13.0 NOISE AND VIBRATION

This chapter describes the location of potential noise and vibration sensitive receptors within the study area for the proposed LYNX Blue Line Extension Northeast Corridor Light Rail Project (LYNX BLE). It also discusses the potential long-term and short-term affects to these receptors for the alternatives under consideration in this Final Environmental Impact Statement (EIS). Mitigation measures have been identified, where noise or vibration impacts are predicted. Additional technical information may be found in the supporting *Detailed Noise and Vibration Technical Report* (August 2011).

13.1 Changes to this Chapter since the Draft EIS

This chapter has been revised to reflect the results of the detailed noise and vibration analysis. This chapter has also been revised to identify the Light Rail Alternative as the Preferred Alternative. Since the Draft EIS, design of the Light Rail Alternative has been refined as described in Chapter 2.0: Alternatives Considered. These refinements, including the potential effects to Noise and Vibration, are also included in this chapter.

13.2 Noise and Vibration Impact Assessment Guidelines

The process for assessing the potential impact for noise and vibration reported in the Draft EIS and subsequently in this Final EIS follows the U.S. Federal Transit Administration (FTA) guidance manual *Transit Noise and Vibration Impact Assessment* (May 2006). This process involves three levels of assessment: 1) screening, 2) general assessment and 3) a detailed assessment. A screening is typically done for locating project alignments and involves the identification of noise sensitive receptors along a corridor. A general assessment identifies the existing noise levels, the noise sensitive receptors along a corridor, projects noise from project-related sources, assesses potential impact and proposes a range of mitigation options. For purposes of the Draft EIS (August 2010), a general assessment was conducted. A detailed assessment has been completed for this Final EIS in order to identify specific noise conditions and mitigation methods for each sensitive receptor.

13.2.1 Human Perception of Noise

Noise is typically defined as unwanted or undesirable sound. Urban environments are comprised of “background noise” consisting of daily urban sounds such as traffic, air conditioners, telephones, bird calls and other familiar noises. Human reaction to sounds above this background noise is dependent on the intensity or level (such as high or low pitch sounds), the frequency and the variation in the sound level. The U.S. Environmental Protection Agency (EPA) has studied human annoyance to noise and has quantified the level of noise that most humans recognize in an urban environment as new noise. Community reaction in the EPA studies identified ranges of reaction from “no reaction” to “vigorous action.” The body of research developed by the EPA on the subject of noise served as the basis for the development of the FTA guidance manual for identifying noise and vibration impacts for transit projects.

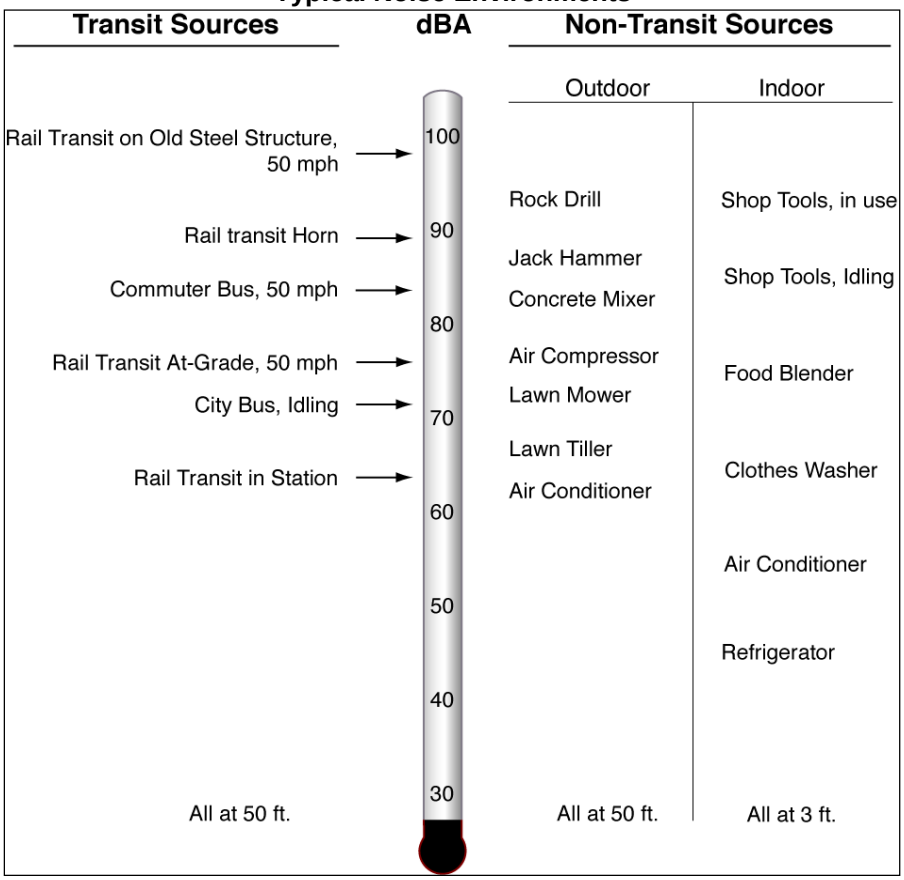
Noise is generated in two ways: through the air as “airborne noise” and through the ground as “ground-borne noise.” Airborne noise is the most common form of noise while ground-borne noise is created from vibration, such as the rattling of dishes that occurs in houses located close to freight railroad tracks.

Noise is measured in a logarithmic unit called a decibel (dBA). Human perception of noise is measured in decibels on a scale that has been weighted to middle and high frequency sounds that are more discernible to humans. This scale is called an A-weighted scale. By using this scale, the range of normally encountered sound can be expressed by values from 0 to 120 decibels. On a comparative basis, a 3-decibel change in sound level generally represents a barely-noticeable change outside the laboratory, whereas a 10-decibel change in sound level would typically be perceived as a doubling (or halving) in the loudness of a sound.

Noise levels are commonly measured and analyzed in two ways: Leq (sound level equivalent) and Ldn (24-hour day night average). Leq is a steady sound level over a specified period of time, such as one hour. It is often used to determine noise near areas where quiet is essential at all hours, such as a school or a park. The Ldn is commonly used to describe the 24-hour day-night average and assigns a 10-decibel

penalty to night-time hours. Ldn is commonly used to analyze noise impacts in areas where people sleep. Figure 13-1 provides examples of typical noise environments and criteria. In most communities, Ldn is generally found to range between 55 dBA and 75 dBA. As shown in Figure 13-1, this spans the range between an "ideal" residential environment and the threshold for an unacceptable residential environment according to U.S. Federal agency criteria

Figure 13-1
Typical Noise Environments



Source: HMMH, 2011.

13.2.1.1 Federal Transit Administration Noise Criteria

The FTA has established criteria to assess potential impacts of transit projects from rail operations at sensitive locations. These criteria do not generally apply to industrial or commercial areas since they are generally compatible with high noise levels. The FTA groups noise sensitive land uses into the following three categories:

- **Category 1**: Buildings or parks where quiet is an essential element of their intended purpose.
- **Category 2**: Residences and buildings where people normally sleep. This includes residences, hospitals, hotels and hospitals where night-time sensitivity is assumed to be of utmost importance.
- **Category 3**: Institutional land uses with primarily daytime and evening use. This category includes schools, libraries, theaters and churches where it is important to avoid interference with such activities as speech, meditation and concentration on reading material.

