ENVIRONMENTAL REQUIREMENTS

General: Before the location of a specific training facility is finalized, the natural and historical resources survey and the environmental assessment/environmental impact statement must be completed in order to comply with the National Environmental Policy Act (NEPA). No project shall be allowed to start construction without a finalized environmental documentation. Therefore, it is imperative that close coordination between the range designer and the installation environmental coordinator be exercised throughout each phase of planning, design, and construction. As a minimum, the designer must verify that the project is part of the installation's current Land-Use Requirements Study (LURS) in accordance with AR 350-19, TC 25-1 and its Real Property Master Plan.

The designer must perform an evaluation of compliance during the planning phase. The installation's operational overlay graphics should be used to display areas that should be avoided. The range design must comply with stipulations discovered in environmental studies and provided by permits. In addition, if the range is sited in an area that contains wetlands, a wetland's delineation shall be required before design begins. This wetland delineation is intended to minimize wetland disturbance.

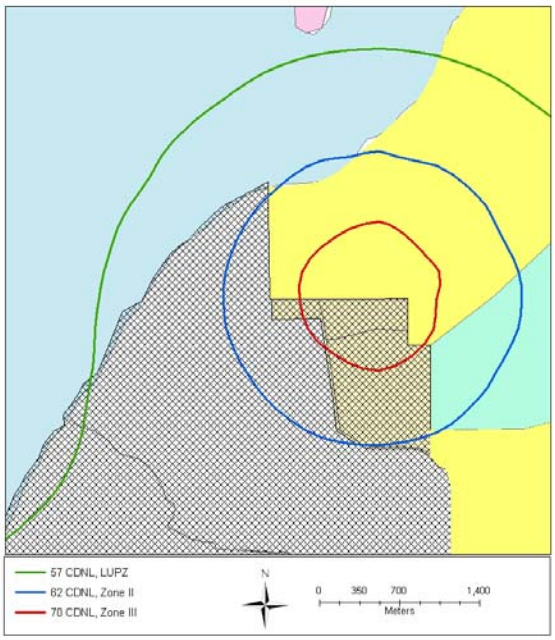
The following sections deal with noise impacts due to training, first large arms noise impacts followed by small arms noise impacts:

Large Arms Operational Noise: Large guns and explosive charges are fired extensively at some military training ranges. Noise emitted from large arm ranges is of high energy and is very impulsive. As a consequence, the noise often annoys people living in surrounding communities, even at distances of many miles. Their response may include noise complaints, political pressure, legal action, and efforts to curtail the firing activity. All of these actions may impair range sustainability.

a. BNOISE2 – Blast Noise Impact Assessment: is a software application that provides the capability to calculate and display noise level contours for firing operations at large arms ranges. Developed by the US Army at the Engineering Research and Development Center / Construction Engineering Research Laboratory (ERDC / CERL), BNOISE2 accounts for statistical variation in received noise levels and can be useful for a variety of noise management tasks:

- Planning range operations.
- Exploring noise ramifications of range design options such as location and orientation.
- Examination of noise levels due to a single firing event (ONESHOT).
- Buffer land acquisition decisions.

Large Arms
CDNL Noise Contours



Per Army Regulations (AR200-1 Chapter 7), the primary means of noise assessment is through "mathematical modeling and computer simulation". Noise maps are prepared showing noise zones as shown in the example above. **Noise levels vary over a wide range of values, primarily due to weather. Spot measurements will often give an inaccurate indication of the noise environment.**

b. Noise Metrics for Large Arm Ranges: AR 200-1 Chapter 7 outlines the day-night level (DNL) metric for large arm range assessment. This metric represents the best available scientific quantification for assessing noise of large arms ranges.

