DESIGN NOISE REPORT

I-40 Widening from I-85 in Orange County to the Durham County Line

Orange County

STIP Project No. I-3306A
WBS No. 34178.3.GV3

Prepared for:

North Carolina Department of Transportation
Environmental Analysis Unit
Traffic Noise and Air Quality Group

Date of Public Knowledge: March 29, 2019
In compliance with the 2016 NCDOT Traffic Noise Policy

Prepared by:

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440 S. Church Street, Suite 1000
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July 2023

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Traffic Noise and Air Quality Group
Environmental Analysis Unit

Executive Summary

The North Carolina Department of Transportation (NCDOT) is constructing the I-3306A Design-Build Project in Orange County, which is widening I-40 from I-85 to the Durham County Line, a distance of approximately 11.4 miles. The Project will provide a six-lane facility and improve the I-40 / NC 86 interchange. The project is included in the State Transportation Improvement Program (STIP) as I-3306A. Federal funds are used for this project. A Traffic Noise Report (TNR) was prepared in March 2019 and addended in June 2021. This Design Noise Report (DNR) reexamines the impacts and mitigation at all noise sensitive land uses within the I-3306A project limits using the final design data and geometry.

The project Date of Public Knowledge is the March 29, 2019 approval date of the Categorical Exclusion (CE). In accordance with NCDOT Policy, federal and state governments are not responsible for providing noise abatement measures for traffic noise impacts for which building permits were issued after the Date of Public Knowledge.

The following are design construction elements of the project:

- Typical section consisting of six-lane divided facility with a 22-foot barrier protected median
- Minimum 14-foot outside shoulders (12-foot useable shoulder width plus two feet)
- 10-foot inside median shoulders along I-40
- I-40 / NC 86 interchange reconfiguration and improvements
- Design speed of 70 mph and posted speed of 65 mph

Because this project involves the construction of new through-traffic lanes, it is a Type I project per FHWA 23 CFR 772 and NCDOT Policy.

Figure 1 shows the study area map for the project. There are 36 Noise Study Areas (NSAs), labeled 01 through 35 including 22a and 22b. Each NSA contains noise-sensitive land uses with similar noise environments.

This DNR documents the project final design noise analysis of predicted traffic noise impacts and noise abatement assessments. The noise analysis was performed utilizing validated computer models created with the Federal Highway Administration Traffic Noise Model® (FHWA TNM v.2.5) to predict future noise levels in areas where traffic noise is dominant, and to define impacted receptors in the project vicinity. A total of 784 discrete receptor locations were modeled. One receptor was modeled to represent each of the 646 residences and 138 receptor locations were modeled to represent 25 non-residential Equivalent Receptors (ERs). The project final design will require acquisition of one residence represented by one modeled receptor for right-of-way.

Design Year 2045 build condition traffic noise is predicted to impact 109 residences and 4 non-residential ERs represented by 24 discrete modeled receptor locations for a total of 113 impacts. Noise abatement was considered for all predicted traffic noise impacts. Fourteen noise walls under the Build Alternative were evaluated for their ability to feasibly and reasonably reduce noise levels at impacted receptors.

With a total length of 5,760 feet and a total area of 96,858 square feet, the following four noise abatement measures for the corresponding predicted traffic noise impacts in the I-3306A project vicinity are recommended for construction, pending completion of the public involvement process:

- **Noise Wall 06 (NW06) –** Adjacent to I-40 westbound between SR 1006 (Orange Grove Road) and I-85: With a length of 1,440 feet and an area of 19,427 square feet, the optimal NW06 configuration will benefit 17 total receptors, including 16 of 23 predicted traffic noise impacts, and 15 receptors will receive at least a 7 decibel (7 dB(A)) noise level reduction. At 1,143 square feet per benefit, NW06 will meet the applicable area per benefit Policy cost reasonableness criterion of 1,500 square feet. Refer to Section 11 and Figures 2-2 and 2-2A-1 for additional information pertaining to NW06 analysis.
- **Noise Wall 13 (NW13) –** Adjacent to I-40 westbound east of SR 1009 (Old NC 86): With a length of 1,155 feet and an area of 24,880 square feet, the optimal NW13 configuration will benefit 25 total receptors, including 10 of 10 predicted traffic noise impacts, and 11 receptors will receive at least a 7 decibel (7 dB(A)) noise level reduction. At 995 square feet per benefit, NW13 will meet the applicable area per benefit Policy cost reasonableness criterion of 1,500 square feet. Refer to Section 11 and Figures 2-5 and 2-6 for additional information pertaining to NW13 analysis.
- **Noise Wall 22b (NW22b) –** Adjacent to NC 86 southbound north of the access to Hilltop Mobile Home Park: With a length of 420 feet and an area of 5,753 square feet, the optimal NW22b configuration will benefit four total receptors, including four of four predicted traffic noise impacts, and four receptors will receive at least a 7 decibel (7 dB(A)) noise level reduction. At 1,438 square feet per benefit, NW22b will meet the applicable area per benefit Policy cost reasonableness criterion of 1,500 square feet. Refer to Section 11 and Figures 2-11 and 2-12 for additional information pertaining to NW22b analysis.
- **Noise Wall 32 (NW32) –** Adjacent to I-40 eastbound between SR 1732 (Sunrise Road) and SR 1734 (Erwin Road): With a length of 2,745 feet and an area of 46,798 square feet, the optimal NW32 configuration will benefit 40 total receptors, including 19 of 19 predicted traffic noise impacts, and 24 receptors will receive at least a 7 decibel (7 dB(A)) noise level reduction. At 1,170 square feet per benefit, NW32 will meet the applicable area per benefit Policy cost reasonableness criterion of 1,500 square feet. Refer to Section 11 and Figures 2-16 and 2-17 for additional information pertaining to NW32 analysis.

The following ten noise abatement measures for the following predicted traffic noise impacts are not feasible and reasonable and will not be constructed:

- **Noise Wall 02 (NW02) –** Adjacent to I-40 westbound west of SR 1134 (Dimmocks Mill Road): With a length of 765 feet and an area of 22,950 square feet, the optimal NW02 configuration would benefit 2 total receptors, including 2 of 2 predicted traffic noise impacts, and one receptor would receive at least a 7 decibel (7 dB(A)) noise level reduction. The optimal NW02 configuration would be acoustically feasible and acoustically reasonable, however, at 11,475 square feet per benefit NW02 would exceed the allowable 1,500 square feet per benefit Policy cost reasonableness criterion. Refer to Section 11 and Figure 2-1 for additional information pertaining to NW02 analysis.
- **Noise Wall 03 (NW03) –** Adjacent to I-40 eastbound east of SR 1134 (Dimmocks Mill Road): With a length of 1,380 feet and an area of 41,400 square feet, the optimal NW03 configuration would benefit only one receptor, including one of the two predicted traffic

noise impacts. The optimal NW03 configuration would not meet the Policy acoustical feasibility criterion. Refer to Section 11 and Figures 2-1 and 2-2 for additional information pertaining to NW03 analysis.

- **Noise Wall 09 (NW09) –** Adjacent to I-40 westbound east of SR 1006 (Orange Grove Road): With a length of 300 feet and an area of 3,080 square feet, the optimal NW09 configuration would benefit two total receptors, including two of three predicted traffic noise impacts, and one receptor would receive at least a 7 decibel (7 dB(A)) noise level reduction. The optimal NW09 configuration would be acoustically feasible and acoustically reasonable; however, at 1,540 square feet per benefit NW09 would exceed the allowable 1,500 square feet per benefit Policy cost reasonableness criterion. Refer to Section 11 and Figure 2-3 for additional information pertaining to NW09 analysis.
- **Noise Wall 12 (NW12) –** Adjacent to the on-ramp from SR 1009 (Old NC 86) to I-40 eastbound: With a length of 540 feet and an area of 5,132 square feet, the optimal NW12 configuration would benefit two total receptors, including two of four predicted traffic noise impacts, and one receptor would receive at least a 7 decibel (7 dB(A)) noise level reduction. The optimal NW12 configuration would be acoustically feasible and acoustically reasonable; however, at 2,566 square feet per benefit NW12 would exceed the allowable 1,500 square feet per benefit Policy cost reasonableness criterion. Refer to Section 11 and Figures 2-5 and 2-6 for additional information pertaining to NW12 analysis.
- **Noise Wall 14 (NW14) –** Adjacent to I-40 westbound north of SR 1723 (New Hope Church Road): With a length of 3,960 feet and an area of 72,960 square feet, the optimal NW14 configuration would benefit four total receptors, including three of three predicted traffic noise impacts, and four receptors would receive at least a 7 decibel (7 dB(A)) noise level reduction. The optimal NW14 configuration would be acoustically feasible and acoustically reasonable; however, at 18,240 square feet per benefit NW14 would exceed the allowable 1,500 square feet per benefit Policy cost reasonableness criterion. Refer to Section 11 and Figures 2-6 and 2-7 for additional information pertaining to NW14 analysis.
- **Noise Wall 17 (NW17) –** Adjacent to I-40 westbound south of SR 1723 (New Hope Church Road): With a length of 1,080 feet and an area of 16,216 square feet, the optimal NW17 configuration would benefit seven total receptors, including six of 11 predicted traffic noise impacts, and two receptors would receive at least a 7 decibel (7 dB(A)) noise level reduction. The optimal NW17 configuration would be acoustically feasible and acoustically reasonable; however, at 2,317 square feet per benefit NW17 would exceed the allowable 1,500 square feet per benefit Policy cost reasonableness criterion. Refer to Section 11 and Figures 2-8, 2-9, and 2-10 for additional information pertaining to NW17 analysis.
- **Noise Wall 20 (NW20) –** Adjacent to I-40 westbound over SR 1725 (Millhouse Road): With a length of 900 feet and an area of 10,969 square feet, the optimal NW20 configuration would benefit six total receptors, including five of five predicted traffic noise impacts, and one receptor would receive at least a 7 decibel (7 dB(A)) noise level reduction. The optimal NW20 configuration would be acoustically feasible and acoustically reasonable; however, at 1,828 square feet per benefit NW20 would exceed the allowable 1,500 square feet per benefit Policy cost reasonableness criterion. Refer to Section 11 and Figures 2-10 and 2-11 for additional information pertaining to NW20 analysis.

- **Noise Wall 22a (NW22a) –** Adjacent to I-40 westbound north of NC 86 (Martin Luther King Jr. Boulevard): With a length of 1,080 feet and an area of 14,301 square feet, the optimal NW22a configuration would benefit two total receptors, including two of two predicted traffic noise impacts, and two receptors would receive at least a 7 decibel (7 dB(A)) noise level reduction. The optimal NW22a configuration would be acoustically feasible and acoustically reasonable; however, at 7,150 square feet per benefit NW22a would exceed the allowable 1,500 square feet per benefit Policy cost reasonableness criterion. Refer to Section 11 and Figures 2-11 and 2-12 for additional information pertaining to NW22a analysis.
- **Noise Wall 22b2 (NW22b2) –** Adjacent to the onramp from NC 86 (Martin Luther King Jr. Boulevard) to I-40 westbound: With a length 1,530 feet and an area of 40,348 square feet, the optimal NW22b2 configuration would benefit 15 total receptors, including three of three predicted traffic noise impacts, and one receptor would receive at least a 7 decibel (7 dB(A)) noise level reduction. The optimal NW22b2 configuration would be acoustically feasible and acoustically reasonable; however, at 2,690 square feet per benefit NW22b2 would exceed the allowable 1,500 square feet per benefit Policy cost reasonableness criterion. Refer to Section 11 and Figures 2-11 and 2-12 for additional information pertaining to NW22b2 analysis.
- **Noise Wall 26 (NW26) –** Adjacent to I-40 westbound east of NC 86 (Martin Luther King Jr. Boulevard): With a length of 1,680 feet and an area of 22,566 square feet, the optimal NW26 configuration would benefit six total receptors, including five of five predicted traffic noise impacts, and one receptor would receive at least a 7 decibel (7 dB(A)) noise level reduction. The optimal NW26 configuration would be acoustically feasible and acoustically reasonable; however, at 3,761 square feet per benefit NW26 would exceed the allowable 1,500 square feet per benefit Policy cost reasonableness criterion. Refer to Section 11 and Figures 2-14 and 2-15 for additional information pertaining to NW26 analysis.

The final decision on the installation of an abatement measure shall be made upon completion of the public involvement process.

