NOISE MITIGATION PLAN

PR-5

REQUIRED

GOAL

Reduce or eliminate annoyance or disturbance to surrounding neighborhoods and environments from road construction noise.

REQUIREMENTS

Establish, implement, and maintain a formal Noise Mitigation Plan (NMP) during construction for the prime contractor. The NMP must address, at minimum, the following elements:

1. Responsible party for noise mitigation activities, contact information, their responsibilities and their qualifications. Include information for NMP preparer, if applicable or completed by an outside party.
2. Project location and distance to closest receptor of noise. Include a description of the surrounding zoning and parcel information (i.e., commercial, residential, hospitals, schools, parks, sensitive habitat).
3. A list of proposed construction activities (e.g. demolition, excavation, paving, bridge foundations, finishing).
4. Dates and working hours of proposed construction activities.
5. A list of noise-generating devices used during each construction activity listed in #3.
6. A list of noise-mitigating devices used during each construction activity listed in #3, including personal safety equipment requirements for all site employees.
7. Noise permit numbers, agency or local authority policies associated with construction work, as applicable.
8. Description of noise monitoring standards, methods, and acceptable levels.
9. Description of correction procedures for non-compliant noise levels.
10. Signature of responsible party.

Details

The NMP should cover all of construction, including subcontractor work activities. Some state and local owner agencies already have requirements for such plans written in their standard specifications. However, a written specification requiring the prime contractor to have a Noise Mitigation Plan is insufficient, especially because many local authorities and owner agencies offer certain exemptions to their policies, such as daylight work schedules or projects with minimal areas of land-disturbing activities.

A large document need not be generated for this requirement. For projects that are deemed locally exempt (as noted above), show that the prime contractor has completed a review of noise as part of project planning. The New York Department of Environmental Protection (NYDEP 2008) offers a 4-page checklist-style NMP that addresses all of the elements above, except for items 9 and 10, which can be easily addressed in 1 page: http://nyc.gov/html/dep/pdf/noise_mitigation.pdf.

DOCUMENTATION

- Copy of the Noise Mitigation Plan.
- A copy of any applicable noise permits, or agency or local authority noise policies (a live hyperlink to any large policy documents is sufficient).

RELATED CREDITS

- ✓ PR-1 Environmental Review Process
- ✓ PT-5 Quiet Pavement

SUSTAINABILITY COMPONENTS

- ✓ Equity
- ✓ Expectations
- ✓ Experience
- ✓ Exposure

BENEFITS

- ✓ Improves Human Health & Safety
- ✓ Improves Accountability
- ✓ Increases Awareness
- ✓ Increases Aesthetics

APPROACHES & STRATEGIES

- Read the Federal Highway Administration (FHWA) *Highway Construction Noise Handbook* (Knauer et al., 2006) to understand the aspects of construction noise that could be relevant to your project. The *Highway Construction Noise Handbook* is available as a web document at: http://www.fhwa.dot.gov/environment/noise/handbook/index.htm. The Handbook is a relatively short read—Chapters 5-8 may be especially helpful for prime contractors or project leads not familiar with NMPs.
- Complete the NMP during the environmental review process, when the environmental documentation is being generated. Most environmental review regulations at federal and state levels, including the National Environmental Policy Act (NEPA), include an investigation of noise-related project impacts to surrounding communities, and these impacts often can be addressed in short narrative form (Knauer et al., 2006).
- Use the checklist-style NMP available from the NYDEP as a template to create and assemble custom owner agency NMPs for use on future projects. The NYDEP checklist is available here: http://nyc.gov/html/dep/pdf/noise_mitigation.pdf
- Estimate noise levels from your construction project by using the Roadway Construction Noise Model (RCNM) software available from the FHWA (Reheman et al., 2006). A user's guide for the software program is also available as part of the *Highway Construction Noise Handbook* as an Appendix. Most projects will not need comprehensive or detailed noise modeling and simplified manual noise analysis will be adequate (Knauer et al., 2006). However, local noise ordinances may be more stringent than what is called for in the environmental review requirements and may need more detailed analysis. (Knauer et al., 2006) The RCNM software tool is available for free download here: http://www.fhwa.dot.gov/environment/noise/cnstr_ns.htm.
- Communicate to stakeholders that noise mitigation is actively being investigated on your project and that a plan is being developed. This may help quell the potential "political noise" that often stems from too much "construction noise" (Thalheimer, 2000), especially for high impact, high dollar, or sensitive public projects.
- Hire an acoustical engineering firm or other qualified professional to complete the NMP.
- Deliver noise awareness training regarding the noise mitigation strategies and noise safety efforts employed on the project to all construction project employees, including subcontractor employees. This training will help ensure that the NMP is implemented effectively.
- Review individual state and local jurisdiction noise ordinances and any permits or agency coordination efforts during the project development process. Sometimes these ordinances contain restrictions associated with construction noise levels, even though there are currently no federal regulations for noise levels.
- Identify noise abatement opportunities during project design. Such things as locating storage areas, stationary equipment, haul roads and detours away from sensitive receivers, planning for concurrent construction, maintaining existing noise barriers for use during construction and scheduling the construction of new noise barriers early on in the project, can reduce noise impacts.
- Achieve mitigation of noise at the source by specifying use of less noisy equipment, requiring muffler systems on equipment, employing shields and modifying vehicles and equipment to reduce noise levels.
- Achieve path mitigation by building noise barriers, using tiered or layered vegetative barriers (Anderson, Mulligan &Goodman, 1984), or using existing barriers where appropriate.
- Achieve receiver mitigation by sealing intakes of sensitive receivers, acoustic window treatments (Thalheimer, 2000) or, where feasible, by temporarily relocating residents.

