COUNTY OF VENTURA

CONSTRUCTION NOISE THRESHOLD CRITERIA AND CONTROL PLAN

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TABLE OF CONTENTS

LIST OF FIGURES

APPENDICES

Construction and Noise

A distinct difference between the construction industry and other industries is that construction is, in the vast majority of cases, a temporary activity. There are very few construction projects that last several years. Even very large buildings and roads are under construction in a particular area for only a reasonably short time period, seldom more than two years. As the construction project progresses, the noise from such a project changes as the different phases of the construction are undertaken. Noise mitigation programs that take a long time to implement or officials that are very slow to act usually find that the problem is gone by the time the remedies are in place. Often a construction contractor can avoid most community complaints simply by notifying the potentially affected residents and other sensitive receptors regarding the purpose of the project and the expected completion schedule. People want to know how soon the construction will be finished and what are the project benefits to the neighborhood.

Thus, rather than being a continuous problem, construction noise is always a temporary site-specific problem. As such, there are many factors that contribute to the potential impacts due to construction noise, including the location of sensitive receptors, the type or phase of construction, the combination of equipment used, the site layout, and the construction methods employed. The noise created by construction equipment will vary greatly during a project, depending on such factors as the type of equipment, the specific equipment models, the operation being performed, the care employed by equipment operators and the condition of the equipment being used.

Fundamentals of Sound

A brief introduction to the fundamentals of sound may be useful. Physically, sound magnitude is measured and quantified in terms of the decibel (dB), which is a unit on a logarithmic scale based on the ratio of the measured sound pressure to the reference sound pressure of 20 micropascal (20 μPa = 20 x 10^{-6} N/m^2). The decibel system can be very confusing to people since it is logarithmic and not arithmetic. For example, doubling or halving the number of sources of equal sound (a 2-fold change in acoustic *energy*) changes the receptor sound by only 3 dB, which is a barely perceptible sound loudness change for humans. On the other hand, a doubling or halving the sound *loudness* at the receiver results from a 10 dB change, which also represents a 10-fold change in the acoustic *energy*.

In addition, the human hearing system exhibits a slow time response and also is not equally sensitive to the same sound pressure level at low, middle and high acoustic frequencies. Because of this variability, a frequency-dependent, adjustment called “A-weighting” has been devised so that sound may be measured in a manner similar to the way the human hearing system responds. The A-weighted sound level is abbreviated "dBA". Figure 1 gives typical A-weighted sound levels for various noise sources and the typical reactions to these levels. All sound levels referred to in this document are A-weighted, slow response, sound pressure levels.

The two acoustical metrics most frequently used to provide a single number sound level for time-varying sounds over a given time period are the energy equivalent or energy average sound level (L_{eq}) and the “slow response” maximum sound level (L_{max}). The long-term A-weighted energy average sound level, called the 24-hour equivalent sound level, $L_{eq}(24h)$, is the logarithmic average of the individual 24 hourly equivalent sound levels, $L_{eq}(h_i)$. Since it has been found that noise is more disturbing in the evening and nighttime when the ambient noise is

generally quieter, modifications to the 24-hour L_{eq} have been adopted. The Day-Night sound level (DNL or L_{dn}) is a 24-hour energy average noise level based on the daytime and nighttime hourly average $L_{eq}(h)$ noise levels, with a 10 dB penalty added to each hourly nighttime average

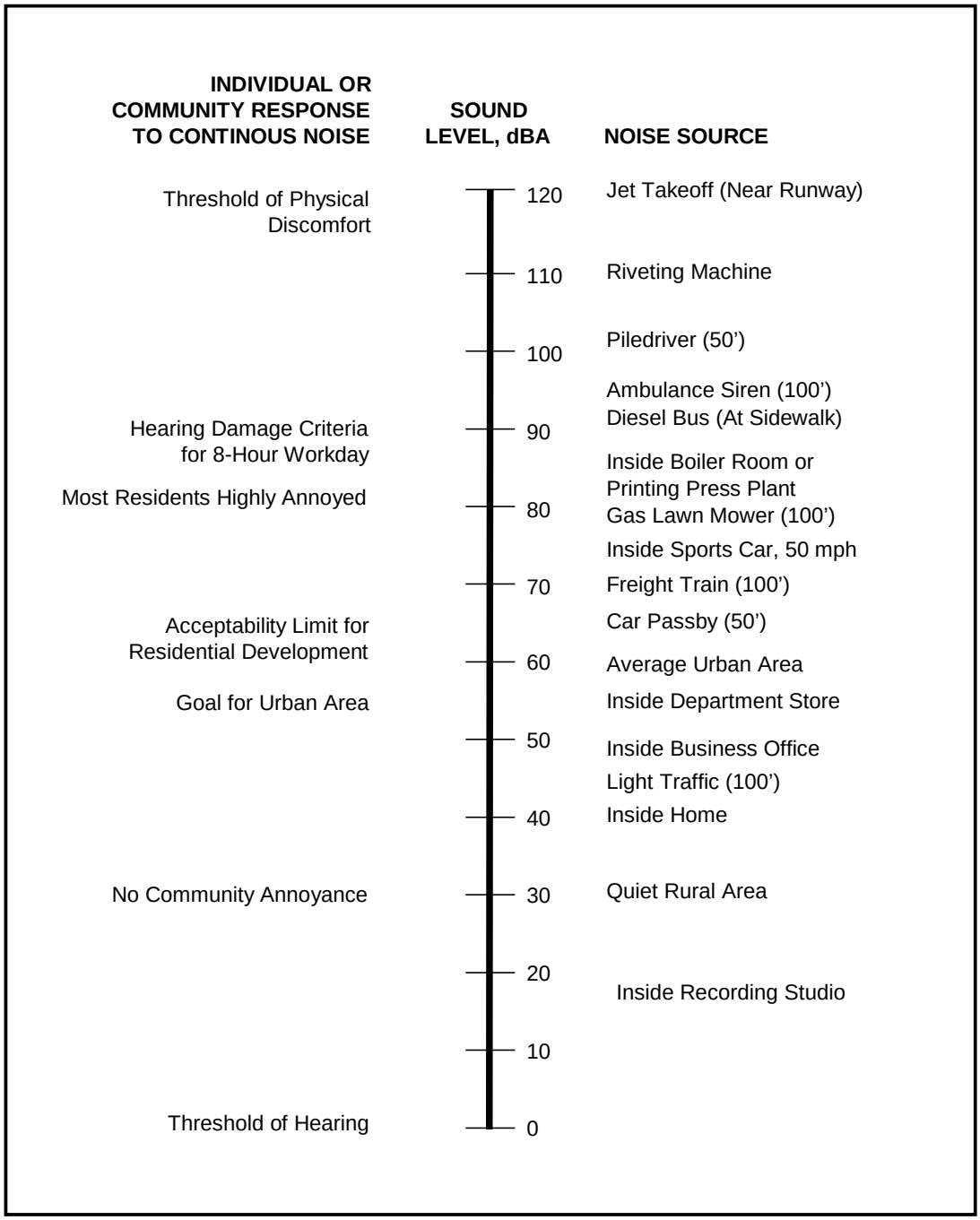

Figure 1. Typical Sound Levels of Noise Sources and Expected Reactions

noise level. Another long-term noise descriptor is the Community Noise Equivalent Level (CNEL or L_{den}). The CNEL is a 24-hour average noise level based on the daytime, evening and nighttime hourly average noise levels, with a 5 dB penalty added to each of the three evening hourly average noise levels and a 10 dB penalty added to each of the nine hourly nighttime average noise levels. The CNEL is used primarily in the State of California.

Noise from Typical Construction Equipment and Operations

The equivalent sound level (L_{eq}) as it relates to construction activity depends on several factors including machine power, the manner of operation and the amount of time the equipment is operated over a given time period. The following provides information on typical levels generated by various construction equipment and provides guidance on determining the noise from construction activities.

