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Central Florida Commuter Rail Transit
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S-Line Noise and Vibration Technical Report

for the

DeLand Amtrak Station in Volusia County to Poinciana Industrial Park Station in Osceola County Environmental Assessment & Conceptual Engineering Phase

Prepared for:

Florida Department of Transportation - District 5

Prepared by:

EARTH TECH CONSULTING, INC.

In association with:

Vanasse Hangen Brustlin, Inc.
SYSTRA Consulting, Inc.
Keville Enterprises, Inc.
KM Chng Environmental Inc.
Helman Hurley Charvat Peacock Architects, Inc.
Dovetail Consulting, Inc.
Glatting Jackson Kercher Anglin Lopez Rinehart, Inc.
Nick Serianni Transportation Consulting and Government Relations
Jeffrey A. Parker & Associates, Inc.
Luke Transportation Engineering Consultants, Inc.
Buchheit Associates, Inc.
Archaeological Consultants, Inc.
Geotechnical & Environmental Consultants, Inc.

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1 Executive Summary

The Federal Transit Administration is serving as the lead agency in the preparation of a Supplemental Environmental Assessment to the approved Environmental Assessment for the Central Florida Commuter Rail Transit (CRT) project. The CRT project sponsors include the Florida Department of Transportation (FDOT), the Central Florida Regional Transportation Authority, and Volusia County Public Transit System. The Full Build option of the CRT is 60.8 miles long extending along the CSXT A-Line from the DeLand Amtrak station in DeLand in the north to Poinciana Boulevard in the south. Commuter rail service would be operated with diesel multiple unit cars. The communities directly served by the CRT are DeLand, Orange City, DeBary, Volusia County, Sanford, Lake Mary, Longwood, Altamonte Springs, Maitland, Winter Park, Orlando, Meadow Woods, Orange County, Kissimmee and Osceola County.

A detailed noise and vibration assessment was previously performed (2004) along the CRT project Corridor, from DeLand in Vousia County to Poinciana Boulevard in Osceola County. Since the approved EA/FONSI, FTA has requested that FDOT perform a general noise and vibration analysis associated with CSXT's decision to move some freight operations from the A-Line to the S-Line which extends from Baldwin in the north to Vitis in the south including parts of the AR-Line and the A-Line from Vitis through Lakeland to Auburndale. The location of the A-Line and S-Line rail corridors are shown in Figure 1-1.

Currently the S-Line has significant CSXT freight service along its entire length with an average of 27 trains daily through Wildwood to 18 trains daily through Auburndale. Due to the approximate 200 mile length and largely rural nature of the S-Line, this noise assessment does not include noise calculations at all receptors along the corridor. Instead, the assessment focused on cities and towns and developed detailed noise contours along the S-Line at 12 locations along the corridor where noise measurements were obtained.

Areas potentially impacted by the additional freight rail operations on the S-Line are shown in the graphics in Appendix A. Residential receptors located within the noise contour lines would be considered impacted by the additional freight train operations. The noise contour for moderate impact is approximately 106-104 feet from the nearest rail in the vicinity of grade crossings where horns are sounded. In other areas of the corridor, the noise contour for moderate impact is approximately 26 feet from the nearest rail. The noise contour for severe impact is approximately 27-45 feet in the vicinity of grade crossings, and approximately 7-11 feet in other areas.

It should be recognized that many of these affected receptors are currently exposed to noise from warning horns from existing freight operations along the corridor. The horn soundings introduced by the additional freight operations will increase the cumulative horn noise exposure in the corridor by an insignificant amount.

Figure 1-1 CSXT A-Line and S-Line

1.1 Freight Shifted from A-Line to S-Line

A map of the Lakeland area showing train movement after the relocation of A-line traffic to the S-Line is shown in Figure 1.2. The figure shows A-Line, S-Line, CSXT corridor and regional connections.

Currently coal traffic represented by the green line travels to and from the Orlando Utilities Commission (OUC) Stanton Coal Plant east of the Orlando International Airport via the A-Line from the north and the OUC spur line south of Taft Yard in Orlando. This traffic occurs approximately 6 days a week (one loaded train to the Stanton Plant and one empty train from the plant each day, 6 out of 7 days a week). With the proposed CSXT train shift, this bi-directional train movement will now occur via the S-Line through Lakeland to the OUC Spur in Orlando via the south end of the A-Line (two additional coal train movements).

Two daily intermodal trains, one in each direction and represented in blue currently travel via the A-Line destined for Taft Intermodal Yard. Based on the CSXT Business Plan, Taft Intermodal Yard business is being incorporated in the Winter Haven ILC Terminal. As a result, these two daily intermodal trains represented by the blue line will shift from the A-Line to the S-Line and travel to and from Winter Haven through the City of Lakeland (two additional intermodal train movements).

Two daily intermodal trains are represented by the yellow line. These two trains, one in each direction, currently stop in Taft Intermodal Yard and then travel to and from Tampa via the City of Lakeland. This traffic will now travel via the S-Line through Vitis and Lakeland Junction (lighter green line) bypassing the City of Lakeland (two eliminated intermodal train movements).

The Auto Rack trains (tri-level automobile railway cars) are represented by the red line. These two daily trains, one in each direction, are currently routed via the A-Line to and from Taft Intermodal Yard. These Auto Rack trains will now be routed via the S Line through Lakeland to and from Winter Haven (two additional auto train movements).

In summary, after the CSXT proposed A-line railroad traffic shift, there will be 4 additional train movements operating through Lakeland daily (2 two additional trains moving both ways daily).

