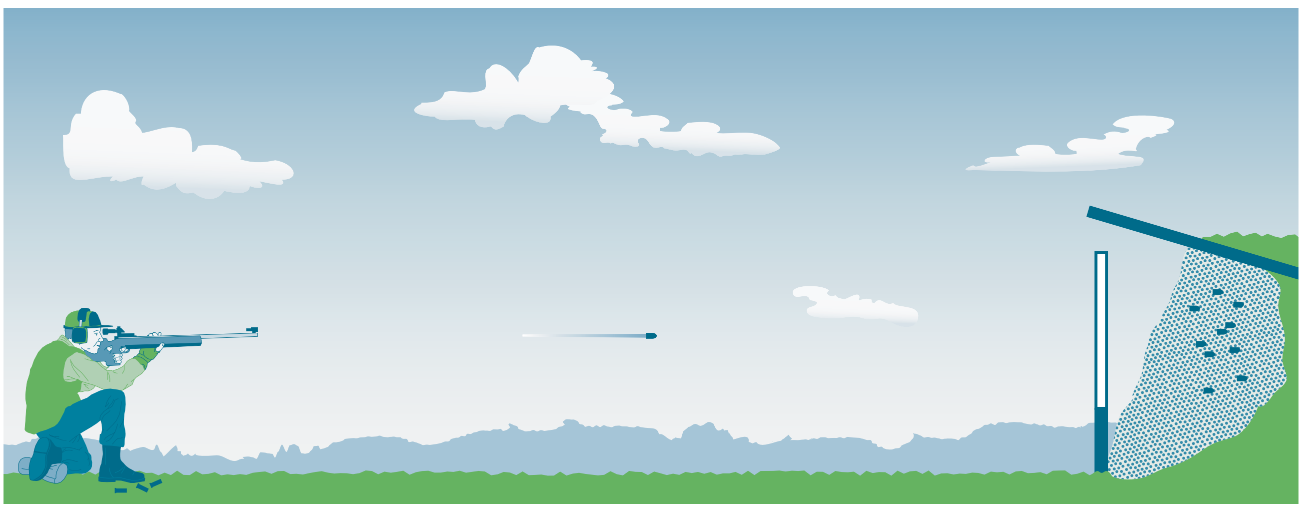
Technical Guideline

Environmental Management at Operating Outdoor Small Arms Firing Ranges



February 2005

Prepared by
The Interstate Technology & Regulatory Council
Small Arms Firing Range Team

ABOUT ITRC

Established in 1995, the Interstate Technology & Regulatory Council (ITRC) is a state-led, national coalition of personnel from the environmental regulatory agencies of some 44 states and the District of Columbia; three federal agencies; tribes; and public and industry stakeholders. The organization is devoted to reducing barriers to, and speeding interstate deployment of, better, more cost-effective, innovative environmental techniques. ITRC operates as a committee of the Environmental Research Institute of the States (ERIS), a Section 501(c)(3) public charity that supports the Environmental Council of the States (ECOS) through its educational and research activities aimed at improving the environment in the United States and providing a forum for state environmental policy makers. More information about ITRC and its available products and services can be found on the Internet at **www.itrcweb.org.**

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ITRC (Interstate Technology & Regulatory Council). 2005. *Environmental Management at Operating Outdoor Small Arms Firing Ranges*. SMART-2. Washington, D.C.: Interstate Technology & Regulatory Council, Small Arms Firing Range Team. Available on the Internet at http://www.itrcweb.org.

ACKNOWLEDGEMENTS

The members of the Interstate Technology & Regulatory Council (ITRC) Small Arms Firing Range Team wish to acknowledge the individuals, organizations, and agencies that contributed to this technical guideline.

As part of the broader ITRC effort, this Small Arms Firing Range Team work is funded primarily by the United States Department of Energy. Additional funding and support have been provided by the United States Department of Defense and the United States Environmental Protection Agency. ITRC operates as a committee of the Environmental Research Institute of the States (ERIS), a Section 501(c)(3) public charity that supports the Environmental Council of the States (ECOS) through its educational and research activities aimed at improving the environment in the United States and providing a forum for state environmental policy makers.

The Small Arms Firing Range Team also wishes to recognize the following states' support of team leadership and guidance preparation:

- New Jersey Department of Environmental Protection: Bob Mueller, former Team Co-Leader, and Ed Stevenson
- Washington Department of Environment: Dibakar (Dib) Goswami, Ph.D., Team Co-Leader
- Massachusetts Department of Environmental Protection: Elizabeth Callahan
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- California EPA Department of Toxics Substance Control: John Christopher
- Florida Department of Environmental Protection: Jeff Lockwood
- South Carolina Department of Health and Environmental Control: Stacey French
- District of Columbia Department of Health: Richard Albright
- Colorado Department of Health and Environment: Susan Newton

The team also recognizes the exceptional contributions from Michael Warminsky, AMEC Earth and Environmental, Inc.; Keith Hoddinott, U.S. Army Center for Health Protection and Preventive Medicine; Michael Burkett and Scott Edwards, Metals Treatment Technologies; Jim Dawson and Terry Jennings, Concurrent Technologies Corporation; Chuck Harmon, AMEC Earth and Environmental, Inc.; Rick Patterson, National Shooting Sports Foundation; Bob Byrne, Wildlife Management Institute; Ioana Petrisor, DPRA, Inc.; Satish Kastury, WRS Infrastructure and Environment; Greg Butler, BEM Systems; and Bill Call, PMK Group. We also wish to thank Peter Strauss of PM Strauss & Associates for contributing his community stakeholder perspectives to this document and his never-ending contribution to ITRC. Thanks to Ed Guster and George Meyers, EPA Region 2, who offered an EPA regional and national overview during the guidance development. Other unnamed members also contributed valuable perspectives through their advice throughout the project. Special thanks to the Department of Defense and the Army Environmental Center's Kimberly Watts and Bonnie Packer for the valuable contribution of military range information, technical research, and department-wide coordination. The Army Environmental Center added a distinct perspective to range management and improved the guidance in the process. Thanks also to Steve Hill, RegTech, Inc., for urging constant progress during development of the guidance and assisting wherever necessary.

Lastly, without the leadership, common sense, and coordination of Bob Mueller and Dib Goswami, Team Co-Leaders, and Mark Begley who stepped in as Team Co-Leader when Bob

Mueller became ITRC Co-Chair, this guidance would not have been prepared. They spent many hours of their own time researching, reviewing drafts, and planning conference calls and meetings. They are the cohesive leadership of the team, and the substance of the guidance is much better due to their efforts.

EXECUTIVE SUMMARY

Small arms ranges are important locations to provide safe places to learn and practice shooting skills for law enforcement, military and recreational shooters. Contaminants from projectiles, targets, or primers used at a range can potentially migrate in the environment. Depending on the depth of groundwater, climate, soil chemistry, or proximity to surface water at the range, contaminants can reach groundwater or surface waters. In some instances, projectiles and targets are discharged directly to wetlands or surface waters. Left unmanaged, contaminants at or from a range could pose a health risk to wildlife or people who are exposed to affected environmental media. Some range operators may be unaware of the potential for range activities to impact the environment and have not designed or operated the range in a protective manner. State and federal environmental agencies generally have no specific regulations overseeing the operation of ranges. These agencies can and do, however, enforce laws regulating releases of contaminants to the environment and the disposal of wastes. Some state and federal agencies have developed technical assistance programs and guidance to inform range owners and operators and community stakeholders of the design and management options for improved environmental operation of ranges.

This document addresses the minimization of potential exposure to metals, especially lead, associated with shooting ranges. It is not a general discussion of health effects stemming from exposures to lead, nor is it intended to be a manual on range safety. The reader is encouraged to access other sources of more detailed information on these subjects.

Many range operators are committed to being stewards of the environment. The growth of environmental awareness, loss of rural areas through continued land development, and mixed public attitudes toward firearms and ranges shape the context in which ranges operate. Practicing environmental stewardship provides an opportunity for operators to proactively manage their ranges and prepares them to respond to concerns that may arise from range neighbors, the community, or others. Voluntary implementation of science-based environmental stewardship encourages self-oversight rather than regulatory intervention with the range. Well-designed and -managed ranges should incur only manageable environmental issues during operation. Environmental conditions at operating ranges need to be evaluated, however, to delineate any existing and potential risks to the environment. Upon identifying a problem, measures should be undertaken to correct, prevent, or minimize adverse environmental impacts.

This guidance, a follow-up to *Characterization and Remediation of Soils at Closed Small Arms Firing Ranges* (ITRC 2003a), is designed to assist range operators in developing, using, and monitoring environmental management plans at active outdoor small arms firing ranges. The central task in formulating an environmental management plan is the selection and implementation of effective and reliable pollution prevention and mitigation measures, otherwise referred to as “best management practices” (BMPs). This document—developed by a partnership among state and federal environmental representatives, U.S. Department of Defense (DoD), shooting sports industry, and stakeholders—focuses on providing range operators with the guidance they need to identify and undertake BMPs that are appropriate for and tailored to the site-specific environmental conditions at their ranges. It is a synthesis of several of the most used and tested guidance documents to date and builds upon this information by adding experiences from case studies.

This guidance is organized according to the sequence of activities a range operator undertakes to develop and implement an environmental management plan. Beginning with the identification of range-specific environmental issues, options for BMPs provide the most reliable and effective techniques to address the particular issues identified by the range evaluation. Incorporating selected BMPs into an environmental management plan; implementing, assessing and modifying the plan, as necessary; and documenting its implementation should become a routine operation to provide an environmentally safe and secure range.

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1. INTRODUCTION

Sportsmen and -women, the military, and government agencies share a common goal of a clean and healthy environment. These groups also share a commitment to sound, science-based environmental management of small arms firing ranges (hereafter referred to as "ranges") to ensure the achievement of this goal. Successful range operators—be they recreational, military, or law enforcement—serve as good stewards of the environment. Their efforts result in the preservation of open space and the protection of wildlife and other natural resources encompassed by and associated with the lands they manage.

> Small arms firing ranges are the focus of this document. The terms "range" and "ranges" used herein refer specifically to small arms firing ranges.

The growth of environmental awareness, loss of rural areas through continued land development, and mixed public attitudes toward firearms and ranges provide a context in which ranges operate. Many already conduct their activities knowing that range operations could cause environmental problems if not adequately managed. Practicing environmental stewardship provides an opportunity for operators to proactively manage their ranges and prepares them to respond to concerns that may arise from range neighbors, the community, or others. Voluntary implementation of science-based environmental stewardship encourages self-oversight rather than regulatory intervention with the range. Range operators—whether military, recreational or law enforcement—should recognize that potential environmental issues, left unattended, could be magnified beyond the real or initial environmental impacts. Environmental issues are manageable as a function of site conditions, designs, and/or operating procedures. Environmental conditions at operating ranges need to be evaluated, however, to delineate any existing and potential risks to the environment. Upon identifying a problem, measures should be undertaken to correct, prevent, or minimize adverse environmental impacts.

Small arms firing ranges are those ranges accepting .50-caliber or smaller nonexploding ammunition. This document does not specifically cover tracer or incendiary ammunition. The central task in formulating an environmental management plan is the selection and implementation of effective and reliable pollution prevention and mitigation measures, otherwise referred to as "best management practices" (BMPs). This document focuses on providing range operators with the guidance they need to identify and undertake BMPs that are appropriate for and tailored to the site-specific environmental conditions at their ranges.

> This guidance is designed to assist range operators in developing, using, and monitoring environmental management plans at their active outdoor small arms firing ranges.

This guidance is a follow-up to *Characterization and Remediation of Soils at Closed Small Arms Firing Ranges* (SMART-1, ITRC 2003a). That guidance document, addressing the cleanup of closed ranges (i.e., the remediation of a former range so that the location may be suitable for some other future use), includes an easy-to-follow decision process for determining the best remedial alternatives for lead and lead-contaminated soils at closed ranges.

While this document and SMART-1 deal with different topics, there is an obvious and important connection between them—to the extent that operators of active ranges prevent or minimize the impact of activities on the environment through the use of BMPs, they reduce the scope, magnitude, complexity, and cost of future cleanup if the range closes.

This document was developed by a partnership among state and federal environmental representatives, U.S. Department of Defense (DoD), industry, and stakeholders. It is a synthesis of several of the most used and tested guidance documents to date and builds upon this information by adding experiences from case studies. The case studies highlight environmental management plans implemented at public and private facilities and state and federal technical assistance programs that help ranges operate their facilities in an environmentally protective manner.

Other existing guidance documents contain valuable information on environmental management of active ranges, but none bring together the broad state and stakeholder acceptance and the mix of skills and experience used in preparation of this ITRC guidance. ITRC team members, which include some of the most active and informed of the small arms shooting and environmental community, provide a valuable resource in the compilation of information for this guidance manual (see Appendix E).

Primary sources of information for this guidance include the following:

Association of European Manufacturers of Sporting Ammunition. 2002. *Shooting Ranges and the Environment: A Handbook for European Range Managers.*

Department of the Air Force, Headquarters Air Force Civil Engineer Support Agency. 2002. "Small Arms Range Design," Engineering Technical Letter (ETL) 02-11 (November). Tyndall Air Force Base, Fla.

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Massachusetts Department of Environmental Protection. 2001. "Lead Shot in the Environment." Available on the Internet at http://www.state.ma.us/dep/files/pbshot/working.htm.

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National Shooting Sports Foundation. 1997. *Environmental Aspects of Construction and Management of Outdoor Shooting Ranges*. Available on the Internet at www.rangeinfo.org.

U.S. Army Environmental Center. 1997. "The Range Evaluation Software Tool (REST)" and *Army Sampling and Analysis Plan for Small Arms Ranges* (SFIM-AEC-ET-CR-97037) Available on the Internet at http://aec.army.mil/usaec/technology/rangexxi03g.html.

U.S. Environmental Protection Agency. 2003. *Best Management Practices for Lead at Outdoor Shooting Ranges.* EPA-902-B-01-001, Revised. Available in the Internet at http://www.epa.gov/region2/waste/leadshot/.

1.1 Problem Statement

There are thousands of active outdoor small arms firing ranges in the United States, including an estimated 9,000 nonmilitary ranges (EPA 2001) and more than 3,000 small arms ranges operated by DoD. Lead and other metals associated with projectiles are of potential concern at these outdoor ranges (ITRC 2003a, Section 1). Lead is present at ranges in the form of spent bullets and shot. Lead can contaminate range soil as the result of projectile fragmentation and leaching due to weathering. Other metals commonly associated with range activities include copper, zinc, tungsten, arsenic, antimony, and nickel. Lead is the metal most often identified as a concern because lead is the principal component of the projectiles; however, other metals may be present and may need to be addressed appropriately.

In addition to affecting soil, contaminants from projectiles, targets, or primers used at a range can potentially migrate in the environment. Polycyclic aromatic hydrocarbons (PAHs) are present in clay targets; however, studies have shown that the targets did not exhibit the characteristics of toxicity as determined by the EP toxicity test. Results from new and aged targets suggest that PAHs are tightly bound in the petroleum pitch and limestone matrix and are unlikely to be readily available in the environment (Baer et al. 1995). Depending on the depth of groundwater, climate, soil chemistry, or proximity to surface water at the range, contaminants can reach groundwater or surface waters. In some instances, projectiles and targets are discharged directly to wetlands or surface waters. Left unmanaged, contaminants at or from a range could pose a health risk to wildlife or people who are exposed to affected environmental media.

Some range operators may be unaware of the potential for range activities to affect the environment and have not designed or operated the range in a protective manner. State and federal environmental agencies generally have no specific regulations overseeing the operation of ranges. These agencies can and do, however, enforce laws regulating releases of contaminants to the environment and the disposal of wastes. For example, according to the U.S. Environmental Protection Agency (EPA) Region 2 manual, "Lead is not considered a hazardous waste subject to RCRA at the time it is discharged from a firearm because it is used for its intended purpose. As such, shooting lead shot (or bullets) may not be regulated nor is a RCRA permit required to operate a shooting range." Some state and federal agencies have developed technical assistance programs and guidance to inform range owners and operators and community stakeholders of the design and management options for improved environmental operation of ranges.

Many outdoor ranges are operated in conjunction with indoor ranges. Indoor ranges are not addressed by this guidance, but indoor range operators should be actively managing environmental issues at their facilities. These operators should be aware that indoor firing ranges that vent air to the outdoors without a filtering system have the potential to deposit particulate lead below the air system outdoor exhaust vent. This is an outdoor environmental issue created by an indoor range.

1.2 Environmental Stewardship Principles

In developing this guidance, the Small Arms Firing Range Team adopted the following established principles of environmental stewardship as they relate to active outdoor ranges:

- Minimize potential impact on human health and the environment.
- Protect groundwater, surface water, wetlands, and wildlife.
- Prevent subsurface soil contamination and erosion.
- Manage sound.

These principles served as the framework used by the team in selecting the BMPs and outlining the process for developing environmental management plans discussed in this guidance. These same principles provide range operators with a framework for successful environmental management. That is, range design plans and day-to-day operations should be evaluated in terms of consistency with these principles.

1.3 Document Overview

This guidance is organized sequentially in the order of activities range operators should undertake in developing and implementing an environmental management plan. Figure 1-1 depicts the topics covered in each chapter of the document that follows. Chapter 2 deals with identification of the range-specific environmental issues. Chapter 3 discusses which BMPs are most reliable and effective in addressing the particular issues identified by the range evaluation. Chapter 4 provides guidance on incorporating the selected BMPs into an environmental management plan for the facility; implementing, assessing and modifying the plan, as necessary; and documenting its implementation.

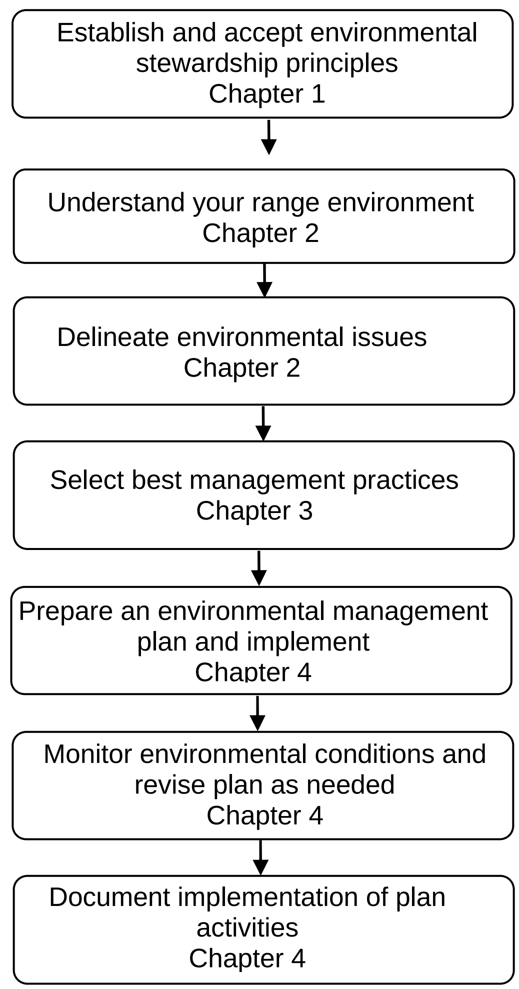

Figure 1-1. Typical sequence for establishing a range environmental management program.

2. POTENTIAL ENVIRONMENTAL ISSUES AT RANGES

The principal metal causing environmental contamination at most ranges is lead. Other contaminants can occur (see Table 2-1), but exposure to lead is used in this section to illustrate how humans, animals, and environmental resources can be affected by contamination from ranges. Many lead management activities are effective for other potential metal contaminants; however, much of the testing and research focuses on lead. If other constituents of concern have been identified at a range, management activities need to account for the fate and transport of those metals even though they may not have been studied in a shooting range setting as extensively as lead. Appropriate response action(s) at an operating range should be based on a range assessment, including potential fate, transport, and impact of lead and/or other constituents in the environment.

Table 2-1. Contaminants potentially found at ranges (modified from ITRC 2003a)

Constituent	Source (Comment)
Lead	Primary constituent of most projectiles
Lead styphnate/ lead azide	Primary constituent of most primers
Antimony	Alloy used as a hardening agent (Increases hardness)
Antimony sulfide	From 5% to 30% is used in most primer compounds
Arsenic	Lead shot constituent (Used in the production of small shot since it increases the surface tension of dropped lead, thereby improving lead shot roundness)
Copper	• Sometimes a primary alloy in center-fire ammunition and some small-caliber rifle bullets; also used in frangible pistol ammunition • Jacket alloy metal (Increases hardness)
Bismuth	Bismuth is used for lead shot replacement
Tin	Primary metal for center-fire ammunition and shot (Increases hardness)
Zinc	Jacket alloy metal
Iron	Iron tips on penetrator rounds and steel shot (Has been used successfully to remediate high levels of lead and arsenic in some soils)
Tungsten	Alternative projectile material to lead (Recent research indicates there may be some adverse environmental and human health concerns regarding tungsten)
Nickel	Coating to improve shot performance
Cobalt and chromium	Alloys in some ammunition rounds
Polycyclic aromatic hydrocarbons (PAHs)	Clay targets (Concentration of PAHs in clay targets varies from one manufacturer to the next but may be as high as 1000 mg/kg [Baer et al. 1995])

Moving through a typical set of questions outlined below or using a program like REST (Range Evaluation Software Tool, USAEC 1997a) can assist range managers in making qualitative assessments. Figure 2-1 provides a decision tree that enables a range operator to evaluate the range appropriately and, based on the outcome, to select the appropriate technique(s) that can be applied to prevent potential surface water, groundwater, or air transport. The bracketed numbers in the decision tree refer to the section in this document discussing that topic.

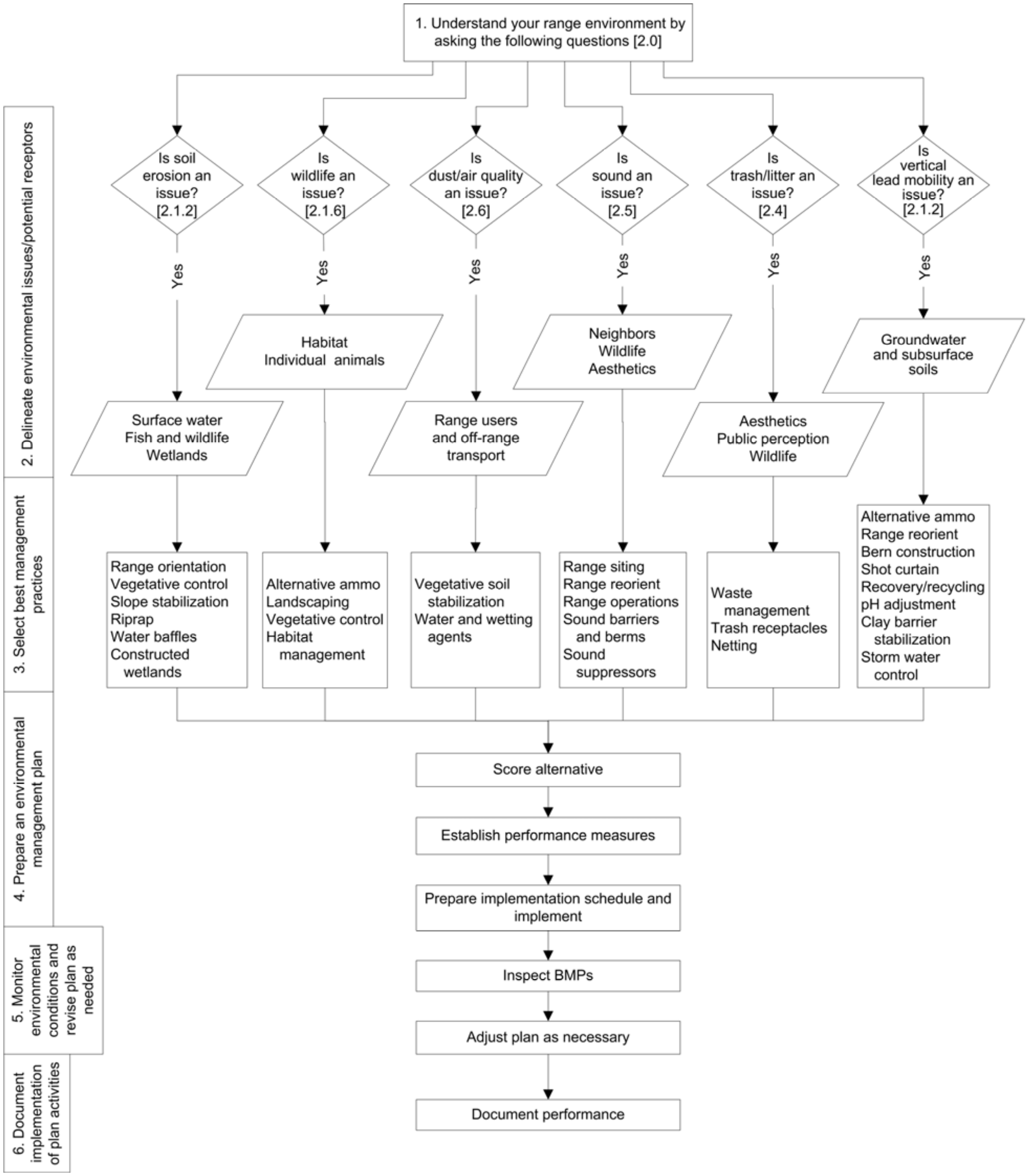

Figure 2-1. Decision tree.

Later (Table 4.2), this guidance also provides a "sample project evaluation comparison sheet," offering a possible scoring mechanism for the range manager to help determine which range response actions or BMPs best suit the overall need. The actions/practices selected should address the potential consequence of an identified issue, site-specific condition, range design feature, or maintenance procedure that most effects lead risk on the range or lead transport. These actions may involve pollution prevention, prevention of lead migration, or lead removal.

The following questions help range operators collect and compile information necessary to adequately understand the characteristics of shot and bullet distribution and the potential for lead and other heavy-metal transport. Note that the following questions are only guidelines and may not, in all circumstances, apply or be the full complement of all necessary questions.

- Where are the property boundaries, and do any rounds or shot fall beyond them?
- How is the metal distributed over the range property?
- Is the metal in areas of soil disturbed by bullet impact (e.g., bullet pockets)? Pulverized soil with high concentrations of lead and lacking vegetative cover is most susceptible to surface water transport.
- Can and have I calculated the mass of shot or bullets fired at each range on a regular basis?
- Are there hot spots (areas of concentrated lead)?
- Does wind or water erosion occur near these concentrated areas? If yes, then surface water and/or wind transport may be an issue.
- How deep is groundwater below the concentrated areas? If it is shallow (<10 feet, depending on soil type, pH, and mass of lead), groundwater transport may be an issue (see Figure 2-2).

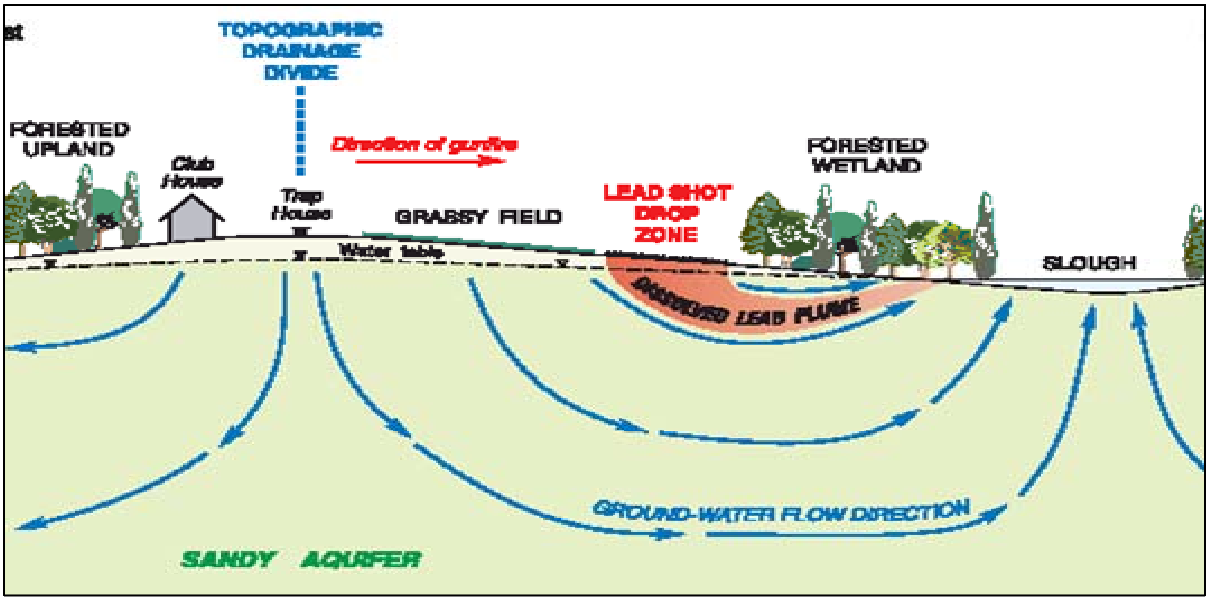

Figure 2-2. Conceptual model of groundwater flow and contaminant transport (from Soeder and Miller 2003).

