Tampa Streetcar Extension

NOISE & VIBRATION TECHNICAL STUDY REPORT

Proposed Tampa Streetcar Extension

Along Florida Avenue, Palm Avenue, and Tampa Street

July 2019

Prepared For:

Prepared By:

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1.0 Project Overview

The City of Tampa proposes to construct a 1.3-mile-long extension of the Tampa Historic Streetcar (THS) system as well as modernize the existing 2.7-miles of track to accommodate larger, modern streetcar vehicles. The current streetcar system was completed in December 2010 and connects downtown Tampa with the Ybor City district.

The proposed streetcar extension will begin at the intersection of Franklin Street and Brorein Street and extend eastbound on Brorein Street to Florida Avenue. The track will then turn northbound on Florida Avenue and extend to Palm Avenue. At Palm Avenue, the track will traverse in a westbound direction, intersect with Tampa Street, and then turn southbound. The track continues southbound on Tampa Street to Whiting Street where it turns east, connecting to the existing station at Franklin Street. The noise and vibration assessment presented in this report summarizes the existing conditions along the proposed THS system extension and modernization as well as anticipated future noise and vibration levels.

2.0 Procedure

The information contained in this noise and vibration assessment is based on the guidelines outlined in the Federal Transit Administration's (FTA) *Transit Noise and Vibration Impact Assessment Manual* (September 2018). This document provides information on transit noise and vibration, establishes FTA's transit noise and vibration impact threshold criteria, and provides methodologies for assessing noise and vibration impacts as well as how to mitigate them. The future noise and vibration levels determined during this analysis were compared to the impact threshold criteria in order to identify potential impacts. If impacts were predicted, potential mitigation measures were assessed.

3.0 Characteristics of Noise

Noise is generally defined as unwanted sound and is emitted from many natural and man-made sources. Transit noise is usually a composite of noises from vehicle propulsion units and the interaction of wheels/tires with their running surfaces.

The magnitude of noise is typically described by a ratio of its sound pressure to a reference sound pressure, which is usually 20 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 are between the threshold of hearing at 0 decibels and the threshold of pain at 140 dB.

Sound frequencies are reported 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 10 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 and 6,000 Hz.

Although people are generally not as sensitive to lower-frequency sounds as they are to higher frequencies, most people lose the ability to hear high-frequency sounds as they age. To accommodate varying receptor sensitivities, frequency sound levels are commonly adjusted, or ‘filtered,’ before being logarithmically added and reported as a single ‘sound level’ magnitude of that filtering scale. The ‘A-weighted’ decibel (dBA) 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.

Several examples of noise levels expressed in dBA are listed in **Table 1**. As shown in **Table 1**, most individuals are exposed to fairly 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 3-decibel change in the noise level; however, variations of 3-dBA or less are commonly considered “barely perceptible” to normal human hearing. A 5-dBA change is more readily noticeable. By definition, a ten-fold increase in the sound pressure level correlates to a 10-dBA noise level increase; however, it is judged by most people 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 the disturbing noise is heard

In considering the first of these factors, it is important to note that individuals have varying sensitivity to noise. Loud noises bother some people more than other people, and some individuals become increasingly upset if an unwanted noise persists. The time patterns 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 to be 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 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-dBA 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 and has been theorized to pose health risks.

Table 1. Common Indoor and Outdoor Noise Levels

Common Outdoor Noise Levels	Noise Level (dBA)	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).

The Hourly Equivalent Sound Level ($L_{eq(h)}$) and Day-Night Average Sound Level (L_{dn}) are the single-number descriptors used for transit-noise measurements, computations, and assessment. The $L_{eq(h)}$ is an hourly measure that accounts for the moment-to-moment fluctuations in A-weighted sound levels due to all sound sources during a cumulative one-hour exposure. The L_{dn} is a 24-hour measure that accounts for the moment-to-moment fluctuations in A-weighted sound levels due to all sound sources during a cumulative 24-hour exposure. An additional 10 dBA are added to the noise levels during the nighttime hours (10 PM to 7 AM) to account for humans' greater nighttime sensitivity to noise. All noise levels in this assessment are reported in A-weighted sound levels.

4.0 Existing Noise Environment

Existing noise exposure along the proposed Tampa Streetcar Extension varies from the southern portion of the project area in downtown Tampa to the northern portion of the project area north of I-275. Traffic noise from I-275 and the Selmon Expressway are the dominant noise sources for receptors adjacent or in close proximity to the study area. Additional sources of noise within the project area include all nearby roads intersecting the project corridor including Brorein Street, Florida Avenue, Palm Avenue, Tampa Street, Whiting Street, and Franklin Street as well as multiple cross streets.

To assess existing noise conditions within the project study area, long-term noise measurements were collected for 24-hour durations from June 25, 2019 to June 26, 2019. Two Larson Davis LxT and two Norsonic 140 Type I Precision Integrating Sound Level Meters were set up at four noise monitoring sites along the project corridor. The measurements were taken using the A-weighted scale and are reported in decibels (dBA). Data collected by the noise meters included time, average noise level (L_{eq}), maximum noise level (L_{max}), and instantaneous peak noise level (L_{pk}) for each interval. Hourly average noise levels ($L_{eq(h)}$) were derived from the L_{eq} values. The existing noise measurements were collected under meteorologically acceptable conditions and were conducted based on the acceptable collection of existing noise level readings. Long-term noise measurement hourly L_{eq} values obtained in the field ranged between 66 dBA and 69 dBA. The location of each monitoring site as well as the long-term noise field data is shown in **Table 2**. A map showing the monitoring site locations is included as an additional figure.