The most dominant source of noise for the majority of construction equipment is the engine exhaust, which is usually a diesel engine. However, for some construction work, such as impact pile driving or pavement breaking, the noise produced by the work process is the dominant source. Similar construction activities can create different noise impacts, depending on the location of the construction site, the terrain and other intervening features and the type of receptor populations in the vicinity of the construction site.

For most construction activities, different construction equipment operate in one of two modes, *stationary* and *mobile*. *Stationary* equipment are those that operate in one small area for one or more days at a time, with either a steady power cycle operation (e.g., pumps, generators, compressors, etc.) or a periodic impulsive operation (e.g., pile drivers, pavement breakers, etc.). *Mobile* equipment are those that frequently move around a much larger area of the construction site with power applied in a rapidly changing, non-steady fashion (e.g., bulldozers, loaders, etc.), or move to and from the construction site (e.g., haul trucks, material trucks, etc.). These variations in operating power and location add a great deal of complexity in characterizing the source noise level of a given piece of construction equipment. This complexity can be simplified by determining the equipment noise level at a 50-foot reference distance from the equipment operating at full power and adjusting its full power noise level according to the duty cycle or “usage factor” of the particular construction activity and project phase to determine the characteristic noise level of the operation during each phase.

The Society of Automotive Engineers has developed standardized procedures for measuring reference noise levels for the certification of mobile and stationary construction equipment. For informational purposes, typical 50-foot reference noise levels from representative pieces of construction equipment are listed in Figure 2. The major noise producing construction activities within the County would likely be pile driving, pavement breaking, demolition, excavation, earth moving, and haul trucking.

Noise-sensitive receptors that would be affected by such construction activities within the County are listed in Figure 3, along with their periods of greatest sensitivity to construction noise.

Construction activity noise is characterized by the combined duty cycle and resulting noise emission of each piece of equipment. The duty cycle is expressed in terms of the "usage factor" of the equipment, which is the percentage of time during the work period that the equipment is

operating under load or at near full power. In addition to the minute-by-minute variations in noise producing activities, construction projects are carried out in several different phases.

Figure 2. Typical Construction Equipment Noise

Equipment Type Noise Source	Dominant Noise Components[1]	50-Foot Noise Level (L_{eq}) dBA[2, 3]	Noise Level Range (L_p) dBA[2, 3]	50-Foot Maximum Noise Level (L_{max}) dBA[2 3]
Air Compressor (portable)[4]	E, C, H, I	81	76-89	89
Air Compressor (stationary)	E, C, H, I	82	76-89	89
Auger, Drilled Shaft Rig	E, C, F, I, W	82	76-89	89
Backhoe	E, C, F, I, H, W	85	81-90	90
Bar Bender	E, P, W	82	78-88	85
Chain Saw	E, W, C	85	72-88	88
Compactor	E, C, F, I, W	82	81-85	85
Concrete Batch Plant	W, E, C	92	80-96	96
Concrete Mixer (small trailer)	W, E, C	67	65-68	68
Concrete Mixer Truck	E, C, F, W, T	85	69-89	89
Concrete Pump Trailer	E, C, H	82	74-84	84
Concrete Vibrator	W, E, C	76	68-81	81
Crane, Derrick	E, C, F, I, T	88	79-90	90
Crane, Mobile	E, C, F, I, T	83	80-85	85
Dozer (Bulldozer)	E, C, F, I, H	80	77-90	90
Excavator	E, C, F, I, H, W	87	83-92	92
Forklift	E, C, I, W	84	81-86	86
Front End Loader	E, C, F, I, H	79	77-90	90
Generator	E, C	78	71-87	87
Gradall	E, C, F, I, W	82	78-85	85
Grader	E, C, F, I, W	85	79-89	89
Grinder	W	80	75-82	82
Hydraulic Hammer	W, E, C, H	102	99-105	105
Impact Wrench	W, P	85	75-85	85
Jack Hammer	P, W, E, C	82	75-88	88
Paver	E, D, F, I	89	82-92	92
Pile Driver (Impact/ Sonic/ Hydraulic)	W, P, E	101 / 96 / 65	94-107 / 90-99 / 65	107 / 99 / 65
Pavement Breaker	W, E, P	82	75-85	85
Pneumatic Tool	P, W, E, C	85	78-88	88
Pump	E, C	76	68-80	80
Rock Drill	W, E, P	98	83-99	99
Roller	E, C, F, I, W	74	70-83	83
Sand Blaster	W, E, C, H, I	85	80-87	87
Saw, Electric	W	78	59-80	80
Scraper	E, C, F, I, W	88	82-91	91
Shovel	E, C, F, I, W	82	77-90	90
Tamper	W, E, C	86	85-88	88
Tractor	E, C, F, I, W	82	77-90	90
Trencher		83	81-85	85
Trucks (Under Load)	E, C, F, I, T	88	81-95	95
Water Truck	W, E, C, F, I, T	90	89-94	94
Other Equipment with Diesel	E, C, F, I	82	75-88	88

Note 1. Ranked noisy components. C=Casing, E=Exhaust, F=Fan, H=Hydraulics, I=Intake air, P=Pneumatic exhaust, T=Transmission, W=Work tool.

Note 2. Table based on EPA studies and measured data from various construction equipment and manufacturer's data.

Note 3. Equipment noise levels are at 50 feet from individual construction equipment and with no other noise contributors.

Note 4. Portable air compressor rated at 75 cfm or greater and operating at greater than 50 psi.

Each phase has a different equipment mix depending on the work to be accomplished. Some have more continuous noise, while others may have more impact type noise. Typical construction phases and equipment usage factors are given in Appendix A. Construction phase equipment usage factors, combined with receptor distances and equipment noise emissions, can be used in estimating future project noise. Such methods are discussed in Appendix B.

Figure 3. Noise-Sensitive Receptors

Receptor Description	Typical Sensitive Time Period
Hospitals, Nursing Homes (quasi-residential)	24 hours
Single-Family and Multi-Family Dwellings (residential)	Evening/Night
Hotels/Motels (quasi-residential)	Evening/Night
Schools, Churches, Libraries (when in use)	Daytime/Evening

Construction Noise Threshold Criteria

Standardized federal or state criteria have not been adopted for assessing construction noise impacts. Therefore, municipal planning criteria are generally developed and applied on a project-specific basis. Construction project noise criteria take into account the existing noise environment, the time-varying noise during the various phases of construction activities, the duration of the construction, and the adjacent land use.

Specific construction noise limits for noise-sensitive locations are not currently specified in the General Plan or administrative code of the County of Ventura. This document, therefore, is intended to establish construction noise thresholds and standard noise monitoring and control measures. These threshold criteria, monitoring and control measures shall be applied to all discretionary development projects (public projects, PD Permits, Conditional Use Permits) and should be applied to ministerial development permits by amending the county building code (including excavation and grading). Construction noise monitoring methods are discussed in Appendix C. Construction projects that exceed the noise threshold criteria at sensitive receptor sites, shall implement effective noise mitigation measures recommended by the manufacturers, considering the guidelines of Appendix D. The permitting agency/department shall review the construction noise mitigation measures and confirm compliance with the noise threshold criteria.

During daytime hours, construction work should comply with the County of Ventura construction noise threshold criteria (NTC), defined hereafter. Normally, no evening or nighttime construction activity is permitted in areas having noise-sensitive receptors. However, in the event such activity is deemed necessary and is permitted, reduced noise threshold criteria are provided for construction that must occur during evening and/or nighttime hours. Emergency construction work is exempt from these construction noise thresholds.

Daytime Construction[1] - Daytime (7:00 a.m. to 7:00 p.m. Monday through Friday, and from 9:00 a.m. to 7:00 p.m. Saturday, Sunday and local holidays) generally means any time period not

[1] These criteria only apply to the noise-sensitive receptors that are sensitive to noise impacts during the daytime. See Figure 3 (above).

specifically defined as a more noise-sensitive time period. The daytime construction noise threshold criteria are given in Figure 4. Depending on project duration, the daytime noise threshold criteria shall be the greater of the fixed $L_{eq}(h)$ limit (which includes non-construction evening and nighttime noise) or the measured ambient $L_{eq}(h)$ plus 3 dB.