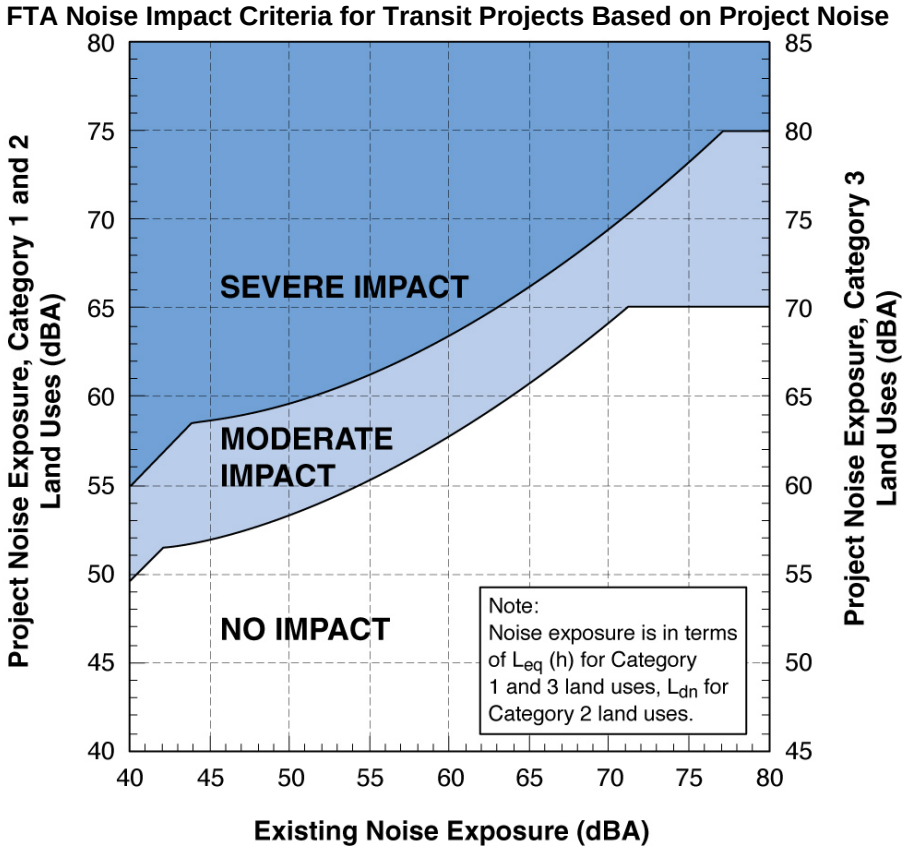
Historic properties are sensitive to noise from transit operations based on the land use activities per the FTA categories. For example, historical buildings used as residences are assessed for potential impact according to Category 2. If historical buildings are used for commercial or industrial purposes they are not considered sensitive to noise from transit operations.

Noise impacts resulting from a proposed project are determined by comparing the existing and future project-related outdoor noise levels as illustrated in the graph provided in Figure 13-2. Existing noise exposure is shown on the horizontal axis of the graph, and the vertical axis shows the noise exposure from the transit project noise sources that would cause either moderate or severe impact. Noise impacts can also be assessed by comparing existing noise conditions to future noise conditions, where future noise includes existing noise sources and project noise. This approach is necessary when the project would change existing noise sources such as shifting or adding lanes of roadway traffic or modifying existing train operations. Figure 13-3 presents the noise impact criteria based on future noise conditions. This figure shows existing noise conditions on the horizontal axis and the increase in future conditions on the vertical axis. As the existing level of ambient noise increases, the allowable level of transit project noise also increases, but the total amount, by which that community's noise can increase, without an impact, is reduced.

There are two levels of impact included in the FTA criteria, as summarized below:

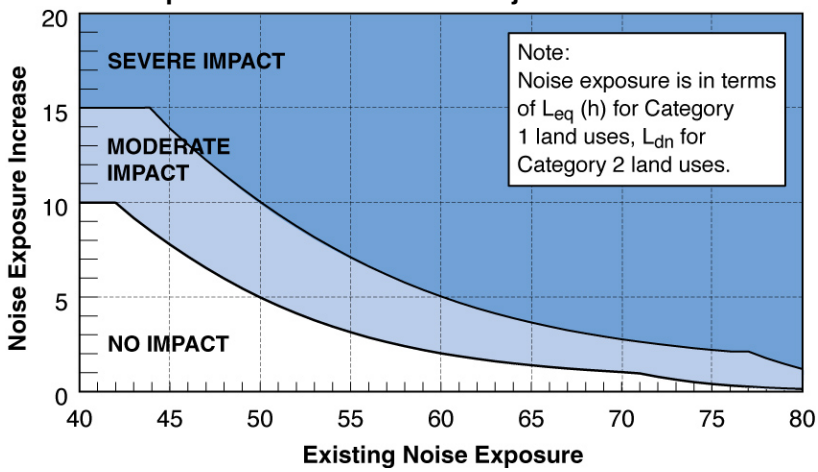
- **Severe Impact**: Project-generated noise in the severe impact range can be expected to cause a significant percentage of people to be highly annoyed by the new noise and represents the most compelling need for mitigation. Noise mitigation will normally be specified for severe impact areas unless there are truly extenuating circumstances that prevent it.
- **Moderate Impact**: In this range of noise impact, the change in the cumulative noise level is noticeable to most people but may not be sufficient to cause strong, adverse reactions from the community. In this transitional area, other project-specific factors must be considered to determine the magnitude of the impact and the need for mitigation. These factors include the existing noise level, the predicted level of increase over existing noise levels, the types and numbers of noise-sensitive land uses affected, the noise sensitivity of the properties, the effectiveness of the mitigation measures, community views and the cost of mitigating noise to more acceptable levels.

Figure 13-2
FTA Noise Impact Criteria for Transit Projects Based on Project Noise



Source: FTA, *Transit Noise and Vibration Impact Assessment*, May 2006.

Figure 13-3
FTA Noise Impact Criteria for Transit Projects Based on Future Noise



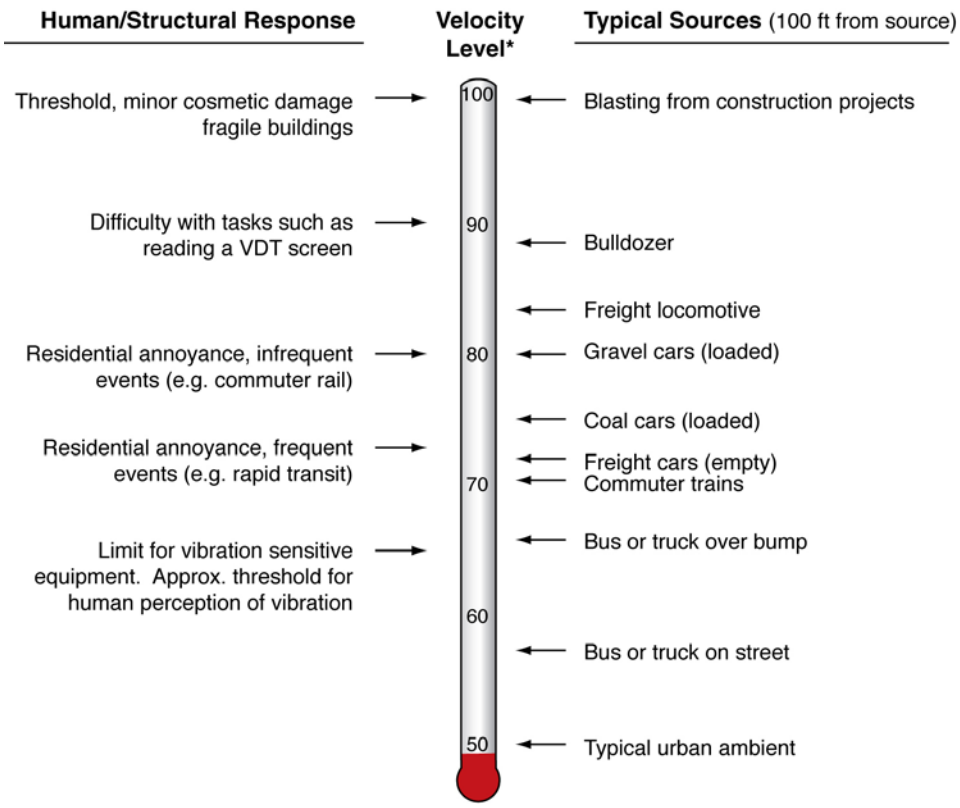
Source: FTA, *Transit Noise and Vibration Impact Assessment*, May 2006.

