

# Construction Noise Analysis

### Summation of Noise Levels

**Equation:**  $N_s = 10 \times \text{LOG}_{10}((10^{(N_1/10)}) + (10^{(N_2/10)}) + (10^{(N_3/10)}) + (10^{(N_4/10)}))$

N<sub>s</sub> = Noise Level Sum

N<sub>1</sub> = Noise Level 1

N<sub>2</sub> = Noise Level 2

N<sub>3</sub> = Noise Level 3

N<sub>4</sub> = Noise Level 4

**Source:** California Department of Transportation, *Technical Noise Supplement*, 2009

### Noise Distance Attenuation

**Equation:**  $N_i = N_o - 20(\log D_i/D_o)$

**N<sub>i</sub>** = attenuated noise level of interest

**N<sub>o</sub>** = reference noise level

**D<sub>i</sub>** = distance to receptor (D<sub>i</sub>>D<sub>o</sub>)

**D<sub>o</sub>** = reference distance

**Source:** (Bolt, Beranek, and Newman, 1971)

**Construction Noise Analysis**

<b>Unmitigated Construction Noise Levels</b>						
Receptor	Distance from construction (feet) (D)	Attenuation Factor	Max Construction Noise Level (dBA)	Existing Ambient Noise level (dBA, Leq)	New Ambient Noise level (dBA, Leq)	Increase (dBA)
<b>Phase 1</b>						
Single-family residences to the West	50	20	69.0	53.5	69.1	15.6
Multi-family residences to the Northwest	50	20	69.0	63.3	70.0	6.7
Angels Community Park	50	20	69.0	66.4	70.9	4.5
Multi-family residences to the Southeast	130	0	80.7	66.4	80.9	14.5
Santa Ana Public Library	300	0	73.4	67.7	74.5	6.8
Old Courthouse Museum	300	20	53.4	57.3	58.8	1.5
Katherine Irvine Day School (KIDS) Head Start	360	20	51.9	53.5	55.8	2.3
Sasscer Park	480	0	69.4	64	70.5	6.5
<b>Phase 2</b>						
Single-family residences to the West	50	20	69.0	53.5	69.1	15.6
Multi-family residences to the Northwest	50	20	69.0	63.3	70.0	6.7
Angels Community Park	50	0	89.0	66.4	89.0	22.6
Multi-family residences to the SouthEast	130	0	80.7	66.4	80.9	14.5
Santa Ana Public Library	140	0	80.1	67.7	80.3	12.6
Katherine Irvine Day School (KIDS) Head Start	360	20	51.9	53.5	55.8	2.3
<b>Phase 3</b>						
Single- and multi-family residences to the north	100	0	79.0	54.9	79.0	24.1
Single-family residences to the Northwest	300	0	69.4	54.9	69.6	14.7
Orange County Educational Arts Academy to the East	350	0	68.1	66.6	70.4	3.8
El Sol Science and Arts Academy of Santa Ana to the Northeast	360	20	47.9	66.6	66.7	0.1
<b>Phase 4</b>						
Old Courthouse Museum	170	0	78.4	57.3	78.4	21.1
Orange County Educational Arts Academy to the Northeast	450	0	69.9	66.6	71.6	5.0
First Presbyterian Church Santa Ana	470	0	69.5	57.3	69.8	12.5
University of California Irvine Family Health Center	500	0	69.0	66.6	71.0	4.4
<b>Reference Construction Noise Level</b>	<b>89</b>					
<b>Structural Construction Noise Level</b>	<b>85</b>					

