Coolidge Terminal Replacement Project
Environmental Assessment
January 2023

APPENDIX F

NOISE AND VIBRATION TECHNICAL MEMORANDUM

Noise and Vibration Technical Memorandum

Coolidge Terminal Replacement Project

Detroit Department of Transportation

Detroit, Michigan

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1.0 Project Description

Detroit Department of Transportation (DDOT) proposes to construct a new bus maintenance, storage, and operations center on the existing Coolidge Terminal site in Detroit, Michigan. The entire Coolidge Terminal site will be demolished and cleared, including all six existing structures.

The Coolidge Replacement Facility will accommodate 24-hour operations, and initially accommodate 148 buses, with the capacity to expand to up to 216 buses in the future. Both modern 40' buses and 60' articulated buses will be stored and maintained at this facility. The new facility will provide 245 parking spaces (230 staff including bus drivers, maintenance, operations, and administrative personnel, and 15 parking spaces for visitors. DDOT plans already include perimeter fencing and landscaping along the eastern edge, and an 8-10' noise attenuating barrier along the southern edge. Additionally, 36 adjacent residential parcels along Ward Street and Compass Avenue will be transferred from the Detroit Land Bank Authority for this project. The existing structures on these parcels will be demolished. The conceptual site plan is shown in Figure 1.

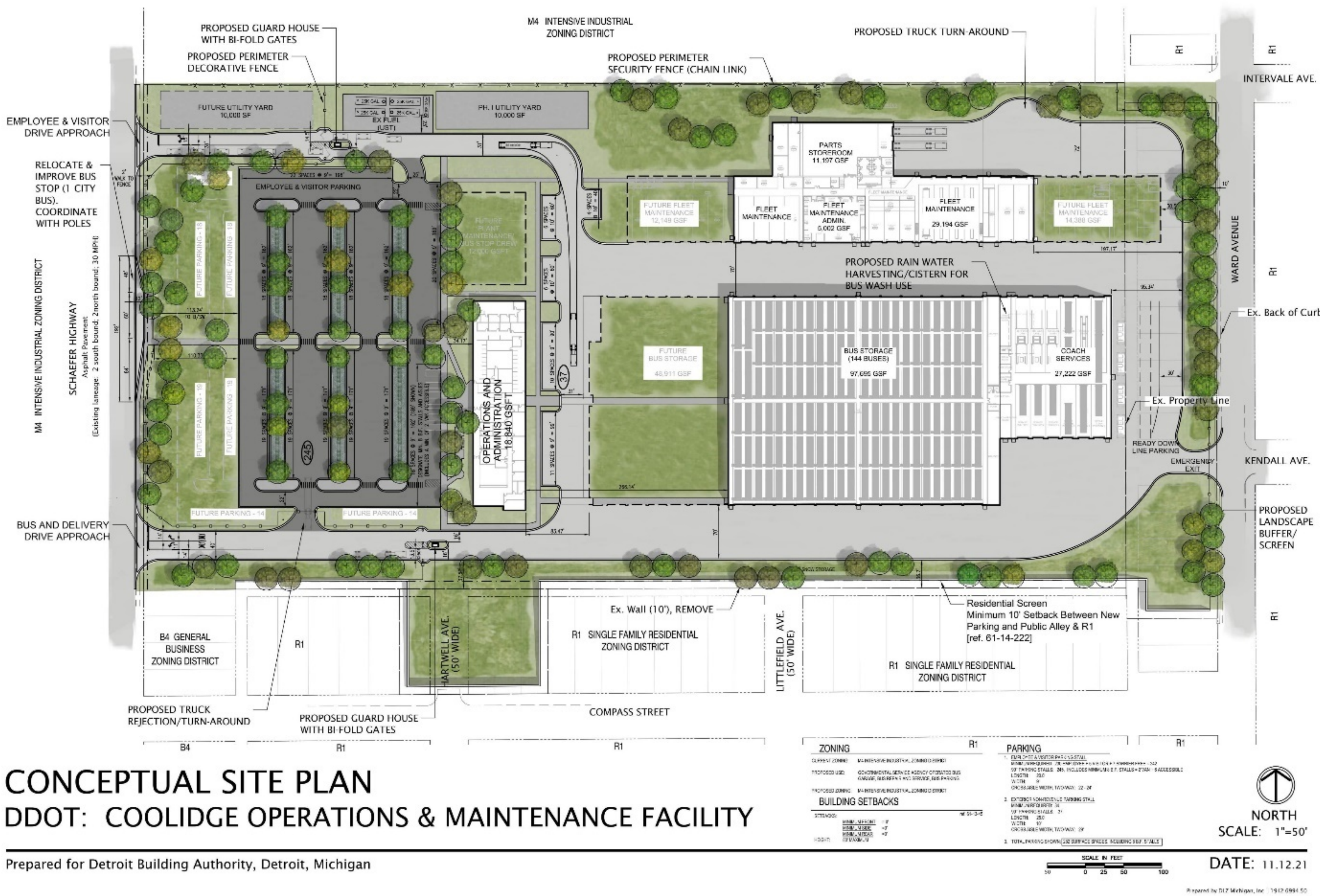
The Coolidge Terminal Replacement Project (the Project) includes construction of three new buildings:

