. 29

Figure 22. FHWA TNM Barrier View of a noise barrier design..... 30

Figure 23. FHWA TNM program Tables pull-down menu accessing Sound Levels results table. 30

Figure 24. Portion of FHWA TNM Sound Levels results table for a particular barrier design. 31

Figure 25. Selection of rows in the FHWA TNM Sound Levels results table. 32

Figure 26. Section of individual case worksheet showing a portion of the pasted FHWA TNM Sound Levels results table for a particular barrier design. 33

Figure 27. Section of individual case worksheet showing where additional input is needed (within yellow-highlighted cells). 34

Figure 28. Plan view (top) and cross-sectional view (bottom) of roadways and noise barrier portion of FHWA TNM model for sensitivity test cases. 39

Figure 29. Sketches of receptor scenarios used in modeling the sensitivity test cases for first-row receptors 90 feet (top) and 140 feet (bottom) from barrier. 40

Figure 30. TNM plan view plots of receptor scenarios in FHWA TNM model for sensitivity test cases: 140 feet back (top) and 90 feet back (bottom). 41

Figure 31. Portion of reasonableness decision array for the sensitivity test cases: NRDG of 7 dB, Benefited noise reduction of 5 dB, 50-ft receptor spacing, 50-ft distance back to first-row (90 ft from barrier), and mostly one-row cases. 43

Figure 32. Details of the columns representing a portion of the factor combinations. 44

Figure 33. Portion of the cases included in the tool. 45

Figure 34. Portion of the tool showing samples of the decisions. 45

Figure 35. Portion of tool showing sample policy factor values in the first five columns and the sample policy set number in the sixth column. 46

Figure 36. Portion of tool showing where the user enters criteria values. 47

CHAPTER 1. INTRODUCTION

This report documents the development of two tools to evaluate the effects of policy changes on the feasibility and reasonableness of noise abatement for the factors described in the Federal Highway Administration (FHWA) noise regulation in Title 23 CFR Part 772.¹ These tools allow a user to evaluate different combinations of factors to determine the effects of policy changes.

Feasibility and reasonableness are determined based on the effect the abatement measure has on adjacent noise “receptors.” A receptor is an activity area on a parcel of property being studied for noise impacts from a nearby highway project. Receptors can be residential or non-residential land uses.

The Noise Abatement Feasibility and Reasonableness Analysis Tool (NAFRAT) allows the noise analyst or policy maker to test the effects of changes of the several factors that go into the determination of the feasibility and reasonableness of a noise abatement feature as required in Title 23 CFR Part 772. In its current format, several combinations of factors can be tested at one time for feasibility and multiple combinations of factors can be tested for reasonableness. NAFRAT also includes 33 sets of sample policies on a separate worksheet. The analyst may copy and paste these values into the decision-testing section of the spreadsheet and vary them as desired or automatically populate these values by selecting a sample policy from a drop-down list at the bottom of each table.

This spreadsheet tool uses results from noise barrier designs that have been done in the FHWA Traffic Noise Model (FHWA TNM). The tool is specific to the output format for TNM Version 2.5. Results for two designs for each of four actual highway projects are built into the spreadsheet. This tool also permits the analyst to paste his or her own designs into it. This feature gives the analyst several options for studying criteria:

- One project’s barrier design may be used to test effects of changes in the policy criteria on that design.
- Multiple projects, all using the same values for the criteria factors, may be tested for effects of changes on a group of projects.
- Abatement decisions for a series of different potential designs for the same project may be compared using the same criteria for each case.
- Finally, several projects or designs may be tested against several sets of criteria at the same time, within the current limit of 88 combinations.

¹ The initial report was the second deliverable in Task 3 of Task Order No. DTFH61-D-00028-T12-002, *23 CFR 772 Streamlining, Analysis, and Outreach*. This updated report is the second of two Final Task 3 Deliverable Documents under Task Order No. DTFH61-D-00028-0005.

A second tool, the Noise Abatement Reasonableness Sensitivity Analysis Tool (NARSAT), focuses on reasonableness and is based on series of 108 cases derived from a set of hypothetical scenarios involving one, two, and three rows of receptors; three different receptor densities; two different setbacks from the barrier to the first row of receptors; and six different barrier heights.

This tool also includes sample policy criteria. This feature allows for easy comparison of the reasonableness of decisions from various policies and allows the analyst to test, compare, and contrast different criterion values.

The feasibility and reasonableness factors that have been included in the tools are:

- Feasibility
 - **Feasibility noise reduction:** A noise reduction of at least 5 decibels (dB) that must be achieved for a noise abatement measure to be feasible.
 - **Feasibility quantity:** The minimum number or percentage of impacted receptors that must achieve the feasibility noise reduction. The percentage may be a percentage of first-row impacted receptors or of all impacted receptors.
- Reasonableness
 - **Benefited noise reduction:** The minimum noise reduction for a receptor to be counted as benefited by a noise abatement measure.
 - **Noise reduction design goal (NRDG):** The noise reduction that must be achieved for a noise abatement measure to be reasonable
 - **NRDG quantity:** The minimum number or percentage of benefited receptors that must achieve the NRDG. The percentage may be a percentage of first-row benefited receptors or of all benefited receptors.
 - **Cost effectiveness (CE) in Area per Benefited Receiver (APBR):** The allowable barrier area in square feet (SF) per benefited receptor. APBR can be derived from allowable cost per benefited receptor (CPBR) by dividing CPBR by the abatement measure unit cost in dollars/SF.
 - **Barrier surface area:** The surface area computed by FHWA TNM based on the heights and lengths of noise barrier segments for a particular barrier design.

The one difference between the two tools regarding the above factors is that the barrier areas for the hypothetical cases used in the second tool are already built into the spreadsheet, while, with the first tool, the analyst has the ability to directly enter an area from the Barrier Descriptions table for a particular barrier design done in FHWA TNM.

In addition, NAFRAT includes these Consideration of Viewpoints factors:

- **Votes Needed:** The minimum percentage of votes needed to accept or reject the barrier
- **% Based On:** This calculates the vote percentage based on “All” possible votes or % of votes that were actually “Received.”

- **% is:** This describes whether the vote percentage applies to those who are “For” or “Against” the barrier.
- **Non-Response:** This addresses how non-votes are treated (“For”, “Against,” or “Not Counted”) when the voting % is based on the votes that are “received.”
- **Weighting Factors:** The multiplier(s) applied to each response from benefited Owner-Occupants, Non-Resident Owners, and Renters.
- **Additional Weighting based on:** An (optional) second set of weighting factors used to further differentiate benefits by either location (first row vs. non-first-row) or impact condition (impacted vs. non-impacted).

The tools were implemented using Microsoft Excel 2007[®].

CHAPTER 2. THE NOISE ABATEMENT FEASIBILITY AND REASONABLENESS ANALYSIS TOOL (NAFRAT)

This spreadsheet tool is divided into three sections:

- A Summary worksheet.
- A worksheet with several samples of feasibility and reasonableness criteria.
- Individual case worksheets: eight built-in barrier design scenarios worksheets based on the examples from *Noise Barrier Acceptance Criteria: Analysis* and 80 worksheets where custom TNM runs can be entered.

The spreadsheet includes results for noise barrier designs done in FHWA TNM for four real-world highway projects. Two designs from each project are built in, based on these criteria:

- Feasibility (both designs): minimum reduction of 5 dB at 50 percent or more of first-row impacted receptors.
- Reasonableness:
 1. Design 1: NRDG of 7 dB at 25 percent of first-row benefited receptors, with a reduction of 5 dB or more to be counted as benefited, and an APBR at or below 1,250 SF per benefited receptor.
 2. Design 2: NRDG of 10 dB at 75 percent of all benefited receptors, with a reduction of 5 dB or more to be counted as benefited, and an APBR at or below 2,600 SF per benefited receptor.

On one or more of the other “unused” individual worksheets (“TNM Run n”, where “n” is from 1 to 80), the analyst may paste the results from an FHWA TNM barrier design into a particular location on each worksheet, along with:

- the background sound level (in dBA), which would come from information external to TNM,
- the resulting barrier area (in SF), and
- additional information about each FHWA TNM receiver (e.g., “first-row”, # of rental units represented, and voting responses).

Up to 1,000 TNM receivers can be accommodated per barrier design. The Summary worksheet then processes the sound level results and applies a series of user-selected values that are used to make the feasibility and reasonableness decisions.

Section 2.1 describes the Summary worksheet, Section 2.2 reviews the Sample Policies worksheet, and Section 2.3 describes the individual case worksheets. Section 2.4 then provides step-by-step instructions for use of the tool.

2.1 SUMMARY WORKSHEET

This spreadsheet begins with a Summary worksheet containing three tables: Feasibility Results (Figure 1), Reasonableness Results (Figure 6), and a combined Feasibility & Reasonableness Results table (Figure 17). Generally, the analyst enters the desired values for the different feasibility and reasonableness factors into these tables, and the results are calculated to the right.

Each row in each table represents a “case” (i.e., a particular combination of the criteria and their application to a particular barrier design) and includes the criteria used in the design and the results.

At the top of the worksheet, the analyst enters a **Title** and **Date**. The **Title** is incorporated by reference into the table titles, and the **Title** and **Date** are referenced on each individual case worksheet.

2.1.1 Feasibility Results Table

The entire Feasibility Results table is shown in Figure 1. The next series of figures focus in on different sections of this table.

Enter Title: Projects A-D, 2 designs each
Enter Date: 8/1/2015

Feasibility Results for Projects A-D, 2 designs each

Worksheet Name	FHWA TNM "RUN" from "Results: Sound Levels" table	FHWA TNM "BARRIER DESIGN" from "Results: Sound Levels" table	Case	Feasibility Factors					Feasibility Results						
				Help	Help	Help	Help	Help	Help	Help	Help	Help	Help	Help	
				Feas NR	Feas Type	Feas Crit #	Feas Crit % 1R (P1)	Feas Crit % All (PA)	# Impacts ALL	# Impacts 1R	Feas # 1R	Feas # ALL	Feas % 1R	Feas % ALL	Feas?
Proj A APBR 1250	Project A Area 2E Final Design - Smoothed Top	R-1 (NRDG=7, 25% 1st-row BR, Ben=5, APBR=1250)	1	5	#	2	50%	95%	57	34	34	52	100%	91%	Yes-#
Proj B APBR 1250	Project B	R-2 (NRDG=7, 25% 1st-row BR, Ben=5, APBR=1250)	2	5	PA		50%	80%	14	7	7	14	100%	100%	Yes-%A
Proj C APBR 1250	Project C	R-1 (NRDG=7, 25% 1st-row BR, Ben=5, APBR=1250)	3	5	P1		50%		26	14	12	20	86%	77%	Yes-%1
Proj D APBR 1250	Project D	R-10 (NRDG=7, 25% 1st-row BR, Ben=5, APBR=1250)	4	5	P1		50%		9	9	9	9	100%	100%	Yes-%1
			5												
			6												
1	Proj A APBR 1250	Project A Area 2E Final Design - Smoothed Top	7	5	P1		50%		57	34	34	52	100%	91%	Yes-%1

CHOOSE SAMPLE POLICY

Figure 1. Feasibility Results table.

Figure 2 illustrates the first five columns. In the first column of the last row, the user can select a sample policy which will populate the table with corresponding Feasibility Factors. As shown, when clicking on this cell, a drop-down list appears with the available sample policy numbers. In the second column, the user selects the **Worksheet Name** where the TNM run is stored by also selecting from a drop-down list of available worksheet names. Once a worksheet is selected, the next two columns automatically show the **FHWA TNM Run** and **FHWA TNM Barrier Design** names. These titles are brought in from the individual TNM results table pasted into the individual worksheets. Note that the **FHWA TNM Run** is the **Run Title** assigned by the analyst in the **FHWA TNM Run Identification** dialog box under the **TNM Setup** menu command, not

the name of the directory created with the **File/New** or **File/Save As** commands in FHWA TNM. The **Case** number listed in the fifth column is simply a sequential list.

Worksheet Name	FHWA TNM "RUN" from "Results: Sound Levels" table	FHWA TNM "BARRIER DESIGN" from "Results: Sound Levels" table	Case	
Proj A APBR 1250	Project A Area 2E Final Design - Smoothed Top	R-1 (NRDG=7, 25% 1st-row BR, Ben=5, APBR=1250)	1	
Proj B APBR 1250	Project B	R-2 (NRDG=7, 25% 1st-row BR, Ben=5, APBR=1250)	2	
Proj C APBR 1250	Project C	R-1 (NRDG=7, 25% 1st-row BR, Ben=5, APBR=1250)	3	
Proj D APBR 1250	Project D	R-10 (NRDG=7, 25% 1st-row BR, Ben=5, APBR=1250)	4	
			5	
			6	
1	Proj A APBR 1250	Project A Area 2E Final Design - Smoothed Top	R-1 (NRDG=7, 25% 1st-row BR, Ben=5, APBR=1250)	7

Figure 2. Feasibility Results table: case identification.

The next five columns are the feasibility factors that the analyst would enter, as illustrated in Figure 3. The factors tested for feasibility are:

- Feasibility noise reduction criterion, in dB.
- Feasibility quantity, the minimum number or percentage of impacted receptors that must have a noise reduction of at least the feasibility noise reduction.

The first column is the feasibility noise reduction (**Feas NR**). Its value is currently limited by FHWA to be 5 dB.

IER ults: e	Case	Feasibility Factors					#
		Help	Help	Help	Help	Help	
		Feas NR	Feas Type	Feas Crit #	Feas Crit % IR (P1)	Feas Crit % All (PA)	
ow)	1	5	P1		50%		
ow)	#				50%		
ow)	3	5	P1		50%		
ow)	4	5	P1		50%		
	5						
	6						
	7						

Figure 3. Feasibility Results table: feasibility factors.

The next column is the feasibility quantity type (**Feas Type**) used as part of the criterion. Three entries — #, P1, and PA — are permitted:

- Entry of “#” indicates an integer number of impacted receptors. For this feasibility type, the analyst enters an integer into the third column (**Feas Crit #**) and leaves the fourth and fifth columns blank.
- If the analyst wants to specify the criterion in terms of percentage of first-row impacted receptors, a code of P1 is entered, followed by a percentage between 1 percent and 100 percent in the fourth column (**Feas Crit % 1R (P1)**), leaving the third and fifth columns blank.
- If the analyst wants to examine the feasibility criterion in terms of the percentage of all impacted receptors, a code of PA is entered and the percentage between 1 percent and 100 percent is entered into the fifth column (**Feas Crit % All (PA)**), leaving the third and fourth columns blank.

The program automatically fills, in dark blue, cells that do not require values to be entered.

Figure 3 shows that four different criteria are being tested, all with a **Feas NR** of 5 dB. In this example, each case tests if the design will result in at least half of first-row receptors meeting the feasibility noise reduction criterion.

