Appendix K
Noise and Vibration Supporting Documentation

SOUTHWEST
Green Line LRT Extension

Noise and Vibration Technical Report

May 2016
Southwest LRT Project Technical Report

METROPOLITAN COUNCIL

Executive Summary

This Noise and Vibration Technical Report has been prepared as a supplement to the Final EIS document, to provide additional information on the noise and vibration impact assessment for the Project. The technical report contains detailed information regarding the criteria, methodology, noise and vibration measurements, impact assessment results, and proposed mitigation measures. Additional information regarding the measurements and other technical data are found in the appendixes to this report.

The results of the noise and vibration assessment for the Project indicate that with the proposed mitigation measures, there will be no residual noise or vibration impacts from the Project. The majority of the noise impacts from the Project will be eliminated through the use of quiet zones or wayside bells. The vibration impacts from the Project are localized to two areas and can be mitigated through conventional mitigation measures. Section 1 of the report provides a summary of the impacts and mitigation measures for the Project.

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Acronyms and Abbreviations

ANSI	American National Standard Institute
ASTM	American Society for Testing and Materials
dB	decibels
dBA	A-weighted decibels
DOT	Department of Transportation
EIS	Environmental Impact Statement
FD	Force Density
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
GRHD	Grand Rounds Historic District
Hz	Hertz
KPRHD	Kenwood Parkway Residential Historic District
Ldn	Day-Night Sound Level
Leq	Equivalent sound level
LIRHD	Lake of the Isles Residential Historic District
LRT	Light Rail Transit
LSTM	Line Source Transfer Mobility
MnDOT	Minnesota Department of Transportation
MPCA	Minnesota Pollution Control Agency
mph	miles per hour
N/A	not applicable
NIST	National Institute of Standards and Technology
OMF	operations and maintenance facility
PEC	Preliminary Engineering Consultant
POS	period of significance
PPV	Peak Particle Velocity
SEL	sound exposure level
VdB	vibration decibels

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1 Introduction and Summary

Cross-Spectrum Acoustics Inc. conducted a noise and vibration impact assessment for the Southwest Light Rail Transit (LRT) Project. The assessment was carried out in support of the Final Environmental Impact Statement (Final EIS). The objective of the assessment was to document the noise and vibration impacts at sensitive locations and identify mitigation measures as a part of the Project.

This assessment addresses the following:

- Section 1 (Introduction and Summary) provides assessment results
- Section 2 (Regulatory Context) provides a discussion of the regulatory context, including noise and vibration basics and details regarding the noise and vibration criteria used to assess impact
- Section 3 (Impact Assessment Methodology) describes the methodology used to assess noise and vibration impact
- Section 4 (Affected Environment) discusses the existing conditions, including a description of the noise and vibration sensitive land uses and the measurements conducted to determine the existing noise and vibration conditions
- Section 5 (Environmental Consequences) includes the results of the noise and vibration impact assessment
- Section 6 (Mitigation Measures) discusses mitigation measures for the Southwest Light Rail Transit (LRT) Project (the Project)

The following list briefly describes the contents of the appendices to the assessment:

- Appendixes A and B contain detailed information on the existing noise and vibration measurements, respectively
- Appendix C contains information on the sound insulation testing conducted for the Project
- Appendix D contains pictures of the existing measurement locations
- Appendixes E and F show the location of noise and vibration impacts, respectively
- Appendix G contains the HDR memo regarding existing noise measurement data for the Draft EIS
- Appendix H is a memorandum summarizing freight vibration assessment for the Project
- Appendix I contains the noise and vibration fact sheets
- Appendixes J and K contain detailed noise and vibration impact assessment projections, respectively.

1.1 Noise

Prior to mitigation, there would have been 228 moderate and 590 severe noise impacts at residential locations along the Project. There would also be a noise impact at the Kenilworth Channel. The majority of the noise impacts would have been due to the sounding of LRT horns at at-grade crossings, primarily those shared with existing freight operations. The remaining noise impacts would have been due to a combination of LRT speed and proximity of sensitive receptors to the proposed alignment.

Mitigation measures, as detailed in Section 6, will eliminate noise impacts at locations throughout the Project corridor. The primary mitigation measure is the implementation of Quiet Zones at the shared at-grade crossings. This will eliminate the sounding of LRT horns and will have the benefit of eliminating the sounding of freight horns during normal operations as well. Other mitigation measures include a wayside bell at 21st Street, wayside noise barriers, and sound insulation improvements to buildings. Details regarding specific mitigation measures are contained in Section 6.

1.2 Vibration

There are no vibration impacts along the Project. Prior to mitigation, there would have been ground-borne noise impacts at 54 residential locations and at a business (Hearing Care Specialists) in Hopkins. The ground-borne noise impacts are due to the proximity of sensitive receptors to the proposed alignment and the high-frequency content of the vibration.

Mitigation measures, as detailed in Section 6, eliminate all ground-borne noise impacts at locations throughout the Project corridor. The mitigation measure is the use of highly resilient fasteners in the Kenilworth Tunnel. At the Hearing Care Specialists site, the mitigation measure is the replacement of the existing vibration isolation elements between the floor of the building and the sound booth. Details regarding specific mitigation measures are contained in Section 6.

2 Regulatory Context

2.1 Noise

2.1.1 Noise Overview

Sound is defined as small changes in air pressure above and below the standard atmospheric pressure and noise is usually considered to be unwanted sounds. The three parameters that define noise include:

- **Level**. The level of sound is the magnitude of air pressure change above and below atmospheric pressure, and is expressed in decibels (dB). Typical sounds fall within a range between 0 dB (the lower limits of human hearing) and 120 dB (the highest sound levels experienced in the environment). A 3 dB change in sound level is perceived as a barely noticeable change outdoors and a 10-dB change in sound level is perceived as a doubling (or halving) of the sound level.
- **Frequency**. The frequency (pitch or tone) of sound is the rate of air pressure changes and is expressed in cycles per second, or Hertz (Hz). Human ears can detect a wide range of frequencies from around 20 Hz to 20,000 Hz; however, human hearing is not effective at high and low frequencies, and A-weighting decibels (dBA) are used to correlate with human response to noise. The A-weighted sound level has been widely adopted by acousticians as the most appropriate descriptor for environmental noise.
- **Time Pattern**. Because environmental noise is constantly changing, it is common to condense all of this information into a single number, called the "equivalent" sound level (Leq). The Leq represents the changing sound level over a period of time, typically 1 hour or 24-hours in transit noise assessments. For LRT and freight rail projects, the Day-Night Sound Level (Ldn) is the common noise descriptor used, and has been adopted by most agencies as the best way to describe how people respond to noise in their environment. Ldn is a 24-hour cumulative A-weighted noise level that includes all noises that happen within a day, with a 10 dB penalty for nighttime noise (10 pm to 7 am). This nighttime penalty means that any noise events at night are equivalent to ten similar events during the day. Typical Ldn values for various transit and freight operations are shown on Exhibit 2.1-1.

2.1.2 Noise Impact Criteria

2.1.2.1 Federal Transit Administration Transit Noise Criteria

The noise impact criteria used for the Project are based on the information contained in Chapter 3 of the Federal Transit Administration (FTA) noise and vibration guidance manual[1]. The FTA noise impact criteria are based on well-documented research on community response to noise and are based on both the existing level of noise and the change in noise exposure due to a project. The FTA noise criteria compare the Project noise with the existing noise (not the No Build noise).

The FTA noise criteria are based on the land use category of the sensitive receptor, and use Ldn for locations where people sleep (Category 2) and Leq for locations with daytime and/or evening use (Category 1 or 3), as shown in Table 2.1-1.

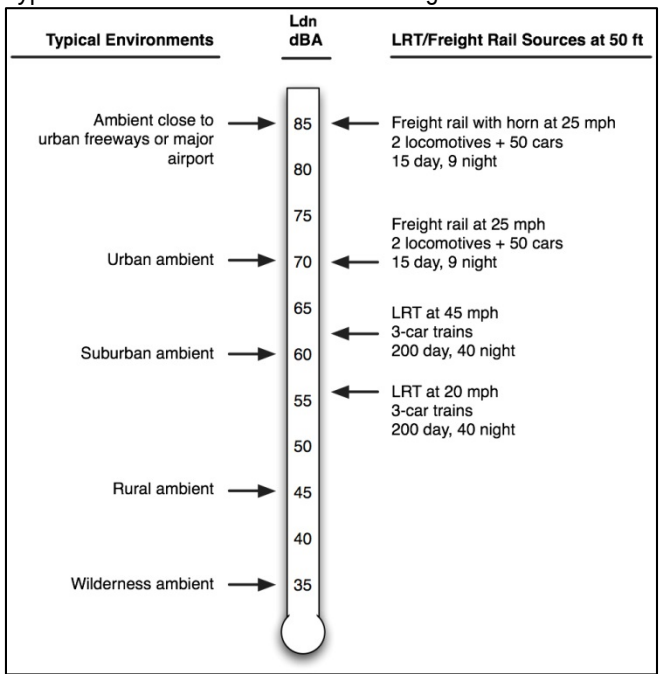
The noise impact criteria are defined by the two curves shown in Exhibit 2.1-2, which allow increasing project noise as existing noise levels increase, up to a point at which impact is determined based on project noise alone. The FTA noise impact criteria include three levels of impact, as shown on Exhibit 2.1-2. The three levels of impact include:

- **No Impact:** In this range, the Project is considered to have no impact since, on average; the introduction of the Project will result in an insignificant increase in the number of people highly annoyed by the new project noise.

[1] Federal Transit Administration, "Transit Noise and Vibration Impact Assessment." Report FTA-VA-90-1003-06, May 2006.

EXHIBIT 2.1-1

Typical Noise Levels from LRT and Freight Rail



Source: Cross-Spectrum Acoustics, 2015.

- **Moderate Impact:** At the moderate impact range, changes in the cumulative noise level are 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, such as the existing level, predicted level of increase over existing noise levels and the types and numbers of noise-sensitive land uses affected.
- **Severe Impact:** At the severe impact range, a significant percentage of people would be highly annoyed by the new project noise. Severe noise impacts are considered to be "significant" under the National Environmental Policy Act, and should be avoided if possible. Noise mitigation should be applied for severe impacts where feasible.

TABLE 2.1-1

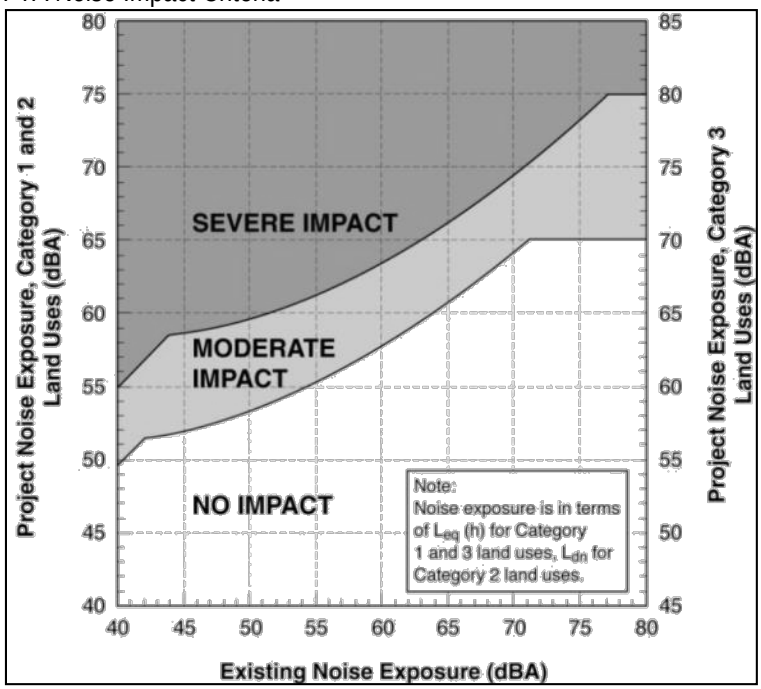
Land Use Categories and Metrics for Transit Noise Impact Criteria*

Land Use Category	Noise Metric (dBA)	Description of Land Use Category
1	Outdoor Leq(h)[a]	Tracts of land where quiet is an essential element in their intended purpose. This category includes lands set aside for serenity and quiet, and such land uses as outdoor amphitheaters and concert pavilions, as well as National Historic Landmarks with significant outdoor use. Also included are recording studios and concert halls.
2	Outdoor Ldn	Residences and buildings where people normally sleep. This category includes homes, hospitals, and hotels where a nighttime sensitivity to noise is assumed to be of utmost importance.
3	Outdoor Leq(h)*	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. Places for meditation or study associated with cemeteries, monuments, museums, campgrounds and recreational facilities can also be considered to be in this category. Certain historical sites and parks are also included.

[a] Leq for the noisiest hour of transit-related activity during hours of noise sensitivity.

Source: FTA, 2006.

EXHIBIT 2.1-2
FTA Noise Impact Criteria



For roadway improvements and changes to feeder bus routes, a screening procedure consistent with FTA methodology was conducted. This included identifying locations where changes to the traffic volumes, roadways, or bus routes were significant and identifying any potentially sensitive land uses near these areas. Except for locations with major park-and-ride facilities or transit centers, the Project noise levels are dominated by LRT operations.

2.1.2.2 Cultural Resources

Under FTA guidance, historic sites are designated as noise sensitive depending on the land use of the site, not their designation as historic. Sites of national significance with considerable outdoor use required for site interpretation would be in Category 1.[2] Historic sites that are currently used as residences would be in Category 2. Historic buildings with indoor use of an interpretive nature involving meditation and study would be in Category 3. These include museums, significant birthplaces and buildings in which significant historical events occurred.

Most downtown areas have buildings which are historically significant because they represent a particular architectural style or are prime examples of the work of a historically significant designer. If the buildings or structures are used for commercial or industrial purposes and are located in busy commercial areas, they are not considered noise sensitive and the impact criteria do not apply.

Similarly, historical transportation structures, such as terminals and railroad depots, are not considered noise sensitive land uses. These buildings or structures may however be afforded special protection under Section 4(f) of the Department of Transportation (DOT) Act and Section 106 of the National Historic Preservation Act.

In the Section 106 process protecting historic and cultural properties, noise may or may not be considered an "adverse effect" depending on the individual circumstances and whether or not the use is noise sensitive, because, as previously noted, historic and cultural properties are only noise sensitive based on how they are used. The regulatory processes stemming from these statutes require coordination and consultation with agencies and organizations having jurisdiction over these resources. Their views on the

[2] Transit Noise and Vibration Impact Assessment, Chapter 3 (FTA, 2006)

Project's impact on protected resources are given careful consideration by FTA and the Project sponsor, and their recommendations may influence the decision to adopt noise reduction measures.[3]

2.1.2.3 Minnesota Pollution Control Agency Noise Standards

The Minnesota Pollution Control Agency (MPCA) has an established set of Noise Standards (Minnesota Rules, Chapter 7030), which provide limits on environmental noise using the L10 and L50 descriptors, which represent the noise level exceeded 10 percent (6 minutes) and 50 percent (30 minutes) of the time during an hour, respectively. The standards include both daytime and nighttime limits for three different categories of land use or noise area classification, with residential lands included in noise area classification 1. Classifications 2 and 3 are generally for commercial and industrial land uses, respectively. The standards are shown in Table 2.1-2.

TABLE 2.1-2
MPCA Noise Standards

Noise Area Classification	Daytime		Nighttime	
	L10 (dBA)	L50 (dBA)	L10 (dBA)	L50 (dBA)
1	65	60	55	50
2	70	65	70	65
3	80	75	80	75

Because of the time limit component of the MPCA noise standards, the Project will not exceed the standards under the proposed operating conditions. Light rail vehicles will pass by a location for approximately 10 seconds 12 times an hour (based on the operating assumptions of 10-minute headways in each direction), for a total of 120 seconds, or two minutes. Because the duration of exposure to LRT noise does not exceed the L10 (six minutes) and L50 (30 minutes) time components, there is no potential for the Project to exceed MPCA thresholds. Because the Project does not exceed the MPCA thresholds, the FTA noise impact criteria described previously are more protective than the MPCA standards and have been used to assess and mitigate noise impacts identified within this Final EIS. Information regarding the existing noise levels in the Project corridor and any exceedances of the MPCA standards is described in Section 4.1.2.

2.1.2.4 FTA Construction Noise Criteria

The FTA's construction noise criteria, summarized in Table 2.1-3, were used for the short-term noise impact analysis. The FTA construction noise criteria provide adequate protection for short-term noise impacts and allow for reasonable mitigation measures to be applied to the Project. Additionally, MPCA noise criteria were evaluated for the Project. MPCA recommends the Project work with local jurisdictions to ensure that reasonable measures are taken to limit construction noise, and the Project will work with local governments to ensure that reasonable measures are taken to limit construction noise.

[3] For historic or cultural resources, the following two circumstances in assessing impacts and mitigation measures: 1) The noise sensitivity of the property. While Table 2.1-1 gives a list of noise sensitive land uses, there can be differences in noise sensitivity depending on individual circumstances. For example, a historic park or recreational area could vary in its sensitivity to noise depending on the type of use of the park (active versus passive recreation) and the settings in which it is located. 2) Special protection provided by law. Section 106 of the National Historic Preservation Act and Section 4(f) of the DOT Act (which protects historic sites, as well as publicly owned parks, recreation areas, wildlife, and waterfowl refuges) come into play frequently during the environmental review of transit projects. See pages 3-12 and 3-13 of the FTA Transit Noise and Vibration Impact Assessment for additional information on considerations given to resources that have special protection provided by law.

TABLE 2.1-3
FTA Construction Noise Criteria

Land Use	8-hour Leq, dBA		Noise Exposure, dBA
	Day	Night	30-day Average
Residential	80	70	75
Commercial	85	85	80
Industrial	90	90	85

2.2 Vibration

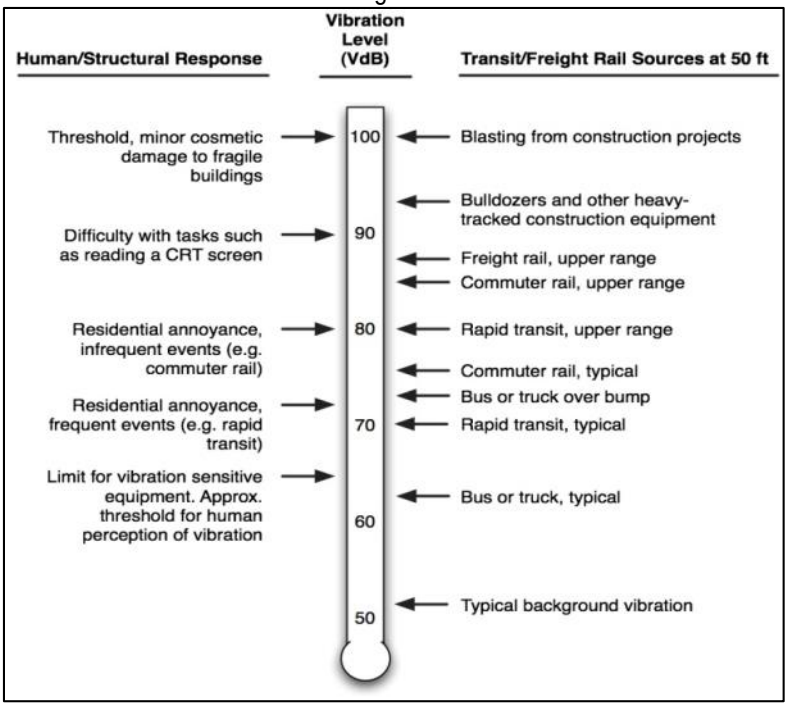
2.2.1 Vibration Overview

Ground-borne vibration is the motion of the ground transmitted into a building that can be described in terms of displacement, velocity, or acceleration. Vibration velocity is used in transit and freight rail and is defined by the following:

- **Level:** Vibration is expressed in terms of vibration velocity level, using vibration decibels (VdB), with a reference of one micro-inch per second. The level of vibration represents how much the ground is moving. The threshold of human perception to transit and freight rail vibration is approximately 65 VdB and annoyance begins to occur for frequent events at vibration levels over 70 VdB.
- **Frequency:** Vibration frequency is expressed in Hz. Human response to vibration is typically from about 6 Hz to 200 Hz.
- **Time Pattern:** Environmental vibration changes all the time and human response is roughly correlated to the number of vibration events during the day. The more events that occur, the more sensitive humans are to the vibration.

Exhibit 2.2-1 shows typical ground-borne vibration levels for transit and freight projects as well as the corresponding human and structural responses to vibration.

EXHIBIT 2.2-1
Vibration Levels from LRT and Freight Rail



2.2.2 Vibration Impact Criteria

2.2.2.1 FTA Transit Vibration Criteria

The vibration impact criteria used for the Project are based on the information contained in Chapter 8 of the FTA noise and vibration guidance manual. The criteria for a general vibration assessment are based on land use and train frequency, as shown in Table 2.2-1. Some buildings, such as concert halls, recording studios and theaters, can have a higher sensitivity to vibration (or ground-borne noise) but do not fit into the three categories listed in Table 2.2-1. Because of the sensitivity of these buildings, special attention is paid to these buildings during the environmental assessment of a project. Table 2.2-2 shows the FTA criteria for acceptable levels of vibration for several types of special buildings.

Table 2.2-1 and Table 2.2-2 include additional criteria for ground-borne noise, which is a low-frequency noise that is radiated from the motion of room surfaces, such as walls and ceilings in buildings due to ground-borne vibration. Ground-borne noise is defined in terms of dBA, which emphasizes middle and high frequencies, which are more audible to human ears. The criteria for ground-borne noise are much lower than for airborne noise to account for the low-frequency character of ground-borne noise; however, because airborne noise typically masks ground-borne noise for above ground (at-grade or elevated) transit systems, ground-borne noise is only assessed for operations in tunnels, such as in the Kenilworth Corridor, where airborne noise is not a factor, or at locations such as recording studios, which are well insulated from airborne noise.

TABLE 2.2-1
Ground-Borne Vibration and Ground-Borne Noise Impact Criteria for General Assessment

Land Use Category	Ground-Borne Vibration Impact Levels (VdB re 1 micro-inch /sec)			Ground-Borne Noise Impact Levels (dBA re 20 micro Pascals)		
	Frequent Events[a]	Occasional Events[b]	Infrequent Events[c]	Frequent Events[a]	Occasional Events[b]	Infrequent Events[c]
Category 1: Buildings where vibration would interfere with interior operations.	65[d]	65[d]	65[d]	N/A[e]	N/A[e]	N/A[e]
Category 2: Residences and buildings where people normally sleep.	72	75	80	35	38	43
Category 3: Institutional land uses with primarily daytime use.	75	78	83	40	43	48

[a] "Frequent Events" is defined as more than 70 vibration events of the same source per day. Most rapid transit projects fall into this category.

[b] "Occasional Events" is defined as between 30 and 70 vibration events of the same source per day. Most commuter trunk lines have this frequency of operations.

[c] "Infrequent Events" is defined as fewer than 30 vibration events of the same kind per day. This category includes most commuter rail branch lines.

[d] 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.

[e] Vibration-sensitive equipment is generally not sensitive to ground-borne noise.

TABLE 2.2-2
Ground-Borne Vibration and Ground-Borne Noise Impact Criteria for Special Buildings

Type of Building or Room	Ground-Borne Vibration Impact Levels (VdB re 1 micro-inch /sec)		Ground-Borne Noise Impact Levels (dBA re 20 micro Pascals)	
	Frequent Events[a]	Occasional or Infrequent Events[b]	Frequent Events[a]	Occasional or Infrequent Events[b]
Concert Halls	65	65	25	25
TV Studios	65	65	25	25
Recording Studios	65	65	25	25
Auditoriums	72	80	30	38
Theaters	72	80	35	43

[a] "Frequent Events" is defined as more than 70 vibration events per day. Most rapid transit projects fall into this category.

[b] "Occasional or Infrequent Events" is defined as fewer than 70 vibration events per day. This category includes most commuter rail systems.

If the building will rarely be occupied when the trains are operating, there is no need to consider impact. As an example, consider locating a commuter rail line next to a concert hall. If no commuter trains will operate after 7 pm, it would be rare that the trains interfere with the use of the hall.

The criteria for a detailed vibration assessment are shown in Exhibit 2.2-2 and descriptions of the curves are shown in Table 2.2-3. The curves in Exhibit 2.2-2 are applied to the projected vibration spectrum for the Project. If the vibration level at any one frequency exceeds the criteria, there is impact. Conversely, if the entire proposed vibration spectrum of the Project is below the curve, there will be no impact.

For the Project, the general vibration assessment criteria were used to assess LRT ground-borne noise in the tunnel section. The detailed vibration assessment criteria were used to assess LRT ground-borne vibration.

EXHIBIT 2.2-2
Detailed Vibration Criteria

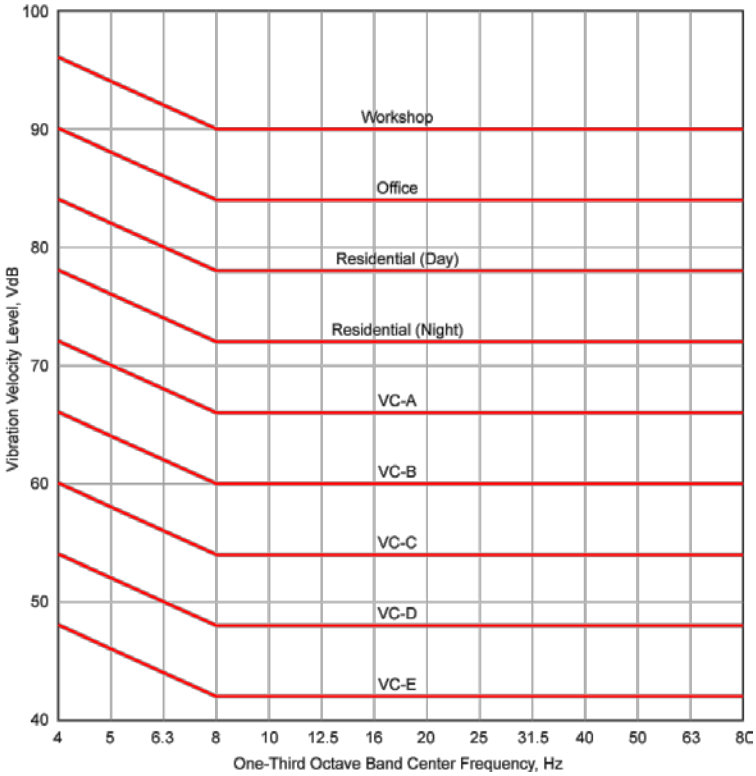


TABLE 2.2-3
Interpretation of Vibration Criteria for Detailed Analysis

Criterion Curve (See Exhibit 2.2-2)	Max Level (VdB)[a]	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	The most demanding criterion for extremely vibration-sensitive equipment.

[a] As measured in 1/3-octave bands of frequency over the frequency range 8 to 80 Hz.

2.2.2.2 Cultural Resources

Under FTA guidance, historic sites are designated as vibration sensitive depending on the land use of the site, not their designation as historic. Historical sites that are currently used as residences will be in Category 2. Historic buildings with indoor use of an interpretive nature involving meditation and study will be in Category 3. These include museums, significant birthplaces, and buildings in which significant historical events occurred. One difference between noise and vibration is that outdoor land uses are not considered vibration sensitive. Only indoor land uses are considered vibration sensitive.

Most downtown areas have buildings which are historically significant because they represent a particular architectural style or are prime examples of the work of a historically significant designer. If the buildings or structures are used for commercial or industrial purposes and are located in busy commercial areas, they are not considered vibration sensitive and the impact criteria do not apply.

Similarly, historical transportation structures, such as terminals and railroad depots, are not considered vibration-sensitive land uses. These buildings or structures may however be afforded special protection under Section 4(f) of the DOT Act and Section 106 of the National Historic Preservation Act.

In the Section 106 process protecting historic and cultural properties, vibration may or may not be considered an "adverse effect" depending on the individual circumstances and whether or not the use is vibration sensitive, because, as previously noted, historic and cultural properties are only vibration sensitive based on how they are used. The regulatory processes stemming from these statutes require coordination and consultation with agencies and organizations having jurisdiction over these resources. Their views on the project's impact on protected resources are given careful consideration by FTA and the applicant, and their recommendations may influence the decision to adopt vibration reduction measures.

2.2.2.3 FTA Construction Vibration Criteria

In addition to the vibration criteria for human annoyance and interference with equipment and spaces described above, there are also vibration criteria for damage from construction activities. Typical transit operations do not have the potential for damage, so only certain construction activities are assessed for damage.

The thresholds for damage to structures are typically several orders of magnitude above the thresholds for human response to vibration. Table 2.2-4 shows the FTA criteria for vibration damage to structures. This is

based on the structure and construction type (and not a designation as historic). Table 2.2-4 includes criteria in both VdB and Peak Particle Velocity (PPV).

TABLE 2.2-4
FTA Vibration Damage Criteria from Construction

Building Category	PPV (in/sec)	Approximate Lv[a]
I. Reinforced-concrete, steel or timber (no plaster)	0.5	102
II. Engineered concrete and masonry (no plaster)	0.3	98
III. Non-engineered timber and masonry buildings	0.2	94
IV. Buildings extremely susceptible to vibration damage	0.12	90

[a] RMS velocity in VdB re: 1 micro-inch/second.

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3 Impact Assessment Methodology

3.1 Noise

Noise has been assessed in accordance with guidelines specified in the FTA's *Transit Noise and Vibration Impact Assessment* guidance manual (FTA, 2006). This section describes the methodology used for assessing the potential impact from the Project.

Projected noise levels for the Final EIS Detailed Noise Analysis are based on noise measurements of the METRO Blue Line vehicles, which were conducted for the Central Corridor LRT Project, and the operating characteristics and current design of the proposed Project. Specific inputs used in the noise impact assessment include the following assumptions:

- Speeds range from 20 miles per hour (mph) to 65 mph for revenue operations, except for entry and exit from station areas, and reflect train operating characteristics, track geometry, and stations.
- Three car consists during hours of operation.
- The operating hours and headways[4] will be as follows:
  - Early morning hours (12:15 a.m. to 2:00 a.m.): 60-minute headways
  - Morning hours (4:00 a.m. to 5:30 a.m.): 30-minute headways
  - Prepeak morning operating hours (5:30 a.m. to 6:30 a.m.) 15-minute headways
  - AM peak hours (6:30 a.m. to 8:30 a.m.): 10-minute headways
  - Mid-day operating hours (8:30 a.m. to 3:30 p.m.) 10-minute headways
  - PM peak operating hours (3:30 p.m. to 6:00 p.m.): 10-minute headways
  - Post PM peak operating hours (6:00 p.m. to 9:00 p.m.): 10-minute headways
  - Evening hours (9:00 p.m. to 10:15 p.m.): 20-minute headways
  - Late evening hours (10:15 p.m. to 12:15 a.m.): 30-minute headways
- The reference noise levels are shown as follows in Table 3.1-1:

TABLE 3.1-1
Green Line Reference Noise Levels

Noise Source	Sound Exposure Level[a], 50 feet (dBA)
LRT on embedded track	84
LRT on ballast-and-tie track	81
Crossing bells	76[b]
LRT Bells	86/87[c]
LRT Horn	109/115[d]

[a] The sound exposure level (SEL) is the cumulative noise from a single event, taking into account both the level and duration of the sound.

[b] The maximum noise level from crossing bells is 77 dBA at 10 feet. Crossing bells will be sounded for 20 seconds for each light rail vehicle at an at-grade crossing.

[c] The maximum noise level from LRT bells is 80 dBA at 50 feet. LRT bells will be sounded 3 times when entering and exiting stations (86 dBA SEL) and will be sounded for 5 seconds at each non-FRA at-grade crossing (87 dBA SEL).

[4] Headways are the average time between transit vehicles operating in the same direction by a common point over a given period of time (e.g., four inbound light rail trains passing by a station within one hour will result in a 15-minute headway).

[d] The maximum noise level from LRT horns is 96 dBA at 100 feet. LRT horns will be sounded for 5 seconds at certain higher speed at-grade crossings (109 dBA SEL) and for 20 seconds at all FRA at-grade crossings (115 dBA SEL).

- Locations of elevated structures, crossovers and embedded track were identified based on project engineering plan and profile maps.
- Crossovers increase the noise levels by up to 6 dB for nearby sensitive receptors due to the gap in the track.
- Elevated structures increase the noise levels by 4 dB for nearby sensitive receptors due to structure-borne noise.
- Noise at proposed light rail tunnel portals is projected to increase noise levels by 1 dB for wayside locations within 100 feet of the tunnel portal to account for reverberation inside the tunnel. Wayside noise at tunnel portals was modeled with computer noise modeling software (Olive Tree Labs Terrain v 1.4.3.0) to quantify any increase created by reverberation inside the tunnel. Two geometries were constructed. First, a finite line source, composed of incoherent point sources over hard ground, was modeled to provide a baseline train noise level at receivers located at distances of 25 to 75 feet at various angles with respect to the right-of-way. A second model used the same geometry and receiver positions as the baseline model, but included an enclosure made of up of hard surfaces above and to the sides of the line source to represent the tunnel. The front and rear of this enclosure were left open to characterize the portal openings.

  The computer model includes the effects of reflections and diffractions inside the tunnel enclosure and at the tunnel mouth to accurately depict sound emissions from the portal. The projected levels of the tunnel geometry were compared with the baseline results to quantify the increase in noise near the tunnel portals due to reverberation. The analysis indicates that receivers closest to the tunnel with direct line of sight to the portal would experience the greatest increase, while receivers farther away or with no direct line of sight to the portal would experience a lower increase or reduction in wayside noise. The increase in noise due to portal effects at a receiver located 75 feet directly in front of the portal is calculated to be 3 dB. For wayside receivers located 75 feet or farther away from the portal, the increase caused by portal effects is calculated to be approximately 1 dB. Noise levels would be reduced compared to baseline levels for wayside receivers without a direct line of sight to the tunnel portal.
- Anticipated use of bells and horns at each at-grade crossing, station, and tunnel portal was determined in consultation with Metro Transit Operations based on the following considerations:
  - Light rail vehicle bells will be sounded three times when entering and exiting station platforms
  - Light rail vehicle horns or bells will be sounded at at-grade crossings – horn or bell usage is determined by Metro Transit Operations and is based on a variety of factors, including train speeds at the crossing, type of crossing warning devices, at-grade crossing and adjacent roadway geometry, proximity to a freight rail crossing under the jurisdiction of the Federal Railroad Administration (FRA) (the light rail vehicle horn or bell will be sounded for five seconds at non-FRA crossings; the light rail vehicle horn or bell will be sounded long, long, short, long for 15 seconds at FRA crossings[5]) and other relevant factors
  - Grade crossing bells will be used at at-grade crossings for 20 seconds for each light rail train where there will be flashing lights and gates at the crossing.
  - Light rail bells or horns will not be used at tunnel portals (entrances and exits) under normal operating conditions.
- Light rail bells or horns will be sounded in the following manner for locations with stations directly adjacent to at-grade crossings:

[5] Applies to 5th Avenue in Hopkins; Blake Road, Wooddale Avenue, and Beltline Boulevard in St. Louis Park; and 21st Street in Minneapolis.

- For the side opposite the station, vehicles will sound their horns or bells in accordance with the procedures above for an at-grade crossing. No additional sounding will occur upon entering the station.
- For the side with the station, vehicles will sound their bells in accordance with the procedure above upon entering the station. The vehicle will then sound either the horn or bell upon exiting the station until the front of the vehicle passes through the far side of the crossing.

3.2 Vibration

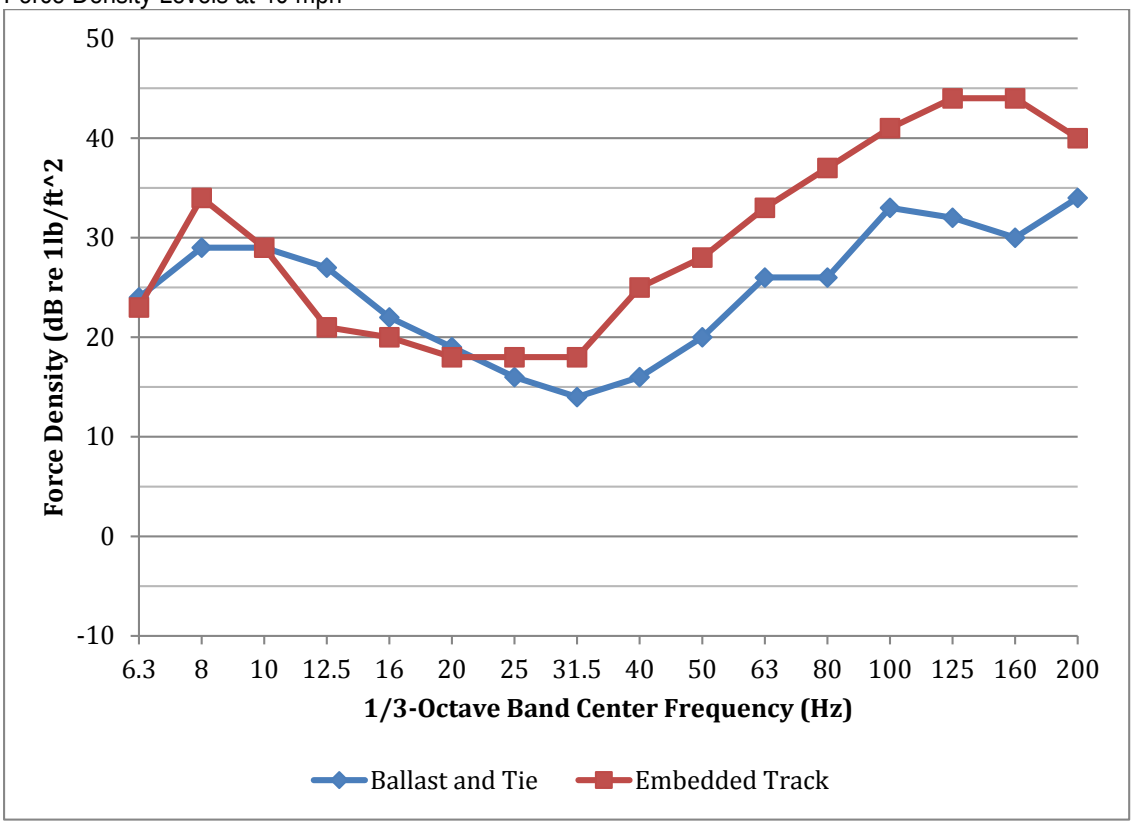
Vibration has been assessed in accordance with guidelines specified in the FTA's *Transit Noise and Vibration Impact Assessment* guidance manual (FTA, 2006). This section describes the methodology used to assess the potential impact from the Project. Specific inputs used in the noise impact assessment include the following:

- Projected LRT operating speeds range from approximately 20 mph to 65 mph for LRT revenue operations, except for entry and exit from station areas. Light rail train speeds are based on modeled speed profiles in both directions (i.e., inbound and outbound) that reflect train operating characteristics, track geometry, and stations.
- Three car consists during hours of operation.
- Operating hours and headways are described in Section 3.1, which will result in "frequent" events, as defined in the vibration criteria section.
- Locations of elevated structures, crossovers, and embedded track were identified based on project engineering plan and profile maps.
- Crossovers increase vibration levels by up to 10 dB for nearby sensitive receptors due to the gap in the track.
- Elevated structures decrease vibration levels by 10 dB for nearby sensitive receptors.
- Future vibration levels from LRT operations were based on a combination of the force density (vehicle) and propagation (soil) data at sensitive locations. The procedure for projecting future vibration levels is to measure the vibration propagation characteristics of the soil (Line Source Transfer Mobility [LSTM]) and combine that information with the vehicle information independent of the soil (Force Density [FD]). The formula for calculating the future vibration levels is:

  Lv = FD + LSTM

  Where: Lv is the projected train vibration level, FD is the vehicle force density, and LSTM is the line source transfer mobility at a site.
- Vehicle force density levels were based on measurements conducted for the Central Corridor LRT Project (ATS Consulting, 2008) for both ballast-and-tie and embedded track. Representative force density spectra for both ballast-and-tie and embedded track are shown on Exhibit 3.2-1.
- Vibration propagation measurements were conducted at representative locations throughout the Final EIS project vicinity.
- A general assessment of freight vibration was also conducted for the area near the Kenilworth Channel where the freight tracks will be shifted closer to sensitive receptors to provide room for the LRT tracks.

EXHIBIT 3.2-1
Force Density Levels at 40 mph



4 Affected Environment

4.1 Noise

4.1.1 Noise Sensitive Land Use

Noise-sensitive land use for the Final EIS was identified based on aerial photography, project drawings, and a site survey. Based on the information from these sources, the noise-sensitive land use, from south to north by city were identified as follows:

Eden Prairie

The noise-sensitive land uses in Eden Prairie include Southwest Station Condos, Purgatory Creek Park, two apartment complexes on Singletree Lane (Water Tower Apartments and Lincoln Parc Apartments), several hotels on Flying Cloud Drive, FOX 9 Studios, Eagle Ridge Academy near Nine Mile Creek, and ShopHQ studios. The dominant noise sources include traffic on local streets, Highway 212 and Interstate 494.

Minnetonka

The noise-sensitive land uses in Minnetonka include Sunrise International Montessori School, Claremont Apartments, and Deer Ridge Apartments. The dominant noise sources include traffic on local streets and distant noise from several highways.

Hopkins

The noise-sensitive land uses in Hopkins include Greenfield Apartments; single family residences north of Excelsior Boulevard. 11th Avenue, 7th Avenue, 6th Avenue, and 5th Avenue; Parkside, Mayfair and Royal Apartments; an audiologist (Hearing Care Specialists); Towne Terrace, Sonoma, and Hopkins Plaza Apartments; single-family residences south of Excelsior Boulevard near Monroe Avenue; Westside Apartments; and Creekwood Estates. The dominant noise sources include traffic on local streets and noise from existing freight operations.

St. Louis Park

The noise-sensitive land uses in St. Louis Park include single-family residences along Edgebrook Drive, single-family residences along West 37th Street, single-family residences along Railroad Avenue, Village in the Park Condominiums, TowerLight, 35th Street Apartment, two apartment complexes west of Highway 100 (Cityscape Apartments and Hoigaard Village Apartments), Park Glen Townhomes, Inglewood Trails Apartments, and Lilac Park. The dominant noise sources include traffic on local streets, existing freight operations and aircraft overflights.

Minneapolis

The noise-sensitive land uses in Minneapolis include single-family residences and multi-family residences within the Kenilworth Corridor from West 32nd Street to just north of West 21st Street, the Kenilworth lagoon bank, single-family residences along Kenwood Parkway, Higher Ground Catholic Charities and Mary's Place near downtown. The dominant noise sources include traffic on local streets, existing freight operations, aircraft overflights and Interstate 394.

4.1.2 Existing Noise Measurements

4.1.2.1 Noise Measurement Procedures and Equipment

Existing noise levels were measured at sites near the Project during March 2010 (Draft EIS), July and August 2013, and May 2015 (Final EIS). The additional noise measurements conducted in 2013 and 2015 were located in areas where measurements had not been conducted during the Draft EIS and in the freight co-location portions of the corridor. These additional efforts were necessary to update the existing condition noise measurements and to reflect changes in freight operations since the Draft EIS.

Because the thresholds for impact in the FTA noise criteria are based on the existing noise levels, measuring the existing noise and characterizing noise levels at sensitive locations along the corridor is an important step in the impact assessment. The noise measurements included both long-term (24-hour) and short-term (one hour) monitoring of the A-weighted sound level at noise-sensitive locations near the Project.

The noise measurements were performed with NTi Audio model XL2 noise monitors that conform to American National Standard Institute (ANSI) standards for Type 1 (precision) sound measurement equipment. Calibrations, traceable to the National Institute of Standards and Technology (NIST) were conducted before and after each measurement. The noise monitors were set to continuously monitor and record multiple noise level metrics, as well as obtain audio recordings during the measurement periods.

Sound insulation testing procedures were conducted in accordance with the American Society for Testing and Materials (ASTM) Standard Guide for Field Measurements of Airborne Sound Attenuations of Building Facades and Façade Elements (ASTM E966-10). The sound insulation measurements were conducted with equipment that conforms to ANSI standards for Type 1 (precision) microphones. Predicted interior project noise levels were calculated in accordance with ASTM Standard Classification for Rating Outdoor-Indoor Sound Attenuation (ASTM E1332-10a) using a reference source spectrum of a typical light rail vehicle passby.

4.1.2.2 Noise Measurement Locations and Results

Table 4.1-1 summarizes the results of the existing noise measurement program and Exhibit 4.1-1 shows the location of the 15 long-term noise monitoring sites, two short-term noise monitoring sites, and two site-specific interior noise measurements for the Project. The long-term noise measurements were used to characterize the existing noise at residential locations, and the short-term noise measurements were used to characterize the existing noise at non-residential locations. Additional interior noise measurements were conducted to determine the project noise levels inside the hearing testing booth at the audiologist (Hearing Care Specialists) and at the hotels in Eden Prairie where impact was identified but where no outdoor land use was present (see Section 5.1 for more information).

At each site, the measurement was conducted at the approximate set back of the building or buildings relative to the Project location. The results of the existing noise measurements program were used to determine the existing noise levels for all the noise-sensitive locations. Table 4.1-1 summarizes the noise measurement results at each site.

Appendix A includes detailed information regarding the noise measurement results, and Appendix D includes photographs of noise measurement sites.

Eden Prairie

- **Site N2 – Southwest Station Condos:** The Ldn measured at this location was 71 dBA. The dominant noise source was traffic on Highway 212. Noise levels were measured for 24 hours in a landscaped area on the Highway 212 side of the condos. This site is representative of the ambient noise conditions at the Southwest Station Condos.
- **Site N3 – Purgatory Creek Park:** The Leq measured at this location was 54 dBA. The dominant noise source was traffic on local roads. Noise levels were measured for one hour at the gazebo in the park. This site is representative of the ambient noise conditions at the Purgatory Creek Park.
- **Site N4 – Apartments on Singletree Lane:** The Ldn measured at this location was 62 dBA. The dominant noise sources were traffic on local streets and Highway 212. Noise levels were measured for 24 hours near the Eden Prairie Marketplace water tower. This site is representative of the ambient noise conditions at the apartments on Singletree Lane and the hotels on Flying Cloud Drive south of I-494.

TABLE 4.1-1
Summary of Existing Noise Level Measurements

Site No.	City	Measurement Location	Measurement Start		Meas. Duration (hrs)	Noise Level (dBA)[d]	
			Date	Time		Ldn	Leq
N2[a]	Eden Prairie	Southwest Station Condos	7/25/13	14:00	24	71	--
N3[a]	Eden Prairie	Purgatory Creek Park	7/25/13	7:30	1	--	54
N4[a]	Eden Prairie	Apartments on Singletree Lane	8/7/13	16:00	24	62	--
N25[b]	Eden Prairie	Homestead Hotel	3/8/10	10:07	24	61	--
N25a[c]	Eden Prairie	Hampton Inn/Baymont Inn	5/13/15	Interior Noise Measurements[e]			
N26[b]	Eden Prairie	Nine Mile Creek Apartments	3/2/10	14:05	24	64	65
N5a[c]	Eden Prairie	ShopHQ	5/13/15	11:02	1	--	53
N5[a]	Minnetonka	Claremont Apartments	8/7/13	14:00	24	57	--
N27[b]	Hopkins	Nolan Drive	3/4/10	10:15	24	62	--
N6a[c]	Hopkins	Hearing Care Specialists (Audiologist)	5/14/15	Interior Noise Measurements[e]			
N6[a]	Hopkins	6th Avenue and Excelsior Blvd	7/24/13	14:00	24	65	59
N7[a]	Hopkins	Jackson Ave S	7/24/13	14:00	24	58	--
N8[a]	Hopkins	Westside Apartments	7/25/13	13:00	24	60	--
N9[a]	St. Louis Park	Edgebrook Drive	7/25/13	11:00	24	57	--
N14[a]	St. Louis Park	W 37th Street	7/23/13	11:00	24	58	54
N15[a]	Minneapolis	Calhoun Isle Condos	7/23/13	11:00	24	64	--
N16[a]	Minneapolis	Kenilworth Place and S. Upton Ave	7/23/13	10:00	24	61	--
N17[a]	Minneapolis	21st Street and Upton Street	7/23/13	11:00	24	56	--
N18[a]	Minneapolis	Mary's Place	8/7/13	11:00	24	74	--

[a] Noise sites from Supplemental Draft EIS/Final EIS measurements conducted during July and August 2013.

