November 9, 2022

Warmington Residential
3090 Pullman Street
Costa Mesa, California 92626

Attention: Moses Kim | Senior Project Manager

Subject: **Jackson Street Development**
Riverside, CA
Construction Vibration Control Plan
Veneklasen Project No. 5798-009

Dear Moses:

This plan addresses the vibration control during construction for the proposed Jackson Street Development project, located in Riverside, California. Pursuant to the City of Riverside Conditions of Approval (COA), this document serves as Construction Vibration Mitigation Plan for demolition and excavation/grading phases. In formulating the plan, we have reviewed the following documents:

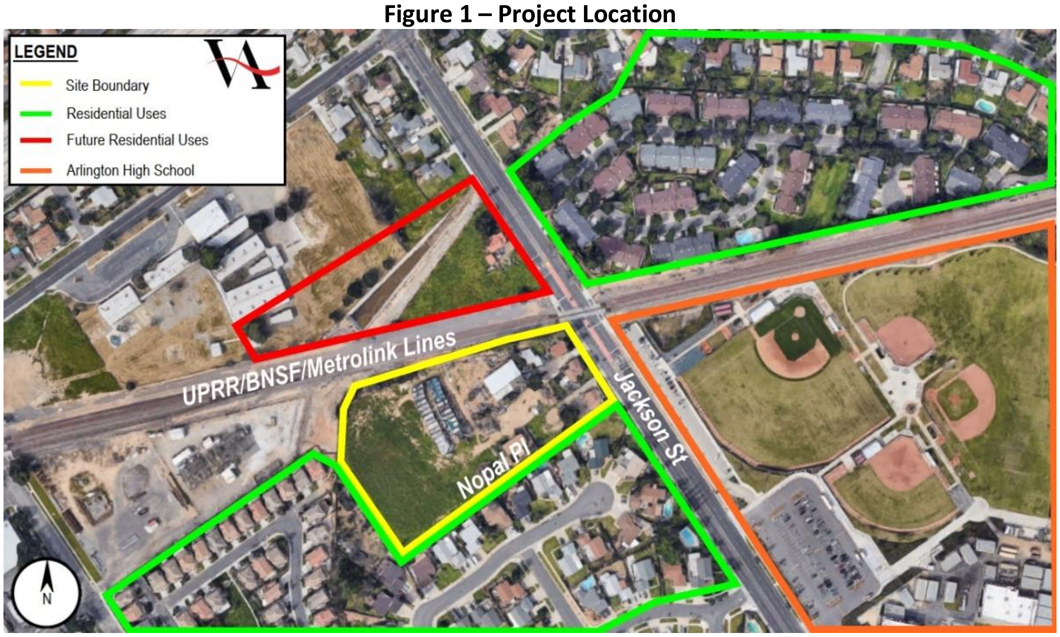
- City of Riverside Municipal Code
- City of Riverside General Plan, Noise Element
- Federal Transit Administration Transit Noise and Vibration Impact Assessment Guidance Manual, September 2018

1.0 PROJECT DESCRIPTION

The purpose of this section is to define the characteristics of the Jackson Street Development project. As discussed below, the project includes the demolition of existing single-family residential buildings to the east of the project site and will involve the construction of 19 3- and 4-plex buildings with a total of 70 residential units.

The main concern regarding the potential impacts are single-family uses to the south and north of the project site.

Figure 1 – Project Location



2.0 PROJECT VIBRATION CRITERIA

2.1 Vibration Criteria

The City of Riverside Municipal Code and General Plan Noise Element does not provide limits for vibration generation from construction activities to closest receptors.

The Federal Transit Administration (FTA) addresses the impacts in terms of building damage (Peak Particle Velocity PPV, in/s) for construction activities. Recommended maximum vibration values are shown in Table 1.

Table 1 – Typical Construction Vibration Limits

Criteria Description	Vibration Criteria PPV (in/s)
Buildings extremely susceptible to vibration damage, such as historic buildings	0.12
Non-engineered timber and masonry buildings	0.2
Engineered concrete and masonry (no plaster)	0.3
Reinforced-concrete, steel or timber (no plaster)	0.5

Source: FTA Transit Noise and Vibration Impact Assessment Guidance Manual, September 2018.

FTA guidelines are not enforced by the state or city code and compliance is not required.

