APPENDIX D

Updated Noise and Vibration Technical Report

Note: This Technical Report has been updated to account for construction of the California High-Speed Rail column.

Div. 20 Portal Widening/Turnback Facility
Noise and Vibration Technical Report
Draft September 17, 2018

Prepared by:
ATS Consulting

EXECUTIVE SUMMARY

A noise and vibration analysis was conducted as part of an Environmental Impact Report for the Div. 20 Portal Widening/Turnback Facility Project in Los Angeles, California. For the Project, Metro is proposing to widen the portal for the Metro Red/Purple Line in and adjacent to the Metro Red/Purple Line Maintenance Yard (Division 20 or Santa Fe Yard) near the Los Angeles River, provide for a turnback facility, and increase storage capacity in the yard. The Division 20 rail yard, also identified as the Metro Red Line/Santa Fe Yards, is an approximately forty-five (45) acre site and is home to the Metro Red/Purple Line train storage and maintenance facilities. It is located primarily between the 1st and 6th Street bridges, running parallel to the Los Angeles River Channel and east of Santa Fe Avenue.

There are three main noise- and vibration-sensitive receivers in the project area: the One Santa Fe (OSF) Apartment Complex, the Southern California Institute of Architecture (SCI-Arc), and Willow Studios (film). The existing noise levels at the receivers are 65-69 dBA (Ldn/CNEL) for OSF, 70 dBA (Leq) for SCI-Arc, and 76 dBA (Leq) for Willow Studios (note that a metric that includes nighttime hours applies to the residential receiver, and one that is primarily for daytime use applies to the other receivers).

Predictions for operational and construction noise and vibration were made by applying FTA methodology (FTA 2006), and impacts were determined by applying FTA limits and state/local regulations, all as part of the California Environmental Quality Act (CEQA) analysis. A summary of the operational noise and vibration impact and mitigation assessments follow, along with a summary of the construction noise and vibration analysis.

SUMMARY OF NOISE IMPACTS

Noise predictions were made applying the FTA detailed analysis method. Noise was predicted for all relevant sources in the vicinity of the sensitive receivers. The sources include new ones associated with the project and existing noise sources that will remain and contribute to the future noise environment. Together, these include: rapid transit train noise from the storage, yard, and turnback track types (with horn use); non-Metro commuter rail train noise (with horn use); additional noise from special trackwork and wheel squeal; a TPSS unit; PA system; Maintenance Facility noise, including the HVAC system on the roof; platform car wash; storage area light maintenance; road traffic noise; and aircraft noise. The noise sources associated with the project are: a new storage yard adjacent to OSF, storage area light maintenance, new yard tracks, new turnback tracks, increased operations on yard tracks entering the Maintenance Facility, and a new TPSS unit (to replace the existing unit). These plus the other (existing) noise sources contribute to the total noise, and all were included to evaluate an increase in noise under CEQA.

Following is a summary of the noise impact assessment of the proposed project:

- For Category 2 land uses, there are two moderate impacts and three severe impacts according to FTA thresholds. The impacts represent most sections of the One Santa Fe Apartments. The severe impacts are in sections of the buildings near tracks with curvature and special trackwork; this includes the northern two sections of the north building (IDs R-1 and R-2) and the north section of the south building (ID R-5). The moderate impacts are in the southern two sections of the south building (IDs R-6 and R-7). Only FTA severe impacts are considered impacts under CEQA.

  Assuming a building noise reduction of 30 dB as described in Section 3.2.6, with windows and doors closed, none of these sensitive receivers would be impacted, since the predicted interior noise levels are less than 45 dBA CNEL, the Los Angeles Building Code requirements.

- For Category 3 land uses, there is one moderate impact predicted. The impact represents the outdoor common use barbeque area of the One Santa Fe Apartments (ID R-A). This is not considered an impact under CEQA.
- There are no impacts predicted for the One Santa Fe Apartments pool/spa area (ID R-B), Southern California Institute of Architecture (ARC-Sci, IDs R-C, R-D, and R-E), and Willow Studios (ID R-F).

Table ES-1summarizes predicted noise limit exceedances and mitigation recommendations for each potentially impacted sensitive receiver applying the FTA limits. Predicted impact exceedance is shown as the amount above a severe impact level and moderate impact level. Also shown in the table are the primary causes of the impact.

For the northern building of the One Santa Fe Apartments, the sections of the building potentially impacted under CEQA are R-1 and R-2. The primary causes of the impact are wheel squeal and noise from wheels crossing over gaps in standard frogs for the yard tracks leading into the storage yard adjacent to the apartments and those passing under the bridge heading toward the Maintenance Facility. Although lubrication applied to the track would help to address wheel squeal, this mitigation option is not feasible for this project. The recommended mitigation is to install low-impact frogs in the OSF-adjacent storage yard and in any yard tracks within a 200-foot radius of the northern portion of the northern building (R-1). Using low-impact frogs would remove the northern building impacts. The type of low-impact frogs typically used in yards are flange-bearing frogs, monoblock frogs, or conformal top rail bound manganese (RBM) frogs; refer to Appendix D for more information. For these receivers, a separate analysis showed no impact from TPSS noise per LA Metro design criteria.

For the southern building of the One Santa Fe Apartments, one section of the building is potentially impacted under CEQA: R-5. The primary causes of the impact are wheel squeal and noise from wheels crossing over gaps in standard frogs for the yard tracks leading into the Maintenance Facility. Although lubrication applied to the track would help to address wheel squeal, this mitigation option is not feasible for this project. The recommended mitigation is to install low-impact frogs in the existing yard tracks that lead to the Maintenance Facility and in new yard tracks within a 200-foot radius of the northern portion of the southern building (R-5). Using low-impact frogs (including replacing existing ones) would result in no impacts. The type of low-impact frogs typically used in yards are flange-bearing frogs, monoblock frogs, or conformal top rail bound manganese (RBM) frogs; refer to Appendix D for more information.

For all predictions and mitigation recommendations, it is assumed that the track and wheels would be maintained in a state of good repair (that is, rail corrugations and wheel flats would be minimized through maintenance procedures—rail grinding and wheel truing).

If it can be verified that a building noise reduction of at least 30 dB applies to the One Santa Fe Apartments, mitigation would not be required for R-1, R-2, and R-5, based on an interior noise limit of 45 dBA CNEL. Assuming no impacts for the interior, noise for the exterior apartment balconies was analyzed. It was determined that there could be potential noise impacts for these spaces without mitigation. However, the low-impact frogs installed as recommended for R-1, R-2, and R-5 would mitigate these impacts. As an alternative to low-impact frogs, transparent noise barriers could be placed on the affected apartment balconies to reduce the noise below impact level.

Table ES-1: Summary of Recommended Noise Mitigation

ID[a]	Desc.[b]	Sensitive Receiver Location	Impact Exceedance[c] (dB)	Impact Exceedance[c] Primary Causes	Recommended Mitigation
R-1	MF	One Santa Fe (north bldg - north end)	0.7 sev 2.6 mod	Wheel squeal; standard frog impacts[d]	Low-impact frogs
R-2	MF	One Santa Fe (north bldg - mid)	0.7 sev 2.6 mod	Wheel squeal; standard frog impacts[d]	Low-impact frogs
R-5	MF	One Santa Fe (south bldg - north end)	0.4 sev 2.7 mod	Wheel squeal; standard frog impacts[e]	Low-impact frogs

[a] ID identifies sensitive receivers as shown Table C-1 in Appendix C. Refer to Table C-1 in Appendix C for indications of special trackwork for each receiver; the special trackwork increases noise levels.
[b] MF = multifamily, REC = recreational.
[c] Exceedances are shown as the value above the FTA severe and moderate limits.
[d] Yard tracks leading into the storage yard adjacent to OSF Apartments and other yard tracks in the vicinity (within 200 feet of R-1).
[e] Yard tracks leading into the Maintenance Facility, including existing and new track within 200 feet of (R-5).

SUMMARY OF VIBRATION IMPACTS

Vibration predictions were made applying the FTA general analysis method. Groundborne vibration and noise were predicted for all relevant sources in the vicinity of the sensitive receivers. This sources rapid transit train noise from the storage, yard, and turnback track types and additional vibration from special trackwork.

Following is a summary of the noise impact assessment of the proposed project. No groundborne vibration or noise impacts are predicted using FTA methods/limits at any sensitive receivers.

SUMMARY OF CONSTRUCTION NOISE AND VIBRATION

Construction Noise

Construction noise levels were predicted using FTA methods and the FHWA Roadway Construction Noise Model (RCNM) for the types of equipment likely to be used during demolition of existing structures/pavement and track construction operations. The use of heavy equipment during project construction has the potential to result in substantial, yet temporary, increases in local noise levels.

Applying FTA limits, the only sensitive receiver potentially impacted by construction noise is the One Santa Fe Apartments. Results show that the proximity of the One Santa Fe Apartment complex to the adjacent building and pavement demolition, as well as construction of the storage tracks can potentially cause large exceedances of the FTA general assessment limits. Since the apartments are elevated above the demolition and construction activities, typical mitigation measures such as noise barriers/blankets would not provide adequate noise reduction. To minimize the construction noise, practices outlined below should be implemented, where applicable.

- Avoid nighttime construction when possible.

- Use specialty equipment with enclosed engines and/or high-performance mufflers.
- Locate equipment and staging areas as far from noise-sensitive receivers as possible.
- Limit unnecessary idling of equipment.
- Reroute construction-related truck traffic away from local residential streets and/or sensitive receivers.

When the noise will be loudest and most intrusive (based on equipment use and limits), unconventional measures may be appropriate, such as temporarily relocating residents to a hotel (if overnight work is necessary). A Noise Control Plan and Noise Monitoring Plan must be submitted to LA Metro; the Plans will identify times of peak noise generation. Specific mitigation measures should be developed by the construction contractor as part of the Noise Control Plan per Metro technical requirement 01 56 19 — Construction Noise and Vibration Control.

The LA Municipal Code restricts construction activities to the following hours: 7 am – 9 pm weekdays and 8 am – 6 pm weekends. A variance needs to be granted by the Executive Director of the Board of Police Commissioners to operate outside these hours, and consideration of LA Metro nighttime limits is necessary.

Construction Vibration

Construction vibration levels were predicted using FTA methods for the types of equipment likely to be used during demolition of existing structures/pavement and track construction operations. The use of heavy equipment during project construction has the potential to result in substantial, yet temporary, increases in local vibration levels.

The primary concern regarding construction vibration is potential damage to structures. The thresholds for potential damage are much higher than the thresholds for evaluating potential annoyance used to assess impact from operational vibration.

Applying FTA vibration limits, the only sensitive receiver potentially impacted by construction vibration is the One Santa Fe Apartments. The results predict that the contractor would exceed the impact threshold when operating very close to the receiver, as is the case near the One Santa Fe apartment complex during the building and concrete demolition operations. In the event that vibration-generating equipment must be used for a sustained period of time, the Noise Control Plan should include measures to minimize potential vibration impacts during construction. These measures/strategies could include:

- **Preconstruction Survey**: The survey should include inspecting building foundations and taking photographs of preexisting conditions. The survey can be limited to buildings within 25 feet of high-vibration-generating construction activities. The only exception is if an important and potentially fragile historic resource is located within approximately 200 feet of construction, in which case it should be included in the survey. For this project, the only known building that may fall into that category is the Citizens Warehouse/Lysle Storage Company building.
- **Vibration Limits**: The FTA Guidance Manual suggests vibration limits in terms of peak particle velocity, ranging from 0.12 inches/second for “buildings extremely susceptible to vibration damage” to 0.5 inches/second for “Reinforced-concrete, steel or timber” buildings. The contract specifications should limit construction vibration to a maximum of 0.2 inches/second for all buildings in the corridor.
- **Vibration Monitoring**: The contractor should be required to monitor vibration at any building where vibratory rollers or similar high-vibration-generating equipment would be operated within 25 feet of buildings and at any location where complaints about vibration are received from building occupants.

- **Alternative Construction Procedures**: If high-vibration construction activities must be performed close to structures, it may be necessary for the contractor to use an alternative procedure that produces lower vibration levels. Examples of high-vibration construction activities include the use of vibratory compaction or hoe rams next to sensitive buildings. Alternative procedures include use of non-vibratory compaction in limited areas and a concrete saw in place of a hoe ram to break up pavement. Refer to Section 7.4 for vibration levels by equipment type and distance and applicable thresholds to include in the Noise Control Plan.

Limiting use time for rollers and compactors during the construction operations would remove the vibration impacts for all operations occurring at least 45 feet from the nearest receiver. When construction or demolition operations must occur very close to the receiver, other less conventional techniques could be employed to avoid annoyance due to vibration. Residents could be temporarily relocated to a hotel during construction times when the vibration will be the greatest and most intrusive.

CEQA SUMMARY

For operations, there are potentially significant noise impacts predicted at the OSF Apartments. With recommended mitigation applied, the impacts become less-than-significant. There are no impacts for vibration.

For construction, there is a potentially significant noise impact in relation to a temporary increase in ambient noise. There are also potentially significant impacts in relation to excessive noise and vibration. To minimize these, recommendations to minimize the construction noise and vibration should be implemented.

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1.0 INTRODUCTION

This *Noise and Vibration Technical Report* has been prepared to support the Environmental Impact Report (EIR) for the Div. 20 Portal Widening/Turnback Facility Project in Los Angeles, California. It presents the methodology and assumptions that were used to assess the potential environmental impacts from noise and vibration generated by the operations and construction at the facility, which supports the Metro Red and Purple Rail Transit Lines. The proposed project consists of adding storage yards and adding/modifying yard tracks and turnback tracks. The report separates the impact evaluation of operations and construction, where impacts, consequences, and mitigation are discussed for each. The analysis for operations is described in multiple sections, followed by the construction analysis as the final technical section.

This report was made in compliance of the California Environmental Quality Act (CEQA) using the Federal Transit Administration's (FTA) guidance manual Transit Noise and Vibration Impact Assessment (FTA 2006).

In addition to the main text that addresses the regulatory framework, noise and vibration prediction methodologies, the affected environment, potential noise and vibration impacts, consequences, and mitigation for operations and construction, the document includes the following appendices:

- Appendix A: Fundamentals of Noise and Vibration
- Appendix B: Ambient Noise Measurements
- Appendix C: Sensitive Receiver Inventory
- Appendix D: Mitigation for Switches
- Appendix E: Construction Noise and Vibration Predictions

The remainder of this section discusses the proposed project, including specific project features. In addition, a brief review of potential noise and vibration concerns related to the project is provided.

1.1 PROJECT DESCRIPTION

For the Div. 20 Portal Widening/Turnback Facility Project, Metro is proposing to widen the portal for the Metro Red/Purple Line in and adjacent to the Metro Red/Purple Line Maintenance Yard (Division 20 or Santa Fe Yard) near the Los Angeles River, and provide for a turnback facility. On March 23, 2017, an Initial Study/Mitigated Negative Declaration (IS/MND) was adopted by the Metro Board of Directors, and the preliminary engineering and complete final design contract was awarded. Since then, the design team has been looking at various design refinements, which were a result of Operations' request to revise the configuration to maximize operational flexibility in the operations of the turnback. These refinements will thus require additional environmental analysis. The project aims to address the service and capacity limitations with three core improvements, which include:

- Widening of the heavy rail tunnel south of U.S. Highway 101 (Portal Widening), including construction of a column in the portal area and a new ventilation shaft building;
- Development of a new, surface-level Turnback Facility in the existing Division 20 Rail Yard; and
- Reconfiguration and expansion of the surface-level rail storage tracks.

Specific refinements relevant to the noise and vibration analysis include:

- The demolition of the existing MOW 61A building.

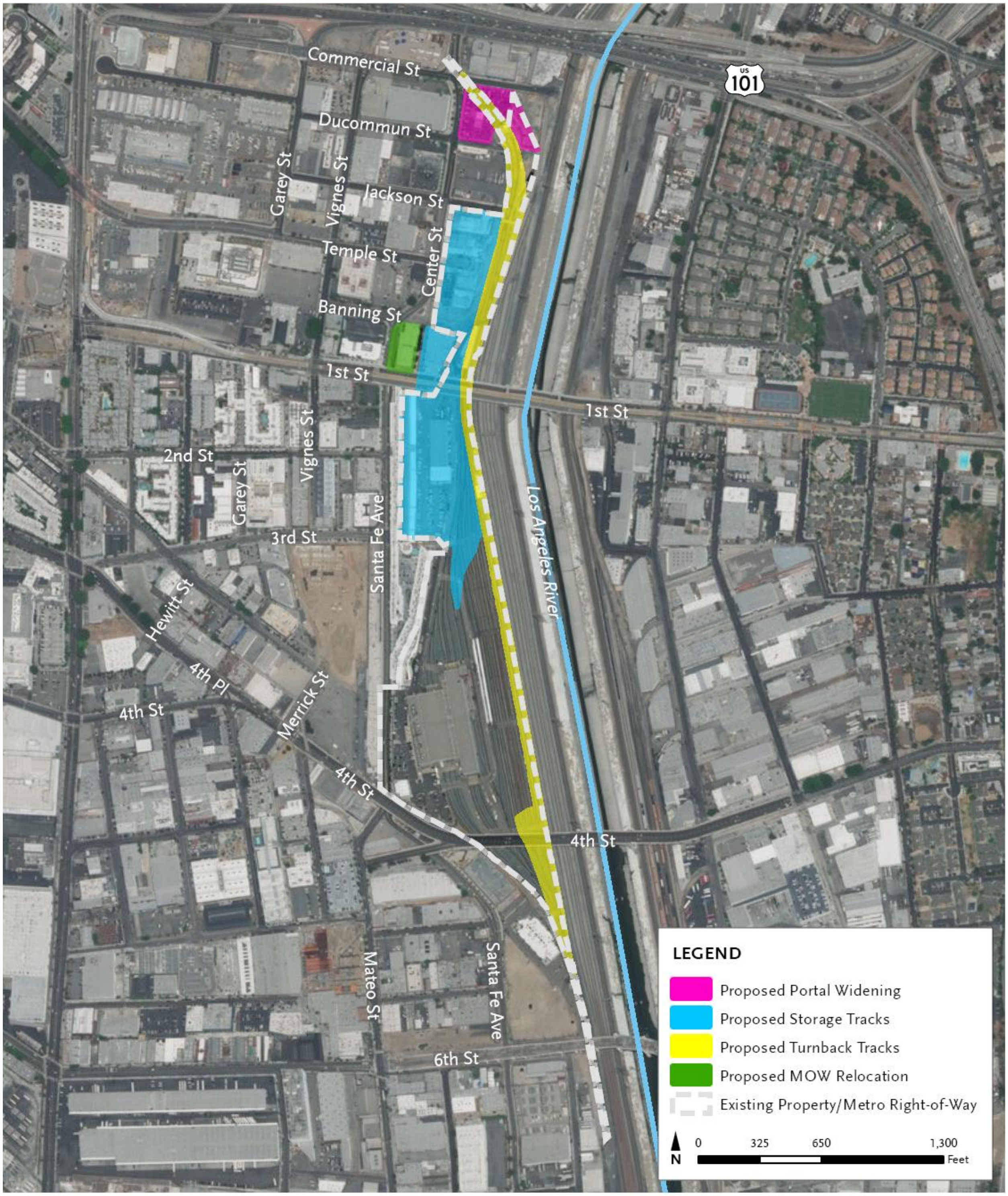
- The reconfiguration of trackwork: the turnback tracks placed on the east side of the yard as opposed to the west which in the previous concept showed terminating adjacent to One Santa Fe with 3 operator relief platforms.
- The removal of the operator relief platforms from the previous conceptual plans.
- Storage tracks in One Santa Fe area where turnback was previously shown in concepts.
- Proposed turnback tracks extending further south to tie-in at the existing tail tracks near 6th St.
- The acquisition of Citizens Warehouse/Lysle Storage Company building (site of former Pickle Works), National Cold Storage, and Duck Factory properties currently located west of the Division 20 rail yard and east of Center St between Jackson St and 1st St to provide additional storage tracks.
- The modification of the First St Bridge. Removal and modification of existing piers and superstructure to allow for more flexibility and access to new storage tracks.
- Internal restructuring of the building at 100-120 North Santa Fe Rd for use as new MOW building.

Figure 1-1 shows the preliminary Project layout concept.

The Division 20 rail yard, also identified as the Metro Red Line/Santa Fe Yards, is an approximately forty-five (45) acre site and is home to the Metro Red/Purple Line train storage and maintenance facilities. It is located primarily between the 1st and 6th Street bridges, running parallel to the Los Angeles River Channel and east of Santa Fe Avenue.

The Metro Red/Purple Line portal is situated between Commercial Street to the north; Ducommun Street to the south; Center Street to the west; and the Los Angeles River Channel to the east.

The General Plan Land Use designation is cited in the City’s zoning database (www.zimas.lacity.org) as Heavy/Light Manufacturing, as well as being identified as a transit priority area.



NOTE: Exact location of storage tracks and turnback tracks to be determined.

Source: Terry A. Hayes Associates Inc., 2018.

Figure 1-1: Project Area

1.2 NOISE CONCERNS ASSOCIATED WITH THE RAIL YARD

The following list summarizes most of the major noise sources associated with the future rail yard with improvements:

Rail Operations: This is the normal noise from the operation of rail vehicles and includes noise from steel wheels rolling on steel rails (wheel/rail noise) and from propulsion motors, air conditioning and other auxiliary equipment on the vehicles. At the time of this study the maximum operating speed is either 5 mph (storage and yard tracks) or 20 mph (proposed turnback tracks). A key assumption in the noise predictions is that the optimal wheel and rail profiles would be maintained through periodic truing of the wheels and rail grinding.

Audible Warnings: The rail vehicles would be equipped with horns and as audible warning devices. For the Red and Purple Line trains, horns will be used in accordance with current safety practices employed in the yard: the horn is sounded prior to moving, as warning to all around the area. The non-Metro commuter rail lines adjacent to the yard area also sound warning horns.

Special Trackwork: Turnouts and crossovers, where two rails cross, are the primary type of special trackwork on an alignment. This type of special trackwork is sometimes referred to as a *frog*. Standard frogs have gaps, and the train wheels must "jump" across the gap. The wheels striking the ends of the gap increase noise levels. A standard frog can cause noise levels to increase by approximately 10 decibels (dB) at a distance of 35 feet or closer. Low-impact frogs are available that smooth the transition through the gap in the rail and can be used as a mitigation measure where the noise from special trackwork results in a predicted impact. Examples of low-impact frogs include flange-bearing frogs, monoblock frogs, spring-rail frogs and moveable point frogs. More information on frogs can be found in Appendix D.

Wheel Squeal: Wheel squeal is generated when steel-wheel transit vehicles traverse tight radius curves. It is very difficult to predict when and where wheel squeal will occur. A general guideline is that there is the potential for wheel squeal at any curve with a radius that is less than approximately 1000 feet. Common approaches to controlling wheel squeal include (1) applying a friction modifier to the railhead and/or the wheel tread, (2) applying lubricant to the gauge face of the rail or the wheel flange and (3) optimizing the wheel and rail profiles. Using resilient wheels and maintaining the tracks would help control wheel squeal; also, periodically truing wheels would maintain an optimum profile and can help minimize wheel squeal.

Ancillary Equipment: The ancillary equipment associated with the rail yard includes, one existing traction power substation (TPSS) unit, a PA system throughout the yard, activities and HVAC system associated with the Maintenance Facility, and light outdoor car washing and light maintenance. For TPSS units, a general guideline is that locating the TPSS at least 50 feet from the closest residential land use would avoid noise impacts; this has already been implemented for the existing TPSS unit that is in the project area, and no other units are planned.

Construction: All the sources discussed above are associated with the operation of the proposed project. The use of heavy equipment during project construction has the potential to result in substantial but temporary increases in local noise levels along the corridor. Potential construction noise impacts are discussed in Section7.0.

1.3 VIBRATION CONCERNS ASSOCIATED WITH THE RAIL YARD

The following list summarizes the significant vibration sources associated with the rail yard:

Rail Operations: Rail operations create groundborne vibration that can be intrusive to occupants of buildings close to the tracks. This is particularly important for residential land uses that are located within 75 feet of vehicles operating at 30 mph. Note that for this project, the trains within 75 feet are operating at 5 mph. The FTA impact criteria for vibration is based on annoyance, and the predicted levels of rail vibration at all receivers are well below the thresholds used to protect sensitive and fragile historic structures from damage. The potential for vibration from rail operations to be annoying to occupants of historic structures is based on the appropriate vibration impact criteria for the current use of the building. A key assumption in the vibration predictions is that the optimal wheel and rail profiles would be maintained through periodic truing of the wheels and rail grinding.

Special Trackwork: Turnouts and crossovers, where two rails cross, are the primary type of special trackwork on the alignment. This type of special trackwork is sometimes referred to as a *frog*. Standard frogs have gaps, and the train wheels must "jump" across the gap. The wheels striking the ends of the gap increase vibration levels as well as noise levels. The groundborne vibration levels near special trackwork increase by approximately 10 VdB because of wheel impacts at the gaps in the rails. Similar to noise, low-impact frogs can be used as a mitigation measure where the vibration from special trackwork results in a predicted vibration impact. More information on low-impact frogs can be found in Appendix D.

Construction: Construction operations can generate perceptible vibration levels. It is also possible to generate levels that risk damage to susceptible buildings if they are close to the construction activities. Potential construction vibration impacts are discussed in Section 7.0.

2.0 REGULATORY FRAMEWORK

In compliance with the California Environmental Quality Act (CEQA), this noise and vibration impact assessment was performed in accordance with regulations set forth by federal, state, and local entities.

At the federal level, the Federal Transit Administration (FTA) of the United States Department of Transportation (USDOT) regulations apply. Although this project does not require a NEPA analysis, the federal regulations provide reasonable limits. FTA criteria are published in the FTA Guidance Manual called *Transit Noise and Vibration Impact Assessment* (FTA 2006), henceforth referred to as *FTA Guidance Manual*. This is the approach used to discuss noise and vibration environmental analysis, consequences, and abatement in this report.

CEQA requires evaluation of potential effects of proposed government actions on the environment. The acts call for an agency relevant to the project to approve the analysis. The Lead Agency for CEQA is the Metropolitan Transportation Authority (MTA). CEQA is a state act that requires additional questions be answered in evaluating potential noise and vibration impacts. These questions are provided in Appendix G of the 2016 CEQA Statutes and Guidelines (CEQA 2016). To address CEQA questions relating to "local noise elements and noise codes and applicable standards of other agencies," the noise and vibration levels predicted by the FTA model are later compared to transportation-project impact criteria set in the FTA and local guidance. In addition, the LA Metro Rail Design Criteria are applied for a separate TPSS analysis and for construction noise. At the local level, the following regulations apply:

- Los Angeles County Metropolitan Transportation Authority (LA Metro) Rail Design Criteria
- City of Los Angeles General Plan
- City of Los Angeles Municipal Code

The criteria described in this section are for operational noise and vibration. The criteria set forth for construction noise and vibration can be found in Section 7.0. LA Metro Division 01 Specifications (METRO 2012) also apply in describing a construction Noise Control Plan; information on this is also found in Section 7.0.

The sub-sections below state the FTA criteria followed by state and local criteria, first for noise then for vibration.

2.1 FTA NOISE IMPACT CRITERIA

The FTA noise impact criteria are based on the best available research on community response to noise. This research shows that characterizing the overall noise environment using measures of noise exposure provides the best correlation with human annoyance. Noise exposure characterizes noise levels over a period of time.

FTA provides different thresholds for different land uses. Table 2-1 lists the three FTA land-use categories and the applicable noise metric for each category. For Category 2 land uses (residential areas where people sleep), noise exposure is characterized using Ldn. In calculating Ldn, noise generated during nighttime hours is more heavily weighted than daytime noise to reflect residents' greater sensitivity to noise during those hours. For Category 1 and Category 3 land uses (areas with primarily daytime use), noise exposure is characterized using the peak hour Leq, which is a time-averaged sound level over the noisiest hour of transit-related activity. Appendix A provides background information on the Ldn and Leq noise descriptors.

Table 2-1: FTA Land Use Categories and Noise Metrics

Land Use Category	Noise Metric (dBA)	Description of Land Use Category
1	Outdoor Leq(h)[a]	A tract of land where quiet is an essential element of the 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[b]	Residences and buildings in which people 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)[a]	Institutional land uses with primarily daytime and evening use. This category includes schools, libraries 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: Federal Transit Administration (FTA 2006)
[a] Leq for the noisiest hour of transit-related activity during hours of noise sensitivity.
[b] Ldn is a measure that counts for full 24 hours of noise, with penalties for noise at night, which is defined as 10 PM to 7 AM.

The FTA noise impact threshold is a sliding scale based on existing noise exposure and land use of sensitive receivers. The basic concept of the FTA noise impact criteria is that more project noise is allowed in areas where existing noise is higher. However, in areas where existing noise exposure is higher, the allowable increase above the existing noise exposure decreases. For example, in an area with an existing noise level of 55 dBA, the allowable increase in noise level is 3 dBA, resulting in a total future noise level of 58 dBA. For an area with an existing noise level of 60 dBA, the allowable increase in noise level is only 2 dBA, resulting in a total future noise level of 62 dBA.