[b] Noise sites from Draft EIS measurements conducted during March 2010.

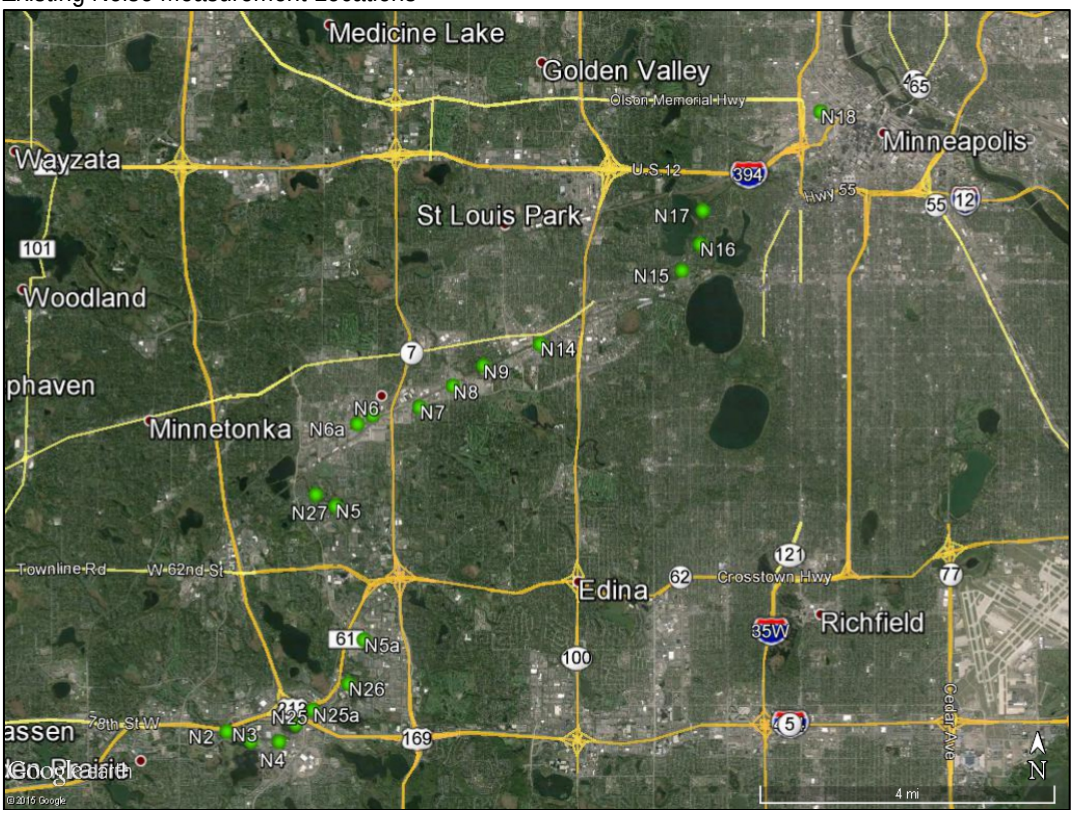
[c] Noise site from Final EIS measurement conducted during May 2014.

[d] Ldn is used for Category 2 (residential) land use and Leq is used for Category 3 (institutional land use).

[e] Site-specific outdoor-indoor noise measurements conducted at these locations to determine the reduction in noise due to the building for interior spaces.

- **Site N25 (Draft EIS) – Homestead Hotel:** The Ldn measured at this location was 61 dBA. The dominant noise sources were traffic on Highway 212 and Interstate 494. Noise levels were measured for 24 hours adjacent to the hotel. This site is representative of the ambient noise conditions at the hotels on Flying Cloud Drive north of I-494.
- **Site N25a – Hampton Inn and Baymont Inn:** Site-specific outdoor-indoor sound insulation noise measurements (see Appendix C of this document for more information) were conducted at these two hotels to determine the reduction in noise due to the building for interior spaces.
- **Site N26 (Draft EIS) – Nine Mile Creek Apartments:** The Ldn measured at this location was 64 dBA and the Leq was 65 dBA. The dominant noise source was traffic on Highway 212. Noise levels were measured for 24 hours adjacent to the apartments. This site is representative of the ambient noise conditions for sensitive receptors to the east of Highway 212.
- **Site N5a – ShopHQ:** The Leq measured at this location was 53 dBA. The dominant noise source was distant traffic on local roadways. This site is representative of the ambient noise conditions for the outdoor studio at ShopHQ.

EXHIBIT 4.1-1
Existing Noise Measurement Locations



Minnetonka

- **Site N5 – Claremont Apartments:** The Ldn measured at this location was 57 dBA. The major noise source was local community noise. Noise levels were measured for 24 hours adjacent to the apartments. This site is representative of the ambient noise conditions at the Claremont Apartments.

Hopkins

- **Site N27 (Draft EIS) – Nolan Drive:** The Ldn measured at this location was 62 dBA. The major noise sources were local community noise and noise from freight operations. Noise levels were measured for 24 hours adjacent to the apartments. This site is representative of the ambient noise conditions at the Greenfield Apartments and the Deer Ridge Apartments.
- **Site N6a – Hearing Care Specialists:** Site-specific outdoor-indoor sound insulation noise measurements (see Appendix C of this document for more information) were conducted at this location to determine the reduction in noise due to the building for interior spaces, including the sound booth.
- **Site N6 – 6th Avenue and Excelsior Boulevard:** The Ldn measured at this location was 65 dBA and the Leq was 59 dBA. The major noise sources were traffic on Excelsior Boulevard and noise from freight operations. Noise levels were measured for 24 hours adjacent to the Towne Terrace Apartments. This site is representative of the ambient noise conditions at the noise-sensitive locations to the north of the corridor in Hopkins.
- **Site N7 – Jackson Avenue South:** The Ldn measured at this location was 58 dBA. The major noise sources were traffic on Excelsior Boulevard and noise from freight operations. Noise levels were measured for 24 hours in the backyard of a single-family residence. This site is representative of the ambient noise conditions to the south of the corridor in Hopkins.
- **Site N8 – Westside Apartments:** The Ldn estimated at this location was 60 dBA. The major noise sources were local community noise, traffic on local roads, and noise from freight operations. Noise

levels were measured for three hours during the peak hour, mid-day, and late night adjacent to the apartments. This site is representative of the ambient noise conditions at the Westside Apartments.

St. Louis Park

- **Site N9 – Edgebrook Drive:** The Ldn measured at this location was 57 dBA. The major noise sources were local community noise and noise from freight operations. Noise levels were measured for 24 hours in the backyard of a single-family residence. This site is representative of the ambient noise conditions for the southern portion of St. Louis Park.
- **Site N14 – West 37th Street:** The Ldn measured at this location was 58 dBA and the Leq was 54 dBA. The major noise sources were local community noise and noise from freight operations. Noise levels were measured for 24 hours in the front yard of a single-family residence. This site is representative of the ambient noise conditions for the northern portion of St. Louis Park.

Minneapolis

- **Site N15 – Calhoun Isle Condos:** The Ldn measured at this location was 64 dBA. The dominant noise sources are freight activity in the Kenilworth Corridor and aircraft overflights. Other noise sources included local traffic and bike path activities. Noise levels were measured for 24 hours at the side of the condos facing the corridor. This site is representative of the ambient noise conditions at the residences and condos in the southern portion of the freight rail co-location tunnel section.
- **Site N16 – Kenilworth Place and South Upton Avenue:** The Ldn measured at this location was 61 dBA. The dominant noise sources are freight activity in the Kenilworth Corridor and aircraft overflights. Other noise sources included local traffic and bike path activities. Noise levels were measured for 24 hours in the backyard of a residence facing the corridor. This site is representative of the ambient noise conditions at the residences and condos in the middle portion of the freight rail colocation tunnel section near the proposed at-grade section of the shallow tunnel option.
- **Site N17 – 21st Street and Upton Street:** The Ldn measured at this location was 56 dBA. The dominant noise sources are freight activity in the Kenilworth Corridor and aircraft overflights. Other noise sources included local traffic and bike path activities. Noise levels were measured for 24 hours in the backyard of a residence facing the corridor. This site is representative of the ambient noise conditions at the residences and condos in the northern portion of the freight rail colocation tunnel section.
- **Site N18 – Mary's Place:** The Ldn measured at this location was 74 dBA. The dominant noise sources are highway noise, local traffic noise, and general community noise. Noise levels were measured for 24 hours at the Mary's Place site. This site is representative of the ambient noise conditions for the downtown portion of Minneapolis.

4.1.2.3 MPCA Noise Standards Analysis

Using the noise measurement data gathered during the Final EIS at the long-term noise measurement sites described above, an analysis was also conducted using the MPCA L10 and L50 noise standards. At each location where a long-term noise measurement was conducted, the maximum L10 and L50 over a 24-hour period was calculated.

The results, shown in Table 4.1-2, show that at most locations along the corridor, the L10 and L50 standards are already being exceeded by existing noise sources. Most of the exceedances are due to exempt noise sources, such as roadway noise and aircraft overflights. The higher existing L10 and L50 noise levels are at locations close to major roadways along the corridor. At locations further from roadways, the L10 and L50 noise levels are lower.

TABLE 4.1-2
Summary of Existing L10 and L50 Noise Levels at Final EIS Long-Term Noise Measurement Sites

Site No.	City	Measurement Location	Max L10 (dBA) [a]	Max L50 (dBA) [b]
N2	Eden Prairie	Southwest Station Condos	72	69
N4	Eden Prairie	Apartments on Singletree Lane	76	59
N5	Minnetonka	Claremont Apartments	74	55
N6	Hopkins	6th Avenue and Excelsior Blvd	72	65
N7	Hopkins	Jackson Ave S	71	53
N8	Hopkins	Westside Apartments	69	58
N9	St. Louis Park	Edgebrook Drive	59	50
N14	St. Louis Park	W 37th Street	66	51
N15	Minneapolis	Calhoun Isle Condos	67	55
N16	Minneapolis	Kenilworth Place and S. Upton Ave	62	45
N17	Minneapolis	21st Street and Upton Street	58	47
N18	Minneapolis	Mary's Place	76	59

[a] The L10 descriptor represents noise levels exceeded 10 percent (6 minutes) of the time during an hour (60 minutes). This standard include both daytime and nighttime limits

[b] The L50 descriptor represents noise levels exceeded 50 percent (30 minutes) of the time during an hour (60 minutes). This standard include both daytime and nighttime limits

Source: Cross Spectrum Acoustics, Inc., 2015

4.2 Vibration

4.2.1 Vibration Sensitive Land Use

Vibration-sensitive land uses were identified based on aerial photography, project drawings, and a site survey. Based on the information from these sources, the identified vibration-sensitive land uses, from south to north by city, include:

- **Eden Prairie.** The vibration-sensitive land uses in Eden Prairie include the Southwest Station Condos, two apartment complexes on Singletree Lane (Water Tower and Lincoln Parc Apartments), several hotels on Flying Cloud Drive, Access Genetics, Eagle Ridge Academy near Nine Mile Creek, and ShopHQ studios.
- **Minnetonka.** The vibration-sensitive land uses in Minnetonka include Sunrise International Montessori School, American Medical Systems, Claremont Apartments, and Deer Ridge Apartments.
- **Hopkins.** The vibration-sensitive land uses in Hopkins include Greenfield Apartments, single family residences north of Excelsior Boulevard, an audiology clinic, Towne Terrace Apartments, single-family residences south of Excelsior Boulevard near Monroe Avenue, and Westside Apartments.
- **St. Louis Park.** The vibration-sensitive land uses in St. Louis Park include single-family residences along Edgebrook Drive, single-family residences along West 37th Street, single-family residences along Railroad Avenue, Village in the Park Condominiums, two apartment complexes west of Highway 100 (Cityscape Apartments and Hoigaard Village Apartments), Park Glen Townhomes, and Englewood Trails Apartments.
- **Minneapolis.** The vibration-sensitive land uses in Minneapolis include single-family residences and multi-family residences within the Kenilworth Corridor from West 32nd Street to just north of West 21st Street, single-family residences along Kenwood Parkway, Higher Ground Catholic Charities and Mary's Place near downtown.

4.2.2 Existing Vibration Measurements

4.2.2.1 Vibration Measurement Procedures and Equipment

Vibration propagation measurements were conducted in the project vicinity during July 2013 and August 2015 to determine the vibration response characteristics of the ground near vibration-sensitive locations. A custom-built instrumented hammer was used to generate an impulsive force into the ground. The magnitude of the impulse force was calculated based on the acceleration and mass of the falling hammer. The resulting vibration signals were measured using high-sensitivity accelerometers (PCB Model 393C and 393B05) mounted in the vertical direction on pavement, on the floors of buildings, or on steel spikes driven into the ground. The signals from the hammer and accelerometers were recorded using Data Translation DT9837A digital acquisition hardware. Data Translation's QuickDAQ software, running on a laptop computer, was used to review the measurement data in the field.

The vibration propagation test procedure is shown schematically in Exhibit 4.2-1. The instrumented hammer was used to generate impulses at specific locations spaced 15 feet apart along a line on or parallel to the proposed transit right-of-way. A line of accelerators was placed perpendicular to the line of impacts as shown in the figure. The relationship between the input force and the resulting vibration measured by the accelerometers, called the transfer mobility, was calculated using proprietary software in the CSA laboratory. The transfer mobility represents the vibration propagation characteristics of the ground at the measurement site and at other sites with similar geology. Vibration levels from a light rail vehicle were estimated by mathematically combining the force generated by a train (the force density) with the transfer mobility as described in the Detailed Vibration Assessment methodology provided in the FTA guidance manual.

For the laboratory analysis, the following steps were used to calculate the transfer mobility at each measurement site:

- Narrow-band transfer functions for each accelerometer/force pair were computed using custom CSA software. Signal processing and averaging techniques were used to maximize the signal-to-noise ratio for each measurement. Numerical integration was used to convert the acceleration data into velocity.
- Narrowband data were converted to one-third-octave band data.
- Numerical integration was used to convert the measured point source transfer mobility data into line source transfer motilities.
- For each one-third-octave band, linear or quadratic regression was used to determine smoothed estimates for each line source transfer mobility as a function of distance from the source.
- For site-specific transfer mobility measurements, the outdoor-to-indoor propagation characteristics were calculated by subtracting the measured indoor transfer mobility data from the transfer motilities measured outside of the building.

The FTA manual provides more details regarding the propagation test and analysis procedures.

4.2.2.2 Vibration Measurement Locations and Results

The vibration measurements conducted in July 2013 and August 2015 were used to characterize the response of the soil and/or building foundations, where applicable, at locations within the corridor. At each site, vibration propagation tests were conducted by impacting the ground with an instrumented weight and measuring the response of the soil and/or building foundations at various distances (LSTM). The results of the vibration propagation tests were combined with the force density (vehicle input force) to project vibration levels from LRT operations at locations along the corridor.

Table 4.1-3 and Exhibit 4.2-2 show the locations of the ten vibration measurement sites. Exhibit 4.2-3 shows the results of the LSTM tests, and Exhibits 4.2-4 and 4.2-5 show the projected vibration levels (combining the force density and transfer mobility data) for the Project for ballast-and-tie and embedded track, respectively.

Appendix B includes detailed information regarding the vibration propagation measurement results and Appendix D includes photographs of all vibration measurement sites.

EXHIBIT 4.2-1
Vibration Propagation Measurement Schematic

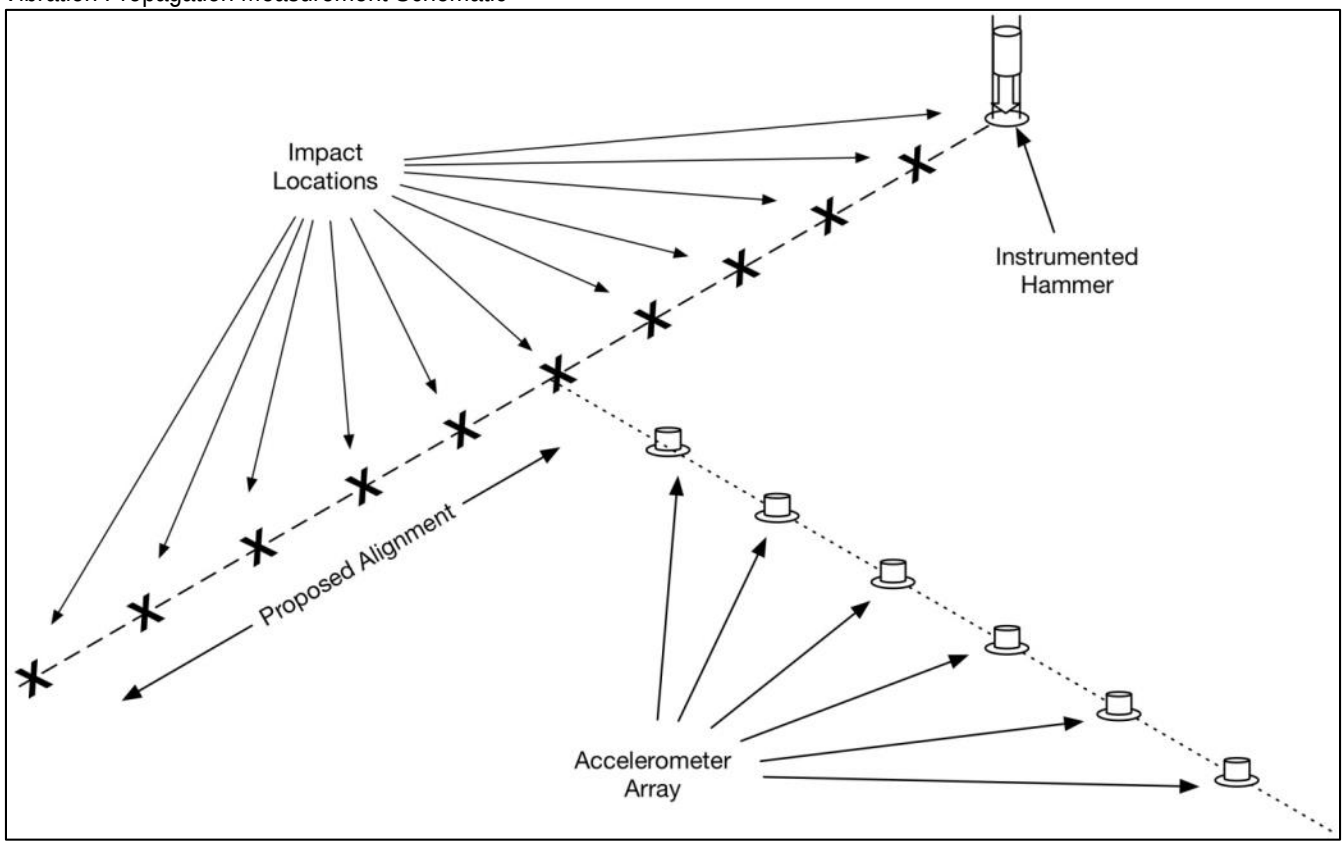


TABLE 4.1-3
Summary of Vibration Propagation Measurement Sites*

Site No.[a]	City	Measurement Location	Type	Date
V2	Eden Prairie	SouthWest Transit Station	Vibration Propagation	July 2013
V3	Eden Prairie	ShopHQ	Site-specific Building	July 2013
V4	Minnetonka	AMS	Site-specific Building	July 2013
V5	Minnetonka	Claremont Apartments	Vibration Propagation	July 2013
V6a	Hopkins	Hearing Care Specialists	Site-specific Buildings	August 2015
V6	Hopkins	Jackson Avenue S	Vibration Propagation	July 2013
V7	St. Louis Park	Edgebrook Drive	Vibration Propagation	July 2013
V8	Minneapolis	Dean Ct and W 28th Street	Vibration Propagation	July 2013
V9	Minneapolis	21st Street	Vibration Propagation	July 2013
V10	Minneapolis	Royalston Avenue	Vibration Propagation	July 2013

*Source: Cross Spectrum Acoustics, Inc, 2015.

[a] The vibration measurement site V1 (Eaton) was at a location that was eliminated from the Project during Project Development and is not a part of the current project.

EXHIBIT 4.2-2
Vibration Propagation Measurement Locations

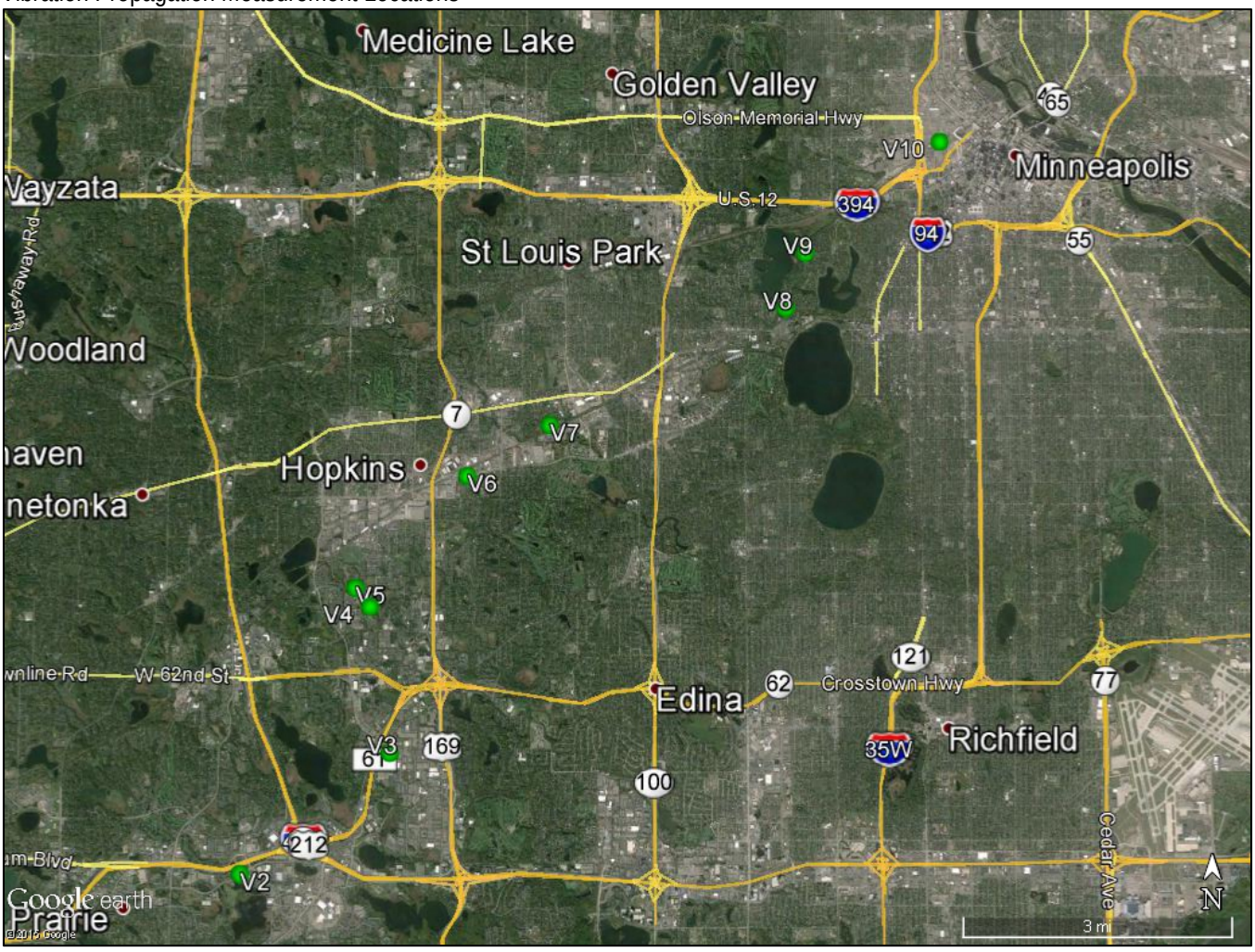


EXHIBIT 4.2-3
Line Source Transfer Mobility Results at 50 feet

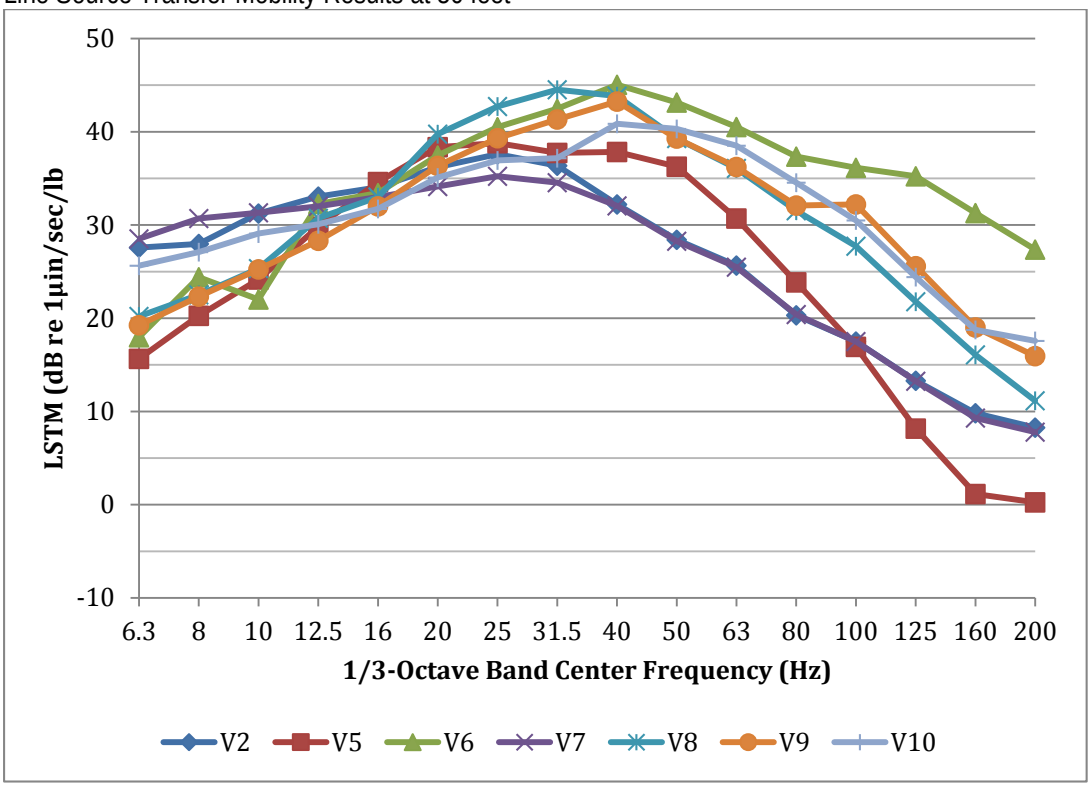


EXHIBIT 4.2-4
Vibration Levels at 50 feet, Ballast and Tie Track

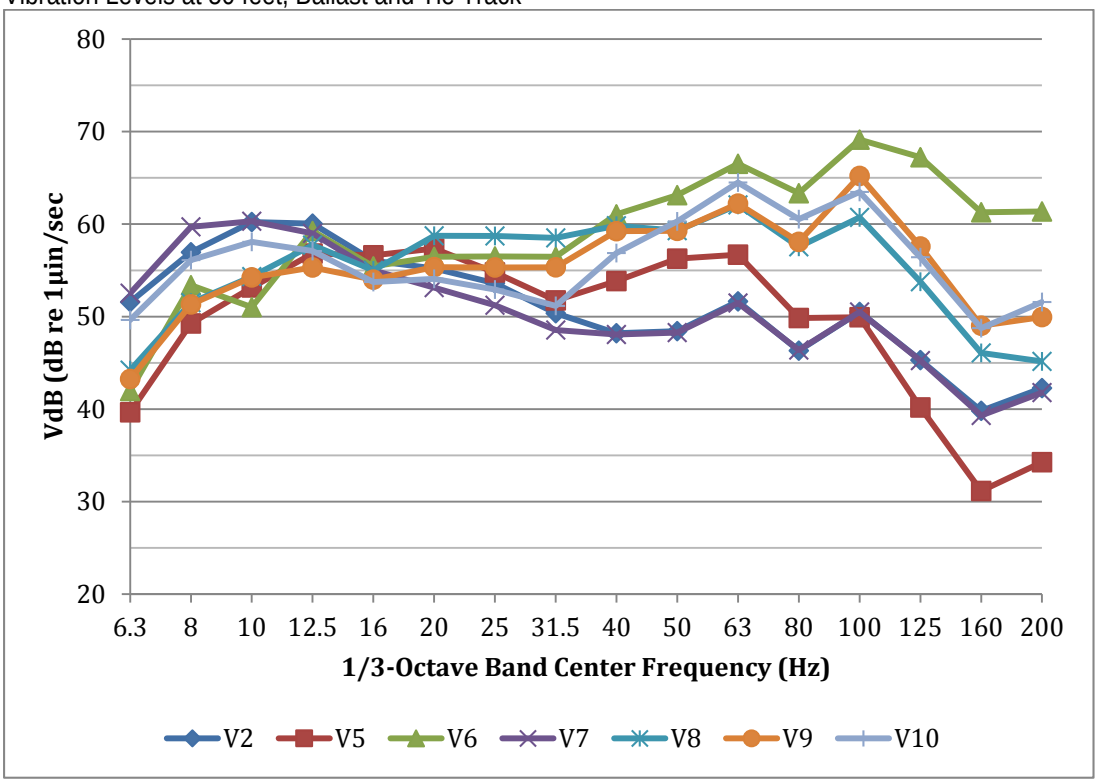
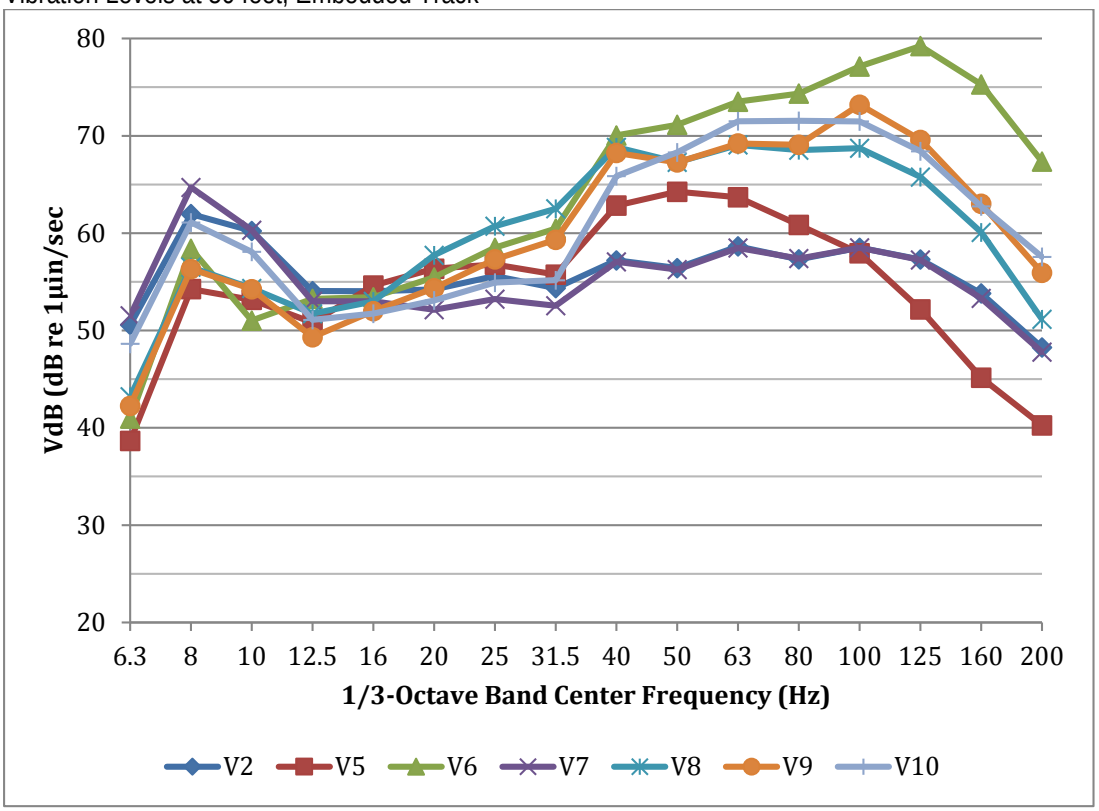


EXHIBIT 4.2-5
Vibration Levels at 50 feet, Embedded Track



Eden Prairie

- **Site V2 – SouthWest Transit Station.** The vibration propagation measurement was conducted in the driveway of the SouthWest Transit Station. The measurement at this site is representative of all vibration-sensitive land use in Eden Prairie.
- **Site V3 – ShopHQ.** The vibration propagation measurement was conducted at the ShopHQ studios. The measurement at this site is representative of the ShopHQ studios.

Minnetonka

- **Site V4 – AMS.** The vibration propagation measurement was conducted at the American Medical Systems facility. The measurement at this site is representative of manufacturing facilities at this location.
- **Site V5 – Claremont Apartment.** The vibration propagation measurement was conducted on the bike path adjacent to the Claremont Apartments. The measurement at this site is representative of the apartments on either side of Smetana Road.

Hopkins

- **Site V6a – Hearing Care Specialists.** The vibration propagation measurement for this site was conducted at the audiologist offices. The measurement at this site is representative of the audiologist at this site.
- **Site V6 – Jackson Avenue South.** The vibration propagation measurement was conducted on the street at the corner of Jackson Avenue South and Excelsior Boulevard. The measurement at this site is representative of the vibration-sensitive land use in Hopkins.

St. Louis Park

- **Site V7 – Edgebrook Drive.** The vibration propagation measurement was conducted on the street at the corner of Pennsylvania Avenue and Edgebrook Drive. The measurement at this site is representative of the vibration-sensitive land use in St. Louis Park.

Minneapolis

- **Site V8 – Dean Ct and West 28th Street.** The vibration propagation measurement was conducted on the street at the corner of Dean Court and West 28th Street. The measurement at this site is representative of all vibration-sensitive land use in the southern portion of the Kenilworth Corridor.
- **Site V9 – 21st Street.** The vibration propagation measurement was conducted on the street at the intersection of 21st Street and the bikeway. The measurement at this site is representative of all vibration-sensitive land use in the northern portion of the Kenilworth Corridor.
- **Site V10 – Royalston Avenue.** The vibration propagation measurement was conducted on the street at the intersection of Royalston Avenue and Holden Street. The measurement at this site is representative of all vibration-sensitive land use in downtown Minneapolis.

5 Environmental Consequences

5.1 Noise

The FTA guidance manual on noise and vibration (FTA, 2006) is the primary source for the noise methodology. Noise impacts due to the Project were evaluated using the Detailed Noise Assessment methodology contained in Chapter 6 of the FTA guidance manual (FTA, 2006). The noise assessment included the following steps:

- Identified noise-sensitive land uses in the corridor using aerial photography, GIS data and field surveys, typically within 300 feet of the alignment.
- Measured the existing noise levels in the corridor at sensitive receptors (See Affected Environment – Section 4.1).
- Projected Project noise levels from transit operations, using project drawings and information on speeds, headways, track type, vehicle type, and at-grade-crossing operations.
- Assessed the impact from transit by comparing the Project noise with the existing noise using the FTA noise impact criteria in Chapter 3 of the FTA guidance manual (FTA, 2006).
- Recommended mitigation at locations where projected Project noise levels exceeded the impact criteria.

5.1.1 Project Noise

This section describes the noise impacts for the Project. The results of the Detailed Noise Analysis are presented in Tables 5.1-1 and 5.1-2 for residential and institutional (e.g., churches and schools) land uses, respectively. Detailed noise impact assessment results are contained in Appendix J.

The results include a tabulation of location information for each sensitive receptor group, the existing noise levels, the projections of future noise levels, the impact criteria, and whether there will be noise impacts. The tables also show the total number of moderate and severe noise impacts for each location, without mitigation measures. Because the Project does not exceed the MPCA thresholds, the FTA criteria described previously are more protective than MPCA standards and have been used in assessing impacts from the Project.

As shown in Table 5.1-1, the Project would result in 237 moderate noise impacts (52 buildings) and 558 severe noise impacts (69 buildings) for residential land uses (see Appendix E for locations of impacts) without mitigation. The majority of the noise impacts would be related to LRT horn sounding at -shared LRT and freight rail at-grade crossings in the corridor. The proposed tunnel in the Kenilworth Corridor would eliminate most noise impacts compared to an at-grade light rail alignment within the same segment of the corridor. Without the tunnel, the number of noise impacts shown in Table 5.1-1 would be much greater.

TABLE 5.1-1
Summary of Noise Assessment and Impacts for Residential Land Use (without Mitigation)

Location	City	Side of Track	Distance from near LRT Track Centerline (feet)	LRT Speed (mph)	Existing Noise Level (dBA)	Project Noise Levels (dBA)[b]			Type and # of Impacts	
							FTA Criteria			
						Project	Mod	Sev	Mod	Sev
Southwest Station Condos	Eden Prairie	W	125	20	71	62	65	70	0	0
Water Tower Apartments	Eden Prairie	E	100	35	62	55	59	64	0	0
Lincoln Parc Apartments	Eden Prairie	E	125	25	62	58	59	64	0	0
Extended Stay America	Eden Prairie	W	470	45	61	48	58	64	0	0
Town Place Suites	Eden Prairie	E	550	45	61	46	58	64	0	0
Residence Inn	Eden Prairie	W	40	45	61	65	58	64	1 bldg	1 bldg
Baymont Inn	Eden Prairie	W	80	45	61	61	58	64	1 bldg	0
Marriott	Eden Prairie	E	500	45	61	48	58	64	0	0
Claremont Apts	Minnetonka	E	80	45	57	58	56	62	4 bldgs (126 units)	0
Greenfield Apts	Hopkins	E	200[a]	55	57	54	56	62	0	0
Deer Ridge	Minnetonka	E	300	55	57	56	56	62	0	0
Parkside Apts	Hopkins	W	780	65	65	46	61	66	0	0
Mayfair Apts	Hopkins	W	720	65	65	47	61	66	0	0
11th Avenue	Hopkins	W	640	65	65	48	61	66	0	0
Royal Apts	Hopkins	W	610	65	65	48	61	66	0	0
Hopkins Plaza Apts	Hopkins	W	350	20	65	71	61	66	0	5 bldgs (71 units)
7th Avenue	Hopkins	W	430	35	65	66	61	66	2	0
Sonoma Apts	Hopkins	W	350	45	65	66	61	66	1 bldg (12 units)	0
6th Avenue	Hopkins	W	400	45	65	65	61	66	5	0
Town Terrace Apts	Hopkins	W	250	55	65	68	61	66	0	5 bldgs (68 units)
Monroe Avenue	Hopkins	E	200	55	58	59	57	63	2	0
Westside Apts	Hopkins	E	125	35	60	78	58	63	0	6 bldgs (171 units)
Creekwood Estates	Hopkins	W	270	55	57	68	56	62	0	6 bldgs (72 units)
Edgebrook Drive	St. Louis Park	W	250	55	57	53	56	62	0	0
Railroad Avenue	St. Louis Park	E	50	55	58	82	57	62	0	42 bldgs (44 units)
Village in the Park Condos	St. Louis Park	E	150	35	65	76	61	66	0	2 bldgs (64 units)
TowerLight	St. Louis Park	E	355	20	65	73	61	66	0	1 bldg (66 units)
35th St. Apts	St. Louis Park	W	540	35	65	65	61	66	1 bldg (16 units)	0
Hoigaard Village	St. Louis Park	E	50	55	65	64	60	66	1 bldg (32 units)	0

Location	City	Side of Track	Distance from near LRT Track Centerline (feet)	LRT Speed (mph)	Existing Noise Level (dBA)	Project Noise Levels (dBA)[b]			Type and # of Impacts	
							FTA Criteria			
						Project	Mod	Sev	Mod	Sev
Cityscape Apts	St. Louis Park	W	125	55	65	58	60	66	0	0
Park Glen Townhomes	St. Louis Park	E	113	45	65	61	60	66	16	0
Inglewood Trails Apts	St. Louis Park	W	250	45	65	51	60	66	0	0
Ewing Avenue South	Minneapolis	W	100	45	65	57	60	66	0	0
Lake Citihomes	Minneapolis	W	88	20	65	62	60	66	1 bldg (7 units)	0
Chowen Avenue South	Minneapolis	E	75	35	65	58	60	66	0	0
St. Louis Avenue	Minneapolis	W	63	45	65	57	60	66	0	0
Benton Boulevard	Minneapolis	E	88	45	61	55	58	64	0	0
South Upton Avenue	Minneapolis	E	100	45	61	57	58	64	0	0
Thomas Lane	Minneapolis	E	130	35	56	53	56	62	0	0
Burnham Road South	Minneapolis	W	100	45	61	56	58	64	0	0
Burnham Road North	Minneapolis	W	50	45	61	63	58	64	5	0
Thomas Avenue South	Minneapolis	E	50	35	56	66	56	62	3	1
Sheridan Avenue South	Minneapolis	E	135	45	56	59	56	62	3	0
South Upton Avenue	Minneapolis	W	125	40	56	57	56	62	6	0
Kenwood Parkway	Minneapolis	E	140	45	56	54	56	62	0	0
Catholic Charities	Minneapolis	W	50	55	74	63	65	72	0	0
Mary's Place	Minneapolis	E	40	20	74	60	65	72	0	0
Total:									52/237	69/558

Notes:

The "Type and # of Impacts" column identifies whether the LRT noise level exceeds FTA's moderate or severe noise impact criteria thresholds, which are found under the "Project Noise Levels" column. It also reports the number of buildings or units that experience a moderate or severe noise impact.

Predicted noise levels for each location are highest at the representative site. Projected noise levels at other receptors within each location are lower.

The impact assessment at the Water Tower and Lincoln Parc Apartments includes the deferred Eden Prairie Town Center Station. Under both conditions, with or without the Eden Prairie Town Center Station, there are no impacts at the two locations.

The reported noise levels are rounded to the nearest decibel.

Note: bldg = building; Mod = moderate; Sev = severe.

[a] The distance measurement provided represents a building with the greatest increase (change) in noise levels over ambient conditions. There is another building within the complex where the distance from the LRT alignment to the apartment building is closer than this distance (approximately 125 feet); however, the noise level increase at that building is lower, so the distance provided (approximately 200 feet) is representative of the noise level increase at this location.

[b] The Project noise level and the existing noise level are independent values. The existing noise level represents the current noise without the Project. The Project noise level is the noise from the Southwest LRT Project only (not the future noise level), which is used to determine impact. Because they are independent values, the Project noise can be higher or lower than the existing noise.

A summary of each residential location that will experience noise impacts is as follows (see Table 5.1-1 above for more information):

- **Residence Inn/Baymont Inn.** These hotels are located adjacent to the Viking Drive at-grade-crossing in Eden Prairie. The impacts are due primarily to the sounding of the LRT bell at the at-grade crossing.
- **Claremont Apartments.** These apartments are located to the east of the proposed alignment in the Opus Hill area. The apartments are projected to have moderate noise impacts, without noise mitigation. The noise impacts at this location are due to the proximity of the residences to the proposed LRT alignment.
- **Hopkins Plaza Apartments/7th Avenue/Sonoma Apartments/6th Avenue/Town Terrace Apartments.** These residences are located to the north of the proposed alignment, near the 5th Avenue at-grade crossing. The apartments and single-family residences are projected to have severe and moderate noise impacts, without noise mitigation. The noise impacts at this location are due to the use of the LRT horn at the 5th Avenue at-grade crossing.
- **Monroe Avenue.** These residences are located to the south of the proposed alignment, near the Excelsior Avenue elevated structure. The single-family residences are projected to have moderate noise impacts, without noise mitigation. The noise impacts at this location are due to the presence of the elevated structure at Excelsior Avenue.
- **Westside Apartments/Creekwood Estates.** These residences are located to the south (Westside Apartments) and north (Creekwood Estates) of the proposed alignment, near the Blake Road at-grade crossing. The apartments are projected to have severe noise impacts, without noise mitigation. The noise impacts at this location are due to the use of the LRT horn at the Blake Road at-grade crossing.
- **Railroad Avenue.** These residences are located to the south of the proposed alignment, near the Wooddale Avenue at-grade crossing. The single family residences are projected to have severe noise impacts, without noise mitigation. The noise impacts at this location are due to the use of the LRT horn at the Wooddale Avenue at-grade crossing, the presence of a crossover and the proximity of the residences to the proposed alignment.
- **Village in the Park Condos/35th Street Apartments/TowerLight.** These residences are located to the south (Village in the Park Condos and TowerLight) and north (35th Street Apartments) of the proposed alignment, near the Wooddale Avenue at-grade crossing. The apartments are projected to have severe and moderate noise impacts, without noise mitigation. The noise impacts at this location are due to the use of the LRT horn at the Wooddale Avenue at-grade crossing.
- **Hoigaard Village Apartments.** These residences are located to the south of the proposed alignment, near Highway 100. The apartments are projected to have moderate noise impacts, without noise mitigation. The noise impacts at this location are due to the proximity of the residences to the proposed alignment.
- **Park Glen Townhomes.** These residences are located to the south of the proposed alignment, near Beltline Boulevard. The multi-family residences are projected to have moderate noise impacts, without noise mitigation. The noise impacts at this location are due to the presence of the nearby crossover.
- **Lake Citihomes.** These residences are located to the south of the proposed alignment, near the West Lake Station. The multi-family residences are projected to have moderate noise impacts, without noise mitigation. The noise impacts at this location are due to the presence of the West Lake Station.
- **Burnham Road North.** These residences are located to the west of the proposed alignment, north of the Kenilworth Channel crossing. The single-family residences are projected to have moderate noise impacts, without noise mitigation. The noise impacts at this location are due to the proximity of the residences to the proposed alignment.
- **Thomas Avenue South/Sheridan Avenue South/South Upton Avenue.** These residences are located to the east and west of the proposed alignment, near the 21st Street Station. The single-family

residences are projected to have severe and moderate noise impacts, without noise mitigation. The noise impacts at this location are due to the presence of the at-grade crossing and station at 21st Street.

As shown in Table 5.1-2, the Project results in one moderate noise impact for institutional land uses. A summary of the noise impacts follows.

- **Kenilworth Channel.** The Kenilworth Channel is projected to have moderate noise impacts, without noise mitigation. The noise impact at this location is due to the proximity of the channel to the proposed alignment.

TABLE 5.1-2
Summary of Noise Impacts for Institutional Land Use (without Mitigation)

Location	City	Side of Track	Distance from near LRT Track Centerline (feet)	LRT Speed (mph)	Existing Noise Level (dBA)	Project Noise Levels (dBA)			Type and # of Impacts	
							Criteria			
						Project	Mod	Sev	Mod	Sev
Purgatory Creek Park	Eden Prairie	W	270	25	54	47	60	66	0	0
Fox 9 Studios	Eden Prairie	E	450	45	61	45	58	64	0	0
Eagle Ridge Academy	Eden Prairie	E	225	35	65	51	66	71	0	0
Shop HQ Outdoor Studio	Eden Prairie	E	100	35	53	52	54	60	0	0
Sunrise Montessori	Eden Prairie	E	300	40	65	49	66	71	0	0
Hearing Care Specialists (Audiologist)	Hopkins	E	70	35	See text below and Table 5.1-3				0	0
Lilac Park	St. Louis Park	W	150	55	56	53	61	66	0	0
Kenilworth Channel	Minneapolis	E	20	45	54	64	60	66	1	0
Kenilworth Lagoon Bank[a]	Minneapolis	E	200	45	54	54	55	61	0	0
Total:									1	0

The reported noise levels are rounded to the nearest decibel.

[a] This receptor was analyzed as a Category 1 land use.

The sensitive use area of Open Space B in Minnetonka is outside the distance where there is the potential for impact (250 feet) and was not included in the assessment.