Based on the existing condition at each sensitive receptor, character-defining features, soils conditions, anticipated construction practices, industry standard references with respect to construction vibration and potential effects to buildings, and Veneklasen's own project experience, Veneklasen defines the project criteria as follows:

- The maximum vibration values shall not exceed 0.2 inches per second PPV for building damage at residential uses and Arlington High School,

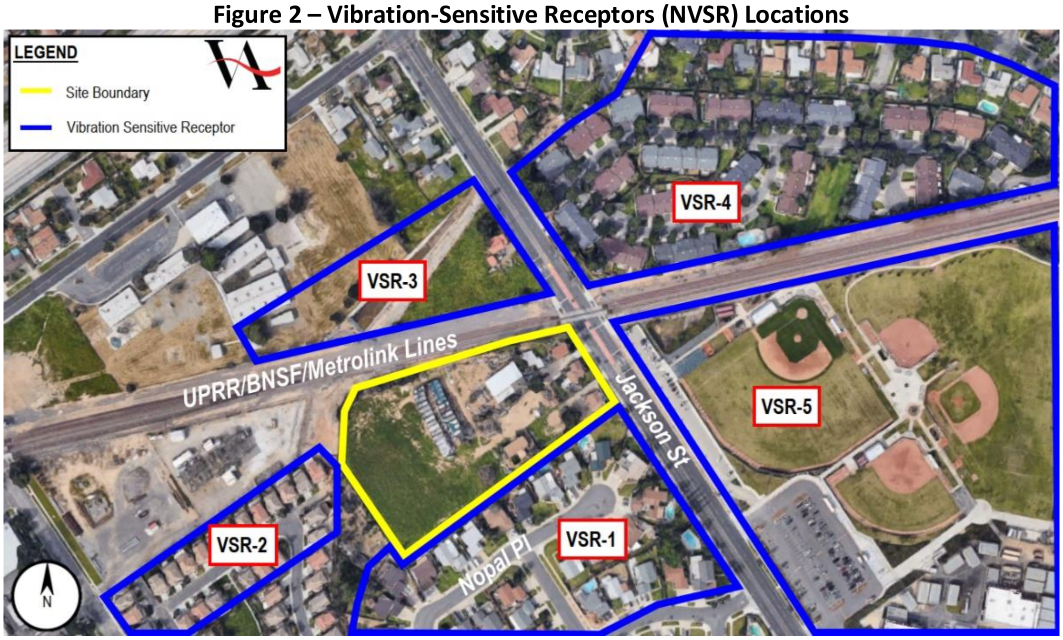
3.0 VIBRATION SENSITIVE RECEPTORS

The project site and vibration-sensitive receptors (VSR) to the north, south, east, and west of the site are shown in Table 2 and Figure 2. For the purposes of this analysis, individual receptors (e.g. individual apartment units, office spaces, windows/doors, etc.) located within the same property constitute the combined receptor group as defined within Table 2.

Table 2 – Vibration Sensitive Receptors (VSR)

Receptor Group for Analysis	Address	Cardinal Direction from Project Site	Type of Receptor	Approximate Distance from Center of Project Site to Vibration Receptor (ft)
VSR-1	9149 Nopal Pl	South	Residential	155
VSR-2	9205 Maywood Way	West	Residential	355
VSR-3	3284 Jackson Street	North	Future Residential	245
VSR-4	9042 Chaucer Cir	Northeast	Residential	420
VSR-5	2951 Jackson Street	East	Educational	440

Figure 2 – Vibration-Sensitive Receptors (NVSR) Locations



4.0 CONSTRUCTION EQUIPMENT VIBRATION LEVELS

The list of equipment types scheduled for this project and their construction phases duration was obtained from the client on November 7, 2022. This list was compared to industry standard reference database Federal Transit Administration (FTA) for equipment typical to projects of this scale. Veneklasen was informed that no pile driving, rock blasting or rock crushing will take place on site.

The estimated construction schedule for demolition and grading is as follows:

- Demolition: Five (5) business days
- Rough grading: Fifteen (15) business days

Table 3 below lists the heaviest equipment anticipated for use on the project along with associated vibration values at reference distances. Note that only vibration intensive equipment types are included on this list. Any equipment omitted from this list produce insignificant vibration levels.

Table 3 – Vibration Data for Selected Construction Equipment

Construction Equipment	Phase of Construction	Quantity	PPV Level at Reference Distance (in/s at 25-feet)
Large Bulldozer	Demolition & Site Clearance/Grading	2	0.089
Loaded Trucks	Demolition & Site Clearance/Grading	4	0.076
Small Bulldozer	Demolition & Site Clearance/Grading	1	0.003
Jackhammer	Demolition & Site Clearance/Grading	1	0.035
Vibratory Compactor	Demolition & Site Clearance/Grading	1	0.210

Source: FTA Transit Noise and Vibration Impact Assessment Guidance Manual dated September 2018, Table 7-4 (see Appendix III)

5.0 PREDICTION AND MODELING

No other significantly heavy equipment should be in use during this period of construction. Vibration levels of various equipment were based upon the FTA Noise Guidance Manual.