**Mitigated Construction Noise Levels**

Receptor	Distance from construction (feet) (D)	Attenuation Factor	Max Construction Noise Level (dBA)	Existing Ambient Noise level (dBA, Leq)	New Ambient Noise level (dBA, Leq)	Increase (dBA)
<b>Phase 1</b>						
Single-family residences to the West	50	23	66.0	53.5	66.2	12.7
Multi-family residences to the Northwest	50	23	66.0	63.3	67.9	4.6
Angels Community Park	50	23	66.0	66.4	69.2	2.8
Multi-family residences to the Southeast	130	3	77.7	66.4	78.0	11.6
Santa Ana Public Library	300	3	70.4	67.7	72.3	4.6
Old Courthouse Museum	300	23	50.4	57.3	58.1	0.8
Katherine Irvine Day School (KIDS) Head Start	360	23	48.9	53.5	54.8	1.3
Sasscer Park	480	3	66.4	64	68.3	4.3
<b>Phase 2</b>						
Single-family residences to the West	50	23	66.0	53.5	66.2	12.7
Multi-family residences to the Northwest	50	23	66.0	63.3	67.9	4.6
Angels Community Park	50	3	86.0	66.4	86.0	19.6
Multi-family residences to the SouthEast	130	3	77.7	66.4	78.0	11.6
Santa Ana Public Library	140	3	77.1	67.7	77.5	9.8
Katherine Irvine Day School (KIDS) Head Start	360	23	48.9	53.5	54.8	1.3
<b>Phase 3</b>						
Single- and multi-family residences to the north	100	3	76.0	54.9	76.0	21.1
Single-family residences to the Northwest	300	3	66.4	54.9	66.7	11.8
Orange County Educational Arts Academy to the East	350	3	65.1	66.6	68.9	2.3
El Sol Science and Arts Academy of Santa Ana to the Northeast	360	23	44.9	66.6	66.6	0.0
<b>Phase 4</b>						
Old Courthouse Museum	170	3	75.4	57.3	75.4	18.1
Orange County Educational Arts Academy to the Northeast	450	3	66.9	66.6	69.8	3.2
First Presbyterian Church Santa Ana	470	3	66.5	57.3	67.0	9.7
University of California Irvine Family Health Center	500	3	66.0	66.6	69.3	2.7

<b>Reference Construction Noise Level</b>	<b>89</b>
<b>Structural Construction Noise Level</b>	<b>85</b>

# Mobile Noise Analysis

Mobile Noise Analysis - Operational Activity

Existing Without Project (2016)

Table with 14 columns: Int Number, ROAD SEGMENT, TOT. # VEH., EQUIVALENT LANE DISTANCE, VEHICLE TYPE %, VEHICLE SPEED, NOISE LEVEL (dBA), ROW CNEL (dBA). Rows 1-21.

Table with 2 columns: 2035 Analysis, Increase CNEL (dBA). Rows for Existing vs Future with Project and Future Without vs Future with Project.

Existing With Project (2016) Phase 1

Table with 14 columns: Int Number, ROAD SEGMENT, TOT. # VEH., EQUIVALENT LANE DISTANCE, VEHICLE TYPE %, VEHICLE SPEED, NOISE LEVEL (dBA), ROW CNEL (dBA). Rows 1-21.

Table with 2 columns: 2021 Analysis, Increase CNEL (dBA). Rows for Existing vs Future with Project and Future Without vs Future with Project.

Existing With Project (2016) Phases 1-4

Table with 14 columns: Int Number, ROAD SEGMENT, TOT. # VEH., EQUIVALENT LANE DISTANCE, VEHICLE TYPE %, VEHICLE SPEED, NOISE LEVEL (dBA), ROW CNEL (dBA). Rows 1-21.

Future Without Project (2021)

Table with 14 columns: Int Number, ROAD SEGMENT, TOT. # VEH., EQUIVALENT LANE DISTANCE, VEHICLE TYPE %, VEHICLE SPEED, NOISE LEVEL (dBA), ROW CNEL (dBA). Rows 1-21.

**Future With Project (2021) Phase 1**

Int Number	ROAD SEGMENT	TOT. # VEH.	EQUIVALENT LANE DISTANCE			VEHICLE TYPE %			VEHICLE SPEED					NOISE LEVEL (dBA)			ROW CNEL (dBA)					
			D1	D2	Eq. Dis.	Auto			k/h			Auto										
						%	MT	HT	k/h	MT	k/h	HT	k/h	MT	HT							
2	Washington Ave	Broadway to Main St	670	6	30	13	90	603	5	33.5	5	33.5	25	40	25	40	25	40	57.9	57.0	64.7	65.0
3	Broadway	Civic Center Dr to 10th St	2058	7	53	19	90	1852	5	103	5	103	35	56	35	56	35	56	67.0	64.2	69.4	70.7
5	Civic Center Dr	Flower St to Ross St	1556	5	45	15	90	1400	5	77.8	5	77.8	35	56	35	56	35	56	65.8	62.9	68.2	69.7
6	Civic Center Dr	Ross St to Broadway	1599	5	45	15	90	1439	5	80	5	80	35	56	35	56	35	56	65.9	63.1	68.3	69.9
7	Broadway	Santa Ana Blvd to Civic Center Dr	1584	8	52	20	90	1426	5	79.2	5	79.2	35	56	35	56	35	56	65.8	63.0	68.2	69.5
8	Main St	Santa Ana Blvd to Civic Center Dr	2441	8	50	20	90	2197	5	122	5	122	35	56	35	56	35	56	67.7	64.9	70.1	71.4
10	Flower st	1st st to 3rd st	1664	6	60	19	90	1498	5	83.2	5	83.2	35	56	35	56	35	56	66.1	63.2	68.4	69.8
12	Ross St	Santa Ana Blvd to Civic Center Dr	635	7	45	18	90	571.5	5	31.8	5	31.8	35	56	35	56	35	56	61.9	59.1	64.3	65.7
14	Santa Ana Blvd	Main St to Broadway	806	6	30	13	90	725.4	5	40.3	5	40.3	30	48	30	48	30	48	61.0	59.0	64.7	65.9
16	5th st	Ross St to Broadway	907	6	30	13	90	816.3	5	45.4	5	45.4	35	56	35	56	35	56	63.4	60.6	65.8	67.5
18	Bush St	5th St to Santa Ana Blvd	614	6	27	13	90	552.6	5	30.7	5	30.7	25	40	25	40	25	40	57.5	56.6	64.3	64.7
20	4th St	Broadway to Main St	410	7	17	11	90	369	5	20.5	5	20.5	25	40	25	40	25	40	55.8	54.9	62.5	63.1
21	Ross St	1st St to 3rd St	609	7	40	17	90	548.1	5	30.5	5	30.5	35	56	35	56	35	56	61.7	58.9	64.1	65.6