CDNL: The 24-hour average sound level, for a period from midnight to midnight, obtained after multiplying by a factor of ten the average C-weighted sound pressures occurring in the nighttime hours 0000 to 0700 hours and 2200 to 2400 hours. (*Note that C-weighting incorporates a slight de-emphasis of the low and high portion of the audible frequency spectrum. The de-emphasis of the low frequencies is less than the A-scale. The C-weighted sound level is used to assess the additional annoyance caused by low frequency vibration of structures and is the standard weighting used by the US Army for arms greater than 20mm.)

PK: Gun blasts and demo rounds are impulsive in nature and occur over a very short period in time, only a small fraction of a second. The peak sound pressure level, PK, is defined as the level, expressed in decibels, of the highest

instantaneous sound pressure that occurs during a given time period. PK has correlated well with risk of complaints for large arms (see below).

PK15 (met): For multiple identical firing events, the peak sound pressure level expressed in decibels, exceeded by (only) 15 percent of firings (same gun, firing position, target position, propelling charge, ammunition, elevation angle, etc.). Variations in weather conditions (meteorological) are mainly responsible for the observed variation in this received sound level. Note how this quantity can be quite different from PK. For multiple non-identical firings, the quantity is the maximum value of all values of the PK15 (met), taken for each distinct firing.

Large arms: Weapons whose bore diameter ("calibers") is 20 mm or greater.

c. Land Use Guidelines: The Department of Defense has developed land use guidelines for areas on and/or near large arm firing ranges (see table below). Based on The Federal Interagency Committee on Urban Noise (FICUN) (FICUN 1980), these guidelines designate Noise Zones (NZ) for land use planning. By projecting these zones onto an area map, land use guidelines can be used to help range planners.

Noise Zone	**Noise Limits**
	High Energy Impulsive (20mm or greater)
	CDNL (dB)
LUPZ	57-62
I	<62
II	62-70
III	>70

Noise Zone III**:** NZ III consists of the area around the source of the noise (the large arms range) in which CDNL is greater than 70 dB. The noise level within NZ III is considered so severe that noise-sensitive land uses should not be considered therein.

Noise Zone II: NZ II consists of an area where the CDNL is between 62 dB and 70 dB. Exposure to noise within this area is considered significant and use of land within NZ II should normally be limited to activities such as industrial, manufacturing, transportation and resource production.

Noise Zone I: NZ I include all areas around a noise source in which the CDNL is less than 62 dB. This area is usually suitable for all types of land use activities.

Land Use Planning Zone: LUPZ consists of an area where the CDNL is between 57 and 62 dB. Exposure to noise within this area is considered significant during periods of increased operations. The LUPZ accounts for the variability of noise levels caused by higher daily numbers of operations than the annual average. It shows where levels of annoyance usually associated with Noise Zone II can be found during periods of increased operations. The LUPZ provides the installation with a means to predict possible complaints, and meet the public demand for a description of what will exist during a period of increased operations.
Risk of Complaint Guidelines:

To evaluate the complaint potential from impulsive noise, the US Army uses a set of guidelines (Pater 1976) developed by the Naval Surface Warfare Center, Dahlgren, Virginia. These guidelines for delaying tests at Dahlgren are based on over 10 years experience using meteorological forecasts. The guidelines are shown in the table below. These levels resulted from the best compromise between cost, efficiency of range operations, and good community relations.

IMPULSE NOISE GUIDELINES

Predicted Sound Level, PK	Risk of Complaints	Action
< 115	Low risk of noise complaints.	Fire all programs
115 – 130	Moderate risk of noise complaints.	Fire important tests. Postpone non-critical testing, if feasible.
130 – 140	High risk of noise complaints, possibility of damage	Only extremely important tests should be fired
> 140	Threshold for permanent physiological damage to unprotected human ears. High risk of physiological and structural damage claims.	Postpone all explosive operations.

*Note: For rapid-fire test programs and/or programs that involve many repetitions of impulse noise; reduce allowed sound levels by 15 dBP.