- Are site soils sandy and highly permeable, or do the soils contain significant quantities of clay or organic matter? Sandy soils may allow vertical migration of dissolved lead, while clay or organic rich soils may adsorb the lead. Adsorbed lead may still be transported off site by surface water and wind erosion.
- Does slope of the ground surface encourage surface water runoff? Rills and gullies are an indication of erosion.
- Does the pH of the soil impact areas fall within the low solubility values (~6.0–9.0, ITRC 2003a)? If the pH is outside this range, there is a higher potential for lead migration in surface water or groundwater.

- Is the impact area in a surface water body or wetland?
- How far is the impact area from flowing or nonflowing streambeds?

Figure 2-1 lists the surface and subsurface, climate, operational, physical, and chemical characteristics of a range that operators should consider when initially characterizing potential environmental impacts the range operations might cause. The diagram further lists the possible techniques, technologies, and equipment a range manager can consider to prevent the potential issue from actually deteriorating the environment or posing a risk to humans or wildlife.

To confirm the presence or absence of a transport pathway (see Section 2.1.2), you may choose to conduct limited investigative field sampling. Be aware that such sampling and analytical results may be subject to state notification or reporting requirements. Guidance on sampling and analytical procedure for soil characteristics at ranges can be found in *Characterizing and Remediating Soils at Closed Small Arms Firing Ranges* (ITRC 2003a). The user is cautioned that confirmatory sampling for understanding the environmental characteristics of an operating range is unlikely to involve the scale or detail required when characterizing a closed site in preparation for remediation; however, the sample collection procedures and analytical techniques may be the same in both cases.

2.1 Fate, Transport, and Exposure

Lead contamination associated with operating ranges is normally limited to surface and near-surface soil. However, lead can be dispersed into the environment at ranges in one or more of the following ways:

- Lead oxidizes when exposed to moist air and can dissolve when exposed to moist soil or acidic water.
- Lead bullets or shot, bullet particles, or dissolved lead can be moved by storm water runoff (erosion).
- Lead particles or lead adsorbed to silt and clay can move by siltation in strong winds where little vegetation exists to prevent its movement.
- Dissolved lead can migrate through soils to groundwater.
- Plants can uptake lead and introduce it into the food chain.
- Wildlife may ingest lead shot, particles, or lead-contaminated soil.

2.1.1 Fate

When exposed to moist air and/or water, lead oxidizes and forms a variety of weathering products that can include lead oxides, sulfates, carbonates, and organic complexes. The solubility of lead in water is highly dependent on solution pH, increasing the dissolved lead concentration as water pH decreases. While increasing the pH of soil or water generally results in a decrease in soluble metal concentration, these conditions can also result in an increase in soluble metalloids such as arsenic and antimony. Increased contact time between lead and acidic water generally results in an increased amount of dissolved lead in solution and potentially in storm water runoff and groundwater. In contrast, raising the water pH causes dissolved lead to precipitate out of solution, particularly at pH values above 7.5 and below 9.5. Factors such as high clay and organic carbon can further retard the transport of lead in the dissolved phase through adsorptive and absorptive processes, inhibiting lead's mobility to both surface water and groundwater. High organic carbon content can also induce reducing conditions favorable to the formation of lead sulfides, which are relatively insoluble and immobile as long as these reducing soil conditions are maintained. Rainfall also increases the likelihood that lead will be mobilized in the environment, either through dissolution or erosive sediment transport. The primary factors that most influence the dissolution of lead in water are discussed further below.

Annual Precipitation Rate

The higher the annual precipitation rate, the faster lead weathers and the greater the volume of lead-containing water percolating through the soil (vertically or laterally) to surface and or groundwater. Periodic ponding from precipitation or irrigation can increase the amount of lead going into solution, particularly in areas where water pH is low (acidic). Also, during prolonged rains, the contact time between water and lead is increased. Acid rain and/or acidic soils may influence the dissolution of lead.

Soil Cover

Organic material and clay adsorb lead and remove it from water. Organic carbon in anoxic (oxygen-deficient) conditions may reduce oxidized forms of lead into lead sulfides, which remain relatively immobile in anoxic environments. Therefore, thicker organic-rich soil covers (e.g., leaf and peat cover) generally result in lower concentrations of lead in groundwater or pore moisture. Studies have shown that organic material has a strong ability to extract lead from water (EPA 2003).

2.1.2 Transport

Erosion is the movement and loss of surface layers of soil mainly by water but also by wind and other factors (Figure 2-3). Soil type and structure and slope of ground and its vegetation cover are important determinants of soil erosion. Topsoil can be lost and deep runoff channels created. Water quality and aquatic habitats can be degraded, and lead can be transported off range. Construction and poorly timed range management activities may increase the risk of such erosion.

Figure 2-3. Example of berm erosion.

Wind

Wind erosion is most likely in arid environments or during extended dry periods in other environments where the soil surface is friable and loose. A cover of suitable vegetation may be the most effective preventive measure. Further protection could be achieved by natural or artificial windbreaks, both within the range and on its perimeter, positioned according to the prevailing or most problematic winds.

In susceptible areas concentrated human use of parts of a range can encourage erosion. Access roads, unsurfaced parking lots, and walkways may need to be vegetated or otherwise protected with gravel, stone chippings, or chipped bark to reduce erosion risks. Similarly, range management and construction work involving removal of vegetation or other protective coverings can lead to increased erosion and generation of soil dust that can be blown off site if not carefully conducted or preventive measures applied.

Precipitation

> Lead shot, lead bullets, projectile fragments, or dissolved metals can be moved by storm water runoff.

Water can transport metals in both the metallic form (bullets, shot, fragments, etc.) and through sediment transport where lead (and other metals) has been adsorbed and through percolation of soil pore water. Water's physical ability to transport metal is influenced by the velocity of water and by the density and size of the particle being transported. Water's capacity to carry small particles is proportional to the water's velocity, while sediment-laden water can carry even larger particles than clear water. The factors that most influence velocity of runoff are as follows (EPA 2003):

- Rainfall intensity—The greater the volume of rainfall during a short period of time, the faster the velocity of surface runoff created to carry the rainfall off site. This factor may also increase the volume of pore water within the soil horizon.
- Topographic slope—Generally, the steeper the slope, the faster the storm water runoff.
- Soil type—More rainfall will soak into sandy soils than into clay soils. Hence, for a given rainfall intensity, the volume of runoff will be greater from areas underlain by clays or other low-permeability soils than from permeable, sandy soil.
- Stream width—Velocity tends to decrease as stream width increases. Merging streams, eddy currents, and curves in streams are other factors that may reduce the velocity.
- Vegetative cover—Vegetation on slopes and drainage ways physically stabilizes soil and reduces sheet flow velocities, preventing erosion. Grass and other vegetation reduce runoff velocity and act as a filter to remove suspended solids from the water. Vegetative growth requires proper soil quality. Contact your county extension service for advice and assistance.
- Manmade structures—Structures such as dams and dikes reduce water's velocity and proportionally reduce the size and weight of the lead particles the water can carry. Since lead particles are heavy compared to the other suspended particles of similar size, they are more likely to be deposited under reduced velocity of the storm water runoff.

Runoff flowing down backstops and berms or over ranges and shot fall zones loosens and carries soil particles. Eroded soils can degrade aquatic environments, including streams, ponds, estuaries, and wetlands both on property owned or controlled by the range and off site. Soils eroded from ranges may transport dissolved or particulate lead, increasing the potential for environmental impacts. Generally, the shorter the distance from the soils containing lead fragments to the range boundary or closest stream bed, the more likely it is that the lead fragments in suspension will be transported off range.

In general, the greater the amount of impervious land surface area, the greater the amount of runoff generated, and the higher the erosion potential. Vegetation tends to decrease the erosion potential by holding soils in place and reducing runoff velocity. Gently sloping ranges are less susceptible to erosion from runoff than are more steeply sloped sites. Finer sands and silts are more easily eroded than coarse sands and gravels are. Range sites should be examined for erosion. Regular inspections of berms and bullet impact areas and shot fall zones are advised to identify areas requiring erosion protection or restoration efforts. Information on the amount and intensity of rainfall can be obtained from the National Climactic Data Center of the National Weather Service (http://lwf.ncdc.noaa.gov/oa/ncdc.html). Information on soil texture and soil structure can be obtained from the Natural Resources Conservation Service (NRCS) of the U.S. Department of Agriculture (USDA, http://www.fl.nrcs.usda.gov/soils.htm). The slope of the ground, vegetative cover, and amount of impervious area can be easily observed or measured at the site by the range manager.

Rainwater can move dissolved lead downward toward the groundwater. Groundwater can discharge and become part of the surface water flow (see Figure 2-2). If the water flowing underground passes through rocks containing calcium, magnesium, iron, or other minerals more soluble than lead or through minerals that raise the pH of the water, then the lead in solution may precipitate or be replaced (removed) from solution. However, if the sediment matrix is a clean silica sand and gravel, fractured granite, or similar type material, then dissolved lead can move longer distances. Factors most likely to affect the amount of lead carried by the groundwater in solution are as follows:

- Annual precipitation—Generally, high annual precipitation results in extended contact between metallic lead and rain water. This can increase the potential for oxidation and/or dissolution (corrosion and leaching) of lead.

- Soil types—Clays have a high ionic exchange capacity and more surface area to which metals such as lead can adsorb. Also, groundwater movement in clay is very slow, which increases the contact time for lead to absorb to the clay. Lower surface area and faster permeability of sandier soils lead to longer transport distance of dissolved lead. All of the basic calcium and related minerals generally will have been removed from the clean silica sand and gravel soils, so dissolved lead in groundwater in these type soils can move long distances (miles) relatively unchanged.

- Soil chemistry—Soils containing carbonates along the pathways through which the groundwater moves increase lead precipitation (removal) rate. Lead should move in solution only a short distance (a few feet) through sand composed of shell fragments but could move in solution long distances (miles) through clean quartz sand. Note that pH above 9.5 mobilizes lead as well (ITRC 2003a, Fig. 3-1).

- Depth to groundwater—The shorter the distance traveled, the greater the risk that the lead will migrate into the environment. Shallow depth to groundwater is indicative of potentially higher risk for mobilized lead to reach the groundwater.

2.1.3 Human Health and Exposure

Exposure to lead can be a health risk to people at any age. At high concentrations lead exposure causing high blood lead levels can lead to convulsions, coma, and even death. At low concentrations, it is dangerous to infants and young children, damaging the developing brain and resulting in both learning and behavioral problems. EPA's *Best Management Practices for Lead at Outdoor Shooting Ranges* (EPA 2003) describes the effects of exposure to lead on children and adults. At firing ranges, shooters, firearms instructors, and other range employees can be exposed to significant levels of lead dust and fumes. Protecting the health of range employees and shooters, while minimizing environmental contamination from lead exposures, is an important element in the safety plan for ranges. During shooting activities, lead is deposited at the firing line and the impact berm or drop zone. Lead at the firing line comes from the precipitation of lead compounds from muzzle vapors, from lead azide and lead stiphnate primers, and from abrasion between the shotgun pellets or the projectile and the gun barrel. Berm or downrange deposits of lead come entirely from whole and fragmented projectiles.

> This manual does not cover many of the potential serious health effects caused by exposures to lead and lead poisoning. The reader is encouraged to use other sources of more detailed information on those subjects.

Exposure to lead at outdoor shooting ranges can occur by two main pathways: inhalation and incidental ingestion. Inhalation of lead vapors and dust can occur during both shooting and maintenance activities. Direct inhalation of muzzle vapors can expose shooters and bystanders to lead at the firing line. Exposure to lead-containing dust particles can occur anywhere on the range but is mostly a concern for maintenance workers performing duties in the area of impact. Incidental ingestion occurs from repeated hand-to-mouth actions. For example, lead particles generated by the discharge of a firearm can collect on the hands of a shooter, or lead-contaminated soil or dust can be picked up during maintenance activities. These particles can be ingested if shooters eat or smoke prior to washing their hands after shooting. This pathway usually generates the majority of lead exposures.

Range operators are required to protect workers from overexposure by following the recommendations and requirements, where applicable, of the Occupational Safety and Health Administration (OSHA), which is charged to protect employee health and safety in the workplace. OSHA has a comprehensive lead regulation, 29 Code of Federal Regulations (CFR) 1910.1025. This standard defines the legal responsibilities to limit employee exposure to lead, provide protective equipment and hygiene facilities, maintain a clean workplace, and provide employees with safety training and medical care. The lead standard also establishes a limit on the amount of lead that can be in the air workers breathe. Failure to comply with the requirements of the lead standard could result in fines to a business. OSHA does not endorse any specific equipment; its only function is to regulate the impact on the employee. For a copy of the complete standard, contact OSHA (http://www.osha.gov). OSHA training videos and manuals can be obtained at http://www.osha-safety-training.net/ and are a good source of personal protective equipment recommendations.

> To reduce the possibility of exposure, impact areas of the range should be posted and access restricted.

Range workers should be trained in the procedures required to handle lead and the possibility of overexposure to lead particles. Everyone using or working on the range should be encouraged to wash hands often in facilities provided for this purpose. Workers and users should be cautioned about eating and drinking in these areas. Simple placards should be posted at a range noting the presence of lead. Consider prohibiting food, drinks, and use of tobacco products on the range. See http://www.state.ma.us/dos/leaddocs/Lead-firing.htm and http://www.tdh.state.tx.us/epitox/firingranges_emp.pdf for more information on the health effects of lead. As noted earlier, this document is intended to address the minimization of potential exposures to lead associated with shooting ranges. It is not a general discussion of health effects stemming from exposures to lead, nor is it intended to be a document on range safety. The reader is encouraged to find other sources of more detailed information on these subjects.

> The relative risk of lead exposure to people is low in a well-designed and -managed facility, where common-sense precautions are taken.

Detrimental effects due to elevated lead levels can also be found in both domestic and wild animals. Excessive exposure to lead, primarily from ingestion, can cause increased mortality rates in cattle, sheep, and waterfowl. Many of the legal and government actions that have been brought against ranges are based on elevated levels of lead and increased mortality in waterfowl.

2.1.4 Lead in Plants and Crops

Most of the effects of lead in plants and crops involve the lead pellet fallout area. Pellets are unlikely to damage plants except where trees and shrubs are damaged or disfigured by shot-in or passing pellets. Embedded lead pellets in trees grown for timber are not normally a problem; however, trees with steel shot imbedded in them have been rejected as timber products. Falling pellets can accumulate in certain crops with upturned leaves or in cereal or grass crops that have been flattened by weather. This has been known to affect feeding livestock or cause a crop to be rejected at point of sale. Once lead has decomposed into a more soluble form, it can enter certain types of plants from the soil through their roots. While most plant species that accumulate lead deposit it in the subsurface portions, a number of agriculturally significant plants can translocate the lead to areal parts. Crop plants like broccoli, cabbages, wheat, rutabaga, and turnip; forage crops like fescue; and stock feed plants like corn and sunflowers have all been noted as hyperaccumulators of lead.

2.1.5 Lead Shot and Livestock

In general livestock are unlikely to eat shotgun pellets. Spent pellets usually settle through vegetation to the soil surface. Cattle and horses rarely graze down to the soil itself, although sheep and goats can do so. Pellets trapped in growing or conserved herbage, however, can be ingested. The digestive system of livestock is normally resistant to lead poisoning.

2.1.6 Wildlife and Habitat Concerns

Spent lead may be available to wildlife and, when it is, may result in detrimental effects. Under existing law, suits and/or regulatory actions can be brought upon parties that are thought to be involved with damage to natural resources, including wildlife populations or their habitats. Ranges can take steps to minimize lead availability and reduce the opportunity for birds and other animals to ingest lead. The presence of wildlife near ranges is often desirable. The goal of protecting wildlife in areas where lead is present goes hand in hand with that of having wildlife present in high-quality habitat on other parts of the range property.

Direct ingestion of lead shot or lead bullet fragments is the most important exposure pathway for wildlife. Birds may consume lead shot as grit for the gizzard, or it may be mistaken for small seeds and eaten. This can occur whether birds are feeding on land or in the water. Waterfowl are particularly susceptible to lead poisoning, a fact that resulted in the ban on lead shot for waterfowl hunting.

Lead shot and small bullet fragments may also be mistakenly eaten by birds and animals feeding on earthworms, soil insects, fallen seeds, and other foods at the surface of the soil. Range soils with elevated lead levels may also be inadvertently ingested by wildlife while feeding or when animals are cleaning their fur or feathers. The soil ingestion exposure pathway is generally considered a secondary risk for most animals; however, this exposure pathway may be more significant for terrestrial invertebrates and/or aquatic benthic organisms and for small mammals that may have a significant portion of their territories on the shot fall or impact area of a range than for larger mammals or birds that use larger areas. Generally, except for endangered or threatened species, unacceptable adverse effects are related to maintaining viable reproducing local populations rather than maintaining individual animals. For example, some small mammals whose restricted feeding territories substantially overlap the shot fall zone may be at high risk but represent only minimal impact on the local population.

Lead from shot or bullets in the soil that has weathered can be absorbed by plants and may accumulate in roots, leaves, seeds, and other parts that may be eaten by birds or animals. However, this pathway has not been demonstrated to be a major risk to most wildlife (Eisler 1988). If a range shoots into a field of corn or similar forage crop, there may be potential for ingestion of shot embedded in plants by domestic animals as well as wildlife (U.S. Department of the Interior 1986).

Generally, risks to wildlife at ranges are as follows:

- Waterfowl, coots, and snipe—Numerous studies have documented the risk to waterfowl. The risk is especially high if spent shot falls into wetlands or water where waterfowl may feed. However, waterfowl (especially geese) may be at risk if they are allowed to feed in shot fall areas that are maintained as a short grass habitat.

- Small, ground-feeding, seed-eating birds—Few studies have been conducted on this exposure; however, they are believed to be at a moderate risk. Mourning doves have been documented to ingest spent shot in heavily hunted areas. Because ranges represent only a fraction of a population’s distribution, any exposure is likely at the local level only.

- Small mammals—Most studies generally have identified small mammals as being at risk at ranges; however, they conclude that the exposure is only at the local level.

- Ground-feeding, worm- or insect-eating birds—These birds have a potential risk. The exposure pathway is through inadvertent ingestion of soil associated with worms or subterranean insects. Because ranges represent only a fraction of a population’s distribution, any impact is likely at only the local level. As a result, the risk is believed to be moderate to low.

- Medium-sized and larger mammals—These animals have a low risk. Several studies considered this exposure and concluded that any risks present were not significant.

- Fish-eating wading birds, fish, reptiles, amphibians, and invertebrates—Localized elevated lead levels may pose a risk where lead-contaminated runoff or shot is allowed migrate or fall into wetlands or water.

2.1.7 Lead Shot in Water

Spent lead pellets either sink into the sediments or remain on the bed of a water body (such as ponds, lakes, marshes, reservoirs and rivers) unless they are carried elsewhere by currents. The pellets, however, can remain potentially available to feeding waterfowl in shallow water bodies. In acidic water some lead may dissolve into surface water and reach regulatory limits.

2.2 Shot and Bullet Distribution

Knowing where projectiles are deposited on a range is a key first step in the management of lead and other constituents. Projectiles land in a particular area based on range design, site conditions, range activities, and operating procedures. Typically, these variables are part of a safety plan. The goal of the safety plan is to keep projectiles within a defined area. The range can then control the access to and use of that area. However, this practice also has a direct bearing on lead management. As was discussed earlier, you need to know where the projectiles are deposited in order to know where to focus your management efforts.

Whether at a recreational, military, or law enforcement training facility, there are three basic types of rifle and handgun ranges. The first and most common is the static range. A static range has fixed firing points and fixed targets. The static nature of both the shooter and target results in a very concentrated lead deposition area right behind a clearly defined target. Typical distances from a shooter to a target include 25 feet, 25 yards, 40 yards, 50 yards, and 100 yards up through 1000 yards in 100-yard increments.

The second type of range is the dynamic range. With this type of range, there is some movement on the part of the shooter and some on the part of the target, but the movement is planned in advance, and the target is clearly defined. Dynamic ranges are more typical of law enforcement and military training, but recreational ranges that have some form of "action" shooting (International Practical Shooting Confederation, International Defensive Pistol Association, cowboy action, etc.) exhibit similar lead deposition patterns. The areas of lead deposition are clearly identifiable, but less concentrated than with a static range.

The third type of rifle/handgun range is the interactive range, commonly known as a "tactical range." Tactical ranges, designed to simulate shooting scenarios in the field, are used almost exclusively in military and advanced law enforcement training. There is considerable movement on the part of both shooters and targets. The targets themselves are typically hidden in random patterns to add an element of surprise to the shooter's training. Lead deposition is widely dispersed throughout such ranges.

From an environmental perspective, the major difference between rifle/pistol ranges and shotgun ranges relates to the physical distribution of the lead. The vast majority of rifle/pistol ranges have a backstop berm, and lead is typically concentrated in a small area of the backstop berm behind the targets. Although bullets may occasionally strike the side berms or the foreground between the firing line and the targets, lead is usually sparsely distributed throughout these areas relative to its concentration in the backstop berm. Range use should be carefully considered when choosing a backstop design. Ricochets increase the distribution of lead to other areas. In heavily used ranges with bullet traps, significant lead recovery and recycling is feasible. A variety of different bullet traps are available.

2.2.1 Military Range Configurations

Rifle/pistol qualification ranges have a variety of layouts depending on the weapon and shooting scenario. They may use fixed distances and/or pop-up target configurations (Packer 1996). Figure 2-4 depicts one lane of a 25-m range. A 25-m rifle/pistol range may have 110 firing lanes, each 4 m wide. The distribution of bullets on this type of range is highly concentrated at the "bullet pocket" and the "toe" area. The toe area lies below the pocket where much of the debris (dirt and spent rounds) splatters and falls. This toe area is at the intersection of the berm base and the range floor. Its loose nature and high concentration of projectiles make it susceptible to surface water transport. Rounds that do not hit the target may either impact higher on the berm or skip over the berm and fall in a highly diffuse area behind the berm, defined as the "safety danger zone" or the "range fan."

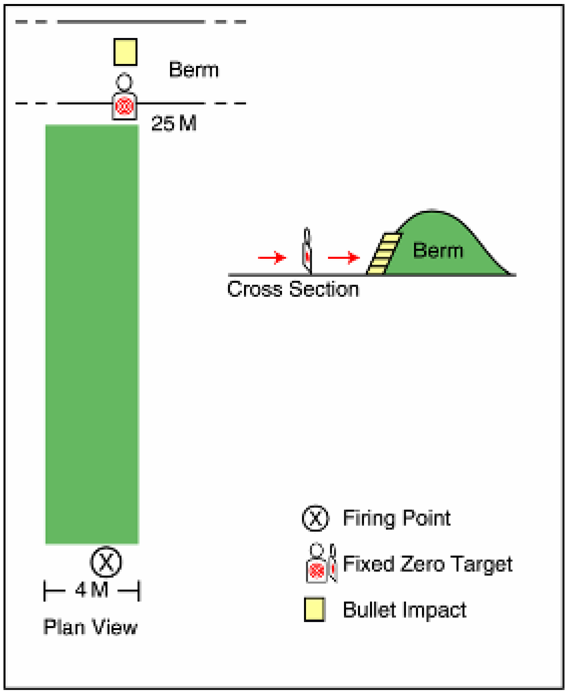

Figure 2-4. Military rifle range.

An automated field-fire range typically has 32 firing lanes, each 15 m wide, with known pop-up targets at 75, 175, and 300 m. The shooter normally fires 40 rounds: 10 at 75 m, 20 at 175 m, and 10 at 300 m. Figure 2-5 shows a single lane of an automated field-fire range. Note that the area over which the bullets land increases with distance from the firing point (indicated by yellow areas). These yellow highlighted areas have the highest projectile concentration. Bullet pocket and toes (impact related dug-out areas and piles of splattered soil) may exist as a result of repeated impacts on the mounds in front of the target. Although many of the rounds hit the target and also the mound in front of the "target coffin" (generally a hardened rectangular container for the pop-up target that protects the mechanical parts), rounds do miss the target and the mound in front of it. Rounds that miss generally fall to the ground as they lose velocity downrange. Therefore, an area of diffuse lead distribution exists in a fan shape out from each lane. Range fan maps exist for military ranges for safety purposes and are a good indicator of where these diffuse areas may be.

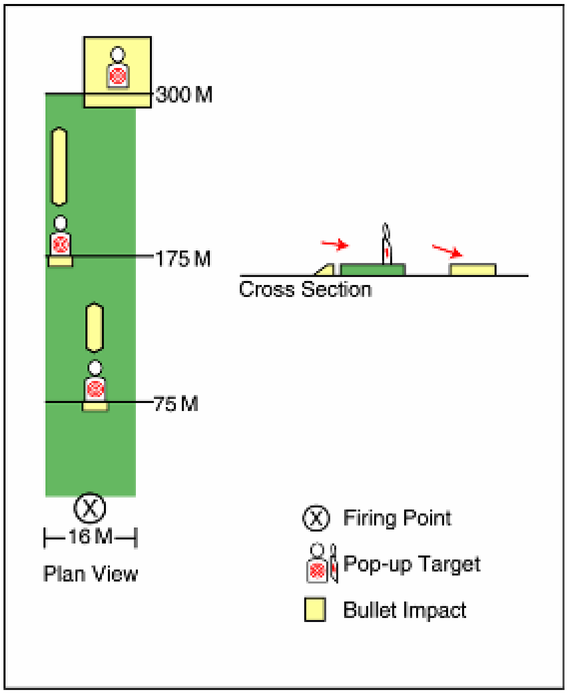

Figure 2-5. Automated field-fire range.

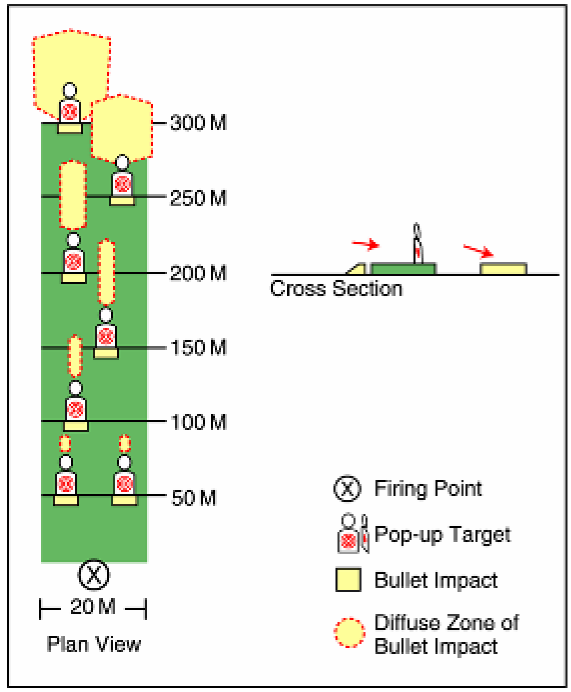

Figure 2-6. Automated record-fire range.

Figure 2-6 shows one firing lane on an automated record-fire range. The range generally has 16 firing lanes with seven pop-up targets per lane at 50, 100, 150, 200, 250, and 300 m. The shooter fires 40 rounds at various targets. The projectile distribution pattern on this range is similar to that on the automated field-fire range, with targets at greater distances having more diffuse distribution. The mounds in front of the targets have a high concentration of projectile material and may show distinct bullet pockets. An area of diffuse lead distribution exists in a fan out from each lane, and a range fan exists for the entire range, indicating the total area of diffuse projectile distribution.

