Quantifying the Benefits of Noise Abatement Measures

PART 3: BENEFIT-COST ANALYSIS TOOL TUTORIAL

FOCUS AREA: NOISE WALLS

FHWA-HEP-24-004 | July 2023

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13. ABSTRACT (Maximum 200 words) This document provides a tutorial (Part 3) on the use of the Noise Wall Cost-Benefit Analysis Tool, which is based on the Evaluation Framework (Part 2) for quantifying the benefits and costs of noise abatement measures for transportation projects. To the extent that the benefits of noise reduction can be monetized, noise can be included in a benefit/cost analysis (BCA) along with other monetizable benefits and costs of transportation projects such as travel time savings, crash reduction, and emission reductions.			
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I. INTRODUCTION

Costs of sound walls have been rising in recent years, and planning staff need tools to demonstrate the usefulness of such projects. This tutorial provides practical advice regarding one such tool, benefit cost analysis (BCA), and how it can be applied to compare the costs of a sound wall to the benefits of a sound wall. The information on the benefits of sound walls found in this tutorial is derived from the report titled *Quantifying the Benefits of Noise Abatement Measures Part 1* and *Part 2*.

Note: the methods used in this tutorial assume that information on the expected noise levels (measured in dB(A)[1]) in a residential area before and after a sound wall is constructed is available. This tutorial does NOT cover methods of modeling the noise impacts from sound walls or other noise abatement measures. Analysts are encouraged to use the FHWA Traffic Noise Model for noise analyses, and several resources are available to help analysts understand and use that model.[2]

[1] An A-weighted decibel (dB(A)) is a measure of loudness of sound that is weighted to approximate the way that sound is experienced by the human ear. Unweighted decibels are referred to as dB. The remainder of this document will exclusively refer to dB(A).

[2] https://www.fhwa.dot.gov/environment/noise/traffic_noise_model/

2. BENEFIT COST ANALYSIS FOR NOISE ABATEMENT

This tutorial document is concerned with the specifics of applying the results of *Quantifying the Benefits of Noise Abatement Measures* to a BCA for a sound wall project, and generally assumes that analysts are already familiar with the general principles of conducting a BCA. A brief background on BCAs is provided here for additional context, but interested parties are encouraged to review the USDOT BCA Guidance for further information about BCAs and about relevant parameters and techniques for conducting a BCA. [3]

A benefit-cost analysis (BCA) is a systematic process for identifying, quantifying, and comparing expected benefits and costs of an investment, action, or policy. A BCA provides estimates of the anticipated stream of benefits from a given project and compares them against the anticipated costs of the project. In a BCA, streams of benefits and costs must be converted into dollar values and converted to their present value using discounting to allow for comparison. The primary output of a BCA is a benefit-cost ratio (BCR), which is calculated as [Present Value of Benefits / Present Value of Costs]. A BCR above 1 indicates that the project's benefits are larger than the costs. The results of a BCA can also be expressed as "net present value", which is calculated as [Present Value of Benefits – Present Value of Costs]. A net present value greater than 0 means the project provides net benefits. Both of those figures can be used in deciding whether to pursue a project and in comparing alternative projects to each other.

For standard benefit areas, such as safety, the method for converting safety outcomes such as avoided injuries and fatalities to monetized benefits is relatively well-established. For noise reductions from transportation sources, the available research is less robust. Recent versions of the USDOT BCA Guidance have included valuations for noise reductions from reduced vehicle travel, however this value is based on changes in vehicle miles traveled and is therefore not applicable to sound wall applications where vehicle travel is unchanged but the noise experienced by nearby households has changed. There is currently no standard USDOT-wide guidance on how to value noise reductions from noise abatement measures, such as sound walls.

2.1. Methodology

Before beginning a BCA, one needs to clearly define the potential sound wall project. This includes both basic construction information and more detailed information about neighborhood characteristics. Necessary information includes, but is not strictly limited to, the following:

- How much will the sound wall cost?
- What is the proposed construction timeline for the sound wall?
- What is the size (height and length) of the sound wall?
- What is the expected useful life of the sound wall?

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[3] The USDOT Benefit-Cost Analysis Guidance for Discretionary Grant Programs can be found at the following link: https://www.transportation.gov/mission/office-secretary/office-policy/transportation-policy/benefit-cost-analysis-guidance The guidance receives updates, typically annually, but the latest version can be found at the provided link.