Table 2. Long-term Noise Measurement Data

Setup	Location Description	Measurement Time	Leq Noise Level (dBA)	Ldn Noise Level* (dBA)
LT 1	~25 ft west of Tampa Street and ~130 feet north of Tyler Street	7:21 AM (6/25) – 7:20 AM (6/26)	66.2	70.3
LT 2	~15 ft west of Florida Avenue and ~15 feet north of Palm Avenue	7:42 AM (6/25) – 7:41 AM (6/26)	69.0	71.3
LT 3	~15 ft west of Florida Avenue and ~30 feet north of Brorein Street	8:21 AM (6/25) – 8:20 AM (6/26)	69.2	74.1
LT 4	~15 ft east of Florida Avenue and ~20 feet south of Twiggs Street	8:40 AM (6/25) – 8:39 AM (6/26)	69.1	74.0
**An additional 10 decibels were added to the noise levels during the nighttime hours (10 PM to 7 AM)*				

5.0 Noise Impact Criteria for Transit Projects

The FTA noise impact criteria were developed specifically for transit noise sources operating on fixed-guideways or at fixed facilities in urban areas. These criteria are based on well-documented research on human response to community noise and represent a reasonable balance between community benefit and project costs.

The criteria shown in **Figure 1** are based on a comparison of the existing outdoor noise levels and the future outdoor noise levels from a proposed project. They incorporate both absolute criteria, which consider activity interference caused by the transit project alone, and relative criteria, which consider annoyance due to the change in the noise environment caused by the transit project.

The criteria also consider land use, which is an important factor that reflects noise sensitivity based on activity and time period of concern. The criteria are defined with the expectation that some land uses are already exposed to high levels of noise and can only tolerate a small increase in noise levels. On the other hand, if the existing noise levels are low, it is reasonable to allow a greater change in the surrounding noise levels. The noise criteria and descriptors based on land use are defined in **Table 3**.

Figure 1. Noise Impact Criteria for Transit Projects

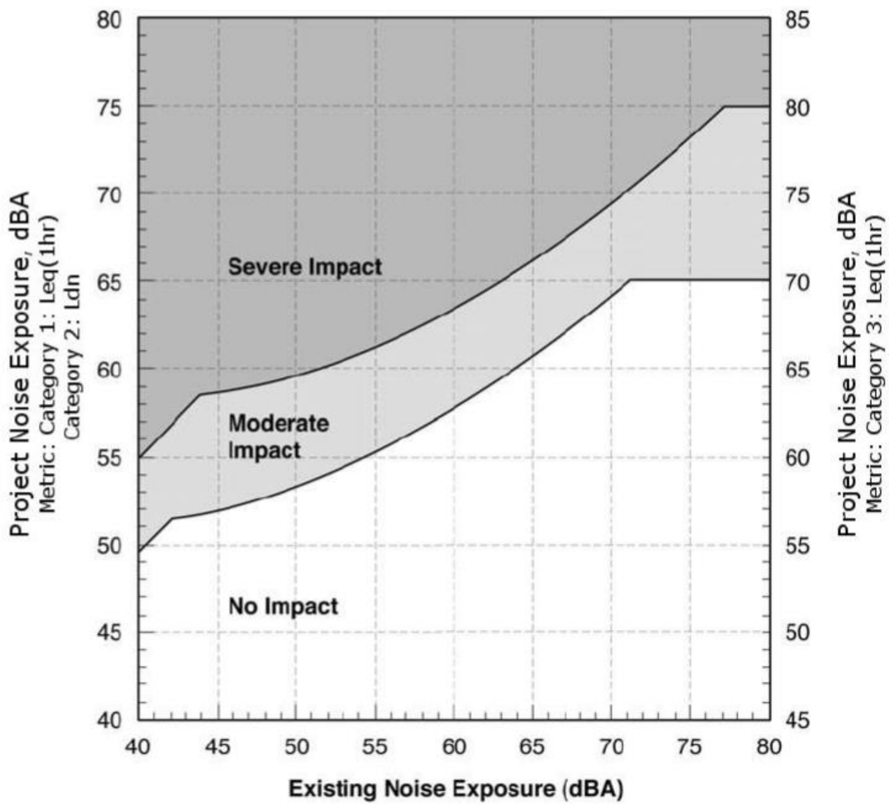


Table 3. Land Use Categories and Metrics for Transit Noise Impact Criteria

Land Use Category	Land Use Type	Noise Metric dBA	Description of Land Use Category
1	High Sensitivity	Outdoor L_{eq}(h)*	Land where quiet is an essential element of its intended purpose. Example land uses include preserved land for serenity and quiet, outdoor amphitheaters and concert pavilions, and national historic landmarks with considerable outdoor use. Recording studios and concert halls are also included in this category.
2	Residential	Outdoor L_{dn}	This category is applicable all residential land use and buildings where people normally sleep, such as hotels and hospitals.
3	Institutional	Outdoor L_{eq}(h)*	This category is applicable to institutional land uses with primarily daytime and evening use. Example land uses include schools, libraries, theaters, and churches where it is important to avoid interference with such activities as speech, meditation, and concentration on reading material. Places for meditation or study associated with cemeteries, monuments, museums, campgrounds, and recreational facilities are also included in this category.

* L_{eq} for the noisiest hour of transit-related activity during hours of noise sensitivity.

6.0 Noise Impact Assessment

Land uses along the proposed Tampa Streetcar Extension are comprised of a mix of commercial, retail, office, institutional, residential, medical, and recreational land uses. According to the land use categories outlined in **Table 3**, no Category 1 land uses exist along the proposed Tampa Streetcar Extension, and the primary land uses of interest are classified as a Category 2 or Category 3 land use. Noise mitigation measures are to be considered when moderate impacts or severe impacts are predicted.

Operations along the proposed Tampa Streetcar Extension may emit noise from the following sources:

- Rolling noise from the interaction of wheels/tires with their running surfaces.
  - This is a function of the speed at which the transit vehicle operates and the condition of the running surface (rail) and the wheels/tires.
- Impact noise from wheels/tires at turnouts.
- Noise from the interaction of wheels/tires in tight radius curves (i.e., wheel squeal).
  - This was not modeled in this assessment since it is variable. Transit vehicles can be equipped with a friction modifier dispenser, which reduces the potential for wheel squeal when applied to the wheel-rail contact area.
- Noise from auxiliary equipment, such as ventilation units and electric drive motors.
- Noise from warning devices, such as bells and horns.
  - It is not anticipated that warning devices will be an issue for this project since the streetcars will operate within the right-of-way with local traffic. Warning devices will only be sounded if the operator feels that it is necessary to avoid a dangerous situation.
- Noise from traction power substations.
  - Transformers located within each substation emit a low-frequency hum, and the HVAC systems used to heat and cool the building emit noise like a residential air conditioner.