- Bus Storage and Coach Services Building, including bus washing and temporary bus storage bays and expandable in the future
- Fleet Maintenance with Parts Storeroom, expandable in the future
- Operations & Administration

Additionally, the Project includes:

- Bus circulation within the site
- 245-space employee/visitor surface parking lot, expandable in the future
- Utility Yard
- Stormwater management, landscaping, perimeter visual barriers
- Space for future plant maintenance/bus stop crew, bus stop maintenance yard
- Ancillary services for non-revenue and coach tires (supply, repair, recap, scrap).

Figure 1: Conceptual Site Plan



2.0 Regulatory Context

HDR prepared the noise and vibration analyses for this Project in accordance with FTA's noise and vibration guidance manual, *Transit Noise and Vibration Impact Assessment* (FTA 2018). 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.

2.1 Noise

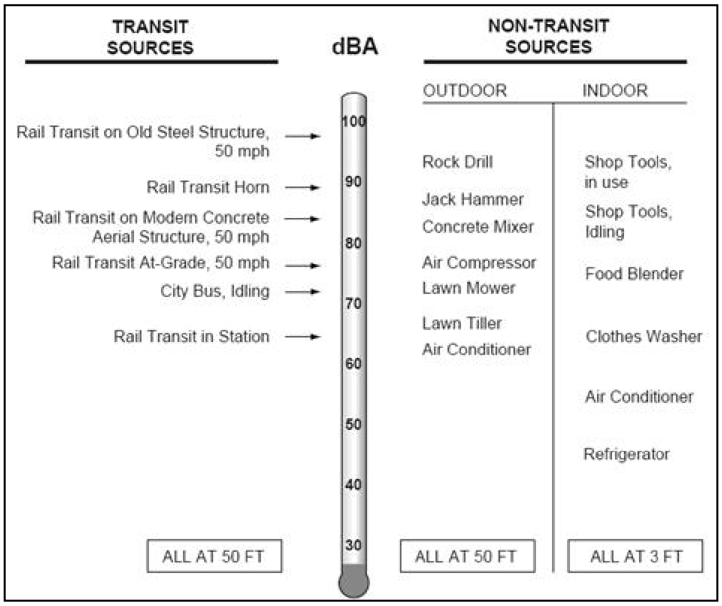
Noise is typically defined as unwanted or excessive sound. Sound becomes unwanted when it interferes with normal activities such as sleep, speech, or recreation. Sound is what we hear when fluctuations in air pressure occur above and below the standard atmospheric pressure. Three variables define characteristics 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 2.

Figure 2: Typical Noise Levels



Source: FTA 2018.

As stated in the FTA guidance manual (FTA 2018), 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.

2.2 FTA Transit Noise Criteria

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 receiver 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 **Error! Reference source not found.**.