The next seven columns are the feasibility results, as illustrated in Figure 4. These results are determined in the individual case worksheets, as will be described in the next section of this report. Each row is for an individual case.

Feasibility Results						
Help	Help	Help	Help	Help	Help	Help
# Impacts ALL	# Impacts 1R	Feas # 1R	Feas # ALL	Feas % 1R	Feas % ALL	Feas?
57	34	34	52	100%	91%	Yes-% 1
26	14	12	20	86%	77%	Yes-% 1
14	7	7	14	100%	100%	Yes-% 1
9	9	9	9	100%	100%	Yes-% 1

Figure 4. Feasibility Results table: feasibility results.

The results are:

- **# Impacts ALL:** The total number of impacted receptors.
- **# Impacts 1R:** The number first-row impacted receptors; the analyst designates if a receptor is to be considered “first-row” in the individual case worksheets.
- **Feas # 1R:** The number of first-row receptors that meet the feasibility noise reduction criterion.
- **Feas # ALL:** The total number of receptors that meet the feasibility noise reduction criterion regardless of location.
- **Feas % 1R:** The percentage of the impacted first-row receivers that meet the feasibility noise reduction, equal to $(\text{Feas \#1R}) / (\text{\# Impacts 1R})$.
- **Feas % ALL:** The percentage of all impacted receptors that meet the feasibility noise reduction, equal to $(\text{Feas \# ALL}) / (\text{\# Impacts ALL})$.
- **Feas?:** The feasibility decision for the case (Yes or No). The decision is based on the value entered into the **Feas Type** column:
 - If the value is #, then if **# Impacts ALL** equals or exceeds **Feas Crit #**, a decision of **Yes-#** is returned.
 - If the value is P1, then if **Feas % 1R** equals or exceeds **Feas Crit % 1R (P1)**, a decision of **Yes-%I** is returned.
 - If the value is PA, then if **Feas % All** equals or exceeds **Feas Crit % All (PA)**, a decision of **Yes-%A** is returned.

The designator after the **Yes** answer is only meant as information on the type of comparison made for this case.

As shown in Figure 3 and Figure 4, there is a **Help** cell above each of the columns. When any one of these cells is selected, a dialog box appears offering help on the particular column. An example is shown in Figure 5.

Feasibility Results				
elp	Help	Help	Help	Help
as #	Feas #	Feas %	Feas %	Feas?
IR	ALL	% IR	ALL	
34	Total Receptors Feasible The total number of receptors that meet the feasibility noise reduction criterion regardless of location			%1
12				%1
7	14	100%	100%	Yes-%1
9	9	100%	100%	Yes-%1

Figure 5. Example help text.

2.1.2 Reasonableness Results Table (NRDG and APBR)

Figure 6 illustrates the first part of the Reasonableness Results table, which investigates the NRDG and APBR criteria. The last part of this table examines the viewpoints of the residents and is discussed and shown later in Section 2.1.3. The next series of figures explore different sections of the first part of this table.

Reasonableness Results for Projects A-D, 2 designs each

Worksheet Name	FHWA TNM "RUN" from "Results: Sound Levels" table	FHWA TNM "BARRIER DESIGN" from "Results: Sound Levels" table	Case	Reasonableness Factors (for NRDG and APBR)						Reasonableness Results (for NRDG and APBR)											
				NRDG	Ben NR	NRDG Type (R, P1, PA)	NRDG Crit #	NRDG Crit %	NRDG Crit % All	APBR Crit	Area from TNM Run	# Ben 1R	# Ben ALL	# Ben NRDG 1R	# Ben NRDG ALL	Ben % 1R	Ben % ALL	Reasonable: NRDG?	APBR Calc	Reasonable: APBR?	Reasonable: NRDG and APBR?
				Help	Help	Help	Help	Help	Help	Help	Help	Help	Help	Help	Help	Help	Help	Help	Help	Help	Help
Proj A APBR 1250	Project A Area 2E Final Design - Smoothed Top	R-1 (NRDG=7, 25% 1st-row BR, Ben=5, APBR=1250)	1	7	5	P1		25%		1,250	64,569	35	75	31	38	89%	51%	Yes-NR-%1	861	Yes-APBR	Yes
Proj A APBR 2600	Project A, Area 2E Final Dgn Smooth Top	10dB DG, %All (NRDG=10, 75% all BR, Ben NR=5, APBR=2600)	2	10	5	PA			75%	2,600	115,001	35	90	33	64	94%	71%	No-NR-%A	1,278	Yes-APBR	No
Proj B APBR 2600	Project B	R-82 (NRDG=10, 75% all BR, Ben NR=5, APBR=2600)	3	7	5	P1		75%		1,250	54,646	7	24	7	24	100%	100%	Yes-NR-%1	2,277	No-APBR	No
Proj B APBR 2500	Project B	R-82 (NRDG=10, 75% all BR, Ben NR=5, APBR=2600)	4	10	5	PA			75%	2,600	54,646	7	24	7	15	100%	65%	No-NR-%A	2,277	Yes-APBR	No
Proj C APBR 1250	Project C	R-1 (NRDG=7, 25% 1st-row BR, Ben=5, APBR=1250)	5	7	5	P1		25%		1,250	34,696	13	28	5	11	38%	39%	Yes-NR-%1	1,239	Yes-APBR	Yes
Proj C APBR 2600	Project C	R-82 (NRDG=10, 75% all BR, Ben NR=5, APBR=2600)	6	10	5	PA			75%	2,600	70,053	14	33	11	17	79%	52%	No-NR-%A	2,123	Yes-APBR	No
Proj D APBR 1250	Project D	R-10 (NRDG=7, 25% 1st-row BR, Ben=5, APBR=1250)	7	7	5	P1		25%		1,250	79,078	16	34	13	18	81%	53%	Yes-NR-%1	2,326	No-APBR	No
Proj D APBR 2600	Project D	R-75 (NRDG=10, 75% all BR, Ben NR=5, APBR=2600)	8	10	5	PA			75%	2,600	157,631	16	40	11	18	69%	45%	No-NR-%A	3,641	No-APBR	No
			87																		
1	Proj A APBR 2600	Project A, Area 2E Final Dgn Smooth Top	88	7	5	P1		60%		2,400	115,001	35	90	35	90	100%	100%	Yes-NR-%1	1,278	Yes-APBR	Yes

Figure 6. Reasonableness Results table (NRDG and APBR).

Figure 7 shows the first five columns (note that the rows for Cases 9 through 86 are not shown in this figure). These columns work the same way as the first five columns in the Feasibility table, shown in Figure 2 and described in Section 2.1.1. That is, in the first column of the last row, the user can select a sample policy, which will automatically populate the table with corresponding Reasonableness Factors. Also, a worksheet is selected from the drop-down list in the second column, and the third and fourth columns populate with the **FHWA TNM "RUN"** and **FHWA TNM "Barrier Design"** pulled from the TNM run as shown. If the analyst desires to use a single barrier design for each case, for example, then he or she could select the case from the first row, and then uses Excel's FILL DOWN function to copy the same case down.

Worksheet Name	FHWA TNM "RUN" from "Results: Sound Levels" table	FHWA TNM "BARRIER DESIGN" from "Results: Sound Levels" table	Case	
Proj A APBR 1250	Project A Area 2E Final Design - Smoothed Top	R-1 (NRDG=7, 25% 1st-row BR, Ben=5, APBR=1250)	1	
Proj A APBR 2600	Project A, Area 2E Final Dgn - Smooth Top	10dB DG, %All (NRDG=10, 75% all BR, Ben NR=5, APBR=2600)	2	
Proj B APBR 2600	Project B	R-82 (NRDG=10, 75% all BR, Ben NR=5, APBR=2600)	3	
Proj B APBR 2600	Project B	R-82 (NRDG=10, 75% all BR, Ben NR=5, APBR=2600)	4	
Proj C APBR 1250	Project C	R-1 (NRDG=7, 25% 1st-row BR, Ben=5, APBR=1250)	5	
Proj C APBR 2600	Project C	R-82 (NRDG=10, 75% all BR, Ben NR=5, APBR=2600)	6	
Proj D APBR 1250	Project D	R-10 (NRDG=7, 25% 1st-row BR, Ben=5, APBR=1250)	7	
Proj D APBR 2600	Project D	R-75 (NRDG=10, 75% all BR, Ben NR=5, APBR=2600)	8	
			87	
1	Proj A APBR 2600	Project A, Area 2E Final Dgn - Smooth Top	10dB DG, %All (NRDG=10, 75% all BR, Ben NR=5, APBR=2600)	88

Figure 7. Reasonableness Results table: case identification.

The next five columns are the reasonableness factors that the analyst enters, as illustrated in Figure 8. The factors tested for reasonableness are:

- Noise reduction design goal (NRDG) criterion, in dB.
- Benefited noise reduction criterion, in dB.
- NRDG quantity, the minimum number or percentage of benefited receptors that must have a noise reduction of at least the NRDG.

Reasonableness Factors							
se	Help NRDG	Help Ben NR	Help NRDG Type (#, P1, PA)	Help NRDG Crit #	Help NRDG Crit % 1R (P1)	Help NRDG Crit % All (PA)	Help APBR Crit Calc
	7	5	P1		25%		1,250
	10	5	#			75%	2,600
	7	5	P1		25%		1,250
	10	5	PA			75%	2,600
	7	5	P1		25%		1,250
	10	5	PA			75%	2,600
	7	5	P1		25%		1,250
	10	5	PA			75%	2,600

Figure 8. Reasonableness Results table: reasonableness factors.

The first column is the NRDG (NRDG). Its value is currently limited by FHWA to within a range of 7 to 10 dB. The program will display an error if the input is outside this range.

The second column is the benefited noise reduction criterion (Ben NR). Its value is currently limited by FHWA to be no less than 5 dB and no more than the NRDG. The program displays an error if the input is outside this range.

The third column is an indicator of the type of the NRDG quantity that is being tested in this case (NRDG Type). This factor has three possible values — #, P1 and PA — as did the feasibility type:

- Entry of “#” indicates an integer number of benefited receptors. For this NRDG type, the analyst enters an integer in the fourth column (NRDG Crit #) and leaves the fifth and sixth columns blank.
- If the analyst wants to specify the NRDG criterion in terms of percentage of first-row benefited receptors, a code of P1 is entered, followed by a percentage between 1 percent and 100 percent in the fifth column (NRDG Crit % 1R (P1)), leaving the fourth and sixth columns blank.
- If the analyst wants to examine the NRDG criterion in terms of the percentage of all benefited receptors, a code of PA is entered and a percentage between 1 percent and 100 percent is entered into the sixth column (NRDG Crit % All (PA)), leaving the fourth and fifth columns blank.

The seventh column is the Cost Effectiveness criterion in terms of area per benefited receptor (**APBR Crit**), with a unit of square feet (SF) per benefited receptor. FHWA has no limit on this range. If an analyst wants to use the spreadsheet to study cost per benefited receptor (CPBR), in terms of dollars per benefited receptor, since CPBR is ABPR multiplied by abatement unit cost (dollars per SF), the CPBR criterion needs to be divided by the abatement unit cost used by the SHA, to convert CPBR to APBR. The corresponding APBR would then be entered into the spreadsheet.

APBR can be calculated by clicking on the “**Calc**” button in the APBR heading cell. This brings up a dialog box where the CPBR and unit cost are entered, and APBR is calculated (Figure 9).

Case	NRDG	Ben NR	NRDG Type (#, P1, PA)	NRDG Crit #	NRDG Crit % 1R (P1)	NRDG Crit % All (P1)	APBR Crit	Area from TNM Run	# Ben 1R
25% 1st-row (BR=1250)	7	5	P1		25%		1,250	64,569	35
10, 75% all BR, BR=2600)	10	5	PA			75%	2,600	70,053	14
25% 1st-row (BR=1250)	7	5	P1		25%		1,250	22,002	7
10, 25% 1st-row (BR=1250)	10	5	PA			75%	2,600	79,078	16

Figure 9. APBR calculator.

While an APBR calculator is provided, the spreadsheet can also be used directly “as is” using barrier cost and CPBR:

1. Enter the CPBR criterion (\$/BR) in the **APBR Crit** column.
2. Enter the barrier’s cost in the **Area** column.
3. The resulting CBPR for this design will appear in the **APBR Calc** column.
4. The decision on cost-effectiveness will be in the **Reas APBR** column.

What cannot be automatically tested for CPBR is the effect of varying the abatement unit cost.

Figure 8 shows that two different reasonableness criteria combinations are being tested, with NRDGs of 7 dB or 10 dB and a benefited noise reduction of 5 dB in each case. In this example, the built-in test cases are analyzed comparing 25 percent first-row benefited receptor with an APBR of 1,250 SF per benefited receptor to 75 percent of all benefited receptor at an APBR of 2,600 per benefited receptor.

The next eleven columns are the reasonableness results, as illustrated in Figure 10. Each row is for an individual case.

Reasonableness Results (for NRDG and APBR)										
Area from TNM Run	# Ben 1R	# Ben ALL	# Ben NRDG 1R	# Ben NRDG ALL	Ben % 1R	Ben % ALL	Reasonable: NRDG?	APBR Calc	Reasonable: APBR?	Reasonable: NRDG and APBR?
64,569	35	75	31	38	89%	51%	Yes-NR-%1	861	Yes-APBR	Yes
115,001	35	90	33	64	94%	71%	No-NR-%A	1,278	Yes-APBR	No
54,646	7	24	7	24	100%	100%	Yes-NR-%1	2,277	No-APBR	No
54,646	7	24	7	15	100%	63%	No-NR-%A	2,277	Yes-APBR	No
34,696	13	28	5	11	38%	39%	Yes-NR-%1	1,239	Yes-APBR	Yes
70,053	14	33	11	17	79%	52%	No-NR-%A	2,123	Yes-APBR	No
79,078	16	34	13	18	81%	53%	Yes-NR-%1	2,326	No-APBR	No
157,631	16	40	11	18	69%	45%	No-NR-%A	3,941	No-APBR	No

Figure 10. Reasonableness Results table: reasonableness results.

The first column is titled **Area from TNM Run**. The barrier surface areas for the pre-loaded designs are already in the spreadsheet.

For other designs, the analyst gets this value from the particular FHWA TNM barrier design being studied and enters it into the individual worksheet for that barrier design, as will be shown in the next section; the area is then referenced in this table. The area is found in the FHWA TNM Barrier Descriptions Table for that barrier design, as illustrated in Figure 11.

The sound level results for that design are also pasted into the individual case worksheet, as described in the next section.

Name	Type	Heights along Barrier			Length	If Wall Area	If Berm Volume	Top Width	Run:Rise	Cost
		Min	Avg	Max						
Potential Barrier	W	16.00	20.49	24.00	2694	55208				0
Total Cost:										0

Figure 11. FHWA TNM Barrier Descriptions Table highlighting location of Area in sq ft (SF) for a particular barrier design.