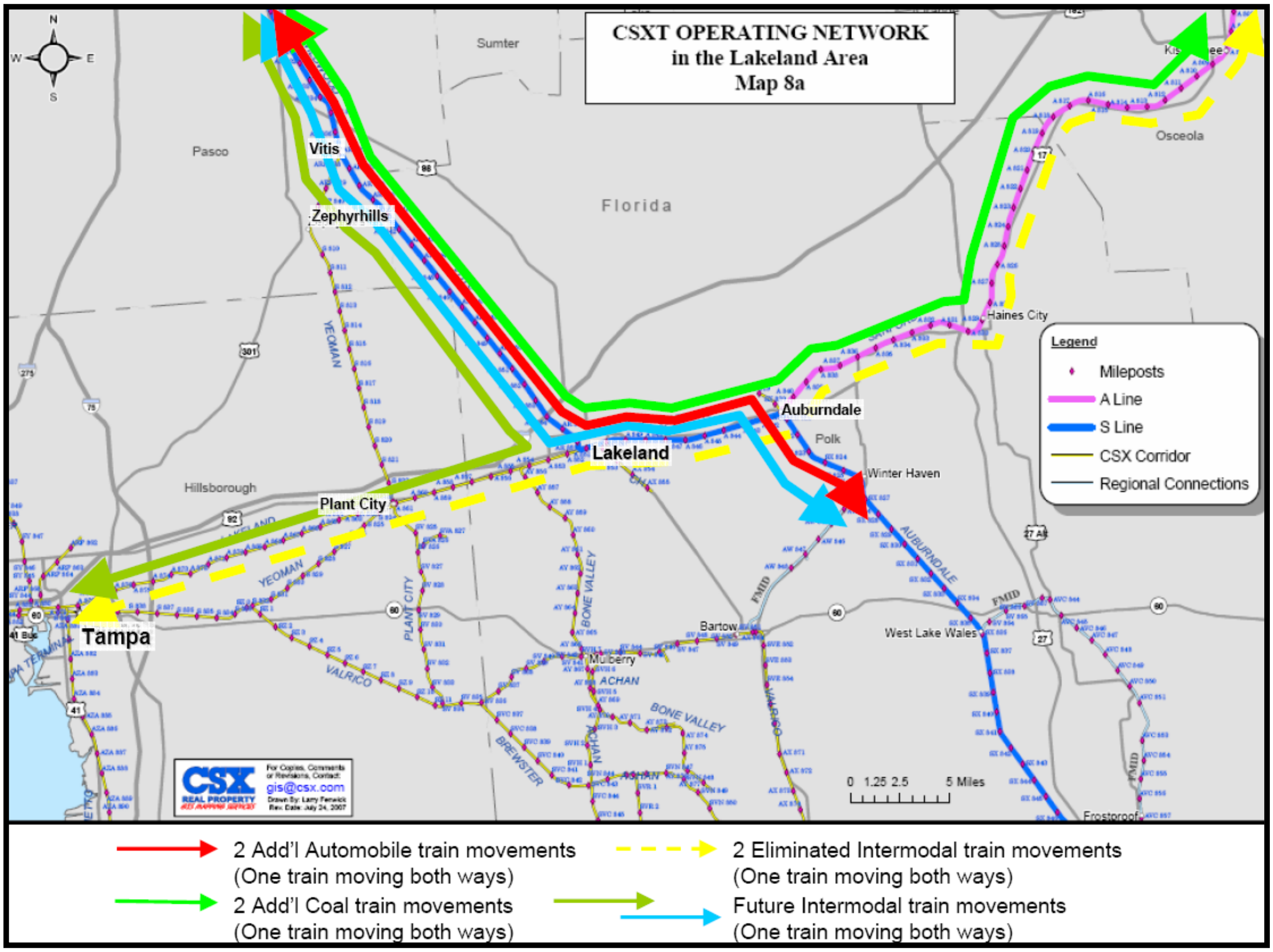


Figure 1-2 Freight Traffic in Lakeland Area after A-Line Shift

Noise

This report includes an introduction to basic noise concepts including noise descriptors, the prediction methodologies and modeling assumptions, the results of the ambient noise monitoring program, and the evaluation of potential impacts along the S-Line.

2.1 Human Perception of Noise

The characteristics and properties of noise are explained in the following subsections.

2.1.1 Describing Noise

Noise is "unwanted sound" and, by this very definition, the perception of noise is a subjective process. Several factors affect the actual level and quality of sound (or noise) as perceived by the human ear and can generally be described in terms of loudness, pitch (or frequency), and time variation.

Loudness. The loudness, or magnitude, of noise determines its intensity and is measured in decibels (dB). The noise decibel is used to describe a large range of sound levels. For example, ambient noise ranges from 40 decibels from the rustling of leaves to over 70 decibels from a truck passby to over 100 decibels from a rock concert.

Pitch. Pitch describes the character and frequency content of noise. Measured in Hertz (Hz), frequency is typically used to identify the annoying characteristics of noise and thereby identify the proper mitigation to help eliminate or minimize its magnitude. The human ear is typically sensitive to noise frequencies between 20 Hz (low-pitched noise) and 20,000 Hz (high-pitched noise). For example, noise may range from very low-pitched "rumbling" noise from stereo sub-woofers to mid-range traffic noise to very high-pitched whistle noise.

Time Variation. The time variation of some noise sources can be characterized as continuous, such as a building ventilation fan, intermittent, such as for a train passby, or impulsive, like a car backfire.

2.1.2 Description of Noise Levels

Various levels are used to quantify noise from transit sources including a sound's loudness, duration, and tonal character. For example, the A weighted decibel (dBA) is commonly used to describe the overall noise level. Because the decibel is based on a logarithmic scale, a 10 decibel increase in noise level is generally perceived as a doubling of loudness, while a 3-decibel increase in noise is just barely perceptible to the human ear. The A weighting is an attempt to take into account the human ear's response to audible frequencies. Typical A weighted sound levels from transit and other common sources are shown in Figure 2-1. The following A weighted noise descriptors are typically used to determine impacts from transit related sources:

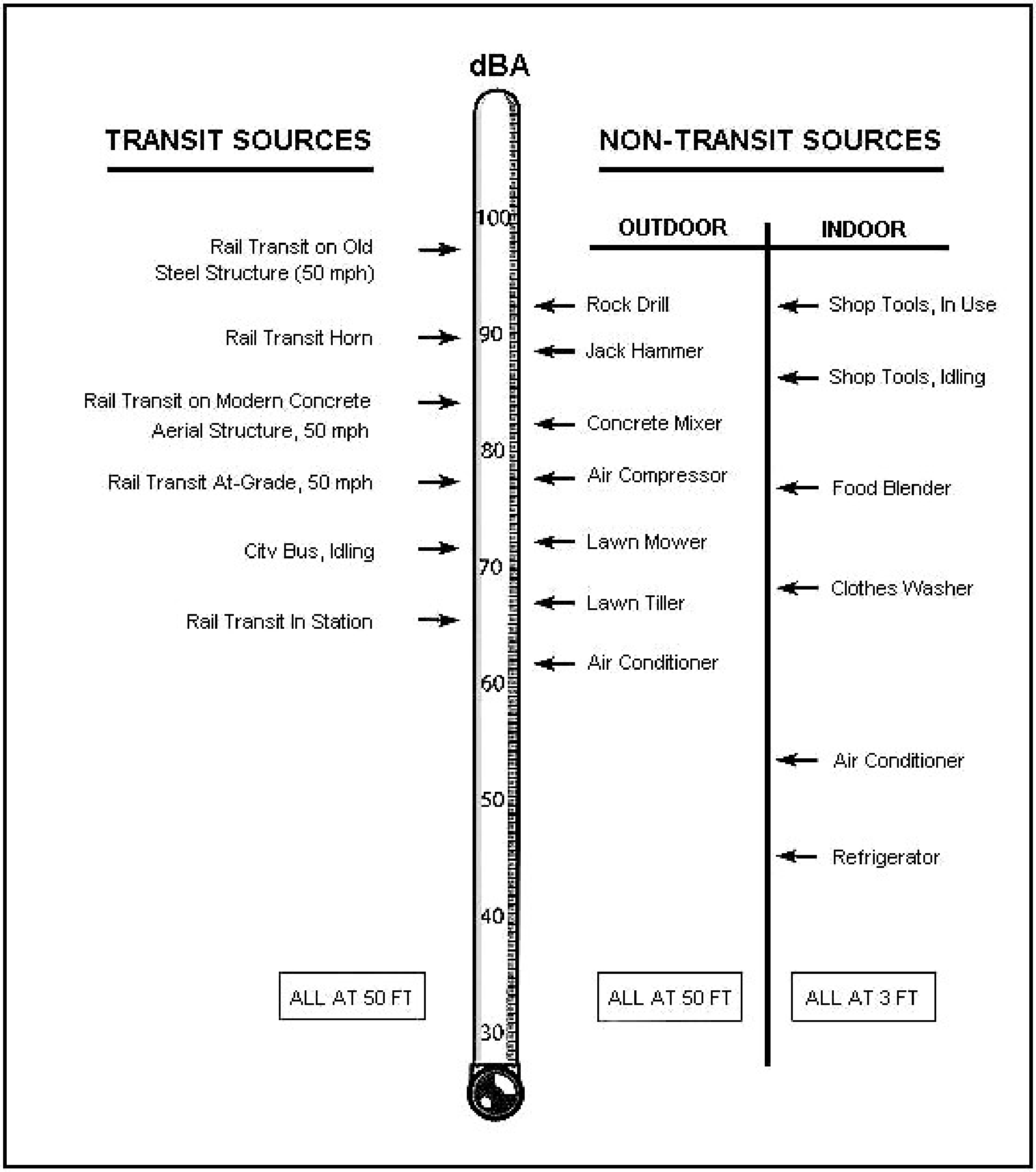


Figure 2-1 A-Weighted Noise Levels

- L_{MAX} represents the maximum noise level that occurs during an event or train passby and is the noise level actually heard during the event or passby.