Anticipated L_{eq} and L_{dn} noise levels were calculated using equations provided in the FTA Noise and Vibration Manual as well as the Noise Impact Assessment Spreadsheet created by FTA. The calculated L_{eq} and L_{dn} noise levels are a function of: 1) the noise source (i.e., the streetcar), 2) the speed at which the streetcar operates, and 3) the distance from the track to the noise-sensitive receiver. It was assumed that the proposed Tampa Streetcar Extension would have single streetcar vehicles operating at a maximum speed of 25 mph with 15-minute headways during the daytime and 30-minute headways during the nighttime. Given the urban nature of the corridor, it is anticipated that the streetcars will operate at lower speeds than what was used for impact calculations.

Based on the collected noise data, the existing L_{dn} noise level in the vicinity of the project corridor ranges between 70 dBA and 74 dBA, and the existing $L_{eq(h)}$ noise level in the vicinity of the project corridor ranges between 66 dBA and 69 dBA. The operations associated with the streetcar along the proposed extension are anticipated to create L_{dn} noise levels that range between 43 and 58 dBA as well as $L_{eq(h)}$ noise levels that range between 36 and 54 dBA. The combined L_{dn} noise levels are anticipated to remain near the existing L_{dn} noise level of 74 dBA. Increases in the L_{dn} and $L_{eq(h)}$ noise levels in the vicinity of the project corridor are not anticipated. Therefore, the noise sensitive land uses in the immediate vicinity of the proposed streetcar track are not anticipated to experience noise levels resulting in a moderate impact from the operations of the streetcar system. Based on the corresponding land use category, the resulting L_{eq} and L_{dn} noise levels along the project corridor are shown in **Appendix A**.

It should be noted that the proposed modernizations along the existing streetcar track are being completed in the same locations as the existing track or stations; therefore, changes in noise levels are not expected to occur.

7.0 Vibration Impact Assessment

Ground-borne vibration can be a concern for noise-sensitive land uses in the vicinity of a transit system route. Vibrations generated from wheel/rail interaction may cause nearby buildings to shake, the rattling of windows, shaking of items on shelves or hanging on walls, and rumbling sounds.

Vibrations travel from the source and excites the adjacent ground, which creates vibration waves that propagate through soil layers and rock strata to the foundations of nearby buildings. The vibration then propagates from the foundation throughout the remainder of the building structure. The vibration of the building structure and room surfaces can radiate a low-frequency rumble called ground-borne noise. Land use categories sensitive to vibrations are listed in **Table 4**.

Table 4. Land Use Categories for General Vibration Assessment Impact Criteria

Land Use Category	Land Use Type	Description of Land Use Category
-	Special Buildings	This category includes special-use facilities that are very sensitive to vibration and noise that are not included in the categories below and require special consideration. However, if the building will rarely be occupied when the source of the vibration (e.g., the train) is operating, there is no need to evaluate for impact. Examples of these facilities include concert halls, TV and recording studios, and theaters.
1	High Sensitivity	This category includes buildings where vibration levels, including those below the threshold of human annoyance, would interfere with operations within the building. Examples include buildings where vibration-sensitive research and manufacturing* is conducted, hospitals with vibration-sensitive equipment, and universities conducting physical research operations. The building's degree of sensitivity to vibration is dependent on the specific equipment that will be affected by the vibration. Equipment moderately sensitive to vibration, such as high resolution lithographic equipment, optical microscopes, and electron microscopes with vibration isolation systems are included in this category.** For equipment that is more sensitive, a Detailed Vibration Analysis must be conducted.
2	Residential	This category includes all residential land use and buildings where people normally sleep, such as hotels and hospitals. Transit-generated ground-borne vibration and noise from subways or surface running trains are considered to have a similar effect on receivers.***
3	Institutional	This category includes institutions and offices that have vibration-sensitive equipment and have the potential for activity interference such as schools, churches, doctors' offices. Commercial or industrial locations including office buildings are not included in this category unless there is vibration-sensitive activity or equipment within the building. As with noise, the use of the building determines the vibration sensitivity.

** Manufacturing of computer chips is an example of a vibration-sensitive process*

*** Standard optical microscopes can be impacted at vibration levels below the threshold of human annoyance*

**** Even in noisy urban areas, the bedrooms will often be in quiet buildings with effective noise insulation. However, ground-borne vibration and noise are experienced indoors, and building occupants have practically no means to reduce their exposure. Therefore, occupants in noisy urban areas are just as likely to be exposed to ground-borne vibration and noise as those in quiet suburban areas.*

No special building or high sensitivity land uses are located along the proposed Tampa Streetcar Extension. The primary land uses of interest are classified as a land use Categories 2 or 3.

Vibration can be described in terms of the displacement, velocity, or acceleration. Displacement is simply the distance that a point moves away from its static position. The velocity represents the instantaneous speed of movement, and acceleration is the rate of change of the speed. Peak velocity is appropriate for evaluating the potential of building damage; however, it is not suitable for evaluating human response. Since it takes some time for the human body to respond to vibration signals, an average vibration amplitude is used to assess transit vibration. The accepted reference quantity for vibration velocity is 1×10^{-6} inches/second, and the abbreviation "VdB" is used for vibration decibels to reduce the potential for confusion with sound decibels.

Ground-borne vibration is not something that most people experience on a daily basis. The typical vibration velocity level in residential areas is usually 50 VdB or lower, well below the threshold of perception for humans which is around 65 VdB. Although the perceptibility threshold is about 65 VdB, human response to vibration is not usually significant unless the vibration exceeds 70 VdB. Rapid transit or light rail systems typically generate vibration levels of 70 VdB or more near their tracks.