Evening Construction[2] - Evening hours (7:00 p.m. to 10:00 p.m.) are more noise-sensitive time periods. Therefore, evening construction noise threshold criteria differ from the daytime criteria. Overall project construction noise, for the noise-sensitive hours specified, shall not exceed the noise threshold criteria listed in Figure 5, at the nearest noise-sensitive receptor area or 10 feet from the façade of the nearest noise-sensitive building.

Nighttime Construction[3] - Nighttime hours (10:00 p.m. to 7:00 a.m. Monday through Friday, and from 10:00 p.m. to 9:00 a.m. Saturday, Sunday and local holidays) are the most noise-sensitive time periods. Therefore, nighttime and holiday construction noise threshold criteria differ from the daytime and evening criteria. Overall project construction noise, for the noise-sensitive hours specified, shall not exceed the noise threshold criteria listed in Figure 6, at the nearest noise-sensitive receptor area or 10 feet from the façade of the nearest noise-sensitive building.

Maximum Construction Noise - In addition, the construction-related, slow response, instantaneous maximum noise (L_{max}) shall not exceed the noise threshold criteria by 20 dBA more than eight times per daytime hour, more than six times per evening hour and more than four times per nighttime hour.

Determination of Compliance - The construction noise at sensitive receptor locations for each construction phase is due to the contributions of each piece of noise producing equipment used in each construction phase. The resulting construction phase noise must be compared to the construction noise threshold criteria to determine whether noise mitigation measures are required. The construction noise monitoring methods are discussed in Appendix C and typical noise mitigation measures are given in Appendix D. During periods of greater construction noise activity, the construction noise shall be monitored by a designated person trained in the use of a sound meter in accordance with the methods of Appendix C. When construction noise fails to comply with the appropriate noise threshold criteria, or falls out of compliance during use, the designated noise monitor shall immediately identify the non-compliant activity or equipment. Either the non-compliant activity must be stopped and the equipment removed from service or effective remedial action must be taken, similar to the noise mitigation measures of Appendix D, to restore compliance with the respective noise threshold criteria.

[2] These criteria apply to all noise-sensitive receptors. See Figure 3 (above).

[3] These criteria only apply to the noise-sensitive receptors that are sensitive to noise impacts during the nighttime. See Figure 3 (above).

Figure 4. Daytime Construction Activity Noise Threshold Criteria

Construction Duration Affecting Noise-sensitive Receptors	Noise Threshold Criteria shall be the greater of these noise levels at the nearest receptor area or 10 feet from the nearest noise-sensitive building	
	Fixed Leq(h), dBA	Hourly Equivalent Noise Level (L_{eq}), dBA[1, 2]
0 to 3 days	75	Ambient L_{eq}(h) + 3 dB
4 to 7 days	70	Ambient L_{eq}(h) + 3 dB
1 to 2 weeks	65	Ambient L_{eq}(h) + 3 dB
2 to 8 weeks	60	Ambient L_{eq}(h) + 3 dB
Longer than 8 weeks	55	Ambient L_{eq}(h) + 3 dB

Note 1. The instantaneous L_{max} shall not exceed the NTC by 20 dBA more than 8 times per daytime hour.
Note 2. Local ambient Leq measurements shall be made on any mid-week day prior to project work.

Figure 5. Evening Construction Activity Noise Threshold Criteria

Receptor Location	Evening Noise Threshold Criteria shall be the greater of these noise levels at the nearest receptor area or 10 feet from the nearest noise-sensitive building	
	Fixed Leq(h), dBA	Hourly Equivalent Noise Level (L_{eq}), dBA[1, 2]
Residential	50	Ambient L_{eq}(h) + 3 dB

Note 1. The instantaneous L_{max} shall not exceed the NTC by 20 dBA more than 6 times per evening hour.
Note 2. Hourly evening local ambient noise measurements shall be made on a typical mid-week evening prior to project work.

Figure 6. Nighttime Construction Activity Noise Threshold Criteria

Receptor Location	Nighttime Threshold Criteria shall be the greater of these noise levels at the nearest receptor area or 10 feet from the nearest noise-sensitive building	
	Fixed Leq(h), dBA	Hourly Equivalent Noise Level (L_{eq}), dBA[1, 2]
Resident, Live-in Institutional	45	Ambient L_{eq}(h) + 3 dB

Note 1. The instantaneous L_{max} shall not exceed the NTC by 20 dBA more than 4 times per nighttime hour.
Note 2. Hourly nighttime local ambient noise measurements shall be made on a typical mid-week night prior to project work.

Construction Noise Complaints

The daytime noise threshold criteria for construction activity are provided in Figure 4. When evening and nighttime construction is necessary, evening and nighttime construction operations (except for emergency construction) must comply with the evening and nighttime noise threshold criteria listed in Figures 5 and 6, respectively. If these respective construction noise threshold criteria are exceeded, there would likely be strong adverse community reaction. However, noise complaints are possible, even when construction work complies with the criteria.

The project, therefore, must be prepared to appropriately respond to complaints and keep a "Complaint Log," noting date, time, complainant's name, nature of the complaint, and any corrective action taken. The project manager shall publish and distribute to the potentially affected community, a "Hot Line" telephone or pager number, that is attended during active construction working hours, for use by the disturbed public to register complaints.

Since noise complaints are still possible, even when construction work complies with the noise threshold criteria. Noise characteristics other than loudness (e.g., squeals, incessant banging, etc.) can result in complaints. An unusual number of construction noise complaints may require that additional noise mitigation be undertaken. Careful identification of the specific conditions of activity responsible for the noise complaints would be necessary to determine additional appropriate mitigation measures. Appendix D suggests typical measures to be considered for greater mitigation than previously implemented. Proper measures shall be applied before continuing the activity responsible for the unusual number of complaints. For especially difficult cases, the assistance of a qualified construction noise control consultant may be required.

APPENDICES

A. Typical Equipment Noise, Construction Phases and Use Factors

B. Estimating Construction Equipment and Project Noise

C. Construction Noise Monitoring

D. Construction Noise Mitigation Measures

Appendix A

Typical Equipment Noise, Construction Phases and Use Factors

Figure A-1. Typical Construction Equipment Noise

Equipment Type Noise Source	Dominant Noise Components[1]	50-Foot Noise Level (L_{eq}) dBA[2, 3]	Noise Level Range (L_p) dBA[2, 3]	50-Foot Maximum Noise Level (L_{max}) dBA[2 3]
Air Compressor (portable)[4]	E, C, H, I	81	76-89	89
Air Compressor (stationary)	E, C, H, I	82	76-89	89
Auger, Drilled Shaft Rig	E, C, F, I, W	82	76-89	89
Backhoe	E, C, F, I, H, W	85	81-90	90
Bar Bender	E, P, W	82	78-88	85
Chain Saw	E, W, C	85	72-88	88
Compactor	E, C, F, I, W	82	81-85	85
Concrete Batch Plant	W, E, C	92	80-96	96
Concrete Mixer (small trailer)	W, E, C	67	65-68	68
Concrete Mixer Truck	E, C, F, W, T	85	69-89	89
Concrete Pump Trailer	E, C, H	82	74-84	84
Concrete Vibrator	W, E, C	76	68-81	81
Crane, Derrick	E, C, F, I, T	88	79-90	90
Crane, Mobile	E, C, F, I, T	83	80-85	85
Dozer (Bulldozer)	E, C, F, I, H	80	77-90	90
Excavator	E, C, F, I, H, W	87	83-92	92
Forklift	E, C, I, W	84	81-86	86
Front End Loader	E, C, F, I, H	79	77-90	90
Generator	E, C	78	71-87	87
Gradall	E, C, F, I, W	82	78-85	85
Grader	E, C, F, I, W	85	79-89	89
Grinder	W	80	75-82	82
Hydraulic Hammer	W, E, C, H	102	99-105	105
Impact Wrench	W, P	85	75-85	85
Jack Hammer	P, W, E, C	82	75-88	88
Paver	E, D, F, I	89	82-92	92
Pile Driver (Impact/ Sonic/ Hydraulic)	W, P, E	101 / 96 / 65	94-107 / 90-99 / 65	107 / 99 / 65
Pavement Breaker	W, E, P	82	75-85	85
Pneumatic Tool	P, W, E, C	85	78-88	88
Pump	E, C	76	68-80	80
Rock Drill	W, E, P	98	83-99	99
Roller	E, C, F, I, W	74	70-83	83
Sand Blaster	W, E, C, H, I	85	80-87	87
Saw, Electric	W	78	59-80	80
Scraper	E, C, F, I, W	88	82-91	91
Shovel	E, C, F, I, W	82	77-90	90
Tamper	W, E, C	86	85-88	88
Tractor	E, C, F, I, W	82	77-90	90
Trencher		83	81-85	85
Trucks (Under Load)	E, C, F, I, T	88	81-95	95
Water Truck	W, E, C, F, I, T	90	89-94	94
Other Equipment with Diesel	E, C, F, I	82	75-88	88