- L_{EQ} represents a level of constant noise with the same acoustical energy as the fluctuating noise levels (e.g., highway traffic) observed during a given interval such as one hour. For transit projects the Leq noise level is commonly used to describe levels at non-residential receptors (such as offices, schools, and churches) with primarily daytime uses. L_{EQ}(h) is a noise level averaged over one hour.

- L_{DN}, the day-night noise level, represents the average noise level evaluated over a 24 hour period. A 10-decibel penalty is added to events that occur during the nighttime hours (10:00 p.m. to 7:00 a.m.) to account for people's increased sensitivity to noise while they are sleeping. For transit projects the L_{DN} is commonly used to describe noise at residences.

- SEL is the sound exposure level typically used to predict overall transit source levels. The SEL converts the time period of the Leq to one second allowing for the direct comparison of events or passbys with different time durations.

Unlike the L_{MAX} level, the hourly L_{EQ} noise level describes noise over a longer time duration than just a single event. For example, a single six-car train passby at 50 mph has an L_{MAX} of 88 dBA but a L_{EQ} (h) level of only 54 dBA. This is due to the concept of time averaging whereby the overall average noise level (L_{EQ}) during the one-hour period is much less than the short-duration passby level of the event (L_{MAX}). The L_{MAX} and the hourly L_{EQ} levels are theoretically equivalent for constant noise sources such as a transformers or rooftop ventilation units.

2.2 Evaluation Criteria

The criteria used to evaluate noise impacts are described in the following subsections. Criteria used to evaluate operational and construction impacts are discussed separately.

2.2.1 Operational Noise

Operational criteria are used to assess noise impacts from the project alternatives when they are fully operational. These criteria are, therefore, typically evaluated against the project operations that occur in the design year.

Federal Noise Guidelines

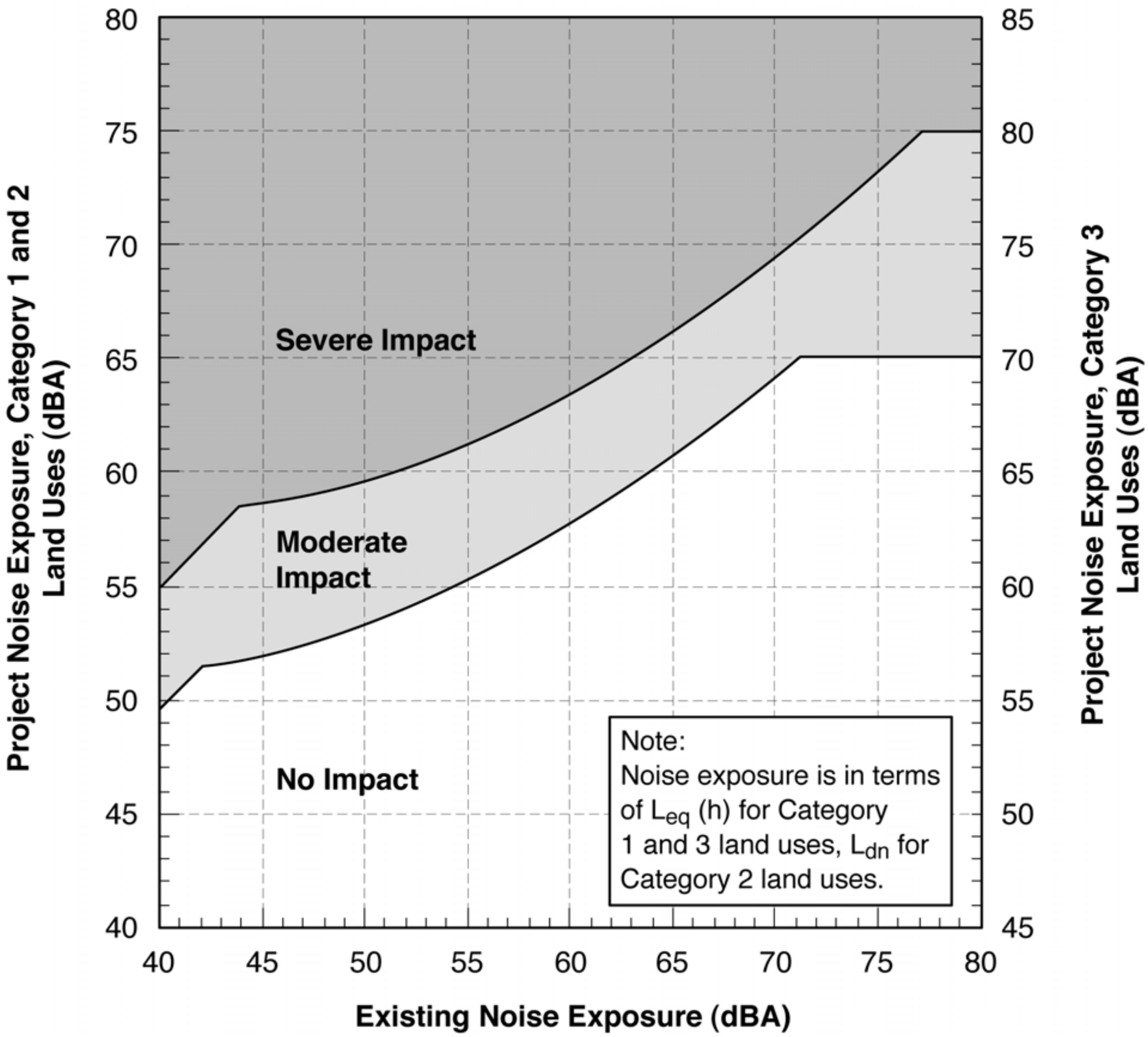
The Federal Transit Administration's *Transit Noise and Vibration Impact Assessment* guidance manual (FTA-VA-90-1003-06, May 2006) presents the basic concepts, methods, and procedures for evaluating the extent and severity of noise impacts from transit projects. Transit noise impacts are assessed based on land use categories and sensitivity to noise from transit sources under the FTA guidelines. The FTA noise impact criteria are defined by two curves that allow increasing project noise levels as existing noise increases up to a point, beyond which impact is determined based on project noise alone. The FTA land use categories and required noise metric are described in Table 2-1.

Table 2-1 FTA Land Use Categories and Noise Levels

LAND USE CATEGORY	NOISE LEVEL	DESCRIPTION
1	L_{EQ}(h)	Tracts of land set aside for serenity and quiet, such as outdoor amphitheaters, concert pavilions, and historic landmarks.
2	L_{DN}	Buildings used for sleeping such as residences, hospitals, hotels, and other areas where nighttime sensitivity to noise is of utmost importance
3	L_{EQ}(h)	Institutional land uses with primarily daytime and evening uses including schools, libraries, churches, museums, cemeteries, historic sites, and parks, and certain recreational facilities used for study or meditation.

Source: Transit Noise and Vibration Impact Assessment – Final Report, Federal Transit Administration, Washington, D.C., May, 2006.