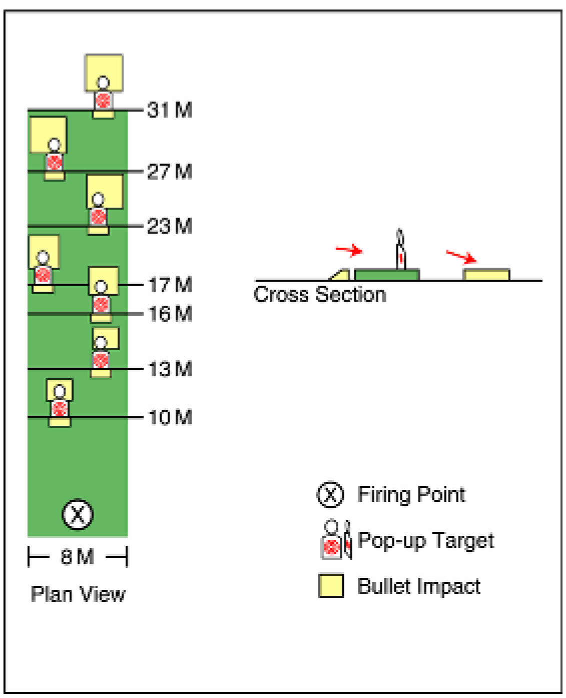

Figure 2-7. Combat pistol qualification course.

Figure 2-7 shows a combat pistol qualification course. The course has 15 lanes, each 8 m wide, with pop-up targets at 10, 13, 16, 17, 23, 27, and 31 m. Given the shorter distances, the distribution of projectiles on this range is more focused than those on automated field- and record-fire ranges and similar to that on a 25-m range. Again, the highest concentration is in the mound in front of the target, and targets at greater distances have wider projectile distribution, including a range fan for shots that miss the target.

2.2.2 Shotgun Ranges

In contrast to rifle/pistol ranges, shot at shotgun ranges (trap, skeet, and sporting clays) is widely distributed. When a shotgun target is hit by a well-centered shot, only a relatively few of the several hundred pellets in the shot string actually strike the target. These may be deformed or deflected and fall to the ground nearby. Most of the pellets in the load, however, continue beyond where the target was hit.

The full extent of the total shot fall zone at a trap or skeet field or sporting clays stations must be known before effective lead management practices can be implemented. Careful examination of the ground for the presence of shot around the theoretical shot fall zone perimeter (indicated by the size and shape of the theoretical shot fall zones in Figures 2-8, 2-9, and 2-10) should be performed to determine the extent of the actual shot fall zones. In general, actual shot fall zones should not be considered to be any smaller than those illustrated in the figures unless unusual topography exists. If shots are fired on a downhill slope, the actual shot fall zones could be considerably larger than indicated in the figures.

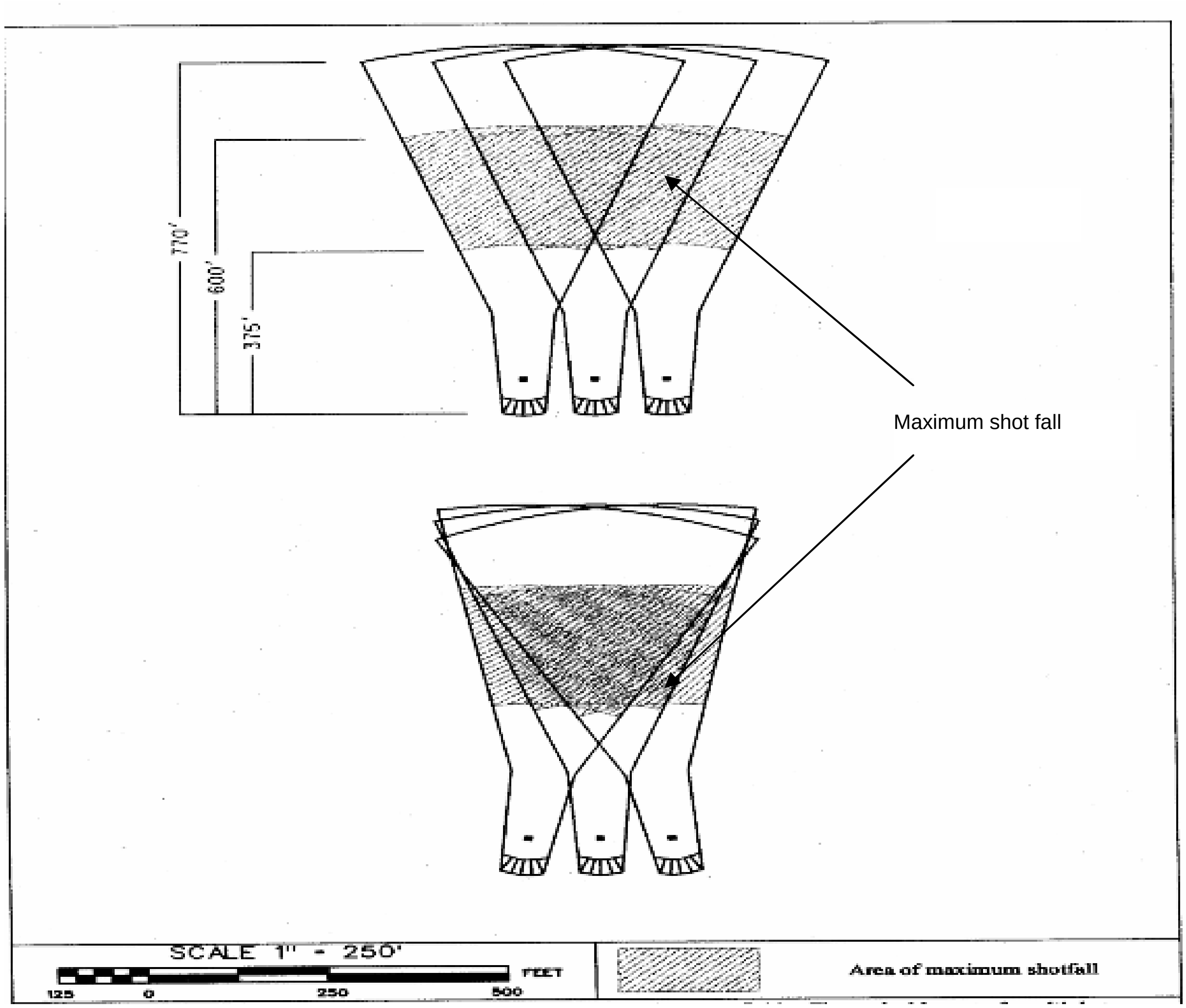

Figure 2-8. Theoretical shot fall zone and area of maximum shot fall at trap fields. Typical layout of multiple trap fields at top; modified layout to minimize total shot fall zone at bottom (NSSF 1997).

Distribution of Shot at Trap Ranges

The positions of the shooters and the angles at which trap targets are thrown result in a funnel-shaped theoretical shot fall zone as illustrated in Figure 2-8. Depending on the load, the angle at which the shot was fired, wind, and other factors, typical lead trap loads can reach about 770 feet from the shooter, although most shot tends to fall roughly 375–600 feet from the shooter. (Note: The maximum range of shot is highly variable and is directly related to elevation above sea level.) Figure 2-8 illustrates the theoretical shot fall zone and the area of maximum shot fall at a trap field. Note the overlap of the shot fall zones from adjacent fields, resulting in areas with increased amounts of lead. The theoretical shot fall zone of a single trap field covers approximately 4 acres, and about 1¾ acres are added with each additional overlapping field (assuming the trap houses are spaced 100 feet apart). The top of Figure 2-8 illustrates a typical layout for multiple trap fields. The lower portion of Figure 2-8 illustrates a slightly different layout to maximize the overlap of the shot fall zones, which confines the lead to a smaller area and results in easier recovery and less potential environmental disturbance. If shooting games other than regulation trap are shot on a trap field, the shot fall zone and area of maximum shot fall tend to expand to the sides, depending on the angles at which targets are thrown and shots fired. At a maximum, they resemble the shape described below for skeet fields, with an outer perimeter about 770 feet from the shooters.

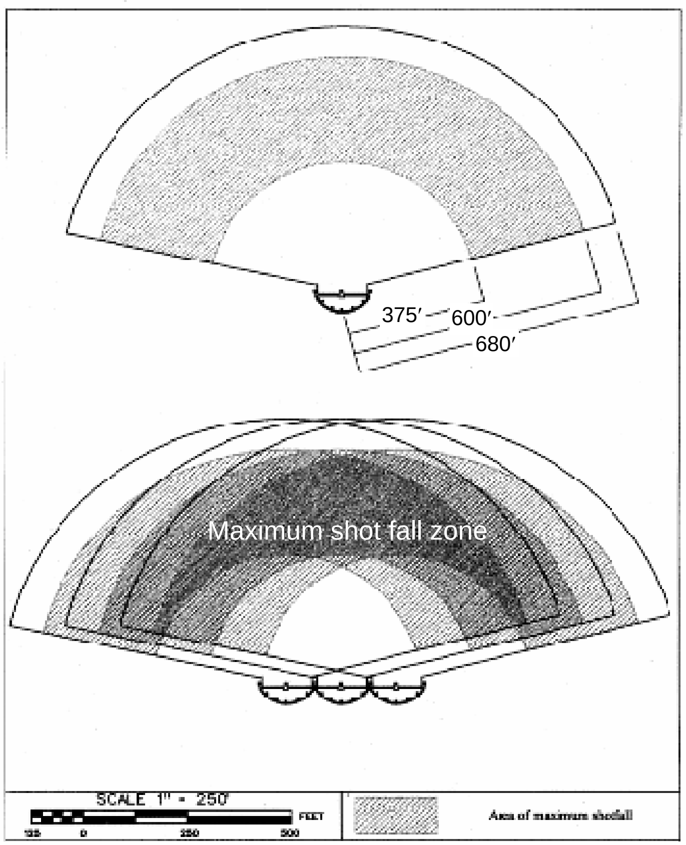

Figure 2-9. Theoretical shot fall zone and area of maximum shot fall at skeet fields. Single field shown at top; multiple adjacent fields shown at bottom (NSSF 1997).

Distribution of Shot at Skeet Ranges

At skeet ranges, the positions of the shooters and the angles at which targets are thrown result in a fan-shaped theoretical shot fall zone. Depending on the load, the angle at which the shot was fired, wind, and other factors, typical lead skeet loads can reach about 680 feet from the shooter, although most shot typically tends to fall roughly 375–600 feet from the shooter. The theoretical shot fall zone and the area of maximum shot fall at a skeet field are illustrated at the top of Figure 2-9. The lower part of Figure 2-9 shows the shot fall zone and area of maximum shot fall from several adjacent skeet fields. The theoretical shot fall zone of a single skeet field is approximately 14 acres, and about 2 acres is added with each additional overlapping field. Even if shooting games other than regulation skeet are shot on a skeet field, the shot fall zone and area of maximum shot fall are typically no larger than those described above for standard skeet.

The shot fall zone at a single combination trap and skeet field is very similar to that at a single skeet field, except that the "funnel" of trap shot fall extends about 90 feet beyond the perimeter of the skeet shot fall zone due to the greater range of typical trap loads. The areas of maximum shot fall overlap, producing an area of maximum lead in the center of the fan. Where there are several adjacent combination trap and skeet fields, multiple shot fall zones and areas of maximum shot fall overlap.

Distribution of Shot at Sporting Clays Courses

The defining feature of sporting clays courses is the complete flexibility in target angles and shooting directions. Because there is no standard layout, it is impossible to illustrate a standard shot fall zone or area of maximum shot fall for a sporting clays course. Figure 2-10 illustrates a typical configuration of a sporting clays course. As you can see, the shot fall zones do not overlap, and shot distribution is widespread. Figure 2-11 illustrates an idealized layout for a 10-station sporting clays course which provides overlapping shot fall areas and makes shot deposition more manageable. The boxes around the perimeter represent the shooting stations, and the colored lines represent the direction of shot from each station. The oval represents the overlapping shot fall area for each shooting station. This illustration makes it clear that sporting clays courses can distribute shot widely or provide overlapping shot fall areas depending on the characteristics of the course area. The theoretical shot fall zones could extend 770 feet from the firing positions, depending on the loads and angles at which they are fired.

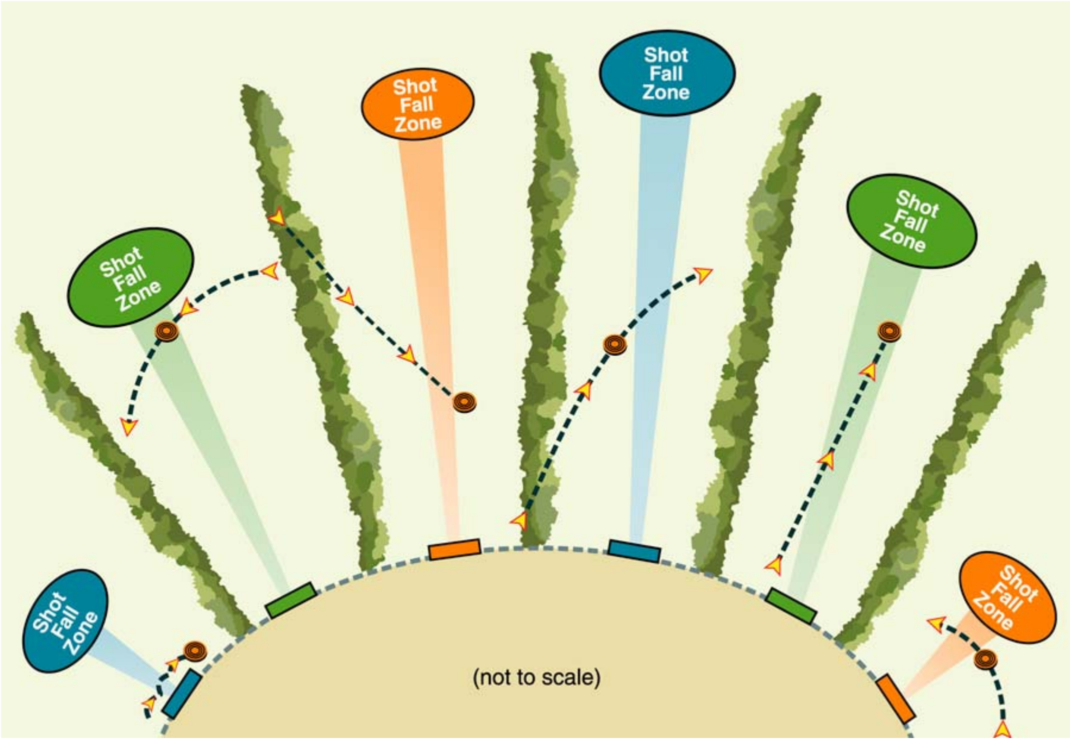

Figure 2-10. A **sporting clays course configuration with six shooting stations and multiple fall zones**.

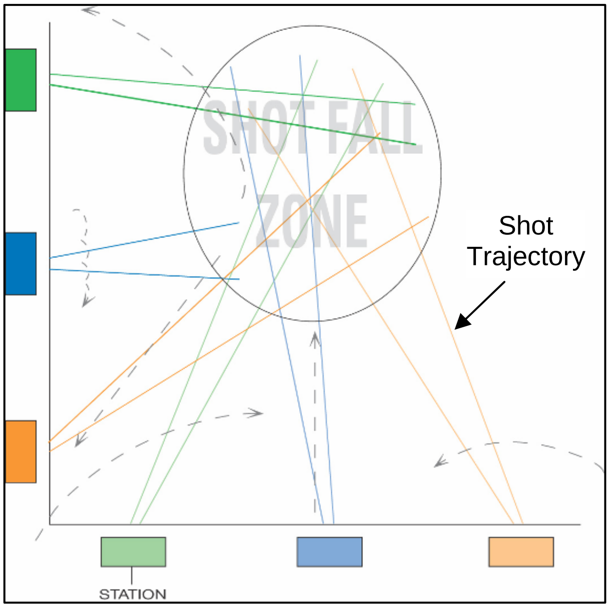

Figure 2-11. Layout for a sporting clays course with a single shot fall zone.

2.3 Shooting Off Property

For ranges where shooting activities impact properties not owned or controlled by the range, there is potential human health concern if current or future use of that property increases potential exposure. Off-property lead shot deposition could be resolved through remediation or property acquisition for incorporation into the existing range. It could also be controlled by using shot curtains as can be seen later in Section 3.13.

2.4 Cartridges and Clay Targets and Litter

In addition to spent lead shot, other components, such as cartridge cases, wads, and clay targets, are produced and need to be considered (Figure 2-12).

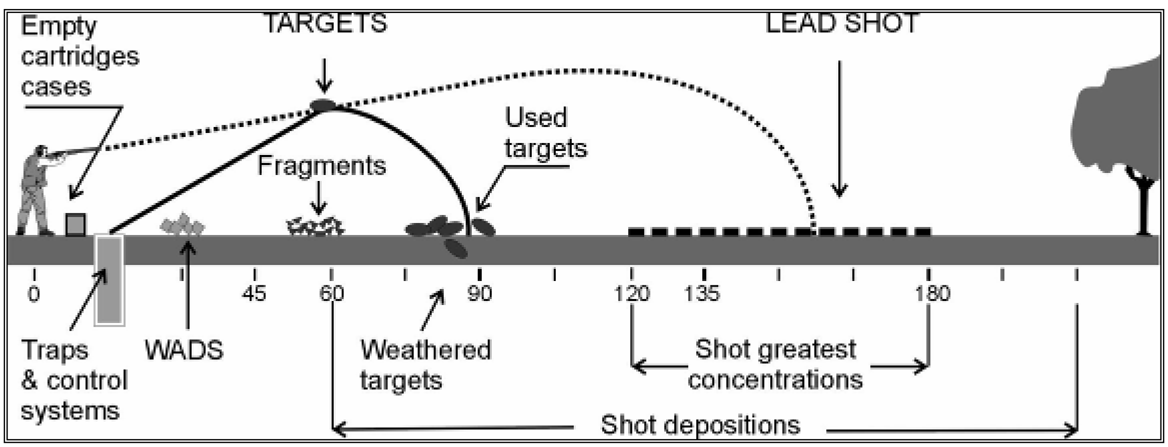

Figure 2-12. Flight paths of different materials resulting from clay target shooting (in meters, 1 m = 3.28 feet).

Cartridge Cases and Wads

Spent cartridge cases and wads are unsightly litter and contain metals and other residue that can contribute to contamination issues at a range.

Clay Targets

Clay targets are typically made of about 70% limestone bound with 30% pitch, bitumen, or other organic material. The binding material, particularly if derived from tar or pitch, may contain a complex mix of PAHs, some of which are regarded as toxic. The PAH content varies considerably, with bitumen binding containing the lowest levels. The use of clay targets with low or zero PAH levels is likely to increase in the future. In addition to low-PAH traditional clay targets, new materials are being developed in both America and Europe, including true clay material. These are claimed to have no hazardous components and to break down rapidly in the environment. Fragments of clay targets are not known to cause problems for wildlife. Farmers sometimes express concern over their livestock, but no current information indicates any problems. Uncontrolled accumulations of clay fragments may become an aesthetic problem or interfere with other land uses.

2.5 Shooting Sound

> Whether or not shooting sounds are perceived by neighbors as unwanted noise, the key issue is how such noise can be controlled.

Sounds of shooting and other activities from a range are inevitable. They create one of the most common issues for both proposed and existing ranges with respect to range neighbors. What to one person is a sound of no great consequence may be an unacceptable noise to another. The perception of sound is both a psychological and physical process, and how people respond to it depends on many factors, including its nature, the time of day, and whether they like its cause. A community's reaction to the sounds of shooting can be influenced by its attitude to the range itself. Range managers need to develop and maintain good community relations with all in the neighborhood (see Section 3).

The sound at the muzzle of a shotgun firing a typical clay shooting cartridge reaches some 140–150 decibels [dB(A), A = weighted scale to approximate human hearing for steady state noise]. For comparison, normal speech is around 50–60 dB(A), and clapping hands up to around 80 dB(A). For many people sound levels above 140 dB(A) become painful. A relevant feature of sound is that with increasing distance its level rapidly declines. At 1 km from a range, for example, the sound level can be 60–70 dB(A).

The main sources of sound on rifle/pistol ranges are muzzle blast, supersonic bullet flight, and, least importantly, bullet impact. Muzzle blast is caused by rapidly expanding gas from the burning propellant powder as it leaves the barrel. The sound level of a large-caliber rifle bullet traveling at 700–1000 m/sec (supersonic) is much lower than the muzzle blast, but, because it is typically in a much higher frequency band (some 1–4 kHz, compared with the broad spectrum of the muzzle blast), it is often perceived to be a more unpleasant sound. This ballistic sound does decline more quickly, however, with distance from the bullet path. Sound from bullet impacts varies; it is generally lowest in sand traps or earth berms and highest in metallic bullet traps. The extent to which the sounds from rifle/pistol ranges are perceived as unwanted noise by people outside depends much on the type of range itself.

2.6 Dust

Dust from bullets impacting berms and from lead recovery/recycling operations often contains lead. Lead recovery may be a large generator of dust at shotgun and rifle/pistol ranges. Lead can also enter the air from

- a release of lead due to the heat of burning powder acting on bullet base with exposed lead,
- friction between the barrel and an unjacketed bullet, and
- burning lead compounds used in primer mixtures.

These minute lead particles can fall onto shooting benches or to the ground where they mix with or attach to soil. These particles may become airborne dust when the soils are disturbed. Several of these sources of lead may occur close to the breathing zone of the shooter. These processes introduce lead into the air, where it could be inhaled. Range operators should be aware of potential concerns about inhalation of lead and take appropriate steps to control dust. Dust from these sources, especially lead recovery operations, can also contribute to aesthetic concerns discussed above.

> The possibility of inhaling lead from the air is probably greatest for recovery/recycling workers, who should always wear respiratory protection and otherwise comply with applicable safety and health standards. Good ventilation should be maintained at the shooting positions to minimize any potential for inhalation of lead by shooters.

Mechanized lead shot recovery equipment is designed to scrape the upper layer of soil, which inevitably generates airborne particles. Some of the particles can contain lead. The amount of dust generated by these operations is dependent on timing. Recovery that is done when soil is moist may generate less dust; however, any dust generated from these activities could result in lead exposure to range operators and nearby areas.

3. BEST MANAGEMENT PRACTICES

Prevention of metal migration from the range bullet impact area is typically the least expensive and easiest to implement of the actions that may be taken to manage metal issues on operating small arms ranges. The selection of the appropriate metal migration prevention method is the key to successful lead management on a range or group of ranges because each range is unique in terms of metal concentration, climate, soils physical and chemical properties, and topography. A plan for controlling metal migration must be designed based on these site characteristics. Typically, these plans include designs to control storm water runoff, which is the predominant transport mechanism for metal contaminants. Some methods of controlling storm water runoff that may be used in a metal migration prevention plan are identified below.

A wide array of options exists for managing lead and other environmental issues at ranges. These include range layout, bullet or shot containment structures, bullet or shot recovery and recycling, lead stabilization and control measures, and use of nonlead bullets or shot. Operational methods for range improvement are minor to moderate changes in the way a range is used or maintained in an effort to reduce contaminant transport from the range areas. In particular, concerns from lead residues and suspended solids (from soil erosion) leaving ranges or range areas may be decreased or eliminated through relatively simple changes to range management. Some changes have no impact on operations and can be implemented with little or no cost to the installation or range. These operational methods include the following:

> *Range Environmental Management Goal*
> - ✓ Manage detrimental or potential impacts posed by range activities on the public health or environment.
>
> *Range Environmental Management Objectives*
> - ✓ Keep lead in its metallic form.
> - ✓ Minimize the surface distribution and prevent surface migration of lead and other hazardous constituents.
> - ✓ Prevent projectiles from affecting wetlands or surface waters.
> - ✓ Prevent projectiles from landing off property.
> - ✓ Reduce noise impacts to surrounding properties.

> The general goal of environmental management at ranges is to effectively eliminate detrimental impacts posed by the range or shooting activities on the environment, public health, or public welfare. Options to accomplish these objectives vary and require thorough understanding of the potential environmental issue and consequences if potential contaminants are not properly managed.

- Evenly distribute/stagger firing lane usage to minimize impact to berm stability and vegetation in the high-use areas of the berm and to reduce the frequency of berm repairs.

- Minimize or eliminate firing into bodies of water or wetlands, which increases the potential for ecological risk to lead exposure as well as the risk for lead migration.

- Sustain vegetative cover on and around the range. If vegetation is present, ensure maintenance activities will sustain and promote its growth, especially on the berm and in storm water runoff pathways. Caution should be exercised during irrigation to prevent overirrigation and possible dissolution of lead. Sustainable activities include annual fertilization and/or lime addition based on a soil nutrient analysis and a mowing regime that allows tall vegetation on the berm and runoff pathways. Tall grass slows storm water runoff and filters out suspended solids before they leave the range.

- Improve impact berm maintenance and repair. Do not grade the berm at a steep slope. A 2:1 slope will produce an inherently stable berm for most soil types and will be easier to vegetate. When repairing a berm, or a section of a berm, focus on filling the impact points where concentrated impacts have created holes in the berm. Remove rocks, which can ricochet, while avoiding widespread damage or unnecessary removal of established vegetation. Avoid bulldozing or pushing berms back. These practices loosen soils and increase potential for erosion.

3.1 Identification of Best Management Practices

Table 3-1 lists specific actions that can be taken at shotgun and outdoor rifle/pistol ranges to address specific environmental concerns like those discussed in Section 2. Once environmental concerns at a particular facility have been identified, the actions listed in this table, supplemented by the background information in Section 2, will provide a starting point for designing an effective environmental management plan.

The range manager should consider the specific range situation before choosing any one of the techniques shown in Table 3.1. There is no perfect solution to manage lead on ranges, and time, as well as money, is always a factor. Each technique has its pluses and minuses, and each range must be evaluated based on its unique circumstances. Some range managers may have a situation that requires a smaller range layout than is needed for a typical range (large surface danger zone) and thus, have a special requirement for a bullet trap and baffle. An important shallow aquifer may also influence this choice. Alternatively, other range managers may have a high tempo of range use that keeps their ranges operating all but a few days per year, leaving them little time to manage high-maintenance structures. They might choose to focus on techniques to manage bullet pocket metals mass and maintain a well-groomed and vegetated range.

Table 3-1. Summary of potential operational and engineering approaches for control of lead at outdoor ranges

Approach type	Shotgun ranges	Rifle/pistol ranges
Operational	• Range reorientation • Shot recovery and recycling • Target recovery • Alternative shot materials • Chemical soil amendment	• Bullet recovery and recycling • Chemical soil amendment • Nonlead bullets
Engineering	• Range siting • Clay layers/mixing • Physical barriers to shot distribution • Shot curtains • Shot fall zones designed to be outside of surface water bodies • Ranges designed to maximize overlap of shot fall zones while maintaining shooter safety • Elimination of depressions that hold water • Storm water management/erosion control	• Range siting • Clay layers/mixing • Bullet containment • Baffles/tube ranges • Berm construction and maintenance • Bullet traps • Runoff controls • Storm water management/erosion control

The list below outlines some important considerations before choosing one management technique over another:

- Will the technique I am considering (e.g., bullet trap, berm, and vegetation) contain the metal debris, thus reducing or preventing transport?
- What type of metal particulate will form as a result of this technique? Will it be very fine dust or larger particles? What percentage of this particulate will be released to the environment (e.g. not contained within the berm or trap)?
- Will the technique encourage or discourage corrosion or leaching of the metal into the environment?
- Will any other hazards be incurred as a result of this technique (e.g., ricochet, fire hazard, stagnant water collection point, increased exposure to range users or maintenance personnel)?
- Will the material used generate any wastes that will be designated hazardous, requiring special disposal considerations? If so, how much and how often? How much will this cost?
- What are the maintenance time requirements for the technique I am choosing? Does it require a daily inspection? Weekly mowing? How often will I need to do minor maintenance (fertilize for berm and patch repairs for hardened structures)? Can this maintenance be done such that it does not interfere with range use? If not, how long will the range be out of commission? Is this time frame acceptable?
- How much will minor routine maintenance cost? Is there special equipment or personnel necessary for doing this maintenance? How much of it can range personnel do themselves, and what type of protective equipment might they need to do it? At some point in time, especially with bullet traps, a major maintenance or complete replacement is going to be

required. This requirement should to be determined prior to procurement. When will this need arise? How much range downtime will be required? How much will this process cost?
- How will my particular climate affect the performance of this technique? If, for example, fine dust is generated by the technique under consideration and the dust is exposed to the elements, including wind and surface water, this technique may not be well matched to the users needs. Excessive rain and humidity may increase the frequency of maintenance needed for harden metal structures and may also decrease the life of the structure.
- What is the capital cost for the technique under consideration? Does it require a concrete pad or grading of the range to install?
- What express warranty does the vendor or maintenance crew/groundskeeper provide for this technique?
- Will the vendor supply a list of prior clients with long-term history with this product for me to do an adequate assessment?