Example: Noise Mitigation Plan Sample Forms – City of New York, NY

The New York City Department of the Environmental Protection (NYDEP, 2008) enacted new noise rules in 2007 for construction activities requiring that unique noise mitigation plans are adopted, posted, applied, and monitored on construction projects when specific devices are used or certain activities are performed within city limits. Their municipal code rules list typical equipment, activities, and other devices that produce noise, and also establish minimum noise levels allowed for construction activities. The intent of the noise requirements is "to inform the user of the required plan elements that a responsible party must include when the listed devices are being used on site, and the mitigation strategies and best management practices that are being employed" (NYDEP, 2008). Alternative noise mitigation plans (ANMPs) may also be filed if the project cannot comply with the sound level criteria without undue hardship and can reduce or exempt certain activities from non-compliance penalties.

- The NYDEP Sample Noise Mitigation Plan is available here: http://nyc.gov/html/dep/pdf/noise_mitigation.pdf
- The NYDEP Sample Alternative Noise Mitigation Plan is available here: http://nyc.gov/html/dep/pdf/noise_alternative_mitigation.pdf

Additional information about NYDEP's noise code and noise mitigation planning rules for construction projects are available at: http://nyc.gov/html/dep/html/noise/index.shtml

Example: Case Study — Central Artery/Tunnel ("The Big Dig") in Boston, MA

This case study summarizes the article by Thalheimer (2000), which describes the noise control program for the Central Artery/Tunnel (CA/T) project in Boston, Massachusetts. The CA/T may be more commonly recognized by the public as the "Big Dig," and it was an engineering mega-project with "the most comprehensive and stringent construction noise control specification of any public works project in the country." The sheer size and duration of its construction impacts on the Boston's residents and businesses made noise mitigation a crucial aspect of the project. Note that most projects will not need to provide nearly the level of detail as that required for noise mitigation on the Central Artery/Tunnel (CA/T), however the approaches and strategies used for this project helped develop many of the guidance documents that are available on construction noise, such as the FHWA *Highway Construction Noise Handbook* (Knauer et al., 2006).

The project was championed by the former Massachusetts Turnpike Authority (MTA), which is currently managed by the Massachusetts Department of Transportation (MassDOT) Highway Division. Construction began in 1991 and was considered complete in 2006, with a multibillion dollar price tag. More information about the Big Dig project can be found at the following site: http://www.massdot.state.ma.us/Highway/bigdig/bigdigmain.aspx.

The project's noise control program had two main goals: 1) meet the commitments for mitigating environmental noise as stated in the environmental impact report and 2) control construction noise without posing hardship to local communities, project budget or construction schedule to the maximum extent feasible. Meeting these goals posed a significant challenge because construction activity occurred at all times of day in many areas of Boston, and sometimes in very close proximity (with 10 feet) of residences and sensitive locations. Additionally, the project was critical politically: function of Boston's core infrastructure depended on the outcome and the level of stakeholder involvement was extraordinarily high.

