ATTACHMENT D – NOISE AND VIBRATION

Kansas City Streetcar Riverfront Extension
Noise and Vibration Technical Report

3 May 2018

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Acronyms and Abbreviations

dB	decibels
dBA	A-weighted decibel
FTA	Federal Transit Administration
GBN	ground-borne noise
GBV	Ground-borne vibration
Hz	hertz
KCSA	Kansas City Streetcar Authority
L_{dn}	day-night sound level
L_{eq}	equivalent sound level
$L_{eq(h)}$	1-hour equivalent average sound level
L_{max}	maximum noise level
Project	Kansas City Streetcar Riverfront Extension Project
RMS	root mean square
SEL	sound exposure level
SPL	sound pressure level
SWL	sound power level
VdB	vibration decibels

EXECUTIVE SUMMARY

The Kansas City Streetcar Authority is conducting the environmental review process for the Kansas City Streetcar Riverfront Extension Project (Project) in downtown Kansas City, Missouri. The Project proposes to introduce new track alignment with streetcar service from the downtown loop to the Berkley Riverfront Park area.

This *Noise and Vibration Technical Report* has been prepared in support of the Categorical Exclusion documentation for the Project. The objective of this report is to evaluate the Project's anticipated effects on noise- and vibration-sensitive land use in the Project area. This evaluation as completed in accordance with Federal Transit Administration (FTA) methodologies for general noise and vibration assessment of a transit project. The modeling results presented in this report indicate no impacts are anticipated to occur with implementation of the Project; therefore, no mitigation measures are required.

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1.0 INTRODUCTION

This report presents the technical assessment of noise and vibration effects of the Kansas City Streetcar Riverfront Extension Project (Project). The noise and vibration impact assessment has been prepared in support of a Categorical Exclusion and in accordance with Federal Transit Administration (FTA) guidelines.

1.1 PROJECT BACKGROUND

In early 2017, the Kansas City Streetcar Authority (KCSA), Kansas City Area Transportation Authority, Port KC, and the City of Kansas City, Missouri (collectively the Project Owners) initiated a study to review the feasibility of extending streetcar service approximately ½-mile to the Kansas City Riverfront area. In July 2017, the Project Team determined that it was feasible for the streetcar to be extended to the riverfront. The team determined that the extension should begin at the intersection of 3rd St. and Grand Boulevard, extend over the Grand Boulevard Bridge, travel briefly on River Front Road, and then veer to the northeast to parallel River Front Road to a stub end stop near the middle of the riverfront property (mid-river stop). To advance the Project into design, the Project Owners requested completion of a noise and vibration assessment as part of the environmental analysis.

1.2 PROJECT DESCRIPTION

1.2.1 No Build Alternative

The No Build Alternative will not introduce any additional rail service. Therefore, no analysis is required.

1.2.2 Build Alternative

The Build Alternative will include new track alignment with streetcar service from the downtown loop to the Berkley Riverfront Park area. The alignment will begin at the intersection of 3rd St. and Grand Boulevard, extend over the Grand Boulevard Bridge, travel briefly on Berkley Parkway, and then veer to the northeast to parallel River Front Road to a stub end stop near the middle of the riverfront property (mid-river stop). The Project will introduce new track turnout locations, a new roadway-railroad at-grade crossing at the veer off of River Front Road, and a new station at the mid-river stop.

2.0 REGULATORY CONTEXT

The noise and vibration analyses for the Project were prepared in accordance with FTA's noise and vibration guidance manual, *Transit Noise and Vibration Impact Assessment* (FTA 2006). The manual includes noise and vibration assessment methods and impact thresholds. Operation of the Project will not be subject to state or local noise regulations. Construction contractors will have to comply with local construction noise limits, if they exist.

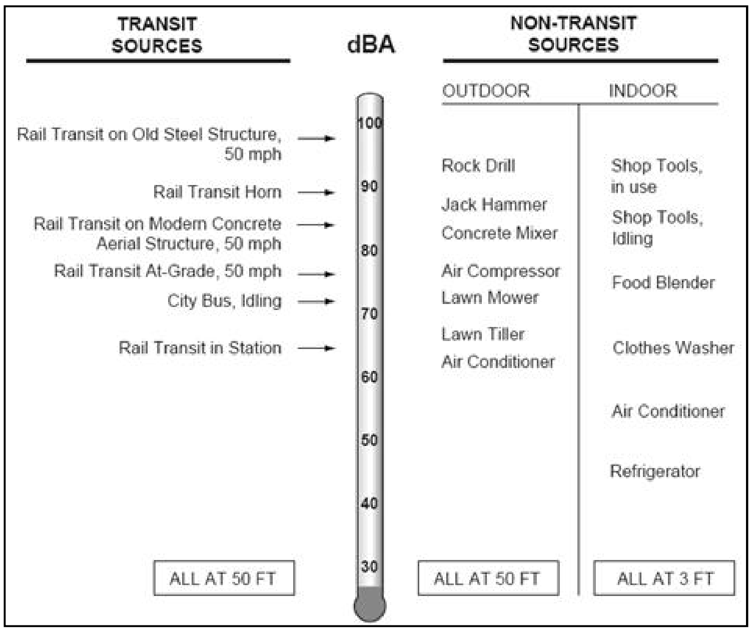
1.3 NOISE

Noise is typically defined as unwanted or excessive sound. Sound becomes unwanted when it interferes with normal activities such as sleep, speech, or recreation. Sound is what we hear when fluctuations in air pressure occur above and below the standard atmospheric pressure. Three variables define characteristics of noise: level (or amplitude), frequency, and time pattern.

Sound pressure level is expressed in decibels (dB) on a logarithmic scale. Typical sound levels generally fall between 20 and 120 dB, similar to the range of human hearing. A 3 dB change in sound level is widely considered to be barely noticeable in outdoor environments, and a 10 dB change in sound level is perceived as a doubling (or halving) of the loudness.

The frequency of sound is the rate at which fluctuations in air pressure occur and is expressed in cycles per second, or hertz (Hz). Most sounds consist of a broad range of sound frequencies. The average human ear does not perceive all frequencies equally. Therefore, the A-weighted decibel (dBA) scale was developed to approximate the way the human ear responds to sound levels; it mathematically applies less "weight" to frequencies we do not hear well and applies more weight to frequencies we do hear well. Typical A-weighted noise levels for various types of sound sources are summarized in Figure 1.

Figure 1: Typical Noise Levels



Source: FTA 2006.

As stated in Chapter 2 of the FTA guidance manual, human reaction to environmental noise depends on the number of noise events, how long they last, and whether they occur during the daytime or nighttime. While the maximum noise level provides information about the amplitude of noise generated by a source, it does not provide any information about how long the noise event lasted. The sound exposure level (SEL) is a noise metric that takes into account both how loud a noise source is and how long the event occurs. The SEL of a noise event is a building block used to determine cumulative noise exposure over a one-hour or 24-hour long period.

Analysts use two primary noise measurement descriptors to assess noise impacts from transit projects. They are the equivalent sound level (L_{eq}) and the day-night sound level (L_{dn}). The L_{eq} is often used to describe sound levels that vary over time, typically for a 1 hour period. Using 24 consecutive 1 hour L_{eq} values, it is possible to calculate daily cumulative noise exposure. The L_{dn} is a 24 hour cumulative A-weighted noise level that includes all noise that occurs throughout a 24 hour period, with a 10 dBA penalty on noise that occurs during nighttime hours (between 10 PM and 7 AM) where sleep interference might be an issue. The 10 dBA penalty makes the L_{dn} useful when assessing noise in residential areas or other land uses where overnight sleep occurs.

1.3.1 FTA Transit Noise Criteria

Chapter 3 of FTA's guidance manual presents the noise impact criteria used for transit projects. The FTA noise impact criteria are based on well-documented studies regarding community response to noise. These thresholds are based on the land use of the noise-sensitive receptor and existing noise level. The L_{dn} is used to assess transit-related noise for residential areas and land uses where overnight sleep occurs (Land Use Category 2), and the 1-hour L_{eq} [$L_{eq(h)}$] is used to assess impact at locations with daytime and/or evening use (Land Use Category 1 or 3), as shown in Table 1.

Table 1: FTA Noise Land Use Categories

Land Use Category	Noise Metric (dBA)	Description of Land Use Category
1	Outdoor $L_{eq(h)}$[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 L_{dn}	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 $L_{eq(h)}$	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.

Source: FTA 2006.