Note 1. Ranked noisy components. C=Casing, E=Exhaust, F=Fan, H=Hydraulics, I=Intake air, P=Pneumatic exhaust, T=Transmission, W=Work tool.
Note 2. Table based on EPA studies and measured data from various construction equipment and manufacturer's data.
Note 3. Equipment noise levels are at 50 feet from individual construction equipment and with no other noise contributors.
Note 4. Portable air compressor rated at 75 cfm or greater and operating at greater than 50 psi.

Figure A-2
Typical Domestic Housing Construction Equipment and Use Factors

Equipment Item	50-Foot Leq, dBA	Mitigated1 Leq, dBA	Highest Hourly Use Percentage per Construction Phase				
			Clear	Excavate	Base	Build	Finish
Air Compressor	81	75	--2	10	--	--	25
Backhoe	85	75	2	4	--	--	2
Concrete Mixer	85	75	--	--	4	8	16
Concrete Pump	82	75	--	--	--	--	--
Concrete Vibrator	76	75	--	--	--	--	--
Crane, Derrick	88	75	--	--	--	--	--
Crane, Mobile	83	75	--	--	--	10	4
Dozer	80	75	4	8	--	--	4
Generator	78	75	4	--	--	--	--
Grader	85	75	5	--	--	--	2
Jack Hammer	82	75	--	--	--	--	3
Loader	79	75	4	8	--	--	4
Paver	89	80	--	--	--	--	3
Pile Driver	101	95	--	--	--	--	--
Pneumatic Tool	85	80	--	--	4	10	4
Pump	76	75	--	4	7	--	--
Rock Drill	98	80	--	1	--	--	0.5
Roller	74	74	--	--	--	--	4
Saw, Electric	78	75	--	--	4 (2) 3	10 (2)	4 (2)
Scraper	88	80	5	--	--	--	1
Shovel	82	75	--	2	--	--	--
Truck	88	75	16	40	--	--	16

Note 1. Estimated level obtainable by quieter methods or equipment and implementing feasible noise controls.
Note 2. "--" indicates typically zero or very little use during construction phase.
Note 3: Numbers in parentheses are greatest multiple number of same items in use.

Figure A-3
Typical Large Building and Institutional Construction Equipment and Use Factors

Construction Equipment	50-Foot Leq, dBA	Mitigated1 Leq, dBA	Highest Hourly Use Percentage per Construction Phase				
			Clear	Excavate	Base	Build	Finish
Air Compressor	81	75	--2	100 (2) 3	100 (2)	100 (2)	40 (2)
Backhoe	85	75	04	16	--	--	4
Concrete Mixer	85	75	--	--	40	40	16
Concrete Pump	82	75	--	--	40	8	8
Concrete Vibrator	76	75	--	--	40	10	4
Crane, Derrick	88	75	--	--	--	16	4
Crane, Mobile	83	75	--	--	--	16 (2)	4 (2)
Dozer	80	75	16	40	--	--	16
Generator	78	75	40 (2)	100 (2)	--	--	--
Grader	85	75	8	--	--	--	2
Jack Hammer	82	75	--	10	4	4	4
Loader	79	75	16	40	--	--	16
Paver	89	80	--	--	--	--	10
Pile Driver	101	95	--	--	4	--	--
Pneumatic Tool	85	80	--	--	4	16 (2)	4 (2)
Pump	76	75	--	100 (2)	100 (2)	40	--
Rock Drill	98	80	--	4	--	--	0.5
Roller	74	74	--	--	--	--	--
Saw, Electric	78	75	--	--	4 (3)	100 (3)	--
Scraper	88	80	55	--	--	--	--
Shovel	82	75	--	40	--	--	--
Truck	88	75	16 (2)	40	--	--	16

Note 1. Estimated level obtainable by quieter methods or equipment and implementing feasible noise controls.
Note 2. "--" indicates typically zero or very little use during construction phase.
Note 3: Numbers in parentheses are greatest number of same items in use during any hour.

Figure A-4
Typical Commercial and Industrial Construction Equipment and Use Factors

Construction Equipment	50-Foot Leq, dBA	Mitigated1 Leq, dBA	Highest Hourly Use Percentage per Construction Phase				
			Clear	Excavate	Base	Build	Finish
Air Compressor	81	75	--2	100	40	40	40
Backhoe	85	75	4	16	--	--	4
Concrete Mixer	85	75	--	--	40	16	16
Concrete Pump	82	75	--	--	40	--	8
Concrete Vibrator	76	75	--	--	--	--	--
Crane, Derrick	88	75	--	--	--	4	2
Crane, Mobile	83	75	--	--	--	8	4
Dozer	80	75	4	16	--	--	4
Generator	78	75	40	40	--	--	--
Grader	85	75	5	--	--	--	2
Jack Hammer	82	75	--	10	4	4	4
Loader	79	75	16	16	--	--	4
Paver	89	80	--	--	--	--	12
Pile Driver	101	95	--	--	4	--	--
Pneumatic Tool	85	80	--	--	4	10 (3) 3	4 (3)
Pump	76	75	--	40	100 (2)	40	--
Rock Drill	98	80	--	4	--	--	5
Roller	74	74	--	--	--	--	10
Saw, Electric	78	75	--	--	4 (2)	10 (2)	--
Scraper	88	80	14	--	--	--	8
Shovel	82	75	--	20	--	--	6
Truck	88	75	16 (2)	16 (2)	--	--	16

Note 1. Estimated level obtainable by quieter methods or equipment and implementing feasible noise controls.
Note 2. "--" indicates typically zero or very little use during construction phase.
Note 3: Numbers in parentheses are greatest number of same items in use during any hour.

Figure A-5
Typical Public Works and Roadway Construction Equipment and Use Factors

Construction Equipment	50-Foot Leq, dBA	Mitigated1 Leq, dBA	Highest Hourly Use Percentage per Construction Phase				
			Clear	Excavate	Base	Build	Finish
Air Compressor	81	75	--2	100 (2)3	40	40	40 (2)
Backhoe	85	75	4	40	--	--	16
Concrete Mixer	85	75	--	--	16 (2)	40 (2)	16 (2)
Concrete Pump	82	75	--	--	--	--	--
Concrete Vibrator	76	75	--	--	--	--	--
Crane, Derrick	88	75	--	10	4	4	--
Crane, Mobile	83	75	--	--	--	16	--
Dozer	80	75	4	40	--	--	16
Generator	78	75	100 (2)	40 (2)	40 (2)	40	40 (2)
Grader	85	75	8	--	--	20	8
Jack Hammer	82	75	--	--	--	4	10 (2)
Loader	79	75	4	40	--	--	16
Paver	89	80	--	--	--	--	--
Pile Driver	101	95	--	--	--	--	--
Pneumatic Tool	85	80	--	--	4 (2)	10	4
Pump	76	75	--	40 (2)	100 (2)	40 (2)	--
Rock Drill	98	80	--	4	--	--	--
Roller	74	74	--	--	100	--	--
Saw, Electric	78	75	--	--	4 (2)	--	--
Scraper	88	80	8		20	8	8
Shovel	82	75	4	40	4	--	4
Truck	88	75	16 (2)	16	40 (2)	--	16 (2)

Note 1. Estimated level obtainable by quieter methods or equipment and implementing feasible noise controls.
Note 2. "--" indicates typically zero or very little use during construction phase.
Note 3: Numbers in parentheses are greatest number of same items in use during any hour.