The FTA noise criteria are delineated into two categories: moderate impact and severe impact. The moderate impact threshold defines areas where the change in noise is noticeable but may not be sufficient to cause a strong, adverse community reaction. The severe impact threshold defines the noise limits above which a significant percentage of the population would be highly annoyed by new noise. The level of impact at any specific site can be established by comparing the predicted project noise level at the site to the existing noise level at the site. The FTA noise impact criteria for all three land use categories are shown in Figure 2-2.



Source: Transit Noise and Vibration Impact Assessment – Final Report, Federal Transit Administration, Washington, D.C. ,May 2006.

Figure 2-2 FTA Noise Impact Criteria for Transit Projects

2.3 Modeling Methodology and Assumptions

A Noise Modeling Protocol with a detailed description of the modeling methodology was prepared and the types of noise sources included in the modeling prediction are included in the following sub-sections. The impact assessment from future transit noise sources along the project corridor was determined according to the FTA guidelines for general assessment.

2.3.1 S-Line CSX Passbys

The CSX freight trains along the S-Line corridor are modeled using two standard locomotives and 75 rail car consists. These trains generally operate on continuously welded rail tracks. Adjustments to the predicted noise levels for each passby included the following:

- Track type;
- Train speed;
- Consist size; and;
- Period volumes.

For this assessment, all tracks were assumed to be at-grade. The train speed profile was assumed to be 40 mph at all locations. Reference noise level data are shown in Table 2-2 for freight rail noise sources. Train operations data for the S-Line and shifted A-Lines trains was provided by CSXT and is summarized in Appendix B. This operations data was aggregated into 8 regions from Auburndale and Lakeland in the south to Starke in the north. The impact assessment from future freight noise sources along the project corridor was determined according to the FTA guidelines.

Table 2-2 Summary of Noise Source Reference Data

NOISE SOURCE		***NOISE LEVEL (dBA)***
NAME	***DESCRIPTION***	***SEL***
Locomotives	**Diesel-Electric , 3000 HP, Throttle 5**	**92**
Rail Transit	**At-grade, ballast, welded rail**	**82**
Horns	**Within ¼ mile of grade crossing**	**110**

Source: Transit Noise and Vibration Impact Assessment – Final Report, Federal Transit Administration, Washington, D.C., May, 2006, Table 5.1

Using the peak- and 24-hour CRT volumes listed in the Appendix, passby noise levels from commuter rail vehicles were predicted at each of the identified receptor locations along the project corridor using the FTA fixed-guideway algorithm shown in Equation 1.

$$LeqM_{50}(h) = SEL_{ref} + 10\log(N_{cars}) + 20\log\left(\frac{S}{50}\right) + 10\log(V) + C_{adj} - 10\log(3600) \quad \text{[Equation. 1]}$$

where:

$LeqM_{50}(h)$	= hourly Leq noise level at 50 feet (in dBA) from commuter rail passbys;
SEL_{REF}	= reference SEL noise level at 50 feet (in dBA);
N_{CARS}	= average consist size (i.e., number of DMU cars per train);
S	= train speed (in mph);
V	= average hourly commuter rail volumes as follows (in trains/hour):

$$V_D = \left(\frac{\sum_{7AM}^{10PM} number\ of\ trains}{15} \right)$$ [average hourly daytime volume];

$$V_N = \left(\frac{\sum_{10PM}^{7AM} number\ of\ trains}{9} \right)$$ [average hourly nighttime volume];

$$V_{PK} = \sum_{PK-HR} number\ of\ trains$$ [average hourly peak-hour volume];

C_{ADJ}	= adjustment factor applied to track type as follows (in dBA):	
	= +5	for jointed rail track;
	= +4	for aerial structure with slab track; and,
	= +3	for embedded track on grade.
-10log(3600)	= L_{EQ}(h) adjustment factor based on the number of seconds in one hour (in dBA).	

2.3.2 Horn Equipment

The FTA methodology does not provide a specific procedure for modeling particular types of warning horns and mounting systems. The FTA guidelines are based on a body of research which takes into account both the wide variety of horn and mounting systems used in railroad rolling stock, and the perceived annoyance level which takes into account psycho-acoustic research. Therefore, horn noise was modeled according to FTA requirements as shown in Equation 2.

$$L_{eq}(h) = SEL_{ref} - 10\log(S/50) + 10\log(V) - 35.6 \qquad \text{[Equation 2]}$$

where:

SEL_{REF}= reference SEL noise level at 50 feet for warning horns (110 dBA);
S = train speed (in mph);
V = average hourly commuter rail volumes as follows (in trains/hour):

2.3.3 24 –Hour L_{DN} Noise Level

At residential receptors identified along the project corridor the 24-hour L_{DN} noise level was used to assess impact against the FTA impact criteria. Using Equation 3, average hourly L_{EQ} noise levels during the daytime (from 7 a.m. to 10 p.m.) and the nighttime (from 10 p.m. to 7 a.m.) periods were used to develop an overall 24-hour L_{DN} noise level.

$$Ldn_{50} = 10\log\left[15 \times 10^{\left(\frac{LeqD_{50}}{10}\right)} + 9 \times 10^{\left(\frac{LeqN_{50}+10}{10}\right)}\right] - 10\log(24) \qquad \text{[Equation 3]}$$

where:

Ldn50	= 24-hour Ldn noise level at 50 feet (in dBA);
LeqD50	= average daytime hourly Leq(h) noise level at 50 feet between 7 a.m. and 10 p.m. (in dBA);
LeqN50	= average nighttime hourly Leq(h) noise level at 50 feet with 10-dBA penalty applied for nighttime events between 10 p.m. and 7 a.m. (in dBA); and,
-10log(24)	= Ldn adjustment factor based on the number of hours in a day (in dBA).

2.4 Existing Conditions

Existing noise along the S-Line corridor was measured to characterize ambient background levels in the community as well as to document freight sources that currently operate along the corridor. The scope and the results of the noise measurement program are described in the following subsections. Figure 1-1 shows the general location of the S-Line Corridor

2.4.1 Background Ambient Noise Levels

In accordance with FTA noise guidelines, a noise-monitoring program was conducted along the S-Line Corridor to (1) establish the existing ambient background levels within the project area and (2) develop project criteria noise limits.

As shown in Figure 2-3, noise measurements were obtained at 12 receptor locations along the corridor. The measurements at 11 of the locations consist of 24 hours of continuous noise montoring at residential receptors. The remaining location was in a public park where hour-long noise measurements were collected. The results were used to establish baseline noise levels for both residential and non-residential receptors. The existing noise environment was characterized according to the FTA land use categories shown in Table 2-1.

Existing land uses along the S-Line corridor are exposed to a variety of noise sources ranging from vehicular traffic along major roads and cross streets to noise generated by existing CSX freight operations along the railway. For most of the locations measured, the existing freight operations dominate the recorded noise levels.

The selection process used to determine monitoring locations began with the study of land use maps, USGS maps, and aerial photography. First, 12 preliminary locations were selected that would be (1) evenly distributed in the corridor, (2) representative of typical land use for the various communities adjacent to the corridor, and (3) were close enough to the existing railway corridor so that existing railway operations noise would be a significant component of the noise measurements. After the noise measurement technicians visited the actual sites, some adjustments were made to a few of the locations for logistical reasons.

The results of the community noise-monitoring program were used to establish the existing background noise levels and to develop the allowable project criteria using the FTA guidelines. The noise-monitoring program was conducted in March 2008 to establish existing peak hour L_{EQ} noise levels at non-residential locations and 24-hour L_{DN} noise levels at residences. The results of the noise-monitoring program are summarized in Table 2-3 for each of the 12 measurement locations. Locations 2 and 7 had the lowest measured L_{DN} levels because of fewer freight train operations on those days of monitoring. The lower measured L_{DN} noise level at location 5 in Wildwood (63 dBA) is due to the distance of the residences in this area from the nearest track (150 feet). The remaining nine locations had higher L_{DN} noise levels due to the higher density of existing trains during the monitoring period. Currently the S-Line has significant CSXT freight service along its entire length with an average of 27 trains daily through Wildwood to 18 trains daily through Auburndale (refer to Average Train Counts, Appendix B).[1]

[1] CSXT Average Train Counts 2006 and January through October, 2007.