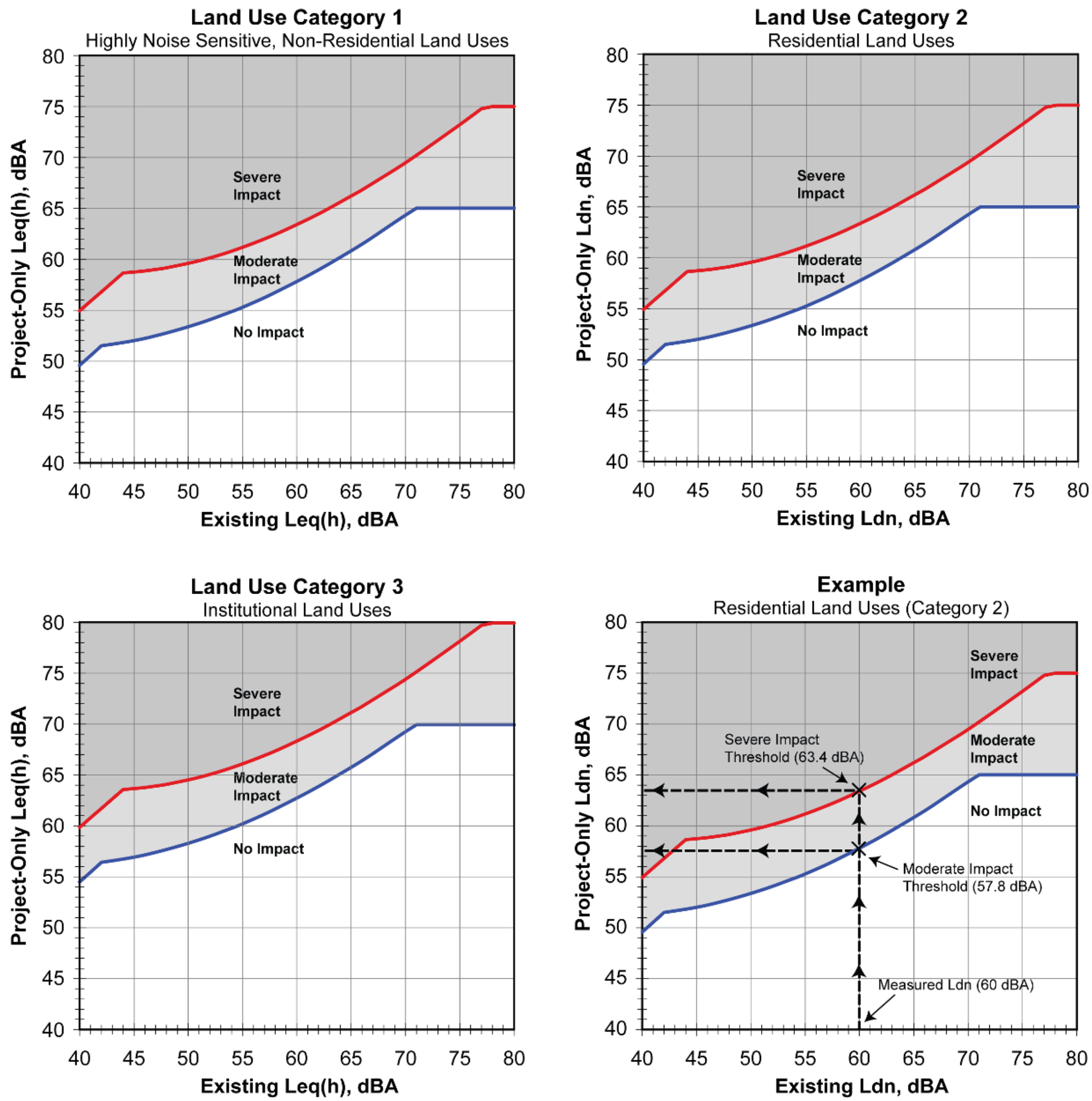
FTA defines two levels of noise impact: moderate and severe. Severe noise impacts are usually considered significant within the context of CEQA. Severe noise impacts require the evaluation of alternative locations/alignments or other mitigation measures to avoid severe impacts altogether. Mitigation measures must be considered and incorporated into the project to avoid severe impacts unless there are truly extenuating circumstances that prevent it. Moderate noise impacts are not necessarily significant within the context CEQA, but also require consideration. For this project, moderate impacts are not considered to be significant due to the nature of the project and the existing environment.

The FTA noise impact criteria are shown graphically in Figure 2-1 for the different categories of land use along with an example of how the criteria are applied. The two graphs on the left are for nonresidential land uses where Leq(h) represents the noise exposure metric, and the top right graph is for residential land uses where Ldn represents the noise exposure metric. As shown in Figure 2-1, the impact threshold is a sliding scale and it typically increases with an increase in existing noise exposure. The existing noise appears on the horizontal axis, and the amount of new noise that the project can create is on the vertical axis. The lower curve (blue) defines the threshold for moderate impact and the upper curve (red) defines the threshold for severe impact.

The sample graph located in the bottom right corner of Figure 2-1 may help clarify the concept of a sliding scale for noise impact. Assume that the existing noise has been measured at 60 dBA Ldn. This is the total noise from all existing noise sources over a 24-hour period: traffic, aircraft, lawnmowers, children playing, birds chirping, etc. Starting at 60 dBA on the horizontal axis, follow the vertical line up to where it intersects the moderate and severe impact curves. Then refer to the left axis to see the impact thresholds. An existing noise of 60 dBA Ldn gives thresholds of 57.8 dBA Ldn for moderate impact and 63.4 dBA Ldn for severe impact. Note that the values are measured in tenths of a decibel to avoid confusion from rounding off; in reality, one cannot perceive a tenth of a decibel change in sound level.

Note that the curves in Figure 2-1 are defined in terms of project-only noise (on the vertical axes) and the existing noise (on the horizontal axes). The project-only noise is the noise introduced into the environment by the project; it is not the future noise levels with the project. The project-only noise does not include noise from existing noise sources in the area that won’t change as a result of the project such as automobile traffic and airplanes.

Figure 2-1: FTA Impact Criteria for Noise



Source: Federal Transit Administration (FTA 2006).

2.2 FTA IMPACT CRITERIA FOR GROUNDBORNE VIBRATION AND NOISE

The potential adverse effects of rail transit groundborne vibration include perceptible building vibration, rattle noises, reradiated noise (groundborne noise) and cosmetic or structural damage to buildings. The vibration caused by modern rapid transit rail operations is well below what is considered necessary to damage buildings (for this Project, the operational levels are well below the potential damage limits for even the most fragile type of building, which includes historic structures). Therefore, the criteria for building vibration caused by transit operations are only concerned with potential annoyance of building occupants. Damage limits are only discussed in terms of construction-related vibration in Section 7.0.

The FTA vibration impact criteria are based on the maximum indoor vibration level as a train passes. There are no impact criteria for outdoor spaces such as parks because outdoor groundborne vibration does not provoke the same adverse human reaction as indoor vibration. The FTA Guidance Manual (FTA 2006) provides two sets of criteria: one based on the overall vibration velocity level for use in General Vibration Impact Assessments, and one based on the maximum vibration level in any 1/3 octave band (the band maximum level) for use with a Detailed Vibration Assessment. This study uses the General Vibration Assessment methodology. The intent of a General Vibration Assessment is to provide a relatively simple method of developing overall levels of groundborne vibration and noise that can be compared to acceptability criteria. The assessment method is described in Section 3.0. The vibration criteria are shown in Table 2-2. These criteria assume frequent train events (more than 70 per day). The Category 1 criteria are applied to buildings where vibration would interfere with interior operations (none for this project). The Category 2 criteria are applied to residential land uses (homes, hotels, etc.), where there is nighttime use; this category is similar to the Category 2 land use defined for noise. The Category 3 criteria are applied to institutional land uses (schools, libraries, churches, etc.), where use is primarily during the daytime; this category is similar to the Category 3 land use defined for noise analysis.

Some buildings, such as concert halls, recording studios and theaters, can be very sensitive to vibration. Given the sensitivity of these buildings, they usually warrant special attention during the environmental evaluation of a transit project. Table 2-3 gives the FTA criteria for acceptable levels of groundborne vibration and groundborne noise for various categories of special buildings. These criteria are for limits on the overall vibration or noise levels, not the 1/3 octave band spectra. The listed criteria assume frequent train events (more than 70 per day).

The FTA vibration thresholds do not specifically account for existing vibration. In certain cases, this is examined if potential vibration impacts are predicted. Such is not the case for this project.

Note that historic structures that do not fall into the FTA land use categories are not included in the assessment for vibration impact from rapid transit rail operations. The vibration impact thresholds are based on annoyance, and the primary concern for historic structures is the risk of damage. The recommended limit in the FTA Guidance Manual for buildings extremely susceptible to damage is 90 VdB, which is 18 decibels higher than the limit for Category 2 (residential) land uses. Vibration from rapid transit rail operations will be well below the limit for buildings extremely susceptible to damage.

Table 2-2: FTA Groundborne Noise and Vibration Impact Criteria for General Assessment

Location	Groundborne Vibration Impact Levels (VdB)	Groundborne Noise Impact Levels (dBA)
Category 1	65	N/A
Category 2	72	35
Category 3	75	40

Source: Federal Transit Administration (FTA 2006).

Table 2-3: Groundborne Noise and Vibration Impact Criteria for Special Buildings

Location	Groundborne Vibration Impact Levels (VdB re 1 micro-inch/second)	Groundborne Noise Impact Levels (dBA re 20 micro Pascals)
Concert halls	65	25
TV studios	65	25
Recording studios	65	25
Auditoriums	72	30
Theaters	72	35

Source: Federal Transit Administration (FTA 2006).

Groundborne noise criteria are also listed in Table 2-2 and Table 2-3. Groundborne noise is caused by the vibration of room surfaces radiating sound waves. When audible groundborne noise occurs, it sounds like a low-frequency rumble. When the tracks are above ground, the groundborne noise is usually masked by the normal airborne noise radiated from the rails and it is not necessary to assess impact from groundborne noise. However, for buildings that have no windows facing the rail, or have interior spaces where airborne noise does not penetrate, groundborne noise may be a factor.

It is possible that airborne noise will dominate the noise at a receiver, in which case the FTA limits may be more stringent than is necessary. Therefore, where FTA limits result in groundborne noise impacts, it may be appropriate to compare the predicted groundborne noise levels to either predicted indoor noise levels or to measured existing noise to further assess whether there could be a potential impact. Since FTA limits show no impacts for this project, additional analysis based on airborne noise is not applied.

2.3 STATE NOISE AND VIBRATION IMPACT CRITERIA (CEQA)

While the State of California does not provide specific limits for noise and vibration from transit projects, it does provide the following checklist to evaluate potential noise and vibration impacts in Appendix G of the State CEQA Guidelines:

a) Would the project result in exposure of persons to or generation of noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies?

b) Would the project result in exposure of persons to or generation of excessive ground-borne vibration or ground-borne noise levels?

c) Would the project result in a substantial permanent increase in ambient noise levels in the project vicinity above levels existing without the project?

d) Would the project result in a substantial temporary or periodic increase in ambient noise levels in the project vicinity above levels existing without the project?

e) For a project located within an airport land use plan, or where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project expose people residing or working in the project area to excessive noise levels?

f) For a project within the vicinity of a private airstrip, would the project expose people residing or working in the project area to excessive noise levels?

The checklist requires each question be answered by checking off one of the following columns:

Table 2-4: CEQA Impact Checklist Terminology

Potentially Significant Impact	Less-than-Significant Impact with Mitigation Incorporated	Less-than-Significant Impact	No Impact
❑	❑	❑	❑

The City of Los Angeles 2006 *L.A. CEQA Thresholds Guide* provides guidance on complying with CEQA. Questions (a), (c), and (d) in the checklist are evaluated using the local standards (Los Angeles plans, codes, and requirements) and FTA criteria. Question (b) in the checklist is evaluated using the vibration impact thresholds from the FTA Guidance Manual. It is assumed that any FTA vibration or ground-borne noise impact is a vibration impact for CEQA.

The Portal Widening/Turnback Project is not included in any airport land use plan, so questions (e) and (f) do not apply and would simply be categorized as "No Impact."

To answer the checklist set forth by CEQA, the definition of significant impact must be defined. For this project, a significant impact is identified by applying the FTA severe impact limit. The *L.A. CEQA Thresholds Guide* significance threshold discussing acceptability is not applied. FTA limits are more conservative/strict.

2.4 LOCAL NOISE IMPACT CRITERIA

The following summarizes the finding from a survey of local jurisdiction regulations. County codes do not apply.

The **Los Angeles Metro Design Criteria** (METRODESIGN 2012) incorporates application of the FTA noise and vibration criteria. There are some slight modifications in frequency of events, but for this study, the standard FTA criteria apply. In addition, the Metro design criteria include a separate examination of noise from TPSS units. At sensitive receivers, the noise from TPSS units is limited to 5 dB below ambient noise.

The **City of Los Angeles General Plan** Noise Element discusses rail systems complying with NEPA and CEQA for noise. Vibration is also discussed, and it is assumed that NEPA compliance applies. As such, FTA methods/analysis apply to the city general plan.

The **City of Los Angeles Municipal Code** (Chapter XI Noise Regulation) prohibits unnecessary, excessive, and annoying noise from all sources subject to its police power. This does not apply to train operations. There is, however, as special section on construction noise, which is described in Section 7.0.

3.0 ASSESSMENT METHODOLOGY

3.1 NOISE ASSESSMENT APPROACH

The noise assessment methodology follows the Detailed Noise Assessment guidelines outlined in the FTA Guidance Manual. The detailed assessment for noise includes the following steps:

1. **Identify sensitive receivers**. Noise-sensitive land uses along the corridor are identified using aerial photography and field visits. For this study, the sensitive receiver buildings are divided based on their location relative to various sound sources. The land uses that qualify as noise-sensitive are defined in the FTA Guidance Manual and include spaces where quiet is an important element of their intended uses such as concert halls, residential land uses where people sleep such as houses or hotels, and institutional land uses such as schools or churches. Appendix C details the receiver locations used in the assessment.
2. **Determine existing conditions**. Existing noise levels were measured throughout the project area. FTA noise impact thresholds are a function of the measured existing noise levels.
3. **Apply prediction models**. The noise prediction models in the FTA Guidance Manual use standard formulas to characterize noise from rapid transit rail vehicles. Measurements of noise at the existing the existing rail yard are also incorporated into the prediction model.
4. **Evaluate receivers for predicted impact**. The prediction models are used to estimate future noise for each sensitive receiver. Predictions for each receiver are compared to the applicable FTA impact thresholds to identify potential noise impacts.
5. **Evaluate mitigation options**. Mitigation options are evaluated for all sensitive receivers where the predicted noise levels exceed the applicable threshold.

Noise impacts from construction were also assessed using the procedures in the FTA Guidance Manual and the FHWA Roadway Construction Noise Model (RCNM). The method, which allows predictions of construction operation-specific noise levels, along with noise levels from individual pieces of equipment, is explained further in Section 7.0. Actual construction noise levels would depend on the means and methods decided upon by the contractor, which are not available at this time. The predicted construction noise levels are based on hypothetical scenarios developed from similar projects for the purposes of modeling.

3.2 NOISE PREDICTION MODEL

The existing rail yard in this project includes numerous sources of noise. Some of these noise sources will change as a result of the project. As such, noise predictions for the project include all future noise sources, and predicted noise levels are compared to existing with allowable increase criteria applied. The noise sources include all the project elements: turnback tracks, yard tracks, and storage tracks and associated wheel squeal, use of horns, and light maintenance. They also include other noise sources in the area: TPSS unit, yard PA system, maintenance facility and associated HVAC system, washing platform, traffic on Santa Fe Ave., aircraft flyovers, and non-Metro commuter rail (Metrolink and Amtrak). Each of the noise concerns has a subsection below describing how the noise levels are added to the project noise model. Any noise or vibration from the new MOW building (both for construction and operations) is assumed to be negligible and is not included in the predictions; assumptions are based on the distance from the nearest sensitive receiver to the MOW building, entrances being on the east and west sides, shielding of noise due to the 1st Street bridge, and that there will be only internal construction.

3.2.1 Noise from Train Operations

The noise prediction model follows the noise impact assessment methodology for detailed noise predictions presented in the FTA Guidance Manual and incorporates assumptions on operating conditions specific to the project, including speeds, vehicle type and train frequencies.

For well-maintained rail systems, the wheel-rail noise dominates above 25 mph and the noise from propulsion motors, air conditioning and other auxiliary equipment on the vehicles dominate below 25 mph. The noise predictions for this analysis are based on reference noise levels state in FTA Guidance.

The reference levels used for rapid transit trains for this analysis are:

- Sound Exposure Level (SEL) of a one-car train operating at 50 mph on ballast and tie track at a distance of 50 feet: **82 dBA.** (The approximate Lmax is 80 dBA.)
- Train speed: **5 or 20 mph** (5 mph for yard tracks and storage tracks, 20 mph for turnback tracks).
- Train length: **Six cars for all trains.** A six-car consist has been used as the normal train configuration for all noise modeling.
- Noise amplification from crossover frogs: **+10 dB** at a distance of **35 feet** (adjusted by distance)
- Noise amplification from wheel squeal: **+10 dB** applied to yard tracks for 50% of the trains on project yard tracks and 33% on yard tracks leading to the maintenance facility. The percentages are based on observations, estimated track curvature, and estimated number or trains per track.
- Note that it is assumed that the rails and wheels would be maintained in a state of good repair such that noise from rail corrugations and wheels flats would be minimized, and additional noise for these elements is not included in the predictions.

The reference levels used for non-Metro commuter (Metrolink and Amtrak) trains for this analysis are taken from FTA Guidance. The references levels and other assumptions are:

- Sound Exposure Level (SEL) of a one-car train operating at 50 mph on ballast and tie track at a distance of 50 feet: **82 dBA.** (The approximate Lmax is 80 dBA.)
- Sound Exposure Level (SEL) of one locomotive operating at 50 mph on ballast and tie track at a distance of 50 feet: **92 dBA.** (The approximate Lmax is 88 dBA.)
- Train speed: **55 mph** (depending on section and direction, nominal maximum operational speed can range from 45 to 79 mph; applied 55 mph based on actual operations).
- Train length: **1 locomotive and 7.9 cars for all trains.** This is based on Metrolink assumptions in the Gold Line Extension study.

The reference values were used with formulas included in the FTA Guidance Manual to predict the noise levels at each sensitive receiver. The FTA use a descriptor known as the Sound Exposure Level (SEL), which normalizes the sound of an event to a 1-second duration. The principal formulas are:

Calculation of Ldn and hourly Leq from SEL:

$$Ldn = SEL_{ref} + 10\log(N_{TrainDAY} + N_{TrainNIGHT} \times 10) - 10\log\left({}^{Dist}/_{Dist_{ref}}\right) - 49.4$$

$$Leq(hour) = SEL_{ref} + 10\log(N_{TrainHOUR}) - 10\log\left({}^{Dist}/_{Dist_{ref}}\right) - 35.6$$

where:

SEL_{ref} = SEL reference levels, adjusted for speed applying the following:
speed ≥ 25 mph, +20 log (speed/50 mph)
speed < 25 mph, +2 log (speed/50 mph); corrections are first made to 25

		mph, then from 25 down to actual speed using this adjustment
$N_{TrainDAY}$	=	Number of trains during daytime hours (7 a.m. to 10 p.m.)
$N_{TrainNIGHT}$	=	Number of trains during nighttime hours (10 p.m. to 7 a.m.)
$N_{TrainHOUR}$	=	Number of trains during1 hour
$Dist$	=	Distance from train tracks to the sensitive receiver
$Dist_{ref}$	=	Reference distance (50 feet)

Also included in the noise prediction calculations are adjustments for ground type (for this project, hard ground is assumed) and shielding due to buildings (for receivers beyond the first row) as described in the FTA Guidance Manual.

The proposed operations for Rapid Transit are shown in Table 3-1, which applies to the yard tracks (other than those leading to the Maintenance Facility) and the storage tracks; Table 3-2, which applies to the yard tracks leading to the Maintenance Facility; and Table 3-3, which applies to the turnback tracks. It is assumed that all Rapid Transit future operations listed in the tables apply only to the project, and in the no-project case, would not apply. The assumed operations for the Metrolink and Amtrak trains are shown in Table 3-4, which is extracted from current schedules.

Table 3-1: Assumed Rapid Transit Operations: Yard Tracks and Storage Tracks

Hours	Number of Moves
3 a.m.-6 a.m.	40
9 a.m.-11 a.m.	24
2 p.m.-3 p.m.	24
7 p.m.-10 p.m.	28
12 a.m.-3 a.m.	12

Table 3-2: Assumed Rapid Transit Operations: Existing Yard Tracks Leading to Maintenance Facility

Hours	Number of Moves
24 hours	70 (equally distributed over 24 hours)

Table 3-3: Assumed Rapid Transit Operations: Turnback Tracks

Hours	Number of Moves (2*round trips)
6 a.m.-9 a.m.	2*90 = 180
3 p.m.-7 p.m.	2*120 = 240

Table 3-4: Assumed Metrolink and Amtrak Operations: West Side of River Only

Hours	Number of Metrolink Trains	Number of Amtrak Trains
5 a.m.-7 a.m.	4 (2/hour)	4 (2/hour)
7 a.m.-8 a.m.	5	2

8 a.m.-9 a.m.	3	2
9 a.m.-11 a.m.	2 (1/hour)	4 (2/hour)
11 a.m.-2 p.m.	0	6 (2/hour)
2 p.m.-3 p.m.	1	2
3 p.m.-5 p.m.	6 (3/hour)	4 (2/hour)
5 p.m.-6 p.m.	3	2
6 p.m.-7 p.m.	3	1
7 p.m.-8 p.m.	1	1
10 p.m.-12 a.m.	0	4 (2/hour)
12 a.m. – 1 a.m.	0	1

3.2.2 Noise from Audible Warnings

For this project, audible warnings for the trains include only horns mounted on the vehicle. This applies to both rapid transit and commuter rail in the project area.

Rapid transit train horns are sounded in the yard prior to vehicle movement. Noise from the horn use at the train yard was included as measured in the vicinity of One Santa Fe Apartments. A representative horn event was extracted to obtain a SEL of 66.1 dBA at 50 feet. See Appendix B for more measurements. To calculate Ldn and Leq values, it was assumed that the train horns would sound with each train movement. The same distances to the rapid transit tracks as was assumed for the trains is applied, and adjustments are made for distance by applying the following equations.

Calculation of Ldn and hourly Leq from SEL:

$$Ldn = SEL_{Horn} + 10\log(N_{TrainDAY} + N_{TrainNIGHT} x10) - 10\log\left({}^{Dist}/_{Dist_{ref}}\right) - 49.4$$

$$Leq(hour) = SEL_{Horn} + 10\log(N_{TrainHOUR}) - 10\log\left({}^{Dist}/_{Dist_{ref}}\right) - 35.6$$

where:

SEL_{Horn}	=	SEL reference level as measured
$N_{TrainDAY}$	=	Number of trains sounding horn during daytime hours
$N_{TrainNIGHT}$	=	Number of trains sounding horn during nighttime hours
$N_{TrainHOUR}$	=	Number of trains sounding horn during 1 hour
$Dist$	=	Distance from the track to the sensitive receiver
$Dist_{ref}$	=	Reference distance (50 feet)

Commuter rail train horns are sounded as they travel through the train yard. The SEL applied for a locomotive horn is 113 dBA, as per FTA Guidance. To calculate Ldn and Leq values, it was assumed that the train horns would sound with each train pass-by event. The same distances to the commuter rail tracks as was assumed for the trains is applied, and adjustments are made for distance by applying the following equations.

Calculation of Ldn and hourly Leq from SEL:

$$Ldn = SEL_{Horn} + 10\log(N_{TrainDAY} + N_{TrainNIGHT} x10) - 15\log\left({}^{Dist}/_{Dist_{ref}}\right) - 49.4$$

$$Leq(hour) = SEL_{Horn} + 10\log(N_{TrainHOUR}) - 15\log\left({}^{Dist}/_{Dist_{ref}}\right) - 35.6$$

where:

SEL_{Horn}	=	SEL reference level for locomotives, assuming horn soundings are directly in front of each receiver (other adjustments apply when this is not the case)
$N_{TrainDAY}$	=	Number of trains sounding horn during daytime hours
$N_{TrainNIGHT}$	=	Number of trains sounding horn during nighttime hours
$N_{TrainHOUR}$	=	Number of trains sounding horn during 1 hour
$Dist$	=	Distance from the tracks to the sensitive receiver
$Dist_{ref}$	=	Reference distance (50 feet)

3.2.3 Ancillary Equipment/Noise

The following ancillary noise sources are included in the noise analysis:

- **TPSS units**: The primary noise sources from the TPSS units are the transformer hum and noise from cooling systems. On most modern TPSS units the transformer hum is minimal, so only the ventilation and cooling system has potential to cause noise impacts. The noise level is assumed to be 50 dBA Leq at 50 feet (limit from any side of a TPSS unit typically included in purchase specifications). Level is adjusted based on distance and other sound propagation effects (ground type and shielding). Continuous operation is assumed 24 hours a day, seven days a week.
- **PA System**: Noise from the PA system at the train yard was included as measured in the vicinity of One Santa Fe Apartments. PA system uses were extracted and averaged to obtain a representative SEL of 71.0 dBA at 50 feet; this is applied to only the receivers in the immediate vicinity, which includes all of One Santa Fe Apartments. To calculate Ldn and Leq values, it was assumed that there were four uses of the PA system per hour (as measured when present) for 24 hours a day, seven days a week. See Appendix B for more information about measured data.
- **Maintenance facility shops and HVAC units on roof**: Noise from the maintenance facility includes the shops and HVAC units on the roof. Each was included as measured at a similar facility. A representative SEL of 58.0 dBA at 50 feet was used for the shops and 65 dBA at 50 feet for the HVAC units. These sources are only applied to receivers with direct line of sight. To calculate Ldn and Leq values, it was assumed that the shops were operating continuously and the HVAC units 50% of the time over 24 hours.
- **Light maintenance**: Noise from light maintenance applies to the storage yard adjacent to the One Santa Fe Apartments. The assumed level was based on a review of power hand tools, and a representative level was calculated by averaging levels from several power hand drills. The SEL applied is 63.4 dBA at 50 feet. To calculate Ldn and Leq values, it was assumed that the light maintenance occurs 5% of the time.
- **Platform car wash**: Noise from a platform car wash applies to the existing storage yard adjacent to the maintenance facility. The assumed level was based on a review of car wash noise and the assumption that the platform light washing is estimated to be 5 dB lower than standard car wash noise. The SEL applied is 70.0 dBA at 50 feet. To calculate Ldn and Leq values, it was assumed that the platform car washing occurs 5% of the time.

3.2.4 Road Traffic Noise

Road traffic noise was included as measured adjacent to Santa Fe Ave. Interfering noise sources (such as train pass-by events and aircraft flyovers) were removed from the data to determine road traffic noise levels from Santa Fe Ave. near SCI-Arc and One Santa Fe Apartments (northern portion of the project), and also near Willow Studios (southern portion of the project). Road traffic noise levels were determined to be 69.6 dBA for the northern portion of the project and 70.3 dBA for the southern portion of the project (loudest hour Leq). The Leq values for non-residential receivers facing Santa Fe Ave were directly added to predicted noise levels for other sources. For residential receivers, whose facades face the rail yard, shielding from the apartment buildings and influence of 1st St traffic were accounted for in the applied traffic noise levels; in addition, a conversion from loudest hour Leq to Ldn was used according to FHWA estimates (Ldn = Leq + 2). These traffic Ldn values were then directly added to predicted noise levels for other sources. See Appendix B for more information about measured data.

3.2.5 Aircraft Noise

Aircraft noise was included as measured in the vicinity of One Santa Fe Apartments. Aircraft flyover events were extracted and averaged to obtain a representative SEL of 74.7 dBA for the whole project area. To calculate Ldn and Leq values, it was assumed that there were 15 flyovers per hour (as measured when present), between the hours of 6 am and 11 pm. No adjustments were made for distances. See Appendix B for more information about measured data.

3.2.6 Building Noise Reduction

For the One Santa Fe Apartment buildings, the Final EAF/Initial Study/Mitigated Negative Declaration 2007 report (OSF 2007) requires that the building shell construction, i.e., exterior wall assembly, windows, doors, and roof assembly, shall be designed with a minimum Sound Transmission Class (STC) rating of 35 or as required to meet the interior noise level of 45 dBA. To be conservative, a 30 dB STC was applied to this analysis. Predicted sound levels are shown for both exterior and interior for the apartment building. The actual STC that was implemented needs to be determined if building noise reduction influences mitigation decisions.