The major construction elements of this project are expected to be earth removal, tree clearing, hauling, grading, bridge construction, and paving. General construction noise impacts, such as temporary speech interference for passers-by and those individuals living or working near the project, can be expected particularly from paving operations, pile driving at bridges, and earth moving equipment during grading operations.

Construction noise impacts may occur due to the close proximity of numerous noise-sensitive receptors to project construction activities. It is the recommendation of this DNR that all reasonable efforts should be made to minimize exposure of noise-sensitive areas to construction noise impact.

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1 Project Location, Description, and Background

The North Carolina Department of Transportation (NCDOT) is constructing the I-3306A Design-Build Project in Orange County, which is widening I-40 from I-85 to the Durham County Line, a distance of approximately 11.4 miles. The Project will provide a six-lane facility and improve the I-40 / NC 86 interchange. The project is included in the State Transportation Improvement Program (STIP) as I-3306A. Federal funds are used for this project.

The project Date of Public Knowledge is the March 29, 2019 approval date of the Categorical Exclusion (CE). In accordance with NCDOT Policy, federal and state governments are not responsible for providing noise abatement measures for traffic noise impacts for which building permits were issued after the Date of Public Knowledge. NCDOT advocates the use of local government authority to regulate land development, planning, design and construction in such a way that noise impacts are minimized.

Because this project involves the addition of through-traffic lanes, it is a Type I project per FHWA 23 CFR 772 and NCDOT Policy.

A Traffic Noise Report (TNR) was accepted in March 2019 and was addended with analysis for additional areas in June 2021. The purpose of this DNR is to reexamine the I-3306A project using the final design data and geometry. This report documents the evaluation of noise impacts and assessment of traffic noise abatement for noise sensitive land uses in the project, and has been prepared in accordance with 23 CFR 772, the NCDOT Traffic Noise Policy effective October 6, 2016 (Policy), and the accompanying NCDOT Traffic Noise Manual effective October 6, 2016, updated January 2017 (Manual).

For this DNR, final designs were utilized for build-condition traffic noise modeling and evaluation with a design year of 2045. The new roadway will construct a six-lane, divided freeway with paved shoulders and a double-faced barrier-divided median in order to improve roadway connectivity, reduce traffic congestion, improve mobility, and enhance safety. The total project length is approximately 11.4 miles. The proposed design speed is 70 miles per hour (mph) with a posted speed of 65 mph. This DNR uses a 70 mph design speed. All noise abatement measures analyzed herein have been evaluated for feasibility and reasonableness. It was assumed that the surrounding roadways would maintain their existing speed limits.

The following are design construction elements of the project:

- Typical section consisting of six-lane divided facility with a 22-foot barrier protected median
- Minimum 14-foot outside shoulders (12-foot useable shoulder width plus two feet)
- 10-foot inside median shoulders along I-40
- I-40 / NC 86 interchange reconfiguration and improvements
- Design speed of 70 mph and posted speed of 65 mph

1.1 Land Uses and Noise Study Areas

Figure 1 shows the study area map for the project. A total of 784 discrete receptor locations were modeled. One receptor was modeled to represent each of the 646 residences and 138 receptor locations were modeled to represent 25 non-residential Equivalent Receptors (ERs). The project final design will require acquisition of one residence represented by one modeled receptor location, for right-of-way. Each noise study area (NSA) is included on the map. There are 36 NSAs, labeled 01 through 35 including 22a and 22b. Each NSA contains noise-sensitive land uses with similar noise environments. Receptors within each NSA are shown in Figure 2.

Noise Study Area 01

NSA 01 includes the area south of I-40 west of SR 1134 (Dimmocks Mill Road). NSA 01 contains one single-family residence. The receptor within NSA 01 appears in Figure 2-1.

Noise Study Area 02

NSA 02 includes the area north of I-40 west of SR 1134 (Dimmocks Mill Road). NSA 02 contains two single-family residences. The receptors within NSA 02 appear in Figure 2-1.

Noise Study Area 03

NSA 03 includes the area south of I-40 east of SR 1134 (Dimmocks Mill Road). NSA 03 contains two single-family residences. The receptors within NSA 03 appear in Figures 2-1 and 2-2.

Noise Study Area 04

NSA 04 includes the area north of I-40 east of SR 1134 (Dimmocks Mill Road). NSA 04 contains two single-family residences. The receptors within NSA 04 appear in Figure 2-1.

Noise Study Area 05

NSA 05 includes the area south of I-40 between the interchange with I-85 and SR 1006 (Orange Grove Road). NSA 05 contains 1 receptor representing Cedar Ridge High School, and 47 receptor points representing the school athletic field, which represent 0.02 ER each, rounding up to 1 ER. The receptors within NSA 05 appear in Figure 2-2.

Noise Study Area 06

NSA 06 includes the area east of I-40 north of SR 1006 (Orange Grove Road). NSA 06 contains 91 single-family residences. The receptors within NSA 06 appear in Figures 2-2, 2A-1, and 3A-1.

Noise Study Area 07

NSA 07 includes the area west of I-40 south of SR 1006 (Orange Grove Road). NSA 07 contains 12 single-family residences. The receptors within NSA 07 appear in Figures 2-2 and 2-3.

Noise Study Area 08

NSA 08 includes the area east of I-40 south of SR 1006 (Orange Grove Road) and north of SR 1133 (Oakdale Drive). NSA 08 contains 43 single-family residences. The receptors within NSA 08 appear in Figures 2-2, 2-3, and 3A-1.

Noise Study Area 09

NSA 09 includes the area east of I-40 south of SR 1133 (Oakdale Drive). NSA 09 contains 26 single-family residences. The receptors within NSA 09 appear in Figures 2-3, 2-4, and 3A-1.

Noise Study Area 10

NSA 10 includes the area south of I-40 west of SR 1009 (Old NC 86). NSA 10 contains five single-family residences. The receptors within NSA 10 appear in Figure 2-5.

Noise Study Area 11

NSA 11 includes the area north of I-40 west of SR 1009 (Old NC 86). NSA 11 contains one single-family residence. The receptor within NSA 11 appears in Figure 2-5.

Noise Study Area 12

NSA 12 includes the area south of I-40 east of SR 1009 (Old NC 86). NSA 12 contains six single-family residences. The receptors within NSA 12 appear in Figures 2-5 and 2-6.

Noise Study Area 13

NSA 13 includes the area north of I-40 east of SR 1009 (Old NC 86). NSA 13 contains 48 single-family residences and one receptor representing the UNC Hospitals Hillsborough Campus. The receptors within NSA 13 appear in Figures 2-5 and 2-6.

Noise Study Area 14

NSA 14 includes the area east of I-40 south of NSA 13 and north of SR 1723 (New Hope Church Road). NSA 14 contains three single-family residences and 16 receptors representing the Blackwood Farm Park Trail, which represent 0.01 ER each, rounding up to 1 ER. The receptors within NSA 14 appear in Figures 2-6 and 2-7.

Noise Study Area 15

NSA 15 includes the area west of I-40 north of SR 1723 (New Hope Church Road). NSA 15 contains two single-family residences. The receptors within NSA 15 appear in Figure 2-8.

Noise Study Area 16

NSA 16 includes the area west of I-40 south of SR 1723 (New Hope Church Road). NSA 16 contains three single-family residences. The receptors within NSA 16 appear in Figures 2-8 and 2-9.

Noise Study Area 17

NSA 17 includes the area east of I-40 south of SR 1723 (New Hope Church Road). NSA 17 contains three receptors representing Sunrise Church and its outdoor areas of human use, and 26 single-family residences. The receptors within NSA 17 appear in Figures 2-8, 2-19, and 2-10.

Noise Study Area 18

NSA 18 includes the area east of I-40 north of SR 1725 (Millhouse Road). NSA 18 contains six single-family residences. The receptors within NSA 18 appear in Figure 2-10.

Noise Study Area 19

NSA 19 includes the area west of I-40 north of SR 1725 (Millhouse Road). NSA 19 contains one receptor representing the playground of Emerson Waldorf School. The receptor within NSA 19 appears in Figure 2-10.

Noise Study Area 20

NSA 20 includes the area east of I-40 south of SR 1725 (Millhouse Road). NSA 20 contains six single-family residences. The receptors within NSA 20 appear in Figure 2-10.

Noise Study Area 21

NSA 21 includes the area south of I-40 west of NC 86 and north of SR 1727 (Eubanks Road). NSA 21 contains one single-family residence. The receptor within NSA 21 appears in Figure 2-13.

Noise Study Area 22a

NSA 22a includes the area east of I-40 along SR 2200 (Clyde Road). NSA 22a contains three single-family residences. The receptors within NSA 22a appear in Figure 2-11.

Noise Study Area 22b

NSA 22b includes the area north of I-40 west of NC 86. NSA 22b contains 33 single-family residences. The receptors within NSA 22b appear in Figures 2-11 and 2-12.

Noise Study Area 23

NSA 23 includes the area north of SR 1730 (Whitfield Road). NSA 23 contains six single-family residences. The receptors within NSA 23 appear in Figures 2-12 and 2-14.

Noise Study Area 24

NSA 24 includes the area west of NC 86 and south of SR 1727 (Eubanks Road). NSA 24 contains 18 single-family residences and two receptors representing North Chapel Hill Baptist Church and its outdoor seating area. The receptors within NSA 24 appear in Figures 2-12, 2-13, and 2-14.

Noise Study Area 25

NSA 25 includes the area south of I-40 east of NC 86. NSA 25 contains one receptor representing a restaurant with outdoor seating, 114 receptors representing apartment residences, and 24 receptor points representing outdoor recreational areas associated with the apartment community, including a basketball court, dog park, garden, patio, playground, picnic areas, and trails. A total of eight ERs are represented by the 24 recreational area receptor points. The receptors within NSA 25 appear in Figures 2-14 and 2-14A-1 through 2-14A-4.

Noise Study Area 26

NSA 26 includes the area north of I-40 east of SR 1730 (Whitfield Road). NSA 26 contains eight single-family residences. The receptors within NSA 26 appear in Figures 2-14 and 2-15.

Noise Study Area 27

NSA 27 includes the area south of I-40 from Vilcom Center Drive to Essex Drive. NSA 27 contains 28 receptors representing apartment residences, and one receptor representing St. Benedict’s Anglican Church. The receptors within NSA 27 appear in Figures 2-14, 2-15, and 2-15A-1.

Noise Study Area 28

NSA 28 includes the area north of I-40 between NSA 26 and NSA 30. NSA 28 contains 18 single-family residences. The receptors within NSA 28 appear in Figures 2-15, 2-16, and 2-15A-1.

Noise Study Area 29

NSA 29 includes the area south of I-40 east of NSA 27 and west of SR 1732 (Sunrise Road). NSA 29 contains 25 receptors representing apartment, cottage, duplex cottage, and townhome residences in the Carol Woods development, and 40 receptor points representing recreational uses in the development, including a dog park, gardens, and trails. A total of 4 ERs are represented by the 40 recreational area receptor points. The receptors within NSA 29 appear in Figures 2-15 and 2-15A-1.

Noise Study Area 30

NSA 30 includes the area north of I-40 east of NSA 28 and west of SR 1732 (Sunrise Road). NSA 30 contains five single-family residences. The receptors within NSA 30 appear in Figure 2-16.

Noise Study Area 31

NSA 31 includes the area north of I-40 east of SR 1732 (Sunrise Road). NSA 31 contains two single-family residences and the Chapel Hill Wesleyan Church. The receptors within NSA 31 appear in Figure 2-16.

Noise Study Area 32

NSA 32 includes the area south of I-40 between SR 1732 (Sunrise Road) and SR 1734 (Erwin Road). NSA 32 contains 95 single-family residences. The receptors within NSA 32 appear in Figures 2-16 and 2-17.

Noise Study Area 33

NSA 33 includes the area north of I-40 at the end of SR 1897 (Dry Creek Road). NSA 33 contains two single-family residences. The receptors within NSA 33 appear in Figure 2-17.