- Does the sound wall have anticipated annual maintenance costs? If so, how large are these costs expected to be?
- What is the nature of the surrounding residential area? How many residential units are there, and what is the average number of residents per unit?

This tutorial document recommends the use of the FHWA Traffic Noise Model to estimate the dB(A) levels experienced by residents in the area currently (i.e., without the sound wall, also referred to as the baseline or "no build" scenario) and with the sound wall. However, any reputable noise modeling software can be used so long as it provides results in dB(A).

Do not calculate an "average" noise level for residents. Your depiction should ideally be nuanced to recognize that that some residents will experience no change in noise, some residents will experience a moderate change, and some residents will experience a large change. The recommended way to represent a distribution of possible impacts is to model each residential unit individually using the FHWA traffic noise model as shown in this tutorial.[4]

In a BCA, the analyst will calculate the present value of the costs of the project using discounting. Current USDOT BCA guidance recommends a discount rate of 7%.

The analyst will also calculate the annual benefits of the project for each year and the similarly discount them to a present value. In this context, the annual benefits of the sound wall are calculated by calculating the costs of the baseline level of noise and subtracting the costs of the noise if a sound wall is built. The difference between the two cost estimates is the benefit of the wall. The benefit in each year is discounted to present value and then summed over the expected useful life of the wall.

To help identify techniques for BCAs on noise abatement, FHWA developed the report *Quantifying the Benefits of Noise Abatement Measures.* That report identified multiple possible unit values for monetizing noise levels. The report also provides an example BCA, using the noise monetization figures from Nellthorp, Bristow, and Day (2007), hereafter referred to as "NBD." Although the report contains a listing of other possible unit values, the NBD unit values are the most useful because they are provided for specific decibel ranges, allowing for increased accuracy relative to the other values that are provided as overall averages across all dB(A) values. Additionally, the NBD unit values are based on data from the United Kingdom, which was viewed to be the most similar to the U.S. experience, relative to the other available studies. Therefore, this tutorial uses the estimated dB(A) values from NBD. The basic method demonstrated here could potentially be used with other unit values from other research.

The unit values for monetizing a change in dB(A) (expressed in 2020 dollars) from NBD are presented in **Table 1**.

Table 1. Noise Costs per Decibel per Person per Year, by Baseline Decibel Level

Decibel Level	Noise Costs per Decibel per Person per Year (2020$)
>45 dB(A)	$11
>50 dB(A)	$22

[4] Quantifying the Benefits of Noise Abatement Measures (2013) provides an example BCA calculation that uses a less granular approach. However, FHWA recommends using the more granular approach explained here.

Decibel Level	Noise Costs per Decibel per Person per Year (2020$)
>55 dB(A)	$33
>60 dB(A)	$44
>65 dB(A)	$55
>70 dB(A)	$66
>75 dB(A)	$77
>80 dB(A)	$81

Source: Nellthorp, Bristow, Day (2007) as presented in Quantifying the Benefits of Noise Abatement Measures

The values provided by NBD show that the per decibel cost of noise increases with overall noise level. That is, the cost of one additional decibel of noise is higher moving from, say, 80 dB(A) to 81 dB(A) than moving from 60 dB(A) to 61 dB(A). This cost structure slightly complicates the monetization approach. To accurately reflect this cost structure, the analyst must apply each per decibel unit value solely within its defined range and then sum across all the ranges. An estimated cost for the baseline conditions and the costs with the project should both be calculated. To more clearly explain this concept, consider an example where the baseline decibel level at a certain housing unit is 64 dB(A). At this level, the baseline noise cost is:

$$(50-45)\times\$11+(55-50)\times\$22+(60-55)\times\$33+(64-60)\times\$44=\$506$$

This is the cost of the noise level to each resident of that housing unit in the baseline scenario, without the sound wall. In the build scenario with the wall, suppose that the noise decreases to 52 decibels. At this level, the total cost is:

$$(50-45)\times\$11+(52-50)\times\$22=\$99$$

The benefit of the sound wall, per person per year, is then calculated as:

$$Cost\ in\ Baseline-Cost\ in\ Build\ Scenario=\$506-\$99=\$407$$

In **TABLE 2**, below, the calculations to estimate the cost for the baseline and build scenarios have already been performed, such that to get the value per person from a change in noise levels, the analyst can simply take the difference between the two relevant rows in the table. For example, moving from 53 to 48 decibels would be estimated at

$$\$121-\$33=\$88\ per\ person$$

Values under 46 decibels do not seem to impose any cost, and should accordingly be assessed as if they have a cost of $0 per person.