Ground-borne noise occurs when vibrations radiate through a building interior and create a low-frequency sound as a transit vehicle passes by. Ground-borne noise is typically characterized with the A-weighted sound level. Characterizing low-frequency noise using A-weighting can be challenging due to the non-linearity of human hearing, which causes sounds dominated by low-frequency components to seem louder than sounds consisting of many frequency components with no dominant frequencies (i.e., broadband sounds) that have the same A-weighted level. The result is that ground-borne noise with a level of 40 dBA sounds louder than a broadband noise level of 40 dBA. Because ground-borne noise sounds louder than broadband noise at the same noise level, the limits for ground-borne noise are lower than would be the case for broadband noise. The criteria for environmental impact from ground-borne vibration and noise are described in **Table 5**.

Table 5. Ground-Borne Vibration (GBV) and Ground-Borne Noise (GBN) Impact Criteria

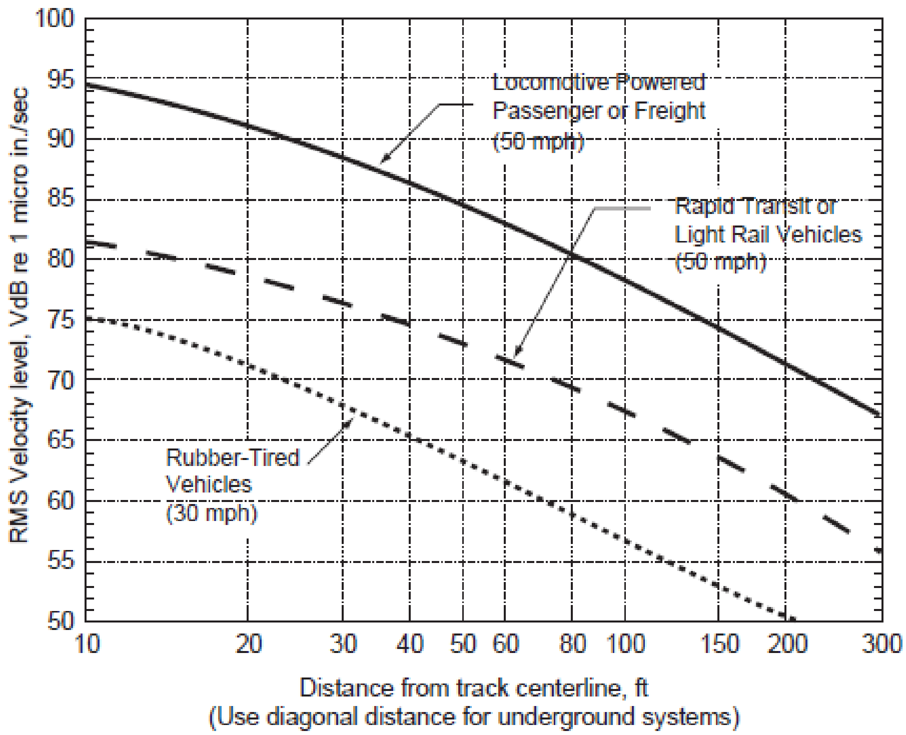
Land Use Category	GBV Impact Levels			GBN Impact Levels		
	Frequent Events[1]	Occasional Events[2]	Infrequent Events[3]	Frequent Events[1]	Occasional Events[2]	Infrequent Events[3]
Category 1: Buildings where vibration would interfere with interior operations.	65 VdB[4]	65 VdB[4]	65 VdB[4]	N/A[4]	N/A[4]	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 primarily 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 of the same source per day. Most rapid transit projects fall into this category.*
2. *"Occasional Events" is defined as between 30 and 70 vibration events of the same source per day. Most commuter trunk lines have this many operations.*
3. *"Infrequent Events" is defined as fewer than 30 vibration events of the same kind per day. This category includes most commuter rail branch lines.*
4. *This criterion limit is based on levels that are acceptable for most moderately sensitive equipment such as optical microscopes. Vibration-sensitive manufacturing or research will require detailed evaluation to define the acceptable vibration levels. Ensuring lower vibration levels in a building often requires special design of the HVAC systems and stiffened floors.*
5. *Vibration-sensitive equipment is generally not sensitive to ground-borne noise.*

The vibration impacts from light-rail transit and streetcar vehicle operations (Project Type 3) were predicted using the default FTA ground surface vibration curves shown in **Figure 2** as well as using equations provided in the FTA Noise and Vibration Manual.

As previously stated, it was assumed that the proposed Tampa Streetcar Extension would have single streetcar vehicles operating at a maximum speed of 25 mph. The generalized ground surface vibration equation (Eq. 6-2 in the FTA Noise and Vibration Manual) was used to calculate approximate VdB levels for land use categories listed in Table 4 based on their distance from the proposed tracks. The calculated VdB levels were adjusted based on the maximum anticipated travel speed using Eq. 6-4 in the FTA Noise and Vibration Manual. Additionally, all of the residential land uses along the project corridor were multi-story buildings with parking garages located at the ground level; therefore, floor-to-floor attenuation adjustments were applied.

Figure 2. Generalized Ground Surface Vibration Curves



Ground-borne vibration (GBV) levels along the project corridor are anticipated to range from 56 to 72 VdB for Land Use Category 2 properties, and GBV levels are anticipated to range from 52 to 74 VdB for Land Use Category 3 properties. The GBV levels are below the FTA Impact Criteria of 75 VdB and 78 VdB for Land Use Category 2 properties and Land Use Category 3 properties, respectively.

Ground-borne noise (GBN) levels along the project corridor are anticipated to range from 21 to 37 dBA for Land Use Category 2 properties, and GBN levels are anticipated to range from 17 to 39 dBA for Land Use Category 3 properties. None of these levels are expected to exceed the ground-borne noise criteria of 38 dBA and 43 dBA for Land Use Category 2 properties and Land Use Category 3 properties, respectively. The results of the vibration analysis are shown in **Appendix B**.

8.0 Mitigation Measures

Since the land uses adjacent to the proposed Tampa Streetcar Extension are not anticipated to experience noise or vibration levels resulting in an impact from the anticipated streetcar operations, noise and vibration mitigation measures were not included in this analysis. However, proper maintenance of wheels and rails will help reduce any potential future increases in noise and vibration levels during the life of the streetcar.