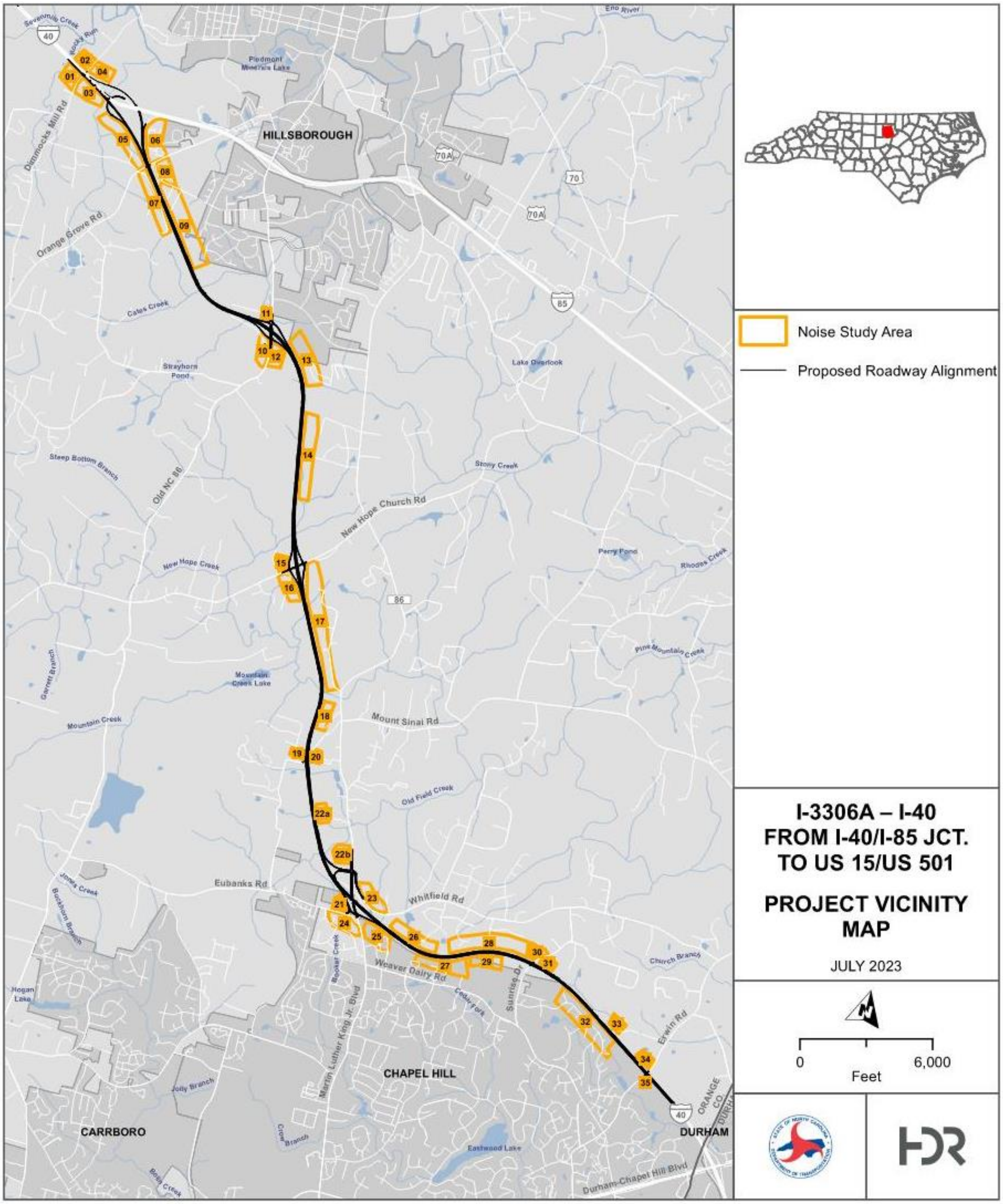
Noise Study Area 34

NSA 34 includes the area north of I-40 west of SR 1734 (Erwin Road). NSA 34 contains two single-family residences. The receptors within NSA 34 appear in Figure 2-18.

Noise Study Area 35

NSA 35 includes the area south of I-40 east of SR 1734 (Erwin Road). NSA 35 contains one single-family residence. The receptor within NSA 35 appears in Figure 2-18.

Figure 1. Project Vicinity Map



2 Procedure

This DNR documents the Final Design Noise Analysis of the predicted traffic noise impacts and assessment of acceptable noise abatement measures for the I-40 Widening from I-85 in Orange County to the Durham County Line project (TIP#: I-3306A).

The analysis herein has been prepared in accordance with the NCDOT Policy and the accompanying Manual, as well as Title 23 Code of Federal Regulations, Part 772 (23 CFR 772). The Policy is applicable to projects with a Date of Public Knowledge on or after the effective date of the Policy. Accordingly, the Policy and accompanying Manual were used in this DNR analysis to assess traffic noise impacts and evaluate noise abatement measures. Where FHWA has given highway agencies flexibility in executing the 23 CFR 772 standards, Policy describes the NCDOT approach to implementation.

The noise measurement procedures that were used considered the methodologies contained in the FHWA publication *Noise Measurement Handbook* (FHWA-HEP-18-065). These measurements assisted in validating the project noise modeling, and in establishing baseline ambient noise levels. The short-term measurements were conducted on November 15-18, 2021 and January 18-19, 2022.

In accordance with the Manual, the FHWA Traffic Noise Model® (TNM v.2.5) was used to predict base year 2019 existing and design year 2045 hourly equivalent traffic noise levels, $L_{eq(h)}$, for the noise-sensitive land uses along the project corridor in areas where traffic noise is dominant. TNM models for the build case were created using the final project design.

The NCDOT noise abatement criteria and the increase over base year 2019 existing levels were used to evaluate potential noise impacts (see Section 10). Once impacts were identified, NCDOT criteria were applied to evaluate noise abatement feasibility and reasonableness (see Section 11).

Project-related construction noise is discussed in Section 13.

3 Characteristics of Noise

Noise can be described as unwanted or excessive sound that may interfere with communication or disturb the community. It is emitted from many sources including airplanes, factories, railroads, commercial businesses, and highway vehicles. Roadway vehicle noise (traffic noise) consists of three primary parts: tire noise, engine noise, and exhaust noise. Of these sources, tire noise is typically the most offensive at unimpeded travel speeds.

The magnitude of noise is usually described by a ratio of its sound pressure to a reference sound pressure, which is usually 20 micropascals (20µPa). Since the range of sound pressure ratios varies greatly over many orders of magnitude, a base-10 logarithmic scale is used to express sound levels in dimensionless units of decibels (dB). The commonly accepted limits of human hearing to detect sound magnitudes are between the threshold of hearing at 0 dB and the threshold of pain at 140 dB.

Sound frequencies are represented in units of Hertz (Hz), which correspond to the number of vibrations per second of a given tone. A cumulative sound level is equivalent to ten times the base-10 logarithm of the ratio of the sum of the sound pressures of all frequencies to the reference sound pressure. To simplify the mathematical process of determining sound levels, sound frequencies are grouped into ranges, or bands. Sound levels are then calculated by adding the cumulative sound pressure levels within each band – which are typically defined as either one octave or 1/3 octave of the sound frequency spectrum.

The commonly accepted limitation of human hearing to detect sound frequencies is between 20 Hz and 20,000 Hz, and human hearing is most sensitive to the frequencies between 1,000 Hz and 6,000 Hz. Although people are generally not as sensitive to lower-frequency sounds as they are to higher frequencies, most people lose the ability to hear high frequency sounds as they age. To accommodate varying receptor sensitivities, frequency sound levels are commonly adjusted, or filtered, before being logarithmically added and reported as a single sound level magnitude of that filtering scale. For traffic noise purposes the A-weighted scale is used, which provides a single number measure that weighs different frequencies in a manner similar to the sensitivity of the human ear. Thus, the A-weighted sound level in decibels, expressed in dB(A), provides a simple measure of intensity and frequency that correlate well with the human response to environmental noise.

The A-weighted decibel filtering scale applies numerical adjustments to sound frequencies to emphasize the frequencies at which human hearing is sensitive, and to minimize the frequencies to which human hearing is not as sensitive. This concept is demonstrated for a truck in Table 1, below.

Table 1. Comparison of Unweighted vs. A-Weighted Sound Levels for a Truck

Octave-Band Center Frequency (Hz)	A	B	C = A + B
	Unweighted Sound Level from a Truck (dB)	Adjustment of Unweighted Sound to Represent What Human Ear Hears (dB)	Sound Level that Human Ear Perceives = A-Weighted Sound Level or dB(A)
31	75	-39	36
63	78	-26	52
125	83	-16	67
250	84	-9	75
500	81	-3	78
1000	75	0	75
2000	71	1	72
4000	63	1	64
8000	54	-1	53
	89		**82**
	Total Unweighted Sound Level in dB		**Total A-Weighted Sound Level in dB(A)**

Source: Table 3.1, *Traffic Noise Manual*, NCDOT. October 6, 2016. Revised January 2017.

The A-weighted scale is commonly used in highway traffic noise studies because the typical frequency spectrum of traffic noise is higher in magnitude at the frequencies at which human hearing is most sensitive (1,000 Hz to 6,000 Hz). Several examples of noise levels, expressed in dB(A), are listed in Table 2.

Review of Table 2 indicates that most individuals in urbanized areas are exposed to high levels of noise from many sources as they go about their daily activities. The degree of disturbance or annoyance of unwanted sound depends essentially on three things:

- The amount and nature of the intruding noise.
- The relationship between the background noise and the intruding noise.
- The type of activity occurring when the noise is heard.

In considering the first of these factors, it is important to note that individuals have varying sensitivity to noise. Loud noises bother some people more than other people, and some individuals become increasingly upset if an unwanted noise persists. The time patterns of noise also enter into perception as to whether or not a noise is an annoyance. For example, noises that occur during nighttime (sleeping) hours are usually considered more annoying than the same noises in the daytime.

With regard to the second factor, individuals tend to judge the annoyance of an unwanted noise in terms of its relationship to noise from other sources (background noise). The blowing of a car horn at night when background noise levels are approximately 45 dB(A) would generally be more objectionable than the horn blowing in the afternoon when background noises might be 55 dB(A).

The third factor is related to the interference of noise with activities of individuals. In a 60 dB(A) environment, normal conversation would be possible, while sleep might be difficult. Work activities requiring high levels of concentration may be interrupted by loud noises, while activities requiring manual effort may not be interrupted to the same degree. Over time, if the noises occur at predicted intervals, individuals tend to accept the noises that intrude into their lives, i.e., regularly scheduled trains or subways in a city. Attempts have been made to regulate many of these types of noises including airplane noise, factory noise, railroad noise, and highway noise. In relation to highway traffic noise, methods of analysis and control have developed rapidly in recent years.

Table 2. Common Indoor and Outdoor Noise Levels

Common Outdoor Noise Levels	Noise Level (dB(A))	Common Indoor Noise Levels
	110	Rock Band
Jet Flyover at 1,000 feet	100	Inside Subway Train (NY)
Gas Lawn Mower at 3 feet		
Diesel Truck at 50 feet	90	Food Blender at 3 feet
Noisy Urban Daytime	80	Garbage Disposal at 3 feet
Gas Lawn Mower at 100 feet	70	Vacuum Cleaner at 10 feet
Commercial Area		Normal Speech at 3 feet
	60	
		Large Business Office
Quiet Urban Daytime	50	Dishwasher Next Room
Quiet Urban Nighttime	40	Small Theater, Large Conference Room (Background)
Quiet Suburban Nighttime		Library
	30	
Quiet Rural Nighttime		Bedroom at Night, Concert Hall (Background)
	20	
		Broadcast and Recording Studio
	10	
	0	Threshold of Hearing

Source: Table 3.2, *Traffic Noise Manual*, NCDOT. October 6, 2016. Revised 2017. Adapted from Guide on Evaluation and Attenuation of Traffic Noise, American Association of State Highway and Transportation Officials (AASHTO). 1974 (revised 1993).

Lastly, the noise level descriptor used by NCDOT is the equivalent sound pressure level (L_{eq}). L_{eq} is defined as the continuous steady sound level that would have the same total A-weighted sound energy as the real fluctuating sound measured over a given period of time. Traffic noise levels are measured with the hourly equivalent sound pressure level, expressed as $L_{eq(h)}$.

4 Noise Abatement Criteria

4.1 Title 23 Code of Federal Regulations, Part 772 (23 CFR 772)

Under Title 23 CFR 772 the FHWA has developed Noise Abatement Criteria (NAC) and procedures to be used in the planning and design of highways. The purpose of Title 23 CFR Part 772 is:

> *To provide procedures for noise studies and noise abatement measures to help protect the public's health, welfare and livability, to supply noise abatement criteria, and to establish requirements for information to be given to local officials for use in the planning and design of highways approved pursuant to Title 23 United States Code(U.S.C.)* (23 CFR 772.1).