Appendix B
Estimating Construction Project Noise

For project planning purposes, where the potential for noise impacts exist, it is possible to estimate the potential construction noise impacts in advance by developing an inventory of noisy construction equipment and processes for the various stages and phases of the project. Such screening methods assist construction project managers and estimators in planning for the potential need for noise mitigation.

Construction Equipment Inventory

An inventory of the number and type of noisy construction equipment to be used during planned daytime, evening and nighttime construction activities, their associated noise emissions, and other relevant information can be included on Figure B-2, Construction Phase Receptor Noise Estimation Worksheet. Using this form, construction noise levels for the various phases of construction can be estimated using the phase's equipment inventory, the typical 50-foot equipment noise levels (listed in Figure A-1 of Appendix A) along with typical by-phase construction equipment use factors, provided in Figures A-1 through A-5 of Appendix A.

Construction Noise Estimates

Calculations can be performed to estimate the daytime, evening and nighttime maximum (L_{max}) and one-hour energy average (L_{eq}) noise levels expected at the noise-sensitive location, based on the typical maximum equipment noise levels listed in Figure A-1 in Appendix A. The calculations are to be made for the various activities and locations where project construction noise will result in the greatest noise impact (*noise levels at other sensitive locations can also be calculated, if necessary*). The calculations and results should be entered on a form similar to Figure B-2, the Construction Phase Receptor Noise Estimation Worksheet. The result of a sample construction noise calculation is provided in Figure B-1.

The following calculation procedures may be used to estimate the construction noise by phase.

1. Calculate each phase's L_{max} according to the following method:

   L_{max} [equipment type] = ML – 20 $\log_{10}$ (D/50)

   where:

   ML = Typical single equipment maximum noise level (L_{max}) at 50 feet, in dBA. (*This may be replaced by a measured, under-load, maximum noise level*).

   D = Distance from the equipment to the noise-sensitive location, in feet.

   Repeat the above calculation for each item of potentially noisy equipment. Then, select the noisiest individual pieces of equipment that operate in their loudest mode at the very same time and combine them logarithmically to estimate the overall maximum construction noise level (L_{max}) at the noise-sensitive location(s) for each project phase, as follows:

   L_{max} [overall project at receptor] = 10 $\log_{10}(\Sigma 10^{(L_{max}\text{ [equipment type]} / 10)})$

2. Calculate each phase's one-hour L_{eq} according to the method recommended by the U.S. Federal Highway Administration ("Highway Construction Noise: Measurement, prediction and mitigation," U.S. Department of Transportation, Federal Highway Administration Special Report, March 1977), as follows:

   First, the construction phase's one-hour L_{eq} is to be calculated at the sensitive receptor location for each item of potentially noisy equipment using the following equation:

   $$L_{eq}(h) \text{ [equipment type]} = ML - 20 \log_{10} (D/50) + 10 \log_{10} (N \times HP/100)$$

   where:

   ML = Typical single equipment maximum noise level (L_{max}) at 50 feet, in dBA. (*This may be replaced by a measured, under-load, maximum noise level*).

   D = Shortest distance (feet) from the equipment type to the nearest noise-sensitive location, or if a more sensitive receptor is further away, to the noise-sensitive receptor with the greatest impact. If the distance is measured in meters, use the ratio D/15 instead of D/50.

   N = Maximum number of the same equipment type operating hourly on the project during the construction phase.

   HP = "Hourly percentage," expressed as the greatest nominal percent of time that the equipment is operated under load at the project site. This factor is based on EPA values or is estimated based on past experience with similar projects. Thus, the effective usage factor is (EUF) = N x HP/100.

   Repeat the above calculations for each item of potentially noisy equipment. Then, the individual contribution of every item of equipment are to be combined logarithmically to obtain the overall construction hourly L_{eq} at the noise-sensitive location(s) for each project phase, as follows:

   $$L_{eq}(h) \text{ [overall project at receptor]} = 10 \log_{10} (\Sigma 10^{(\text{one-hour Leq [equipment type]} / 10)})$$

3. The calculated L_{max} and $L_{eq}(h)$ levels can then be compared with the construction noise threshold criteria. Where it is estimated that the criteria would be exceeded, noise mitigation planning can be undertaken.

Figure B-1.
Example of Construction Phase Receptor Noise Estimation Worksheet

A	B	C	D	E	F	G	H	I	J	K
Construction Phase Equipment Item	# of Items	Item Lmax at 50 feet, dBA	Dist. to Recptr.	Item Usage Percent	Usage Factor	Dist. Adj., dB	Usage Adj., dB	Recptr. Item Lmax, dBA	Recptr. Item Leq, dBA	**Log_{10} Sums of Receptor Item L_{eq} Yield the Combined Receptor L_{eq}, dBA**
1. DOZER	1	90	100	70	0.70	-6	-1.6	84.0	82.4	82.4
2. GRADER	1	89	200	75	0.75	-12	-1.2	77.0	75.7	83.3
3. SCRAPER	2	91	150	20	0.40	-6	-4.0	81.5	77.5	84.4
4. WATER TRUCK	1	94	50	5	0.05	-6	-13.0	94.0	81.0	86.0
5.										
6.										
							Log Sum	94.7	86.0	

Figure B-2.
Construction Phase Receptor Noise Estimation Worksheet

A	B	C	D	E	F	G	H	I	J	K
Construction Phase Equipment Item	# of Items	Item Lmax at 50 feet, dBA	Dist. to Recptr.	Item Usage Percent	Usage Factor	Dist. Correction dB	Usage Adj. dB	Recptr. Item Lmax, dBA	Recptr. Item Leq, dBA	**Log10 Sums of Receptor Item Leq Yield the Combined Receptor Leq, dBA**
1.										
2.										
3.										
4.										
5.										
6.										
							Log Sum			

Appendix C
Construction Noise Monitoring

This appendix outlines the noise measurement instrumentation and monitoring procedures.

Noise Measurement Instruments

1. Noise measurements shall be performed with an instrument that is in compliance with or exceeds the criteria for a Type 2 (General Purpose) Sound Level Meter, as defined in the most recent revision of ANSI Standard S1.4.2.

2. Sound level meters shall be capable of measuring the slow response L_{max} and one-hour L_{eq} on the A-Weighted scale, as required by the construction noise threshold criteria and construction project noise limits. Where possible, integrating-type instruments may monitor the percentile (L_1, L_{50}, etc.) noise levels, as well, to show construction noise statistics.

3. Sound level meters, microphones, and field calibrators shall be calibrated by a certified laboratory at least once a year. A valid certificate of calibration conformance shall be obtained and be available for each instrument before using sound level meters. Updated certificates shall be maintained following subsequent yearly calibrations and upon the completion of repairs to noise monitoring instruments.

Noise Measurement Procedure

1. The sound level meter shall be calibrated using an acoustic calibrator, according to the manufacturer's specifications, just before each measurement.

2. Except as otherwise indicated, measurements shall be performed using the A-weighting network and the slow response setting of the sound level meter.

3. Impulsive or impact noises shall be measured using the C-weighting network and the fast response setting of the sound level meter.

4. The measurement microphone shall be fitted with an appropriate windscreen and the sound level meter shall be placed at the location of the sensitive receptor with the microphone approximately 5 feet above the ground or floor and at least 10 feet away from any vertical surfaces.