3.3 VIBRATION ASSESSMENT APPROACH

The vibration assessment methodology follows the General Vibration Assessment guidelines outlined in the FTA Guidance Manual. The approach for the vibration assessment is similar to the approach for the noise assessment (see Section 3.1) and follows the same basic steps list below:

1. Identify sensitive receivers. Vibration-sensitive land uses along the corridor were identified using the same procedure as the noise analysis. Some buildings were split into multiple sensitive receivers due to their length. The residential land use receivers were the same for both noise and vibration assessments. Predictions for each receiver are based on the distance from the proposed project to the closest sensitive receiver. Appendix C details the receiver locations used in the assessment. Noise-sensitive institutional land uses are also vibration-sensitive. The exception is open spaces such as parks, which are not considered vibration-sensitive land uses. The FTA Guidance Manual does identify vibration-sensitive land uses that are not noise sensitive, such as research laboratories with vibration-sensitive equipment. However, no such land uses exist within the project study area.

2. Develop prediction models. The vibration prediction models are based on level curves (Figure **3-1**) developed from generalized data. The vibration prediction models are based on the FTA Guidance Manual's general vibration assessment methodology. The vibration levels at specific buildings are estimated by reading values from the curve and applying adjustments to account for factors such as track support system, vehicle speed, type of building, and track and wheel condition. The general level deals only with the overall vibration velocity level and the A-weighted sound level. It does not consider the frequency spectrum of the vibration or noise.
3. Estimate future vibration levels at the representative receivers. The prediction models were used to predict vibration levels from train operations at all sensitive receivers in the project area. The predictions were compared to the applicable FTA impact thresholds to identify potential vibration impacts.
4. Evaluate mitigation options. Mitigation options were evaluated for all locations where the predicted vibration levels exceed the FTA impact thresholds.

The primary differences between the noise and vibration assessments are

- **Sensitive Receivers:** Outdoor spaces are not considered sensitive to ground-borne vibration. In contrast, outdoor spaces where quiet is important for their intended function are considered noise sensitive. However, the outdoor recreation spaces of One Santa Fe were included in the vibration analysis of this project. For this analysis, the list of sensitive receivers is the same for both noise and vibration.
- **Existing Conditions**: Existing vibration is usually not a consideration when assessing vibration impacts because it is relatively rare for people to be exposed to perceptible groundborne vibration unless they are near a construction site or near roadways with large potholes and heavy vehicles. When doing a detailed analysis, existing vibration is taken into consideration for sensitive receivers located near existing rail operations. Existing vibration is not considered when doing a General Assessment, and therefore existing vibration is not considered here.

Vibration impacts from construction were also assessed using the procedures in the FTA Guidance Manual. Actual construction vibration levels would depend on the means and methods decided upon by the contractor, which are not available at this time. The predicted construction vibration levels in Section 7.0 of this report are based on hypothetical scenarios developed from similar projects for the purposes of modeling.

3.4 VIBRATION PREDICTION MODEL

Localized geologic conditions such as soil stiffness, soil layering and depth to bedrock have a strong effect on groundborne vibration. However, it is difficult to obtain information on subsurface conditions in sufficient detail so that computer models can be used to accurately predict ground vibration. As a result, most detailed predictions of ground vibration are based largely on empirical methods that involve measuring vibration propagation in the soil.

The predictions of groundborne vibration for this study follow the General Vibration Assessment procedure of the FTA Guidance Manual (2006).

The approach for the General Assessment is to define a curve, or set of curves, that predicts the overall groundborne vibration as a function of distance from the source, then apply adjustments to these curves to account for factors such as vehicle speed, building type, and receiver location within the building. The General Assessment vibration level curves as a function of distance are shown in Figure 3-1. For this project, the Rapid Transit curve is applied. The predicted vibration levels are compared to vibration criteria to determine whether there is impact and whether mitigation or further detailed study is required.

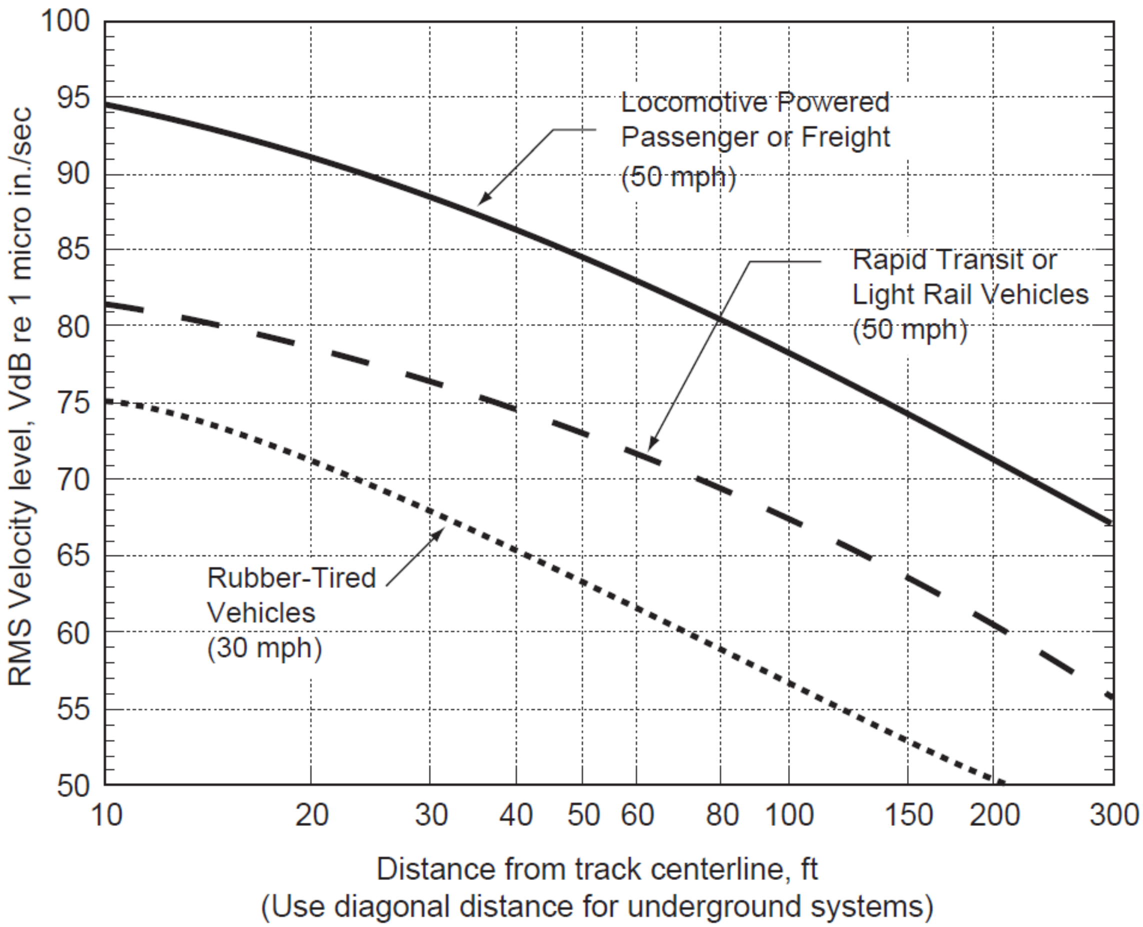


Figure 3-1: FTA Generalized Vibration Curves – Vibration Level as a Function of Distance (Source: Figure 10-1 in FTA 2006)

3.4.1 Adjustments of Level for Prediction Model

After determining the predicted vibration level from the FTA curves, the following adjustments were incorporated into the prediction model to estimate vibration levels in occupied spaces of buildings:

- **Speed Adjustment**: FTA Curves represent a train traveling at 50 mph. Adjustments to other speeds are made using 20*log(speed/50mph).
- **Special Trackwork**: The additional vibration at special trackwork was accounted for by adding 10 decibels to the predicted vibration levels when the special trackwork frog would be located less than 50 feet from a sensitive receiver. At distances greater than 50 feet, the additional vibration from crossovers is assumed to decay at a rate of 15*log(dist/50 feet) (decay rate based on measured vibration propagation).

- **Theoretical Coupling Loss and Floor Amplification**: For 3-4 story masonry buildings, the FTA Guidance Manual suggests -10 dB adjustment for coupling between the building and the foundation. The manual also suggests a +6 dB adjustment for floor amplification and –2 dB per floor for floor-to-floor attenuation up to five floors above grade. At One Santa Fe the 3rd floor is the lowest floor with residences, which would lead to a net adjustment of -10 dB at that floor. Therefore, a -10 dB adjustment is applied to account for coupling loss and floor amplification for the One Santa Fe building in the prediction model. No adjustment was made for other buildings.
- **Building Amplification Safety Factor**: It is not feasible to consider each receiver individually without a considerable amount of additional measurements. Therefore, to account for potential amplification effects from buildings and other possible sources of error in the predictions, a safety factor of +5 dB was added to the predicted vibration level. This is a conservative approach, ensuring that in the majority of cases the predicted vibration levels are higher than what would occur after the proposed project is operational.

3.4.2 Converting Vibration to Groundborne Noise

Under the General Assessment methodology, vibration is converted to A-weighted groundborne noise based on general guidelines which classify the frequency characteristics in three groups: Low Frequency, Typical, and High Frequency, with each designation corresponding to an adjustment to the vibration level curve as described above. For most surface tracks Low Frequency is appropriate, but to be conservative, this analysis uses the Typical group and a -35 dB adjustment is made to the general vibration level curve.

4.0 AFFECTED ENVIRONMENT

Noise and vibration sensitive receivers were identified using the FTA Guidance Manual's definitions of noise- and vibration-sensitive land uses. Existing noise-sensitive receivers in the project area consist of multi-family residences and associated outdoor recreational areas, a school, and a film studio. A full list of sensitive receivers can be found in Appendix C. The list includes receivers potentially sensitive to train noise and vibration, as well as noise from related facilities (maintenance facility, TPSS unit, etc.). The one indoor residential land use in the project area is One Santa Fe Apartments, two multi-family residence buildings divided into different receiver groupings by similar noise environments, where many of the dwelling units are facing the train facilities. The school building is the Southern California Institute of Architecture (SCI-Arc), one long building across the street from the apartments, also divided into multiple receivers by similar noise environments. The last receiver is Willow Studios (film studios).

Ambient noise in the project area was established by noise measurements. The purpose of the noise measurements was to document the existing noise environment and to develop baseline data for assessing the potential noise impacts resulting from the project. To characterize the noise at One Santa Fe Apartments, data were collected in November 2016 by AECOM (AECOM 2016), as part of their noise analysis for the area. The data collection included two long-term (24-hour) noise measurements (LT-1, LT-2) and two short-term (10-20 minutes representing 1 hour) noise measurements (ST-1, ST-2). The AECOM data are applied to this study. For the other receivers (school and studio), ATS Consulting conducted two short-term (2-hour) noise measurements (ST-3, ST-4).

More details about the measurements can be found in Appendix B. A map of measurement locations in relation to sensitive receivers is shown in Figure 4-1 and Figure 4-2 and Appendix C.

The results of the noise measurements can be found in Appendix B. The established existing noise levels for each sensitive receiver are shown in Table 4-1. Details on noise metrics used in this section can be found in Appendix A. The noise sources at One Santa Fe Apartments are: train operations, yard noise, aircraft overflights, and traffic on One Santa Fe, as observed by AECOM. The noise sources at SCI-Arc are: traffic on One Santa Fe, aircraft overflights, and train operations. The noise sources near Willow Studios are: traffic on One Santa Fe, aircraft overflights, and train operations.

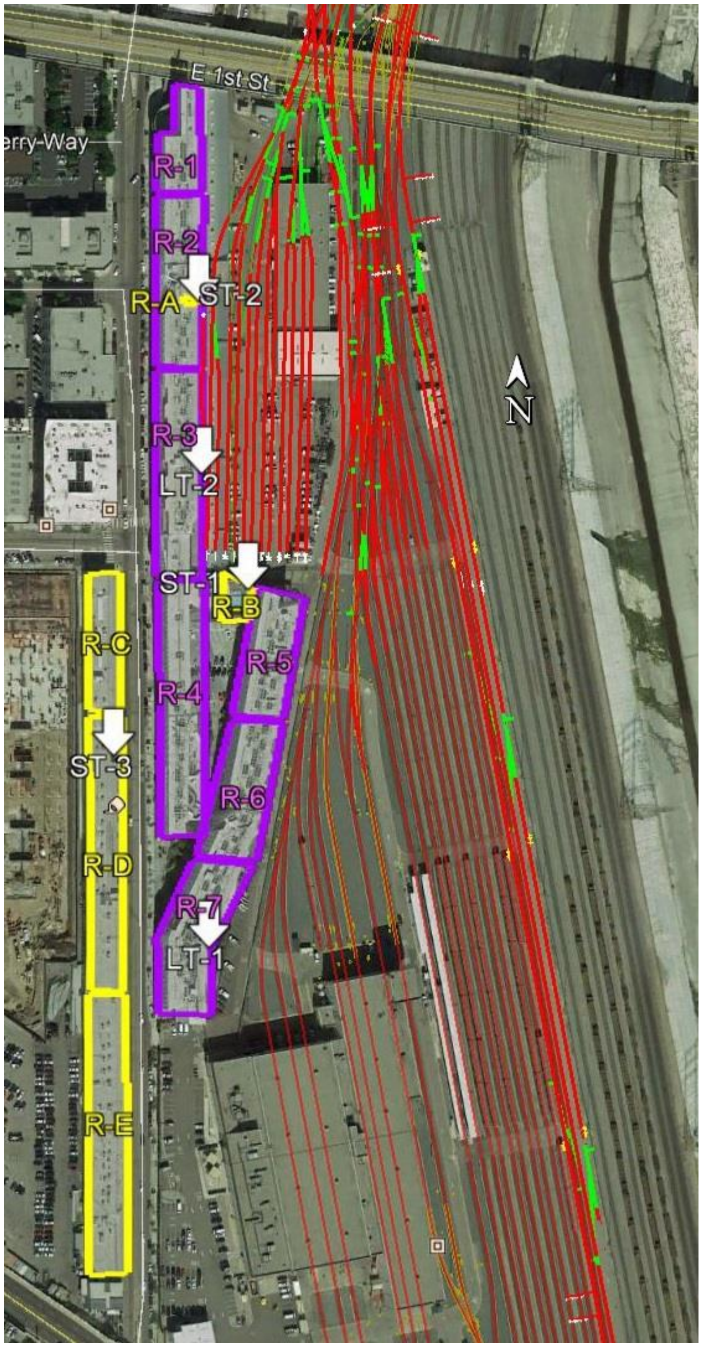


Figure 4-1: Measurement Locations in Relation to Sensitive Receivers (Northern Portion)

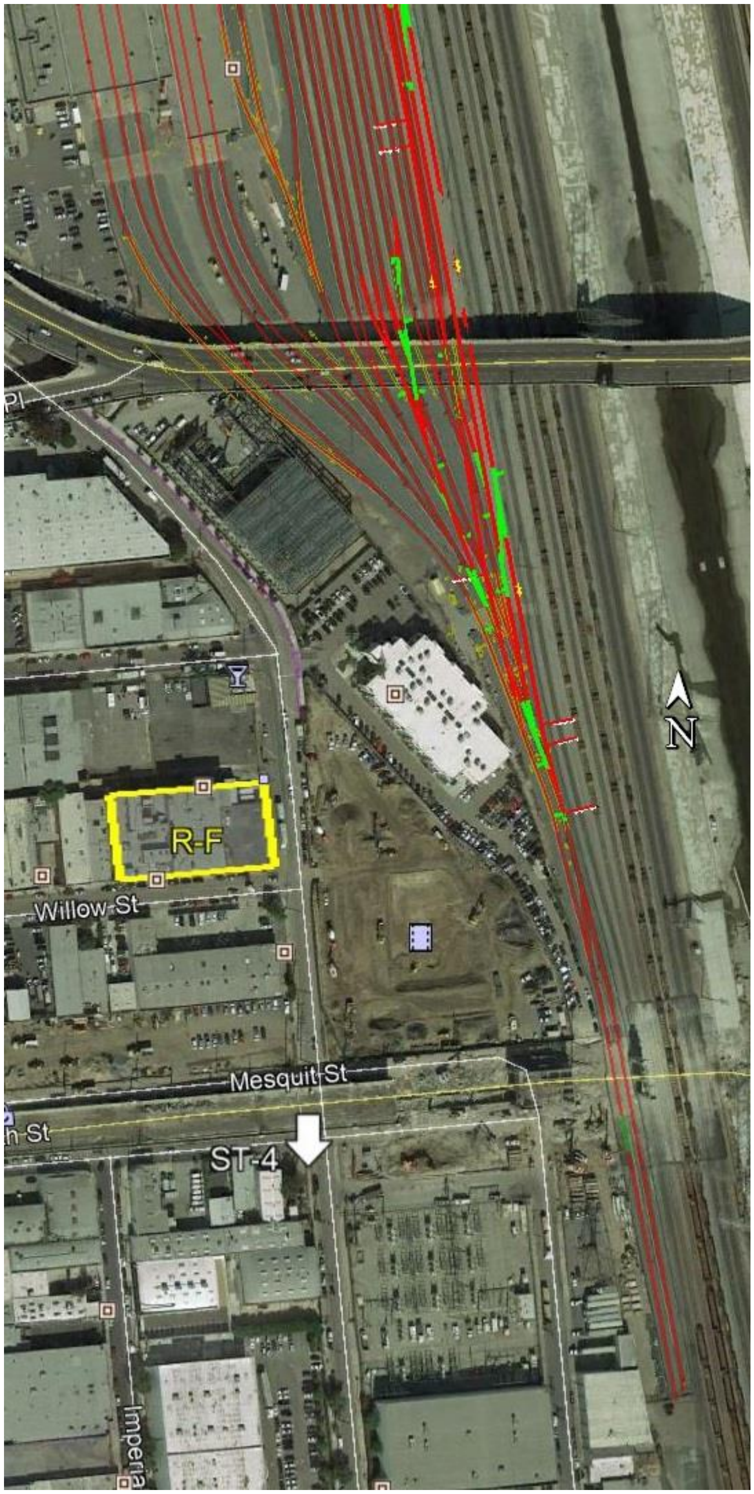


Figure 4-2: Measurement Locations in Relation to Sensitive Receivers (Southern Portion)

Table 4-1: Summary of Existing Noise at Sensitive Receivers

Sensitive Receiver		Applicable Measure-ment Site	Loudest Hour Leq (dBA)	Ldn (dBA)	CNEL (dBA)
ID	Location				
R-1	One Santa Fe (north bldg - north end)	LT-2	62	68	69
R-2	One Santa Fe (north bldg - mid)	LT-2	62	68	69
R-3	One Santa Fe (north bldg - south end)	LT-2	62	68	69
R-4	One Santa Fe (north bldg - south end, shielded)	LT-2	62	68	69
R-5	One Santa Fe (south bldg - north end)	LT-1	61	65	66
R-6	One Santa Fe (south bldg - mid)	LT-1	61	65	66
R-7	One Santa Fe (south bldg - south end)	LT-1	61	65	66
R-A	One Santa Fe, BBQ	ST-2	62	NA	NA
R-B	One Santa Fe, Pool/Spa	ST-1	59	NA	NA
R-C	Sci-Arc, 360 E 3rd St (north end)	ST-3	70	NA	NA
R-D	Sci-Arc, 360 E 3rd St (center)	ST-3	70	NA	NA
R-E	Sci-Arc, 360 E 3rd St (south end)	ST-3	70	NA	NA
R-F	Willow Studios, 1350 Palmetto St	ST-4	76	NA	NA

Source: AECOM 2016 data (AECOM 2016) and ATS Consulting 2017 data. See Appendix B for more details.

[a] For this study, it is assumed that CNEL is the same value as Ldn. In support of this, 24-hours measurements of existing noise show CNEL to be within 0.3 dB of Ldn values, as shown in Table B-1 in Appendix B.

5.0 ENVIRONMENTAL CONSEQUENCES AND IMPACTS

5.1 OPERATIONS NOISE IMPACTS

This section provides results for the impact analysis for noise from the rapid transit operations and related noise sources. Where impacted, suggestions for mitigating noise are provided in Section 6.0.

5.1.1 No Project

There is no predicted change in the noise or vibration levels for the future without project conditions; therefore, the noise levels would not exceed the CEQA significance thresholds.

The Link US Through-Tracks is the Related Project with the most potential to affect cumulative noise levels at the east side of OSF. Other Related Projects are not in the direct line-of-site of OSF impacts (e.g., projects located within the Arts District) or do not include significant sources of operational noise (e.g., LA River Restoration). Link US proposes to improve rail connectivity by constructing new run-through tracks over the US-101 Freeway. Link US would also be constructed to accommodate the California High Speed Rail through Union Station. New tracks associated with Link US would connect to existing tracks east of OSF. It is not anticipated that Link US would affect OSF or other sensitive receivers based on distance (being approximately 500 feet away or further) and the existing baseline background of commuter and freight train noise. In addition, given funding and construction uncertainty, Metro considers the implementation of the High Speed Rail to be speculative and it is not included in a detailed noise analysis of cumulative conditions for the Proposed Project.

5.1.2 Proposed Project

Project area noise-sensitive land uses for FTA Categories 1, 2, and 3 are listed and seen in Section 4.0 and Appendix C. The noise predictions are based on the closest part of each building or portion of building that is closest to the tracks.

Table 5-1 presents the predicted noise levels from train operations for all receivers. Category 2 land uses are multi-family residences. Category 1 land use is a film studio, and Category 3 land uses are a school and outdoor recreation areas for multi-family residences.

The columns in the tables provide the following information:

- **ID**: Sensitive receiver identification number. The location of each sensitive receiver cluster is presented in the maps in Appendix C.
- **Desc.**: Describes the type of land use.
- **Near Track Dist.**: Distance in feet from the near track centerline to the closest part of the noise-sensitive building. Appendix C provides more information on the applicable track type and distance.
- **Existing**: Estimated existing noise level (Ldn for Category 2, Leq for Categories 1 and 3) at each sensitive receiver based on the existing noise measurement results.
- **Predicted**: Predicted future exterior Ldn/CNEL (assumed equivalent – see footnote) or Leq from all noise sources in the project area. This includes rapid transit train noise from the various track types (with horn use); commuter rail train noise (with horn use); additional noise from special trackwork and wheel squeal; a TPSS unit; PA system; Maintenance Facility noise, including the HVAC system on the roof; platform car wash; storage area light maintenance; road traffic noise; and aircraft noise. For each noise source, receivers out to a distance of 350 feet were evaluated. Interior predictions are also

provided, based on a building noise reduction of 30 dBA, as presumed to be applied to the One Santa Fe Apartments.

- **Allowable Increase**: The FTA allowable decibel increases from existing noise, for moderate and severe impact, are based on the existing noise levels.
- **Number of Impacts**: The number of dwelling units within each sensitive receiver where the predicted noise levels exceed the Moderate (Mod.) and Severe impact allowances. Note that the number of units for One Santa Fe Apartments has yet to be determined.

Following is a summary of the noise impact assessment of the proposed project (the causes of impacts and recommended mitigation are described for each potentially impacted receiver in Section 6.1):

- For Category 2 land uses, there are two moderate impacts and three severe impacts according to FTA thresholds. The impacts represent most sections of the One Santa Fe Apartments. The severe impacts are in sections of the buildings near tracks with curvature and special trackwork; this includes the northern two sections of the north building (IDs R-1 and R-2) and the north section of the south building (ID R-5). The moderate impacts are in the southern two sections of the south building (IDs R-6 and R-7). Only FTA severe impacts are considered impacts under CEQA. For the Category 2 land use, a separate analysis showed no impact from TPSS noise per LA Metro design criteria; TPSS noise at R-1 and R-2, the only receivers in the vicinity, was 51 dBA and 46 dBA, respectively, which are well below the 5 dB below ambient (68-5=63 dBA) criteria.

  Assuming a building noise reduction of 30 dB as described in Section 3.2.6, with windows and doors closed, none of these sensitive receivers would be impacted, since the predicted interior noise levels are less than 45 dBA CNEL, the Los Angeles Building Code requirements.
- For Category 3 land uses, there is one moderate impact predicted. The impact represents the outdoor common use barbeque area of the One Santa Fe Apartments (ID R-A). This is not considered and impact under CEQA.
- There are no impacts predicted for the One Santa Fe Apartments pool/spa area (ID R-B), Southern California Institute of Architecture (ARC-Sci, IDs R-C, R-D, and R-E), and Willow Studios (ID R-F).

Table 5-1: Summary of Predicted Noise Impacts

ID[a]	Desc.[b]	Near Track Dist. (ft)[c]	Sensitive Receiver Location	Metric Applied	Noise Level (dBA)				# of Impacts[f]	
					Existing[d]	Predicted[d, e]	Allowable Increase			
							Mod.	Severe	Mod.	Severe
R-1	MF	120	One Santa Fe (north bldg - north end)	Ldn/CNEL[g]	68	72 / 42	1.2	3.1	--	TBD
R-2	MF	85	One Santa Fe (north bldg - mid)	Ldn/CNEL[g]	68	72 / 42	1.2	3.1	--	TBD
R-3	MF	80	One Santa Fe (north bldg - south end)	Ldn/CNEL[g]	68	67 / 37	1.2	3.1	--	--
R-4	MF	105	One Santa Fe (north bldg - south end, shielded)	Ldn/CNEL[g]	68	66 / 36	1.2	3.1	--	--
R-5	MF	50	One Santa Fe (south bldg - north end)	Ldn/CNEL[g]	65	69 / 39	1.4	3.6	--	TBD
R-6	MF	50	One Santa Fe (south bldg - mid)	Ldn/CNEL[g]	65	69 / 39	1.4	3.6	TBD	--
R-7	MF	65	One Santa Fe (south bldg - south end)	Ldn/CNEL[g]	65	69 / 39	1.4	3.6	TBD	--
R-A	REC	85	One Santa Fe, BBQ	Leq	60	69	4.6	9.0	Com-mon area	--
R-B	REC	60	One Santa Fe, Pool/Spa	Leq	59	64	4.9	9.4	--	--
R-C	SC	215	SCI-Arc, 360 E 3rd St (north end)	Leq	70	70	2.8	6.0	--	--
R-D	SC	260	SCI-Arc, 360 E 3rd St (center)	Leq	70	70	2.8	6.0	--	--
R-E	SC	260	SCI-Arc, 360 E 3rd St (south end)	Leq	70	70	2.8	6.0	--	--
R-F	ST	410	Willow Studios, 1350 Palmetto St	Leq	76	71	0.3	2.1	--	--

ID[a]	Desc.[b]	Near Track Dist. (ft)[c]	Sensitive Receiver Location	Metric Applied	Noise Level (dBA)				# of Impacts[f]	
					Existing[d]	Predicted[d, e]	Allowable Increase			
							Mod.	Severe	Mod.	Severe

[a] ID identifies sensitive receivers as shown Table C-1 in Appendix C. Refer to Table C-1 in Appendix C for indications of special trackwork for each receiver; the special trackwork increases noise levels.
[b] MF = multifamily, REC = recreational, SC = school, ST = film studio.
[c] Refer to Table C-1 in Appendix C regarding tracks to which this distance applies.
[d] FTA requires reporting a rounded whole number. The increase from existing to predicted is actually calculated as a decimal, and impacts are based on decimal-based increases compared to allowable increases, not the difference in rounded values.
[e] For OSF residences, a building noise reduction of 30 dB is applied, and the interior noise assuming windows and doors closed is also presented. The limit for interior noise is 45 dBA CNEL.
[f] Number of Impacts. This is a count of the number of properties/units represented for each potentially impacted sensitive receiver. The number of units for One Santa Fe Apartments has yet to be determined.
[g] For this study, it is assumed that CNEL is the same value as Ldn. In support of this, 24-hours measurements of existing noise show CNEL to be within 0.3 dB of Ldn values, as shown in Table B-1 in Appendix B. FTA impacts are indicated in these columns.

5.2 OPERATIONS GROUNDBORNE VIBRATION AND NOISE IMPACT

This section provides results for the impact analysis for groundborne vibration and noise from the maintenance yard operations.

5.2.1 No Project

There is no predicted change in the noise or vibration levels for the future without project conditions; therefore, the vibration levels would not exceed the CEQA significance thresholds.

As with noise, other projects are not expected to affect vibration levels at the sensitive receivers for this project.

5.2.2 Proposed Project

As discussed in Section 2.3, the FTA Guidance Manual provides two criteria for assessing vibration impacts. The first criterion is based on the overall vibration velocity level and is intended for use with a General Assessment. The FTA indicates that the second criterion is intended for use with a Detailed Assessment when vibration propagation testing has been performed and the predictions include the vibration spectrum. For this reason, only the first criterion was assessed in this analysis. All groundborne vibration and groundborne noise impacts are defined in the interior of occupied spaces. There are no criteria defined for exterior spaces, such as parks and residential yards, but the outdoor recreation spaces of One Santa Fe were included in this analysis for the sake of completeness.

The key thresholds applicable to the Division 20 Portal Widening Project are a maximum vibration level of 72 VdB for Category 2 (residential), 78 VdB for Category 3 (institutional) land uses, and 65 VdB for recording studios. The thresholds apply to the overall L_{max} vibration level and an impact would occur if this level exceeds those thresholds for receivers of the applicable type. (Note that no vibration Category 1 properties exist in the project area, which would include vibration-sensitive research and manufacturing, hospitals with vibration-sensitive equipment and university research operations.)