The NAC and procedures are set forth in Title 23 CFR Part 772, which also states:

In determining and abating traffic noise impacts, primary consideration is to be given to exterior areas of frequent human use.

4.2 North Carolina Department of Transportation Traffic Noise Policy

Because the CE was approved on March 29, 2019, the NCDOT *Traffic Noise Policy* effective October 6, 2016 (Policy), establishes official policy on highway noise for this project. This policy sets guidelines for determining traffic noise impacts and abatement measures, including general criteria and specific factors that determine feasibility and reasonableness of noise abatement measures on NCDOT highway projects. This policy is included as Appendix G of this report. Feasibility and reasonableness criteria for noise abatement are defined in Section 11.1.

4.3 Noise Abatement Criteria

The two categories of traffic noise impacts are defined as:

1) Predicted traffic noise levels that "approach" or exceed the FHWA Noise Abatement Criteria (NAC). An approaching noise level is defined by NCDOT as being 1 dB(A) less than the noise level listed as the FHWA NAC for Activity Categories A through E in Table 3.
2) Predicted traffic noise levels that "substantially increase" over existing noise levels. NCDOT defines a "substantial increase" when the predicted future hourly equivalent noise level exceeds existing ambient noise levels by 10 dB(A).

A summary of the NAC for various land uses is presented in Table 3.

Table 3. Noise Abatement Criteria

Hourly Equivalent A-Weighted Sound Level (decibels (dB(A)))			
Activity Category	Activity Criteria[1] $L_{eq(h)}$[2]	Evaluation Location	Activity Description
A	57	Exterior	Lands on which serenity and quiet are of extraordinary significance and serve an important public need, and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose.
B[3]	67	Exterior	Residential
C[3]	67	Exterior	Active sport areas, amphitheaters, auditoriums, campgrounds, cemeteries, daycare centers, hospitals, libraries, medical facilities, parks, picnic areas, places of worship, playgrounds, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, recreation areas, Section 4(f) sites, schools, television studios, trails, and trail crossings.
D	52	Interior	Auditoriums, day care centers, hospitals, libraries, medical facilities, places of worship, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, schools, and television studios.
E[3]	72	Exterior	Hotels, motels, offices, restaurants/bars, and other developed lands, properties or activities not included in A-D or F.
F	--	--	Agriculture, airports, bus yards, emergency services, industrial, logging maintenance facilities, manufacturing, mining, rail yards, retail facilities, shipyards, utilities (water resources, water treatment, electrical), and warehousing.
G	--	--	Undeveloped lands that are not permitted.

Source: Table 9.2, *Traffic Noise Manual*, NCDOT. October 6, 2016. Revised January 2017.

[1] The $L_{eq(h)}$ Activity Criteria values are for impact determination only, and are not design standards for noise abatement measures.

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

[3] Includes undeveloped lands permitted for this activity category.

For Category D receptors, interior noise levels were evaluated using Table 4. All six Category D receptors in the study area were determined to be of masonry construction with single glazed windows or light frame construction with storm windows, for an outdoor to indoor noise reduction of 25 dB.

Table 4. Building Noise Reduction Factors

Building Type	Window Condition[1]	Noise Reduction Due to Exterior of the Structure
All	Open	10 dB
Light Frame	Ordinary Sash (closed)	20 dB
	Storm Windows	25 dB
Masonry	Single Glazed	25 dB
	Double Glazed	35 dB

Source: Table 8.3, *Traffic Noise Manual*, NCDOT. October 6, 2016. Revised January 2017.

[1] The windows shall be considered open unless there is firm knowledge that the windows are in fact kept closed almost every day of the year.

5 Ambient Noise Levels

Ambient noise is the combination of all noise sources that occur in an area, typically described for a specific environment, location, and/or period of time. Ambient noise level data are obtained to quantify the existing acoustic environment, provide a basis for assessing the existing loudest-hour traffic noise levels, define noise levels in the areas for which traffic and/or construction noise may create an impact or impacts, and define noise levels in the areas for which traffic and/or construction noise does not create impacts.

5.1 Ambient Noise Level Monitoring

Noise monitoring along the project corridor was performed during two periods: November 15-18, 2021, and January 18-19, 2022. The measurements were used to validate the use of FHWA's Traffic Noise Model.

Noise measurements and concurrent traffic data were collected at 73 individual monitoring sites during 40 short-term monitoring sessions on November 15-18, 2021, and January 18-19, 2022. Representative field measurement sites along the project corridor were chosen based on proximity and area characteristics or noise-sensitive receptors. Depending on the presence of traffic noise sources, each location consisted of either a single sound level meter (SLM) or an array of two or three SLMs. Measured noise levels ranged from 50 dB(A) to 72 dB(A). See Appendix A for detailed information for each measurement including start and stop times, weather conditions, traffic data collected, photographs of meter set-ups, and documentation of any other contributing noise sources or events.

The short-term measurements were performed with three Larson Davis 831C Type I SLMs. Calibration certificates are included in Appendix A. The results from the short-term measurements were used in noise model validation.

Because noise barriers can only reduce traffic noise levels and per Manual definition of Noise Level Reduction (NLR), with-barrier sound levels were screened against measured or otherwise quantified noise sources. Collected ambient levels for each NSA with measurement source designations are shown in Table 5 below.

Table 5. Ambient Noise Levels

NSA	Ambient Sound Level (dBA)	Measurement Source
05	59	M5.1
06	55	M6.3
13	54	M13.6
17	54	M17.2
22b	55	M22b.3
32	50	M32.6

Additional noise measurement data, including site photographs, field monitoring logs, and annual laboratory calibration sheets, are included in Appendix A.

5.2 Classified Traffic Counts and Vehicle Speed Data

Traffic counts and vehicle speed data were noted on the log sheets for each short-term measurement, which can be found in Appendix A. During the traffic noise measurements, the speeds of passing vehicles were measured by handheld radar speed detector.

5.3 Weather

Weather conditions during all fieldwork periods were generally clear with dry pavement and low wind speeds. Weather conditions for individual measurements were noted on the log sheets for each measurement, which can be found in Appendix A.

6 Noise Model Validation

Title 23 CFR 772.11(d)(2) requires that the analysis of traffic noise impacts, for projects on new or existing alignments, validate predicted noise levels through comparison between measured and predicted levels. A TNM model is considered ‘validated’ if it is a reasonable representation of the existing noise sensitive area and/or project area, and the TNM-predicted noise levels are within the acceptable tolerance of the noise level data obtained in the field. The NCDOT-accepted tolerance for TNM model validation is ±3.0 decibels (±3.0 dB(A)).

In accordance with Policy, this DNR utilized validated computer models created with TNM v.2.5 to predict noise levels (baseline and future conditions) and define impacted receptors along the project. Validation results are located in Appendix A. TNM predicted traffic noise levels to within ±3.0 dB(A) for 71 of the 72 short-term monitoring locations for which traffic was the dominant noise source. The TNM-predicted traffic noise level at M6.3 was more than -3.0 dB(A) below the monitored level because traffic was not the dominant source at M6.3 during noise monitoring. The TNM-predicted traffic noise level at M22b.3 of more than +3.0 dB(A) above the monitored level is considered aberrant. Since TNM-predicted traffic noise levels at M22b.1 and M22b.2 (much closer to NC 86) were well within the ±3.0 dB(A) validation tolerance, the aberrant validation result at M22b.3 does not affect considerations for NSA 22b noise abatement.

7 Procedure for Predicting Existing Noise Levels

Base year 2019 existing noise conditions within the study area were evaluated to assist in determining the noise impacts of the proposed project. Noise levels have been predicted for the hour of the day when the vehicle volume, operating speed and number of heavy trucks combine to produce the worst traffic noise conditions. This condition usually occurs at the Level of Service (LOS) C/D threshold. A traffic forecast was prepared for the project to develop future traffic volumes in 2045 and is documented in the *Traffic Forecast Update for I-3306A* dated July 2019. The forecasted traffic volumes for the base year 2019 existing and design year 2045 build conditions were converted to peak hour volumes utilizing the K factors provided in the report to determine the highest two-way volume anticipated along each roadway segment throughout the day (Design Hourly Volumes).

7.1 Noise-Sensitive Sites

A receptor is a discrete or representative location of a noise-sensitive site or area for any of the land use categories listed in Table 3. Noise-sensitive land use in the project were represented by a total of 784 discrete receptor locations. One receptor was modeled to represent each of the 646 residences and 138 receptor locations were modeled to represent 25 non-residential Equivalent Receptors (ERs). The project final design will require acquisition of one residence represented by one modeled receptor for right-of-way. The receptors were grouped into 36 NSAs, as described in Section 1.1.

In determining traffic noise impacts, primary consideration is given to exterior areas where frequent human use occurs. If no exterior areas of frequent human use exist, no further analysis is required, with the exception being any impacted Category D land uses. At least one receptor was modeled for each noise-sensitive property within the study area, with some non-residential exterior areas of frequent human use modeled as a grid or array of receptors according to the guidance in the Manual. ER values for non-residential receptors were calculated based on usage data or assumptions for receptors that were impacted and/or included in noise wall analyses. For other non-residential receptors, ERs were assigned by dividing one ER across all points representing a given use[1]. The location of each receptor is shown on the detailed mapping figures presented in Section 16.

For this DNR, base year 2019 existing loudest-hour noise levels were assessed as the TNM-predicted noise levels in areas where traffic noise was dominant. The TNM-predicted noise levels were based on existing loudest-hour traffic estimates for each of these NSAs and the receptors contained within.[2] Under the base year 2019 existing conditions, exterior L_{eq} sound levels range from 43 dB(A) to 74 dB(A) and are a result of a given sensitive receptor's proximity to traffic on existing roadways.

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[1] For example, a trail with 10 receptor points that was not impacted or included in a noise wall analysis would have an ER value of 1/10=0.1 for each point, for 1 ER total.

[2] Existing noise levels are defined as "the worst noise hour resulting from a combination of natural and mechanical sources and human activity usually present in a particular area."

8 Traffic Data

Traffic noise consists of three primary parts: tire/pavement noise, engine noise, and exhaust noise. Of these sources, tire noise is typically the most offensive at unimpeded travel speeds. Sporadic traffic noises such as horns, squealing brakes, screeching tires, etc. are considered aberrant and are not included within the predictive model algorithm. Traffic noise is not constant; it varies in time depending upon the number, speed, type, and frequency of vehicles that pass by a given receptor. Furthermore, since traffic noise emissions are different for various types of vehicles, the TNM algorithm distinguishes between the source emissions from the following vehicle types: automobiles, medium trucks, heavy trucks, buses, and motorcycles (see Table 6).

Table 6. Traffic Noise Model (TNM) Vehicle Classification Types

TNM Vehicle Type	Description
Autos	All vehicles with two axles and four tires, including passenger cars and light trucks, weighing 10,000 pounds or less
Medium Trucks	All vehicles having two axles and six tires, weighing between 10,000 and 26,000 pounds
Heavy Trucks	All vehicles having three or more axles, weighing more than 26,000 pounds
Buses	All vehicles designed to carry more than nine passengers
Motorcycles	All vehicles with two or three tires and an open-air driver/passenger compartment

Sources: FHWA Measurement of Highway-Related Noise, § 5.1.3 Vehicle Types
FHWA Traffic Monitoring Guide § 4.1 Classification Schemes

TNM modeled traffic volumes were calculated from the "*Traffic Forecast Update for I-3306A (I-40 widening) in Durham and Orange Counties*" dated July 2019. In accordance with Manual §8.4, the number of automobiles, medium trucks, and heavy trucks for a given roadway segment were calculated as the Average Annual Daily Traffic multiplied by the Design Hour Volume (AADT x DHV). Truck restrictions are not anticipated for any through-traffic lanes throughout the project; therefore, predicted volumes of the three vehicle classifications were distributed evenly across all modeled lanes for each roadway segment.