The sections that follow describe various management techniques in detail. It should be noted that range use (shooting regularity, intensity, etc.) has an effect on the environmental management of a facility. The appropriateness of many alternatives is range specific.

3.2 Alternative Shot Materials

> If the cost of environmental management of lead shot, particularly the potential cost of removal, is factored in, then the net cost of using newer material is much less.

In response to environmental concerns associated with lead, manufacturers have examined a variety of alternative shot materials. Manufacturers continue to develop target loads with shot materials such as steel, bismuth, tungsten, tin, molybdenum, and other substances. For shooting clay targets, there is no current perfect replacement in terms of cost and performance. However, as these and other new target loads are developed, the potential environmental benefits of switching to nonlead loads should be seriously considered. The added cost of nonlead shot is often noted as a reason for not using newer materials. It is important to note that fate and transport of many of these alternative metals and their environmental impacts are not well known.

> Ranges that shoot into or over water, wetlands, or other sensitive areas should reorient to avoid sensitive areas.

Today, steel shot is the most common alternative to lead, and steel target loads are presently available in most areas of the country. Although slightly more costly than lead and ballistically different, steel is the most viable alternative shot material for shotgun target shooting. To encourage use of lead shot alternatives, some ranges provide nontoxic shot for range users.

> The use of steel or other alternative shot is a recommended BMP in established sporting clays areas at which reclamation of lead shot is difficult or impossible.

It should be noted that other metals used as a replacement for lead shot may have different physical or chemical properties. For example, lead shot produces very little ricochet, but steel shot may produce high-energy ricochets off many surfaces, which could pose a safety risk. If a range switches to steel or other shot material, care should be taken to update safety measures appropriate for that material. Whatever type of nonlead shot is used, there still may be potential, even though minor, environmental issues arising from the cartridges and their components. Depending on the location, it may be necessary to recover spent shot even from nonlead materials.

3.3 Nonlead Bullets and Primers

Recent innovations in projectile technology have allowed most major munitions manufacturers the ability to offer low-lead, nonlead, and nonlead frangible type rounds for shooters. Environmental impact considerations for long-term use of frangible projectiles include the release of nonlead metals and the inability to recover intact projectiles in the environment. Frangible ammunition also works well in indoor ranges with containment bullet stops and is commonly available for many handgun and rifle calibers at a slightly higher cost than conventional ammunition. Lead-free and reduced-lead ammunition for hunting purposes is also available in limited calibers and bullet weights. Copper, tungsten, and zinc are the primary replacement metals being used. Some ammunition uses a lead core contained in a jacket of nonlead metal. These bullets are designed to maintain the integrity of the lead core so that no lead is exposed after impact. Additional research on both bullet design and alternative materials is ongoing.

Lead-free primers are available for pistol cartridges and are being developed for center-fire and rim-fire ammunition. These primers are not yet as reliable or available as standard primers—however, research and development continue. A well-designed and -implemented environmental management plan for these areas should reduce the need to change to nonlead alternatives. However, as in shotgun shooting, if the cost of environmental management of lead bullets, particularly the cost of reclaiming, is factored in, then the net cost of using newer material is much less.

Nonlead ammunition is being developed under a DoD program to eliminate the use of hazardous materials in small-caliber ammunition manufacturing processes and in the ammunition itself. Tungsten has been used as the primary metal to replace lead in the 5.56-mm round. However, recent research on the environmental fate and transport and human health implications of tungsten has resulted in reappraising its future use in small-caliber ammunition. Other nonlead ammunition is being developed.

3.4 Control of Lead Shot Dispersion

Controlling dispersion can be one of the most cost-effective means of managing spent lead shot (and other cartridge components) on a range. Conventional layouts of trap, skeet, sporting, and other clay target disciplines are shown in Section 2. Realigning the shooting stands and the angles and trajectories of clay targets to concentrate the spent shot into a smaller area can reduce the potential for environmental contamination and/or keep shot from landing in sensitive areas (waterways) or off property (Figure 3-1). Use of barriers, such as shot curtains, is another means of controlling lead shot dispersion. Concentrating the shot then helps reduce the area subject to potential lead reclamation or other management efforts.

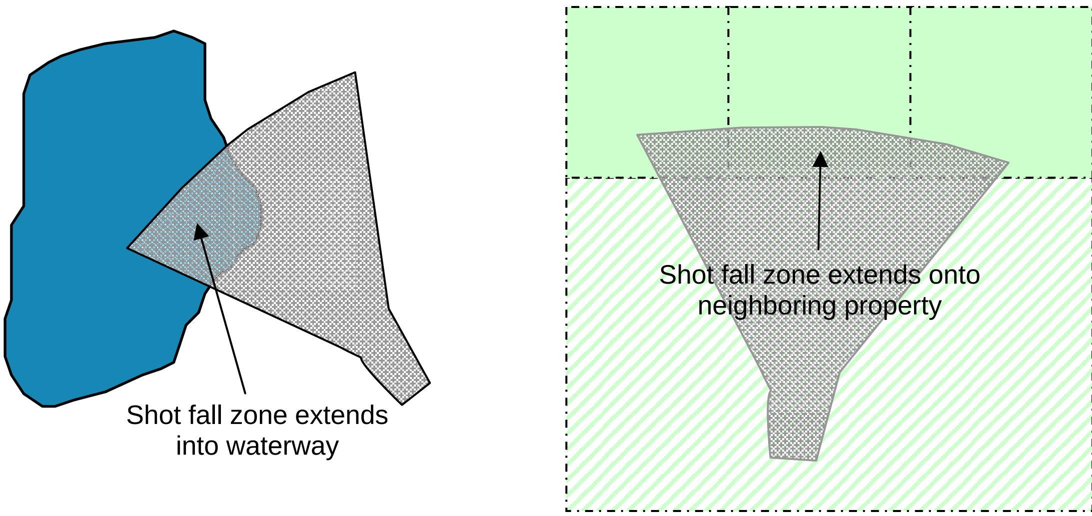

Figure 3-1. Range siting problems identified at some trap and skeet ranges.

3.4.1 Range Reorientation

Reorientation can involve changing the direction of shooting to prevent shot and targets from landing in wetlands or waterways or landing off property. Reorientation can also involve rotating shooting positions at trap, skeet, or sporting clay ranges to decrease the overall shot fall area. This type of reorientation not only reduces the area affected by shot, but also concentrates the shot into a smaller area (Figure 3-2). Reorientation can also avoid shot fall accumulations in potential erosional areas and storm water runoff control zones. Efforts to concentrate shot fallout must be implemented in a manner that does not compromise the safety of the shooters or others at the range. Once reorientation is completed, the range operator must continue to manage shot present at the previous location and must understand potential environmental issues associated with it. For facilities with limited acreage or land surrounded by wetlands or waterways, however, reorientation is not always an option.

> Range managers should evaluate whether reorientation can be used to reduce overall shot fall zone area.

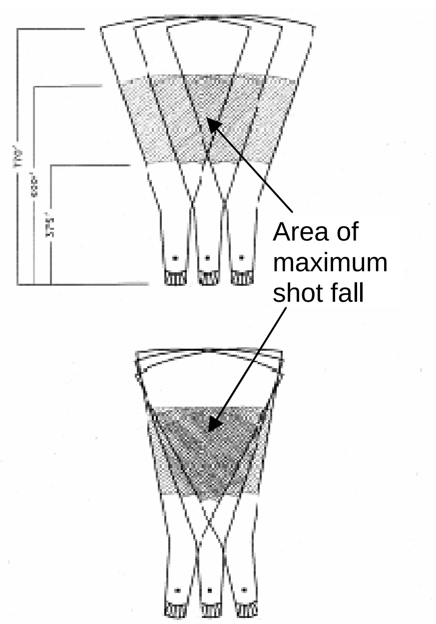

Figure 3-2. Range reorientation to reduce shot fall zone
(from NSSF 1997).

3.4.2 Shotgun Pellet Barriers

In addition to range reorientation, a shot barrier can be used to limit the shot fall zone size or prevent shot from landing in wetlands, waterways, or off property. Barriers can take several forms, such as a curtain (Figure 3-3) or a berm (see Figure 3-5). Because captured lead pellets accumulate at their base, shot curtains provide the added benefit of making it easier to recover and recycle lead. Some clubs have erected shot curtains using a woven nylon material suspended from telephone poles. Shot curtains are an option for clubs that cannot or choose not to reorient their range; however, several factors may limit their application in some settings. First, curtains must be located at least 60 yards from the firing line to allow sufficient distance for the target flight path. Some facilities with a small footprint, such as those shooting directly over wetlands or waterways, may be unable to meet this requirement. Second, curtains may need to span multiple fields to be effective. If a facility needs to limit the flight of shot pellets on multiple trap fields, the cost of erecting a barrier across several fields may be prohibitive. Finally, shot curtains have a limited and uncertain lifespan, so a facility must factor in maintenance and replacement costs as it evaluates this option.

Figure 3-3. A shot curtain at a trap range.

A club in the Northeast has erected a shot curtain across a single trap field. The curtain fabric is a green nylon resistant to degradation associated with ultraviolet radiation. It hangs from 11 telephone poles, which rise 47 feet above ground surface and located 100 yards from the shooting positions. The club spent approximately $17,000 to purchase the materials and install the curtain and provided the following breakdown of costs: $5,100 for telephone poles; $5,000 for fabric; and the balance for equipment rental, labor, and wire/hardware. The Billerica curtain comprises vertically hung panels, each 20 feet in width, which can be readily raised and lowered via a system of wires and pulleys. The club initially fixed the curtain to the telephone poles as one continuous horizontal panel. Strong winds, however, began to pull a few of the telephone poles over. The club subsequently redesigned the curtain into sections that more effectively shed the wind and could be lowered in high winds. The curtain is stored in boxes at the base of the telephone poles when it is not in use. By providing protection for the curtain fabric during inclement weather and periods of infrequent use, the retractable curtain system extends the lifespan of the shot curtain fabric.

An April 2000 article in *Shotgun Sports* magazine featured a range in California that had erected a curtain made of paper-making felts. These discarded felts, used by the paper industry to press and dry paper pulp, are a possible free source of shot curtain fabric. The felts are made of Kevlar, which effectively stops shot pellets in flight. The felts are not, however, impervious to ultraviolet light, so their life span is expected to be limited.

Figure 3-4 illustrates how a shot barrier can limit the size of a shot fall zone and prevent shot from entering a surface water or wetland. A strategically placed barrier of trees is often assumed to be effective at intercepting shot. It can be helpful, but its value is often limited, and other problems can be created. For example, pellets concentrate under the trees, where they are more difficult to recover. It may be possible to hang a curtain between a stand of trees at the front of a wooded area, preventing shot from traveling into the woods, where it is difficult to recover. Using the trees as the curtain mounts, however, may result in a less conspicuous, more aesthetically pleasing shot barrier.

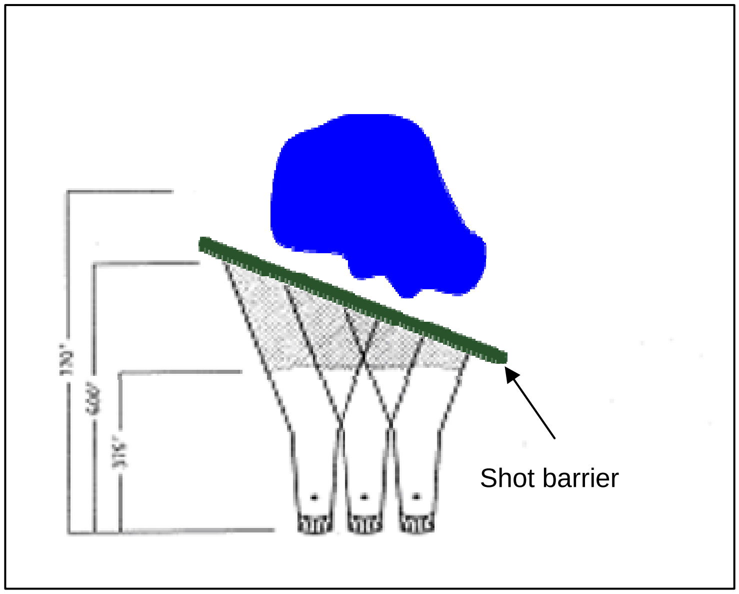

Figure 3-4. A shot curtain protecting a water body.

Earth banks (or berms) can help control pellets, but they need to be carefully researched to determine their cost-effectiveness. In Germany, soil berms up to 20 m high are being developed to reduce substantially the area of shot dispersion. This approach has potential to reduce lead solute transport problems, simplify lead shot recovery and sound control, and reduce the need for large land areas for shooting ranges. Figure 3-5 shows a conceptual design of berms (about 20 m high) being used to combine trap, skeet, and other layouts. Figure 3-6 depicts a new European concept (Ceccarelli and Stefano 2004) that combines a curtain or intercepting net atop a berm.

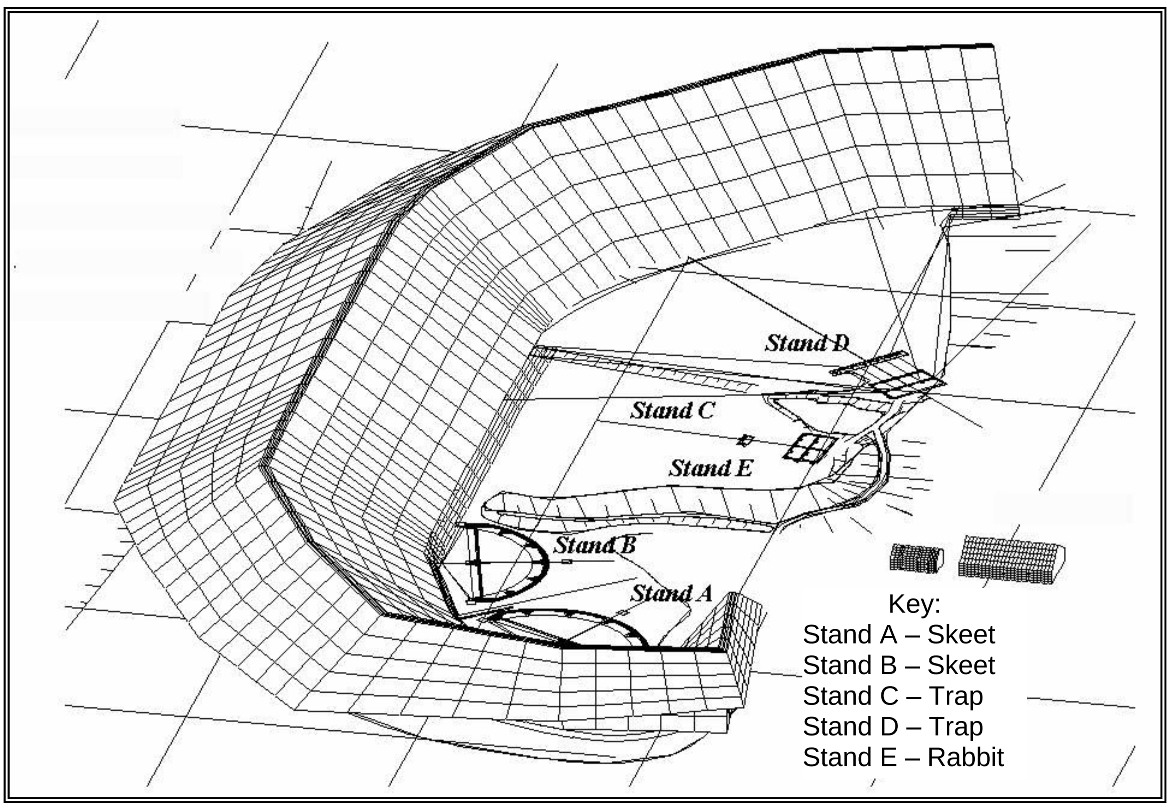

Figure 3-5. Design of shooting range in Garlstorf, near Hamburg, Germany. (Made by SUG Germany in cooperation with BVS. Opened in October 2000. Drawing not to scale. From Association of European Manufacturers of Sporting Ammunition 2002.)

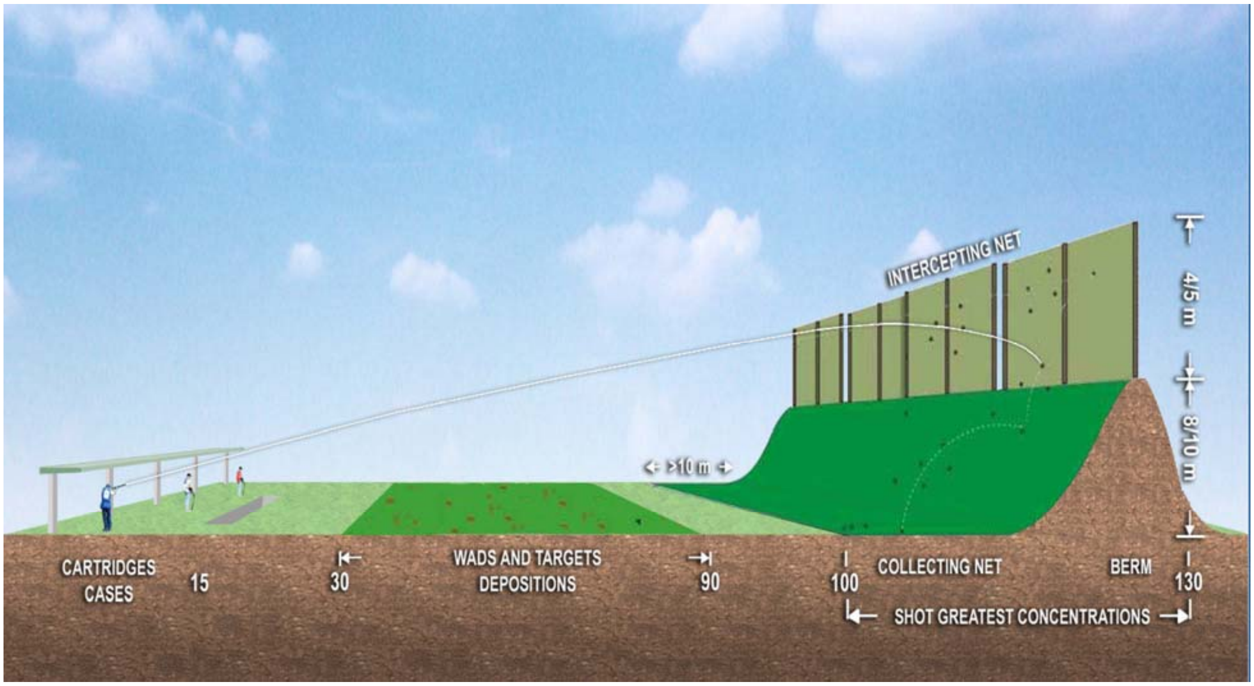

Figure 3-6. Conceptual berm and net system (in meters, 1 m = 3.28 feet, Ceccarelli and Stefano 2004, copyright World Forum on the Future of Sport Shooting Activities).

3.5 Bullet Containment

Bullet containment is extremely important not only for shooter/public safety reasons, but also metal recovery and containment to mitigate impacts to the environment. Figure 3-7 shows a constructed berm at Fort Rucker, Alabama. Typically, the mostly likely pathway for lead to leave a range is through overshoot, ricochet, or erosion runoff. Under some environmental conditions, lead may dissolve and leach into the ground. Berms, bullet traps, and baffles are all components of a containment system.

Figure 3-7. Fort Rucker berm and backstop.

The selected containment system should be designed to meet site-specific training/shooting requirements, as well as available space for surface danger zone (SDZ), and address all of the environmental concerns. A typical containment system using an earth berm and overhead baffles is detailed in Figure 3-8.

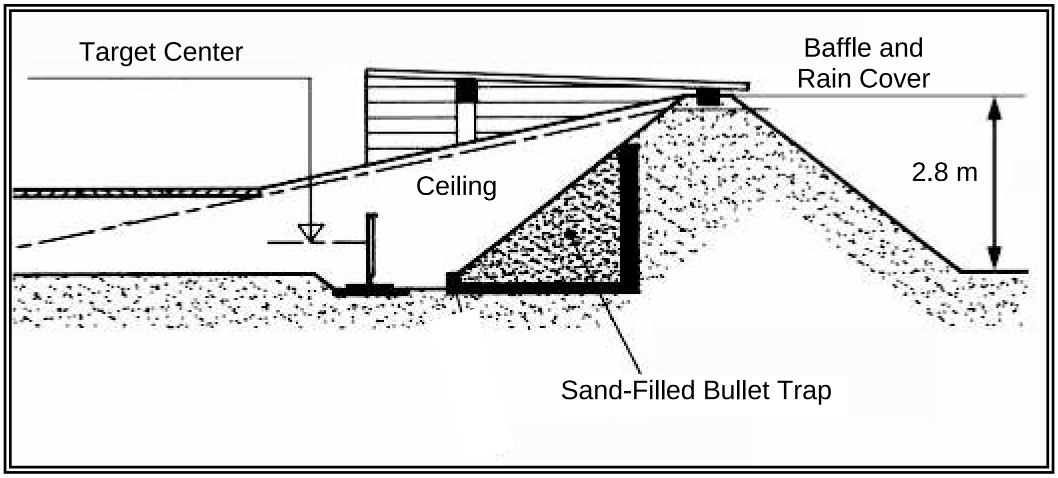

Figure 3-8. Diagram of a bullet trap including a sand trap, ceiling, rain cover, and berm as platform for the sand trap material.

Bullets should be contained in the defined area of the range—the smaller the area of containment, the smaller the potential for environmental impacts due to lead. This includes bullets that may ricochet off previously fired rounds or small rocks in the backstop berm or off the surface of the side berms or the foreground soil. There are several ways to contain bullets after hitting the targets on rifle/pistol ranges. The most common is a simple earth berm behind the targets. More sophisticated containment systems include sand traps, steel bullet traps, shock-absorbing concrete (SACON), crumb-rubber blocks, granular-rubber (shredded-tire) berms, and other materials that contain and decelerate projectiles, improve safety on the range, and collect the bullets for recovery.

Overhead baffles can also be part of a containment system, with varying degrees of containment based on size, location, and orientation of the baffles. These are generally described as "total containment," "partial containment," or "open" ranges. Each has a specific SDZ requirement that needs to be considered during range design (USAF 2002).

A total containment range includes baffles oriented such that no blue sky is visible by the shooter aiming at the target. The total containment range also includes a safety ceiling or ballistic canopy over the firing line. When coupled with a steel bullet trap or other manufactured backstop, it provides total containment with the absolute smallest "footprint" for lead containment. With regard to SDZ size/orientation, a properly designed backstop with total containment overhead baffles and sidewall containment, while more costly to construct than an open earth berm range, can significantly reduce or eliminate the SDZ.

A partially contained range contains a reduced number of baffles and reduces the SDZ, but not to the level of a totally contained range. The baffle orientation is such that there is no line of sight past the baffles from typical firing positions/weapons orientation during firing. The partially contained range has fewer baffles than a totally contained range and a larger SDZ.

An open range, with an earth berm and no overhead baffles, is the least expensive to build of all of the containment scenarios but has the largest SDZ and is the range layout most likely to have rounds leave the range proper. Each has advantages and disadvantages to be considered during range design.

3.5.1 Design Considerations

Selection of bullet containment involves many factors, including the size of the range, the location of the range, types of weapons to be used (bolt action, semiautomatic, full automatic), the number, caliber, and types (penetrators, tracers, etc.) of rounds to be fired, tactical training requirements (if any), and the targetry systems to be used. In addition, site-specific conditions must also be factored into the design, including static temperature ranges, statutory snow loads, prevailing wind loads, and rainfall. An engineering firm or other subject matter experts with range experience can provide assistance with new range construction or existing range upgrading, including calculation of the SDZ for the containment system selected.

Field-testing and performance should be accommodated before investing in specific bullet containment systems. As a reference, the Army Environmental Center tested three bullet trap designs under military test scenarios, with notably higher automatic firing sequences than commercial range conditions. The test included a composite-rubber block trap, a granular-rubber trap, and a steel deceleration trap. The rubber media traps appeared to function as specified except for heat transfer. Each rubber trap design caught fire, an event attributed to the poor heat dissipation of the rubber media under automatic fire tests (USAEC 2003). The steel trap design performed, but airborne lead levels were exceeded. The Army concluded that the lead concentration in the soil near the trap would increase over time due to the airborne lead. The Army test raised concerns, but it should be noted that test design was conservative for military use and cannot and should not be applied to commercial ranges.

Since that test, another steel bullet trap has been developed using a circular deceleration chamber and “wet” ramps. This design differs significantly from the one tested in that it does not fragment the rounds in the deceleration chamber, and the “wet” ramps cause the incoming rounds to “hydroplane” up the ramp, totally eliminating all dust.

The need for the safety of range users, workers, and nearby residents greatly emphasizes the containment and recovery of spent bullets. The bullets can be trapped after hitting the target (Figure 3-8), and individual ranges, or the complex as a whole can be contained by earth berms. By implementing these measures and by controlling lead, range managers can minimize the potential for additional problems.

Where berms are used as a backstop, they have to be managed for both safety and environmental stewardship. Berm management is likely to involve the periodic restoration to original dimensions and removal of the projectiles. Soil amendments (See Section 3.7 of this document), if needed, can be added at this time and the surface re-vegetated as appropriate. Please refer to Section 3.13 on newer and emerging technologies for more information on this topic.

The chemical processes acting on lead bullets and fragments within a berm (Section 2.1) are much like those acting on spent lead shot and are likely to increase the mobility of lead. If these processes are not controlled, then lead-contaminated runoff may leave the berm and, depending on drainage conditions and distance to receptors, cause problems away from the range.

Often, very important environmental as well as occupational health issues are overlooked. Note that the use of hard soil or soil with rocks in berm construction may increase ricochet and usually requires an increase in the range SDZ. An improperly designed containment system or a system used in a manner outside the design parameters can potentially result in lead exposure to maintenance personnel and in some cases generate a more mobile lead form than shooting into the soil, thus increasing the environmental risk to the range.

With all containment designs, erosion/runoff control needs to be addressed, including steps such as establishing vegetative cover and redesigning berms to reduce erosion, storm water controls, etc. If a bullet trap is used, the design needs to address not only the bullet trap, but also management/containment of the collected lead. Regardless of what containment method is considered—steel bullet traps, block traps, or engineered berms—the ultimate selection should be made only after a life-cycle cost analysis has been performed. All containment methods, including earth berms, require maintenance and repair as part of their operation. Some state-of-the-art bullet traps of hardened steel make bullet recovery easy.

3.5.2 Berm Construction and Maintenance

Backstop berms and side berms are commonly the major components of the bullet containment system at outdoor rifle/pistol ranges and typically have to be constructed. However, a fairly steep, natural hill may serve as the backstop berm at some ranges. If so, the lower part of the hill where bullets hit should be actively managed as a backstop berm.

Soil Berm—A soil berm is typically constructed of site soils. However, imported soil may be used if the site soil is not suitable (hard clay or contains large rocks, etc.). Reducing the contact between water and projectiles can minimize the possibility for metals in the backstop berm deteriorating. A variety of berm designs can help keep water away from lead in berms. In addition, many approaches can be used to control the pH, which would reduce the potential for lead to dissolve in water. A waterproof material can be placed over the top of the berm to prevent the infiltration of water. The material can be extended to include an “eyebrow” to reduce the amount of rain hitting the face of the berm. Figure 3-9 also illustrates an approach that collects water running off the berm and manages its pH with limestone. A similar approach could be applied in conjunction with ground baffles in the foreground of rifle/pistol ranges. Other techniques (e.g., side wings and terraced face) reduce erosion and water contact with lead particles (see Section 3.10).

Berm Maintenance—Berm maintenance between lead recovery and recycling operations for earth berms typically involves periodically replacing eroded dirt, reseeding bare areas, fertilizing, watering, and otherwise maintaining vegetation. On small ranges, people who operate or use the range may perform maintenance. It can be done with hand tools such as rakes and shovels, and should be done according to a schedule in the environmental management plan (see Chapter 4). Application of insoluble phosphate additives (Apatite II) can reduce lead leaching and runoff, and since it is relatively insoluble, it does not wash away during rain events.