The Noise Mitigation Program for the CA/T involved establishing lot-line and equipment emission noise criteria limits, defining operational and/or equipment restrictions and also required the submission of noise control and monitoring plans, baseline and compliance noise data, equipment noise certification tests, and designs for proposed noise mitigation measures. "Mitigation measures were implemented only when justified based on careful consideration of all relevant technical, cost and policy issues."

The NMP prioritized mitigation measures as follows: source control, path control, and finally receptor control. Source control was most effective and easiest to monitor, but where this was not possible, path control measures were implemented to block sound directed at receptors. Path control options were considered cost-effective only if they could prevent noise at multiple receptors. Receptor control was also used in some cases, such as window treatments on buildings, and the success of this program was due largely to an effective public involvement process as well as partnerships developed during project design and planning.

Noise control lessons learned from the CA/T project that may be applicable to projects developing their own noise mitigation plans include:

- **Upholding noise policy commitments and goals.** To be effective, it is crucial that noise policies are communicated from the top layers of the project team and applied project-wide.
- **Engaging the public for active feedback.** Informing the public is critical to the overall success of the project noise mitigation plan, and a 24-hour hotline for communication was used successfully on the CA/T project.
- **Establishing an ambient level and monitoring construction noise.** Equitable noise policies cannot be created without first establishing a baseline noise level. Noise controls are not as effective if not monitored on a continuous basis.
- **Engaging professionals.** Noise technicians can often preempt noise problems and can quickly respond to complaints given proper authority.
- **Addressing the biggest complaints.** The biggest public complaint was vehicle backup alarms during night work, which was addressed by mandating installation of in-vehicle controls that were manually adjustable or ambient sensitive and prohibiting alarm use in especially sensitive areas at night with additional supervision from safety personnel.
- **Implementing comprehensive and concise specifications.** Contract specification language for contractors that is clear and unambiguous is essential for management of contractors and for implementation of a noise control plan.
- **Using multiple controls.** Noise mitigation measures must be flexible and include many alternatives and combinations of methods to meet noise policy goals.
- **Targeting receptor controls.** Prevention of noise at the receptor, such as acoustical treatments for windows, can be cost-effective solutions.
- **Using sound barriers as visual barriers.** Public perceptions of construction noise and level of nuisance or annoyance depend on sound levels of the activity as well as visibility of the activity. Thalheimer (2000) states that noise barriers were effective in reducing the level of annoyance perceived on the CA/T project. However, Aylor and Marks (1976) and Anderson, Mulligan and Goodman (1984) demonstrate that this perception is extremely variable with locale, typical ambient noise levels, type of barrier, how much of the activity is obscured by the barrier, familiarity of sound, and public expectations.

POTENTIAL ISSUES

1. It is not feasible to eliminate all construction noise, but it is often feasible to control most or all of it.
2. Multiple work sites may require a variety or combination of different controls. Some special areas of work sites may require closer analysis or modeling, which may be cost and time intensive.
3. Noise mitigation plans and project policies apply to all contractors and subcontractors on a construction site. Training may be necessary for some parties who are otherwise unfamiliar with noise mitigation or policies.
4. The subjectivity involved with perceptions of sound and noise presents an issue for managing public opinion and expectations.
5. Most jurisdictions provide an exemption from noise associated with daytime construction activities. For Greenroads all projects must create an NMP, even if exempt from noise policies and local ordinances.

RESEARCH

Noise issues on most roadway projects are initially addressed during the project environmental review (see PR-1 Environmental Review Process). This Project Requirement (PR) focuses on planning for and management of noise generated by the roadway project throughout its construction and operation phases.

What is Noise?

Noise is defined as unwanted sound (Environmental Protection Agency, 1973). Sound is part of the science of acoustics, which is a complex field dealing with sound generation, propagation and reception. This credit does not go into detail on sound physics. However, some terminology is useful for a basic understanding of noise.

