TRAFFIC NOISE REPORT

Apex Peakway Connector

(STIP Project U-5928)

Wake County

WBS 36249.3505

Prepared for:

North Carolina Department of Transportation
Project Development and Environmental Analysis Unit

Prepared by:

February 2017

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Accepted by:

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Executive Summary

The North Carolina Department of Transportation (NCDOT) plans to build a new roadway connecting the northwestern and southwestern sections of Apex Peakway in Wake County. This connection will include a bridge over S Salem St and existing railroad tracks between the Whitehall Manor and James Street Station neighborhoods. Additionally, there will also be a ramp in the northeast quadrant of the interchange linking S Salem St to Apex Peakway. This will improve traffic flow along the existing Peakway by creating a smooth link between segments. The project corridor is about 0.5 miles long in each direction. The future travel speed of this road will remain at 35 miles per hour. There is no approved final environmental document at this time, but it is anticipated that the Federal NEPA CE will be signed in April of 2017.

Traffic noise impacts and temporary construction noise impacts can be a consequence of transportation projects. This Traffic Noise Report utilized computer models created with the latest Federal Highway Administration's (FHWA's) Traffic Noise Model software (TNM 2.5) to predict noise levels and define impacted receptors along the proposed new roadway project. VHB examined a total of 352 identified receptor locations; primarily residences along with one public swimming pool. Existing traffic noise levels were taken at two (2) locations and an existing noise level was taken at one (1) location where traffic was not the major source of noise.

Under the Design Year (2040) Build conditions, VHB expects there to be five impacts. These five receptors will approach or exceed NCDOT's and FHWA's noise abatement criteria while one will also be impacted due to a substantial increase in predicted noise levels over existing. These impacted receptors are residential.

Receptors R-135, R-268, R-273, R-297, and R-302 are the only predicted traffic noise impacts for this project. Receptor R-135 is located at the northeast corner of Towhee Drive and Apex Peakway. A noise wall would not be reasonable because it would restrict the line of sight for anyone turning onto Apex Peakway. Receptor R-268 has direct access (driveway) to S. Salem St. A noise wall at this location is not reasonable due to ingress and egress being eliminated should a noise wall be constructed. Noise abatement for receptor R-273 is not feasible due to the inability to achieve a noise reduction level of 5 dB(A) for two (2) impacted receptors. Noise abatement for receptors R-297 and R-302 are also not feasible due to the inability to achieve a noise reduction level of 5 dB(A) for two (2) impacted receptors.

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1.0 PROJECT LOCATION AND DESCRIPTION

The North Carolina Department of Transportation (NCDOT) plans to build a new roadway connecting the northwestern and southwestern extents of Apex Peakway in Wake County. This connection will include a bridge over S Salem St between the Whitehall Manor and James Street Station neighborhoods. Additionally, there will also be a ramp in the northeast quadrant of the interchange linking S Salem St to Apex Peakway. This will improve traffic flow along the existing Peakway by creating a smooth link between segments. The project corridor is about 0.5 miles long in each direction. The future travel speed of this road will remain at 35 miles per hour. Figure 1 illustrates the study area for the project.

2.0 PROCEDURE

This Traffic Noise Report represents the preliminary analyses of the probable traffic noise impacts of the Apex Peakway connector (STIP U-5928). VHB undertook noise monitoring and traffic data collection for this project on Friday, October 28, 2016 and Friday, December 30, 2016. Generally, weather conditions were warm and sunny with temperatures in the upper 60's to low 70's (°F) during the monitoring sessions in October. In December, the average temperature was 45°F. VHB completed our data collection using Larson-Davis Type 1 Sound Level Meters and Jamar traffic count boards. Table 1 summarizes the location, time, and measurements recorded during ambient sound monitoring.

Table 1 Existing Noise Data Collection Locations, Schedule and Results

Monitor ID	Location	Date of Collection	Time	Measured Sound Level (A-Weighted)
1001	James St & Apex Peakway (S)	October 28, 2016	10:19 AM – 10:54 AM	50
1002	Treeline behind 1428 Padstone	October 28, 2016	10:19 AM – 10:53 AM	44
1003	In front of 1425 Padstone	October 28, 2016	10:21 AM – 10:21 AM	---
2001	S Salem St & Apex Peakway (N)	October 28, 2016	11:14 AM – 11:40 AM	59
2002	Between 1006 & 1005 Marston	October 28, 2016	11:13 AM – 11:41 AM	49
2003	Center of Marston Ct cul-de-sac	October 28, 2016	11:11 AM – 11:41 AM	49
3001	South end of Licorice Dr	December 30, 2016	10:50 AM – 11:20 AM	56

In accordance with NCDOT Traffic Noise Manual, this Traffic Noise Analysis utilized validated computer models created with the FHWA Traffic Noise Model software (TNM 2.5) to predict noise levels (baseline and future conditions) and define impacted receptors along the proposed new interchange project. Validation results are located in Appendix A.

3.0 CHARACTERSITICS OF NOISE

Noise is defined as unwanted sound. Many natural and manmade sources can emit noise. Highway traffic noise is usually a composite of noises from engine exhaust, drive train, and tire-roadway interaction.

The magnitude of noise is usually described by a ratio of its sound pressure to a reference sound pressure, which is usually twenty micro-Pascals (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 detectable human hearing sound magnitudes is between the threshold of hearing at 0 decibels and the threshold of pain at 140 decibels.

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 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 – 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. 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 (refer to Table 2).

Several examples of noise levels expressed in dB(A) are listed in Table 3. As shown, most individuals are exposed to high noise levels from many sources on a regular basis. In order to perceive sounds of greatly varying pressure levels, human hearing has a non-linear sensitivity to sound pressure exposure. For example, doubling the sound pressure results in a three decibel change in the noise level; however, variations of 3 dB(A) or less are commonly considered "barely perceptible" to normal human hearing. A 5 dB(A) change is more readily noticeable. By definition, a ten-fold increase in the sound pressure level correlates to a 10 dB(A) noise level increase; however, most people judge it as only a doubling of the loudness, – sounding "twice as loud".

The degree of disturbance or annoyance from exposure to unwanted sound – noise – depends upon three factors:

1. The amount, nature, and duration of the intruding noise
2. The relationship between the intruding noise and the existing (ambient) sound environment; and
3. The situation in which one hears the disturbing noise.

Table 2 Comparison: Flat vs. A-Weighted Frequency Scaling

Octave-Band Center Frequency (Hz)	A-Weighted Adjustment[1]	Sample Frequency Sound Levels (Flat)	Sample Frequency Sound Levels (A-Weighted)
31	-39.53	90.00	50.47
63	-26.22	80.00	53.78
125	-16.19	70.00	53.81
250	-8.68	65.00	56.32
500	-3.25	60.00	56.75
1000	0.00	60.00	60.00
2000	+1.20	60.00	61.20
4000	+0.96	55.00	55.96
8000	-1.14	50.00	48.86
16000	-6.7	45.00	38.30
	Overall Sound Levels:	**90.48 dB[2]**	**66.32 dB(A)[2]**

[1] *Based on the ISO 226:2003 standard for normal equal-loudness contours, the A-weighted decibel network filtering scale is defined for a frequency, f, by the equation:* $20 \times \log_{10} (A(f) / A(1000))$, *where* $A(f) = [12{,}200^2 \times f^4] / [(f^2 + 20.6^2) \times (f^2 + 12{,}200^2) \times (f^2 + 107.7^2)^{0.5} \times (f^2 + 737.9^2)^{0.5}]$.

[2] *Although the energy in the flat sound source would create an actual sound level = 90.48 dB, it would be perceived as a sound level of 66.32 dB(A) by human hearing due to the decreased sensitivity of human hearing to lower sound frequencies.*

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. The time patterns and durations of noise(s) also affect perception as to whether or not it is offensive. For example, noises that occur during nighttime (sleeping) hours are typically considered more offensive 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). A car horn blowing at night when background noise levels are low would generally be more objectionable than one blowing in the afternoon when background noise levels are typically higher. The response to noise stimulus is analogous to the response to turning on an interior light. During the daytime, an illuminated bulb simply adds to the ambient light, but when eyes are conditioned to the dark of night, a suddenly illuminated bulb can be temporarily blinding.

The third factor – situational noise – is related to the interference of noise with activities of individuals. In a 60 dB(A) environment such as is commonly found in a large business office, normal conversation would be possible, while sleep might be difficult. Loud noises may easily interrupt activities that require a quiet setting for greater mental concentration or rest; however, the same loud noises may not interrupt activities requiring less mental focus or tranquility.

Over time, individuals tend to accept the noises that intrude into their lives on a regular basis. However, exposure to prolonged and/or extremely loud noise(s) can prevent use of exterior and interior spaces. It has also been theorized to pose health risks. Appropriately, regulations exist for noise control or mitigation from many particularly offensive sources, including airplanes, factories, railroads, and highways. For all “Type I” federal, state, or federal-aid highway projects in the State of North Carolina, traffic and construction noise impact analysis and mitigation assessment is dictate by the applicable North Carolina Department of Transportation Traffic Noise Abatement Policy.

Table 3 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

Adapted from Guide on Evaluation and Attenuation of Traffic Noise, American Association of State Highway and Transportation Officials (AASHTO), 1974 (revised 1993)

4.0 NOISE ABATEMENT CRITERIA

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

The Federal Highway Administration (FHWA) has developed Noise Abatement Criteria (NAC) and procedures to be used in the planning and design of highways. The purpose of 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.).

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

> …In determining traffic noise impacts, a highway agency shall give primary consideration to exterior areas where frequent human use occurs.

Table 4 presents a summary of the NAC for various land uses. The L_{eq}, or equivalent sound level, is the equivalent steady-state sound level, which in a stated period of time contains the same acoustic energy as a time-varying sound level during the same period. With regard to traffic noise, fluctuating sound levels of traffic noise are represented in terms of L_{eq}, the steady, or 'equivalent', noise level with the same energy.

4.2 North Carolina Department of Transportation Traffic Noise Policy

The North Carolina Department of Transportation Traffic Noise Policy effective October 6, 2016 establishes official policy on highway noise. This policy describes the NCDOT process used in determining traffic noise impacts and abatement measures and the equitable and cost-effective expenditure of public funds for traffic noise abatement. Where the FHWA has given highway agencies flexibility in implementing the 23 CFR 772 standards, this policy describes the NCDOT approach to implementation. This policy is included as Appendix E of this report.

4.3 Noise Abatement Criteria

The two categories of traffic noise impacts are defined as (1) those that "approach" or exceed the FHWA Noise Abatement Criteria (NAC), as shown in Table 4 and (2) those that represent a "substantial increase" over existing noise levels as defined by NCDOT. An impact is defined as "approaching NAC" according to NCDOT as reaching one decibel less than the applicable NAC $L_{eq(h)}$ values shown in Table 4. An impact that represents a "substantial increase" according to NCDOT is when the predicted design year build condition noise levels exceed the existing noise levels by 10 dB(A) or greater.

Table 4 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, Section4(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

1 *The Leq(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.*

5.0 AMBIENT NOISE LEVELS

Ambient noise is that noise which is all around us, caused by natural and manmade events. It includes the wind, rain, thunder, birds chirping, insects, household appliances, commercial operations, lawn mowers, airplanes, automobiles, etc. It is all noise present in a particular area.

Existing traffic noise exposure varies along the future interchange. Traffic noise is dominant at locations closer to Apex Peakway (N) and S Salem St while sound levels are quieter at locations around Apex Peakway (S) and James St where there is much less traffic. With the variations in land use and vehicle speeds, the ambient traffic noise measured ranges from approximately 40 dB(A) to approximately 59 dB(A).

VHB collected traffic noise monitoring data at two (2) sites, each using three meters, in conjunction with this traffic noise analysis (presented earlier in Table 1). VHB chose these based upon their proximity to the proposed corridor and were generally located between 25 and 250 feet from the existing roadways. The purpose of collecting noise level information is to quantify the existing acoustic environment and to provide a base for assessing impacts caused by the increase in noise levels in the Build Year. The primary noise sources in the project study area are the two main roadways; S Salem St and Apex Peakway (N). James St and Apex Peakway (S) were also sources of traffic noise, though there is very little traffic on them. Field observations indicated that actual speeds along these roads were roughly the same as the posted speed limits. In the Existing, No-Build, and Build models, VHB modeled the roadways with their posted speed limits. VHB assessed the average existing noise levels as the TNM-predicted noise levels based on existing average traffic estimates, or the ambient noise levels obtained at representative locations in the field.[1] Then VHB used these readings and traffic volumes to validate the TNM model.

VHB also collected short-term ambient data at one additional site: at the southern end of Licorice Dr. Here it was determined that at 56 dB(A), the ambient noise levels were slightly higher than the rest of the project. Normally one would assume a quiet urban area to have an ambient noise level of around 50 dB(A) as shown in Table 3. But because the ambient noise level was higher in the Sugarland neighborhood, VHB assumed an ambient noise level of 56 dB(A) for all receptors in the vicinity of Sugarland when calculating existing noise levels.

Appendix A contains the ambient noise level monitoring field notes and a summary of adjacent roadway traffic volumes collected during the monitoring effort. Appendix B contains the traffic forecast volumes for the project.

Within the TNM model, a representative receptor was included for each noise sensitive location such as a residence or office. Figure 2 illustrates the ambient monitoring locations as well as the receptor locations evaluated in this analysis.

6.0 PROCEDURE FOR PREDICTING FUTURE NOISE LEVELS

Traffic noise emissions are composed of 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 weather and intervening topography affect the transmission of traffic noise from the vehicle(s) to noise sensitive receptors.

In accordance with industry standards and accepted best practices, VHB created detailed computer models of the study area using the Federal Highway Administration Traffic Noise Model® (FHWA TNM v.2.5). VHB then validated the computer models to within acceptable tolerances of field-

[1] Per 23 CFR 772.5, existing noise levels are defined as "the average noise hour resulting from the combination of natural and mechanical sources and human activity usually present in a particular area." If the TNM-predicted existing loudest-hour *traffic* noise levels are lower than the hourly-equivalent noise levels obtained in the field, then existing noise levels are assessed as the latter.

monitored traffic noise data, and used them to predict traffic noise levels for receptor locations in the vicinity of the new interchange project. Traffic noise consists of three primary parts: tire/pavement noise, engine noise, and exhaust noise. Of these sources, tire/pavement 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, as shown in 5. The computer traffic noise prediction model uses the number and type of vehicles on the planned roadway, vehicle speeds, the physical characteristics of the road (curves, hills, depressions, elevations, etc.), receptor location and height, and, if applicable, barrier type, barrier ground elevation, and barrier segment top elevations.

Table 5 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 9,900 pounds or less
Medium Trucks	All vehicles having two axles and six tires, weighing between 9,900 and 26,400 pounds
Heavy Trucks	All vehicles having three or more axles, weighing more than 26,400 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

Per FHWA guidance, the predictions documented in this report are based upon the project Design Year (2040) Build Condition traffic conditions (including proposed horizontal alignment) resulting in the predicted hourly-equivalent traffic noise levels for each receptor. These volumes were taken from the Traffic Operations Analysis Memo, completed by VHB Engineering in September 2016. Because the derived volumes reflected peak hour traffic volumes, and not necessarily the loudest traffic hour volumes, a check was done to compare these derived volumes to the LOS C capacity threshold volumes. It is assumed that traffic at LOS C is free flowing, and would therefore have a greater noise impact than traffic that is congested and moving at a slower speed. If the peak hour volume was less than the LOS C capacity threshold, VHB applied the peak hour volume to the roadway; if the derived volume exceeded the LOS C capacity threshold, VHB used the LOS C threshold volume instead. Under the Design Year (2040) Build Condition , design speed was used instead of posted speed for Apex Peakway, which does not exceed 5 mph over the posted speed per the 2016 Traffic Noise Manual.

All but one of the receptors included in this analysis are residential, and therefore fall into NAC Category B. These are mainly single-family residences. However, The Townes at Sugarland townhomes and mobile homes within Shangri-la Mobile Park are also included. The remaining receptor is a public swimming pool near the intersection of S Salem St and Apex Barbecue Rd, which falls into NAC Category C.

See Appendix C for a comprehensive list of receptors, and existing and predicted Design Year (2040) hourly equivalent traffic noise levels. Appendix D contains illustrations of the Traffic Noise Model.

7.0 TRAFFIC NOISE IMPACTS AND NOISE CONTOURS

NCDOT considers traffic noise impacts occur when the predicted traffic noise levels either: [a] approach or exceed the FHWA noise abatement criteria (with "approach" meaning within 1 dB(A) of the NAC values listed in Table 4), or [b] substantially exceed the existing noise levels. FHWA and NCDOT require that feasible and reasonable measures be considered to abate traffic noise at all predicted traffic noise impacts. Mitigation measures considered include the highway alignment selection, traffic systems management, buffer zones, noise walls, and earth berms.

Predicted noise levels would approach or exceed NCDOT noise abatement criteria under the Design Year (2040) Build Conditions. The potential number and types of predicted traffic noise impacts from the Project are shown in Table 6 with impacts delineated as either approaching or exceeding the FHWA NAC, by a substantial increase in Design Year (2040) Build condition traffic noise levels over existing ambient noise levels, or by exceeding both criteria.

Predicted build-condition traffic noise level contours are not a definitive means by which to assess traffic noise level impacts; however, they can aid in future land use planning efforts in presently undeveloped areas. Correlating to NCDOT's traffic noise impact threshold for NAC "B" and "C" land uses, VHB expects the 66 dB(A) contour to occur approximately adjacent to all roadways, spreading out further to the first row of houses along Marston Ct and Proper Ct. Results are similar for the undeveloped land to the south and east of the proposed connector, where the 66 dB(A) contour occurs at up to 25ft from the edge of the roadways. Noise levels greater than or equal to 71 dB(A) were only predicted to occur directly adjacent to the point where Apex Peakway passes over S Salem St.

Many variations in terrain, development types and density contribute to the general distance at which these noise thresholds are likely to occur. Thus, per 23 CFR 772.9(c) and NCDOT Policy, noise contour lines shall not be used for determining highway traffic noise impacts. However, the 66 dB(A) and 71 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 incompatible activities adjacent to the roadways within local jurisdiction.