5. Ambient noise measurements shall be taken during periods of the least noise-producing activity in the vicinity of noise sensitive locations that may be impacted by the construction operations. Ambient noise measurements shall be conducted for at least 20 minutes at representative locations for potentially impacted receptors.

6. Construction noise measurements shall be taken during periods of greatest noise-producing activity at noise sensitive locations in the vicinity of the construction site a minimum of once each shift and also after a sustained perceptible change in noise-producing construction activity or location. Noise measurements shall be conducted for at least 20 minutes each monitoring session.

7. Construction noise measurements shall coincide with daytime, evening and nighttime daily time periods of maximum noise-generating construction activity and shall be taken or repeated during the construction phase or activity that has the greatest potential to create annoyance or to exceed applicable noise regulations and restrictions.

8. If, in the estimation of the person performing the measurements, non-project related noise sources contribute significantly to the measured noise level, additional measurements (with the same non-project noise source contributions) shall be repeated when project construction is inactive to determine the non-project ambient background noise level.

9. Noise data shall be logged using the Noise Measurement Report Form and maintained for at least six months following the completion of the construction project. The type of measurement (e.g. baseline ambient, on-going construction, major change, etc.) shall be noted on the form.

10. Monitoring locations shall be clearly identified and sketched on the Noise Measurement Report Form along with the locations of and monitoring site distances to the noise-sensitive receptors.

11. Construction equipment operating during the noise monitoring period and their locations shall be identified and sketched on the Noise Measurement Report Form, along with the locations of and equipment distances to the noise sensitive receptors.

Figure C-1
Noise Measurement Report Form - Part A

Project: _____ Contract No(s): _____

Date: _____ Day of Week: _____ Time: _____

Monitoring Site Number: _____ Monitoring Site Address: _____

Measurement Taken By: _____ of _____

Approximate Wind Speed: _____ mph [km/hr]. Approximate Wind Direction: From the _____

Approximate distance of Sound Level Meter from Receptor Location: _____

Approximate distance of Sound Level Meter from Construction Site: _____

(Leave Blank for Baseline Ambient)

Receptor Land Use (Check One): ☐ Residential / Institutional ☐ Commercial / Recreational

Sound Level Meter: Make and Model: _____ Serial Number _____

Meter Setting: ☐ A-Weighted Sound Level (SLOW) ☐ C-Weighted Sound Level (FAST) for Impacts

Duration of Measurement: _____ (at least 20 Minutes)

Check the measurement purpose:

☐ Baseline condition ☐ Ongoing construction ☐ Major change ☐ Complaint response

Measurement Results:

Measurement Type	Measured Level	Noise Criteria Threshold	Exceedance
CALIBRATION		n/a	n/a
L_{eq}			
L_{max}			
L_1		n/a	n/a
L_8 or L_{10} (circle which)		n/a	n/a
L_{25}		n/a	n/a
L_{50}		n/a	n/a
L_{90}		n/a	n/a

Field Notes:

1. _____

2. _____

3. _____

4. _____

Complete all that apply below:

Active Equipment: _____

(List construction equipment that contribute to measured noise)

Complaint Response: _____

(Describe complaint; include log-in number)

Complaint Mitigation Measure(s): _____

(Describe complaint response mitigation)

Figure C-2
Noise Measurement Report Form - Part B

Project: _____ Contract No(s): _____

Date: _____ Day of Week: _____ Time: _____

Monitoring Site Number: _____ Monitoring Site Address: _____

Site Map

Field Notes:

1. _____

2. _____

3. _____

4. _____

5. _____

6. _____

Noise Monitor's Signature: _____ Date: _____

Appendix D
Construction Noise Mitigation Measures

Construction noise is to be monitored at the most affected sensitive receptor location (10 feet from the construction activity side of a noise-sensitive receptor building or at the outdoor living area). Noise measurements are to be conducted using the procedures in this Appendix and the measurement results logged in a format similar to that of the Construction Noise Mitigation Form in this Appendix. Where the construction noise threshold criteria are exceeded, at noise-sensitive locations, noise abatement measures, such as those in this Appendix, are to be implemented and adequate noise reduction achieved to bring the construction activities into compliance with the construction noise threshold criteria.

Construction noise mitigation may be achieved using various combinations of equipment source noise reduction, propagation path noise reduction and sensitive receptor noise reduction.

Construction Equipment Source Noise Reduction Methods

Feasible and reasonable equipment noise mitigation measures may need to be implemented to meet the construction noise threshold criteria. Examples of equipment source noise reduction methods to reduce construction noise impacts at sensitive receptor locations are listed in this section. The implementation of one or more of these measures, along with those of the other sections, may be necessary to achieve compliance with the construction noise threshold criteria.

<u>Equipment Noise Reduction:</u>

1. Minimize the use of impact devices, such as jackhammers, pavement breakers, and hoe rams. Where possible, use concrete crushers or pavement saws rather than hoe rams for tasks such as concrete or asphalt demolition and removal.

2. Pneumatic impact tools and equipment used at the construction site shall have intake and exhaust mufflers recommended by the manufacturers thereof, to meet relevant noise limitations.

3. Provide impact noise producing equipment, i.e. jackhammers and pavement breaker(s), with noise attenuating shields, shrouds or portable barriers or enclosures, to reduce operating noise.

4. Line or cover hoppers, conveyor transfer points, storage bins, and chutes with sound-deadening material (e.g., apply wood or rubber liners to metal bin impact surfaces).

5. Provide upgraded mufflers, acoustical lining or acoustical paneling for other noisy equipment, including internal combustion engines.

6. Avoid blasting and impact-type pile driving.

7. Use alternative procedures of construction and select a combination of techniques that generate the least overall noise and vibration. Such alternative procedures could include the following:

    a. Use electric welders powered by remote generators.

b. Mix concrete at non-sensitive off-site locations, instead of on-site.

c. Erect prefabricated structures instead of constructing buildings on-site.

8. Use construction equipment manufactured or modified to reduce noise and vibration emissions, such as:

   a. Electric instead of diesel-powered equipment.

   b. Hydraulic tools instead of pneumatic tools.

   c. Electric saws instead of air- or gasoline-driven saws.

9. Turn off idling equipment when not in use for periods longer than 30 minutes.

Operations Noise Reduction Methods:

In no case shall the following mitigation measures alter the project's responsibility for compliance with applicable Federal, state, and local safety ordinances and regulations, as well as project-specific construction specifications.

1. Operate equipment so as to minimize banging, clattering, buzzing, and other annoying types of noises, especially near residential and other noise sensitive areas during the evening and nighttime hours.

2. To the extent feasible, configure the construction site in a manner that keeps noisier equipment and activities as far as possible from noise sensitive locations and nearby buildings.

3. All back-up alarms should be disarmed at 8:00 p.m. and not reactivated until 7:00 a.m. on weekdays and 9:00 a.m. on weekends and local holidays. Signal persons and strobe lights must be used during periods when the back-up alarms are disarmed.

4. Maximize physical separation, as far as practicable, between noise generators and noise receptors. Separation includes following measures:

   a. Provide enclosures for stationary items of equipment and noise barriers around particularly noisy areas at the project site.

   b. Locate stationary equipment to minimize noise and vibration impacts on community.

5. Minimize noise-intrusive impacts during most noise sensitive hours.

   a. Plan noisier operations during times of highest ambient noise levels.

   b. Keep noise levels relatively uniform; avoid excessive and impulse noises.

   c. Turn off idling equipment.

   d. Phase in start-up and shut-down of project site equipment.

6. Select truck routes for material delivery and spoils disposal so that noise from heavy-duty trucks will have a minimal impact on noise sensitive receptors. Proposed truck haul routes are to be submitted to the County Transportation Division for approval.

    a. Conduct truck loading, unloading, and hauling operations so noise and vibration are kept to a minimum.

    b. Route construction equipment and vehicles carrying soil, concrete or other materials over streets and routes that will cause the least disturbance to residents in the vicinity of construction sites and haul roads.

    c. Do not operate haul trucks on streets within 250 feet of school buildings during school hours or hospitals and nursing homes at any time, without a variance.

    d. Submit haul routes and staging areas to the County Transportation Division for approval, at least 30 days before the required usage date.