TABLE 2. NOISE COSTS BY BASELINE DECIBEL LEVEL FOR NON-SPREADSHEET BCA APPROACH

Decibels	Cost
46	$11
47	$22
48	$33
49	$44
50	$55

Decibels	Cost
51	$77
52	$99
53	$121
54	$143
55	$165
56	$198
57	$231
58	$264
59	$297
60	$330
61	$374
62	$418
63	$462
64	$506
65	$550
66	$605
67	$660
68	$715
69	$770
70	$825
71	$891
72	$957
73	$1,023
74	$1,089
75	$1,155
76	$1,232
77	$1,309
78	$1,386
79	$1,463
80	$1,540
81	$1,621
82	$1,702
83	$1,783
84	$1,864
85	$1,945
86	$2,026
87	$2,107
88	$2,188
89	$2,269
90	$2,350

The per person benefit value is then applied to the number of residents of that household to estimate the benefit for a given household in one year. This approach must then be replicated across all households in the project area and summed to estimate the annual benefits of the project.[5] This annual value can then be applied for every year after construction in the analysis period.

2.2. BCA Example

To illustrate how to conduct a BCA for a noise mitigation project, a simple example of a sound wall installation was developed, modeled, and analyzed. The example is meant to be realistic, however it does not reflect any actual real-world location, and makes a variety of simplifying assumptions within the noise modeling. As previously noted, this guide is not meant to instruct practitioners on how to model changes in noise, but rather on how to conduct a BCA for noise reduction benefits.

The simple example is based on installing a 3,200-foot sound wall along a major road. The sound wall has a height of 20 feet, and speeds along the road are modeled at 65 mph. The dwellings are arranged in a grid pattern, with a rough estimate of 10,000 square feet per lot. A mixture of single-family homes and small multi-unit buildings (such as a triple-decker) are assumed to populate the area. The noise modeling extends to households up to 800 feet away from the sound wall. A simplified sketch of part of the modeled area can be seen in **Figure 1**.

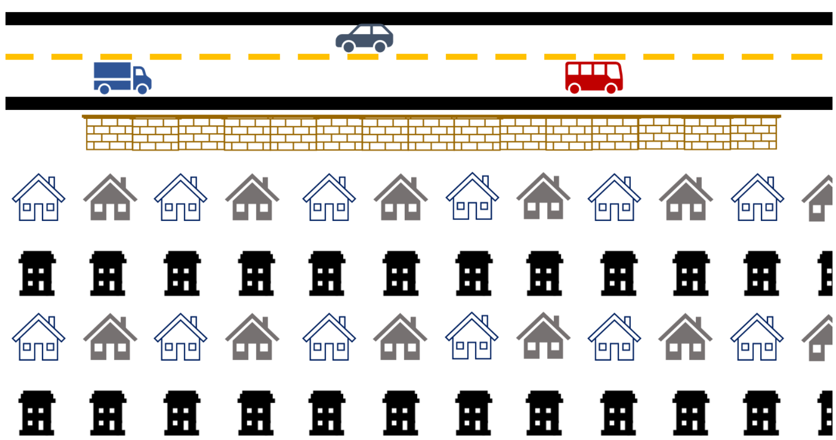

Figure 1 Image Depicting Simple Example

Numbers and results throughout this report are based on this example. The final BCA results should *not* be extrapolated to real-world noise applications, as every project has unique characteristics and needs to be modeled independently. The purpose of this example is simply to help illustrate how a BCA should be conducted.

[5] This document does not cover disbenefits during the construction project.

3. Guide to Using Accompanying Spreadsheet

The spreadsheet is designed to be intuitive and easy to use. This guide is meant to intended to provide clarification on the proper set-up and application of the Noise BCA Spreadsheet. The spreadsheet is designed based on the benefits and costs of a sound wall - other types of noise abatement measures would require adjustments for proper calculation; however, the spreadsheet may still serve as an appropriate tool to start from. Details on other noise abatement measures can be found in the *Quantifying the Benefits of Noise Abatement Measures* report.

The spreadsheet has four tabs, which will be explained in turn.