A source is the point where a sound is generated. Sources can be mobile or stationary. For example, traffic noise sources are mobile, while construction noise is generally a mixture of stationary and mobile sources. The receptor (also, receiver) is the endpoint where sound is observed. The route along which sound passes from the source to the receptor is known as the path. The length of the path is important, as is the rate of change in length of the path. Generally, perception of sound changes along a path according to the "inverse square law": as the distance between source and receiver increases, the sound decreases in proportion to the inverse square of the path length. (New York Division of Environmental Permits, 2001) The path length of sound from mobile sources changes with time (this is perceived by the human ear as what is commonly known as the Doppler Effect).

The following sound terms are briefly described (Sandberg & Ejsmont, 2002):

- **Sound pressure**. Sound travels through the surrounding medium (often air) as pressure waves. Measuring sound involves measuring the pressure of these waves. Thus a common measure of sound is in units of pressure. The perceived loudness of sound varies with pressure. Higher pressures are generally associated with sounds we perceive of as louder.
- **Sound pressure level and the decibel (dB)**. Sound pressure varies over such a wide range that it is commonly measured in a logarithmic unit called the decibel (dB) so reported numbers are easier to work with. Using the dB scale, a difference in 10 dB roughly corresponds to a doubling or halving of our hearing perception of that sound. Also, 1 dB is about the smallest difference in sound pressure that humans can perceive. Finally, if two incoherent sounds of equal sound pressure level (e.g., 70 dB) are added together, the resulting overall sound is 3 dB greater. Thus, 70 dB + 70 dB = 73 dB.
- **Frequency weighting**. Sound can occur over a wide range of frequencies. The human ear does not perceive all of these frequencies equally. Generally, for sound at a given pressure level, low and very high frequencies are interpreted as quieter than mid-range frequencies. Therefore, for sound measurements to be most meaningful to human hearing, the frequencies of sound need to be filtered such that the sound pressure levels of low and very high frequencies count less than the sound pressure levels of mid-range frequencies. A good approximation to human hearing is the "A filter," thus sound is often reported as an "A weighted sound pressure level," dB(A) or dBA.

It is important to emphasize the complexity in analyzing sound and the difference of sound perception in humans to the physical measurements of sound pressure. The response to any sound is a subjective experience and can depend on age, health, familiarity, time of day and more in addition to the characteristic of the sound itself. This complexity makes it somewhat difficult to express and compare sound levels using simplified numbers or averages such as the A-weighted decibel scale (dBA) that is typically used to describe transportation noise.

Undesirable Consequences of Noise

Noise can have an effect on human health and also on the general desirability of a location based on its exposure to noise. Noise impacts human health and well-being by increasing stress, causing hearing loss (in the case of loud noise), disrupting sleep, causing fatigue, hinders work efficiency, interrupting activities, and interfering with speech communication (Passchier-Vermeer & Passchier, 2000; EPA, 1978). Noise can also produce unwanted vibrations that may cause human discomfort (sonic fatigue) or disturb activities (EPA, 1973). In addition to the physiological and emotional responses of noise, transportation noise in particular can also impact real estate values hence impacting a community's social, economical and development status.

Noise impacts from human activities do not only affect human populations. Kaseloo and Tyson (2004) synthesized the ecological information on noise impacts to wildlife populations living near roadways and determined there is sufficient evidence that noise effects populations, breeding habits, and biodiversity. However, there is very little conclusive data relative to road noise and populations of fish, amphibians, reptiles, and invertebrates. Burrowing species may be impacted due to road noise and noise vibrations, but this area also requires further study. Bird populations appear to be the most negatively impacted, with impacts proportional to the levels of traffic noise and volume. In many locations there is clear evidence of decreased bird breeding activity and population declines near rights-of-way (however, this may be related to displacement of prey or vegetation change). Large and small mammals may also be repelled by roadway noise.

Wildlife can experience similar adverse health effects and stresses because the structure and function of most animal ears is similar to the human ear (EPA, 1978). Not only do sound level ranges heard by animals differ from what is heard by humans (EPA, 1978), but their sensitivity to and corresponding health impacts from sound also vary. Physiological effects of noise on wildlife include stresses to endocrine, digestive, cardiovascular, and immune systems as well as reproductive function (Kaseloo & Tyson, 2004). Roadway noise can also impact vocalization and communication between wildlife species, especially where roadway noise may cause background noise across distances (Kaseloo & Tyson, 2004).