The next four columns shown in Figure 10 are the reasonableness results in terms of the number of benefited receptors, as determined from the TNM Sound Levels results and the user-supplied factors. Each row is for an individual case.

The results for number of benefited receptors are:

- **# Ben 1R:** The number first-row benefited receptors; the analyst designates if a receptor is to be considered “first-row” in the individual case worksheets.
- **# Ben ALL:** The total number of benefited receptors.
- **# Ben NRDG 1R:** The number of first-row receptors that meet the NRDG criterion.
- **# Ben NRDG ALL:** The total number of receptors that meet the NRDG criterion regardless of location.

The next two columns show the percentage of the first-row and total benefited receptors that meet the NRDG:

- **Ben % 1R:** The percentage of the benefited first-row receivers that meet the NRDG, equal to $(\# \text{ Ben NRDG 1R}) / (\# \text{ Ben 1R})$.
- **Ben % ALL:** The percentage of all benefited receptors that meet the NRDG, equal to $(\# \text{ Ben NRDG ALL}) / (\# \text{ Ben ALL})$.

The next column, **Reas NRDG?**, is the reasonableness decision for the NRDG criterion for this case (Yes or No). The decision is based on the value entered into the **NRDG Type** column:

- If the value is #, then if **# Ben ALL** equals or exceeds **NRDG Crit #**, a decision of **Yes-NR-#** is returned; if not, the decision shows as **No-NR-#**.

- If the value is P1, then if **Ben % 1R** equals or exceeds **NRDG Crit % 1R (P1)**, a decision of **Yes-N-%I** is returned; if not, the decision shows as **No-NR-%I**.
- If the value is PA, then if **Ben % ALL** equals or exceeds **NRDG Crit % All (PA)**, a decision of **Yes-N-%A** is returned; if not, the decision shows as **No-NR-%A**.

The designator after the **Yes** or **No** answer is only meant as information on the type of comparison.

The next three columns of the table show:

- **APBR Calc:** The calculated APBR, computed as the **Area** entered from the FHWA TNM run divided by # **Ben ALL** (total number of benefited receptors).
- **Reas APBR?:** The reasonableness decision for cost effectiveness for this case, as to whether the calculated APBR is above (**No-APBR**) or below (**Yes-APBR**) the APBR criterion (**APBR Crit**).
- **Reas?:** The overall reasonableness decision (**Yes** if both the NRDG and cost effectiveness criteria are met, and **No** if one or both are not met).

The designator after a **Yes** or **No** answer is only meant as information on the type of comparison made for this case.

Note that in making the comparisons of the **Noise Reductions** to the criteria, the formulas use rounding. For example, if the NRDG was 7 dB and the calculated **Noise Reduction** was 6.5 dB, the receiver is considered as meeting the NRDG; in essence, the **Noise Reduction** is rounded up to 7 dB.

2.1.3 Reasonableness Results Table (Viewpoints Criterion)

Figure 12 illustrates the last part of the Reasonableness Results table, which investigates the viewpoints criterion. The next series of figures explore different sections of the final part of this table.

TOOLS TO EVALUATE NOISE BARRIER ACCEPTANCE CRITERIA

Reasonableness Factors (for Viewpoints)											Reasonableness Results (for Viewpoints)					
Help	Help	Help	Help	WEIGHTING FACTORS			Help	ADDITIONAL WEIGHTING FACTORS (for either non-1st row or non-impacted benefits)			Help	Help	Help	Help	Help	Help
Votes Needed Criterion (%)	% Based On ("All" possible or "Received") votes	% is ("For" or "Against") barrier	"Non-Responses" are ("For", "Against", or "not counted")	Owner-Occupant	Non-Resident Owner (Rental)	Renter	Additional Weighting based on ("Row" "Impact Condition" "none")	Owner-Occupant	Non-Resident Owner (Rental)	Renter	Total # of possible responses	Total # of responses received	Response Rate	% voting yes	% voting no	Reasonable: Viewpoints?
50%	Received	For	Not counted	1	0.9	0.1	Row	1	0.5	0.5	80	20	25%	72.67%	27.33%	Yes-Viewpoints
67%	Received	For	Not counted	1.5	1	0.5	None	1	1	0.5	101	57	56%	67.39%	32.61%	Yes-Viewpoints
60%	All	For	Not counted	2	1	1	Row	2	1	1	32	0	0%	0.00%	0.00%	No-Viewpoints
40%	Received	Against	Against	5	3	2	Impact Condition	3	2	1	32	0	0%	0.00%	100.00%	No-Viewpoints
50%	All	Against	For	5	3	2	Row	3	2	1	34	25	74%	22.73%	53.64%	No-Viewpoints
66%	Received	For	For	4	2	1	None	2	1	1	40	27	68%	52.00%	48.00%	No-Viewpoints
75%	Received	For	Not counted	5	4	1	Row	3	2	1	44	33	75%	45.00%	55.00%	No-Viewpoints
80%	Received	For	Not counted	1	1	1	Impact Condition	1	0.9	0.1	50	28	56%	85.61%	14.39%	Yes-Viewpoints

Figure 12. Reasonableness Results table (Viewpoints).

Figure 13 shows the first four columns of this part of the table, where the analyst enters the initial viewpoints factors. The first column is the **Votes Needed Criterion**, which defines the percentage of votes needed to for a barrier to be considered reasonable or not reasonable. Its value is limited to a range between 0% and 100%.

Help	Help	Help	Help
Votes Needed Criterion (%)	% Based On ("All" possible or "Received") votes	% is ("For" or "Against") barrier	"Non-Responses" are ("For", "Against", or "not counted")
51%	Received	For	Not counted
67%	Received	For	Not counted
60%	All	For	Not counted
40%	Received	Against	Against
50%	All	Against	For
66%	Received	For	For
75%	Received	For	Not counted
80%	Received	For	Not counted

Figure 13. Reasonableness Results table: Viewpoints Factors.

Next, the **% based on** column is used to describe whether the **Votes Needed Criterion** is based on either "All" of the possible votes or only based on percentage of the votes that were actually "Received." This selection is accomplished using a drop-down list. The user should use "Received" if: 1) non-responses are not to be counted, or 2) if those non-responses are to be interpreted as either votes "in favor" or "against" the construction of the barrier.

The third column (**% is**) simply designates how the **Votes Needed Criterion** is to be applied, either as a percentage that is “For” or “Against” the barrier.

The fourth column (**“Non-Responses” are**) designates how “non-responses” are to be treated: as votes “For,” “Against,” or “Not counted.” Note that if the user selects “All” in the second column, the fourth column will automatically turn dark blue, indicating that non-responses will be used only to determine the *total possible* amount of votes.

As an example, the first row in Figure 13 indicates that at least “51%” of the “Received” votes must be “For” the barrier in order for it to be reasonable (and non-responses are “Not counted”). As another example, the fifth row in Figure 13 indicates that “50%” of “All” possible votes must be “Against” the barrier in order for the barrier to be considered not reasonable.

Figure 14 shows the next set of viewpoints factors that can be used to assign a weighted value of each benefited receptor’s response based on: 1) type of ownership/occupancy, and 2) an additional option accounting for either the location *or* the impact condition of the receptor.

Help			Help	Help		
WEIGHTING FACTORS			Additional weighting based on? ("Row"/"Impact Condition"/"none")	ADDITIONAL WEIGHTING FACTORS (for either non-1st row or non-impacted benefits)		
Owner-Occupant	Non-Resident Owner (Rental)	Renter		Owner-Occupant	Non-Resident Owner (Rental)	Renter
1	0.9	0.1	Row	1	0.5	0.5
1.5	1	0.5	None	1	1	0.5
2	1	1	Row	2	1	1
5	3	2	Impact Condition	3	2	1
5	3	2	Row	3	2	1
4	2	1	None	2	1	1
5	4	1	Row	3	2	1
1	1	1	Impact Condition	1	0.9	0.1

Figure 14. Reasonableness Results table: Viewpoints Factors (vote weighting).

The first three columns in Figure 14 are used to apply weightings to responses based on ownership and type of occupancy: Each eligible voting response on the corresponding project worksheet will be *multiplied* by these factors. For example, in the first column, entering a value of “1.5” will give assign 1.5 votes for *each* response from a benefited and owner-occupied dwelling. Similarly, weightings for benefited non-resident owners and their renters can be specified in the second and third columns, respectively. Leaving any of these columns blank will result in a weighting factor of *zero*, effectively *not counting* any responses from any of those benefited receptors.

The fourth column in Figure 14 (**Additional Weighting based on**) can be used to apply an additional weighting distinction. Selecting “Row” enables the analyst to apply *two different sets* of weighting factors based on a receptor’s location: 1) the first set of factors (the **Weighting**

Factors column) would be applied only to first row benefited receptors, and 2) a second set of factors (**Additional Weighting Factors** column) could then be applied to only those other benefited receptors that are not located in the first row.

Similarly, selecting “Impact Condition” in the fourth column of Figure 14 enables the analyst to apply two different sets of weighting factors based on whether the receptor was impacted or not: 1) the first set of factors (**Weighting Factors** column) would be applied only to impacted benefited receptors, and 2) a second set of factors (**Additional Weighting Factors** column) could be applied to only other non-impacted benefited receptors.

If the fourth column is left blank or set “None,” all three columns under the **Additional Weighting Factors** will be filled dark blue; no *additional* weighting will be applied and all benefited responses will be weighted solely by ownership/occupancy (i.e., only using the factors in the first three columns shown in Figure 14).

Figure 15 shows the results of the voting based on responses of each benefited receptor and the viewpoints factors chosen by the analyst. The first column indicates the *total possible* number of responses from benefited receptors, determined by the data that is supplied on the project worksheets (discussed further in the next section). Note that this tally is simply based on the total amount of eligible responses and *does not apply any weighting*. The second column counts the amount of responses that were received. Next, the third column calculates a simple **Response Rate** by dividing the responses received by the total number of possible responses. Note that although some policies may use Response Rate as a factor in their reasonableness decisions, the calculated response rate within this tool is for informational purposes only and does not factor into the reasonableness decisions or any other calculations.

Reasonableness Results (for Viewpoints)						Display Eligible Voters	
Help	Help	Help	Help	Help	Help	Help	Help
Total # of possible responses	Total # of responses received	Response Rate	% voting yes	% voting no	Reasonable: Viewpoints?	Show only eligible voters (on Project Sheet)	Hyperlink to Project Page
80	20	25%	72.67%	27.33%	Yes-Viewpoints	Show	Click here to go to Project sheet
101	57	56%	67.39%	32.61%	Yes-Viewpoints		
32	0	0%	0.00%	0.00%	No-Viewpoints		
32	0	0%	0.00%	100.00%	No-Viewpoints		
34	25	74%	22.73%	53.64%	No-Viewpoints		
40	27	68%	52.00%	48.00%	No-Viewpoints		
44	33	75%	45.00%	55.00%	No-Viewpoints		
50	28	56%	85.61%	14.39%	Yes-Viewpoints		
101	57	56%	74.70%	25.30%	Yes-Viewpoints		

Figure 15. Reasonableness Results table: Viewpoints Results.

The fourth and fifth columns (**% voting yes** and **% voting no**, respectively) shown in Figure 15 calculates the overall percent of weighted responses that are “in favor” and “against” the construction of the barrier, respectively. These percentages are based on the viewpoints factors that are designated by the analyst; simply changing some of those factors can alter these calculated percentages. These two columns will always add to 100% when the analyst elects to base the voting on “Received” responses. However, if the vote is based on “All” possible responses, these percentages would sum to less than 100% if the response rate is less than 100% (the third and fifth rows in Figure 15 illustrate this point).

The sixth column (**Reasonable: Viewpoints?**) gives the reasonableness decision for the viewpoints criterion for a particular case. Again, the designator after the “Yes” or “No” answer indicates that this answer is based on the viewpoints criterion.

The seventh and eighth columns (**Show only eligible voters** and **Hyperlink to Project Page** shown in Figure 15) are used in conjunction, as described below:

- Selecting “Show” in the drop-down list indicates the desire to view the eligible voters on the associated TNM project worksheet.

- “Click here to go to Project sheet” link will then be displayed in the adjacent column to the right.
- Clicking that link will take the user to the associated project worksheet, where only the eligible voters will be displayed based on the **Benefited NR Criteria** designated for that row. Figure 16 shows a section of the project worksheet with rows filled in black for non-eligible voters. The user can quickly return to the Summary worksheet by using the “Click here to return to Summary worksheet” link, which is shown in the upper left-hand corner of Figure 16.
- If the same project is being analyzed in more than one row, the first “show” selection will cause the other row(s) with the same project to fill in dark blue, emphasizing the fact that only one set of eligible voters can be displayed at a time.
- Also, if the “Show” selection happens to be applied to two or more rows that contain the same project, only the uppermost “show” will be available. To minimize confusion, once the eligible voters have been viewed, the analyst should return to the Summary worksheet and delete the contents of the “Show” cell.

[Click here to return to Summary worksheet](#)

Note: Cells that turn red need to be corrected

Note: Rows that turn black have a NR less than:

8

Background Level (dBA) applied to all receivers	0	VOTING RESPONSES							
Barrier Area (sf)	64,569							Total	
Enter "y" below if receiver represents 1st Row receptor(s)	# of DUs that are rental units	Owner-Occupant		Rental (Owner)		Rental (Renter)		# of responses possible	# of responses received
		"Yes"	"No"	"Yes"	"No"	"Yes"	"No"		
y	1				1	1		2	2
	1				1	1		2	2
y		1						1	1
y		1						1	1
y		1						1	1
y		1						1	1
y		1						1	1

Figure 16. Section of an individual project worksheet showing only the eligible voters.

2.1.4 Combined Feasibility and Reasonableness Results Table: One project applied to all sample policies

A portion of the Combined Feasibility and Reasonableness Results table is shown in Figure 17. This table combines the previous two Feasibility and Reasonableness tables into one large table,

which is pre-populated with the Feasibility and Reasonableness factors from each of the sample policies (supplied from data on the “Sample Policies” worksheet described in Section 2.2 and illustrated in Figure 19).

Figure 18 shows a zoomed in view of the upper left portion of this combined table. The user is only required to select one of the projects from the drop-down list, which is highlighted in yellow in Cell D136. Starting in Row 147, each of the 33 sample policies are then applied to this project, and detailed results for each policy can be viewed by scrolling to the right.