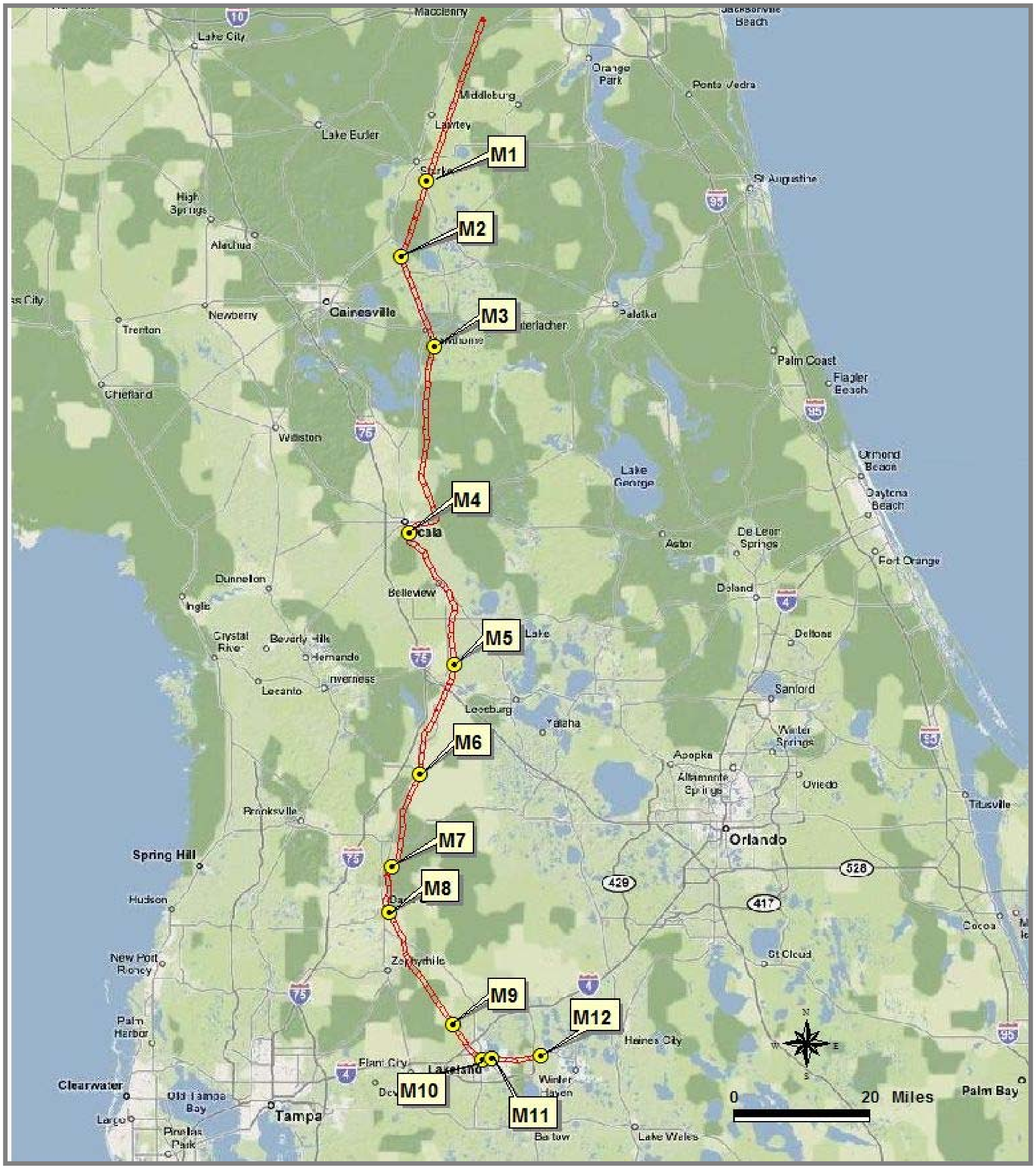


Figure 2-3 Community Noise-Monitoring Locations Along the S-Line Corridor

Table 2- 3 Summary of Noise Measurements

NUMBER	DESCRIPTION	TOWN	FTA CATEGORY	MEASURED NOISE LEVEL
1	346 North Thompson	Starke	2	77 L_{DN}
2	14394 NE 137th	Waldo	2	65 L_{DN}
3	6936 SE 272nd	Hawthorne	2	73 L_{DN}
4	521 SW 2nd	Ocala	2	82 L_{DN}
5	4545 Cr 116	Wildwood	2	63 L_{DN}
6	109 E. Virginia	Bushnell	2	74 L_{DN}
7	38635 Patti	Lacoochee	2	63 L_{DN}
8	14006 Blake	Dade City	2	72 L_{DN}
9	5940 Ivy Branch	Galloway	2	74 L_{DN}
10	Munn Park	Lakeland	3	70 L_{EQ}
11	1610 East Fern	Lakeland	2	75 L_{DN}
12	2127 Hillcrest	Auburndale	2	73 L_{DN}

2.5 Noise Assessment

A noise assessment was completed to determine the noise contours for potential noise related impacts at various sensitive receptor locations along the S-Line corridor. The noise contours were determined using the FTA guidelines and methodologies.

Based on the noise measurements obtained along the S-Line, criteria levels were established from Figure 2-2 for moderate and severe impact conditions along the S-Line based solely on the additional freight train operations shifted from the A-Line. Calculations were then performed using the equations in Section 2.3 to determine the noise generated by the proposed additional freight train operations on the S-Line. These calculated noise levels, at the reference distance of 50 feet from the nearest rail, were then extrapolated to the FTA moderate and severe impact criteria levels to determine the distance from the nearest track within which moderate and severe noise impacts would be expected to occur due to the additional freight trains shifted from the A-Line. These calculated impact distances were then graphed as contours, superimposed on 2004 Florida GIS aerial quad maps of the region of interest. The results of the noise contour analysis are shown in Appendix A. The results of the analysis of impact criteria and contour distances for the additional freight rail operations shifted from the A-Line to the S-Line are shown in Table 2-4.

The information contained in Table 2-4 is used as follows. For example, in the Lakeland area, the measured Ldn noise level was 75 dBA. Using the curves in Figure 2-2, the FTA moderate impact criterion is 65.0 dBA, and the severe impact criterion is 73.3 dBA. From Table 2-5 (discussed below), the predicted L_{DN} noise level from the four additional freight trains (two during the daytime hours and two during the nighttime hours) that are expected to operate along this section of the corridor is 67.7 dBA (with horns) at a reference distance of 50 feet from the nearest rail. Extrapolating this noise level using sound propagation attenuation over soft ground (per the FTA methodology) would result in an L_{DN} noise level of 65 dBA (the FTA moderate impact criterion) at a distance of approximately 68 feet from the from the nearest rail. As a result, any residential receptor located within 68 feet of the rail corridor would exceed the FTA moderate impact criterion of 65 dBA. Without horns, the moderate impact distance is 17 feet as indicated in Table 2-4.