Table 6 Traffic Noise Impact[5] Summary

Alternative	Approximate number of Impacted Receptors Approaching or Exceeding FHWA NAC per Activity Category[1]								Substantial Noise Level Increase[2]	Impacts Due to Both Criteria[3]	Total Traffic Noise Impacts per NCDOT Policy[4]
	A	B	C	D	E	F	G	*Total*			
Build	0	5	0	0	0	0	0	5	5	1	**5**

1 *Predicted traffic noise level impact due to approaching or exceeding NAC (refer to Table 4).*

2 *Predicted "substantial increase" traffic noise level impact (refer to Table 5).*

3 *Predicted traffic noise level impact due to exceeding NAC and "substantial increase" in build-condition noise levels.*

4 *The total number of predicted impacts is not duplicated if receptors are predicted to be impacted by more than one criterion.*

5 *Impact totals account for assumed NCDOT property takes along the alternative alignments (i.e., if a receptor is impacted but will be a relocation due to new alignment, it is not counted in the impact total.*

8.0 POTENTIAL TRAFFIC NOISE ABATEMENT MEASURES

Per NCDOT Policy, the following traffic noise abatement measures are to be considered when impacts are predicted: highway alignment selection, traffic systems management, buffer zones, noise barriers (earth berms and noise walls), and noise insulation of Activity Category D land use facilities.

8.1 Highway Alignment Selection

Highway alignment selection for traffic noise abatement measures involves modifying the horizontal and vertical geometry of the proposed facility to minimize the impact of traffic noise on noise-sensitive receptors. 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 locating the roadway at a sufficient distance from noise sensitive receptors. Appreciable reductions in traffic noise transmissions to sensitive receptors can be made by adjusting the vertical highway alignment and/or section geometry. For example, lowering a roadway below existing grade creates a cut section, which could act similarly as an earth berm, depending upon the relative location(s) of noise-sensitive receptor(s). Because VHB predicted very few impacts in comparison to the number of receptors analyzed, the proposed alignment is considered sufficient.

8.2 Traffic Systems Management Measures

Traffic management measures such as prohibition of truck traffic, lowering speed limits, limiting of traffic volumes, and/or limiting time of operation were considered as possible traffic noise impact abatement measures. The limitations associated with this type of abatement measures would result in a change in use of the road that would no longer serve the purpose and need of the improvements; thus, VHB did not consider this mitigation further.

8.3 Buffer Zones

Buffer zones are typically not practical and/or cost effective for noise mitigation due to the substantial amount of right-of-way required, and would not be a feasible noise mitigation measure for this project. Furthermore, if the acquisition of a suitable buffer zone had been feasible, the costs to acquire buffer zones for impacted receptors would likely exceed maximum allowable cost. The NCDOT base dollar value for a buffer zone is $22,500 per benefited receptor plus the incremental increase of $7,500 per dB(A) average increase between 5-10 dB(A) and $15,000 per dB(A) average increase above 10 dB(A) in the modeled exterior noise levels of the impacted receptors of the area. For this reason, this abatement measure is unreasonable.

8.4 Noise Barriers

Passive noise abatement measures are effective because they absorb sound energy, extend the source-to-receptor sound transmission path, or both. Sound absorption is a function of abatement medium (e.g., earth berms absorb more sound energy than noise walls of the same height because earth berms are more massive). The source-to-receptor path is extended by placement of an obstacle, such as a wall, that sufficiently blocks the transmission of sound waves that travel from the source to the receptor.

Highway noise barriers are primarily constructed as earth berms or solid-mass walls adjacent to limited-access freeways that are in close proximity to noise-sensitive land use(s). To be effective, a noise barrier must be long enough and tall enough to shield the benefitted receptors. For this project, VHB did not find earthen berms to be a viable abatement measure at any location because the proposed barrier locations are too narrow for efficient earthen berms. Generally, the noise wall length must be eight times the distance from the barrier to the receptor. For example, if receptors were 200 feet from the roadway, an effective 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 render the barrier ineffective in impeding the transmission of traffic noise. Due to the requisite lengths for effectiveness, noise barriers are typically not economical for isolated or most low-density areas.

However, noise barriers may be economical for the benefit of as few as two predicted traffic noise impacts if the barrier can benefit enough total receptors – impacted and non-impacted combined – to meet applicable reasonableness criteria.

8.5 Noise Insulation

Insulating buildings can greatly reduce highway traffic noise, especially when windows are sealed and cracks and other openings are filled. Noise-absorbing material can be placed in the walls of new buildings during construction but is rarely retrofitted into existing buildings. While federal-aid highway project dollars can be used for noise insulation of public-use or non-profit institutional structures, the typical beneficiaries of this type of abatement are school facilities where no other type of abatement is possible.

Since there are no NAC D receptors in the project area, interior noise insulation was not considered as a potential traffic noise impact mitigation measure as part of the analysis for this Traffic Noise Report.

9.0 FEASIBILITY AND REASONABLENESS DETERMINATION

FHWA and NCDOT require consideration and evaluation of feasible and reasonable noise abatement measures for the benefit of all predicted build-condition traffic noise impacts. Feasibility is the consideration as to whether noise abatement measures *can* be implemented. Reasonableness is the consideration as to whether noise abatement measures *should* be implemented. All of the following conditions regarding feasibility and reasonableness must be met in order for noise abatement to be justified and incorporated into project design, as applicable. Failure to achieve any single element of feasibility or reasonableness will deem the noise abatement measure as not feasible or not reasonable, whichever applies.

9.1 Feasibility

The combination of acoustical and engineering factors considered in the evaluation of a noise abatement measure.

a) Any receptor that receives a minimum noise level reduction of 5 dB(A) due to noise abatement measures shall be considered a benefited receptor. Noise reduction of 5 dB(A) must be achieved for at least two impacted receptors.
b) Engineering feasibility of the noise abatement measure(s) shall consider adverse impacts created by or upon property access, drainage, topography, utilities, safety, and maintenance requirements.
c) The effects of secondary traffic noise (e.g., non-project traffic noise) and non-traffic noise sources on attainable Noise Level Reduction shall be considered when developing effective noise abatement measures.

9.2 Reasonableness

The combination of social, economic, and environmental factors considered in the evaluation of a noise abatement measure.

a) Viewpoints of the property owners and residents of all benefited receptors shall be solicited. One owner ballot and one resident ballot shall be solicited for each benefited receptor. Points per ballot shall be distributed in the following weighted manner:
   - 5 points/ballot for adjacent property owners who reside at property
   - 4 points/ballot for adjacent property owners who rent property
   - 3 points/ballot for all non-adjacent property owners who reside at property
   - 2 points/ballot for all non-adjacent property owners who rent property
   - 1 point/ballot for all tenants of rental property

   Where an adjacent receptor is a benefited receptor that either represents a property that shares the highway right of way or has no benefited receptor between it and the highway.

b) The maximum allowable base quantity of noise walls and/or earthen berms per benefited receptor shall not exceed 1,500 ft^2 and 4,200 yd^3, respectively. Additionally, an incremental increase of 500 ft^2 for noise walls and 1,400 yd^3 for earthen berms shall be added to the base quantity per the average increase in dB(A) of 5-10 dB(A) between existing and predicted exterior noise levels of all impacted receptors within each noise sensitive area. An incremental increase of 1,000 ft^2 for noise walls and 2,800 yd^3 for earthen berms shall be added to the base quantity per the average noise increase in dB(A) of greater than 10 dB(A) between existing and predicted exterior noise levels of impacted receptors. A base dollar value of $22,500 plus an incremental increase of $7,500 for a 5-10 dB(A) increase or $15,000 for an increase exceeding 10 dB(A) (as defined earlier in Section 8.3) shall be used to determine reasonableness of buffer zones and noise insulation.

c) A noise reduction design goal of at least 7 dB(A) must be evaluated for all benefited receptors. At least one benefited receptor must achieve the noise reduction design goal of 7 dB(A) to indicate the noise abatement measure effectively reduces traffic noise.

9.3 Noise Barrier Recommendations

Receptors R-135, R-268, R-273, R-297, and R-302 are the only predicted traffic noise impacts for this project. Receptor R-135 is located at the northeast corner of Towhee Drive and Apex Peakway. A noise wall would not be reasonable because it would restrict the line of sight for anyone turning onto Apex Peakway. Receptor R-268 has direct access (driveway) to S. Salem St. A noise wall at this location is not reasonable due to ingress and egress being eliminated should a noise wall be constructed. Noise abatement for receptor R-273 is not feasible due to the inability to achieve a noise reduction level of 5 dB(A) for two (2) impacted receptors. Noise abatement for receptors R-297 and R-302 are also not feasible due to the inability to achieve a noise reduction level of 5 dB(A) for two (2) impacted receptors. Therefore, VHB does not recommend any noise barriers within the project area.

<u>10.0</u> CONSTRUCTION NOISE

The predominant construction activities associated with this project are expected to be Earth removal, hauling, grading, and paving. These activities will likely occur because of temporary and localized construction noise impacts. During daytime hours, the predicted effects of these impacts will be temporary speech interference for passers-by and those individuals living or working near the project. 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 will likely cause severe impacts to the general peace and usage of noise-sensitive areas – particularly residences.

Extremely loud construction noise activities such as usage of impact-hammers (jackhammer, hoe-ram) may provide sporadic and temporary construction noise impacts in the near vicinity of those activities (refer to 7).

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, and paving is anticipated to occur in the near vicinity of numerous noise-sensitive receptors. Although construction noise impact mitigation should not place an undue burden upon the financial cost of the project or the project construction schedule, pursuant to the requirements of 23 CFR 772.19, it is the recommendation of this traffic noise analysis that:

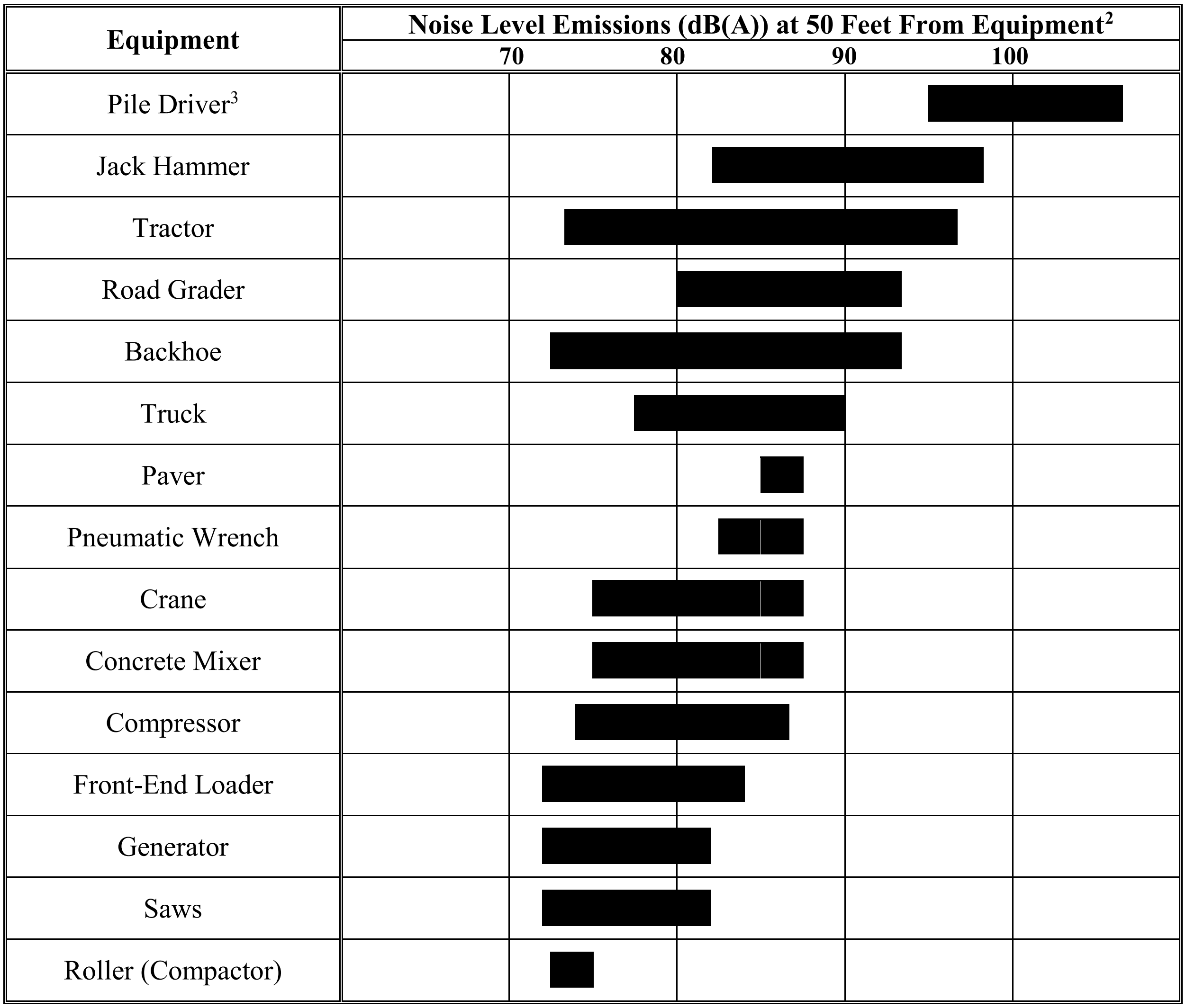
- Earth removal, grading, hauling, and paving activities in the vicinity of residences should be limited to weekday daytime hours.

  If meeting the project schedule requires that earth removal, grading, hauling and / or paving must occur during evening, nighttime and / or weekend hours in the vicinity of residences neighborhoods, 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 mitigation of the predicted construction noise impacts upon the affected property owners and / or residents.

- 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 barriers and / or other equipment-quieting devices shall be considered.

- Some construction activities may create extreme noise impacts for nearby noise-sensitive land uses. It is the recommendation of this Traffic Noise Report that considerations be made for any nearby residences for all potentially affected time periods throughout which extremely loud construction activities might occur.

Table 7 Construction Equipment Typical Noise Level Emissions[1]



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

2 *Cited noise level ranges are typical for the equipment cited. Noise energy dissipates as a function of distance between the source and the receptor. 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.*

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

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: http://www.fhwa.dot.gov/environment/noise/cnstr_ns.htm.

11.0 NOISE COMPATIBLE LAND USE

One of the most effective means to prevent future traffic noise impacts is noise-sensitive land-use development. The compatibility of highways and neighboring local areas is essential for continued growth and can be achieved if local governments and developers require and practice noise-sensitive land-use planning.

Although regulation of land use is not within the purview of FHWA or NCDOT, some widely accepted techniques for noise-sensitive land use planning in the vicinity of existing and proposed highway facilities include:

- Locating commercial retail, industrial, manufacturing, warehousing and other noise-compatible land-uses adjacent to highways

- Incorporating effective traffic noise mitigating features, such as earth berms and solid-mass noise walls, as part of residential developments

- Utilization of noise-sensitive architectural design and site planning, such as the orientation of quiet spaces away from roadways

- Required use of sound insulating building materials and construction methods

As indicated in the October 2016 NCDOT Traffic Noise Abatement Policy, local jurisdictions with zoning control should use the information contained in this report to develop policies and/or ordinances to limit the growth of noise-sensitive land uses located adjacent to roadways. Furthermore, NCDOT encourages the dissemination of this information to all people who may be affected by, or who might influence others affected by, traffic noise.

12.0 CONCLUSION

Traffic noise and temporary construction noise can be a consequence of transportation projects, especially in areas in close proximity to high-volume, existing steady-state traffic noise sources. This Traffic Noise Report for NCDOT STIP U-5928 utilized computer models created using TNM 2.5, validated to field-collected ambient traffic noise monitoring data, to predict future noise levels and define impacted receptors along the proposed project.

Under the Design Year (2040) Build conditions there are five predicted traffic noise impacts. These five receptors will approach or exceed NCDOT's and FHWA's noise abatement criteria while one will also be impacted due to a substantial increase in predicted noise levels over existing. These impacted receptors are residential.

Receptors R-135, R-268, R-273, R-297, and R-302 are the only predicted traffic noise impacts for this project. Receptor R-135 is located at the northeast corner of Towhee Drive and Apex Peakway. A noise wall would not be reasonable because it would restrict the line of sight for anyone turning onto Apex Peakway. Receptor R-268 has direct access (driveway) to S. Salem St. A noise wall at this location is not reasonable due to ingress and egress being eliminated should a noise wall be constructed. Noise abatement for receptor R-273 is not feasible due to the inability to achieve a noise reduction level of 5 dB(A) for two (2) impacted receptors. Noise abatement for receptors R-297 and R-302 are also not feasible due to the inability to achieve a noise reduction level of 5 dB(A) for two (2) impacted receptors.

13.0 REFERENCES

Bowlby, W.; *Fundamentals of Noise and FHWA Traffic Noise Model (TNM) 2.5 Training Course*. Bowlby & Associates, Inc., Franklin, TN. February 1-5, 2010.

Federal Highway Administration. *Analysis of Highway Construction Noise*. 1984.

Federal Highway Administration. CFR 23 Part 772 – Procedures for Abatement of Highway Traffic Noise and Construction Noise. [75 FR 39820-39838, July 13, 2010].

Federal Highway Administration. *Highway Traffic Noise Analysis and Abatement Policy and Guidance*. Original June 2010 and revised December 2010.

Federal Highway Administration. *Highway Traffic Noise Analysis: Reasonableness and Feasibility of Abatement*. U.S. Department of Transportation. Washington, D.C. 1992.