Note: Mod = moderate; Sev = severe

Hearing Care Specialists contains a sound booth where hearing tests are conducted. There are two thresholds established for these types of booths at certain frequencies (see Table 5.1-3). Based on measurements of the noise levels from outdoor to indoor sound insulation testing at the site, and projections of LRT noise at the site, the noise levels inside the booth will be below the thresholds for both testing procedures at all frequencies. Detailed sound insulation information is contained in Appendix C.

TABLE 5.1-3
Summary of Hearing Care Specialists Noise Assessment*

Hearing Test Type	125-Hz Octave Band	250-Hz Octave Band	500-Hz Octave Band	1000-Hz Octave Band	2000-Hz Octave Band	4000-Hz Octave Band	8000-Hz Octave Band
ANSI Ears covered TDH	35	25	21	26	34	37	37
ANSI Ears covered insert	59	53	50	47	49	50	56
Estimated levels from LRT	30	12	3	0	0	0	0

*Source: Cross Spectrum Acoustics, Inc., 2015.

ANSI = American National Standards Institute; TDH = Telephonics Dynamic Headphone

5.1.2 Cultural Resources

Based on data provided by MnDOT CRU of listed and eligible historic properties within the project vicinity, an assessment of the historic and cultural resources was conducted for the Project. The assessment was conducted to determine the noise sensitivity of the resources along the corridor. For each resource site, a determination was made regarding the noise sensitivity of the use and the FTA category it would fall under based on FTA guidance. The result of the cultural resource assessment, which is summarized in Table 5.1-4, is that only two cultural resources, Kenilworth Lagoon and the Kenwood Parkway Residential Historic District, are noise sensitive and close enough to the Project to warrant a noise impact assessment. Each of these locations was assessed for impact as a part of the noise assessment detailed in Section 5.1.1.

TABLE 5.1-4
Summary of Historic and Cultural Resources Noise Assessment

Inventory #	Property Name	City	FTA Noise Cat[a]	Notes
HE-HOC-0026	Hopkins City Hall (E)	Hopkins	None	Not noise sensitive
HE-HOC-0027	Hopkins Commercial Historic District (E)	Hopkins	None	Not noise sensitive
HE-HOC-0014	Minneapolis & St. Louis Rwy. Depot (E)	Hopkins	None	Not noise sensitive
HE-SLC-0008	Chicago Milwaukee & St. Paul R.R. Depot (L)	St. Louis Park	None	Not noise sensitive
HE-SLC-0009	Peavey-Haglin Concrete Grain Elevator (L)[b]	St. Louis Park	None	Not noise sensitive
HE-SLC-0055	Hoffman Callan Building (E)	St. Louis Park	None	Not noise sensitive
HE-MPC-17102	Minikahda Club (E)	Minneapolis	3	Outside area of concern for noise
HE-MPC-1811	Lake Calhoun (GRHD) (E)	Minneapolis	3	Outside area of concern for noise
HE-MPC-1833	Cedar Lake Parkway (GRHD) (E)	Minneapolis	None	Not noise sensitive
HE-MPC-1822	Kenilworth Lagoon [c] (GRHD, LIRHD) (E)	Minneapolis	3/1	Assessed for noise impact. Impact identified at the channel.
HE-MPC-1820	Cedar Lake (GRHD) (E)	Minneapolis	3	Outside area of concern for noise
HE-MPC-1825	Lake of the Isles Parkway (GRHD, LIRHD) (E)	Minneapolis	None	Not noise sensitive
HE-MPC-1824	Lake of the Isles (GRHD, LIRHD) (E)	Minneapolis	3	Outside area of concern for noise
HE-MPC-1796	Kenwood Parkway (GRHD, KPRHD) (E)	Minneapolis	None	Not noise sensitive
HE-MPC-6901	Park Board Bridge No. 4 / Bridge L5729 (Individual, GRHD, LIRHD) (E)	Minneapolis	None	Not noise sensitive
HE-MPC-1797	Kenwood Park (GRHD) (E)	Minneapolis	3	Outside area of concern for noise
HE-MPC-6475	Kenwood Water Tower (Individual, GRHD) (E)	Minneapolis	None	Not noise sensitive
HE-MPC-1782	The Parade (GRHD) (E)[e]	Minneapolis	None	Not noise sensitive
XX-PRK-001	Grand Rounds Historic District (GRHD) (E)	Minneapolis	3/1[d]	Not noise sensitive
HE-MPC-18059	Kenwood Parkway Residential Historic District (KPRHD) (E)	Minneapolis	2	Assessed for noise impact. No impacts identified.
HE-MPC-9860	Lake of the Isles Residential Historic District (LIRHD) (E)	Minneapolis	2	Outside area of concern for noise
HE-MPC-6766	Mahalia & Zachariah Saveland House (E)	Minneapolis	2	Outside area of concern for noise
HE-MPC-6603	Frank & Julia Shaw House (E)	Minneapolis	2	Outside area of concern for noise
HE-MPC-6068	Frieda & Henry J. Neils, House (L)	Minneapolis	2	Outside area of concern for noise
HE-MPC-8763	Mac Martin House (E)	Minneapolis	2	Outside area of concern for noise
HE-MPC-16387	St. Paul, Minneapolis & Manitoba R.R./ Great Northern Rwy. Historic District (E)	Minneapolis	None	Not noise sensitive
HE-MPC-16389	Osseo Branch, St. Paul, Minneapolis & Manitoba R.R. Historic District (E)	Minneapolis	None	Not noise sensitive
HE-MPC-6641	Dunwoody Institute (E)	Minneapolis	3	Outside area of concern for noise
HE-MPC-0441	Minneapolis Warehouse Historic District (L)	Minneapolis	None	Not noise sensitive

[a] None – Not included in any of the FTA noise-sensitive categories. Not noise sensitive.

[b] Also a National Historic Landmark

[c] Non-contributing element of the GRHD

[d] See individual resources.

[e] Parade was non-contributing before State Historic Preservation Office and the Minneapolis Parks and Recreation Board started to consider extending the period of significance (POS) for the Grand Rounds into the 1970s.

(E) – Eligible for listing under the National Historic Preservation Act

(L) – Listed under the National Historic Preservation Act

GRHD – Grand Rounds Historic District

LIRHD – Lake of the Isles Residential Historic District

KPRHD – Kenwood Parkway Residential Historic District

N/A – Vibration not assessed for outdoor land uses.

5.1.3 Station Noise

The primary noise source at stations is the sounding of the LRT bells as the trains enter and exit the stations. The noise from LRT bells was captured in the Project noise assessment.

5.1.4 Operations and Maintenance Facility Noise

The operations and maintenance facility (OMF) is not located near noise-sensitive receptors and therefore no noise impact is projected.

5.1.5 Construction Noise

Elevated noise levels are, to a degree, unavoidable for this type of project. Construction noise levels are subject to local noise ordinances and noise rules administered by the MPCA (Minnesota Rules Chapter 7030). MPCA administers these noise rules to establish maximum allowable noise levels for construction activities. To address both the applicable local noise ordinances and the MPCA noise rules, the Council will develop a Noise Control Plan. The Noise Control Plan will contain information regarding when advanced notice of construction activities will be provided to affected communities. The Noise Control Plan will also contain other stipulations, as described below, to help avoid or minimize construction noise impacts.

The Council will require that construction equipment used by contractors be properly muffled and in proper working order. Advanced notice of any planned abnormally loud construction activities will be provided to affected communities. In general, construction will occur within daytime hours. However, night construction may sometimes be required, for example to minimize traffic impacts or to improve safety. If nighttime construction is deemed necessary, during the Project's final design and construction stages, a nighttime construction mitigation plan will be developed.

For most construction equipment, diesel engines are typically the dominant noise source. For other activities, such as impact pile driving and jackhammering, noise generated by the actual process dominates. Short-term noise during construction of the Project can be intrusive to residents near the construction sites. Construction will consist of demolition, site preparation, laying new tracks, and erecting stations and will occur primarily during daytime hours. At some locations, more intensive work will occur, such as pile driving for structures and retaining walls, vibratory hammers and hydraulic "press-in" machinery for excavation support installation and excavation for the tunnels at the Highway 62 crossing and in the Kenilworth Corridor.

Table 5.1-5 shows noise levels of typical construction equipment from the FTA guidance manual, in terms of the maximum levels at a distance of 50 feet. Construction noise predictions at noise-sensitive locations depends on the amount of noise during each construction phase, the duration of the noise, and the distance from the construction activities to the sensitive receptor. The Leq for a particular set of assumptions is estimated using typical noise levels from Table 5.1-5.

TABLE 5.1-5
Typical Construction Noise Levels[a]

Equipment Type	Typical Noise Level (dBA) 50 feet
Backhoe	80
Compactor	82
Concrete Mixer	85
Concrete Pump	82
Crane, Derrick	88
Crane, Mobile	83
Dozer	85
Grader	85
Loader	85
Paver	89
Pump	76
Roller	74
Truck	88

[a] Conducting a construction noise impact assessment requires knowledge of the equipment likely to be used, the duration of its use, and the way it will be used by a contractor.

Source: FTA, 2006.

Table 5.1-6 provides an example of a construction noise projection for typical at-grade track construction. Using these assumptions, an 8-hour Leq of 88 dBA would be projected at a distance of 50 feet from the construction site.

Using the criteria in Section 2.1.2 and the example for at-grade construction in Table 5.1-5, screening distances for at-grade construction noise impact can be determined. For residential land use, the potential for short-term at-grade construction noise (Table 5.1-6) impact could extend to approximately 120 feet from the corridor; however, if nighttime construction is conducted, the potential for short-term noise impact from at-grade construction could extend approximately 380 feet from the corridor.

Typically, a contractor will provide this information as a part of a noise control plan for construction. See Section 6.1.2 for more information regarding the approach to mitigating construction noise.

TABLE 5.1-6
Typical Construction Scenario, At-Grade Track Construction

Equipment Type	Typical Noise Level (dBA) 50 ft	Equipment Utilization Factor (%)	Leq (dBA)
Grader	85	50	82
Backhoe	80	40	76
Compactor	82	20	75
Loader	85	20	78
Roller	74	20	67
Truck	88	40	84
Crane, Mobile	83	20	76
Total 8-hour workday Leq at 50 feet			88

5.2 Vibration

The FTA guidance manual on noise and vibration (FTA, 2006) is the primary source for the vibration methodology. The Draft EIS used the FTA general vibration assessment methodology, as described in Chapter 10 of the FTA guidance manual (FTA, 2006). The Final EIS uses a Detailed Vibration Assessment methodology, as described in Chapter 11 of the FTA guidance manual (FTA, 2006).

The vibration assessment included the following steps:

- Identified vibration-sensitive land uses in the corridor using aerial photography, GIS data, and field surveys, typically within 300 feet of the alignment.
- Measured vibration-propagation characteristics of the soil in the corridor at sensitive receptors (See Affected Environment – Section 4.2.2).
- Projected project vibration levels from transit operations, using project drawings provided by the PEC teams, and information on speeds, headways, track type, and vehicle vibration characteristics.
- Assessed the impact from transit by comparing the project vibration with the FTA vibration impact criteria in Chapter 8 of the FTA guidance manual (FTA, 2006).
- Recommended mitigation at locations where project vibration levels exceed the impact criteria.

5.2.1 Project Vibration

This section describes the vibration impacts for the Project. The project team conducted a Detailed Vibration Analysis and summaries of the analysis results are presented in Tables 5.2-1 and 5.2-2 for residential and institutional (e.g., churches and schools) land uses, respectively. Detailed vibration impact assessment results are contained in Appendix K.

The results include a tabulation of location information for each sensitive receptor group, the projections of future vibration levels, the impact criteria, and whether there will be vibration impacts. The tables also show the total number vibration impacts for each location, without mitigation measures.

As shown in Table 5.2-1, the Project will result in no vibration impacts for residential land uses (see Appendix E for locations of impacts).

TABLE 5.2-1
Summary of Vibration Assessments and Impacts for Residential Land Use[a]

Location	City	Side of Track	Distance from near LRT Track Centerline (feet)	LRT Speed (mph)	Max Vibration Velocity Level (VdB) in any 1/3-Octave Band		# of Impacts
					Project	FTA Impact Criterion	
Southwest Station Condos	Eden Prairie	W	125	20	51	72	0
Water Tower Apartments	Eden Prairie	E	100	35	56	72	0
Lincoln Parc Apartments	Eden Prairie	E	125	25	53	72	0
Residence Inn	Eden Prairie	W	40	45	63	72	0
Baymont Inn	Eden Prairie	W	80	45	59	72	0
Claremont Apts	Minnetonka	E	80	45	57	72	0
Greenfield Apts	Hopkins	E	200	55	46	72	0
Deer Ridge Apts	Minnetonka	W	250	55	46	72	0
Town Terrace Apts	Hopkins	W	300	55	55	72	0
Monroe Avenue	Hopkins	E	200	55	46	72	0
Westside Apts	Hopkins	E	125	35	55	72	0
Creekwood Estates	Hopkins	W	160	55	56	72	0

Location	City	Side of Track	Distance from near LRT Track Centerline (feet)	LRT Speed (mph)	Max Vibration Velocity Level (VdB) in any 1/3-Octave Band		# of Impacts
					Project	FTA Impact Criterion	
Edgebrook Drive	St. Louis Park	W	250	55	54	72	0
Railroad Avenue	St. Louis Park	E	50	55	69	72	0
Hoigaard Village	St. Louis Park	E	50	55	62	72	0
Cityscape Apts	St. Louis Park	W	125	55	58	72	0
Park Glen Townhomes	St. Louis Park	E	113	45	66	72	0
Inglewood Trails Apts	St. Louis Park	W	250	45	55	72	0
Ewing Avenue South	Minneapolis	W	100	45	56	72	0
Lake Citihomes	Minneapolis	W	88	20	54	72	0
Chowen Avenue South	Minneapolis	E	75	35	57	72	0
St. Louis Avenue	Minneapolis	W	44	45	57	72	0
Calhoun Isle Condos	Minneapolis	E	43	45	57	72	0
Dean Court	Minneapolis	E	45	45	57	72	0
Xerxes Avenue South	Minneapolis	E	45	45	57	72	0
Benton Boulevard	Minneapolis	E	43	45	57	72	0
Thomas Lane	Minneapolis	E	130	45	56	72	0
Burnham Road South	Minneapolis	W	102	45	56	72	0
Burnham Road North	Minneapolis	W	50	45	65	72	0
Thomas Avenue South	Minneapolis	E	50	35	62	72	0
Sheridan Avenue South	Minneapolis	E	130	45	54	72	0
South Upton Avenue	Minneapolis	W	125	40	54	72	0
South Upton Avenue	Minneapolis	E	100	45	57	72	0
Kenwood Parkway	Minneapolis	E	140	45	60	72	0
Catholic Charities	Minneapolis	W	50	55	65	72	0
Mary's Place	Minneapolis	E	40	20	57	72	0
Total							0

[a] The tunnel slab, a Project feature within the Kenilworth Corridor, will eliminate the vibration impacts relative to an LRT tunnel system with no slab in the same segment of the corridor

Notes:
The vibration levels for each location are the highest levels projected for that location. Vibration projections at other receptors within each location will be lower. The threshold of human perception to LRT and freight rail vibration is approximately 65 VdB or less, and annoyance begins to occur for frequent events at vibration levels over 70 VdB.

The impact assessment at the Water Tower and Lincoln Parc Apartments includes the deferred Eden Prairie Town Center. There will be no impact at either location without the station.

As shown in Table 5.2-2, the Project will result in no vibration impacts for institutional land uses.

TABLE 5.2-2
Summary of Vibration Impacts for Institutional Land Use

Location	City	Side of Track	Distance from near LRT Track Centerline (feet)	LRT Speed (mph)	Max Vibration Velocity Level (VdB) in any 1/3-Octave Band		# of Impacts
					Project Vibration Level	FTA Impact Criterion	
Access Genetics	Eden Prairie	E	125	25	53	72	0
Eagle Ridge Academy	Eden Prairie	E	225	35	42	75	0
Sunrise International Montessori School	Eden Prairie	E	300	40	52	75	0
American Medical Systems	Minnetonka	W	70	45	58	72	0
Total							0

The vibration levels for each location are the highest levels projected for that location. Vibration projections at other receptors within each location will be lower. The threshold of human perception to LRT and freight rail vibration is approximately 65 VdB or less, and annoyance begins to occur for frequent events at vibration levels over 70 VdB.

5.2.2 Project Ground-Borne Noise

This section describes the ground-borne impacts for the Project. The project team conducted a Detailed Vibration Analysis, and summaries of the analysis results are presented in Tables 5.2-3 and 5.2-4 for residential and institutional (e.g., churches and schools) land uses, respectively.

The results include a tabulation of location information (ground-borne noise is only assessed for tunnels and for locations such as studios) for each sensitive receptor group, the projections of future ground-borne noise levels, the impact criteria, and whether there will be ground-borne noise impacts. The tables also show the total number ground-borne noise impacts for each location, without mitigation measures.

As shown in Table 5.2-3, the Project would result in 54 ground-borne noise impacts for residential land uses in the tunnel section south of the Kenilworth Channel (see Appendix E for locations of impacts), without mitigation.

TABLE 5.2-3
Summary of Ground-Borne Noise Assessments and Impacts for Residential Land Use (without mitigation)[a]

Location	City	Side of Track	Distance from near LRT Track Centerline (feet)	LRT Speed (mph)	Ground-Borne Noise Level (dBA)		# of Impacts
					Project Ground-Borne Noise Level	FTA Impact Criterion	
St. Louis Avenue	Minneapolis	W	44	45	37	35	1 bldg (3 units)
Calhoun Isle Condos	Minneapolis	E	43	45	37	35	1 bldg (36 units)
Dean Court	Minneapolis	E	45	45	37	35	1 bldg (6 units)
Xerxes Avenue South	Minneapolis	E	45	45	37	35	1 bldg (8 units)
Benton Boulevard	Minneapolis	E	43	45	37	35	1
Burnham Road South	Minneapolis	W	102	45	25	35	0

Location	City	Side of Track	Distance from near LRT Track Centerline (feet)	LRT Speed (mph)	Ground-Borne Noise Level (dBA)		# of Impacts
					Project Ground-Borne Noise Level	FTA Impact Criterion	
Total							5 bldg/ 54 units

[a] The tunnel slab, a Project feature within the Kenilworth Corridor, will significantly reduce the number and magnitude of the ground-borne noise impacts relative to a tunnel without a slab within the same segment of the corridor.

Note: The ground-borne noise levels for each location are the highest levels projected for that location. Ground-borne noise projections at other receptors within each location will be lower. Ground-borne noise at the impact criterion of 35 dBA or less is generally acceptable to people for sleeping areas. Ground-borne noise levels are only assessed for tunnel sections.

TABLE 5.2-4
Summary of Ground-Borne Noise Assessments and Impacts for Institutional Land Use

Location	City	Side of Track	Distance from near LRT Track Centerline (feet)	LRT Speed (mph)	Ground-Borne Noise Level (dBA)		# of Impacts
					Project Ground-Borne Noise Level	Impact Criterion	
Shop HQ	Eden Prairie	E	100	35	17	25	0
Hearing Care Specialists (Audiologist)	Hopkins	E	See discussion below				
Total:							--

As shown in Table 5.2-4, the Project would not have a ground-borne noise impact at the Shop HQ (see Appendix F for locations of impacts); however, there is the potential for impact at the Hearing Care Specialists site in Hopkins. The Hearing Care Specialists site contains a sound booth where hearing tests are conducted. There are two thresholds established for these types of booths at certain frequencies. These frequencies are shown in Table 5.2-5. At each frequency there is a threshold established based on the testing method. The levels in the last row of the table show the projections of ground-borne noise from LRT operations inside the booth based on the measurements conducted in August 2015. Based on the results of the testing conducted at the site, the ground-borne noise would exceed the threshold at 125 Hz for the "Ears covered Telephonics Dynamic Headphone" testing method but will be below the threshold at 250 Hz for this testing method and below the thresholds for the "Ears Covered Insert" testing method (see Table 5.2-5).

TABLE 5.2-5
Summary of Hearing Care Specialist Ground-Borne Noise Impacts (without mitigation)

Hearing Test Type	125-Hz Octave Band	250-Hz Octave Band
ANSI Ears covered TDH	35	25
ANSI Ears covered insert	59	53
Estimated levels from LRT	37	20

5.2.3 Freight Vibration

A general assessment of freight vibration was also conducted for the Project for the area near the Kenilworth Channel where the freight tracks will be shifted closer to sensitive receptors to provide room for the LRT tracks. The results of the assessment indicated that there would be no vibration impacts from freight trains due to the shift in freight tracks, due primarily to the very low speeds of the freight trains. More information regarding the freight vibration assessment can be found in Appendix H of this document.

5.2.4 Cultural Resources

Based on data provided by MnDOT CRU of listed and eligible historic properties within the project vicinity, an assessment of the historic and cultural resources was conducted for the Project. The assessment was conducted to determine the vibration sensitivity of the resources along the corridor. For each resource site, a determination was made regarding the vibration sensitivity of the use and the FTA category it would fall under based on FTA guidance. The result of the cultural resources assessment, which is summarized in Table 5.2-6, is that only the Kenwood Parkway Residential Historic District is vibration sensitive and close enough to the Project to warrant a vibration impact assessment. This location was assessed for impact as a part of the vibration assessment detailed in Section 5.2.1.

In addition to the operational (long-term) assessment described above, an assessment for the potential for vibration-related construction (short-term) impacts was also conducted. The criteria for construction vibration impacts to damage buildings are based on the building category and fragility of the building, not its designation or use as a historic resource. In most cases, vibration generated by construction activities does not approach levels high enough to cause damage, even for fragile buildings. The exceptions to this can be for activities such as vibratory rolling and impact pile driving. At distances within approximately 50 feet, these activities have the potential for damage to the most sensitive structures. Based on the list of the structures contained in Table 5.2-6, they will either not be included in the most stringent category or will not be close enough for there to be any potential for damage. Therefore additional assessment is not warranted.

TABLE 5.2-6
Summary of Historic and Cultural Resources Vibration Assessment

Inventory #	Property Name	City	FTA Vib Cat[a]	Notes
HE-HOC-0026	Hopkins City Hall (E)	Hopkins	None	Not vibration sensitive
HE-HOC-0027	Hopkins Commercial Historic District (E)	Hopkins	None	Not vibration sensitive
HE-HOC-0014	Minneapolis & St. Louis Rwy. Depot (E)	Hopkins	None	Not vibration sensitive
HE-SLC-0008	Chicago Milwaukee & St. Paul R.R. Depot (L)	St. Louis Park	None	Not vibration sensitive
HE-SLC-0009	Peavey-Haglin Concrete Grain Elevator (L)[b]	St. Louis Park	None	Not vibration sensitive
HE-SLC-0055	Hoffman Callan Building (E)	St. Louis Park	None	Not vibration sensitive
HE-MPC-17102	Minikahda Club (E)	Minneapolis	3	Outside area of concern for vibration
HE-MPC-1811	Lake Calhoun (GRHD) (E)	Minneapolis	N/A	Not vibration sensitive
HE-MPC-1833	Cedar Lake Parkway (GRHD) (E)	Minneapolis	N/A	Not vibration sensitive
HE-MPC-1822	Kenilworth Lagoon[c] (GRHD, LIRHD) (E)	Minneapolis	N/A	Not vibration sensitive
HE-MPC-1820	Cedar Lake (GRHD) (E)	Minneapolis	N/A	Not vibration sensitive
HE-MPC-1825	Lake of the Isles Parkway (GRHD, LIRHD) (E)	Minneapolis	N/A	Not vibration sensitive
HE-MPC-1824	Lake of the Isles (GRHD, LIRHD) (E)	Minneapolis	N/A	Not vibration sensitive
HE-MPC-1796	Kenwood Parkway (GRHD, KPRHD) (E)	Minneapolis	N/A	Not vibration sensitive
HE-MPC-6901	Park Board Bridge No. 4 / Bridge L5729 (Individual, GRHD, LIRHD) (E)	Minneapolis	N/A	Not vibration sensitive
HE-MPC-1797	Kenwood Park (GRHD) (E)	Minneapolis	N/A	Not vibration sensitive
HE-MPC-6475	Kenwood Water Tower (Individual, GRHD) (E)	Minneapolis	None	Not vibration sensitive
HE-MPC-1782	The Parade (GRHD) (E)[e]	Minneapolis	N/A	Not vibration sensitive
XX-PRK-001	Grand Rounds Historic District (GRHD) (E)	Minneapolis	None[d]	Not vibration sensitive
HE-MPC-18059	Kenwood Parkway Residential Historic District (KPRHD) (E)	Minneapolis	2	Assessed for vibration impact. No impacts identified.
HE-MPC-9860	Lake of the Isles Residential Historic District (LIRHD) (E)	Minneapolis	2	Outside area of concern for vibration

Inventory #	Property Name	City	FTA Vib Cat[a]	Notes
HE-MPC-6766	Mahalia & Zachariah Saveland House (E)	Minneapolis	2	Outside area of concern for vibration
HE-MPC-6603	Frank & Julia Shaw House (E)	Minneapolis	2	Outside area of concern for vibration
HE-MPC-6068	Frieda & Henry J. Neils, House (L)	Minneapolis	2	Outside area of concern for vibration
HE-MPC-8763	Mac Martin House (E)	Minneapolis	2	Outside area of concern for vibration
HE-MPC-16387	St. Paul, Minneapolis & Manitoba R.R./ Great Northern Rwy. Historic District (E)	Minneapolis	None	Not vibration sensitive
HE-MPC-16389	Osseo Branch, St. Paul, Minneapolis & Manitoba R.R. Historic District (E)	Minneapolis	None	Not vibration sensitive
HE-MPC-6641	Dunwoody Institute (E)	Minneapolis	3	Outside area of concern for vibration
HE-MPC-0441	Minneapolis Warehouse Historic District (L)	Minneapolis	None	Not vibration sensitive

[a] None – Not included in any of the FTA vibration sensitive categories. Not vibration sensitive.
[b] Also a National Historic Landmark
[c] Non-contributing element of the GRHD
[d] See individual resources.
[d] Parade was non-contributing before State Historic Preservation Office and the Minneapolis Parks and Recreation Board started to consider extending the period of significance for the Grand Rounds into the 1970s.
(E) – Eligible for listing under the National Historic Preservation Act
(L) – Listed under the National Historic Preservation Act

5.2.5 Station Vibration

There is no additional vibration associated with stations; therefore, a vibration assessment for stations was not conducted.

5.2.6 Operations and Maintenance Facility Vibration

The OMF is not located near vibration-sensitive receptors and therefore no vibration impact is projected.

5.2.7 Construction Vibration

Unlike typical LRT operations, there is the potential for damage to nearby structures at close distances due to construction vibration from activities such as pile driving, hoe rams, vibratory compaction and loaded trucks. Most limits on construction vibration are based on reducing the potential for damage to nearby structures. Although construction vibrations are only temporary, it is still reasonable to assess the potential for human annoyance and damage.

In order to provide screening distances for potential monitoring of construction vibration throughout the corridor, a vibration criterion of 102 VdB (0.5 in/s) was used. A limit of 72 VdB was used to assess the potential for vibration annoyance from construction activities. Vibration source levels at 25 feet and the distances for potential monitoring and residential annoyance are shown in Table 5.2-7. With the exception of impact pile driving, most of the distances for potential monitoring are within 30 feet of construction activities. For impact pile driving, the distance for the potential for damage is up to 40 feet.

Because the exact location of construction equipment is important in projecting vibration levels, a pre-construction survey will be performed during final design when more information is known about equipment locations. It is important to note that this survey does not address potential damage to structures due to soil settlement or displacement due to construction activities.

TABLE 5.2-7
Summary of Potential Construction Vibration Impacts

Equipment	Vibration Level at 25 ft (VdB)	Distance for Construction Monitoring[a]	Distance to Potential Annoyance
Impact Pile Driving (Upper Range)	112	55	530
Impact Pile Driving (Typical)	104	30	300
Push Piling	84	6	62
Vibratory Piling (Upper Range)	105	32	310
Vibratory Piling (Typical)	93	13	125
Hoe Ram	87	8	80
Caisson Drilling	87	8	80
Loaded Trucks	86	7	75
Clam Shovel	94	13	135
Vibratory Roller	94	13	135

[a] These distances are to be used as guidance for construction vibration monitoring. Specific buildings to be monitored will be determined by the design team and contractors.

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6 Mitigation Measures

6.1 Noise

FTA guidance states that severe noise impacts should be mitigated unless there are no feasible or practical means to do so (FTA, 2006). For moderate impacts, discretion should be used, and project-specific factors should be included in the consideration of mitigation. The project-specific factors can include both the existing noise levels and the projected increase in noise levels; the types and number of noise-sensitive land uses with impacts; existing sound insulation of buildings; and the cost-effectiveness of providing noise mitigation. The Noise mitigation procedure contained in the Regional Transitway Guidelines (March 2016) (see Appendix D of the Final EIS) details which moderate impacts will qualify for mitigation. This procedure is detailed in Section 6.1.1 below, and the full procedure is contained in Appendix D of the Final EIS.

6.1.1 Noise Mitigation Procedure

6.1.1.1 Noise Mitigation Thresholds (Part A)

Per FTA guidance, noise mitigation will be provided for all "Severe" impacts that meet the criteria for reasonableness, feasibility, and cost effectiveness, as defined under Part B below.

At the "Moderate" impact level, FTA guidance requires the project sponsor to consider mitigation based on a number of factors, as defined in the FTA guidance manual. For the Project, noise mitigation will be provided for all "Moderate" impacts, caused by the Project, that meet the criteria for reasonableness, feasibility, and cost effectiveness, as defined under Part B below, and at locations where the Project has a "Moderate" impact and one of the following thresholds are exceeded:

1. Location(s) where the existing noise levels without the Project are already 65 dBA Ldn or greater (see Exhibit 2.1-1).[6]
2. Location(s) where there is an increase of 3 dB or more in the Ldn over the existing level due to the project.[7]
3. The predicted increase in the Ldn over the existing level is less than 3 dB, the location is adjacent to an area with either "Severe Impact" or "Moderate Impact" with an increase in the Ldn of 3 dB or greater, and the inclusion of the adjacent properties will provide a logical and equitable terminus to the mitigation.

6.1.1.2 Noise Mitigation Criteria (Part B)

Criteria for reasonableness, feasibility, and cost effectiveness as included in FTA guidance are described below.

1. Reasonableness: For noise mitigation to be considered reasonable, it must provide at least a 5 dB reduction in project noise.[8]
2. Feasibility:
    - For noise mitigation to be considered feasible it must be practical from engineering, operations, and safety standpoints.

[6] A noise level of 65 dBA or greater is considered a "normally unacceptable" noise environment by HUD. This threshold is also used by FAA for compatible land use.

[7] An increase in noise of 3 dB is generally considered the threshold for a noticeable change in noise in an outdoor setting and falls roughly at the midpoint of the "Moderate" impact range. This is a common threshold used in transit agency noise mitigation policies for an increase requiring mitigation.

[8] 5 dB is a typical minimum reduction used by many agencies for mitigation to be considered an effective and reasonable mitigation measure.

- Other Project factors may need to be considered in determining feasibility of mitigation. These could include community input, visual impacts and other Project features that might limit mitigation.

3. Cost Effectiveness: For noise mitigation to be considered cost effective, the cost per benefited receptor should be approximately what it would cost to build a ten foot high noise wall.

6.1.2 Noise Mitigation Methods

Several options exist for providing noise mitigation at the source, path or receiver. The most common noise mitigation measures are described below.

6.1.2.1 Source

Resilient or Damped Wheels: Using either resilient or damped wheels can achieve approximately a 2 dB reduction in wheel/rail noise from transit vehicles on typical track sections.

Rail Dampers: Using damping materials on tracks can achieve an approximately 1-3 dB reduction in noise radiated from the tracks on typical track sections.

Vehicle Design: Certain design features of transit vehicles can provide some shielding and/or absorption of the noise generated by the vehicle. Acoustical absorption under the car can provide up to a 5 dB reduction in wheel/rail noise and propulsion-system noise on rapid transit trains. Similarly, vehicle skirts (which the existing Metro Transit vehicles have) over the wheels can provide up to 5 dB of reduction in noise.

Special Trackwork: Gaps in the rails at crossovers and turnouts generates around 6 dB of increased noise for locations close to the track. If crossover are located in sensitive areas and cannot be moved, one approach is to use special trackwork, such as spring-rail, moveable point, or flange bearing frogs to eliminate the gap in the rail at the crossover.

Quiet Zones: Quiet Zones are locations, as least one-half mile in length, where the sounding of horns has been eliminated because of safety improvements at at-grade crossings, including modifications to the streets, raised median barriers, four quadrant gates, and other improvements. Horns will only be sounded in emergency situations at these locations.

Wayside Bells: Wayside bells are mounted at the at-grade-crossing, directed down the roadway instead of mounted on the vehicle. The wayside bells are directive and provide warning to motorists and pedestrians at the at-grade crossing while limiting the noise exposure to areas adjacent to the crossing.

6.1.2.2 Path

Noise Barriers: This is the most common approach to reducing noise impacts from transit and rail projects. For noise barriers to be effective, they must break the line-of-sight between the source of the noise and the receiver. Additionally, the barrier must be made of a material that has a minimum surface density of four pounds/square foot and not have any gaps or holes that could degrade the performance of the barrier. Noise barriers can be made of virtually any material that meets these requirements, and can typically provide between 5 and 10 dB of reduction, depending on the design of the barrier. Project features, such as retaining walls or crash walls can act as effective noise barriers.

Berms: Berms are another approach to mitigating noise at the path. Berms work in much the same way as barriers, and need to block the line of sight between the source and the receiver to be effective. Berms can also provide between 5 and 10 dB of reduction, but are not commonly used in transit applications due to the space requirements (a berm typically must be twice as wide as it is tall).

6.1.2.3 Receiver

Sound Insulation: In locations where noise barriers are not feasible or practical, for multi-story buildings, or at locations where there is no exterior use, sound insulation of buildings can be an effective approach to noise mitigation. While it does not provide mitigation for exterior use, it can be very effective for indoor uses and provide between 5 and 10 dB of reduction. Sound insulation typically focuses on improvements to

windows and doors, sealing any gaps or holes and if necessary, providing central ventilation and air conditioning so that windows can remain closed. The criterion for indoor noise levels is 45 dBA Ldn.

6.1.3 Project Noise Mitigation

At most locations, quiet zones, which allow for the use of LRT bells instead of horns at at-grade crossings, will eliminate most noise impacts. Additionally, the quiet zones will have the additional benefit of eliminating the existing freight horns as well. In addition to the specific noise mitigation measures listed below in Table 6.1-1, the Project will employ several best practice methods to minimize noise project-wide. These measures include using wheel skirts (panels over the wheels) to reduce wheel/rail noise and continuously welded rail to eliminate gaps in the tracks that generate additional noise. Throughout the design process, noise generating elements (e.g., crossovers) have been located, where possible, away from sensitive locations. At other locations, more detailed descriptions of the noise mitigation measures are provided after the table.

TABLE 6.1-1
Summary of Mitigation Measures for Residential Locations

Location	City	Side of Track	Type and # of Impacts without Mitigation		Noise Level Increase (dB)[a]	Mitigation Measure[b,c]	Residual Impacts	
			Mod	Sev			Mod	Sev
Residence Inn	Eden Prairie	W	1 bldg	1 bldg	5.9	Sound insulation improvements at nearest building	0	0
Baymont Inn	Eden Prairie	W	1 bldg	0	3.0	Interior noise levels meet interior criterion – No mitigation required	0	0
Claremont Apartments	Minnetonka	E	4 bldgs (126 units)	0	3.7	8' high noise barrier extending 1,800 feet	0	0
Hopkins Plaza Apartments	Hopkins	W	0	5 bldgs (71 units)	6.6	Quiet Zone eliminating LRT horns, LRT bells only	0	0
7th Avenue	Hopkins	W	2	0	3.5	Quiet Zone eliminating LRT horns, LRT bells only	0	0
Sonoma Apartment	Hopkins	W	1 bldg (12 units)	0	3.7	Quiet Zone eliminating LRT horns, LRT bells only	0	0
6th Avenue	Hopkins	W	5	0	3.2	Quiet Zone eliminating LRT horns, LRT bells only	0	0
Town Terrace Apartments	Hopkins	W	0	5 bldgs (68 units)	4.7	Quiet Zone eliminating LRT horns, LRT bells only	0	0
Monroe Avenue	Hopkins	E	2	0	3.2	3' high parapet barrier extending 500 feet on elevated structure over Excelsior Boulevard	0	0
Westside Apartments	Hopkins	E	0	6 bldgs (171 units)	17.4	Quiet Zone eliminating LRT horns, LRT bells only	0	0
Creekwood Estates	Hopkins	W	0	6 bldgs (72 units)	12.1	Quiet Zone eliminating LRT horns, LRT bells only	0	0
Railroad Avenue	St. Louis Park	E	0	42 bldgs (44 units)	24.0	Quiet Zone eliminating LRT horns, LRT bells only + 8' to 11' noise barrier extending 760 feet	0	0
Village in the Park Condos	St. Louis Park	E	0	2 bldgs (64 units)	12.0	Quiet Zone eliminating LRT horns, LRT bells only	0	0
TowerLight	St. Louis Park	E	0	1 bldg (66 units)	8.8	Quiet Zone eliminating LRT horns, LRT bells only	0	0
35th St. Apartments	St. Louis Park	W	1 bldg (16 units)	0	3.0	Quiet Zone eliminating LRT horns, LRT bells only	0	0

Location	City	Side of Track	Type and # of Impacts without Mitigation		Noise Level Increase (dB)[a]	Mitigation Measure[b,c]	Residual Impacts	
			Mod	Sev			Mod	Sev
Hoigaard Village	St. Louis Park	E	1 bldg (32 units)	0	2.3	No mitigation required[d]	1 bldg (32 units)	0
Park Glen Townhomes	St. Louis Park	E	16	0	1.5	No mitigation required[d]	16	0
Lake Citihomes	Minneapolis	W	1 bldg (7 units)	0	1.8	No mitigation required[d]	1 bldg (7 units)	0
Kenilworth Channel	Minneapolis	E/W	1	0	7.2	2' high parapet wall and rail dampers 300'	0	0
Burnham Road North	Minneapolis	W	1	0	4.4	Interior testing[e]	0	0
Burnham Road North	Minneapolis	W	4	0	2.9	No mitigation required[d]	4	0
Thomas Avenue South	Minneapolis	E	3	1	8.4	Wayside bell eliminating one impact, plus sound insulation of remaining residences[e]	0	0
Sheridan Avenue South	Minneapolis	E	3	0	3.7	Wayside bell	0	0
South Upton Avenue	Minneapolis	W	6	0	3.6	Wayside bell	0	0
Total:			52/238	69/558			22/59	0

[a] The noise level increase represents the total change in noise level (without mitigation) from the existing to the future noise level with the introduction of the Project.

[b] If the noise mitigation guidelines, as contained in the Regional Transitway Guidelines (March 2016) (see Appendix D) is found to not meet reasonable criterion or if the property owner(s) does not approve sound insulation, the Project will result in additional residual noise impacts.

[c] Quiet zones are locations, at least one-half mile in length, where the routine sounding of horns has been eliminated because of safety improvements at at-grade crossings, including modifications to the streets, raised median barriers, four quadrant gates, and other improvements designed and implemented by the Project and consistent with quiet zone readiness. Horns are sounded in emergency situations at these locations. Municipalities must apply to FRA for approval of quiet zones. If the municipality fails to apply for a quiet zone or FTA fails to approve the quiet zone, the Project may result in residual noise impacts.

[d] The moderate impacts at these locations do not meet the threshold for mitigation (e.g., impact does not meet 3-dB increase threshold) as defined in the Regional Transitway Guidelines (March 2016) (see Appendix D).

[e] The Council has determined that a noise barrier at these locations would not meet the noise mitigation guidelines for reasonable and feasible criteria contained in the Regional Transitway Guidelines (March 2016) (see Appendix D). As such, no noise barrier will be constructed to mitigate impacts to these residences. Final determination of mitigation measures for these residences will be assessed with on-site testing to determine if the residences meet the interior noise level criteria (defined in Appendix K). Based on the results, the Council will identify the noise mitigation to be implemented for these residences during Engineering and once on-site measurements are completed. If an exceedance of interior noise level is identified at these locations, the Council will work with property owners on applicable mitigation. This could include implementation of sound insulation, which would still require approval by the property owner(s).

- **Residence Inn/Baymont Inn.** These hotels have only interior uses. Therefore, the interior criterion of 45 dBA Ldn was used to determine if there would be any impact inside the buildings. Based on outdoor-indoor testing at both hotels, the existing sound insulation of the all the buildings except the nearest building at the Residence Inn would be sufficient to meet the indoor criterion and no further mitigation is required. At the remaining building (at the southeast portion of the property) the projected interior noise level is 46 dBA Ldn. Replacing the sliding glass doors with an STC 50 rating equivalent and sealing off the chimney openings will bring the interior noise levels to within the criterion and eliminate the impact.

- **Claremont Apartments.** The proposed mitigation at this location is a noise barrier, approximately eight feet in height above the top of the rail extending for approximately 1,800 feet. The proposed mitigation measure would eliminate all the moderate noise impacts.
- **Monroe Avenue.** The proposed mitigation at this location is a parapet noise barrier on the elevated structure, approximately three feet in height above the top of the rail extending for approximately 1,500 feet. The proposed mitigation measure will eliminate all the moderate noise impacts.
- **Railroad Avenue.** In addition to a quiet zone at Wooddale Avenue, the proposed mitigation at this location is a noise barrier, approximately 8 to 11 feet in height above the top of the rail at the southern end tapering to 13 feet in height above the top of the rail at the northern end, extending for approximately 760 feet. The proposed mitigation measure will eliminate all the severe and moderate noise impacts.
- **Kenilworth Channel.** The mitigation measure at this location is a 2-foot-high noise barrier above the top of the rail on both sides of the LRT bridge, along with rail dampers on both tracks, extending 150 feet in each direction from the center of the LRT bridge (300 feet total). This mitigation measure will eliminate the moderate impact at the channel.
- **Burnham Road North.** The mitigation at this location is sound insulation of the single residence over the mitigation threshold located to the northwest of the channel. The remaining residences are all below the mitigation threshold. The mitigation measure will eliminate the moderate noise impact at the residence over the mitigation threshold.
- **Thomas Avenue South/Sheridan Avenue South/South Upton Avenue.** The mitigation at this location includes a combination of a wayside bell and sound insulation at residences with impacts remaining after implementation of the wayside bell. Because the residences are immediately adjacent to the at-grade crossing at 21st Street and the geometry of the location is not favorable to barrier design, noise barriers are not feasible. Sound insulation testing, to determine the existing outdoor-indoor noise reduction and improvements required to meet the 45 dBA Ldn interior criterion, will be conducted during Engineering.

6.1.4 Construction Noise Mitigation

The primary means of mitigating noise from construction activities is to require the contractors to prepare a detailed Noise Control Plan. A noise control engineer or acoustician will work with the contractor to prepare a Noise Control Plan in conjunction with the contractor's specific equipment and methods of construction. Key elements of a Plan include:

- Contractor's specific equipment types
- Schedule and methods of construction
- Maximum noise limits for each piece of equipment with certification testing
- Prohibitions on certain types of equipment and processes during the nighttime hours without local agency coordination and approved variances
- Identification of specific sensitive sites near construction sites
- Methods for projecting construction noise levels
- Implementation of noise control measures where appropriate
- Methods for responding to community complaints

6.2 Vibration

Vibration and ground-borne noise impacts that exceed the FTA criteria are considered significant and should be mitigated unless there are no feasible or practical means to do so. Vibration mitigation is primarily applied at the source, generally the track structure, and is dependent on the frequency content of

the vibration and any resonances of the materials. The most common vibration mitigation measures are described below.

6.2.1 Vibration Mitigation Methods

Ballast Mats: A ballast mat is a pad made of rubber or other material placed underneath the ballast and mounted on top of an asphalt or concrete base. Ballast mats provide a modest reduction in vibration levels at frequencies above 40 Hz.

Resilient Rail Fasteners: Resilient fasteners are typically used on direct fixation track on aerial structures or in tunnels. They include a resilient component in the fastener to provide vibration isolation. Resilient rail fasteners provide a reduction in vibration at frequencies above 40 Hz. In addition, the efficacy of resilient rail fasteners as a mitigation measure for vibration and also for ground borne noise impacts has been broadly studied and documented in the U.S. and globally. The degree of insertion loss or effectiveness of resilient rail fasteners is shown to be largely dependent on the degree of stiffness change between the typical fastener and the resilient fastener. Based on data obtained before and after installation of resilient fasteners, there is typically a 15-dB change in insertion loss for each tenfold change in fastener static stiffness. Resilient rail fasteners have been shown (based on before and after study) to result in an insertion loss between 30 hz - 80 Hz of approximately 14 dB.

Resiliently Supported Concrete Ties: Resiliently supported concrete ties, or undertie pads, consist of a rubber pad mounted on the bottom of a concrete tie. The pads provide vibration isolation at frequencies above 25 Hz.

Special Trackwork: Gaps in the rails at crossovers and turnouts generates around 10 dB of increased vibration for locations close to the track. If crossovers are located in sensitive areas and cannot be moved, one approach is to use special trackwork, such as spring-rail, moveable point, or flange bearing frogs to eliminate the gap in the rail at the crossover.

6.2.2 Project Vibration Mitigation

The proposed vibration mitigation measures for the Project include the following:

- **Kenilworth Tunnel**: Highly resilient rail fasteners in the tunnel section (approximately 2,200 feet) to eliminate the ground-borne noise impacts. The fasteners should be designed to provide at least 5 dB of reduction in vibration levels at 80 Hz and higher.
- **Hearing Care Specialists**: Replace the existing vibration isolation elements between the floor of the building and the sound booth. The vibration isolation (rubber pads or springs) should have a resonance frequency no greater than 40 Hz and should provide at least 10 dB of reduction in vibration levels at 80 Hz and higher.

6.2.3 Construction Vibration Mitigation

The most effective methods for minimizing the impact from construction vibration is to limit the use of high-vibration activities such as impact pile driving and vibratory rolling when construction is especially close to existing structures or sensitive land uses and to include vibration limits in the construction specifications. To mitigate potential vibration impact from construction activities, the following measures will be applied where feasible:

- **Limit Construction Hours:** Limit high-vibration activities at night.
- **Construction Specifications:** Include limits on vibration in the construction specifications, especially at locations where high-vibration activities such as impact pile driving may occur.
- **Alternative Construction Methods:** Minimize the use of impact and vibratory equipment, where possible and appropriate. Use low vibration alternatives, such as push piling or pre-drilled holes for piling.
- **Truck Routes:** Use truck haul routes that minimize exposure to sensitive receptors and minimize damage to roadway surfaces, where appropriate.

- **Pre-Construction Survey:** Perform pre-construction surveys to document the existing conditions of structures in the vicinity of sites where high-vibration construction activities will be performed.
- **Vibration Monitoring:** If a construction activity has the potential to exceed the damage criteria at any building, the contractor is required to conduct vibration monitoring and, if the vibration exceeds the limit, the activity must be modified or terminated.

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7 References

Federal Transit Administration (FTA). 2006. *Transit Noise and Vibration Impact Assessment.*

ATS Consulting. 2008. *Vibration Measurements and Predictions for Central Corridor LRT Project*.

Minnesota Pollution Control Agency (MPCA). 2015. *A Guide to Noise Control in Minnesota*.