Notes: Outdoor $L_{eq(h)}$ uses the noisiest hour of transit-related activity during hours of noise sensitivity

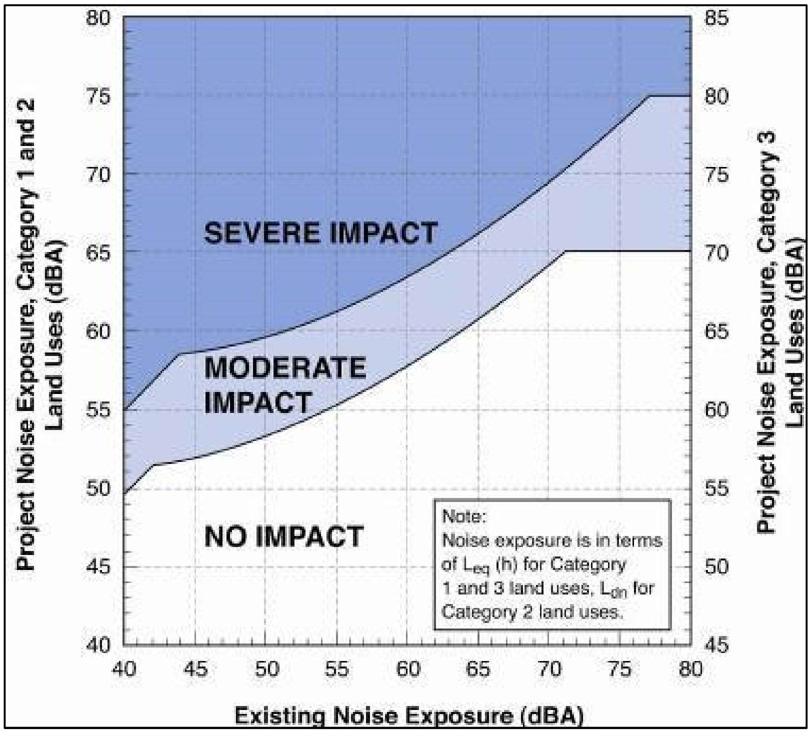
[a] 1-hour L_{eq}

The FTA noise impact criteria are defined by two curves that allow a varying amount of project noise based on the existing noise level, as shown in Figure 2. Below the lower curve, a project is considered to have no impact because the introduction of the project noise would result in an insignificant increase in noise level and number of people highly annoyed. The two degrees of noise impact defined by the FTA criteria are defined as follows:

Severe Impact: In the severe impact range, a large percentage of people would be highly annoyed by the project noise. Noise mitigation will normally be specified for severe impact areas unless it is not feasible or reasonable (meaning there is no practical method of mitigating the impact or mitigation measures are cost-prohibitive).

Moderate Impact: In the moderate impact range, changes in the cumulative noise level are noticeable, but may not be sufficient to cause strong, adverse reactions from the community. In this range, other project-specific factors are considered to determine the magnitude of the impact and the need for mitigation. Other factors include the predicted increase over existing noise levels, the types and number of noise-sensitive land uses affected, existing outdoor-indoor sound insulation, and the cost-effectiveness of mitigating noise to more acceptable levels.

Figure 2: FTA Noise Impact Criteria



Source: FTA 2006.

1.3.2 FTA Construction Noise Criteria

FTA's guidance manual does not provide standardized criteria for construction noise impacts. However, the manual suggests that the guidelines in Figure 2 are reasonable criteria for assessment. These construction noise criteria are intended to be compared with the combined 1 hour L_{eq} [$L_{eq(h)}$] of the two noisiest pieces of construction equipment during 1 hour.

Table 2: FTA Construction Noise Limits

Land Use	Daytime Noise Limit (dBA)	Nighttime Noise Limit (dBA)
Residential	90	80
Commercial and industrial	100	100

Source: FTA 2006.

Note: Noise limit is the combined $L_{eq(h)}$ of the two noisiest pieces of construction equipment during 1 hour.

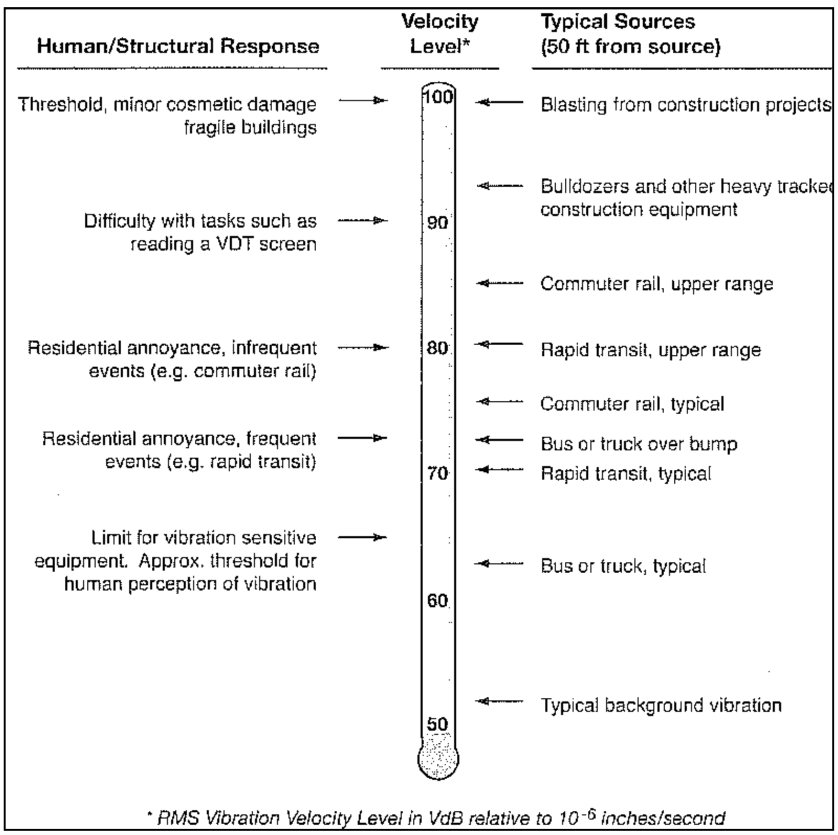
1.4 VIBRATION

Ground-borne vibration (GBV) consists of rapidly fluctuating motions of the ground transmitted into a receptor (building) from a vibration source, such as transit trains. FTA uses vibration velocity to describe vibration levels for transit projects.

The root mean square (RMS) amplitude of a motion over a 1 second period is commonly used to predict human response to vibration. The vibration velocity level is expressed in terms of vibration decibels (VdB), which is decibels relative to a reference quantity of 1 micro-inch per second. The level of vibration represents how much the ground is moving. The background vibration level in residential areas is usually 50 VdB or lower—well below the threshold of perception for humans, which is around 65 VdB. Annoyance begins to occur for frequent transit events at vibration levels over 70 VdB.

Vibration frequency is also expressed in Hz, and the human response to vibration generally falls between 6 and 200 Hz. Human response to vibration is a function of the average motion over a period of time, such as 1 second. Human response to vibration also roughly correlates to the number of vibration events during the day. The more events that occur, the more sensitive humans are to vibration. Figure 3 illustrates common vibration sources and associated human and structural responses to GBV.

Figure 3: Typical Vibration Levels



Source: FTA 2006.

1.4.1 FTA Transit Vibration Criteria

The vibration impact criteria used for transit projects are presented in Chapter 8 of FTA's guidance manual. FTA identifies separate criteria for both GBV and ground-borne noise (GBN). GBN is often masked by airborne noise; therefore, GBN criteria are primarily applied to subway operations in which airborne noise is negligible. FTA differentiates vibration-sensitive land uses into three distinct categories—similar but not identical to the noise-sensitive land use categories, as shown in Table 3. The vibration thresholds vary based on the land use and the frequency of the vibration events. The proposed Project will include 186 to 210 streetcar pass-by events depending on the weekday, subjecting the Project to the frequent event thresholds.

Table 3: FTA Vibration Impact Criteria

Land Use Category	Frequent Events[a]	Occasional Events[b]	Infrequent Events[c]
GBV impact level (VdB re 1 micro-inch/second)			
Category 1[d] (highly sensitive, where vibration would interfere with operations)	65	65	65
Category 2 (where overnight sleep occurs)	72	75	80
Category 3 (institutional with primarily daytime use)	75	78	83
GBN impact level (dBA re 20 micropascals)			
Category 2 (where overnight sleep occurs)	35	38	43
Category 3 (institutional with primarily daytime use)	40	43	48

Source: FTA 2006.

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

[b] Occasional events is defined as between 30 and 70 vibration events of the same source per day. Most commuter rail trunk lines have this many 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] The Category 1 criteria limits are 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. Vibration-sensitive equipment is generally not sensitive to GBN.

1.4.2 FTA Construction Vibration Criteria

Vibration attributable to construction activities is usually temporary. Thus, the principal concern for construction vibration is potential damage to structures. Table 4 lists damage criteria that can be applied to protect sensitive or fragile structures. These criteria can be used to identify locations that should be considered more carefully during the Project's final design phases.

Table 4: FTA Vibration Damage Criteria

Building Category	Peak Particle Velocity (inch/second)	RMS Velocity (VdB)
I. Reinforced-concrete, steel, or timber (no plaster)	0.50	102
II. Engineered concrete and masonry (no plaster)	0.30	98
III. Non-engineered timber and masonry buildings	0.20	94
IV. Buildings extremely susceptible to vibration damage	0.12	90

Source: FTA 2006.

Note: RMS velocity is provided as a reference to the general magnitude of vibration, compared with the operational vibration impact thresholds; assumes a crest factor of 4 (12 VdB).

3.0 METHODOLOGY

1.5 NOISE

1.5.1 Operation Noise Evaluation Methods

This section describes the methodology used to assess potential noise impacts from operation of the Project. The noise assessment was conducted according to the FTA manual's General Assessment methods. The methodology and modeling assumptions used in this noise analysis were based on the methods and default data presented in FTA's guidance manual, except where use of measurement data was noted. Operational information was provided to HDR by other members of the project design team.

The FTA manual provides noise screening distances for different types of transit projects in Chapter 4. The screening distance defines the noise study area for the Project and identifies noise-sensitive land use in the noise study area.

Noise-sensitive receptors were identified by reviewing a combination of available land use-related geographic information system data, windshield surveys, and available digital aerial photography, including publicly available internet imagery. Noise-sensitive receptors in the study area were identified and then categorized for noise sensitivity based on the descriptions in Table 1.