Limits are also set by FTA for maximum groundborne noise: 35 dBA for Category 2, 40 dBA for Category 3, and 25 dBA for recording studios. Groundborne noise radiates off the structure and is caused directly by groundborne vibration.

The vibration predictions are presented in

Table 5-2 for all receivers. The data presented in the table includes:

- **ID**: Sensitive receiver identification number. The location of each sensitive receiver cluster is presented in the maps in Appendix C.
- **Desc**.: Describes the type of land use.
- **Near Track Dist**.: Distance in feet from the near track centerline to the facade of the closest vibration-sensitive building. Appendix C provides more information on the applicable track type and distance.
- **Groundborne Vibration**: The predicted level of light rail vibration in VdB. This value is compared to the FTA General Assessment criteria to determine impact.
- **Groundborne Noise**: Predicted groundborne noise in dBA based on overall vibration level.
- **GBV Limit**: Limit for groundborne vibration. This limit is typically 72 VdB for residential receivers and 78 VdB for institutional receivers (this appears in the FTA Guidance Table 8-3 for

daytime use facilities). The Willow Studios were assessed using the recording studio limit of 65 VdB.

- **GBN Limit**: Receiver-specific limit for groundborne noise, in dBA. This limit is based on the FTA limits.
- **GBV Impact**: Indicates "Y" for yes as to whether the predicted levels exceed the applicable General Assessment criterion, given in column "GBV Limit."
- **GBN Impact**: Indicates "Y" for yes as to whether the predicted levels exceed the applicable limit set for each receiver. The limit for each receiver is given in column "GBN Limit."

As shown in

Table 5-2, no groundborne vibration or noise impacts are predicted using FTA methods/limits at any sensitive receivers.

Table 5-2: Summary of Predicted Vibration Impacts

ID[a]	Desc.[b]	Near Track Dist. (ft)[c]	Sensitive Receiver Location	Ground-borne Vibration (VdB)	Ground-borne Noise (dBA)	GBV Criter-ia (VdB)	GBN Criter-ia (dBA)	GBV Im-pact	GBN Im-pact
R-1	MF	65	One Santa Fe (north bldg - north end)	53	18	72	35	--	--
R-2	MF	10	One Santa Fe (north bldg - mid)	67	32	72	35	--	--
R-3	MF	10	One Santa Fe (north bldg - south end)	67	32	72	35	--	--
R-4	MF	60	One Santa Fe (north bldg - south end, shielded)	48	13	72	35	--	--
R-5	MF	40	One Santa Fe (south bldg - north end)	60	25	72	35	--	--
R-6	MF	40	One Santa Fe (south bldg - mid)	60	25	72	35	--	--
R-7	MF	40	One Santa Fe (south bldg - south end)	60	25	72	35	--	--
R-A	REC	10	OSF BBQ Area	67	32	78	40	--	--
R-B	REC	40	OSF Pool Area	51	16	78	40	--	--

ID[a]	Desc. [b]	Near Track Dist. (ft)[c]	Sensitive Receiver Location	Ground-borne Vibration (VdB)	Ground-borne Noise (dBA)	GBV Criter-ia (VdB)	GBN Criter-ia (dBA)	GBV Im-pact	GBN Im-pact
R-C	SC	150	SCI-Arc, N End	53	18	78	40	--	--
R-D	SC	230	SCI-Arc, Middle	53	18	78	40	--	--
R-E	SC	230	SCI-Arc, S End	53	18	78	40	--	--
R-F	ST	410	Willow Studios (film)	53	18	65	25	--	--

[a] ID identifies sensitive receivers as shown Table C-1 in Appendix C. Refer to Table C-1 in Appendix C for indications of special trackwork for each receiver; the special trackwork increases vibration levels.
[b] MF = multifamily, REC = recreational, SC = school, ST = film studio.
[c] Refer to Table C-1 in Appendix C regarding tracks to which this distance applies.

6.0 MITIGATION MEASURES

6.1 PROJECT OPERATIONS NOISE MITIGATION

Table 6-1summarizes predicted noise limit exceedances and mitigation recommendations for each potentially impacted sensitive receiver applying the FTA limits. Predicted impact exceedance is shown as the amount above a severe impact level and moderate impact level. Also shown in the table are the primary causes of the impact.

For the northern building of the One Santa Fe Apartments, the sections of the building potentially impacted under CEQA are R-1 and R-2. The primary causes of the impact are wheel squeal and noise from wheels crossing over gaps in standard frogs for the yard tracks leading into the storage yard adjacent to the apartments and those passing under the bridge heading toward the Maintenance Facility. Although lubrication applied to the track would help to address wheel squeal, this mitigation option is not feasible for this project. The recommended mitigation is to install low-impact frogs in the OSF-adjacent storage yard and in any yard tracks within a 200-foot radius of the northern portion of the northern building (R-1). Using low-impact frogs would remove the northern building impacts. The type of low-impact frogs typically used in yards are flange-bearing frogs, monoblock frogs, or conformal top rail bound manganese (RBM) frogs; refer to Appendix D for more information. For these receivers, a separate analysis showed no impact from TPSS noise per LA Metro design criteria.

For the southern building of the One Santa Fe Apartments, one section of the building is potentially impacted under CEQA: R-5. The primary causes of the impact are wheel squeal and noise from wheels crossing over gaps in standard frogs for the yard tracks leading into the Maintenance Facility. Although lubrication applied to the track would help to address wheel squeal, this mitigation option is not feasible for this project. The recommended mitigation is to install low-impact frogs in the existing yard tracks that lead to the Maintenance Facility and in new yard tracks within a 200-foot radius of the northern portion of the southern building (R-5). Using low-impact frogs (including replacing existing ones) would result in no impacts. The type of low-impact frogs typically used in yards are flange-bearing frogs, monoblock frogs, or conformal top rail bound manganese (RBM) frogs; refer to Appendix D for more information.

For all predictions and mitigation recommendations, it is assumed that the track and wheels would be maintained in a state of good repair (that is, rail corrugations and wheel flats would be minimized through maintenance procedures—rail grinding and wheel truing).

If it can be verified that a building noise reduction of at least 30 dB applies to the One Santa Fe Apartments, mitigation would not be required for R-1, R-2, and R-5, based on an interior noise limit of 45 dBA CNEL. Both the OSF Final EAF/Initial Study/Mitigated Negative Declaration (OSF 2007) and the Exterior Noise Impact Report [OSF NOISE 2008] indicate that a building noise reduction of 30 dB may have been used for construction of the building, however, this would need to be verified with the architect. Assuming no impacts for the interior, noise for the exterior apartment balconies was analyzed. It was determined that there could be potential noise impacts for these spaces without mitigation. However, the low-impact frogs installed as recommended for R-1, R-2, and R-5 would mitigate these impacts. As an alternative to low-impact frogs, transparent noise barriers could be placed on the affected apartment balconies to reduce the noise below impact level.

Table 6-1: Summary of Recommended Noise Mitigation

ID[a]	Desc.[b]	Sensitive Receiver Location	Impact Exceedance[c]		Recommended Mitigation
			(dB)	Primary Causes	
R-1	MF	One Santa Fe (north bldg - north end)	0.7 sev 2.6 mod	Wheel squeal; standard frog impacts[d]	Low-impact frogs
R-2	MF	One Santa Fe (north bldg - mid)	0.7 sev 2.6 mod	Wheel squeal; standard frog impacts[d]	Low-impact frogs
R-5	MF	One Santa Fe (south bldg - north end)	0.4 sev 2.7 mod	Wheel squeal; standard frog impacts[e]	Low-impact frogs

[a] ID identifies sensitive receivers as shown Table C-1 in Appendix C. Refer to Table C-1 in Appendix C for indications of special trackwork for each receiver; the special trackwork increases noise levels.
[b] MF = multifamily, REC = recreational.
[c] Exceedances are shown as the value above the FTA severe and moderate limits.
[d] Yard tracks leading into the storage yard adjacent to OSF Apartments and other yard tracks in the vicinity (within 200 feet of R-1).
[e] Yard tracks leading into the Maintenance Facility, including existing and new track within 200 feet of (R-5).

6.2 PROJECT OPERATIONS VIBRATION MITIGATION

No vibration potential vibration impacts are predicted for any of the sensitive receivers in the project area. Therefore, no vibration mitigation measures are recommended.

7.0 CONSTRUCTION NOISE AND VIBRATION IMPACT EVALUATION

This section explores the noise and vibration generated by construction activities for the Div. 20 Portal Widening/Turnback Facility Project. Appropriate limits for construction noise and vibration are determined through a review of applicable regulations, and the limits applied to this project are described below. Predictions of the noise and vibration levels at each nearby sensitive receiver are then compared to those limits. Mitigation measures are recommended for areas where levels are expected to exceed the limits. Detailed information on the construction noise and vibration predictions is available in Appendix E.

In summary, the proximity of the proposed storage tracks to the One Santa Fe apartment complex will make it difficult to keep noise and vibration levels acceptably low during certain construction operations. In particular, large noise and vibration exceedances are expected when the building and concrete parking lot adjacent to One Santa Fe are being demolished. Assuming contractors use the equipment outlined in the following section, it is unlikely that any typical mitigation measures would fully eliminate the intrusion that this demolition would cause residents, and therefore less conventional measures are called for. This could include temporarily relocating residents to a hotel.

Before operations begin, the contractor should create a Noise Control Plan outlining the operations that will take place as well as the equipment which will be used for each operation, per Metro Requirement 01 56 19—Construction Noise and Vibration Control (hereafter referred to as LA Metro Specifications). The Noise Control Plan will be updated at three month intervals, or upon any major change in work schedule, construction methods, or equipment operations not included in the most recent Plan.

7.1 CONSTRUCTION NOISE REGULATIONS

The use of heavy equipment during project construction has the potential to result in substantial increases in local noise levels along the corridor. The noise limits applied combine FTA limits and the City of Los Angeles Municipal Code time limitations as per LA Metro. The combined limitations are shown in Table 7-1.

The FTA Guidance Manual recommends using local construction noise limits, if possible, and also provides reasonable criteria for assessing construction noise. Per Chapter 12 of the FTA guidance manual, a potential impact could occur from construction noise if the noise level exceeds the general assessment limits listed in Table 7-1. These limits are for the combined noise level in one hour from the two noisiest pieces of equipment, assuming they both operate at the same time. To assess this, construction operations relevant to this project are evaluated, where each type of equipment related to the operation in included with the appropriate usage factor to get a combined noise level that represents one hour of operations. The FTA guidance also includes detailed assessment criteria using the eight-hour Leq and the 30-day average Ldn. The detailed analysis requires very specific information including the specific equipment in use at any given time, horsepower, and precise duration of activities. The analysis is based on the equipment that is likely to be used during the noisiest periods of construction, along with their measured sound levels at a distance of 50 feet. This level of detail was not available during the Draft EIR phase of the planning process, so the impact determination for construction noise is based on the FTA general assessment guidelines set forth above.

The City of Los Angeles Municipal Code Chapter IV - Section 41.40 contains restrictions for when construction activities may take place. The code prohibits construction activities before 7:00 AM and after 9:00 PM on weekdays. Construction activities are prohibited before 8:00 AM and after 6:00 PM on Saturdays and holidays, and are prohibited during all hours on Sundays. The time restrictions apply to land developed with residential buildings. These time restrictions shall not apply if a written application is submitted to the Executive Director of the Board of Police Commissioners and a variance is approved. Since the LA Municipal Code is the most restrictive regarding when construction activities may take place on weekends (Saturdays and Sundays), the hourly limitations listed in the LA Municipal Code for those days apply to this project and are included in Table 7-1.

Table 7-1: Construction Noise Limits for the Div. 20 Portal Widening/Turnback Facility Project

Land Use	One-hour Leq Day (dBA)	One-hour Leq Night (dBA)
Residential	90	80
Commercial	100	100
Industrial	100	100
Construction activities are prohibited before 7 AM and after 9 PM on weekdays, before 8 AM and after 6 PM on Saturdays and holidays, and during all hours on Sundays, unless a variance is approved.		
(Source: FTA Guidance, Section 12.1.3, 2006 and LAMC)		

The LA Metro (METRO 2012) requires the completion of a Noise Control Plan, which outlines procedures to reduce the impact that construction noise will have on areas near the construction site. Within 180 days prior to the start of construction, the contractor must submit the name and qualifications of the Acoustical Engineer responsible for preparing and overseeing the implementation of the Noise Control Plan to LA Metro or its designee. The minimum requirements for the acoustical engineer are available in section 3.02 of the LA Metro Specifications.

A Noise Control Plan must be submitted to LA Metro no later than 100 days prior to the start of construction. The Noise Control Plan must include the following information for nighttime construction activities that may take place at the construction site: a site drawing, an inventory of equipment, and calculations of the Lmax and one-hour Leq noise levels expected at the nearest receiver. Any equipment that will operate during nighttime hours for greater than 5 days must be tested for compliance with noise emission limits in LA Metro Specifications Table 3. Tables 4-5 and Figures 1-4 of the LA Metro Specifications provide forms that may be used to compile and present the data in the Noise Control Plan. An updated Noise Control Plan must be completed and submitted within 10 days of the start of each quarterly period, or whenever there is a major change in work schedule, construction methods, or equipment operations that was not included in the most recent plan.

In addition to the Noise Control Plan, the contractor's Acoustical Engineer must submit a Noise Monitoring Plan to LA Metro within 45 days of the notice to proceed. The Noise Monitoring Plan must include the following information for all daytime and nighttime construction activities that may take place at the construction site: planned construction activities, noise monitoring locations, equipment, procedures, schedule of measurements, and reporting methods to be used. Results from the measurements must be submitted to LA Metro on a weekly basis, or any time the measured noise levels exceed the allowable limits. Figure 2 of the LA Metro Specifications is the form that should be used when presenting the results of noise measurements.

7.2 CONSTRUCTION NOISE IMPACTS

Construction noise levels depend on the number of active pieces and type of equipment, their general condition, the amount of time each piece operates per day, the presence or lack of noise-attenuating features such as walls and berms and the location of the construction activities relative to the sensitive receivers. The majority of these variables are left to the discretion of the construction contractor selected as the project approaches the construction phase.

Two demolition and three construction operations are assumed when estimating the noise generated for this project. Construction operations are segregated into multiple phases, separating equipment that will not be used concurrently to avoid an overestimation of the noise generated. The operational groupings are listed here:

1. Demolition of the yard buildings (south of 1st Street and east of One Santa Fe)
2. Demolition of the concrete parking (lot south of 1st Street and east of One Santa Fe)
3. Construction of an asphalt access road
    a. Phase 1 – Preparation of land
    b. Phase 2 – Laying of asphalt
4. Construction of storage tracks
    a. Phase 1 – Preparation of land and railroad ties
    b. Phase 2 – Installation of ballast and rail
5. Construction of yard tracks
    a. Phase 1 – Preparation of land and railroad ties
    b. Phase 2 – Installation of ballast and rail

In addition to the operations listed above, pile installation will be required in a single location to build a support column for the aerial structure of the future California High-Speed Rail. The proposed column location is roughly 125 feet west of the existing Amtrak and Metrolink tracks, between Ducommun St. and Jackson St. The location of the proposed column is shown circled in red in Figure 7-1. The proposed piling method to support the column is cast-in-drilled-hole (CIDH). This method generates noise levels that are roughly 15 dBA lower than conventional impact piling, assuming an auger drill rig will be used to drill the hole. In addition, the land use of the surrounding area is industrial and commercial, and the nearest sensitive receivers are approximately 500 feet feet away from the piling across Commercial Street and Center Street. At these distances, noise from construction of the proposed column would be well below the commercial and industrial land use noise threshold of 100-dBA referenced in Table 7-1.

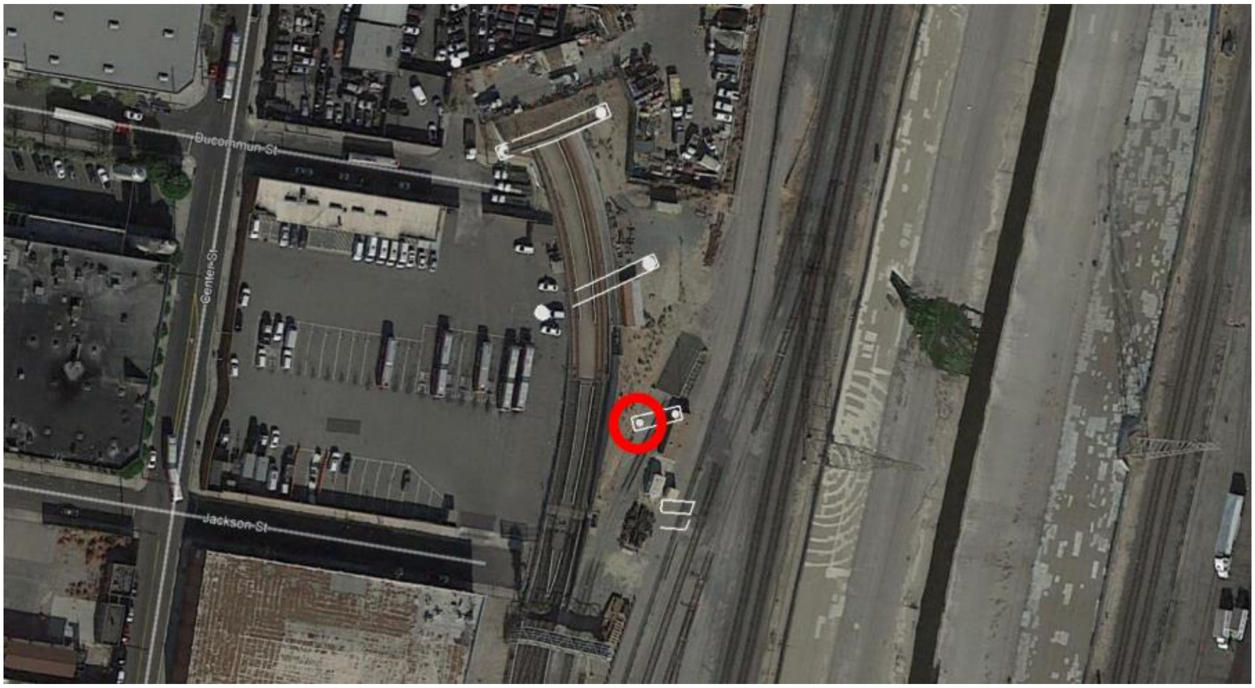


Figure 7-1: Location of Pile Drilling

The equipment that is likely to be used during the nosiest periods of construction, along with their measured sound levels at a distance of 50 feet, are listed in Table 7-2. Reference noise levels and usage factors for these pieces of equipment are collected from the Federal Highway Administration's Roadway Construction Noise Model (RCNM). The breakdown of equipment assumed for each phase of construction, as well as noise levels for individual pieces of equipment at each receiver are available in Appendix E.

Table 7-2: Construction Noise by Equipment Piece at 50 feet

Equipment Description	Source Usage Factor (% time under full load)	Lmax Sound Level at 50 ft (dBA)
Auger Drill Rig	20	84
Backhoe	40	78
Compactor (ground)	20	83
Concrete Saw	20	90
Dozer	40	82
Drum Mixer	50	80
Dump Truck	40	76
Excavator	40	81
Front End Loader	40	79
Grader*	40	85
Grapple (on backhoe)	40	87

Equipment Description	Source Usage Factor (% time under full load)	Lmax Sound Level at 50 ft (dBA)
Hydra Break Ram*	10	90
Jackhammer	20	89
Mounted Impact Hammer (hoe ram)	20	90
Pavement Scarafier	20	90
Paver	50	77
Roller	20	80
Scraper	40	84
Shears (on backhoe)	40	96
Welder / Torch	40	74
* Value taken from equipment specifications. Other values are from measured data. (Source: FHWA RCNM)		

For construction operations, two noise metrics are evaluated: Lmax (maximum level reached during specified time period or operation) and Leq (average level during a specified time period or operation). For this analysis, Lmax is shown just for reference, and Leq is compared to the FTA daytime limits to determine potential impacts. Predicted noise levels are shown first as plots as a function of distance, and second in tables with noise levels predicted for each sensitive receiver.

Figure 7-2 and Figure 7-3 respectively show the Leq and Lmax vs distance for equipment that is likely to be used during construction and demolition. Each figure has been separated into two graphs for clarity, and the legend lists the equipment with the highest noise generating equipment at the top and lowest at the bottom. These figures can be used to determine the distance from the receiver that a piece of equipment needs to be in order to fall below a particular noise level.

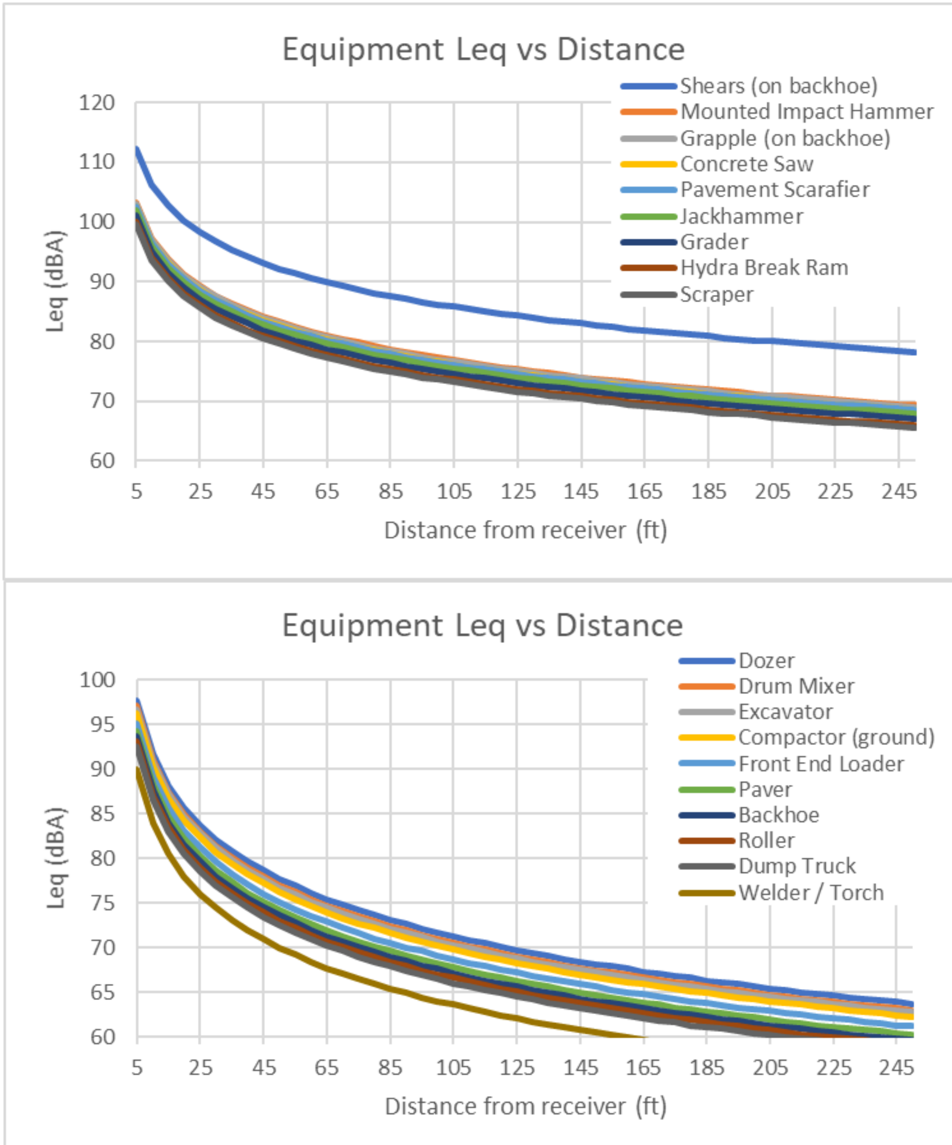


Figure 7-2: Equipment Leq vs Distance from Receiver

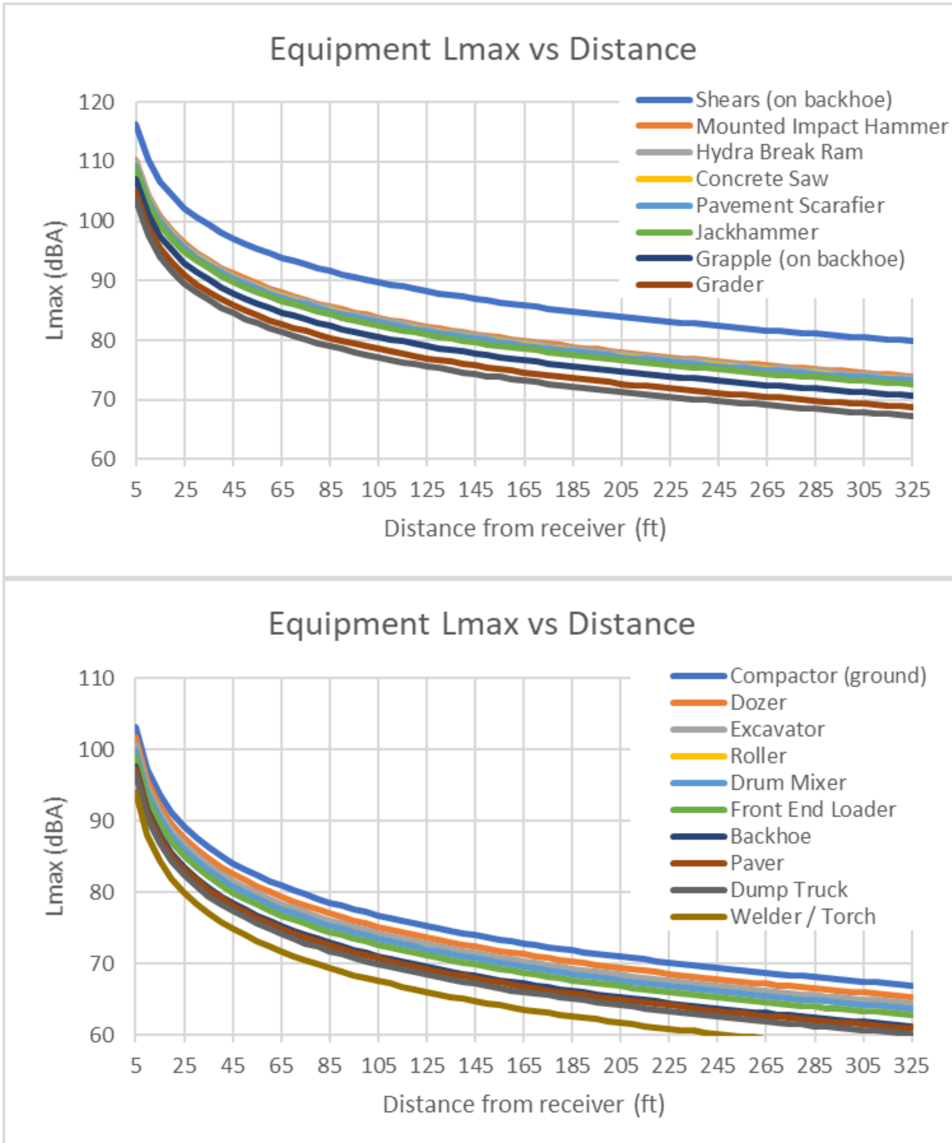


Figure 7-3: Equipment Lmax vs Distance from Receiver

Results in Table 7-3 through Table 7-7 show a combined Lmax and Leq for every phase of construction at each receiver; this includes all construction equipment expected to be used during the operation/phase, each with the appropriate usage factor applied. Levels that exceed the daytime impact threshold of 90 dBA Leq have been identified in bold. The results predict that without mitigation the contractor would exceed the impact threshold for many receivers, most notably at the One Santa Fe apartment complex which is within 25 feet of the equipment during multiple phases of construction. The contractor may need to implement noise control measures when working in these areas, where impacts are likely.

The FTA has identified a 100-dBA threshold for commercial and industrial land uses. This noise level would be exceeded for land uses located within approximately 20 feet of heavy-duty equipment. The nearest commercial/industrial facilities to proposed construction activities are located approximately 40 feet to the north across Commercial Street. Construction noise levels for commercial and industrial uses would be less than the FTA criteria.

Table 7-3: Building Demolition Overall Noise Predictions

Receiver ID	Receiver Name	Distance between Noise Source and Receiver (ft)	Noise Lmax[a] (dBA)	Noise Leq[b] (dBA)
R-1	One Santa Fe (north bldg - north end)	12	108.6	**105.9**
R-2	One Santa Fe (north bldg - mid)	12	108.6	**105.9**
R-3	One Santa Fe (north bldg - south end)	12	108.6	**105.9**
R-4	One Santa Fe (north bldg - south end)	12	93.6	**90.9**
R-5	One Santa Fe (south bldg - north end)	57	95.1	**92.4**
R-6	One Santa Fe (south bldg - mid)	246	77.4	74.7
R-7	One Santa Fe (south bldg - south end)	488	71.4	68.8
R-A	One Santa Fe, BBQ	24	102.6	**99.9**
R-B	One Santa Fe, Pool/Spa	24	102.6	**99.9**
R-C	SCI -Arc, 360 E 3rd St (north end)	143	77.1	74.4
R-D	SCI -Arc, 360 E 3rd St (center)	293	70.8	68.2
R-E	SCI -Arc, 360 E 3rd St (south end)	730	62.9	60.3
R-F	Willow Studios, 1350 Palmetto St	n/a	n/a	n/a

Note: Nighttime activities are only permitted if a variance is granted by the Executive Director of the Board of Police Commissioners. Noise limits for nighttime activities are listed in Table 7-1.