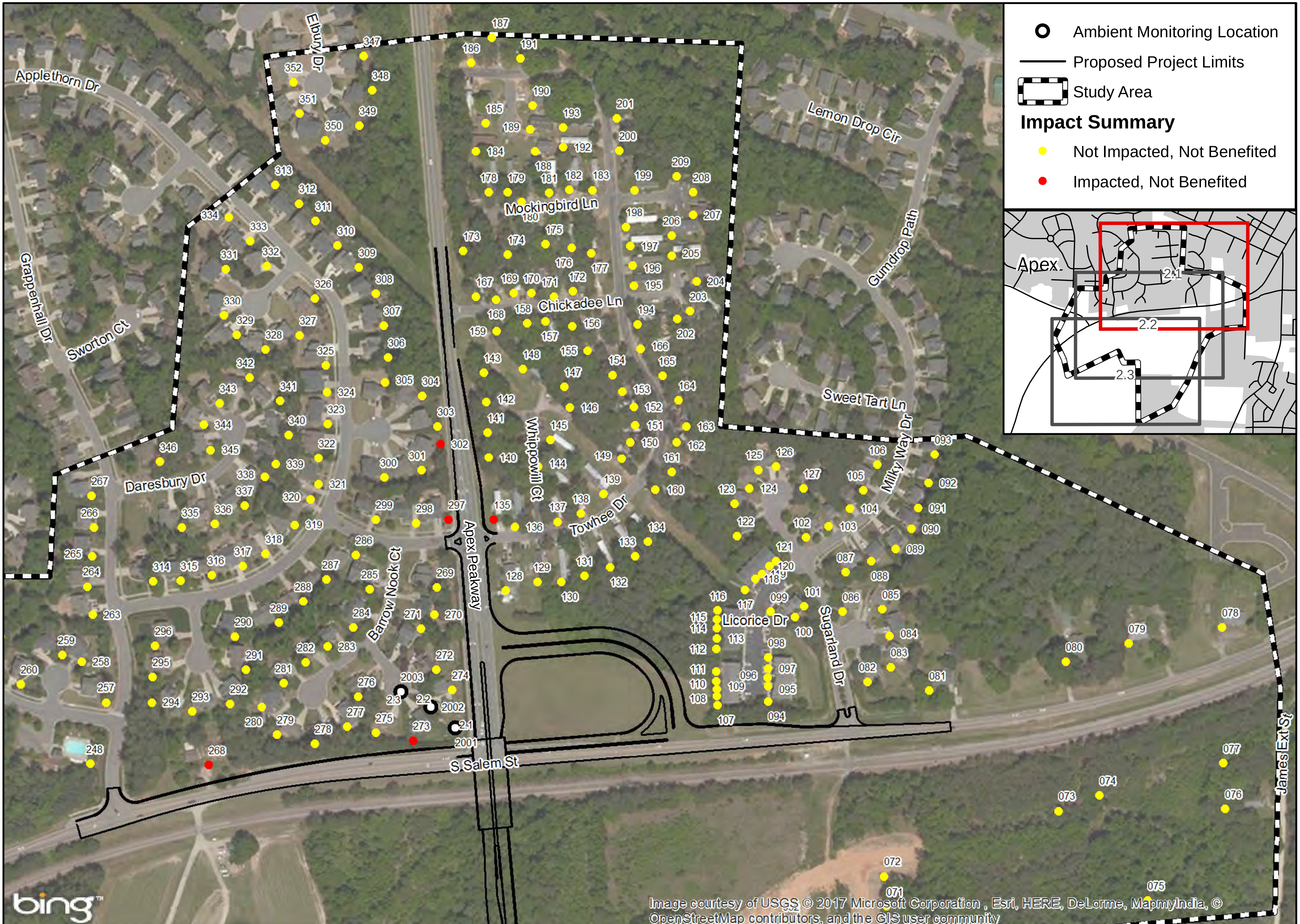
North Carolina Department of Transportation. *Traffic Noise Policy*. October 2016.

North Carolina Department of Transportation. *Traffic Noise Manual*. 2016.

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

Figure 1
Project Study Area

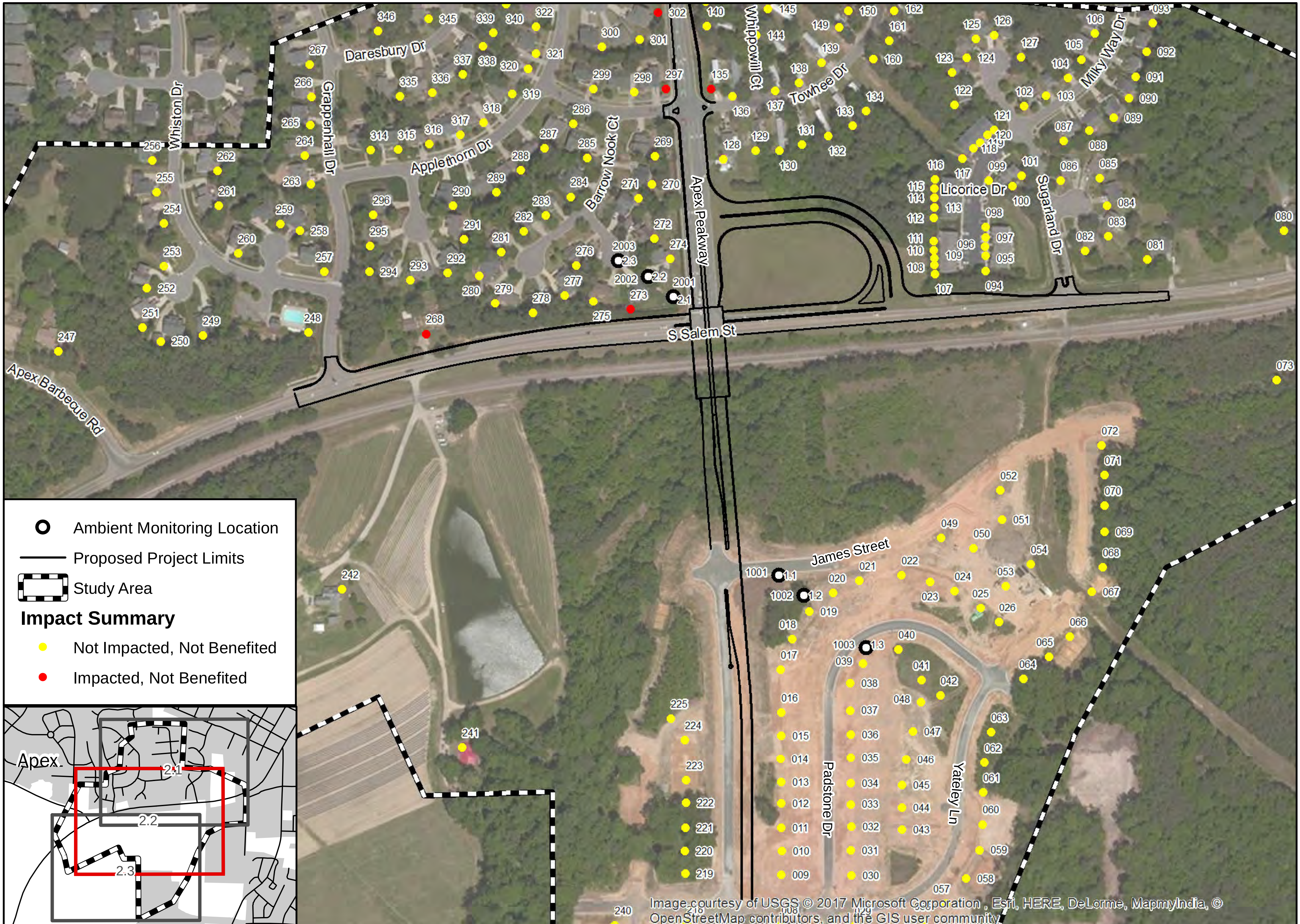
Apex Peakway Connector TNR
STIP U-5928
Wake County
February 2017



0 75 150 300 Feet

Figure 2.1
TNR Results - Build Alternative

Apex Peakway Connector TNR
STIP U-5928
Wake County



0 75 150 300 Feet

Figure 2.2
TNR Results - Build Alternative

Apex Peakway Connector TNR
STIP U-5928
Wake County

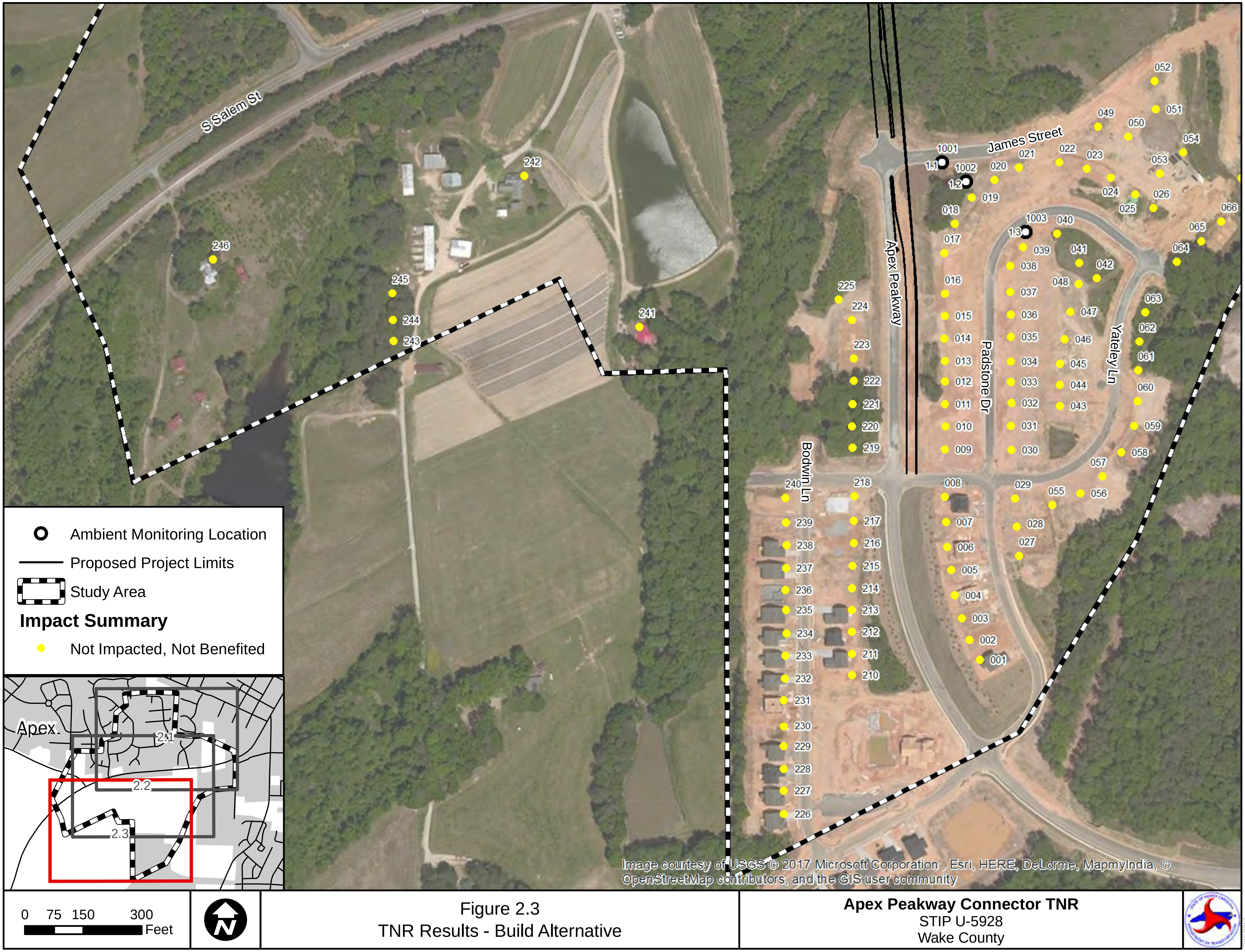


Figure 2.3
TNR Results - Build Alternative

Apex Peakway Connector TNR
STIP U-5928
Wake County

APPENDICES

Appendix A

Ambient Noise Level Monitoring

Table A-1: Validation

Setup	Location Description	Measured Sound Level	TNM Calculated	Δ	Validate?
1001	Behind 1428 Padstone Dr, adjacent to James St along the top of the hill	49.6	52.6	-3	**YES**
1002	Behind 1428 Padstone Dr, just in front of the treeline along the bottom of the hill	44.4	45.1	-0.7	**YES**
1003	To the west of the driveway of 1425 Padstone Dr - NOT ENOUGH DATA	---	---	---	**---**
2001	At the corner of S Salem St and Apex Peakway N, behind the berm	59.4	57.2	2.2	**YES**
2002	Just east of the northeast corner of 1006 Marston Ct, in the driveway	49.5	52	-2.5	**YES**
2003	Center of Marston Ct cul-de-sac	48.9	49.1	-0.2	**YES**

Count Number:	1001 / 1002 / 1003	Count Type:	NL - Noise Measurement
County:	Wake	Duration:	33 minutes
City:	Apex	Method Used:	Larson-Davis 831
Division:	05	Completed By:	Topp/Brownlow

Location: James St & Apex Peakway S to Padstone Dr

Count Date: Friday, October 28, 2016

Count Time: 10:23 AM to 10:56 AM

Weather Conditions

Temp (°F)	Dew Point (°F)	Pressure (in)	Wind Dir.	Wind Speed (mph)	Relative humidity	Precip. (in)
68	57	30.3	NW	4.6	67%	0

* Source: Weather Underground (www.wunderground.com) for local weather information

Comments:

1	Counted By:	Topp
2	School in Session:	Yes
3	Instrument Calibrated	Yes
4	Surrounding Land-Uses:	Residential
5	Equipment was working properly	Yes
6	Temp high/low/average:	73,49,62
7	Wind	4.6
8	Precipitation	0

Setup Location

Vicinity Map

Observed Traffic Volumes:

	NB	SB	WB	EB	
Passenger cars	5	4	0	5	vph
Medium Trucks	0	0	0	5	vph
Tractor Trailers	0	0	0	2	vph
Buses	0	0	0	0	vph
Motorcycles	0	0	0	0	vph

Meter 1 Meter 2 Meter 3

Aerial

Event Notes:

Despiking necessary to remove train horn, speaking, and car door slamming.

VHB | VHB Engineering NC, PC
Transportation Planning
Land Development | Engineering

Intersection: James St & Apex Peakway S to Padstone Dr

Location 1001 - Looking Southeast

Location 1002 - Looking Northwest

Count Number: 1001 / 1002 / 1003
County: Wake
City: Apex
Division: 05

VHB | VHB Engineering NC, PC
Transportation Planning
Land Development | Engineering

Intersection: James St & Apex Peakway S to Padstone Dr

Location 1003 - Looking Southeast

Count Number:	2001 / 2002 / 2003	Count Type:	NL - Noise Measurement
County:	Wake	Duration:	24 minutes
City:	Apex	Method Used:	Larson-Davis 831
Division:	05	Completed By:	Topp/Brownlow

Location: S Salem St & Apex Peakway N to Marston Ct

Count Date: Friday, October 28, 2016

Count Time: 11:13 AM to 11:37 AM

Weather Conditions

Temp (°F)	Dew Point (°F)	Pressure (in)	Wind Dir.	Wind Speed (mph)	Relative humidity	Precip. (in)
69	54	30.3	WNW	4.6	59%	0

* Source: Weather Underground (www.wunderground.com) for local weather information

Comments:

1	Counted By:	Topp
2	School in Session:	Yes
3	Instrument Calibrated	No
4	Surrounding Land-Uses:	Residential
5	Equipment was working properly	Yes
6	Temp high/low/average:	73,49,62
7	Wind	4.6
8	Precipitation	0

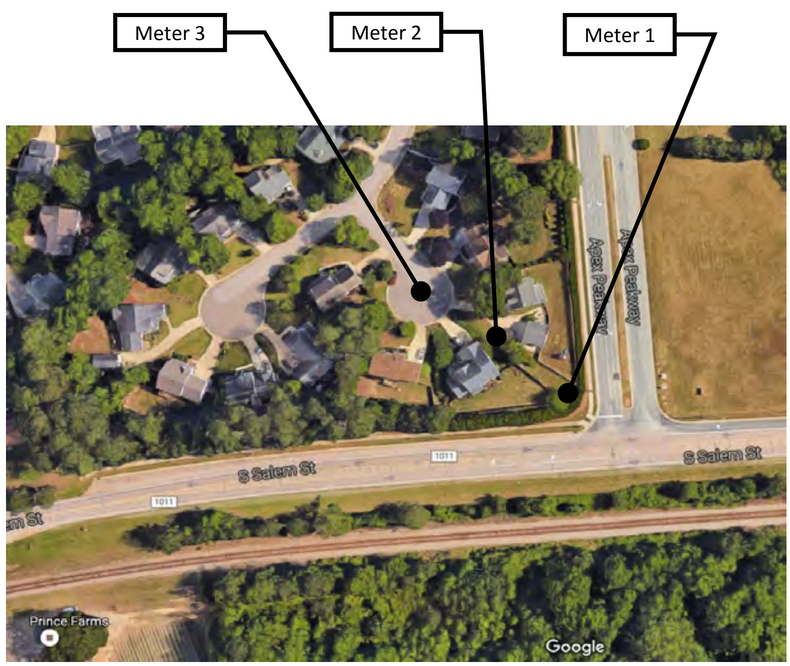
Vicinity Map

Observed Traffic Volumes:

	NB	SB	WB	EB	
Passenger cars	333	178	0	75	vph
Medium Trucks	15	8	0	3	vph
Tractor Trailers	13	3	0	13	vph
Buses	3	0	0	0	vph
Motorcycles	0	0	0	0	vph

Event Notes:

Despiking necessary to remove noise caused by screeching brakes, train horns, and a jet flyover.



Aerial

Count Number: 2001 / 2002 / 2003
County: Wake
City: Apex
Division: 05

VHB | VHB Engineering NC, PC
Transportation Planning
Land Development | Engineering

Intersection: S Salem St & Apex Peakway N to Marston Ct

Location 2001 - Looking Southeast

Location 2002 - Looking Northwest

Count Number: 2001 / 2002 / 2003
County: Wake
City: Apex
Division: 05

VHB | VHB Engineering NC, PC
Transportation Planning
Land Development | Engineering

Intersection: S Salem St & Apex Peakway N to Marston Ct

Location 2003 - Looking East

Count Number:	3001	Count Type:	NL - Noise Measurement
County:	Wake	Duration:	30 minutes
City:	Apex	Method Used:	Larson-Davis 831
Division:	05	Completed By:	Topp/Brownlow

Location: South end of Licorice Dr

Count Date: Friday, December 30, 2016

Count Time: 10:50 AM to 11:20 AM

Weather Conditions

Temp (°F)	Dew Point (°F)	Pressure (in)	Wind Dir.	Wind Speed (mph)	Relative humidity	Precip. (in)
44	18.9	30.04	W	13.8	36%	0

* Source: Weather Underground (www.wunderground.com) for local weather information

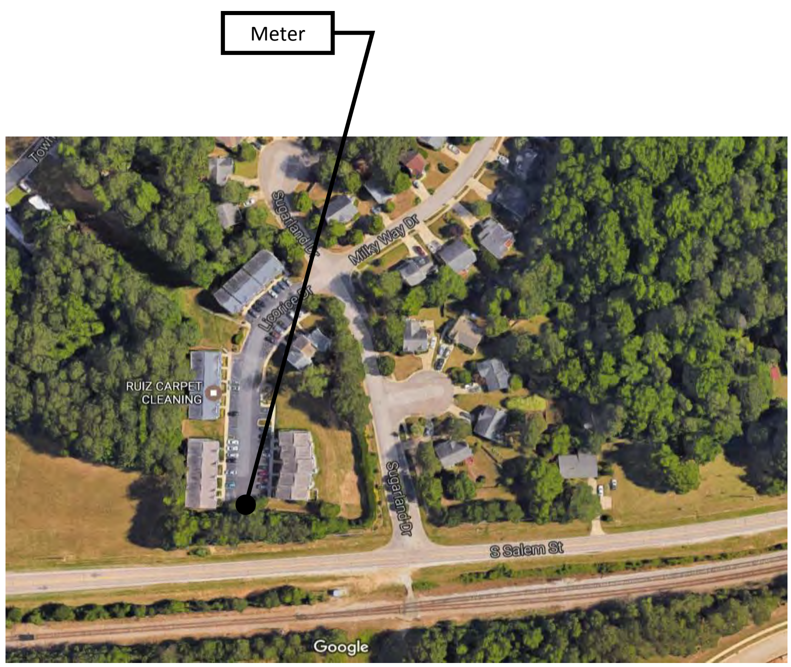
Comments:

1	Counted By:	N/A
2	School in Session:	No
3	Instrument Calibrated	Yes
4	Surrounding Land-Uses:	Residential
5	Equipment was working properly	Yes
6	Temp high/low/average:	46,32,39
7	Wind	6
8	Precipitation	0

Vicinity Map

Observed Traffic Volumes:

	NB	SB	WB	EB	
Passenger cars					vph
Medium Trucks					vph
Tractor Trailers					vph
Buses					vph
Motorcycles					vph



Aerial

Event Notes:

Despiking necessary to remove noise cause by a nearby garbage truck.