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Appendix A. Noise Measurement Data

EXHIBIT A-1
Long-Term Noise Measurement Data – Site N2

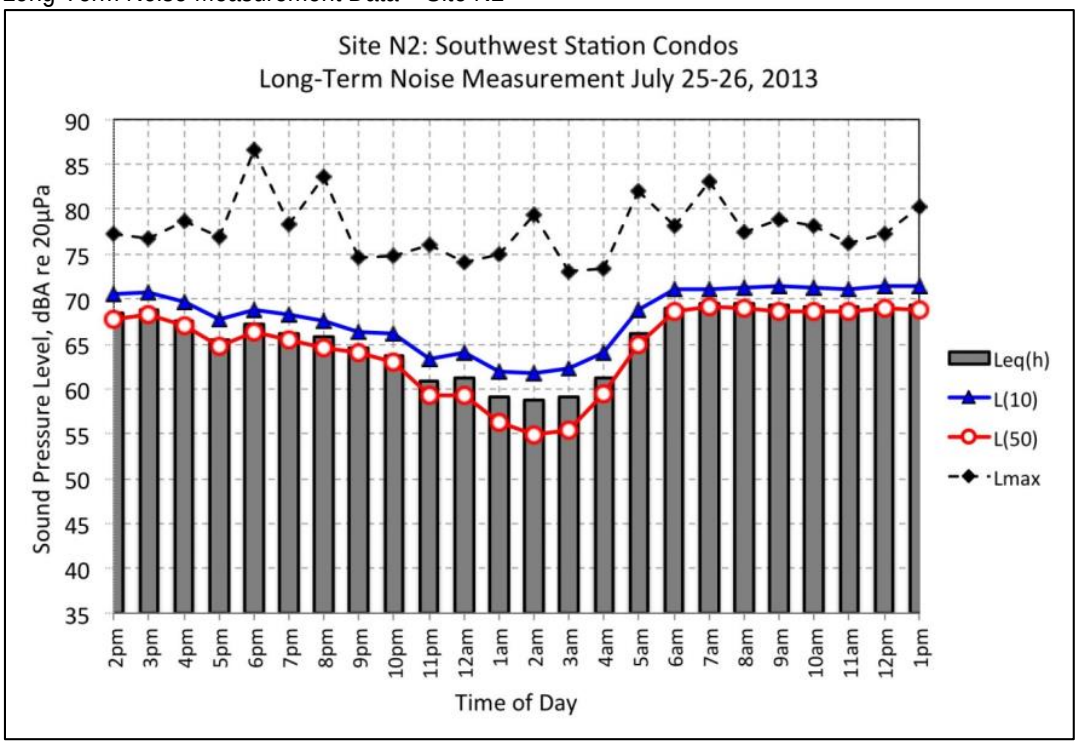


EXHIBIT A-2
Long-Term Noise Measurement Data – Site N4

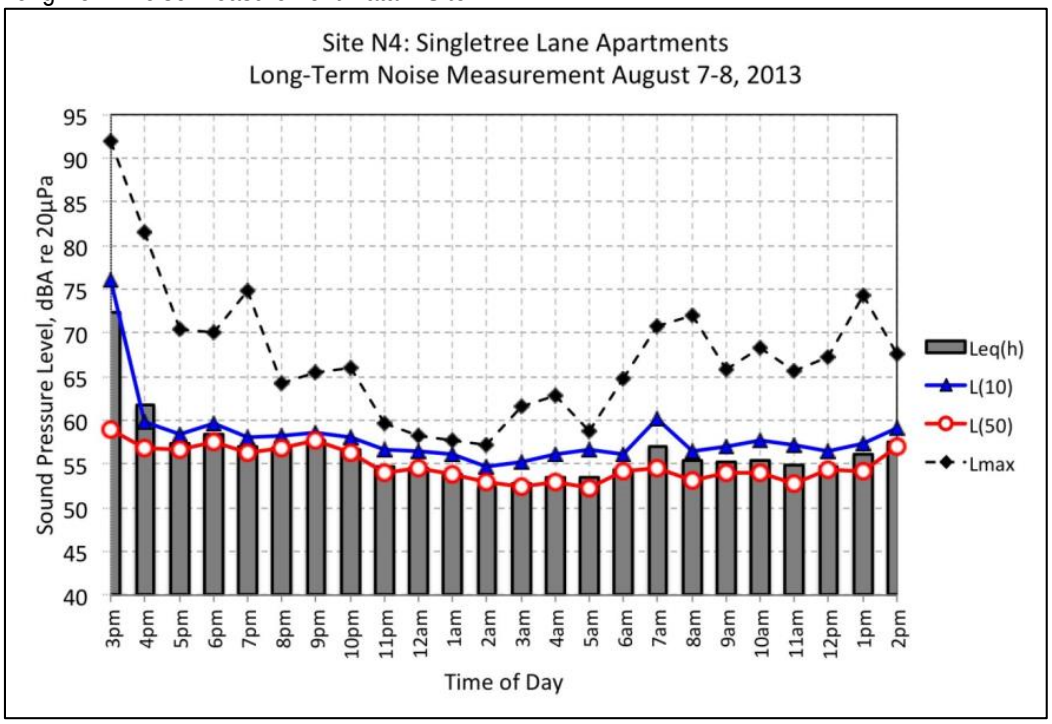


EXHIBIT A-3

Long-Term Noise Measurement Data – Site N5

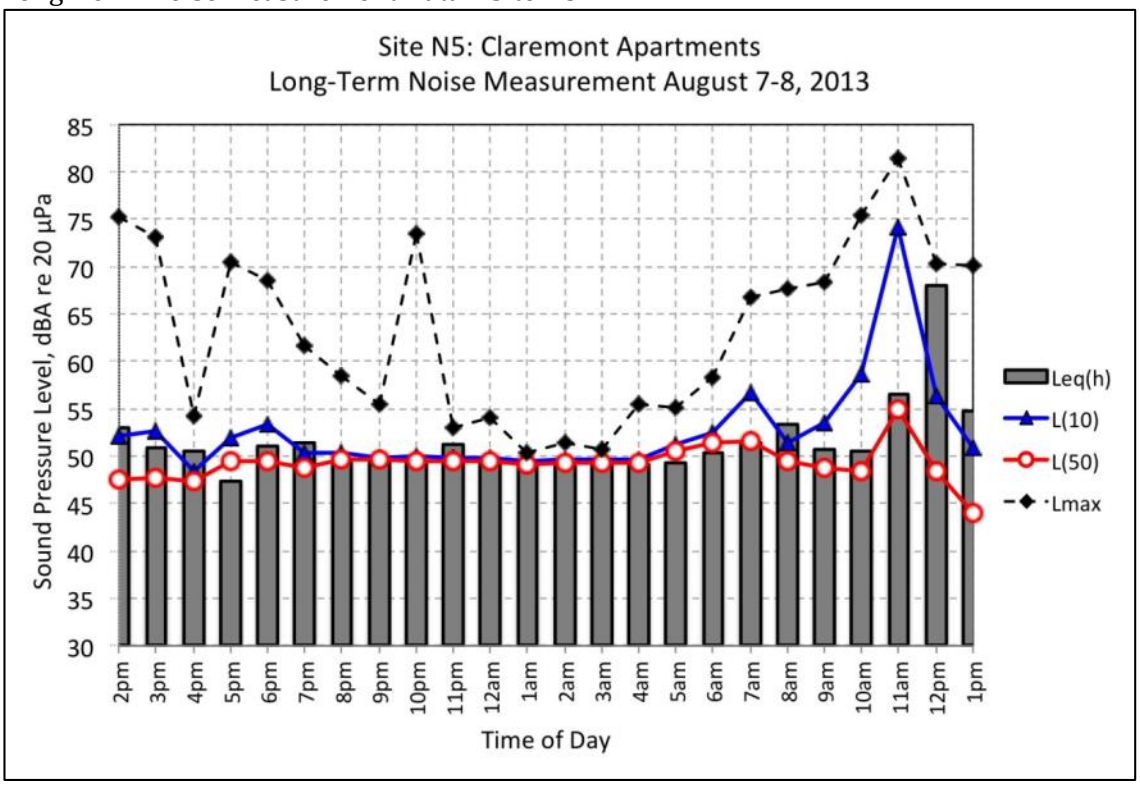


EXHIBIT A-4

Long-Term Noise Measurement Data – Site N6

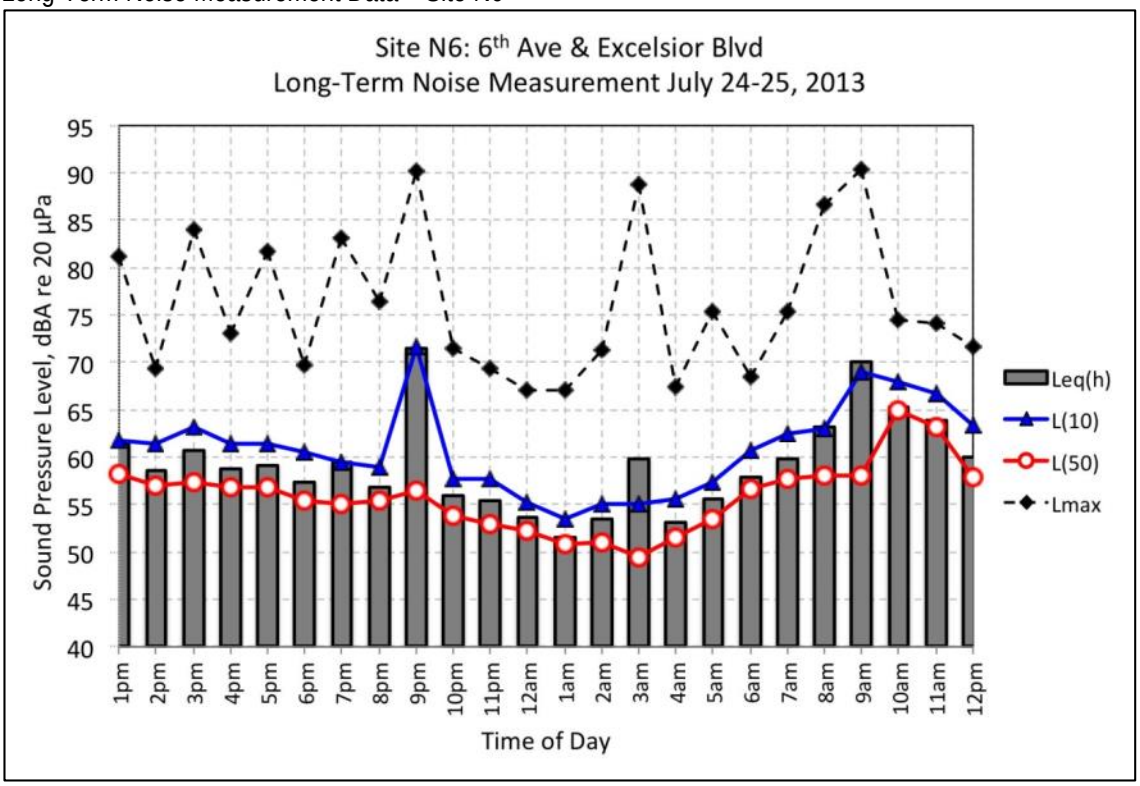


EXHIBIT A-5
Long-Term Noise Measurement Data – Site N7

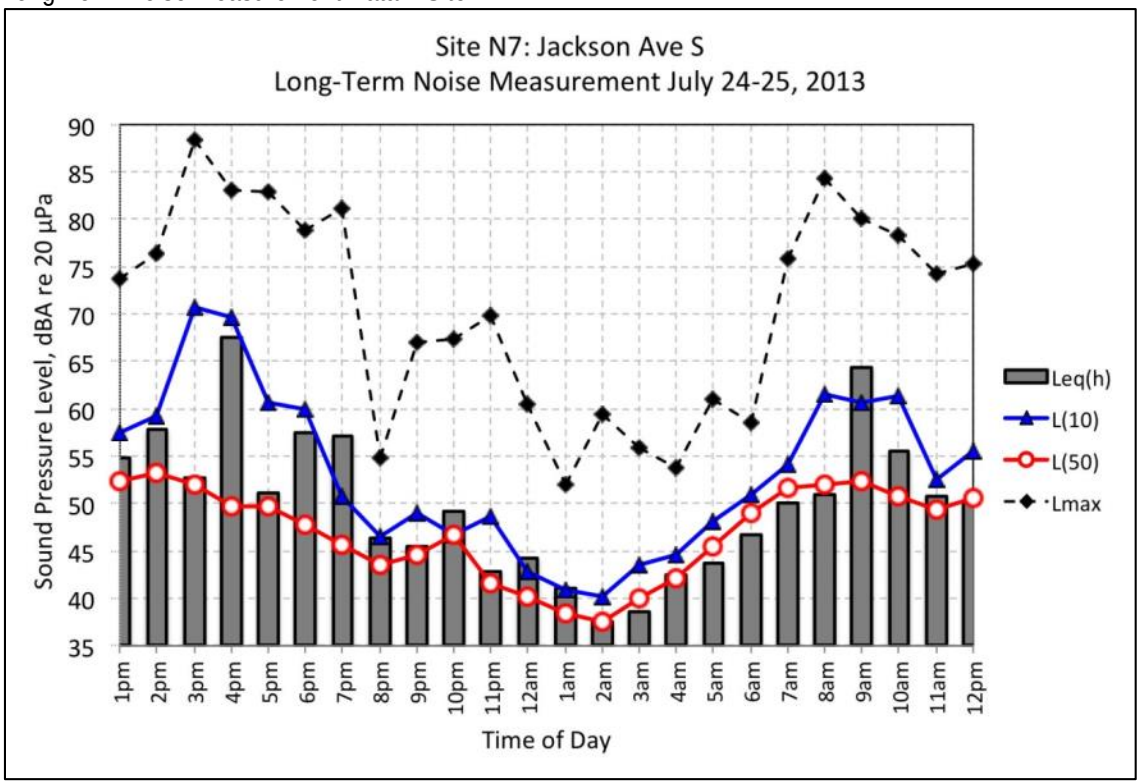


EXHIBIT A-6
Long-Term Noise Measurement Data – Site N8

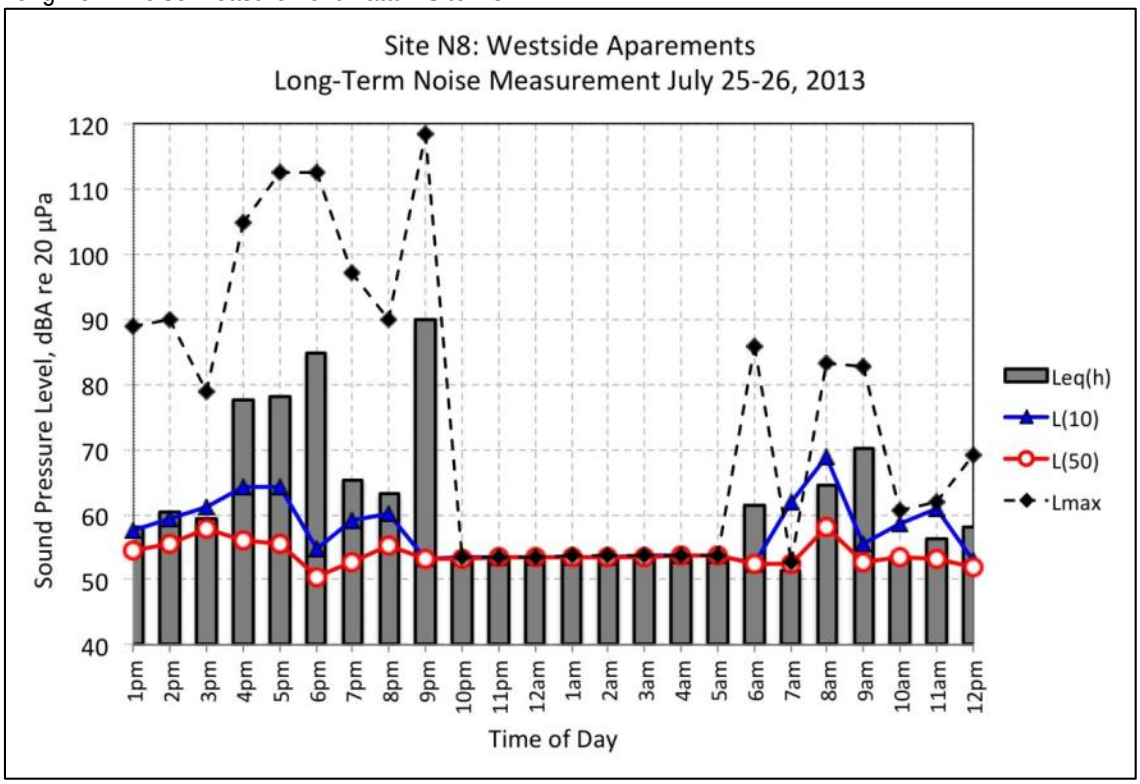


EXHIBIT A-7
Long-Term Noise Measurement Data – Site N9

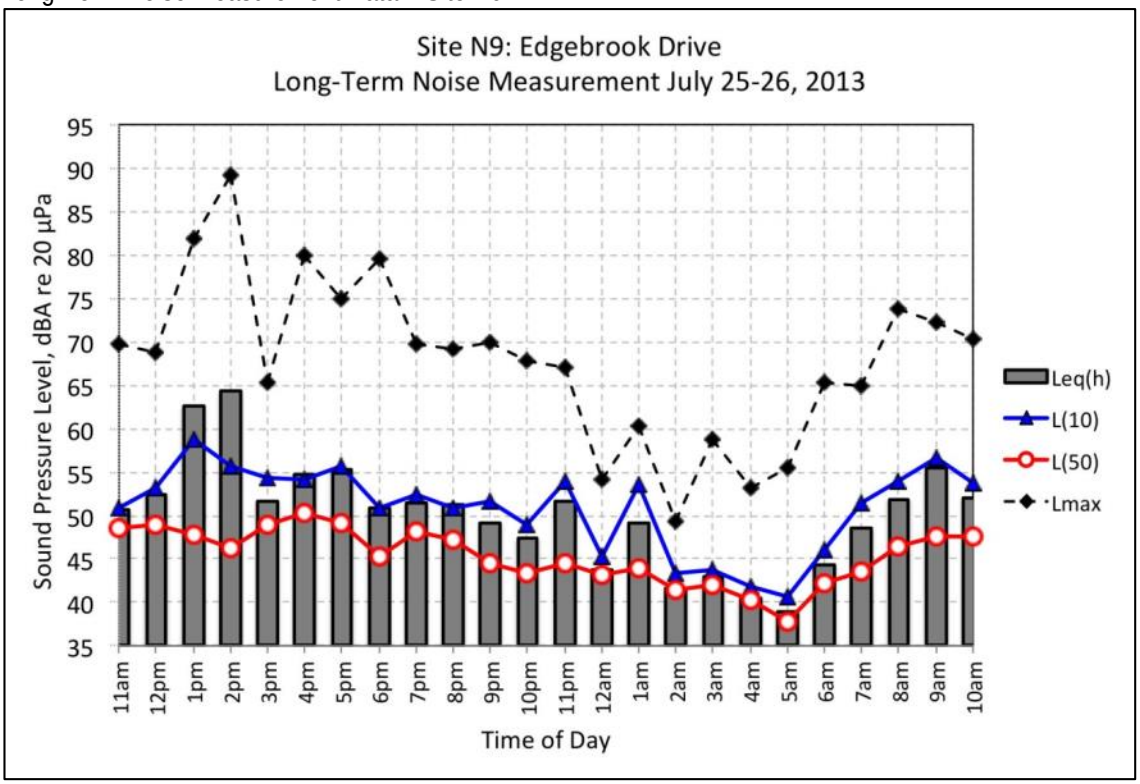


EXHIBIT A-8
Long-Term Noise Measurement Data – Site N14

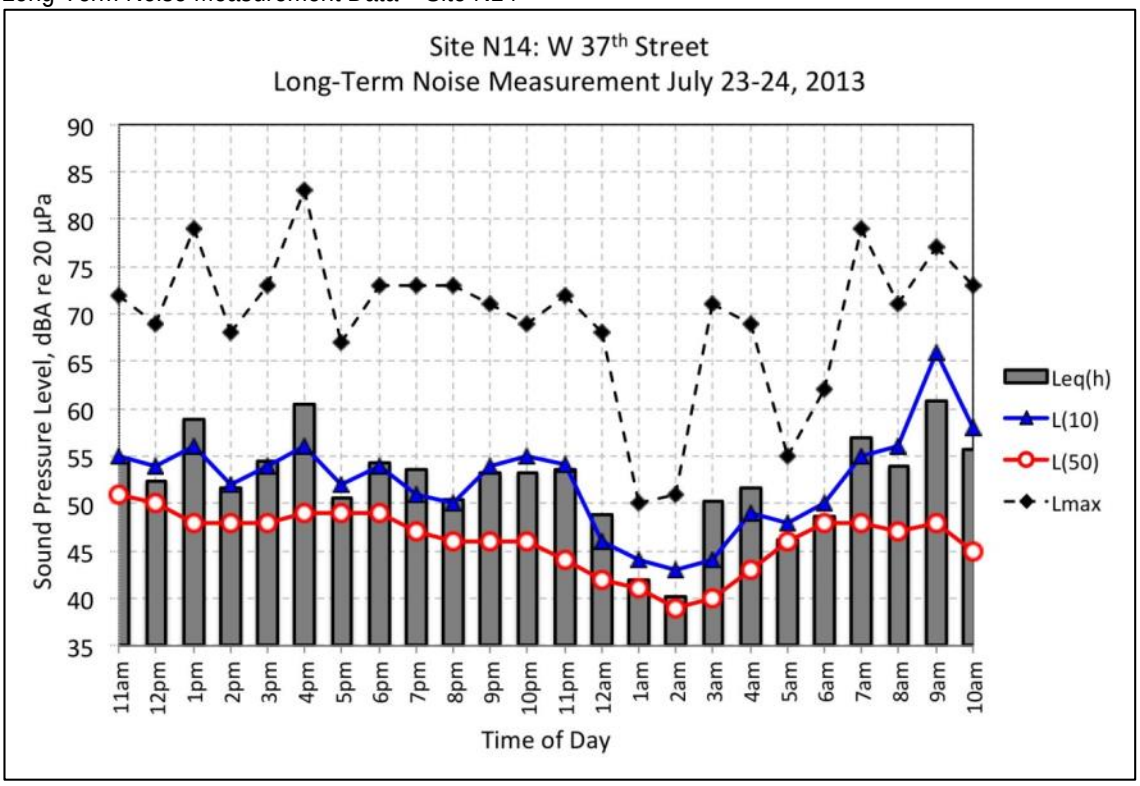


EXHIBIT A-9

Long-Term Noise Measurement Data – Site N15

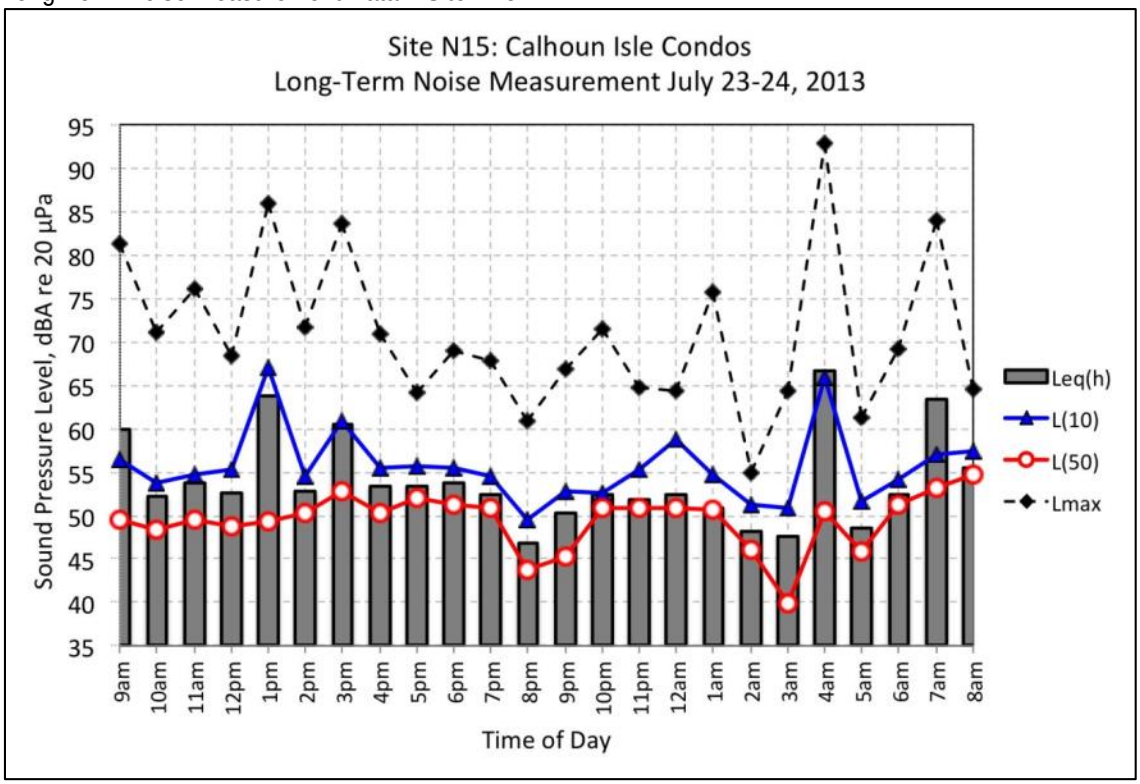


EXHIBIT A-10

Long-Term Noise Measurement Data – Site N16

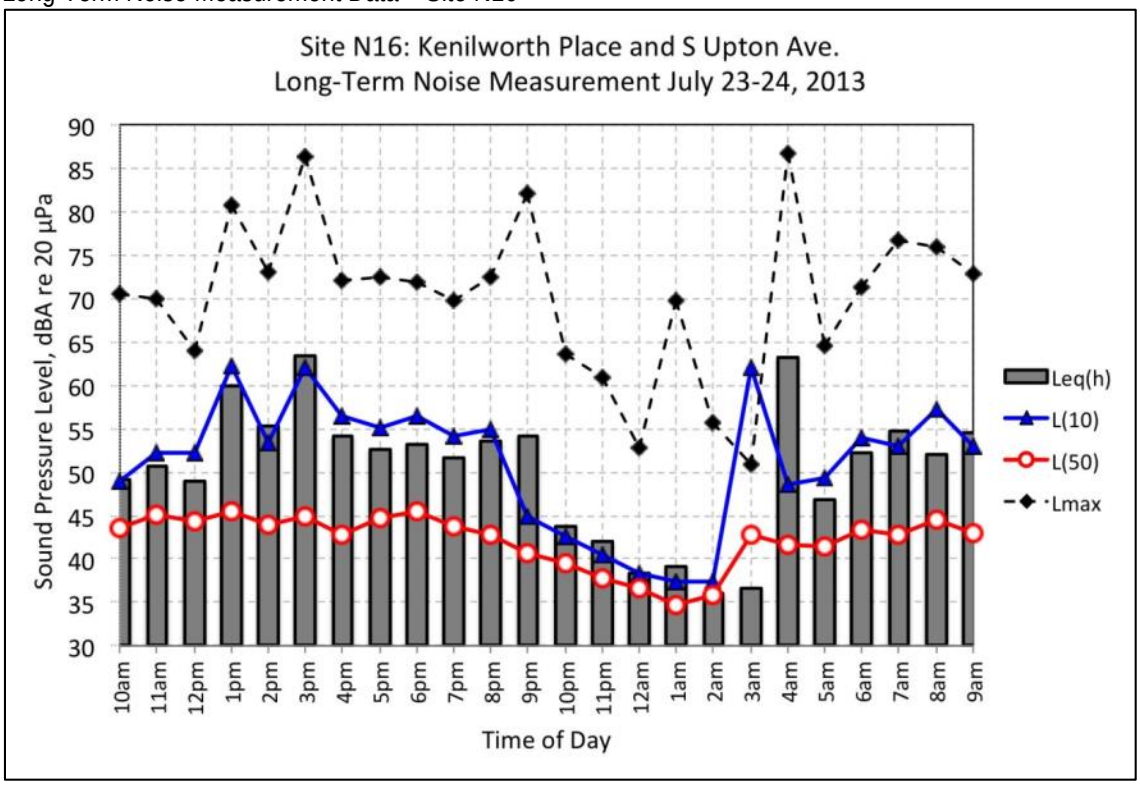


EXHIBIT A-11
Long-Term Noise Measurement Data – Site N17

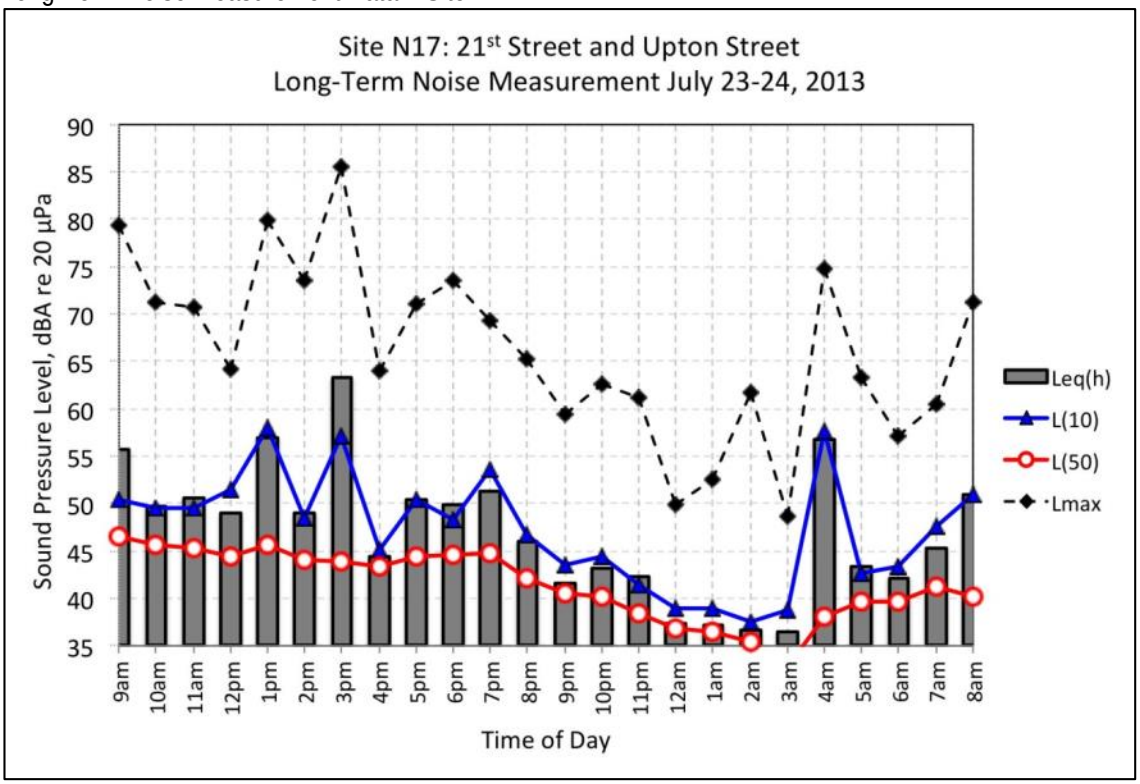
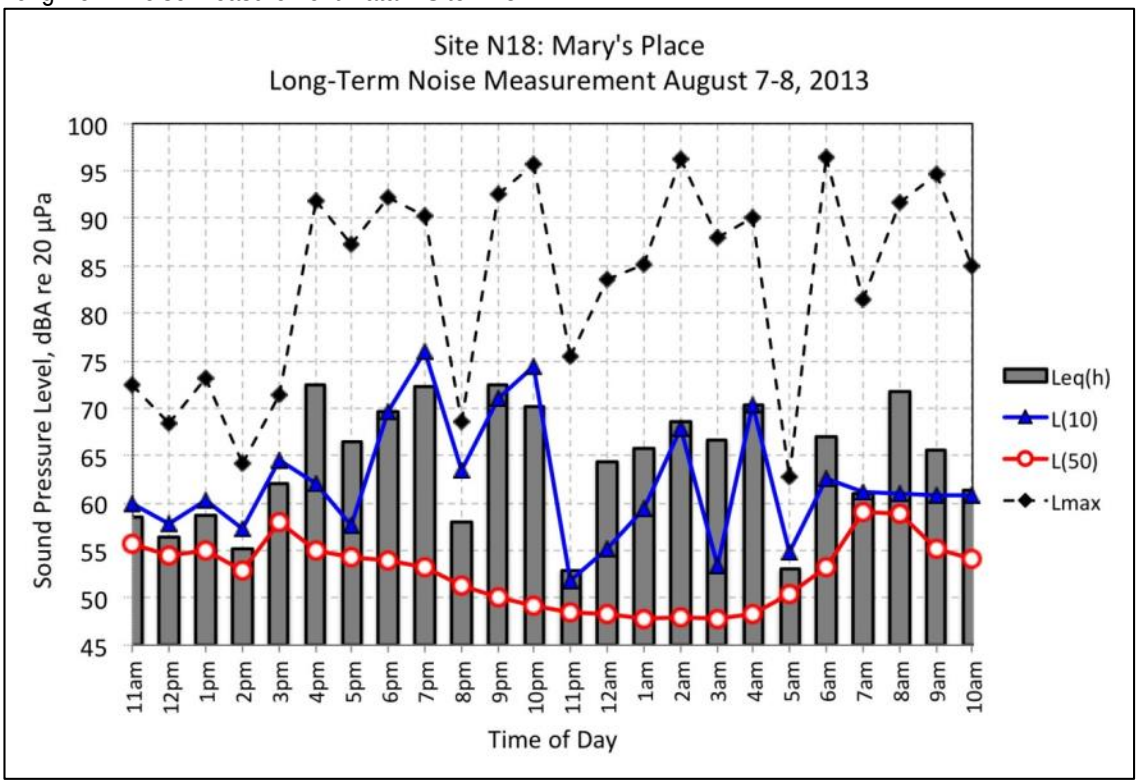


EXHIBIT A-12
Long-Term Noise Measurement Data – Site N18



Appendix B. Vibration Propagation Measurement Data

TABLE B-1
1/3-Octave Band Transfer Mobility Coefficients – Site V2

Coefficients	6.3 Hz	8 Hz	10 Hz	12.5 Hz	16 Hz	20 Hz	25 Hz	31.5 Hz	40 Hz	50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz	200 Hz
A	48.4	43.2	50.9	58.3	52.4	60.3	59.2	60.6	55.8	54.4	58.8	63.8	68.0	63.1	42.5	32.1
B	-12.3	-9.0	-11.6	-14.9	-10.8	-14.2	-12.7	-14.2	-13.9	-15.3	-19.5	-25.6	-29.7	-29.3	-19.3	-14.1
C	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

$$TM= A+B*\log(dist)+C*\log(dist)^2$$

EXHIBIT B-1
Line Source Transfer Mobility – Site V2

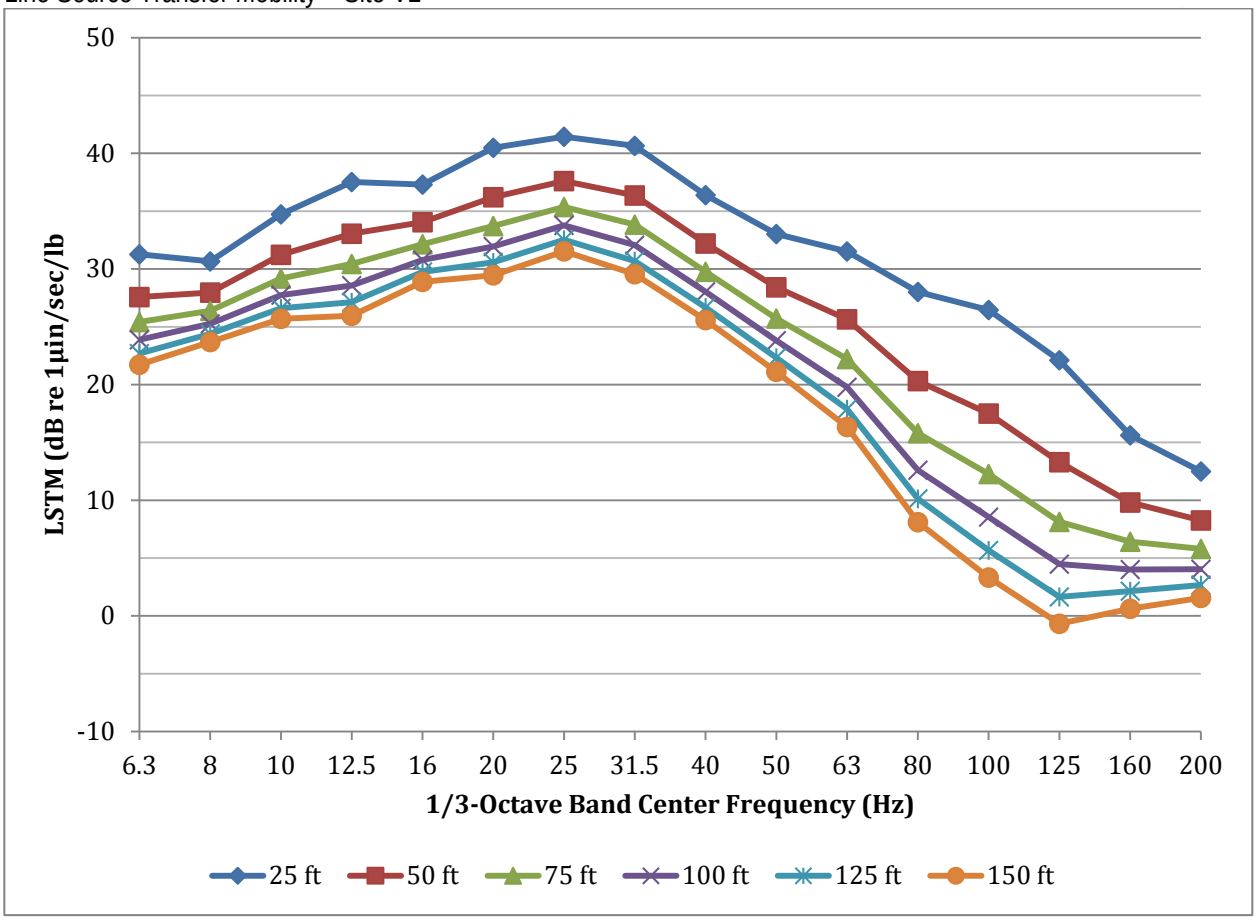


EXHIBIT B-2

Line Source Transfer Mobility – Site V3 ShopHQ Interior Locations

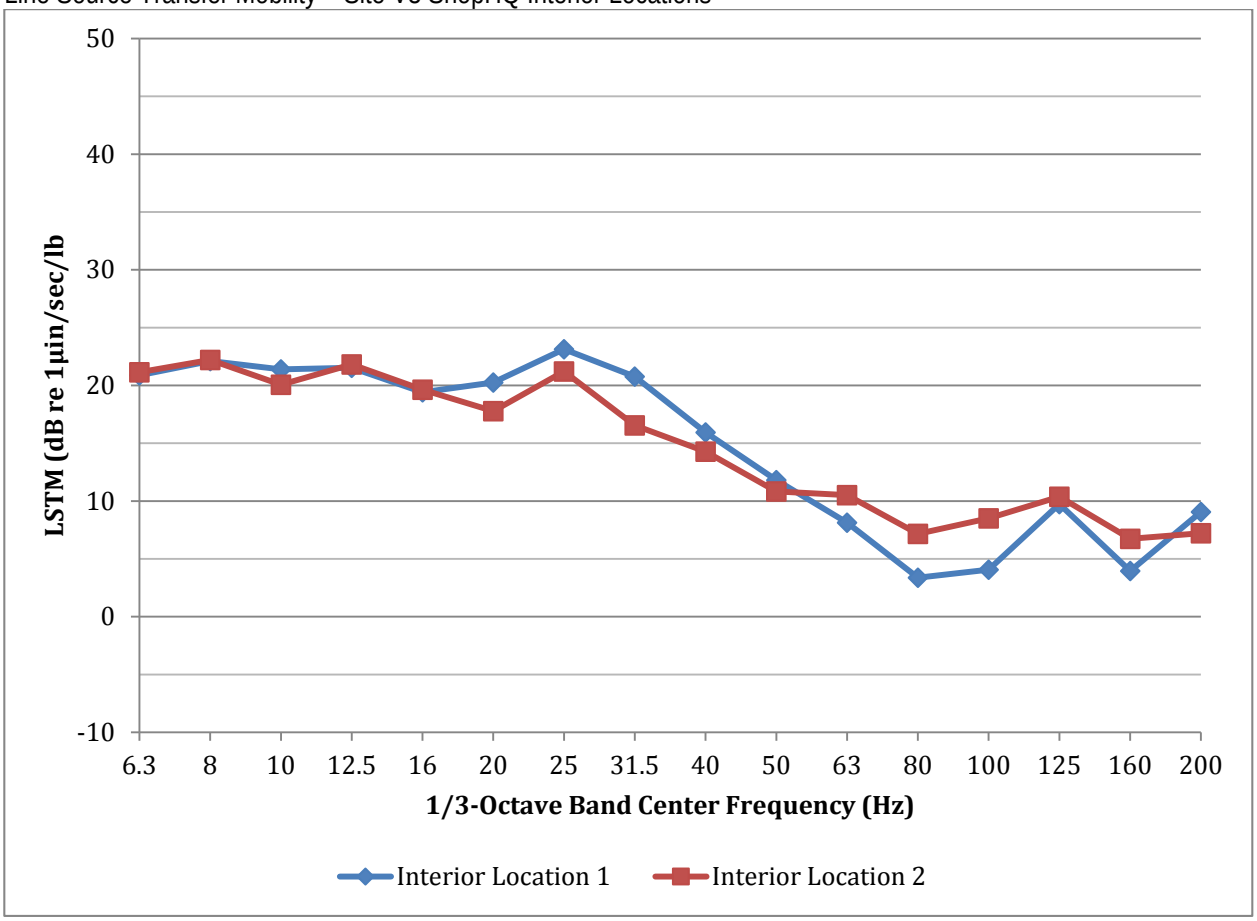


EXHIBIT B-3

Line Source Transfer Mobility – Site V4 AMS Work Room

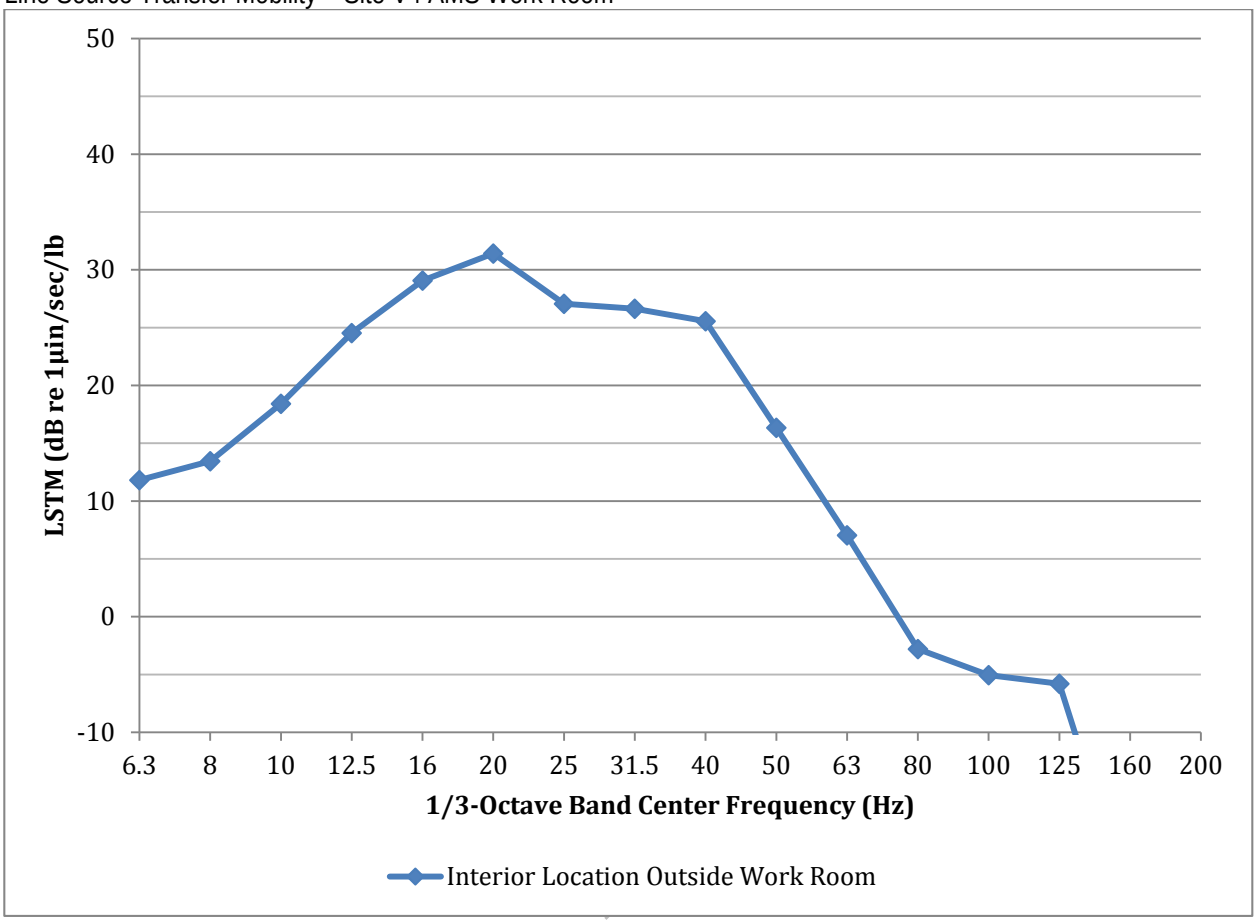


TABLE B-2
1/3-Octave Band Transfer Mobility Coefficients – Site V5

Coefficients	6.3 Hz	8 Hz	10 Hz	12.5 Hz	16 Hz	20 Hz	25 Hz	31.5 Hz	40 Hz	50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz	200 Hz
A	20.3	41.4	40.7	40.0	45.3	30.5	-0.3	-23.5	11.7	-0.1	-0.1	32.2	83.4	125.6	83.7	60.4
B	-2.7	-12.5	-9.7	-6.0	-6.3	13.4	57.0	93.6	63.0	79.4	72.1	36.9	-24.9	-78.5	-48.6	-35.4
C	0.0	0.0	0.0	0.0	0.0	-5.1	-20.0	-33.9	-28.0	-34.2	-31.8	-24.6	-8.3	5.5	0.0	0.0