3.1. Noise Model Output

The first tab of the spreadsheet, "Noise Model Output", is where the user should enter results from their noise modeling analysis. While this tutorial explains how to utilize results from the FHWA Traffic Noise Model, any modeling output can be used—the necessary outputs are the baseline decibels prior to sound wall construction and the decibels post-sound wall construction for every household of interest, measured in dB(A). Any model that provides these outputs can be used.

If using output from the FHWA Traffic Noise Model, the user should copy four columns of data into the Noise BCA Spreadsheet Tool. **Figure 2** shows an example of output from the FHWA Traffic Noise Model, and in the figure, the required columns are highlighted. In order, these four columns represent the receiver or household identifier, the baseline decibel level, the decibel level after sound wall construction, and the change in decibels for each receiver or household.

REPORT:	**Results: Sound Levels - Input Heights**		
TNM VERSION:	3.1.7970.37608	REPORT DATE:	13 April 2023
CALCULATED WITH:	3.1.7970.37608	CALCULATION DATE:	4/13/2023 1:08:09 PM
CASE:	Barrier = 20 ft Tall, 3200 ft long, Speed = 65 mph	ORGANIZATION:	Volpe Center
ANALYSIS BY:		PROJECT/CONTRACT:	Noise BCA
DEFAULT GROUND TYPE:	Lawn		
ATMOSPHERICS:	68°F, 50%	Average pavement type shall be used unless a state highway agency	
PAVEMENT TYPE(S) USED:	Average	substantiates the use of a different type with approval of FHWA.	

Results for:		DUs	Noise Reduction Min dB	Noise Reduction Avg dB	Noise Reduction Max dB	Barrier Cost Area / Volume $	Barrier Cost Lineal $	Barrier Cost Total $	Barrier Cost Total/DUs $
Receivers in the Barrier Design:	All	0	0.2	6.7	13.0	0	0	0	NaN
	All Impacted	0	---	---	---	0	0	0	---
Meeting Noise Reduction Goal:	All	0	---	---	---	0	0	0	---
	All Impacted	0	---	---	---	0	0	0	---

Receiver				Modeled Traffic Noise Levels								
				All Abatement Barriers at Zero Height					With Abatement Barriers			
			Existing	LAeq		Increase over Existing		Type		Noise Reduction		Calc.
Name	No.	DUs	LAeq dBA	Calc. dBA	Absolute Criterion dBA	Calc. dBA	Relative Criterion dBA	of Impact	Calc. LAeq dBA	Calc. dBA	Goal dBA	Minus Goal dBA
Receiver X0, Y100	0	0	---	64.2	0.0	---	---	Sound Level	51.2	13.0	8.0	5.0
Receiver X0, Y200	0	0	---	58.8	0.0	---	---	Sound Level	48.2	10.7	8.0	2.7
Receiver X0, Y300	0	0	---	55.4	0.0	---	---	Sound Level	46.0	9.5	8.0	1.5
Receiver X0, Y400	0	0	---	52.9	0.0	---	---	Sound Level	44.1	8.8	8.0	0.8
Receiver X0, Y500	0	0	---	50.9	0.0	---	---	Sound Level	42.5	8.4	8.0	0.4
Receiver X0, Y600	0	0	---	49.1	0.0	---	---	Sound Level	41.2	7.9	8.0	-0.1
Receiver X0, Y700	0	0	---	47.5	0.0	---	---	Sound Level	40.2	7.3	8.0	-0.7
Receiver X0, Y800	0	0	---	46.1	0.0	---	---	Sound Level	39.3	6.9	8.0	-1.1
Receiver X200, Y100	0	0	---	64.2	0.0	---	---	Sound Level	51.3	13.0	8.0	5.0
Receiver X200, Y200	0	0	---	58.8	0.0	---	---	Sound Level	48.2	10.6	8.0	2.6
Receiver X200, Y300	0	0	---	55.4	0.0	---	---	Sound Level	46.0	9.5	8.0	1.5
Receiver X200, Y400	0	0	---	52.9	0.0	---	---	Sound Level	44.1	8.8	8.0	0.8
Receiver X200, Y500	0	0	---	50.9	0.0	---	---	Sound Level	42.5	8.3	8.0	0.3
Receiver X200, Y600	0	0	---	49.1	0.0	---	---	Sound Level	41.3	7.8	8.0	-0.2
Receiver X200, Y700	0	0	---	47.5	0.0	---	---	Sound Level	40.2	7.3	8.0	-0.7
Receiver X200, Y800	0	0	---	46.1	0.0	---	---	Sound Level	39.3	6.8	8.0	-1.2
Receiver X400, Y100	0	0	---	64.2	0.0	---	---	Sound Level	51.3	12.9	8.0	4.9
Receiver X400, Y200	0	0	---	58.8	0.0	---	---	Sound Level	48.2	10.6	8.0	2.6
Receiver X400, Y300	0	0	---	55.4	0.0	---	---	Sound Level	46.0	9.4	8.0	1.4