Construction Noise

Construction noise is temporary but may adversely affect nearby property owners, residents and wildlife. The FHWA provides guidance in its *Highway Construction Noise Handbook* (Knauer et al., 2006). Many of the recommendations for this guidance document were generated by the Central Artery/Tunnel project in Boston (featured in the Examples section above), and were documented by Thalheimer (2000) prior to being published by the FHWA.

Road construction noise is typically generated by three source types: mobile equipment, stationary equipment and blasting activity. Noise levels for individual equipment typically used on road construction projects are presented in Table PR-5.1.

Table PR-5.1: Maximum Sound Level of Construction Equipment Activity Measured at 50 feet. (Adapted from Thalheimer, 2000; Knauer et al., 2006)

Equipment	dBA	Equipment	dBA	Equipment	dBA
Auger Drill Rig	85	Flat Bed Truck	84	Rivet buster/Chipping gun	85
Backhoe	80	Front End Loader	80	Rock Drill	85
Bar Bender	80	Generator	82	Roller	85
Blasting	94	Gradall	85	Sand Blasting (Single Nozzle)	85
Boring Jack Power Unit	80	Grader	85	Scraper	85
Chain Saw	85	Grapple (on backhoe)	85	Shears (on backhoe)	85
Clam Shovel (dropping)	93	Horizontal Boring Hydraulic Jack	80	Slurry Plant	78
Compactor (ground)	80	Hydra Break Ram	90	Slurry Trenching Machine	82
Compressor (air)	80	Impact Pile Driver	95	Soil Mix Drill Rig	80
Concrete Batch Plant	83	Jackhammer	85	Tractor	84
Concrete Mixer Truck	85	Man Lift	85	Vacuum Excavator	85
Concrete Saw	90	Mounted Impact Hammer (hoe ram)	90	Vacuum Street Sweeper	80
Crane	85	Pavement Scarifier	85	Ventilation Fan	85
Dozer	85	Paver	85	Vibrating Hopper	85
Drill Rig Truck	84	Pickup Truck	55	Vibratory Concrete Mixer	80
Drum Mixer	80	Pneumatic Tools	85	Vibratory Pile Driver	95
Dump Truck	84	Pumps	77	Warning Horn	85
Excavator	85	Refrigerator Unit	82	Welder/Torch	73

The relative A-weighted noise levels of common sounds measured in the environment and industry for various qualitative sound levels are provided in Figure PR-5.1.