9.0 Construction Noise

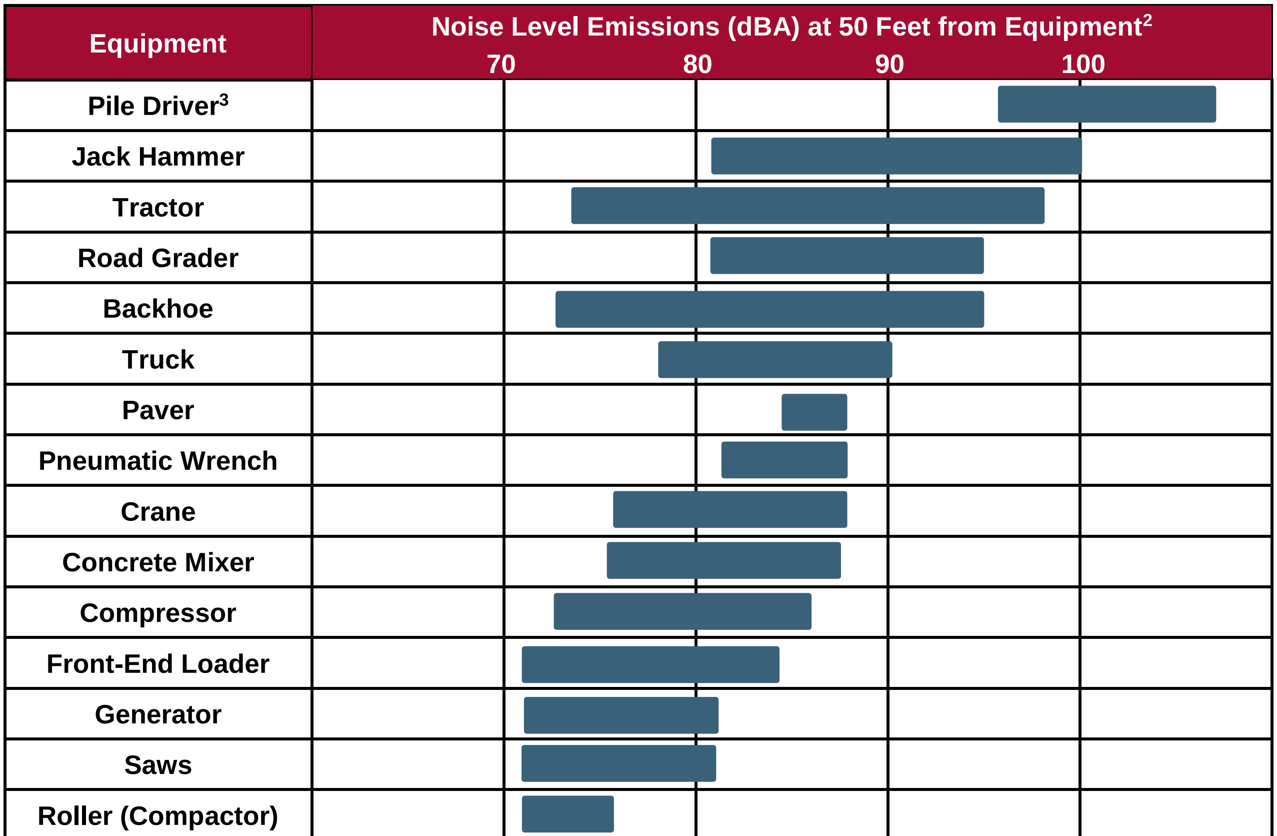
The predominant construction activities associated with this project are expected to be pavement removal, hauling, grading, and paving. Temporary and localized construction noise and vibration impacts may occur as a result of these activities. **Table 6** lists typical operating noise levels at a distance of 50 feet from various construction equipment.

During daytime hours, the potential effects of these impacts will be temporary speech interference for passers-by and those individuals living or working near the project. Loud construction noise activities, such as the usage of impact-hammers (jack hammer, hoe-ram), will provide sporadic and temporary construction noise and vibration impacts in the vicinity of those activities (refer to **Table 6**).

Construction noise from the proposed streetcar project along the corridor could impact noise and vibration sensitive receptors directly adjacent to these activities. It is anticipated that construction activities in any one area for extended periods will be limited; therefore, any such intrusive noise and/or vibration will be temporary and would not be considered an impact under FTA criteria.

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, elimination of “tail gate banging”, ambient-sensitive backup alarms, construction noise complaint mechanisms, as well as consistent and transparent community communication. Construction activities will comply with Chapter 5, Section 301 of the City of Tampa’s Code of Ordinances.

Table 6. 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 respective equipment. For "point sources" such as the construction equipment listed above, noise levels generally dissipate at a rate of -6 dBA for every doubling of distance. For example, if the noise level from a pile driver at a distance of 50 feet = 100 decibels (dBA), then at 400 feet, it will generally be 82 decibels (dBA) or less.*
3. *Due to project safety and potential construction noise concerns, pile driving activities are typically limited to daytime hours.*

10.0 Conclusion

The noise and vibration assessments for the proposed Tampa Streetcar Extension was conducted in accordance with the FTA *Transit Noise and Vibration Impact Assessment Manual* (September 2018). Land uses located along the project corridor are classified as either Category 2 or Category 3 land uses.

Streetcar operations are anticipated to create L_{dn} noise levels that range between 43 and 58 dBA as well as $L_{eq(h)}$ noise levels that range between 36 and 54 dBA. Increases in the L_{dn} and $L_{eq(h)}$ noise levels in the vicinity of the project corridor are not expected. Therefore, noise levels resulting in an impact from the operations of the streetcar system are not anticipated.

Ground-borne vibration (GBV) levels are anticipated to range from 56 to 72 VdB for Land Use Category 2 properties and from 52 to 74 VdB for Land Use Category 3 properties. Ground-borne noise (GBN) levels are anticipated to range from 21 to 37 dBA for Land Use Category 2 properties from 17 to 39 dBA for Land Use Category 3 properties. GBV and GBN levels are not anticipated to exceed the respective FTA Impact Criteria for the land uses along the proposed streetcar extension.