13.2.1.2 Human Perception of Ground-Borne Vibration

In addition to noise, rail transit projects have the potential to generate ground-borne vibration. Ground-borne vibration generally occurs most frequently with transit systems that are built underground. However, at-grade rail transit projects can also result in ground-borne vibration under certain soil and rock conditions. Ground-borne vibration is vibration that moves through the ground to a stationary object, such as a building. An example of ground-borne vibration is movement of wall hangings as a freight train passes by a residence.

Figure 13-4 illustrates typical ground-borne vibration levels for common sources. As shown, the range of interest is from approximately 50 to 100 VdB, from imperceptible background vibration to the threshold of damage. Although the approximate threshold of human perception of vibration is 65 VdB, annoyance is usually not significant unless the vibration exceeds 70 VdB.

Figure 13-4
Typical Ground-Borne Vibration Levels



** RMS Vibration Velocity Level in VdB relative to 10^{-6} inches/second*

Source: FTA, *Transit Noise and Vibration Impact Assessment*, May 2006.

13.2.1.3 Federal Transit Administration Vibration Criteria

Similar to the FTA noise criteria, the FTA vibration criteria are based on three land use categories, although the categories are somewhat different. One important difference is that outdoor spaces are not included in Category 3 for vibration. This is because human annoyance from ground-borne vibration requires the interaction of the ground vibration with a building structure. Consequently, the criteria apply to indoor spaces only and there are no vibration impact thresholds for outdoor spaces such as parks. Table 13-1 illustrates the FTA ground-borne vibration impact criteria, based on land use and train frequency. For residential buildings (Category 2), the threshold applicable to this project is 72 VdB. The applicable threshold for schools and churches (Category 3) is 75 VdB.

It should also be noted that Table 13-1 includes separate FTA criteria for ground-borne noise, the "rumble" that can be radiated from the motion of room surfaces in buildings due to ground-borne vibration. Although expressed in dBA, which emphasizes the more audible middle and high frequencies, the criteria are set significantly lower than for airborne noise to account for the annoying low-frequency character of ground-borne noise. Because airborne noise often masks ground-borne noise for above-ground (i.e. at-grade or elevated) rail systems, ground-borne noise criteria are primarily applied to subway operations where airborne noise is not a factor. Since the proposed LYNX BLE does not have any significant tunnel sections and there are no sensitive locations without windows or other openings to the outdoors, ground-borne noise has not been assessed.

Historic properties are sensitive to vibration from transit operations based on the land use activities per the FTA categories. For example, historical buildings used as residences are assessed for potential

impact according to Category 2 and historical buildings used for meditation, study or museums fall into Category 3. If historical buildings are used for commercial or industrial purposes they are not considered sensitive to vibration from transit operations.

Potential vibration impact that could cause damage to structures is assessed at all buildings regardless of the nature of their use (i.e. residential, institutional, commercial or industrial). Very rarely do vibration levels from transit operations approach levels that could cause even minor cosmetic damage to structures. Therefore, potential damage to structures has only assessed for construction activities (i.e. pile driving, vibratory compaction and bull dozers). (See Chapter 18.0 Construction Impacts)

Table 13-1
Ground-Borne Vibration (GBV) and Ground-Borne Noise (GBN) Impact Criteria for General Assessment

Land Use Category	GBV Impact Levels (VdB re: 1 micro-inch / sec)			GBN Impact Levels (dBA re: 20 micro Pascals/sec)		
	Frequent Events [1]	Occasional Events [2]	Infrequent Events [3]	Frequent Events [1]	Occasional Events [2]	Infrequent Events [3]
Category 1: Buildings where vibration would interfere with interior operations	65 VdB	65 VdB	65 VdB	n/a [4]	n/a [4]	n/a [4]
Category 2: Residences and buildings where people normally sleep	72 VdB	75 VdB	80 VdB	35 dBA	38 dBA	43 dBA
Category 3: Institutional land uses with primary daytime use	75 VdB	78 VdB	83 VdB	40 dBA	43 dBA	48 dBA

[1] "Frequent Events" is defined as more than 70 vibration events per day.
[2] "Occasional Events" is defined as between 30 and 70 vibration events per day.
[3] "Infrequent Events" is defined as less than 30 vibration events per day.
[4] n/a means "not applicable". Vibration-sensitive equipment is not sensitive to ground-borne noise.
Source: FTA, *Transit Noise and Vibration Impact Assessment*, May 2006.

In addition to the criteria provided in Table 13-1 for general assessment purposes, FTA has established criteria in terms of one-third octave band frequency spectra for use in detailed analyses. Table 13-2 shows the more detailed vibration criteria and the description of their use.

Table 13-2
Vibration Criteria for Detailed Analysis

Criterion Curve	Max. Vibration Level (VdB)	Description of Use
Workshop	90	Distinctly feelable vibration. Appropriate to workshops and non-sensitive areas
Office	84	Feelable vibration. Appropriate to offices and non-sensitive areas
Residential Day	78	Barely feelable vibration. Adequate for computer equipment and low-power optical microscopes (up to 20X)
Residential Night, Operating Rooms	72	Vibration not feelable, but ground-borne noise may be audible inside quiet rooms. Suitable for medium-power optical microscopes (100X) and other equipment of low sensitivity
VC-A	66	Adequate for medium- to high-power optical microscopes (400X), microbalances, optical balances, and similar specialized equipment
VC-B	60	Adequate for high-power optical microscopes (1000X), inspection and lithography equipment to 3 micron line widths
VC-C	54	Appropriate for most lithography and inspection equipment to 1 micron detail size
VC-D	48	Suitable in most instances for the most demanding equipment, including electron microscopes operating to the limits of their capability
VC-E	42	Most demanding criterion for extremely vibration-sensitive equipment

Source: FTA, *Transit Noise and Vibration Impact Assessment*, May 2006.

For residential buildings, the applicable criterion for vibrations generated by LYNX BLE trains (frequent events) is a maximum velocity level of 72 VdB measured in any one-third octave band between four and 80 Hertz. For institutional buildings such as schools, libraries and churches, the applicable criterion for vibration generated from LYNX BLE trains is 75 VdB.

13.3 Affected Environment

Land use sensitive to noise and vibration from long-term transit operations near the proposed alignment includes residential properties, hotels, motels, mobile homes, schools, churches and medical facilities. Noise and vibration-sensitive land uses were identified by screening Geographic Information Systems (GIS) data and subsequently by field observation. The following describes some of the noise and vibration sensitive land use that would be close to the proposed alignment, along with the existing noise and vibration conditions at those locations.

Sensitive land use between 7th Street and I-277 includes the ImaginOn library at 300 East 7th Street, the First United Presbyterian Church at 201 East 7th Street, a 10-floor high rise UNC Charlotte multi-use building (under construction) at 320 East 9th Street and governmental offices at 618 North College Street. These receptors are 150 to 330 feet from the proposed alignment. Existing noise conditions are dominated by vehicular traffic at these sensitive receptors.

The Alpha Mill Apartments at 311 East 12th Street north of I-277 are sensitive to noise and vibration. The existing noise conditions at the Alpha Mill Apartments are dominated by vehicular traffic on I-277 and 12th Street and railroad activity on the CSX and Norfolk Southern railroads.

Sensitive land use between 16th Street and North Brevard Street includes single-family residences on Parkwood Avenue and East 19th Street. Existing noise conditions at these locations are dominated primarily by vehicular traffic on Parkwood Avenue with contributions from the Norfolk Southern Intermodal Facility.

On North Brevard Street between Parkwood Avenue and Mallory Street, sensitive land use includes single-family residences set back on East 22nd Street and Charles Avenue and the Highland Mill Apartments at 2901 North Davidson Street. The existing noise conditions in this area are dominated by vehicular traffic on North Brevard Street with contributions from the Norfolk Southern mainline railroad.

On North Davidson Street between East 36th Street and East Craighead Road, sensitive land use includes single-family residences on North Davidson Street, East 37th Street, Patterson Street and Herrin Avenue and multi-family residences including The Colony (mixed-use development) at 3440 North Davidson Street and the Renaissance Apartments on North Davidson Street. The existing noise conditions are dominated by vehicular traffic on North Davidson Street with contributions from the Norfolk Southern mainline railroad.