[a] Lmax values listed just for reference.

[b] Leq values are compared to the Table 7-1 daytime limit of 90 dBA, which applies to combined, overall construction noise. Exceedances are indicated in **bold**.

Table 7-4: Concrete Demolition Overall Noise Predictions

Receiver ID	Receiver Name	Distance between Noise Source and Receiver (ft)	Noise Lmax[a] (dBA)	Noise Leq[b] (dBA)
R-1	One Santa Fe (north bldg - north end)	24	96.7	**96.8**
R-2	One Santa Fe (north bldg - mid)	24	96.7	**96.8**
R-3	One Santa Fe (north bldg - south end)	24	96.7	**96.8**
R-4	One Santa Fe (north bldg - south end)	24	81.7	81.8
R-5	One Santa Fe (south bldg - north end)	24	96.7	**96.8**
R-6	One Santa Fe (south bldg - mid)	246	71.4	71.6
R-7	One Santa Fe (south bldg - south end)	488	65.5	65.6
R-A	One Santa Fe, BBQ	36	93.1	**93.3**
R-B	One Santa Fe, Pool/Spa	36	93.1	**93.3**
R-C	SCI -Arc, 360 E 3rd St (north end)	143	66.2	66.3

Receiver ID	Receiver Name	Distance between Noise Source and Receiver (ft)	Noise Lmax[a] (dBA)	Noise Leq[b] (dBA)
R-D	SCI -Arc, 360 E 3rd St (center)	293	59.9	60.1
R-E	SCI -Arc, 360 E 3rd St (south end)	730	52.0	52.1
R-F	Willow Studios, 1350 Palmetto St	n/a	n/a	n/a

Note: Nighttime activities are only permitted if a variance is granted by the Executive Director of the Board of Police Commissioners. Noise limits for nighttime activities are listed in Table 7-1.

[a] Lmax values listed just for reference.

[b] Leq values are compared to the Table 7-1 daytime limit of 90 dBA, which applies to combined, overall construction noise. Exceedances are indicated in **bold**.

Table 7-5: Asphalt Road Construction Overall Noise Predictions

			Phase 1 – Land Prep		Phase 2 – Lay Asphalt	
Receiver ID	Receiver Name	Distance between Noise Source and Receiver (ft)	Noise Lmax[a] (dBA)	Noise Leq[b] (dBA)	Noise Lmax[a] (dBA)	Noise Leq[b] (dBA)
R-1	One Santa Fe (north bldg - north end)	24	84.7	84.6	82.9	81.1
R-2	One Santa Fe (north bldg - mid)	24	76.6	76.5	74.9	73
R-3	One Santa Fe (north bldg - south end)	24	66.6	66.5	64.8	63
R-4	One Santa Fe (north bldg - south end)	24	46.2	46.1	44.5	42.7
R-5	One Santa Fe (south bldg - north end)	24	61.2	61.1	59.5	57.7
R-6	One Santa Fe (south bldg - mid)	246	54	53.9	52.2	50.4
R-7	One Santa Fe (south bldg - south end)	488	52.1	52	50.4	48.5
R-A	One Santa Fe (BBQ)	36	69.4	69.3	67.6	65.8
R-B	One Santa Fe (Pool/Spa)	36	61.4	61.3	59.7	57.9
R-C	SCI -Arc, 360 E 3rd St (north end)	143	46.2	46.1	44.4	42.6
R-D	SCI -Arc, 360 E 3rd St (center)	293	43.9	43.8	42.1	40.3
R-E	SCI -Arc, 360 E 3rd St (south end)	730	40.6	40.5	38.8	37

			Phase 1 – Land Prep		Phase 2 – Lay Asphalt	
Receiver ID	**Receiver Name**	**Distance between Noise Source and Receiver (ft)**	**Noise Lmax[a] (dBA)**	**Noise Leq[b] (dBA)**	**Noise Lmax[a] (dBA)**	**Noise Leq[b] (dBA)**
R-F	Willow Studios, 1350 Palmetto St	n/a	n/a	n/a	n/a	n/a

Note: Nighttime activities are only permitted if a variance is granted by the Executive Director of the Board of Police Commissioners. Noise limits for nighttime activities are listed in Table 7-1.

[a] Lmax values listed just for reference.

[b] Leq values are compared to the Table 7-1 daytime limit of 90 dBA, which applies to combined, overall construction noise. Exceedances are indicated in **bold**.

Table 7-6: Storage Track Construction Overall Noise Predictions

			Phase 1 – Land & Tie Prep		Phase 2 – Install Rail	
Receiver ID	**Receiver Name**	**Distance between Noise Source and Receiver (ft)**	**Noise Lmax[a] (dBA)**	**Noise Leq[b] (dBA)**	**Noise Lmax[a] (dBA)**	**Noise Leq[b] (dBA)**
R-1	One Santa Fe (north bldg - north end)	65	84.7	82.7	79.4	78
R-2	One Santa Fe (north bldg - mid)	5	107	**104.9**	101.7	**100.3**
R-3	One Santa Fe (north bldg - south end)	5	107	**104.9**	101.7	**100.3**
R-4	One Santa Fe (north bldg - south end)	60	70.4	68.4	65.1	63.7
R-5	One Santa Fe (south bldg - north end)	65	84.7	82.7	79.4	78
R-6	One Santa Fe (south bldg - mid)	281	67	65	61.7	60.3
R-7	One Santa Fe (south bldg - south end)	520	61.7	59.6	56.3	54.9
R-A	One Santa Fe (BBQ)	5	107	**104.9**	101.7	**100.3**
R-B	One Santa Fe (Pool/Spa)	40	88.9	86.9	83.6	82.2
R-C	SCI-Arc, 360 E 3rd St (north end)	150	62.5	60.4	57.1	55.7
R-D	SCI-Arc, 360 E 3rd St (center)	320	55.9	53.8	50.5	49.1
R-E	SCI -Arc, 360 E 3rd St (south end)	765	48.3	46.3	43	41.6

			Phase 1 – Land & Tie Prep		Phase 2 – Install Rail	
Receiver ID	**Receiver Name**	**Distance between Noise Source and Receiver (ft)**	**Noise Lmax[a] (dBA)**	**Noise Leq[b] (dBA)**	**Noise Lmax[a] (dBA)**	**Noise Leq[b] (dBA)**
R-F	Willow Studios, 1350 Palmetto St	n/a	n/a	n/a	n/a	n/a
Note: Nighttime activities are only permitted if a variance is granted by the Executive Director of the Board of Police Commissioners. Noise limits for nighttime activities are listed in Table 7-1. [a] Lmax values listed just for reference. [b] Leq values are compared to the Table 7-1 daytime limit of 90 dBA, which applies to combined, overall construction noise. Exceedances are indicated in **bold**.						

Table 7-7: Yard Track Construction Overall Noise Predictions

			Phase 1 – Land & Tie Prep		Phase 2 – Install Rail	
Receiver ID	**Receiver Name**	**Distance between Noise Source and Receiver (ft)**	**Noise Lmax[a] (dBA)**	**Noise Leq[b] (dBA)**	**Noise Lmax[a] (dBA)**	**Noise Leq[b] (dBA)**
R-1	One Santa Fe (north bldg - north end)	200	75	72.9	69.6	68.2
R-2	One Santa Fe (north bldg - mid)	230	73.7	71.7	68.4	67
R-3	One Santa Fe (north bldg - south end)	225	73.9	71.9	68.6	67.2
R-4	One Santa Fe (north bldg - south end)	220	59.1	57.1	53.8	52.4
R-5	One Santa Fe (south bldg - north end)	60	85.4	83.4	80.1	78.7
R-6	One Santa Fe (south bldg - mid)	130	78.7	76.6	73.4	72
R-7	One Santa Fe (south bldg - south end)	257	72.8	70.7	67.5	66.1
R-A	One Santa Fe (BBQ)	230	73.7	71.7	68.4	67
R-B	One Santa Fe (Pool/Spa)	120	79.4	77.3	74.1	72.7
R-C	SCI -Arc, 360 E 3rd St (north end)	340	55.3	53.3	50	48.6
R-D	SCI -Arc, 360 E 3rd St (center)	400	53.9	51.9	48.6	47.2
R-E	SCI -Arc, 360 E 3rd St (south end)	560	51	49	45.7	44.3

			Phase 1 – Land & Tie Prep		Phase 2 – Install Rail	
Receiver ID	**Receiver Name**	**Distance between Noise Source and Receiver (ft)**	**Noise Lmax[a] (dBA)**	**Noise Leq[b] (dBA)**	**Noise Lmax[a] (dBA)**	**Noise Leq[b] (dBA)**
R-F	Willow Studios, 1350 Palmetto St	415	68.6	66.6	63.3	61.9

Note: Nighttime activities are only permitted if a variance is granted by the Executive Director of the Board of Police Commissioners. Noise limits for nighttime activities are listed in Table 7-1.

[a] Lmax values listed just for reference.

[b] Leq values are compared to the Table 7-1 daytime limit of 90 dBA, which applies to combined, overall construction noise. Exceedances are indicated in **bold**.

7.3 CONSTRUCTION NOISE MITIGATION

Listed below are some typical approaches to reducing noise levels associated with the construction phase of major projects. Requiring the contractor to employ these methods should leave the contractor with enough flexibility to perform the work without undue financial or logistical burdens while protecting adjacent noise-sensitive receivers from excessive construction noise levels.

- Use specialty equipment with enclosed engines, acoustically attenuating shields, and/or high-performance mufflers.
- Locate equipment and staging areas away from noise-sensitive receivers.
- Limit unnecessary idling of equipment.
- Install temporary noise barriers, noise control curtains, and/or noise enclosures. This approach can be particularly effective for stationary noise sources such as compressors and generators. These methods may not be effective for elevated receivers; blocking line-of-sight is necessary.
- Reroute construction-related truck traffic away from local residential streets and/or sensitive receivers.
- Avoid impact pile driving where possible. Where geological conditions permit, the use of drilled piles or a vibratory pile driver is generally quieter.
- Use electric instead of diesel powered equipment and hydraulic instead of pneumatic tools.
- Where possible, minimize the use of impact devices such as jackhammers and hoe rams, using concrete crushers and pavement saws instead.

Other less conventional techniques could be employed when the options above will not suffice, particularly when loud, necessary construction operations must take place. For instance, residents could be temporarily relocated to a hotel during construction times when the noise will be the loudest and most intrusive.

Specific measures to be employed to mitigate construction noise impacts should be developed by the contractor and presented in the form of the Noise Control Plan. Impacts may be significant and unavoidable, even with mitigation measures applied. If nighttime construction is necessary, consider nighttime noise limits, the need for a variance, and potential mitigation.

7.4 CONSTRUCTION VIBRATION REGULATIONS

The primary concern regarding construction vibration is potential damage to structures. The thresholds for potential damage are much higher than the thresholds for evaluating potential annoyance used to assess impact from operational vibration. The FTA Guidance Manual provides construction vibration limits for various building categories, as shown in Table 7-8. The peak particle velocity (PPV) and root mean square (RMS) amplitude are two separate metrics used to quantify a vibration signal. Lv vibration levels are a decibel representation of the RMS velocity levels, using a reference of 1 micro-inch/second (μin/sec.). More information regarding vibration descriptors is available in Appendix A.2. It is important to note that the vibration limits in Table 7-8 are the levels at which there is a risk for damage for each building category, not the level at which damage would occur.

Table 7-8: FTA Construction Vibration Damage Risk Criteria

Building Category	Peak Particle Velocity (inches/second)	Approximate Lv (VdB)
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

Source: Federal Transit Administration (FTA 2006)

Previous LA Metro projects required that vibration measurements be conducted on a weekly basis or as often as the construction setup changes. Measurements should be taken during peak vibration generating construction activities, and the results must be submitted to LA Metro on a weekly basis. Consult with LA Metro for requirements for this project.

7.5 CONSTRUCTION VIBRATION IMPACTS

The same demolition and construction operations assumed when estimating the noise generated have been assumed when estimating the construction vibration. A list of the operational groupings and phases is available in Section 7.2. Pile drilling for the California High-Speed Rail support column, the location of which is shown in Figure 7-1, was considered as well. The nearest permanent building is approximately 500 feet away from the piling. Caisson drilling is typically used for the proposed CIDH pile, and at a distance of 500 feet the vibration levels generated from pile drilling is well below all PPV limits listed in Table 7-8.

The equipment that is likely to be used during construction, along with reference vibration levels at a distance of 50 feet are listed in Table 7-9. Reference vibration levels are collected from the FTA Guidance and Dowding, and the most applicable reference values were selected for each piece of equipment. Table 7-9 also shows the minimum distance in feet that a piece of equipment must be from the nearest receiver to not have its operation time limited by the FTA annoyance limit for daytime use (nighttime should be addressed separately). The breakdown of equipment assumed for each phase of construction, as well as vibration levels for individual pieces of equipment at each receiver are available in Appendix E.

Table 7-9: Construction Vibration by Equipment Piece at 50 feet

Equipment Description	Reference Level Source	Peak Particle Velocity at 50 ft (inches/second)	Lv at 50 ft (VdB)	Minimum Distance from Receiver w/ Unlimited Use Time[b] (ft)
Backhoe	FTA - Hoe Ram	0.031	78	80
Caisson Drilling	FTA – Caisson Drilling	0.031	78	80
Compactor (ground)[a]	Dowding - Heavy Vehicles	0.063	84	117
Concrete Saw	n/a	n/a	n/a	n/a
Dozer	FTA - Large Bulldozer	0.031	78	80
Drum Mixer	FTA - Loaded Trucks	0.027	77	74
Dump Truck	FTA - Loaded Trucks	0.027	77	74
Excavator	FTA - Hoe Ram	0.031	78	80
Front End Loader	FTA - Small Bulldozer	0.001	49	10
Grader	FTA - Large Bulldozer	0.031	78	80
Grapple (on backhoe)	FTA - Hoe Ram	0.031	78	80
Hydra Break Ram[a]	Dowding - Pavement Breaker	0.052	82	109
Jackhammer	FTA - Jackhammer	0.012	70	44
Mounted Impact Hammer (hoe ram)	FTA - Hoe Ram	0.031	78	80
Pavement Scarafier[a]	Dowding - Pavement Breaker	0.052	82	109
Paver	FTA - Large Bulldozer	0.031	78	80
Roller	FTA - Vibratory Roller	0.074	85	136
Scraper	FTA - Large Bulldozer	0.031	78	80
Shears (on backhoe)	FTA - Hoe Ram	0.031	78	80
Welder / Torch	n/a	n/a	n/a	n/a

[a] Lv values from the Dowding reference were calculated by converting PPV to RMS, assuming a crest factor of 4.
[b] Unlimited use distance determined as distance where the level falls below 72 VdB FTA annoyance limit in Table 2-2.

The FTA limits in Table 7-8 are based on PPV values, so PPV vibration predictions are compared to the FTA limits to determine exceedances. The FTA daytime limits in Table 2-2 are based on vibration decibel values, so Lv vibration predictions are compared to the FTA limits to determine exceedances based on annoyance. They annoyance level exceedances are only evaluated for OSF, since this is the only sensitive receiver close to the construction activities. Figure 7-4 and Figure 7-5 respectively show the PPV and vibration level vs distance for the equipment that is likely to be used during construction and demolition. Equipment with equivalent vibration values have been lumped together for figure clarity. For example, the backhoe line can be used as a reference to all equipment with a PPV of 0.031 in/sec, including the dozer, excavator, grapple, and paver to name a few. These figures can be used to estimate the distance from the receiver that a piece of equipment may need to be in order to fall below the limit.

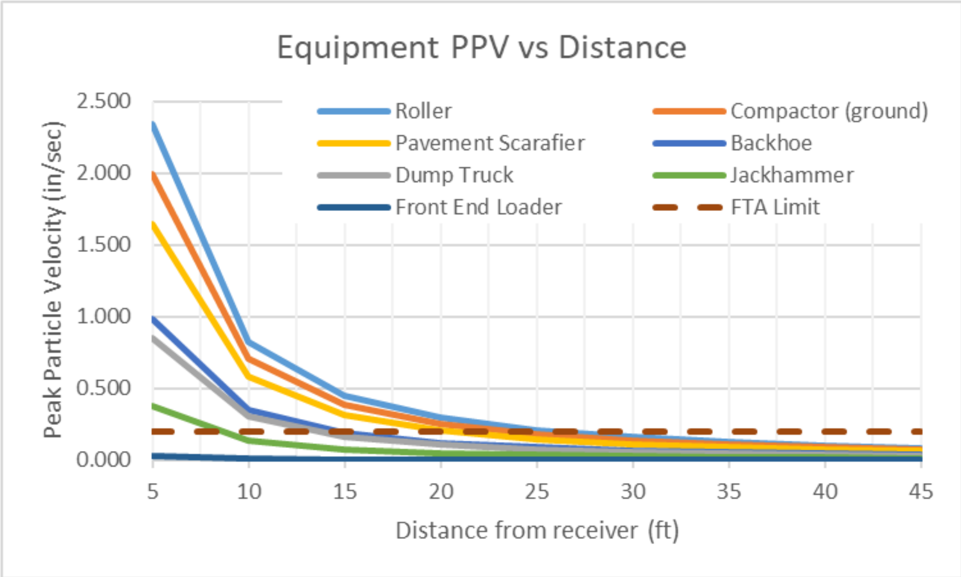


Figure 7-4: Equipment PPV vs Distance from Receiver

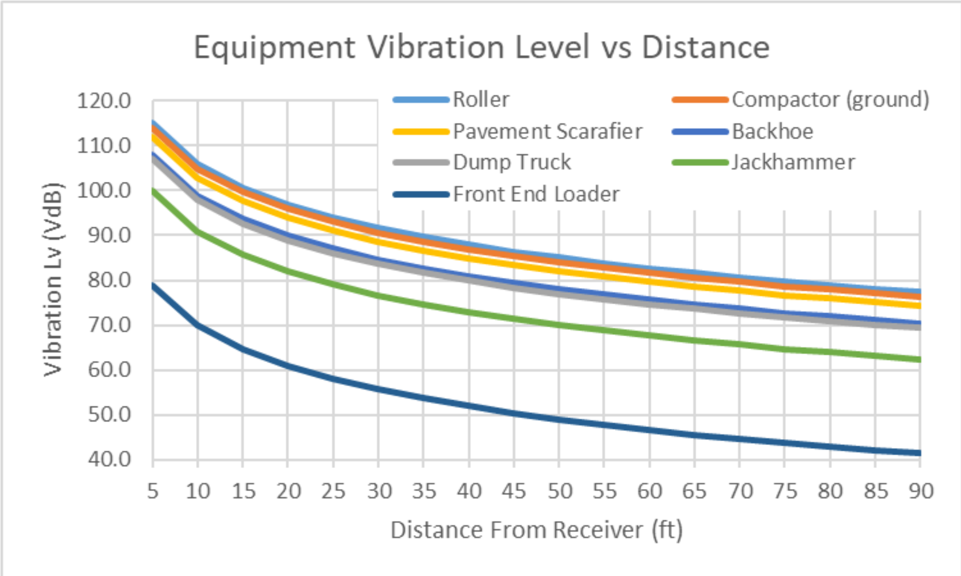


Figure 7-5: Equipment Vibration Level (VdB) vs Distance from Receiver

Results in Table 7-10 through Table 7-14 show the maximum predicted vibration PPV and Lv for every phase of construction at each receiver, and values that exceed the FTA impact thresholds have been identified in bold. The results predict that the contractor would exceed the impact threshold when operating very close to the receiver, as is the case near the One Santa Fe apartment complex during the building and concrete demolition operations. In the event that vibration-generating equipment must be used for a sustained period of time, the Contractor should utilize alternative procedures of construction, and select proper combination of techniques that generate least overall noise and vibration.

Table 7-10: Building Demolition Maximum Vibration Predictions

Receiver ID	Receiver Name	Distance between Vibration Source and Receiver (ft)	PPV (inches/sec)	Lv (VdB)
R-1	One Santa Fe (north bldg - north end)	5	**0.980**	**108.0**
R-2	One Santa Fe (north bldg - mid)	5	**0.980**	**108.0**
R-3	One Santa Fe (north bldg - south end)	5	**0.980**	**108.0**
R-4	One Santa Fe (north bldg - south end)	5	**0.980**	**108.0**
R-5	One Santa Fe (south bldg - north end)	57	0.025	**76.3**
R-6	One Santa Fe (south bldg - mid)	246	0.003	57.2
R-7	One Santa Fe (south bldg - south end)	488	0.001	48.3
R-A	One Santa Fe, BBQ	5	**0.980**	108.0
R-B	One Santa Fe, Pool/Spa	5	**0.980**	108.0
R-C	SCI -Arc, 360 E 3rd St (north end)	143	0.006	64.3
R-D	SCI -Arc, 360 E 3rd St (center)	293	0.002	55.0
R-E	SCI -Arc, 360 E 3rd St (south end)	730	0.001	43.1
R-F	Willow Studios, 1350 Palmetto St	n/a	n/a	n/a
Note: Values in **bold** indicate an exceedance of the 0.2 in/sec PPV damage limit applied to all receivers or 72 VdB Lv annoyance limit applied to residential receivers only.				

Table 7-11: Concrete Demolition Maximum Vibration Predictions

Receiver ID	Receiver Name	Distance between Vibration Source and Receiver (ft)	PPV (inches/sec)	Lv (VdB)
R-1	One Santa Fe (north bldg - north end)	5	**1.644**	**112.3**
R-2	One Santa Fe (north bldg - mid)	5	**1.644**	**112.3**
R-3	One Santa Fe (north bldg - south end)	5	**1.644**	**112.3**
R-4	One Santa Fe (north bldg - south end)	5	**1.644**	**112.3**
R-5	One Santa Fe (south bldg - north end)	24	0.156	**91.8**
R-6	One Santa Fe (south bldg - mid)	246	0.005	61.5
R-7	One Santa Fe (south bldg - south end)	488	0.002	52.6
R-A	One Santa Fe, BBQ	5	**1.644**	112.3
R-B	One Santa Fe, Pool/Spa	5	**1.644**	112.3
R-C	SCI -Arc, 360 E 3rd St (north end)	143	0.011	68.6
R-D	SCI -Arc, 360 E 3rd St (center)	293	0.004	59.2
R-E	SCI -Arc, 360 E 3rd St (south end)	730	0.001	47.3
R-F	Willow Studios, 1350 Palmetto St	n/a	n/a	n/a
Note: Values in **bold** indicate an exceedance of the 0.2 in/sec PPV damage limit applied to all receivers or 72 VdB Lv annoyance limit applied to residential receivers only.				

Table 7-12: Asphalt Road Construction Maximum Vibration Predictions

			Phase 1 – Land Prep		Phase 2 – Lay Asphalt	
Receiver ID	**Receiver Name**	**Distance between Vibration Source and Receiver (ft)**	**PPV (inches/sec)**	**Lv (VdB)**	**PPV (inches/sec)**	**Lv (VdB)**
R-1	One Santa Fe (north bldg - north end)	52	0.029	**77.5**	0.070	**84.5**
R-2	One Santa Fe (north bldg - mid)	131	0.007	65.5	0.017	**72.5**
R-3	One Santa Fe (north bldg - south end)	416	0.001	50.4	0.003	57.4
R-4	One Santa Fe (north bldg - south end)	770	0.001	42.4	0.001	49.4
R-5	One Santa Fe (south bldg - north end)	770	0.001	42.4	0.001	49.4
R-6	One Santa Fe (south bldg - mid)	998	0.000	39.0	0.001	46.0
R-7	One Santa Fe (south bldg - south end)	1238	0.000	36.2	0.001	43.2
R-A	One Santa Fe (BBQ)	302	0.002	54.6	0.005	61.6
R-B	One Santa Fe (Pool/Spa)	753	0.001	42.7	0.001	49.7
R-C	SCI -Arc, 360 E 3rd St (north end)	776	0.001	42.3	0.001	49.3
R-D	SCI -Arc, 360 E 3rd St (center)	1015	0.000	38.8	0.001	45.8
R-E	SCI -Arc, 360 E 3rd St (south end)	1475	0.000	33.9	0.000	40.9
R-F	Willow Studios, 1350 Palmetto St	n/a	n/a	n/a	n/a	n/a
Note: Values in **bold** indicate an exceedance of the 0.2 in/sec PPV damage limit applied to all receivers or 72 VdB Lv annoyance limit applied to residential receivers only.						

Table 7-13: Storage Track Construction Maximum Vibration Predictions

			Phase 1 – Land & Tie Prep		Phase 2 – Install Rail	
Receiver ID	**Receiver Name**	**Distance between Vibration Source and Receiver (ft)**	**PPV (inches/sec)**	**Lv (VdB)**	**PPV (inches/sec)**	**Lv (VdB)**
R-1	One Santa Fe (north bldg - north end)	65	0.043	**80.5**	0.050	**81.6**

			Phase 1 – Land & Tie Prep		Phase 2 – Install Rail	
Receiver ID	**Receiver Name**	**Distance between Vibration Source and Receiver (ft)**	**PPV (inches/sec)**	**Lv (VdB)**	**PPV (inches/sec)**	**Lv (VdB)**
R-2	One Santa Fe (north bldg - mid)	5	**1.992**	**113.9**	**2.340**	**115.0**
R-3	One Santa Fe (north bldg - south end)	5	**1.992**	**113.9**	**2.340**	**115.0**
R-4	One Santa Fe (north bldg - south end)	60	0.048	**81.6**	0.056	**82.6**
R-5	One Santa Fe (south bldg - north end)	65	0.043	**80.5**	0.050	**81.6**
R-6	One Santa Fe (south bldg - mid)	281	0.005	61.5	0.006	62.5
R-7	One Santa Fe (south bldg - south end)	520	0.002	53.4	0.002	54.5
R-A	One Santa Fe (BBQ)	5	**1.992**	113.9	**2.340**	115.0
R-B	One Santa Fe (Pool/Spa)	40	0.088	86.9	0.103	87.9
R-C	SCI-Arc, 360 E 3rd St (north end)	150	0.012	69.6	0.014	70.7
R-D	SCI-Arc, 360 E 3rd St (center)	320	0.004	59.8	0.005	60.8
R-E	SCI -Arc, 360 E 3rd St (south end)	765	0.001	48.4	0.001	49.5
R-F	Willow Studios, 1350 Palmetto St	n/a	n/a	n/a	n/a	n/a
Note: Values in **bold** indicate an exceedance of the 0.2 in/sec PPV damage limit applied to all receivers or 72 VdB Lv annoyance limit applied to residential receivers only.						

Table 7-14: Yard Track Construction Maximum Vibration Predictions

			Phase 1 – Land & Tie Prep		Phase 2 – Install Rail	
Receiver ID	**Receiver Name**	**Distance between Vibration Source and Receiver (ft)**	**PPV (inches/sec)**	**Lv (VdB)**	**PPV (inches/sec)**	**Lv (VdB)**
R-1	One Santa Fe (north bldg - north end)	200	0.008	65.9	0.009	66.9
R-2	One Santa Fe (north bldg - mid)	230	0.006	64.1	0.008	65.1
R-3	One Santa Fe (north bldg - south end)	225	0.007	64.3	0.008	65.4

			Phase 1 – Land & Tie Prep		Phase 2 – Install Rail	
Receiver ID	**Receiver Name**	**Distance between Vibration Source and Receiver (ft)**	**PPV (inches/sec)**	**Lv (VdB)**	**PPV (inches/sec)**	**Lv (VdB)**
R-4	One Santa Fe (north bldg - south end)	220	0.007	64.6	0.008	65.7
R-5	One Santa Fe (south bldg - north end)	60	0.048	**81.6**	0.056	**82.6**
R-6	One Santa Fe (south bldg - mid)	130	0.015	71.5	0.018	**72.6**
R-7	One Santa Fe (south bldg - south end)	257	0.005	62.6	0.006	63.7
R-A	One Santa Fe (BBQ)	230	0.006	64.1	0.008	65.1
R-B	One Santa Fe (Pool/Spa)	120	0.017	72.5	0.020	73.6
R-C	SCI -Arc, 360 E 3rd St (north end)	340	0.004	59.0	0.004	60.0
R-D	SCI -Arc, 360 E 3rd St (center)	400	0.003	56.9	0.003	57.9
R-E	SCI -Arc, 360 E 3rd St (south end)	560	0.002	52.5	0.002	53.5
R-F	Willow Studios, 1350 Palmetto St	415	0.003	56.4	0.003	57.4
Note: Values in **bold** indicate an exceedance of the 0.2 in/sec PPV damage limit applied to all receivers or 72 VdB Lv annoyance limit applied to residential receivers only.						