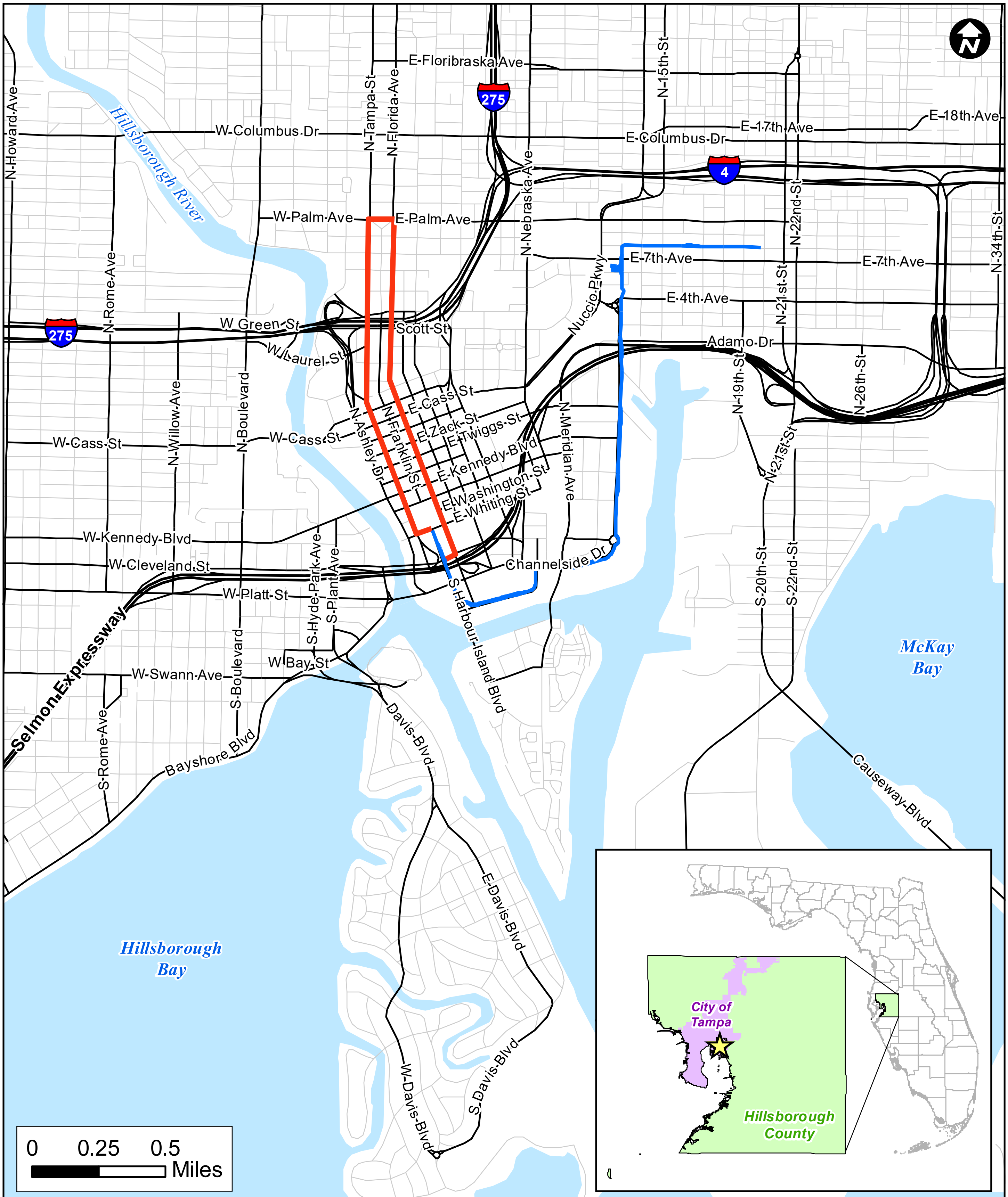
11.0 References

Federal Transit Administration. *Transit Noise and Vibration Impact Assessment Manual*. Prepared by John A. Volpe National Transportation Systems Center. FTA Report No. 0123. September 2018.