Sensitive land use between Sugar Creek Road and Eastway Drive includes single-family residences on Bearwood Avenue, Howie Circle, Leafmore Drive, Clintwood Drive, Barrymore Drive, St. Anne Place, Prince Charles Street and Eastway Drive, the Vietnamese Baptist Church on Howie Circle and the Carolinas Medical Center - North Park on Eastway Drive. The existing noise conditions are dominated by freight train and Amtrak train activity on the Norfolk Southern mainline railroad.

Sensitive land use on North Tryon Street/US-29 between Eastway Drive and the North I-85 Service Road includes the Crossroads Charter High School at 5500 North Tryon Street/US-29, Shady Grove Mobile Home Park at 400 Lambeth Drive, Pines Mobile Homes at 5635 North Tryon Street/US-29, the Harbor Baptist Church at 5801 Old Concord Road, the Holiday Motel at 6001 North Tryon Street/US-29 the Fairyland Learning Center at 6442 North Tyron Street and single-family residences on Northridge Village Drive, 6919 North Tyron Street and 6811 Kemp Street. The existing noise conditions in this area are dominated by vehicular traffic on North Tryon Street/US-29.

On North Tryon Street/US-29 between the North I-85 Service Road and UNC Charlotte Research Drive, sensitive land use includes Intown Suites Hotels at 110 W. Rocky River Road And 7706 North Tryon Street/US-29, the Microtel Inn Hotel at 132 East McCullough Drive, the Hampton Inn at 8419 North Tryon

Street/US-29, the Marriott Residence Inn at 8503 North Tryon Street/US-29 and the CMC-University at 8800 North Tryon Street/US-29 which includes hospital beds and vibration-sensitive equipment. The existing noise conditions in this area are dominated by vehicular traffic on North Tryon Street/US-29.

Noise and vibration-sensitive buildings at UNC Charlotte CRI include the Bioinformatics building, Duke Centennial Hall, Grigg Hall, Laurel Hall, Witherspoon Hall, Spruce Hall and the EPIC building (under construction), with sensitive uses as follows:

- The Bioinformatics building, Duke Centennial Hall, Grigg Hall and EPIC building have classrooms and labs that are considered to be sensitive to noise as a Category 3 institutional land use.
- Laurel Hall, Witherspoon Hall and Spruce Hall are considered sensitive to noise as Category 2 land use (residential) receptors.
- Bioinformatics, Duke Centennial Hall and Grigg Hall contain the following equipment which are sensitive to vibration with sensitivities ranging from the VC-B to VC-E criteria: DNA Microarray (VC-B); an atomic force microscope (VC-D); an E-beam lithography machine (VC-E); a scanning electron microscope (VC-E); general metrology equipment (VC-D), a six-axis alignment system (VC-B), a mask aligner system (VC-C), a stepper with built in vibration control (VC-E); general lithography equipment (VC-D); laser and optical setups (VC-C); an atomic force microscope (VC-D), a diamond turning center (VC-E), a diamond machining center (VC-E), surface quality gauges, metrology equipment (VC-D); and a scanning electron microscope (VC-E).

13.3.1 Existing Ambient Noise Levels

Monitoring sites were selected on the basis of several factors, the most important of which was the site's potential sensitivity to changes in noise or vibration levels. Each site selected was either representative of a unique noise environment or that of similarly situated receptors nearby. While the majority of the selected sensitive receptors are residential in nature, schools, churches and medical offices were also identified. Both long-term (24-hour) and short-term monitoring was conducted at numerous sites along the proposed alignment. A tabulation of the existing noise levels is provided in Table 13-3. Monitoring locations are shown on Figures 13-5a and 13-5b.

Table 13-3
Noise Monitoring Results – Existing Noise Exposure

Site#[1]	Monitoring Location Description	Date	Duration (hour)	Existing Noise Exposure	
				Ldn[2]	Leq[3]
1	United Presbyterian, Church 201 East 7th Street	10/04/2005*	1	61.0	63.0
2	Alpha Mill Apartments, 311 East 12th Street	10/01/2008**	3	71.0	59.1
3	Single-family residence, 234 Parkwood Avenue	10/01/2008**	3	72.7	73.9
4	Single-family residence, 405 East 19th Street	10/03/2005*	24	69.0	69.0
5	Single-family residence, 423 East 22nd Street	10/01/2008**	3	60.1	56.0
6	GDR Holiness Church, 2604 North Brevard	10/04/2005*	1	59.0	61.0
7	Highland Mill Apartments, 2901 North Davidson Street	10/01/2008**	3	63.1	61.3
8	The Colony (mixed-use), 3440 North Davidson Street	10/03/2005*	24	69.0	71.0
9	Single-family residence, 4031 Bearwood Avenue	10/03/2005*	24	76.0	67.0
10	Single-family residence , 332 St Anne Place***	12/15/2008**	24	71.4	58.8
11	Elmore Mobile Home Park, 4832 North Tryon Street/US-29	10/02/2008**	3	53.8	50.2
12	Crossroads Charter High School, 5500 North Tryon Street/US-29	10/02/2008**	2	69.6	71.8
13	Pines Mobile Park, 5636 North Tryon Street/US-29	10/12/2010*	24	61.5	60.2
14	Harbor Baptist Church, 5801 Old Concord Road	10/02/2008**	2	59.8	62.0
15	Holiday Motel, 6001 North Tryon Street/US-29	10/03/2005*	24	70.0	68.0
16	Single-family residence, 201 Kingville Drive	10/08/2008**	24	63.6	66.4
17	InTown Suites Motel, 110 Rocky River Road	10/04/2005*	1	62.0	64.0

Table 13-3 (continued)
Noise Monitoring Results – Existing Noise Exposure

Site#[1]	Monitoring Location Description	Date	Duration (hour)	Existing Noise Exposure	
				Ldn[2]	Leq[3]
18	Marriott Residence Inn Hotel, 8503 North Tryon Street/US-29	10/06/2008**	3	66.1	66.4
19	Carolinas Medical Center- University, 8800 North Tryon Street/US-29	10/06/2008**	1	58.1	60.1
20	UNC Charlotte Duke Centennial Hall	10/06/2008**	1	63.3	65.3
21	Summit Green Apartments, 209 Barton Creek Drive	10/03/2005*	24	62.0	61.0
22	UNC Charlotte Laurel Hall,	10/08/2008**	24	62.1	55.3
23	Mallard Creek Apartments, 420 Michelle Linnea Drive	10/07/2008**	1	50.5	52.5
24	Hunt Club Apartments, 208 Northbend Drive	10/04/2005*	1	63.0	65.0
25	Queen's Grant Mobile, 124 Carnival Street	10/06/2008**	3	55.4	52.5

* Measurements Conducted by: Harris Miller Miller and Hanson Inc.
** Measurements Conducted by: STV Incorporated.
*** Property was previously identified as 342 St. Anne Place in Draft EIS.
Source: STV, *Noise and Vibration Technical Report*, 2010; STV, *Noise and Vibration Technical Report Addendum #1*, 2010; STV, *Noise and Vibration Technical Report Addendum #2*, 2010, HMMH, *Detailed Noise and Vibration Technical Report*, 2011.

13.3.2 Existing Vibration Conditions

Existing vibration conditions in the study area are characterized by the ambient levels near sensitive receptors, vibration levels of existing rail activity (Amtrak and freight) and line source transfer mobility (LSTM) measurements to characterize the vibration propagation conditions of the soil. Table 13-4 summarizes the vibration measurement sites selected for the detailed assessment of the LYNX BLE. Measurement locations are shown on Figures 13-5a and 13-5b.