Table 1: Noise Land Use Categories

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

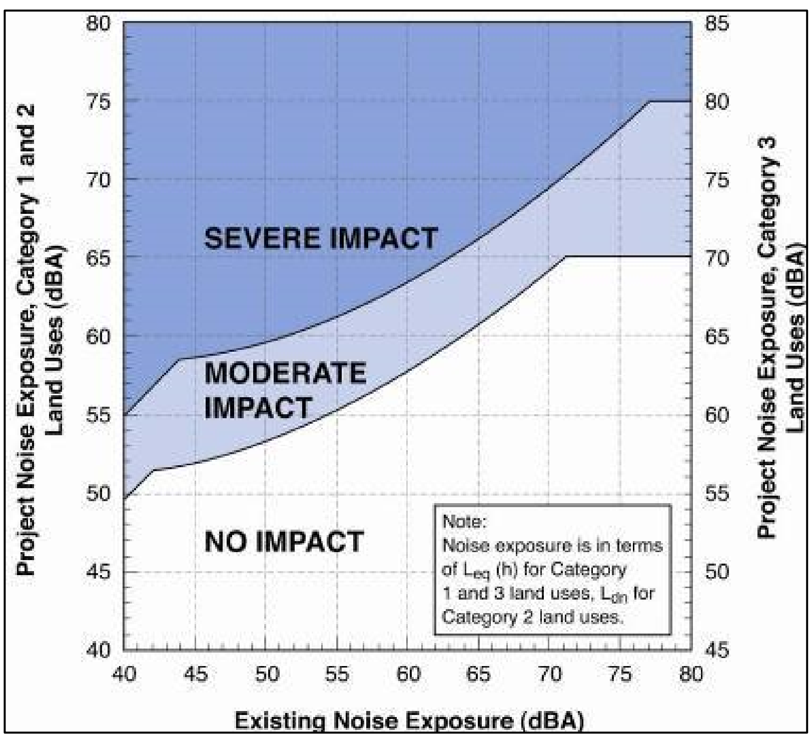
Source: FTA 2018Notes: Outdoor $L_{eq(h)}$ uses the noisiest hour of transit-related activity during hours of noise sensitivity [a] 1-hour L_{eq}

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 3. 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 3: FTA Noise Impact Criteria



Source: FTA 2018.

2.3 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 3 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 Criteria

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

Source: FTA 2018.
Note: Noise limit is the combined $L_{eq(h)}$ of the two noisiest pieces of construction equipment during 1 hour.

2.4 Vibration

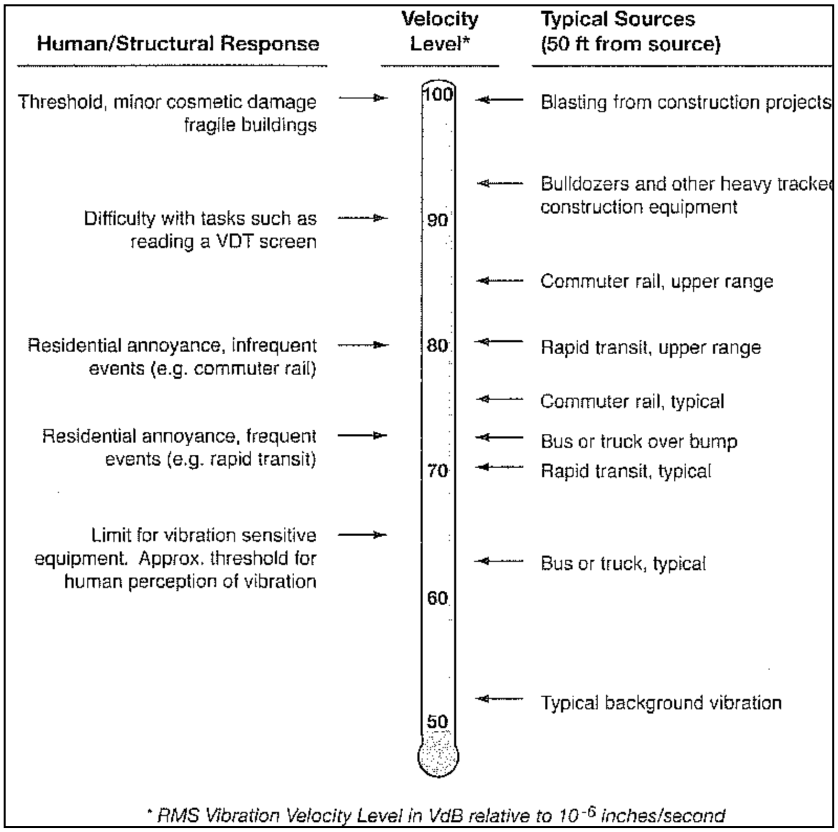
Ground-borne vibration (GBV) consists of rapidly fluctuating motions of the ground transmitted into a receiver (building) from a vibration source, such as transit trains. FTA uses vibration velocity to describe vibration levels for transit projects.