Numerous empirical evaluations and theoretical assessments have confirmed a widely accepted relationship between the loudest traffic hour and the cap of "Level of Service" (LOS) C traffic volumes. If traffic volumes exceed LOS C, vehicles must slow down, and noise emissions are reduced. For roadway segments for which traffic is predicted to exceed LOS C, TNM traffic volume inputs are limited by LOS C thresholds according to 'Hourly Volumes for Level of Service C' from Level of Service C Volumes for Traffic Noise Modeling (Institute for Transportation Research and Education (ITRE) / North Carolina State University. September 19, 2018). Refer to Appendix F for the modeled roadway segments for which TNM traffic volume inputs were limited by LOS C thresholds.

A design speed of 70 mph was used in the modeling for the final design. See Appendix F for the traffic data used in this study.

Final plans of the project improvements were used for the DNR. According to guidance from the Manual, the predictions documented in this report are based on Design Year 2045 Build-condition traffic conditions resulting in the loudest predicted hourly-equivalent traffic noise levels for each receptor.

The traffic parameters used in the noise model for prediction of existing and predicted noise levels for Design Year (2045) are presented in Appendix F.

9 Procedure for Predicting Future Noise Levels

Traffic noise emission comprises several variables, including the number, types, and travel speeds of the vehicles, as well as the geometry of the roadway(s) on which the vehicles travel. Additionally, variables such as meteorological conditions and intervening topography affect the transmission of traffic noise from the vehicles to noise-sensitive receptors. In accordance with industry standards and accepted best practices, computer models were created using the FHWA TNM v.2.5. These standards and practices were used to determine traffic noise levels for receptors located near the project, and worst-hour future noise levels were predicted using TNM and the calculated ambient noise level at receptors based on the measurements.

The traffic noise prediction model uses the number and type of vehicles on the planned roadway, their speeds (posted for all conditions), the physical characteristics of the road (e.g., curves, hills, depressed, elevated, etc.), receptor location and height, and if applicable, noise wall type, noise wall ground elevation, and noise wall segment top elevations. Final project plans for the recommended design alternative were used in this DNR. According to FHWA guidance, the predictions documented in this report are based upon the proposed roadway alignment design and 2045 traffic conditions used to predict the loudest hourly-equivalent traffic noise levels for each receptor.

10 Traffic Noise Impacts

NCDOT considers traffic noise impacts to occur when the predicted traffic noise levels either:

1) Approach or exceed the NAC; with “approach” meaning within 1 dB(A) of the NAC values shown in Table 3.

   or

2) Substantially increase over existing noise levels, with “substantial increase” meaning a 10-dB(A) increase over the existing noise level.

Traffic noise levels were modeled for the existing conditions (2019) and future (Design Year 2045) conditions at 784 discrete receptor locations. One receptor was modeled to represent each of the 646 residences and 138 receptor locations were modeled to represent 25 non-residential Equivalent Receptors (ERs). Table 7 provides a summary of the impacts for the Build Alternative and Appendix B provides the detailed Hourly Traffic Noise levels table. The results of the noise analysis predict that traffic-related noise impacts would occur for 109 residences and four non-residential ERs represented by 24 discrete modeled receptor locations under the Build Alternative, for a total of 113 impacts. All noise impacts were due to noise levels approaching or exceeding the NAC; there were no impacts due to a substantial increase in noise levels. Modeled receptors are shown on the detailed mapping figures presented in Section 16.

Table 7. Traffic Noise Impact Summary for Design Year 2045 Build Condition

Reason for Noise Impact	Summary of Impacted Receptors[7]							
	By Activity Category							
	A	B	C	D	E	F[5]	G[6]	All Activity Categories
Based on NAC Criteria Only[1]	0	109	4	0	0	--	--	113
Based on Substantial Increase Criteria Only[2]	0	0	0	0	0	--	--	--
Based on Both Criteria[3]	0	0	0	0	0	--	--	--
Total Impacts[4]	**0**	**109**	**4**	**0**	**0**	**--**	**--**	**113**

[1] Predicted traffic noise impact due to approaching or exceeding NAC (refer to Table 3).

[2] Predicted substantial increase noise impact (refer to Section 10).

[3] Predicted traffic noise level impacts due to both 1 and 2 above.

[4] The number of predicted impacts is not duplicated if receptors are predicted to be impacted by more than one criterion (e.g., if a receptor is impacted by NAC criteria and also by Substantial Increase criteria, it is counted as only one impact).

[5] There are no impact criteria for land use facilities in this activity category and no analysis of noise impacts is required.

[6] There are no impact criteria for undeveloped lands but some noise levels may need to be provided to local officials to aid them in future land use planning efforts.

[7] Values noted for Activity Category C, D, and E represent ER values for these non-residential land uses. The total number of impacted ERs in each NSA are rounded up to the next whole number.

The ranges of predicted exterior and interior base year 2019 existing loudest-hour equivalent sound levels, $L_{eq(h)}$, are between 43 dB(A) to 74 dB(A), and between 35 dB(A) to 46 dB(A), respectively. The ranges of predicted exterior and interior design year 2045 build condition loudest-hour equivalent sound levels, $L_{eq(h)}$, are between 45 dB(A) to 76 dB(A), and between 35 dB(A) to 48 dB(A), respectively. The predicted increase in design year 2045 build condition over base year 2019 existing condition loudest-hour equivalent sound levels, $L_{eq(h)}$, will be +5 dB(A) for two receptors in the project vicinity (receptors 06-076 at 117 Binford Street and 12-003 at 3224 Old NC 86); however, will be between -2 dB(A) to +3 dB(A) — that is, between "no change" to "barely perceptible" — for all other noise-sensitive receptors (refer to Manual Table 3.4).

10.1 Traffic Noise Impacts by NSA

Noise Study Area 01

One receptor representing a single-family residence was impacted in NSA 01. Noise abatement was not analyzed for this receptor because noise abatement measures must benefit at least two impacted receptors to be considered feasible.

Noise Study Area 02

Two receptors representing two single-family residences were impacted in NSA 02. Noise abatement analysis for these impacts is described in Section 11.1.

Noise Study Area 03

Two receptors representing two single-family residences were impacted in NSA 03. Noise abatement analysis for these impacts is described in Section 11.1.

Noise Study Area 04

One receptor representing a single-family residence was impacted in NSA 04. Noise abatement was not analyzed for this receptor because noise abatement measures must benefit at least two impacted receptors to be considered feasible.

Noise Study Area 05

Seven receptor points representing the Cedar Ridge High School athletic field were impacted in NSA 05. At 0.02 ERs per point, a total of 0.14 ERs rounding up to 1 ER was impacted. Noise abatement was not analyzed for this receptor because noise abatement measures must benefit at least two impacted receptors to be considered feasible.

Noise Study Area 06

27 receptors representing single-family residences were impacted in NSA 06. Noise abatement analysis for 23 of these impacts is described in Section 11.1. Because the other four impacted receptors (06-001 through 004) were primarily impacted by traffic noise from I-85 outside of the project limits and were located beyond the feasible length of the noise wall, noise abatement could not be analyzed for those receptors.

Noise Study Area 07

Two receptors representing single-family residences were impacted in NSA 07. These receptors were located at opposite ends of the NSA, far enough apart that a separate abatement measure would have to be considered for each. Noise abatement was not analyzed for these receptors because noise abatement measures must benefit at least two impacted receptors to be considered feasible.

Noise Study Area 08

No noise impacts occurred in NSA 08.

Noise Study Area 09

Three receptors representing single-family residences were impacted in NSA 09. Noise abatement analysis for these impacts is described in Section 11.1.

Noise Study Area 10

Three receptors representing single-family residences were impacted in NSA 10. Gaps in a barrier to maintain driveway access would render the barrier infeasible for construction.

Noise Study Area 11

No noise impacts occurred in NSA 11.

Noise Study Area 12

Four receptors representing single-family residences were impacted in NSA 12. Noise abatement analysis for these impacts is described in Section 11.1.

Noise Study Area 13

10 receptors representing single-family residences were impacted in NSA 13. Noise abatement analysis for these impacts is described in Section 11.1.

Noise Study Area 14

Two receptors representing single-family residences were impacted in NSA 14, as well as 13 receptor points representing a trail at Blackwood Farm Park. At 0.01 ERs per point, a total of 0.13 ERs rounding up to 1 ER were impacted, for a total of 3 impacts overall in NSA 14. Noise abatement analysis for these impacts is described in Section 11.1.

Noise Study Area 15

No noise impacts occurred in NSA 15.

Noise Study Area 16

One receptor representing a single-family residence was impacted in NSA 16. Noise abatement was not analyzed for this receptor because noise abatement measures must benefit at least two impacted receptors to be considered feasible.

Noise Study Area 17

11 receptors representing single-family residences were impacted in NSA 17. Noise abatement analysis for these impacts is described in Section 11.1.

Noise Study Area 18

No noise impacts occurred in NSA 18.

Noise Study Area 19

No noise impacts occurred in NSA 19.

Noise Study Area 20

Five receptors representing single-family residences were impacted in NSA 20. Noise abatement analysis for these impacts is described in Section 11.1.

Noise Study Area 21

No noise impacts occurred in NSA 21.

Noise Study Area 22a

Two receptors representing single-family residences were impacted in NSA 22a. Noise abatement analysis for these impacts is described in Section 11.1.

Noise Study Area 22b

Seven receptors representing single-family residences were impacted in NSA 22b. Noise abatement analysis for these impacts is described in Section 11.1. Note that separate abatement was considered depending on whether the primary source of traffic noise for a receptor was I-40 (three receptors) or NC 86 (four receptors).

Noise Study Area 23

No noise impacts occurred in NSA 23.

Noise Study Area 24

One receptor representing outdoor use at North Chapel Hill Baptist Church with a value of 1 ER was impacted in NSA 24. Noise abatement was not analyzed for this receptor because noise abatement measures must benefit at least two impacted receptors to be considered feasible.

Noise Study Area 25

Three receptor points representing outdoor uses including a dog park, a playground, and a basketball court at Chapel Hill North Apartments were impacted in NSA 25. At 0.3 ERs per point, a total of 0.9 ERs rounding up to 1 ER were impacted. Noise abatement was not analyzed for this receptor because noise abatement measures must benefit at least two impacted receptors to be considered feasible.

Noise Study Area 26

Five receptors representing single-family residences were impacted in NSA 26. Noise abatement analysis for these impacts is described in Section 11.1.

Noise Study Area 27

No noise impacts occurred in NSA 27.

Noise Study Area 28

One receptor representing a single-family residence was impacted in NSA 28. Noise abatement was not analyzed for this receptor because noise abatement measures must benefit at least two impacted receptors to be considered feasible.

Noise Study Area 29

No noise impacts occurred in NSA 29.

Noise Study Area 30

One receptor representing a single-family residence was impacted in NSA 30. Noise abatement was not analyzed for this receptor because noise abatement measures must benefit at least two impacted receptors to be considered feasible.

Noise Study Area 31

No noise impacts occurred in NSA 31.

Noise Study Area 32

19 receptors representing single-family residences were impacted in NSA 32. Noise abatement analysis for these impacts is described in Section 11.1.

Noise Study Area 33

No noise impacts occurred in NSA 33.

Noise Study Area 34

No noise impacts occurred in NSA 34.

Noise Study Area 35

No noise impacts occurred in NSA 35.

11 Potential Traffic Noise Abatement Measures

Policy requires that, when traffic noise impacts are identified, noise abatement measures shall be considered and evaluated for feasibility for all impacted receptors and reasonableness for all benefited receptors. Measures typically considered include highway alignment selection, traffic systems management, buffer zones, proper use of land controls, noise walls and earth berms, and insulation of NAC D land use facilities.

11.1 Noise Barriers

Noise barriers are primarily constructed as earth berms or solid-mass, impervious walls adjacent to limited-access freeways that are in close proximity to noise-sensitive land uses. To be effective, a noise barrier must be long enough and tall enough to shield the impacted receptors. Generally, the noise barrier length should be eight times the distance from the noise barrier to the receptor. For example, if a receptor is 200 feet from the roadway, an effective noise barrier would be approximately 1,600 feet long – with the receptor in the horizontal center. On roadway facilities with direct access for driveways, noise barriers are typically not feasible because the openings undermine the noise barrier's ability unable to attenuate traffic noise sufficiently. Due to the requisite lengths for effectiveness, noise barriers are commonly not economical for secluded or most low-density areas, or for most uncontrolled access facilities. However, noise barriers occasionally are found to be feasible and reasonable for as few as two impacted receptors (if the noise barrier can benefit enough total receptors), and on some limited control of access highway facilities for which de-facto control of exists via a single access point serving numerous receptors (e.g. an entrance street to a residential subdivision).