Table 13-4
Vibration Measurement Locations in Study Area

Measurement Site	Location	Type of Measurement
V-1	East 11th Street & Brevard Street	LSTM
V-2	North Davidson Street	LSTM
V-3	North Park Mall	LSTM / Amtrak / Freight
V-4	Carolinas Medical Center - University	LSTM
V-5	UNC Charlotte	LSTM / Ambient
V-6	Kirk Farm Fields[1]	LSTM
FD	Remount Road	Force Density

1 Measurements conducted at Kirk Farm Fields for alignment proposed in Draft EIS extending to I-485.
Source: HMMH, *Detailed Noise and Vibration Technical Report*, 2011.

UNC Charlotte provided vibration data that was previously collected at two of their existing academic buildings, namely Duke Centennial Hall and Grigg Hall. At Duke Centennial Hall, the greatest measured vertical vibration level was approximately 46 VdB (monitored in 2002). At Grigg Hall, the greatest measured vertical vibration level was approximately 43 VdB (monitored in 2007). The Duke Centennial Hall monitoring was taken prior to the actual construction of the building, while the Grigg Hall monitoring was taken within the buildings existing research facilities, which incorporates the use of a dual vibration isolation system. As such, the most accurate measure of existing vibration would be at Duke Centennial Hall as readings were taken on solid ground. While the Grigg Hall monitoring is not representative of a true measure of existing vibration conditions, it does serve to demonstrate the effectiveness of the current vibration isolation system within the building.

Subsequently ambient vibration measurements were taken on the UNC Charlotte campus during the detailed assessment for this Final EIS. Although vibration criteria do not depend on existing conditions as noise criteria do, measuring the existing vibration conditions near vibration-sensitive equipment provides an indication of how existing conditions compare to the impact criteria for the equipment.

A summary of ambient vibration measurement results is provided in Table 13-5. This table shows that existing ambient vibration conditions at UNC Charlotte CRI typically meet the VC-E criterion at ground floor receptors and meet the VC-B criterion at upper floor receptors.

Table 13-5
Ambient Vibration Measurement Results

Measurement Location	Vibration-Sensitive Equipment	Vertical L10 Vibration Level (VdB)	Horizontal Perpendicular L10 Vibration Level (VdB)	Horizontal Transverse L10 Vibration Level (VdB)	Existing Vibration Levels Meet Vibration Criterion
Duke Centennial Hall Room 240 (2nd floor)	Scanning electron microscope	61.1	39.4	38.2	VC-B
Duke Centennial Hall Room 138C (ground floor on slab)	(Metrology Lab) Atomic force microscope, diamond machining center	36.8	29.6	35	VC-E
Duke Centennial Hall Room 138C (ground floor on inertia block)	(Metrology Lab) Atomic force microscope, diamond machining center	32.7	40.4	37.8	VC-E
Bioinformatics Room 332A (3rd floor)	DNA microarray	56.1	41.5	43.0	VC-B
Grigg Hall Room 239 (2nd floor)	Six-axis alignment system	64.1	49.8	45.6	VC-A
Grigg Hall Room 137 (ground floor)	Atomic force microscope	40.8	26.6	25.7	VC-E
Grigg Hall Room 153 (ground floor)	E-beam lithography	41.2	29.2	28.7	VC-E
Grigg Hall Room 152 (ground floor)	Scanning electron microscope	44.2	29.2	34.0	VC-D
Grigg Hall Room 371 (3rd floor)	(Clean room) General lithography equipment, mask aligner system	57.4	52.8	50.1	VC-B

Source: HMMH, *Detailed Noise and Vibration Technical Report*, 2011.

13.4 Environmental Consequences

This section includes projections of noise and vibration from the proposed project, an assessment of potential impact and proposed mitigation, where necessary. Potential impact has been assessed for direct noise and vibration impacts of the No-Build Alternative and the Preferred Alternative according to the methodology described in the FTA guidance manual. Construction-related impacts, along with avoidance, minimization, and mitigation measures, are discussed in Chapter 18.0: Construction Impacts.

13.4.1 Analysis Assumptions

Noise and vibration projections take into account the operations of the proposed light rail including the speed of the trains, headways, train consists, the use of audible warning devices and the track design including special trackwork (crossovers and turnouts), track curvature, adjustments for elevated guideways, terrain, building rows and other features that may affect sound propagation conditions. Other sources included in the projections are noise from park and ride facilities, traction power sub stations and

noise and vibration from the proposed storage yard and dispatch facility. A detailed description of principal analysis assumptions is included in the *Detailed Noise and Vibration Technical Report* (2011).

13.4.2 Noise Impact Assessment

13.4.2.1 No-Build Alternative

Light rail would not be constructed under this alternative; therefore, no noise impacts would occur.

13.4.2.2 Preferred Alternative

Noise impact has been assessed for the Preferred Alternative using the FTA detailed noise impact assessment methodology. The proposed LYNX BLE would introduce a new noise source into the environment which may cause impact to sensitive receptors. Table 13-6 summarizes the receptors that may be exposed to potential noise impact prior to mitigation. Noise impact locations are shown in Figure 13-6.

Table 13-6
Potential Noise Impact Prior to Mitigation – Preferred Alternative

Noise Sensitive Receptor Location	Side of Tracks	Distance to Near Track Centerline (feet)	Speed of LRV (mph)	Existing Noise Level (Ldn)	Project Noise Impact Criteria (Ldn)		Project Noise Level (Ldn)	Future Noise Level (Ldn)	Total Number of Impacts (Buildings)	
					Mod.	Sev.			Mod.	Sev.
311 East 12th Street (Alpha Mill Apartments)	East	90	45	71.0	65.0	70.2	67.0	72.5	2	0
328 Parkwood Avenue (single-family residence)	East	100	30	69.0	63.6	68.8	72.3[1]	74.0	0	1
402 East 19th Street (single-family residence)	East	150	25	69.0	63.6	68.8	68.2[1]	71.6	1	0
358 Leafmore Drive (single-family residences)	West	65	55	70.4	64.7	69.8	67.7	72.3	1	0
352 and 364 Leafmore Drive (single-family residences)	West	80	55	69.8	64.1	69.3	66.3	71.4	2	0
8503 North Tryon Street/US-29 (hotel)	West	90	45	71.4	65.0	71.4	66.9[3]	72.7	1	0
UNC Charlotte Spruce Residence Hall	South	250	15[2]	62.1	59.0	64.5	72.6[1]	73.0	0	1
UNC Charlotte Laurel Residence Hall	South	220	15[2]	62.1	59.0	64.5	67.7[1]	68.8	0	1
Total Noise Impacts for Category 2 Land Use (Residential)									7	3
Total Noise Impacts for Category 3 Land Use (Institutional)									0	0
Total Noise Impacts for Category 3 Land Use (Park)									0	0

[1] Projections include contribution from wheel squeal on tight-radius curve.
[2] Receptor is near station. Projections include use of bells, acceleration and deceleration into station.
[3] Projections include grade-crossing bells and train horn.
Source: HMMH, *Detailed Noise and Vibration Technical Report*, 2011.

Noise impact to two residential buildings at 311 East 12th Street (Alpha Mill Apartments) is due primarily to the horn sounding through the gated at-grade crossing at 12th Street. Noise impact near Parkwood Station is due primarily to the potential for wheel squeal on tight-radius curves. Noise impact near Leafmore Drive is due to the close proximity of sensitive receptors to the proposed alignment and the speed of the trains. Noise impact at 8503 North Tryon Street/US-29 is due primarily to the proximity to the proposed crossing bells at Ken Hoffman Drive gated grade-crossing and the horn sounding of the train. Noise impact near UNC Charlotte Station is due primarily to increased noise from a double-crossover and the potential for wheel squeal on a tight-radius curve.

The detailed assessment revealed no impact at the following receptors identified in the Draft EIS: Pines Mobile Home Park; a single-family residence at 332 St. Anne Place; InTown Suites Hotel at 110 West Rocky River Road; or at CMC-University. Additionally, due to the project scope reduction described in Chapter 2.0: Alternatives Considered (Section 2.2.8,) impacts previously identified at Mallard Creek Apartments and the Kirk Farm Fields Wetland Viewing Area would no longer occur. Noise impacts would not occur at any of the Category 3 land uses as a result of the Preferred Alternative.