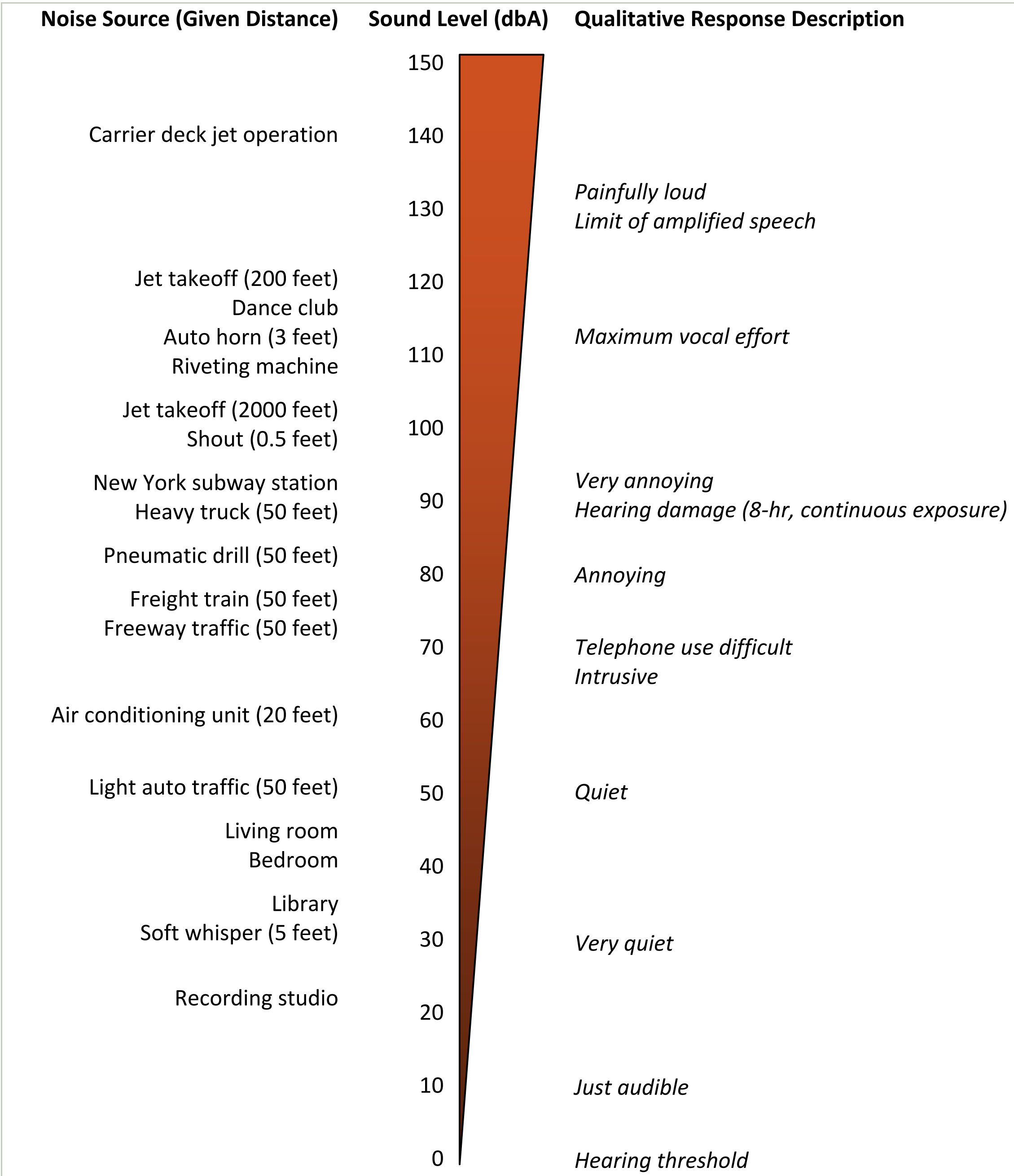

Figure PR-5.1: Typical Sound Levels Measured in the Environment and Industry (Adapted from Barksdale, 1991).

Traffic Noise

A discussion on traffic noise sources is provided in Credit PT-5 Quiet Pavement.

Regulation of Noise

In 1981, the Environmental Protection Agency (EPA) Office of Noise Abatement and Control (ONAC) was abolished and noise management authority was granted to individual states and municipalities. However, the 1972 Noise Act and the 1978 Quiet Communities Act are still valid but unfunded (EPA, 2009). Prior to the disintegration of ONAC, EPA did establish baseline guidance dBA levels for both indoor and outdoor receivers and exposure time criteria for preventing or limiting hearing loss (EPA, 2009). These laws were primarily put in place to protect noise-sensitive receivers. A noise-sensitive receiver is a location where people or endangered wildlife reside or where the presence of unwanted sound could adversely affect the designated use of the land or habitat (Knauer et al., 2006). Typically, noise-sensitive receivers include residences, hospitals, places of worship, libraries, schools, and may include nature and wildlife preserves and parks. For example, "Levels of 45 decibels are associated with indoor residential areas, hospitals and schools, whereas 55 decibels is identified for certain outdoor areas where human activity takes place. The level of 70 decibels is identified for all areas in order to prevent hearing loss." (EPA, 2009). Roadway projects near these locations may be restricted by more stringent noise policies during both construction and operation (Knauer et al., 2006).