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

ADDITIONAL

FIGURES



Kimley»Horn

Proposed Extension

Existing Streetcar

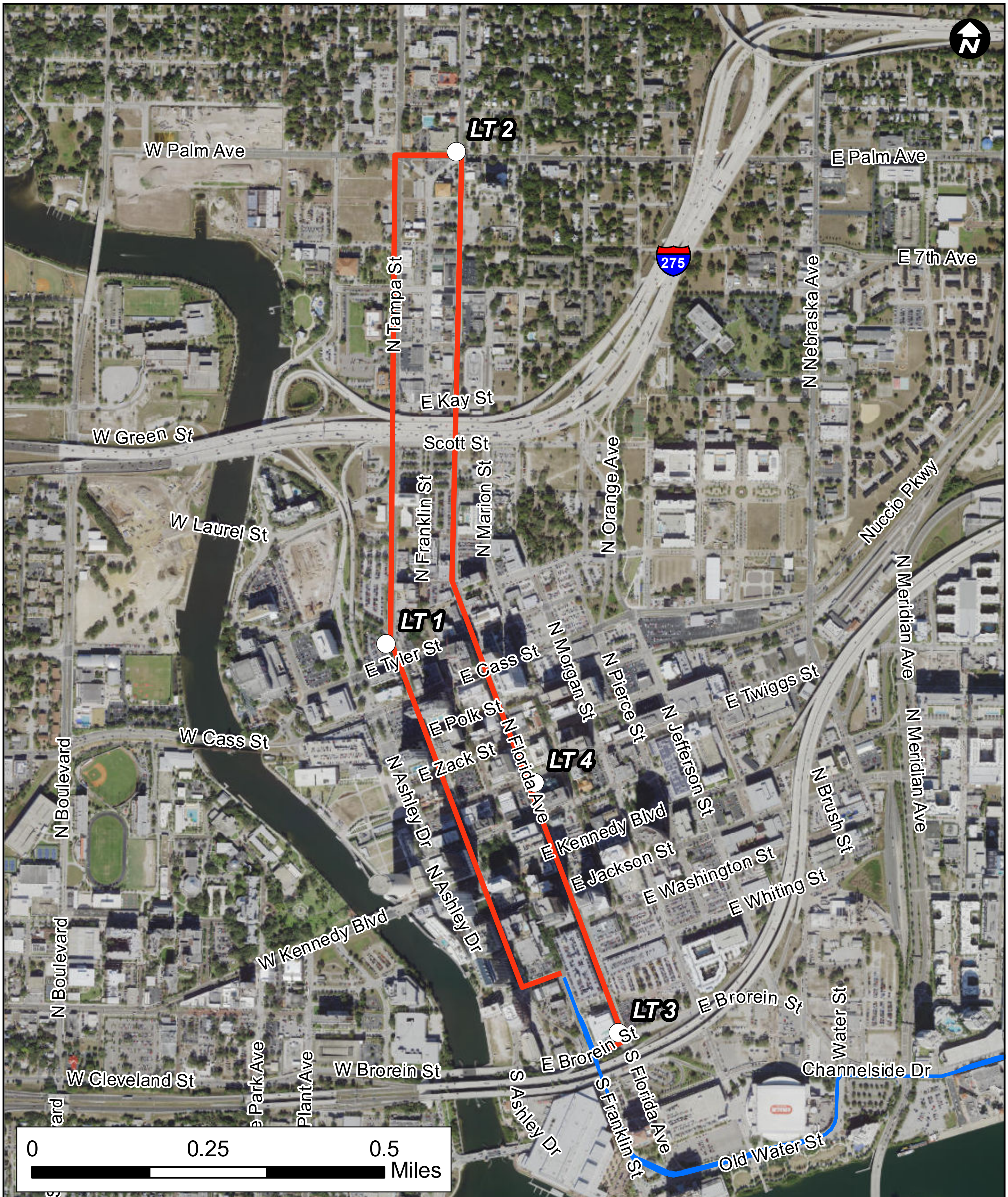
City of Tampa

Hillsborough County

Vicinity Map

Tampa Streetcar Extension

Tampa, Hillsborough County



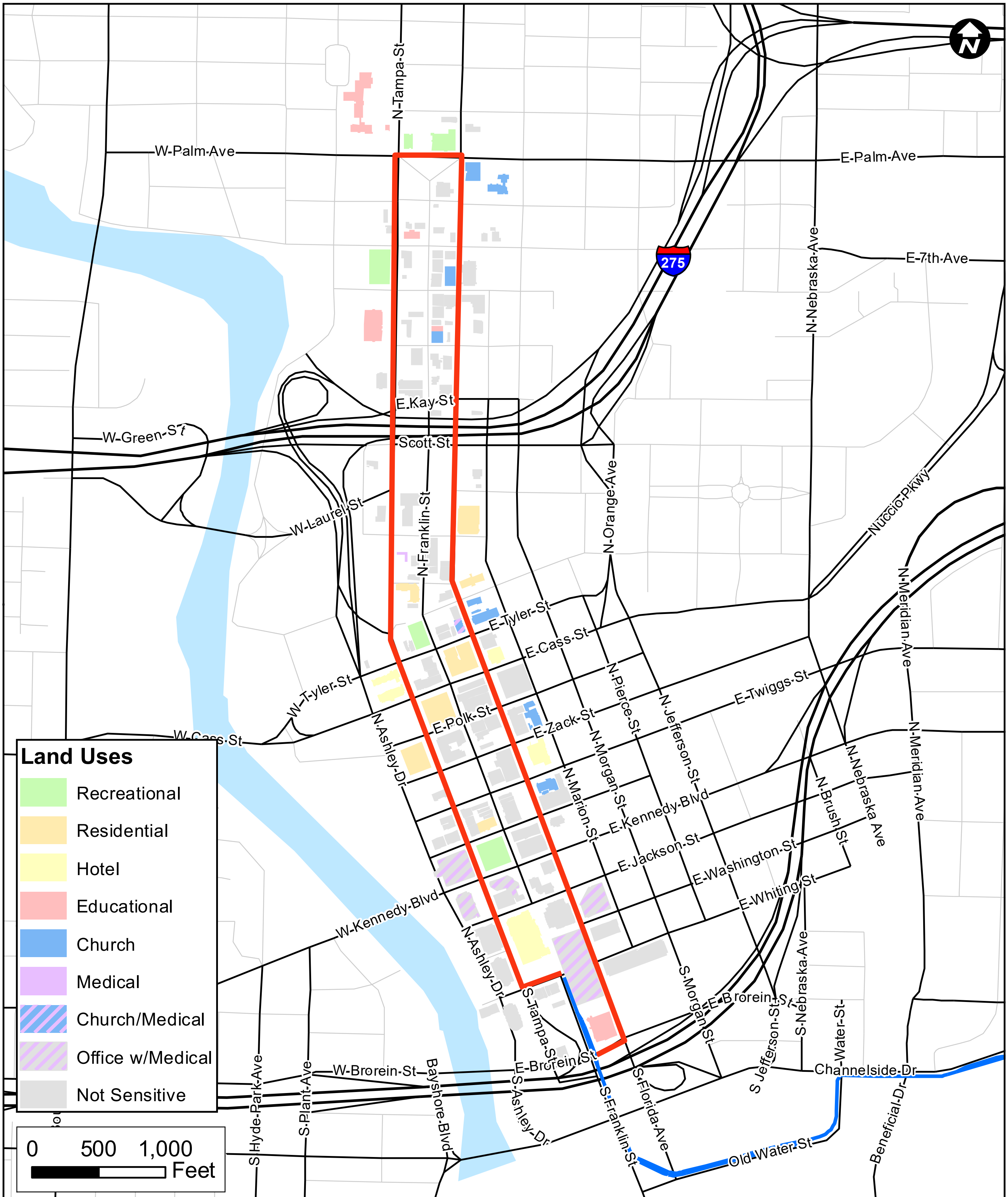
Noise Monitoring Site

Proposed Extension

Existing Streetcar

Kimley»Horn

Measurement Locations
Tampa Streetcar Extension
Tampa, Hillsborough County



Proposed Extension

Existing Streetcar

Surrounding Land Uses
Tampa Streetcar Extension
Tampa, Hillsborough County

Appendix A

Table A-1: Noise Impact Assessment (Land Use Category 2)