Appendix II offers details of our calculation results. Calculations were performed for each piece of equipment to determine the noise and vibration level for demolition/grading phase of construction. Calculations were then completed separately at each receptor location (VSR-1 to VSR-5).

5.1 Construction Vibration Calculations

Attenuation of vibration levels with distance varies depending on the local soil conditions. The following calculations estimate the vibration levels that will be generated by the construction activities using the propagation formula published in the FTA Guidance Manual. The propagation formula for PPV values (building damage) a is as follows:

$$PPV_{Equip} = PPV_{ref} * \left(\frac{25}{D}\right)^{1.5}$$

Where:

PPV_{equip}= the Peak Particle Velocity (PPV) of the equipment adjusted for distance, in/sec

PPV_{ref} = the source reference vibration level at 25 ft, in/sec (Table 3)

D = distance from the equipment to receiver, ft

The estimated vibration due to each of the construction activities at each receptor are presented in Table 4. For the demolition and excavation/grading activity, minimum setback and vibration information are given. Receptor vibration levels are calculated as a function of the 25-foot reference vibration level (PPV_{ref}) shown in Table 3 and the receptor setback (D). The minimum setbacks were derived from the project work areas indicated on the project drawings and Google Maps. A comparison of the calculated vibration levels to the project criteria is shown in Table 4.

6.0 RESULTS AND MITIGATION MEASURES

6.1 Calculated Vibration Results

Vibration levels were modeled for the construction equipment assumed to be used for this project. Vibration levels for various equipment were assumed to be equivalent to similar equipment specified in the FTA Transit Noise and Vibration Guidance Manual. The reference levels for each type of equipment assumed to generate appreciable vibration levels are shown in Table 3. Vibration criteria for various structural responses are shown in Table 1 of this report.

The main concern for vibration generated by ground-disturbing construction activities is the potential for architectural/structural damage to adjacent sensitive receptors.

Vibration limits for structures are assessed using the peak particle velocity (PPV) metric. This metric refers to the maximum speed of a particular particle as it oscillates about a point of equilibrium that is moved by a passing wave.

Table 4 – Predicted Continuous Construction Vibration Levels

Receptor	Minimum Distance from Construction Site to Vibration Receptor (ft.)	Vibration Level Criteria (Exterior) (PPV [in/s)/VdB)	Predicted Construction Maximum Vibration Level (PPV [in/s)	Compliance with Damage Criteria
VSR-1	30	0.2	0.16	Yes
VSR-2	35	0.2	0.13	Yes
VSR-3	100	0.2	0.03	Yes
NSR-4	180	0.2	0.01	Yes
NSR-5	135	0.2	0.02	Yes

For demolition/grading activities, projected maximum PPV levels at each sensitive receptor are anticipated to meet the project criteria.

6.2 Recommended Mitigation Measures

In order to mitigate/minimize the vibration impact at closest receptors, the FTA Manual and Veneklasen recommends the following:

1. Design consideration and project layout
    - Route heavily-loaded trucks away from residential property limits.
    - Operate earth-moving equipment on the construction lot as far away from vibration-sensitive sites as possible.
2. Sequence of operations
    - Phase demolition, earth-moving, and ground impacting operations so as not to occur in the same time period. Unlike noise, the total vibration level produced could be substantially less when each vibration source operates separately.
    - Avoid nighttime activities. Sensitivity to vibration increases during the nighttime hours in residential neighborhoods.
3. Alternate construction methods
    - Select demolitions methods involving little to no impact, where possible.
    - Avoid vibratory rollers and packers near sensitive areas.

If you have any questions or comments regarding this report, please do not hesitate to contact us.

Sincerely,
Veneklasen Associates, Inc.

John LoVerde, *FASA*
Principal

Elias Montoya
Associate

APPENDIX I – GLOSSARY OF ACOUSTICAL TERMS

Definitions of Acoustical and Other Related Terms

Term	Definition
Construction Site	For the purpose of noise and vibration control requirements, the construction site includes property lines, construction easement boundaries, and contractor staging areas outside the defined boundary lines, used expressly for construction.
Decibel (dB)	A unit describing the amplitude of sound in a logarithmic ratio to a reference value.
A-weighted Decibels (dBA)	A filter applied to sound pressure levels in decibel to simulate the response of the human ear at the threshold of hearing. A-weighting de-emphasizes the low frequency components of a sound similar to the human ear at these levels. This metric has been closely tied to subjective reactions of annoyance to noise, and is used as a noise metric in this and in many other environmental acoustics reports. In this report, all dBA levels reported refer to the sound pressure level, referenced to 20µPa
Sound Pressure Level (L_p)	The amplitude of sound compared to the reference value of 20µPa. Sound Pressure Level is what we perceive as audible sound. Sound Pressure Level decreases as distance from the source to the receiver increases. All sound values discussed in this report refer to Sound Pressure Levels.
Equivalent Sound Level (L_{eq})	The time-weighted average sound or vibration level for a given period of time. Use of this metric allows the observation of the overall sound level for the measurement period.
Maximum Sound Level (L_{max})	The instantaneous maximum sound or vibration level of an event. The L_{max} can occur over very short periods of time, and fluctuates much more than the L_{eq} due to the presence of short events in the environment.
Vibration Decibel (VdB)	A measure of vibration amplitude in decibels, referenced to 1µin/sec, most commonly used for assessment and prediction of annoyance due to perceptible vibration and ground-borne noise. The V is added for clarity to easily distinguish between sound and vibration decibels.