13.4.3 Vibration Impact Assessment

13.4.3.1 No-Build Alternative

No project-generated vibration impacts would occur under the No-Build Alternative.

13.4.3.2 Preferred Alternative

Vibration impact has been assessed for residential and institutional land uses along the proposed light rail alignment. The results indicate that a single-family residence at 332 St. Anne Place is the only property along the proposed alignment that would potentially be impacted by vibration prior to mitigation. This vibration impact location is shown in Figure 13-6.

Vibration impacts were also assessed for vibration-sensitive equipment at UNC Charlotte Bioinformatics building, Duke Centennial Hall, Grigg Hall and EPIC building (under construction) and CMC-University. Vibration levels would be four decibels or more below the VC-E criterion at all receptor locations at UNC Charlotte and three decibels or more below the VC-D criterion at CMC-University.

13.5 Mitigation

13.5.1 Noise Mitigation

Noise mitigation is considered depending on the need, feasibility, reasonableness and effectiveness of potential options. The FTA states that in considering potential noise impact, severe impacts should be mitigated if at all practical and effective. At the moderate impact level, more discretion should be used, and other project-specific factors should be included in considering mitigation. These factors include the existing noise level, future increase over existing noise levels with the project, the types and number of noise-sensitive land uses affected, the acoustic effectiveness of mitigation options and the cost-effectiveness of mitigating the noise. There is a stronger need for mitigation if a project is proposed in an area currently experiencing high noise levels (Ldn above 65 dBA) from similar surface transportation sources. This is generally the case at sensitive receptors along the existing NCRR/NS mainline where existing Ldn levels range from 70 to 75 dBA.

To mitigate noise impact from train operations, noise control can be considered at the source, along the sound path, or at the receiver. Source noise control options may include special hardware at turnout locations (i.e. spring-rail or moveable-point frogs in place of standard rigid frogs), relocating special trackwork away from sensitive areas and using continuous welded rail. To address wheel squeal from trains operating on tight-radius curves, automated wayside top of rail friction modifier systems provide another source noise control option. These devices put a small amount of lubricant which maintains a constant coefficient of friction onto the top of the rail. This type of lubricant has been shown to reduce or eliminate the potential for wheel squeal.

Noise barrier construction is the most common sound path noise control treatment and can be very effective at reducing noise levels in the community. Noise barriers have been used to mitigate potential noise impact for numerous transit lines across the United States and internationally. Noise barriers are generally effective means of reducing noise from most transit sources when they break the line-of-sight between the source and the receiver. The height necessary for providing sufficient noise reduction depends on the source and receiver heights and the distances from the source and receiver to the barrier. Effective noise barriers can easily reduce noise levels 10 decibels or more depending on the specific implementation.

Noise control at the receiver can be achieved by using building sound insulation treatments. Such treatments may include replacing windows and doors of a sensitive property with windows and doors that provide greater noise reduction properties or adding insulation to the building to seal any air gaps that may allow noise to easily enter. Sound insulation mitigation does not provide any benefit for exterior land uses and is generally considered when other mitigation such as noise barriers are not feasible or effective and/or at receptors that do not have significant exterior land use. Sound insulation treatments are needed to mitigate potential impact if interior noise levels with existing windows and doors would be greater than 45 Ldn. Sound insulation improvements, such as replacing windows and doors with ones that provide greater outdoor-to-indoor noise reduction, would be considered effective if they were to improve existing outdoor-to-indoor noise reduction by five decibels or more and future interior noise levels including project noise sources would be below 45 Ldn. A minimum Sound Transmission Class (STC) rating of 39 should be used for any window exposed to the noise sources. Since sound insulation improvements are only effective when windows remain closed, it is necessary for buildings to have adequate heating and cooling that allow for windows to be closed, if desired.

A summary of noise mitigation measures proposed for the LYNX BLE is provided in Table 13-9. Descriptions of these measures are as follows:

- To mitigate the potential moderate noise impact at 311 East 12th Street (Alpha Mill Apartments), a noise barrier approximately 600 feet in length and four feet in height on the east side of the proposed alignment would be reasonable, feasible and effective in reducing impact. Mitigation for these moderate noise impacts is required because existing noise levels are greater than 65 Ldn from noise sources similar to the proposed project, and these moderate impacts should be considered as thought they were severe based on FTA guidance. The barrier would be at-grade for approximately 200 feet and then transition to the top of the proposed retaining wall for the elevated guideway which eventually goes over the CSX railroad. For the historic building adjacent to the railroad corridor, the noise barrier would reduce noise approximately five decibels and future noise levels would be below the moderate criterion. For the building on the south side of 12th Street, the noise barrier would reduce noise approximately 2-3 decibels, and would not completely mitigate the potential impact. Therefore, this building is a candidate for sound insulation improvements. Sound insulation improvements would be necessary if future interior noise levels with the existing windows would exceed 45 Ldn. During Final Design, the existing outdoor-to-indoor noise reduction of the units will be tested to determine the need for sound insulation improvements. These tests are conducted by playing noise through a speaker outside the building and measuring the levels inside and outside with the windows and doors closed.
- To mitigate potential severe noise impact at 328 Parkwood Avenue and moderate noise impact at 402 East 19th Street near Parkwood Station, installing an automated top of rail friction modifier system along the curve would be reasonable, feasible and effective in reducing potential wheel squeal. With mitigation, project noise levels would be four to seven decibels below the moderate noise impact criterion.
- To mitigate potential moderate noise impact at Leafmore Drive, a noise barrier approximately 600 feet long and approximately 10 feet in height would be effective in reducing future noise levels, including noise from existing Amtrak and freight trains by five decibels or more. Mitigation for these moderate noise impacts is required because existing noise levels are greater than 65 Ldn from noise sources similar to the proposed project and these moderate impacts should be considered as though they were severe based on FTA guidance.

- To mitigate potential moderate noise impact at 8503 North Tryon Street/US-29 (Marriott Residence Inn), sound insulation improvements to approximately 16 units, including first and second floor units, closest to North Tryon Street/US-29 would be effective in mitigating potential noise impact. Noise barriers would not be effective mitigation measures for the units due to the large gap that would be needed for the driveway providing access to North Tryon Street/US-29. Mitigation for these noise impacts must be considered because existing noise levels are greater than 65 Ldn from noise sources similar to the proposed project and these moderate impacts should be considered as though they were severe. Sound insulation improvements would be necessary if future interior noise levels with the existing windows would exceed 45 Ldn. During Final Design, the existing outdoor-to-indoor noise reduction of the units will be tested to determine the need for sound insulation improvements. These tests are conducted by playing noise through a speaker outside the building and measuring the levels inside and outside with the windows and doors closed. Because the hotel already has central heating, ventilation and air-conditioning (HVAC), no improvements to the HVAC system are required.
- Mitigation for potential severe noise impact at UNC Charlotte Spruce Hall and UNC Charlotte Laurel Hall would include an automated top of rail friction modifier system on curve LRT NB-27/SB-39 at station number 3133+00 and the use of specially-engineered hardware for the double-crossover just west of the proposed UNC Charlotte Station. Specially-engineered hardware may include flange-bearing or spring-rail frogs to minimize the gaps in the rail running surface associated with the double-crossover. With mitigation, future noise levels at these receptors would be four decibels below the moderate noise impact criterion. Automated top of rail friction modifier systems are estimated to cost $15,000 each ($30,000 for both tracks). Spring-rail frogs are estimated to cost $8,000 each.

Table 13-7
Summary of Proposed Noise Mitigation

Receptor Locations	Mitigation Location (Station Numbers)	Type of Mitigation	Length (feet)	Side of Tracks	Barrier Height (feet)
311 East 12th Street (Alpha Mill Apartments)	1026+00 to 1032+00	Noise Barrier	600	East	4
	1026+00	Sound Insulation Improvements	n/a	n/a	n/a
328 Parkwood Avenue and 402 East 19th Street	1055+00 Curves LRT NB-5/SB-5	Automated TOR friction modifier	n/a	n/a	n/a
352, 358 and 364 Leafmore Drive	1192+00 to 1198+00	Noise Barrier	600	North	10
8503 North Tryon Street/US-29	3064+00	Sound Insulation Improvements	n/a	n/a	n/a
UNC Charlotte Spruce Hall and Laurel Hall	3133+00 Curve LRT NB-27/SB-39	Automated TOR friction modifier	n/a	n/a	n/a
UNC Charlotte Spruce Hall and Laurel Hall	3135+00	Specially-engineered trackwork at double-crossover	n/a	n/a	n/a

Source: HMMH, *Detailed Noise and Vibration Technical Report*, 2011.