The existing noise environment was characterized by measuring outdoor noise in the Project area, as described in Section 4.1.2. The noise impact thresholds used for this assessment were based on measured existing noise levels and the FTA limits of allowable increase in noise levels when compared to existing noise levels. The FTA manual provides a method for calculating the noise emissions of rail-related noise sources and the propagation from the source to a receptor. The noise emission of each project-related noise source was estimated as a sound pressure level at 50 feet. For the proposed Project, the noise sources included the rolling and propulsion noise of the transit vehicle, the vehicle rolling over rail frogs in turnouts and other special trackwork, and the transit vehicle's warning horns. Crossing bells associated with a proposed railroad-roadway crossing were also included in the noise assessment. For the general noise assessment, the sound exposure level (SEL) for a streetcar measured at 50 feet was adjusted for the sound attenuation over distance, the operation volumes, and the speeds of the proposed Project.

The noise modeling assumptions used in this assessment, including noise levels for proposed noise sources and operating characteristics, are described below:

- The noise analysis used a SEL of 85 dBA at 50 feet for the streetcar vehicle, as measured from an existing RideKC streetcar vehicle pass-by in March 2018 by HDR. The proposed streetcar will consist of one electric articulated vehicle during hours of operation.
- The noise analysis used a SEL of 72 dBA at 50 feet for the streetcar's audible warning bell, as measured from an existing RideKC streetcar vehicle pass-by in March 2018 by HDR. The streetcar will sound an audible warning bell when entering and exiting stations. Onboard warning bells were assumed to be used within 100 feet of the center of station platforms.
- The noise analysis used a SEL of 93 dBA at 50 feet for the streetcar's audible warning horn based on the existing RideKC streetcar vehicle pass-by measured in March 2018 by HDR and vehicle audible warning device data provided by KCSA. The train will sound an audible warning horn at a roadway-railroad crossing where the alignment turns east off of Grand Street.
- The noise analysis used a SEL of 109 dBA at 50 feet for crossing bells at the railroad-roadway crossing, as provided in the FTA manual. Stationary crossing bells were assumed to sound for a duration of 40 seconds every 12 minutes at the crossing.
- The schedule is based on the *Streetcar Riverfront Extension and Multi-Modal Feasibility Study's* future train schedule proposed for Alternative 1. A separate weekday train schedule was given for Monday through Thursday operations and Friday operations. As such, a typical weekday schedule was estimated by using a weighted average of the Monday through Thursday and Friday schedule operations, resulting in 154 modeled trains during the daytime (7 AM to 10 PM), 36 modeled trains during the nighttime (10 PM to 7 AM), and 11 modeled trains during the peak hour.
- Locations of elevated structures, turnouts, the railroad crossing location, and station platforms were identified based on conceptual engineering drawings provided by the engineering team.
- Noise levels were assumed to increase by 4 dB for the portion of the alignment on elevated structure because of structure-borne noise.
- Noise levels were assumed to increase by 6 dB at the location of turnouts along the Project alignment.
- The speed of the streetcar was modeled as the design speed of 30 miles per hour.

1.5.2 Construction Noise Evaluation Methods

The construction noise assessment was based on the methodology described in FTA's guidance manual. The construction noise analysis identified construction equipment commonly used for this type of Project. Data from similar projects were used to estimate sound levels for internal combustion engines, numbers of equipment to be used during each phase of construction, the rated horsepower for each piece of equipment, and the duration that each piece of equipment is anticipated to operate during construction activities.

To estimate construction noise levels from construction equipment with engines, a sound power level (SWL) was calculated by converting horsepower to kilowatts, then to SWL. A utilization factor representing the percentage of time items would be in use during an hour was developed using FTA's guidance manual. An adjusted SWL was determined by accounting for the number of pieces of equipment and their utilization factor. The adjusted SWL was then converted to sound pressure level (SPL) at distances of 100, 200, 500, and 1,000 feet. The SPL is expressed as $L_{eq(h)}$ in dBA and is an energy-based average noise level over a 1 hour period.

1.6 VIBRATION

1.6.1 Operation Vibration Evaluation Methods

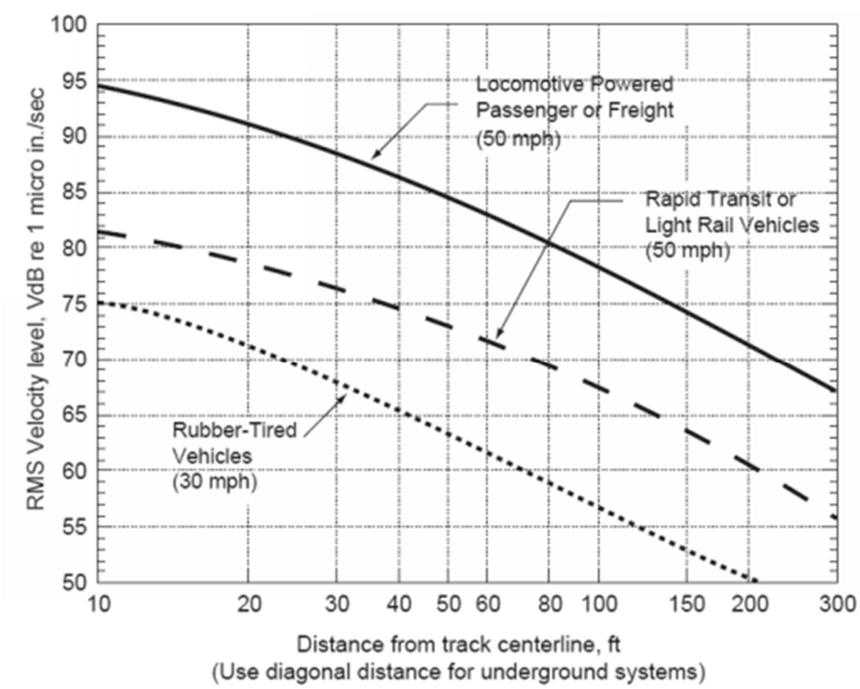
This section describes the methodology used to assess potential vibration impacts from operation of the Project. The vibration assessment was conducted according to the FTA manual's General Assessment methods. The methodology and modeling assumptions used in this vibration analysis were based on the methods and default data presented in FTA's guidance manual. Operational information was provided to HDR by other members of the project design team.

The FTA manual provides vibration screening distances for different types of transit projects in Chapter 9. The screening distance defines the vibration study area for the Project and identifies vibration-sensitive land uses in the study area.

Vibration-sensitive receptors were identified by reviewing a combination of available land use-related geographic information system data, windshield surveys, and available digital aerial photography, including publicly available internet imagery. Receptors in the study area were identified and then categorized for vibration sensitivity based on the descriptions in Table 3.

Projected GBV levels from streetcar pass-by events were predicted using the default ground-surface vibration curves in FTA's guidance manual. These GBV curves are shown in Figure 4. The streetcars will travel up to a design speed of 30 miles per hour. Following FTA guidance, the surface vibration curve for Rapid Transit or Light Rail Vehicles in Figure 4 was adjusted to reflect changes in train speed, track on elevated structure, and special trackwork such as turnouts. No adjustments were applied for corrugated rail, wheel flats, or other unmaintained rolling stock. Adjustments were applied for different receptor building construction types (i.e., masonry versus timber) at the multiple-family buildings in the study area that are 3- to 4-story masonry structures, including coupling to building foundation loss, amplification due to floor resonances, and effect of floors above grade.

Figure 4: FTA Surface Vibration Curves



SOURCE: USDOT FTA 2006.

1.6.2 Construction Vibration Evaluation Methods

FTA's guidance manual provides guidance for construction vibration assessment. Most construction equipment can cause ground-borne vibration, which rapidly diminishes in strength with distance. A quantitative construction vibration assessment is generally necessary only when the construction activities have potential for damaging fragile buildings or interfering with equipment or activities that are highly sensitive to GBV. Examples include projects that use blasting, pile driving, pavement breaking, vibratory compaction, and drilling or excavating the ground near sensitive structures. Construction vibration was not evaluated quantitatively because the primary vibration sources or activities of concern are not currently proposed. Other activities have potential to create temporary, perceptible vibrations when construction activities move very close to a structure, but these impacts will be temporary and will occur only while the construction equipment moves through that location.

A brief qualitative assessment is provided, as suggested by FTA's guidance manual.