$$TM= A+B*\log(dist)+C*\log(dist)^2$$

EXHIBIT B-4
Line Source Transfer Mobility – Site V5

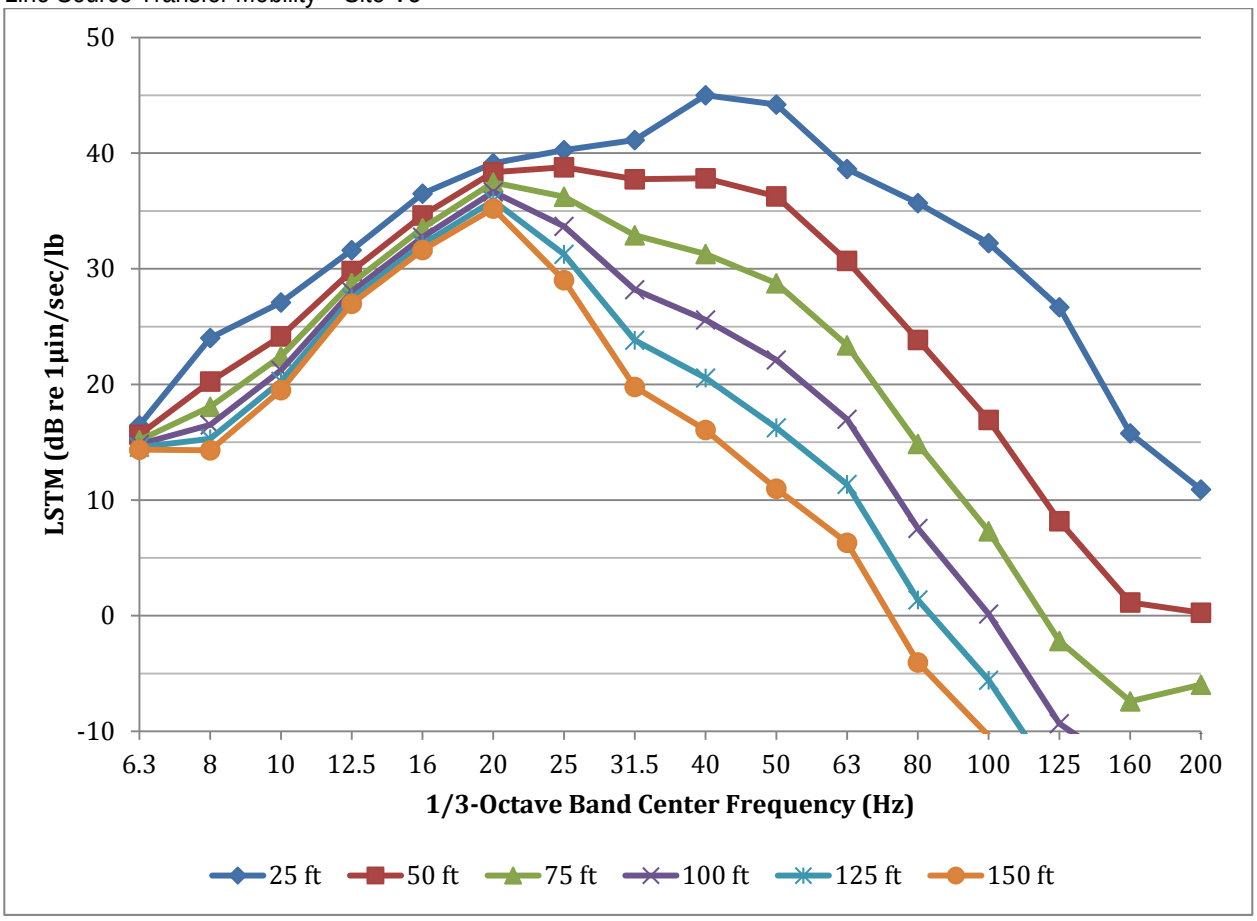


TABLE B-3
1/3-Octave Band Transfer Mobility Coefficients – Site V6

Coefficients	6.3 Hz	8 Hz	10 Hz	12.5 Hz	16 Hz	20 Hz	25 Hz	31.5 Hz	40 Hz	50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz	200 Hz
A	16.7	28.4	26.8	49.0	43.0	55.1	58.1	58.1	91.6	86.3	90.2	88.5	94.2	104.5	109.0	113.9
B	0.7	-2.4	-2.8	-9.9	-5.7	-10.4	-10.4	-5.7	-34.6	-25.4	-29.2	-30.1	-34.2	-40.8	-45.7	-50.9
C	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-2.1	4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0

$$TM= A+B*\log(dist)+C*\log(dist)^2$$

EXHIBIT B-5
Line Source Transfer Mobility – Site V6

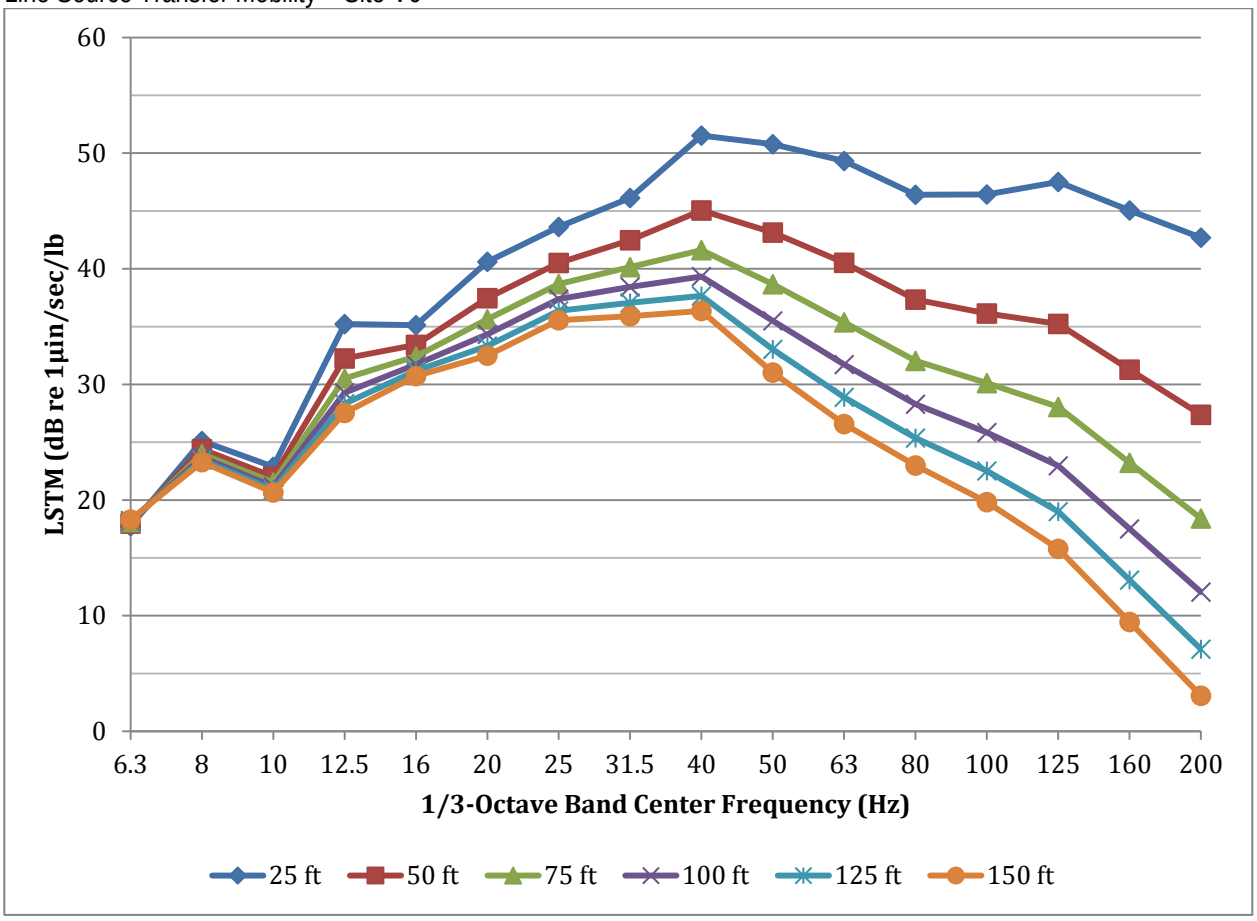


TABLE B-4
1/3-Octave Band Transfer Mobility Coefficients – Site V7

Coefficients	6.3 Hz	8 Hz	10 Hz	12.5 Hz	16 Hz	20 Hz	25 Hz	31.5 Hz	40 Hz	50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz	200 Hz
A	54.4	55.7	52.2	51.0	49.1	49.8	43.6	50.3	57.6	56.3	60.7	62.8	68.0	63.7	48.5	37.7
B	-15.2	-14.7	-12.3	-11.2	-9.5	-9.2	-4.9	-9.3	-15.0	-16.5	-20.7	-25.0	-29.7	-29.7	-23.0	-17.6
C	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

$$TM= A+B*\log(dist)+C*\log(dist)^2$$

EXHIBIT B-6
Line Source Transfer Mobility – Site V7

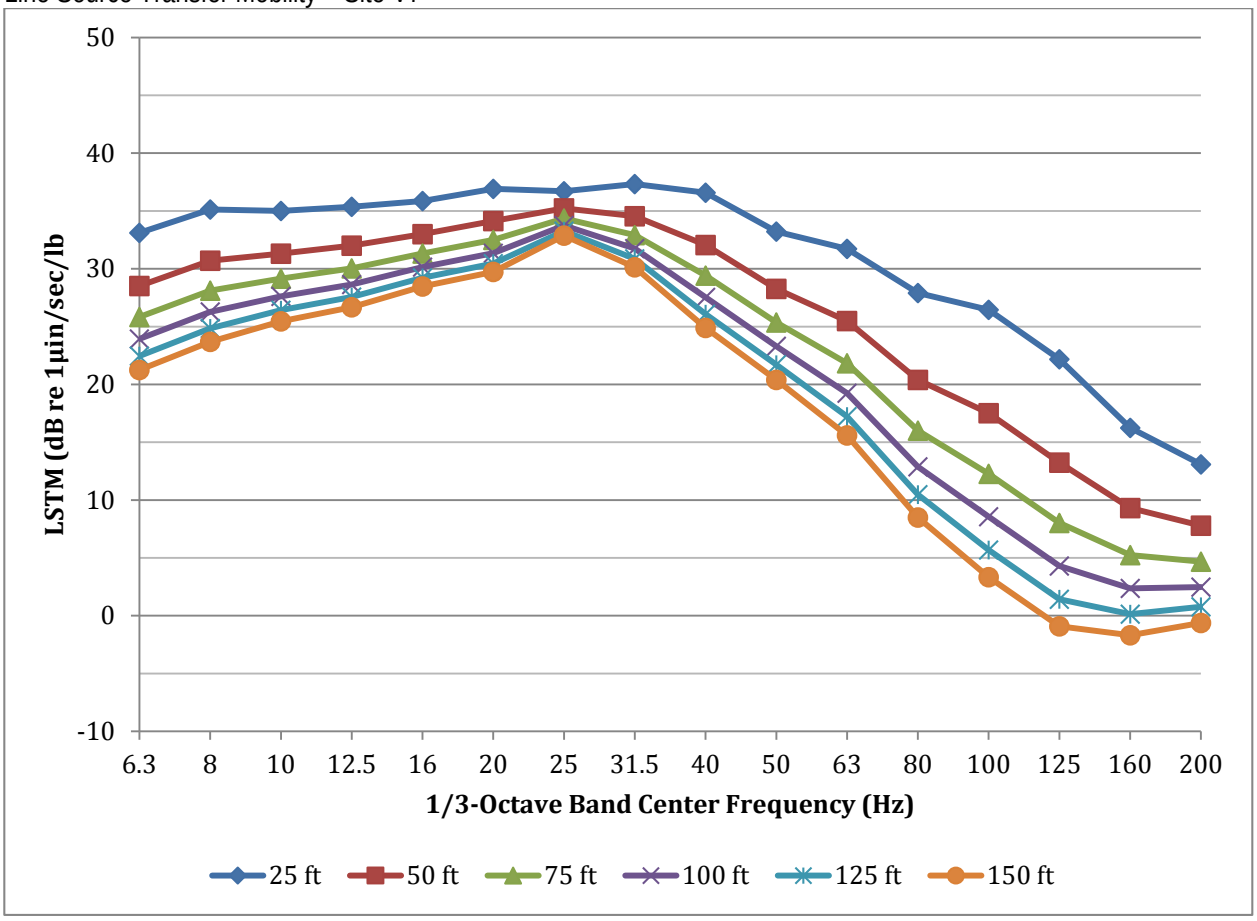


TABLE B-5
1/3-Octave Band Transfer Mobility Coefficients – Site V8

Coefficients	6.3 Hz	8 Hz	10 Hz	12.5 Hz	16 Hz	20 Hz	25 Hz	31.5 Hz	40 Hz	50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz	200 Hz
A	36.5	25.1	41.8	39.2	44.5	60.6	67.4	-4.6	13.5	93.6	88.4	81.0	85.9	81.9	68.6	47.2
B	-9.6	-1.5	-9.7	-5.0	-6.8	-12.3	-14.5	74.6	59.7	-32.0	-30.8	-29.1	-34.3	-35.4	-30.9	-21.2
C	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-26.9	-24.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0

$$TM= A+B*\log(dist)+C*\log(dist)^2$$

EXHIBIT B-7
Line Source Transfer Mobility – Site V8

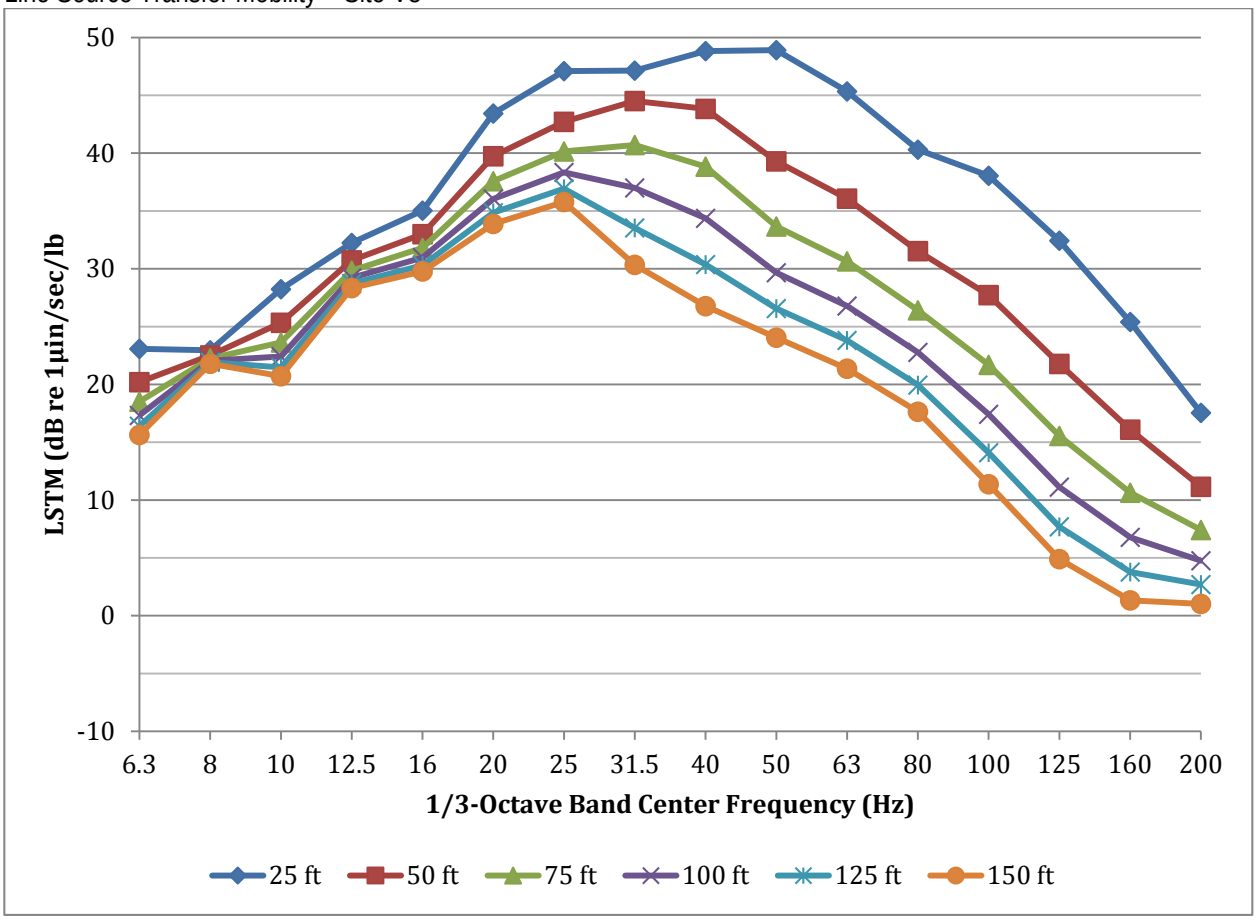


TABLE B-6
1/3-Octave Band Transfer Mobility Coefficients – Site V9

Coefficients	6.3 Hz	8 Hz	10 Hz	12.5 Hz	16 Hz	20 Hz	25 Hz	31.5 Hz	40 Hz	50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz	200 Hz
A	38.7	33.7	34.6	35.2	42.4	52.0	-32.6	-21.8	20.5	0.0	0.1	0.0	0.0	0.0	0.1	0.1
B	-11.4	-6.7	-5.5	-4.0	-6.1	-9.2	90.9	88.8	52.0	69.9	66.3	57.1	66.2	61.1	52.8	48.4
C	0.0	0.0	0.0	0.0	0.0	0.0	-28.6	-30.4	-22.7	-27.5	-26.5	-22.5	-27.8	-27.1	-24.5	-23.0

$$TM= A+B*\log(dist)+C*\log(dist)^2$$

EXHIBIT B-8
Line Source Transfer Mobility – Site V9

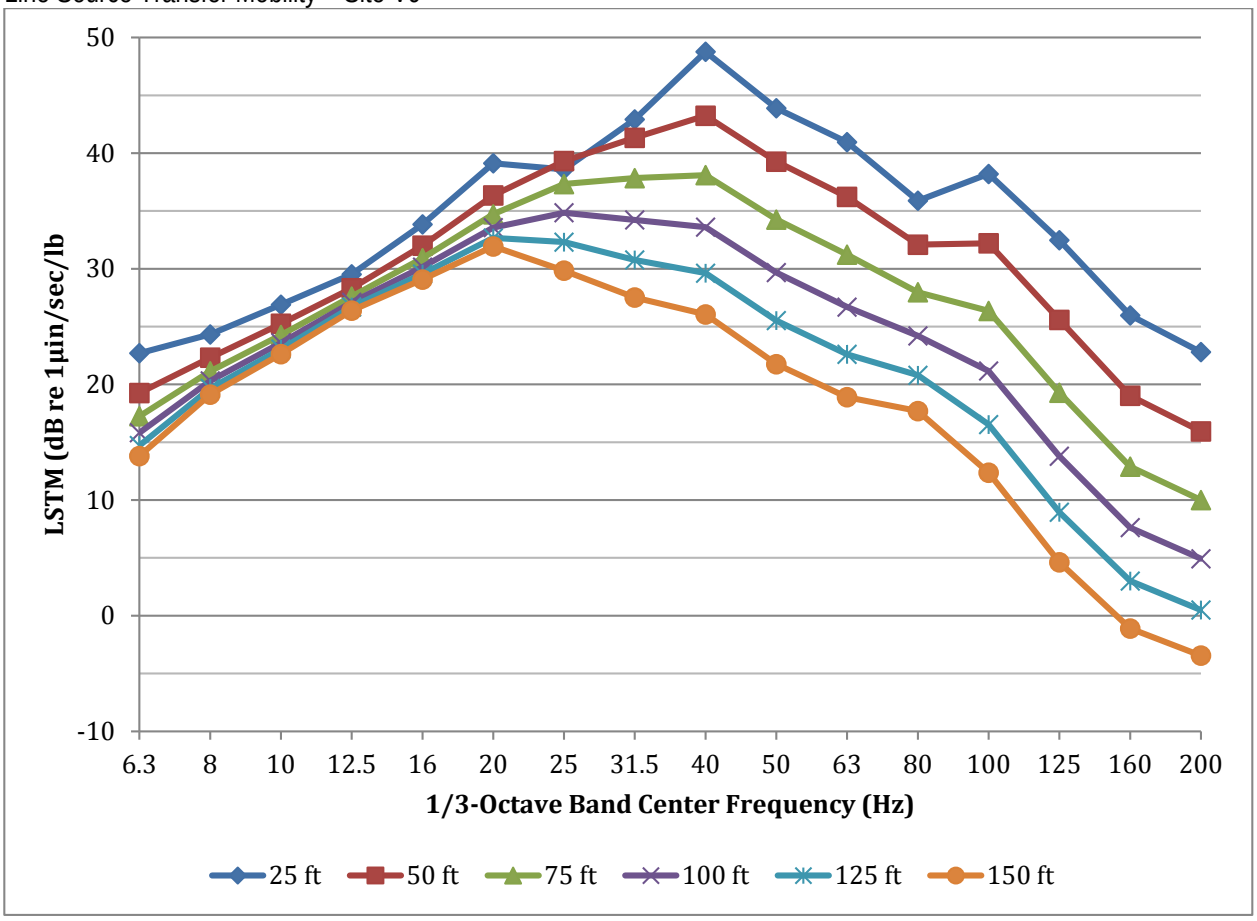
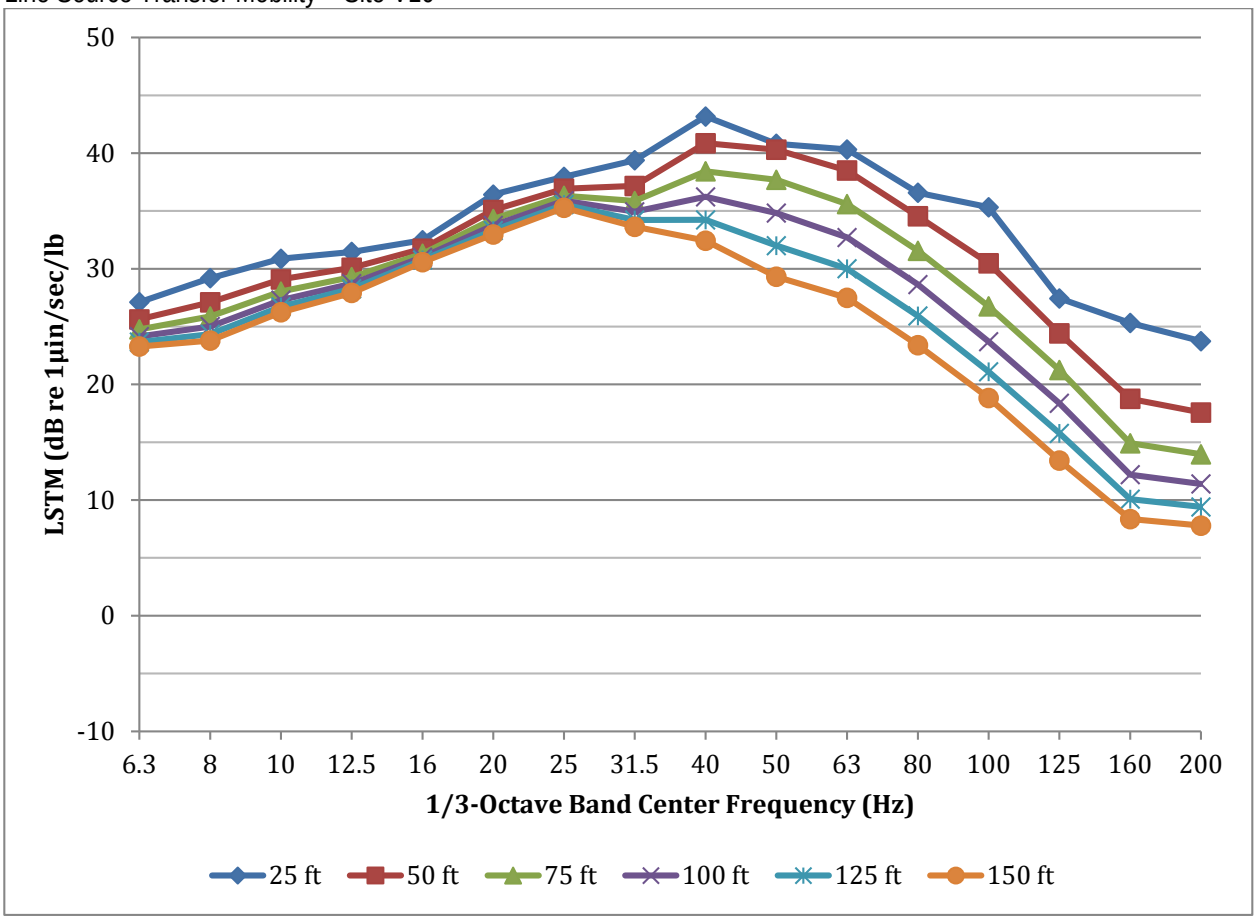


TABLE B-7
1/3-Octave Band Transfer Mobility Coefficients – Site V10

Coefficients	6.3 Hz	8 Hz	10 Hz	12.5 Hz	16 Hz	20 Hz	25 Hz	31.5 Hz	40 Hz	50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz	200 Hz
A	34.0	38.9	39.2	37.8	35.9	42.6	42.8	49.7	23.4	-21.9	-3.2	-4.6	32.3	1.8	55.8	52.4
B	-4.9	-6.9	-5.9	-4.6	-2.4	-4.4	-3.4	-7.4	32.1	83.2	61.7	59.3	17.1	41.8	-21.8	-20.5
C	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-12.8	-27.4	-21.9	-21.3	-10.7	-16.7	0.0	0.0

$$TM= A+B*\log(dist)+C*\log(dist)^2$$

EXHIBIT B-9
Line Source Transfer Mobility – Site V10



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Appendix C. Sound Insulation Measurement Data

TABLE C-1
Residence Inn Sound Insulation Measurement Results – Building 40 ft from Proposed Track Centerline

Octave Band Center Frequency (Hz)	125	250	500	1000	2000	4000
Reverberation Time, RT60 (s)	0.43	0.49	0.45	0.41	0.38	0.39
Interior Background Leq (dB)	43.0	38.9	33.0	34.5	31.3	16.9
Exterior Façade Leq (dB)	96.4	97.5	97.0	98.3	92.1	93.2
Interior Façade Leq (dB)	77.4	78.1	73.0	72.3	67.5	66.7
Interior Room Leq (dB)	71.9	71.4	67.4	65.8	58.4	57.9
Outdoor-Indoor Noise Reduction, OINR (dB)	19.5	21.1	24.7	27.5	28.8	30.4
Room Sound Absorption, A (m^2)	27.0	23.8	25.8	28.0	30.5	29.7
Outdoor-Indoor Transmission Loss, OITL (dB)	21.7	23.8	27.1	29.6	30.5	32.2
Future Exterior Source Level (dB)	74.5	66.3	67.6	71.7	70.2	62.1
Future Interior Source Level (dB)	52.8	42.5	40.5	42.1	39.8	30.0
A-Weighting Adjustments (dB)	-16.1	-8.6	-3.2	0.0	1.2	1.0
Future Interior Level (dBA)	36.7	33.9	37.3	42.1	41.0	31.0
Overall Future Interior Level (dBA)						46.3

EXHIBIT C-1
Sound Insulation Test Results – Residence Inn at 40 ft

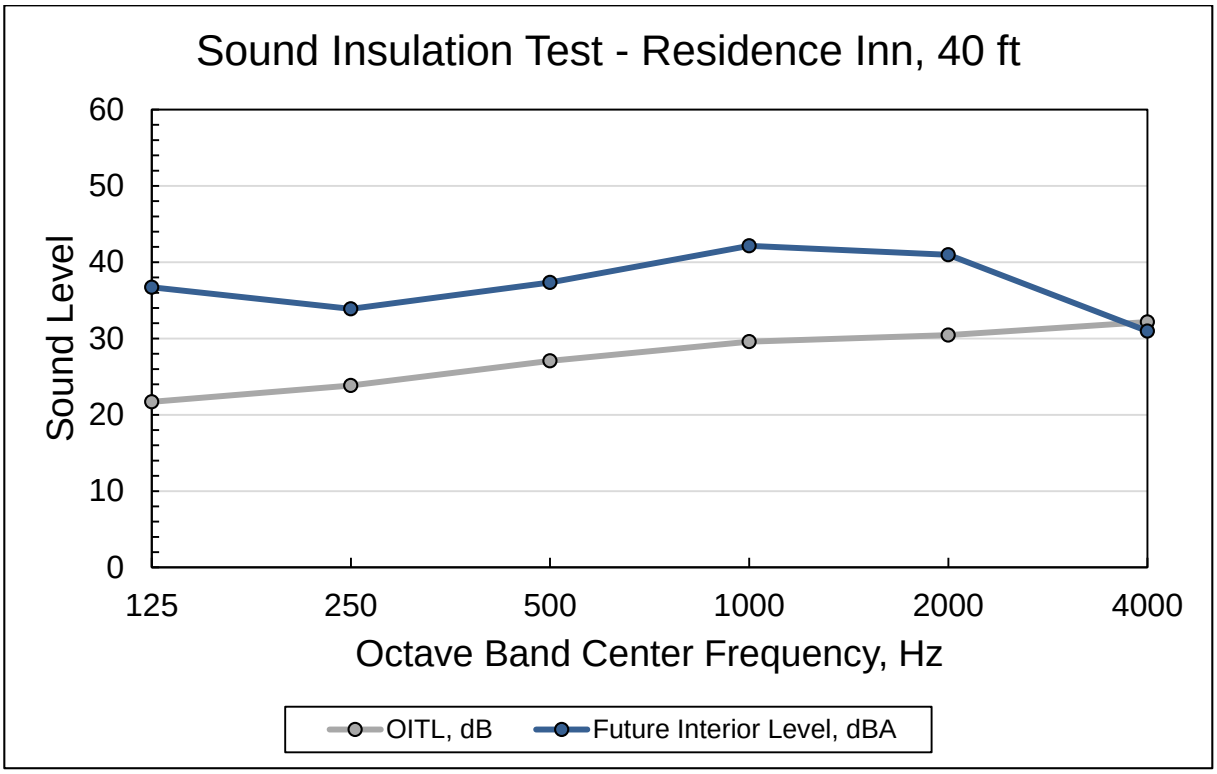


TABLE C-2
Residence Inn Sound Insulation Measurement Results – Building 100 ft from Proposed Track Centerline

Octave Band Center Frequency (Hz)	125	250	500	1000	2000	4000
Reverberation Time, RT60 (s)	0.43	0.49	0.45	0.41	0.38	0.39
Interior Background Leq (dB)	43.0	38.9	33.0	34.5	31.3	16.9
Exterior Façade Leq (dB)	96.4	97.5	97.0	98.3	92.1	93.2
Interior Façade Leq (dB)	77.4	78.1	73.0	72.3	67.5	66.7
Interior Room Leq (dB)	71.9	71.4	67.4	65.8	58.4	57.9
Outdoor-Indoor Noise Reduction, OINR (dB)	19.5	21.1	24.7	27.5	28.8	30.4
Room Sound Absorption, A (m^2)	27.0	23.8	25.8	28.0	30.5	29.7
Outdoor-Indoor Transmission Loss, OITL (dB)	21.7	23.8	27.1	29.6	30.5	32.2
Future Exterior Source Level (dB)	70.5	62.3	63.6	67.7	66.2	58.1
Future Interior Source Level (dB)	48.8	38.5	36.6	38.2	35.8	26.0
A-Weighting Adjustments (dB)	-16.1	-8.6	-3.2	0.0	1.2	1.0
Future Interior Level (dBA)	32.7	29.9	33.4	38.2	37.0	27.0
Overall Future Interior Level (dBA)						42.3

EXHIBIT C-2
Sound Insulation Test Results – Residence Inn at 100 ft

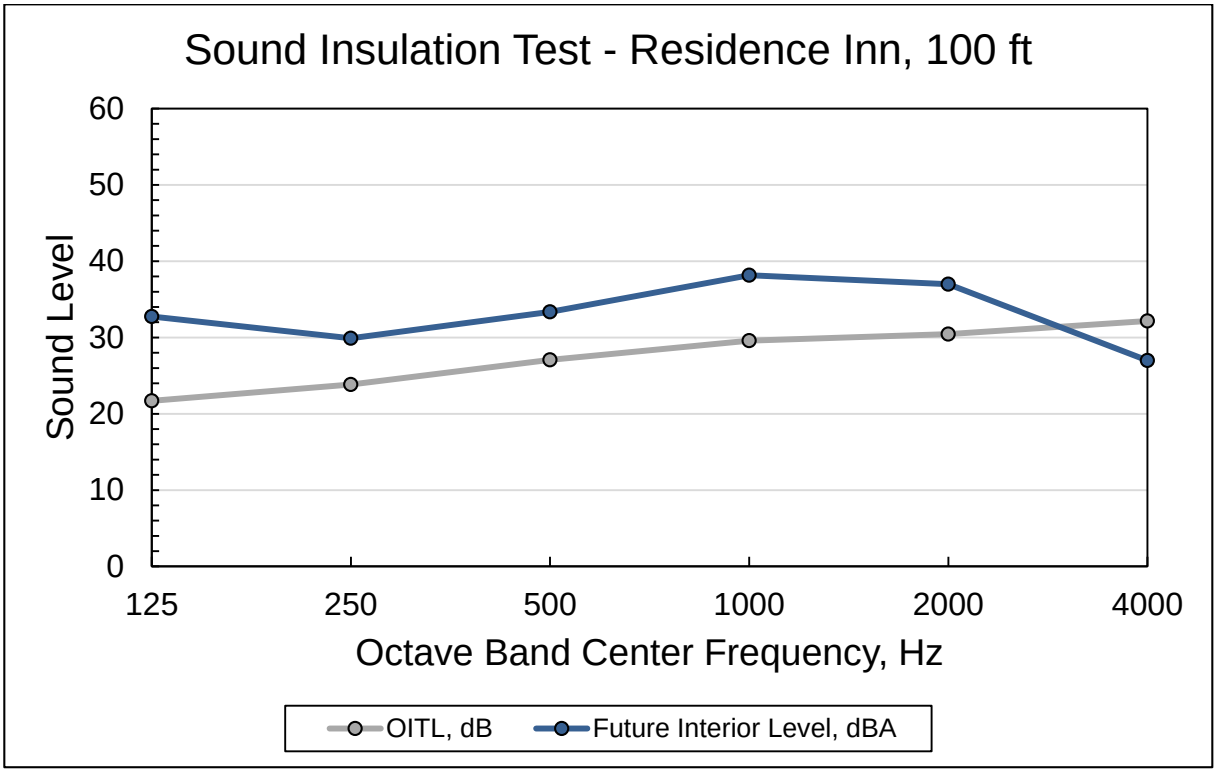


TABLE C-3
Baymont Inn Sound Insulation Measurement Results – Building 80 ft from Proposed Track Centerline

Octave Band Center Frequency (Hz)	125	250	500	1000	2000	4000
Reverberation Time, RT60 (s)	1.20	0.63	0.45	0.34	0.37	0.31
Interior Background Leq (dB)	47.4	43.3	36.4	31.3	23.0	15.3
Exterior Façade Leq (dB)	99.9	101.6	100.5	101.7	97.2	96.6
Interior Façade Leq (dB)	86.7	85.2	75.3	73.8	62.2	61.6
Interior Room Leq (dB)	78.4	75.8	65.8	65.1	53.9	52.3
Outdoor-Indoor Noise Reduction, OINR (dB)	16.5	20.8	29.7	31.6	38.3	39.4
Room Sound Absorption, A (m^2)	7.2	13.8	19.5	25.2	23.6	27.9
Outdoor-Indoor Transmission Loss, OITL (dB)	22.2	23.7	31.1	31.9	38.9	39.2
Future Exterior Source Level (dB)	71.5	63.3	64.6	68.7	67.2	59.1
Future Interior Source Level (dB)	49.3	39.6	33.5	36.8	28.3	19.9
A-Weighting Adjustments (dB)	-16.1	-8.6	-3.2	0.0	1.2	1.0
Future Interior Level (dBA)	33.2	31.0	30.3	36.8	29.5	20.9
Overall Future Interior Level (dBA)						40.1

EXHIBIT C-3
Sound Insulation Test Results – Baymont Inn

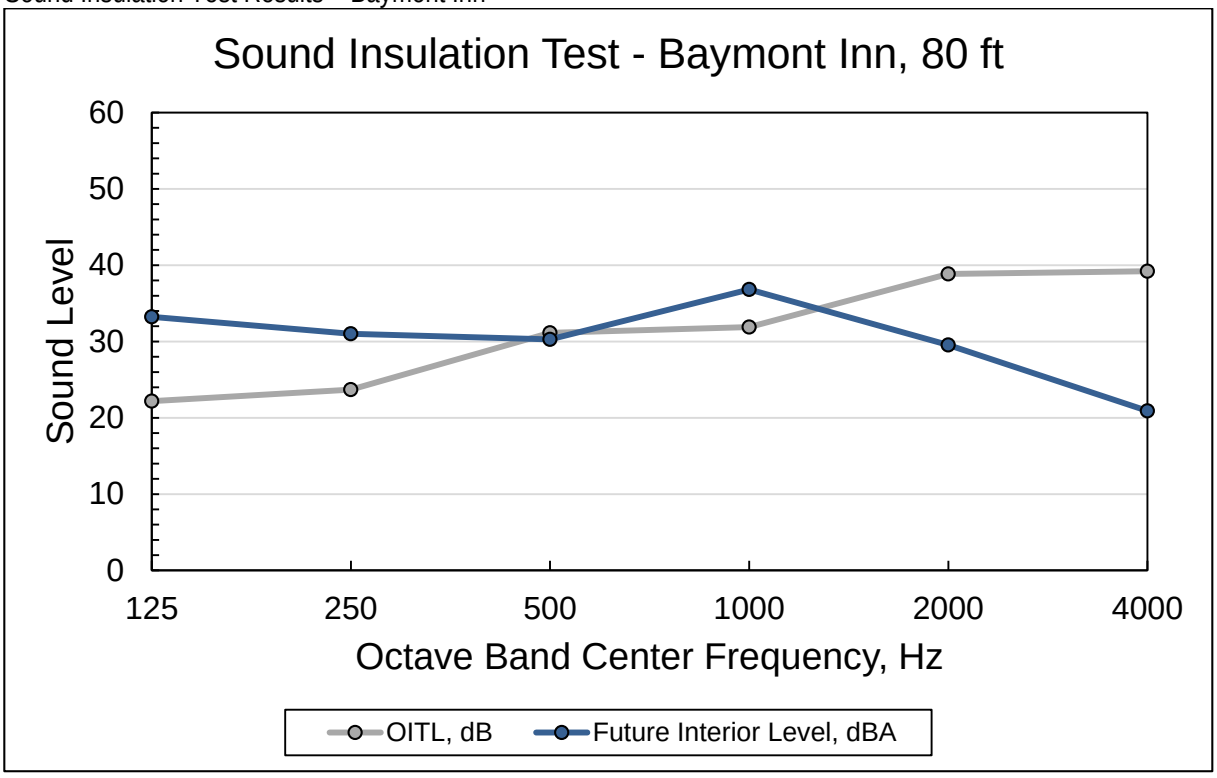
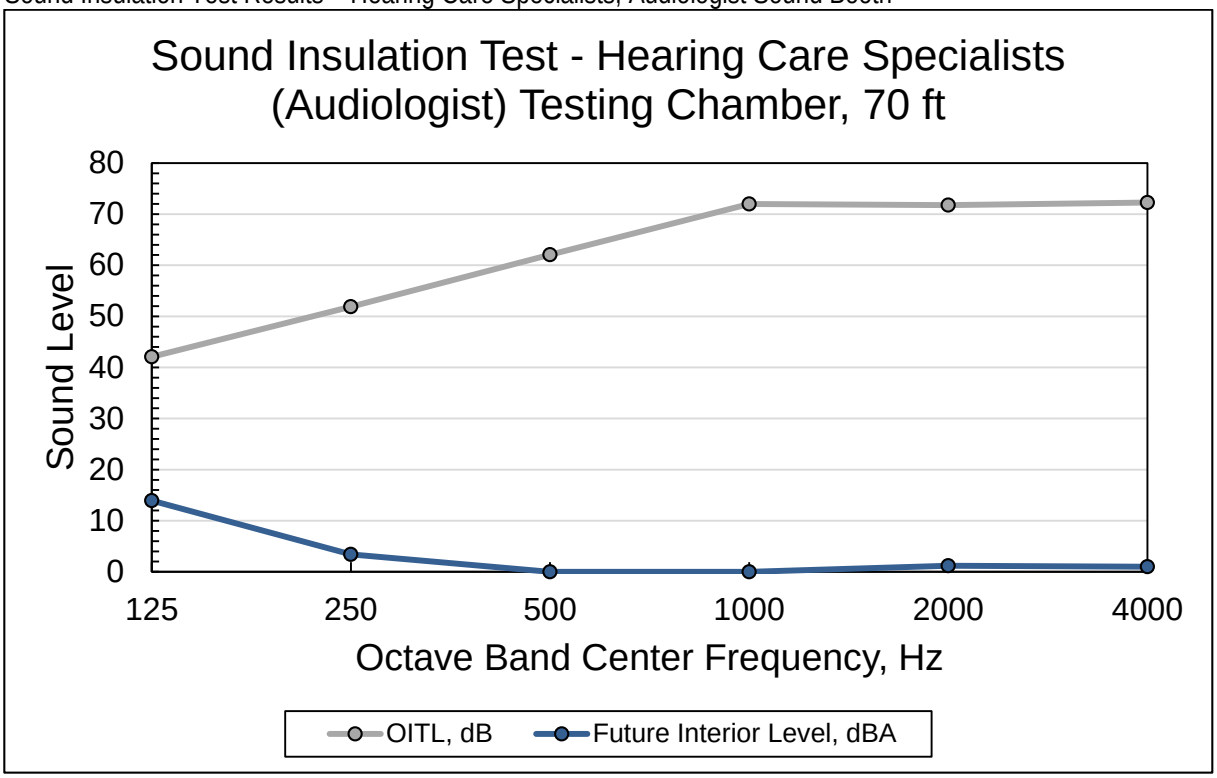


TABLE C-4
Hearing Care Specialist Sound Insulation Measurement Results – Sound Booth

Octave Band Center Frequency (Hz)	125	250	500	1000	2000	4000
Reverberation Time, RT60 (s)	--	--	--	--	--	--
Interior Background Leq (dB)	28.2	17.5	9.9	8.0	8.5	10.0
Exterior Façade Leq (dB)	90.3	88.1	86.6	88.8	87.1	87.8
Interior Façade Leq (dB)	--	--	--	--	--	--
Interior Room Leq (dB)	44.8	32.8	21.1	13.4	11.9	12.1
Outdoor-Indoor Noise Reduction, OINR (dB)	40.5	50.3	60.5	70.4	70.2	70.7
Room Sound Absorption, A (m^2)	24.0	24.0	24.0	24.0	24.0	24.0
Outdoor-Indoor Transmission Loss, OITL (dB)	42.1	51.9	62.1	72.0	71.8	72.3
Future Exterior Source Level (dB)	72.1	63.9	65.2	69.3	67.8	59.7
Future Interior Source Level (dB)	30.0	12.0	3.1	0.0	0.0	0.0
A-Weighting Adjustments (dB)	-16.1	-8.6	-3.2	0.0	1.2	1.0
Future Interior Level (dBA)	13.9	3.4	0.0	0.0	1.2	1.0
Overall Future Interior Level (dBA)						15.0

EXHIBIT C-4
Sound Insulation Test Results – Hearing Care Specialists, Audiologist Sound Booth