FIGURE 2 FHWA TRAFFIC NOISE MODEL (TNM) OUTPUT

This data will then need to be copied into the Noise BCA Spreadsheet Tool. The tab Noise Model Output provides a table with six columns. The first column, "Household/Receiver Identifier", is not strictly required to be filled in, but is provided to allow analysts to easily identify various households. The second, third, and fourth columns capture the baseline decibels, the decibels with the sound wall, and the change in decibels. As previously noted, all inputs should be in dB(A). The user can enter estimates with any degree of specificity, but all values will be rounded to the nearest dB(A) automatically in the calculation process.

The fifth column requires manual user entry, as it requires the "People in Household". Because the benefits are on a per *person* level, an estimate is required of the total affected persons. It is not necessary - nor recommended - to have specific data on the occupancy of each household as the exact number of individuals in a given unit is likely to change over time. Instead, it is preferable to use an average estimate of the number of people in a household, with possible variations based on the type of unit (e.g., the average number of individuals may be higher in a multi-unit dwelling than in a single-family home). For simplicity in the example analysis, the example uses an estimate of 4 people per large single-family home and 18 per triple-decker, with the logic that a single 10,000-square-foot lot can fit three tightly packed triple-deckers, each of which houses 6 residents (2 residents per unit, 3 units per triple-decker). Users should update values with estimates that align with the available housing and occupancy rates.

The final column in the table, "Total Benefit to Household", automatically populates once those five columns are filled in. The user should not need to update this column. **Noise Model Output Tab Table 1** shows this table populated with data from the aforementioned simplified BCA example - only 26 rows are included in this document, but the table is designed in the spreadsheet to automatically accommodate up to 1,000 entries.

Noise Model Output Tab Table 1: Noise Model Output and People per Household

Household/Receiver Identifier	Baseline Decibels	Decibels with Sound Wall	Change in Decibels	People in Household	Total Benefit to Household
Receiver X0, Y100	64.2	51.2	13.0	4	$1,716
Receiver X0, Y200	58.8	48.2	10.7	4	$1,056
Receiver X0, Y300	55.4	46.0	9.5	4	$616
Receiver X0, Y400	52.9	44.1	8.8	4	$484
Receiver X0, Y500	50.9	42.5	8.4	4	$308
Receiver X0, Y600	49.1	41.2	7.9	4	$176
Receiver X0, Y700	47.5	40.2	7.3	4	$88
Receiver X0, Y800	46.1	39.3	6.9	4	$44
Receiver X200, Y100	64.2	51.3	13.0	18	$7,722
Receiver X200, Y200	58.8	48.2	10.6	18	$4,752
Receiver X200, Y300	55.4	46.0	9.5	18	$2,772
Receiver X200, Y400	52.9	44.1	8.8	18	$2,178
Receiver X200, Y500	50.9	42.5	8.3	18	$1,386
Receiver X200, Y600	49.1	41.3	7.8	18	$792
Receiver X200, Y700	47.5	40.2	7.3	18	$396
Receiver X200, Y800	46.1	39.3	6.8	18	$198
Receiver X400, Y100	64.2	51.3	12.9	4	$1,716
Receiver X400, Y200	58.8	48.2	10.6	4	$1,056
Receiver X400, Y300	55.4	46.0	9.4	4	$616
Receiver X400, Y400	52.9	44.2	8.7	4	$484
Receiver X400, Y500	50.9	42.7	8.2	4	$308
Receiver X400, Y600	49.1	41.4	7.7	4	$176
Receiver X400, Y700	47.5	40.3	7.1	4	$88
Receiver X400, Y800	46.1	39.5	6.6	4	$44
Receiver X600, Y100	64.2	51.3	12.9	18	$7,722
Receiver X600, Y200	58.9	48.3	10.5	18	$4,752

3.2. Noise Valuation

The "Noise Valuation" tab contains the two tables of monetization values that were previously introduced in the Methodology subsection. This tab should not require any adjustment by the user. **Noise Valuation Tab Table 1** presents the results from the NBD report, inflated to 2020 dollars as seen in *Quantifying the Benefits of Noise Abatement Measures*. **Noise Valuation Tab Table 2** provides the more detailed data by decibel level to allow for the actual calculation—these values are automatically calculated based on the first table. Any changes made to Table 1 will be reflected in Table 2.