Table 2-5 shows the calculated L_{DN} noise exposure levels with and without horns at a reference distance of 50 feet for the current S-Line freight rail operations, the additional A-Line freight rail operations, and the calculated L_{DN} noise level from the combined total freight rail operations on the S-Line. The values were calculated using the same FTA methodology used to calculate the L_{DN} noise levels for the noise contours. The results show a range of 0.8 to 1.4 dBA increase in the average daily L_{DN} noise exposure level at a reference distance of 50 feet. Again, using the Lakeland area as an example, the current predicted L_{DN} noise at a reference distance of 50 feet from the corridor is 74.4 dBA with horns. Adding an additional four freight trains will generate an L_{DN} noise level of 67.7 dBA for a total L_{DN} noise level of 75.2 dBA (the logarithmic sum of 74.4 dBA + 67.7 dBA = 75.2 dBA). This results in an increase in the L_{DN} noise level of 0.8 dBA at a reference distance of 50 feet. If the existing L_{DN} noise level of 74.4 dBA were expressed as a noise contour at a distance of 50 feet from the corridor, then adding an additional four freight trains would increase the distance of this noise contour by approximately 8 feet. As a result, the existing 74.4 dBA noise contour line would now be located approximately 58 feet from the rail corridor.

As a noise mitigation measure, CSX has committed to develop quiet zones in the downtown Lakeland area that will restrict the use of warning horns as the freight trains approach the grade crossings. Since the warning horns are the major noise source from the freight trains, this will have a significant effect in reducing the overall noise levels in the downtown Lakeland area. The location of the quiet zones and the existing grade-separated crossings are shown in Figure 2-4. In addition, the results of this noise mitigation are reflected in the noise contours shown in Appendix A for the Lakeland area.

Table 2-4 Summary of FTA Noise Criteria and Noise Contour Impact Distances due to the Additional Freight Train Operations on the S-Line

	FTA MODERATE IMPACT			*FTA SEVERE IMPACT*		
REGION	L_{DN}	*DISTANCE NEAR GRADE CROSSING (with Horns)*	*DISTANCE (withoutHorns)*	L_{DN}	*DISTANCE NEAR GRADE CROSSING (with Horns)*	*DISTANCE (withoutHorns)*
Starke	**65.0 dBA**	**104 feet**	**26 feet**	**74.7 dBA**	**27 feet**	**7 feet**
Waldo	**65.0 dBA**	**105 feet**	**26 feet**	**71.6 dBA**	**42 feet**	**11 feet**
Ocala	**65.0 dBA**	**104 feet**	**26 feet**	**75.0 dBA**	**26 feet**	**7 feet**
Wildwood	**65.0 dBA**	**104 feet**	**26 feet**	**71.2 dBA**	**38 feet**	**9 feet**
Lacoochee	**65.0 dBA**	**104 feet**	**26 feet**	**71.6 dBA**	**44 feet**	**11 feet**
Vitis	**65.0 dBA**	**105 feet**	**26 feet**	**71.2 dBA**	**45 feet**	**11 feet**
Lakeland	**65.0 dBA**	**68 feet**	**17 feet**	**73.3 dBA**	**21 feet**	**5 feet**
Auburndale	**65.0 dBA**	**68 feet**	**17 feet**	**71.8 dBA**	**27 feet**	**7 feet**

Table 2-5 Summary of Calculated L_{DN} Levels at a Reference Distance of 50 Feet

	CALCULATED L_{DN} @ 50 FEET WITH HORNS (dBA)				*CALCULATED L_{DN} @ 50 FEET WITHOUT HORNS (dBA)*			
REGION	*S-LINE*	*A-LINE*	*A+S LINE*	*DIFFERENCE*	*S-LINE*	*A-LINE*	*A+S LINE*	*DIFFERENCE*
Starke	**76.0**	**70.8**	**77.2**	**1.2**	**66.0**	**60.8**	**67.2**	**1.2**
Waldo	**75.2**	**70.9**	**76.6**	**1.4**	**65.2**	**60.9**	**66.6**	**1.4**
Ocala	**75.2**	**70.8**	**76.6**	**1.4**	**65.2**	**60.8**	**66.6**	**1.4**
Wildwood	**75.7**	**70.8**	**76.9**	**1.2**	**65.7**	**60.8**	**66.9**	**1.2**
Lacoochee	**75.0**	**70.8**	**76.4**	**1.4**	**65.0**	**60.8**	**66.4**	**1.4**
Vitis	**74.9**	**70.9**	**76.3**	**1.4**	**64.9**	**60.9**	**66.3**	**1.4**
Lakeland	**74.4**	**67.7**	**75.2**	**0.8**	**64.4**	**57.7**	**65.2**	**0.8**
Auburndale	**74.4**	**67.7**	**75.2**	**0.8**	**64.4**	**57.7**	**65.2**	**0.8**