Appendix D. Measurement Site Photographs

EXHIBIT D-1
Noise Measurement Site N2 – Southwest Station Condos

EXHIBIT D-2
Noise Measurement Site N3 – Purgatory Creek Park

EXHIBIT D-3

Noise Measurement Site N4 – Apartments on Singletree Lane

EXHIBIT D-4

Noise Measurement Site N25a – Hampton Inn Sound Insulation

EXHIBIT D-5
Noise Measurement Site N5a – ShopHQ

EXHIBIT D-6

Noise Measurement Site N5 – Claremont Apartments

EXHIBIT D-7

Noise Measurement Site N6a – Hearing Care Specialists

EXHIBIT D-8

Noise Measurement Site N6 – 6th Avenue and Excelsior Boulevard

EXHIBIT D-9

Noise Measurement Site N7 – Jackson Avenue

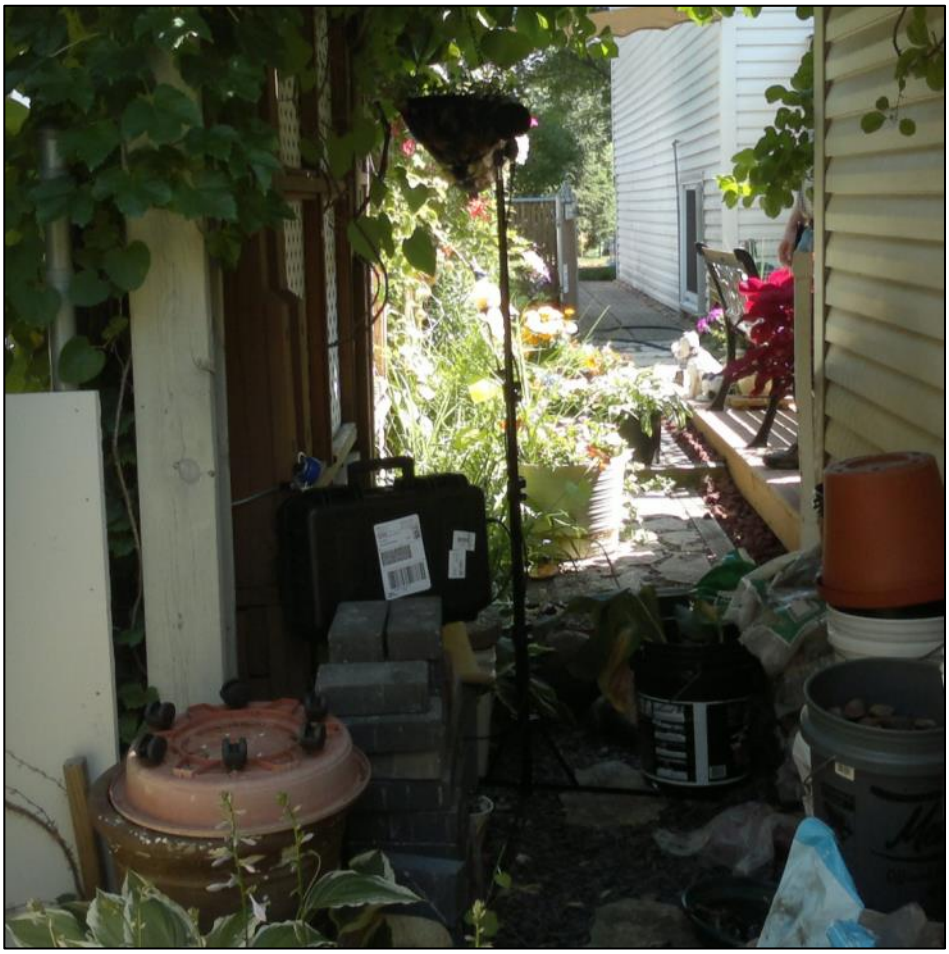


EXHIBIT D-10
Noise Measurement Site N8 – Westside Apartments

EXHIBIT D-11
Noise Measurement Site N9 – Edgebrook Drive

EXHIBIT D-12

Noise Measurement Site N14 – West 37th Street

EXHIBIT D-13

Noise Measurement Site N15 – Calhoun Isle Condos

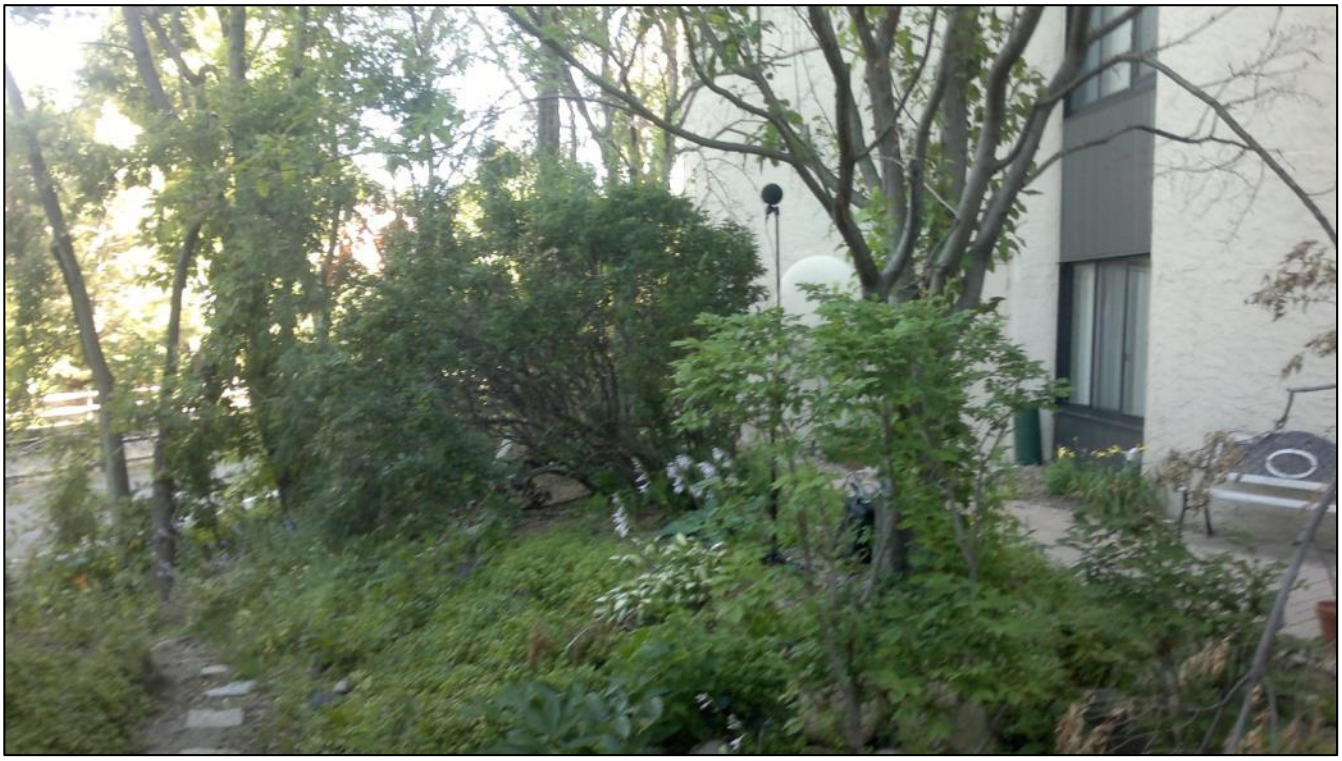


EXHIBIT D-14

Noise Measurement Site N16 – Kenilworth Place and South Upton Avenue

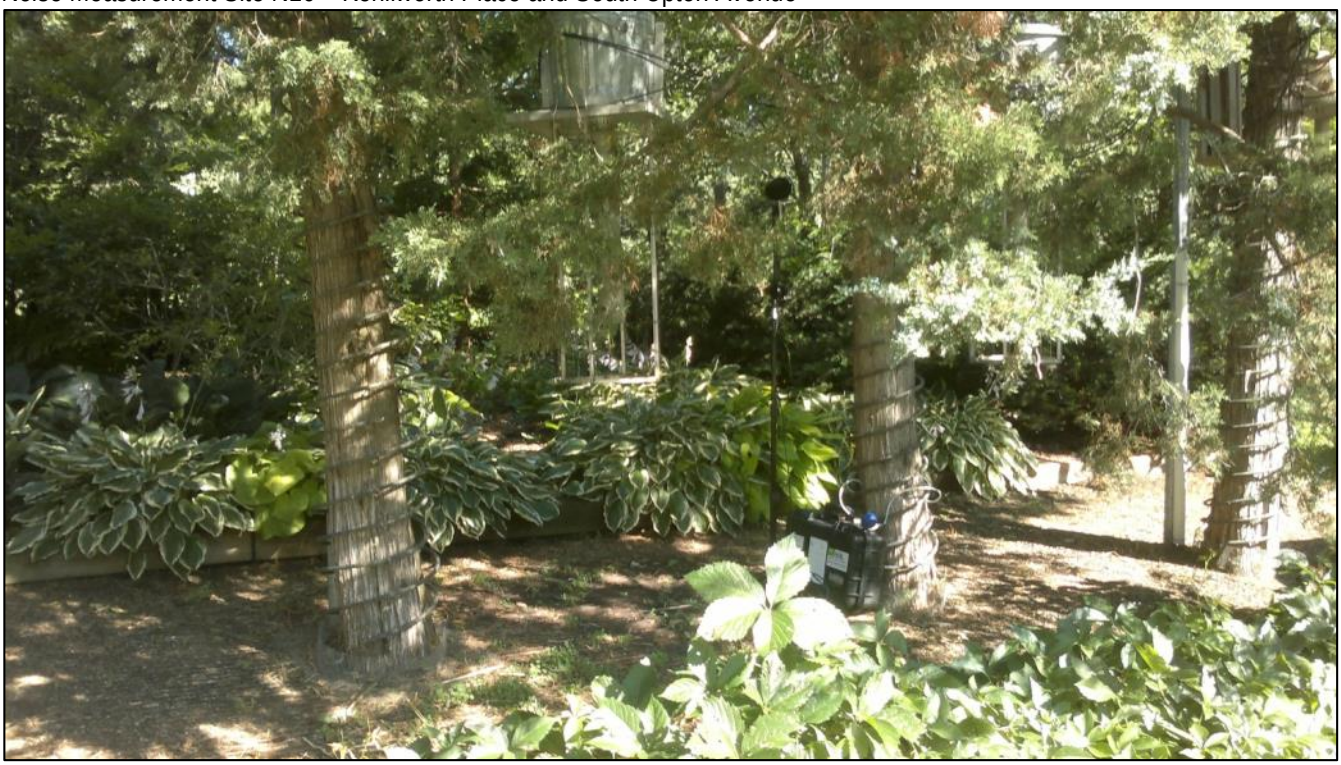


EXHIBIT D-15

Noise Measurement Site N17 – 21st Street and Upton Street

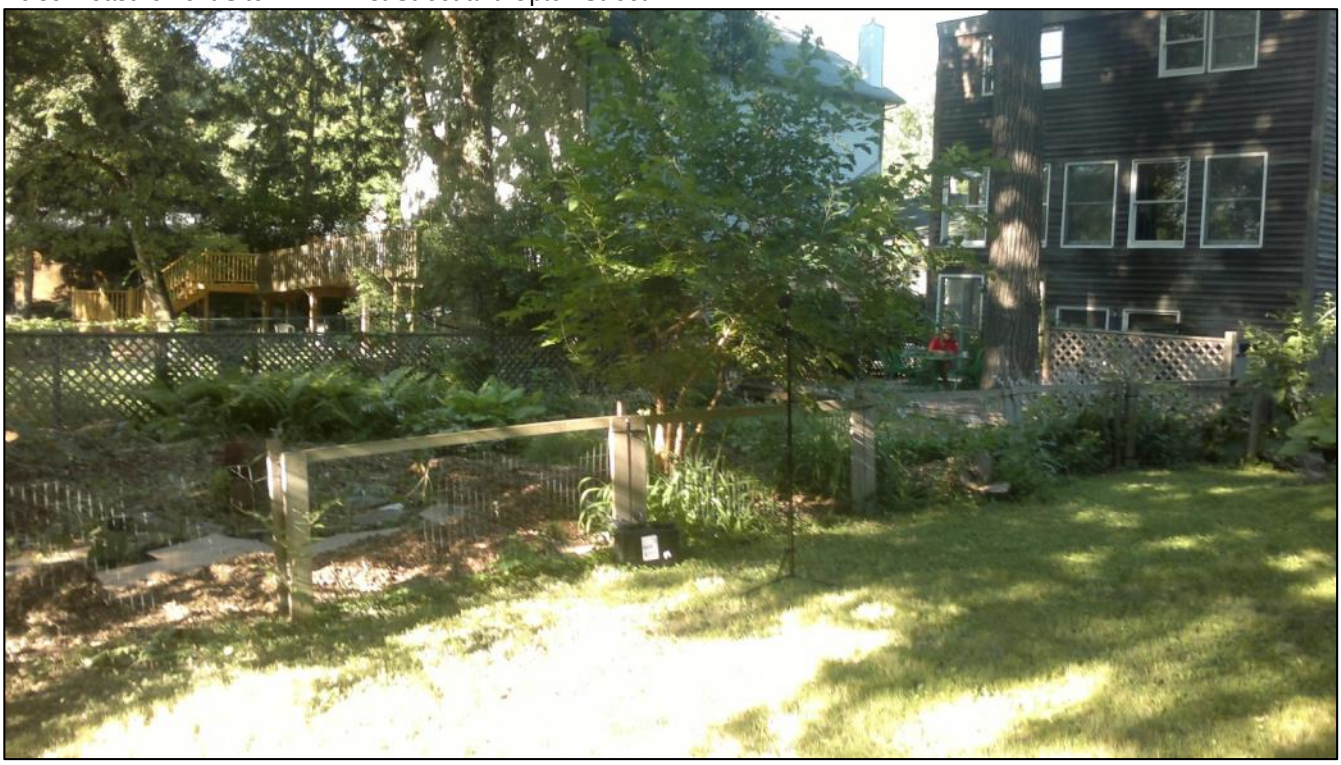


EXHIBIT D-16

Noise Measurement Site N17 – Mary's Place

EXHIBIT D-17

Vibration Propagation Measurement Site V2 – SouthWest Transit Station

EXHIBIT D-18
Vibration Propagation Measurement Site V3 – ShopHQ

EXHIBIT D-19
Vibration Propagation Measurement Site V4 – AMS

EXHIBIT D-20

Vibration Propagation Measurement Site V5 – Claremont Apartments

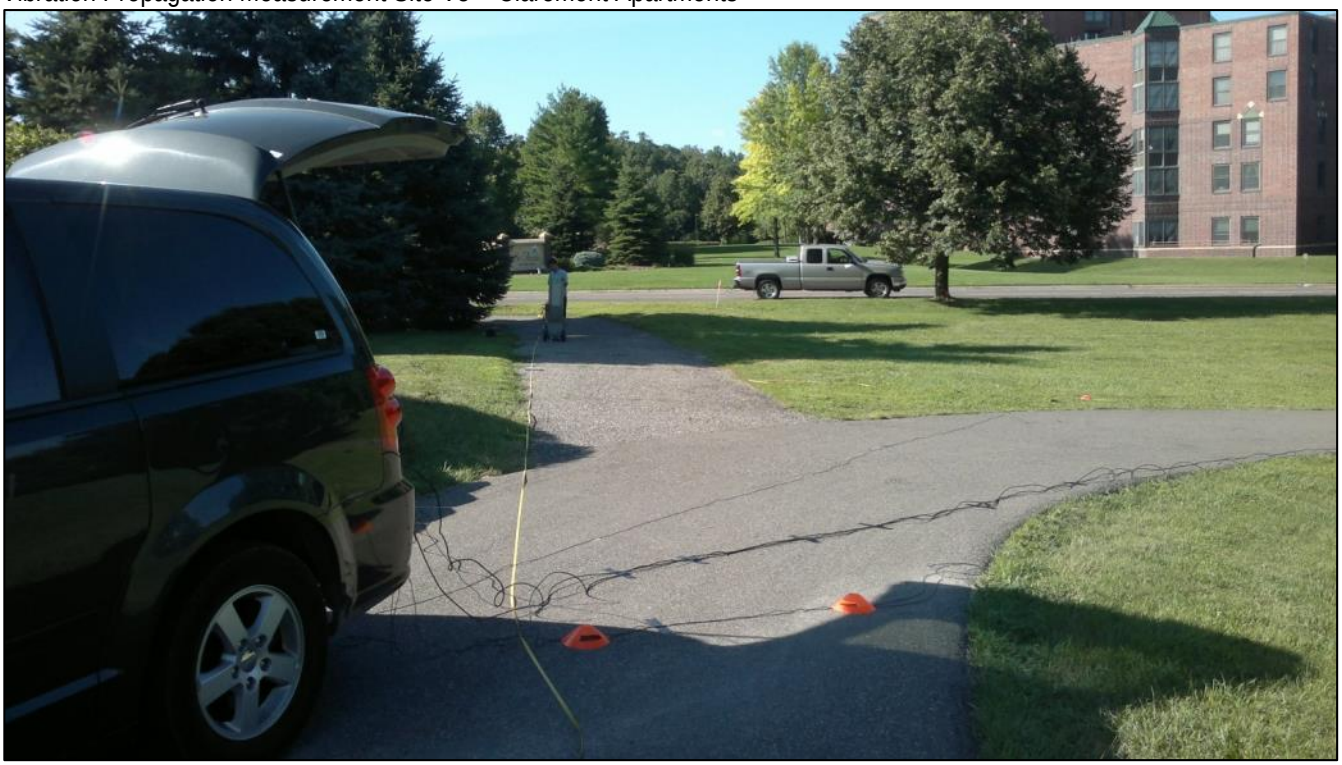


EXHIBIT D-21

Vibration Propagation Measurement Site V6 – Jackson Avenue South

EXHIBIT D-22
Vibration Propagation Measurement Site V7 – Edgebrook Drive

EXHIBIT D-23
Vibration Propagation Measurement Site V8 – Dean Ct and West 28th Street

EXHIBIT D-24
Vibration Propagation Measurement Site V9 – 21st Street

EXHIBIT D-25
Vibration Propagation Measurement Site V10 – Royalston Avenue

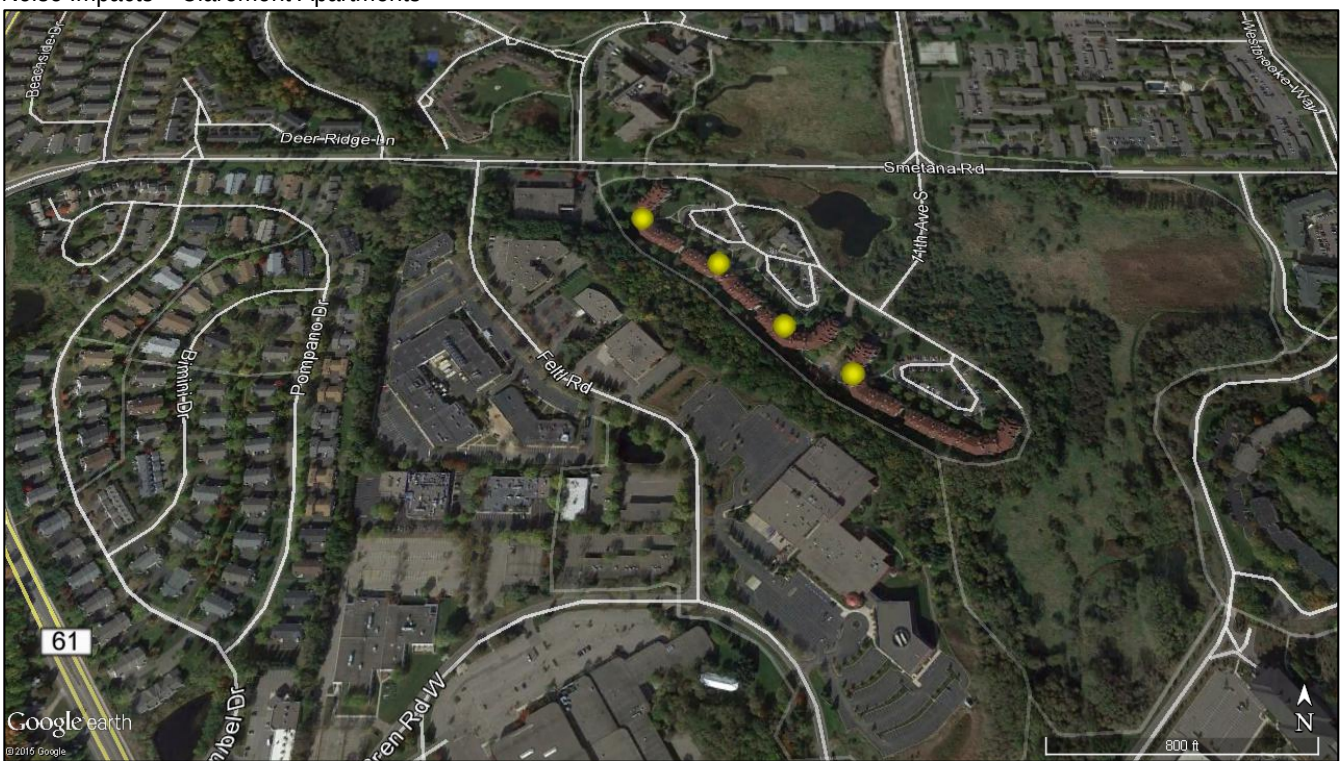
Appendix E. Noise Impact Location Exhibits

EXHIBIT E-1*

Noise Impacts – Eden Prairie

EXHIBIT E-2*

Noise Impacts – Claremont Apartments



* Red dots indicate severe noise impacts and yellow dots indicate moderate noise impacts

EXHIBIT E-3*

Noise Impacts – Hopkins

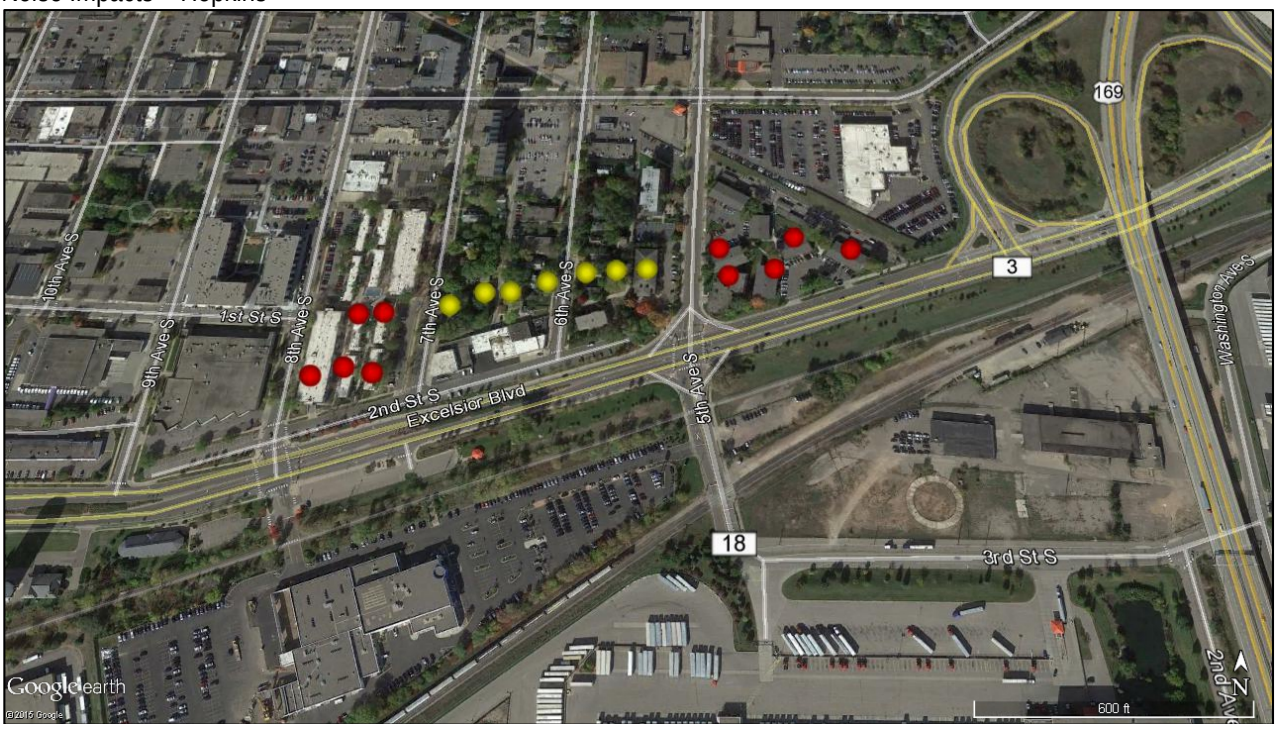
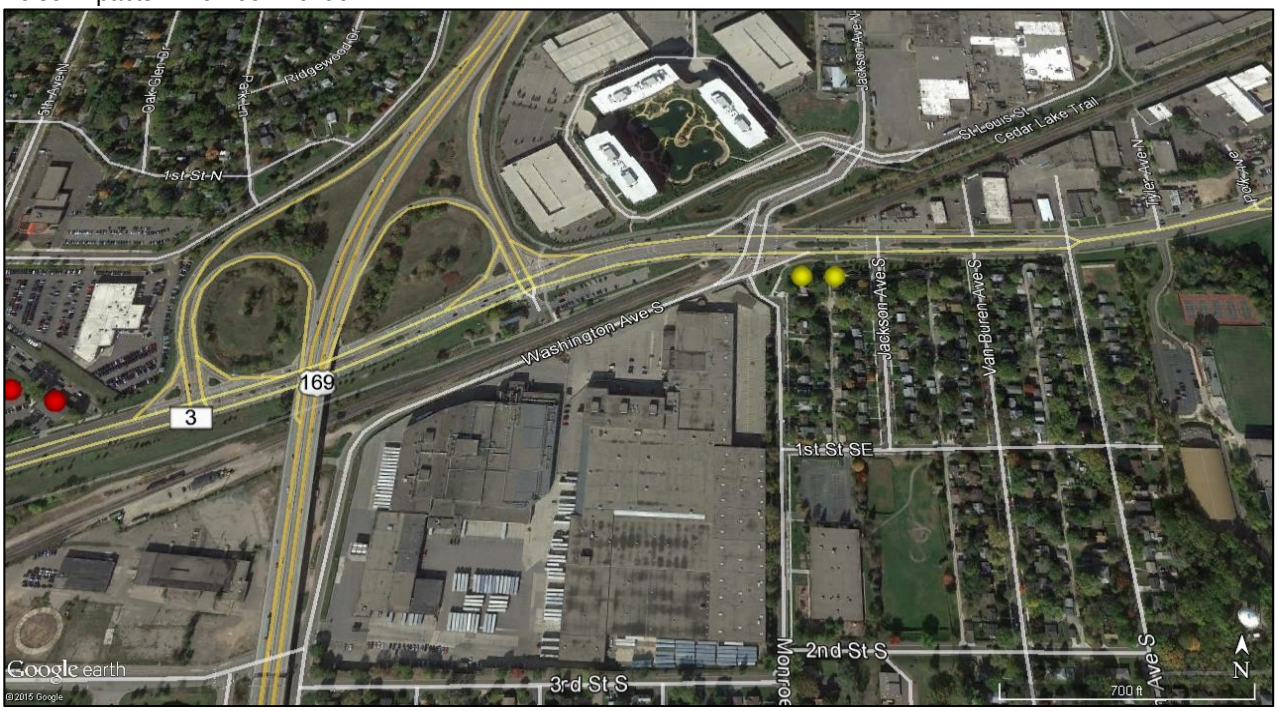


EXHIBIT E-4*

Noise Impacts – Monroe Avenue



* Red dots indicate severe noise impacts and yellow dots indicate moderate noise impacts

EXHIBIT E-5*

Noise Impacts – Blake Road

EXHIBIT E-6*

Noise Impacts – Wooddale Avenue

* Red dots indicate severe noise impacts and yellow dots indicate moderate noise impacts

EXHIBIT E-7*

Noise Impacts – Westlake

EXHIBIT E-8*

Noise Impacts – Kenilworth

* Red dots indicate severe noise impacts and yellow dots indicate moderate noise impacts

Appendix F. Vibration and Ground-Borne Noise Impact Location Exhibits

EXHIBIT F-1**

Ground-Borne Noise Impacts – Hearing Care Specialists

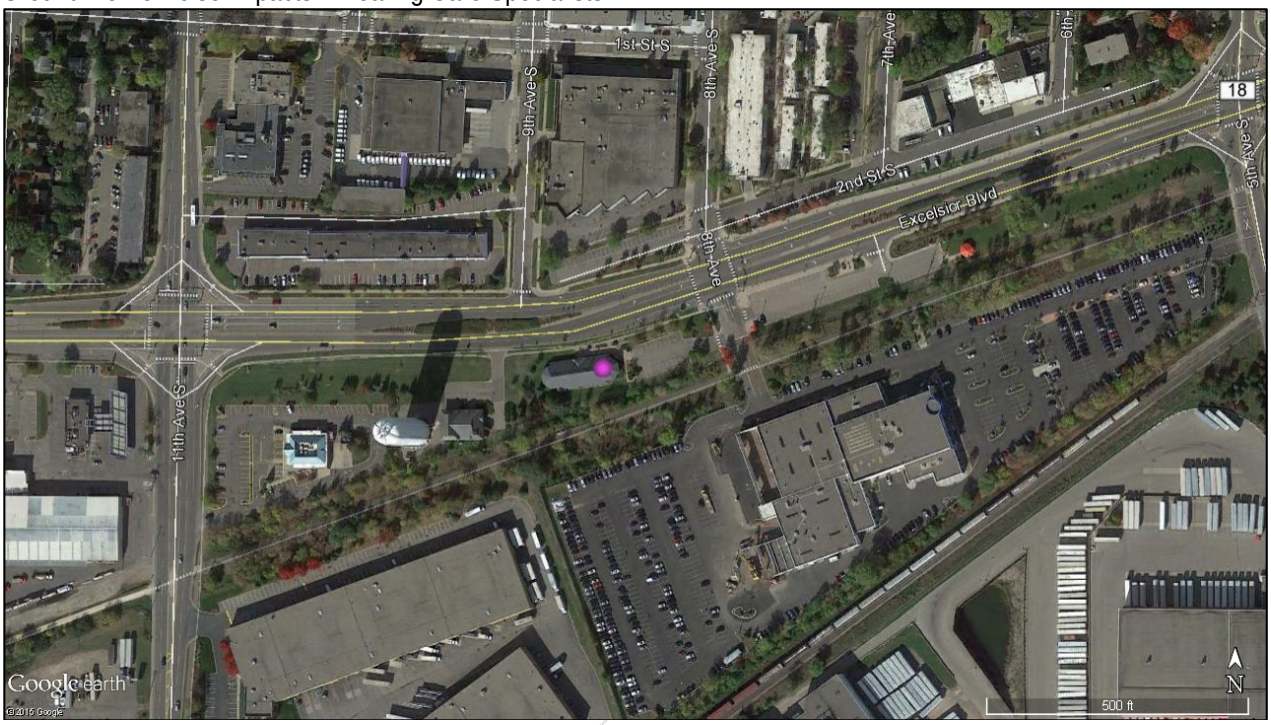


EXHIBIT F-2

Ground-Borne Noise Impacts – Kenilworth Tunnel

** Pink dots indicate the location of a ground-borne noise impact

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Appendix G. HDR Noise Measurement Data

Memo - HDR

Date:	Thursday, January 28, 2016
Project:	Green Line Extension/SWLRT
To:	Nani Jacobson
From:	Scott Reed and Tim Casey, HDR
Subject:	HDR Noise Measurement Data

HDR acousticians reviewed archived records associated with measurements of existing noise levels in the SWLRT corridor. The measurement results were reported both without and with the inclusion of noise from freight train pass-by events in 2010 and 2012, respectively. The purposes of this memo are to: clarify information presented in the 2010 and 2012 noise measurement results table; explain how noise from freight train pass-bys was removed from the measurement results (as presented in the 2010 version), and; explain how the noise from freight train pass-bys was re-inserted into the measurement results (as presented in the 2012 version).

Clarify Information Presented in 2010 and 2012

Text in the "Measurement Location Description" column of the "Ambient Noise Table" created some confusion when the measurement results for sites 10, 14, 15, 29, 30, and 31 changed between 2010 and 2012. The change in measurement results occurred because the 2010 version of the data did not include noise from freight train pass-bys, and the 2012 version did contain noise from freight train pass-bys. The numeric values in each table are correct. Footnote C, added to the 2012 version of the table, is also correct. However, the Measurement Location Description text in the 2012 version incorrectly stated that noise from freight trains was removed from the data set; that sentence should have been deleted during the document revisions that occurred in 2012.

Explain how Noise from Freight Trains was Removed from the Measurement Results

HDR acousticians performed long-term (24-hour, unattended) and short-term (pairs of attended 1-hour) measurements of existing outdoor noise levels in this portion of the project area. The long-term measurements utilized Larson-Davis model 831 real-time analyzers. The LD831 has a feature that creates a WAV file if a preset (sound level) trigger is exceeded; this feature was used to create audio recordings of noisy events. Using this feature, HDR acousticians listened to the WAV files and determined when train pass-bys occurred; the timestamp associated with freight train events was noted.

Then HDR imported the long-term acoustical measurement data into Excel spreadsheets for analysis and inspection. HDR also made a copy of those Excel spreadsheets and labeled them "filtered". The "filtered" files were manipulated by removing noise from freight train pass-bys based on the timestamps identified as mentioned in the preceding paragraph, and recalculated the Leq and Ldn values without the contribution of noise from freight trains. These results were reported in 2010.

The pairs of short-term (one-hour), attended measurements utilized a Larson-Davis model 824 real-time analyzer. The LD824 cannot create WAV files. Therefore HDR acousticians took notes to indicate the presence of a freight train during these measurements. HDR staff also manually created tags in the acoustical measurement files by pausing and restarting the measurement as a train approached, then pausing and restarting when the freight train had passed. The hand-written notes and the tags in the data files identified the portion of the acoustical measurement data that should be removed in order to create measurement results that exclude noise from freight trains (reported in 2010).

Explain how Noise from Freight Trains was Re-inserted into the Measurement Results

HDR simply reported the original long-term and short-term measurement results, which included noise from freight trains in the project area. Each pair of short-term 1-hour measurements were averaged then used to calculate an Ldn using FTA methods.

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Appendix H. Summary of Freight Vibration Assessment for Kenilworth Corridor

Internal Memorandum

DATE: February 16, 2016

TO: Nani Jacobson, SPO

FROM: Lance Meister, Cross-Spectrum Acoustics

SUBJECT: Summary of Freight Vibration Assessment

This memorandum summarizes the assessment of the freight vibration for the Project for the Final EIS. In locations where existing freight tracks will be moved as a part of the proposed project, freight rail vibration is assessed to determine if there would be impacts at locations where vibration levels from freight would increase at sensitive receptors due to the shift in tracks. In most locations throughout the shared freight corridor (including the Kenilworth Corridor), the freight tracks remain in place, or are only shifted by a small distance, relative to any sensitive receptors and the changes in vibration levels would not approach the impact criteria.

In the area between Cedar Lake Parkway and the Kenilworth Channel, the tracks are shifted closer to some residences to make room for the LRT tracks (up to a 40 foot shift to the northwest). At the closest residence (on Washburn Avenue), the distance to the shifted freight tracks would be 25 feet. All other residences would be further from the shifted tracks, so this residence represents the worst case. In this case, the vibration levels from freight trains were compared with the appropriate criteria to determine if there would be any vibration impacts from freight operations.

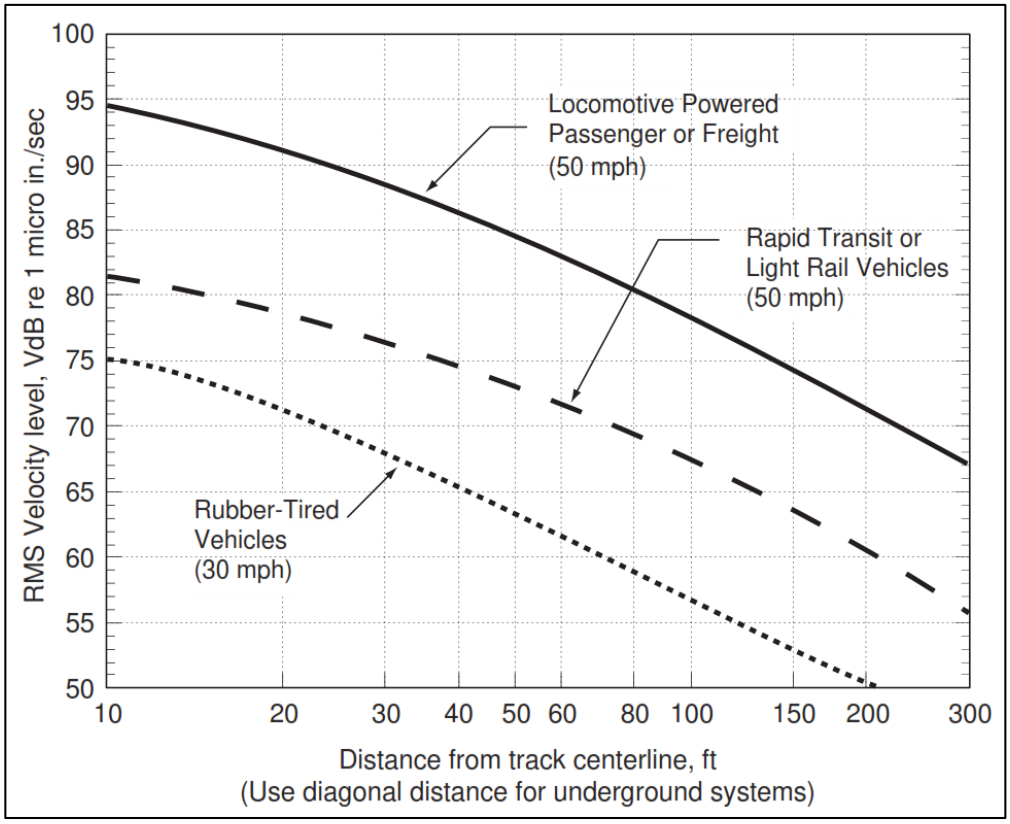
To accomplish this, a general assessment of freight train vibration was conducted to determine if the vibration levels from freight operations at residences near the freight track shift would exceed the FTA vibration criteria (Chapter 10 of the FTA noise and vibration guidance manual). The general assessment methodology is a conservative approach that provides a modest overestimation of vibration levels to determine if a detailed assessment needs to be conducted. If the vibration levels estimated using the general assessment methodology do not exceed the impact criteria, there would be no impact and no further analysis needs to be completed. If the vibration levels do exceed the criteria, a detailed assessment needs to be conducted.

The steps in the general assessment include:

1. Pick a curve from Figure 1 for the source of vibration.
2. Find the vibration level at the distance from the source to the receiver.
3. Adjust the vibration level from the reference speeds in Figure 1 to the actual speed of the source.
4. Compare the vibration levels to the appropriate criteria to determine if there would be impact.

Figure 1 shows the general vibration assessment curve for vibration level (y-axis) vs. distance (x-axis) for various sources. The top curve is used to assess vibration from freight locomotives at 50 mph. The other curves are used for other sources of vibration.

Figure 1. FTA Generalized Ground Surface Vibration Curve



Source: FTA, 2006

Table 1. Ground-Borne Vibration Impact Criteria for General Assessment

Land Use Category	Ground-Borne Vibration Impact Levels (VdB re 1 micro-inch/sec)		
	Frequent Events[a]	Occasional Events[b]	Infrequent Events[c]
Category 1: Buildings where vibration will interfere with interior operations.	65[d]	65[d]	65[d]
Category 2: Residences and buildings where people normally sleep.	72	75	80
Category 3: Institutional land uses with primarily daytime use.	75	78	83

[a] "Frequent Events" are defined as more than 70 vibration events of the same source per day. Most rapid transit projects fall into this category.

[b] "Occasional Events" are defined as between 30 and 70 vibration events of the same source per day. Most commuter trunk lines have this many operations.

[c] "Infrequent Events" are defined as fewer than 30 vibration events of the same kind per day. This category includes most commuter rail branch lines.

[d] 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.

Source: FTA, 2006

The residence nearest to the shifted freight tracks would be at 25 feet from the freight tracks, which, using the top curve in Figure 1, results in a vibration level of 89 VdB at 50 mph for locomotives. The freight trains in the Kenilworth Corridor travel at approximately 10 mph, which when adjusted for speed, using a 20 log speed adjustment (14 VdB reduction due to speed from 50 mph to 10 mph) would result in a vibration level of 75 VdB. Because there are very few freight locomotives, the "infrequent" criterion of 80 VdB for Category 2 residential land use is used to assess impact (See Table 1).

Vibration levels for typical freight cars are 5-9 VdB below those of freight locomotives. Using the freight locomotive vibration level of 75 VdB, this would result in a range of vibration levels of 64-70 VdB for freight cars. Because there are typically many cars per train, the "frequent" criterion of 72 VdB for Category 2 residential land use is used to assess impact (See Table 1).

The results of the general vibration assessment for freight trains at the closest residence to the freight shift are summarized below in Table 2. The vibration levels at residences further from the freight tracks would be lower than those shown in Table 2, so this assessment represents the worst case for the freight shift in the Kenilworth Corridor. Because there are no exceedances of the vibration impact criteria using the general assessment methodology, no impacts are projected, and no further assessment is required.

Table 2. Summary of General Assessment of Freight Vibration

Vibration Source	Vibration Level, VdB		Impact Criterion, VdB	General Assessment Impact?
	50 mph*	10 mph		
Locomotives	89	75	80	No
Cars	80-84	64-70	72	No

* These are reference levels from Figure 1 and do not represent vibration levels from freight trains in the Kenilworth Corridor. The trains travel at much lower speeds, represented by the following column.

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Appendix I. Noise and Vibration Fact Sheets

NOISE FACT SHEET

HOW IS NOISE DEFINED?

Level: Sound level is expressed in decibels (dB). Typical sounds fall between 0 and 120 dB. A 3dB change in sound level represents a barely noticeable change outdoors; a 10 dB change is perceived as a doubling (or halving) of the sound level.

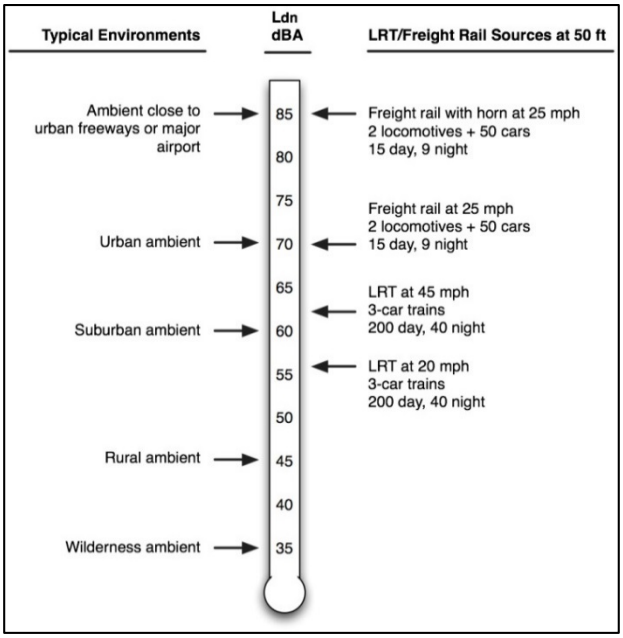
Frequency: The tone or pitch of a sound is expressed in Hertz (Hz). Human ears can detect a wide range of frequencies from about 20 Hz to 20,000 Hz. However, human hearing is not effective at high and low frequencies; we use a measure called an A-weighted level (dBA) to correlate with human response.

Time Pattern: Because environmental noise changes all the time, it is common to condense all of this information into a single number, called the "equivalent" sound level. It represents the changing sound level over a period of time.

For light rail transit (LRT) and freight rail projects, the Day-Night Sound Level (Ldn) is the common noise descriptor adopted by most agencies as the best way to describe how people respond to noise in their environment.

The Ldn is a ***24-hour cumulative noise level*** that includes all noises that happen within a day, with a penalty for nighttime noise (10 PM to 7 AM). This nighttime penalty means that any noise events at night are equal to ten events during the daytime.

Cumulative Noise Levels from LRT and Freight Rail



HOW LOUD ARE LRT AND FREIGHT RAIL?

Noise levels (in Ldn) from LRT and freight rail depend on the type of vehicle, how loud each individual vehicle could be (see table below), the number of trains per day, and train length and speed. In addition, noise levels decrease with increasing distance from the tracks.

Typical Maximum Noise Levels (dBA)

Distance	LRT @ 45 mph	Freight Rail @ 20 mph	Other Sources
50 feet	76	88	Lawnmower: 72
100 feet	71	83	Bus Idling: 66
200 feet	66	78	Diesel Generator: 67

Light Rail Transit (LRT) Vehicle

HOW IS NOISE IMPACT ASSESSED?

Noise impact from LRT and freight rail projects are assessed by comparing the existing (ambient) noise with the noise predicted to be generated by the project.

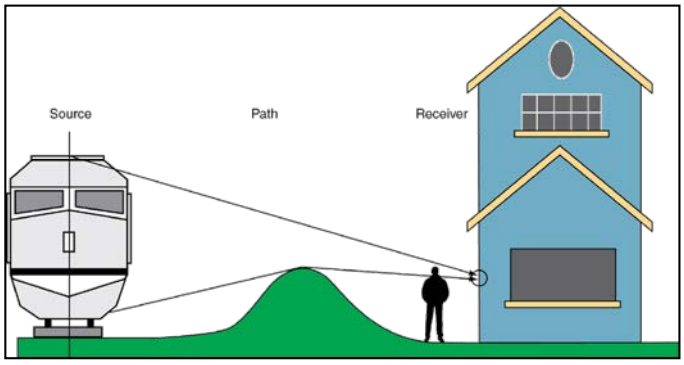
The Federal Transit Administration's (FTA's) noise criteria take into account the noise sensitivity of the receiver by land use category, including:

- **Category 1**: Highly noise sensitive, such as recording studios
- **Category 2**: Residences and other places where people sleep
- **Category 3:** Schools, churches and other places with daytime use

A noise assessment is broken down into three pieces:

Source: What is generating the noise, such as a LRT vehicle or freight train
Path: How far and over what type of ground does the noise travel
Receiver: Who or what is experiencing the noise, such as a residence or a school

The Source – Path – Receiver Concept



Noise impact assessments are based on applicable FTA and Federal Railroad Administration (FRA) models, and are assessed using the source-path-receiver framework. Some of the key components of a noise impact assessment include:

Source

- Noise levels of transit and freight trains
- Number, length and speed of LRT and freight trains
- Time of day of train passing by
- At-grade crossings, including horns and bells
- Track type including elevated tracks, tunnels or at-grade track
- Special trackwork including crossovers

Path

- Distance to noise sensitive locations
- Rows of buildings
- Ground type

Receiver

- Type of land use (Category 1, Category 2 or Category 3)
- Sensitivity of the land use, including highly sensitive locations such as recording studios, residences or parks

Noise impact assessments also address the potential for impacts from maintenance facilities and stations.

Typical Output of a Noise Impact Assessment

The output of a noise impact assessment includes locations with Severe Impact (yellow) and Moderate Impact (orange). This information is used to determine the location and extent of any potential noise mitigation.

HOW IS NOISE MITIGATED?

Noise mitigation is applied at locations where impact is identified. Severe impacts generally require noise mitigation. At the moderate impact level, noise mitigation is also addressed. Mitigation can be applied at the source of the noise, along the path, or at the receiver. Examples of typical LRT and freight rail noise mitigation include:

Typical Mitigation Measures

Mitigation measures can be applied to the source, the path and/or the receiver:

Source: Rail damping, rail grinding, wheel truing, wheel skirts, quiet zones
Path: Noise barriers, berms, buffer zones
Receiver: Sound insulation

VIBRATION FACT SHEET

HOW IS VIBRATION DEFINED?

Vibration is the motion of the ground transmitted into a building that can be described in terms of displacement, velocity or acceleration. Vibration velocity is used in light rail transit (LRT) and freight rail and is defined by the following:

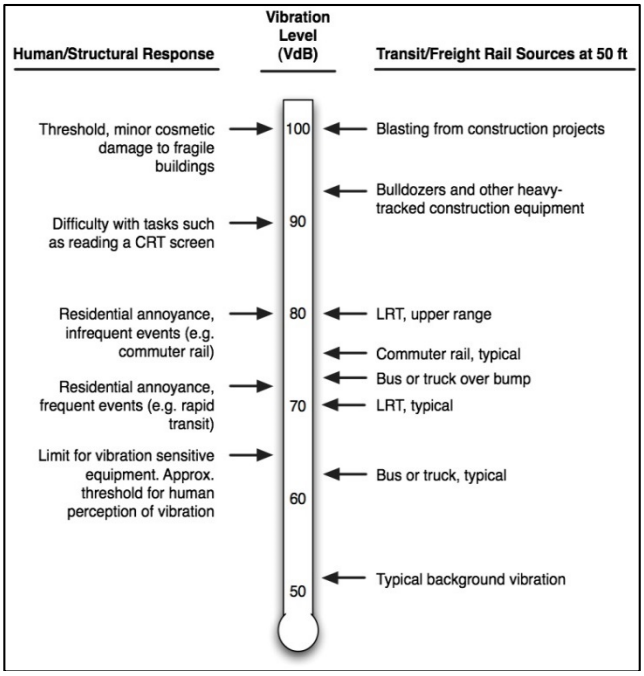
Level: Vibration is expressed in vibration decibels (VdB). The level of vibration represents how much the ground is moving. The threshold of human perception to LRT and freight rail vibration is approximately 65 VdB and annoyance begins to occur for frequent events at vibration levels over 70 VdB.

Frequency: Vibration frequency is expressed in Hertz (Hz). Human response to vibration is typically from about 6 Hz to 200 Hz.

Time Pattern: Environmental vibration changes all the time and human response is correlated to the number of vibration events during the day.

Vibration velocity (VdB) is used to describe LRT and freight rail vibration because it corresponds well to human response to environmental vibration. Vibration is defined by the maximum vibration level during a transit or freight rail event. Human sensitivity to vibration increases with increasing numbers of events during the day.

Vibration Levels from LRT and Freight Rail



Ground-borne noise (GBN) is also assessed. GBN is a form of low-frequency noise that radiates from building walls and ceilings due to vibration caused by LRT or freight rail operation. Because airborne noise typically masks GBN for above ground (at-grade or elevated) transit systems, GBN is only assessed for operations in tunnels (where airborne noise is not a factor) or near locations such as recording studios that are well insulated from airborne noise.

HOW MUCH VIBRATION IS CREATED BY LRT AND FREIGHT RAIL?

Vibration levels from LRT and freight rail depend on the type of vehicle, track conditions, soil type, and train speed. Vibration levels also decrease with increasing distance from the tracks. Vibration levels based on typical LRT and freight rail operations and speeds are shown below.

Vibration and GBN Levels (VdB) at 45 mph

Distance	LRT		Freight Rail
	Vib	GBN	
50 feet	71	39	88
100 feet	66	34	82
200 feet	58	26	76

Light Rail Transit (LRT) Vehicle

HOW IS VIBRATION IMPACT ASSESSED?

Vibration and GBN impact from LRT and freight rail projects are assessed by comparing the levels predicted to be generated by the project with the appropriate criteria.

The vibration and GBN criteria use by the Federal Transit Administration (FTA) take into account the sensitivity of the receiver by land use category, including:

- **Category 1**: Highly vibration sensitive, such as manufacturing facilities
- **Category 2**: Residences and other places where people sleep

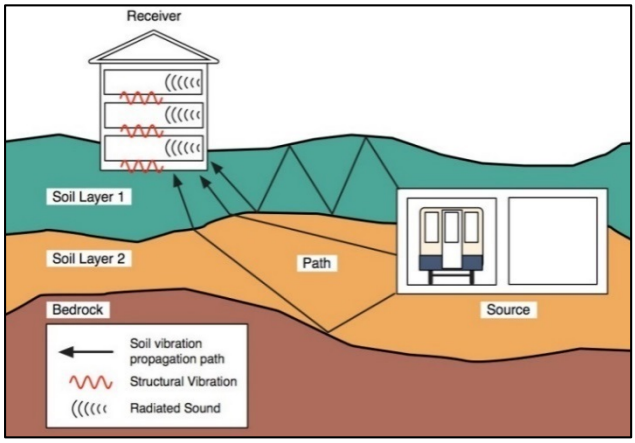
Category 3: Schools, churches and other places with daytime use. A vibration and GBN assessment is broken down into three pieces:

Source: What is generating the vibration or GBN, such as a transit vehicle or freight train

Path: How far and over what type of ground does the vibration or GBN travel

Receiver: Who or what is experiencing the vibration, such as a residence or a school

The Source – Path – Receiver Concept



Vibration and GBN impact assessments are based on applicable FTA and Federal Railroad Administration (FRA) models, and are assessed using the source-path-receiver framework. Some of the key components of a vibration impact assessment include:

Source

- Vibration levels of LRT and freight trains
- Number and speed of LRT and freight trains
- Track type including elevated tracks, tunnels or at-grade track
- Special trackwork including crossovers

Path

- Distance to vibration sensitive locations
- Soil and bedrock characteristics
- Building foundations

Receiver

- Type of land use (Category 1, Category 2 or Category 3)
- Sensitivity of the land use, including highly sensitive locations such as manufacturing facilities, residences or parks

Vibration and GBN impact is primarily assessed to determine the potential for human annoyance. However, vibration is also assessed for activity interference at highly sensitive sites, and in very rare cases, damage to fragile structures, usually during construction. Vibration assessments also address the potential for impacts from maintenance facilities and stations.

Typical Output of a Vibration Impact Assessment

The output of a vibration or GBN impact assessment includes locations with vibration or GBN impact (purple). This information is used to determine the location and extent of any potential vibration mitigation.

HOW IS VIBRATION MITIGATED?

Vibration or GBN mitigation is applied at locations where impact is identified. Vibration impacts generally require mitigation where reasonable and feasible. Because mitigation is highly dependent on engineering details, specific mitigation measures are usually identified during the design of a project.

Vibration or GBN mitigation is most commonly applied at the source (in the tracks), but can also be applied along the path or at the receiver. Examples include:

Source: Rail grinding, wheel truing, resilient fasteners, ballast mats, floating track slabs

Path: Trenches, buffer zones

Receiver: Building modifications, isolated tables, floating floors.