4.0 AFFECTED ENVIRONMENT

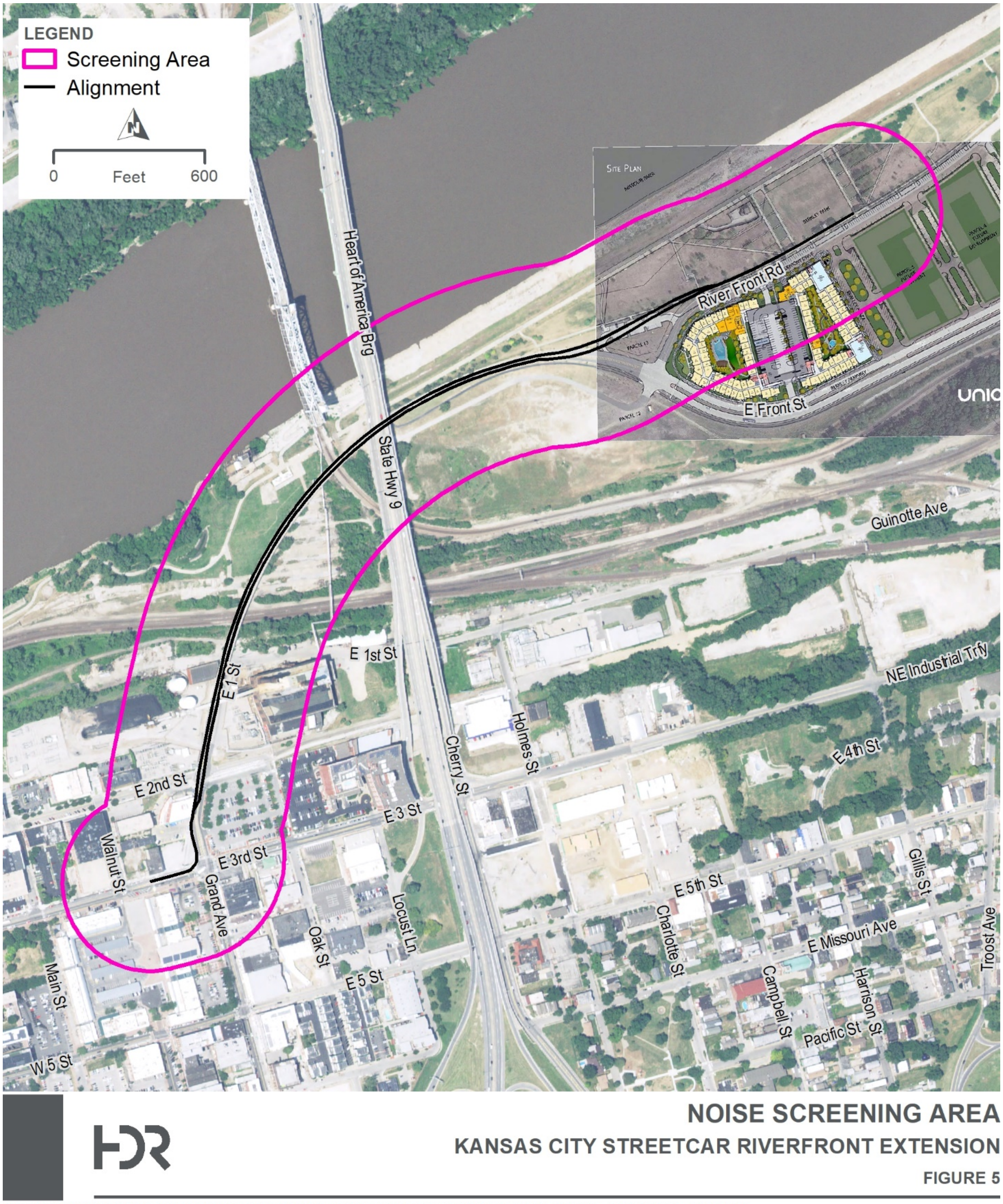
1.7 NOISE

This section discusses noise-sensitive land use in the Project Area and presents noise measurement results.

1.7.1 Noise-Sensitive Land Use and Noise Screening

The noise screening distance for a transit project without intervening buildings is 350 feet, and any noise-sensitive land use within this distance from the proposed track centerline was considered for the general noise assessment. Noise-sensitive land use in the study area includes a multiple-family property at 207 and 213 Walnut Street, passive use recreation such as picnic tables and benches in Berkley Riverfront Park, and a multiple-family development called Union Berkley Riverfront Apartments currently under construction south of Berkley Riverfront Park. Figure 5 presents the noise screening area for the Project.

Figure 5: Noise Screening Area



1.7.2 Existing Noise Conditions

Existing noise was measured in the study area from March 7 to March 8, 2018. Table 5 summarizes the existing noise measurements, and Figure 6 shows the noise measurement locations. Noise measurements were conducted using Larson Davis 824 noise monitors that conform to American National Standard Institute standards for Type 1 (precision) sound measurement equipment. Photographs of each measurement site are provided in Appendix A.

Table 5: Noise Measurement Sites

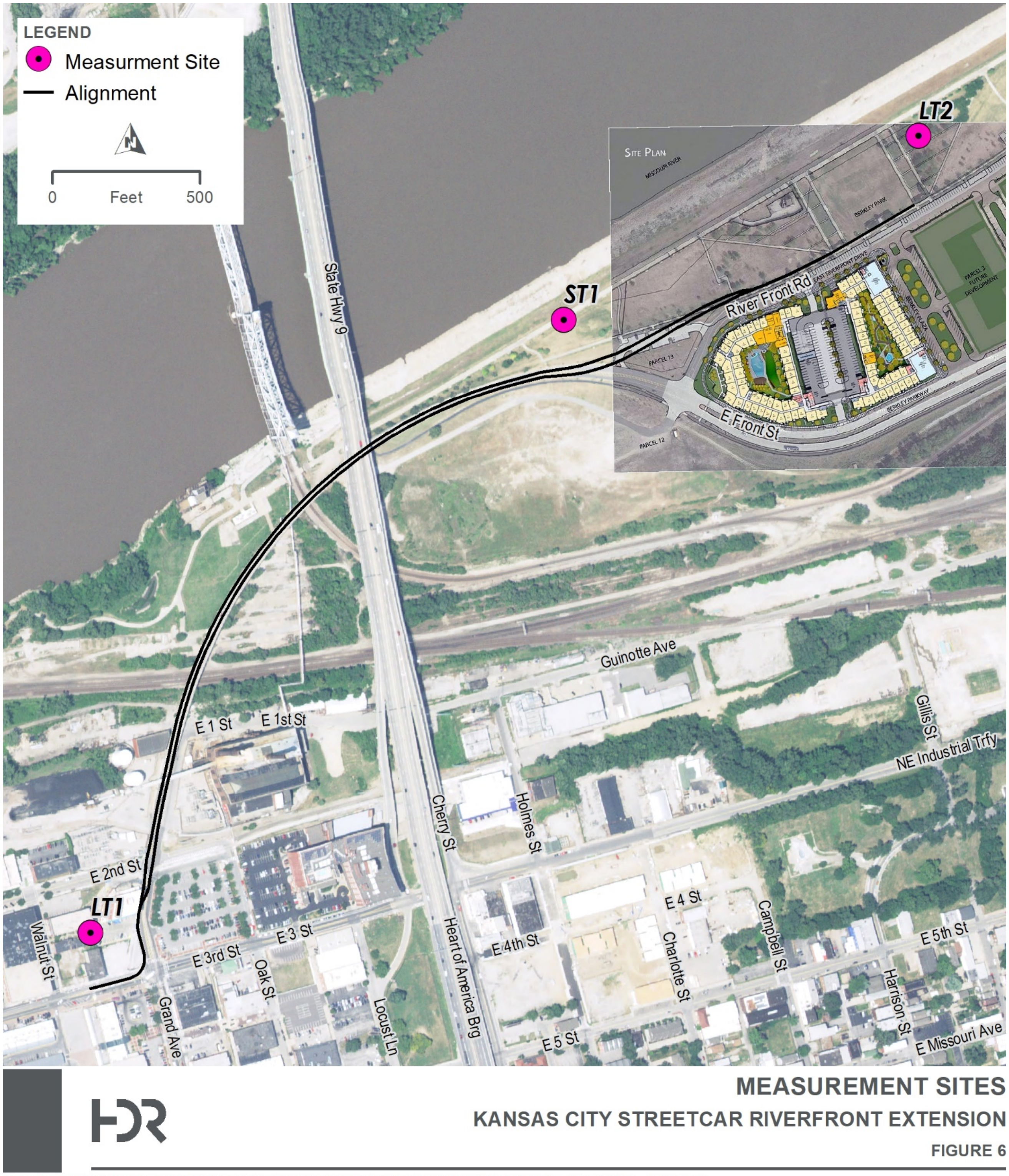
Site	Receptor Description	FTA Land Use Category	Peak Hour Noise Level (L_{eq})	Day-Night Noise Level (L_{dn})
LT-1	207 and 213 Walnut Street	2	59	65
LT-2	Berkley Riverfront Park	3	59	63[a]
ST-1	Berkley Riverfront Park	3	58	63[a]

a Due to noise monitor malfunction at LT-2, only 9 hours of data was collected. The L_{dn} for the Berkley Riverfront Park area was calculated based on data gathered at ST-1 and LT-2 and the formula for L_{dn} estimation given in Appendix D of the FTA manual.

As shown in Table 5, the L_{dn} ranged from 63 dBA in Berkley Riverfront Park to 65 dBA at 207 and 213 Walnut Street near the downtown loop.

Source reference-level measurements were also performed adjacent to the existing Kansas City Streetcar alignment in the downtown loop. Measurements of train pass-by events occurred along 3rd Street and 5th Street at 50 feet from the existing track centerline. Measurements along 5th Street included train pass-by events and the vehicle bell. These measurements were used to determine the SEL of the streetcar vehicle and the vehicle bell, as outlined in Section 3.1.1.

Figure 6: Noise Measurement Locations



1.8 VIBRATION

This section discusses vibration-sensitive land uses in the Project Area.