The prior tab, "Noise Model Output", automatically pulls data from this tab. The user should only adjust this tab if they wish to change the monetization values for inflation. The tables are included below for reference.

Noise Valuation Tab Table 1: Benefit per Decibel per Person per Year: Decibel Ranges

Value	Decibel Range	Source
$11	>45 dB(A)	FHWA, *Quantifying the Benefits of Noise Abatement Measures*
$22	>50 dB(A)	FHWA, *Quantifying the Benefits of Noise Abatement Measures*
$33	>55 dB(A)	FHWA, *Quantifying the Benefits of Noise Abatement Measures*
$44	>60 dB(A)	FHWA, *Quantifying the Benefits of Noise Abatement Measures*
$55	>65 dB(A)	FHWA, *Quantifying the Benefits of Noise Abatement Measures*
$66	>70 dB(A)	FHWA, *Quantifying the Benefits of Noise Abatement Measures*
$77	>75 dB(A)	FHWA, *Quantifying the Benefits of Noise Abatement Measures*
$81	>80 dB(A)	FHWA, *Quantifying the Benefits of Noise Abatement Measures*

Noise Valuation Tab Table 2: Total Cost at Each Decibel Level

Decibels	Cost
46	$11
47	$22
48	$33
49	$44
50	$55
51	$77
52	$99
53	$121
54	$143
55	$165
56	$198
57	$231
58	$264
59	$297

Decibels	Cost
60	$330
61	$374
62	$418
63	$462
64	$506
65	$550
66	$605
67	$660
68	$715
69	$770
70	$825
71	$891
72	$957
73	$1,023
74	$1,089
75	$1,155
76	$1,232
77	$1,309
78	$1,386
79	$1,463
80	$1,540
81	$1,621
82	$1,702
83	$1,783
84	$1,864
85	$1,945
86	$2,026
87	$2,107
88	$2,188
89	$2,269
90	$2,350

3.3. BCA Inputs and Calculations

This tab is for all other inputs to the BCA, separate from the noise modeling output and noise monetization figures. Users can edit any of the values in this tab as necessary, however certain values should likely remain fixed.

BCA Inputs and Calculations Tab Table 1 covers the general analysis period and the discount rate. USDOT BCA Guidance recommends that all benefits and costs are discounted at a rate of 7%, and as such, 7% is the default value provided. The user must provide input as to the analysis period, the year that the costs will occur, and the first year of benefits - default values are provided in the spreadsheet, but the user is highly encouraged to revise these values to match their project. The final value worth noting is the base year - this is set to 2020 by default in the spreadsheet

BCA Inputs and Calculations Tab Table 1: Basic BCA Inputs

Value	Input Type	Source
30	Years of Benefits	User Input
2023	Year of Costs	User Input
2023	First Year of Benefits	User Input
7%	Discount Rate	USDOT BCA Guidance
2020	Base Year	Recommend 2020$

BCA Inputs and Calculations Tab Table 2 covers the cost of the sound wall. The example BCA uses cost estimates from *Quantifying the Benefits of Noise Abatement Measures,* however the applicant should update these values with their actual estimated construction costs. There is also a place for the user to input annual maintenance costs—including maintenance is a necessary consideration for a BCA, but the user should only include the difference in maintenance costs between the scenarios with and without the sound wall. Finally, the spreadsheet asks for the expected useful life of the sound wall—this allows the spreadsheet to calculate a residual value. The residual value captures any remaining value of the asset at the end of the analysis period, as many assets have useful lives that extend beyond the analysis period of a typical BCA. An estimate of 50 years is included by default, but the user should adjust this value to match their expectations.