BNOISE2 Considers:

- Weapon and Ammunition**:** The US Army defines large arms as weapons 20mm or greater. These commonly include artillery, tank guns, bombs, explosive demolition charges and grenades. BNOISE2 accounts for the type of weapon and ammunition (including sound energy, spectrum and directivity for muzzle blast, projectile detonation and sonic boom).

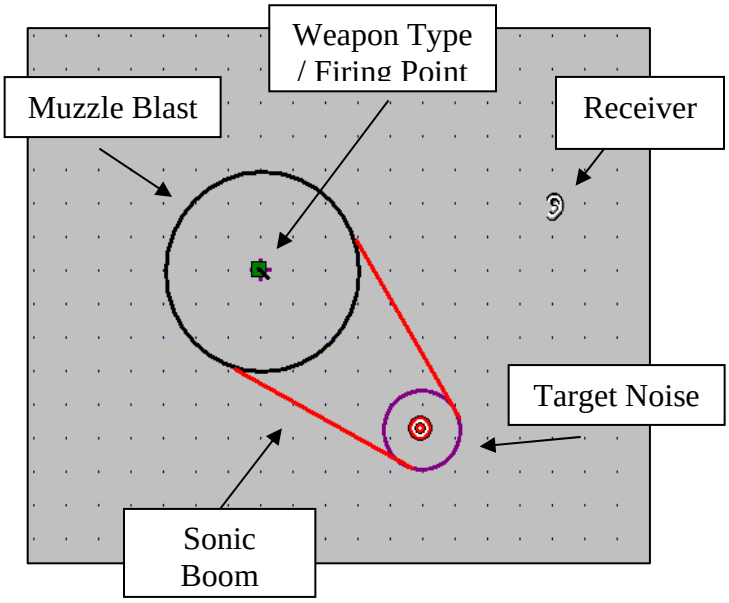
- Directivity: Noise is not emitted equally in all directions. Levels in front of the firing weapon can be 15-20 dB higher than directly behind. This can be a useful tool in range siting and orientation.

- Target Noise: BNOISE2 allows target noise to be accounted for with a "high explosives" (HE) setting or an "inert" setting. The "HE" setting accounts for the

additional noise emitted when the projectile detonates; with the “inert” setting no sound is emitted from the target.

- Target Location: Firing location can be adjusted in BNOISE2. Target location affects the position of the target area noise source, but also changes the area that the sonic boom enters. In general, the farther the target is from the firing point, the larger the sonic boom region. This is another tool that can be helpful for range siting and orientation.

- Projectile Sonic Boom: When the projectile (bullet) breaks the speed of sound, a boom is produced which is similar to the much more powerful sonic booms associated with supersonic aircraft. This additional acoustical energy can incrase perceived sound levels in nearby neighborhoods, thus increasing the risk of complaints. Since the sonic boom is not emitted inall directions or by all large arms weapons, BNOISE2 can be utilized to site ranges less likely to affect nearby neighborhoods.



- Muzzle Blast: All large arms emit a spherical “muzzle blast” wave when firing. This is a result from the rapid expansion of gases associated with the projectile firing. The muzzle blast emitted by some guns exhibit considerable directivity which BNOISE2 takes into consideration.

- Environmental Factors: Weather and geographic factors can play a major role in large arm noise propagation from source to receiver. Depending on conditions, sound levels at a given point can range from barely noticeable to extremely loud and annoying. Studies have shown there can be a 50 dB variance. In terms of human perception this would be 32 times as loud. BNOISE can model sound propagation over surfaces (ex. water, mixed vegetation, desert) and atmospheric conditions (ex. night focus, day focus) as a tool to help designers with range siting. Below is a simplified technique developed by the Explosives Research Group (ERG) (University of Utah 1958) to predict atmospheric refraction conditions. The ERG technique summarizes the results of this research into a series of "good" and "bad" firing times. This technique provides a good first approximation of the effects of the existing weather conditions on noise

propagation. Installations could use this technique to reduce the possibility of complaints.