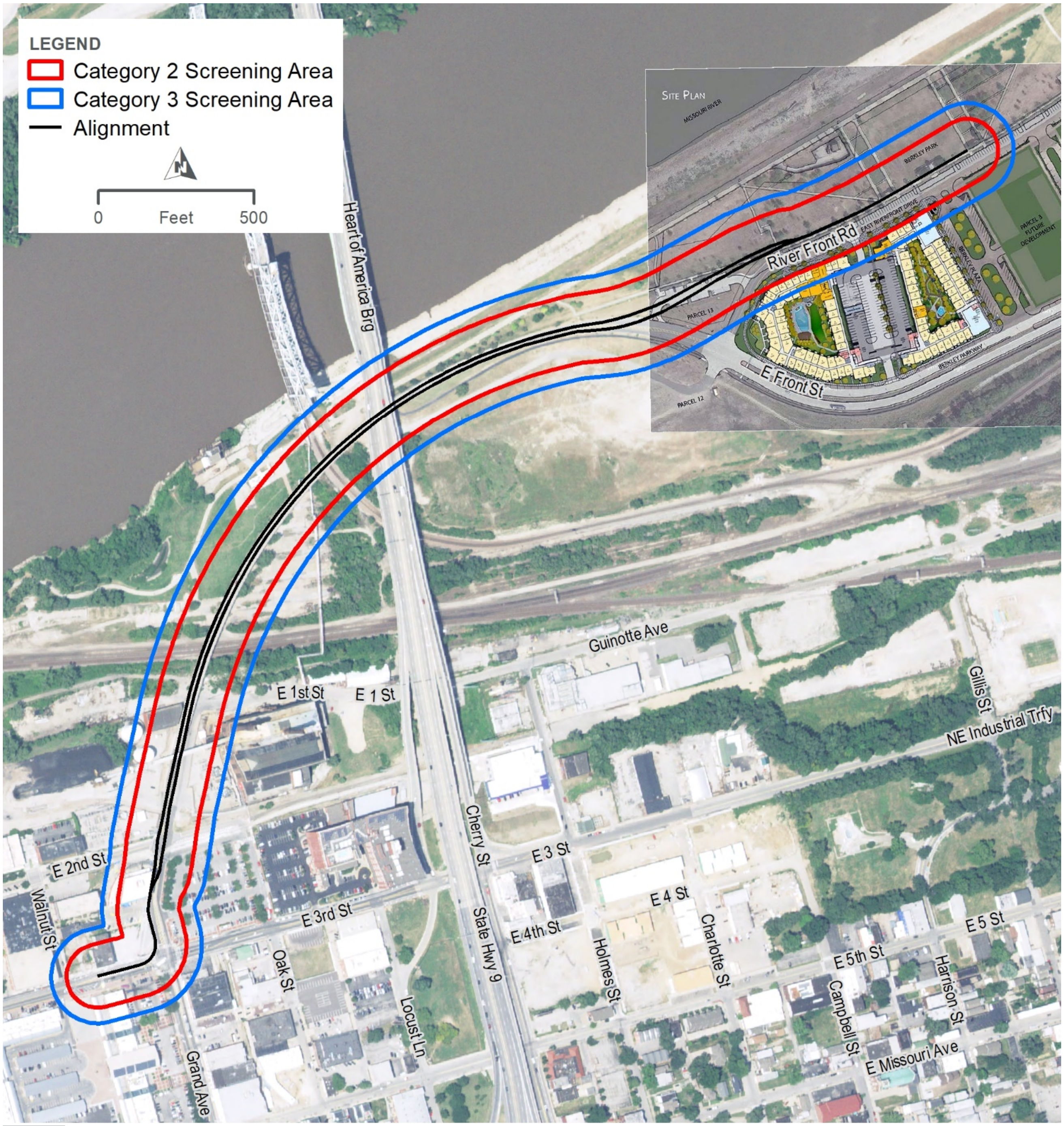
1.8.1 Vibration-Sensitive Land Use and Vibration Screening

The vibration screening distance for a transit project is 150 feet for Category 2 receptors and 100 feet for Category 3 receptors. Vibration-sensitive land use in the study area includes a multiple-family property at 207 and 213 Walnut Street and a multiple-family development called Union Berkley Riverfront Apartments currently under construction south of Berkley Riverfront Park. Figure 7 presents the vibration screening area for the Project.

1.8.2 Existing Vibration Conditions

Existing vibration sources in the Project Area include traffic on local streets and existing freight rail lines.

Figure 7: Vibration Screening Area



VIBRATION SCREENING AREA
KANSAS CITY STREETCAR RIVERFRONT EXTENSION
FIGURE 7

PATH: \\MSPE-GIS-FILE\GISPROJ\133_KC\10090607_KCSTREETCAR\7.2_WORK_IN_PROGRESS\MAP_DOCS\DRAFT\VIBRATIONSCREENING_8X11P.MXD - USER: STUOHEY - DATE: 4/3/2018

5.0 ENVIRONMENTAL CONSEQUENCES

1.9 NOISE

1.9.1 Long-term Operating Effects

Using FTA methods, this analysis calculated the distance from the proposed streetcar centerline to the point at which noise impacts will no longer occur. A noise impact contour was drawn around the proposed streetcar centerline, and the radius of that contour is the distance at which noise impacts no longer occur. Noise-sensitive land uses inside the noise impact contour are considered impacted. Analysis results indicate that the proposed project will not cause noise impacts, as defined by FTA, at noise-sensitive land uses in the study area, as shown on Figures B1 through B3 in Appendix B. These figures demonstrate that no noise-sensitive receptors exist within the noise impact contours. The area with the greatest distance to impact is at the railroad-roadway crossing located at River Front Road where the streetcar vehicle crosses out of the roadway and on to dedicated track as it heads to the Riverfront Station.

1.9.2 Short-term Construction Effects

Construction of the Project will likely result in a temporary increase in noise levels during the construction process. Pieces of equipment used to move soil and other earthen materials are often the loudest construction noise sources. Table 6 presents typical noise levels, by construction phase. This is based on the typical equipment used for different phases of railroad construction with typical noise levels, quantities, and estimated uses for each type of equipment. Table C-1 in Appendix C shows the typical equipment, uses, and sound levels for construction equipment by phase. The table also shows the SWL used to determine the SPL at different distances.

The noise level estimates presented in Table 6 conservatively overestimate actual expected construction noise levels by assuming that all of the equipment (i.e., all of the dump trucks or all of the pickup trucks) will operate at the same location simultaneously. Typically, construction equipment is spread throughout the construction work zone. Given the linear nature of the Project and the relatively confined width of the streetcar ROW, it is reasonable to assume that all pieces of equipment will not operate next to each other in the same (stationary) location for the entirety of 1 hour.

Using this conservative construction noise assessment approach, analysis results shown in Table 6 indicate the total combined noise for all construction equipment types, and construction phases will never exceed the 90 dBA threshold at 200 feet. The estimated noise levels presented in Table C-1 show that numerous single pieces of equipment may exceed the FTA recommendations if running constantly for 1 hour within 100 feet of a receptor. The installation of track has the potential to exceed 90 dBA at 100 feet, although this assumes all equipment required for this construction is running at the same time at one location. During the final design and construction phase, KCSA will require construction contractors to develop a construction noise management plan which includes identifying and complying with any applicable local noise ordinances; therefore, construction noise impacts will not be anticipated to occur.

Table 6: Estimated Noise Levels by Construction Phase

Construction Phase	SPL (dBA) at 100 feet	SPL (dBA) at 200 feet	SPL (dBA) at 500 feet	SPL (dBA) at 1,000 feet
Utility relocation	86	80	72	66
Earthwork	86	80	72	66
Bridge construction for overpasses	82	76	68	62
Retaining walls	76	70	62	56
Signals	75	69	61	55
Track installation	91	85	77	71
Demolish existing bridge	82	76	68	62
Track and subballast installation	85	79	71	65
Final cut-over and removal of turnouts	85	79	71	65

1.10 VIBRATION

1.10.1 Long-term Operating Effects

Analysis results indicate that the proposed Project is not expected to cause vibration impacts. Wayside vibration from wheels rolling on the track is not predicted to exceed vibration impact thresholds beyond a distance of 10 feet from the track centerline throughout the Project alignment. Vibration levels will increase up to 10 VdB at the location of track turnouts, resulting in a vibration impact distance of 55 feet from turnouts at Category 2 receptors and 35 feet at Category 3 receptors. As shown on Figures B4 through B6 in Appendix B, no Category 2 or 3 receptors exist within those impact distances. Because the only two vibration-sensitive receptors in the study are multiple-family 3-4 story masonry buildings, the analysis took into account the building construction and applied FTA adjustments for coupling to building foundation loss, amplification due to floor resonances, and effect of floors above grade.

1.10.2 Short-term Construction Effects

Construction-related ground-borne vibration very rarely damages buildings. Construction activities that typically generate the most severe vibrations with the potential for building damage including blasting and pile-driving. No blasting or pile-driving activities are expected to be included on this Project. Examples of other construction activities with a potential for vibration impact include concrete pavement breaking, vibratory compaction, and drilling or excavating in the ground near sensitive structures. During the final design and construction phase, KCSA will require construction contractors to develop a construction vibration management plan and include vibration performance specifications in the construction contract documents; therefore, construction-related ground-borne vibration impacts are not be anticipated to occur.

6.0 MITIGATION MEASURES

No noise or vibration impacts are predicted to occur for the Project; therefore, no mitigation measures are recommended or required.

7.0 CONCLUSIONS

The modeling results presented in this report indicate that noise or vibration impacts are not anticipated to occur with implementation of the Project; therefore, mitigation is not recommended or required.

8.0 REFERENCES

FTA. 2006. *Transit Noise and Vibration Impact Assessment*. May.

Burns & McDonnell. 2017. *Streetcar Riverfront Extension and Multi-Modal Feasibility Study.* August.