An overall summary of all of the results is displayed in the cells directly beneath the user-selected project. As shown in Figure 18, these results show the number of policies where the selected project is:

- Feasible
- Reasonable – based only on the NRDG
- Reasonable – based only on the APBR
- Reasonable – based on both the NRDG and the APBR
- Reasonable – based on Viewpoints of the residents/owners
- Reasonable (Overall) – based on NRDG, APBR, and Viewpoints

CHOOSE Project → Proj A APBR 1250		Feasibility & Reasonableness Results for 'Proj A APBR 1250' using all Sample Policies																								
# of policies where Feasible	33	# of policies where Project is Reasonable based on NRDG	33	# of policies where Project is Reasonable based on APBR	26	# of policies where Reasonable based on both NRDG and APBR	26	# of policies where Reasonable based on Viewpoints	30	# of policies where Reasonable (Overall)	23	Feasibility Factors					Feasibility Results					Reasonableness Factors (for NRDG and APBR)				
Policy	Worksheet Name	FHWA TNM "RUN" from "Results: Sound Levels" table	FHWA TNM "BARRIER DESIGN" from "Results: Sound Levels" table	Case	Feas NR	Feas Typ	Feas Crit #	Feas Crit % 1R (P1)	Feas Crit % All (PA)	Impacts ALL	Impacts 1R	Feas # 1R	Feas # ALL	Feas % 1R	Feas % ALL	Feas?	NRD G	Ben NR	NRD G Type (#, P1, PA)	NRD G Crit #	NRD G Crit % 1R (P1)	NRD G Crit % All (PA)	APBR Crit Calc	Area from TNM Run	# Ben 1R	# Ben ALL
1	Proj A APBR 1250	Project A Area 2E Final Design - Smoothed Top	R-1 (NRDG=7, 25% 1st-row BR, Ben=5,	1	5	P1		50%		57	34	34	52	100%	91%	Yes-X1	7	5	P1		60%		2,400	64,569	35	75
2	Proj A APBR 1250	Project A Area 2E Final Design - Smoothed Top	R-1 (NRDG=7, 25% 1st-row BR, Ben=5,	2	5	PA		50%		57	34	34	52	100%	91%	Yes-%A	7	5	PA		40%		1,167	64,569	35	75
3	Proj A APBR 1250	Project A Area 2E Final Design - Smoothed Top	R-1 (NRDG=7, 25% 1st-row BR, Ben=5,	3	5	P1		50%		57	34	34	52	100%	91%	Yes-X1	7	5	#	1			700	64,569	35	75
4	Proj A APBR 1250	Project A Area 2E Final Design - Smoothed Top	R-1 (NRDG=7, 25% 1st-row BR, Ben=5,	4	5	#	1			57	34	34	52	100%	91%	Yes-#	8	5	#	1			1,480	64,569	35	75
5	Proj A APBR 1250	Project A Area 2E Final Design - Smoothed Top	R-1 (NRDG=7, 25% 1st-row BR, Ben=5,	5	5	#	2			57	34	34	52	100%	91%	Yes-#	7	5	#	1			1,400	64,569	35	75
6	Proj A APBR 1250	Project A Area 2E Final Design - Smoothed Top	R-1 (NRDG=7, 25% 1st-row BR, Ben=5,	6	5	#	1			57	34	34	52	100%	91%	Yes-#	7	5	#	1			2,150	64,569	35	75
7	Proj A APBR 1250	Project A Area 2E Final Design - Smoothed Top	R-1 (NRDG=7, 25% 1st-row BR, Ben=5,	7	5	#	1			57	34	34	52	100%	91%	Yes-#	7	5	P1		75%		1,200	64,569	35	75
8	Proj A APBR 1250	Project A Area 2E Final Design - Smoothed Top	R-1 (NRDG=7, 25% 1st-row BR, Ben=5,	8	5	PA		50%		57	34	34	52	100%	91%	Yes-%A	7	5	#	1			2,000	64,569	35	75
9	Proj A APBR 1250	Project A Area 2E Final Design - Smoothed Top	R-1 (NRDG=7, 25% 1st-row BR, Ben=5,	9	5	P1		75%		57	34	34	52	100%	91%	Yes-X1	8	8	P1		75%		1,500	64,569	16	20
10	Proj A APBR 1250	Project A Area 2E Final Design - Smoothed Top	R-1 (NRDG=7, 25% 1st-row BR, Ben=5,	10	5	P1		50%		57	34	34	52	100%	91%	Yes-X1	7	5	#	1			1,380	64,569	35	75
11	Proj A APBR 1250	Project A Area 2E Final Design - Smoothed Top	R-1 (NRDG=7, 25% 1st-row BR, Ben=5,	11	5	#	1			57	34	34	52	100%	91%	Yes-#	9	8	#	1			1,667	64,569	16	20
9	Proj A APBR 1250	Project A Area 2E Final Design - Smoothed Top	R-1 (NRDG=7, 25% 1st-row BR, Ben=5,	9	5	P1		75%		57	34	34	52	100%	91%	Yes-X1	8	8	P1		75%		1,500	64,569	16	20
10	Proj A APBR 1250	Project A Area 2E Final Design - Smoothed Top	R-1 (NRDG=7, 25% 1st-row BR, Ben=5,	10	5	P1		50%		57	34	34	52	100%	91%	Yes-X1	7	5	#	1			1,380	64,569	35	75
11	Proj A APBR 1250	Project A Area 2E Final Design - Smoothed Top	R-1 (NRDG=7, 25% 1st-row BR, Ben=5,	11	5	#	1			57	34	34	52	100%	91%	Yes-#	9	8	#	1			1,667	64,569	16	20
12	Proj A APBR 1250	Project A Area 2E Final Design - Smoothed Top	R-1 (NRDG=7, 25% 1st-row BR, Ben=5,	12	5	#	1			57	34	34	52	100%	91%	Yes-#	9	5	#	1			1,029	64,569	35	75
13	Proj A APBR 1250	Project A Area 2E Final Design - Smoothed Top	R-1 (NRDG=7, 25% 1st-row BR, Ben=5,	13	5	PA		50%		57	34	34	52	100%	91%	Yes-%A	7	5	#	1			1,990	64,569	35	75
17	Proj A APBR 1250	Project A Area 2E Final Design - Smoothed Top	R-1 (NRDG=7, 25% 1st-row BR, Ben=5,	17	5	P1		50%		57	34	34	52	100%	91%	Yes-X1	7	5	P1		60%		250	64,569	35	75
18	Proj A APBR 1250	Project A Area 2E Final Design - Smoothed Top	R-1 (NRDG=7, 25% 1st-row BR, Ben=5,	18	5	PA		50%		57	34	34	52	100%	91%	Yes-%A	7	5	#	1			1,000	64,569	35	75
19	Proj A APBR 1250	Project A Area 2E Final Design - Smoothed Top	R-1 (NRDG=7, 25% 1st-row BR, Ben=5,	19	5	#	1			57	34	34	52	100%	91%	Yes-#	7	5	#	1			1,500	64,569	35	75
20	Proj A APBR 1250	Project A Area 2E Final Design - Smoothed Top	R-1 (NRDG=7, 25% 1st-row BR, Ben=5,	20	5	PA		50%		57	34	34	52	100%	91%	Yes-%A	7	5	#	1			1,250	64,569	35	75

Figure 17. Screenshot showing a portion of the Combined Feasibility & Reasonableness Results table.

CHOOSE Project

Proj A APBR 1250	
# of policies where Feasible	33
# of policies where Project is Reasonable based on NRDG	33
# of policies where Project is Reasonable based on APBR	26
# of policies where Reasonable based on both NRDG and APBR	26
# of policies where Reasonable based on Viewpoints	30
# of policies where Reasonable (Overall)	23

Figure 18. Screenshot showing the summary portion of the Combined Feasibility & Reasonableness Results table.

2.2 SAMPLE POLICIES WORKSHEET

Figure 19 displays a portion of the Sample Policies worksheet. Each row within this table provides the details for a given sample policy. A total of 33 policies are available.

Sample Policies

Policy Set #	Feasibility					Reasonableness					Reasonableness (Viewpoints)					Additional Weighting Factors (for either non-1st row or non-impacted)							
	Feas NR	Feas Type	Feas Crit #	Feas Crit % TR (P1)	Feas Crit % All (PA)	NRDG	Sen NR	NRDG Type (P1, PA)	NRDG Crit #	NRDG Crit % TR (P1)	NRDG Crit % All (PA)	APBR Crit	www needed threshold	% Based on (All or Received) votes	% is (For or Against) barrier	"Non-Votes" are (For/Against/not counted)	Owner-Occupant	Non-Resident Owner (Rental)	Renter	Weighting based on T (row or impacted or none)	Owner-Occupant	Non-Resident Owner (Rental)	Renter
1	5	P1		50%		7	5	P1		60%		2400	51.00%	Received	Against		2	1	1	Impact Condition	1	0.5	0.5
2	5	PA			50%	7	5	PA			40%	1167	50.01%	Received	For		4	3	1	Row	2	1	1
3	5	P1		50%		7	5	#	1			700	50.01%	Received	Against		1.5	0.75	0.75	Row	1	1	0.5
4	5	#	1			8	5	#	1			1480	50.01%	Received	For		2	2	2	Row	1	1	1
5	5	#	2			7	5	#	1			1400	50.01%	Received	Against		1	0.9	0.1	None			
6	5	#	1			7	5	#	1			2150	50.01%	All	Against		6	4	2	Row	3	2	1
7	5	#	1			7	5	P1		75%		1200	51.00%	Received	For		4	3	1	Row	2	1	1
8	5	PA			50%	7	5	#	1			2000	50.00%	Received	For		1	1	1	None			
9	5	P1		75%		8	8	P1		75%		1500	75.00%	Received	For		5	5	1	None			
10	5	P1		50%		7	5	#	1			1300	50.01%	Received	Against		1.5	0.75	0.75	Row	1	0.5	0.5
11	5	#	1			9	8	#	1			1667	50.01%	Received	For		1	1	1	None			
12	5	#	1			9	5	#	1			1029	51.00%	All	For		1	0.5	0.5	None			
13	5	PA			50%	7	5	#	1			1990	50.01%	Received	For		1	1	1	None			
14	5	P1		66%		7	5	PA		0.4		857	50.01%	Received	Against		4	3	1	Row	2	1	1
15	5	PA			50%	7	5	PA		0.5		1000	25.00%	All	Against		1	1	1	None			
16	5	PA			50%	7	5	P1		0.5		833	50.01%	Received	For		1	1	1	None			
17	5	P1		50%		7	5	P1		0.6		250	51.00%	Received	Against		2	1	1	Impact Condition	1	0.5	0.5
18	5	PA			50%	7	5	#	1			1000	50.01%	Received	For		1	1	1	None			
19	5	#	1			7	5	#	1			1500	51.00%	All	For		2	1	1	None			
20	5	PA			50%	7	5	#	1			1250	51.00%	Received	For		1	1	1	None			
21	5	P1		50%		7	5	#	1			1200	50.01%	Received	For		1	1	0	None			
22	5	PA			50%	7	5	#	1			1600	50.00%	Received	For		5	3	2	Impact Condition	3	2	1
23	5	PA			40%	7	5	#	1			1400	50.00%	Received	For		1	1	1	None			
24	5	P1		80%		7	5	P1		0.4		909	75.00%	Received	For		4	2	1	Row	2	1	1
25	5	#	1			7	5	#	1			2750	50.01%	Received	For		2	4	1	None			
26	5	#	1			8	5	#	1			960	50.01%	Received	For		2	2	2	Row	1	1	1
27	5	#	1			7	5	P1		0.75		1600	51.00%	Received	For		4	3	1	Row	2	1	1
28	5	#	1			7	5	#	1			2500	50.01%	Received	Against		4	3	1	Row	2	1	1
29	5	P1		67%		7	7	P1		67%		1440	50.01%	Received	For		0.75	0.75	0.25	None			
30	5	PA			50%	7	5	PA		50%		2700	50.01%	All	Against		4	2	2	Impact Condition	2	1	1
31	5	PA			75%	10	5	#	1			945	50.00%	Received	For	For	1	1	0.5	None			
32	5	PA			50%	7	5	P1		0.5		1000	50.01%	Received	For		1	1	1	None			
33	5	PA			78%	7	5	PA		50%		945	50.00%	Received	For	For	1	1	0.5	None			

Figure 19. Screenshot showing a portion of the Sample Policies worksheet.

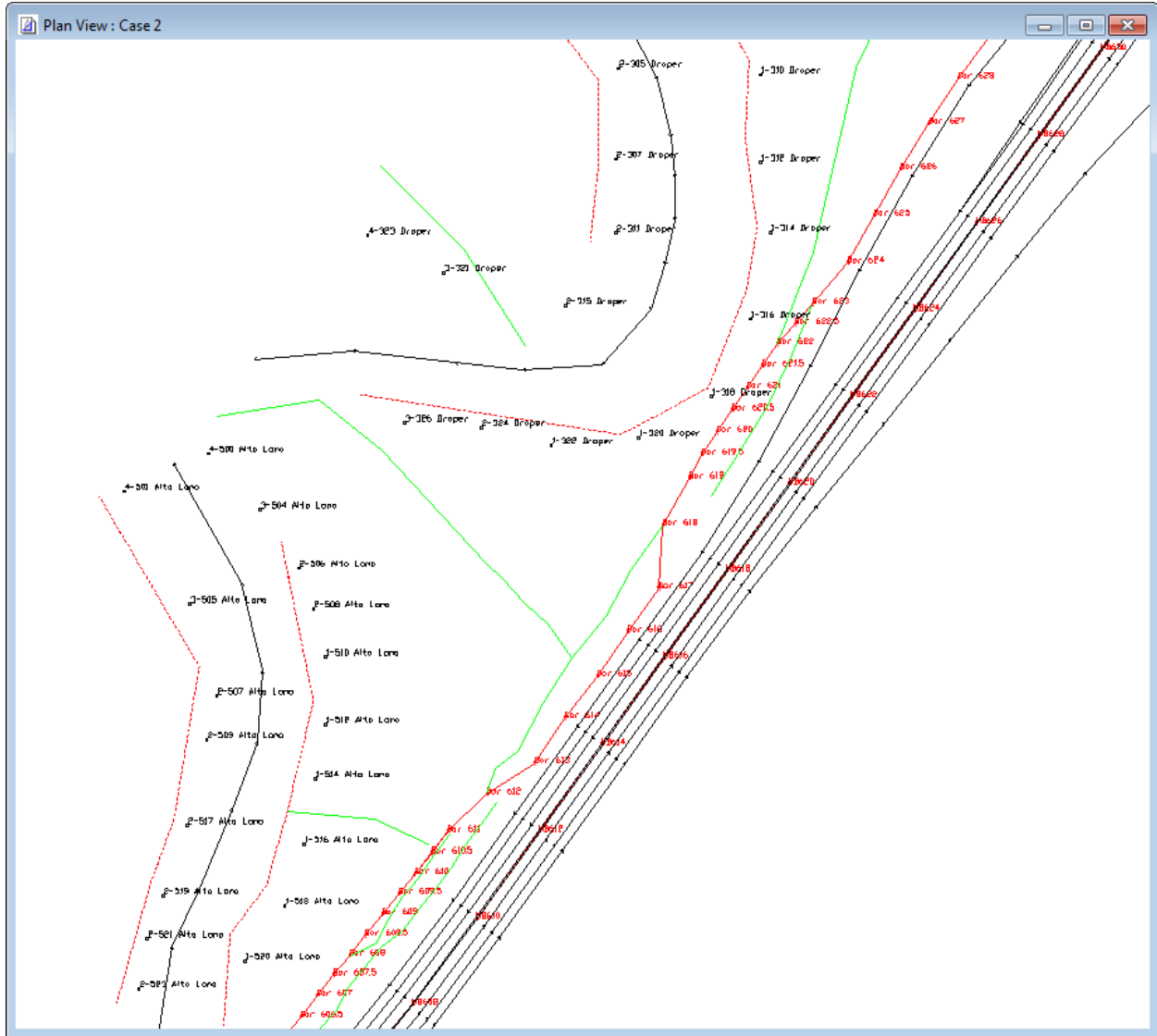


Figure 21. FHWA TNM Plan View of a portion of a model of a study area.