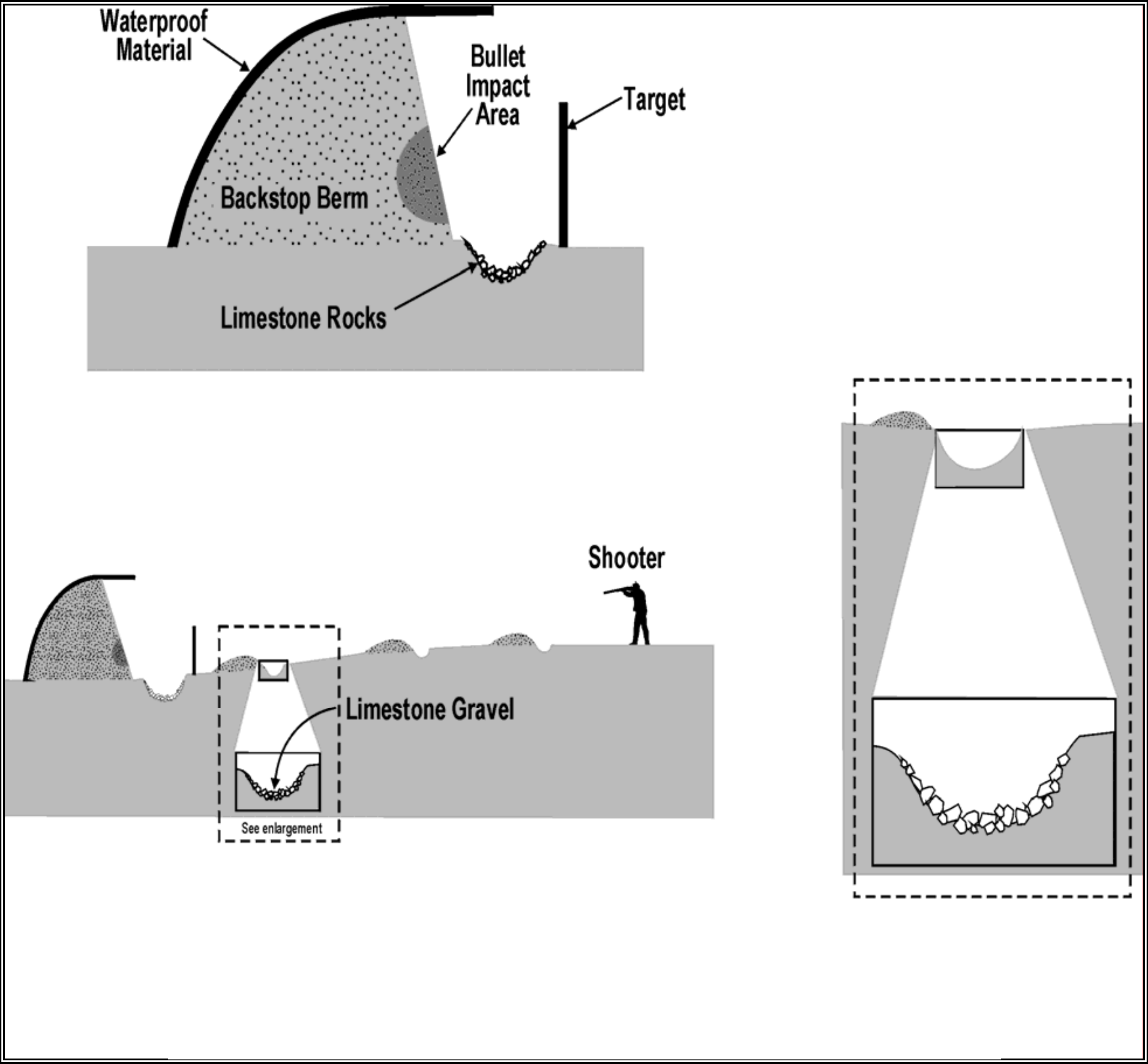

Figure 3-9. Examples of backstop berm and runoff trenching designed to collect bullets and lead runoff (from NSSF 1997).

3.5.3 Bullet Trap Construction and Maintenance

Some bullet traps, unlike earth berms, are fabricated systems that need to be installed on properly prepared foundations. These include steel bullet traps, rubber or SACON block traps, and granular-rubber traps. Considerations as identified in Section 3.5.1 must be incorporated into the design. In addition, foundation design must account for live loads and dead loads associated with the trap installation, and the electrical/plumbing requirements and physical space requirements for the installed equipment must be accounted for.

Steel Bullet Trap Construction—Steel bullet traps consist of a top and bottom ramp leading to a circular deceleration chamber. These systems typically require 25–40 feet front to back to accommodate the trap, depending on design and use parameters. Included in the system is a lead collection conveyor/auger under the deceleration chamber (Figure 3-10) to collect and transfer the collected rounds to an appropriately sized container, such as a 55-gallon drum. The trap can also incorporate a "wet" ramp which includes a holding tank and pumps to circulate the lubricant on the ramps. The system may also be outfitted with a pulstronic dust collection system to collect and filter the air from the deceleration chamber if a dry trap is used in an indoor application. The trap can also be used dry in an outdoor application, without the pulstronic system.

Figure 3-10. Side view of bullet traps and auger removal system for deceleration chamber at Kirkland Air Force Base.

Steel Bullet Trap Maintenance—Maintenance of a steel bullet trap is relative simple and consists primarily of visual inspection, emptying the collection drum, and lubricating rotating parts. High-wear areas such as the hot zone of the scroll require replacement in time (>10-year service life), and this is a bit more involved, requiring unbolting/removing the worn pieces and replacing/rebolting the replacement parts.

Rubber/SACON Block Trap Construction (see Section 3.13)—The rubber and SACON block traps are similar in that they consist of media blocks stacked on top of each other to form a wall. Each requires mechanical bracing to maintain the wall in a vertical configuration. The wall is relatively shallow front to back and does not encroach on the range floor.

Rubber/SACON Block Trap Maintenance—These blocks are not practical for heavy-use, fixed-target ranges. Maintenance includes removing the blocks saturated with spent rounds, and replacing them with new blocks. Rubber blocks can generally be moved with manual labor, while the SACON blocks require a small machine to lift and place. A suitable recycling method has yet to be developed for SACON, and this media is typically disposed of. The rubber blocks can be shredded and recycled at a secondary smelter.

3.6 Metal Recovery Techniques for Berm Maintenance

Periodic removal of projectiles from the range may be considered pollution prevention if it is used to control the migration of lead and (or) other metals, by removing the source. Periodic removal is also a range maintenance activity when operational or maintenance issues arise (ricochets off of accumulated metals, elevated airborne lead level, etc.). Periodic removal can be a simple focused removal or removal of the entire berm face. The majority of this section focuses on large-scale removals; however, information on focused removal can be found in Section 3.6.1.1.

Metal recovery, as a maintenance activity on an operating range, is exempted from the Resource Conservation and Recovery Act (RCRA) Subtitle C requirements when the lead removed is recycled and the soil from which the lead was removed is returned to the range. EPA considers this to be range maintenance activities and not hazardous waste management activities (Heckelman 1997). Although the recovered metal fragments are solid waste being recycled, the metal fragments are considered a reclaimed scrap metal that is exempt from RCRA Subtitle C requirements. Storage, handling, and shipping requirements should be closely monitored. This method of removing lead from open ranges can be very expensive, depending on the scale of removal, and may result in range downtime.

After the necessary scale of removal is determined, if most rounds enter bullet pocket/toe areas of the berm, then focused removal around these areas may suffice, particularly if focused removal is part of the regular scheduled activity. In that case it may not take a significant amount of time, effort, or money and may be completed by on-site labor (see Section 3.6.1.1). If the face of the berm has the potential to create lead transport, a large-scale removal may be necessary.

Periodic metals-removal programs for ranges should be coordinated with the range or installation environmental manager since some state and local regulations may be more stringent than the federal regulations. This method of managing lead on ranges can be expensive and can result in range downtime during the maintenance event. Metal removal should be considered as a part of a larger BMP program, especially when other migration and pollution prevention methods have been exhausted or operation and maintenance safety is jeopardized (e.g., ricochet and airborne lead).

Regardless of the scale of the removal, lead and other metals may be removed from a range by physical separation methods alone or by a combination of physical and chemical (soil washing) separation methods. Factors include soil physical and chemical characteristics, moisture content, lead physical and chemical characteristics, and organic content. There are five classes of physical separation techniques: size separation (screening), hydrodynamic separation (classification), density (gravity) separation, froth flotation, and magnetic separation. After physical separation, which removes the coarse particulate metals, an acid leaching (soil washing) process may be needed to remove the lead still remaining in the soil either as fine particulates or as molecular or ionic species bound to the soil matrix. Two basic steps must be taken to determine the best method to remove the lead:

- The lead removal goal for the maintenance action must be determined. For example, if lead is being removed to mitigate a ricocheting issue with the accumulated metal, then the lead removal action need remove only the metal particle size fraction that creates the ricochet hazard. This approach would probably require a simple screening process as the removal method. However, if lead removal is desired to prevent migration to a shallow water table, a more aggressive removal and mitigation plan may be necessary to ensure that dissolved lead does not migrate vertically. In this case, lead fixation, acid leaching, pH adjustment, and wholesale disposal of affected soil may all be considered as possibilities to mitigate the situation. If lead removal is desired to mitigate fine particulate lead from moving into surface water, simple focused sieving may not be sufficient. Additional measures may be necessary to keep the lead on the range and include focused lead fixation; focused disposal of affected soil and replacement with coarse sand at bullet pockets; as well as standard erosion prevention techniques on the berm and range floor (soil amendments, vegetation, riprap areas, side berms). Simply removing the coarse particulate lead will not eliminate a lead transport problem because the finer particles are more easily transported. The smallest fraction is the most difficult and therefore expensive fraction to remove.

- Since the most efficient removal method will be site specific, a bench-scale treatability study may be required to determine the most efficient method to reach the established lead removal goal. Treatability studies can be conducted in accordance with ITRC guidance document for characterizing and remediating small arms firing ranges (SMART-1, ITRC 2003a).

Ranges in regions with high precipitation and/or with acidic soil conditions may require more frequent lead recovery since the potential for physical and chemical lead migration is greater. In regions with little precipitation and/or where the soil is somewhat alkaline, lead shot, bullets and fragments may be allowed to accumulate on the soil for a longer time between reclamation events. The ITRC Small Arms Team considers that well-planned and -executed environmental management using the best available technologies and documenting their performance may help ensure that lead is not classified as discarded or abandoned, which could trigger additional requirements.

Since cost of BMPs is of high importance, range operators should always perform a cost evaluation to determine what methods would most effectively reduce the availability of lead to the environment. The answer may involve one or more of the following:

- lead recycling/recovery
  - size separation (screening)
  - hydrodynamic separation (classification)
  - density (gravity) separation
  - froth flotation
  - magnetic separation for iron based alloys
- hand raking and sifting
- vacuuming
- treatment additives
- soil treatment
- soil washing (wet screening, gravity separation, pneumatic separation)

> "Routine recovery and recycling of lead may be one of the most basic and cost-effective environmental actions a range manager can undertake. Lead recovery and recycling on a regular schedule should be part of the Environmental Stewardship Plan for every shooting range. Simply put, lead that is removed from the range in a timely manner cannot cause a problem." (NSSF 1997)

(EPA is completing a study on lead-reclaiming technologies that is expected in 2005.)

3.6.1 Recovery of Lead Shot from Shotgun Ranges

As depicted in Figures 2-8 through 2-11, lead shot fall is rather predictable at shotgun ranges. Recovery and recycling of lead is easier if shotgun ranges are constructed and operated in a manner consistent with periodic lead recovery and removal. Strategically positioning shooters or targets so that shot fall areas overlap concentrates the shot and lessens the area to be mined. Recovery of shot from water or wetlands, steep slopes, and bushy or wooded areas can be very difficult, inefficient, and expensive. Recovery is generally easiest from relatively smooth, barren areas and is simplified if the approximate amount of lead present is known. Records of rounds shot annually or estimates from the number of targets purchased annually can be used to approximate the mass of shot in the shot fall area. Since sporting clay ranges often have trees and or shrubs/brush, lead recovery may be difficult and may in fact allow erosion if precautions are not properly implemented in the recovery process. However, removing vegetative debris (fallen limbs, tree bark, etc.) and some trees prior to reclamation at these ranges may allow adequate access for recovery equipment. Of course, when designing a new sporting clay range, steps to facilitate future lead reclamation should be considered in the original range design and layout.

3.6.1.1 Sifting and Raking for Spot Removal

A simple BMP is raking and/or sifting bullet fragments and shot from the soil. (Ensure workers are adequately protected from exposure to lead dust.) Sifting and raking activities are effective at the surface. This is a cost-effective management alternative employing relatively simple lead-recovery techniques.

Once collected, the lead must be taken to a recycler or reused. Arrangement with a recycler should be made prior to lead collection to avoid having to store the lead and incur associated potential health, safety, and regulatory concerns.

At trap and skeet ranges, sifting and raking activities in the shot fall zone yield the most lead. For sporting clay ranges where trees exist, lead shot may collect at tree bases. Basically, the process consists of raking the topsoil in the shot fall areas into piles with a yard rake as if raking leaves, removing any large debris (rocks, twigs, leaves, etc.), and then sifting the soil with screens.

> Those conducting the hand-raking and sifting reclamation at ranges should protect themselves from exposure to lead. Proper protective gear and breathing apparatus should be worn. OSHA or an appropriate health professional should be contacted to learn about proper protection.

Once the soil has been raked and collected, pass it through a standard 3/16-inch screen to remove the large particles. This process will allow the shot-sized particles to pass through the screen. The sifted material (that not captured by the 3/16-inch screen) should be passed through a 1/20-inch screen to capture the lead and lead fragments. This process will also allow sand and other small sediment to pass through the screen. Screens can be purchased at many local hardware stores. The screens should be mounted on frames for support. The frame size will vary based on the technique used. If one person is holding the framed screen, it may be better to use a smaller frame (2 × 2 feet); if several people are holding the framed screen, it can be larger.

At recreational ranges, raking and sifting can be performed by gun club members on a volunteer basis. Some clubs provide incentives, such as reduced fees, to members who assist with lead removal. A number of small clubs have found that reloaders volunteer to rake in exchange for collected shot. Hand-raking and sifting are cost-effective lead-removal techniques for small and low-shooting-volume ranges; however, these techniques may not be appropriate where there is a large volume of lead on the range. In this instance, reclamation machinery may be more appropriate.

Recovered lead should not be stored or accumulated indefinitely on the premises and should be sent to a recycler as soon as possible. Any required lead storage should be conducted in an environmentally responsible manner.

> BMPs for storing lead on site must, at a minimum, prevent lead from exposure to the elements and should be managed so as to prevent releases to the environment.

3.6.1.2 Mechanical Separation (Screening) Machinery

It may be possible to rent equipment for lead shot reclamation such as a screening machine (also referred to as a "mobile shaker," "gravel sizer," or "potato sizer"). This machine uses a stacked series of vibrating screens of different mesh sizes to sift soil containing lead shot. The uppermost screen (approximately 3/16-inch mesh) collects larger than lead shot particles and allows the smaller particles to pass through to the second screen. To minimize cost, this size screen will be 75%–95% effective to remove lead shot from a range. For trap and skeet ranges a second screen (approximately 1/20-inch mesh) is added to capture the small shot sizes of lead shot but allow smaller particles to pass through. The lead shot is then containerized. In its 2003 update, EPA noted, "In the Northeastern United States, the typical rental cost for this equipment is between $500 and $4,500 a week, depending on the size shaker desired" (EPA 2003).

3.6.2 Recovery of Lead Bullets from Rifle/Pistol Ranges

For ranges with effective bullet traps, recovering bullets may be as easy as emptying the catchment areas of the traps (see Figure 3-8). Bullets in earthen berms may be deep (up to 1–2 feet) in the berm and should be included in the recovery effort. Depending on usage rate and firing accuracy, metal may begin to accumulate in the face of the berm away from the bullet pocket. Recovery may require excavation of 1–2 feet of the face of the berm, mechanical screening of the soil to separate the bullets, and replacement of the soil on the berm face. Ranges should consider amending soils with lime, phosphate, or other stabilization additives prior to replacing the amended material on the backstop berm. Recovery from side berms and the foreground is similar, although excavation does not have to be as deep or frequent. Depth of bullet penetration and the resulting depth of excavation is a function of the angle of impact and the caliber of the ammunition. After lead recovery is completed, the areas should be regraded and vegetation reestablished to control soil erosion.

Using machinery to reclaim lead usually requires that the area be clear of scrub vegetation, grass, mulch, or compost. Regardless of how lead-laden soil is collected, the actual separation of the lead from sediments, soils, and debris is the same as described above. Soil, sediment, and debris screened out during the process is either returned to the field/berm or rescreened to ensure that no lead remains. Moist, clayey soils are more difficult in lead-recovery processes because they bind into shot-sized pellets, producing more "false product" from the screening process. Wet soils can also clog the screens.

After sifting the soil and returning the separated soil to the range surface or berm, some take reclamation one step further by sending the resulting lead, soil, and other lead-sized particles through a blowing system. Here the remaining lead particles are separated from the soil and other debris by the blowing air—the lead is much denser than the soil and other debris, so it falls through the column of air. Traditional screening cannot separate shot and bullets from other shot- and bullet-sized material (i.e., rocks, stones, roots, and various debris). A recycling facility considers nonlead items as "contaminants" that drastically reduce the value of the recycled lead. Pneumatic separation is an effective means of enhancing traditional screening.

Reclamation activities may generate dust, especially in drier locations. To prevent or minimize dust from traveling off the range and causing problems for neighbors, reclamation activities potentially generating dust should be controlled.

3.7 Stabilization of Lead Shot and Bullets in Soil

Layers of clay soil, either natural or constructed, can act as barriers to control mobility of soluble lead. A clay layer can restrict downward (but not lateral) movement of dissolved lead and lead particles. Even if the clay has to be imported from an off-site source, costs per acre are relatively low, depending on the location and the size of the shot fall zone (see ITRC 2003a).

Where lead is present and there is a potential for it to be transported to groundwater or off site by surface runoff, ranges can benefit from soil amendments reducing the availability of lead that can migrate. Amendments may be applied to ranges soils to chemically stabilize soluble lead in the soil pore fluid (see Section 3.13). These chemicals promote the precipitation of lead ions and the formation of relatively insoluble lead species. This procedure can be used in areas where lead in the shallow surface soil is providing a source of soluble lead ions to surface and/or groundwater. At this point, the application guidance and performance of this method of mitigating lead mobility is conceptual. The chemistry supporting the use of phosphate as a stabilizing amendment has not been proven in large-scale field tests. For more information, see Sporting Arms and Ammunition Manufacturers Institute 1996; Ma et al. 1993 and 1994; Ma, Logan, and Traina 1995; Wright et al. 2001; and Conca et al. 2002. Larson et al. (2004) show that lead phosphate (calcium phosphate and potassium phosphate) has a greater potential for surface transport, due to low particle density, than does the lead soil prior to treatment. Additionally, Larson et al. show that some forms of lead phosphate can leach significant amounts of phosphate, affecting local surface waters and shallow groundwater. It may not be advisable to use this technique if surface water transport is an issue at your particular range. When this method is considered, small test plots should first be designed and monitored to assess its lead stabilization performance, application rate, frequency, and efficiency and to ensure the chemical amendments are not mobilized and become a surface runoff or groundwater problems. This work should be coordinated with the range environmental management team and local environmental oversight agencies. Large-scale application should not be implemented until these application and mobility issues are addressed.

Range operators can purchase additives designed to chemically stabilize lead to reduce its mobility. These additives can be applied in a wet or dry form. Amendments (phosphate, lime, iron, etc.) can be topically applied on ranges soils either through direct broadcast or spraying in a slurried form. Depending upon the effectiveness, the range owner/manager may simply spread the additive over the soil; however, to maximize effectiveness, the additive should be raked (mixed) into the soil to maximize contact between the additive and lead particles. Some amendments can actually exacerbate transport (see Section 3.13.3).

When purchasing soil amendments, the range owner/manager should

- determine the credibility of the company offering the additives,
- review the application instructions to ensure the capacity to meet the requirements,
- review the additive's warranty to ensure protection from product failure, and
- require a treatability study using range soil before purchasing.

These additives are cost-effective because they can be used in a variety of methods and not all of the lead fragments need to be removed to achieve significant stabilization. This fact provides tremendous cost advantage because the range does not need 100% removal of lead shot, bullets, or fragments. See Section 5 for case studies of soil amendment applications. In addition, Section 3.3 of ITRC 2003a provides greater detail on the application of soil stabilization techniques. It also discusses various compounds frequently used. Soil stabilization is as effective and necessary in active ranges as in closed ranges.

3.8 Soil Washing (Physical and Gravity Separation)

Soil washing is the separation of soils into their constituent particles of gravel, sand, silt, and clay. It is a reclamation method used to separate lead particles from soils. It generates a clean sand and gravel fraction by removing fines particles adhering to the larger soil particles and, if necessary, to transfer contaminants bound to the surface of the larger particles to the smaller soil particles.

Soil washing uses mineral processing techniques and procedures to recover particulate lead and refined products (see ITRC 2003a, pp. 29–31). The operation requires soils to be excavated from the range and mixed into a water-based wash solution. The wet soil is then separated using either wet screening or gravity separation techniques (see ITRC 2003a, Section 3.2). Since excavation is required, soil washing is more appropriate at closing ranges, which will no longer be used as a range. The technique is virtually cost-prohibitive as a regular maintenance operation on operating sites other than very large ranges.

3.9 Vegetative Control

Vegetative cover reduces erosion by slowing down water and wind and effectively holding the soil in place. This technique is natural, relatively inexpensive, and self-sustaining through production of seeds or roots by the plants. Another benefit of vegetative cover is to filter nutrients and pollutants from runoff (see ITRC 2003b). Vegetation can be uprooted by rapidly flowing water, thereby increasing the erosion of soil (see the photos in Section 5-4).

> Woody vegetation should not be planted in impact and shot fall areas where it is likely to impede lead recovery (see Section 3.6).

Vegetative control requires that the community of plants (i.e., trees, shrubs, grasses, and herbs) be well delineated and located to facilitate lead recovery and erosion control. Soil texture is an expression of the relative amounts of sand, silt, and clay. Texture is a key property of soils that affects a wide variety of soil-related phenomena, including drainage, erosion, plant ecology, and suitability for construction. The selection of the appropriate vegetation for the range area may be dependent on or limited by soil texture. Modifications to soil texture are possible; however, it is recommended only when the available vegetative options for the type of soil present do not provide protection from storm water erosion effects. The primary nutrients for vegetative growth are nitrogen, phosphorus (phosphate), and potassium (potash). Also, soils that contain a low organic content and an inactive microbial population inhibit the ability to establish and maintain vegetative growth. Soil amendments and fertilizers should be applied based on soil analysis results and recommendations provided by the state agriculture agency or natural resource program office.

Following the design and selection of plants, establish how to start the plants community (i.e., plants, rhizomes, or seeds), and density of plants needed to adequately cover the soil and produce the optimal control. Special care must be taken during plant selection to avoid noxious and invasive plants. Soil stabilization is the most desired effect of the vegetative community. The most effective vegetative plantings include a variety of long-lived trees, fast-growing nurse trees, and shrubs interspersed with grasses and herbs. Cost of vegetative plantings is comparatively low; however, periodic care and maintenance are required after new plantings are established. Some of the kinds of plants that can be effective in erosion control attract birds and wildlife and may not be suitable for shotgun ranges, while others may not be suitable for berms or foregrounds at rifle/pistol ranges. Assistance in selecting plants may be obtained from local landscaping firms, county NRCS office, and environmental consulting firms.

> Remember to avoid noxious and invasive species of plants when selecting your plant community.

The pattern and type of vegetation at a range influences the suitability of habitat and the types of wildlife that occurs there. Any time there are vegetated areas, there is the potential for wildlife to use the area. Most ranges are intentionally maintained in relatively open condition to establish a clear field of view for shooting. These open, often grass-covered areas are suitable habitat for deer, small mammals, and ground-foraging birds. Preferred wildlife food, such as plants that produce edible fruits and seeds, should not be planted around operating range areas. Other areas of firing facilities (away from the ranges) may be managed to support wildlife.

Mowing as an approach to vegetation management can be desirable because grass provides limited habitat for many animals. Grassy areas should be planted in less palatable plants, such as fescue and Bermuda grass. Your state wildlife agency may be able to suggest other plants that are *not* attractive to wildlife in your area. These management techniques can be used to keep shooting areas in open cover, keep weedy vegetation away from structures and equipment, and manage ornamental plantings for aesthetic purposes.

Vegetation condition also affects where, when, and how wildlife use a site. Deterring sensitive wildlife (such as waterfowl) from a range pond is important. Not planting or discouraging preferred food or cover plants will create marginal habitat in areas of potential lead deposition. Planting trees or other tall woody plants on the edges of ponds will deter some waterfowl, such as geese and swans, from landing and using the pond. In field areas, dense, higher vegetation and small shrubs may deter geese, crows, gulls, and several other types of birds from landing.

However, as is the case with many factors of range use, the actual management techniques and vegetative condition of range areas depends upon the specific situation of a range layout and the associated shooting needs.

> Many state natural resources departments, wildlife divisions, heritage programs, and other similar agencies have recommended planting lists for important native species valuable to wildlife.

Areas of range facilities where active shooting does not occur are potential areas to undertake wildlife food and habitat enhancement. Many types of fruit-bearing trees and shrubs can be planted for wildlife value, including apples, cherries, blueberries, blackberries, dogwoods, grapes, and nut-bearing trees such as beeches, hickories, and oaks, among others. Field areas can be planted in wildlife food and cover, including grasses, wildflowers, clover, lespedezas, etc. to provide for wildlife needs. The exact species of plants best suited to a given area differ depending on the region of the country and associated climate and soils.

It is important to note that wildlife should be kept wild and well away from areas used by people. If an artificial feeding program is undertaken, only recommended foods should be used. Bread products or other human food items should be avoided. Feeding areas should be kept well away from lead impact on shot fall areas. Artificial feeding may quickly attract animals that become problems. Any feeding should be carefully evaluated before it is initiated and only after seeking the advice of the state's natural resources department.

3.10 Management Alternatives for Erosion

Storm water management to improve runoff quality from ranges or range areas is an effective overall range sustainment effort that can be performed by personnel at military, public safety, or recreational ranges. Storm water runoff represents the predominant mechanism that transports the greatest volume of pollutants (lead residues and eroded soils/sediments), the quickest and for the greatest distances. It also represents the media and quickest pathway for affecting human or ecological health by potentially introducing pollutants into nearby surface water resources. The establishment and maintenance of vegetation on the berm, in impact areas, and in storm water pathways has already been discussed. Other storm water management methods include the following:

- Promote sheet flow of runoff water over the range surface. Sheet flow will lower the water velocity, which will lower the water's sediment load–carrying capacity. It reduces the potential for erosion on the range and avoids potential point source discharge issues and monitoring requirements that may occur with channeled flow. Promoting sheet flow may be accomplished by regrading and flattening out the slope of the land surfaces and by creating broad, very shallow drainage pathways to replace ditches or deep, narrow channels.

- Prevent storm water from impact berms or areas that have the highest potential for erosion from flowing onto comparatively clean range areas or mixing with storm water from the clean areas. This tactic minimizes the land area affected by mobilized contaminants in the runoff and the volume of contaminated runoff requiring management. It is accomplished by grading the slope of range area surface to change drainage patterns and constructing diversion channels/swales and small berms to alter runoff flow and drainage patterns.

- Detention ponds are a valuable last resort to manage storm water in areas where the runoff waters have the highest potential for carrying sediments and lead residues. Detention ponds must be designed and sized properly to effectively slow the water and allow the suspended solids to settle out. The drainage area that the pond will serve must be well defined, and the calculated volume of water the pond must handle must be accurate; otherwise, the pond's effectiveness will be minimal. Often range space is limited, and installing these types of structures is costly. Also, under the strictest interpretation of the current definitions for point source and nonpoint source discharges, the discharge pipe or effluent from a storm water detention pond could be considered a point source. Installing a detention pond creates the possibility that sampling/monitoring as part of a storm water program or NPDES permit may be required. Consult with installation environmental management or the local oversight agency before designing a detention pond.