Area	Land Use	Land Use Category	Distance from Track (ft)	Existing Noise Level	FTA Moderate Impact Threshold	FTA Modeled Noise Level	Combined Noise Level	Noise Level Impact?
				Ldn (dBA)				
Florida Street	Hotel	2	55	74	70	50	74	No
Florida Street	Hotel	2	120	74	70	45	74	No
Florida Street	Residential	2	20	74	70	56	74	No
Florida Street	Residential	2	30	74	70	54	74	No
Franklin Street	Residential	2	20	74	70	56	74	No
Franklin Street	Residential	2	15	74	70	58	74	No
Madison Street	Residential	2	150	74	70	43	74	No
Tampa Street	Hotel	2	70	74	70	48	74	No
Tampa Street	Hotel	2	70	74	70	48	74	No
Tampa Street	Hotel	2	40	74	70	52	74	No
Tampa Street	Residential	2	15	74	70	58	74	No
Ashley Drive	Residential	2	15	74	70	58	74	No

Table A-2: Noise Impact Assessment (Land Use Category 3)

Area	Land Use	Land Use Category	Distance from Track (ft)	Existing Noise Level	FTA Moderate Impact Threshold	FTA Modeled Noise Level	Combined Noise Level	Noise Level Impact?
				Leq (dBA)				
Florida Street	Church	3	45	69	64	47	69	No
Florida Street	Church	3	85	69	64	43	69	No
Florida Street	Church	3	25	69	64	51	69	No
Florida Street	Church	3	65	69	64	45	69	No
Florida Street	Church	3	20	69	64	52	69	No
Florida Street	Institutional	3	15	69	64	54	69	No
Florida Street	Medical Office	3	20	69	64	52	69	No
Florida Street	Medical Office	3	30	69	64	50	69	No
Franklin Street	Church	3	150	69	64	39	69	No
Franklin Street	Institutional	3	125	69	64	40	69	No
Franklin Street	Medical Office	3	180	69	64	38	69	No
Franklin Street	Recreational	3	150	69	64	39	69	No
Marion Street	Church	3	135	69	64	40	69	No
Palm Street	Recreational	3	40	69	64	48	69	No
Tampa Street	Institutional	3	100	69	64	42	69	No
Tampa Street	Institutional	3	255	69	64	36	69	No
Tampa Street	Institutional	3	40	69	64	48	69	No
Tampa Street	Medical Office	3	25	69	64	51	69	No
Tampa Street	Medical Office	3	135	69	64	40	69	No
Tampa Street	Medical Office	3	20	69	64	52	69	No
Tampa Street	Medical Office	3	55	69	64	46	69	No
Tampa Street	Recreational	3	65	69	64	45	69	No
Tampa Street	Recreational	3	20	69	64	52	69	No

Appendix B

Table B-1: Noise Impact Assessment (Land Use Category 2)

Area	Land Use	Land Use Category	Distance from Track (ft)	Ground Bourne Vibration (VdB)			Ground Bourne Noise (dBA)		
				Impact Threshold	Modeled Level	Impact?	Impact Threshold	Modeled Level	Impact?
Florida Street	Hotel	2	55	75	66	No	38	31	No
Florida Street	Hotel	2	120	75	60	No	38	25	No
Florida Street	Residential	2	20	75	71	No	38	36	No
Florida Street	Residential	2	30	75	68	No	38	33	No
Franklin Street	Residential	2	20	75	71	No	38	36	No
Franklin Street	Residential	2	15	75	72	No	38	37	No
Madison Street	Residential	2	150	75	56	No	38	21	No
Tampa Street	Hotel	2	70	75	65	No	38	30	No
Tampa Street	Hotel	2	70	75	65	No	38	30	No
Tampa Street	Hotel	2	40	75	69	No	38	34	No
Tampa Street	Residential	2	15	75	72	No	38	37	No
Ashley Drive	Residential	2	15	75	72	No	38	37	No

Table B-2: Noise Impact Assessment (Land Use Category 3)

Area	Land Use	Land Use Category	Distance from Track (ft)	Ground Bourne Vibration (VdB)			Ground Bourne Noise (dBA)		
				Impact Threshold	Modeled Level	Impact?	Impact Threshold	Modeled Level	Impact?
Florida Street	Church	3	45	78	68	No	43	33	No
Florida Street	Church	3	85	78	63	No	43	28	No
Florida Street	Church	3	25	78	71	No	43	36	No
Florida Street	Church	3	65	78	65	No	43	30	No
Florida Street	Church	3	20	78	73	No	43	38	No
Florida Street	Institutional	3	15	78	74	No	43	39	No
Florida Street	Medical Office	3	20	78	73	No	43	38	No
Florida Street	Medical Office	3	30	78	70	No	43	35	No
Franklin Street	Church	3	150	78	58	No	43	23	No
Franklin Street	Institutional	3	125	78	59	No	43	24	No
Franklin Street	Medical Office	3	180	78	56	No	43	21	No
Franklin Street	Recreational	3	150	78	58	No	43	23	No
Marion Street	Church	3	135	78	59	No	43	24	No
Palm Street	Recreational	3	40	78	69	No	43	34	No
Tampa Street	Institutional	3	100	78	61	No	43	26	No
Tampa Street	Institutional	3	255	78	52	No	43	17	No
Tampa Street	Institutional	3	40	78	69	No	43	34	No
Tampa Street	Medical Office	3	25	78	71	No	43	36	No
Tampa Street	Medical Office	3	135	78	59	No	43	24	No
Tampa Street	Medical Office	3	20	78	73	No	43	38	No
Tampa Street	Medical Office	3	55	78	66	No	43	31	No
Tampa Street	Recreational	3	65	78	65	No	43	30	No
Tampa Street	Recreational	3	20	78	73	No	43	38	No