Count Number:	3001
County:	Wake
City:	Apex
Division:	05

VHB | VHB Engineering NC, PC
Transportation Planning
Land Development | Engineering

Intersection: South end of Licorice Dr

Location 3001 - Looking East

4000 WestChase Boulevard, Suite 530 / Raleigh, NC 27607 / p: 919.829.0328

Calibration Certificate

Certificate Number 2016000610

Customer:
Vanasse Hangen Brustlin
101 Walnut Street
Watertown, MA 02471, United States

Model Number	LxT SE
Serial Number	0003707
Test Results	**Pass**
Initial Condition	Inoperable
Description	Sound Expert LxT

Procedure Number	D0001.8378		
Technician	Ron Harris		
Calibration Date	21 Jan 2016		
Calibration Due	21 Jan 2017		
Temperature	22.99	°C	± 0.01 °C
Humidity	49.5	%RH	± 0.5 %RH
Static Pressure	87.58	kPa	± 0.03 kPa

Evaluation Method Tested electrically using PRMLxT1L S/N 028010 and a 12.0 pF capacitor to simulate microphone capacitance. Data reported in dB re 20 µPa assuming a microphone sensitivity of 23.6 mV/Pa.

Compliance Standards Compliant to Manufacturer Specifications and the following standards when combined with Calibration Certificate from procedure D0001.8384:

IEC 60651:2001 Type 1	ANSI S1.4-2014 Class 1
IEC 60804:2000 Type 1	ANSI S1.4 (R2006) Type 1
IEC 61252:2002	ANSI S1.11 (R2009) Class 1
IEC 61260:2001 Class 1	ANSI S1.25 (R2007)
IEC 61672:2013 Class 1	ANSI S1.43 (R2007) Type 1

Issuing lab certifies that the instrument described above meets or exceeds all specifications as stated in the referenced procedure (unless otherwise noted). It has been calibrated using measurement standards traceable to the SI through the National Institute of Standards and Technology (NIST), or other national measurement institutes, and meets the requirements of ISO/IEC 17025:2005. **Test points marked with a ‡ in the uncertainties column do not fall within this laboratory's scope of accreditation.**

The quality system is registered to ISO 9001:2008.

This calibration is a direct comparison of the unit under test to the listed reference standards and did not involve any sampling plans to complete. No allowance has been made for the instability of the test device due to use, time, etc. Such allowances would be made by the customer as needed.

The uncertainties were computed in accordance with the ISO Guide to the Expression of Uncertainty in Measurement (GUM). A coverage factor of approximately 2 sigma (k=2) has been applied to the standard uncertainty to express the expanded uncertainty at approximately 95% confidence level.

Standards Used

Description	Cal Date	Cal Due	Cal Standard
SRS DS360 Ultra Low Distortion Generator	02/06/2015	02/06/2016	006239
Hart Scientific 2626-H Temperature Probe	06/17/2015	06/17/2016	006798

Calibration Certificate

Certificate Number 2015006853

Customer:

Vanasse Hangen Brustlin
101 Walnut Street
Watertown, MA 02471, United States

Model Number	831
Serial Number	0002555
Test Results	**Pass**
Initial Condition	AS RECEIVED same as shipped
Description	Larson Davis Model 831

Procedure Number	D0001.8384		
Technician	Ron Harris		
Calibration Date	21 Jul 2015		
Calibration Due	21 Jul 2016		
Temperature	23.11	°C	± 0.01 °C
Humidity	49.9	%RH	± 0.5 %RH
Static Pressure	86.39	kPa	± 0.03 kPa

Evaluation Method ***Tested with:***
PRM831, S/N 019119
377B02, S/N 122951

Data reported in dB re 20 μPa.

Compliance Standards Compliant to Manufacturer Specifications and the following standards when combined with Calibration Certificate from procedure D0001.8378:

IEC 60651:2001 Type 1	ANSI S1.4-2014 Class 1
IEC 60804:2000 Type 1	ANSI S1.4 (R2006) Type 1
IEC 61252:2002	ANSI S1.11 (R2009) Class 1
IEC 61260:2001 Class 1	ANSI S1.25 (R2007)
IEC 61672:2013 Class 1	ANSI S1.43 (R2007) Type 1

Issuing lab certifies that the instrument described above meets or exceeds all specifications as stated in the referenced procedure (unless otherwise noted). It has been calibrated using measurement standards traceable to the SI through the National Institute of Standards and Technology (NIST), or other national measurement institutes, and meets the requirements of ISO/IEC 17025:2005.
Test points marked with a ‡ in the uncertainties column do not fall within this laboratory's scope of accreditation.

The quality system is registered to ISO 9001:2008.

This calibration is a direct comparison of the unit under test to the listed reference standards and did not involve any sampling plans to complete. No allowance has been made for the instability of the test device due to use, time, etc. Such allowances would be made by the customer as needed.

The uncertainties were computed in accordance with the ISO Guide to the Expression of Uncertainty in Measurement (GUM). A coverage factor of approximately 2 sigma (k=2) has been applied to the standard uncertainty to express the expanded uncertainty at approximately 95% confidence level.

Standards Used

Description	Cal Date	Cal Due	Cal Standard
SRS DS360 Ultra Low Distortion Generator	06/24/2015	06/24/2016	006311
Hart Scientific 2626-H Temperature Probe	06/17/2015	06/17/2016	006798
Larson Davis CAL200 Acoustic Calibrator	08/06/2014	08/06/2015	007027
Larson Davis Model 831	03/05/2015	03/05/2016	007182
1/2 inch Microphone - P - 0V	03/11/2015	03/11/2016	007185
Larson Davis CAL291 Residual Intensity Calibrator	09/26/2014	09/26/2015	007287

Calibration Certificate

Certificate Number 2016001607

Customer:

Vanasse Hangen Brustlin
101 Walnut Street
Watertown, MA 02471, United States

Model Number	831	***Procedure Number***	D0001.8384
Serial Number	0003502	***Technician***	Ron Harris
Test Results	**Pass**	***Calibration Date***	19 Feb 2016
Initial Condition	AS RECEIVED same as shipped	***Calibration Due***	19 Feb 2017
Description	Larson Davis Model 831	***Temperature***	23.05 °C ± 0.01 °C
		Humidity	50.3 %RH ± 0.5 %RH
		Static Pressure	86.41 kPa ± 0.03 kPa

Evaluation Method ***Tested with:***
PRM831. S/N 026155
377B02. S/N 140815

Data reported in dB re 20 μPa.

Compliance Standards Compliant to Manufacturer Specifications and the following standards when combined with Calibration Certificate from procedure D0001.8378:

IEC 60651:2001 Type 1	ANSI S1.4-2014 Class 1
IEC 60804:2000 Type 1	ANSI S1.4 (R2006) Type 1
IEC 61252:2002	ANSI S1.11 (R2009) Class 1
IEC 61260:2001 Class 1	ANSI S1.25 (R2007)
IEC 61672:2013 Class 1	ANSI S1.43 (R2007) Type 1

Issuing lab certifies that the instrument described above meets or exceeds all specifications as stated in the referenced procedure (unless otherwise noted). It has been calibrated using measurement standards traceable to the SI through the National Institute of Standards and Technology (NIST), or other national measurement institutes, and meets the requirements of ISO/IEC 17025:2005. **Test points marked with a ‡ in the uncertainties column do not fall within this laboratory's scope of accreditation.**

The quality system is registered to ISO 9001:2008.

This calibration is a direct comparison of the unit under test to the listed reference standards and did not involve any sampling plans to complete. No allowance has been made for the instability of the test device due to use, time, etc. Such allowances would be made by the customer as needed.

The uncertainties were computed in accordance with the ISO Guide to the Expression of Uncertainty in Measurement (GUM). A coverage factor of approximately 2 sigma (k=2) has been applied to the standard uncertainty to express the expanded uncertainty at approximately 95% confidence level.

Standards Used

Description	Cal Date	Cal Due	Cal Standard
SRS DS360 Ultra Low Distortion Generator	06/24/2015	06/24/2016	006311
Hart Scientific 2626-H Temperature Probe	06/17/2015	06/17/2016	006798
Larson Davis CAL200 Acoustic Calibrator	08/12/2015	08/12/2016	007027
Larson Davis Model 831	03/05/2015	03/05/2016	007182
1/2 inch Microphone - P - 0V	03/11/2015	03/11/2016	007185
Larson Davis CAL291 Residual Intensity Calibrator	09/24/2015	09/24/2016	007287

Larson Davis, a division of PCB Piezotronics, Inc
1681 West 820 North
Provo, UT 84601, United States
716-684-0001

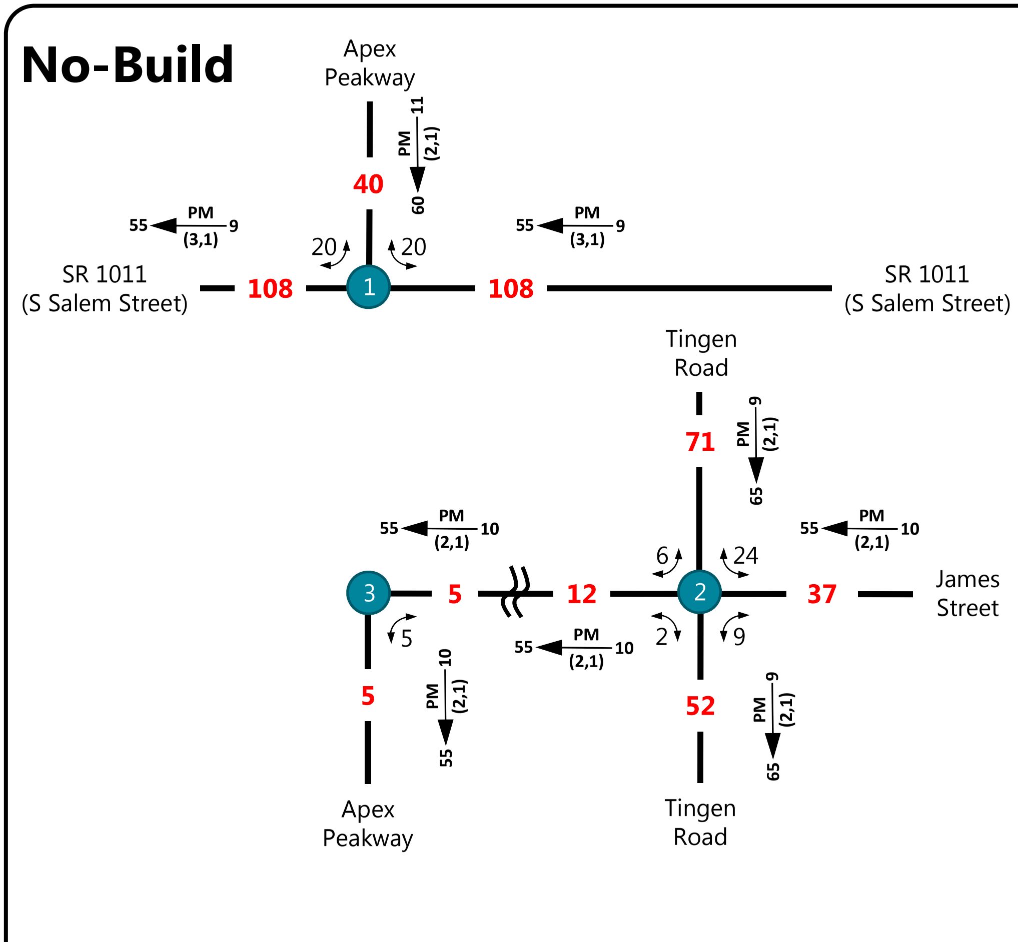
ACCREDITED
Cert. #3622.01

LARSON DAVIS
A PCB PIEZOTRONICS DIV.