There are currently no federally regulated levels of construction noise; however the FHWA has set some standards for traffic noise levels. "The regulations [23 CFR § 772] contain noise abatement criteria which represent the upper limit of acceptable highway traffic noise for different types of land uses and human activities. The regulations do not require that the abatement criteria be met in every instance. Rather, they require that every reasonable and feasible effort be made to provide noise mitigation when the criteria are approached or exceeded." (2006). In general, federally funded highway projects are required to follow a three step process during project development for noise abatement involving identification and mitigation of noise impacts, as well as land use planning coordination with local officials. Long-term noise control and mitigation measures for traffic noise are currently assessed via the environmental review process and associated documentation for the National Environmental Policy Act (NEPA) of 1969 under 23 CFR § 772. However, in September 2009, the FHWA published a Notice of Proposed Rulemaking (NPRM) to amend the current federal noise policy contained in 23 CFR § 772 which could mean highway agencies will need to review their existing noise policies, revise them, and obtain approval by the FHWA. (USDOT & FHWA, 2009)

Occupational exposures to noise for construction workers are closely regulated by the Occupational Health and Safety Administration (OSHA). For more information on OSHA noise and hearing safety standards, visit: http://www.osha.gov/SLTC/noisehearingconservation/

Considerations for Mitigating Noise

Many design and project planning methods can reduce engine or blast related noise from construction projects. Also, certain techniques and roadway surfacing materials can be used to reduce tire-pavement noise. The *FHWA Highway Construction Noise Handbook* (Knauer et al., 2006) describes the following elements for effective control of highway construction and operational noise which are applicable to all roadway projects.

- **Alternative design options.** Avoid generation of noise altogether. Examples are designated construction traffic routes, specially locating storage areas, or possibly even selection of an entirely different roadway alignment. Another design option would be considering alternative construction approaches, such as vibratory pile driving instead of impact pile driving. Alternative designs are usually very effective approaches, but they are not always cost-effective or practical.
- **Mitigation at the source.** Reduce, minimize or eliminate initial noise generation. An example would be installing mufflers or baffles on construction equipment or on a motor vehicle using the roadway. Contract specifications and special provisions are an excellent means of source mitigation, such as requiring contractors to use quieter equipment or setting strict noise limits for specific types of equipment. Additionally, construction employee training is considered a source mitigation technique. Quiet pavements, where tire-pavement noise is reduced at the source, may be a viable strategy for mitigating operational traffic noise (see Credit PT-5 Quiet Pavement). Source reduction is the most effective and often also most cost-effective type of mitigation strategy, because it is easiest to observe and inspect (Thalheimer, 2000).
- **Mitigation along the path.** Reduce or minimize noise propagation. Noise barriers and shields can be natural such as grade changes or permanent such as sound walls. Path mitigation is the least effective mitigation strategy, and has a number of disadvantages, especially if manmade. Path mitigation methods, such as sound barrier structures, are only effective at certain distances and geometries in relation to the roadway. Commonly, these are permanent manmade structures that tend to reduce visual quality, are high cost, energy-intensive, materials-intensive, and may potentially fragment or obstruct natural habitats depending on their placement in the right-of-way.

- **Mitigation at the receiver.** Reduce, minimize or avoid noise reception. Some examples are noise "masking" where unpleasant sound is covered up or interfered by a more pleasant sound, building envelope improvements, and temporary relocation of residents. Depending on the scale and location of the project, as well as the level of public and stakeholder involvement and project acceptability, receiver mitigation methods vary in cost. However, these methods are more effective at reducing noise received by the human ear than path mitigation, especially in targeted sensitive receptors (Thalheimer, 2000).

Most noise mitigation plans created for roadway projects will include a combination of many of these strategies.

GLOSSARY

ANMP	Alternative Noise Mitigation Plan
CA/T	Central Artery/Tunnel project. Also known as the Big Dig.
CFR	Code of Federal Regulations
dB	Decibel
dBA	A-weighted decibels
EPA	Environmental Protection Agency
FHWA	Federal Highway Administration
HMA	Hot mix asphalt
Masking	using acoustical techniques to cover up or interfere with unpleasant sound
MassDOT	Massachusetts Department of Transportation
MTA	Massachusetts Turnpike Authority
NMP	Noise Mitigation Plan
Noise	Unwanted sound, undesirable sound
Noise-sensitive receiver	A location where people or endangered wildlife reside or where the presence of unwanted sound could adversely affect the designated use of the land or habitat (Knauer et al., 2006)
NYDEP	New York City Department of Environmental Protection
Path	The route along which sound passes from the source to the receptor
PCC	Portland cement concrete
Receptor (receiver)	An endpoint where sound is observed
Source	A point where a sound is generated
USDOT	United States Department of Transportation

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