APPENDIX II – CALCULATION RESULTS

Vibration Estimation at Sensitive Receptors (VSR-1 to VSR-3) for Selected Construction Equipment

	Receptor R1		Receptor R2		Receptor R3	
	Building category		Building category		Building category	
	III. Non-engineered timber and masonry buildings		III. Non-engineered timber and masonry buildings		III. Non-engineered timber and masonry buildings	
	gory II: Residences and building where people normally s		gory II: Residences and building where people normally s		gory II: Residences and building where people normally s	
Equipment type	**Distance (ft) to R1**	**PPV_{equip} at R1**	**Distance (ft) to R2**	**PPV_{equip} at R2**	**Distance (ft) to R3**	**PPV_{equip} at R3**
Large Bulldozer	30	0.07	35	0.05	100	0.01
Large Bulldozer	30	0.07	35	0.05	100	0.01
Loaded trucks	30	0.06	35	0.05	100	0.01
Loaded trucks	30	0.06	35	0.05	100	0.01
Loaded trucks	30	0.06	35	0.05	100	0.01
Loaded trucks	30	0.06	35	0.05	100	0.01
Small bulldozer	30	0.00	35	0.00	100	0.00
Jackhammer	30	0.03	35	0.02	100	0.00
Vibratory Roller	30	0.16	35	0.13	100	0.03
No Equipment	30	0.00	35	0.00	100	0.00

Vibration Estimation at Sensitive Receptors (VSR-4 to VSR-5) for Selected Construction Equipment

		Receptor R4		Receptor R5	
		Building category		Building category	
		I. Reinforced-concrete, steel or timber (no plaster)		III. Non-engineered timber and masonry buildings	
		ategory III:Institutional land uses with primarly daytime u		ategory III:Institutional land uses with primarly daytime u	
Equipment type	**PPV_{ref} at 25 ft (in/sec)**	**Distance (ft) to R4**	**PPV_{equip} at R4**	**Distance (ft) to R5**	**PPV_{equip} at R5**
Large Bulldozer	0.089	180	0.00	135	0.01
Large Bulldozer	0.089	180	0.00	135	0.01
Loaded trucks	0.076	180	0.00	135	0.01
Loaded trucks	0.076	180	0.00	135	0.01
Loaded trucks	0.076	180	0.00	135	0.01
Loaded trucks	0.076	180	0.00	135	0.01
Small bulldozer	0.003	180	0.00	135	0.00
Jackhammer	0.035	180	0.00	135	0.00
Vibratory Roller	0.210	180	0.01	135	0.02
No Equipment	N/A	180	0.00	135	0.00

APPENDIX III – FTA REFERENCES

FTA Transit Noise and Vibration Impact Assessment Guidance Manual dated September 2018, Table 7-4

- **Vibration Source Levels from Construction Equipment** – Table 7-4 presents average source levels in terms of velocity for various types of construction equipment measured under a wide variety of construction activities. The approximate rms vibration velocity levels were calculated from the PPV limits using a crest factor of 4, representing a PPV-rms difference of 12 dB. Note that although the table gives one level for each piece of equipment, there is considerable variation in reported ground vibration levels from construction activities. The data in Table 7-4 provide a reasonable estimate for a wide range of soil conditions.(66)(67)(68)(69)

Table 7-4 Vibration Source Levels for Construction Equipment

Equipment		PPV at 25 ft, in/sec	Approximate Lv* at 25 ft
Pile Driver (impact)	upper range	1.518	112
	typical	0.644	104
Pile Driver (sonic)	upper range	0.734	105
	typical	0.17	93
Clam shovel drop (slurry wall)		0.202	94
Hydromill (slurry wall)	in soil	0.008	66
	in rock	0.017	75
Vibratory Roller		0.21	94
Hoe Ram		0.089	87
Large bulldozer		0.089	87
Caisson drilling		0.089	87
Loaded trucks		0.076	86
Jackhammer		0.035	79
Small bulldozer		0.003	58

* RMS velocity in decibels, VdB re 1 micro-in/sec