- When designing a range, consider berm orientation such that storm water and prevailing winds minimize the transport of lead off the range. Side berms may provide an effective wind break and surface water break.

Protection and stabilization of soil surfaces from excessive rainfall or snowmelt and diversion of runoff from them may be needed, depending on the soil types present. For any one range, a combination of control measures may be appropriate. A decision tree and detailed technical information about using constructed treatment wetlands as a form of storm water control is found in *Technical and Regulatory Guidance for Constructed Treatment Wetlands* (ITRC 2003b). This natural or created cover of suitable vegetation can

- reduce the eroding impact of heavy rain on the soil surface,
- slow down the flow of surplus water over its surface,
- bind the soil more tightly through the root systems, and
- filter out lead particles or other constituents of concern from runoff water.

Establishing suitable vegetation cover is relatively easy and cheap, but advice from environmental consultants or other subject matter experts may be needed to ensure the most appropriate plant species are used and to guide their subsequent management. Care is needed to ensure such vegetation does not jeopardize lead and other recovery operations or attract wildlife species susceptible to harm from range activities.

In general, the steeper the slope, the more likely soil erosion. Terracing slopes can greatly reduce downhill runoff, especially if they are also suitably vegetated. Riprap can prevent channel erosion and provide a stable bank where velocity and channeling promote erosion. Water baffles, dams, and dikes reduce the velocity on steep slopes, thereby allowing suspended lead to be deposited upgradient of the structure. Construction of channels, low banks, or other features can also be used to collect runoff water and divert it from susceptible areas of the range.

Geosynthetic and erosion control materials are used in a wide range of applications, such as general land management and rehabilitation, sediment and erosion control, and storm water management. Uses at small arms ranges include soil stabilization on eroding impact berms, hillsides, or stream banks; seeding or vegetating range areas; as a waterproof liner underneath a storm water drainage channel or detention pond; and silt fencing to filter or trap sediments in runoff. Geosynthetics and erosion control materials encompass a wide range of material types and compositions, physical properties, and applications. When choosing the type of material for a range project, it is important to have a clear understanding of what needs to be accomplished, how any given product needs to perform, and what properties it must possess to be able to do that. Some of the factors to be considered when making the decision of which product, if any, to use includes intended use, ultraviolet stability, biodegradability, strength rating, temperature rating, permeability, filtering capabilities, and material composition. Generalized types of geosynthetic and erosion control materials are listed below:

- Geotextiles are any permeable textile used with foundation, soil, rock, earth, or any other geotechnical engineering material as an integral part of a structure or system. Geotextiles are used for a variety of applications, such as filtration, separation, slope stabilization, drainage, and soil erosion control. The geotextile acts as a filter through which water passes while it restricts soil from passing.

- Geogrids are net-shaped synthetic polymer-coated fibers used to reinforce soil structure. This stabilization occurs as the soil fills and interlocks with the grid. The interlocking effect is determined by the geogrid strength, mesh size, and base materials used. Typical applications include slope reinforcement and berm reinforcement.

- Geocells, or geowebs, are a class of geosynthetic product designed in some form of rigid or flexible material that has three dimensions and contains or holds a volume of soil or fill materials for soil stabilization and reinforcement. Geocells can improve the performance of vegetated slopes by reinforcing root systems and directing hydraulic flows over the top of cells, with the cells acting as a series of check dams. A geocell placed on a steep slope not only holds the soil in place, but the cell walls slow the flow of water down the slope. This feature reduces or eliminates the formation of rills on the slope face. In addition, water is trapped in the cells and seeps down through the soil, which is conducive for deep root growth.

- Liners are impervious sheets of rubber or plastic material used that may be used to limit downward migration of lead to groundwater. They may be installed under areas where lead concentrations are likely to accumulate. The use of liners often requires drainage systems to manage the water that collects above the liner.

- Erosion control blanket materials can be divided into two large categories, temporary (degradable) materials and permanent (nondegradable) materials. Temporary erosion control blankets are designed to provide immediate and short-term soil erosion protection and promote vegetation establishment on moderate slopes and low-flow channels where bare-ground seeding and loose mulches often fail. Permanent erosion control blankets or materials are designed to be a long-term part of an overall soil erosion protection project. These materials provide immediate as well as permanent soil stabilization and assistance to revegetation efforts.

Structural enhancements to impact berms can be used to provide an inherent stability to the slope of the berm and the concentrated impact points. Steep berm slopes naturally erode excessively. This erosion is accelerated by the soil disturbance caused by the impact of the rounds on the berm. Also, the establishment of vegetation on berms with steep slopes is extremely difficult. The following methods may be used to enhance the structure and stability of a berm:

- The berm slope may vary slightly depending upon the soil characteristics; however, a 2:1 slope produces an inherently stable berm for most soil types and is easier to vegetate. This slope is conducive of low-velocity sheet flow, which reduces the potential for rills and gullies to develop on the berm. A concern with this slope is that there may be a slightly increased potential for rounds to skip over the berm than on berms with steeper slopes; however, the reduced slope does not affect the SDZ for the range.

- Structural enhancement of the bullet pocket (a concentrated impact point on a berm formed from repeated firing on a static target) helps mitigate the erosion and soil loss from the berm. This type of structural enhancement may be implemented simultaneously with vegetative efforts to stabilize the berm. The bullet pocket structural support can consist of a small roof over the impact point that provides weather protection to the disturbed soil. This will provide stability by preventing runoff water from eroding the sides of the hole formed by the impact of the rounds on the berm. This weather protection structure, along with vegetation, provides surface and subsurface structural stability to the berm and greatly reduces erosion, lead transport, and maintenance frequency. The size of the structure is site specific and varies with the spread of fire on each firing lane. Typically, the larger the impact area on the berm, the less effective and more costly this structural enhancement is. The structure may be fabricated from wood or from a material such as shock-absorbing concrete.

Wind erosion is most likely in arid environments where the soil surface is friable and loose. A cover of suitable vegetation may be the most effective preventive measure; however, design should account for the additional irrigation water applied to maintain the vegetative cover. This could unintentionally produce vertical migration of soluble lead. Further protection could be achieved by natural or artificial windbreaks both within the range and on its perimeter, positioned according to the prevailing or most problematic winds.

Windbreaks can also be beneficial for aesthetic and sound-management objectives but should be planned so as not to interfere with other range management needs, such as lead recovery operations.

Concentrated human use of parts of a range can encourage erosion in susceptible areas. Access roads, unsurfaced car parks, and walkways may need to be vegetated or otherwise protected with gravel, stone chippings, or chipped bark to reduce erosion risks.

3.11 Targets, Casings, and Wads and Environmentally Friendly Targets

In addition to the spent lead, target and other shooting debris can be an environmental issue at a range. Components of a shot cartridges need to be considered along with the clay targets (see Figure 2-12).

3.11.1 Cartridge Cases and Wads

Spent cartridges and wads constitute litter. In addition, plastic wads, which form shot cups, may contain a residue of lead from the shot, observable as black or gray spots on the white plastic cups. Regular collection as part of normal housekeeping helps to prevent migration and potential exposure.

3.11.2 Clay targets

Whether or not broken clay targets can cause significant environmental problems is still debated. They contain PAHs and therefore continue to be of environmental interest. Baer et al. (1995) found that targets did not exhibit characteristics of toxicity using an EPA leachability test (Toxic Contaminant Leaching Procedure [TCLP]). Results from new and aged targets suggest that PAHs are tightly bound in the petroleum pitch and limestone matrix. However, they do constitute litter on ranges, and litter control measures can be taken, such as alignment of the shooting layout and shooting stands to limit the litter coverage area.

Clay fragments typically accumulate 20–80 m from each stand, depending on the layout, with missed targets up to 90 m away. Netting material laid over the fallout zone can be effective in facilitating recovery. Hand raking or mechanical scraping can also be used, depending on the terrain. Since sporting clay ranges generally have many trees or brush, removal of vegetation may not directly apply. At these ranges, the focus is on removing vegetative debris (fallen limbs, tree bark, etc.) prior to reclamation. This process may include removing some trees to gain better access with the reclamation machinery. Of course, when designing a new sporting clay range, steps to facilitate future lead reclamation should be considered. Recovery of spent shot, concentrating the fall of clays into flat areas free of vegetation, and rough ground will help this operation.

Options for their subsequent disposal depend on any state or local environmental laws applying to such waste and whether facilities can accept the target fragments under the terms of their operating/environmental permits. These may include landfill, incineration, road making, or new clay target manufacture.

3.11.3 Environmentally Friendly Clay Targets

> In view of the environmental interest caused by high-PAH clays, it is recommended that ranges use low-PAH clays.

Bitumen-free clays are slightly more expensive, but the small increase in cost is more than justified by the demonstration of the range's efforts to practice pollution prevention and be responsive to environmental concerns. Research and development continue among manufacturers to find effective and affordable clay materials. Their suitability for both shooting and disposal needs to be assessed. If colored clays are desired, only those with harmless pigments should be used.

3.12 Controlling Shooting Sound

Ranges that are not managed responsibly generate opposition. Local support for, or at least tolerance of, a new or established range is vital for its future. That future is more certain if potential objectors can be persuaded of the community benefits of the range and that all reasonable measures will be taken to minimize any unwelcome effect on their community. In some instances range activities or designs have been altered to address noise concerns.

3.12.1 Siting of Range to Control Sound Levels

> It is preferable that there be no line of sight between a range and any noise-sensitive premises.

New firing ranges should be located and designed to minimize the potential for objections to the sounds produced. Complaints about the sound of shooting can be difficult to resolve and often evolve into environmental complaints. Ranges have historically tended to be located in rural areas where land costs and sparse development are more suitable for this type of activity. However, the rapid development of rural areas is making it inevitable that range owners and operators will have to address the effect that development may have. Whether operating an existing range or planning a new one, it is important to consider surrounding land uses and landowners. Particular care is needed with the local topography. Hills and woods can reduce awareness of the range on neighboring land, but they can also reflect and increase sound levels.

When planning a new range, the manager should consult with the local administrative authorities about the level of sound permitted and any control measures required. A common mistake is to assume too low a daily use of the range. Predictions of future use should be based on the *busiest* days. The impact of the likely sound levels on the residents and users of the neighborhood should be assessed and steps taken to reduce it, if appropriate.

Direction and Angles of Shooting

The propagation of sound from a shotgun is largely directional, with its loudness being nearly halved to the side and less still behind the shooting stands. Shooting should be away from noise-sensitive premises. This orientation can be difficult, though, as shooting is usually best facing north for favorable light conditions.

Altering the angles of shooting can focus the resulting sounds away from sensitive areas. Some layouts, such as down-the-line, are more directional than others and can be used to help direct sounds. Sporting layouts create the widest acoustic impact, as it generally spreads all around each stand.

Amount, Frequency, and Timing of Shooting

Sound can be characterized by its duration, frequency, loudness, pitch, and impulsivity, and any of these features can cause annoyance to the local community. The range manager can alter many aspects of the shooting operation to help reduce problems for the enterprise:

- the number of different layouts;
- the amount of shooting at any one time;
- the number of shots fired on any one day;
- the times of day and days of the week for shooting;
- the rate of shooting per hour;
- the size and number of competitions, club, and open events;
- the number, size, and timing of practice sessions; and
- the types of cartridges.

> Incentives such as reduced fees may prove helpful to offset unwanted restrictions or to encourage shooters at times to meet community concerns.

A general contribution to lowering sound levels can be made by using subsonic cartridges or cartridges with smaller loads, as both produce lower sound levels. The time of day when shooting takes place is particularly important. Shooting can be confined to certain hours of the day, with the total number of hours fixed. The limits may be different on days of religious or cultural importance. Some balance is needed in applying such measures, however, as the manager is responsible for a business that depends on shooter custom and satisfaction. If either is reduced too far, the business will suffer.

Other Sounds

Less obvious, ancillary sounds associated with the range may also need attention. Public address systems can produce far-carrying sounds, as can the vehicles of visitors and range workers and the equipment and machinery used in the day-to-day management. If range facilities are used at night for social or other purposes, care may be needed to prevent these sounds from troubling the local community.

3.12.2 Sound Barriers and Berms

Barriers to sound propagation can be used to reflect, redirect, absorb, contain, and isolate sounds from ranges. Natural barriers should be used where possible, including banks, cliffs, rock or quarry faces, woods and other thickly vegetated areas, walls, and buildings. Care is needed, however, that they not increase sound levels at noise-sensitive sites. No one type, construction method, or material will solve all the problems. The best combinations vary from range to range, depending on specific needs. Banks of trees are often favored but, in fact, are rarely effective. They take years to develop fully and need to be more than 50 m thick, with aisles spaced through them, to reduce sound levels substantially. They can scatter rather than reduce sound. Vegetation barriers need to be managed to maintain their density. Finally, they can make the reclamation of spent shot difficult, as noted previously. Trees can provide visual barriers between a range and the surrounding people, enhance the wildlife interest of the site, and act as windbreaks in exposed areas.

Artificial barriers or berms can be an effective solution to noise problems since they can be tailored to the specific requirements of the range. Their effectiveness depends on their design and positioning in relation to the source of sound and the sensitive areas. They should be close to the source and acoustically "soft" to help absorb the sounds. Two or more barriers can be placed around a given shooting stand. Their effectiveness is increased if the stands are set into the ground so that the guns project just above ground level. Large straw or hay bales around a stand can provide cheap and effective sound reduction. Once individual stands have been considered, larger berms can be constructed strategically around the periphery of the range. They should be built in a way to prevent echoes and to be environmentally friendly. Permission to make such constructions on the site may be needed from the local administrative authority, and advice from acoustic engineers is strongly recommended.

Sound barriers and berms may be expensive to construct and take up land, but they can have additional benefits beyond sound containment.

Sound barriers

- permanently depress sound levels from the range;
- can reduce the land needed for the range since less separation is needed from its neighbors;
- break the line of sight between the range and neighbors, which can reduce local opposition;
- increase safety for range users and workers; and
- reduce the natural air flow, perhaps decreasing airborne lead (and other compounds) exposure to the shooters and range workers.

If perimeter berms are vegetated with shrubs and trees, they can improve the appearance of the range (provided the vegetation does not increase noise problems). Another form of barrier, vegetation on the ground, can help reduce sound propagation from shooting. Maintaining a grass covering is better than hard, bare surfaces from which sound waves readily reflect. Such a covering should be compatible with other management needs, including the recovery of lead shot, cartridge components, or clays. Vegetative covering can also control runoff (see Section 3.9).

Care is needed where shooting stands are set on concrete or other hard material and provided with some form of weather protection. The combination of hard surfaces can cause increased sound reflection and greater sound levels.

Bullet traps, baffles, and side berms may be enough to control sound levels. If large-caliber rifles are used, then side berms or walls on either side of each firing line may be needed. Further sound reduction, particularly from muzzle blast, can be achieved by roofing each firing line, but some roof designs can amplify sounds. The use of side and end berms for bullet containment, each up to some 2.5 m high, can reduce sound levels by 10–20 dB. Greater reductions can be achieved by creating narrow alleyways with berms or other structures, each some 2 m wide, from the shooting position to the target.

As circumstances and local needs dictate, additional measures can be considered:

- Firing positions can be partly surrounded by sound-absorbing materials, such as glass or rock wool.
- More effective is the partial roofing of the positions with similar materials to reduce muzzle blast levels.
- Bullet sound levels can be greatly reduced by applying sound-absorbing materials on side baffles and hanging plates of sound-absorbing material from overhead baffles at around 1-m intervals, down the range.
- Where several ranges lie parallel to each other, sound-absorbent partitions can be placed between them.
- Tube ranges assist in the reduction of sound. (The “tube range” is aptly named simply because it involves shooting within a tube to attenuate or redirect sound. The muzzle is enclosed and muzzle blast is reduced in many directions. It has been criticized by shooters because of the sound directed back at the shooter and gasses).
- Impact surfaces on bullet traps can be covered with sound-absorbent materials.

Weather Influences

Weather is particularly important on the propagation of shooting sounds. During windy conditions, for example, the sound from the range may be hardly audible in upwind locations, but up to a 30-dB increase in sound levels can be recorded downwind. Under clear skies and calm winds, sound propagation can be at its greatest; however, a layer of snow or low clouds can cause reflect/redirect sound and therefore increase its perceived level. The range manager can’t control the effects of local weather, especially where they vary greatly, but it is worth being aware of weather effects on shooting sound propagation.

3.12.3 Measurement of Shooting Sound

Before a shooting sound reduction program is considered, the sound levels produced by the proposed or current shooting stands should be measured. This step gives a baseline both for comparison with any government limits applying in the vicinity and for assessing the effectiveness of any sound reduction measures undertaken. Sound measurement is complicated by the facts that different characteristics of sound can be measured, equipment and units of measurement vary, and interpretation of results can be difficult.

An International Working Group, CEN/ISO, with experts in acoustics from around the world, is developing ISO standards on the measurement and prognosis of shooting noise for new or existing ranges. These standards will provide the measurement criteria necessary to calculate and assess the effect of shooting sound in the vicinity of a range. The standards will allow the calculation of ambient shooting sound levels without the need to record individual sound measurements. If no emission data for the specific range and its buildings are available, methods are given to obtain these data from measurements in the vicinity.

3.12.4 Sound Suppression

The development of sound suppressors (“silencers”) or sound moderators for sporting and target shooting use is increasing. They can be used on rifles and pistols and can remove the need for special sound containment measures on a range. Some designs are specifically for supersonic, high-powered ammunition. Regulations on the use of suppressors vary from country to country. Suppressors control only muzzle blast, reducing large-caliber sound levels for shooters from ~160 dB to <140 dB, and, at 10 m to the side, to <130 dB. They do affect the mean point of impact, but this factor can be corrected by adjusting the sights.

Suppressors cannot affect the ballistic downrange sound from a supersonic bullet. Management of this source of shooting sound may still need berms or other constructions. The use of subsonic ammunition is particularly beneficial with suppressors (or with standard rifles and pistols). The main benefit of suppressors is to reduce the overall sound levels from a rifle/pistol range, which may then reduce the need for greater separation distances from human habitation. They also help to protect the hearing of range users and bystanders. For a given rifle/pistol range, a combination of management techniques may provide the most cost-effective means of controlling sound levels. Siting and other factors are also important.

3.13 Newer and Emerging Technologies

A variety of new or emerging technologies and research on existing technologies with new application may have a role in managing environmental conditions at a given range. All of the following have applications but depend entirely on range characteristics and shooting practices. Many are being developed for military applications and are not likely cost-effective in commercial and private applications. They are, however, valuable to the industry and should be considered and tested at the appropriate level before investing in fully operational systems. The status of several technologies at the time of this writing is described below. They will have advanced by the time you use this guidance, so Web addresses are included where possible to facilitate access to updated information that may be available on specific technologies or techniques. The DoD Environmental Security Technology Certification Program (ESTCP, see http://www.ESTCP.gov) is a major source of the following information.

3.13.1 Berms

Copius Sand Trap—Improvements to the traditional berm are the Copius Sand Trap, developed by Copius Consultants, and the PRBerm, a collaborative effort between the U.S. Army Engineer Research and Development Center (ERDC) and AMEC Earth and Environmental. For the Copius Sand Trap, a sand berm is constructed within a concrete catchment. The design includes proprietary water collection and recycle systems such that all water contacting the berm is collected and recycled for dust control. The PRBerm involves cutting a notch in the face of the impact berm, using a nonwoven geofabric to isolate the native soil from the ballistic sand, and placing ballistic sand, amended with Apatite II, in the berm face.

Maintenance is simplified for the Copius Sand Trap and the PRBerm, as the ballistic media in each is an easily sifted sand. Sifting can be by hand or with a rotary screen bucket mounted to a skid steer loader. For the Copius Sand Trap and the PRBerm, vegetation is not present in the impact area but is established on areas outside the impact area to prevent erosion. Vegetation in the impact area can hinder lead recovery efforts.

Granular-Rubber Trap/Berm—The granular-rubber berm is similar to both the Copius Sand Trap and the PRBerm, except that granular rubber is the ballistic media instead of sand. While it offers very good bullet capture, it is a flammable material and could pose problems when using full automatic weapons or firing tracers. In collaboration with SuperTrap, ERDC has developed an improvement to the granular-rubber trap, incorporating a water-retaining gel to provide integral fire suppression.

For granular-rubber traps, maintenance is not as simple and requires specialized pneumatic separation equipment to recover the spent rounds from the rubber media. Also, continued heavy use can cause the rubber particles to break down, requiring disposal of the degraded particles and replacement with new media.

3.13.2 Shot Curtains

The Massachusetts Department of Environmental Protection is working with researchers from the University of Massachusetts at Dartmouth, with the support of a grant from the Massachusetts Strategic Envirotechnology Partnership, to evaluate suitable and cost-effective materials for the construction of shot curtains. The Massachusetts Lead Shot Initiative team has estimated that about over half of the state's 150 shooting sports clubs could use a shot barrier on trap or skeet ranges to prevent lead from landing in or near wetlands/waterways or off property and to limit the shot fall zone. The research to date has made some initial identification of fabrics that meet the cost and durability criteria. Researchers teamed with a textile manufacturer to produce sample materials for field testing in 2004. A number of Massachusetts shooting sports clubs are consulting on the project and have agreed to participate in the field testing.

3.13.3 Phosphate-Based Stabilization

Purpose—Soil and groundwater in the United States at numerous locations are contaminated with metals, including lead. Phosphate-induced metal stabilization (PIMS) is a technology developed to treat the metal contamination in place, either by mixing the amendments directly into the soil or by emplacing the amendments within a permeable reactive barrier to passively treat groundwater. At the U.S. Army's Camp Stanley Storage Activity, a subinstallation of Red River Army Depot, in Boerne, Texas, a demonstration of an in situ process using PIMS for remediation of lead-contaminated soil from training ranges will be conducted.

Description—PIMS stabilizes metals using a natural and reportedly benign additive, Apatite II, which chemically binds the metals into stable, insoluble minerals. PIMS technology is applicable for cleaning up soil and groundwater contaminated with soluble lead and other metals. Treatment can occur in place or in an aboveground facility. PIMS is suitable for all types of soil and groundwater and for all contaminant concentrations, from parts-per-billion to weight-percent levels. PIMS reportedly reduces the bioavailability of the metals if the treated soils are ingested, which is particularly important for public health concerns. Apatite II can hold up to 20% of its weight in lead, uranium, or other metals, and once the metals are sequestered, they are stable under a wide range of environmental conditions for geologically long time periods. The sequestration reactions are fast, occurring in seconds to minutes. PIMS has been tested successfully at bench to pilot scale on soils and water from mining sites and Department of

Energy sites through Small Business Innovative Research, EPA, and Strategic Environmental Research and Development Program–funded efforts. The ESTCP demonstration at Camp Stanley Storage Activity will be the first field-scale demonstration of this technology. This demonstration will validate the technical effectiveness and costs associated with the application of PIMS for the remediation of lead-contaminated soil.

Benefits—The benefits of this technology are the ability to treat the metal-contaminated materials in place without removal and disposition at a landfill or other treatment facility. Apatite II, available in large quantities at relatively low cost, can be mixed directly with contaminated soil; used as a liner; or mixed with grout, clay, and other reactive media. In addition, PIMS can potentially be used in combination with other technologies, such as soil washing. The technology should not harm existing ecosystems and, therefore, may be ideal for revegetation efforts and wetlands development.

Lead Immobilization Using Phosphate-Based Binders—In situ solidification/stabilization, the most used in situ metal treatment technology, reduces the metals' mobility although metal contaminants remain in the soil and may cause long-term problems. If treatment is not complete due to issues such as poor mixing, future contaminant migration is possible.

Recent studies have shown that the in situ treatment of soil with phosphate-based binders reduces soluble lead and other metals contaminants to below the RCRA standards for hazardous waste. The phosphate-based binders react with the metal ions, such as lead, to form insoluble metal phosphate complexes called "pyromorphites." Phosphate binders can be added in many forms that will create the desired pyromorphites; however, the kinetics of the reaction depend on the phosphate form. In situ treatment methods include land-farming application of the binder (plowing and grading), injection, and surface application of the binder, as well as mixing the binder with the soil in situ via auguring. With the soluble fraction of the metal contaminants bound by the phosphate binders, the only remaining mobility pathway is surface transport of particulate metals by quick-moving surface runoff to nearby streams. Erosion control measures may be necessary to eliminate this mobility pathway. Another concern is the potential transport of the phosphate binder out of the treatment area through leaching or physical transport, thus leaving any elemental lead particles free to oxidize and form soluble, mobile complexes.

The ESTCP demonstration project (http://www.estcp.org/projects/cleanup/200111o.cfm) validating the long-term immobilization of lead via phosphate amendment will assess the effects of erosion and precipitation on the in situ application of various forms of phosphate binders. The project will use treatment methods employing phosphate-based binders coupled with appropriate leaching, wind, storm water runoff, and vegetation monitoring methods to assess the stability of the treatment area and the potential for metals or phosphate transport. Potential effects of changes in the redox and pH characteristics of treated soil on the stability of the insoluble phosphate complexes will also be investigated.

Immobilization of metals eliminates the risk of metals migration to groundwater and surface water receptors. Also, as a result of the insoluble lead species formed, the bioavailability of the lead remaining in the soil is greatly reduced. Reducing the bioavailability of the species may lead to less-restrictive cleanup requirements. With approximately 200 small arms ranges currently slated for closure (or transfer), the cost savings to DoD alone could easily be in excess of $100 million.

Lead Stabilization using Phosphates (U.S. Army Corp of Engineers)—Through the Environmental Quality and Technology program, the U.S. Army Corps of Engineers has performed the first laboratory rainfall simulation study on soil treated using phosphate amendments (Larson et al. 2004, Figure 3-11). A complete mass balance for the lead and phosphate leaving the treated soil through runoff and leaching was determined for four phosphate treatments with rainfall of a neutral pH and an acid rain. In none of the four treatments (1% and 5% potassium phosphate and 1% and 5% hydroxyl apatite) was there a statistically significant reduction in the total lead leaving the simulator system. Reductions in the mass of lead leaving the system as dissolved lead in both the leachate water and the runoff water and the total lead in the leachate water were observed, but these reductions were less than the increase in the total lead leaving the system in the runoff water. With regards to phosphate, all four systems had elevated phosphate levels in both the runoff and the leachate from the systems. Potassium phosphate showed levels exceeding 1 g/L.

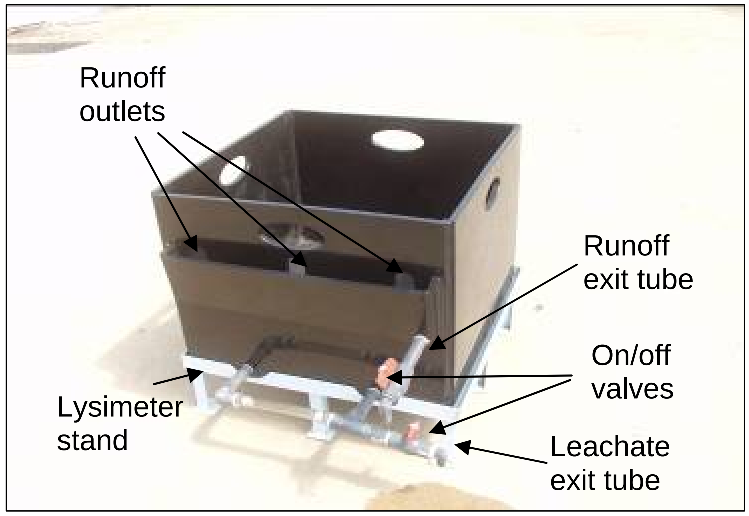

Figure 3-11. Test simulator system.

Many claims are made about the effectiveness of berm amendment using phosphates. The state of the practice is that a demonstration of the effectiveness of the technology has not been performed. The work performed at ERDC is indicating that phosphate treatment may exacerbate lead transport from berms.

3.13.4 Vacuuming

Vacuuming has traditionally been used for removal of lead shot from trap, skeet, and sporting clay ranges. Another way to apply this method involves removing the top layer of an earthen backstop or sand trap with shovels and spreading it thinly over an impermeable material such as plywood. A vacuuming device is then used to collect the materials lighter than lead (e.g., sand or soil), while leaving behind the heavier materials (i.e., lead bullets/shots and fragments). The soil can then be returned to the range. This process is most efficient for dry, sandy soils without a lot of organic material. A more recent innovation is the use of a high-suction vacuum. This vacuum itself does not have to be moved about, since a very long hose (up to 600 feet) is used to move in and around trees during the collection of lead shot at trap and skeet ranges (Figure 3-12).