The Manual outlines the criteria for determining if a noise abatement measure is feasible and reasonable. A noise barrier is considered feasible if it is predicted to reduce traffic noise levels by at least 5 dB(A) for at least two impacted receptors. Engineering feasibility of noise abatement considers adverse impacts to property access, drainage, topography, utilities, and safety and maintenance requirements. A noise barrier is evaluated for its reasonableness based on a maximum allowable base quantity of wall or berm, and its ability to reduce traffic noise effectively. The allowable base quantity of noise walls and/or earthen berms shall not exceed 1,500 square feet (ft^2) and 4,200 cubic yards (yd^3), respectively. Additionally, an incremental increase of up to 2,000 ft^2 for noise walls and 5,600 yd^3 for earthen berms shall be added to the base quantity to reflect the average degree of increase in dB(A) between existing and predicted exterior noise levels of all impacted receptors within each NSA, as shown in Table 8.

A noise reduction design goal (NRDG) of 7 dB(A) shall be evaluated for all benefited receptors. To be considered reasonable, at least one benefited receptor must achieve the NRDG of 7 dB(A) to indicate effective reduction of traffic noise. Preferences of property owners and tenants would also be considered to determine final reasonableness of any proposed abatement measure. Table 8 below provides the allowable noise abatement base quantities based on level of noise reduction.

With respect to the potential use of earth berms for the potential benefit of predicted traffic noise impacts in the project vicinity, adverse impacts that would be created to property access and/or to streams, wetlands, and other natural features will prevent the feasibility of earth berms. Furthermore, earth berms will not be reasonable due to the cost of right-of-way acquisition in comparison to the expense of solid-mass noise walls.

Table 8. Allowable Noise Abatement Base Quantities

Maximum Allowable Base Quantity	Noise Level Consideration	Noise Wall ($1,500\ ft^2$)	Berm ($4,200\ yd^3$)	Buffer Zone / Noise Insulation ($22,500)
Average dB(A) Increase between Existing and Future Build for All Impacted Receptors	<5 dB(A)	$+0\ ft^2$	$+0\ yd^3$	+$0
	5-10 dB(A)	$+500\ ft^2$	$+1,400\ yd^3$	+$7,500
	>10 dB(A)	$+1,000\ ft^2$	$+2,800\ yd^3$	+$15,000
Average Exposure to Absolute Noise Levels for All Impacted Receptors	5-10 dB(A) Over NAC Activity Category	$+500\ ft^2$	$+1,400\ yd^3$	+$7,500
	>10 dB(A) Over NAC Activity Category	$+1,000\ ft^2$	$+2,800\ yd^3$	+$15,000

Consideration for potentially feasible and reasonable noise abatement was given to all predicted traffic noise impacts. Fourteen (14) noise walls were assessed for the potential benefit of 96 impacted receptors. As documented below, noise abatement was not assessed for the potential benefit of 17 impacted receptors due to feasibility conflicts that abatement would cause due to adverse impacts created by or upon property access, drainage, topography, utilities, safety, and maintenance requirements, or because abatement is not acoustically feasible for isolated impacts. The noise walls were analyzed for the impacted receptors in NSAs 02, 03, 06, 09, 12, 13, 14, 17, 20, 22a, 22b (two walls), 26, and 32. Noise barriers for some impacted receptors located along cross streets and side streets could not be considered due to engineering feasibility issues regarding required gaps for driveway access. Maps of the locations of the evaluated noise walls are provided in Section 16. Detailed tabular results for the optimal configuration of each evaluated noise wall are provided in Appendix D. Table 9 below shows a summary of results for each investigated noise wall. Noise walls that are not recommended for construction are shaded in gray.

Table 9. Build Alternative Summary of Noise Wall Evaluations

Noise Wall	Length (feet)	Avg. Height (feet)	Area ($feet^2$)	Number of Impacted Receptors/ Number of Impacted Receptors Benefited	Number of Benefited Receptors/ Number of Benefits ≥ 7 dB(A) Reduction	Area per Benefited Receptor / Allowable Area per Benefited Receptor ($feet^2$)	Preliminary Recommendation for Construction
NW02	765	30	22,950	2 / 2	2 / 1	11,475 / 1,500	No
NW03	1,380	30	41,400	2 / 1	1 / 0	N/A[1]	No
NW06	1,440	13.5	19,427	23 / 16	17 / 15	1,143 / 1,500	Yes
NW09	300	10.3	3,080	3 / 2	2 / 1	1,540 / 1,500	No
NW12	540	9.5	5,132	4 / 2	2 / 1	2,566 / 1,500	No
NW13	1,155	21.5	24,880	10 / 10	25 / 11	995 / 1,500	Yes
NW14	3,960	18.4	72,960	3 / 3	4 / 4	18,240 / 1,500	No
NW17	1,080	15.0	16,216	11 / 6	7 / 2	2,317 / 1,500	No
NW20	900	12.2	10,969	5 / 5	6 / 1	1,828 / 1,500	No
NW22a	1,080	13.2	14,301	2 / 2	2 / 2	7,150 / 1,500	No
NW22b	420	13.7	5,753	4 / 4	4 / 4	1,438 / 1,500	Yes
NW22b2	1,530	26.4	40,348	3 / 3	15 / 1	2,690 / 1,500	No
NW26	1,680	13.4	22,566	5 / 5	6 / 1	3,761 / 1,500	No
NW32	2,745	17	46,798	19 / 19	40 / 24	1,170 / 1,500	Yes

1. Unable to meet acoustical feasibility criterion of providing benefits to two impacted receptors

Noise Wall 02 (NW02): NW02 was evaluated along westbound I-40 west of SR 1134 (Dimmocks Mill Road) for the potential benefit of up to two impacted receptors along Dimmocks Mill Road. No configuration of NW02 would meet all applicable Policy feasibility and reasonableness criteria.

With a length of 765 feet and an average height of 30 feet for an area of 22,950 square feet, the optimal NW02 configuration would benefit two total receptors including both traffic noise impacts, and one receptor would receive at least a 7 decibel (7 dB(A)) noise level reduction. NW02 would be acoustically feasible and acoustically reasonable; however, at 11,475 square feet per benefit NW02 would exceed the allowable 1,500 square feet per benefit Policy cost reasonableness criterion. Refer to Table 9, Table D-1, and Figure 2-1.

Noise Wall 03 (NW03): NW03 was evaluated along I-40 eastbound east of SR 1134 (Dimmocks Mill Road) for the potential benefit of up to two impacted receptors along Dimmocks Mill Road. No configuration of NW03 would meet all applicable Policy feasibility criteria.

With a length of 1,380 feet and an average height of 30 feet for an area of 41,400 square feet, the optimal NW03 configuration would benefit only one receptor, including one of the two predicted traffic noise impacts. Because the optimal NW03 configuration would not meet the Policy acoustical feasibility criterion, the Policy acoustical reasonableness and cost reasonableness criteria were not evaluated. Refer to Table 9, Table D-2, and Figures 2-1 and 2-2.

Noise Wall 06 (NW06): NW06 was evaluated along I-40 westbound between SR 1006 (Orange Grove Road) and I-85 for the potential benefit of up to 23 impacted receptors within the Timbers Manufactured Homes community and along Orange Grove Road. Receptors 06-001 through 06-004 were found to be primarily impacted by I-85 traffic and not from the I-3306A project; therefore, they were not included in the NW06 assessment. NW06 will meet all Policy feasibility and reasonableness criteria.

The optimal NW06 configuration was evaluated based on a maximum potentially feasible length with a southern terminus constrained by overhead utilities northwest of Orange Grove Road and a northern terminus constrained by stopping sight distance on the I-40 westbound ramp to I-85 northbound. The seven impacted receptors 06-022 through 06-026, 06-050 and 06-091 are outside the horizontal limits of the maximum potentially feasible NW06 length; therefore, these impacted receptors cannot be benefited. Impacted receptor 06-091 could not be benefited since the noise wall was required to stop short on the south end due to an overhead utility right-of-way (ROW) conflict. The utility owner will not allow encroachment into the utility easement. Extending NW06 further south would require relocating the overhead utility; therefore, extending NW06 further south end is not feasible. Extending NW06 further north was also investigated for the potential benefit of impacted receptors 06-022 through 06-026 and 06-050. For the 50 mph design speed, the minimum required stopping sight distance for the I-40 westbound ramp to I-85 northbound is 425 feet. Extending NW06 north to potentially benefit these impacted receptors would limit the stopping sight distance to 363 feet and create an unsafe driving condition; therefore, extending NW06 further north is not feasible.

With a length of 1,440 feet and average height of 13.5 feet for a total area of 19,427 square feet, the optimal NW06 configuration will benefit 17 total receptors, including 16 of 23 predicted traffic noise impacts, and 15 receptors will receive at least a 7 decibel (7 dB(A)) noise level reduction, meeting the Policy acoustical feasibility and reasonableness criteria. At 1,143 square feet per benefit, NW06 will meet the applicable area per benefit Policy cost reasonableness criterion of 1,500 square feet. Refer to Table 9, Table D-3, Figures 2-2 and 2-2A-1, and Appendix E.

Noise Wall 09 (NW09): Two configurations of NW09 were evaluated adjacent to I-40 westbound east of SR 1006 (Orange Grove Road) for the potential benefit of up to three impacted receptors along Oakdale Drive and Blair Drive. No configuration of NW09 would meet all applicable Policy feasibility and reasonableness criteria. The results of the two NW09 evaluations are as follows:

A NW09 configuration 1,020 feet long with an average height of 10.7 feet for a minimum area of 10,921 square feet would benefit three receptors, including all three impacted receptors, and three receptors would receive at least a 7 decibel (7 dB(A)) noise level reduction. This NW09 configuration would be acoustically feasible and acoustically reasonable; however, at 3,640 square feet per benefit would exceed the allowable 1,500 square feet per benefit Policy cost reasonableness criterion.

With a length of 300 feet and an average height of 10.4 feet for an area of 3,080 square feet, the optimal NW09 configuration with the lowest attainable area per benefit would benefit two total receptors including the traffic noise impacts 09-002 and 09-003, and one receptor would receive at least a 7 dB(A) noise level reduction. The optimal NW09 configuration would be acoustically feasible and acoustically reasonable; however, at 1,540 square feet per benefit would exceed the allowable 1,500 square feet per benefit Policy cost reasonableness criterion. With respect to the degree to which NW09 would exceed the allowable 1,500 square feet per benefit Policy cost reasonableness criterion, the optimal NW09 configuration was assessed to a resolution of 1' height and 15' length segments. The further reduction of 15 square feet from the optimal NW09 configuration area would result in losing at least one benefited impact, the one 7 dB(A) noise level reduction benefit, or both. Refer to Table 9, Table D-4 and Figure 2-3.

Noise Wall 12 (NW12): Two configurations of NW12 were evaluated adjacent to the onramp from SR 1009 (Old NC 86) to I-40 eastbound for the potential benefit of up to four impacted receptors along Old NC 86. No configuration of NW12 would meet all applicable Policy feasibility and reasonableness criteria. The results of the two NW12 evaluations are as follows:

A NW12 configuration 1,440 feet long with an average height of 30 feet for a maximum area of 43,200 square feet would only benefit two impacted receptors 12-001 and 12-003, and both receptors would receive at least a 7 decibel (7 dB(A)) noise level reduction. Benefiting the remaining two impacted receptors 12-002 and 12-004 will not be feasible due to direct driveway access to SR 1009 (Old NC 86). This NW12 configuration would be acoustically feasible and acoustically reasonable; however, at 21,600 square feet per benefit would exceed the allowable 1,500 square feet per benefit Policy cost reasonableness criterion.

With a length of 540 feet and an average height of 9.5 feet for an area of 5,132 square feet, the optimal NW12 configuration with the lowest attainable area per benefit would benefit two total receptors including the traffic noise impacts 12-001 and 12-003, and one receptor would receive at least a 7 dB(A) noise level reduction. NW12 would be acoustically feasible and acoustically reasonable; however, at 2,566 square feet per benefit would exceed the allowable 1,500 square feet per benefit Policy cost reasonableness criterion. Refer to Table 9, Table D-5, and Figures 2-5 and 2-6.

Noise Wall 13 (NW13): NW13 was evaluated along I-40 westbound east of SR 1009 (Old NC 86) for the potential benefit of up to 10 impacted receptors along Alice Loop. NW13 will meet all Policy feasibility and reasonableness criteria.