The green lines in the FHWA TNM Plan View represent terrain features, the dashed red lines are the location of rows of houses that block some of the noise (TNM “building rows”), and the curved black lines are wide local streets that were modeled without traffic to represent wide expanses of hard pavement that affect the sound propagation and also model terrain as defined by the edges of the roadway (it is not always necessary to model local streets to capture this effect).

Figure 22 then shows FHWA TNM’s Barrier View for a barrier design that was developed to reduce the sound levels at the modeled receivers. This view is a perspective view of just the barrier and the receivers, with exaggerated heights, looking from above and on the other side of the roadway. The roadway is not shown in the view.

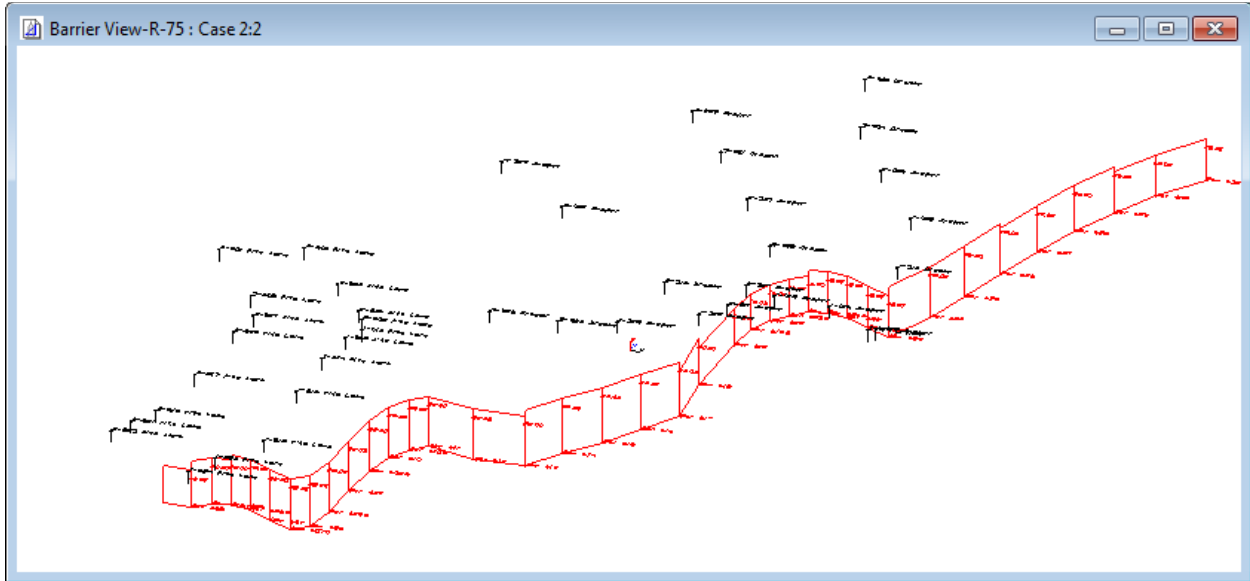


Figure 22. FHWA TNM Barrier View of a noise barrier design.

The sound level results for this design are in a table that is accessed in the FHWA TNM program through the Tables menu drop-down list, as shown in Figure 23.

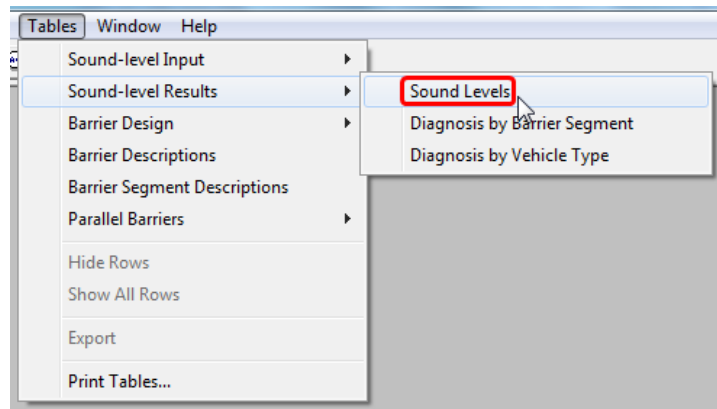


Figure 23. FHWA TNM program Tables pull-down menu accessing Sound Levels results table.

Figure 24 then shows a portion of the FHWA TNM Sound Levels results table for a particular barrier design as viewed from within the FHWA TNM program. Highlighted are the **RUN** and **BARRIER DESIGN** names that will be displayed in the feasibility and reasonableness results tables in the spreadsheet’s Summary worksheet.

Also highlighted is the **#DUs** column. A “DU” is a dwelling unit; the analyst may use this input parameter as a means of indicating that an FHWA TNM receiver point represents more than one receptor in the study area.

The highlighted column labeled **Noise Reduction – Calculated** is used in the spreadsheet for determining the number of benefited receptors.

Sound Levels : Case 2:3

Bowlby and Associates, Inc. 5 March 2013
 D. Reiter/G. Pratt TNM 2.5
 Calculated with TNM 2.5

RESULTS: SOUND LEVELS
 PROJECT/CONTRACT: 12-23
 RUN: Case 2
 BARRIER DESIGN: R-75

ATMOSPHERICS: 68 deg F, 50% RH

Average pavement type shall be used unless a State highway agency substantiates the use of a different type with approval of FHWA.

Receiver Name	No.	#DUs	No Barrier			Increase over existing		Type Impact	With Barrier			
			Existing LAeq1h	LAeq1h Calculated	Crit'n	Calculated	Crit'n Sub'l Inc		Calculated LAeq1h	Noise Reduction Calculated	Goal	Calculated minus Goal
			dBA	dBA	dBA	dB	dB		dBA	dB	dB	dB
4-300 Draper	19	1	0.0	66.5	66	66.5	10	Snd Lvl	63.9	2.6	7	-4.4
3-304 Draper	20	1	0.0	67.2	66	67.2	10	Snd Lvl	63.9	3.3	7	-3.7
2-306 Draper	21	1	0.0	67.3	66	67.3	10	Snd Lvl	63.6	3.7	7	-3.3
1-308 Draper	22	1	0.0	67.9	66	67.9	10	Snd Lvl	63.8	4.1	7	-2.9
1-310 Draper	23	1	0.0	66.5	66	66.5	10	Snd Lvl	62.0	4.5	7	-2.5
1-312 Draper	24	1	0.0	64.9	66	64.9	10	—	58.0	6.9	7	-0.1
1-314 Draper	25	1	0.0	67.8	66	67.8	10	Snd Lvl	60.4	7.4	7	0.4
1-316 Draper	26	1	0.0	75.6	66	75.6	10	Snd Lvl	63.7	11.9	7	4.9

Figure 24. Portion of FHWA TNM Sound Levels results table for a particular barrier design.

In order to copy the table into the spreadsheet, the analyst holds down the left mouse button on the uppermost of the row selector buttons on the left-hand side of the table (the blank row above the organization name) and, keeping the left mouse button held, drags the cursor down to the last row of the table. This action highlights in black the buttons and the selected rows. Figure 25 shows the selection of the rows in progress.

Bowby and Associates, Inc. D. Reiter/G. Pratt		Row selector buttons		7 March 2013 TNM 2.5 Calculated with TNM 2.5								
RESULTS: SOUND LEVELS												
PROJECT/CONTRACT:		12-23										
RUN:		Case 2										
BARRIER DESIGN:		INPUT HEIGHTS		Average pavement type shall be used unless a State highway agency substantiates the use of a different type with approval of FHWA.								
ATMOSPHERICS:		68 deg F, 50% RH										
Receiver												
Name	No.	#DUs	Existing LAeq1h	No Barrier		Increase over existing		Type	With Barrier		Calculated minus Goal	
			Calculated	Crit'n	Calculated	Crit'n	Impact	Calculated	Noise Reduction	Goal	Calculated minus Goal	
			dBA	dBA	dB	dB		dBA	dB	dB	dB	
4-300 Draper	19	1	0.0	66.5	66	66.5	10	Snd Lvl	64.0	2.5	7	-4.5
3-304 Draper	20	1	0.0	67.2	66	67.2	10	Snd Lvl	64.0	3.2	7	-3.8
2-306 Draper	21	1	0.0	67.3	66	67.3	10	Snd Lvl	63.7	3.6	7	-3.4
1-308 Draper	22	1	0.0	67.9	66	67.9	10	Snd Lvl	63.9	4.0	7	-3.0
1-310 Draper	23	1	0.0	66.5	66	66.5	10	Snd Lvl	62.2	4.3	7	-2.7
1-312 Draper	24	1	0.0	64.9	66	64.9	10	—	58.5	6.4	7	-0.6
2-517 Alta Loma	56	1	0.0	61.5	66	61.5	10	—	60.5	1.0	7	-6.0
2-519 Alta Loma	57	1	0.0	60.3	66	60.3	10	—	60.2	0.1	7	-6.9
2-521 Alta Loma	58	1	0.0	62.8	66	62.8	10	—	61.5	1.3	7	-5.7
2-523 Alta Loma	59	1	0.0	66.1	66	66.1	10	Snd Lvl	64.6	1.5	7	-5.5
Dwelling Units		# DUs	Noise Reduction									
			Min	Avg	Max							
			dB	dB	dB							
All Selected		41	0.1	6.3	11.2							
All Impacted		26	1.5	7.2	11.2							
All that meet NR Goal		17	7.2	9.0	11.2							

Figure 25. Selection of rows in the FHWA TNM Sound Levels results table.

The analyst then copies this table using the Ctrl-C keystroke command. Then, the analyst moves to the desired case worksheet in the spreadsheet, clicks into cell A10, and uses the “Ctrl-V” shortcut to paste the FHWA TNM Sound Levels results table into the case worksheet.

Figure 26 shows a portion of the table that has been pasted into the worksheet. Cell A10 is highlighted in yellow. Note that the first piece of data from the table actually appears in cell B11 even though the paste was initiated in cell A10. If the blank first row in the Sound Levels results table was not copied, the pasting would need to go into cell A11. No effort should be made to move the rows or columns, as this will cause errors in the formulas on the worksheet. The instruction in red reads:

“Paste TNM Sound Level Results table for a particular barrier design into cell A10 (highlighted in yellow) so <Organization> appears in cell B11 (no more than 1000 receivers). Do not move results. If there are fewer than 1000 receivers, be sure to delete the content in Columns A-N ONLY of any rows with prior data below the last row of the current design.”

Also note that the **Title** in cell B8 (e.g., “Projects A-D”) and **Date** in cell B7 on the case worksheet have been carried over from the user-input values on the Summary worksheet.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
6															
7				3/14/2013											
8	Task 3	Projects A-D, 2 designs each													
9	Paste TNM Sound Level Results table for a particular barrier design into cell A10 (highlighted in yellow) so <Organization> appears in cell B11 (no more than 1000 receivers). Do not move results. If there are fewer than 1000 receivers, be sure to delete the content in Columns A-N ONLY of any rows with prior data below the last row of the current design.														
10	Paste here														
11		Bowlby and Associates, Inc.													
12		D. Reiter/G. Pratt													
13															
14		RESULTS: SOUND LEVELS													
15		PROJECT/CONTRACT:		23-Dec											
16		RUN:		Project B											
17		BARRIER DESIGN:		R-1 (NRDG=7, 25% 1st-row BR, Ben=5, APBR=1250)											
18															
19		ATMOSPHERICS:		68 deg F, 50% RH											
20															
21		Receiver													
22		Name	No.	#DUs	Existing LAeq1h	No Barrier Calculated	Increase over existing Crit'n	Calculated	Crit'n Sub1 Inc	Type Impact	With Barrier Calculated LAeq1h	Reduction Calculated	Goal	Calculated minus Goal	
23															
24															
25															
26															
27					dB	dB	dB	dB	dB		dB	dB	dB	dB	
28															
29		4-300 Draper	19	1	0	66.5	66	66.5	10	Snd Lvl	64.6	1.9	7	-5.1	
30		3-304 Draper	20	1	0	67.2	66	67.2	10	Snd Lvl	64.6	2.6	7	-4.4	
31		2-306 Draper	21	1	0	67.3	66	67.3	10	Snd Lvl	64.4	2.9	7	-4.1	
32		1-308 Draper	22	1	0	67.9	66	67.9	10	Snd Lvl	64.5	3.4	7	-3.6	
33		1-310 Draper	23	1	0	66.5	66	66.5	10	Snd Lvl	62.9	3.6	7	-3.4	
34		1-312 Draper	24	1	0	64.9	66	64.9	10	---	59.1	5.8	7	-1.2	
35		1-314 Draper	25	1	0	67.8	66	67.8	10	Snd Lvl	61.6	6.2	7	-0.8	
36		1-316 Draper	26	1	0	75.6	66	75.6	10	Snd Lvl	66.2	9.4	7	2.4	
37		1-318 Draper	27	1	0	78.2	66	78.2	10	Snd Lvl	70	8.2	7	1.2	
38		1-320 Draper	28	1	0	75.1	66	75.1	10	Snd Lvl	67.2	7.9	7	0.9	
39		1-322 Draper	29	1	0	72.9	66	72.9	10	Snd Lvl	63.8	9.1	7	2.1	
40		2-324 Draper	30	1	0	69.0	66	69.0	10	Snd Lvl	60.0	9.0	7	2.0	

Figure 26. Section of individual case worksheet showing a portion of the pasted FHWA TNM Sound Levels results table for a particular barrier design.