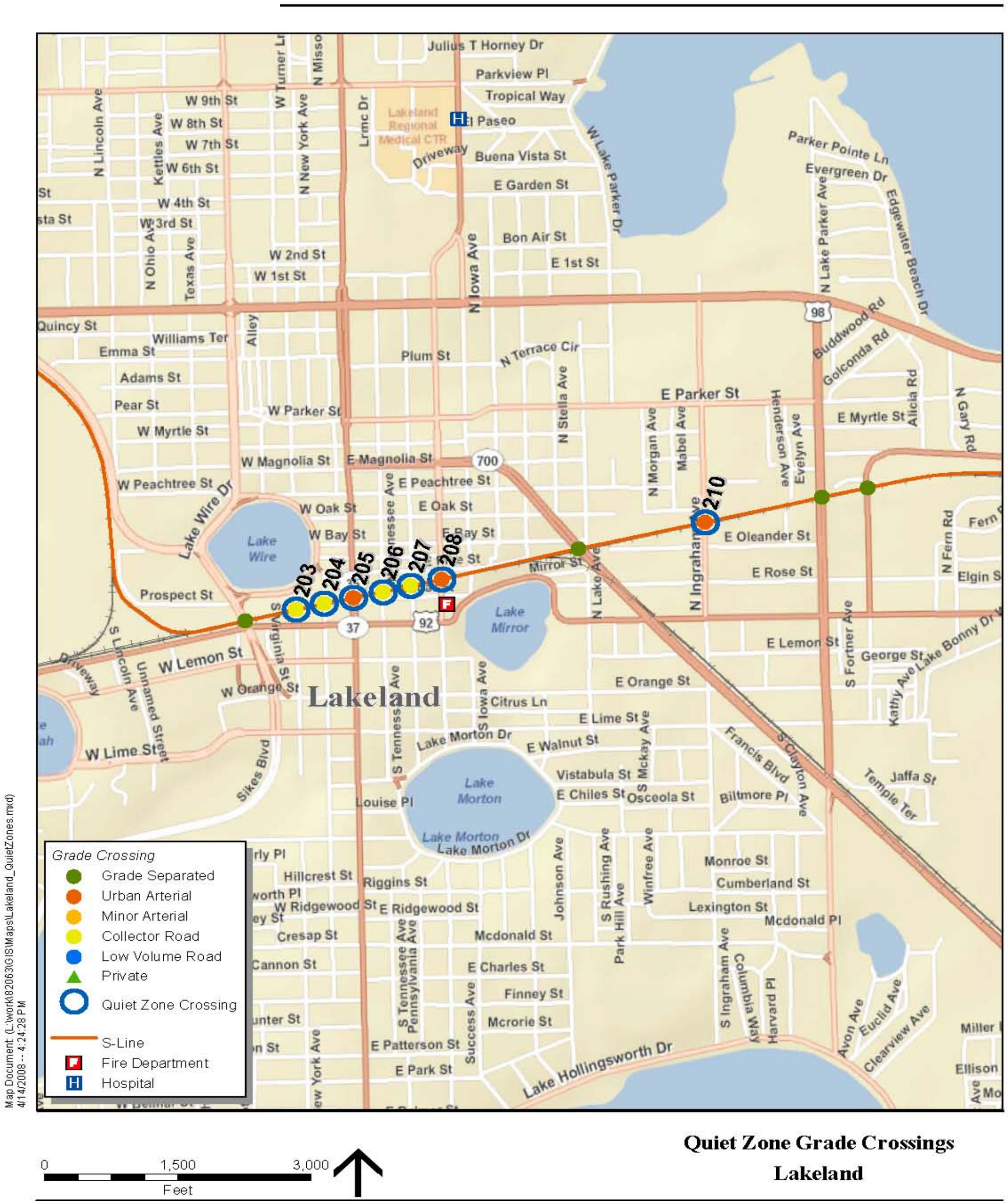


Figure 2-4 Proposed Lakeland Quiet Zones

3 Vibration

This section introduces some basic ground-borne vibration and ground-borne noise concepts including the prediction methodologies and modeling assumptions, the results of the existing source vibration measurement program, and the evaluation of impacts along the S-Line.

3.1 Human Perception of Vibration

The characteristics and properties used to describe ground-borne vibration and noise are explained in the following subsections.

3.1.1 Describing Vibration

Ground-borne vibration associated with vehicle movements is usually the result of uneven interactions between the wheel and the road or rail surfaces. Examples of such interactions (and subsequent vibrations) include train wheels over a jointed rail, an untrue railcar wheel with “flats”, and motor vehicle wheels hitting a pothole or even a manhole cover.

Unlike noise, which travels in air, transit vibration typically travels along the surface of the ground. Depending on the geological properties of the surrounding ground and the type of building structure exposed to transit vibration, vibration propagation may be more or less efficient. Buildings with a solid foundation set in bedrock are “coupled” more efficiently to the surrounding ground and experience relatively higher vibration levels than those buildings located in sandier soil.

Similarly, ground-borne noise results from vibrating room surfaces located near a heavily traveled transit corridor, such as a subway line. Consequently, annoyance resulting from the “rumbling” sound of ground-borne noise is only evaluated indoors and is described using the A-weighted decibel.

3.1.2 Description of Vibration Levels

Vibration induced by vehicle passbys can generally be discussed in terms of displacement, velocity, or acceleration. However, human responses and responses by monitoring instruments and other objects are more accurately described with velocity. Therefore, the vibration velocity level is used to assess vibration impacts.

To describe the human response to vibration, the average vibration amplitude called the root mean square (RMS) amplitude, is used to assess impacts. The RMS velocity is expressed in inches per second (ips) or decibels (VdB). All VdB vibration levels are referenced to 1 µips.

To evaluate the potential for damage to buildings, the peak particle velocity (PPV) is also used to characterize the vibration. Typically expressed in units of ips, PPV represents the maximum instantaneous vibration velocity observed during an event. Typical ground-borne vibration levels from transit and other common sources are shown in Figure 3-1.

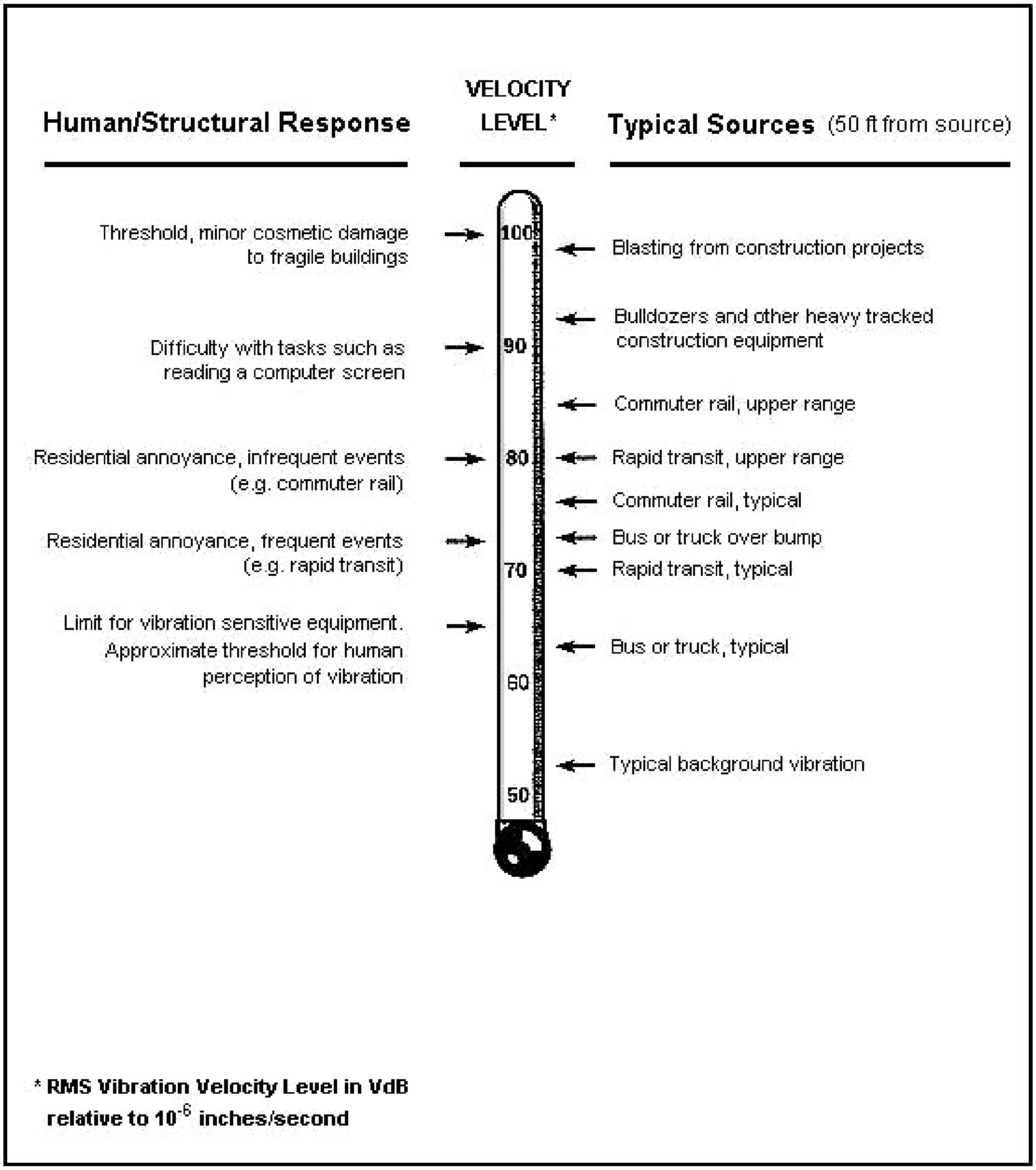


Figure 3-1 Typical Ground-Borne Vibration Levels

3.2 Evaluation Cirteria

As described in the following subsections, the FTA criteria will be used to assess annoyance due to vibration and ground borne noise from single event freight operations.