With a length of 1,155 feet and an average height of 21.5 feet for an area of 24,880 square feet, the optimal NW13 configuration will benefit 25 total receptors, including 10 of 10 predicted traffic noise impacts, and 11 receptors will receive at least a 7 decibel (7 dB(A)) noise level reduction. At 995 square feet per benefit, NW13 will meet the applicable area per benefit Policy cost reasonableness criterion of 1,500 square feet. Refer to Table 9, Table D-6, Figures 2-5 and 2-6, and Appendix E.

Noise Wall 14 (NW14): NW14 was evaluated along I-40 westbound north of SR 1723 (New Hope Church Road) for the potential benefit of three impacted receptors, including two impacted residential receptors along East Scarlett Mountain Road and the Blackwood Farm Park trail. No configuration of NW14 would meet all applicable Policy feasibility and reasonableness criteria.

With a length of 3,960 feet and an average height of 18.4 feet for an area of 72,960 square feet, the optimal NW14 configuration would benefit four total receptors including three of three predicted traffic noise impacts, and four receptors would receive at least a 7 decibel (7 dB(A)) noise level reduction. The optimal NW14 configuration would be acoustically feasible and acoustically reasonable; however, at 18,240 square feet per benefit NW14 would exceed the allowable 1,500 square feet per benefit Policy cost reasonableness criterion. Refer to Table 9, Table D-7, and Figures 2-6 and 2-7.

Noise Wall 17 (NW17): Three configurations of NW17 were evaluated along I-40 westbound south of SR 1723 (New Hope Church Road) for the potential benefit of up to 11 impacted receptors along SR 1203 (Hideaway Drive). No configuration of NW17 would meet all applicable Policy feasibility and reasonableness criteria. The results of the three NW17 evaluations are as follows:

A NW17 configuration 4,320 feet long with an average height of 17.3 feet for an area of 74,719 square feet would benefit 17 receptors including 11 of 11 predicted traffic noise impacts, and six receptors would receive at least a 7 dB(A) noise level reduction. This NW17 configuration would be acoustically feasible and acoustically reasonable; however, at 4,395 square feet per benefit would exceed the allowable 1,500 square feet per benefit Policy cost reasonableness criterion.

A NW17 configuration 1,320 feet long with an average height of 17.3 feet for an area of 22,850 square feet would benefit five receptors including impacted receptors 17-024 through 17-026 and 17-029, and one receptor would receive at least a 7 dB(A) noise level reduction. This NW17 configuration would be acoustically feasible and acoustically reasonable; however, at 4,570 square feet per benefit would exceed the allowable 1,500 square feet per benefit Policy cost reasonableness criterion.

With a length of 1,080 feet and an average height of 15.0 feet for an area of 16,216 square feet, the optimal NW17 configuration with the lowest attainable area per benefit would benefit seven total receptors including the impacted receptors 17-006 through 17-011, and two receptors would receive at least a 7 dB(A) noise level reduction. NW17 would be acoustically feasible and acoustically reasonable; however, at 2,317 square feet per benefit would exceed the allowable 1,500 square feet per benefit Policy cost reasonableness criterion. Refer to Table 9, Table D-8, and Figures 2-8, 2-9, and 2-10.

Noise Wall 20 (NW20): Two configurations of NW20 were evaluated along I-40 westbound over SR 1725 (Millhouse Road) for the potential benefit of up to five impacted receptors in Homestead Mobile Home Park and along Millhouse Road. No configuration of NW20 would meet all applicable Policy feasibility and reasonableness criteria. The results of the two NW20 evaluations are as follows:

A NW20 configuration 1,980 feet long with an average height of 30 feet for a maximum area of 59,400 square feet would benefit six receptors including all five impacted receptors, and six receptors would receive at least a 7 decibel (7 dB(A)) noise level reduction. This configuration of NW20 would be acoustically feasible and acoustically reasonable; however, at 9,900 square feet per benefit would exceed the allowable 1,500 square feet per benefit Policy cost reasonableness criterion.

With a length of 900 feet and an average height of 12.2 feet for an area of 10,969 square feet, the optimal NW20 configuration would benefit six receptors including all five impacted receptors, and one receptor would receive at least a 7 dB(A) noise level reduction. The optimal configuration of NW20 would be acoustically feasible and acoustically reasonable; however, at 1,828 square feet per benefit would exceed the allowable 1,500 square feet per benefit Policy cost reasonableness criterion. Refer to Table 9, Table D-9, and Figures 2-10 and 2-11.

Noise Wall 22a (NW22a): NW22a was evaluated along I-40 westbound north of NC 86 (Martin Luther King Jr. Boulevard) for the potential benefit of up to two impacted receptors along Clyde Road. NW22a would not meet all applicable Policy feasibility and reasonableness criteria.

With a length of 1,080 feet and average height of 13.2 feet for an area of 14,301 square feet, the optimal NW22a configuration would benefit two receptors including two of two predicted traffic noise impacts, and two receptors would receive at least a 7 decibel (7 dB(A)) noise level reduction. The optimal NW22a configuration would be acoustically feasible and acoustically reasonable; however, at 7,150 square feet per benefit would exceed the allowable 1,500 square feet per benefit Policy cost reasonableness criterion. Refer to Table 9, Table D-10, and Figure 2-11.

Noise Wall 22b (NW22b): NW22b was evaluated along NC 86 southbound north of the access to Hilltop Mobile Home Park for the potential benefit of the four impacts within Hilltop Mobile Home Park for which NC 86 will be the dominant traffic noise source. NW22b will meet all Policy feasibility and reasonableness criteria.

With a length of 420 feet and an average height of 13.7 feet for an area of 5,753 square feet, the optimal NW22b configuration will benefit four total receptors, including all four predicted traffic noise impacts, and four receptors will receive at least a 7 decibel (7 dB(A)) noise level reduction. At 1,438 square feet per benefit, NW22b will meet the applicable area per benefit Policy cost reasonableness criterion of 1,500 square feet. Refer to Table 9, Table D-11, Figures 2-11 and 2-12, and Appendix E.

Noise Wall 22b2 (NW22b2): NW22b2 was evaluated along the onramp from NC 86 to I-40 westbound for the potential benefit of the three impacts within Hilltop Mobile Home Park for which I-40 will be the dominant traffic noise source. NW22b2 would not meet all applicable Policy feasibility and reasonableness criteria.

A continuous noise wall in this location would conflict with the Duke Energy overhead transmission line, and any modification of the transmission line to facilitate noise wall installation would be in conflict with the RFP provision that “At the I-40 / NC 86 (Martin Luther King, Jr. Boulevard) interchange, the Design-Build Team shall not impact the existing Duke Energy Transmission Tower in Quadrant B." Therefore, a gap in the wall must be present at the transmission line corridor, which negatively affects the acoustical performance of the wall.

With a length of 1,530 feet and average height of 26.4 feet for an area of 40,348 square feet, the optimal NW22b2 configuration would benefit 15 receptors including all three predicted traffic noise impacts, and one receptor would receive at least a 7 decibel (7 dB(A)) noise level reduction. The optimal NW22b2 configuration would be acoustically feasible and acoustically reasonable; however, at 2,690 square feet per benefit would exceed the allowable 1,500 square feet per benefit Policy cost reasonableness criterion. Refer to Table 9, Table D-12, and Figures 2-11 and 2-12.

Noise Wall 26 (NW26): Two configurations of NW26 were evaluated along I-40 westbound east of NC 86 (Martin Luther King Jr. Boulevard) for the potential benefit of up to five impacted receptors along SR 1730 (Whitfield Road) and SR 2235 (Foxridge Road). No configuration of NW26 would meet all applicable Policy feasibility and reasonableness criteria. The results of the two NW26 evaluations are as follows:

A NW26 configuration 3,240 feet long with an average height of 30 feet for a maximum area of 97,200 square feet would benefit six receptors including all five impacted receptors, and six receptors would receive at least a 7 decibel (7 dB(A)) noise level reduction. This configuration of NW26 would be acoustically feasible and acoustically reasonable; however, at 16,200 square feet per benefit would exceed the allowable 1,500 square feet per benefit Policy cost reasonableness criterion.

With a length of 1,680 feet and an average height of 13.4 feet for an area of 22,566 feet, the optimal NW26 configuration would benefit six receptors including all five predicted traffic noise impacts, and one receptor would receive at least a 7 decibel (7 dB(A)) noise level reduction. The optimal NW26 configuration would be acoustically feasible and acoustically reasonable; however, at 3,761 square feet per benefit would exceed the allowable 1,500 square feet per benefit Policy cost reasonableness criterion. Refer to Table 9, Table D-13, and Figures 2-14 and 2-15.

Noise Wall 32 (NW32): NW32 was evaluated along I-40 eastbound between SR 1732 (Sunrise Road) and SR 1734 (Erwin Road) for the potential benefit of 19 impacted receptors along Sweeten Creek Road and Perry Creek Drive. NW32 is a noise abatement system that incorporates a noise wall in two segments (NW32A and NW32B), along with the existing high ground between them, for optimal and cost-effective traffic noise mitigation. NW32 will meet all Policy feasibility and reasonableness criteria.

With a length of 2,745 feet and an average height of 17.0 feet for an area of 46,798 square feet, the optimal NW32 configuration will benefit 40 total receptors, including all 19 predicted traffic noise impacts, and 24 receptors will receive at least a 7 decibel (7 dB(A)) noise level reduction. At 1,170 square feet per benefit, NW32 will meet the applicable area per benefit Policy cost reasonableness criterion of 1,500 square feet. Refer to Table 9, Table D-14, Figures 2-16 and 2-17, and Appendix E.

11.2 Highway Alignment Selection

Highway alignment selection involves the horizontal or vertical orientation of the proposed improvements in such a way as to minimize impacts and costs. The selection of alternative alignments for noise abatement purposes must consider the balance between noise impacts and other engineering and environmental parameters. For noise abatement, horizontal alignment selection is primarily a matter of constructing the proposed roadway at a sufficient distance from noise-sensitive areas. Appreciable reductions in traffic noise transmissions to sensitive receptors can also be achieved by adjusting the vertical highway alignment and/or section geometry. For example, lowering a roadway below existing grade creates a cut section (in-cut) which could act similarly to an earth berm, depending upon the relative location of noise-sensitive receptors. The selected alignment has been located to minimize impacts to residences, businesses, historic properties, and recreational areas.

11.3 Traffic System Management Measures

Traffic management measures such as prohibition of truck traffic, lowering speed limits, limiting of traffic volumes, and/or limiting times of operation were considered as possible traffic noise abatement measures. The purpose of the proposed project includes improving mobility, increasing roadway connectivity, and reducing congestion. Prohibition of truck traffic, speed limit reduction, or screening total traffic volumes would diminish the functional capacity of the highway facility and are not considered practicable.

11.4 Buffer Zones

Buffer zones are typically not practical nor cost effective for noise abatement due to the substantial amount of right of way required and would not be a feasible noise abatement measure for this project due to the proximity of existing development to the right of way.

11.5 Statement of Likelihood

Policy requires the identification as to whether it is “likely” or “unlikely” that noise abatement measures will be installed for each noise-sensitive area identified. “Likely” does not mean a firm commitment. The final decision on the installation of the abatement measures shall be made upon completion of the public involvement process.

With a total length of 5,760 feet and a total area of 96,858 square feet, the following four noise abatement measures for the corresponding predicted traffic noise impacts in the I-3306A project vicinity are recommended for construction, pending completion of the public involvement process:

- Noise Wall 6
- Noise Wall 13
- Noise Wall 22b
- Noise Wall 32.

12 Traffic Noise Levels for Undeveloped Lands Where No Building Permits Have Been Issued

According to Manual and FHWA regulation, noise contour lines shall not be used for determining highway traffic noise impacts. However, the 71 dB(A) and 66 dB(A) noise level contour information should assist local authorities in exercising land use control over the remaining undeveloped lands, so as to avoid development of lands for use by incompatible activities adjacent to the roadways within local jurisdiction.

Table 10 presents the approximate distance from the outer edge of the nearest travel lane reached by noise level contours correlating to the traffic noise impact thresholds for land uses for undeveloped areas. A 71 dB(A) hourly-equivalent noise level correlates to the NCDOT impact threshold for a NAC E land use. An hourly-equivalent noise level of 66 dB(A) correlates to the NCDOT impact threshold for NAC B and C land uses. The distances at which 71 dB(A) and 66 dB(A) hourly-equivalent traffic noise levels are predicted to occur vary depending on traffic conditions and elevations throughout the project area and were derived via TNM.