A summary of equipment noise control methods is given in Figure D-1. Incorporating the construction noise mitigation methods and techniques would reduce construction noise and vibration impacts.

Construction Noise Propagation Path Reduction Methods

Feasible and reasonable propagation path mitigation measures may need to be implemented to help meet the construction noise threshold criteria. Examples of propagation path noise reduction methods to reduce construction noise impacts at sensitive receptor locations are listed in this section. The implementation of one or more of these measures, along with those of the other sections, may be necessary to achieve compliance with the construction noise threshold criteria.

Construction Site Noise Barriers

Moveable noise barriers can be positioned and relocated along a construction corridor, while fixed noise barriers can be located at a fixed construction site.

Moveable Construction Noise Blankets

1. For lesser noise reduction, install moveable frame-mounted noise curtains, blankets or enclosures adjacent to or around noisy equipment where required to meet the project noise limits. Noise control shields shall be made of a durable, flexible composite material featuring a noise barrier layer bonded to a weather-protected, sound-absorptive material on the construction-activity side of the noise shield.

2. Provide readily removable and moveable noise shields so that they may be repositioned, as necessary, to provide noise abatement for non-stationary and stationary processes along a construction corridor as the construction process moves.

Figure D-1
Some Construction Equipment Noise Sources and Typical Mitigation Measures

Construction Equipment	Source(s) of noise	Possible mitigation measures (may need to be discussed with equipment manufacturer)		Possible alternative construction methods[1]
Impact Pile Driver	Pneumatic/diesel hammer or steam winch vibrator driver	Enclose hammer head and top of pile in an acoustical screen or acoustical blankets, apply acoustical damping to sheet steel piles to reduce vibration and resonant noise		(1) Use alternative methods of pile driving, e.g. drill and drop, poured in place, hydraulic driver, etc. (2) Alternative methods of soil retention and ground improvement, e.g. retaining walls, ground anchors, shafts formed of pre-cast concrete segments sunk into the ground, etc.
	Impact on pile	Use resilient pad between pile and hammer head.		
	Crane cables, pile guides and attachments	Careful alignment of pile and rig, lubricate screeching cables, guides and pulleys.		
	Power unit	Install more efficient exhaust silencer; apply acoustical damping and protected internal noise absorption layers to vibrating panels and covers. Manufacturer's access panels should be kept closed. Use properly ventilated acoustical enclosures where possible.		
Bulldozer Compactor Crane Dump truck Excavator Grader Loader Scraper Shovel	Engine	Install more efficient exhaust silencer. Apply acoustical damping and protected internal noise absorption layers to vibrating panels and covers. Enclosure panels should be kept closed. Operate without excessive engine revving.		
Compressor Generator	Engine	Install more efficient exhaust silencer.	Locate the compressor or generator within an acoustical enclosure or behind an absorptive, three-sided sound wall.	Use electric motors instead of diesel or gasoline engines to drive compressors. If there is no electrical supply, use a reduced noise compressor or generator. A remote electrical generator can be used to supply power to several pieces of equipment.
	Compressor or generator	Apply acoustical damping and protected noise absorption layers to internal of vibrating panels and covers. Enclosure panels should be kept closed		

Construction Noise Threshold Criteria

Pneumatic concrete breaker and tools	Tool	Install a muffler and acoustic shroud to reduce noise without impairing efficiency	Operate equipment inside a portable acoustical enclosure	Use rotary drill and buster. Use hydraulic and electric equipment. A thermal lance can be used to burn holes in concrete and to cut through large sections of concrete. For breaking large areas of concrete, use equipment which breaks concrete by bending it.
	Bit	Use a damped bit to eliminate "bit ringing." Noise drops as surface is broken through		
	Air line	Stop all air line leaks.		
	Motor	Install muffler to pneumatic saws		
Power saws	Vibration of blade and cut material	Keep saw blades sharp. Use a damped blade. Use blades with random tooth spacing. Tightly clamp material during cutting, if possible		
Rotary drills, diamond drilling and boring	Drive motor and bit	Use equipment inside an acoustical enclosure.		Use thermal lance
Construction Equipment	**Source(s) of noise**	**Possible mitigation measures (may need to be discussed with equipment manufacturer)**		**Possible alternative construction methods[1]**
Riveters	Impact on rivets	Enclose working area with acoustic barriers.		Use high tensile steel bolts instead of rivets
Cartridge gun	Cartridge blast	Use a muffled cartridge gun.		Drilled attachments
Pump	Engine or motor, pulsing, cavitation	Use an acoustical enclosure (allow for engine cooling and exhaust) or use motor suction and girdle mutes.		
Batch plant Concrete mixer	Engine	Install more efficient silencer on diesel or gasoline engine. Enclose engine.	Locate batch or mixing plant as far as possible from noise-sensitive receptors.	Use electric motor instead of diesel or gasoline engine
	Filling	Keep aggregate from falling from an excessive height		
	Cleaning	Do not hammer the drum.		
Hammer	Impact on nail			Use screw attachment
Impact chisel	Impact on stock			Use rotary hand milling machine
Materials handling	Impact of material	Prevent high material drops. Shield drop areas, especially for conveyor systems		Cover surface with resilient material or unload remotely
Steam cleaning	Escaping jet of steam, interaction with surface	Pass escaping steam through silencer or screen the cleaning area and use quieter nozzles.		

Note 1. Care should be taken when selecting a quieter process, so that ancillary equipment noise sources, such as cranes and compressors, are mitigated so they do not become new dominant noise sources.

3. Installation and Maintenance:

    a. Install noise blanket shields with sound-absorptive surfaces facing the noise source.

    b. Maintain the moveable noise shields and repair damage that occurs, including, but not limited to, keeping noise shields clean and free from graffiti, and maintaining structural integrity. Promptly repair or replace gaps, holes, and weaknesses in the noise shields, and openings between, or under the noise shield blankets.

Moveable Construction Noise Barriers

1. For greater noise reduction, install moveable paneled noise shields, barriers or enclosures adjacent to or around noisy equipment where required to meet the project noise limits. Noise control shields shall be made of panels featuring a solid panel with a weather-protected, sound-absorptive material on the construction-activity side of the noise shield.

2. Provide readily removable and moveable noise shields so that they may be repositioned, as necessary, to provide noise abatement for non-stationary and stationary processes along a construction corridor as the construction process moves.

3. Installation and Maintenance:

    a. Install paneled noise shields with sound-absorptive surfaces facing the noise source.

    b. Maintain the moveable noise shields and repair damage that occurs, including, but not limited to, keeping noise shields clean and free from graffiti, and maintaining structural integrity. Promptly repair or replace gaps, holes, and weaknesses in the noise shields, and openings between, or under the noise shield panels.

Fixed Construction Noise Curtains

1. For lesser noise reduction, install frame-mounted sound noise control curtains or noise control blankets in locations adjacent to or around noisy equipment as required to meet the noise limits specified in this document and to shield the public from excessive construction noise. Noise control curtains shall be made of a durable, flexible composite material featuring a noise barrier layer bonded to a weather-protected, sound-absorptive material on one or both sides. The supporting structure shall be engineered and erected according to applicable codes.

2. Noise control curtains shall be installed, as necessary, to provide greater noise abatement for non-stationary and stationary processes.

3. Installation, Maintenance and Removal

    a. Noise control curtains shall be installed without any gaps and with the sound absorptive side facing the construction activity area.

    b. Maintain the noise control curtains and promptly repair any damage that may occur. Gaps, holes or weaknesses in the curtain, or openings between the curtain and the ground shall be promptly repaired.

c. The fixed noise control curtains and associated elements shall be completely removed and the site appropriately restored upon the conclusion of the construction activity.