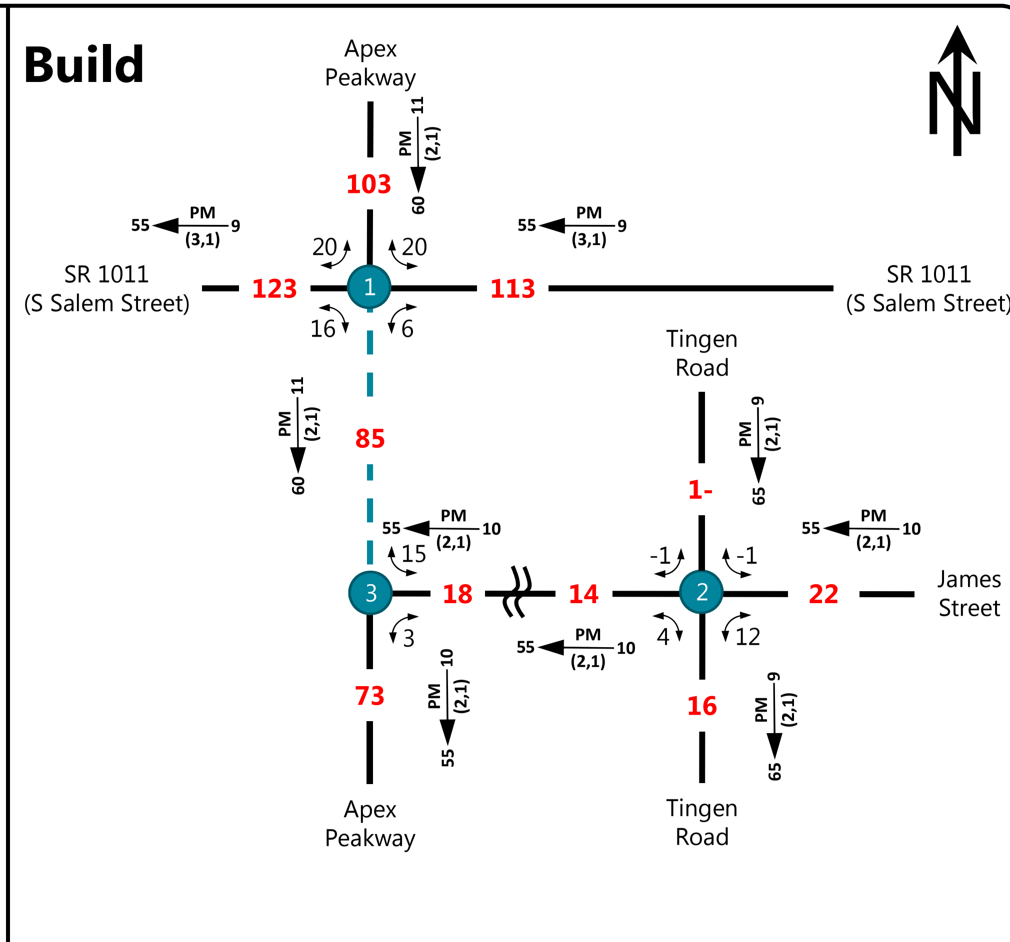
Appendix B

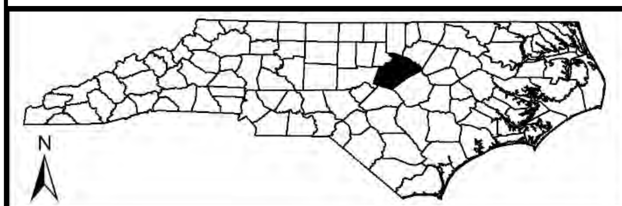
Predicted Traffic Volumes

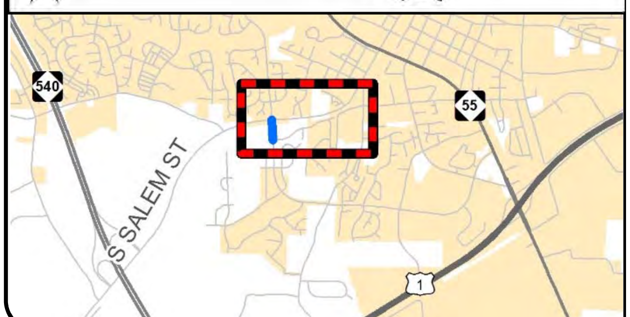
No-Build



Build







2016 Average Annual Daily Traffic Alternatives

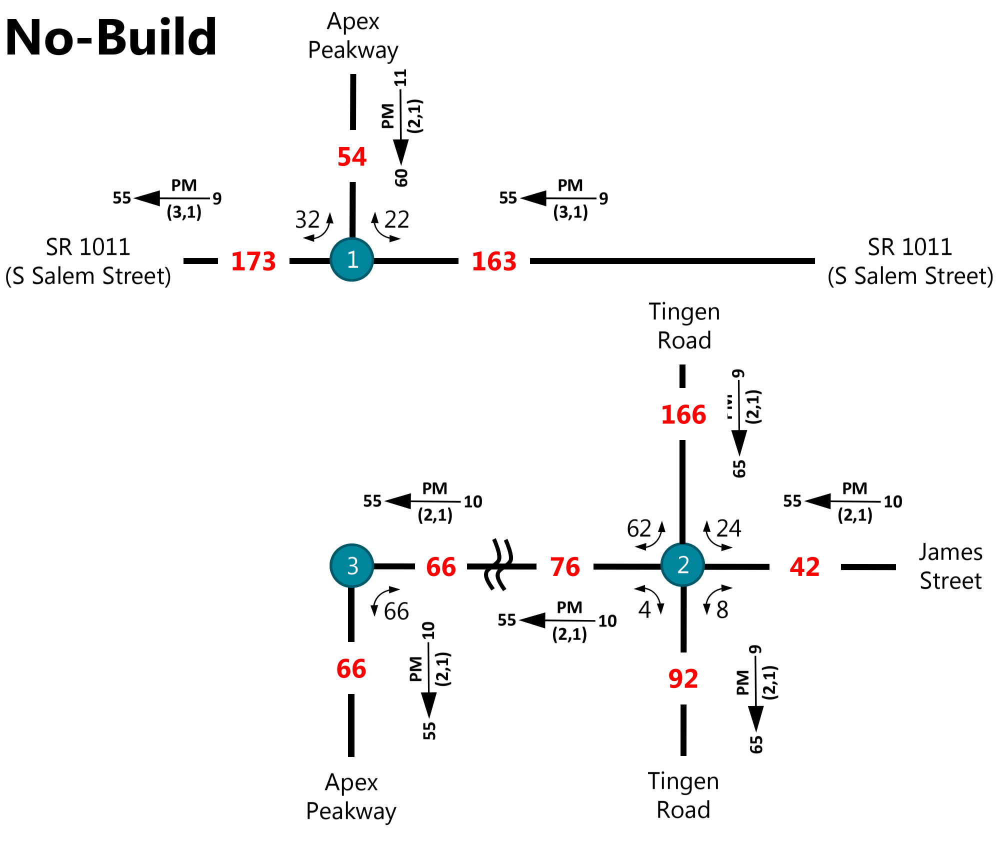
L E G E N D

K —PM (d, t)→ D

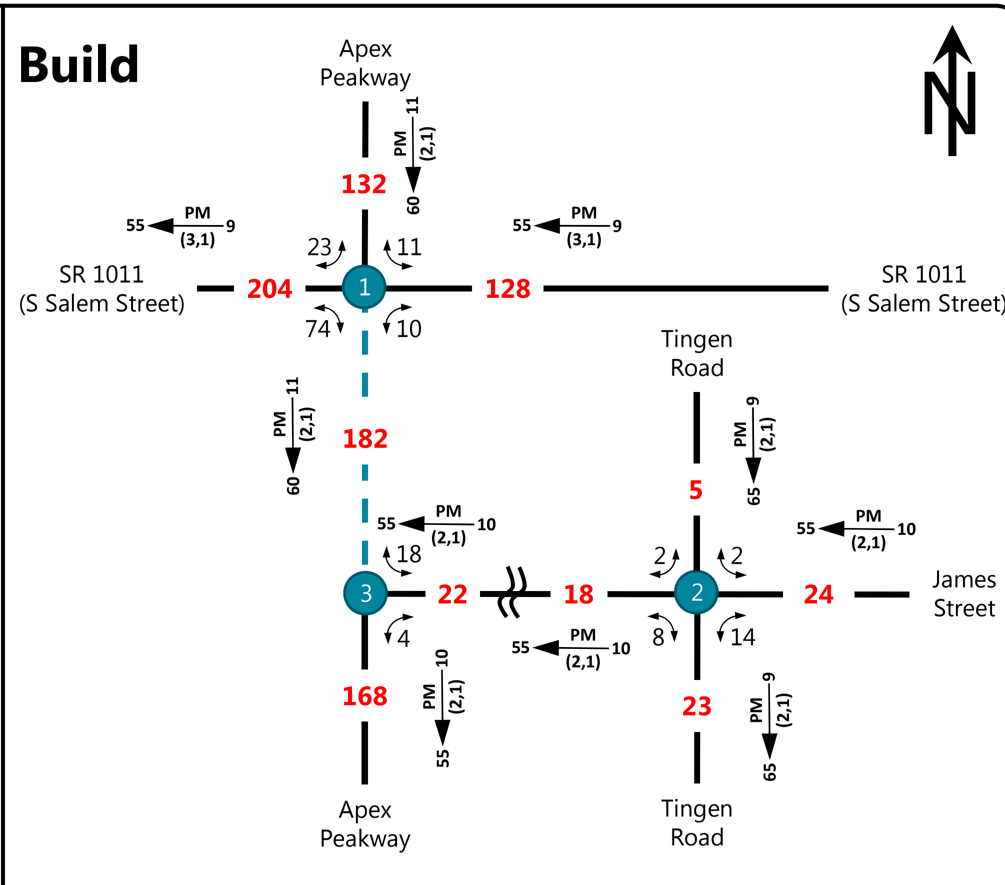
###	No. of Vehicles per Day (VPD) in 100s	PM	PM Peak Hour
—	Existing Roadway	D	Peak Hour Directional Split (%)
- -	Future Roadway	→	Indicates Direction of D
		(d,t)	Duals, TTSTs (%)
		K	Design Hour Factor (%)
		1-	Less than 50 VPD

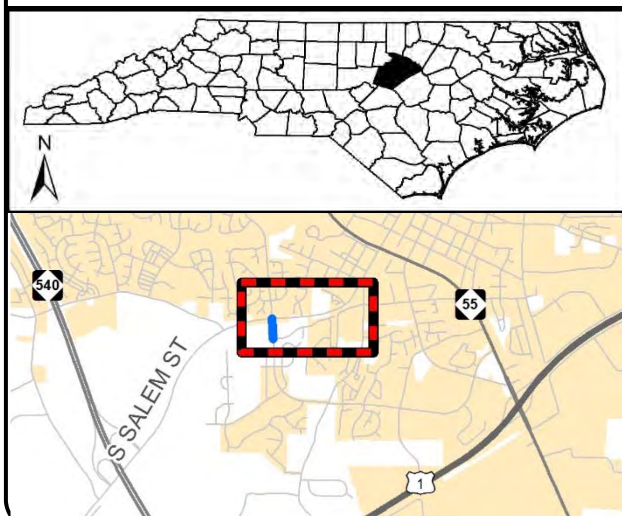
TIP: U-5928	**WBS:** --
COUNTY: Wake	**DIVISION:** 5
DATE: 08/01/2016	
PREPARED BY: VHB Engineering NC, P.C.	
LOCATION: Apex Peakway Connector between SR (1011) S Salem Street and James Street	
PROJECT: Apex Peakway Southwest Connector	

No-Build



Build





2040 Average Annual Daily Traffic

Alternatives

L E G E N D

K —PM/(d, t)→ D

###	No. of Vehicles per Day (VPD) in 100s (Forecast)
—	Existing Roadway
- -	Future Roadway

PM	PM Peak Hour
D	Peak Hour Directional Split (%)
→	Indicates Direction of D
(d,t)	Duals, TTSTs (%)
K	Design Hour Factor (%)
1-	Less than 50 VPD

TIP: U-5928	**WBS:** --
COUNTY: Wake	**DIVISION:** 5
DATE: 08/01/2016	
PREPARED BY: VHB Engineering NC, P.C.	
LOCATION: Apex Peakway Connector between SR (1011) S Salem Street and James Street	
PROJECT: Apex Peakway Southwest Connector	

Appendix C

Traffic Noise Analysis Results

Table C-1: Apex Peakway Connector (STIP No. U-5928) Receptors, Noise Levels, and Noise Impacts

Receptors					Predicted Noise Levels, $L_{eq(h)}$ (dB(A))			
Receptor Number	Address	NAC	Use	DUs	Existing	No-Build	Build	Change
R-001	1528 PADSTONE DR	B	Residential	1	50*	52	57	7
R-002	1524 PADSTONE DR	B	Residential	1	50*	52	57	7
R-003	1520 PADSTONE DR	B	Residential	1	50*	52	57	7
R-004	1516 PADSTONE DR	B	Residential	1	50*	52	56	6
R-005	1512 PADSTONE DR	B	Residential	1	50*	52	55	5
R-006	1508 PADSTONE DR	B	Residential	1	50*	52	55	5
R-007	1504 PADSTONE DR	B	Residential	1	50*	52	56	6
R-008	1500 PADSTONE DR	B	Residential	1	50*	52	57	7
R-009	1472 PADSTONE DR	B	Residential	1	50*	53	58	8
R-010	1468 PADSTONE DR	B	Residential	1	50*	53	58	8
R-011	1464 PADSTONE DR	B	Residential	1	50*	53	58	8
R-012	1460 PADSTONE DR	B	Residential	1	50*	53	58	8
R-013	1456 PADSTONE DR	B	Residential	1	50*	54	58	8
R-014	1452 PADSTONE DR	B	Residential	1	50*	53	57	7
R-015	1448 PADSTONE DR	B	Residential	1	50*	52	57	7
R-016	1444 PADSTONE DR	B	Residential	1	50*	52	56	6
R-017	1436 PADSTONE DR	B	Residential	1	50*	52	56	6
R-018	1432 PADSTONE DR	B	Residential	1	50*	52	55	5
R-019	1428 PADSTONE DR	B	Residential	1	50*	52	54	4
R-020	1424 PADSTONE DR	B	Residential	1	50*	54	53	3
R-021	1420 PADSTONE DR	B	Residential	1	50*	56	52	2
R-022	1416 PADSTONE DR	B	Residential	1	50*	55	52	2
R-023	1412 PADSTONE DR	B	Residential	1	50*	53	50*	0
R-024	1408 PADSTONE DR	B	Residential	1	50*	50*	50*	0
R-025	1404 PADSTONE DR	B	Residential	1	50*	50*	50*	0
R-026	1400 PADSTONE DR	B	Residential	1	50*	50*	50*	0
R-027	1511 PADSTONE DR	B	Residential	1	50*	50*	50*	0
R-028	1505 PADSTONE DR	B	Residential	1	50*	50*	50*	0
R-029	1501 PADSTONE DR	B	Residential	1	50*	50*	50*	0
R-030	1473 PADSTONE DR	B	Residential	1	50*	50*	50*	0
R-031	1469 PADSTONE DR	B	Residential	1	50*	50*	50*	0
R-032	1465 PADSTONE DR	B	Residential	1	50*	50*	50*	0
R-033	1461 PADSTONE DR	B	Residential	1	50*	50*	50*	0
R-034	1457 PADSTONE DR	B	Residential	1	50*	50*	50*	0
R-035	1453 PADSTONE DR	B	Residential	1	50*	50*	50*	0
R-036	1449 PADSTONE DR	B	Residential	1	50*	50*	50*	0
R-037	1445 PADSTONE DR	B	Residential	1	50*	50*	50*	0
R-038	1439 PADSTONE DR	B	Residential	1	50*	50*	50*	0
R-039	1425 PADSTONE DR	B	Residential	1	50*	50*	50*	0
R-040	1415 PADSTONE DR	B	Residential	1	50*	50*	50*	0
R-041	1405 PADSTONE DR	B	Residential	1	50*	50*	50*	0
R-042	1401 PADSTONE DR	B	Residential	1	50*	50*	50*	0
R-043	1778 YATELEY LN	B	Residential	1	50*	50*	50*	0
R-044	1774 YATELEY LN	B	Residential	1	50*	50*	50*	0
R-045	1770 YATELEY LN	B	Residential	1	50*	50*	50*	0
R-046	1766 YATELEY LN	B	Residential	1	50*	50*	50*	0
R-047	1762 YATELEY LN	B	Residential	1	50*	50*	50*	0
R-048	1758 YATELEY LN	B	Residential	1	50*	50*	50*	0
R-049	36 JAMES ST	B	Residential	1	50*	59	54	4
R-050	40 JAMES ST	B	Residential	1	50*	53	50	0

Receptors					Predicted Noise Levels, $L_{eq(h)}$ (dB(A))			
Receptor Number	Address	NAC	Use	DUs	Existing	No-Build	Build	Change
R-051	44 JAMES ST	B	Residential	1	50*	54	51	1
R-052	48 JAMES ST	B	Residential	1	50*	59	54	4
R-053	1708 YATELEY LN	B	Residential	1	50*	50*	50*	0
R-054	1704 YATELEY LN	B	Residential	1	50*	50*	50*	0
R-055	1793 YATELEY LN	B	Residential	1	50*	50*	50*	0
R-056	1789 YATELEY LN	B	Residential	1	50*	50*	50*	0
R-057	1785 YATELEY LN	B	Residential	1	50*	50*	50*	0
R-058	1781 YATELEY LN	B	Residential	1	50*	50*	50*	0
R-059	1777 YATELEY LN	B	Residential	1	50*	50*	50*	0
R-060	1773 YATELEY LN	B	Residential	1	50*	50*	50*	0
R-061	1767 YATELEY LN	B	Residential	1	50*	50*	50*	0
R-062	1761 YATELEY LN	B	Residential	1	50*	50*	50*	0
R-063	1751 YATELEY LN	B	Residential	1	50*	50*	50*	0
R-064	1713 YATELEY LN	B	Residential	1	50*	50*	50*	0
R-065	1709 YATELEY LN	B	Residential	1	50*	50*	50*	0
R-066	1705 YATELEY LN	B	Residential	1	50*	50*	50*	0
R-067	1721 CADEN HILL CT	B	Residential	1	50*	50*	50*	0
R-068	1717 CADEN HILL CT	B	Residential	1	50*	50*	50*	0
R-069	1713 CADEN HILL CT	B	Residential	1	50*	50*	50*	0
R-070	1709 CADEN HILL CT	B	Residential	1	50*	50*	50*	0
R-071	1705 CADEN HILL CT	B	Residential	1	50*	51	50*	0
R-072	1701 CADEN HILL CT	B	Residential	1	50*	58	53	3
R-073	84 JAMES ST	B	Residential	1	52	58	54	2
R-074	88 JAMES ST	B	Residential	1	53	59	55	2
R-075	1718 MINLEY WAY	B	Residential	1	50*	50*	50*	0
R-076	1707 MINLEY WAY	B	Residential	1	50*	53	51	1
R-077	1701 MINLEY WAY	B	Residential	1	53	58	55	2
R-078	720 S SALEM ST	B	Residential	1	59	61	60	1
R-079	740 S SALEM ST	B	Residential	1	56	58	57	1
R-080	800 S SALEM ST	B	Residential	1	56	58	57	1
R-081	808 S SALEM ST	B	Residential	1	59	61	61	2
R-082	101 SUGARLAND DR	B	Residential	1	56**	58	59	3
R-083	101 SUGARLAND DR	B	Residential	1	56**	56**	56**	0
R-084	103 SUGARLAND DR	B	Residential	1	56**	56**	56**	0
R-085	107 SUGARLAND DR	B	Residential	1	56**	56**	56**	0
R-086	109 SUGARLAND DR	B	Residential	1	56**	56**	56**	0
R-087	101 MILKY WAY DR	B	Residential	1	56**	56**	56**	0
R-088	103 MILKY WAY DR	B	Residential	1	56**	56**	56**	0
R-089	105 MILKY WAY DR	B	Residential	1	56**	56**	56**	0
R-090	107 MILKY WAY DR	B	Residential	1	56**	56**	56**	0
R-091	109 MILKY WAY DR	B	Residential	1	56**	56**	56**	0
R-092	111 MILKY WAY DR	B	Residential	1	56**	56**	56**	0
R-093	113 MILKY WAY DR	B	Residential	1	56**	56**	56**	0
R-094	139 LICORICE DR	B	Residential	1	56**	57	62	6
R-095	137 LICORICE DR	B	Residential	1	56**	56**	57	1
R-096	135 LICORICE DR	B	Residential	1	56**	56**	56**	0
R-097	133 LICORICE DR	B	Residential	1	56**	56**	56**	0
R-098	131 LICORICE DR	B	Residential	1	56**	56**	56**	0
R-099	105 LICORICE DR	B	Residential	1	56**	56**	56**	0
R-100	103 LICORICE DR	B	Residential	1	56**	56**	56**	0
R-101	101 LICORICE DR	B	Residential	1	56**	56**	56**	0
R-102	100 MILKY WAY DR	B	Residential	1	56**	56**	56**	0

Receptors					Predicted Noise Levels, $L_{eq(h)}$ (dB(A))			
Receptor Number	Address	NAC	Use	DUs	Existing	No-Build	Build	Change
R-103	100 MILKY WAY DR	B	Residential	1	56**	56**	56**	0
R-104	104 MILKY WAY DR	B	Residential	1	56**	56**	56**	0
R-105	104 MILKY WAY DR	B	Residential	1	56**	56**	56**	0
R-106	110 MILKY WAY DR	B	Residential	1	56**	56**	56**	0
R-107	138 LICORICE DR	B	Residential	1	56**	58	63	7
R-108	136 LICORICE DR	B	Residential	1	56**	56**	62	6
R-109	134 LICORICE DR	B	Residential	1	56**	56**	61	5
R-110	132 LICORICE DR	B	Residential	1	56**	56**	60	4
R-111	130 LICORICE DR	B	Residential	1	56**	56**	59	3
R-112	128 LICORICE DR	B	Residential	1	56**	56**	57	1
R-113	126 LICORICE DR	B	Residential	1	56**	56**	56**	0
R-114	124 LICORICE DR	B	Residential	1	56**	56**	56**	0
R-115	122 LICORICE DR	B	Residential	1	56**	56**	56**	0
R-116	120 LICORICE DR	B	Residential	1	56**	56**	56**	0
R-117	108 LICORICE DR	B	Residential	1	56**	56**	56**	0
R-118	106 LICORICE DR	B	Residential	1	56**	56**	56**	0
R-119	104 LICORICE DR	B	Residential	1	56**	56**	56**	0
R-120	102 LICORICE DR	B	Residential	1	56**	56**	56**	0
R-121	100 LICORICE DR	B	Residential	1	56**	56**	56**	0
R-122	204 SUGARLAND DR	B	Residential	1	56**	56**	56**	0
R-123	206 SUGARLAND DR	B	Residential	1	56**	56**	56**	0
R-124	208 SUGARLAND DR	B	Residential	1	56**	56**	56**	0
R-125	207 SUGARLAND DR	B	Residential	1	56**	56**	56**	0
R-126	207 SUGARLAND DR	B	Residential	1	56**	56**	56**	0
R-127	203 SUGARLAND DR	B	Residential	1	56**	56**	56**	0
R-128	801 TOWHEE DR	B	Residential	1	63	65	64	1
R-129	803 TOWHEE DR	B	Residential	1	51	53	54	3
R-130	805 TOWHEE DR	B	Residential	1	50*	50*	51	1
R-131	807 TOWHEE DR	B	Residential	1	50*	50*	50*	0
R-132	809 TOWHEE DR	B	Residential	1	50*	50*	50*	0
R-133	811 TOWHEE DR	B	Residential	1	50*	50*	50*	0
R-134	813 TOWHEE DR	B	Residential	1	50*	50*	50*	0
R-135	800 TOWHEE DR	B	Residential	1	60	61	66	6
R-136	802 TOWHEE DR	B	Residential	1	54	56	59	5
R-137	201 WHIPPOWILL CT	B	Residential	1	50*	50*	51	1
R-138	810 TOWHEE DR	B	Residential	1	50*	50*	50*	0
R-139	814 TOWHEE DR	B	Residential	1	50*	50*	50*	0
R-140	202 WHIPPOWILL CT	B	Residential	1	58	59	65	7
R-141	204 WHIPPOWILL CT	B	Residential	1	56	58	63	7
R-142	206 WHIPPOWILL CT	B	Residential	1	54	55	61	7
R-143	208 WHIPPOWILL CT	B	Residential	1	54	56	61	7
R-144	203 WHIPPOWILL CT	B	Residential	1	50*	50*	50*	0
R-145	205 WHIPPOWILL CT	B	Residential	1	50*	50*	50*	0
R-146	207 WHIPPOWILL CT	B	Residential	1	50*	50*	51	1
R-147	209 WHIPPOWILL CT	B	Residential	1	50*	50*	51	1
R-148	211 WHIPPOWILL CT	B	Residential	1	50*	50*	55	5
R-149	818 TOWHEE DR	B	Residential	1	50*	50*	50*	0
R-150	820 TOWHEE DR	B	Residential	1	50*	50*	50*	0
R-151	822 TOWHEE DR	B	Residential	1	50*	50*	50*	0
R-152	824 TOWHEE DR	B	Residential	1	50*	50*	50*	0
R-153	826 TOWHEE DR	B	Residential	1	50*	50*	50*	0
R-154	828 TOWHEE DR	B	Residential	1	50*	50*	50*	0