13.5.2 Vibration Mitigation

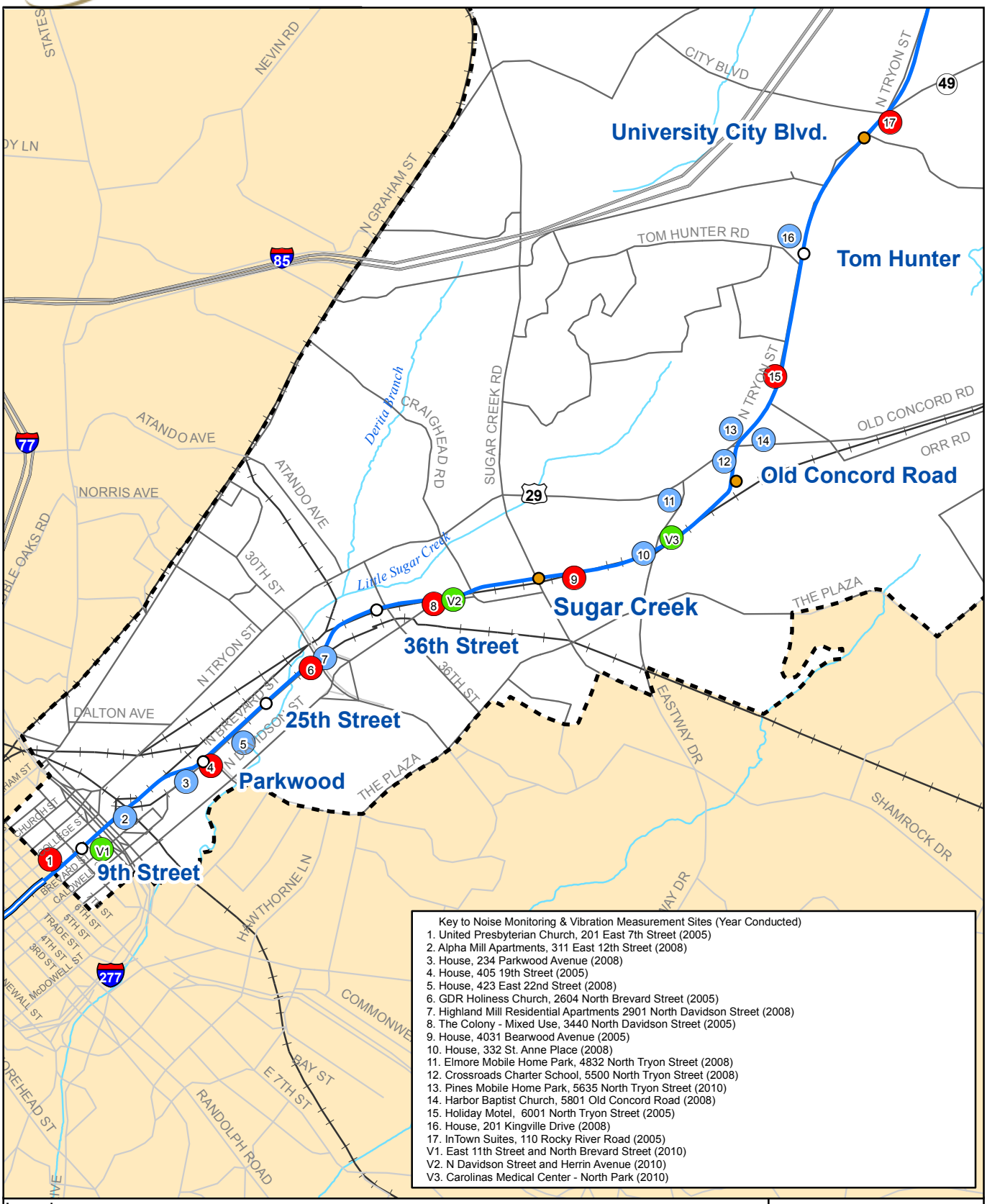
Many vibration impacts can be controlled or eliminated by the use of several general control measures. As described in the FTA manual, these measures include High Resilience Rail Fasteners, Ballast Mats or Tire Derived Aggregate, Floating Slab Track Bed, and Resilient Supported Ties.

The vibration assessment indicates that only one residence, located at 332 St. Anne Place (previously identified as 342 St. Anne Place in the Draft EIS) would experience a project-related vibration impact. Approximately 150 feet of track vibration isolation treatment installed in the LYNX BLE trackform would be effective in mitigating potential vibration impact at 332 St. Anne Place. Treatments such as ballast mats and tire derived aggregate (TDA, otherwise known as shredded tires) can reduce vibration levels from light rail trains by up to 15 VdB. With such mitigation, vibration levels from light rail trains would be below the vibration impact criterion.

LYNX Blue Line Extension

Figure 13-5a

Noise Monitoring Sites in Southern Portion of Corridor



Legend

- Northeast Corridor Limits
- Proposed Light Rail Alignment
- Proposed Stations
- Proposed Stations with Park-and-Ride
- LYNX Existing Ligh Rail Tranist
- Highway
- Highway (Future)
- Major Roads
- Railroads
- 2005 Noise Monitoring Sites
- 2008 Noise Monitoring Sites
- 2010 Vibration Measurement Sites

N

0 0.25 0.5
Mile

Data Source:
CATS, City of Charlotte GIS, and Mecklenburg County GIS, STV Field Investigation, 2009