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 4 illustrates common vibration sources and associated human and structural responses to GBV.

Figure 4: Typical Vibration Levels



Source: FTA 2018.

2.5 FTA Transit Vibration Criteria

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 approximately 116 bus 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

Land Use Category	Frequent Events[a]	Occasional Events[b]	Infrequent Events[c]
	GBV impact level (VdB re 1 micro-inch/second)		
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 2018.

[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.

2.6 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 2018.
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

HDR performed FTA's noise screening assessment and general noise assessment, which consist of the following general steps:

- Establish the Project Area and identify noise-sensitive receivers
- Perform Noise Screening Assessment
- If there are noise-sensitive receivers within the screening distances, proceed to the Noise General Assessment.
- Evaluate the existing conditions and establish corresponding noise impact thresholds
- Calculate project-related noise levels
- Identify receivers anticipated to experience moderate or severe noise impacts under the Build Alternative.
- Evaluate noise mitigation measures per FTA guidelines

3.1 Noise Screening Assessment Methodology

The purpose of the noise screening assessment is to determine if there are noise-sensitive land uses located close enough to a proposed Project to require an additional assessment to evaluate the potential for noise impacts. Using the FTA Manual, the project type is selected and the corresponding screening distance for unobstructed line of sight or the presence of intervening buildings is applied. This assessment used the Bus Storage and Maintenance project type and applied both the intervening and unobstructed screening distances of 125 feet and 350 feet, respectively. Since the Project related noise activities will take place primarily indoors the origin of the screening distances was applied to the center of the Project Area.

Receivers that are potentially influenced by the noise from the proposed Project are those that are described in land use categories 1, 2, or 3, as shown in Table 1. Noise sensitive receivers were identified by reviewing a combination of available land use-related GIS data; available digital aerial photographs; and other area photography, including publicly available internet imagery. Receivers in the Project Area were identified and categorized for noise sensitivity based on the descriptions in Table 1 above.

3.2 Vibration-Screening Assessment

FTA guidance (FTA, 2018) includes a vibration screening procedure for projects that propose to use rubber-tired vehicles, as follows. For projects that involve rubber-tire vehicles and do not meet the following conditions, vibration impact is unlikely, and no further analysis is needed.

- Roadway irregularity – Expansion joints, speed bumps, or other design features that result in unevenness in the road surface can result in perceptible ground-borne vibration at distances up to 75 feet away.

The Project proposes to construct and operate a bus maintenance facility. Bus speeds on-site will be 5-10 mph, and there will be no pavement irregularities. The proposed project does not meet this criterion.

- Operation close to vibration-sensitive buildings – Buses, trucks, or other heavy vehicles operating close to a vibration-sensitive building (within approximately 100 feet from the property line) may impact vibration-sensitive activities, such as research that uses electron microscopes or manufacturing of computer chips.

Parcels whose activities could be interrupted by ground-borne vibration do not exist within 100 feet of the proposed Project site. Furthermore, vibration from bus movements are not a concern due to low operating speeds and pneumatic tires and suspension systems. The proposed project does not meet this criterion.

- Vehicles operating within buildings – Special considerations are often required for shared use facilities where vehicles operate inside or directly underneath buildings such bus stations located inside an office building complex.

The proposed Project does not include vibration-sensitive operations inside or directly above project-related indoor activities. Therefore, the Project does not meet this criterion.

The proposed project does not meet the three conditions described above, therefore FTA considers vibration impact unlikely and no further vibration assessment is necessary.