Receptors					Predicted Noise Levels, $L_{eq(h)}$ (dB(A))			
Receptor Number	Address	NAC	Use	DUs	Existing	No-Build	Build	Change
R-155	830 TOWHEE DR	B	Residential	1	50*	50*	52	2
R-156	811 CHICKADEE LN	B	Residential	1	50*	50*	51	1
R-157	809 CHICKADEE LN	B	Residential	1	50*	50*	52	2
R-158	807 CHICKADEE LN	B	Residential	1	50*	50*	55	5
R-159	805 CHICKADEE LN	B	Residential	1	52	54	59	7
R-160	823 TOWHEE DR	B	Residential	1	50*	50*	51	1
R-161	825 TOWHEE DR	B	Residential	1	50*	50*	50*	0
R-162	827 TOWHEE DR	B	Residential	1	50*	50*	50*	0
R-163	829 TOWHEE DR	B	Residential	1	50*	50*	50*	0
R-164	831 TOWHEE DR	B	Residential	1	50*	50*	50*	0
R-165	833 TOWHEE DR	B	Residential	1	50*	50*	50*	0
R-166	835 TOWHEE DR	B	Residential	1	50*	50*	50*	0
R-167	800 CHICKADEE LN	B	Residential	1	56	57	63	7
R-168	802 CHICKADEE LN	B	Residential	1	51	53	57	6
R-169	804 CHICKADEE LN	B	Residential	1	50*	50*	55	5
R-170	806 CHICKADEE LN	B	Residential	1	50*	50*	54	4
R-171	808 CHICKADEE LN	B	Residential	1	50*	50*	51	1
R-172	810 CHICKADEE LN	B	Residential	1	50*	50*	50*	0
R-173	801 MOCKINGBIRD LN	B	Residential	1	58	60	65	7
R-174	805 MOCKINGBIRD LN	B	Residential	1	50*	50*	53	3
R-175	807 MOCKINGBIRD LN	B	Residential	1	50*	50*	50*	0
R-176	809 MOCKINGBIRD LN	B	Residential	1	50*	50*	50*	0
R-177	811 MOCKINGBIRD LN	B	Residential	1	50*	50*	50*	0
R-178	800 MOCKINGBIRD LN	B	Residential	1	50*	51	56	6
R-179	802 MOCKINGBIRD LN	B	Residential	1	50*	50*	52	2
R-180	804 MOCKINGBIRD LN	B	Residential	1	50*	50*	50*	0
R-181	806 MOCKINGBIRD LN	B	Residential	1	50*	50*	50*	0
R-182	808 MOCKINGBIRD LN	B	Residential	1	50*	50*	50*	0
R-183	810 MOCKINGBIRD LN	B	Residential	1	50*	50*	50*	0
R-184	402 QUAIL CT	B	Residential	1	52	54	59	7
R-185	400 QUAIL CT	B	Residential	1	50*	51	56	6
R-186	927 TOWHEE DR	B	Residential	1	51	53	58	7
R-187	925 TOWHEE DR	B	Residential	1	50*	50*	53	3
R-188	405 QUAIL CT	B	Residential	1	50*	50*	50*	0
R-189	403 QUAIL CT	B	Residential	1	50*	50*	50*	0
R-190	401 QUAIL CT	B	Residential	1	50*	50*	50*	0
R-191	923 TOWHEE DR	B	Residential	1	50*	50*	50*	0
R-192	914 TOWHEE DR	B	Residential	1	50*	50*	50*	0
R-193	916 TOWHEE DR	B	Residential	1	50*	50*	50*	0
R-194	821 CHICKADEE LN	B	Residential	1	50*	50*	50*	0
R-195	901 TOWHEE DR	B	Residential	1	50*	50*	50*	0
R-196	903 TOWHEE DR	B	Residential	1	50*	50*	50*	0
R-197	905 TOWHEE DR	B	Residential	1	50*	50*	50*	0
R-198	821 MOCKINGBIRD LN	B	Residential	1	50*	50*	50*	0
R-199	820 MOCKINGBIRD LN	B	Residential	1	50*	50*	50*	0
R-200	913 TOWHEE DR	B	Residential	1	50*	50*	50*	0
R-201	915 TOWHEE DR	B	Residential	1	50*	50*	50*	0
R-202	823 CHICKADEE LN	B	Residential	1	50*	50*	50*	0
R-203	825 CHICKADEE LN	B	Residential	1	50*	50*	50*	0
R-204	824 CHICKADEE LN	B	Residential	1	50*	50*	50*	0
R-205	822 CHICKADEE LN	B	Residential	1	50*	50*	50*	0
R-206	823 MOCKINGBIRD LN	B	Residential	1	50*	50*	50*	0

Receptors					Predicted Noise Levels, $L_{eq(h)}$ (dB(A))			
Receptor Number	Address	NAC	Use	DUs	Existing	No-Build	Build	Change
R-207	825 MOCKINGBIRD LN	B	Residential	1	50*	50*	50*	0
R-208	824 MOCKINGBIRD LN	B	Residential	1	50*	50*	50*	0
R-209	822 MOCKINGBIRD LN	B	Residential	1	50*	50*	50*	0
R-210	1833 BODWIN LN	B	Residential	1	50*	50*	50*	0
R-211	1829 BODWIN LN	B	Residential	1	50*	50*	51	1
R-212	1825 BODWIN LN	B	Residential	1	50*	51	52	2
R-213	1821 BODWIN LN	B	Residential	1	50*	51	52	2
R-214	1817 BODWIN LN	B	Residential	1	50*	51	52	2
R-215	1813 BODWIN LN	B	Residential	1	50*	52	53	3
R-216	1809 BODWIN LN	B	Residential	1	50*	53	54	4
R-217	1805 BODWIN LN	B	Residential	1	50*	53	56	6
R-218	1801 BODWIN LN	B	Residential	1	50*	53	58	8
R-219	1725 BODWIN LN	B	Residential	1	50*	50*	53	3
R-220	1721 BODWIN LN	B	Residential	1	50*	50*	54	4
R-221	1717 BODWIN LN	B	Residential	1	50*	50*	54	4
R-222	1713 BODWIN LN	B	Residential	1	50*	51	55	5
R-223	1709 BODWIN LN	B	Residential	1	50*	51	54	4
R-224	1705 BODWIN LN	B	Residential	1	50*	52	55	5
R-225	1701 BODWIN LN	B	Residential	1	50*	50*	53	3
R-226	1856 BODWIN LN	B	Residential	1	50*	50*	50*	0
R-227	1852 BODWIN LN	B	Residential	1	50*	50*	50*	0
R-228	1848 BODWIN LN	B	Residential	1	50*	50*	50*	0
R-229	1844 BODWIN LN	B	Residential	1	50*	50*	50*	0
R-230	1840 BODWIN LN	B	Residential	1	50*	50*	50*	0
R-231	1836 BODWIN LN	B	Residential	1	50*	50*	50*	0
R-232	1832 BODWIN LN	B	Residential	1	50*	50*	50*	0
R-233	1828 BODWIN LN	B	Residential	1	50*	50*	50*	0
R-234	1824 BODWIN LN	B	Residential	1	50*	50*	50*	0
R-235	1820 BODWIN LN	B	Residential	1	50*	50*	50*	0
R-236	1816 BODWIN LN	B	Residential	1	50*	50*	50*	0
R-237	1812 BODWIN LN	B	Residential	1	50*	50*	50*	0
R-238	1808 BODWIN LN	B	Residential	1	50*	50*	50*	0
R-239	1804 BODWIN LN	B	Residential	1	50*	50*	50*	0
R-240	1800 BODWIN LN	B	Residential	1	50*	50*	50*	0
R-241	909 S SALEM ST	B	Residential	1	50*	50*	50*	0
R-242	907 S SALEM ST	B	Residential	1	50*	50*	50*	0
R-243	1755 FLINT VALLEY LN	B	Residential	1	50*	50*	50*	0
R-244	1751 FLINT VALLEY LN	B	Residential	1	50*	50*	50*	0
R-245	1747 FLINT VALLEY LN	B	Residential	1	50*	50*	50*	0
R-246	1109 S SALEM ST	B	Residential	1	50*	50*	51	1
R-247	6260 APEX BARBECUE RD	B	Residential	1	50*	52	52	2
R-248	1001 WHISTON DR	C	Pool	1	55	57	58	3
R-249	1001 BRAMHALL CT	B	Residential	1	50*	52	53	3
R-250	1003 BRAMHALL CT	B	Residential	1	50*	52	53	3
R-251	1004 BRAMHALL CT	B	Residential	1	50*	50*	50*	0
R-252	1002 BRAMHALL CT	B	Residential	1	50*	50*	50*	0
R-253	1000 BRAMHALL CT	B	Residential	1	50*	50*	50*	0
R-254	1103 WHISTON DR	B	Residential	1	50*	50*	50*	0
R-255	1105 WHISTON DR	B	Residential	1	50*	50*	50*	0
R-256	1107 WHISTON DR	B	Residential	1	50*	50*	50*	0
R-257	1000 WHISTON DR	B	Residential	1	50*	52	53	3
R-258	1002 BLASTON CT	B	Residential	1	50*	50*	50*	0

Receptors					Predicted Noise Levels, $L_{eq(h)}$ (dB(A))			
Receptor Number	Address	NAC	Use	DUs	Existing	No-Build	Build	Change
R-259	1002 BLASTON CT	B	Residential	1	50*	50*	50*	0
R-260	1001 BLASTON CT	B	Residential	1	50*	50*	50*	0
R-261	1102 WHISTON DR	B	Residential	1	50*	50*	50*	0
R-262	1106 WHISTON DR	B	Residential	1	50*	50*	50*	0
R-263	1105 GRAPPENHALL DR	B	Residential	1	50*	50*	50*	0
R-264	1201 GRAPPENHALL DR	B	Residential	1	50*	50*	50*	0
R-265	1203 GRAPPENHALL DR	B	Residential	1	50*	50*	50*	0
R-266	1205 GRAPPENHALL DR	B	Residential	1	50*	50*	50*	0
R-267	1301 GRAPPENHALL DR	B	Residential	1	50*	50*	50*	0
R-268	910 S SALEM ST	B	Residential	1	63	65	66	3
R-269	1001 BARROW NOOK CT	B	Residential	1	56	58	57	1
R-270	1003 BARROW NOOK CT	B	Residential	1	53	54	56	3
R-271	1005 BARROW NOOK CT	B	Residential	1	50*	52	55	5
R-272	1003 MARSTON CT	B	Residential	1	50*	52	56	6
R-273	1006 MARSTON CT	B	Residential	1	55	57	68	13
R-274	1005 MARSTON CT	B	Residential	1	53	55	52	-1
R-275	1004 MARSTON CT	B	Residential	1	58	60	64	6
R-276	1103 BARROW NOOK CT	B	Residential	1	50*	50*	52	2
R-277	1105 BARROW NOOK CT	B	Residential	1	59	61	59	0
R-278	1107 BARROW NOOK CT	B	Residential	1	57	59	59	2
R-279	1111 BARROW NOOK CT	B	Residential	1	54	56	56	2
R-280	1110 BARROW NOOK CT	B	Residential	1	51	53	53	2
R-281	1106 BARROW NOOK CT	B	Residential	1	50*	50*	50*	0
R-282	1104 BARROW NOOK CT	B	Residential	1	50*	50*	50*	0
R-283	1102 BARROW NOOK CT	B	Residential	1	50*	50*	50*	0
R-284	1006 BARROW NOOK CT	B	Residential	1	50*	50*	50*	0
R-285	1101 TOWHEE DR	B	Residential	1	50*	50*	50*	0
R-286	1101 TOWHEE DR	B	Residential	1	50*	50*	50*	0
R-287	1014 APPLETHORN DR	B	Residential	1	50*	50*	50*	0
R-288	1012 APPLETHORN DR	B	Residential	1	50*	50*	50*	0
R-289	1010 APPLETHORN DR	B	Residential	1	50*	50*	50*	0
R-290	1003 CUDDINGTON CT	B	Residential	1	50*	50*	50*	0
R-291	1005 CUDDINGTON CT	B	Residential	1	50*	50*	50*	0
R-292	1007 CUDDINGTON CT	B	Residential	1	51	53	53	2
R-293	1008 CUDDINGTON CT	B	Residential	1	51	53	54	3
R-294	1006 CUDDINGTON CT	B	Residential	1	50*	51	52	2
R-295	1004 CUDDINGTON CT	B	Residential	1	50*	50*	50*	0
R-296	1002 CUDDINGTON CT	B	Residential	1	50*	50*	50*	0
R-297	1002 TOWHEE DR	B	Residential	1	61	62	66	5
R-298	1004 TOWHEE DR	B	Residential	1	52	54	56	4
R-299	1102 TOWHEE DR	B	Residential	1	50*	50*	50*	0
R-300	1000 PROPER CT	B	Residential	1	50*	50*	50*	0
R-301	1002 PROPER CT	B	Residential	1	52	54	59	7
R-302	1004 PROPER CT	B	Residential	1	59	61	66	7
R-303	1005 PROPER CT	B	Residential	1	59	61	65	6
R-304	1003 PROPER CT	B	Residential	1	56	57	62	6
R-305	1202 APPLETHORN DR	B	Residential	1	50*	50*	55	5
R-306	1204 APPLETHORN DR	B	Residential	1	50*	52	57	7
R-307	1206 APPLETHORN DR	B	Residential	1	50*	51	57	7
R-308	1208 APPLETHORN DR	B	Residential	1	50*	51	56	6
R-309	1210 APPLETHORN DR	B	Residential	1	50*	50*	54	4
R-310	1212 APPLETHORN DR	B	Residential	1	50*	50*	53	3

Receptors					Predicted Noise Levels, $L_{eq(h)}$ (dB(A))			
Receptor Number	Address	NAC	Use	DUs	Existing	No-Build	Build	Change
R-311	1300 APPLETHORN DR	B	Residential	1	50*	50*	52	2
R-312	1302 APPLETHORN DR	B	Residential	1	50*	50*	50*	0
R-313	1304 APPLETHORN DR	B	Residential	1	50*	50*	50*	0
R-314	1001 APPLETHORN DR	B	Residential	1	50*	50*	50*	0
R-315	1003 APPLETHORN DR	B	Residential	1	50*	50*	50*	0
R-316	1007 APPLETHORN DR	B	Residential	1	50*	50*	50*	0
R-317	1009 APPLETHORN DR	B	Residential	1	50*	50*	50*	0
R-318	1011 APPLETHORN DR	B	Residential	1	50*	50*	50*	0
R-319	1015 APPLETHORN DR	B	Residential	1	50*	50*	50*	0
R-320	1017 APPLETHORN DR	B	Residential	1	50*	50*	50*	0
R-321	1101 APPLETHORN DR	B	Residential	1	50*	50*	50*	0
R-322	1103 APPLETHORN DR	B	Residential	1	50*	50*	50*	0
R-323	1201 APPLETHORN DR	B	Residential	1	50*	50*	50*	0
R-324	1203 APPLETHORN DR	B	Residential	1	50*	50*	50*	0
R-325	1205 APPLETHORN DR	B	Residential	1	50*	50*	50*	0
R-326	1001 MODEST WAY	B	Residential	1	50*	50*	50*	0
R-327	1003 MODEST WAY	B	Residential	1	50*	50*	50*	0
R-328	1005 MODEST WAY	B	Residential	1	50*	50*	50*	0
R-329	1006 MODEST WAY	B	Residential	1	50*	50*	50*	0
R-330	1004 MODEST WAY	B	Residential	1	50*	50*	50*	0
R-331	1002 MODEST WAY	B	Residential	1	50*	50*	50*	0
R-332	1301 APPLETHORN DR	B	Residential	1	50*	50*	50*	0
R-333	1303 APPLETHORN DR	B	Residential	1	50*	50*	50*	0
R-334	1305 APPLETHORN DR	B	Residential	1	50*	50*	50*	0
R-335	1002 DARESBURY DR	B	Residential	1	50*	50*	50*	0
R-336	1004 DARESBURY DR	B	Residential	1	50*	50*	50*	0
R-337	1006 DARESBURY DR	B	Residential	1	50*	50*	50*	0
R-338	1008 DARESBURY DR	B	Residential	1	50*	50*	50*	0
R-339	1010 DARESBURY DR	B	Residential	1	50*	50*	50*	0
R-340	1012 DARESBURY DR	B	Residential	1	50*	50*	50*	0
R-341	1014 DARESBURY DR	B	Residential	1	50*	50*	50*	0
R-342	1015 DARESBURY DR	B	Residential	1	50*	50*	50*	0
R-343	1013 DARESBURY DR	B	Residential	1	50*	50*	50*	0
R-344	1011 DARESBURY DR	B	Residential	1	50*	50*	50*	0
R-345	1005 DARESBURY DR	B	Residential	1	50*	50*	50*	0
R-346	1300 GRAPPENHALL DR	B	Residential	1	50*	50*	50*	0
R-347	1105 ELBURY DR	B	Residential	1	51	52	58	7
R-348	1107 ELBURY DR	B	Residential	1	53	54	59	6
R-349	1109 ELBURY DR	B	Residential	1	50*	52	57	7
R-350	1108 ELBURY DR	B	Residential	1	50*	50*	50*	1
R-351	1108 ELBURY DR	B	Residential	1	50*	50*	50*	0
R-352	1104 ELBURY DR	B	Residential	1	50*	50*	50*	0
Predicted Design Year (2040) Traffic Noise Impacts:					**N/A**	**N/A**	**5**	**1**

Notes:

*All noise level results were filtered with an ambient level of 50 dB(A) to compensate for the fact that TNM does not account for non-traffic noise sources. 50 dB(A) was chosen because it is the average ambient noise level for a quiet urban area, based upon data from the *Guide on Evaluation and Attenuation of Traffic Noise* , 1974, revisited 1993. TNM calculated noise levels under 50 dB(A) were raised to 50 dB(A) for reporting.

**These noise level results were filtered with an ambient level of 56 dB(A), based upon ambient noise levels specifically measured in the vicinity of these receptors.