**Future Without Project (2035)**

Int Number	ROAD SEGMENT	TOT. # VEH.	EQUIVALENT LANE DISTANCE			VEHICLE TYPE %			VEHICLE SPEED					NOISE LEVEL (dBA)			50 ft ROW CNEL (dBA)					
			D1	D2	Eq. Dis.	Auto			k/h			Auto										
						%	MT	HT	k/h	MT	k/h	HT	k/h	MT	HT							
2	Washington Ave	Broadway to Main St	702	6	30	13	90	631.8	5	35.1	5	35.1	25	40	25	40	25	40	58.1	57.2	64.9	65.2
3	Broadway	Civic Center Dr to 10th St	2068	7	53	19	90	1861	5	103	5	103	35	56	35	56	35	56	67.0	64.2	69.4	70.7
5	Civic Center Dr	Flower St to Ross St	1643	5	45	15	90	1479	5	82.2	5	82.2	35	56	35	56	35	56	66.0	63.2	68.4	70.0
6	Civic Center Dr	Ross St to Broadway	1624	5	45	15	90	1462	5	81.2	5	81.2	35	56	35	56	35	56	66.0	63.1	68.3	69.9
7	Broadway	Santa Ana Blvd to Civic Center Dr	1594	8	52	20	90	1435	5	79.7	5	79.7	35	56	35	56	35	56	65.9	63.0	68.3	69.5
8	Main St	Santa Ana Blvd to Civic Center Dr	2583	8	50	20	90	2325	5	129	5	129	35	56	35	56	35	56	68.0	65.1	70.4	71.6
10	Flower st	1st st to 3rd st	1772	6	60	19	90	1595	5	88.6	5	88.6	35	56	35	56	35	56	66.3	63.5	68.7	70.1
12	Ross St	Santa Ana Blvd to Civic Center Dr	568	7	45	18	90	511.2	5	28.4	5	28.4	35	56	35	56	35	56	61.4	58.6	63.8	65.2
14	Santa Ana Blvd	Main St to Broadway	804	6	30	13	90	723.6	5	40.2	5	40.2	30	48	30	48	30	48	61.0	59.0	64.7	65.9
16	5th st	Ross St to Broadway	920	6	30	13	90	828	5	46	5	46	35	56	35	56	35	56	63.5	60.7	65.9	67.6
18	Bush St	5th St to Santa Ana Blvd	649	6	27	13	90	584.1	5	32.5	5	32.5	25	40	25	40	25	40	57.8	56.9	64.5	64.9
20	4th St	Broadway to Main St	403	7	17	11	90	362.7	5	20.2	5	20.2	25	40	25	40	25	40	55.7	54.8	62.4	63.0
21	Ross St	1st St to 3rd St	634	7	40	17	90	570.6	5	31.7	5	31.7	35	56	35	56	35	56	61.9	59.0	64.3	65.7