4.0 Existing Conditions

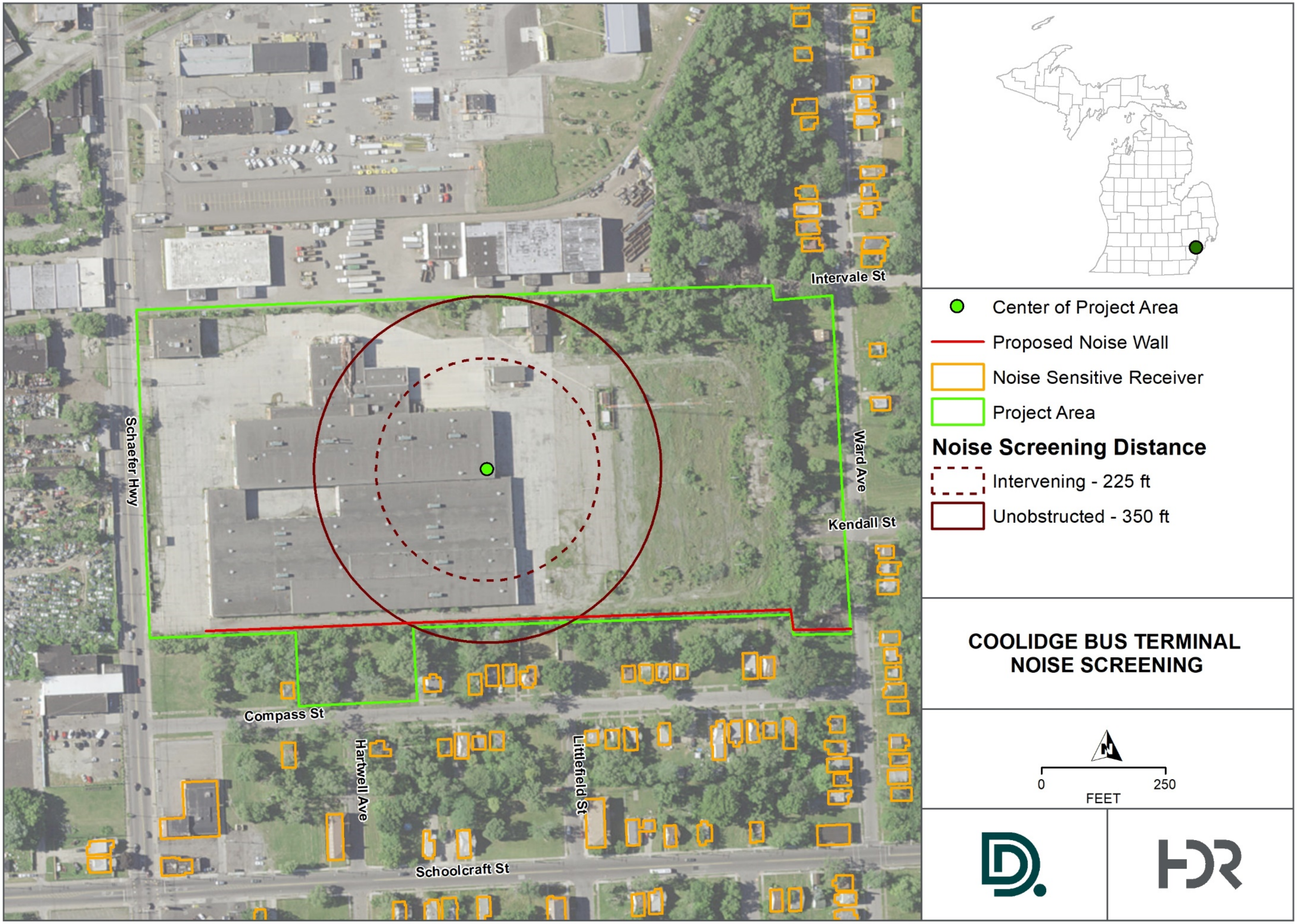
There were no noise-sensitive receivers identified within the noise screening distances. Figure 5 shows the screening distances and nearest sensitive receivers.

5.0 Impacts

5.1 Noise Impacts

There are no noise-sensitive receivers within the screening distances, therefore project-related noise would not cause noise impacts as defined by FTA.