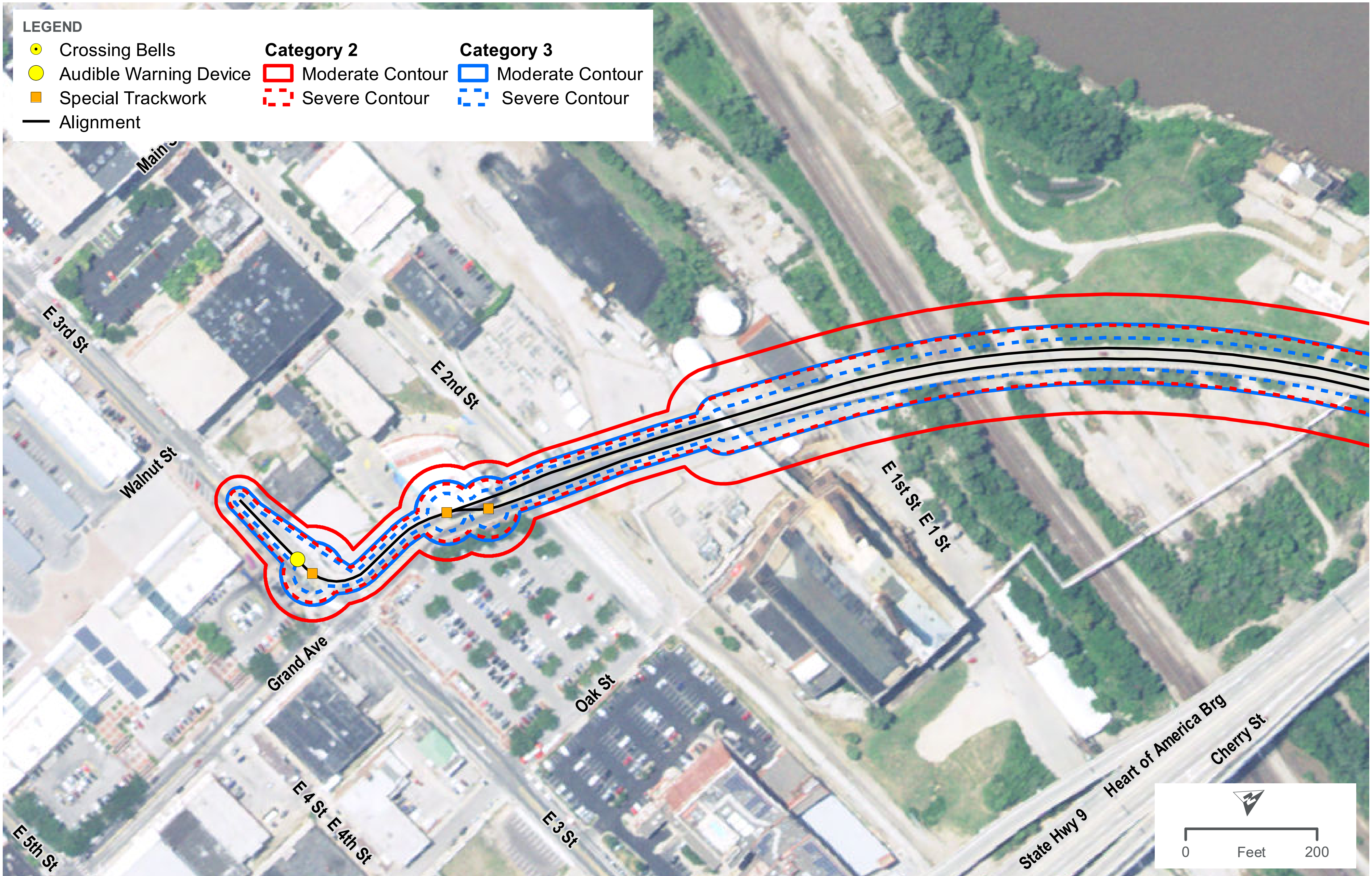
APPENDIX A: NOISE MONITORING LOCATIONS

Site LT-1

Site LT-2

Site ST-1

APPENDIX B: NOISE AND VIBRATION CONTOURS



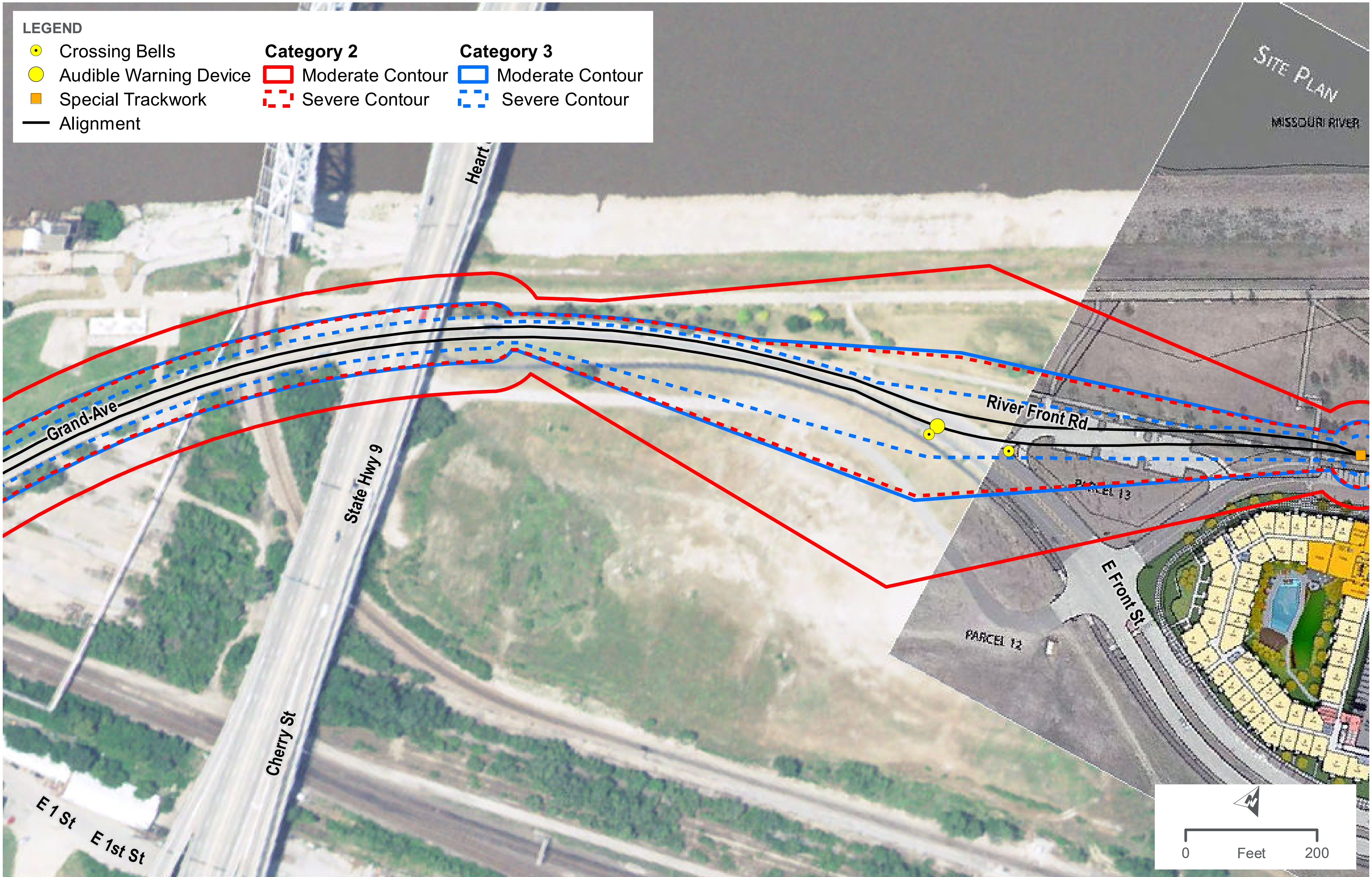
HDR

NOISE CONTOURS

KANSAS CITY STREETCAR RIVERFRONT EXTENSION

FIGURE B1

PATH: \\MSPE-GIS-FILE\GISPROJ\133_KC\10090607_KCSTREETCAR\7.2_WORK_IN_PROGRESS\MAP_DOCS\DRAFT\NOISE_8X11L.MXD - USER: STUOHEY - DATE: 4/3/2018