Impacts = Impact

Appendix D

Traffic Noise Models

General

This appendix documents the TNM Inputs used in this Traffic Noise Report (TNR). Because the limits of the project only extend about 0.5 miles in each direction, there was no need for this model to be split into smaller sections. This model utilized the following TNM object types to approximate the traffic segments assessed for the proposed Apex Peakway Connector project:

- Roadways
- Receivers/Receptors
- Barriers
- Ground Zones
- Terrain Lines

Coordinate System

Each of the objects in the TNM model was plotted using the North American Datum 1983 (NAD83) horizontal coordinate system, and the North American Vertical Datum 1988 (NAVD88).

Modeling Procedure

Roadways:

- The widths of all TNM roadway elements were based upon the MicroStation design files
- Each roadway element represents one or two lanes of traffic
- Each roadway element representing the mainline and significant Y-lines has vertices at approximately every 100ft
- Current Year 2016 peak hour traffic volumes were added to the roadway elements in TNM to determine current noise conditions
- Design Year 2040 peak hour traffic volumes were added to the roadway elements in TNM to determine potential noise impacts
- Traffic was modeled at the design speed of the project (40 mph)

Receivers/Receptors:

- Each noise sensitive area within the project area was assigned a receiver element in TNM
- Receiver elements were placed at the corner of the noise sensitive structure nearest to the noise source
- Receivers were assigned a height of 4.92ft above ground elevation
- Because there were no second or third story receivers, all receivers were assigned this same height
- Each receiver was analyzed for the year 2016 existing, year 2040 no-build, and year 2040 build traffic conditions

Barriers:

- All structures in the project area were modeled with TNM barrier elements
- Barriers were given various heights depending on the estimated height of the structure

Ground Zones:

- Ground zone elements were used to define intervening ground by type and acoustical characteristics wherever ground differed from the default ground type (grass)
- In the project area specifically, ground zones were used to define wide medians between roadway elements as well as bodies of water such as farm ponds

Terrain Lines

- Terrain line elements were added to define significant changes in grade and/or slope throughout the project area
- Coordinates for existing condition terrain lines were based on elevation data from the Triangulated Irregular Network (TIN) associated with the project
- Coordinates for build condition terrain lines were based on the cross sections in the MicroStation design files for the project

TNM Traffic Noise Level Assessment

The TNM traffic noise assessment was divided into five tasks:

1. Creation of a baseline model of the project
2. Validating field measurements in this model
3. Creation of an existing condition model and assessment of peak-hour noise levels
4. Creation of a no-build condition model and assessment of peak-hour noise levels
5. Creation of a build condition model and assessment of peak-hour noise levels

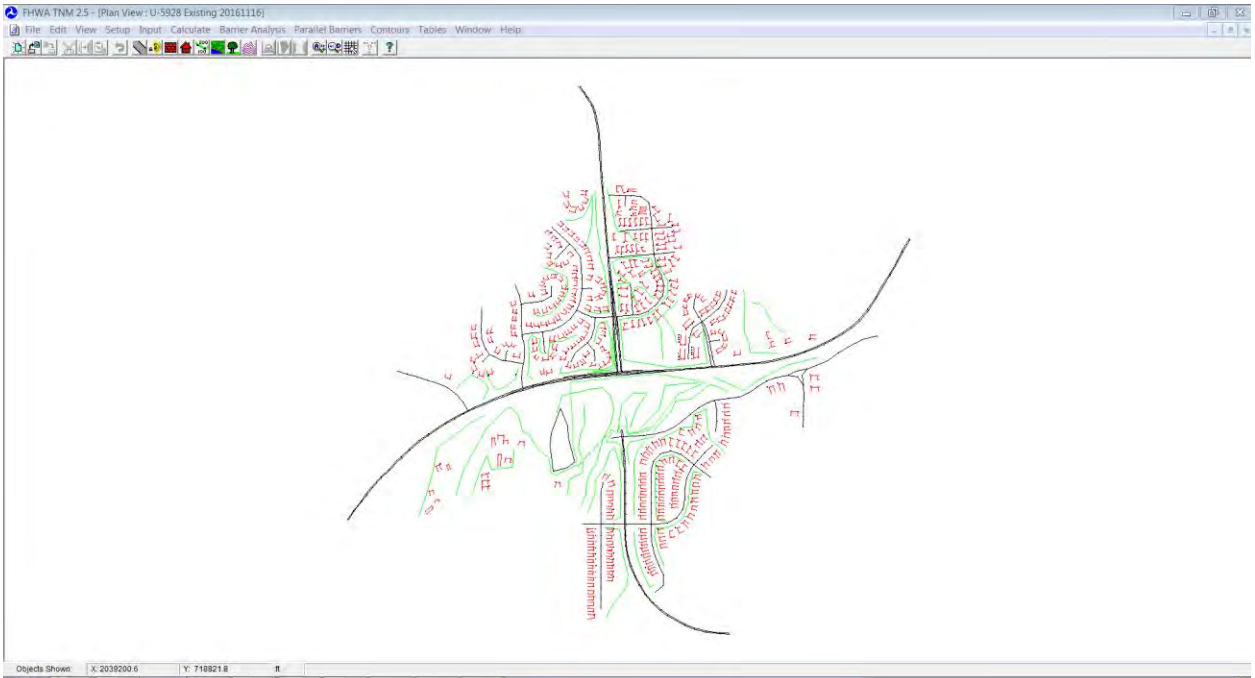


Figure D.1: U-5928 – Existing (2015) Model

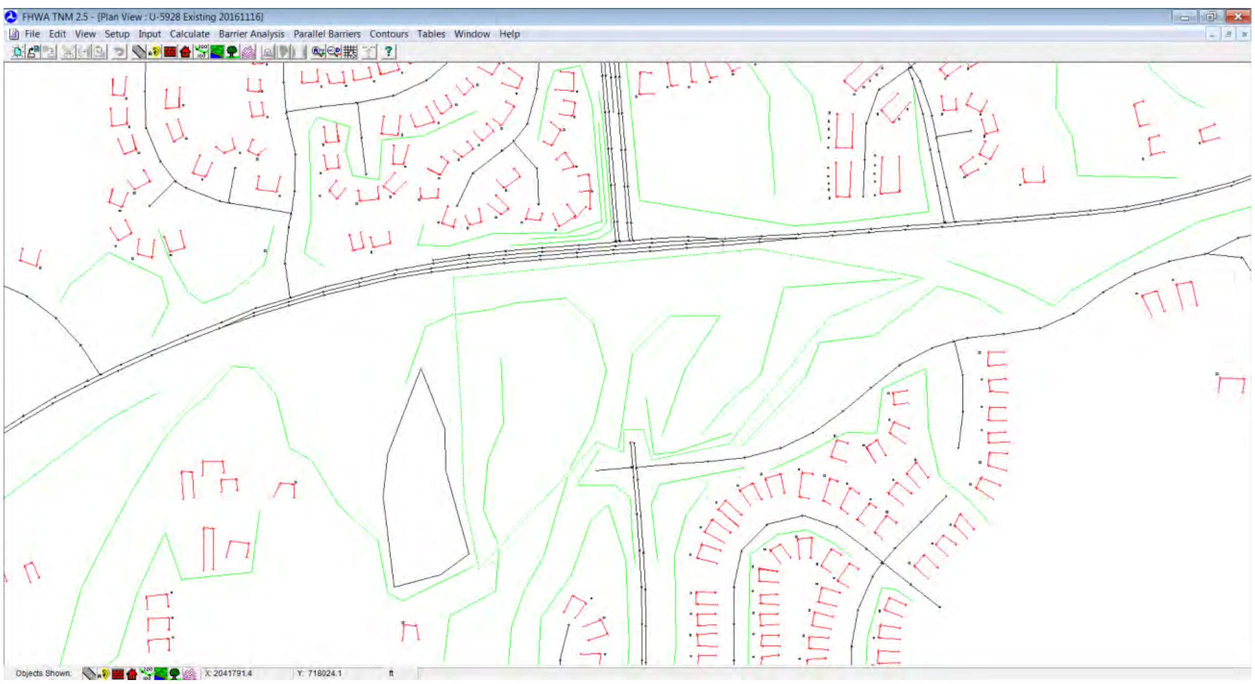


Figure D.2: U-5928 – Existing (2015) Model –Close Up

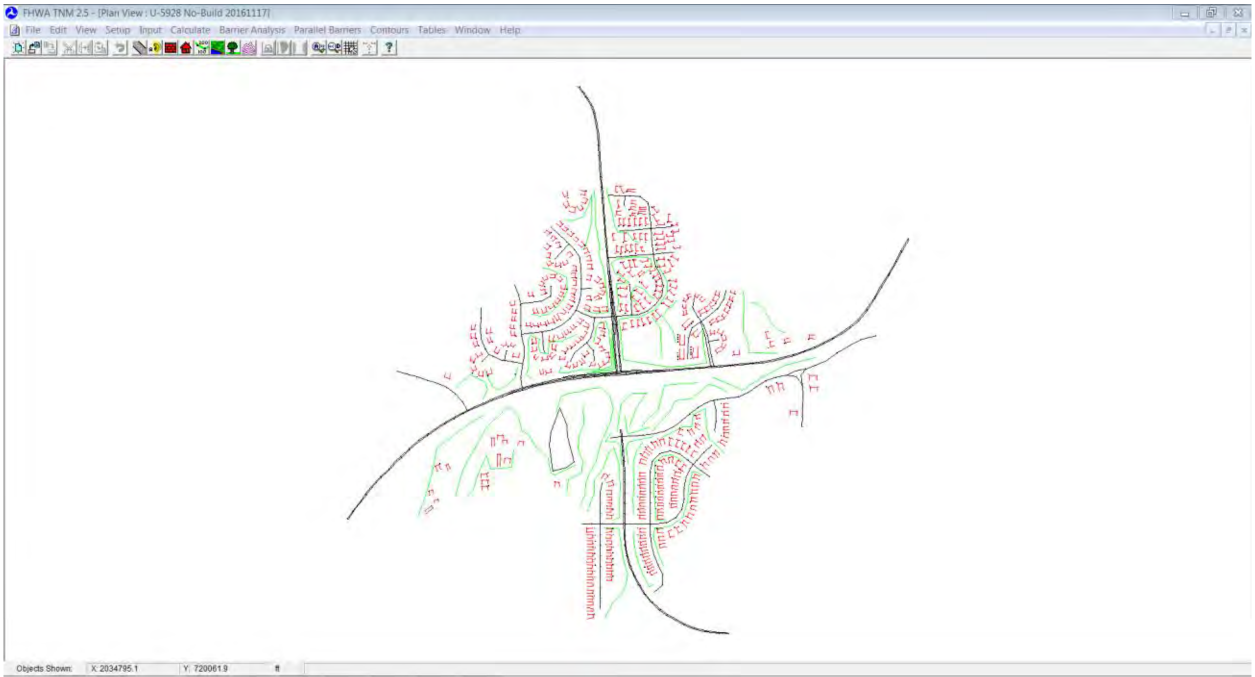


Figure D.3: U-5928 – No Build (2040) Model

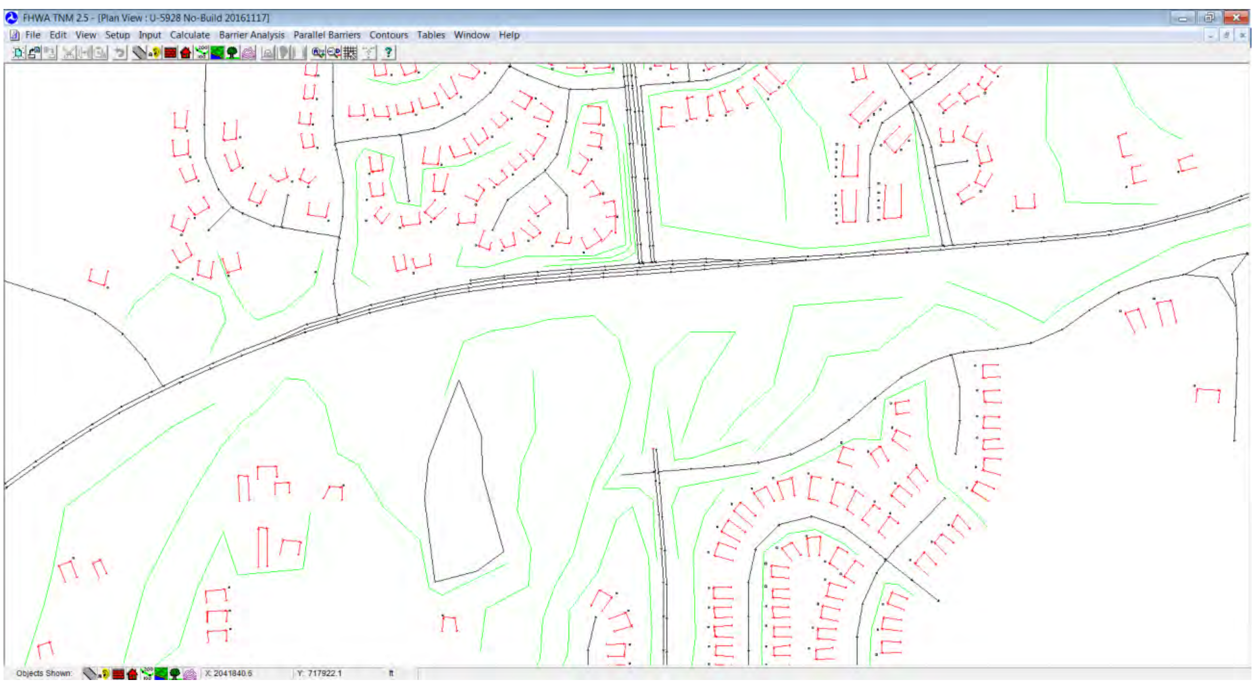


Figure D.4: U-5928 – No Build (2040) Model – Close Up

Figure D.5: U-5928 – Build (2040) Model

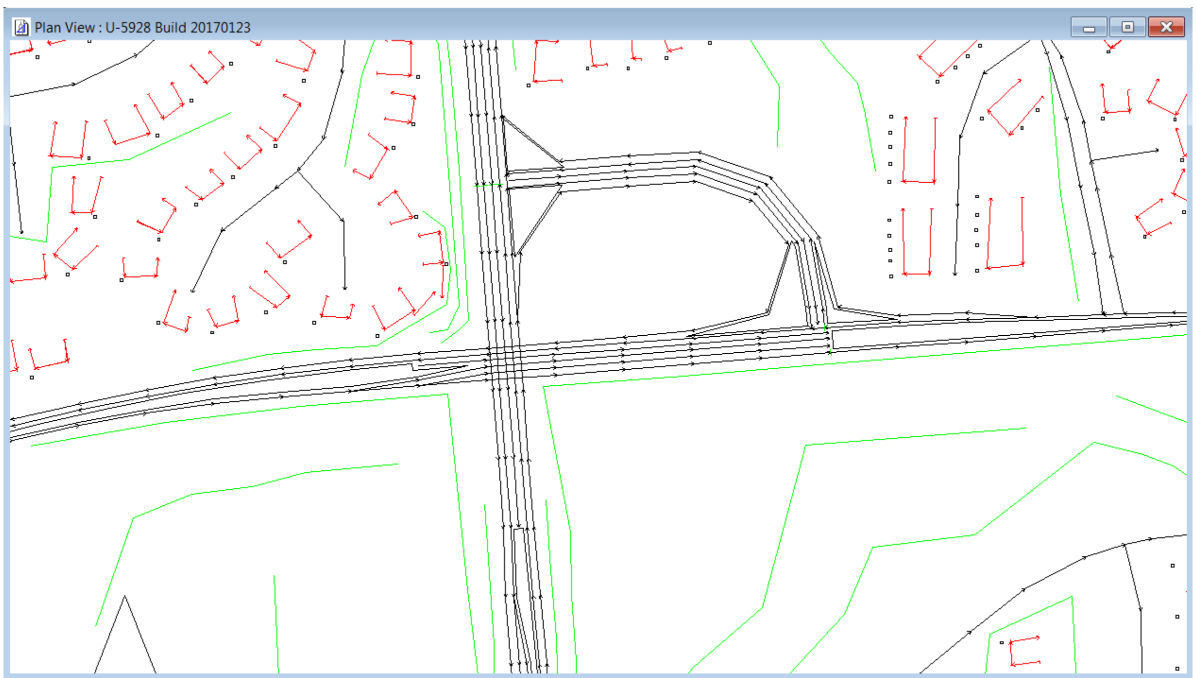


Figure D.6: U-5928 – Build (2040) Model – Close Up

Appendix E

North Carolina Department of Transportation Traffic Noise Policy

NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION

TRAFFIC NOISE POLICY

Effective Date: October 6, 2016

Noise Policy Committee:

Glenn Mumford, PE ……….Roadway Design Unit
Drew Joyner, PE……………Human Environment Section
Brian Hanks, PE…………....Structures Management Unit
Daniel Keel, PE…………….Division of Highways
Mike Mills, PE……………..Division Engineer
Pat Ivey, PE………………..Division Engineer
Greg Smith, PE……………..Human Environment Section

Sponsors:

Clarence Coleman, PE ……..Federal Highway Administration
Felix Davila, PE…………….Federal Highway Administration
Edward L. Curran…………..Board of Transportation

APPROVED BY:

10-6-16 Date of Approval	John F. Sullivan, III, PE, Division Administrator Federal Highway Administration
10.6.16 Date of Approval	Nicholas J. Tennyson Secretary of Transportation
10-5-16 Date of Approval	Edward L. Curran, Chairman Board of Transportation

Person Responsible for Policy:

Traffic Noise & Air Quality Supervisor
Human Environment Section
1598 Mail Service Center
Raleigh, North Carolina 27699-1598
(919) 707-6087

DEFINITIONS

a) Decibel (dB) - The logarithmic unit for measuring sound pressure levels. For traffic noise measurements, decibels are most commonly reported in terms of the A-weighing frequency scale, which best includes the frequencies to which human hearing is typically most sensitive and is denoted by the abbreviation dB(A).

b) Leq – The equivalent steady -state sound level which, in a defined period of time, contains the same amount of acoustic energy as a time-varying sound level during the same period of time.

c) Receptor – Any location that receives traffic noise.

d) Impacted Receptor – A receptor for which the predicted hourly equivalent traffic noise level 1) meets or exceeds the approach criteria value found in Table 1 of this policy or 2) exceeds the existing ambient noise level by 10 dB(A) or more.

e) Benefited Receptor - All receptors, both impacted and non-impacted, that receive a noise level reduction of 5 dB(A) or more through placement of a noise abatement measure.

f) Noise Abatement Measure – Any method used to reduce traffic noise levels, such as noise walls and earthen berms.

g) Worst Noise Hour – The hour within a day in which the highest magnitude hourly equivalent sound level occurs. The worst traffic noise hour typically occurs when traffic is flowing freely at a high volume relative to the peak traffic hour volume, with a high percentage of trucks.

h) Practicable – Available and capable of being done after taking into consideration cost, existing technology, and logistics in light of overall project purposes.