Fixed Noise Control Barriers

1. For greater noise reduction, install solid noise control panels or enclosures in locations adjacent to or around noisy equipment as required to meet the noise threshold criteria specified in this document and to shield the public from excessive construction noise. Noise control panels shall be made of a solid, heavy noise barrier material with a weather-protected, sound-absorptive material on the construction-activity side of the barrier. The supporting structure shall be engineered and erected according to applicable codes.

2. Noise control panels shall be erected, as necessary, to provide greater noise abatement for non-stationary and stationary processes.

3. Installation, Maintenance, and Removal

   a. Solid noise control panels shall be installed without any gaps and with the sound absorptive side facing the construction activity area.

   b. Maintain the noise control panels and promptly repair any damage that may occur. Gaps, holes or weaknesses in the panels or openings between the panels and the ground shall be promptly repaired.

   c. The fixed noise control panels and associated elements shall be completely removed and the site appropriately restored upon the conclusion of the construction activity.

Sensitive Receptor Construction Noise Reduction Methods

Feasible and reasonable receptor noise mitigation measures may be implemented to meet the construction noise threshold criteria. Examples of receptor noise reduction methods to reduce construction noise impacts at sensitive receptor locations are listed in this section. The implementation of one or more of these measures, along with those of the other sections, may be necessary to achieve compliance with the construction noise threshold criteria.

Receptor Building Interior Noise Control Measures

1. For noise reduction at fixed, mid-term construction sites, install removable secondary acoustic window inserts (i.e., Quiet Window, or equal) to existing windows in sensitive receptor buildings as required to meet the noise threshold criteria specified in this document.

2. For noise reduction at fixed, long-term construction sites, install permanent replacement acoustic windows with an STC rating 5 dB greater than the construction noise reduction needed. Where sliding doors are exposed to excessive construction noise, acoustic sliding patio doors may also need to be installed. Careful attention must be taken to seal the frame airtight to the existing structure.

3. Install properly fitted, tubular compression-type weather strip gasketing around the door frames (jamb and head) and install automatic drop thresholds and threshold plates to exposed swinging doors. Careful attention must be taken to seal the existing door frame airtight to the existing structure.

Construction Noise Threshold Criteria

Moveable Exterior Receptor Noise Control Barriers

1. For construction along a construction corridor, install moveable paneled noise shields or barriers at noise sensitive receptor sites. Noise control shields shall be made of panels featuring a solid panel with a weather-protected, sound-absorptive material on the construction-activity side of the noise shield.

2. Provide readily removable and moveable noise shields so that they may be repositioned, as necessary, to provide greater noise abatement along a construction corridor as the construction process moves.

3. Installation and Maintenance:

    a. Install paneled noise shields with sound-absorptive surfaces facing the noise source.

    b. Maintain the moveable noise shields and repair damage that occurs, including, but not limited to, keeping noise shields clean and free from graffiti, and maintaining structural integrity. Promptly repair or replace gaps, holes, and weaknesses in the noise shields, and openings between, or under the noise shield panels.

Fixed Exterior Receptor Noise Control Barriers

1. For noise reduction at fixed construction sites, install solid noise control panels at sensitive receptor locations as required to meet the noise threshold criteria specified in this document and to shield the sensitive receptor from excessive construction noise. Noise control panels shall be made of a solid, heavy noise barrier material with a weather-protected, sound-absorptive material on the construction-activity side of the barrier. The supporting structure shall be engineered and erected according to applicable codes.

2. Noise control panels shall be erected, as necessary, to provide greater noise abatement for non-stationary and stationary processes at fixed construction sites.

3. Installation, Maintenance, and Removal

    a. Solid noise control panels shall be installed without any gaps and with the sound absorptive side facing the construction activity area.

    b. Maintain the noise control panels and promptly repair any damage that may occur. Gaps, holes or weaknesses in the panels or openings between the panels and the ground shall be promptly repaired.

    c. The fixed noise control panels and associated elements shall be completely removed and the site appropriately restored upon the conclusion of the construction activity.

Figure D-2. Construction Noise Mitigation Form

Part A –Construction Equipment Mitigation Measures

Project: _____ Contract No(s):_____ Construction Phase: _____

Measured By: _____ of _____ Date: _____ Time: _____

IMPORTANT: Attach construction equipment noise measurement location sketches (also identify other noise sources in area).

Construction Phase Equipment Inventory: Overall Project Phase Noise Reduction Requirement[1] = _____ dBA.

Code Letter (a)	Equipment				Typical 50-Foot Noise Level (dBA) (f)	Measured 50-Foot Noise Level (dBA) (g)	Equipment Noise Mitigation Measure (h)	Measured 50-Foot Mitigated Noise (dBA) (i)
	Category (b)	Make & Model (c)	ID# (d)	HP (e)				
Example	Front End Loader	Caterpillar 988	50W043xxx	375	85	91	Critical muffler	79

Notes:
Note 1. The noise reduction requirement is the exceedance between the overall construction phase noise from Appendix C and the sensitive receptor noise threshold criteria.
Column (a): Code letter in sketch to indicate position of equipment during noise measurement.
Column (b): Equipment type from Table B-1.
Column (c): Equipment manufacturer and model.
Column (d): Unique identifier (ID), such as VIN or registration number.
Column (e): Equipment rated horsepower.
Column (f): Equipment typical noise level from Table B-1.
Column (q): Estimated noise level at 50 ft. If greater than the level in Column (f), mitigation measures (e.g. mufflers, lower throttle, etc.) shall be implemented.
Column (h): Noise mitigation measure(s) implemented to help achieve compliance with the noise threshold criteria at the sensitive receptor location.
Column (i): Estimated or measured mitigated noise level at 50 ft

Figure D-3. Construction Noise Mitigation Form

Part B – Propagation Path Mitigation Measures

Project: _____ Contract No(s): _____ Construction Phase: _____

Measured By: _____ of _____ Date: _____ Time: _____

(Attach Construction Vicinity Sketch)

Sensitive Receptor Measurement Location during Construction Activities Without Mitigation	Measured Noise Level at Receptor Location, (dBA)*			
	Ambient L_{eq} (dBA)	L_{eq} w/ Project (dBA)	Ambient L_{max} (dBA)	L_{max} w/ Project (dBA)
Noise Threshold Criteria >	n/a		n/a	
1.				
2.				
3.				
4.				

Propagation Path Noise Abatement Measures

1. _____
2. _____
3. _____
4. _____

Anticipated Results

1. _____
2. _____
3. _____
4. _____

Sensitive Receptor Measurement Location during Construction Activities <u>With Additional</u> Mitigation	**Measured Noise Level at Receptor Location, (dBA)***			
	Ambient L_{eq} (dBA)	**L_{eq} w/ Project (dBA)**	**Ambient L_{max} (dBA)**	**L_{max} w/ Project (dBA)**
Noise Threshold Criteria >	n/a		n/a	
1.				
2.				
3.				
4.				

Figure D-4. Construction Noise Mitigation Form

Part C – Sensitive Receptor Measures

Project: _____ Contract No(s): _____ Construction Phase: _____

Measured By: _____ of _____ Date: _____ Time: _____

(Attach Construction Vicinity Sketch)

Sensitive Receptor Measurement Location during Construction Activities Without Mitigation	**Measured Noise Level at Receptor Location, (dBA)***			
	Ambient L_{eq} (dBA)	**L_{eq} w/ Project (dBA)**	**Ambient L_{max} (dBA)**	**L_{max} w/ Project (dBA)**
Noise Threshold Criteria >	n/a		n/a	
1.				
2.				
3.				
4.				

Sensitive Receptor Noise Abatement Measures

1. _____
2. _____
3. _____
4. _____

Anticipated Results

1. _____
2. _____
3. _____
4. _____

Sensitive Receptor Measurement Location during Construction Activities With Additional Mitigation	**Measured Noise Level at Receptor Location, (dBA)***			
	Ambient L_{eq} (dBA)	**L_{eq} w/ Project (dBA)**	**Ambient L_{max} (dBA)**	**L_{max} w/ Project (dBA)**
Noise Threshold Criteria >	n/a		n/a	
1.				
2.				
3.				
4.				