Figure 5: Noise Screening



SERVICE LAYER CREDITS: SOURCE: ESRI, USDA FSA

5.2 Construction Impacts

The construction noise and vibration assessments used the center of the project site as the origin for construction noise and vibration calculations. Construction noise was assessed according to Section 7 of the FTA Transit Noise and Vibration Impact Assessment Manual. A quantitative construction assessment was used to estimate construction noise because construction is expected to be longer than a month, and noisy equipment may be used. For projects in the early assessment stage when construction equipment and schedule are undefined, FTA recommends the general assessment option should be used to evaluate construction noise.

Construction equipment most likely to be used during the proposed project was selected for each of the two phases of site development (demolition and construction) based on assumptions made about the existing conditions on-site and the proposed plan. The following scenarios were assessed:

- Demolition: A jackhammer and bulldozer would be the two loudest pieces of equipment used to break up existing concrete and asphalt.
- Construction: An impact pile driver and a generator would be the two loudest pieces of equipment.

Noise levels for each piece of equipment were calculated using Equation 7-1 from the FTA Manual. Individual equipment noise levels were calculated in A-weighted decibels (dBA) for the two loudest pieces of equipment to be used during each proposed project phase. Noise levels were propagated from the center of the proposed project site towards the nearest receptors.

The nearest receiver has a residential land use and is approximately 395 feet from the center of the project site.

This set of calculations represents the anticipated average noise levels due to the construction equipment being mobile and presumed to operate anywhere within the proposed project site at a given time. Noise levels of combined equipment were then calculated for each phase using decibel addition for comparison to general assessment construction noise criteria from Table 7-2 in the FTA Manual. Results of the construction noise assessment, including FTA general assessment construction noise criteria, are presented in Table 5 below.

Table 5: Quantitative Construction Noise Assessment

Distance	Land Use	Phase	Equipment	Result (dBA)	General Assessment Construction Noise Criteria (dBA)
395 ft. (from center of site)	Residential	Demolition	Jackhammer and bulldozer	72	Residential: Day = 90; Night = 80
		Construction	Impact pile-driver and generator	83	

Source: HDR 2022

The resulting noise for the residential receptor was 72 dBA and 83 dBA for the demolition phase and construction phase, respectively. Construction noise levels are projected to be below the applicable residential land use criterion of 90 dBA for daytime.

Therefore, significant adverse impacts from construction noise are not anticipated at the residential receptor. However, a more detailed assessment of construction noise may be warranted if there are significant changes to the construction equipment, if noise sources are operated for prolonged periods close to receptors, or if construction activities occur during nighttime hours. Construction activities would be conducted in accordance with City, State, and Federal guidelines, and would use best practices to limit noise, such as limiting construction activities to normal daytime working hours, limiting idling equipment, and additional preventative actions as the construction plan is finalized.

Vibration

Construction equipment vibration source levels are assessed in terms of peak particle velocity (PPV in/sec) and vibration velocity level (LV; measured in vibration decibels (VdB), which are compared to FTA criteria for building damage and annoyance, respectively. Per the FTA Manual, construction vibration is assessed for each piece of equipment individually using Equation 7-2 for PPV and Equation 7-3 for LV. The following scenarios were assessed based on the same assumptions made in the construction noise assessment:

- Demolition: Loaded trucks would be the largest vibrational source.
- Construction: An impact pile driver would be the largest vibrational source.

Similar to the general assessment method for construction noise, construction-related vibration levels were calculated at the nearest residential receiver. This set of calculations represents the anticipated average vibration levels due to the construction equipment being mobile and presumed to operate anywhere within the proposed project site at a given time.

A second set of calculations was utilized to represent the maximum vibration levels that may be experienced by sensitive receptors near the proposed project site when vibration sources are operating at the closest proposed project site boundary. The residential receiver is approximately 80 feet from the project boundary.

Table 6 presents FTA's construction vibration criteria from Table 7-5 in the FTA Manual, and it outlines construction vibration criteria for a variety of building types. The nearest receiver building appears to be constructed of non-engineered timber and likely contains plaster, and is categorized as a Type III building for the damage assessment.