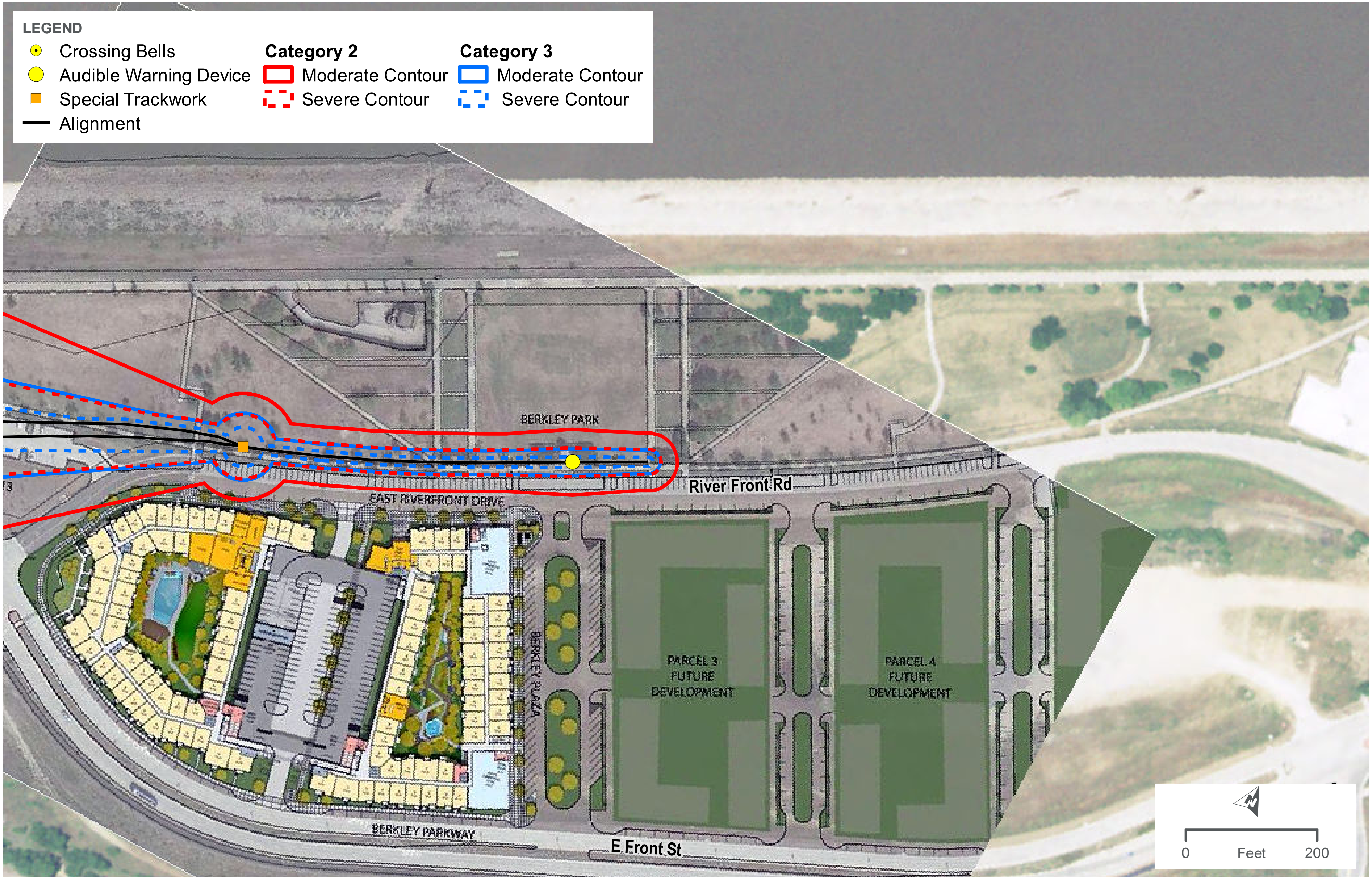
HDR

NOISE CONTOURS

KANSAS CITY STREETCAR RIVERFRONT EXTENSION

FIGURE B2

PATH: \\MSPE-GIS-FILE\GISPROJ\133_KC\10090607_KCSTREETCAR\7.2_WORK_IN_PROGRESS\MAP_DOCS\DRAFT\NOISE_8X11L.MXD - USER: STUOHEY - DATE: 4/3/2018



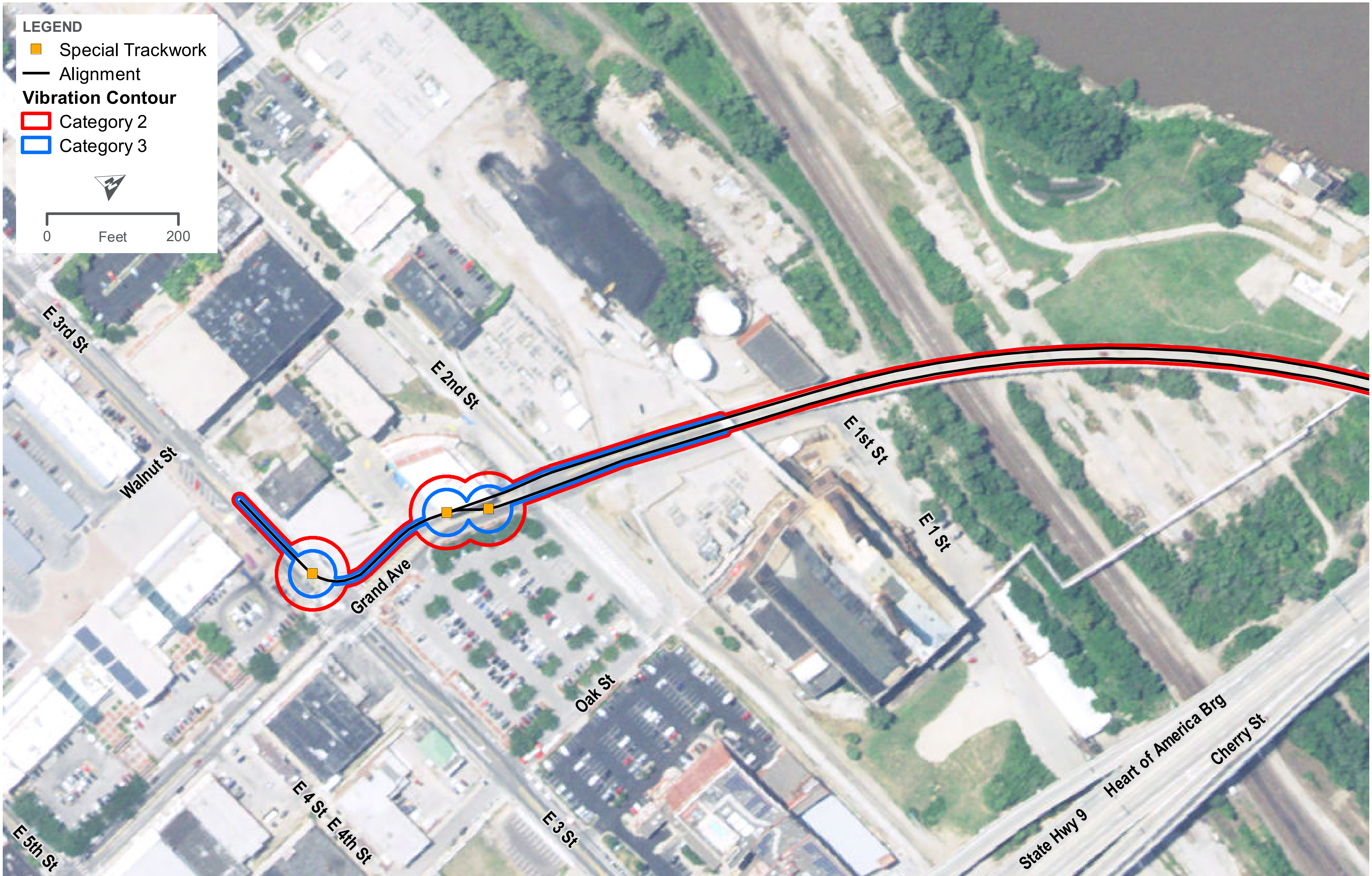
HDR

NOISE CONTOURS

KANSAS CITY STREETCAR RIVERFRONT EXTENSION

FIGURE B3

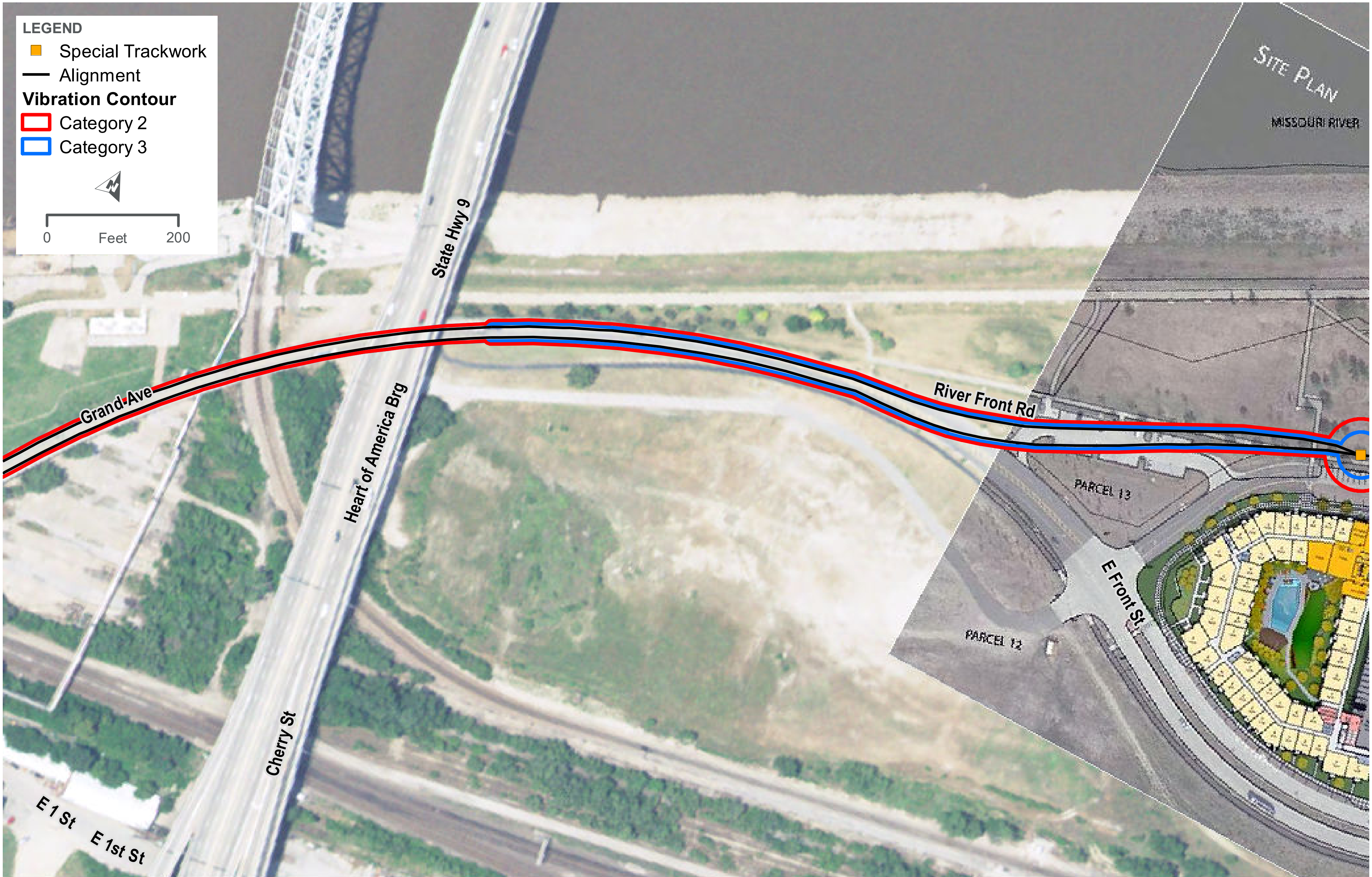
PATH: \\MSPE-GIS-FILE\GISPROJ\133_KC\10090607_KCSTREETCAR\7.2_WORK_IN_PROGRESS\MAP_DOCS\DRAFT\NOISE_8X11L.MXD - USER: STUOHEY - DATE: 4/3/2018