BCA Inputs and Calculations Tab Table 2: Costs and Useful Life of Sound Wall

Value	Input Type	Source
$1,800,000	Total Cost of Sound Barrier	User Input
$5,000	Annual Maintenance Costs	User Input
50	Useful Life of Sound Barrier	User Input

BCA Inputs and Calculations Tab Table 3 combines all the provided information—noise modeling and BCA inputs—and estimates costs and benefits by year. The calculations automatically populate, and the user should not need to adjust any of the calculations.

BCA Inputs and Calculations Tab Table 3: Benefits and Costs by Year

Year	Capital Costs	Maintenance Costs	Noise Benefits	Residual Value	Discounted Costs	Discounted Benefits
2023	$1,800,000	$0	$0	$0	$1,469,336	$0
2024	$0	$5,000	$181,632	$0	$0	$134,752
2025	$0	$5,000	$181,632	$0	$0	$125,936
2026	$0	$5,000	$181,632	$0	$0	$117,697
2027	$0	$5,000	$181,632	$0	$0	$109,998

Year	Capital Costs	Maintenance Costs	Noise Benefits	Residual Value	Discounted Costs	Discounted Benefits
2028	$0	$5,000	$181,632	$0	$0	$102,801
2029	$0	$5,000	$181,632	$0	$0	$96,076
2030	$0	$5,000	$181,632	$0	$0	$89,791
2031	$0	$5,000	$181,632	$0	$0	$83,917
2032	$0	$5,000	$181,632	$0	$0	$78,427
2033	$0	$5,000	$181,632	$0	$0	$73,296
2034	$0	$5,000	$181,632	$0	$0	$68,501
2035	$0	$5,000	$181,632	$0	$0	$64,020
2036	$0	$5,000	$181,632	$0	$0	$59,831
2037	$0	$5,000	$181,632	$0	$0	$55,917
2038	$0	$5,000	$181,632	$0	$0	$52,259
2039	$0	$5,000	$181,632	$0	$0	$48,840
2040	$0	$5,000	$181,632	$0	$0	$45,645
2041	$0	$5,000	$181,632	$0	$0	$42,659
2042	$0	$5,000	$181,632	$0	$0	$39,868
2043	$0	$5,000	$181,632	$0	$0	$37,260
2044	$0	$5,000	$181,632	$0	$0	$34,822
2045	$0	$5,000	$181,632	$0	$0	$32,544
2046	$0	$5,000	$181,632	$0	$0	$30,415
2047	$0	$5,000	$181,632	$0	$0	$28,425
2048	$0	$5,000	$181,632	$0	$0	$26,566
2049	$0	$5,000	$181,632	$0	$0	$24,828
2050	$0	$5,000	$181,632	$0	$0	$23,204
2051	$0	$5,000	$181,632	$0	$0	$21,686
2052	$0	$5,000	$181,632	$720,000	$0	$102,881

3.4. BCA Results

This tab automatically calculates the final results of the BCA based on the data in the previous three tabs. The results include the total discounted costs, the total discounted benefits, the benefit-cost ratio (BCR) and the net present value (NPV). If the BCR is above 1 and the NPV is positive, then the benefits outweigh the costs of the project. This tab is designed to be very simple in presenting the final results.

BCA Results Tab - Table 1: BCA Results

$1,469,336	Total Costs
$1,852,862	Total Benefits
1.26	BCR
$383,526	NPV

As previously noted, the results shown are based on a simplified example. Actual results will vary depending on the nature of a particular project. In this simplified example, the benefits of the example project outweigh the costs, with a BCR of 1.26.

4. Conclusion

This tutorial is intended to aid practitioners in using the findings of FHWA's report on *Quantifying the Benefits of Noise Abatement Measures* for BCA analyses of sound wall projects. This document has provided a brief overview of BCA techniques for sound wall projects, described in detail how to use FHWA's provided spreadsheet tool, and offered an alternative approach if analysts choose not to use the provided spreadsheet tool.

If practitioners choose to conduct a BCA for their noise abatement projects that does *not* follow the method provided in this document and in *Quantifying the Benefits of Noise Abatement Measures Part 2*, then it is highly recommended for practitioners to justify their alternative BCA approach using reputable sources on the benefits and costs of noise abatement measures.

5. REFERENCES

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U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
OFFICE OF PLANNING, ENVIRONMENT, AND REALTY
1200 New Jersey Avenue, SE
Washington, DC 20590

https://www.fhwa.dot.gov/hep/

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