“GOOD" AND "BAD" FIRING CONDITIONS

"Good" Condition	"Bad Conditions
Clear skies with billowy cloud formations, especially during warm periods of the year.	Days of steady winds of 5-10 mph with gusts of greater velocities (above 20 mph) in the direction of residences close by.
A rising barometer immediately following a storm.	Clear days on which "layering" of smoke or fog are observed. Cold hazy or foggy mornings. Days following a day when large extremes of temperature (about 36 degrees F) between day and night is noted. Generally high barometer readings with low temperatures.

d. Success Story: In 2004, BNOISE2 was used to assist a US Army installation in predicting future noise contours for several demolition ranges. Planners were concerned that nearby neighbors would be impacted by relocating these ranges. BNOISE2 confirmed this and as a result the ranges were moved further toward the interior, allowing for larger charges to be fired without affecting neighbors. This proactive measure allowed the US Army to be a “good neighbor” without curtailment of any range activity or loss of any operational capability.

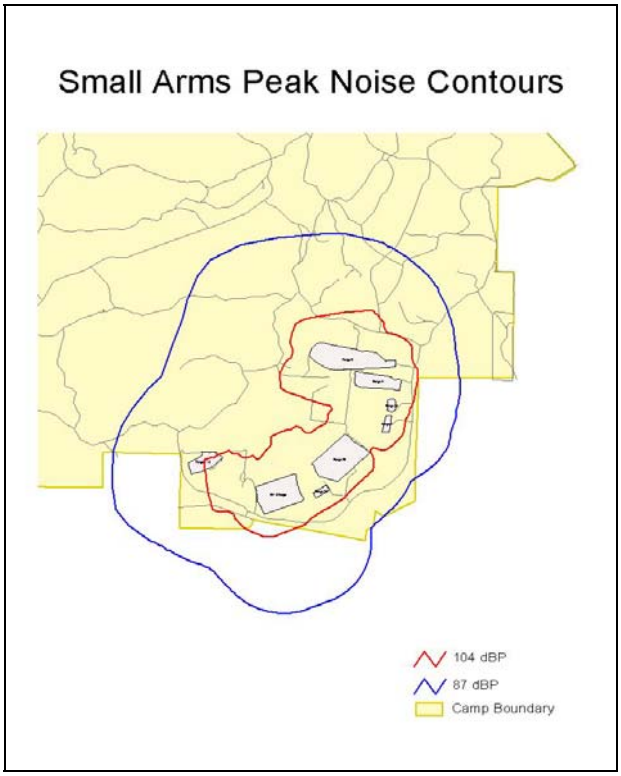
e. Benefits/Savings: BNOISE2 quantifies large arms range noise impact. This facilitates noise management and planning for existing and new ranges, to sustain training capability. Noise management capabilities include examining noise levels due to a particular firing event, planning range operations, guidance for buffer land acquisition and exploring noise ramifications of range design options such as siting and orientation. Noise assessment capability is an essential part of an encroachment management program, which can prevent noise complaints and preclude the need to purchase noise-impacted land. The complexity and computational labor of calculating noise contours demands a computerized tool for cost-effectiveness and practicality.

Small Arms Operational Noise: Rifles and pistols are fired extensively at small arms ranges for purposes of military and law enforcement training and for recreational and competitive shooting. Noise from small arms ranges often annoys people living in

surrounding communities. Their response may include noise complaints, political pressure, legal action, and efforts to curtail the firing activity. All of these actions may impact range sustainability.

a. SARNAM – Small Arms Range Noise Assessment Model: SARNAM is a software application that provides the capability to calculate and display noise level contours for firing operations at small arms ranges (example below). Developed by the US Army at the Engineering Research and Development Center / Construction Engineering Research Laboratory (ERDC / CERL), SARNAM accounts for statistical variation in received noise levels and can be useful for a variety of noise management tasks:

- Planning range operations.
- Examination of noise levels due to a single firing event (ONESHOT).
- Exploring noise ramifications of range design options such as siting, orientation, barriers and safety baffles.
- Buffer land acquisition decision.