Table 6: FTA Construction Vibration Criteria

Building/Structural Category	Damage Assessment (PPV, in/sec)	Annoyance Assessment (VdB)
I. Reinforced-concrete, steel, or timber (no plaster)	0.5	102
II. Engineered concrete and masonry (no plaster)	0.3	90
III. Non-engineered timber and masonry buildings	0.2	94
IV. Buildings extremely susceptible to vibration damage	0.12	90

Source: FTA 2018

Table 7 presents the construction vibration assessment results and facilitates a comparison with FTA construction vibration criteria for building response and human response to vibration.

Table 7: Quantitative Construction Vibration Assessment Results

Distance	Land Use	Phase	Equipment	Damage Assessment (PPV, in/sec)	Annoyance Assessment (VdB)	Building/ Structural Category	FTA Damage Assessment Criteria (PPV, in/sec)	FTA Annoyance Assessment Criteria
395 ft. (from center of site)	Residential	Demolition	Loaded trucks	0	50	III. Non-engineered timber and masonry buildings	0.2	94
		Construction	Impact pile driver (upper range)	<0.1	76			
			Impact pile driver (typical)	<0.1	68			
80 ft. (from project boundary)	Residential	Demolition	Loaded trucks	<0.1	71	III. Non-engineered timber and masonry buildings	0.2	94
		Construction	Impact pile driver (upper range)	0.3	97			
			Impact pile driver (typical)	0.1	89			

Source: HDR 2022

Comparison of the calculated PPV values to FTA damage assessment criteria values indicates that, on average, when the equipment is operating near the center of the proposed project site, construction vibration from an impact pile driver operating in its upper range would not pose a risk of damage to non-engineered timber and masonry buildings that may have plaster walls. Additionally, PPV values calculated using the minimum distance of 80 feet indicate that impact pile drivers at operating in the upper range pose a risk of damage to non-engineered timber and masonry buildings when operated in close proximity to proposed Project Area boundaries.

Comparison of the calculated VdB values to FTA annoyance assessment criteria values indicates that when equipment is operating near the center of the proposed project site, construction vibration would not pose a risk of annoyance to people living in the nearest residence. Additionally, operation of an impact pile driver at its upper range at the proposed project site boundaries would result in increased annoyance to the residential receptor 80 feet away. However, it is unlikely that an impact pile driver would be operated near the project boundary, based on the concept design in Figure 1.

6.0 Measures to Avoid or Minimize Harm

The need to mitigate Project operational noise and vibration is not necessary since there are no noise impacts, and because ground-borne vibration is not a concern with busses on-site. This analysis assumes that the majority of project-related noise would occur indoors. Construction noise levels are projected to be below the FTA's recommended construction noise criterion. A detailed assessment of construction noise may be warranted if there are significant changes to the construction equipment roster or if noise sources are operated for prolonged periods close to receptor buildings.

If impact pile drivers are operated at their upper ranges near the project boundaries, potential construction vibration levels could approach or exceed FTA construction vibration criteria posing a risk of damage to non-engineered timber and masonry.

At a minimum, DDOT will implement the following mitigation measures to minimize the vibration impacts during construction:

- DDOT will include noise and vibration performance specifications in construction contract documents that are consistent with City of Detroit ordinances.
- Construction contractors would be required to develop a construction noise and vibration management plan. This may be a singular plan or it may be included in a larger environmental management plan for the construction project. At a minimum, the plan would include the following:
    - Identification of the proposed Project's noise and vibration control objectives and potential components;
    - Summary of noise and vibration-related criteria and local ordinances for construction contractors to abide by;
    - Requirement of a pre-construction survey to identify receptors potentially affected by construction noise and vibration and documentation of the pre-construction conditions of particularly susceptible receptors;

- List of potential mitigation measures, a plan to implement mitigation, and an approach for deciding the appropriateness of mitigation by construction activity and receptor;
- Identification of methods to minimize noise impacts on adjacent noise-sensitive stakeholders while maintaining construction progress; and
- Plans for coordination with affected project stakeholders to minimize intrusive construction effects;
- Process to handle and resolve any noise or vibration-related complaints.

7.0 References

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