Example Vibration Mitigation: Resilient Fasteners

Appendix J. Detailed Noise Impact Data

								Dist						LRT Noise NB			LRT Noise SB			Grade Crossing Bells NB			Grade Crossing Bells SB			LRT Horns/Bells NB			LRT Horns/Bells SB			Station Bells					Impact Criteria					
Location	# of Units	Stn #	At-grade x-ing Y/N	Station Y/N	Noise Site Used	Land Use Cat	Tunnel Present	NB	SB	Speed (mph)	Track Type	xover	Elevated	Day	Night	Total	Day	Night	Total	Day	Night	Total	Day	Night	Total	Day	Night	Total	Day	Night	Total	Day	Night	Total	Total Project Noise	Exist Noise	Mod	Sev	Impact	# of Impacts	Total Noise	Noise Level Increase
Southwest Station Condos	42	2072	Y	Y	2	2	N	139	125	20	B&T	N	N	42	37	45	43	38	45	27	22	29	27	22	30	0	0	6	55	50	58	44	40	47	62	71	65	70	--	0	72	0.5
Southwest Station Condos	42	2075	Y	Y	2	2	N	139	125	20	B&T	N	N	42	37	45	43	38	45	37	32	40	37	33	40	0	0	6	55	50	58	47	43	50	62	71	65	70	--	0	72	0.5
Purgatory Creek Park	1	2096	N	N	3	3	N	270	284	25	B&T	N	Y	44	0	44	44	0	44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	47	54	60	66	--	0	55	0.9
Water Tower Apartments	24	2112	N	N	4	2	N	100	114	35	B&T	N	N	49	44	52	48	43	51	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	54	62	59	64	--	0	62	0.8
Lincoln Parc Apartments	24	2121	Y	Y	4	2	N	125	139	25	B&T	N	N	45	40	47	44	39	47	35	30	37	34	30	37	54	50	57	0	0	6	48	43	51	59	62	59	64	--	0	63	1.8
Extended Stay	1	2134	Y	N	25	2	N	470	484	45	B&T	N	N	40	35	43	40	35	42	23	18	25	22	17	25	43	38	45	0	0	3	0	0	6	48	61	58	64	--	0	61	0.2
Town Place Suites	1	2132	Y	N	25	2	N	564	550	45	B&T	N	N	39	34	41	39	34	42	19	15	22	20	15	22	0	0	6	41	37	41	0	0	6	46	61	58	64	--	0	61	0.1
Residence Inn	1	2143	Y	N	25	2	N	114	100	45	B&T	N	N	50	46	53	51	47	54	18	13	21	18	14	21	0	0	6	53	49	53	0	0	6	58	61	58	64	--	0	63	1.8
Residence Inn	1	2143	Y	N	25	2	N	164	150	45	B&T	N	N	48	43	50	48	44	51	18	13	21	18	13	21	0	0	6	50	46	50	0	0	6	55	61	58	64	--	0	62	1.0
Residence Inn	1	2146	Y	N	25	2	N	54	40	45	B&T	N	N	56	51	59	58	53	61	24	19	27	25	20	28	0	0	6	60	55	62	0	0	6	66	61	58	64	Sev	1	67	5.9
Residence Inn	1	2146	Y	N	25	2	N	114	100	45	B&T	N	N	50	46	53	51	47	54	24	19	27	24	20	27	0	0	6	53	49	56	0	0	6	59	61	58	64	Mod	1	63	2.3
Residence Inn	1	2143	Y	N	25	2	N	214	200	45	B&T	N	N	46	41	48	46	41	49	18	13	20	18	13	21	0	0	6	48	44	51	0	0	6	54	61	58	64	--	0	62	0.9
Residence Inn	1	2146	Y	N	25	2	N	264	250	45	B&T	N	N	44	39	47	45	40	47	22	18	25	23	18	26	0	0	6	47	42	50	0	0	6	53	61	58	64	--	0	62	0.6
Residence Inn	1	2147	Y	N	25	2	N	214	200	45	B&T	N	N	46	41	48	46	41	49	25	21	28	26	21	29	0	0	6	48	44	51	0	0	6	55	61	58	64	--	0	62	0.9
Residence Inn	1	2147	Y	N	25	2	N	264	250	45	B&T	N	N	44	39	47	45	40	47	24	20	27	25	20	28	0	0	6	47	42	50	0	0	6	53	61	58	64	--	0	62	0.6
Baymont Inn	1	2151	Y	N	25	2	N	80	94	45	B&T	N	N	53	48	56	52	47	54	37	32	40	37	32	40	55	50	58	0	0	6	0	0	6	61	61	58	64	Mod	1	64	3.0
Marriott	1	2147	Y	N	25	2	N	500	514	45	B&T	N	N	39	35	42	39	35	42	20	16	23	20	15	23	42	37	45	0	0	6	0	0	6	48	61	58	64	--	0	61	0.2
Fox 9 Studios	1	2146	Y	N	25	1	N	500	514	45	B&T	N	N	40	0	40	39	0	39	19	0	19	19	0	19	42	0	42	0	0	0	0	0	0	45	61	58	64	--	0	61	0.1
Eagle Ridge Academy	1	2225	N	N	26	3	N	225	239	35	B&T	N	Y	49	0	49	48	0	48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	51	65	66	71	--	0	65	0.2
Shop HQ	1	2098	N	N	26	1	N	100	114	35	B&T	N	N	49	0	49	48	0	48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	52	53	54	60	--	0	55	2.6
Sunrise Montessori	1	2320	Y	N	26	3	N	300	314	40	B&T	N	N	42	0	42	42	0	42	26	0	26	26	0	26	46	0	46	0	0	0	0	0	0	49	65	66	71	--	0	65	0.1
Claremont Apts	30	2363	N	N	5	2	N	130	144	45	B&T	N	N	49	45	52	49	44	51	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	55	57	56	62	--	0	59	2.1
Claremont Apts	30	2365	N	N	5	2	N	90	104	45	B&T	N	N	52	47	55	51	46	54	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	57	57	56	62	Mod	30	60	3.2
Claremont Apts	30	2359	N	N	5	2	N	80	94	45	B&T	N	N	53	48	56	52	47	54	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	58	57	56	62	Mod	30	61	3.7
Claremont Apts	30	2372	N	N	5	2	N	100	114	45	B&T	N	N	51	47	54	50	46	53	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	57	57	56	62	Mod	30	60	2.9
Claremont Apts	30	2375	N	N	5	2	N	100	114	45	B&T	N	N	51	47	54	50	46	53	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	57	57	56	62	Mod	30	60	2.9
Greenfield Apts	30	2384	N	N	27	2	N	125	139	30	B&T	N	N	46	41	49	45	41	48	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	52	62	59	64	--	0	63	0.4
Greenfield Apts	30	2394	N	N	5	2	N	200	214	55	B&T	N	N	48	43	51	47	43	50	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	53	57	56	62	--	0	59	1.6
Deer Ridge	4	2387	N	N	27	2	N	164	150	30	B&T	N	Y	49	44	52	50	45	53	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	55	62	59	64	--	0	63	0.8
Deer Ridge	4	2400	N	N	5	2	N	314	300	55	B&T	N	Y	50	45	53	51	46	53	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	56	57	56	62	--	0	60	2.6
Parkside Apartments	8	2443	Y	N	6	2	N	794	780	65	B&T	N	N	39	35	42	39	35	42	14	10	17	14	10	17	0	0	6	37	33	40	0	0	6	46	65	61	66	--	0	65	0.1
Mayfair Apartments	8	2445	Y	N	6	2	N	734	720	65	B&T	N	N	40	35	43	40	35	43	16	12	19	16	12	19	0	0	6	38	33	41	0	0	6	47	65	61	66	--	0	65	0.1

								Dist						LRT Noise NB			LRT Noise SB			Grade Crossing Bells NB			Grade Crossing Bells SB			LRT Horns/Bells NB			LRT Horns/Bells SB			Station Bells					Impact Criteria					
Location	# of Units	Stn #	At-grade x-ing Y/N	Station Y/N	Noise Site Used	Land Use Cat	Tunnel Present	NB	SB	Speed (mph)	Track Type	xover	Elevated	Day	Night	Total	Day	Night	Total	Day	Night	Total	Day	Night	Total	Day	Night	Total	Day	Night	Total	Day	Night	Total	Total Project Noise	Exist Noise	Mod	Sev	Impact	# of Impacts	Total Noise	Noise Level Increase
11th Ave houses	2	2447	Y	N	6	2	N	654	640	65	B&T	N	N	41	36	43	41	36	44	19	14	21	19	14	21	0	0	6	39	34	42	0	0	6	48	65	61	66	--	0	65	0.1
Royal Apartments	16	2448	Y	N	6	2	N	624	610	65	B&T	N	N	41	36	44	41	36	44	19	15	22	20	15	22	0	0	6	39	34	42	0	0	6	48	65	61	66	--	0	65	0.1
Hearing Care Specialists (audiologist)	1	2076	Y	Y	6	1	N	84	70	35	B&T	N	N	51	0	51	52	0	52	0	0	6	0	0	6	0	0	0	57	0	57	4	0	4	59	59	62	68	--	0	62	2.9
Hopkins Plaza Apts	24	2511	Y	Y	6	2	N	364	350	20	B&T	N	N	35	30	38	35	30	38	15	10	17	15	10	17	0	0	6	70	65	70	50	45	52	70	65	61	66	Sev	24	71	6.1
Hopkins Plaza Apts	12	2513	Y	Y	6	2	N	334	320	20	B&T	N	N	35	31	38	36	31	38	17	12	20	17	13	20	0	0	6	71	66	70	50	45	53	71	65	61	66	Sev	12	72	6.6
Hopkins Plaza Apts	12	2513	Y	Y	6	2	N	454	440	20	B&T	N	N	33	28	36	33	29	36	16	11	19	16	12	19	0	0	6	68	64	68	48	43	51	68	65	61	66	Sev	12	70	5.0
7th Ave Res	2	2517	Y	N	6	2	N	444	430	35	B&T	N	N	38	33	41	38	34	41	21	17	24	22	17	24	0	0	6	66	61	66	0	0	6	66	65	61	66	Mod	2	69	3.5
Sonoma Apartments	12	2518	Y	N	6	2	N	364	350	45	B&T	N	N	42	37	45	42	37	45	24	19	27	25	20	27	0	0	6	67	62	66	0	0	6	66	65	61	66	Sev	12	69	3.7
6th Ave res	5	2519	Y	N	6	2	N	414	400	45	B&T	N	N	41	36	44	41	36	44	24	19	27	24	19	27	0	0	6	66	61	65	0	0	6	65	65	61	66	Mod	5	68	3.2
Town Terrace Apts	40	2525	Y	N	6	2	N	264	250	55	B&T	N	N	46	41	49	46	42	49	21	16	23	21	16	24	0	0	6	68	63	68	0	0	6	68	65	61	66	Sev	40	70	4.7
Monroe Ave	1	2549	N	N	7	2	N	200	214	55	B&T	N	Y	53	48	56	53	48	55	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	59	58	57	63	Mod	1	62	3.2
Monroes Ave	1	2549	N	N	7	2	N	250	264	55	B&T	N	Y	52	47	54	51	47	54	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	57	58	57	63	Mod	1	61	2.5
Westside Apartments	42	2580	Y	N	8	2	N	125	139	35	B&T	N	N	47	43	50	47	42	49	35	30	37	34	30	37	75	70	78	0	0	3	0	0	6	78	60	58	63	Sev	42	78	17.4
Westside Apartments	42	2582	Y	N	8	2	N	125	139	35	B&T	N	N	47	43	50	47	42	49	27	22	29	27	22	30	75	70	78	0	0	3	0	0	6	78	60	58	63	Sev	42	78	17.4
Westside Apartments	42	2580	Y	N	8	2	N	275	289	35	B&T	N	N	42	37	44	41	37	44	28	23	31	28	23	30	69	65	72	0	0	3	0	0	6	72	60	58	63	Sev	42	72	12.2
Westside Apartments	42	2582	Y	N	8	2	N	375	389	35	B&T	N	N	39	35	42	39	34	42	22	18	25	22	18	25	67	62	70	0	0	3	0	0	6	70	60	58	63	Sev	42	70	10.2
Westside Apartments	42	2580	Y	N	8	2	N	625	639	35	B&T	N	N	36	31	38	36	31	38	19	15	22	19	14	22	64	59	66	0	0	3	0	0	6	66	60	58	63	Sev	42	67	7.1
Westside Apartments	42	2582	Y	N	8	2	N	625	639	35	B&T	N	N	36	31	38	36	31	38	18	14	21	18	13	21	64	59	66	0	0	3	0	0	6	66	60	58	63	Sev	42	67	7.1
Creekwood Estates	12	2594	Y	N	9	2	N	284	270	55	B&T	N	N	45	41	48	46	41	49	9	5	12	10	5	12	0	0	6	67	63	67	0	0	6	68	57	56	62	Sev	12	69	12.1
Creekwood Estates	12	2594	Y	N	9	2	N	414	400	55	B&T	N	N	43	38	45	43	38	46	9	4	12	9	5	12	0	0	6	65	60	65	0	0	6	66	57	56	62	Sev	12	66	9.6
Creekwood Estates	48	2594	Y	N	9	2	N	584	570	55	B&T	N	N	40	35	43	40	36	43	9	4	12	9	4	12	0	0	6	62	58	62	0	0	6	63	57	56	62	Sev	48	64	7.5
Edgebrook Residence	30	2607	N	N	9	2	N	264	250	55	B&T	N	N	46	41	49	46	42	49	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	53	57	56	62	--	0	58	1.6
Railroad Ave	1	2652	Y	N	14	2	N	150	164	55	B&T	N	N	50	45	53	49	45	52	0	0	6	0	0	6	72	67	74	0	0	3	0	0	6	74	58	57	62	Sev	1	74	16.5
Railroad Ave	1	2652	Y	N	14	2	N	125	139	55	B&T	N	N	51	47	54	51	46	53	0	0	6	0	0	6	73	68	76	0	0	3	0	0	6	76	58	57	62	Sev	1	76	17.7
Railroad Ave	1	2652	Y	N	14	2	N	50	64	55	B&T	N	N	58	53	61	56	52	59	0	0	6	0	0	6	79	74	82	0	0	3	0	0	6	82	58	57	62	Sev	1	82	24.0
Railroad Ave	1	2653	Y	N	14	2	N	120	134	55	B&T	N	N	52	47	54	51	46	54	0	0	6	0	0	6	73	68	76	0	0	3	0	0	6	76	58	57	62	Sev	1	76	18.0
Railroad Ave	1	2654	Y	N	14	2	N	125	139	55	B&T	N	N	51	47	54	51	46	53	0	0	6	0	0	6	73	68	76	0	0	3	0	0	6	76	58	57	62	Sev	1	76	17.7

								Dist						LRT Noise NB			LRT Noise SB			Grade Crossing Bells NB			Grade Crossing Bells SB			LRT Horns/Bells NB			LRT Horns/Bells SB			Station Bells					Impact Criteria					
Location	# of Units	Stn #	At-grade x-ing Y/N	Station Y/N	Noise Site Used	Land Use Cat	Tunnel Present	NB	SB	Speed (mph)	Track Type	xover	Elevated	Day	Night	Total	Day	Night	Total	Day	Night	Total	Day	Night	Total	Day	Night	Total	Day	Night	Total	Day	Night	Total	Total Project Noise	Exist Noise	Mod	Sev	Impact	# of Impacts	Total Noise	Noise Level Increase
Railroad Ave	1	2655	Y	N	14	2	N	100	114	55	B&T	N	N	53	48	56	52	47	55	0	0	6	0	0	6	74	70	77	0	0	3	0	0	6	77	58	57	62	Sev	1	77	19.2
Railroad Ave	1	2656	Y	N	14	2	N	125	139	55	B&T	Y	N	57	53	60	57	52	59	0	0	6	0	0	6	73	68	76	0	0	3	0	0	6	76	58	57	62	Sev	1	76	17.9
Railroad Ave	1	2656	Y	N	14	2	N	85	99	55	B&T	Y	N	60	55	63	59	54	62	0	0	6	0	0	6	76	71	78	0	0	3	0	0	6	78	58	57	62	Sev	1	79	20.5
Railroad Ave	1	2657	Y	N	14	2	N	150	164	55	B&T	Y	N	56	51	59	55	51	58	0	0	6	0	0	6	72	67	74	0	0	3	0	0	6	75	58	57	62	Sev	1	75	16.6
Railroad Ave	1	2658	Y	N	14	2	N	175	189	55	B&T	Y	N	55	50	58	54	50	57	0	0	6	0	0	6	70	66	73	0	0	3	0	0	6	73	58	57	62	Sev	1	74	15.6
Railroad Ave	1	2659	Y	N	14	2	N	225	239	55	B&T	N	N	47	42	50	47	42	49	0	0	6	0	0	6	69	64	72	0	0	3	0	0	6	72	58	57	62	Sev	1	72	13.7
Railroad Ave	1	2653	Y	N	14	2	N	200	214	55	B&T	N	N	48	43	51	47	43	50	0	0	6	0	0	6	70	65	72	0	0	3	0	0	6	72	58	57	62	Sev	1	73	14.5
Railroad Ave	1	2653	Y	N	14	2	N	225	239	55	B&T	N	N	47	42	50	47	42	49	0	0	6	0	0	6	69	64	72	0	0	3	0	0	6	72	58	57	62	Sev	1	72	13.7
Railroad Ave	1	2654	Y	N	14	2	N	240	254	55	B&T	N	N	47	42	49	46	41	49	0	0	6	0	0	6	68	64	71	0	0	3	0	0	6	71	58	57	62	Sev	1	71	13.3
Railroad Ave	1	2655	Y	N	14	2	N	175	189	55	B&T	N	N	49	44	52	48	44	51	0	0	6	0	0	6	70	66	73	0	0	3	0	0	6	73	58	57	62	Sev	1	73	15.4
Railroad Ave	1	2655	Y	N	14	2	N	225	239	55	B&T	N	N	47	42	50	47	42	49	0	0	6	0	0	6	69	64	72	0	0	3	0	0	6	72	58	57	62	Sev	1	72	13.7
Railroad Ave	1	2655	Y	N	14	2	N	235	249	55	B&T	N	N	47	42	50	46	42	49	0	0	6	0	0	6	68	64	71	0	0	3	0	0	6	71	58	57	62	Sev	1	71	13.5
Railroad Ave	1	2655	Y	N	14	2	N	300	314	55	B&T	N	N	45	40	48	45	40	47	0	0	6	0	0	6	67	62	70	0	0	3	0	0	6	70	58	57	62	Sev	1	70	11.9
Railroad Ave	4	2655	Y	N	14	2	N	240	254	55	B&T	N	N	47	42	49	46	41	49	0	0	6	0	0	6	68	64	71	0	0	3	0	0	6	71	58	57	62	Sev	4	71	13.3
Railroad Ave	4	2655	Y	N	14	2	N	310	324	55	B&T	N	N	45	40	47	44	40	47	0	0	6	0	0	6	67	62	69	0	0	3	0	0	6	69	58	57	62	Sev	4	70	11.6
Railroad Ave	4	2655	Y	N	14	2	N	400	414	55	B&T	N	N	43	38	46	43	38	45	0	0	6	0	0	6	65	60	68	0	0	3	0	0	6	68	58	57	62	Sev	4	68	10.0
Railroad Ave	4	2655	Y	N	14	2	N	450	464	55	B&T	N	N	42	37	45	42	37	45	0	0	6	0	0	6	64	59	67	0	0	3	0	0	6	67	58	57	62	Sev	4	67	9.3
Railroad Ave	4	2655	Y	N	14	2	N	500	514	55	B&T	N	N	41	36	44	41	36	44	0	0	6	0	0	6	63	58	66	0	0	3	0	0	6	66	58	57	62	Sev	4	67	8.7
Railroad Ave	4	2655	Y	N	14	2	N	550	564	55	B&T	N	N	41	36	43	40	36	43	0	0	6	0	0	6	63	58	65	0	0	3	0	0	6	65	58	57	62	Sev	4	66	8.1
Railroad Ave	4	2655	Y	N	14	2	N	700	714	55	B&T	N	N	39	34	42	39	34	41	0	0	6	0	0	6	61	56	64	0	0	3	0	0	6	64	58	57	62	Sev	4	65	6.7
Railroad Ave	32	2665	Y	Y	15	2	N	150	164	35	B&T	N	N	46	41	49	45	41	48	26	22	29	27	22	29	74	69	76	0	0	3	45	40	48	76	65	60	66	Sev	32	77	12.0
Railroad Ave	32	2665	Y	Y	15	2	N	425	439	35	B&T	N	N	39	34	41	38	34	41	22	17	24	21	17	24	66	62	69	0	0	3	43	39	46	69	65	60	66	Sev	32	70	5.8
TowerLight	66	2667	Y	Y	15	2	N	355	369	20	B&T	N	N	35	30	38	35	30	37	23	18	26	23	18	26	70	65	73	0	0	3	46	42	49	73	65	60	66	Sev	66	73	8.8
37th Apts	16	2669	Y	Y	15	2	N	554	540	35	B&T	N	N	37	32	39	37	32	39	21	16	24	21	16	24	0	0	6	65	60	64	44	40	47	64	65	60	66	Mod	16	68	3.0
Camerata Way	32	2680	N	N	15	2	N	150	164	55	B&T	N	N	50	45	53	49	45	52	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	56	65	60	66	--	0	65	0.5
Camerata Way	32	2681	N	N	15	2	N	50	64	55	B&T	N	N	58	53	61	56	52	59	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	63	65	60	66	Mod	32	67	2.3
Cityscape Apartments	32	2682	N	N	15	2	N	139	125	55	B&T	N	N	51	46	53	51	47	54	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	57	65	60	66	--	0	65	0.7
Lilac Park	1	2694	N	N	15	3	N	164	150	55	B&T	N	N	50	0	50	50	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	53	56	60	66	--	0	57	1.9
Park Glen Townhms	3	2720	N	N	15	2	N	112	126	35	B&T	Y	N	54	49	57	53	49	56	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	60	65	60	66	--	0	66	1.2
Park Glen Townhms	3	2722	N	N	15	2	N	112	126	35	B&T	Y	N	54	49	57	53	49	56	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	60	65	60	66	--	0	66	1.2
Park Glen Townhms	8	2735	N	N	15	2	N	112	126	40	B&T	Y	N	55	51	58	55	50	57	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	61	65	60	66	Mod	8	66	1.5
Park Glen Townhms	8	2735	N	N	15	2	N	112	126	40	B&T	Y	N	55	51	58	55	50	57	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	61	65	60	66	Mod	8	66	1.5
Park Glen Townhms	3	2737	N	N	15	2	N	112	126	40	B&T	N	N	49	45	52	49	44	51	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	55	65	60	66	--	0	65	0.4
Glenhurst Ave	1	2742	N	N	15	2	N	214	200	45	B&T	N	N	46	41	48	46	41	49	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	52	65	60	66	--	0	65	0.2
Glenhurst Ave	1	2744	N	N	15	2	N	214	200	45	B&T	N	N	46	41	48	46	41	49	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	52	65	60	66	--	0	65	0.2

								Dist						LRT Noise NB			LRT Noise SB			Grade Crossing Bells NB			Grade Crossing Bells SB			LRT Horns/Bells NB			LRT Horns/Bells SB			Station Bells					Impact Criteria					
Location	# of Units	Stn #	At-grade x-ing Y/N	Station Y/N	Noise Site Used	Land Use Cat	Tunnel Present	NB	SB	Speed (mph)	Track Type	xover	Elevated	Day	Night	Total	Day	Night	Total	Day	Night	Total	Day	Night	Total	Day	Night	Total	Day	Night	Total	Day	Night	Total	Total Project Noise	Exist Noise	Mod	Sev	Impact	# of Impacts	Total Noise	Noise Level Increase
Glenhurst Ave	1	2744	N	N	15	2	N	289	275	45	B&T	N	N	44	39	46	44	39	47	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	49	65	60	66	--	0	65	0.1
Glenhurst Ave	1	2745	N	N	15	2	N	339	325	45	B&T	N	N	42	38	45	43	38	45	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	48	65	60	66	--	0	65	0.1
Glenhurst Ave	1	2745	N	N	15	2	N	339	325	45	B&T	N	N	42	38	45	43	38	45	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	48	65	60	66	--	0	65	0.1
Glenhurst Ave	1	2747	N	N	15	2	N	314	300	45	B&T	N	N	43	38	46	43	38	46	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	49	65	60	66	--	0	65	0.1
Glenhurst Ave	1	2748	N	N	15	2	N	289	275	45	B&T	N	N	44	39	46	44	39	47	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	49	65	60	66	--	0	65	0.1
Glenhurst Ave	1	2749	N	N	15	2	N	289	275	45	B&T	N	N	44	39	46	44	39	47	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	49	65	60	66	--	0	65	0.1
Glenhurst Ave	1	2750	N	N	15	2	N	264	250	45	B&T	N	N	44	39	47	45	40	47	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	50	65	60	66	--	0	65	0.2
Glenhurst Ave	1	2752	N	N	15	2	N	264	250	45	B&T	N	N	44	39	47	45	40	47	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	50	65	60	66	--	0	65	0.2
Glenhurst Ave	1	2753	N	N	15	2	N	264	250	45	B&T	N	N	44	39	47	45	40	47	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	50	65	60	66	--	0	65	0.2
Glenhurst Ave	12	2750	N	N	15	2	N	139	125	45	B&T	N	N	49	44	52	50	45	52	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	55	65	60	66	--	0	65	0.5
Ewing Ave S	1	2755	N	N	15	2	N	189	175	45	B&T	N	N	47	42	49	47	42	50	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	53	65	60	66	--	0	65	0.3
Ewing Ave S	4	2756	N	N	15	2	N	339	325	45	B&T	N	N	42	38	45	43	38	45	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	48	65	60	66	--	0	65	0.1
Ewing Ave S	8	2757	N	N	15	2	N	264	250	45	B&T	N	N	44	39	47	45	40	47	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	50	65	60	66	--	0	65	0.2
Ewing Ave S	24	2760	N	N	15	2	N	114	100	45	B&T	N	N	50	46	53	51	47	54	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	57	65	60	66	--	0	65	0.6
Lake Citihomes	4	2762	N	Y	15	2	N	101	87	35	B&T	N	N	49	44	52	50	45	53	0	0	6	0	0	6	0	0	6	0	0	6	45	40	48	56	65	60	66	--	0	65	0.6
Lake Citihomes	4	2763	N	Y	15	2	N	101	87	30	B&T	N	N	48	43	50	49	44	51	0	0	6	0	0	6	0	0	6	0	0	6	47	42	50	55	65	60	66	--	0	65	0.5
Lake Citihomes	4	2765	N	Y	15	2	N	101	87	20	B&T	N	N	44	39	47	45	40	48	0	0	6	0	0	6	0	0	6	0	0	6	53	48	56	57	65	60	66	--	0	65	0.7
Lake Citihomes	4	2766	N	Y	15	2	N	101	87	20	B&T	N	N	44	39	47	45	40	48	0	0	6	0	0	6	0	0	6	0	0	6	56	52	59	60	65	60	66	--	0	66	1.2
Lake Citihomes	4	2767	N	Y	15	2	N	101	87	20	B&T	N	N	44	39	47	45	40	48	0	0	6	0	0	6	0	0	6	0	0	6	59	54	61	62	65	60	66	Mod	4	66	1.8
Chowen Ave S	1	2756	N	N	15	2	N	250	264	45	B&T	N	N	45	40	47	44	39	47	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	50	65	60	66	--	0	65	0.2
Chowen Ave S	8	2762	N	Y	15	2	N	75	89	35	B&T	N	N	51	46	54	50	45	53	0	0	6	0	0	6	0	0	6	0	0	6	45	40	48	57	65	60	66	--	0	65	0.7
Chowen Ave S	48	2761	N	Y	15	2	N	75	89	35	B&T	N	N	51	46	54	50	45	53	0	0	6	0	0	6	0	0	6	0	0	6	44	39	47	57	65	60	66	--	0	65	0.7
Chowen Ave S	8	2764	N	Y	15	2	N	125	139	25	B&T	N	N	45	40	47	44	39	47	0	0	6	0	0	6	0	0	6	0	0	6	50	45	52	54	65	60	66	--	0	65	0.4
Chowen Ave S	1	2757	N	N	15	2	N	300	314	45	B&T	N	N	43	38	46	43	38	46	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	49	65	60	66	--	0	65	0.1
Chowen Ave S	1	2759	N	N	15	2	N	350	364	45	B&T	N	N	42	37	45	42	37	45	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	48	65	60	66	--	0	65	0.1
Chowen Ave S	2	2754	N	N	15	2	N	125	139	45	B&T	N	N	50	45	52	49	44	52	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	55	65	60	66	--	0	65	0.5
Chowen Ave S	2	2755	N	N	15	2	N	175	189	45	B&T	N	N	47	42	50	47	42	49	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	53	65	60	66	--	0	65	0.3
St Louis Ave	3	2773	N	N	15	2	N	76	62	45	EMB	N	N	50	46	53	52	47	54	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	57	65	60	66	--	0	65	0.7
St Louis Ave	2	2774	N	N	15	2	N	89	75	45	EMB	N	N	49	44	52	50	46	53	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	56	65	60	66	--	0	65	0.5
St Louis Ave	3	2775	N	N	15	2	N	76	62	45	EMB	N	N	50	46	53	52	47	54	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	57	65	60	66	--	0	65	0.7
Benton Blvd	1	2798	N	N	16	2	N	87	101	45	EMB	N	N	49	45	52	48	43	51	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	55	61	58	64	--	0	65	0.9
Benton Blvd	1	2799	N	N	16	2	N	137	151	45	EMB	N	N	52	47	55	51	46	54	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	57	61	58	64	--	0	62	1.6
Benton Blvd	1	2800	N	N	16	2	N	137	151	45	EMB	N	N	52	47	55	51	46	54	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	57	61	58	64	--	0	62	1.6
Channel cat 1	1	2803	N	N	16	1	N	200	214	45	B&T	N	N	51	0	51	51	0	51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	54	54	55	61	--	0	57	2.9
Channel cat 3	1	2803	N	N	16	3	N	40	54	45	B&T	N	N	58	0	58	57	0	57	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60	54	60	66	Mod	1	61	7.2
Burnham Rd	1	2798	N	N	16	2	N	176	162	45	EMB	N	N	50	45	53	51	46	53	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	56	61	58	64	--	0	62	1.3
Burnham Rd	1	2799	N	N	16	2	N	214	200	45	EMB	N	N	49	44	51	49	44	52	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	55	61	58	64	--	0	62	0.9
Burnham Rd	1	2799	N	N	16	2	N	239	225	45	EMB	N	N	48	43	51	48	44	51	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	54	61	58	64	--	0	62	0.8

								Dist						LRT Noise NB			LRT Noise SB			Grade Crossing Bells NB			Grade Crossing Bells SB			LRT Horns/Bells NB			LRT Horns/Bells SB			Station Bells					Impact Criteria					
Location	# of Units	Stn #	At-grade x-ing Y/N	Station Y/N	Noise Site Used	Land Use Cat	Tunnel Present	NB	SB	Speed (mph)	Track Type	xover	Elevated	Day	Night	Total	Day	Night	Total	Day	Night	Total	Day	Night	Total	Day	Night	Total	Day	Night	Total	Day	Night	Total	Total Project Noise	Exist Noise	Mod	Sev	Impact	# of Impacts	Total Noise	Noise Level Increase
Burnham Rd	1	2800	N	N	16	2	N	239	225	45	EMB	N	N	48	43	51	48	44	51	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	54	61	58	64	--	0	62	0.8
Burnham Rd	1	2800	N	N	16	2	N	214	200	45	EMB	N	N	49	44	51	49	44	52	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	55	61	58	64	--	0	62	0.9
S Upton Ave	1	2804	N	N	16	2	N	100	114	45	B&T	N	N	51	47	54	50	46	53	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	57	61	58	64	--	0	62	1.4
S Upton Ave	1	2804	N	N	16	2	N	100	114	45	B&T	N	N	51	47	54	50	46	53	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	57	61	58	64	--	0	62	1.4
S Upton Ave	1	2805	N	N	16	2	N	120	134	45	B&T	N	N	50	45	53	49	44	52	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	55	61	58	64	--	0	62	1.1
S Upton Ave	1	2805	N	N	16	2	N	150	164	45	B&T	N	N	48	44	51	48	43	50	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	54	61	58	64	--	0	62	0.8
S Upton Ave	1	2806	N	N	16	2	N	125	139	45	B&T	N	N	50	45	52	49	44	52	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	55	61	58	64	--	0	62	1.0
S Upton Ave	1	2807	N	N	16	2	N	140	154	45	B&T	N	N	49	44	52	48	43	51	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	54	61	58	64	--	0	62	0.8
S Upton Ave	1	2807	N	N	16	2	N	160	174	45	B&T	N	N	48	43	51	47	42	50	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	53	61	58	64	--	0	62	0.7
S Upton Ave	1	2807	N	N	16	2	N	140	154	45	B&T	N	N	49	44	52	48	43	51	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	54	61	58	64	--	0	62	0.8
S Upton Ave	1	2808	N	N	16	2	N	160	174	45	B&T	N	N	48	43	51	47	42	50	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	53	61	58	64	--	0	62	0.7
S Upton Ave	1	2809	N	N	16	2	N	200	214	45	EMB	N	N	49	44	52	49	44	51	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	55	61	58	64	--	0	62	0.9
Burnham Rd 2	1	2805	N	N	16	2	N	64	50	45	B&T	N	N	55	50	57	56	52	59	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	63	61	58	64	Mod	1	65	4.4
Burnham Rd 2	1	2805	N	N	16	2	N	89	75	45	B&T	N	N	52	47	55	53	49	56	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	61	61	58	64	Mod	1	64	2.9
Burnham Rd 2	1	2805	N	N	16	2	N	139	125	45	B&T	N	N	49	44	52	50	45	52	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	57	61	58	64	--	0	62	1.5
Burnham Rd 2	1	2806	N	N	16	2	N	114	100	45	B&T	N	N	50	46	53	51	47	54	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	59	61	58	64	Mod	1	63	2.0
Burnham Rd 2	1	2807	N	N	16	2	N	94	80	45	B&T	N	N	52	47	54	53	48	56	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	60	61	58	64	Mod	1	64	2.6
Burnham Rd 2	1	2808	N	N	16	2	N	114	100	45	B&T	N	N	50	46	53	51	47	54	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	59	61	58	64	Mod	1	63	2.0
Burnham Rd 2	1	2809	N	N	16	2	N	134	120	45	B&T	N	N	49	44	52	50	45	53	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	57	61	58	64	--	0	62	1.6
Burnham Rd 2	1	2810	N	N	16	2	N	139	125	45	B&T	N	N	49	44	52	50	45	52	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	57	61	58	64	--	0	62	1.5
Burnham Rd 2	1	2811	N	N	16	2	N	124	110	45	B&T	N	N	50	45	52	51	46	53	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	58	61	58	64	--	0	63	1.8
Thomas Ln	1	2814	N	N	17	2	N	160	174	40	B&T	N	N	47	42	50	46	41	49	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	52	56	56	62	--	0	58	1.5
Thomas Ln	1	2815	N	N	17	2	N	150	164	40	B&T	N	N	47	43	50	47	42	49	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	53	56	56	62	--	0	58	1.7
Thomas Ln	1	2815	N	N	17	2	N	140	154	35	B&T	N	N	47	42	49	46	41	49	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	52	56	56	62	--	0	57	1.5
Thomas Ln	1	2816	N	N	17	2	N	130	144	35	B&T	N	N	47	42	50	46	42	49	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	53	56	56	62	--	0	58	1.6
Thomas Ln	1	2816	N	N	17	2	N	150	164	30	B&T	N	N	45	40	48	44	39	47	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	50	56	56	62	--	0	57	1.0
Thomas Ave S	1	2819	N	Y	17	2	N	150	164	30	B&T	N	N	45	40	48	44	39	47	21	17	24	22	17	24	52	47	0	0	0	6	47	42	50	53	56	56	62	--	0	58	2
Thomas Ave S	1	2820	N	Y	17	2	N	160	174	30	B&T	N	N	44	40	47	44	39	46	24	19	26	24	19	27	52	47	0	0	0	6	49	44	51	54	56	56	62	--	0	58	2
Thomas Ave S	1	2821	N	Y	17	2	N	175	189	25	B&T	N	N	42	37	45	42	37	44	26	21	29	26	21	29	52	47	0	0	0	6	51	46	54	55	56	56	62	--	0	58	2
Thomas Ave S	1	2821	N	Y	17	2	N	175	189	25	B&T	N	N	42	37	45	42	37	44	26	21	29	26	21	29	52	47	0	0	0	6	51	46	54	55	56	56	62	--	0	58	2
Thomas Ave S	1	2822	N	Y	17	2	N	200	214	25	B&T	N	N	41	36	44	41	36	43	28	24	31	28	23	31	51	46	0	0	0	6	52	48	55	56	56	56	62	--	0	59	3
Thomas Ave S	1	2823	N	Y	17	2	N	250	264	25	B&T	N	N	39	35	42	39	34	42	29	24	32	28	24	31	49	45	0	0	0	6	51	47	54	55	56	56	62	--	0	58	2
Thomas Ave S	1	2823	N	Y	17	2	N	225	239	25	B&T	N	N	40	35	43	40	35	43	30	25	33	31	25	33	50	45	0	0	0	6	52	47	55	56	56	56	62	--	0	59	3
Thomas Ave S	1	2824	N	Y	17	2	N	200	214	25	B&T	N	N	41	36	44	41	36	43	33	28	35	33	27	35	51	46	0	0	0	6	52	48	55	56	56	56	62	--	0	59	3
Thomas Ave S	1	2824	Y	Y	17	2	N	175	189	25	B&T	N	N	42	37	45	42	37	44	34	29	37	35	28	36	52	47	55	0	0	6	53	48	56	59	56	56	62	Mod	1	61	5
Thomas Ave S	1	2825	Y	Y	17	2	N	175	189	25	B&T	N	N	42	37	45	42	37	44	32	28	35	33	27	35	52	47	55	0	0	6	51	46	54	58	56	56	62	Mod	1	60	4
Thomas Ave S	1	2826	Y	N	17	2	N	180	194	35	B&T	N	N	45	40	48	44	40	47	29	24	32	31	24	32	50	46	53	0	0	6	0	0	6	55	56	56	62	--	0	59	3

								Dist						LRT Noise NB			LRT Noise SB			Grade Crossing Bells NB			Grade Crossing Bells SB			LRT Horns/Bells NB			LRT Horns/Bells SB			Station Bells					Impact Criteria					
Location	# of Units	Stn #	At-grade x-ing Y/N	Station Y/N	Noise Site Used	Land Use Cat	Tunnel Present	NB	SB	Speed (mph)	Track Type	xover	Elevated	Day	Night	Total	Day	Night	Total	Day	Night	Total	Day	Night	Total	Day	Night	Total	Day	Night	Total	Day	Night	Total	Total Project Noise	Exist Noise	Mod	Sev	Impact	# of Impacts	Total Noise	Noise Level Increase
Thomas Ave S	1	2827	Y	N	17	2	N	175	189	40	B&T	N	N	46	41	49	46	41	48	26	21	29	26	21	29	50	45	53	0	0	6	0	0	6	55	56	56	62	--	0	59	3
Thomas Ave S	1	2827	Y	N	17	2	N	170	184	40	B&T	N	N	46	42	49	46	41	49	26	21	29	26	21	29	50	45	53	0	0	6	0	0	6	55	56	56	62	--	0	59	3
Thomas Ave S	1	2828	N	N	17	2	N	180	194	40	B&T	N	N	46	41	49	45	41	48	23	19	26	24	19	26	50	45	52	0	0	6	0	0	6	55	56	56	62	--	0	59	3
Thomas Ave S	1	2829	N	N	17	2	N	175	189	40	B&T	N	N	46	41	49	46	41	48	21	17	24	21	17	24	50	45	53	0	0	6	0	0	6	55	56	56	62	--	0	59	3
Thomas Ave S	1	2830	N	N	17	2	N	150	164	40	B&T	N	N	47	43	50	47	42	49	20	15	22	20	15	23	51	46	57	0	0	6	0	0	6	58	56	56	62	Mod	1	60	4
Thomas Ave S	1	2826	Y	N	17	2	N	50	64	35	B&T	N	N	54	49	57	52	48	55	32	27	34	34	28	36	59	54	65	0	0	6	0	0	6	66	56	56	62	Sev	1	66	10
Thomas Ave S	1	2831	N	N	17	2	N	150	164	45	B&T	N	N	48	44	51	48	43	50	18	13	21	18	13	21	50	46	56	0	0	6	0	0	6	58	56	56	62	Mod	1	60	4
Thomas Ave S	1	2832	N	N	17	2	N	140	154	45	B&T	N	N	49	44	52	48	43	51	16	12	19	17	12	19	51	46	57	0	0	6	0	0	6	59	56	56	62	Mod	1	61	5
Thomas Ave S	1	2833	N	N	17	2	N	135	149	45	B&T	N	N	49	44	52	48	44	51	15	10	18	15	11	18	51	46	57	0	0	6	0	0	6	59	56	56	62	Mod	1	61	5
Thomas Ave S	1	2833	N	N	17	2	N	225	239	45	B&T	N	N	45	41	48	45	40	48	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	51	56	56	62	--	0	57	1
Thomas Ave S	1	2835	N	N	17	2	N	135	149	45	B&T	N	N	49	44	52	48	44	51	0	0	6	0	0	6	0	0	9	0	0	6	0	0	6	55	56	56	62	--	0	58	2
S Upton Ave	1	2827	Y	N	17	2	N	139	125	35	B&T	N	N	47	42	49	47	43	50	25	20	28	27	21	29	0	0	6	53	48	56	0	0	6	57	56	56	62	Mod	1	60	4
S Upton Ave	1	2827	N	N	17	2	N	164	150	35	B&T	N	N	45	41	48	46	41	49	26	21	29	29	22	30	0	0	6	52	47	54	0	0	6	56	56	56	62	Mod	1	59	3
S Upton Ave	1	2828	N	N	17	2	N	164	150	35	B&T	N	N	45	41	48	46	41	49	24	19	26	26	19	27	0	0	6	52	47	54	0	0	6	56	56	56	62	Mod	1	59	3
S Upton Ave	1	2828	N	N	17	2	N	164	150	35	B&T	N	N	45	41	48	46	41	49	24	19	26	26	19	27	0	0	6	52	47	54	0	0	6	56	56	56	62	Mod	1	59	3
S Upton Ave	1	2829	N	N	17	2	N	144	130	35	B&T	N	N	46	42	49	47	42	50	21	17	24	24	17	25	0	0	6	53	48	55	0	0	6	57	56	56	62	Mod	1	60	4
S Upton Ave	1	2829	N	N	17	2	N	174	160	35	B&T	N	N	45	40	48	46	41	48	21	17	24	23	17	25	0	0	6	51	46	54	0	0	6	56	56	56	62	Mod	1	59	3
Kenwood Parkway	1	2865	N	N	17	2	N	250	264	45	B&T	N	N	45	40	47	44	39	47	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	50	56	56	62	--	0	57	1.0
Kenwood Parkway	1	2865	N	N	17	2	N	225	239	45	B&T	N	N	45	41	48	45	40	48	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	51	56	56	62	--	0	57	1.2
Kenwood Parkway	1	2865	N	N	17	2	N	225	239	45	B&T	N	N	45	41	48	45	40	48	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	51	56	56	62	--	0	57	1.2
Kenwood Parkway	1	2866	N	N	17	2	N	250	264	45	B&T	N	N	45	40	47	44	39	47	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	50	56	56	62	--	0	57	1.0
Kenwood Parkway	1	2866	N	N	17	2	N	225	239	45	B&T	N	N	45	41	48	45	40	48	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	51	56	56	62	--	0	57	1.2
Kenwood Parkway	1	2870	N	N	17	2	N	180	194	45	B&T	N	N	47	42	50	46	42	49	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	52	56	56	62	--	0	58	1.6
Kenwood Parkway	1	2870	N	N	17	2	N	150	164	45	B&T	N	N	48	44	51	48	43	50	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	54	56	56	62	--	0	58	2.0
Kenwood Parkway	1	2870	N	N	17	2	N	140	154	45	B&T	N	N	49	44	52	48	43	51	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	54	56	56	62	--	0	58	2.2
Catholic Charities	1	2930	N	N	18	2	N	50	64	55	B&T	N	N	58	53	61	56	52	59	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	63	74	65	72	--	0	74	0.4
Mary's Place	1	2941	Y	N	18	2	N	200	214	10	B&T	N	N	33	28	36	33	28	35	33	28	35	31	27	34	55	50	58	0	0	6	0	0	6	58	74	65	72	--	0	74	0.1
Mary's Place	1	2952	N	N	18	2	N	40	54	20	B&T	N	Y	55	50	58	53	48	56	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	60	74	65	72	--	0	74	0.2