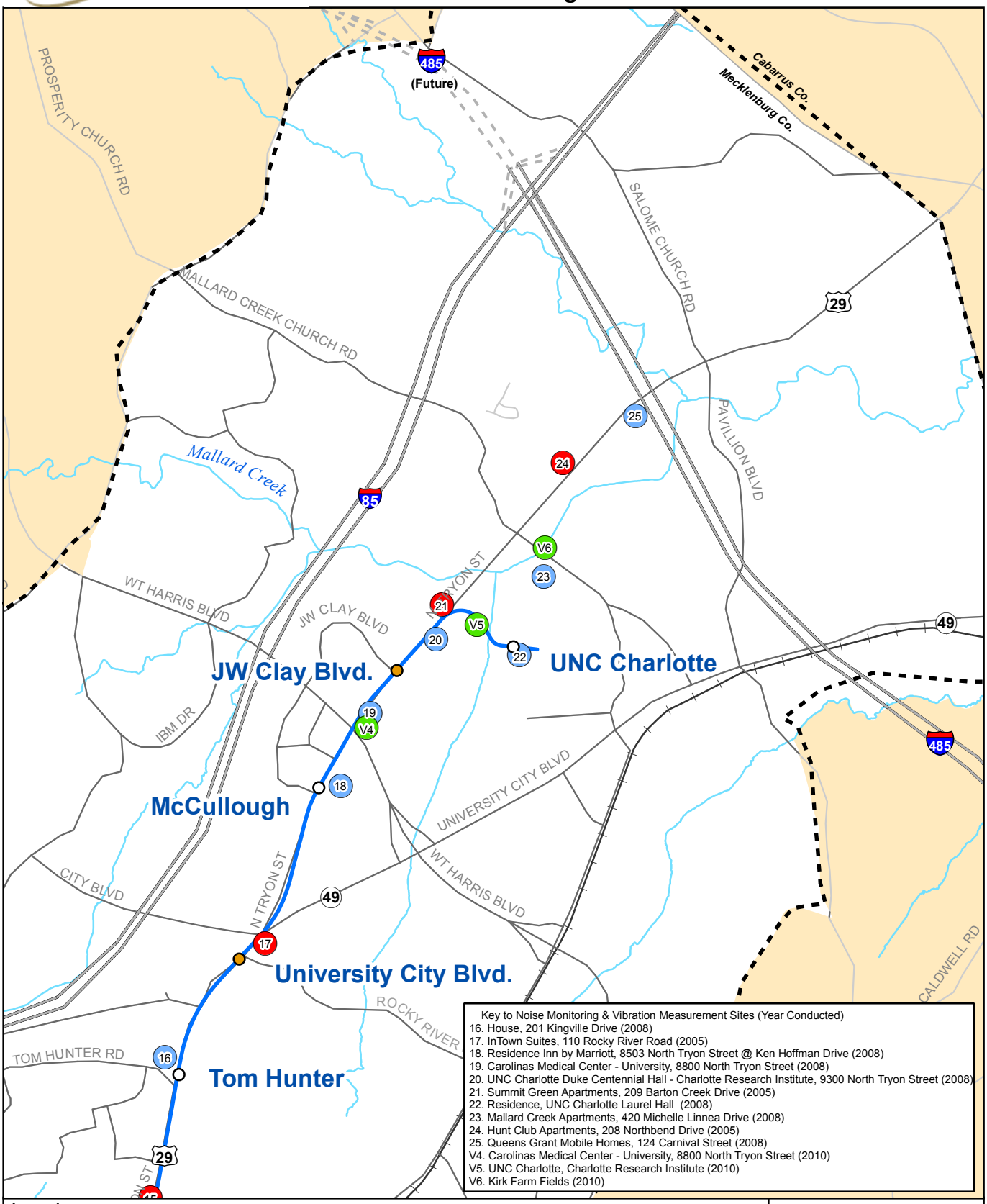
BLE FEIS Figure 13-5a.pdf

5.25.11

LYNX Blue Line Extension

Figure 13-5b

Noise Monitoring Sites in Northern Portion of Corridor



Key to Noise Monitoring & Vibration Measurement Sites (Year Conducted)
16. House, 201 Kingville Drive (2008)
17. InTown Suites, 110 Rocky River Road (2005)
18. Residence Inn by Marriott, 8503 North Tryon Street @ Ken Hoffman Drive (2008)
19. Carolinas Medical Center - University, 8800 North Tryon Street (2008)
20. UNC Charlotte Duke Centennial Hall - Charlotte Research Institute, 9300 North Tryon Street (2008)
21. Summit Green Apartments, 209 Barton Creek Drive (2005)
22. Residence, UNC Charlotte Laurel Hall (2008)
23. Mallard Creek Apartments, 420 Michelle Linnea Drive (2008)
24. Hunt Club Apartments, 208 Northbend Drive (2005)
25. Queens Grant Mobile Homes, 124 Carnival Street (2008)
V4. Carolinas Medical Center - University, 8800 North Tryon Street (2010)
V5. UNC Charlotte, Charlotte Research Institute (2010)
V6. Kirk Farm Fields (2010)

Legend

- Northeast Corridor Limits
- Proposed Light Rail Alignment
- Proposed Stations
- Proposed Stations with Park-and-Ride
- LYNX Existing Light Rail Transit
- Highway
- Highway (Future)
- Major Roads
- Railroads
- 2005 Noise Monitoring Sites
- 2008 Noise Monitoring Sites
- 2010 Vibration Measurement Sites

N

0 0.25 0.5
Mile

Data Source:
CATS, City of Charlotte GIS, and Mecklenburg County GIS, STV Field Investigation, 2009

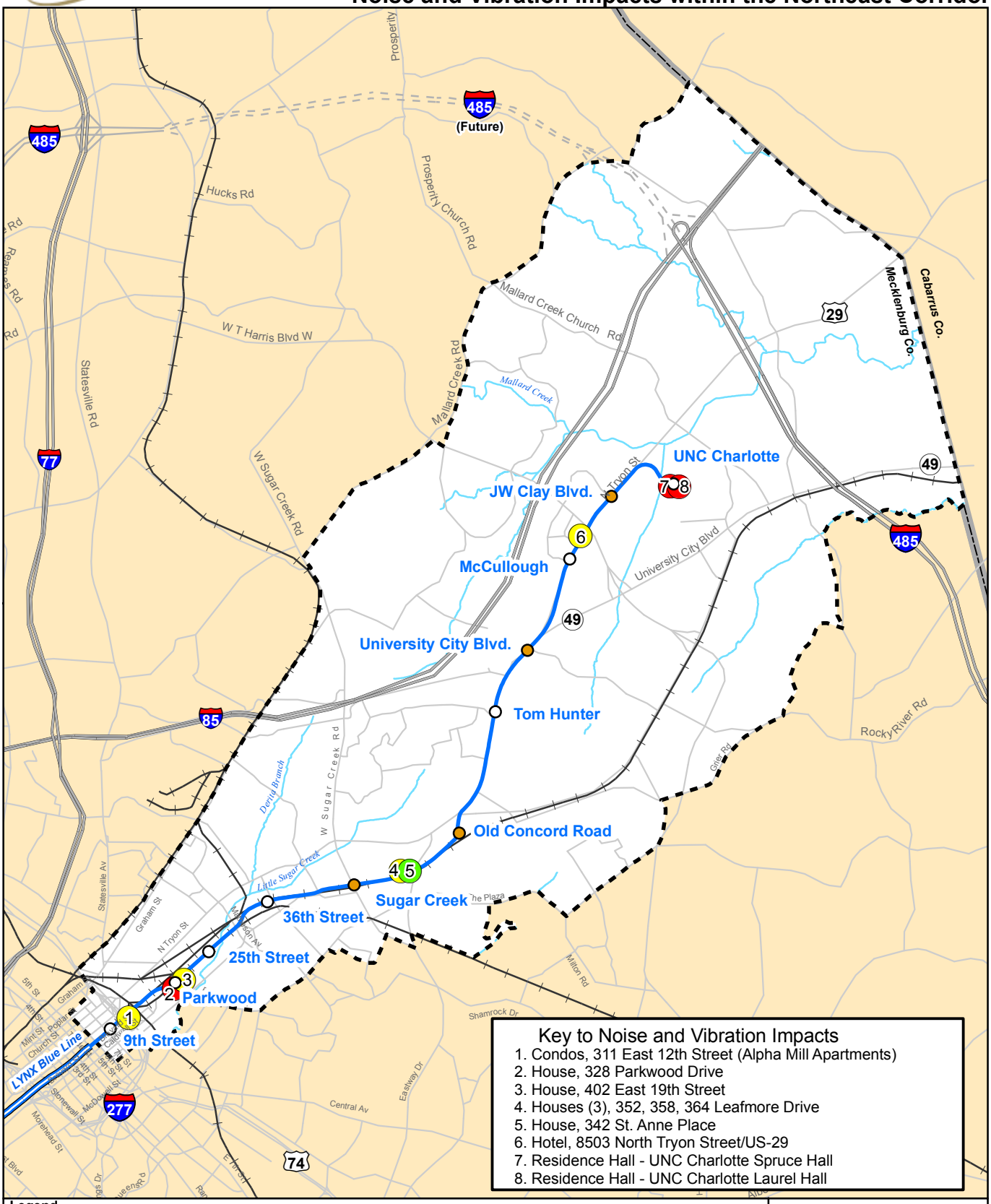
BLE FEIS Figure 13-5b.pdf

5.25.11

LYNX Blue Line Extension

Figure 13-6

Noise and Vibration Impacts within the Northeast Corridor



Legend

- Northeast Corridor Limits
- Proposed Light Rail Alignment
- Proposed Stations
- Proposed Stations with Park-and-Ride
- LYNX Existing Light Rail Transit
- Highway
- Major Roads
- Highway (Future)
- Streams
- Railroads
- County Line
- Moderate Noise Impact
- Severe Noise Impact
- Vibration Impact

0 0.5 1 Mile

Data Source:
CATS, City of Charlotte GIS, and Mecklenburg County GIS, STV Field Investigation, 2009