7.6 CONSTRUCTION VIBRATION MITIGATION

Construction or demolition operations that occur immediately adjacent to the One Santa Fe apartment complex are likely to exceed the impact thresholds. The following precautionary vibration mitigation strategies should be implemented to minimize the potential for damage to any structures in the project area:

- **Preconstruction Survey**: The survey should include inspecting building foundations and taking photographs of preexisting conditions. The survey can be limited to buildings in the project area within 25 feet of high-vibration-generating construction activities. The only exception is if an important and potentially fragile historic resource is located within approximately 200 feet of construction, in which case it should be included in the survey. For this project, the only known building that may fall into that category is the Citizens Warehouse/Lysle Storage Company building.
- **Vibration Limits**: The FTA Guidance Manual suggests vibration limits in terms of peak particle velocity, ranging from 0.12 inches/second for "buildings extremely susceptible to vibration damage" to 0.5 inches/second for "Reinforced-concrete, steel or timber" buildings. The contract specifications

should limit construction vibration to a maximum of 0.2 inches/second for all buildings in the project area (this peak particle velocity limit applies to all equipment).

- **Vibration Monitoring**: The contractor should be required to monitor vibration at any building where vibratory rollers or similar high-vibration-generating equipment would be operated within 25 feet of buildings and at any location where complaints about vibration are received from building occupants.
- **Alternative Construction Procedures**: If high-vibration construction activities must be performed close to structures, it may be necessary for the contractor to use an alternative procedure that produces lower vibration levels. Examples of high-vibration construction activities include the use of vibratory compaction or hoe rams next to sensitive buildings. Alternative procedures include use of non-vibratory compaction in limited areas and a concrete saw in place of a hoe ram to break up pavement.

When construction or demolition operations must occur very close to the receiver, other less conventional techniques could be employed. Residents could be temporarily relocated to a hotel during construction times when the vibration will be the greatest and most intrusive.

Specific measures to be employed to reduce or mitigate construction vibration impacts should be developed by the contractor and presented in the form of a Vibration Monitoring Plan. Impacts may be significant and unavoidable, even with mitigation measures applied.

8.0 CEQA SUMMARY

This section summarizes the CEQA determination and impacts after mitigation for both operational and construction noise and vibration. Table 8-1 and the following text summarize the impacts caused by the project according to the applicable federal/state/local limits described earlier (see Section 2.0) with and without mitigation applied.

Table 8-1: CEQA Project Noise Impacts

Would the project:	Potentially Significant Impact	Less Than-Significant with Mitigation Incorporation	Less Than-Significant Impact	No Impact
a) Exposure of persons to or generation of noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies?	☐	☒	☐	☐
(applied to construction noise)	☒	☐	☐	☐
b) Exposure of persons to or generation of excessive groundborne vibration or groundborne noise levels?	☐	☐	☐	☒
(applied to construction vibration)	☒	☐	☐	☐
c) A substantial permanent increase in ambient noise levels in the project vicinity above levels existing without the project?	☐	☒	☐	☐
d) A substantial temporary or periodic increase in ambient noise levels in the project vicinity above levels existing without the project?	☒	☐	☐	☐
e) For a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project expose people residing or working in the project area to excessive noise levels?	☐	☐	☐	☒
f) For a project within the vicinity of a private airstrip, would the project expose people residing or working in the project area to excessive noise levels?	☐	☐	☐	☒

An explanation for each question follows:

a) Exposure of persons to or generation of noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies?

   a. LESS-THAN-SIGNIFICANT IMPACT WITH MITIGATION INCORPORATED. Without mitigation, potential significant impacts from **operations** are predicted for some sections of the One Santa Fe Apartments. The primary noise sources would be wheel squeal and special trackwork associated with yard tracks leading into the storage yard adjacent to the apartments and leading into the Maintenance Facility. According to FTA limits, there are three severe impacts (northern portion of both the north building and south building). All impacts can be reduced to less-than-significant by applying the mitigation recommended in Section 6.1. The recommended mitigation is the use of low-impact frogs in the storage yard adjacent to OSF and in the new yard tracks within a 200-foot radius of the northern portion of the northern building and southern building of OSF (R-1 and R-5). The recommended mitigation also includes use of low-impact frogs in existing yard tracks leading into the Maintenance Facility.

If it can be verified that a building noise reduction of at least 30 dB applies to the One Santa Fe Apartments, mitigation would not be required for R-1, R-2, and R-5, based on an interior noise limit of 45 dBA CNEL. Assuming no impacts for the interior, noise for the exterior apartment balconies was analyzed. It was determined that there could be potential noise impacts for these spaces without mitigation. However, the low-impact frogs installed as recommended for R-1, R-2, and R-5 would mitigate these impacts. As an alternative to low-impact frogs, transparent noise barriers could be placed on the affected apartment balconies to reduce the noise below impact level.

POTENTIALLY SIGNIFICANT IMPACT. **Construction** activities may cause a significant unavoidable impact. See question d) for more information.

b) Exposure of persons to or generation of excessive groundborne vibration or groundborne noise levels?

   a. NO IMPACT. There are no potential impacts predicted for either groundborne vibration or groundborne noise due to **operations** applying FTA.

   b. POTENTIALLY SIGNIFICANT IMPACT. **Construction** activities may cause a significant unavoidable impact. Expected construction operations were evaluated for vibration, where each operation includes different equipment. Results show that the proximity of the One Santa Fe Apartment complex to the adjacent building and pavement demolition, as well as construction of the storage tracks can potentially cause large exceedances of limits. In addition, yard track construction and pavement construction may result in smaller exceedances. To minimize the construction vibration, practices outlined in Section 7.6 should be implemented, where applicable. Specific measures to be employed to reduce or mitigate construction vibration impacts should be developed by the contractor and presented in the form of a Vibration Monitoring Plan.

c) A substantial permanent increase in ambient noise levels in the project vicinity above levels existing without the project?

   a. LESS-THAN-SIGNIFICANT IMPACT WITH MITIGATION INCORPORATED. In the project vicinity, the ambient noise could permanently increase without mitigation applied. With mitigation incorporated as recommended in Section 6.1, any potential increase in ambient noise is less-than-significant.

d) A substantial temporary or periodic increase in ambient noise levels in the project vicinity above levels existing without the project?

   a. POTENTIALLY SIGNIFICANT IMPACT. Construction activities are a temporary source of noise for the project. Expected construction operations were evaluated for noise, where each operation includes different equipment. Results show that the proximity of the One Santa Fe Apartment complex to the adjacent building and pavement demolition, as well as construction of the storage tracks can potentially cause exceedances of the limits. Since the apartments are elevated above the demolition and construction activities, typical mitigation measures such as noise barriers/blankets would not provide adequate noise reduction. To minimize the construction noise, practices outlined in Section 7.3 should be implemented, where applicable. When the noise will be loudest and most intrusive, unconventional measures may be appropriate, such as temporarily relocating residents to a hotel (if overnight work is necessary). A Noise Control Plan and Noise Monitoring Plan must be submitted to LA Metro. Specific mitigation measures should be developed by the construction contractor as part of the Noise Control Plan.

The LA Municipal Code restricts construction activities to the following hours: 7 am – 9 pm weekdays and 8 am – 6 pm Saturdays. A variance needs to be granted by the Executive Director of the Board of Police Commissioners to operate outside these hours.

e) For a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project expose people residing or working in the project area to excessive noise levels?

  a. NO IMPACT. The project is not within any airport land use plan or within two miles of any public airport or public use airport.

f) For a project within the vicinity of a private airstrip, would the project expose people residing or working in the project area to excessive noise levels?

  a. NO IMPACT. The project is not within the vicinity of any known private airstrips.

9.0 SOURCES AND REFERENCES

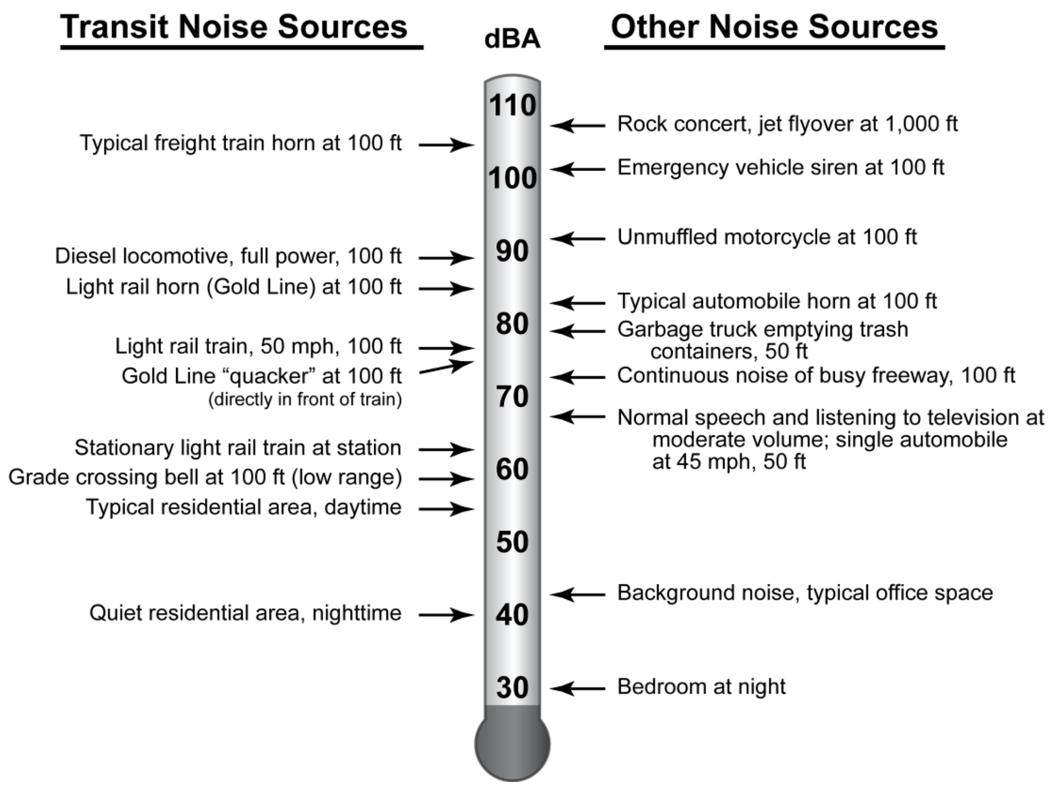
FTA 2006	U.S. Department of Transportation (USDOT), Federal Transit Administration (FTA), Office of Planning and Environment. May 2006. *Transit Noise and Vibration Impact Assessment Guidance Manual*, Document FTA-VA-90-1003-06.
CEQA 2016	California Environmental Quality Act (CEQA) Statute and Guidelines, 2016 (http://resources.ca.gov/ceqa/).
LAMUNI 2016	City of Los Angeles Municipal Code Chapter IV - Section 41.40, 2017 (http://library.amlegal.com/nxt/gateway.dll/California/lamc/municipalcode?f=templates $fn=altmain-nf.htm$3.0$vid=amlegal:losangeles_ca_mc).
LACOUNTY 2018	Los Angeles County Code of Ordinances – Title 12 Environmental Protection, Chapter 12.08 Noise Control, 2018 (https://library.municode.com/ca/los_angeles_county/codes/code_of_ordinances?nodeId=TIT12ENPR_CH12.08NOCO)
METRO 2012	Los Angeles County Metropolitan Transportation Authority (LA Metro). *Specifications: Division 1, Section 01 56 19 Construction Noise and Vibration Control*, September 2012.
OSF 2007	Final EAF/Initial Study/Mitigated Negative Declaration, One Santa Fe Mixed-Use Project, October 2007.
OSF NOISE 2008	*Exterior Noise Impact Analysis Report*, One Santa Fe Mixed-Use Project, Report No. 07015-01, December 2008.
DOWDING 2009	Charles H. Dowding *Construction Vibrations*, 2009.
AECOM 2016	Draft Technical Memorandum, "LA Metro, Metro Red/Purple Line Core Capacity Improvements Project, Noise and Vibration Analysis," AECOM, December 2016.
METRODESIGN 2012	Los Angeles County Metropolitan Transportation Authority (LA Metro). *Metro Rail Design Criteria, Section 2, Environmental Considerations Rev 1*, May 2012.

APPENDIX A FUNDAMENTALS OF NOISE AND VIBRATION

A.1 NOISE

Sound is characterized by both its amplitude and frequency (or pitch). The human ear does not hear all frequencies equally. In particular, the ear deemphasizes low and very high frequencies. To better approximate the sensitivity of human hearing, the A-weighted decibel scale has been developed. A-weighted decibels are abbreviated as "dBA." On this scale, the human range of hearing extends from approximately 3 dBA to around 140 dBA. As a point of reference, Figure includes examples of A-weighted sound levels from common indoor and outdoor sounds.

Figure A-1: Typical Outdoor and Indoor Noise Levels



Using the decibel scale, sound levels from two or more sources cannot be directly added together to determine the overall sound level. Rather, the combination of two sounds at the same level yields an increase of 3 dB. The smallest recognizable change in sound level is approximately 1 dB. A 3-dB increase in the A-Weighted sound level is generally considered perceptible, whereas a 5-dB increase is readily perceptible. A 10-dB increase is judged by most people as an approximate doubling of the perceived loudness.

A.1.1 Noise Terminology

Following are brief definitions of the measures of environmental noise used in this study:

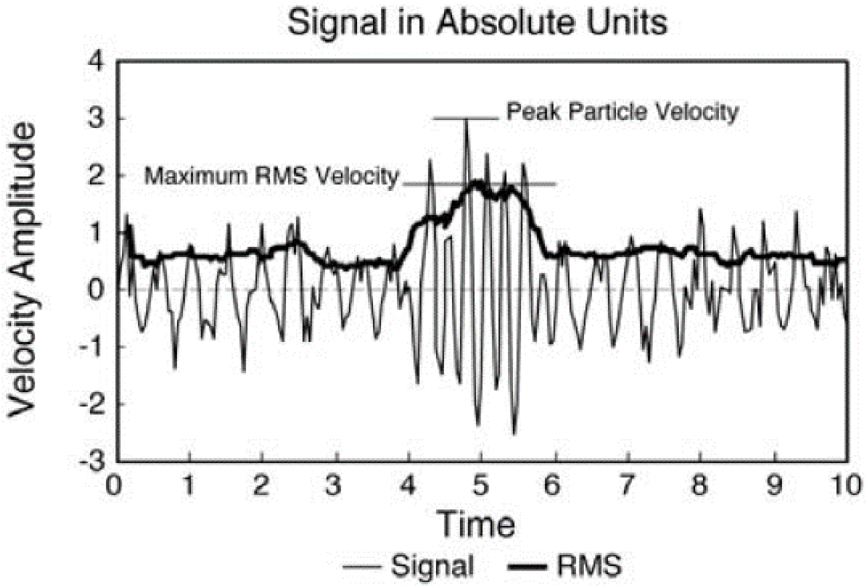
- ***Maximum Sound Level (L_{max}):*** L_{max} is the maximum sound level that occurs during an event such as a train passing. For this analysis L_{max} is defined as the maximum sound level using the slow setting on a standard sound level meter, which is equivalent to the maximum 1-second root mean square (RMS) average sound level.

- ***Equivalent Sound Level (L_{eq}):*** Environment sound fluctuates constantly. The equivalent sound level (L_{eq}) is the most common means of characterizing community noise. L_{eq} represents a constant sound that, over a specified period of time, has the same sound energy as the time-varying sound. L_{eq} is used by the Federal Transit Administration (FTA) to evaluate noise effects at institutional land uses, such as schools, churches, and libraries, from proposed transit projects.
- ***Day-Night Sound Level (L_{dn}):*** L_{dn} is basically a 24 hour L_{eq} with an adjustment to reflect the greater sensitivity of most people to nighttime noise. The adjustment is a 10-dB penalty for all sound that occurs between the hours of 10:00 p.m. to 7:00 a.m. The effect of the penalty is that, when calculating L_{dn}, any event that occurs during the nighttime is equivalent to ten occurrences of the same event during the daytime. L_{dn} is the most common measure of total community noise over a 24-hour period and is used by the FTA to evaluate residential noise effects from proposed transit projects.
- ***Exceedance Level (L_{XX}):*** This is the percent of time a sound level is exceeded during the measurement period. For example, the L_{99} is the sound level exceeded 99 percent of the measurement period. For a-1 hour period, L_{99} is the sound level exceeded for all except 36 seconds of the hour. The tables of the hourly noise levels in Appendix B include L_1, L_{33}, L_{50}, and L_{99}, the sound levels exceeded 1 percent, 33 percent, 50 percent and 99 percent of the hour. L_1 represents typical maximum sound levels, L_{33} is approximately equal to L_{eq} when free-flowing traffic is the dominant noise source, L_{50} is the median sound level, and L_{99} is close to the minimum sound level.
- ***Sound Exposure Level (SEL):*** SEL is a measure of the acoustic energy of an event such as a train passing. In essence, the acoustic energy of the event is compressed into a 1-second period. SEL increases as the sound level of the event increases and as the duration of the event increases. It is often used as an intermediate value in calculating overall metrics such as L_{eq} and L_{dn}.

A.2 VIBRATION

One potential community effect from the proposed project is vibration that is transmitted from the tracks through the ground into adjacent houses. This is referred to as groundborne vibration. When evaluating human response, groundborne vibration is usually expressed in terms of decibels using the RMS vibration velocity. Some limits are also presented in terms of the peak particle velocity (PPV). RMS is defined as the average of the squared amplitude of the vibration signal. To avoid confusion with sound decibels, the abbreviation VdB is used for vibration decibels. All vibration decibels in this report use a decibel reference of 1 micro-inch/second (μin/sec.). PPV is the maximum instantaneous positive or negative peak of an oscillating vibration signal, in this report using velocity in inches/second (in/sec). The RMS amplitude is always positive, and always less than the PPV. Figure A-2 shows a sample vibration signal, where the bold line is the RMS velocity and the lighter-weight line is the raw signal.

Figure A-2: Comparing PPV and RMS Values of a Sample Vibration Signal



Source: Federal Transit Administration (2006)

The potential adverse effects of rail transit groundborne vibration are as follows:

- **Perceptible Building Vibration**: This is when building occupants feel the vibration of the floor or other building surfaces. Experience has shown that the threshold of human perception is around 65 VdB and that vibration that exceeds 75 to 80 VdB may be intrusive and annoying to building occupants.
- **Rattle**: The building vibration can cause rattling of items on shelves and hanging on walls, and various different rattle and buzzing noises from windows and doors.
- **Reradiated Noise**: The vibration of room surfaces radiates sound waves that may be audible to humans. This is referred to as groundborne noise. When audible groundborne noise occurs, it sounds like a low-frequency rumble. For a surface rail system such as the proposed project, the groundborne noise is usually masked by the normal airborne noise radiated from the transit vehicle and the rails.
- **Damage to Building Structures**: Although it is conceivable that vibration from a light rail system could cause damage to fragile buildings, the vibration from rail transit systems is usually one to two orders of magnitude below the most restrictive thresholds for preventing building damage. Hence the vibration impact criteria focus on human annoyance, which occurs at much lower amplitudes than does building damage.

Often it is necessary to determine the contribution at different frequencies when evaluating vibration or noise signals. The 1/3-octave band spectrum is the most common procedure used to evaluate frequency components of acoustic signals. The term “octave” has been borrowed from music where it refers to a span of eight notes. The ratio of the highest frequency to the lowest frequency in an octave is 2:1. For a 1/3-octave band spectrum, each octave is divided into three bands where the ratio of the lowest frequency to the highest frequency in each 1/3-octave band is $2^{1/3}$:1 (1.26:1). An octave consists of three 1/3 octaves.

The 1/3-octave band spectrum of a signal is obtained by passing the signal through a bank of filters. Each filter excludes all components except those that are between the upper and lower range of one 1/3-octave band. The FTA *Guidance Manual* is a good reference for additional information on transit noise and vibration and the technical terms used in this section.

A.1.2 Vibration Terminology

Most noise terms have a vibration equivalent by replacing the noise level with a vibration level. Following are three vibration terms used in this report for quantifying vibration energy:

- ***Equivalent Vibration Level (L_{eq} or L_v):*** The equivalent vibration level (L_{eq} or L_v) represents a constant vibration that, over a specified period of time, has the same sound energy as the time-varying vibration.
- ***Peak Particle Velocity (PPV):*** the maximum, instantaneous positive or negative peak of an oscillating vibration signal.
- ***Exceedance Level (L_{XX}):*** see definition in noise section above and replace noise with vibration.
- ***Maximum Sound Level (L_{max}):*** see definition in noise section above and replace noise with vibration.

Following are some terms related to predicting vibration energy:

- ***Force Density Level (FDL):*** The amount of vibration energy that is generated by the train into the ground under the rail.
- ***Line Source Transfer Mobility (LSTM):*** This is a measure of much vibration energy is absorbed by the ground as on moves away from the source. It is similar to a Point Source Transfer Mobility (PSTM) but uses a line-source such as a rail instead of a point-source.
- ***Vibration Propagation Test:*** This is a non-destructive vibration test performed on the ground to estimate the LSTM of the soil. With the LSTM and measured train levels (L_v) one can estimate the train's FDL.

APPENDIX B AMBIENT NOISE MEASUREMENTS

This appendix provides information on the ambient noise measurement data. This includes data collected at/near the receivers for purposes of establishing existing noise, as well as measurements taken to help determine the levels for various noise sources in the region. ATS Consulting used class 1 sound level meters to collect 1-second A-weighted Leq data during each measurement period.

B.1 EXISTING NOISE ENVIRONMENT FOR SENSTIVE RECEIVERS

Data collected in November 2016 as part of the (AECOM 2016) is applied to this study (Sites LT-1, LT-2, ST-1, and ST-2). This data, along with data ATS Consulting collected on September 13, 2017 (Sites ST-3 and ST-4) is summarized in Table B-1. Maps of measurement locations in relation to sensitive receivers and alignment are shown in Appendix C.

Table B-1 summarizes the ambient noise levels recorded for each site along with Ldn values for the long-term (LT) measurement sites and loudest hour Leq for both the LT and short-term (ST) measurement sites. The Ldn values are a 24-hour average after a +10 dB penalty is added to noise levels recording between 10 pm and 7 am. Appendix A provides a further explanation of the Ldn. Note that Leq levels are fairly consistent over the 24-hour period. Using the LT data to determine loudest hour, a small adjustment was made to the ST-1 and ST-2 data to represent loudest hour. No adjustment was made to ST-3 and ST-4, since these were measured at a different time than the LT data.

LT-1, LT-2, ST-1, and ST-2 were all located at One Santa Fe Apartments facing the rail yard. Noise perceived at these sites include: traffic noise on Santa Fe Avenue and other local streets, HVAC noise from adjacent Metro facilities, commuter rail pass-bys, heavy freight rail pass-bys, and frequent aircraft overflights.

ST-3 was located at SCI-Arc, second floor outside facing One Santa Fe. Noise perceived at this site includes: traffic noise on Santa Fe Avenue (dominant), commuter rail pass-bys, and frequent aircraft overflights. The measurement location is shown in Figure B-1.

ST-4 was located near the corner of 6th Street and Santa Fe Avenue. Noise perceived at this site includes: traffic noise on Santa Fe Avenue (dominant) and other local streets, commuter rail pass-bys, frequent aircraft overflights, and distant construction. The measurement location is shown in Figure B-2.

Table B-1: Summary of Measured Noise Levels

	Hourly Noise Leq, dBA					
Hour	**LT-1[a]**	**LT-2[a]**	**ST-1[a]**	**ST-2[a]**	**ST-3**	**ST-4**
12 am*	54.5	60.4	—	—	—	—
1 am*	54.2	61.5	—	—	—	—
2 am*	55.7	61.2	—	—	—	—
3 am*	53.1	60.9	—	—	—	—
4 am*	54.0	58.3	—	—	—	—
5 am*	60.6	60.4	—	—	—	—
6 am*	55.6	59.6	—	—	—	—
7 am	56.7	60.3	—	—	69.5	76.4
8 am	59.0	61.9	—	—	69.4	69.8
9 am	58.6	61.4	—	—	—	—
10 am	59.3	62.1	—	—	—	—
11 am	60.5	62.9	—	60.2	—	—
12 pm	59.1	61.6	57.5	—	—	—

1 pm	59.5	63.0	—	—	—	—
2 pm	57.5	59.8	—	—	—	—
3 pm	57.7	61.0	—	—	—	—
4 pm	59.0	61.9	—	—	—	—
5 pm	60.0	62.9	—	—	—	—
6 pm	59.8	62.6	—	—	—	—
7 pm**	60.3	61.7	—	—	—	—
8 pm**	59.3	62.0	—	—	—	—
9 pm**	55.9	60.8	—	—	—	—
10 pm*	55.4	60.9	—	—	—	—
11 pm*	53.2	60.3	—	—	—	—
Ldn	65.4	68.3	—	—	—	—
CNEL	65.6	68.6	—	—	71.5[b]	78.4[b]
Loudest hour Leq	60.6	62.0	59.3[c]	62.0[c]	69.5	76.4

*When Ldn and CNEL are calculated, a +10 dB penalty is added to these hourly levels.
**When CNEL is calculated, a +5 dB penalty is added to these hourly levels.
[a] Measured by AECOM.
[b] Estimated based on the following equation: loudest hour Leq + 2 dB (FHWA Noise Measurement Handbook, assuming Ldn is a good approximation of CNEL). Since the dominant noise source at these two receivers is road noise, the FHWA estimate was applied.
[c] Adjusted to loudest hour using closest LT data.

Figure B-1: Site ST-3, Sci-ARC, Top of Stairs Measurement Position

Figure B-2: Site ST-4, 6th and Santa Fe Ave, Measurement Position Representing Southern End of Project

B.2 NOISE LEVELS FOR VARIOUS SOURCES

Noise was measured at two additional locations, in the parking lot between One Santa Fe Apartments and the Maintenance Facility as seen in Figure B-3.

Rapid transit train horns are sounded in the yard prior to vehicle movement. Several horn soundings were captured during data collection. A representative event with three short soundings was used to establish a reference SEL. Corrected to 50 feet, the SEL is 66.1 dBA.

A public address (PA) system is used throughout the train yard, mounted on light poles (estimated to be on every other light pole). Noise from the PA system at the train yard was captured during data collection. The events were extracted and averaged to obtain a representative SEL of 71.0 dBA at 50 feet. The PA system was observed to be used 4 times per hour.

Road traffic noise was measured adjacent to Santa Fe Ave. Interfering noise sources (such as train pass-by events and aircraft flyovers) were removed from the data to determine road traffic noise levels from Santa Fe Ave. at ST-3 and ST-4. Road traffic noise levels were determined to be 69.6 dBA for ST-3 (northern portion of the project) and 70.3 dBA for ST-4 (southern portion of the project), loudest hour Leq.

Aircraft noise was measured in the vicinity of One Santa Fe Apartments. Aircraft flyover events were extracted and averaged to obtain a representative SEL of 74.7 dBA that applies to the whole project area. There were 15 flyovers in one hour.

Figure B-3: Additional Short-Term Measurements in Parking Lot between Maintenance Facility and One Santa Fe Apartments

APPENDIX C SENSITIVE RECEIVER INVENTORY

C.1 TABLE OF INFORMATION FOR SENSITIVE RECEIVERS

This section describes the sensitive receivers discussed in this report. The sensitive land uses were identified within a screening area of 350 feet (one slightly farther due to direct line of site and lower noise limits) from the proposed alignment and grouped based on similar acoustic environments. Table C-1 lists information associated with each receiver and corresponding parameters used in the analysis. Table 5-1 and Table 5-2 list impacts, or lack thereof, associated with each receiver.