For ranges on hilly, rocky, and/or densely vegetated terrain, several reclamation companies employ a vacuum system that collects the lead shot (and soil and other detritus). The resulting mix is then placed into the reclamation machinery discussed above. This method is especially effective for sporting clay ranges where lead shot tends to pile up around tree bases.

Figure 3-12. A lead recovery demonstration at a central Massachusetts range (2001, sponsored by Massachusetts Lead Shot Initiative partnering with the National Shooting Sports Foundation).

3.13.5 Lead-Free Projectiles for .22-Caliber Ammunition (http://www.estcp.org/projects/pollution/200203o.cfm)

Purpose—The military services use .22-caliber ammunition primarily in training environments. The goal of the training is to familiarize recruits with the nature of ballistic performance and weapons in general. Current military specifications specify lead as the only approved material for the projectile. The .22-caliber lead projectiles weigh approximately 40 g. Based on the average of the next five years of production, this weight translates to a total lead production requirement of more than 8,500 pounds of lead per year for this round. This lead not only vaporizes at the weapon as a result of normal firing but also enters the environment when the projectile terminates in berms and sand traps at firing ranges. The current medium-caliber ammunition used during training presents a hazard to human health and the environment.

Description—The overall objective of this project is to eliminate the use of lead in .22-caliber ammunition by demonstrating the viability of using a commercial off-the-shelf (COTS) projectile that qualifies according to the ammunition specification and manufacturing operation requirements. Commercial projectile suppliers will be solicited to provide lead-free .22-caliber projectiles that are expected to meet the performance requirements. These products will be evaluated against the present specifications (MIL-C-70600 and MIL-C-46935) and a qualification test program to be developed jointly through the Non-Toxic Working Group.

Benefits—The economic benefits of lead-free ammunition accrue over the total life cycle of the round. Over the last few years, installations that own firing ranges have halted training because of lead contamination. This lead concentrates in soils and becomes a problem with regard to rainwater runoff and biological uptake. Indoor ranges also have been closed due to airborne lead contamination. By eliminating lead from the projectiles, ranges can continue to operate without causing further damage to either people or the environment.

3.13.6 Field Validation of Real-Time Airborne Lead Analyzer (http://www.estcp.org/projects/compliance/199905v.cfm)

Objective—Many (DoD) facilities require rapid, on-site measurements of airborne lead levels to ensure worker safety and verify that the OSHA permissible exposure limit (PEL) of 50 µg/m^3 has not been exceeded. EPA has mandated (40 CFR 50) monitoring at lead-based paint facilities and firing ranges. Current OSHA protocols require personal breathing zone (PBZ) samples to be sent to an off-site laboratory for analysis, resulting in delayed reporting times and high compliance costs. Field demonstrations of the portable AeroLead™ PBZ Analyzer were conducted at shooting ranges at the Naval Amphibious Base in Little Creek, Virginia and at the Marine Corps Air Ground Combat Center facility in Twentynine Palms, California. The AeroLead™ analyzer was also tested on aerosol lead samples generated under controlled conditions at the Oak Ridge National Laboratory in Tennessee.

Results—The AeroLead™ analyzer automatically samples and measures metal concentrations in ambient air. Air samples are drawn through a sample filter/detector assembly. The airborne lead is then extracted and concentrated into a specially designed aqueous phase consisting of dilute hydrochloric acid and extractants and analyzed voltammetrically. An integrated airflow meter is used to determine air-sample volume, which is combined with the voltammetric data to yield an accurate airborne lead concentration. The instrument then automatically resets for the next sample. The analyzer has the capability to automatically measure airborne lead concentrations to below 10 $\mu g/m^3$ within a total sampling and analysis time of 15 minutes.

AeroLead™ did not meet all of the performance criteria during this program and therefore was not validated. A high degree of variability was observed in performance between the analyzer units at the three standard lead concentrations tested (126–356 $\mu g/m^3$). Interinstrument variability contributed to an overall precision for all instruments of 65%–82%. Interinstrument variability in accuracy (bias) ranged 29%–74%. Capture efficiency (100%) and extraction efficiency (91%) were validated under this program.

Benefits—The AeroLead™ analyzer has several advantages, including rapid, cost-effective turnaround of analytical results and enhanced health and safety for on-site workers. These features will enable workers to adapt to changes in the ambient lead concentrations during training, cleanup, or lead abatement activities and permit rapid reoccupancy of recently abated buildings. Estimates indicated that costs would have been reduced from $25 to less than $3 per sample, which means that potential DoD-wide savings alone could exceed $100 million.

Implications—The primary source of the interinstrument variability was traced to response differences between working electrodes. The manufacturer is currently improving working electrode design and manufacturing techniques so that sensitivity/response issues may be resolved.

3.13.7 Shock-Absorbing Concrete (SACON) Bullet Traps for Small Arms Ranges (http://www.estcp.org/projects/pollution/199609v.cfm)

Objective—Small arms training is a requirement in all branches of the military. In a typical year, small arms training activities consume over 300 million rounds and add 1–2 million pounds of lead to the ranges in the form of bullet debris. Because elevated levels of lead in groundwater and soils can present a health hazard, the migration of heavy metals can result in environmental regulators imposing training restrictions that ultimately would reduce operational readiness. The innovative use of SACON, a low-density, fiber-reinforced foamed concrete, was demonstrated as a bullet-trapping technology to address the lead issues on small arms ranges at West Point, New York and at Fort Knox, Kentucky (Hudson, Fabian, and Malome 1999).

Results—SACON bullet traps tested in a 25-m range application contained 87% of the bullets fired at the trap. The majority of the released fraction of bullet debris was deposited immediately in front of the trap, forming a debris pile. Exposure of the bullet debris to the SACON material resulted in the formation of insoluble lead corrosion products. As a result, even though lead concentrations in the trap and debris pile exceeded 60,000 mg/kg, all weathered SACON debris removed from these ranges was classified as nonhazardous, with TCLP levels below 5 mg/L, and was disposed of as a solid waste. Soil erosion resulting from repeated bullet impacts was reduced in front of and behind the target emplacements by burying SACON in these areas. Ricochet testing determined that SACON had no effect on the SDZ of the range.

Benefit—SACON offers significant benefits in comparison to current COTS technologies and provides a means of effectively capturing and containing lead on small arms ranges. It is able to inhibit the leaching of lead corrosion products. Other COTS bullet traps and soil berms do not have this lead stabilization capability. SACON is not flammable and can be formed in any shape, making it adaptable to more range applications than standard COTS technologies. The waste generated from the use of SACON is not classified as a hazardous waste and can be disposed of as a solid waste. Fixed, start-up costs were estimated at $1,600 per 25-m firing lane. Annual operating and maintenance costs were between $1,000 (low use) and $3,800 (high use) per firing lane. At low usage (7,500 rounds per year per lane), SACON becomes cost-competitive with conventional soil-berm technology on ranges with medium to high risk of lead transport.

Implications—SACON is a technically feasible method of capturing and containing lead on small arms ranges. However, like all bullet traps, it is an expensive means of mitigating lead transport from ranges and should be considered as a last resort for keeping ranges environmentally compliant. Other methods of reducing lead transport risk should be investigated prior to installing any bullet trap technology. New methods of stabilizing the lead on the range and mitigating physical lead transport in storm water runoff are being developed and may provide more cost-effective means of reducing lead transport risk and bioavailability.

4. ENVIRONMENTAL MANAGEMENT PLANNING

Environmental Management Planning

1. Site characteristics
2. Evaluate general environmental conditions
3. Select BMPs
4. Develop plan
5. Implement
6. Monitor

An environmental management plan provides a written framework for planning, implementing, and monitoring progress of good environmental stewardship at a range. Once the manager has assessed the features of a range, potential environmental issues need to be identified (see Section 2). The potential environmental issues determine what problems may arise and provide the basis to select suitable management options (Section 3). The environmental management plan then documents the management techniques, schedule for implementation of priorities, and methods of evaluation and documentation of the management option's performance. See Appendix C for an example outline of an environmental management plan. An environmental management plan and supporting documentation helps demonstrate that the range manager has an active commitment to care for the environment. They can become especially helpful if regulatory action is taken against the range on environmental issues. Well-planned and -executed environmental management using the best available technologies and documenting their performance may help ensure that lead is not classified as discarded or abandoned. Implementing a well-written plan demonstrates that identified environmental concerns are being appropriately managed.

As noted in Figure 2-1, the process of gathering and assessing the necessary information is valuable itself. It helps the range manager understand the interrelations among the many factors involved in managing range environmental conditions effectively and identify the most important issues to be considered first. The selection of the most cost-effective management options and the careful monitoring of their effectiveness then help assure any interested person or organization that the range is being managed both successfully and responsibly with respect to human health and environmental protection.

The public is becoming increasingly aware of environmental issues in general and seeks assurances that range activities are not adversely impacting human health or environment. A plan to listen to the concerns of neighbors provides an opportunity to discuss both the safety and environmental programs incorporated into the operating plans for the range. It is particularly important to inform the community of the safeguards that you are taking to protect the environment. Putting a well-designed and implemented environmental management plan in place helps provide those assurances. Range owners and operators should become involved in local community meetings, zoning boards, and other community activities. Being a part of the community helps others recognize the range as a valuable community asset.

4.1 Site Characteristics

> Step 1
> Evaluate the facility site to determine its environmental features and physical characteristics.

The first step in preparing an environmental management plan is to evaluate the range facility to determine its general environmental features, physical characteristics, and operational attributes. Several sources of information may already be available at the facility or readily obtainable through public sources, some of which are included in the bibliography of this guidance. Table 4-1 lists additional sources of information.

Geological and hydrological maps are useful to determine the type of geologic material beneath the soils profile and the depth to groundwater and whether there are any sensitive groundwater sources (aquifers). Information concerning bedrock may be an indicator of conditions affecting the acidity of surface waters (e.g., limestone areas are typically not acidic). Hydrologic maps give further information on depth to groundwater; show the drainage patterns created by rivers, creeks, and lakes (watersheds); and sometimes show the floodplains of streams, which may influence decisions if a range or components of a range are sighted in a designated floodplain. Soil maps provide useful information regarding the type of soil likely to be found at any particular site along with a wealth of information regarding soil properties, such as thickness, permeability, engineering characteristics, stratified compositions, and vegetation supporting capacity.

> Wetlands, including those entirely on private property, are protected by law and cannot be filled, dredged, or otherwise modified without a permit. Range managers should consult county NRCS offices to determine whether there is a wetland on their range.

Table 4-1. Sources of information

Criteria	Source	Purpose
Geological	• U.S. Geological Survey (USGS, http://www.usgs.gov) and state geologic survey maps	• Evaluate drainage • Factors affecting acidity • Land use planning constraints • Background lead concentrations
Hydrologic	• National Oceanic and Atmospheric Association (http://www.noaa.gov) • USGS and state geologic survey maps	• Rainfall patterns • Depth to subsurface groundwater • Drainage patterns • Flood potential and frequency • Land use planning • Temperature
Soil	• Natural Resource Conservation Service soil conservation surveys (by county)	• Soil properties • Soil stability • Drainage characteristics • Vegetation limitations • Background lead concentrations
Wetland delineation	• National Resource Conservation Service (by county)	• Soil properties • Soil stability • Drainage characteristics • Vegetation limitations
Topography	• USGS 7.5-minute quadrangles	• Site elevations • Drainage patterns • Land use
Aerial photographs	• USGS • Local universities • Planning departments	• Drainage • Ground cover (vegetation) • Stressed areas • Land use
Site layouts	• Construction plans • Maps produced for site design and operations	• Shooting positions and shot fall zones • Berms • Buildings • Roads
Water quality data	• USGS databases • Laboratory results from on-site samples • County extension agent • Local university agriculture department • State and local environmental agencies	• Support facilities (water and sewer lines, etc.) • Acidity • Background lead concentrations • Suspended solids/siltation in water bodies • Concentration of other contaminants
Number of users	• Operating records • Business plans • Club meeting notes • Range control	• Parking, restroom, trash facilities • Amount of lead • Frequency of recovery/recycling • Feasibility studies and projected use figures for new and/or expansion projects
Number of targets	• Operating records • Business plans • Club meeting notes • Range control	• Amount of lead • Amount of target fragments • Frequency of recovery/recycling • Feasibility studies and projected use figures for new and/or expansion projects
Months, days, and hours of operation	• Business plans, club meeting notes • Range control	• Timing of recycling • Magnitude of sound • Feasibility studies and projected use figures for new and/or expansion projects

Criteria	Source	Purpose
Current land use laws and regulations	• Planning boards or governments • Installation environmental office	• Maintaining compliance • Planning expansions

Many wetland areas have been mapped by the U.S. Fish and Wildlife Service or state natural resource agencies. Some areas may be categorized as wetlands because they meet certain technical criteria, yet they may not appear to be wet, marshy, or swampy to the public. An ITRC document (WTLND-2) provides a thorough description of the different types of wetlands. EPA also has a Web site specific to wetlands (www.epa.gov, search for "wetlands"). U.S. Fish and Wildlife maps provide official designation of these areas, which may be important when making range development or range modification decisions (see WTLND-2). Even though an area is not officially designated on government maps or may be too small to show on a map, it may nevertheless qualify as a wetland. Only a trained specialist can make a reliable delineation.

Topographic maps show site elevations (which affect drainage), line of site, steepness of slopes, many manmade excavation and fill features, bridges, roads, etc. If a range is small and the USGS maps are not at an adequate scale to provide useful information, the county planning department, the county extension agent, and local universities (NSSF 1997) can be valuable sources of general information about conditions relevant to environmental issues in the vicinity of the range. Aerial photographs can supplement map information. A "snapshot" using an aerial photograph often helps pinpoint areas of environmental problems such as stressed vegetation, eroding slopes, wetlands, and water bodies. Finally, each facility is likely to have some level of site mapping showing structures, ranges, and supporting utilities. These maps are important for comparing existing or planned changes with the environment "lay of the land" provided by other map and photo sources.

Other components of the range information baseline necessary for developing an environmental management plan are the operating parameters of the range. These are likely available in business and operating records of existing ranges, although they may have to be located and compiled. Information related to the type and amount of range use (e.g., number of shooters, amount of lead used, number of targets thrown, history of lead recovery/recycling) is important. Projections based on this type of information should be included in the business plans for range modifications and expansions and new ranges.

4.2 General Environmental Conditions

> Step 2
> Identify the potential environmental circumstances that require management.

This section recaps issues discussed in Chapter 2. Lead is the fundamental environmental issue facing all outdoor ranges. Scientific evidence establishes that lead is toxic and can be harmful in excess quantities (see Chapter 2). The presence of lead shot or bullets in the environment does not necessarily mean that they will be ingested by birds and wildlife or cause unhealthy effects in humans. However, even if only a small proportion of lead deposited becomes mobile at a range, it could become significant if not properly managed (see Figure 2-1 for environmental mechanisms enabling lead to become a contaminant in the environment).

Spent lead at ranges can interact with the environment in a variety of ways, if conditions allow.

Under certain conditions (ITRC 2003a, Section 2.5), shot or bullets may dissolve in water. Where conditions exist that cause lead to dissolve, rainfall may carry dissolved lead into groundwater or streams, ponds, lakes, and wetlands, where it may affect water quality. It also may have the potential to be taken into the bodies of aquatic animals and plants, where it may affect these organisms or other organisms that eat them. Whether enough lead dissolves to cause adverse environmental effects depends on complex interactions of a variety of factors and can be determined only by an evaluation of the specific site in question. Some of the most important factors determining how much lead will dissolve include how acidic or alkaline the water is (pH below ~6.5 or above ~8.5 increases the rate at which lead dissolves; see ITRC 2003a, Figure 3-1) and how long the water stays in contact with the lead (less lead dissolves if the contact time is short). ITRC 2003a provides a detailed discussion on the stability of lead compounds in soils.

Lead shot can be accidentally consumed by birds as grit for the gizzard or can be mistaken for small seeds and eaten. These events can occur whether birds are feeding on land or in the water. Waterfowl are particularly susceptible, which resulted in the ban on lead shot for waterfowl hunting. Lead shot and small bullet fragments can also be accidentally eaten with food by birds and animals feeding on earthworms, soil insects, fallen seeds, and other foods that are eaten at the surface of the soil. Lead in the soil can be taken up by certain kinds of plants and may accumulate in leaves, seeds, and other parts that can be eaten by birds or animals. Once lead particles or lead-contaminated food is taken in by a bird or animal, that lead can be passed on to predators. For example, if a range shoots into a field of corn or similar crop, there may be potential for bird or wildlife ingestion of shot embedded in plants.

Lead tends to attach to clay particles in the soil, especially if the soil is not acidic (i.e., pH > 6.5). Lead attached to clay has a lower potential to enter groundwater but can enter surface water attached to clay particles that are eroded into a stream, pond, lake, wetland, etc. Groundwater that is below clayey soils is not likely to be contaminated by lead because water doesn't penetrate clay layers very well and because lead in water that does reach clay layers tends to attach to the clay particles and not stay entrained in the water.

4.3 Selecting Best Management Practices

Step 3
Preparation of an environmental management plan involves selecting the appropriate management and engineering solutions for the range and documenting the intended course of action.

Having identified the environmental issue(s) relating to the range, now identify the appropriate management options, or BMPs, (Step 3) and incorporate them into a plan of action. This step requires careful consideration of many factors, including an estimated cost and the projected effectiveness of each option or the series of options, availability of equipment and techniques, ease of on-site implementation, likely benefits, timing, and others related to site and range business requirements.

Table 4-2 provides a comparative matrix to help evaluate alternative methods for managing environmental concerns. Each management option for a given issue can be scored under the description of the option at the head of the column. The totals of the scores for each option offer a guide to the more appropriate management option(s) for a given circumstances. A weighting factor may be added to particular criteria to place importance to certain parameters.

Table 4-2. Sample project evaluation comparison sheet

Criteria	**Alternative projects (each in separate column)** (Values: high = 5, moderate = 3, low = 1)				
	Weighting factor	**Alt # 1**	**Alt # 2**	**Alt. #3**	**Alt #4**
Health and safety impacts					
Erosion benefits					
Wildlife benefits					
Air benefits					
Surface water benefits					
Groundwater benefits					
Soil benefits					
Cost					
Level of professional assistance needed					
Impact on range operations					
Ease of implementation					
Timing					
Regulatory benefits					
Total score					

This step results in an objective comparison of site-specific practicability, cost, and effectiveness of alternative solutions. This information is necessary to accurately assess the various options and document how decisions were made. It also guides range operators in setting site-specific goals that are within the means of the individual range (time, budgets, etc.). This process can be helpful if any question of management priorities arises from either internal or external sources.

4.4 Management Plan Development

> Step 4
> However simple or intricate the format, it is important that some documentation take place to record the basis for decisions and to lay out a plan to guide future actions.

Once the decision-making process is complete, the decisions should be documented in the environmental management plan. Table 4-3 contains a template for the plan itself and will be helpful as an outline for a range's first. This outline, modified from NSSF 1997, may be used by sports clubs and recreational, military, or law enforcement ranges during environmental management plan preparation as a starting point for tailoring a plan to a particular range. This template is simply a tool to assist range owners and operators to make preparation easier and should be modified to incorporate specific information relative to a given range. This template is intended to be used in conjunction with this ITRC document and does not serve as a substitute for understanding the concepts and techniques discussed in this manual. The objective of the plan is usability, not necessarily volume. Each plan can be as detailed or simple as desired. A brief but concise plan is used and referred to more often than a bulky and overly inclusive document.

Table 4-3. Template for an environmental management plan

ENVIRONMENTAL MANAGEMENT PLAN

[Club or Range Name]
[Address]
[City/Town, State Zip Code]
[Date]
[Principal Contact]

Table of Contents

1.0 Introduction
- 1.1 Environmental Principles of the Range
- 1.2 Purpose of Environmental Management
- 1.3 Goals of Environmental Management

2.0 Site Assessment
- 2.1 Description of Ranges and Support Facilities
- 2.2 Existing Environmental Conditions (Range Type 1)
  - 2.2.1 Soil pH
  - 2.2.2 Erosion Due to Storm Water Runoff
  - 2.2.3 Distribution and Type of Vegetation on Range/Berms
  - 2.2.4 Distance to Surface Water (Streams)
  - 2.2.5 Distance to Groundwater
  - 2.2.6 Wind Erosion
  - 2.2.7 Distribution of Projectiles
- 2.3 Existing Environmental Conditions (Range Type 2)
  - 2.3.1 Soil pH
  - 2.3.2 Erosion Due to Storm Water Runoff

3.0 [Range Name 1] Action Plan (e.g., Trap and Skeet Fields, 25-Meter Ranges)
- 3.1 Action Plan
  - 3.1.1 Potential Management Alternatives
  - 3.1.2 Selection of Management Alternatives to Be Implemented
  - 3.1.3 Alternatives Selected
    - a) Management Actions
    - b) Operational Actions
    - c) Construction Actions
- 3.2 Plan Implementation
  - 3.2.1 Schedule for Implementation
  - 3.2.2 Responsibilities

4.0 [Range Name 2] Action Plan (e.g., Rifle, Black Powder, and Outdoor Handgun Range)
- 4.1 Action Plan
  - 4.1.1 Potential Management Alternatives
  - 4.1.2 Selection of Management Alternatives to Be Implemented
  - 4.1.3 Alternatives Selected
    - a) Management Actions
    - b) Operational Actions
    - c) Construction Actions
- 4.2 Plan Implementation

4.2.1 Schedule for Implementation
4.2.2 Responsibilities

5.0 [Range Name 3] Action Plan (e.g., Sporting Clays Course)

5.1 Action Plan
5.1.1 Potential Management Alternatives
5.1.2 Selection of Management Alternatives to Be Implemented
5.1.3 Alternatives Selected
a) Management Actions
b) Operational Actions
c) Construction Actions
5.2 Plan Implementation
5.2.1 Schedule for Implementation
5.2.2 Responsibilities

6.0 Measuring Success

6.1 Planned Monitoring Intervals
6.2 Planned Monitoring Variables
6.2.1 Erosion
6.2.2 Vegetation
6.2.3 Soil Type/Character (e.g., sand, silt, clay, organic content/nutrients)
6.2.4 Soil and Runoff pH

7.0 Plan Review and Revisions

4.5 Environmental Management Plan Implementation

> Step 5
> An environmental management plan must contain a implementation schedule, designated responsibility, and start and completion dates.

Environmental management plans must contain a schedule for implementing the desired actions. They need not occur all occur at once nor immediately; in fact, staging the actions over time may be necessary from a logistical or financial standpoint. Simple, relatively low-cost actions (e.g., changing the mowing schedule or changing positioning of planned vegetative improvements) should be implemented immediately. These pay considerable environmental benefits and improve the facility’s local image. Implementing actions requiring larger investment must be integrated into out-year business planning. Low-cost sources of assistance from colleges and universities, civic and volunteer groups, public programs (e.g., local agricultural extension office) should not be overlooked as valuable methods of implementing various parts of the environmental management plan.

Implementation plans must also contain information concerning the primary person(s) or contractors responsible for carrying out the activities of the environmental management plan and outline the actions required to initiate and implement each environmental improvement. Table 4-4 provides a means of documenting each management action, the person(s) responsible, the start date and planned completion dates, and costs.

Table 4-4. Sample projects implementation schedule (adapted from NSSF 1997)

Project or action	Person or primary responsibility	Initial (I) or recurring (R)	Start date	Completion date	Cost

4.6 Monitoring Review and Evaluation

Step 6
Monitoring and evaluation determine whether the EMP is being implemented as intended and what adjustments must be made to the implementation plan to achieve the desired goals.

Step 6 includes an evaluation of the success of the environmental management plan, which should occur one or more times per year. It also provides documentation of the results from the previous year's activities. The focus of the evaluation is to determine whether the environmental management plan has been implemented and performed as intended, the problems (if any) encountered, and what types of adjustments should be made. It is also useful to monitor the environmental benefits that have resulted from implementation of management and engineering actions. This step demonstrates and documents the effectiveness of the actions that have been taken.

Just as with other aspects of business, record-keeping is essential for evaluation of an environmental management plan. Typical records that may be useful in evaluating the effectiveness of a plan include but may not be limited to the following:

- range "inspections" by a range manager;
- photographs of preexisting conditions versus conditions after environmental improvements have been implemented ("before" and "after" photographs);
- log of actual implementation dates, problems addressed, associated costs, conditions, problems encountered, and follow-up actions;
- frequency of changed operational practices (i.e., mowing on poorly vegetated soils) and observed results;
- comparison of changes in operational costs related to changed procedures; and
- frequency and type of environment-related complaints from customers or the public.

Quantitative measurement of environmental improvements may be beyond the capabilities of range operators and need not be burdensome unless they are necessary to support the resolution of a contentious issue. However, when necessary, evaluating the effectiveness of range modifications at reducing lead transport can be performed in a number of ways. Lead levels found in transport pathways (surface water/runoff, groundwater, air) can be measured directly or calculated as a change in transport potential. Two direct quantitative methods for measuring the effectiveness or success of range modifications are as follows:

- comparison of lead concentrations in a particular transport pathway (surface water/runoff, groundwater, air) before and after range modifications and
- comparison of lead levels to a regulatory standard or concentration goal after modifications.

An indirect quantitative method for measuring the effectiveness or success of range modifications for improving runoff water quality is to calculate a decrease in the potential soil loss. Estimated soil losses are highly dependent on the percentage of vegetative cover on a land area. Any increase in the percentage of vegetative cover on a range, as part of modifications or renovations, should result in a potential decrease in soil loss from erosion. Calculations using the Universal Soil Loss Equation can be performed to estimate the decrease in soil transport.

Regardless of whether direct measurement or an indirect quantitative method is being used, at least one full growing season (one year) should be allowed for vegetation growth before evaluating performance. Two full seasons (years) of growth and establishment are even more desirable to accurately judge the success of revegetation efforts to minimize erosional transport of lead.

5. CASE STUDIES

The following are examples of environmental management at ranges. They range from government programs designed to offer technical assistance to range managers in a voluntary compliance setting, to environmental management approaches at Army ranges. These are included to assist a range operator understand a variety of issues, tests, and approaches often encouraged at ranges to further the effectiveness of environmental management at ranges.

5.1 Massachusetts Initiative Case Study

In Massachusetts, environmental regulators have worked with the shooting sports community to improve the management of lead shot and other environmental issues at ranges. This partnership has developed into an innovative program known as the Massachusetts Lead Shot Initiative (LSI). By providing technical and compliance assistance to range operators, the LSI program aims to protect environmental quality at and around shooting facilities across the state.

This case study describes the development of the LSI and some of the progress it has made in communicating the necessity of lead management to range managers and identifying specific measures ranges should take to prevent or mitigate detrimental impacts from shooting on the environment. This case study also summarizes some of LSI's most recent efforts in the areas of outreach, compliance assistance, and technology and guidance development.

<u>Background</u>

The Massachusetts LSI is a partnership between the Massachusetts Department of Environmental Protection (DEP) and representatives of the shooting sports community, including the Gun Owners' Action League, Massachusetts Sportsmen's Council, National Shooting Sports Foundation (NSSF), and others. The LSI works to protect wildlife habitat and environmental quality on thousands of acres owned and operated by ranges across the state. LSI achieves this goal by assisting range managers with their management of lead shot, bullets, and other environmental issues.

Massachusetts is home to more than 150 operating shooting facilities. These include shooting sports clubs, public safety ranges, and military ranges. Recreational and public safety ranges alone compose well over 10,000 acres of open space statewide with additional thousands of acres of military ranges. In this regard, shooting facilities play an important role in preserving natural resources and habitat as land development pressures continue to rise.

Unfortunately, within the areas of a range that are directly affected by shooting activities, lead from lead shot deposited on the ground or in some cases, into surface waters and wetlands, persists in the environment and can present a threat to wildlife, human health, and/or water quality. After decades of use, tons of lead can accumulate on each of these ranges. Acidic soil and acid rain conditions that exist in much of Massachusetts can dissolve lead shot, and dissolved lead, under certain conditions, can wash into surface waters or enter groundwater. Lead can also spread as airborne dust.

LSI Program Development

DEP developed the lead shot program strategy in 1997 in response to a growing need for a coordinated agency approach to range issues. At that time, DEP staff in different regulatory programs and regional offices were dealing with potential environmental or public health issues at several ranges. DEP was asked to intervene in cases where local conservation commissions had closed ranges because lead shot and targets were landing in wetlands. DEP was also involved in a case where a residential development was being built in the former shot fall zone of a closed club. In addition, DEP received an increasing number of complaints, often by gun club members, about the lack of lead management and environmental protection at ranges.