3.2.1 Federal Criteria

The FTA vibration criteria for evaluating ground borne vibration (and noise) impacts from train passbys at nearby sensitive receptors are shown in Table 3-1 These vibration criteria are related to ground borne vibration levels that are expected to result in human annoyance, and are based on RMS velocity levels expressed in VdB. The FTA's experience with community response to ground borne vibration indicates that when there are only a few train events per day, it would take higher vibration levels to evoke the same community response that would be expected from more frequent events. This is taken into account in the FTA criteria by distinguishing between projects with frequent, occasional, and infrequent events. Frequent events are defined as more than 70 train vibration events per day. Occasional events is defined as between 30 and 70 train vibration events per day, and Infrequent events is defined as fewer than 30 train events per day. The vibration criteria levels shown in Table 3-1 are defined in terms of human annoyance for different land use categories such as high sensitivity (Category 1), residential (Category 2), and institutional (Category 3). In general, the vibration threshold of human perceptibility is roughly 65 VdB.

The vibration levels shown in Table 3-1 are well below the damage criteria levels of approximately 95 to 100 VdB. It is extremely rare for vibration from train operations to cause any sort of building damage, including minor cosmetic damage.

Table 3-1 FTA Ground-Borne Vibration Impact Criteria for Annoyance (VdB)

CATEGORY	*DESCRIPTION*	*FREQUENT EVENTS*	*OCCASIONAL EVENTS*	*INFREQUENT EVENTS*	*FREQUENT EVENTS*	*OCCASTIONAL EVENTS*	*INFREQUENT EVENTS*
1	**Buildings where low vibration is essential for interior operations**	**65**	**65**	**65**	**N/A**	**N/A**	**N/A**
2	**Residences and buildings where people normally sleep**	**72**	**75**	**80**	**35**	**38**	**43**
3	**Daytime Institutional and office use**	**75**	**78**	**83**	**40**	**43**	**48**
Specific Buildings	**TV/Recording Studios/Concert Halls**	**65**	**65**	**65**	**25**	**25**	**25**
	Auditoriums	**72**	**80**	**80**	**30**	**38**	**38**
	Theaters	**72**	**80**	**80**	**35**	**43**	**43**

Note: N/A = not applicable. Vibration-sensitive equipment is not affected by ground-borne noise.
Source: *Transit Noise and Vibration Assessment*, Federal Transit Administration, Washington, D.C., May 2006.

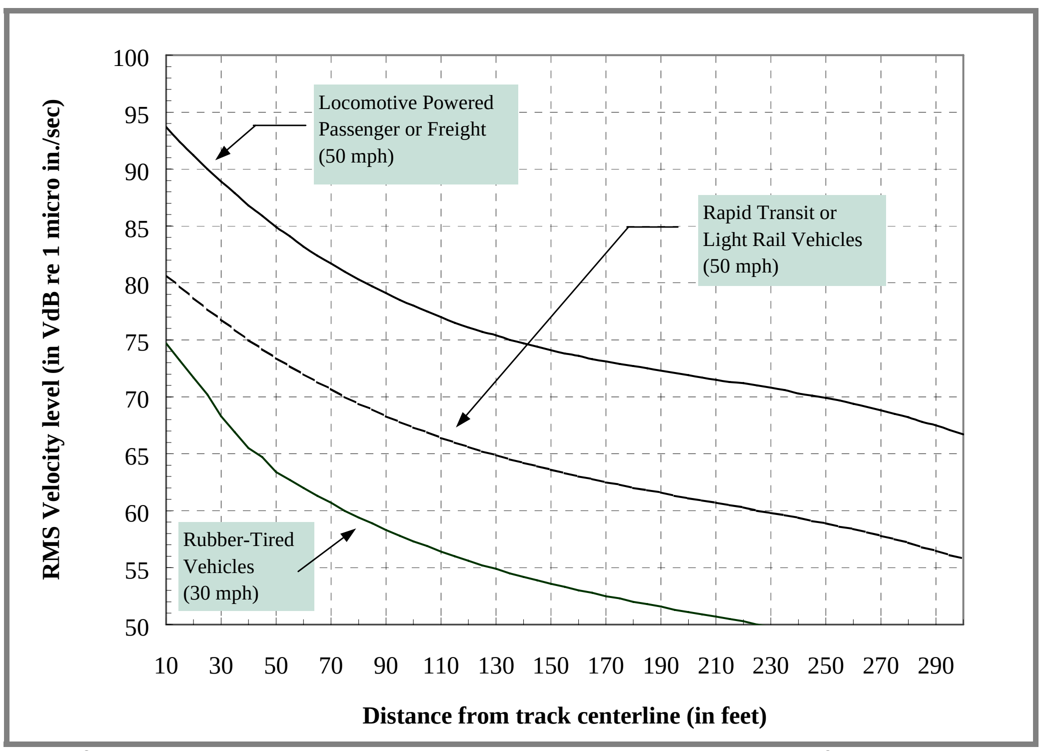
While vibration criteria are generally used to assess annoyance from transit sources at the exterior facade of receptors, ground borne noise, or the rumbling sound due to vibrating room surfaces, is typically assessed indoors. In general, the relationship between vibration and ground borne noise depends on the dominant frequency of the vibration and the acoustical absorption characteristics of the receiving room. Typical soil conditions were assumed everywhere along the corridor for computing ground-borne noise.

3.3 Modeling Methodology and Assumptions

A description of the modeling methodologies and the types of vibration sources included in the modeling prediction are described in the following sub-sections.

3.3.1 Modeling Methodology

Vibration levels from S-Line freight rail passbys at sensitive receptors along the project corridor were determined using the FTA guidelines. A vibration measurement program was conducted to better determine the extent of ground-borne vibration levels from existing freight rail operations. The results of the measurement program are discussed in Section 3.5. The reference vibration levels from freight rail passbys at 50 mph as suggested by FTA are shown in Figure 3-2.



Source: *Transit Noise and Vibration Assessment,* Federal Transit Administration, Washington, D.C., May, 2006.

Figure 3-2 FTA Generalized Ground Surface Vibration Curves

3.4 Existing Conditions

The scope and results of the vibration-monitoring program are described in the following section.

3.4.1 Transit Source Levels

Vibration measurements were conducted at 4 of the 12 noise measurement locations. The results of the vibration measurements are summarized in Table 3-2. The measured levels range from 80 to 92 VdB. The variation in the measured levels is a function of distance, speed, weight and other factors. For instance, the condition of the wheels on the locomotives and the rolling stock can have a large effect on the vibration levels, which may account for differences in level that would not be expected based on distance and speed alone.

Table 3-2 Summary of Vibration Measurement Results

NUMBER	DESCRIPTION	TOWN	FTA CATEGORY	MEASURED VIBRATION LEVEL (VdB)
1	14639 US 98 Bypass	Dade City	2	91.1
2	Munn Park	Lakeland	3	83.1
3	Lake Weir & SE 38th	Ocala	2	88.6
4	NE 42 and CR 106	Oxford	2	90.1

3.5 Vibration Assessment

Vibration impacts from rail freight operations were evaluated at discrete receptors using the FTA criteria based on the maximum vibration levels from single-event passbys. Unlike the cumulative noise criteria, vibration criteria are evaluated based on single-event passbys.

The FTA has revised their impact assessment criteria for rail corridors with existing train operations. For heavily used rail corridors (more than 12 trains per day), where existing vibration levels already exceed the FTA criteria (as shown in Table 3-1), and there is not a significant increase in rail operations (a doubling of trains per day), then only when the project vibration levels are 3 VdB or more higher than the existing vibration levels would an impact condition occur. Since the vibration levels from the additional shifted A-Line freight rail operations are the same as that from the existing freight rail operations on the S-Line, there would be no change (or increase) in the freight rail vibration levels. Therefore, by the FTA's definition, there would be no vibration impact from the additional freight rail operations on the S-Line. Although there will be more freight rail operations per day, the vibration levels from a freight train passby would be similar to those already experienced along the S-Line.