VIBRATION CONTOURS

KANSAS CITY STREETCAR RIVERFRONT EXTENSION

FIGURE B4



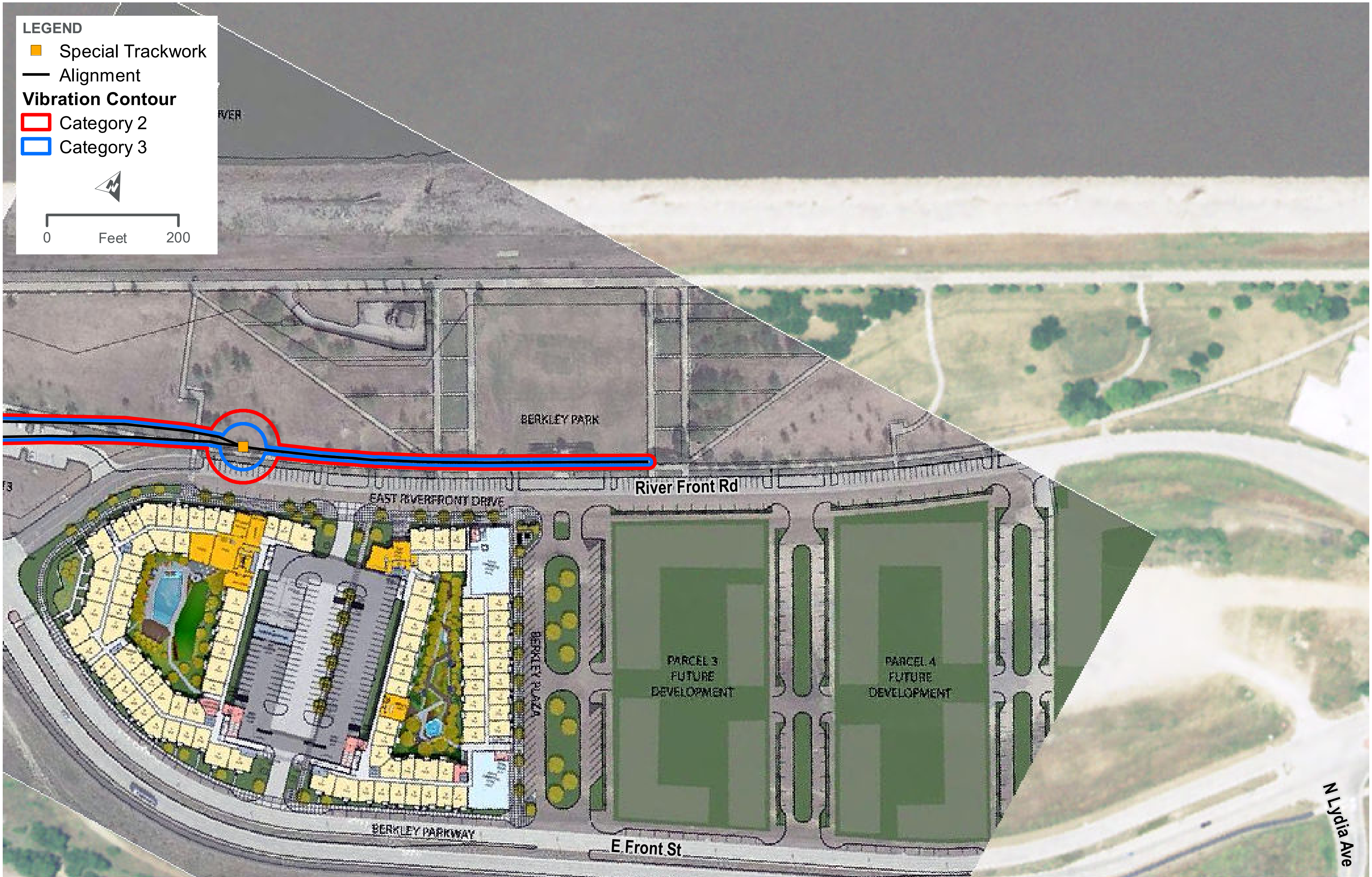
HDR

VIBRATION CONTOURS

KANSAS CITY STREETCAR RIVERFRONT EXTENSION

FIGURE B5

PATH: \\MSPE-GIS-FILE\GISPROJ\133_KC\10090607_KCSTREETCAR\7.2_WORK_IN_PROGRESS\MAP_DOCS\DRAFT\VIBRATION_8X11L.MXD - USER: STUOHEY - DATE: 4/3/2018



VIBRATION CONTOURS

KANSAS CITY STREETCAR RIVERFRONT EXTENSION

FIGURE B6

PATH: \\MSPE-GIS-FILE\GISPROJ\133_KC\10090607_KCSTREETCAR\7.2_WORK_IN_PROGRESS\MAP_DOCS\DRAFT\VIBRATION_8X11L.MXD - USER: STUOHEY - DATE: 4/3/2018

APPENDIX C: CONSTRUCTION NOISE ASSESSMENT

Table C-1: Estimated Construction Equipment Noise Levels by Construction Phase

Construction Phase	Equipment	Number	Hours/day	Utilization	Horsepower	kilowatt	SWL/ unit	Total SWL	SPL (dBA) at distance (ft.)			
									100	200	500	1000
Utility Relocation	Off-Highway Trucks	4	4	40%	350	261	123	125	85	79	71	65
	Rubber Tired Loaders	1	4	40%	199	148	121	117	76	70	62	56
	Tractors/Loaders/Backhoes	2	8	80%	97	72	118	120	79	73	65	59
	Combined Noise Level								86	80	72	66
Earthwork	Off-Highway Trucks	4	4	40%	350	261	123	125	85	79	71	65
	Rollers	1	6	60%	80	60	117	115	74	68	60	54
	Tractors/Loaders/Backhoes	2	8	80%	97	72	118	120	79	73	65	59
	Combined Noise Level								86	80	72	66
Bridge Construction for Overpasses	Cranes	1	3	30%	226	169	121	116	75	69	61	55
	Generator Sets	2	4	40%	84	63	117	116	75	69	61	55
	Tractors/Loaders/Backhoes	2	6	60%	97	72	118	118	78	72	64	58
	Welders	2	6	60%	46	34	114	115	74	68	60	54
	Combined Noise Level								82	76	68	62
Retaining Walls	Tractors/Loaders/Backhoes	2	4	40%	97	72	118	117	76	70	62	56
	Combined Noise Level								76	70	62	56

Signals	Cranes	1	2	20%	226	169	121	114	74	68	60	54
	Tractors/Loaders/Backhoes	1	2	20%	97	72	118	111	70	64	56	50
	Combined Noise Level								75	69	61	55
Track Installation	Air Compressors	1	6	60%	78	58	117	114	74	68	60	54
	Cranes	1	7	70%	226	169	121	120	79	73	65	59
	Forklifts	3	8	80%	89	66	117	121	80	74	66	60
	Generator Sets	1	8	80%	84	63	117	116	75	69	61	55
	Track Laying Machine	1	8	80%	1500	1119	129	129	88	82	74	68
	Track Tamper	1	8	80%	200	149	121	120	79	73	65	59
	Track Stabilizer	1	8	80%	700	522	126	125	85	79	71	65
	Tractors/Loaders/Backhoes	2	8	80%	97	72	118	120	79	73	65	59
	Welders	1	8	80%	46	34	114	113	73	67	59	53
	Combined Noise Level								91	85	77	71
Demolish Existing Bridge	Concrete/Industrial Saws	2	8	80%	85	63	117	119	78	72	64	58
	Tractors/Loaders/Backhoes	2	8	80%	97	72	118	120	79	73	65	59
	Combined Noise Level								82	76	68	62
Install Track and Subballast Over Bridge	Air Compressors	1	6	60%	78	58	117	114	74	68	60	54
	Cranes	1	7	70%	226	169	121	120	79	73	65	59
	Forklifts	3	8	80%	89	66	117	121	80	74	66	60
	Generator Sets	1	8	80%	84	63	117	116	75	69	61	55
	Tractors/Loaders/Backhoes	2	8	80%	97	72	118	120	79	73	65	59
	Welders	1	8	80%	46	34	114	113	73	67	59	53

	Combined Noise Level							85	79	71	65
Final Cut-Over and Removal of Turnouts	Cranes	1	7	70%	226	169	121	120	79	73	65	59
	Forklifts	3	8	80%	89	66	117	121	80	74	66	60
	Generator Sets	1	8	80%	84	63	117	116	75	69	61	55
	Tractors/Loaders/Backhoes	3	7	70%	97	72	118	121	80	74	66	60
	Welders	1	8	80%	46	34	114	113	73	67	59	53
	Combined Noise Level							85	79	71	65