Additional input is needed within the yellow highlighted cells of this worksheet, as illustrated in Figure 27. First, the user enters an overall estimated Background Level in cell Q24 and the Barrier Area in cell Q25 (taken from the FHWA TNM Barrier Descriptions table). Column O then calculates a new noise reduction by logarithmically adding the background level entered in cell Q24 with the no-barrier and with-barrier sound levels for each receiver, and then subtracting those levels. Thus, while the TNM Sound level Results table is pasted into the case worksheet with the TNM-calculated noise reduction in column L, the calculated noise reductions in column O are actually used throughout the spreadsheet to determine the benefited receptors in a more realistic manner.

The analyst then indicates those receivers that are being considered as first-row receivers in this analysis. (Remember that the number of receptors represented by each receiver is indicated in the #DUs column of the FHWA TNM Sound level Results table.) This first-row designation is made by entering a value of “y” in the appropriate row in Column P, which is just to the right of the pasted results table, as shown in Figure 27.

In column Q (starting in cell Q29), the user must also designate how many rental units are being represented by each receiver. This value must be equal to or less than the number of dwelling units which was pasted from the FHWA TNM run into column D. Finally, columns R through W are provided to designate the number of “yes” and/or “no” responses for a given receiver by occupancy type. The weightings of these responses are addressed by the weighting factors on the Summary worksheet.

For the columns Q through W, there are data validation settings that will help prevent the user from entering invalid data. Furthermore, conditional formatting will cause cells to highlight in red if there is an error in data input.

	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB
20														
21		Click here to return to Summary worksheet		Note: Cells that turn red need to be corrected			Note: Rows that turn black have a NR less than:				N/A			
22														
23														
24			Background Level (dBA)	40										
25			Barrier Area (sf)	34,696										
26				VOTING RESPONSES										
27				Owner-Occupant		Rental (Owner)		Rental (Renter)		Total		Total # of "non-responses"		
28	NR (w/background)	Enter "y" below if receiver is 1st Row	# of DUs that are rental units	"Yes"	"No"	"Yes"	"No"	"Yes"	"No"	# of responses possible	# of responses received	Owner-occupant	Rental (owner)	Rental (Renter)
29	1.9									1	0	1	0	0
30	2.6		1			1		1		2	2	0	0	0
31	2.9		1			1		1		2	2	0	0	0
32	3.4	y	1			1		1		2	2	0	0	0
33	3.6	y	1			1		1		2	2	0	0	0
34	5.8	y	1			1		1		2	2	0	0	0
35	6.2	y	1			1		1		2	2	0	0	0
36	9.4	y	1			1		1		2	2	0	0	0
37	8.2	y	1							2	0	0	1	1
38	7.9	y	1			1		1		2	2	0	0	0
39	9.1	y	1			1		1		2	2	0	0	0
40	9.0				1					1	1	0	0	0
41	8.2				1					1	1	0	0	0
42	6.3				1					1	1	0	0	0
43	7.1				1					1	1	0	0	0
44	7.5				1					1	1	0	0	0
45	7.1				1					1	1	0	0	0
46	6.6	y			1					1	1	0	0	0
47	5.6	y			1					1	1	0	0	0
48	5.3	y			1					1	1	0	0	0
49	4.5	y			1					1	1	0	0	0
50	5.1	y			1					1	1	0	0	0

Figure 27. Section of individual case worksheet showing where additional input is needed (within yellow-highlighted cells).

2.4 STEP-BY-STEP INSTRUCTIONS FOR USE OF NAFRAT

The following instructions summarize the use of the Noise Abatement Feasibility and Reasonableness Analysis Tool (NAFRAT). The assumption is that the analyst:

- Created one or more FHWA TNM runs and has developed one or more noise barrier designs for each run
- Has one or more combinations of feasibility and reasonableness factors to be tested and wishes to test them against one or more of the eight pre-set designs in the spreadsheet
- Wants to perform some combination of both of the above options

In creating his or her own barrier designs, the analyst should take care in naming runs and barrier designs because these names will be transferred to the spreadsheet’s results tables.

The spreadsheet is currently set up to accommodate up to 1,000 FHWA TNM receivers per barrier design. By default, each receiver is assigned a value of one dwelling unit. Receivers can

be made to represent more than one receptor by changing the number of Dwelling Units (#DUs) assigned to the receiver in the FHWA TNM Receiver Input dialog box.

There is no particular order in which values need to be entered into the spreadsheet or FHWA TNM results need to be pasted into the spreadsheet. Barrier decisions are calculated for a case when the needed data are present for that case.

Caution should be taken if the spreadsheet is being used for a new analysis, such that previous data have been deleted, including: the user-pasted FHWA TNM Sound Levels results tables, user-entered barrier areas, assigned background noise levels, first-row receiver designations, number of represented rental dwelling units, and voting responses.

In its current version, the spreadsheet has safeguards to ensure that entered data are within allowable ranges. For example, an NRDG of 11 could not be entered since FHWA limits the NRDG to a maximum value of 10 dB. Calculation cells are locked to prevent data from being entered into them or replacing the formulas in them. Rows, columns, and cells should not be added, deleted, or moved. Care needs to be taken to only enter data as described below.

Steps for use:

1. Open the spreadsheet and use **File/Save As** to rename the spreadsheet and preserve the master copy.
2. On the **Summary** worksheet, enter the **Title** and **Date** of the analysis in cells E24 and E25.
3. In the Feasibility Results table, fill in the yellow cells for each case to be tested.
 - a. Enter the Feasibility Noise Reduction Criterion. This should be 5 dB per FHWA policy.
 - b. Enter one type per case for **Feas Type (#, P1, PA)**.
 - c. Enter the corresponding value for that type in one of the three adjacent columns, leaving the other two columns blank. The program will automatically shade the columns that are to be left blank based on the feasibility type selected.
 - d. If desired, sample feasibility factors are shown in the **Sample Policies** worksheet (Figure 19). These can be copied directly into the Feasibility Results table. (Note: It is recommended to use the Excel **Paste Values** function to avoid overwriting conditional formatting. Do not use the Excel **Cut** function) These sample Feasibility Factors can also be automatically populated in the last row of the table by using the drop down list in the first column of the table.
4. In the Reasonableness Results table, fill in the yellow cells for each case to be tested.
 - a. Enter the **NRDG**. This value is currently limited by FHWA policy to be within a range of 7 to 10 dB.
 - b. Enter the **Benefited Noise Reduction** criterion. This value is currently limited by FHWA policy to be no less than 5 dB and no greater than the NRDG.
 - c. Enter one type per case for **NRDG Type (#, P1, PA)**.

- d. Enter the corresponding value for that type in one of the three adjacent columns, leaving the other two columns blank. The program will automatically shade the columns that are to be left blank based on the NRDG type selected.
 - e. Enter the **APBR** value
 - f. Enter the **Votes Needed Criterion** using a value from 0 to 100 percent
 - g. For the **% Based On** column, use the drop-down list to choose “All” or “Received.”
 - h. For the **% is** column, use the drop-down list to choose “For” or “Against.”
 - i. In the **“Non-Responses” are** column, use the drop-down list to indicate whether votes that have not been cast count “For” or “Against” the barrier – or if they are to be “Not counted” at all. If the vote is based on “All” possible votes, the program will automatically shade this column dark blue, indicating that this option is not applicable and can be left blank.
 - j. Enter weighting factors for Owner-Occupants, Non-Resident Owners, and Renters. If using a second set of weightings (based on location or impact condition), these factors will only apply to benefited receptors that are either in the first row or impacted (determined by the selection in the **Additional Weighting based on** column). Otherwise, these weightings apply to all benefited receptors.
 - k. If desired, enter “Row” or “Impact Condition” in the **Additional Weighting based on** column. Use “None” or leave this cell blank when no additional weighting is desired.
 - l. If applicable, enter the **Additional Weighting Factors** that should be applied to Owner-Occupants, Non-Resident Owners, and Renters that are either not in the first row or are not impacted.
 - m. If desired, select “Show” using the drop-down list in the **Show Only Eligible Voters** column. Then click the link the **Hyperlink to Project Page** column to view the eligible voters (which is based on that row’s **Benefited Noise Reduction criterion**).
 - n. If desired, sample reasonableness factors are shown in the **Sample Policies** worksheet (see Figure 19). These can be copied directly into the table. (Note: It is recommended to use the Excel **Paste Values** function to avoid overwriting conditional formatting. Do not use the Excel **Cut** function.) These sample Reasonableness Factors can also be automatically populated in the last row of the table by using the drop down list in the first column of the table.
5. In one or more of the individual case worksheets, paste every row of the FHWA TNM Sound Levels results table *for that barrier design* (not the Sound Levels results table with a BARRIER DESIGN name of INPUT HEIGHTS) in cell A10; results appear starting in cell B11.

6. In each of the above-referenced individual case worksheets, enter the overall background sound level in dBA for the design in Cell Q24.
7. In each of the above-referenced individual case worksheets, enter the barrier area in SF for the design represented by the case, obtained from the FHWA TNM Barrier Descriptions table, in Cell Q25.
8. In each of the above-referenced individual case worksheets, enter a “y” in Column P, starting on Row 29 for each receiver that is being considered as a first-row receiver.
9. In each of the above-referenced individual case worksheets and for each receiver, enter the number of dwelling units that represent rental units in Column P.
10. For each receiver, in columns R through W, enter the number of “yes” and/or “no” responses by occupancy type.
11. When done, the spreadsheet should be saved. The Feasibility and Reasonableness Results tables may be printed or copied and pasted into other documents for further use.

CHAPTER 3. THE NOISE ABATEMENT REASONABLENESS SENSITIVITY ANALYSIS TOOL (NARSAT)

NARSAT focuses on reasonableness and is based on a series of 108 cases derived from a set of hypothetical scenarios involving one, two, and three rows of receptors; three different receptor densities; two different setbacks from the barrier to the first row of receptors; and six different barrier heights.

It includes sample reasonableness criteria, which allows for easy comparison of the reasonableness decisions under various scenarios and allows the analyst to test, compare, and contrast different criterion values.

Section 3.1 describes the barrier design cases and reasonableness factors that are modeled in the tool, and Section 3.2 describes their layout in the tool. Section 3.3 then provides step-by-step instructions for use of the tool.

3.1 MODELED CASES AND REASONABLENESS FACTORS

There are a wide variety of combinations of the various factors in the reasonableness criteria. This section describes the factors and their combinations used in the tool. This material is largely duplicated, with some revision, from the material introducing the sensitivity analysis that was documented in *Noise Barrier Acceptance Criteria: Analysis*.

3.1.1 Modeled Scenarios and Cases

In order to study these combinations for a variety of receptor scenarios with FHWA TNM, a four-lane divided highway model was created. The basic scenario consisted of two travel lanes in each direction. Each travel direction was modeled by a single FHWA TNM roadway with a width computed based on two travel lanes and paved shoulders, not by an FHWA TNM roadway for each travel lane. The difference was not felt to be significant for the purposes of this study. See Figure 28 for a plan view (from above) and a cross-sectional view of the roadway and noise barrier portion of the model.

Each FHWA TNM roadway carried 3,600 vehicles per hour per direction. The traffic was divided into 88 percent automobiles (3,168 veh/hr), and 12 percent trucks (two-thirds heavy trucks [288 veh/hr] and one-third medium trucks [144 veh/hr]). The travel speed was 65 miles per hour.

The noise barrier was located at the edge of the shoulder of the near travel direction. “Lawn grass” ground cover and a flat site were assumed, with a grassy median between the two directions of travel. For each of the cases, a range of six barrier heights was examined: 6, 10, 14, 18, 22, and 26 feet.

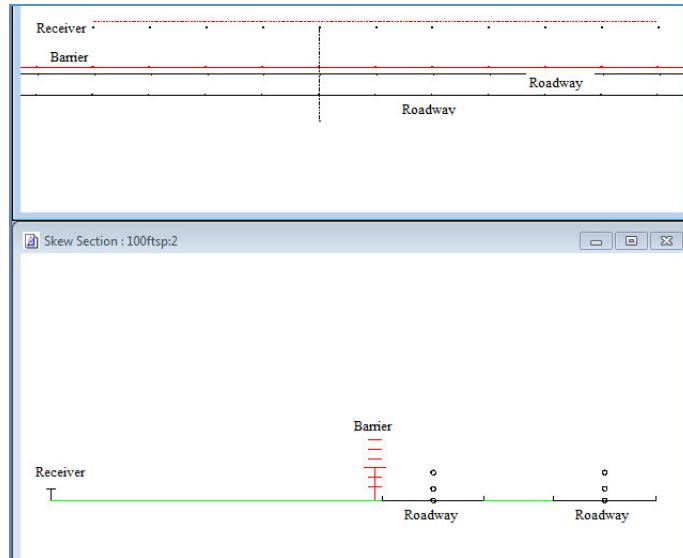


Figure 28. Plan view (top) and cross-sectional view (bottom) of roadways and noise barrier portion of FHWA TNM model for sensitivity test cases.

Several receptor scenarios were modeled:

- Different numbers of rows of receptors.
- Different distances back from the barrier to the first-row of receptors.
- Varying receiver density.

Figure 29 shows that two different distances back from the barrier to the first row of receptors were used. The assumption was that the barrier was located on the edge of the roadway shoulder and that there was 40 feet of right-of-way space from the barrier to the property line. The distances were:

- 90 feet (thus 50 feet back from the property line).
- 140 feet (thus 100 feet back from the property line).

Cases were created representing scenarios with one, two, and three rows of receptors. Eleven FHWA TNM receiver points² per row were placed at 200-ft spacing along a line parallel to the roadway over a distance of 2,000 feet. Figure 30 shows the receiver portion of the FHWA TNM model. In the analysis, each receiver was assigned to represent:

- One receptor, for a receptor spacing of 200 feet and a total of 11 receptors per row.
- Two receptors, for a receptor spacing of 100 feet and a total of 22 receptors per row.
- Four receptors, for a receptor spacing of 50 feet and a total of 44 receptors per row.

² The terminology used is as follows: a “receiver” is a point in an FHWA TNM model at which a sound level is calculated (“predicted”); a “receptor” represents an activity area being studied. A receiver point can, in many cases, represent more than one receptor, such as two or three adjacent houses at the same distance from the road.

The shielding provided by the rows of houses was modeled in FHWA TNM by placing a TNM “building row” object between the first and second, and the second and third, rows of receptors. The building row blockage percentages for the three receptor spacings of 50, 100, and 200 feet were chosen as 40 percent, 60 percent, and 80 percent, respectively.

Thus, a total of 108 “cases” were created (3 receptor spacings x 3 building row cases x 2 distances back from the barrier x 6 barrier heights). Each case had its own barrier noise reductions calculated by FHWA TNM for its receiver points.