b. Army Regulations: Per Army Regulations (AR200-1 Chapter 7), the primary means of noise assessment is through "mathematical modeling and computer simulation". Noise maps are prepared showing noise zones as shown in the

example above. Noise levels vary over a wide range of values due to weather; surface winds are particularly important for small arms. Spot measurements will often give an inaccurate indication of the noise environment.

c. Noise Metrics for Small Arms Ranges: AR 200-1 Chapter 7 outlines the single event metric for small arms range assessment as either unweighted peak sound pressure level (PK) or A-weighted sound exposure level (ASEL). These metrics represent the best available scientific quantification for assessing noise of small arms ranges.

PK: Gunshots are impulsive in nature and occur over a very short period in time, only a few thousandths of a second. The peak sound pressure level (PK) is defined as the level, expressed in decibels, of the highest instantaneous sound pressure that occurs during a given time period.

PK15 (met): For multiple identical firing events, the peak sound pressure level expressed in decibels, exceeded by (only) 15 percent of firings (same gun, firing position, target position, propelling charge, ammunition, elevation angle, etc.). Variations in weather conditions (meteorological) are mainly responsible for the observed variation in this received sound level. Note how this quantity can be quite different from PK. For multiple non-identical firings, the quantity is the maximum value of all values of the PK15 (met), taken for each distinct firing.

ASEL: (A-Weighted Sound Exposure Level) is another metric that has correlated well with assessment of small arms noise. It is loosely defined as the level, also expressed in decibels, formed by summation of acoustical energy over the entire duration of an event (gunshot) and A-weighted to accommodate for human hearing.

Small arms: Weapons whose bore diameter ("caliber") is less than 20 mm.

d. Land Use Guidelines: Acceptable values of noise metrics are different because the character of the noise is different. The Department of Defense has developed land use guidelines for areas on and/or near small arms firing ranges (see table below). Based on The Federal Interagency Committee on Urban Noise (FICUN) (FICUN 1980) these guidelines designate Noise Zones (NZ) for land use planning. By projecting these zones onto an area map, land use guidelines can be used to help range planners.

LAND USE PLANNING GUIDELINES

Noise Zone	Noise Limits	
	Small Arms (caliber < 20mm)	
	ASEL (dB)	PK15 (met) (dB)
I	<56	<87
II	56-71	87-104
III	>71	>104

Noise Zone III**:** NZ III consists of the area around the source of the noise (the small arms range) in which PK15 (met) is greater than 104 dB, or in which ASEL is greater than 71 dB. Either condition is sufficient to establish an area as Zone III. The noise level within NZ III is considered so severe that noise-sensitive land uses should not be considered therein.

Noise Zone II: NZ II consists of an area where the PK15 (met) is between 87 dB and 104 dB, or in which ASEL is between 56 dB and 71 dB. If either of these ranges is exceeded, then the area instead qualifies as Zone III. Exposure to noise within this area is considered significant and use of land within NZ II should normally be limited to activities such as industrial, manufacturing, transportation and resource production. Residential housing located in NZII or NZIII is likely to result in adverse community reaction and perhaps reduced utilization of the ranges.

Noise Zone I: NZ I include all areas around a noise source in which the PK15 (met) is less than 87 dB and ASEL is less than 56 dB. This area is usually suitable for all types of land use activities.

SARNAM Considers:

- Weapon and Ammunition**:** The US Army defines small arms as weapons less than 20 mm. These commonly include .50 cal rifles, pistols, and shotguns. SARNAM considers the type of weapon and ammunition (spectrum and directivity for both muzzle blast and projectile bow shock).