**Future With Project (2035) Phases 1-4**

Int Number	ROAD SEGMENT	TOT. # VEH.	EQUIVALENT LANE DISTANCE			VEHICLE TYPE %			VEHICLE SPEED					NOISE LEVEL (dBA)			ROW CNEL (dBA)					
			D1	D2	Eq. Dis.	Auto			k/h			Auto										
						%	MT	HT	k/h	MT	k/h	HT	k/h	MT	HT							
2	Washington Ave	Broadway to Main St	743	6	30	13	90	668.7	5	37.2	5	37.2	25	40	25	40	25	40	58.4	57.5	65.1	65.5
3	Broadway	Civic Center Dr to 10th St	2406	7	53	19	90	2165	5	120	5	120	35	56	35	56	35	56	67.7	64.8	70.0	71.4
5	Civic Center Dr	Flower St to Ross St	1713	5	45	15	90	1542	5	85.7	5	85.7	35	56	35	56	35	56	66.2	63.4	68.6	70.2
6	Civic Center Dr	Ross St to Broadway	1852	5	45	15	90	1667	5	92.6	5	92.6	35	56	35	56	35	56	66.5	63.7	68.9	70.5
7	Broadway	Santa Ana Blvd to Civic Center Dr	1853	8	52	20	90	1668	5	92.7	5	92.7	35	56	35	56	35	56	66.5	63.7	68.9	70.2
8	Main St	Santa Ana Blvd to Civic Center Dr	2669	8	50	20	90	2402	5	133	5	133	35	56	35	56	35	56	68.1	65.3	70.5	71.8
10	Flower st	1st st to 3rd st	1803	6	60	19	90	1623	5	90.2	5	90.2	35	56	35	56	35	56	66.4	63.6	68.8	70.1
12	Ross St	Santa Ana Blvd to Civic Center Dr	846	7	45	18	90	761.4	5	42.3	5	42.3	35	56	35	56	35	56	63.1	60.3	65.5	66.9
14	Santa Ana Blvd	Main St to Broadway	898	6	30	13	90	808.2	5	44.9	5	44.9	30	48	30	48	30	48	61.5	59.5	65.2	66.4
16	5th st	Ross St to Broadway	1048	6	30	13	90	943.2	5	52.4	5	52.4	35	56	35	56	35	56	64.1	61.2	66.4	68.1
18	Bush St	5th St to Santa Ana Blvd	672	6	27	13	90	604.8	5	33.6	5	33.6	25	40	25	40	25	40	57.9	57.0	64.7	65.1
20	4th St	Broadway to Main St	488	7	17	11	91	444.1	6	29.3	6	29.3	25	40	25	40	25	40	56.6	56.4	64.1	64.5
21	Ross St	1st St to 3rd St	681	7	40	17	92	626.5	7	47.7	7	47.7	35	56	35	56	35	56	62.3	60.8	66.0	67.1

# Vibration Analysis



**Vibration Reference Levels**

Equipment	Reference Vibration Level at 25 feet (VdB)	Reference Vibration Level at 25 feet (Inches Per Second)
Jackhammer	79	0.035
Small Bulldozer	58	0.003

**Vibration Annoyance Analysis**

Distance from equipment (feet) (D)	Jackhammer Vibration Level (VdB)	Vibration Level Bulldozer (VdB)
5	100	79
10	91	70
15	86	65
20	82	61
40	73	52
60	68	47
100	61	40
150	56	35
200	52	31
300	47	26

**Equation:**  $L_v(D) = L_v(25\text{ ft}) - 30\log(D/25)$

**D** = Distance (feet)

**L<sub>v</sub>(D)** = Vibration Level

**Source:** Federal Transit Administration, *Transit Noise and Vibration Impact Assessment*, May 2006.

**Vibration Damage Analysis**

Receptor	Distance from equipment (feet) (D)	Large Bulldozer (Inches Per Second)	Loaded Trucks (Inches Per Second)	Small Bulldozer (Inches Per Second)
<b>Phase 1</b>				
Commercial Building to the east	100	0.011	0.010	0.000
<b>Phase 2</b>				
Commercial Building	65	0.021	0.018	0.001
<b>Phase 3</b>				
Parking Structure	10	0.352	0.300	0.012
<b>Phase 4</b>				
Smith Tuthill Funeral Parlor	80	0.016	0.013	0.001
Commercial Buildings to North	90	0.013	0.011	0.000
Old Courthouse Museum	170	0.005	0.004	0.000

**Equation:**  $PPV_{\text{equip}} = PPV_{\text{ref}} \times (25/D)^{1.5}$

**PPV (equip)** is the peak particle velocity in in/sec of the equipment adjusted for distance

**PPV (ref)** is the reference vibration level in in/sec at 25 feet from Table 12-2

**D** is the distance from the equipment to the receiver.

**Source:** Federal Transit Administration, *Transit Noise and Vibration Impact Assessment*, May 2006.