Table C-1: Sensitive Receiver Inventory

ID	Description	Distance to Near Track (feet) Noise[a]	Distance to Near Track (feet) Vibration[b]	FTA Category	Type[c]	Extra Elements Included in Analysis
R-1	One Santa Fe (north bldg - north end)	120 storage yard	65 storage yard	2 - residential	MF	Crossover, TPSS
R-2	One Santa Fe (north bldg - mid)	85 storage yard	10 storage yard	2 - residential	MF	Crossover, TPSS
R-3	One Santa Fe (north bldg - south end)	80 storage yard	10 storage yard	2 - residential	MF	Crossover
R-4	One Santa Fe (north bldg - south end, shielded)	105 storage yard	60 storage yard	2 - residential	MF	Crossover
R-5	One Santa Fe (south bldg - north end)	50 yard track	40 yard track	2 - residential	MF	Crossover
R-6	One Santa Fe (south bldg - mid)	50 yard track	40 yard track	2 - residential	MF	Crossover
R-7	One Santa Fe (south bldg - south end)	65 yard track	40 yard track	2 - residential	MF	Crossover
R-A	One Santa Fe, BBQ	85 storage yard	10 storage yard	3 - institutional	REC	Crossover
R-B	One Santa Fe, Pool/Spa	60 storage yard	40 storage yard	3 - institutional	REC	Crossover
R-C	Sci-Arc, 360 E 3rd St (north end)	215 storage yard	150 storage yard	3 - institutional	SC	Crossover
R-D	Sci-Arc, 360 E 3rd St (center)	260 yard track	230 yard track	3 - institutional	SC	Crossover
R-E	Sci-Arc, 360 E 3rd St (south end)	260 yard track	230 yard track	3 - institutional	SC	Crossover

ID	Description	Distance to Near Track (feet) Noise[a]	Distance to Near Track (feet) Vibration[b]	FTA Category	Type[c]	Extra Elements Included in Analysis
R-F	Willow Studios, 1350 Palmetto St	410 yard/turnback track	410 yard/turnback track	1 - studio	ST	Crossover

[a] Since noise limits are based on the accumulation of several noise sources from different tracks over time, distance applied to the near track is the average of several grouped to represent a near track, other than for ID F, where the distance applied is the nearest track. Only the closest one applied is listed, with a description of which track type to which it applies. Other distances are applied to other track types, where multiple tracks types (e.g., storage yard, yard tracks, turnback tracks, etc.) are included in the analysis.
[b] Since vibration limits are based on the maximum level, only the nearest track distance is applied, representing worst case. Only the closest one applied is listed, with a description of which track type to which it applies. Other distances are applied to other track types, where multiple tracks types (e.g., storage yard, yard tracks, turnback tracks, etc.) are included in the analysis.
[c] MF = multifamily, REC = recreational, SC = school, ST = film studio

C.2 PLAN VIEWS OF ALIGNMENT WITH SENSITIVE RECEIVERS AND MEASUREMENT SITES

This section contains maps of the project area near noise and vibration sensitive receivers. Sensitive receivers and measurement sites are indicated.

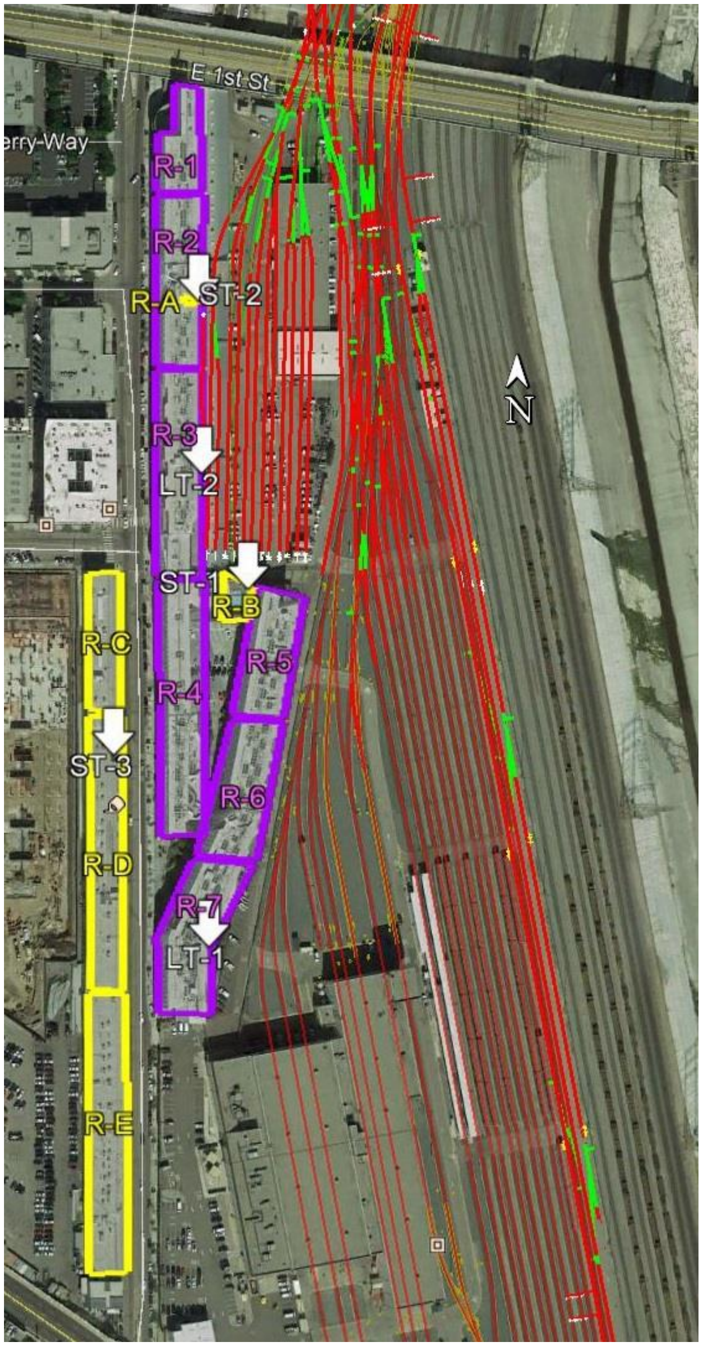


Figure C-1: Sensitive Receivers and Measurement Locations (Northern Portion)

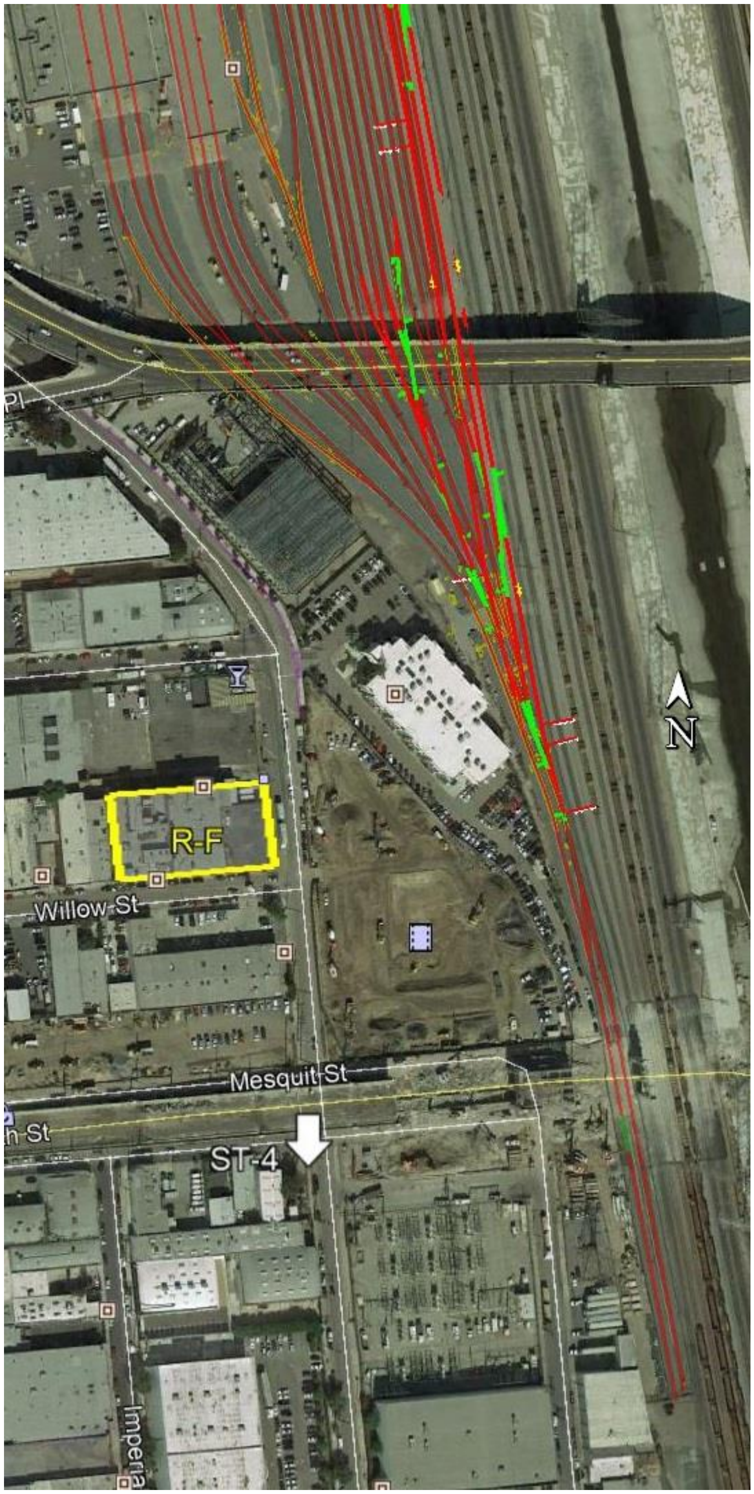


Figure C-2: Sensitive Receivers and Measurement Locations (Southern Portion)

APPENDIX D MITIGATION FOR SWITCHES

The banging that occurs when transit car wheels pass through switches is generally found to increase groundborne vibration and noise levels. Almost all of the increase in groundborne vibration and airborne noise occurs as the wheels pass through frogs. There are several alternatives to typical rail-bound manganese (RBM) frogs that will result in lower vibration and noise levels:

RBM frogs: The common rail-bound manganese (RBM) frog is designed for main line freight track but is often used on transit systems. Wheel impacts as wheels cross the gap in the rail and when wheels hit the frog point typically increase noise levels by approximately 6 dBA and vibration levels by approximately 10 VdB. The actual increase will depend on the condition of the frog, how smoothly the wheel load is transferred from one side of the rail gap to the other, whether the movement over the frog is a straight-through or diverting move and the distance from the frog. Conceptually, higher number frogs have a smaller angle between the rails and the transition over the gap is distributed over a greater distance, so the additional noise and vibration levels should be lower. We are not aware of any measurement results that confirm that higher number frogs generate less noise and vibration than lower number frogs. A low-noise/vibration option for RBM frogs is to design one with a conformal top. This reduces the changes in elevation of the vehicle axle by producing a top running surface that mimics the wheel contact patch as much as possible.

Monoblock frogs: Monoblock frogs are basically milled out of a single block of steel. Because they are machined rather than cast, the tolerances can be tighter. Monoblock frogs are generally thought to create less noise and vibration than RBM frogs. Based on informal measurement that ATS performed at the PATH commuter rail system in New Jersey, it appears that the increase in noise and vibration levels with a good-condition monoblock frog is about half of that with a standard RBM frog. For extra measure, a monoblock frog can be designed with a conformal top. This reduces the changes in elevation of the vehicle axle by producing a top running surface that mimics the wheel contact patch as much as possible.

Flange-bearing frogs: Well-designed and maintained, flange-bearing frogs can generate much less noise and vibration than standard RBM frogs. If the ramps are too short and/or the frogs are not properly maintained, the noise and vibration benefits may be marginal. The recommended length of the ramp in the frog is a minimum of 2 feet. AREMA standards suggest a speed limit of 24 km/h for flange-bearing frogs on transit systems, so special approval may be necessary to operate at higher speeds if a flange-bearing frog is used,

One-way low-speed (OWL) frogs: OWL frogs are designed for use when traffic in the diverting direction is infrequent and low speed. Most OWL designs are flange bearing in the diverting direction and have no break in the rail in the main line direction. These are often referred to as “jump frogs” because in the diverting direction the wheels are lifted up and over the rail with some form of flange-bearing ramps. A Vossloh representative said that the cost of their OWL is about $3,000 more than a standard RBM frog and about the same as a monoblock frog. Because the rail is solid in the main line direction, there would be little or no increase in noise and vibration. Vossloh, Progress Rail and Nortrak all have variants of OWL jump frogs.

Spring rail and moveable point frogs: These frogs can be substantially more expensive in terms of parts, installation and maintenance. When properly designed, installed and maintained, there can be only a marginal increase in noise and vibration levels with spring rail and moveable point frogs.

APPENDIX E CONSTRUCTION NOISE AND VIBRATION PREDICTIONS

This appendix provides detailed information on the construction noise and vibration predictions. Section E.1 tabulates the Lmax and Leq noise levels at each receiver for each construction or demolition operation, broken into phases (where applicable). Results are shown for individual pieces of machinery as well as an energy-summed total for each operation/phase. Noise predictions were generated using the FHWA's Roadway Noise Construction Model (RCNM) and are presented in A-weighted decibels (dBA).

Section E.2 tabulates the PPV (in/sec) and Lv (VdB) vibration levels at each receiver for each construction or demolition operation, broken into phases (where applicable). Results are shown for individual pieces of machinery as well as the maximum value for each operation/phase. Vibration predictions were generated using reference values from the FTA Guidance 2006 and Dowding 2009. Reference vibration values for the equipment pieces in use are available in Table 7-9.

E.1 NOISE PREDICTIONS

Table E-1: Building Demolition Noise Predictions for Category 2 Receivers

	One Santa Fe North Bldg (1)		**One Santa Fe North Bldg (2)**		**One Santa Fe North Bldg (3)**		**One Santa Fe North Bldg (4)[a]**		**One Santa Fe South Bldg (5)**		**One Santa Fe South Bldg (6)[b]**		**One Santa Fe South Bldg (7)[b]**	
	12 ft[c]		**12 ft[c]**		**12 ft[c]**		**12 ft[c]**		**57 ft**		**246 ft**		**488 ft**	
Equipment	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**
Excavator	93.1	89.1	93.1	89.1	93.1	89.1	78.1	74.1	79.6	75.6	61.9	57.9	55.9	51.9
Backhoe	90	86	90	86	90	86	75	71	76.4	72.4	58.7	54.7	52.8	48.8
Front End Loader	91.5	87.5	91.5	87.5	91.5	87.5	76.5	72.5	78	74	60.3	56.3	54.3	50.3
Dump Truck	88.8	84.9	88.8	84.9	88.8	84.9	73.8	69.9	75.3	71.3	57.6	53.6	51.7	47.7
Mounted Impact Hammer	102.7	95.7	102.7	95.7	102.7	95.7	87.7	80.7	89.1	82.2	71.4	64.5	65.5	58.5
Shears (on backhoe)	108.6	104.6	108.6	104.6	108.6	104.6	93.6	89.6	95.1	91.1	77.4	73.4	71.4	67.4
Grapple (on backhoe)	99.4	95.4	99.4	95.4	99.4	95.4	84.4	80.4	85.9	81.9	68.2	64.2	62.2	58.2
Dozer	94.1	90.1	94.1	90.1	94.1	90.1	79.1	75.1	80.5	76.6	62.8	58.9	56.9	52.9
TOTAL	**108.6**	**105.9**	**108.6**	**105.9**	**108.6**	**105.9**	**93.6**	**90.9**	**95.1**	**92.4**	**77.4**	**74.7**	**71.4**	**68.8**

Note: Lmax and Leq values are dBA

[a] 15dBA shielding factor added - RCNM user's guide recommends this factor "if a building stands between the noise source and receiver and completely shields the noise source."
[b] 5dBA shielding factor added - RCNM user's guide recommends this factor "if the noise source is… completely shielded with a solid barrier… [which] has some gaps in it."
[c] Vertical distance to nearest residential unit is used for locations where horizontal distance is 0 feet.

Table E-2: Building Demolition Noise Predictions for Category 1 & 3 Receivers

	One Santa Fe BBQ (A)		One Santa Fe Pool/Spa (B)		SCI-Arc North End (C)[a]		SCI-Arc Middle (D)[a]		SCI-Arc South End (E)[a]		Willow Studios (F)	
	24 ft[c]		24 ft[c]		143 ft		293 ft		730 ft		n/a	
Equipment	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**
Excavator	87.1	83.1	87.1	83.1	61.6	57.6	55.4	51.4	47.4	43.4	-	-
Backhoe	83.9	80	83.9	80	58.4	54.5	52.2	48.2	44.3	40.3	-	-
Front End Loader	85.5	81.5	85.5	81.5	60	56	53.8	49.8	45.8	41.8	-	-
Dump Truck	82.8	78.8	82.8	78.8	57.3	53.3	51.1	47.1	43.2	39.2	-	-
Mounted Impact Hammer	96.7	89.7	96.7	89.7	71.2	64.2	64.9	57.9	57	50	-	-
Shears (on backhoe)	102.6	98.6	102.6	98.6	77.1	73.1	70.8	66.9	62.9	58.9	-	-
Grapple (on backhoe)	93.4	89.4	93.4	89.4	67.9	63.9	61.6	57.7	53.7	49.7	-	-
Dozer	88	84.1	88	84.1	62.5	58.6	56.3	52.3	48.4	44.4	-	-
TOTAL	**102.6**	**99.9**	**102.6**	**99.9**	**77.1**	**74.4**	**70.8**	**68.2**	**62.9**	**60.3**	**-**	**-**

Note: Lmax and Leq values are dBA

[a] 15dBA shielding factor added - RCNM user's guide recommends this factor "if a building stands between the noise source and receiver and completely shields the noise source."
[b] 5dBA shielding factor added - RCNM user's guide recommends this factor "if the noise source is… completely shielded with a solid barrier… [which] has some gaps in it."
[c] Vertical distance to receiver is used for locations where horizontal distance is 0 feet.

Table E-3: Concrete Demolition Noise Predictions for Category 2 Receivers

	One Santa Fe North Bldg (1)		One Santa Fe North Bldg (2)		One Santa Fe North Bldg (3)		One Santa Fe North Bldg (4)[a]		One Santa Fe South Bldg (5)		One Santa Fe South Bldg (6)[b]		One Santa Fe South Bldg (7)[b]	
	24 ft[c]		24 ft[c]		24 ft[c]		24 ft[c]		24 ft		246 ft		488 ft	
Equipment	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**
Jackhammer	95.3	88.3	95.3	88.3	95.3	88.3	80.3	73.3	95.3	88.3	70.1	63.1	64.1	57.1
Concrete Saw	96	89	96	89	96	89	81	74	96	89	70.7	63.8	64.8	57.8
Mounted Impact Hammer (hoe ram)	96.7	89.7	96.7	89.7	96.7	89.7	81.7	74.7	96.7	89.7	71.4	64.5	65.5	58.5
Hydra Break Ram	96.4	86.4	96.4	86.4	96.4	86.4	81.4	71.4	96.4	86.4	71.2	61.2	65.2	55.2
Pavement Scarafier	95.9	88.9	95.9	88.9	95.9	88.9	80.9	73.9	95.9	88.9	70.7	63.7	64.7	57.7
Front End Loader	85.5	81.5	85.5	81.5	85.5	81.5	70.5	66.5	85.5	81.5	60.3	56.3	54.3	50.3
Dump Truck	82.8	78.8	82.8	78.8	82.8	78.8	67.8	63.8	82.8	78.8	57.6	53.6	51.7	47.7

	One Santa Fe North Bldg (1)		One Santa Fe North Bldg (2)		One Santa Fe North Bldg (3)		One Santa Fe North Bldg (4)[a]		One Santa Fe South Bldg (5)		One Santa Fe South Bldg (6)[b]		One Santa Fe South Bldg (7)[b]	
	24 ft[c]		24 ft[c]		24 ft[c]		24 ft[c]		24 ft		246 ft		488 ft	
Equipment	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**
Grapple (on backhoe)	93.4	89.4	93.4	89.4	93.4	89.4	78.4	74.4	93.4	89.4	68.2	64.2	62.2	58.2
Backhoe	83.9	80	83.9	80	83.9	80	68.9	65	83.9	80	58.7	54.7	52.8	48.8
TOTAL	**96.7**	**96.8**	**96.7**	**96.8**	**96.7**	**96.8**	**81.7**	**81.8**	**96.7**	**96.8**	**71.4**	**71.6**	**65.5**	**65.6**

Note: Lmax and Leq values are dBA

[a] 15dBA shielding factor added - RCNM user's guide recommends this factor "if a building stands between the noise source and receiver and completely shields the noise source."
[b] 5dBA shielding factor added - RCNM user's guide recommends this factor "if the noise source is… completely shielded with a solid barrier… [which] has some gaps in it."
[c] Vertical distance to nearest residential unit is used for locations where horizontal distance is 0 feet.

Table E-4: Concrete Demolition Noise Predictions for Category 1 & 3 Receivers

	One Santa Fe BBQ (A)		One Santa Fe Pool/Spa (B)		SCI-Arc North End (C)[a]		SCI-Arc Middle (D)[a]		SCI-Arc South End (E)[a]		Willow Studios (F)	
	36 ft[c]		36 ft[c]		143 ft		293 ft		730 ft		n/a	
Equipment	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**
Jackhammer	91.7	84.8	91.7	84.8	64.8	57.8	58.5	51.5	50.6	43.6	-	-
Concrete Saw	92.4	85.4	92.4	85.4	65.5	58.5	59.2	52.2	51.3	44.3	-	-
Mounted Impact Hammer (hoe ram)	93.1	86.1	93.1	86.1	66.2	59.2	59.9	52.9	52	45	-	-
Hydra Break Ram	92.9	82.9	92.9	82.9	65.9	55.9	59.6	49.6	51.7	41.7	-	-
Pavement Scarafier	92.4	85.4	92.4	85.4	65.4	58.4	59.1	52.2	51.2	44.2	-	-
Front End Loader	82	78	82	78	55	51	48.8	44.8	40.8	36.8	-	-
Dump Truck	79.3	75.3	79.3	75.3	52.3	48.3	46.1	42.1	38.2	34.2	-	-
Grapple (on backhoe)	89.9	85.9	89.9	85.9	62.9	58.9	56.6	52.7	48.7	44.7	-	-
Backhoe	80.4	76.4	80.4	76.4	53.4	49.5	47.2	43.2	39.3	35.3	-	-
TOTAL	**93.1**	**93.3**	**93.1**	**93.3**	**66.2**	**66.3**	**59.9**	**60.1**	**52**	**52.1**	**-**	**-**

Note: Lmax and Leq values are dBA

[a] 15dBA shielding factor added - RCNM user's guide recommends this factor "if a building stands between the noise source and receiver and completely shields the noise source."
[b] 5dBA shielding factor added - RCNM user's guide recommends this factor "if the noise source is… completely shielded with a solid barrier… [which] has some gaps in it."

	One Santa Fe BBQ (A)		One Santa Fe Pool/Spa (B)		SCI-Arc North End (C)[a]		SCI-Arc Middle (D)[a]		SCI-Arc South End (E)[a]		Willow Studios (F)	
	36 ft[c]		36 ft[c]		143 ft		293 ft		730 ft		n/a	
Equipment	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**

[c] Vertical distance to receiver is used for locations where horizontal distance is 0 feet.

Table E-5: Asphalt Road Construction Noise Predictions for Category 2 Receivers

	One Santa Fe North Bldg (1)		One Santa Fe North Bldg (2)		One Santa Fe North Bldg (3)		One Santa Fe North Bldg (4)[a]		One Santa Fe South Bldg (5)		One Santa Fe South Bldg (6)[b]		One Santa Fe South Bldg (7)[b]	
	52 ft		131 ft		416 ft		770 ft		770 ft		998 ft		1238 ft	
Equipment	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**
Scraper	83.2	79.3	75.2	71.2	65.2	61.2	44.8	40.9	59.8	55.9	52.6	48.6	50.7	46.7
Dozer	81.3	77.3	73.3	69.3	63.3	59.3	42.9	38.9	57.9	53.9	50.7	46.7	48.8	44.8
Grader	84.7	80.7	76.6	72.7	66.6	62.6	46.2	42.3	61.2	57.3	54	50	52.1	48.1
Front End Loader	78.8	74.8	70.7	66.8	60.7	56.7	40.4	36.4	55.4	51.4	48.1	44.1	46.2	42.3
Phase 1 SUBTOTAL	**84.7**	**84.6**	**76.6**	**76.5**	**66.6**	**66.5**	**46.2**	**46.1**	**61.2**	**61.1**	**54**	**53.9**	**52.1**	**52**
Compactor (ground)	82.9	75.9	74.9	67.9	64.8	57.8	44.5	37.5	59.5	52.5	52.2	45.2	50.4	43.4
Roller	79.7	72.7	71.6	64.6	61.6	54.6	41.2	34.3	56.2	49.3	49	42	47.1	40.1
Paver	76.9	73.9	68.9	65.8	58.8	55.8	38.5	35.5	53.5	50.5	46.2	43.2	44.3	41.3
Drum Mixer	79.7	76.6	71.6	68.6	61.6	58.6	41.2	38.2	56.2	53.2	49	46	47.1	44.1
Phase 2 SUBTOTAL	**82.9**	**81.1**	**74.9**	**73**	**64.8**	**63**	**44.5**	**42.7**	**59.5**	**57.7**	**52.2**	**50.4**	**50.4**	**48.5**

Note: Lmax and Leq values are dBA

[a] 15dBA shielding factor added - RCNM user's guide recommends this factor "if a building stands between the noise source and receiver and completely shields the noise source."
[b] 5dBA shielding factor added - RCNM user's guide recommends this factor "if the noise source is… completely shielded with a solid barrier… [which] has some gaps in it."

Table E-6: Asphalt Road Construction Noise Predictions for Category 1 & 3 Receivers

	One Santa Fe BBQ (A)		One Santa Fe Pool/Spa (B)		SCI-Arc North End (C)[a]		SCI-Arc Middle (D)[a]		SCI-Arc South End (E)[a]		Willow Studios (F)	
	302 ft		753 ft		776 ft		1015 ft		1475 ft		n/a	
Equipment	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**
Scraper	68	64	60	56	44.8	40.8	42.4	38.5	39.2	35.2	-	-
Dozer	66	62.1	58.1	54.1	42.9	38.9	40.5	36.5	37.3	33.3	-	-

	One Santa Fe BBQ (A)		One Santa Fe Pool/Spa (B)		SCI-Arc North End (C)[a]		SCI-Arc Middle (D)[a]		SCI-Arc South End (E)[a]		Willow Studios (F)	
	302 ft		753 ft		776 ft		1015 ft		1475 ft		n/a	
Equipment	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**
Grader	69.4	65.4	61.4	57.5	46.2	42.2	43.9	39.9	40.6	36.6	-	-
Front End Loader	63.5	59.5	55.6	51.6	40.3	36.3	38	34	34.7	30.7	-	-
Phase 1 SUBTOTAL	**69.4**	**69.3**	**61.4**	**61.3**	**46.2**	**46.1**	**43.9**	**43.8**	**40.6**	**40.5**	**-**	**-**
Compactor (ground)	67.6	60.6	59.7	52.7	44.4	37.4	42.1	35.1	38.8	31.8	-	-
Roller	64.4	57.4	56.4	49.5	41.2	34.2	38.9	31.9	35.6	28.6	-	-
Paver	61.6	58.6	53.7	50.7	38.4	35.4	36.1	33.1	32.8	29.8	-	-
Drum Mixer	64.4	61.4	56.4	53.4	41.2	38.2	38.9	35.8	35.6	32.6	-	-
Phase 2 SUBTOTAL	**67.6**	**65.8**	**59.7**	**57.9**	**44.4**	**42.6**	**42.1**	**40.3**	**38.8**	**37**	**-**	**-**

Note: Lmax and Leq values are dBA

[a] 15dBA shielding factor added - RCNM user's guide recommends this factor "if a building stands between the noise source and receiver and completely shields the noise source."
[b] 5dBA shielding factor added - RCNM user's guide recommends this factor "if the noise source is… completely shielded with a solid barrier… [which] has some gaps in it."

Table E-7: Storage Track Construction Noise Predictions for Category 2 Receivers

	One Santa Fe North Bldg (1)		One Santa Fe North Bldg (2)		One Santa Fe North Bldg (3)		One Santa Fe North Bldg (4)[a]		One Santa Fe South Bldg (5)		One Santa Fe South Bldg (6)[b]		One Santa Fe South Bldg (7)[b]	
	65 ft		5 ft		5 ft		60 ft		65 ft		281 ft		520 ft	
Equipment	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**
Backhoe	75.3	71.3	97.6	93.6	97.6	93.6	61	57	75.3	71.3	57.6	53.6	52.2	48.2
Grapple (on backhoe)	84.7	80.7	107	103	107	103	70.4	66.4	84.7	80.7	67	63	61.7	57.7
Excavator	78.4	74.5	100.7	96.7	100.7	96.7	64.1	60.1	78.4	74.5	60.7	56.7	55.4	51.4
Compactor (ground)	81	74	103.2	96.2	103.2	96.2	66.6	59.7	81	74	63.2	56.2	57.9	50.9
Phase 1 SUBTOTAL	**84.7**	**82.7**	**107**	**104.9**	**107**	**104.9**	**70.4**	**68.4**	**84.7**	**82.7**	**67**	**65**	**61.7**	**59.6**
Dump Truck	74.2	70.2	96.5	92.5	96.5	92.5	59.9	55.9	74.2	70.2	56.5	52.5	51.1	47.1
Dozer	79.4	75.4	101.7	97.7	101.7	97.7	65.1	61.1	79.4	75.4	61.7	57.7	56.3	52.3
Welder / Torch	71.7	67.7	94	90	94	90	57.4	53.4	71.7	67.7	54	50	48.7	44.7
Roller	77.7	70.7	100	93	100	93	63.4	56.4	77.7	70.7	60	53	54.7	47.7
Phase 2 SUBTOTAL	**79.4**	**78**	**101.7**	**100.3**	**101.7**	**100.3**	**65.1**	**63.7**	**79.4**	**78**	**61.7**	**60.3**	**56.3**	**54.9**

Note: Lmax and Leq values are dBA

	One Santa Fe North Bldg (1)		One Santa Fe North Bldg (2)		One Santa Fe North Bldg (3)		One Santa Fe North Bldg (4)[a]		One Santa Fe South Bldg (5)		One Santa Fe South Bldg (6)[b]		One Santa Fe South Bldg (7)[b]	
	65 ft		5 ft		5 ft		60 ft		65 ft		281 ft		520 ft	
Equipment	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**

[a] 15dBA shielding factor added - RCNM user's guide recommends this factor "if a building stands between the noise source and receiver and completely shields the noise source."
[b] 5dBA shielding factor added - RCNM user's guide recommends this factor "if the noise source is… completely shielded with a solid barrier… [which] has some gaps in it."