Table 10. Traffic Noise Contours for Land Use Planning

NSA	Location	Build Alternative Contour Distance from Edge of Nearest Travel Lane	
		66 dB(A)	71 dB(A)
07	I-40 eastbound, between SR 1221 (New Grady Brown School Road) and SR 1009 (Old NC 86)	347 ft	127 ft
15	I-40 eastbound, between SR 1009 (Old NC 86) and SR 1723 (New Hope Church Road).	437 ft	277 ft
19	I-40 eastbound, between SR 1723 (New Hope Church Road) and SR 1725 (Millhouse Road)	317 ft	187 ft
33	I-40 westbound, between SR 1732 (Sunrise Road) and SR 1734 (Erwin Road)	317 ft	147 ft

12.1 Proper Use of Land Controls

One of the most effective means to prevent future traffic noise impacts is the proper use of land controls. According to Policy, NCDOT strongly advocates the planning, design and construction of noise-compatible development and encourage its practice among planners, building officials, developers and others.

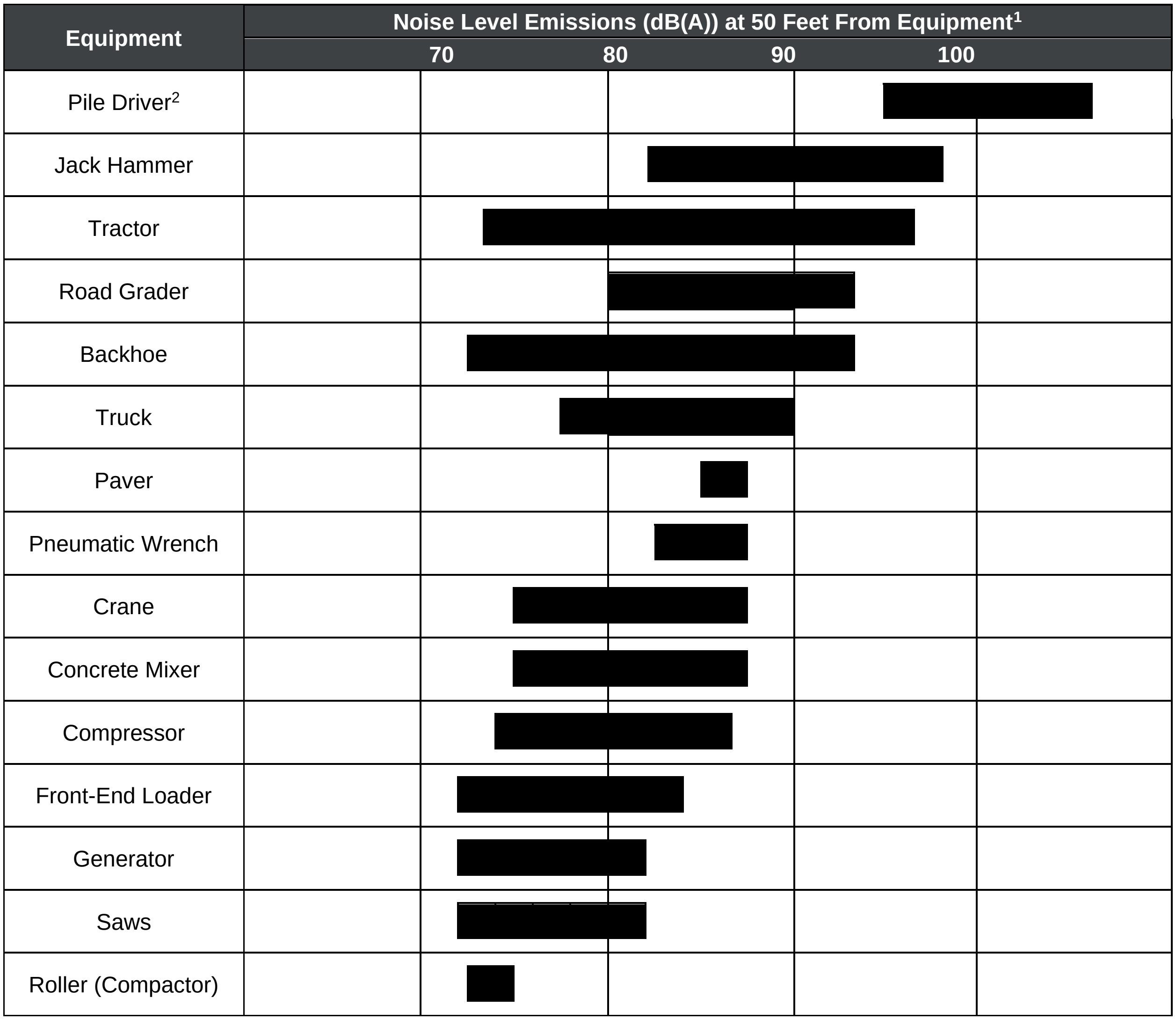
13 Construction Noise

The predominant construction activities associated with this project are expected to be earth removal, tree clearing, hauling, grading, bridge construction, and paving. General construction noise impacts, such as temporary speech interference for passers-by and those individuals living or working near the project, can be expected particularly from paving operations, pile driving at bridges, and earth moving equipment during grading operations. Table 11 summarizes noise level ranges for a typical highway construction equipment.

During evening and nighttime hours, steady-state construction noise emissions such as from paving operations will be audible and may cause impacts to activities such as sleep. Sporadic evening and nighttime construction equipment noise emissions such as from backup alarms, lift gate closures ("slamming" of dump truck gates), etc., will be perceived as distinctly louder than the steady-state acoustic environment, and could cause impacts to the general peace and usage of noise-sensitive areas – particularly residences.

There are 783 noise-sensitive receptors representing 645 non-relocated residences and 25 non-residential ERs in the project noise study area that may be exposed to construction noise. Extremely loud construction noise activities such as usage of pile-drivers and impact-hammers (jackhammer, hoe-ram) will provide sporadic, temporary, and acute construction noise impacts in the near vicinity of those activities (refer to Table 11). Residences in proximity to the I-40 are most likely to be temporarily impacted by loud construction activities, including the demolition of the existing norther on/off ramps at NC86 and the construction of the proposed new I-40 westbound on/off ramp from NC86. Construction activities along I-40 will likely impact residences in close proximity to I-40, especially residences on Dimmocks Mill Road in NSA 01 and NSA 02, residences along Binford St and Orange Grove Road in NSA 06, residences close to I-40 on Sunshine Drive and Blair Drive in NSA 09, residences along Alice Loop in NSA 13, residences on Meadow Greer Road, Stoneywood Road, and Hideaway Drive in NSA 17, residences on Avery Way in NSA 20, residences on Clyde Road in NSA 22a, residences along NC 86 in NSA 22b, Chapel Hill North Apartments in NSA 25, residences along Foxridge Road in NSA 26, residences on Sedgewood Road and North Hill Drive in NSA 28, residences in Carol Woods Community in NSA 29, residences on Northridge Lane in NSA 30, residences along Sunrise Road in NSA 31, and residences along Sweeten Creek Road in NSA 32. It is the recommendation of this DNR that construction activities that will produce extremely loud noises be scheduled during times of the day when such noises will create as minimal disturbance as possible. Additionally, extra caution should be taken to minimize loud construction noises in the vicinity of Cedar Ridge High School in NSA 05 during the school hours/days.

Table 11. Construction Equipment Typical Noise Level Emissions



Source: Adapted from Noise Construction Equipment and Operations, Building Equipment, and Home Appliances. U.S. Environmental Protection Agency. Washington D.C. 1971.

[1] Cited noise level ranges are typical for the respective equipment. For "point sources" such as the construction equipment listed above, noise levels generally dissipate at a rate of -6 dB(A) for every doubling of distance. For example, if the noise level from a pile driver at a distance of 50 feet = 100 decibels (dB(A)), then at 400 feet, it might be 82 decibels (dB(A)) or less.

[2] Due to project safety and potential construction noise concerns, pile-driving activities are typically limited to daytime hours.

Construction activities that will produce extremely loud noises should be scheduled during times of the day when such noises will create as minimal disturbance as possible, typically weekday daytime hours.

Generally, low-cost and easily implemented construction noise control measures should be incorporated into the project plans and specifications to the extent possible. These measures include, but are not limited to, work-hour limits, equipment exhaust muffler requirements, haul-road locations, elimination of "tail gate banging", ambient-sensitive backup alarms, construction noise complaint mechanisms, and consistent and transparent community communication.

While discrete construction noise level prediction is difficult for a particular receptor or group of receptors, it can be assessed in a general capacity with respect to distance from known or likely project activities. For this project, earth removal, grading, hauling, paving, and pile driving are anticipated to occur near noise-sensitive areas along the entire length of the project. Although construction noise impact abatement should not place an undue burden upon the financial cost of the project or the project construction schedule, pursuant to the requirements of Title 23 CFR 772.19, it is the recommendation of this DNR that:

- Earth removal, tree clearing, grading, hauling, paving, and pile driving should be limited to weekday daytime hours.
- If meeting the project schedule requires that earth removal, tree clearing, grading, hauling and/or paving must occur during evening, nighttime and/or weekend hours in the vicinity of residential neighborhoods, daycare centers, places of worship, and schools, the Contractor shall notify NCDOT as soon as possible. In such instance(s), all reasonable attempts shall be made to notify and to make appropriate arrangements for the abatement of the predicted construction noise impacts upon the affected property owners and/or residents.
- Construction noise activities should be kept to a minimum when practicable in the vicinity of residential areas, which are found throughout the project study area. Nearby construction noise should also be kept to a minimum where practicable around Cedar Ridge High School, UNC Hospitals Hillsborough Campus, and Emerson Waldorf School.
- If construction noise activities must occur during context-sensitive hours in the vicinity of noise-sensitive areas, discrete construction noise abatement measures including, but not limited to portable noise walls and/or other equipment-quieting devices shall be considered.
- Some construction activities will create extreme noise impacts for nearby noise sensitive land uses. For example, pile-driving activities can create noise impacts for distances of up to 0.25 mile. It is the recommendation of this DNR that considerations be made for any nearby residences for all evening and/or nighttime periods (7:00 p.m. – 7:00 a.m.), and for all weekend hours throughout which extremely loud construction activities might occur.

For additional information on construction noise, please refer to the FHWA Construction Noise Handbook (FHWA-HEP-06-015) and the Roadway Construction Noise Model (RCNM), available online at https://www.fhwa.dot.gov/environment/noise/construction_noise/handbook/ and https://www.fhwa.dot.gov/environment/noise/construction_noise/rcnm2/.

14 Conclusion

Traffic noise and temporary construction noise can be a consequence of transportation projects, especially in areas in close proximity to high-volume and high-speed existing steady-state traffic noise sources. This analysis was conducted to evaluate the potential noise impacts associated with the I-40 Widening from I-85 in Orange County to the Durham County Line (STIP I-3306A). This DNR utilized computer models created with the FHWA TNM v.2.5 to predict existing and future noise levels in areas where traffic noise is dominant and define impacted receptors along the proposed new highway project. A total of 784 discrete receptor locations were modeled. One receptor was modeled to represent each of the 646 residences and 138 receptor locations were modeled to represent 25 non-residential Equivalent Receptors (ERs). The project final design will require acquisition of one residence represented by one modeled receptor for right-of-way.

Design Year 2045 build condition traffic noise is predicted to impact 109 residences and four non-residential ERs represented by 24 discrete modeled receptor locations for a total of 113 impacts. Noise abatement was considered for all predicted traffic noise impacts. Fourteen noise walls were evaluated under the Build Alternative for their ability to feasibly and reasonably reduce noise levels at impacted receptors. Of the fourteen walls that were evaluated, four walls (Noise Walls 6, 13, 22b, and 32) meet the NCDOT feasibility and reasonableness criteria and are recommended for construction, pending completion of the public involvement process. The other ten evaluated walls did not meet the NCDOT feasibility and reasonableness criteria and will not be constructed.

Construction noise impacts may occur due to the close proximity of noise-sensitive receptors to project construction activities. Construction noise control measures will be incorporated into the project plans and specifications.

15 References

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