Appendix K. Detailed Vibration Impact Data

Location	# of units	Stn #	TM Site	Land Use Cat	Distances			Speed (mph)	Track Type	Crossover Present?	Elevated Structure?	GBN Level			1/3 OB Vibration Levels NB																1/3 OB Vibration Levels SB															
					Depth	NB	SB					NB	SB	Impact?	6.3	8	10	12.5	16	20	25	31.5	40	50	63	80	100	125	160	200	6.3	8	10	12.5	16	20	25	31.5	40	50	63	80	100	125	160	200
Southwest Station Condos	42	2072	2	2	0	139	125	20	B&T	N	N	--	--	--	41	48	51	50	46	46	43	43	36	39	37	32	32	30	30	35	42	48	52	51	47	47	44	44	37	39	38	33	34	32	31	36
Southwest Station Condos	42	2075	2	2	0	139	125	20	B&T	N	N	--	--	--	41	48	51	50	46	46	43	43	36	39	37	32	32	30	30	35	42	48	52	51	47	47	44	44	37	39	38	33	34	32	31	36
Purgatory Creek Park	1	2096	2	3	0	270	284	25	B&T	N	Y	--	--	--	30	36	39	39	38	33	30	29	24	26	23	15	14	13	16	21	30	36	39	39	38	33	30	29	24	26	23	15	14	13	16	21
Water Tower Apartments	24	2112	2	2	0	100	114	35	B&T	N	N	--	--	--	47	52	56	56	55	50	47	45	43	44	44	38	39	35	34	37	46	52	55	55	54	49	46	44	42	43	43	36	37	34	33	36
Lincoln Parc Apts	24	2121	2	2	0	125	139	25	B&T	N	N	--	--	--	44	48	53	53	52	48	44	44	39	40	39	33	33	32	32	36	43	48	52	52	51	47	43	43	38	40	38	32	31	30	31	35
Residence Inn	1	2143	2	2	0	114	100	45	B&T	N	N	--	--	--	47	53	57	56	52	50	50	47	43	45	45	38	40	35	34	37	48	53	58	57	53	51	51	48	44	46	46	40	42	36	35	38
Residence Inn	1	2143	2	2	0	164	150	45	B&T	N	N	--	--	--	45	51	55	53	50	48	48	45	41	43	42	34	35	30	31	35	46	52	56	54	51	48	49	46	42	43	42	35	36	31	32	36
Residence Inn	1	2146	2	2	0	54	40	45	B&T	N	N	--	--	--	51	56	61	61	56	55	54	52	48	50	51	46	50	44	40	42	53	57	62	62	57	57	56	54	50	52	54	50	53	48	43	44
Residence Inn	1	2146	2	2	0	114	100	45	B&T	N	N	--	--	--	47	53	57	56	52	50	50	47	43	45	45	38	40	35	34	37	48	53	58	57	53	51	51	48	44	46	46	40	42	36	35	38
Baymont Inn	1	2151	2	2	0	94	80	45	B&T	N	N	--	--	--	48	54	58	57	53	51	51	48	44	46	46	40	42	37	36	38	49	54	59	58	54	52	52	49	45	47	48	42	44	39	37	39
Access Genetics	1	2212	2	3	0	125	139	25	B&T	N	N	--	--	--	44	48	53	53	52	48	44	44	39	40	39	33	33	32	32	36	43	48	52	52	51	47	43	43	38	40	38	32	31	30	31	35
Eagle Ridge Academy	1	2225	2	3	0	225	239	35	B&T	N	Y	--	--	--	33	39	42	40	41	35	32	30	28	28	27	19	18	15	17	22	32	39	41	40	41	35	32	30	28	28	26	18	17	14	17	22
Shop HQ	1	2098	3	3	0	20	21	35	B&T	N	Y	17	17	No	34	39	39	39	33	28	26	24	21	22	22	18	24	31	24	32	34	39	38	39	34	26	24	20	19	21	25	22	29	31	27	30
Sunrise Montessori	1	2320	2	3	0	300	314	40	B&T	N	N	--	--	--	43	51	52	50	48	45	45	40	38	38	38	28	30	25	26	32	43	51	52	50	48	45	45	40	38	38	38	28	30	25	26	32
American Medical	1	2363	5	1	0	84	70	45	B&T	N	N	--	--	--	36	40	48	52	51	50	43	40	38	34	29	20	23	22	2	10	36	41	48	53	51	50	44	43	42	38	33	24	28	26	6	13
Claremont Apartments	30	2363	5	2	0	130	144	45	B&T	N	N	--	--	--	39	43	50	55	54	55	48	39	36	37	36	27	26	16	12	20	38	43	50	55	54	54	47	37	33	34	33	24	24	14	10	18
Claremont Apartments	30	2365	5	2	0	90	104	45	B&T	N	N	--	--	--	39	45	52	56	55	56	52	46	44	47	45	37	36	25	20	25	39	44	51	56	55	56	50	43	41	43	42	33	32	22	17	23
Claremont Apartments	30	2369	5	2	0	80	94	45	B&T	N	N	--	--	--	39	46	52	57	55	56	53	48	46	49	48	40	39	28	22	27	39	45	51	56	55	56	51	45	43	46	44	36	35	24	19	25
Claremont Apartments	30	2372	5	2	0	100	114	45	B&T	N	N	--	--	--	39	45	51	56	55	56	51	44	42	44	43	35	33	23	18	24	39	44	51	56	54	55	49	42	39	41	40	31	30	19	15	22
Claremont Apartments	30	2375	5	2	0	100	114	45	B&T	N	N	--	--	--	39	45	51	56	55	56	51	44	42	44	43	35	33	23	18	24	39	44	51	56	54	55	49	42	39	41	40	31	30	19	15	22
Greenfield Apartments	30	2384	5	2	0	125	139	30	B&T	N	Y	--	--	--	27	29	37	44	48	43	32	28	25	24	22	14	11	5	2	9	26	29	37	44	48	43	31	26	22	21	19	11	9	3	0	8
Greenfield Apartments	30	2394	5	2	0	200	214	55	B&T	N	Y	--	--	--	28	31	39	46	43	43	35	23	15	16	14	5	5	-4	-7	3	28	30	39	46	43	43	34	21	13	13	11	3	3	-5	-9	2
Deer Ridge	4	2387	5	2	0	164	150	30	B&T	N	Y	--	--	--	26	28	36	44	47	42	29	22	18	16	15	6	4	-1	-4	5	26	28	37	44	48	42	30	24	20	19	17	9	7	1	-2	6
Deer Ridge	4	2400	5	2	0	264	250	55	B&T	N	Y	--	--	--	28	30	38	46	42	42	31	16	9	8	6	-3	-1	-9	-12	0	28	30	38	46	42	42	31	16	9	8	6	-3	-1	-9	-12	0
Hearing Care Specialists (audiologist)	1	2076	6	1	0	84	70	35	B&T	N	N	--	--	--	--	--	--	--	--	--	--	--	--	--	--	35	33	26	23	--	--	--	--	--	--	--	--	--	--	--	--	--	37	35	29	26
Town Terrace Apts	40	2525	6	2	0	314	300	55	B&T	N	N	--	--	--	42	51	51	55	51	49	53	53	50	49	46	44	45	39	30	26	42	51	51	55	51	49	53	53	50	49	46	44	45	39	30	26
Monroe Ave	1	2549	6	2	0	200	214	55	B&T	N	Y	--	--	--	32	41	41	46	42	40	44	44	41	42	39	37	39	33	25	21	32	41	41	46	42	40	44	44	41	41	38	36	38	31	23	19
Monroe Ave	1	2549	6	2	0	250	264	55	B&T	N	Y	--	--	--	32	41	41	45	41	39	43	43	40	39	36	34	35	29	20	16	32	41	41	45	41	39	43	43	40	39	36	34	35	29	20	16
Westside Apartments	42	2580	6	2	0	125	139	35	B&T	N	N	--	--	--	41	50	49	55	55	51	49	50	53	53	53	50	53	50	43	40	41	50	49	55	55	51	49	49	52	52	52	49	51	48	41	38
Westside Apartments	42	2582	6	2	0	125	139	35	B&T	N	N	--	--	--	41	50	49	55	55	51	49	50	53	53	53	50	53	50	43	40	41	50	49	55	55	51	49	49	52	52	52	49	51	48	41	38
Creekwood Estates	12	2596	7	2	0	174	160	55	B&T	N	n	--	--	--	44	51	56	56	50	48	53	50	41	43	40	35	34	29	28	32	45	51	56	56	50	48	53	50	41	44	41	36	35	30	29	33
Edgebrook Residences	30	2607	7	2	0	264	250	55	B&T	N	N	--	--	--	42	48	54	54	48	47	52	48	39	41	37	31	30	24	24	29	42	48	54	54	48	47	52	48	39	41	37	31	30	24	24	29

Location	# of units	Stn #	TM Site	Land Use Cat	Distances			Speed (mph)	Track Type	Crossover Present?	Elevated Structure?	GBN Level			1/3 OB Vibration Levels NB																1/3 OB Vibration Levels SB													
					Depth	NB	SB					NB	SB	Impact?	6.3	8	10	12.5	16	20	25	31.5	40	50	63	80	100	125	160	200	6.3	8	10	12.5	16	20	25	31.5	40	50	63	80	100	125	160	200
Railroad Ave	1	2652	7	2	0	150	164	55	B&T	N	N	--	--	--	45	52	56	57	50	49	53	50	42	44	42	36	36	31	29	33	45	51	56	56	50	48	53	50	41	44	41	36	35	30	28	33
Railroad Ave	1	2652	7	2	0	125	139	55	B&T	N	N	--	--	--	46	53	57	58	51	49	53	51	43	46	43	38	39	33	31	35	46	52	57	57	51	49	53	50	42	45	42	37	37	32	30	34
Railroad Ave	1	2652	7	2	0	50	64	55	B&T	N	N	--	--	--	53	59	62	62	55	53	55	55	49	52	51	48	51	45	40	42	51	57	61	61	54	52	55	54	47	50	49	46	47	42	38	40
Railroad Ave	1	2653	7	2	0	100	114	55	B&T	N	N	--	--	--	48	54	59	59	52	50	54	52	45	47	45	41	42	36	33	36	47	53	58	58	52	50	53	51	44	46	44	39	40	35	32	35
Railroad Ave	1	2654	7	2	0	125	139	55	B&T	N	N	--	--	--	46	53	57	58	51	49	53	51	43	46	43	38	39	33	31	35	46	52	57	57	51	49	53	50	42	45	42	37	37	32	30	34
Railroad Ave	1	2655	7	2	0	100	114	55	B&T	N	N	--	--	--	48	54	59	59	52	50	54	52	45	47	45	41	42	36	33	36	47	53	58	58	52	50	53	51	44	46	44	39	40	35	32	35
Railroad Ave	1	2656	7	2	0	125	139	55	B&T	Y	N	--	--	--	56	63	67	68	61	59	63	61	53	56	53	48	49	43	41	45	56	62	67	67	61	59	63	60	52	55	52	47	47	42	40	44
Railroad Ave	1	2656	7	2	0	85	99	55	B&T	Y	N	--	--	--	59	65	69	69	63	61	64	62	56	58	57	53	54	48	45	48	58	64	69	69	62	60	64	62	55	57	55	51	52	46	43	47
Railroad Ave	1	2657	7	2	0	150	164	55	B&T	Y	N	--	--	--	55	62	66	67	60	59	63	60	52	54	52	46	46	41	39	43	55	61	66	66	60	58	63	60	51	54	51	46	45	40	38	43
Railroad Ave	1	2658	7	2	0	175	189	55	B&T	Y	N	--	--	--	54	61	66	66	60	58	63	60	51	53	50	45	44	39	38	42	54	60	65	66	60	58	62	59	50	53	50	44	43	38	37	42
Railroad Ave	1	2659	7	2	0	225	239	55	B&T	N	N	--	--	--	43	49	54	55	49	47	52	48	39	41	38	32	31	26	25	30	42	49	54	54	49	47	52	48	39	41	37	31	30	25	25	30
Railroad Ave	32	2665	7	2	0	150	164	35	B&T	N	N	--	--	--	44	51	53	54	52	48	46	43	40	40	40	33	33	30	28	32	44	50	53	53	52	47	46	43	39	40	39	33	32	29	27	32
Camerata Way	32	2681	7	2	0	50	64	55	B&T	N	N	--	--	--	53	59	62	62	55	53	55	55	49	52	51	48	51	45	40	42	51	57	61	61	54	52	55	54	47	50	49	46	47	42	38	40
MN 7 Service Rd	32	2682	7	2	0	139	125	55	B&T	N	N	--	--	--	46	52	57	57	51	49	53	50	42	45	42	37	37	32	30	34	46	53	57	58	51	49	53	51	43	46	43	38	39	33	31	35
Park Glen Townhomes	3	2720	8	2	0	113	127	35	B&T	Y	N	--	--	--	50	59	60	66	65	63	61	58	57	58	59	56	56	50	45	47	49	59	59	66	64	63	60	56	55	56	58	55	54	49	44	46
Park Glen Townhomes	3	2722	8	2	0	113	127	35	B&T	Y	N	--	--	--	50	59	60	66	65	63	61	58	57	58	59	56	56	50	45	47	49	59	59	66	64	63	60	56	55	56	58	55	54	49	44	46
Park Glen Townhomes	4	2735	8	2	0	113	127	40	B&T	Y	N	--	--	--	51	61	61	66	63	64	64	59	58	58	61	57	59	51	45	48	50	61	60	66	62	64	63	57	56	56	60	56	57	50	44	47
Park Glen Townhomes	4	2735	8	2	0	113	127	40	B&T	Y	N	--	--	--	51	61	61	66	63	64	64	59	58	58	61	57	59	51	45	48	50	61	60	66	62	64	63	57	56	56	60	56	57	50	44	47
Park Glen Townhomes	3	2737	8	2	0	113	127	40	B&T	N	N	--	--	--	41	51	51	56	53	54	54	49	48	48	51	47	49	41	35	38	40	51	50	56	52	54	53	47	46	46	50	46	47	40	34	37
Glenhurst Ave	1	2742	8	2	0	214	200	45	B&T	N	N	--	--	--	38	50	49	56	51	51	51	39	35	41	43	40	39	31	28	32	38	50	50	56	51	51	51	41	36	42	44	41	40	32	28	32
Glenhurst Ave	1	2744	8	2	0	214	200	45	B&T	N	N	--	--	--	38	50	49	56	51	51	51	39	35	41	43	40	39	31	28	32	38	50	50	56	51	51	51	41	36	42	44	41	40	32	28	32
Glenhurst Ave	1	2744	8	2	0	289	275	45	B&T	N	N	--	--	--	38	49	49	55	50	50	50	36	31	39	41	38	37	29	25	30	38	49	49	55	50	50	50	36	31	39	41	38	37	29	25	30
Glenhurst Ave	1	2745	8	2	0	339	325	45	B&T	N	N	--	--	--	38	49	49	55	50	50	50	36	31	39	41	38	37	29	25	30	38	49	49	55	50	50	50	36	31	39	41	38	37	29	25	30
Glenhurst Ave	1	2745	8	2	0	339	325	45	B&T	N	N	--	--	--	38	49	49	55	50	50	50	36	31	39	41	38	37	29	25	30	38	49	49	55	50	50	50	36	31	39	41	38	37	29	25	30
Glenhurst Ave	1	2747	8	2	0	314	300	45	B&T	N	N	--	--	--	38	49	49	55	50	50	50	36	31	39	41	38	37	29	25	30	38	49	49	55	50	50	50	36	31	39	41	38	37	29	25	30
Glenhurst Ave	1	2748	8	2	0	289	275	45	B&T	N	N	--	--	--	38	49	49	55	50	50	50	36	31	39	41	38	37	29	25	30	38	49	49	55	50	50	50	36	31	39	41	38	37	29	25	30
Glenhurst Ave	1	2749	8	2	0	289	275	45	B&T	N	N	--	--	--	38	49	49	55	50	50	50	36	31	39	41	38	37	29	25	30	38	49	49	55	50	50	50	36	31	39	41	38	37	29	25	30
Glenhurst Ave	1	2750	8	2	0	264	250	45	B&T	N	N	--	--	--	38	49	49	55	50	50	50	36	31	39	41	38	37	29	25	30	38	49	49	55	50	50	50	36	31	39	41	38	37	29	25	30
Glenhurst Ave	1	2752	8	2	0	264	250	45	B&T	N	N	--	--	--	38	49	49	55	50	50	50	36	31	39	41	38	37	29	25	30	38	49	49	55	50	50	50	36	31	39	41	38	37	29	25	30
Glenhurst Ave	1	2753	8	2	0	264	250	45	B&T	N	N	--	--	--	38	49	49	55	50	50	50	36	31	39	41	38	37	29	25	30	38	49	49	55	50	50	50	36	31	39	41	38	37	29	25	30
Glenhurst Ave	12	2750	8	2	0	139	125	45	B&T	N	N	--	--	--	40	50	51	57	52	53	53	48	44	47	48	46	46	38	33	36	40	50	51	57	52	54	54	50	46	49	50	47	47	40	35	37
Ewing Ave S	1	2755	8	2	0	189	175	45	B&T	N	N	--	--	--	39	50	50	56	51	52	51	42	38	43	44	42	41	33	29	33	39	50	50	56	51	52	52	43	39	44	45	43	42	35	30	34
Ewing Ave S	4	2756	8	2	0	339	325	45	B&T	N	N	--	--	--	38	49	49	55	50	50	50	36	31	39	41	38	37	29	25	30	38	49	49	55	50	50	50	36	31	39	41	38	37	29	25	30
Ewing Ave S	8	2757	8	2	0	264	250	45	B&T	N	N	--	--	--	38	49	49	55	50	50	50	36	31	39	41	38	37	29	25	30	38	49	49	55	50	50	50	36	31	39	41	38	37	29	25	30
Ewing Ave S	24	2760	8	2	0	114	100	45	B&T	N	N	--	--	--	41	50	52	57	53	54	55	51	48	50	51	48	48	41	36	38	41	50	52	57	53	55	55	53	50	52	53	50	50	43	38	39
Lake Citihomes	4	2762	8	2	0	102	88	35	B&T	N	N	--	--	--	40	49	50	56	55	54	51	50	49	50	51	48	47	42	37	38	41	49	51	57	55	55	52	52	52	52	53	50	49	44	39	39
Lake Citihomes	4	2763	8	2	0	102	88	30	B&T	N	N	--	--	--	39	46	49	56	57	53	49	51	48	48	48	46	44	41	37	38	40	46	50	57	57	54	50	53	51	50	50	48	46	43	39	39
Lake Citihomes	4	2765	8	2	0	102	88	20	B&T	N	N	--	--	--	36	46	47	53	48	52	49	50	44	47	47	46	45	41	36	38	37	46	48	54	48	53	50	52	47	49	49	48	47	43	38	39

Location	# of units	Stn #	TM Site	Land Use Cat	Distances			Speed (mph)	Track Type	Crossover Present?	Elevated Structure?	GBN Level			1/3 OB Vibration Levels NB																1/3 OB Vibration Levels SB													
					Depth	NB	SB					NB	SB	Impact?	6.3	8	10	12.5	16	20	25	31.5	40	50	63	80	100	125	160	200	6.3	8	10	12.5	16	20	25	31.5	40	50	63	80	100	125	160	200
Lake Citihomes	4	2766	8	2	0	102	88	20	B&T	N	N	--	--	--	36	46	47	53	48	52	49	50	44	47	47	46	45	41	36	38	37	46	48	54	48	53	50	52	47	49	49	48	47	43	38	39
Lake Citihomes	4	2767	8	2	0	102	88	20	B&T	N	N	--	--	--	36	46	47	53	48	52	49	50	44	47	47	46	45	41	36	38	37	46	48	54	48	53	50	52	47	49	49	48	47	43	38	39
Chowen Ave S	1	2756	8	2	0	250	264	45	B&T	N	N	--	--	--	38	49	49	55	50	50	50	36	31	39	41	38	37	29	25	30	38	49	49	55	50	50	50	36	31	39	41	38	37	29	25	30
Chowen Ave S	8	2762	8	2	0	75	89	35	B&T	N	N	--	--	--	42	49	52	57	56	56	53	54	54	54	55	51	52	47	41	40	41	49	51	56	55	55	52	52	51	51	52	49	49	44	38	39
Chowen Ave S	8	2764	8	2	0	125	139	25	B&T	N	N	--	--	--	37	46	47	55	52	52	48	47	42	45	45	43	41	38	34	36	37	46	47	55	52	51	47	45	40	43	43	42	40	36	32	35
Chowen Ave S	1	2757	8	2	0	300	314	45	B&T	N	N	--	--	--	38	49	49	55	50	50	50	36	31	39	41	38	37	29	25	30	38	49	49	55	50	50	50	36	31	39	41	38	37	29	25	30
Chowen Ave S	1	2759	8	2	0	350	364	45	B&T	N	N	--	--	--	38	49	49	55	50	50	50	36	31	39	41	38	37	29	25	30	38	49	49	55	50	50	50	36	31	39	41	38	37	29	25	30
Chowen Ave S	2	2754	8	2	0	125	139	45	B&T	N	N	--	--	--	40	50	51	57	52	54	54	50	46	49	50	47	47	40	35	37	40	50	51	57	52	53	53	48	44	47	48	46	46	38	33	36
Chowen Ave S	2	2755	8	2	0	175	189	45	B&T	N	N	--	--	--	39	50	50	56	51	52	52	43	39	44	45	43	42	35	30	34	39	50	50	56	51	52	51	42	38	43	44	42	41	33	29	33
St Louis Ave	3	2773	8	2	8	77	63	45	EMB	N	N	29	32	No	41	56	53	51	52	34	44	40	37	42	49	49	48	43	40	28	42	56	53	51	52	35	46	42	40	44	51	51	51	46	42	30
St Louis Ave	2	2774	8	2	13	90	76	45	EMB	N	N	27	29	No	41	56	52	50	51	33	43	38	35	40	47	47	46	41	38	27	41	56	53	51	52	34	44	40	37	42	49	49	48	43	40	28
St Louis Ave	3	2775	8	2	16	78	65	45	EMB	N	N	28	31	No	41	56	52	51	52	34	44	40	37	41	49	48	48	43	39	28	42	56	53	51	52	35	45	42	39	44	51	51	51	46	42	30
St Louis Ave	2	2777	8	2	20	91	78	45	EMB	N	N	26	29	No	41	56	52	50	51	33	43	38	34	39	46	46	46	40	37	26	41	56	53	51	52	34	44	40	37	42	49	48	48	43	40	28
St Louis Ave	3	2778	8	2	20	67	54	45	EMB	N	N	31	34	No	42	56	53	51	52	35	45	41	39	44	51	50	50	45	42	29	43	56	54	52	53	36	47	43	42	47	54	53	54	49	45	31
St Louis Ave	2	2779	8	2	20	79	66	45	EMB	N	N	28	31	No	41	56	52	51	52	34	44	39	37	41	48	48	48	42	39	28	42	56	53	51	52	35	45	41	39	44	51	50	51	45	42	29
St Louis Ave	3	2780	8	2	20	79	66	45	EMB	N	N	28	31	No	41	56	52	51	52	34	44	39	37	41	48	48	48	42	39	28	42	56	53	51	52	35	45	41	39	44	51	50	51	45	42	29
St Louis Ave	2	2781	8	2	22	68	55	45	EMB	N	N	31	34	No	42	56	53	51	52	35	45	41	39	44	51	50	50	45	42	29	43	56	54	52	53	36	47	43	41	47	53	53	53	48	44	31
St Louis Ave	3	2782	8	2	23	56	44	45	EMB	N	N	33	37	Yes	43	56	54	51	53	36	46	43	41	46	53	52	53	48	44	31	44	57	55	52	53	37	48	45	44	50	57	56	57	52	47	33
St Louis Ave	2	2783	8	2	24	68	55	45	EMB	N	N	30	33	No	42	56	53	51	52	35	45	41	39	43	50	50	50	45	41	29	43	56	54	52	53	36	46	43	41	46	53	53	53	48	44	31
St Louis Ave	3	2784	8	2	25	69	56	45	EMB	N	N	30	33	No	42	56	53	51	52	35	45	41	39	43	50	50	50	45	41	29	43	56	54	52	53	36	46	43	41	46	53	53	53	48	44	31
St Louis Ave	2	2785	8	2	25	69	56	45	EMB	N	N	30	33	No	42	56	53	51	52	35	45	41	39	43	50	50	50	45	41	29	43	56	54	52	53	36	46	43	41	46	53	53	53	48	44	31
St Louis Ave	3	2786	8	2	25	69	56	45	EMB	N	N	30	33	No	42	56	53	51	52	35	45	41	39	43	50	50	50	45	41	29	43	56	54	52	53	36	46	43	41	46	53	53	53	48	44	31
St Louis Ave	2	2773	8	2	8	177	163	35	EMB	N	N	16	18	No	38	54	48	49	49	28	38	27	21	29	37	38	33	30	29	20	38	54	48	49	50	29	39	28	23	30	38	39	34	31	30	21
St Louis Ave	2	2774	8	2	13	189	175	40	EMB	N	N	16	17	No	38	56	49	49	49	29	39	25	20	29	37	37	35	29	28	20	38	56	49	49	49	29	39	27	22	30	38	38	36	30	29	20
St Louis Ave	2	2775	8	2	16	177	163	45	EMB	N	N	17	18	No	38	56	49	49	49	29	39	26	22	30	38	38	36	30	28	20	38	56	49	49	50	30	40	28	23	31	39	39	37	31	30	21
St Louis Ave	2	2777	8	2	20	190	176	45	EMB	N	N	16	17	No	38	56	49	49	49	29	39	25	20	29	37	37	35	29	28	20	38	56	49	49	49	29	39	27	22	30	38	38	36	30	29	20
St Louis Ave	2	2778	8	2	20	165	151	45	EMB	N	N	18	19	No	38	56	49	49	49	30	39	28	23	31	39	39	37	31	29	21	39	56	50	49	50	30	40	29	25	32	40	40	38	33	31	22
St Louis Ave	2	2779	8	2	20	178	164	45	EMB	N	N	17	18	No	38	56	49	49	49	29	39	26	22	30	38	38	36	30	28	20	38	56	49	49	50	30	40	28	23	31	39	39	37	31	30	21
St Louis Ave	2	2780	8	2	20	178	164	45	EMB	N	N	17	18	No	38	56	49	49	49	29	39	26	22	30	38	38	36	30	28	20	38	56	49	49	50	30	40	28	23	31	39	39	37	31	30	21
St Louis Ave	2	2781	8	2	22	165	152	45	EMB	N	N	18	19	No	38	56	49	49	49	30	39	28	23	31	39	39	37	31	29	21	39	56	50	49	50	30	40	29	25	32	40	40	38	33	31	22
St Louis Ave	2	2782	8	2	23	166	152	45	EMB	N	N	18	19	No	38	56	49	49	49	30	39	28	23	31	39	39	37	31	29	21	39	56	50	49	50	30	40	29	25	32	40	40	38	33	31	22
St Louis Ave	2	2783	8	2	24	166	152	45	EMB	N	N	18	19	No	38	56	49	49	49	30	39	28	23	31	39	39	37	31	29	21	39	56	50	49	50	30	40	29	25	32	40	40	38	33	31	22
St Louis Ave	2	2784	8	2	25	166	152	45	EMB	N	N	18	19	No	38	56	49	49	49	30	39	28	23	31	39	39	37	31	29	21	39	56	50	49	50	30	40	29	25	32	40	40	38	32	31	22
St Louis Ave	2	2785	8	2	25	166	152	45	EMB	N	N	18	19	No	38	56	49	49	49	30	39	28	23	31	39	39	37	31	29	21	39	56	50	49	50	30	40	29	25	32	40	40	38	32	31	22
Silo Condos	36	2781	8	2	22	43	56	45	EMB	N	N	37	33	Yes	44	57	55	52	53	37	48	45	44	50	57	56	57	52	47	33	43	56	54	51	53	36	46	43	41	46	53	52	53	48	44	31
Silo Condos	6	2783	8	2	24	45	57	45	EMB	N	N	37	33	Yes	44	57	55	52	53	37	48	45	44	49	56	55	56	51	47	33	43	56	54	51	53	36	46	43	41	46	53	52	53	48	44	31
Xerxes Ave S	1	2789	8	2	25	152	166	45	EMB	N	N	19	18	No	39	56	50	49	50	30	40	29	25	32	40	40	38	32	31	22	38	56	49	49	49	30	39	28	23	31	39	39	37	31	29	21
Xerxes Ave S	1	2790	8	2	24	115	129	45	EMB	N	N	23	22	No	40	56	51	50	51	32	42	34	30	36	43	43	42	37	34	24	39	56	50	50	50	31	41	32	28	35	42	42	41	35	33	23
Xerxes Ave S	1	2791	8	2	24	79	92	45	EMB	N	N	28	26	No	41	56	52	51	52	34	44	40	37	41	49	48	48	43	39	28	41	56	52	50	51	33	43	37	34	39	46	46	46	40	37	26
Xerxes Ave S	1	2791	8	2	24	55	68	45	EMB	N	N	33	30	No	43	56	54	52	53	36	46	43	41	46	53	53	53	48	44	31	42	56	53	51	52	35	45	41	39	43	50	50	50	45	41	29

Location	# of units	Stn #	TM Site	Land Use Cat	Distances			Speed (mph)	Track Type	Crossover Present?	Elevated Structure?	GBN Level			1/3 OB Vibration Levels NB																1/3 OB Vibration Levels SB													
					Depth	NB	SB					NB	SB	Impact?	6.3	8	10	12.5	16	20	25	31.5	40	50	63	80	100	125	160	200	6.3	8	10	12.5	16	20	25	31.5	40	50	63	80	100	125	160	200
Xerxes Ave S	8	2792	8	2	24	45	57	45	EMB	N	N	37	33	Yes	44	57	55	52	53	37	48	45	44	49	56	55	56	51	47	33	43	56	54	51	53	36	46	43	41	46	53	52	53	48	44	31
Benton Blvd	1	2794	8	2	22	43	56	45	EMB	N	N	37	33	Yes	44	57	55	52	53	37	48	45	44	50	57	56	57	52	47	33	43	56	54	51	53	36	46	43	41	46	53	52	53	48	44	31
Benton Blvd	1	2795	8	2	21	78	91	45	EMB	N	N	29	26	No	41	56	53	51	52	34	44	40	37	42	49	48	48	43	40	28	41	56	52	50	51	33	43	38	34	39	46	46	46	40	37	26
Benton Blvd	1	2795	8	2	21	114	128	45	EMB	N	N	23	22	No	40	56	51	50	51	32	42	34	31	36	43	43	42	37	34	24	39	56	50	50	50	31	41	32	28	35	42	42	41	35	33	23
Benton Blvd	1	2796	8	2	20	66	79	45	EMB	N	N	31	28	No	42	56	53	51	52	35	45	41	39	44	51	50	51	45	42	29	41	56	52	51	52	34	44	39	37	41	48	48	48	42	39	28
Benton Blvd	1	2797	8	2	18	114	128	45	EMB	N	N	23	22	No	40	56	51	50	51	32	42	34	31	36	44	43	42	37	35	24	39	56	50	50	50	31	41	33	29	35	42	42	41	35	33	23
Benton Blvd	1	2797	8	2	18	126	140	45	EMB	N	N	22	20	No	39	56	50	50	50	31	41	33	29	35	42	42	41	35	33	23	39	56	50	49	50	31	41	31	27	33	41	41	39	34	32	22
Benton Blvd	1	2798	8	2	12	88	102	45	EMB	N	N	27	25	No	41	56	52	51	51	33	43	38	35	40	47	47	46	41	38	27	40	56	51	50	51	32	43	36	33	38	45	45	44	39	36	25
Benton Blvd	1	2799	8	2	8	138	152	45	EMB	N	N	21	19	No	39	56	50	50	50	31	41	31	27	34	41	41	40	34	32	23	39	56	50	49	50	30	40	29	25	32	40	40	38	33	31	22
Benton Blvd	1	2800	8	2	4	138	152	45	EMB	N	N	21	19	No	39	56	50	50	50	31	41	31	27	34	41	41	40	34	32	23	39	56	50	49	50	30	40	29	25	32	40	40	38	33	31	22
Burnham Rd	1	2792	8	2	24	153	140	45	EMB	N	N	19	20	No	39	56	50	49	50	30	40	29	25	32	40	40	38	32	30	22	39	56	50	50	50	31	41	31	27	33	41	41	39	34	32	22
Burnham Rd	1	2793	8	2	24	141	127	45	EMB	N	N	20	22	No	39	56	50	49	50	31	40	31	27	33	41	41	39	34	32	22	39	56	50	50	50	31	41	33	29	35	42	42	41	35	33	23
Burnham Rd	1	2794	8	2	22	153	139	45	EMB	N	N	19	20	No	39	56	50	49	50	30	40	29	25	32	40	40	38	32	30	22	39	56	50	50	50	31	41	31	27	33	41	41	39	34	32	22
Burnham Rd	1	2797	8	2	18	115	102	45	EMB	N	N	23	25	No	40	56	51	50	51	32	42	34	30	36	43	43	42	37	34	24	40	56	51	50	51	32	43	36	33	38	45	45	44	39	36	25
Burnham Rd	1	2798	8	2	12	140	126	45	EMB	N	N	20	22	No	39	56	50	50	50	31	41	31	27	33	41	41	39	34	32	22	39	56	50	50	50	31	41	33	29	35	42	42	41	35	33	23
Burnham Rd	1	2798	8	2	12	177	163	45	EMB	N	N	17	18	No	38	56	49	49	49	29	39	27	22	30	38	38	36	30	29	20	38	56	49	49	50	30	40	28	24	31	39	39	37	31	30	21
Burnham Rd	1	2799	8	2	8	214	200	45	EMB	N	N	14	15	No	37	56	48	49	49	28	38	22	17	27	35	35	33	27	26	18	37	56	49	49	49	29	38	24	19	28	36	36	34	28	27	19
Burnham Rd	1	2799	8	2	8	239	225	45	EMB	N	N	13	14	No	37	55	48	48	48	28	37	20	15	26	34	34	31	25	24	17	37	56	48	48	49	28	38	21	16	27	34	35	32	26	25	18
Burnham Rd	1	2800	8	2	4	239	225	45	EMB	N	N	13	14	No	37	55	48	48	48	28	37	20	15	26	34	34	31	25	24	17	37	56	48	48	49	28	38	21	16	27	34	35	32	26	25	18
Burnham Rd	1	2800	8	2	4	214	200	45	EMB	N	N	14	15	No	37	56	48	49	49	28	38	22	17	27	35	35	33	27	26	18	37	56	49	49	49	29	38	24	19	28	36	36	34	28	27	19
S Upton Ave	1	2804	8	2	0	100	114	45	B&T	N	N	--	--	--	41	50	52	57	53	33	42	34	24	32	38	35	36	27	23	19	41	50	52	57	53	33	42	34	24	32	38	35	36	27	23	19
S Upton Ave	1	2804	8	2	0	100	114	45	B&T	N	N	--	--	--	41	50	52	57	53	33	42	34	24	32	38	35	36	27	23	19	41	50	52	57	53	33	42	34	24	32	38	35	36	27	23	19
S Upton Ave	1	2805	8	2	0	120	134	45	B&T	N	N	--	--	--	41	50	52	57	52	33	40	31	21	29	36	33	34	24	21	18	41	50	52	57	52	33	40	31	21	29	36	33	34	24	21	18
S Upton Ave	1	2805	8	2	0	150	164	45	B&T	N	N	--	--	--	40	50	51	56	52	31	39	28	16	26	33	30	30	21	18	16	40	50	51	56	52	31	39	28	16	26	33	30	30	21	18	16
S Upton Ave	1	2806	8	2	0	125	139	45	B&T	N	N	--	--	--	40	50	51	57	52	32	40	31	20	29	35	32	33	23	20	17	40	50	51	57	52	32	40	31	20	29	35	32	33	23	20	17
S Upton Ave	1	2807	8	2	0	140	154	45	B&T	N	N	--	--	--	40	50	51	56	52	32	40	29	18	27	34	31	31	22	19	16	40	50	51	56	52	32	40	29	18	27	34	31	31	22	19	16
S Upton Ave	1	2807	8	2	0	160	174	45	B&T	N	N	--	--	--	39	50	50	56	52	31	39	26	15	25	32	29	29	20	17	15	39	50	50	56	52	31	39	26	15	25	32	29	29	20	17	15
S Upton Ave	1	2807	8	2	0	140	154	45	B&T	N	N	--	--	--	40	50	51	56	52	32	40	29	18	27	34	31	31	22	19	16	40	50	51	56	52	32	40	29	18	27	34	31	31	22	19	16
S Upton Ave	1	2808	8	2	0	160	174	45	B&T	N	N	--	--	--	39	50	50	56	52	31	39	26	15	25	32	29	29	20	17	15	39	50	50	56	52	31	39	26	15	25	32	29	29	20	17	15
S Upton Ave	1	2809	8	2	0	200	214	45	EMB	N	N	--	--	--	37	56	49	49	49	29	38	24	19	28	36	36	34	28	27	19	37	56	49	49	49	29	38	24	19	28	36	36	34	28	27	19
Burnham Rd 2	1	2805	9	2	0	64	50	45	B&T	N	N	--	--	--	42	50	55	56	53	54	55	55	56	58	59	57	62	54	46	46	43	50	55	56	54	55	56	57	59	61	62	59	65	58	50	50
Burnham Rd 2	1	2805	9	2	0	89	75	45	B&T	N	N	--	--	--	40	49	54	55	52	53	53	52	52	54	55	53	56	48	41	41	41	49	54	56	53	54	54	54	54	56	57	55	59	51	44	44
Burnham Rd 2	1	2805	9	2	0	139	125	45	B&T	N	N	--	--	--	38	47	53	55	51	51	48	45	44	45	46	46	47	38	32	32	39	48	53	55	52	52	49	47	46	48	49	48	50	41	34	34
Burnham Rd 2	1	2806	9	2	0	114	100	45	B&T	N	N	--	--	--	39	48	53	55	52	52	50	48	47	49	50	49	52	43	36	36	40	48	54	55	52	53	52	50	50	52	53	51	54	46	39	39
Burnham Rd 2	1	2807	9	2	0	94	80	45	B&T	N	N	--	--	--	40	48	54	55	52	53	52	51	51	53	54	52	55	47	40	40	41	49	54	55	53	53	54	53	53	55	56	54	58	50	43	43
Burnham Rd 2	1	2808	9	2	0	114	100	45	B&T	N	N	--	--	--	39	48	53	55	52	52	50	48	47	49	50	49	52	43	36	36	40	48	54	55	52	53	52	50	50	52	53	51	54	46	39	39
Burnham Rd 2	1	2809	9	2	0	134	120	45	B&T	N	N	--	--	--	38	47	53	55	51	51	48	46	44	46	47	47	48	39	32	33	39	48	53	55	52	52	50	47	46	48	49	48	50	42	35	35
Burnham Rd 2	1	2810	9	2	0	139	125	45	B&T	N	N	--	--	--	38	47	53	55	51	51	48	45	44	45	46	46	47	38	32	32	39	48	53	55	52	52	49	47	46	48	49	48	50	41	34	34
Burnham Rd 2	1	2811	9	2	0	124	110	45	B&T	N	N	--	--	--	39	48	53	55	52	52	49	47	46	48	49	48	50	41	34	35	39	48	53	55	52	52	51	49	48	50	51	50	52	44	37	37
Thomas Ln	1	2814	8	2	0	160	174	40	B&T	N	N	--	--	--	39	51	49	55	52	53	51	43	41	43	47	43	43	36	30	34	39	51	49	55	51	52	51	41	40	42	45	42	42	35	29	34

Location	# of units	Stn #	TM Site	Land Use Cat	Distances			Speed (mph)	Track Type	Crossover Present?	Elevated Structure?	GBN Level			1/3 OB Vibration Levels NB																1/3 OB Vibration Levels SB															
					Depth	NB	SB					NB	SB	Impact?	6.3	8	10	12.5	16	20	25	31.5	40	50	63	80	100	125	160	200	6.3	8	10	12.5	16	20	25	31.5	40	50	63	80	100	125	160	200
Thomas Ln	1	2815	8	2	0	150	164	40	B&T	N	N	--	--	--	40	51	50	55	52	53	52	44	43	44	47	44	44	37	31	35	39	51	49	55	52	52	51	43	41	43	46	43	43	36	30	34
Thomas Ln	1	2815	8	2	0	140	154	35	B&T	N	N	--	--	--	39	49	49	55	54	52	49	45	43	45	46	44	42	37	32	35	39	49	49	55	54	52	49	43	41	44	45	42	41	35	31	34
Thomas Ln	1	2816	8	2	0	130	144	35	B&T	N	N	--	--	--	39	49	49	56	54	53	50	46	45	46	47	44	44	38	33	35	39	49	49	55	54	52	49	44	43	45	46	43	42	37	32	34
Thomas Ln	1	2816	8	2	0	150	164	30	B&T	N	N	--	--	--	38	46	48	55	56	51	47	44	41	42	42	41	38	35	31	34	37	46	47	55	56	50	46	43	39	41	41	40	37	34	30	33
Thomas Ave S	1	2819	9	2	0	150	164	30	B&T	N	N	--	--	--	36	43	50	53	55	49	41	42	40	40	40	41	40	35	29	30	35	43	49	53	55	49	40	40	38	38	38	39	37	33	27	28
Thomas Ave S	1	2820	9	2	0	160	174	30	B&T	N	N	--	--	--	35	43	49	53	55	49	40	40	39	38	39	40	38	33	27	28	35	43	49	53	55	48	39	39	37	36	37	38	36	31	25	26
Thomas Ave S	1	2821	9	2	0	175	189	25	B&T	N	N	--	--	--	34	43	48	52	51	48	38	37	35	36	36	38	36	31	25	26	34	42	48	52	50	48	37	36	33	34	35	36	34	29	23	24
Thomas Ave S	1	2821	9	2	0	175	189	25	B&T	N	N	--	--	--	34	43	48	52	51	48	38	37	35	36	36	38	36	31	25	26	34	42	48	52	50	48	37	36	33	34	35	36	34	29	23	24
Thomas Ave S	1	2822	9	2	0	200	214	25	B&T	N	N	--	--	--	33	42	48	52	50	48	36	35	32	33	33	35	32	27	22	23	33	42	48	52	50	48	35	33	30	31	32	34	30	25	20	21
Thomas Ave S	1	2823	9	2	0	250	264	25	B&T	N	N	--	--	--	32	42	47	51	50	47	32	29	27	27	28	31	26	21	16	17	32	42	47	51	50	47	32	29	27	27	28	31	26	21	16	17
Thomas Ave S	1	2823	9	2	0	200	214	25	B&T	N	N	--	--	--	33	42	48	52	50	48	36	35	32	33	33	35	32	27	22	23	33	42	48	52	50	48	35	33	30	31	32	34	30	25	20	21
Thomas Ave S	1	2824	9	2	0	200	214	25	B&T	N	N	--	--	--	33	42	48	52	50	48	36	35	32	33	33	35	32	27	22	23	33	42	48	52	50	48	35	33	30	31	32	34	30	25	20	21
Thomas Ave S	1	2824	9	2	0	175	189	25	B&T	N	N	--	--	--	34	43	48	52	51	48	38	37	35	36	36	38	36	31	25	26	34	42	48	52	50	48	37	36	33	34	35	36	34	29	23	24
Thomas Ave S	1	2825	9	2	0	175	189	25	B&T	N	N	--	--	--	34	43	48	52	51	48	38	37	35	36	36	38	36	31	25	26	34	42	48	52	50	48	37	36	33	34	35	36	34	29	23	24
Thomas Ave S	1	2826	9	2	0	180	194	35	B&T	N	N	--	--	--	36	46	50	53	53	49	40	37	37	38	39	39	38	31	24	25	36	45	50	53	52	49	39	35	36	36	37	38	36	29	23	23
Thomas Ave S	1	2827	9	2	0	175	189	40	B&T	N	N	--	--	--	37	48	51	53	51	50	43	38	39	38	41	41	42	33	25	27	37	47	51	53	50	50	42	37	37	36	40	39	40	31	23	25
Thomas Ave S	1	2827	9	2	0	160	174	40	B&T	N	N	--	--	--	37	48	51	53	51	51	45	40	41	40	44	43	44	35	27	29	37	48	51	53	51	50	44	39	39	38	42	41	42	33	25	27
Thomas Ave S	1	2828	9	2	0	180	194	40	B&T	N	N	--	--	--	37	48	51	53	51	50	43	38	38	38	41	40	41	32	24	26	37	47	51	53	50	50	42	36	37	36	39	39	39	30	23	24
Thomas Ave S	1	2829	9	2	0	175	189	40	B&T	N	N	--	--	--	37	48	51	53	51	50	43	38	39	38	41	41	42	33	25	27	37	47	51	53	50	50	42	37	37	36	40	39	40	31	23	25
Thomas Ave S	1	2830	9	2	0	150	164	40	B&T	N	N	--	--	--	38	48	52	53	51	51	46	42	42	42	45	44	45	37	29	31	37	48	51	53	51	51	44	40	40	40	43	42	43	34	27	29
Thomas Ave S	1	2826	9	2	0	50	64	35	B&T	N	N	--	--	--	42	49	53	55	56	54	52	54	58	59	60	57	62	57	49	49	41	49	53	55	55	53	51	52	55	56	57	55	59	53	45	45
Thomas Ave S	1	2831	9	2	0	150	164	45	B&T	N	N	--	--	--	38	47	53	54	51	51	47	44	42	44	45	45	45	37	30	31	37	47	52	54	51	51	45	42	40	42	43	43	43	34	28	29
Thomas Ave S	1	2832	9	2	0	140	154	45	B&T	N	N	--	--	--	38	47	53	55	51	51	48	45	43	45	46	46	47	38	31	32	38	47	53	54	51	51	46	43	42	43	44	44	45	36	29	30
Thomas Ave S	1	2833	9	2	0	135	149	45	B&T	N	N	--	--	--	38	47	53	55	51	51	48	45	44	46	47	47	48	39	32	33	38	47	53	54	51	51	47	44	42	44	45	45	46	37	30	31
Thomas Ave S	1	2833	9	2	0	225	239	45	B&T	N	N	--	--	--	36	46	52	54	50	49	40	35	33	34	35	37	35	26	20	21	36	46	52	54	50	49	39	33	32	33	34	36	33	24	18	19
Thomas Ave S	1	2835	9	2	0	135	149	45	B&T	N	N	--	--	--	38	47	53	55	51	51	48	45	44	46	47	47	48	39	32	33	38	47	53	54	51	51	47	44	42	44	45	45	46	37	30	31
S Upton Ave	1	2827	9	2	0	139	125	40	B&T	N	N	--	--	--	38	48	52	54	51	51	47	43	44	43	46	45	47	38	31	32	39	49	52	54	52	52	48	45	46	46	49	47	50	41	33	34
S Upton Ave	1	2827	9	2	0	164	150	40	B&T	N	N	--	--	--	37	48	51	53	51	51	44	40	40	40	43	42	43	34	27	29	38	48	52	53	51	51	46	42	42	42	45	44	45	37	29	31
S Upton Ave	1	2828	9	2	0	164	150	35	B&T	N	N	--	--	--	36	46	50	53	53	50	41	39	39	40	41	41	40	33	27	28	37	46	51	53	53	50	43	41	41	42	43	43	42	36	29	30
S Upton Ave	1	2828	9	2	0	164	150	35	B&T	N	N	--	--	--	36	46	50	53	53	50	41	39	39	40	41	41	40	33	27	28	37	46	51	53	53	50	43	41	41	42	43	43	42	36	29	30
S Upton Ave	1	2829	9	2	0	144	130	35	B&T	N	N	--	--	--	37	46	51	53	53	50	43	41	42	43	44	43	43	37	30	30	38	47	51	54	53	51	45	43	44	45	46	45	46	39	32	33
S Upton Ave	1	2829	9	2	0	174	160	35	B&T	N	N	--	--	--	36	46	50	53	53	49	41	38	38	38	40	40	39	32	25	26	36	46	50	53	53	50	42	39	40	40	42	42	41	34	27	28
Kenwood Parkway	1	2865	9	2	0	250	264	45	B&T	N	N	--	--	--	35	46	51	53	50	49	38	32	31	31	33	35	32	23	17	18	35	46	51	53	50	49	38	32	31	31	33	35	32	23	17	18
Kenwood Parkway	1	2865	9	2	0	225	239	45	B&T	N	N	--	--	--	36	46	52	54	50	49	40	35	33	34	35	37	35	26	20	21	36	46	52	54	50	49	39	33	32	33	34	36	33	24	18	19
Kenwood Parkway	1	2865	9	2	0	225	239	45	B&T	N	N	--	--	--	36	46	52	54	50	49	40	35	33	34	35	37	35	26	20	21	36	46	52	54	50	49	39	33	32	33	34	36	33	24	18	19
Kenwood Parkway	1	2866	9	2	0	250	264	45	B&T	N	N	--	--	--	35	46	51	53	50	49	38	32	31	31	33	35	32	23	17	18	35	46	51	53	50	49	38	32	31	31	33	35	32	23	17	18
Kenwood Parkway	1	2866	9	2	0	225	239	45	B&T	N	N	--	--	--	36	46	52	54	50	49	40	35	33	34	35	37	35	26	20	21	36	46	52	54	50	49	39	33	32	33	34	36	33	24	18	19
Kenwood Parkway	1	2870	9	2	0	180	194	45	B&T	N	N	--	--	--	37	47	52	54	51	50	44	40	38	40	41	41	41	32	25	26	37	46	52	54	50	50	43	38	37	38	39	40	39	30	24	24
Kenwood Parkway	1	2870	9	2	0	150	164	45	B&T	N	N	--	--	--	38	47	53	54	51	51	47	44	42	44	45	45	45	37	30	31	37	47	52	54	51	51	45	42	40	42	43	43	43	34	28	29
Kenwood Parkway	1	2870	9	2	0	140	154	45	B&T	N	N	--	--	--	38	47	53	55	51	51	48	45	43	45	46	46	47	38	31	32	38	47	53	54	51	51	46	43	42	43	44	44	45	36	29	30

Location	# of units	Stn #	TM Site	Land Use Cat	Distances			Speed (mph)	Track Type	Crossover Present?	Elevated Structure?	GBN Level			1/3 OB Vibration Levels NB																1/3 OB Vibration Levels SB													
					Depth	NB	SB					NB	SB	Impact?	6.3	8	10	12.5	16	20	25	31.5	40	50	63	80	100	125	160	200	6.3	8	10	12.5	16	20	25	31.5	40	50	63	80	100	125	160	200
Catholic Charities	1	2930	10	2	0	50	64	55	B&T	N	N	--	--	--	50	55	60	60	54	54	57	57	58	64	65	63	64	56	50	52	49	54	59	60	54	54	57	56	57	63	63	61	61	55	47	49
Mary's Place	1	2941	10	2	0	200	214	20	B&T	N	N	--	--	--	42	47	51	51	47	48	46	46	39	41	43	42	43	39	35	38	42	47	50	51	47	48	46	45	38	40	42	41	42	38	34	38
Mary's Place	1	2952	10	2	0	40	54	20	B&T	N	Y	--	--	--	35	42	45	45	39	42	38	41	42	48	50	49	50	46	40	43	34	41	44	44	39	41	38	40	40	47	48	47	48	44	37	40