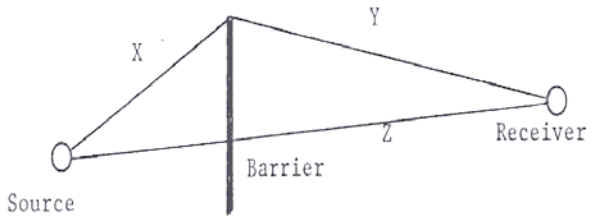
- Directivity: Weapons do not emit sound energy in all directions. Gun directivity describes how sound emission depends on direction, and can greatly affect the noise footprint. Typically levels in front of the firing weapon can be 10-15 dB

higher than directly behind. This can be a useful tool in range siting and orientation.

- Target location: Target location can be adjusted in SARNAM, and it affects the area in which the bow shock exists. In general, the farther the target is away from the firing point, the larger the bow shock region. This is another tool that can be used in range siting and orientation to influence the sound exposure footprint.

- Range Attributes: SARNAM allows the user to place barriers and safety baffles on a range for siting and noise mitigation. Barriers can be placed downrange from the target, to the sides and behind the firing point. Also, adjustments can be made to the barrier type (wall or berm), absorption coefficient, height, and distance from firing point.

The barrier feature is based on a mathematical model developed over 30 years ago by a Japanese engineer, Z. Maekawa.



Maekawa's model deals with the "path length difference," which is the difference between (Z) a straight line drawn from the noise source to the receiver and (X + Y) the distance from the noise source to the top of the barrier plus from the top of the barrier to the receiver. The greater the "path length difference," the more effective the barrier. Also, the higher the frequency, the more effective is a particular path length difference. Smaller weapons typically emit higher frequency acoustic energy, and therefore can be mitigated by smaller barriers.

In addition to providing safety from bullets exiting a range, overhead baffles can redirect noise, sometimes in a disadvantageous way. SARNAM allows for adjustments to the baffle's absorption coefficient, size, and distance down range. This is another useful tool for range siting.

e. Success Story: In 2003, SARNAM was used to assist a US military installation in the siting of a multi-purpose machine gun range near an installation boundary. Planners were concerned that nearby neighbors would be impacted by the noise generated from this range. SARNAM confirmed this and it was shown that moving the range 500 meters east and/or building earth berms to the rear and left would significantly lower noise levels entering the neighborhood. This proactive measure allowed the US Army to be a "good neighbor" with local communities and avoid adverse community reaction that might lead to reduced utilization of the range.

f. Benefits / Savings: SARNAM quantifies small arms range noise impact. This facilitates noise management and planning for existing and new ranges, to sustain training capability. Noise management capabilities include assessing long-term community noise impact, examining noise levels due to a particular firing event, planning range operations, and exploring noise mitigation ramifications of range design options such as siting, orientation, and placement of barriers and safety baffles. Noise assessment capability is an essential part of an encroachment management program, which can prevent noise complaints and preclude the need

to purchase noise-impacted land. The complexity and computational labor of calculating noise contours demands a computerized tool for cost-effectiveness and practicality.

g. ERDC POC: Construction Engineering Research Laboratory (CERL)
PO Box 9005, Champaign, IL, 61826-9005
Phone: 217-373-7253, Fax: 217-373-7251

Distribution Sources:
BNOISE2 and SARNAM software are currently available to government users on request from the listed ERDC POC.

Available Documentation:
The BNOISE2 and SARNAM programs are packaged with a getting started user manual and a help feature. Limited technical assistance is also available through the USACHPPM Operational Noise Program, which can be contacted through e-mail at:
CHPPM-NoiseQuestions@amed.army.mil.

USACHPPM also offers expert noise impact assessment and mitigation consultation and calculation services. More information can be found at: http://chppm-www.apgea.army.mil/dehe/morenoise/ or by calling Phone: 410-436-3829.

Available Training:
No formal classroom training is currently resourced. However, limited technical assistance may be requested through the USACHPPM Operational Noise Program. Some introductory familiarization is occasionally offered as part of noise workshops. User knowledge of acoustics, meteorology and military weapons will enhance the software value and productivity of the software.