INTRODUCTION

This document represents the North Carolina Department of Transportation (hereinafter NCDOT) policy on highway traffic noise and construction noise and describes the implementation of the requirements of the Federal Highway Administration (hereinafter FHWA) Noise Standard at 23 Code of Federal Regulations Part 772 (23 CFR 772) as they relate to federal-aid and select state-funded highway construction in North Carolina. This policy was developed by the NCDOT and reviewed and approved by the FHWA.

The North Carolina Department of Transportation Traffic Noise Manual and 23 CFR 772 are intended to be companion documents to this policy.

PURPOSE

This policy describes the NCDOT process that is used in determining traffic noise impacts and abatement measures and the equitable and cost-effective expenditure of public funds for noise abatement. Where the FHWA has given highway agencies flexibility in implementing the 23 CFR 772 standards, this policy describes the NCDOT approach to implementation.

APPLICABILITY

Projects with a Date of Public Knowledge on or after the effective date of this policy shall comply with the criteria of this policy.

Federal–Aid Projects

This policy applies to all "Type I" federal or federal-aid highway projects in the State of North Carolina, including federal projects that are administered by local public agencies. Therefore, this policy applies to any highway project that is funded with federal-aid highway funds or requires FHWA approval regardless of funding sources. NCDOT does not participate in nor fund Type II (retrofit) projects along existing transportation facilities. Noise analyses are not required for Type III projects. Each of these project types are defined below. This policy shall be applied uniformly and consistently to all Type I federal projects throughout North Carolina.

Type I Project

(a) The construction of a highway on new location; or,

(b) The physical alteration of an existing highway where there is either:
   (i) Substantial Horizontal Alteration. A project that halves the distance between the traffic noise source and the closest receptor between the existing condition to the future build condition; or,
   (ii) Substantial Vertical Alteration. A project that removes shielding, therefore exposing the line-of-sight between the receptor and the traffic noise source. This is done by either altering the vertical alignment of the highway or by altering the topography between the highway traffic noise source and the receptor; or,

(c) The addition of a through-traffic lane(s). This includes the addition of a through-traffic lane that functions as a HOV lane, High-Occupancy Toll (HOT) lane, bus lane, or truck climbing lane; or,

(d) The addition of an auxiliary lane, except for when the auxiliary lane is a turn lane; or,

(e) The addition or relocation of interchange lanes or ramps added to a quadrant to complete an existing partial interchange; or,

(f) Restriping existing pavement for the purpose of adding a through-traffic lane or an auxiliary lane; or,

(g) The addition of a new or substantial alteration of a weigh station, rest stop, ride-share lot or toll plaza.

(h) If a project is determined to be a Type I project under this definition then the entire project area as defined in the environmental document is a Type I project.

Type II Project.

A Federal or Federal-aid highway project for noise abatement on an existing highway. For a Type II project to be eligible for Federal-aid funding, the highway agency must develop and implement a Type II program in accordance with 23 CFR 772.7(e).

Type III Project

A Federal or Federal-aid highway project that does not meet the classifications of a Type I or Type II project. Type III projects do not require a noise analysis.

The highway traffic noise prediction requirements, noise analyses, noise abatement criteria, and requirements for informing local officials in 23 CFR 772 and this policy constitute the noise standards mandated by 23 U.S.C. 109(1). All federally-funded highway projects which are developed in conformance with this policy shall be deemed to be in accordance with the FHWA noise standards.

State-Funded Projects

Projects that are State funded do not use the federal project type designation for applicability.

This policy will apply to State funded projects located on a US or Interstate route that is full control of access where the project involves adding a through-traffic lane.

All other State-funded projects for which a State Environmental Assessment (EA) or State Environmental Impact Statement (EIS) is prepared will comply with the North Carolina Environmental Policy Act (SEPA) and the North Carolina Administrative Code. For these projects, noise barriers will be considered where practicable.

DATE OF PUBLIC KNOWLEDGE

The Date of Public Knowledge of the location and potential noise impacts of a proposed highway project is the approval date of the final environmental document, e.g., Categorical Exclusion (CE), State or Federal Finding of No Significant Impact (FONSI) or State or Federal Record of Decision (ROD).

NCDOT is not responsible for evaluating or implementing any noise barriers to protect developed lands that were not permitted before the Date of Public Knowledge.

The criterion for determining when undeveloped land is permitted for development is the approval date of a building permit for an individual lot or site. Approval of a development plat or any other development plan does not meet the permitted criteria.

NCDOT advocates use of local government authority to regulate land development, planning, design and construction in such a way that noise impacts are minimized.

TRAFFIC NOISE PREDICTION

All traffic noise analyses performed by or for NCDOT must utilize the most current version of the FHWA Traffic Noise Model (TNM®) or any other model determined by the FHWA to be consistent with the methodology of the TNM® model, pursuant to 23 CFR 772.9.

Average pavement type shall be used in the FHWA TNM® for future noise level prediction.

Noise contour lines may be used only for project alternative screening or for providing information to local officials for their land use planning efforts associated with undeveloped lands as per 23 CFR 772.17. Noise contours shall not be used for determining highway traffic noise impacts or assessing noise barriers.

Traffic characteristics that yield the worst noise hour equivalent traffic noise levels, expressed in Leq(h), for the Design Year shall be used in predicting noise levels and assessing noise impacts.

Traffic noise prediction must adhere to all direction contained in the NCDOT Traffic Noise Manual.

NOISE IMPACT DETERMINATION

Noise abatement measures for NCDOT highway projects must be considered when traffic noise impacts are created by either of the following two conditions:

(a) The predicted worst noise hour Leq(h) traffic noise levels for the Design Year approach (reach one decibel less than) or exceed the Noise Abatement Criteria (NAC) contained in 23 CFR 772 and in Table 1, found on page 4 of this policy, OR

(b) The predicted worst noise hour Leq(h) traffic noise levels for the Design Year substantially exceed existing noise by 10 dB(A) or more.

A receptor is a discrete or representative location within a noise sensitive area(s) for any of the land uses listed in Table 1. For multifamily dwellings, each residence shall be counted as one receptor when determining impacted and benefited receptors. Non-residential receptors shall be represented by Equivalent Receptors calculated according to direction contained in the NCDOT Traffic Noise Manual.

Primary consideration shall be given to exterior areas where frequent human use occurs in the determination of traffic noise impacts.

A traffic noise analysis shall be completed for each project alternative under detailed study and for all receptors and Equivalent Receptors defined to represent land use activities A, B, C, D, and E listed in Table 1 that are present in the study area. FHWA approval is required for designating a Category A Activity on federally-funded projects. Traffic noise analyses are not required for Activity Category F land uses. Noise predictions are required for Activity Category G land uses to the extent needed to develop estimated noise levels to provide to local officials for planning purposes.

Table 1			
Noise Abatement Criteria Hourly Equivalent A-Weighted Sound Level (decibels (dB(A))			
Activity Category	**Activity Criteria[1] Leq(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, Section4(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

1 The Leq(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 Leq(h) being the hourly value of Leq.
3 Includes undeveloped lands permitted for this activity category.

ANALYSIS OF NOISE ABATEMENT MEASURES

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. All of the following conditions must be met in order for noise abatement measures to be justified and incorporated into project design, as applicable. Failure to achieve any single element of feasibility or reasonableness will result in the noise abatement measure being deemed not feasible or not reasonable, whichever applies.

NCDOT will provide noise barriers for all possible impacted receptors that meet the feasibility and reasonableness criteria found in this policy. Noise barriers will not be extended solely to provide noise reduction for non-impacted receptors. Benefits for non-impacted receptors will only occur when they are incidental in noise barriers designed for impacted receptors.

Feasibility

The combination of acoustical and engineering factors considered in the evaluation of a noise barrier.

(a) Any receptor that receives a minimum noise level reduction of five dB(A) due to a noise barrier shall be considered a benefited receptor. Noise reduction of five dB(A) must be achieved for at least two impacted receptors.

(b) Engineering feasibility of noise barriers shall consider adverse impacts created by or upon property access, drainage, topography, utilities, safety, and maintenance requirements.

Reasonableness

The combination of social, economic, and environmental factors considered in the evaluation of a noise barrier.

(a) Property owners and tenants of all benefited receptors shall be solicited to obtain their preferences for or against a proposed noise barrier. No tenant ballots are distributed for vacant rental property. Points per ballot shall be distributed in the following weighted manner:

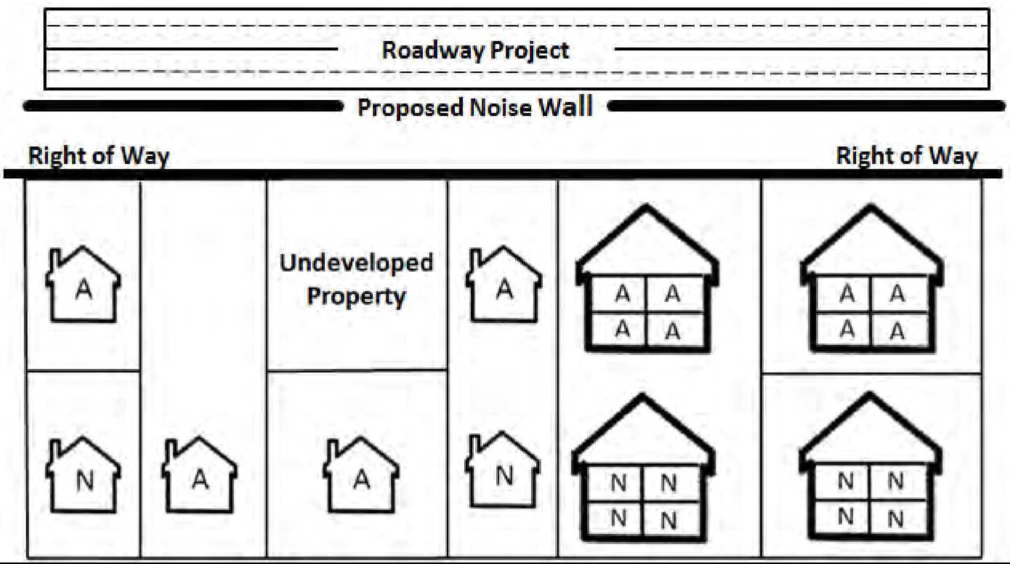
- 5 points/ballot for adjacent property owners who reside at property
- 4 points/ballot for adjacent property owners who rent property to others
- 3 points/ballot for all non-adjacent property owners who reside at property
- 2 points/ballot for all non-adjacent property owners who rent property to others
- 1 point/ballot vote for all tenants of rental property

Adjacent Receptor is a benefited receptor that 1) represents a property that abuts the highway right of way or 2) has no benefited receptor between it and the highway. Where multiple buildings containing benefited receptors are on the same property, such as an apartment or condominium complex, only the building closest to the highway is an adjacent receptor. Adjacent receptors will most often, but not always, be part of the front row of benefited receptors. Figure 1 provides graphic examples of Adjacent Receptors.

Owners of multi-unit rental locations will receive the applicable number of owner points for each individual benefited receptor (rental unit) owned.

Figure 1

Examples of Adjacent Receptors



A = Adjacent Receptor N = Non-Adjacent Receptor
Undeveloped Property = Vacant property for which no building permit has been issued and is not a park or recreation area

If 50% or greater of all possible voting points from benefited receptors for each noise barrier are received on the first solicitation, a simple majority of voting points cast will be used to determine if the proposed noise barrier will be constructed.

If less than 50% of all possible points for each noise barrier are received on the first solicitation, a second solicitation will be sent to benefited receptors who did not respond to the first solicitation.

If a second solicitation is conducted and 50% or greater of all possible voting points for each noise barrier are received after the second solicitation, a simple majority of voting points cast will be used to determine whether or not the proposed noise barrier will be constructed.

If less than 50% of total possible points for a noise barrier are received after the second solicitation, the noise barrier will not be constructed.

Noise barriers will be constructed in the case of a tie (equal number of points for and against a noise barrier).

All balloting soliciting the viewpoints of benefited property owners and applicable residents/tenants that occurs after the effective date of this policy, regardless of the Date of Public Knowledge, shall comply with the criteria of this policy.

(b) The allowable quantities for noise barriers per benefited receptor, with allowances for incremental increases based upon existing and predicted noise levels of all impacted receptors within each noise study area, are shown in Table 2.

For the purpose of calculating the incremental increase, the Noise Abatement Criteria (NAC) values for Activity Categories A, B, C, D, and E, as shown in Table 1, are to be used and not the NCDOT "approach" values used in traffic noise impact determinations.

Table 2

Allowable Noise Barrier Base Quantities

Maximum Allowable Base Quantity	Noise Level Consideration	Noise Wall	Earthen Berm
		1,500 ft^2	4,200 yd^3
Average dB(A) Increase Between Existing and Future Build for All Impacted Receptors	< 5 dB(A)	+ 0 ft^2	+ 0 yd^3
	5-10 dB(A)	+ 500 ft^2	+ 1,400 yd^3
	> 10 dB(A)	+ 1,000 ft^2	+ 2,800 yd^3
Average Exposure to Absolute Noise Levels for All Impacted Receptors	< 5 dB(A) Over NAC Activity Category	+ 0 ft2	+ 0 yd^3
	5-10 dB(A) Over NAC Activity Category	+ 500 ft^2	+ 1,400 yd^3
	> 10 dB(A) Over NAC Activity Category	+ 1,000 ft^2	+ 2,800 yd^3

(c) A noise reduction design goal of at least 7 dB(A) must be evaluated for all benefited receptors. At least one benefited receptor must achieve the noise reduction design goal of 7 dB(A) to indicate the proposed noise barrier effectively reduces traffic noise.

Other Considerations

Prior to CE approval or issuance of a FONSI or ROD, NCDOT shall identify in all applicable environmental documents:

(a) Noise barriers that are feasible and reasonable,

(b) Noise impacts for which no noise barrier appears to be feasible and reasonable;

(c) Locations where noise impacts will occur, where noise barriers are feasible and reasonable, and the locations that have no feasible and reasonable noise barriers.

(d) Whether it is "likely" or "unlikely" that noise barriers will be installed for each noise sensitive area identified. "Likely" does not mean a firm commitment. The final decision on the installation of noise barriers shall be made upon completion of the project design, the public involvement process, compliance with the NCDOT Policy, and FHWA approval.

Third Party Participation

(a) Third party funding of noise barriers cannot be used to make up the difference between the reasonable quantity allowance and the actual quantity of noise barriers. Third party funding is allowed only by local, state and federal government agencies, and can only be used to pay for additional features such as landscaping and aesthetic treatments for noise barriers that meet all feasible and reasonable criteria previously detailed in this policy. Private parties may freely enter into agreements with government agencies to develop noise barrier enhancements; however, all funding for enhancements paid to NCDOT must come from government agencies

(b) Traditional highway construction resources pay for required noise barriers. Should a local government request that materials be used that are more costly than the standard materials proposed by NCDOT, the requesting entity must assume 100% of the actual additional construction cost.

(c) If a local government insists on the provision of a noise barrier deemed not reasonable by NCDOT, a noise barrier may be installed provided the local government assumes 100% of the costs and obtains an encroachment permit from NCDOT to perform the work. These costs include, but are not limited to, preliminary and final engineering, actual construction and all related maintenance. In addition, local governments must ensure that NCDOT's material, design and construction specifications are met. The local government must also assume 100% of the liability associated with the measure and hold harmless the NCDOT.

(d) For (b) and (c) above, the settlement agreement shall be signed before third party noise barrier design begins and payment shall be made to NCDOT in accordance with N.C.G.S. 136-66.3(e).

ARCHITECTURAL TREATMENT OF NOISE WALLS

The standard noise wall architectural treatment consists of:

(a) Concrete columns; Steel piles may be used when necessary to address site conditions adverse to the use of concrete columns;

(b) Precast concrete panels textured on both sides;

(c) No texture on the uppermost foot of each wall segment;

(d) A single color of stain in brown or gray tones applied to both sides of textured panels;

(e) No stain applied to the uppermost foot of each wall segment and the concrete columns.

All enhancements to this standard noise wall must be paid for in accordance with Third Party Participation provisions in this policy.

NCDOT Division Engineers are responsible for determining noise wall textures and colors in their respective Divisions.

PUBLIC INVOLVEMENT

Communication with the community regarding noise impacts and possible noise abatement shall occur at the start of the noise study process and continue throughout the development of the project. NCDOT will communicate with citizens to present information on the nature of highway traffic noise and discuss the effects of noise abatement and how public preferences for noise abatement is solicited via a balloting process.

Noise study areas showing "likely" noise barriers and/or proposed locations of any "recommended" noise barriers will be presented and discussed when holding Public Hearings and Public Meetings. Likely noise barriers are based on preliminary design traffic noise analyses and are described in environmental documents. Recommended noise barriers are based on final design noise analyses and are usually identified after the environmental document is completed. Property owners and tenants who are being balloted for a recommended noise barrier will be provided a visual of the noise barrier location prior to their casting a ballot.

COORDINATION WITH LOCAL OFFICIALS

NCDOT will provide all traffic noise analyses to local government officials within whose jurisdiction a highway project is proposed as early in the project planning process as possible to protect future development from becoming incompatible with traffic noise levels. Specifically, environmental documents and design noise reports will contain information identifying areas that may be impacted by traffic noise, predicted noise level contour information, the best estimation of future noise levels for developed and undeveloped lands or properties in the immediate vicinity of the project and other appropriate design information. If requested, NCDOT will assist local officials with coordination and distribution of this information to residents, property owners and developers. NCDOT will provide information to assist local jurisdictions in the development of local noise controls, when requested. NCDOT strongly advocates the planning, design and construction of noise-compatible development and encourage its practice among planners, building officials, developers and others.

CONSTRUCTION NOISE

To minimize the impacts of construction noise on the public, NCDOT shall:

(a) Identify land uses or activities that may be affected by noise from construction of the project.

(b) Determine the measures that are needed in the plans and specifications to minimize or eliminate adverse construction noise impacts to the community. This determination shall consider the benefits achieved and the overall adverse social, economic, and environmental effects and costs of the abatement measures.

(c) Consider construction techniques and scheduling to reduce construction noise impacts to nearby receptors and incorporate the needed abatement measures in the project plans and specifications.

FEDERAL PARTICIPATION

The costs of noise barriers may be included in federal-aid participating project costs with the federal share being the same as that for the system on which the project is located when:

(a) Traffic noise impacts have been identified; and

(b) Noise barriers have been determined to be feasible and reasonable pursuant to 23 CFR 772 and this policy.

REVIEW OF POLICY

This policy shall be reviewed by the NCDOT Board of Transportation at least every five years.