Table E-8: Storage Track Construction Noise Predictions for Category 1 & 3 Receivers

	One Santa Fe BBQ (A)		One Santa Fe Pool/Spa (B)		SCI-Arc North End (C)[a]		SCI-Arc Middle (D)[a]		SCI-Arc South End (E)[a]		Willow Studios (F)	
	5 ft		40 ft		150 ft		320 ft		765 ft		n/a	
Equipment	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**
Backhoe	97.6	93.6	79.5	75.5	53	49	46.4	42.5	38.9	34.9	-	-
Grapple (on backhoe)	107	103	88.9	85	62.5	58.5	55.9	51.9	48.3	44.3	-	-
Excavator	100.7	96.7	82.6	78.7	56.2	52.2	49.6	45.6	42	38	-	-
Compactor (ground)	103.2	96.2	85.2	78.2	58.7	51.7	52.1	45.1	44.5	37.5	-	-
Phase 1 SUBTOTAL	**107**	**104.9**	**88.9**	**86.9**	**62.5**	**60.4**	**55.9**	**53.8**	**48.3**	**46.3**	**-**	**-**
Dump Truck	96.5	92.5	78.4	74.4	51.9	47.9	45.3	41.3	37.8	33.8	-	-
Dozer	101.7	97.7	83.6	79.6	57.1	53.1	50.5	46.6	43	39	-	-
Welder / Torch	94	90	75.9	72	49.5	45.5	42.9	38.9	35.3	31.3	-	-
Roller	100	93	81.9	74.9	55.5	48.5	48.9	41.9	41.3	34.3	-	-
Phase 2 SUBTOTAL	**101.7**	**100.3**	**83.6**	**82.2**	**57.1**	**55.7**	**50.5**	**49.1**	**43**	**41.6**	**-**	**-**

Note: Lmax and Leq values are dBA

[a] 15dBA shielding factor added - RCNM user's guide recommends this factor "if a building stands between the noise source and receiver and completely shields the noise source."
[b] 5dBA shielding factor added - RCNM user's guide recommends this factor "if the noise source is… completely shielded with a solid barrier… [which] has some gaps in it."

Table E-9: Yard Track Construction Noise Predictions for Category 2 Receivers

	One Santa Fe North Bldg (1)		One Santa Fe North Bldg (2)		One Santa Fe North Bldg (3)		One Santa Fe North Bldg (4)[a]		One Santa Fe South Bldg (5)		One Santa Fe South Bldg (6)		One Santa Fe South Bldg (7)	
	200 ft		230 ft		225 ft		220 ft		60 ft		130 ft		257 ft	
Equipment	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**
Backhoe	65.5	61.5	64.3	60.3	64.5	60.5	49.7	45.7	76	72	69.3	65.3	63.3	59.4
Grapple (on backhoe)	75	71	73.7	69.8	73.9	70	59.1	55.2	85.4	81.4	78.7	74.7	72.8	68.8
Excavator	68.7	64.7	67.5	63.5	67.6	63.7	52.8	48.9	79.1	75.1	72.4	68.4	66.5	62.5
Compactor (ground)	71.2	64.2	70	63	70.2	63.2	55.4	48.4	81.6	74.7	74.9	67.9	69	62
Phase 1 SUBTOTAL	**75**	**72.9**	**73.7**	**71.7**	**73.9**	**71.9**	**59.1**	**57.1**	**85.4**	**83.4**	**78.7**	**76.6**	**72.8**	**70.7**
Dump Truck	64.4	60.4	63.2	59.2	63.4	59.4	48.6	44.6	74.9	70.9	68.2	64.2	62.2	58.3
Dozer	69.6	65.6	68.4	64.4	68.6	64.6	53.8	49.8	80.1	76.1	73.4	69.4	67.5	63.5
Welder / Torch	62	58	60.7	56.8	60.9	57	46.1	42.2	72.4	68.4	65.7	61.7	59.8	55.8
Roller	68	61	66.7	59.8	66.9	59.9	52.1	45.1	78.4	71.4	71.7	64.7	65.8	58.8
Phase 2 SUBTOTAL	**69.6**	**68.2**	**68.4**	**67**	**68.6**	**67.2**	**53.8**	**52.4**	**80.1**	**78.7**	**73.4**	**72**	**67.5**	**66.1**

Note: Lmax and Leq values are dBA

[a] 15dBA shielding factor added - RCNM user's guide recommends this factor "if a building stands between the noise source and receiver and completely shields the noise source."

Table E-10: Yard Track Construction Noise Predictions for Category 1 & 3 Receivers

	One Santa Fe BBQ (A)		One Santa Fe Pool/Spa (B)		SCI-Arc North End (C)[a]		SCI-Arc Middle (D)[a]		SCI-Arc South End (E)[a]		Willow Studios (F)	
	230 ft		120 ft		340 ft		400 ft		560 ft		415 ft	
Equipment	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**
Backhoe	64.3	60.3	70	66	45.9	41.9	44.5	40.5	41.6	37.6	59.2	55.2
Grapple (on backhoe)	73.7	69.8	79.4	75.4	55.3	51.4	53.9	50	51	47	68.6	64.6
Excavator	67.5	63.5	73.1	69.1	49.1	45.1	47.6	43.7	44.7	40.7	62.3	58.3
Compactor (ground)	70	63	75.6	68.6	51.6	44.6	50.2	43.2	47.2	40.3	64.8	57.9
Phase 1 SUBTOTAL	**73.7**	**71.7**	**79.4**	**77.3**	**55.3**	**53.3**	**53.9**	**51.9**	**51**	**49**	**68.6**	**66.6**
Dump Truck	63.2	59.2	68.8	64.9	44.8	40.8	43.4	39.4	40.5	36.5	58.1	54.1
Dozer	68.4	64.4	74.1	70.1	50	46	48.6	44.6	45.7	41.7	63.3	59.3
Welder / Torch	60.7	56.8	66.4	62.4	42.3	38.4	40.9	37	38	34	55.6	51.6
Roller	66.7	59.8	72.4	65.4	48.3	41.4	46.9	39.9	44	37	61.6	54.6
Phase 2 SUBTOTAL	**68.4**	**67**	**74.1**	**72.7**	**50**	**48.6**	**48.6**	**47.2**	**45.7**	**44.3**	**63.3**	**61.9**

Note: Lmax and Leq values are dBA

	One Santa Fe BBQ (A)		One Santa Fe Pool/Spa (B)		SCI-Arc North End (C)[a]		SCI-Arc Middle (D)[a]		SCI-Arc South End (E)[a]		Willow Studios (F)	
	230 ft		120 ft		340 ft		400 ft		560 ft		415 ft	
Equipment	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**	**Lmax**	**Leq**

[a] 15dBA shielding factor added - RCNM user's guide recommends this factor "if a building stands between the noise source and receiver and completely shields the noise source."
[b] 5dBA shielding factor added - RCNM user's guide recommends this factor "if the noise source is… completely shielded with a solid barrier… [which] has some gaps in it."

E.2 VIBRATION PREDICTIONS

Table E-11: Building Demolition Vibration Predictions for Category 2 Receivers

	One Santa Fe North Bldg (1)		One Santa Fe North Bldg (2)		One Santa Fe North Bldg (3)		One Santa Fe North Bldg (4)		One Santa Fe South Bldg (5)		One Santa Fe South Bldg (6)		One Santa Fe South Bldg (7)	
	5 ft[a]		5 ft[a]		5 ft[a]		5 ft[a]		57 ft		246 ft		488 ft	
Equipment	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**
Excavator	0.980	108.0	0.980	108.0	0.980	108.0	0.980	108.0	0.025	76.3	0.003	57.2	0.001	48.3
Backhoe	0.980	108.0	0.980	108.0	0.980	108.0	0.980	108.0	0.025	76.3	0.003	57.2	0.001	48.3
Front End Loader	0.032	79.0	0.032	79.0	0.032	79.0	0.032	79.0	0.001	47.3	0.000	28.2	0.000	19.3
Dump Truck	0.854	107.0	0.854	107.0	0.854	107.0	0.854	107.0	0.022	75.3	0.002	56.2	0.001	47.3
Mounted Impact Hammer	0.980	108.0	0.980	108.0	0.980	108.0	0.980	108.0	0.025	76.3	0.003	57.2	0.001	48.3
Shears (on backhoe)	0.980	108.0	0.980	108.0	0.980	108.0	0.980	108.0	0.025	76.3	0.003	57.2	0.001	48.3
Grapple (on backhoe)	0.980	108.0	0.980	108.0	0.980	108.0	0.980	108.0	0.025	76.3	0.003	57.2	0.001	48.3
Dozer	0.980	108.0	0.980	108.0	0.980	108.0	0.980	108.0	0.025	76.3	0.003	57.2	0.001	48.3
MAXIMUM	**0.980**	**108.0**	**0.980**	**108.0**	**0.980**	**108.0**	**0.980**	**108.0**	**0.025**	**76.3**	**0.003**	**57.2**	**0.001**	**48.3**

Note: PPV values are in/sec and Lv values are VdB
[a] A distance of 5 feet is used for operations where the source is immediately adjacent to the receiver

Table E-12: Building Demolition Vibration Predictions for Category 1 & 3 Receivers

	One Santa Fe BBQ (A)		One Santa Fe Pool/Spa (B)		SCI-Arc North End (C)		SCI-Arc Middle (D)		SCI-Arc South End (E)		Willow Studios (F)	
	5 ft[a]		5 ft[a]		143 ft		293 ft		730 ft		n/a	
Equipment	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**
Excavator	0.980	108.0	0.980	108.0	0.006	64.3	0.002	55.0	0.001	43.1	-	-
Backhoe	0.980	108.0	0.980	108.0	0.006	64.3	0.002	55.0	0.001	43.1	-	-
Front End Loader	0.032	79.0	0.032	79.0	0.000	35.3	0.000	26.0	0.000	14.1	-	-
Dump Truck	0.854	107.0	0.854	107.0	0.006	63.3	0.002	54.0	0.000	42.1	-	-
Mounted Impact Hammer	0.980	108.0	0.980	108.0	0.006	64.3	0.002	55.0	0.001	43.1	-	-
Shears (on backhoe)	0.980	108.0	0.980	108.0	0.006	64.3	0.002	55.0	0.001	43.1	-	-
Grapple (on backhoe)	0.980	108.0	0.980	108.0	0.006	64.3	0.002	55.0	0.001	43.1	-	-
Dozer	0.980	108.0	0.980	108.0	0.006	64.3	0.002	55.0	0.001	43.1	-	-
MAXIMUM	**0.980**	**108.0**	**0.980**	**108.0**	**0.006**	**64.3**	**0.002**	**55.0**	**0.001**	**43.1**	**-**	**-**

Note: PPV values are in/sec and Lv values are VdB
[a] A distance of 5 feet is used for operations where the source is immediately adjacent to the receiver

Table E-13: Concrete Demolition Vibration Predictions for Category 2 Receivers

	One Santa Fe North Bldg (1)		One Santa Fe North Bldg (2)		One Santa Fe North Bldg (3)		One Santa Fe North Bldg (4)		One Santa Fe South Bldg (5)		One Santa Fe South Bldg (6)		One Santa Fe South Bldg (7)	
	5 ft[a]		5 ft[a]		5 ft[a]		5 ft[a]		24 ft		246 ft		488 ft	
Equipment	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**
Jackhammer	0.379	100.0	0.379	100.0	0.379	100.0	0.379	100.0	0.036	79.6	0.001	49.2	0.000	40.3
Concrete Saw	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mounted Impact Hammer	0.980	108.0	0.980	108.0	0.980	108.0	0.980	108.0	0.093	87.6	0.003	57.2	0.001	48.3
Hydra Break Ram	1.644	112.3	1.644	112.3	1.644	112.3	1.644	112.3	0.156	91.8	0.005	61.5	0.002	52.6
Pavement Scarafier	1.644	112.3	1.644	112.3	1.644	112.3	1.644	112.3	0.156	91.8	0.005	61.5	0.002	52.6

	One Santa Fe North Bldg (1)		One Santa Fe North Bldg (2)		One Santa Fe North Bldg (3)		One Santa Fe North Bldg (4)		One Santa Fe South Bldg (5)		One Santa Fe South Bldg (6)		One Santa Fe South Bldg (7)	
	5 ft[a]		5 ft[a]		5 ft[a]		5 ft[a]		24 ft		246 ft		488 ft	
Equipment	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**
Front End Loader	0.032	79.0	0.032	79.0	0.032	79.0	0.032	79.0	0.003	58.6	0.000	28.2	0.000	19.3
Dump Truck	0.854	107.0	0.854	107.0	0.854	107.0	0.854	107.0	0.081	86.6	0.002	56.2	0.001	47.3
Grapple (on backhoe)	0.980	108.0	0.980	108.0	0.980	108.0	0.980	108.0	0.093	87.6	0.003	57.2	0.001	48.3
Backhoe	0.980	108.0	0.980	108.0	0.980	108.0	0.980	108.0	0.093	87.6	0.003	57.2	0.001	48.3
MAXIMUM	**1.644**	**112.3**	**1.644**	**112.3**	**1.644**	**112.3**	**1.644**	**112.3**	**0.156**	**91.8**	**0.005**	**61.5**	**0.002**	**52.6**

Note: PPV values are in/sec and Lv values are VdB
[a] A distance of 5 feet is used for operations where the source is immediately adjacent to the receiver

Table E-14: Concrete Demolition Vibration Predictions for Category 1 & 3 Receivers

	One Santa Fe BBQ (A)		One Santa Fe Pool/Spa (B)		SCI-Arc North End (C)		SCI-Arc Middle (D)		SCI-Arc South End (E)		Willow Studios (F)	
	5 ft[a]		5 ft[a]		143 ft		293 ft		730 ft		n/a	
Equipment	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**
Jackhammer	0.379	100.0	0.379	100.0	0.002	56.3	0.001	47.0	0.000	35.1	-	-
Concrete Saw	-	-	-	-	-	-	-	-	-	-	-	-
Mounted Impact Hammer	0.980	108.0	0.980	108.0	0.006	64.3	0.002	55.0	0.001	43.1	-	-
Hydra Break Ram	1.644	112.3	1.644	112.3	0.011	68.6	0.004	59.2	0.001	47.3	-	-
Pavement Scarafier	1.644	112.3	1.644	112.3	0.011	68.6	0.004	59.2	0.001	47.3	-	-
Front End Loader	0.032	79.0	0.032	79.0	0.000	35.3	0.000	26.0	0.000	14.1	-	-
Dump Truck	0.854	107.0	0.854	107.0	0.006	63.3	0.002	54.0	0.000	42.1	-	-
Grapple (on backhoe)	0.980	108.0	0.980	108.0	0.006	64.3	0.002	55.0	0.001	43.1	-	-
Backhoe	0.980	108.0	0.980	108.0	0.006	64.3	0.002	55.0	0.001	43.1	**-**	**-**
MAXIMUM	**0.980**	**108.0**	**0.980**	**108.0**	**0.006**	**64.3**	**0.002**	**55.0**	**0.001**	**43.1**	**-**	**-**

Note: PPV values are in/sec and Lv values are VdB

	One Santa Fe BBQ (A)		One Santa Fe Pool/Spa (B)		SCI-Arc North End (C)		SCI-Arc Middle (D)		SCI-Arc South End (E)		Willow Studios (F)	
	5 ft[a]		5 ft[a]		143 ft		293 ft		730 ft		n/a	
Equipment	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**
[a] A distance of 5 feet is used for operations where the source is immediately adjacent to the receiver												

Table E-15: Asphalt Road Construction Vibration Predictions for Category 2 Receivers

	One Santa Fe North Bldg (1)		One Santa Fe North Bldg (2)		One Santa Fe North Bldg (3)		One Santa Fe North Bldg (4)		One Santa Fe South Bldg (5)		One Santa Fe South Bldg (6)		One Santa Fe South Bldg (7)	
	52 ft		131 ft		416 ft		770 ft		770 ft		998 ft		1238 ft	
Equipment	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**
Scraper	0.029	77.5	0.007	65.5	0.001	50.4	0.001	42.4	0.001	42.4	0.000	39.0	0.000	36.2
Dozer	0.029	77.5	0.007	65.5	0.001	50.4	0.001	42.4	0.001	42.4	0.000	39.0	0.000	36.2
Grader	0.029	77.5	0.007	65.5	0.001	50.4	0.001	42.4	0.001	42.4	0.000	39.0	0.000	36.2
Front End Loader	0.001	48.5	0.000	36.5	0.000	21.4	0.000	13.4	0.000	13.4	0.000	10.0	0.000	7.2
Phase 1 MAXIMUM	**0.029**	**77.5**	**0.007**	**65.5**	**0.001**	**50.4**	**0.001**	**42.4**	**0.001**	**42.4**	**0.000**	**39.0**	**0.000**	**36.2**
Compactor (ground)	0.059	83.4	0.015	71.4	0.003	56.3	0.001	48.3	0.001	48.3	0.001	44.9	0.001	42.1
Roller	0.070	84.5	0.017	72.5	0.003	57.4	0.001	49.4	0.001	49.4	0.001	46.0	0.001	43.2
Paver	0.029	77.5	0.007	65.5	0.001	50.4	0.001	42.4	0.001	42.4	0.000	39.0	0.000	36.2
Drum Mixer	0.025	76.5	0.006	64.5	0.001	49.4	0.000	41.4	0.000	41.4	0.000	38.0	0.000	35.2
Phase 2 MAXIMUM	**0.070**	**84.5**	**0.017**	**72.5**	**0.003**	**57.4**	**0.001**	**49.4**	**0.001**	**49.4**	**0.001**	**46.0**	**0.001**	**43.2**
Note: PPV values are in/sec and Lv values are VdB														

Table E-16: Asphalt Road Construction Vibration Predictions for Category 1 & 3 Receivers

	One Santa Fe BBQ (A)		One Santa Fe Pool/Spa (B)		SCI-Arc North End (C)		SCI-Arc Middle (D)		SCI-Arc South End (E)		Willow Studios (F)	
	302 ft		753 ft		776 ft		1015 ft		1475 ft		n/a	
Equipment	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**
Scraper	0.002	54.6	0.001	42.7	0.001	42.3	0.000	38.8	0.000	33.9	-	-
Dozer	0.002	54.6	0.001	42.7	0.001	42.3	0.000	38.8	0.000	33.9	-	-
Grader	0.002	54.6	0.001	42.7	0.001	42.3	0.000	38.8	0.000	33.9	-	-

	One Santa Fe BBQ (A)		One Santa Fe Pool/Spa (B)		SCI-Arc North End (C)		SCI-Arc Middle (D)		SCI-Arc South End (E)		Willow Studios (F)	
	302 ft		753 ft		776 ft		1015 ft		1475 ft		n/a	
Equipment	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**
Front End Loader	0.000	25.6	0.000	13.7	0.000	13.3	0.000	9.8	0.000	4.9	-	-
Phase 1 MAXIMUM	**0.002**	**54.6**	**0.001**	**42.7**	**0.001**	**42.3**	**0.000**	**38.8**	**0.000**	**33.9**	**-**	**-**
Compactor (ground)	0.004	60.5	0.001	48.6	0.001	48.2	0.001	44.7	0.000	39.9	-	-
Roller	0.005	61.6	0.001	49.7	0.001	49.3	0.001	45.8	0.000	40.9	-	-
Paver	0.002	54.6	0.001	42.7	0.001	42.3	0.000	38.8	0.000	33.9	-	-
Drum Mixer	0.002	53.6	0.000	41.7	0.000	41.3	0.000	37.8	0.000	32.9	-	-
Phase 2 MAXIMUM	**0.005**	**61.6**	**0.001**	**49.7**	**0.001**	**49.3**	**0.001**	**45.8**	**0.000**	**40.9**	**-**	**-**
Note: PPV values are in/sec and Lv values are VdB												

Table E-17: Storage Track Construction Vibration Predictions for Category 2 Receivers

	One Santa Fe North Bldg (1)		One Santa Fe North Bldg (2)		One Santa Fe North Bldg (3)		One Santa Fe North Bldg (4)		One Santa Fe South Bldg (5)		One Santa Fe South Bldg (6)		One Santa Fe South Bldg (7)	
	65 ft		5 ft[a]		5 ft[a]		60 ft		65 ft		281 ft		520 ft	
Equipment	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**
Backhoe	0.021	74.6	0.980	108.0	0.980	108.0	0.024	75.6	0.021	74.6	0.002	55.5	0.001	47.5
Grapple (on backhoe)	0.021	74.6	0.980	108.0	0.980	108.0	0.024	75.6	0.021	74.6	0.002	55.5	0.001	47.5
Excavator	0.021	74.6	0.980	108.0	0.980	108.0	0.024	75.6	0.021	74.6	0.002	55.5	0.001	47.5
Compactor (ground)	0.043	80.5	1.992	113.9	1.992	113.9	0.048	81.6	0.043	80.5	0.005	61.5	0.002	53.4
Phase 1 MAXIMUM	**0.043**	**80.5**	**1.992**	**113.9**	**1.992**	**113.9**	**0.048**	**81.6**	**0.043**	**80.5**	**0.005**	**61.5**	**0.002**	**53.4**
Dump Truck	0.018	73.6	0.854	107.0	0.854	107.0	0.021	74.6	0.018	73.6	0.002	54.5	0.001	46.5
Dozer	0.021	74.6	0.980	108.0	0.980	108.0	0.024	75.6	0.021	74.6	0.002	55.5	0.001	47.5
Welder / Torch	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Roller	0.050	81.6	2.340	115.0	2.340	115.0	0.056	82.6	0.050	81.6	0.006	62.5	0.002	54.5

	One Santa Fe North Bldg (1)		**One Santa Fe North Bldg (2)**		**One Santa Fe North Bldg (3)**		**One Santa Fe North Bldg (4)**		**One Santa Fe South Bldg (5)**		**One Santa Fe South Bldg (6)**		**One Santa Fe South Bldg (7)**	
	65 ft		**5 ft[a]**		**5 ft[a]**		**60 ft**		**65 ft**		**281 ft**		**520 ft**	
Equipment	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**
Phase 2 MAXIMUM	**0.050**	**81.6**	**2.340**	**115.0**	**2.340**	**115.0**	**0.056**	**82.6**	**0.050**	**81.6**	**0.006**	**62.5**	**0.002**	**54.5**

Note: PPV values are in/sec and Lv values are VdB
[a] A distance of 5 feet is used for operations where the source is immediately adjacent to the receiver

Table E-18: Storage Track Construction Vibration Predictions for Category 1 & 3 Receivers

	One Santa Fe BBQ (A)		**One Santa Fe Pool/Spa (B)**		**SCI-Arc North End (C)**		**SCI-Arc Middle (D)**		**SCI-Arc South End (E)**		**Willow Studios (F)**	
	5 ft[a]		**40 ft**		**150 ft**		**320 ft**		**765 ft**		**n/a**	
Equipment	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**
Backhoe	0.980	108.0	0.043	80.9	0.006	63.7	0.002	53.8	0.001	42.5	-	-
Grapple (on backhoe)	0.980	108.0	0.043	80.9	0.006	63.7	0.002	53.8	0.001	42.5	-	-
Excavator	0.980	108.0	0.043	80.9	0.006	63.7	0.002	53.8	0.001	42.5	-	-
Compactor (ground)	1.992	113.9	0.088	86.9	0.012	69.6	0.004	59.8	0.001	48.4	-	-
Phase 1 MAXIMUM	**1.992**	**113.9**	**0.088**	**86.9**	**0.012**	**69.6**	**0.004**	**59.8**	**0.001**	**48.4**	**-**	**-**
Dump Truck	0.854	107.0	0.038	79.9	0.005	62.7	0.002	52.8	0.000	41.5	-	-
Dozer	0.980	108.0	0.043	80.9	0.006	63.7	0.002	53.8	0.001	42.5	-	-
Welder / Torch	-	-	-	-	-	-	-	-	-	-	-	-
Roller	2.340	115.0	0.103	87.9	0.014	70.7	0.005	60.8	0.001	49.5	-	-
Phase 2 MAXIMUM	**2.340**	**115.0**	**0.103**	**87.9**	**0.014**	**70.7**	**0.005**	**60.8**	**0.001**	**49.5**	**-**	**-**

Note: PPV values are in/sec and Lv values are VdB
[a] A distance of 5 feet is used for operations where the source is immediately adjacent to the receiver

Table E-19: Yard Track Construction Vibration Predictions for Category 2 Receivers

	One Santa Fe North Bldg (1)		One Santa Fe North Bldg (2)		One Santa Fe North Bldg (3)		One Santa Fe North Bldg (4)		One Santa Fe South Bldg (5)		One Santa Fe South Bldg (6)		One Santa Fe South Bldg (7)	
	200 ft		230 ft		225 ft		220 ft		60 ft		130 ft		257 ft	
Equipment	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**
Backhoe	0.004	59.9	0.003	58.1	0.003	58.4	0.003	58.7	0.024	75.6	0.007	65.6	0.003	56.7
Grapple (on backhoe)	0.004	59.9	0.003	58.1	0.003	58.4	0.003	58.7	0.024	75.6	0.007	65.6	0.003	56.7
Excavator	0.004	59.9	0.003	58.1	0.003	58.4	0.003	58.7	0.024	75.6	0.007	65.6	0.003	56.7
Compactor (ground)	0.008	65.9	0.006	64.1	0.007	64.3	0.007	64.6	0.048	81.6	0.015	71.5	0.005	62.6
Phase 1 MAXIMUM	**0.008**	**65.9**	**0.006**	**64.1**	**0.007**	**64.3**	**0.007**	**64.6**	**0.048**	**81.6**	**0.015**	**71.5**	**0.005**	**62.6**
Dump Truck	0.003	58.9	0.003	57.1	0.003	57.4	0.003	57.7	0.021	74.6	0.006	64.6	0.002	55.7
Dozer	0.004	59.9	0.003	58.1	0.003	58.4	0.003	58.7	0.024	75.6	0.007	65.6	0.003	56.7
Welder / Torch	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Roller	0.009	66.9	0.008	65.1	0.008	65.4	0.008	65.7	0.056	82.6	0.018	72.6	0.006	63.7
Phase 2 MAXIMUM	**0.009**	**66.9**	**0.008**	**65.1**	**0.008**	**65.4**	**0.008**	**65.7**	**0.056**	**82.6**	**0.018**	**72.6**	**0.006**	**63.7**

Note: PPV values are in/sec and Lv values are VdB

Table E-20: Yard Track Construction Vibration Predictions for Category 1 & 3 Receivers

	One Santa Fe BBQ (A)		One Santa Fe Pool/Spa (B)		SCI-Arc North End (C)		SCI-Arc Middle (D)		SCI-Arc South End (E)		Willow Studios (F)	
	230 ft		120 ft		340 ft		400 ft		560 ft		415 ft	
Equipment	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**
Backhoe	0.003	58.1	0.008	66.6	0.002	53.0	0.001	50.9	0.001	46.5	0.001	50.4
Grapple (on backhoe)	0.003	58.1	0.008	66.6	0.002	53.0	0.001	50.9	0.001	46.5	0.001	50.4
Excavator	0.003	58.1	0.008	66.6	0.002	53.0	0.001	50.9	0.001	46.5	0.001	50.4
Compactor (ground)	0.006	64.1	0.017	72.5	0.004	59.0	0.003	56.9	0.002	52.5	0.003	56.4
Phase 1 MAXIMUM	**0.006**	**64.1**	**0.017**	**72.5**	**0.004**	**59.0**	**0.003**	**56.9**	**0.002**	**52.5**	**0.003**	**56.4**
Dump Truck	0.003	57.1	0.007	65.6	0.002	52.0	0.001	49.9	0.001	45.5	0.001	49.4

	One Santa Fe BBQ (A)		One Santa Fe Pool/Spa (B)		SCI-Arc North End (C)		SCI-Arc Middle (D)		SCI-Arc South End (E)		Willow Studios (F)	
	230 ft		120 ft		340 ft		400 ft		560 ft		415 ft	
Equipment	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**	**PPV**	**Lv**
Dozer	0.003	58.1	0.008	66.6	0.002	53.0	0.001	50.9	0.001	46.5	0.001	50.4
Welder / Torch	-	-	-	-	-	-	-	-	-	-	-	-
Roller	0.008	65.1	0.020	73.6	0.004	60.0	0.003	57.9	0.002	53.5	0.003	57.4
Phase 2 MAXIMUM	**0.008**	**65.1**	**0.020**	**73.6**	**0.004**	**60.0**	**0.003**	**57.9**	**0.002**	**53.5**	**0.003**	**57.4**
Note: PPV values are in/sec and Lv values are VdB												