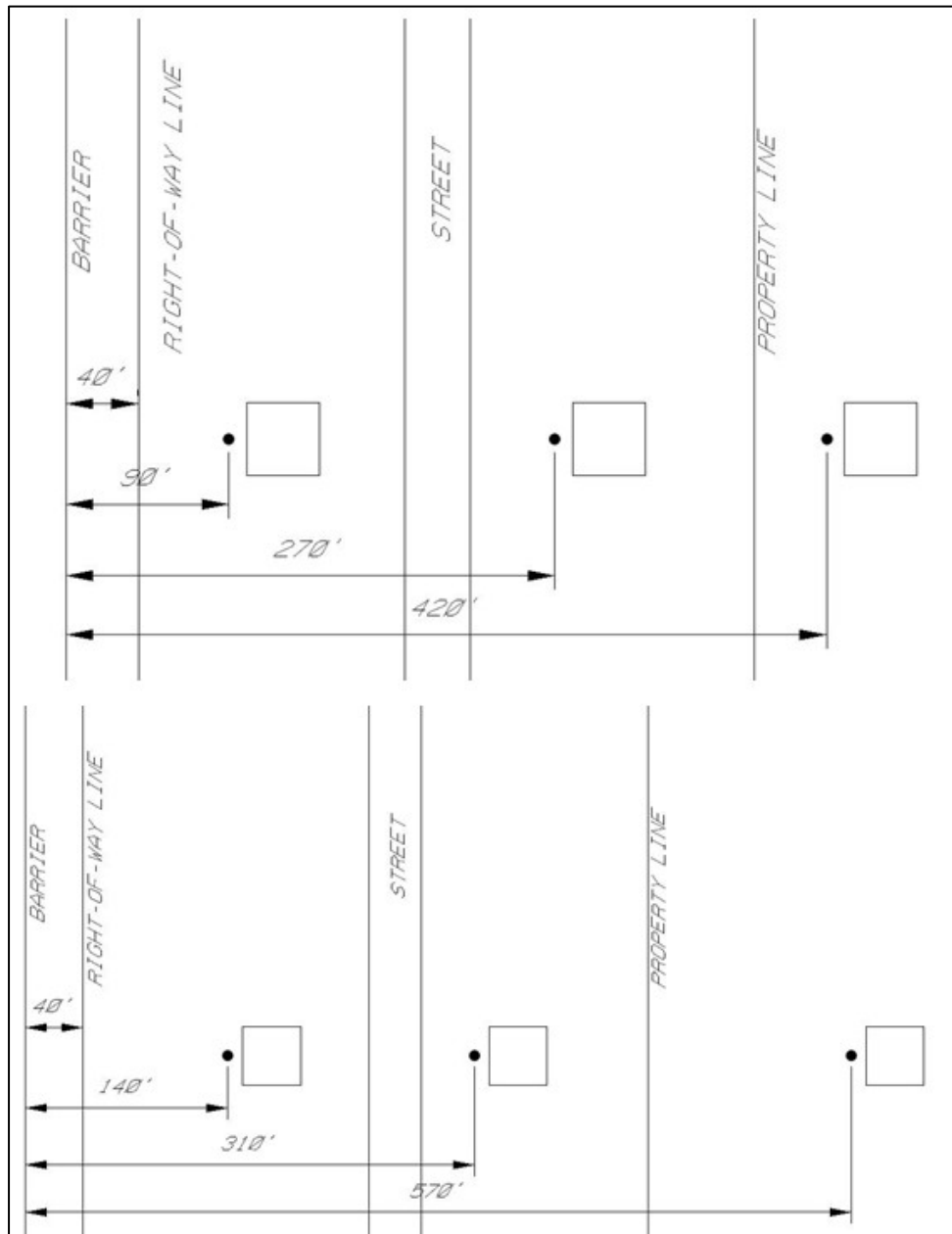


Figure 29. Sketches of receptor scenarios used in modeling the sensitivity test cases for first-row receptors 90 feet (top) and 140 feet (bottom) from barrier.

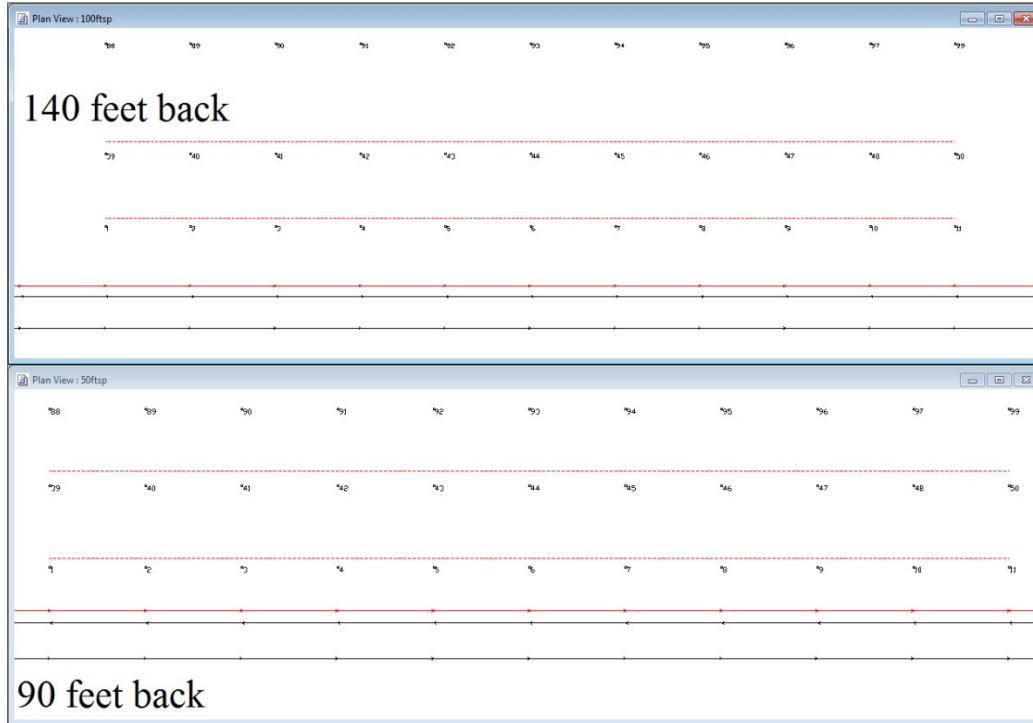


Figure 30. TNM plan view plots of receptor scenarios in FHWA TNM model for sensitivity test cases: 140 feet back (top) and 90 feet back (bottom).

3.1.2 Factors Studied

In *Noise Barrier Acceptance Criteria: Analysis*, four factors were studied:

1. Noise Reduction Design Goal (NRDG) in dB.
2. Benefited noise reduction in dB.
3. NRDG quantity in terms of the number and percentage of benefited receptors.
4. Area per benefited receptor (APBR).

Ranges were defined for these factors and the various resulting combinations of those factors were identified. These combinations were then tested against the results of the modeled cases to determine the resulting decision on reasonableness for the barrier in each case. For a barrier to be reasonable in this analysis, the NRDG criterion had to be met for the specified number or percentage of benefited receptors, and the APBR criterion had to be met.

The ranges in the factors were as follows:

- NRDG, ranging from 7 dB to 10 dB (7, 8, 9 and 10 dB), as permitted in the regulation.
- Benefited noise reduction: values from 5 dB up to the NRDG.
- NRDG quantity in terms of the number and percentage of benefited receptors:
 - For the number of benefited receptors, values 1, 2, and 3 were used.

- For the percentage of benefited receptors, two situations were studied:
 - The percentage of *first-row* benefited receptors only, using 10 percent, 50 percent, 67 percent, and 80 percent.
 - The percentage of *all* of the benefited receptors, using 10 percent, 25 percent, 50 percent, 67 percent, and 80 percent.
- APBR: A range of values from 500 to 2,800 SF per benefited receptor (500, 1000, 1,500, 2,000, and 2,800).

Use of the above values for these different factors resulted in 1,080 different criterion combinations to be analyzed, as presented and discussed in *Noise Barrier Acceptance Criteria: Analysis*.

3.2 LAYOUT OF THE FACTORS AND CASES IN THE TOOL

The resulting decisions on barrier reasonableness for the 1,080 combinations of reasonableness parameters for these 108 barrier cases have been left in the tool. However, specific combinations of values used in sample policies have also been entered into a beginning range of the tool to allow comparison of the decisions that result from sample values for test cases. There is also an area where the analyst may enter new combinations of factors or change existing combinations to test policy changes.

Figure 31 shows a very small portion of the tool to illustrate its layout. Then, Figure 32 shows details on a portion of the rows of the factors, and Figure 33 shows details on a portion of the columns of the cases.

					Case	1	2	3	4	5	6	7	8	
					Receptor spacing	50	50	50	50	50	50	50	50	
					Distance back	50	50	50	50	50	50	50	50	
3/19/2013						Building rows	1	1	1	1	1	1	2	2
					Height	6	10	14	18	22	26	6	10	
NRDG	Ben NR	NRDG type	NRDG #/%	APBR (CPBR/UC)	SHA having these policy values	Is barrier reasonable?								
7	5	N	1	1000		no-n	YES-n	YES-n	YES-n	NO-c	NO-c	no-n	YES-n	
7	5	N	1	1500		no-n	YES-n	YES-n	YES-n	YES-n	YES-n	no-n	YES-n	
7	5	N	1	2000		no-n	YES-n	YES-n	YES-n	YES-n	YES-n	no-n	YES-n	
7	5	N	1	2800		no-n	YES-n	YES-n	YES-n	YES-n	YES-n	no-n	YES-n	
7	5	N	2	500		no-n	NO-c	NO-c	NO-c	NO-c	NO-c	no-n	NO-c	
7	5	N	2	1000		no-n	YES-n	YES-n	YES-n	NO-c	NO-c	no-n	YES-n	
7	5	N	2	1500		no-n	YES-n	YES-n	YES-n	YES-n	YES-n	no-n	YES-n	
7	5	N	2	2000		no-n	YES-n	YES-n	YES-n	YES-n	YES-n	no-n	YES-n	
7	5	N	2	2800		no-n	YES-n	YES-n	YES-n	YES-n	YES-n	no-n	YES-n	
7	5	N	3	500		no-n	NO-c	NO-c	NO-c	NO-c	NO-c	no-n	NO-c	
7	5	N	3	1000		no-n	YES-n	YES-n	YES-n	NO-c	NO-c	no-n	YES-n	
7	5	N	3	1500		no-n	YES-n	YES-n	YES-n	YES-n	YES-n	no-n	YES-n	
7	5	N	3	2000		no-n	YES-n	YES-n	YES-n	YES-n	YES-n	no-n	YES-n	
7	5	N	3	2800		no-n	YES-n	YES-n	YES-n	YES-n	YES-n	no-n	YES-n	
7	5	P1	10%	500		no-p1	NO-c	NO-c	NO-c	NO-c	NO-c	no-p1	NO-c	
7	5	P1	10%	1000		no-p1	YESp1	YESp1	YESp1	NO-c	NO-c	no-p1	YESp1	
7	5	P1	10%	1500		no-p1	YESp1	YESp1	YESp1	YESp1	YESp1	no-p1	YESp1	
7	5	P1	10%	2000		no-p1	YESp1	YESp1	YESp1	YESp1	YESp1	no-p1	YESp1	
7	5	P1	10%	2800		no-p1	YESp1	YESp1	YESp1	YESp1	YESp1	no-p1	YESp1	
7	5	P1	50%	500		no-p1	NO-c	NO-c	NO-c	NO-c	NO-c	no-p1	NO-c	
7	5	P1	50%	1000		no-p1	YESp1	YESp1	YESp1	NO-c	NO-c	no-p1	YESp1	
7	5	P1	50%	1500		no-p1	YESp1	YESp1	YESp1	YESp1	YESp1	no-p1	YESp1	
7	5	P1	50%	2000		no-p1	YESp1	YESp1	YESp1	YESp1	YESp1	no-p1	YESp1	
7	5	P1	50%	2800		no-p1	YESp1	YESp1	YESp1	YESp1	YESp1	no-p1	YESp1	
7	5	P1	67%	500		no-p1	NO-c	NO-c	NO-c	NO-c	NO-c	no-p1	NO-c	
7	5	P1	67%	1000		no-p1	YESp1	YESp1	YESp1	NO-c	NO-c	no-p1	YESp1	
7	5	P1	67%	1500		no-p1	YESp1	YESp1	YESp1	YESp1	YESp1	no-p1	YESp1	
7	5	P1	67%	2000		no-p1	YESp1	YESp1	YESp1	YESp1	YESp1	no-p1	YESp1	
7	5	P1	67%	2800		no-p1	YESp1	YESp1	YESp1	YESp1	YESp1	no-p1	YESp1	
7	5	P1	80%	500		no-p1	NO-c	NO-c	NO-c	NO-c	NO-c	no-p1	NO-c	
7	5	P1	80%	1000		no-p1	YESp1	YESp1	YESp1	NO-c	NO-c	no-p1	YESp1	
7	5	P1	80%	1500		no-p1	YESp1	YESp1	YESp1	YESp1	YESp1	no-p1	YESp1	
7	5	P1	80%	2000		no-p1	YESp1	YESp1	YESp1	YESp1	YESp1	no-p1	YESp1	
7	5	P1	80%	2800		no-p1	YESp1	YESp1	YESp1	YESp1	YESp1	no-p1	YESp1	
7	5	PA	10%	500		no-pa	NO-c	NO-c	NO-c	NO-c	NO-c	no-pa	NO-c	
7	5	PA	10%	1000		no-pa	YESpa	YESpa	YESpa	NO-c	NO-c	no-pa	YESpa	

Figure 31. Portion of reasonableness decision array for the sensitivity test cases: NRDG of 7 dB, Benefited noise reduction of 5 dB, 50-ft receptor spacing, 50-ft distance back to first-row (90 ft from barrier), and mostly one-row cases.

In Figure 32, the first five columns represent the reasonableness factors being varied. The rows are sorted first by **NRDG**, then by benefited noise reduction (**Ben NR**), then by **NRDG type**, then by value for the NRDG type (**NRDG #/%**), and finally by **APBR (CPBR/UC)**. For all of the rows shown in this portion, the NRDG is 7 dB and the benefited noise reduction is 5 dB. The NRDG type has one of three codes:

- **N** (in green) to indicate that NRDG number/percent will be the needed *number* of benefited receptors.
- **P1** (in yellow) to indicate that NRDG number/percent will be the needed *percentage* of first-row benefited receptors.
- **PA** (in red) to indicate that NRDG number/percent will be the needed *percentage* of all benefited receptors.

NRDG	Ben NR	NRDG type	NRDG #/%	APBR (CPBR/UC)
7	5	N	1	1000
7	5	N	1	1500
7	5	N	1	2000
7	5	N	1	2800
7	5	N	2	500
7	5	N	2	1000
7	5	N	2	1500
7	5	N	2	2000
7	5	N	2	2800
7	5	N	3	500
7	5	N	3	1000
7	5	N	3	1500
7	5	N	3	2000
7	5	N	3	2800
7	5	P1	10%	500
7	5	P1	10%	1000
7	5	P1	10%	1500
7	5	P1	10%	2000
7	5	P1	10%	2800
7	5	P1	50%	500
7	5	P1	50%	1000
7	5	P1	50%	1500
7	5	P1	50%	2000
7	5	P1	50%	2800
7	5	P1	67%	500
7	5	P1	67%	1000
7	5	P1	67%	1500
7	5	P1	67%	2000
7	5	P1	67%	2800
7	5	P1	80%	500
7	5	P1	80%	1000
7	5	P1	80%	1500
7	5	P1	80%	2000
7	5	P1	80%	2800
7	5	PA	10%	500
7	5	PA	10%	1000

Figure 32. Details of the columns representing a portion of the factor combinations.

In Figure 33, the rows indicate a portion of the cases being studied:

- A sequential **Case** number.
- The **Receptor spacing** (50, 100, or 200-ft); in this sample, all are at 50 feet.
- The **Distance back** to the first row (50 or 100 ft back from the right-of-way line, representing 90 or 140 feet from the barrier); in this example, all are at 50 feet.
- The number of **Building rows** (1, 2, or 3).

- The barrier **Height** (6 to 26 feet in 4-ft increments).

Case	1	2	3	4	5	6
Receptor spacing	50	50	50	50	50	50
Distance back	50	50	50	50	50	50
Building rows	1	1	1	1	1	1
Height	6	10	14	18	22	26

Figure 33. Portion of the cases included in the tool.

Figure 34 shows the green and yellow cells at the intersection of a row (combination of criterion factors) and a column (the case being studied), which indicate the reasonableness decision of **Yes** or **No**, respectively. These answers are further coded by the deciding factor (i.e., number or percentage of receptors [**n**, **p1**, **pa**] or APBR [**c**]).

NRDG	Ben NR	NRDG type	NRDG #/%	APBR (CPBR/UC)	SHA having these policy values	Is barrier reasonable?			
7	5	N	1	1000		no-n	YES-n	YES-n	YES-n
7	5	N	1	1500		no-n	YES-n	YES-n	YES-n
7	5	N	1	2000		no-n	YES-n	YES-n	YES-n
7	5	N	1	2800		no-n	YES-n	YES-n	YES-n
7	5	N	2	500		no-n	NO-c	NO-c	NO-c
7	5	N	2	1000		no-n	YES-n	YES-n	YES-n
7	5	N	2	1500		no-n	YES-n	YES-n	YES-n
7	5	N	2	2000		no-n	YES-n	YES-n	YES-n
7	5	N	2	2800		no-n	YES-n	YES-n	YES-n
7	5	N	3	500		no-n	NO-c	NO-c	NO-c
7	5	N	3	1000		no-n	YES-n	YES-n	YES-n
7	5	N	3	1500		no-n	YES-n	YES-n	YES-n
7	5	N	3	2000		no-n	YES-n	YES-n	YES-n
7	5	N	3	2800		no-n	YES-n	YES-n	YES-n
7	5	P1	10%	500		no-p1	NO-c	NO-c	NO-c
7	5	P1	10%	1000		no-p1	YESp1	YESp1	YESp1
7	5	P1	10%	1500		no-p1	YESp1	YESp1	YESp1
7	5	P1	10%	2000		no-p1	YESp1	YESp1	YESp1
7	5	P1	10%	2800		no-p1	YESp1	YESp1	YESp1
7	5	P1	50%	500		no-p1	NO-c	NO-c	NO-c

Figure 34. Portion of the tool showing samples of the decisions.

Figure 35 shows the portion of the spreadsheet with sample policy factor values in Columns A through E and the sample policy set number in Column F. Empty cells for APBR means the sample policy uses a cost per benefited residence.

TOOLS TO EVALUATE NOISE BARRIER ACCEPTANCE CRITERIA

NRDG	Ben NR	NRDG Type	NRDG #/%	APBR (CPBRIUC)	Sample policy set #
7	5	N	1	700	1
7	5	N	1	1000	2
7	5	N	1	1053	3
7	5	N	1	1250	4
7	5	N	1	1380	5
7	5	N	1	1389	6
7	5	N	1	1400	7
7	5	N	1	1400	8
7	5	N	1	1500	9
7	5	N	1	1990	10
7	5	N	1	2000	11
7	5	N	1	2150	12
7	5	N	1	2500	13
7	5	N	1	2750	14
7	5	N	1		15
7	5	N	1		16
7	5	N	1		17
7	5	P1	10%	1429	18
7	5	P1	40%	909	19
7	5	P1	50%	714	20
7	5	P1	50%	786	21
7	5	P1	50%	833	22
7	5	P1	50%	1000	23
7	5	P1	50%		24
7	5	P1	60%	250	25
7	5	P1	60%	2400	26
7	5	P1	60%		27
7	5	P1	75%	1200	28
7	5	P1	75%	1600	29
7	5	P1	75%		30
7	5	PA	10%	800	31
7	5	PA	10%	800	32
7	5	PA	25%	1333	33
7	5	PA	40%	857	34
7	5	PA	40%	1167	35
7	5	PA	50%	1000	36
7	5	PA	50%	1137	37
7	5	PA	50%	1400	38
7	5	PA	50%	1600	39
7	5	PA	50%	2000	40
7	5	PA	50%	2700	41
7	5	PA	67%		42
7	7	N	1	1600	43
7	7	P1	67%	1440	44
8	5	N	1	960	45
8	5	N	1	1480	46
8	5	N	1		47
8	5	PA	80%	857	48
8	8	P1	75%	1500	49
9	5	N	1	1029	50
9	8	N	1	1667	51
9	9	PA	25%		52
10	5	N	1	945	53
10	5	N	1		54
10	5	N	1		55
10	5	PA	65%	1000	56
10	7	PA	50%	1000	57
10	7	PA	50%	1250	58
10	7	PA	50%		59
10	8	P1	80%		60

Figure 35. Portion of tool showing sample policy factor values in the first five columns and the sample policy set number in the sixth column.

Figure 36 shows the portion of the spreadsheet where the user may enter criteria values. There are 10 blank rows for entering criteria. The user may type in values or copy and paste values, including values from the portion of the spreadsheet with sample policy values. **However, the user must not “move” rows because the formulas, cell references, and decisions will become incorrect.** Do not use the Excel Cut function in this workbook.

The **NRDG type** cell is conditionally formatted to turn green when a type of **N** is entered, light yellow when **P1** is entered and red when **PA** is entered. As illustrated, the user has entered 9 dB for NRDG, 5 dB for benefited noise reduction, P1 and 67 percent to indicate that the NRDG needs to be met be at least 67 percent of the benefited first-row receptors, and 2,200 SF/benefited receptor. The barrier reasonableness decisions show #NA if all of the criteria are not entered.

A	B	C	D	E	F	G	H	I	J
					Case		1	2	3
					Receptor spacing		50	50	50
					Distance back		50	50	50
3/19/2013					Building rows		1	1	1
					Height		6	10	14
NRDG	Ben NR	NRDG type	NRDG #/%	APBR (CPBR/UC)	SHA having these policy values		Is barrier reasonable?		
9	5	P1	67%	2200			#N/A	#N/A	#N/A
							no-p1	no-p1	YESp1
							#N/A	#N/A	#N/A
							#N/A	#N/A	#N/A
							#N/A	#N/A	#N/A
							#N/A	#N/A	#N/A
							#N/A	#N/A	#N/A
							#N/A	#N/A	#N/A
							#N/A	#N/A	#N/A
							#N/A	#N/A	#N/A

Figure 36. Portion of tool showing where the user enters criteria values.

3.3 STEP-BY-STEP INSTRUCTIONS FOR TOOL USE

The following instructions summarize the use of NARSAT. The assumption is that the analyst has one or more combinations of reasonableness factors to be tested.

The spreadsheet can accommodate up to ten sets of values in addition to the pre-programmed sample values and the pre-set combinations of factors.

There is no particular order in which values need to be entered into the spreadsheet. The decision results are calculated when the needed factors are all entered on a row in the spreadsheet.

In its current version, the **Reas results** worksheet does not have safeguards to see that entered data is within allowable ranges. For example, an NRDG of 11 could be entered even though FHWA limits the NRDG to a maximum value of 10 dB. Also, calculation cells are not locked to prevent data from being entered into them, replacing the formulas in them. Care needs to be taken to only enter data as described below. Rows, columns, and cells should not be added deleted or moved.

The **TNM results** worksheet is also not protected in its current form. This worksheet was set up for a specific series of TNM runs and also should not be modified by the analyst, including the entry of different TNM sound level reductions.

Steps for use:

1. Open the spreadsheet and use File/Save As to rename the spreadsheet and preserve the master copy.
2. On the **Reas results** worksheet, go to the yellow cells starting on Row 120 for Columns A-E (below the section with the sample policy values).
3. Enter the desired values for **NRDG**, **Ben NR**, **NRDG type (N, P1 or PA)**, **NRDG #/%** and **APBR** in Columns A-E. If the goal is to test sample policy values, these values can be copied from the section above this user-entry section and pasted into one or more of the rows with the yellow cells; then the values may be changed as desired
4. If desired, enter a brief comment in Column F.
5. Read the decision results for these reasonableness factors in Columns H-DK.
6. Save the spreadsheet when done, if desired.

CHAPTER 4. CONCLUSION

One objective of this research was to develop a tool that would allow a noise analyst to test various values and combinations of values for feasibility and reasonableness criteria factors in the FHWA noise regulation in Title 23 CFR Part 772.

This report has described two such spreadsheet tools, developed in Microsoft Excel[®]:

- Noise Abatement Feasibility and Reasonableness Analysis Tool (NAFRAT).
- Noise Abatement Reasonableness Sensitivity Analysis Tool (NARSAT).

4.1 NAFRAT

In its current format, multiple combinations of factors can be tested at one time for feasibility and reasonableness. Those factors are:

- Feasibility:
 - Feasibility noise reduction: A noise reduction of at least 5 dB that must be achieved for a noise abatement measure to be feasible.
 - Feasibility quantity: The minimum number or percentage of impacted receptors that must achieve the feasibility noise reduction.
- Reasonableness (Noise Reduction Design Goal and Cost-Effectiveness):
 - Benefited noise reduction: The minimum noise reduction for a receptor to be counted as benefited by a noise abatement measure.
 - Noise reduction design goal (NRDG): The noise reduction that must be achieved for a noise abatement measure to be reasonable.
 - NRDG quantity: The minimum number or percentage of benefited receptors that must achieve the NRDG.
 - Cost Effectiveness (CE): The allowable barrier area (in SF) per benefited receptor (APBR) (or allowable cost per benefited receptor (CPBR) divided by abatement measure unit cost in dollars/SF).
- Reasonableness (Viewpoints of benefited property owners and residents)
 - Votes Needed: The minimum percentage of votes needed to accept or reject the barrier
 - % Based On: This calculates the vote percentage based on “All” possible votes or % of votes that were actually “Received.”
 - % is: This describes whether the vote percentage applies to those who are “For” or “Against” the barrier.
 - Non-Response: This addresses how non-votes are treated (“For”, “Against,” or “Not Counted”) when the voting % is based on the votes that are “received.”

- Weighting Factors: The multiplier(s) applied to each response from benefited Owner-Occupants, Non-Resident Owners, and Renters. An (optional) second set of weighting factors is available to differentiate benefits by either location (first row vs. non-first-row) or impact condition (impacted vs. non-impacted).
- Additional Weighting based on: This allows the designation of a second set of Weighting Factors for benefited receptors that are either not in the first row or not impacted.

The NAFRAT tool is used in conjunction with the FHWA TNM computer program. The spreadsheet includes by default the results for noise barrier designs done in FHWA TNM for four real-world highway projects. Two designs from each project are built in, based on these criteria:

- Feasibility (both designs): minimum reduction of 5 dB at 50 percent or more of first-row impacted receptors.
- Reasonableness:
 1. Design 1: NRDG of 7 dB at 25 percent of first-row benefited receptors, with a reduction of 5 dB or more to be counted as benefited, and an APBR at or below 1,250 SF per benefited receptor.
 2. Design 2: NRDG of 10 dB at 75 percent of all benefited receptors, with a reduction of 5 dB or more to be counted as benefited, and an APBR at or below 2,600 SF per benefited receptor.

These example designs are among those in *Noise Barrier Acceptance Criteria: Analysis*.

The analyst may also create one or more “custom” FHWA TNM runs and barrier designs and then paste the FHWA TNM Sound Levels results table and barrier area for each design into individual case worksheets in the NAFRAT spreadsheet. The analyst may also enter the values for one or more combinations of feasibility and reasonableness factors to be tested.

For both the default projects and any newly-added ones, the analyst also enters an overall estimated background sound level that is mathematically combined with the TNM-calculated No Barrier and With Barrier levels to derive a background-adjusted Noise Reduction for the barrier, a quantity not calculated directly by FHWA TNM. The analyst also designates those receivers to be considered as first-row receivers. For the Consideration of Viewpoints portion of the tool, the analyst also designates how many rental units (if any) are being represented by each receiver, as well as the number of “yes” and/or “no” responses for a given receiver by the type of voter (Owner-Occupants, Non-Resident Owners, and Renters). The voting patterns can be real or created by the analyst to test different scenarios.

The resulting decisions are displayed in Feasibility and Reasonableness Results tables along with the factors being analyzed and values used in making the decision, such as the number of total and first-row impacted and benefited receptors and the number and percentage of impacted and benefited receptors that meet the feasibility and reasonableness criteria.

This tool may be used in several ways:

- A single barrier design's results for a single highway project may be pasted into one individual case worksheet, and then various combinations of criteria may be tested on that design.
- Results for multiple barrier designs for a single highway project may be pasted into different individual case worksheets, and then they may all be tested for the same combination (or multiple combinations) of criteria.
- Results for single barrier designs for many different projects may be pasted into the individual worksheets to test effects of changes in the policy criteria on a series of projects.
- Finally, several projects or designs may be tested against several sets of criteria at the same time.

4.2 NARSAT

NARSAT focuses on reasonableness and is based on series of 108 cases derived from a set of hypothetical scenarios involving one, two, and three rows of receptors; three different receptor densities; two different setbacks from the barrier to the first row of receptors; and six different barrier heights.

Reasonableness factors include:

- Noise reduction design goal (NRDG), in dB.
- Benefited noise reduction, in dB.
- NRDG quantity (minimum number or percentage of benefited receptors that must achieve the NRDG).
- Cost Effectiveness (CE): APBR, in SF/ benefited receptor.

The tool includes sample policy criteria. It allows for easy comparison of the reasonableness decisions from various sample policies and allows the analyst to test, compare, and contrast different criterion values.

The analyst may also enter his or her own values for these criteria, to test a variation of an existing SHA policy or to test new combinations and values.

The tool also includes reasonableness decisions for 1,080 combinations of pre-set values for NRDG and APBR criteria tested on the 108 design cases.