A DEP task force that included the Deputy Commissioner of Operations, a Regional Director, and other senior staff from the Office of General Counsel, wetlands, and RCRA programs was formed. It began reviewing how the agency had handled different cases, checking the case law, and contacting other states and the shooting sports industry. These efforts turned up ample evidence in the scientific literature that lead shot poses a threat to wildlife. The shooting sports industry already recognized the need for lead management at ranges and had begun the process of developing guidance on how to best mitigate the environmental impacts of shooting activities.

The task force put together a “white paper” on the lead shot issue. This paper, presented to senior DEP management, the Division of Fisheries and Wildlife, and the Secretary of Environmental Affairs, outlined the potential environmental problems posed by lead shot at Massachusetts ranges, the relevant legal and regulatory issues, and recommendations on how DEP should proceed in addressing lead shot. The task force advocated an approach of compliance assistance and enforcement discretion, focused on educating range managers and collaborating with the shooting sports community to advance environmentally sound practices at ranges. Members of the task force met with state legislators who, in turn, offered support of the proposed approach.

DEP's Cross-Program Team

In 1999, DEP assembled a team to implement the strategy developed by the lead shot task force. Because the issues of lead at ranges cut across several regulatory areas, by design this team comprises staff from the wetlands, hazardous waste management, and disposal site cleanup programs. The team members from the regional offices serve as the contacts for shooting facilities located in their respective regions. The members from headquarters coordinate the team's efforts to ensure a consistent statewide approach.

LSI Partnership with the Shooting Sports Community

To effectively inform range owners/operators and club members about the risks posed by lead and the need for lead management at ranges, the DEP team began working with the Massachusetts Division of Fisheries and Wildlife and representatives from the Massachusetts shooting sports community, including the Gun Owners' Action League (GOAL) and the Massachusetts Sportsmen's Council in 1999. This group referred to its partnership and program as the "Massachusetts Lead Shot Initiative," or LSI. Its initial priorities included developing an education and outreach program for range managers and gathering better information on the number, location, and environmental conditions at ranges across the state.

From the start, the LSI partners worked closely with representatives of the national shooting sports community. In particular, the group has partnered with NSSF and the Wildlife Management Institute. LSI has also participated in meetings of the environmental subcommittee of the Sporting Arms Ammunition Manufacturing Institute.

LSI's early outreach included attending night and weekend county league and membership meetings at individual

Managing Lead Shot at Your Range

☑ **DO pay attention to this issue.** The sooner your club acts to properly manage lead shot and lead bullets, the better. Managing lead today will protect public health and the environment at and surrounding your range and demonstrate your club's commitment to responsible range management. Clubs that do not act to manage lead shot and lead bullets risk spending more money later to address lead-related problems.

☑ **DO assign one or more club members to the task of lead shot management.** The best way to ensure that your club develops a plan of action for managing lead shot and lead bullets is to assigni the responsibility of learning about the issues and management options to members who are interested and willing to take on this task.

☑ **DO have those members familiarize themselves with available guidance.** Obtain a copy of both the National Shooting Sports Foundation's ***Environmental Aspects of Construction and Management of Outdoor Shooting Ranges*** and the Environmental Protection Agency's ***Best Management Practices for Lead at Outdoor Shooting Ranges.*** Both manuals will help you to identify problems with your existing lead shot management and the best options for improving conditions at its ranges. The NSSF manual may be obtained from NSSF (by calling 203-426-1320 or at http://www.rangeinfo.org) or from the Gun Owners' Action League (by calling 508-393-5333). The EPA manual is available at http://epa.gov/region2/waste/leadshot.

⃠ **DON'T shoot lead shot into open water or wetlands.** Lead is toxic to fish and other aquatic life and can be lethal to birds, such as ducks and geese that ingest lead pellets while feeding. Lead can enter the food chain, poisoning wildlife that feed on animals that have been exposed to lead. If your club currently shoots into open water or wetlands, it must either erect a barrier such as a shot curtain, or reorient the range to prevent the shot from entering the water or wetlands.

clubs, as well as presentations at annual meetings of the Massachusetts Sportsmen's Council and GOAL. Articles about the program were published in *MassWildlife* and *The Message* (GOAL's newsletter). LSI representatives also spoke about the program on a radio show for hunting and shooting sports enthusiasts. At informational seminars, DEP and GOAL gave coordinated presentations on the existing case law and regulations applicable to lead at ranges, the associated environmental and human health concerns, and the objectives of the LSI. The LSI partners also used these meetings to distribute copies of the NSSF guidance manual. By providing range managers with the opportunity to ask questions about the program, these early forums were key to addressing initial concerns and skepticism about the LSI approach and goals.

Range Visits

At every meeting with range managers and club members, the LSI partners also encouraged managers to invite LSI representatives to visit their ranges. Frequently, a representative from GOAL or the Massachusetts Sportsmen's Council also participates in the visit. Many ranges are more comfortable having representatives from the shooting sports community in attendance. NSSF and Wildlife Management Institute representatives have also joined in a dozen range visits. These joint visits help to reinforce the LSI partnership.

During a range visit, the LSI representatives provide the range manager with an assessment of the facility's current lead shot management and direction on correcting existing or potential problems. Such visits enable the LSI team to gather information on the types of problems that exist across the state, look for solutions that may be transferable from one range to the next, and identify any situations that pose an imminent environmental or human health hazard requiring short-term action. As part of the visit the LSI team completes a checklist to record observations and its recommendations for improved environmental management.

Issues Identified by Range Visits

As of the close of 2004, LSI partners have visited more than 100 sport, police, and military firing range facilities. The type (rifle/pistol, trap, skeet, sporting clays), size, and combination of ranges at these facilities vary widely, as do the amount of shooting and environmental setting. Environmental and lead management issues, consequently, depend on-range specific conditions. The LSI partners have found, however, that shotgun ranges—trap, skeet, and sporting clays—generally pose the greatest challenge for lead management. The primary reason is that the lead shot on these ranges is so widely dispersed and were more likely to include wetlands issues.

Bullets discharged at a rifle/pistol range are fired into a backstop berm located behind the targets. While potential lead migration is an issue that needs to be addressed at rifle/pistol ranges, it is one that can be managed in most cases by proper bullet backstop design and maintenance. In contrast, the shot fall zone on a single trap field covers about four acres. Shot is dispersed over an even greater area on a skeet field. Consequently, lead management measures to prevent or mitigate lead migration at trap and skeet ranges must be implemented over a much greater area.

A range's environmental setting can further complicate lead management at trap, skeet, and sporting clays ranges. Most ranges in Massachusetts were set up long before environmental concerns were fully understood. Ranges were sited, in most cases, to face north, minimizing the sun in the eyes of shooters. Some ranges are oriented so that the lead shot and/or targets land in wetlands or waterways. At other ranges, the lead shot is landing beyond the facility's property boundary. Of the more than 100 ranges visited by the LSI partners, approximately half were found to be shooting into or near wetlands or waterways; approximately 20% were shooting onto neighboring property.

Shot Fall Zone Overlay Maps

To assess whether a range may be affecting a wetland/waterway or neighboring property, the LSI program produces range-specific maps (Figure 5-1). These maps overlay the theoretical trap or skeet range shot fall zone developed by MassGIS on an aerial orthophoto of the range. At range visits, these maps are given to the facility managers to confirm the accuracy of the information and provide them with a tool for assessing the extent of lead shot deposition. The maps can be used to evaluate and design appropriate alternatives to address lead management problems. The theoretical shot fall zone as it appears on the maps generally represents the maximum extent of shot dispersion. Under actual range conditions, large trees or an upwardly sloping range can reduce the distance that shot travels.

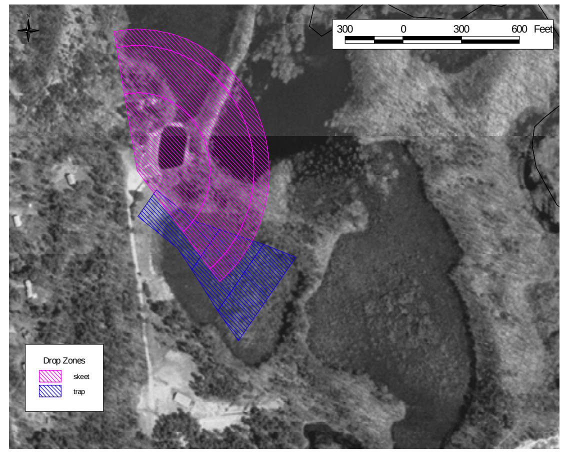

Figure 5-1. Example of a range overlay map. Theoretical trap and skeet range shot fall fans are indicated in blue and pink, respectively.

Environmental Stewardship Plans

The range visit and overlay maps give range managers a starting point for evaluating lead management issues and potential environmental problems that are specific to their facility. Following each visit, the DEP LSI representative sends the facility a letter identifying any lead management or other environmental issues the range needs to address and alternatives for dealing with these issues. Every facility is asked to develop a written best management practices or "Environmental Stewardship Plan" (ESP) for its ranges using NSSF and EPA guidance. To assist clubs, DEP provides them with an electronic ESP outline based on the plan format that appears in *Environmental Aspects of Construction and Management of Outdoor Shooting Ranges* (NSSF 1997, see Appendix C).

LSI Bottom Line

- Stop shooting into wetlands or waterways.
- Stop shooting off property.
- Control off-range migration of lead and other hazardous constituents.
- Conduct periodic lead reclamation.
- Use nontoxic, biodegradable targets.

The environmental setting (soil types, soil pH, type and amount of vegetation, site slope and drainage) and the amount of past and current shooting activity vary widely from facility to facility. These are all factors that present different issues and obstacles for lead management. Consequently, the development of an ESP with the appropriate combination of management alternatives is a very range-specific process.

The general objective of an ESP is the implementation of range improvements and maintenance activities that effectively eliminate detrimental impacts posed by the range or shooting activities on the environment or public health. Specifically, the LSI program directs all facilities to discontinue the discharge of lead shot into surface waters or wetlands, discontinue the discharge of lead shot onto any property not owned or leased by the facility, implement adequate measures to prevent any off-range migration/transport of lead and other hazardous constituents, and implement periodic lead reclamation. In addition, all facilities are encouraged to use nontoxic, biodegradable targets on their trap, skeet, and sporting clays ranges.

DEP's post-visit letter specifies a time period by which the shooting facility should submit its draft plan so that DEP can review the management alternatives the facility intends to implement and the implementation schedule. If necessary, DEP as well as other LSI partners revisit a facility to go over the specifics of the draft plans and provide assistance on implementation issues.

Range Reorientation

Several Massachusetts facilities are in the process of reorienting ranges. Reorientation can involve changing the direction of shooting to prevent shot and targets from landing in wetlands or waterways or landing off property. Reorientation can also entail rotating shooting positions at trap, skeet, or sporting clay ranges to combine drop zones and thereby decrease the overall shot fall area. The latter type of reorientation not only reduces the area affected by shot; it also concentrates the shot in a smaller area, making it easier to reclaim. The LSI staff encourages all facilities to evaluate whether range reorientation can be used to reduce overall shot fall zone area. For facilities with limited acreage or land surrounded by wetlands or waterways, however, reorientation is rarely an option.

Shot Barrier or Curtain

In addition to range reorientation, a shot barrier or "curtain" can be used by facilities with a need to limit shot fall zone size or prevent shot from landing in wetlands, in waterways, or off property. Because captured lead pellets accumulate at their base, shot curtains provide the added benefit of making it easier to recover and recycle the lead. Four Massachusetts clubs to date have erected shot curtains using a woven nylon material suspended from telephone poles. Many other clubs are now considering doing the same (see Section 3.13).

Lead Reclamation and Recycling

At all trap, skeet, and sporting clays ranges where lead pellets have been deposited, the LSI partners are asking facilities to periodically reclaim and recycle the lead as scrap metal. Lead reclamation is routinely done at ranges in Midwestern states using excavation equipment to remove surface soil and lead shot and shaker screens to separate the shot from the soil. Reclaimed shot is subsequently sent to a lead smelter, where it is recycled for use in car batteries and other products.

Unfortunately, the terrain, soil types, and type and amount of vegetation at the majority of Massachusetts' ranges, as they are currently constructed, do not easily lend themselves to lead recovery via soil excavation. Most trap, skeet, and sporting clays ranges are located on hilly terrain, covered with rocks, boulders, trees, and other vegetation. Lead recovery can be done at some ranges using a high-powered vacuum, however. The vacuum method was effectively used to recover tons of lead at a Massachusetts facility.

In partnership with NSSF, LSI sponsored the lead recovery and recycling demonstration project at a club in central Massachusetts. The project looked at the feasibility of using a vacuum truck to recover lead shot from a trap range (Figure 5-2). Over a two-day period 13 tons of lead was recovered from the top 1–3 inches of a 30- by 60-foot area of the shot fall zone. The lead and lesser amounts of soils/organic material recovered from the range were deposited into 55-gallon drums and shipped to a company where it was recycled for use in car batteries. Because of the amount paid by smelters for recovered lead increases as the purity of lead increases, finding better technologies for segregating lead from soil, rocks, and organic material will make lead recovery more affordable.

Figure 5-2. Gray surface of range indicating location of lead shot pellets. At this facility, the density of metallic lead shot is greatly diminished a few inches below the surface.

Nontoxic Shot

Several Massachusetts shooting facilities have switched to using nontoxic (primarily steel) shot pellets at their trap, skeet, or sporting clays ranges. Some facilities are using club funds to make nontoxic shot available for shooters to use. Other facilities have switched to nontoxic shot on ranges where future lead reclamation would be extremely difficult, such as sporting clays ranges where the shot is distributed in irregular patterns in a wooded area. Facilities are looking at using nontoxic shot at newly constructed ranges to avoid the costs and effort of future lead management on those ranges.

Vegetative Maintenance/pH and Erosion Control

All Massachusetts facilities participating in the LSI program are asked to evaluate and, if necessary, manage the vegetation, drainage, and soil pH on their trap, skeet, and sporting clays ranges to reduce the potential off-range transport of lead. Vegetative maintenance can include planting appropriate grasses or other ground cover to prevent soil erosion. It can also include routine mowing of grasses to discourage the presence of wildlife on the range. Drainage controls can include changing the contour of the range to prevent or control surface water runoff. Ranges have been instructed to routinely monitoring soil pH and add amendments to keep it between 6.5 and 8.5. Maintaining a neutral to slightly basic soil pH keeps lead in a stable form, thereby reducing its potential to leach from shot and lead compounds in soil to groundwater.

Environmental Stewardship Plan Workshops

In partnership with GOAL, NSSF, the Wildlife Management Institute, and EPA, DEP's LSI staff sponsored two Environmental Stewardship Plan Workshops. Held in 2001 and 2002, the workshops were offered free of charge to representatives from 35 Massachusetts shooting sports clubs. GOAL provided the workshop accommodations, and both the Wildlife Management Institute and NSSF donated expert instruction. Club representatives received guidance from national experts on their range-specific draft ESPs to improve lead management and address other environmental issues.

Advances in Shot Curtain Material

LSI staff are working with researchers from University of Massachusetts at Dartmouth with the support of a grant from the Massachusetts Strategic Envirotechnology Partnership on evaluating and identifying suitable, cost-effective materials for the construction of shot curtains. The research has made some initial identification of fabrics that meet the cost and durability criteria. Once the candidate fabrics have been identified, the researchers plan to construct a full-scale curtain model and conduct field-testing (see Section 3.13).

Funding for Range Improvements

The LSI partners worked to secure $50,000 in Pittman Robertson funds from a program administered by the Massachusetts Division of Fisheries and Wildlife to help facilities pay for improvements related to environmental management of their ranges.

5.2 Florida Case Study—*Best Management Practices for Environmental Stewardship of Florida Shooting Ranges*

Florida has approximately 400 shooting clubs, and approximately 1 million shooting sports enthusiasts visit these ranges each year. A State of Florida manual, *Best Management Practices for Environmental Stewardship at Florida Shooting Ranges* (Florida Department of Environmental Protection Hazardous Waste Compliance Assistance Program 2003) focuses on lead, which composes 92%–98% of the weight of most bullets and shot. While lead is a natural element, it is rarely found in such concentrated form as in bullets and shot and therefore is rarely found in soils at the high levels encountered in range backstops, berms, and shot fall zones. Until recently people assumed that lead from bullets and shot was stable and therefore did not consider it a potential source of contamination. Based on recent and ongoing research, range owners and operators should recognize the potential environmental risks and understand the importance of managing facilities to minimize such risks. Range management ideas presented in the Florida manual are intended to help minimize, or even eliminate, the amount of lead that breaks down and poses a problem during the operational life of a range.

Florida depends on groundwater for its drinking water supply and on surface water for outdoor recreation industry. High rainfall and acidic conditions, typical in Florida, cause lead to be more mobile in the environment. Therefore, proper management of outdoor shooting ranges is especially important in the Sunshine State. The Florida manual provides owners and operators of outdoor, rifle, pistol, skeet, and sporting clay ranges with information on management of environmental issues. While each range is unique in both the type of shooting activity and its environmental setting, the Florida manual is a reference guide that presents reliable BMPs that effectively reduce or eliminate problems associated with lead. BMPs may also be economically beneficial to the range manager.

Federal, state, and local environmental and regulations provide a framework for environmental stewardship, as well as substantial potential liabilities for poor stewardship. Citizens as well as regulatory agencies may bring suits to enforce compliance with applicable laws.

Florida encourages an environmental stewardship program that includes a written plan or roadmap for planning, implementing, and monitoring the progress of environmental improvements at shooting ranges. By developing and implementing an environmental stewardship program, range management documents its commitment to the environment and the community. Environmental stewardship means taking action to correct current problems and working proactively to prevent future ones. Some of the benefits ranges may realize from implementing BMPs as part of an environmental stewardship program include the following:

- increased protection of the environment,
- evidence of proactive stewardship,
- documentation of any environmental concerns,
- identification of effective and appropriate solutions for any environmental concerns encountered,
- development of information on which to base prudent decision making,
- planning and soliciting support for funding of range improvements,
- enhanced community relations,
- better range aesthetics,
- improved profitability through recovery and recycling lead, and
- reduced public and regulatory scrutiny.

A variety of cost-effective operational and engineering techniques can be used to successfully manage environmental issues at an outdoor shooting range. Some can be implemented immediately; others require long-term planning.

Every owner/operator of a shooting range should begin an environmental stewardship program by documenting the physical and operational characteristics of the range. This process includes description of the facility, documentation of current and past operating practices, and an assessment of existing environmental conditions. An essential element of environmental stewardship is documenting activities and keeping accurate records:

- range inspections;
- photographs of preexisting and improved conditions;
- logs of actual problems encountered and follow-up actions, implementation dates, associated costs and range conditions;
- logs of changed operational practices and observed result;
- comparison of changes in costs related to procedures; and

- frequency and type of environmentally related complaints or compliments from customers, the public, and the regulatory agencies.

Management techniques as described in Chapter 3 of Florida's manual contain BMPs available to protect the environment from the impacts of shooting sports at an outdoor range. A five-step approach to lead management is as follows:

- Evaluate existing environmental conditions.
- Control and contain lead bullets and bullet fragments.
- Prevent migration of lead to the groundwater and surrounding surface water bodies.
- Periodically remove the lead from the range and recycle it.
- Document activities and keep records.

Some combination of BMPs will be appropriate of any particular range.

The Florida Department of Environmental Protection is very interested in any suggestions readers might have about practices in this manual that may have proven effective in preventing lead migration from a range or in recycling led bullets or shot. The full Florida manual can be viewed and downloaded at the following Internet address:
http://www.dep.state.fl.us/waste/categories/hazardous/pages/lead.htm.

5.3 Fort Rucker Case Study

Abstract

The demonstration objective was to mitigate the off-range migration of projectile-related hazardous metal (lead) and identify techniques that the Army could apply to some of its thousands of small arms ranges. This work demonstrates that, for a 25-m range with a berm, lead transport originates primarily from bullet impact depressions (pockets) and soil splatter piles (toes) near the base of the berm. More than 90% of the rounds hit and pulverize soils in pocket and toe areas, creating concentrated source areas. High-energy, storm-generated runoff can move particles, particularly fine-grained material, from bullet pocket areas away from the range.

Some lead migration mitigation techniques were proven useful in this demonstration:

- The addition of bentonite increases slope stability and decreases berm surface erosion.
- Erosion matting promotes vegetation.
- End berms and range grading help manage storm water runoff.
- A detention pond captures some but not all lead particulate material.

Water samples indicated that dissolved lead was not a problem at Fort Rucker's South Range. With regard to mitigating potential lead dissolution, all five test cell bullet pocket/toe areas failed TCLP by a significant margin after six months of firing. These data suggest that these chemical technologies (clay amendments and phosphate fixation), designed for landfill applications, are inappropriate for whole berm application on most operating ranges where significant lead addition and soil disturbance occurs over small areas (pocket/toes).

<u>Partial Project Details</u>

(The full report is *Environmentally Redesigned Small Arms Range Demonstration Final Report,* SFIM-AEC-ET-CR-97042, September 1997.)

The demonstration ran from September 1995 until April 1997 at the 25-m South Range at Fort Rucker, Alabama. The project team left the existing berm in place, excavated high-concentration (lead) surface sediments from the berm and range floor, and removed 78%–81% of the lead by sieving. The sieved soil (866 mg/kg lead) was used to reconstruct the range, which included a large main impact berm, two end berms, a detention pond, and range grading to focus rainwater runoff from the main berm toward the detention pond. The team applied five chemical/physical soil stabilization technologies to the sieved soil and placed this material into five test cells on the berm front. Two test cells used proprietary chemical techniques to reduce the leachable lead while the remaining three test cells used clay or bentonite. Clean soil from a borrow pit (12 mg/kg) was used to construct the remaining range.

The project team collected soil samples five distinct times at South Range: before construction, just after construction (baseline), and three times (two, four, and six months) during live firing on South Range. Soils were tested primarily for lead: total lead and TCLP. A wooden divider system separated the five test cells so that runoff water and sediment from the cells did not commingle on the berm face or at the toe of the berm.

Clogging of automated storm water samplers prevented cell-to-cell comparisons of lead migration. Only nine individual samples were taken. These nine storm water samples were analyzed for dissolved phase lead (filtered), total lead (including particulates), and total suspended solids.

Bullets were tallied to allow calculation of lead mass fired into each test cell. This mass was compared to the starting mass of lead in each test cell (sieved soil) and to the actual lead mass found in each test cell. After six months of firing, the team calculated that approximately 50% of the total lead mass for each test cell should reside in bullet pocket/toe area (90% firing accuracy and an average of 3956 rounds per target) and that the remaining 50% came from the sieved soil (averaged 877 mg/kg) spread over the whole berm front. Predicted six-month lead masses in bullet pockets and toes exceeded actual lead mass (calculated from concentrations), suggesting that lead shot into test cells moved off of the berm.

Photographs and measured lead data in runoff channels and automated samplers also suggest that lead moves away from the berm by physical particle migration in surface water. Soil lead concentrations decrease with distance from the berm to the detention pond inlet (see Figure 6 in the full report, excerpted in Figure 5-3 below), indicating the berm as the source area and therefore the pockets, since pockets should contain 50% of the lead and are pulverized and unvegetated. Concentrations increased over the six-month duration of the demonstration. Within the pond soil, lead concentrations increased from the inlet to the outlet (see figure). This trend suggests that small, less-dense material, which settles out of the water last and therefore at greater distances into the pond, carries some of the lead. Automated storm water samples support this notion. All but one water sample (filtered to remove particulate material) showed lead

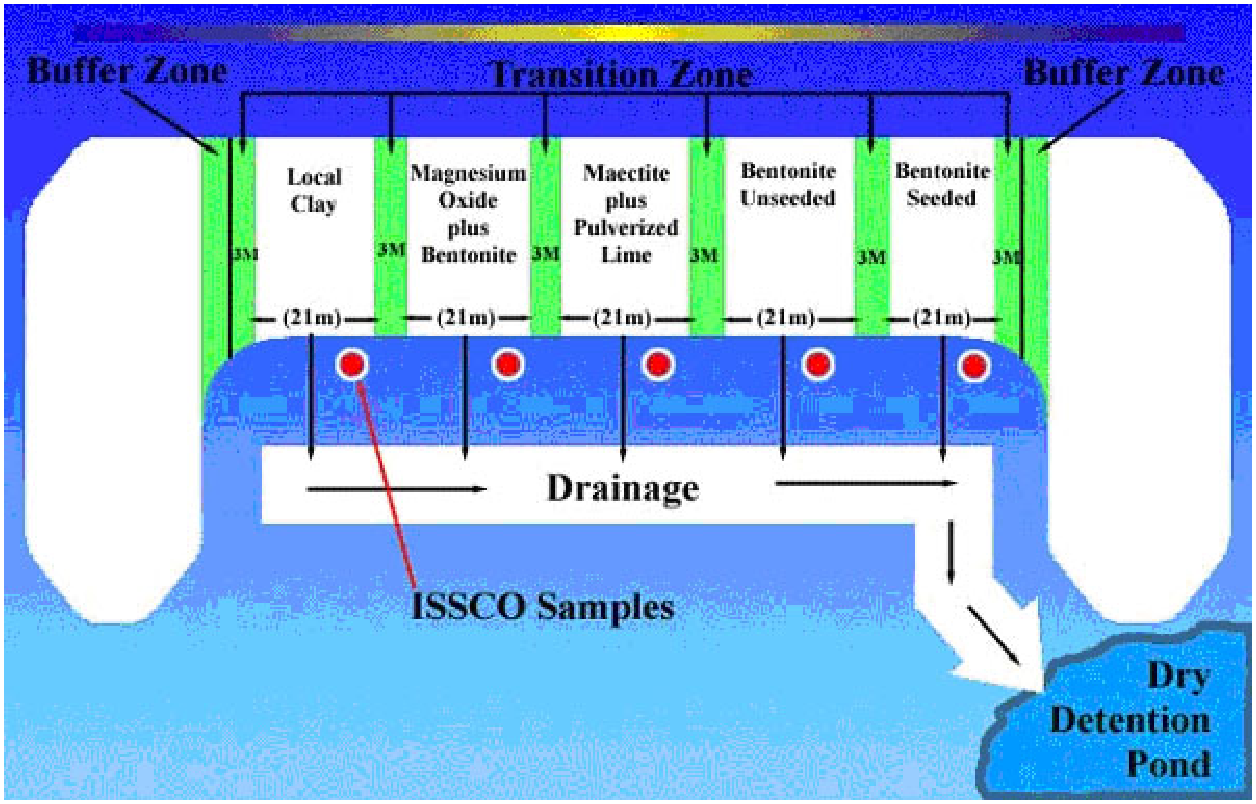

Figure 5-3. Environmentally reengineered berm
(from *Environmentally Redesigned Small Arms Range Demonstration Final Report,* SFIM-AEC-ET-CR-97042).

concentration below the national drinking water standard (15 µg/L). This finding confirms previous work that dissolved phase lead transport is not a problem from many Army ranges (Packer 1997a,b). Unfiltered samples (with suspended solids) show lead concentrations which far exceed the drinking water standard, suggesting that particulate lead is transported in storm water runoff.

With regard to mitigating potential lead dissolution, all five test cell bullet pocket/toe areas failed TCLP by a significant margin after six months of firing, suggesting that these chemical technologies, designed for landfill applications, are inappropriate for whole berm applications on most operating ranges where significant lead addition and soil disturbance occurs over small areas (pocket/toe). Owners or operators should chemically treat sieved range soil if lead is widely dispersed in range soils and (a) a range is closing or (b) there is a high potential for vertical transport to groundwater (e.g., low soil pH, shallow water table) or (c) very little lead will be added to the range. Under these limited circumstances, range soils may benefit from a phosphate treatment similar to that applied in Cell #2, which was the only test soil to pass the TCLP test directly after treatment. This treatment allowed for moderate vegetation and may be compacted in future applications to promote shear strength and internal slope stability. For treated soils on berm surfaces (Cell #2 technology), long-term reduction in leachability (greater than six months) is unknown at this time.

Moreover, given that bullet pocket and toe sediments contain the highest lead concentrations and are continually pulverized by bullets, any significant volume of surface water runoff will inevitably transport particles from these areas, regardless of the erosion resistance and stability of the remaining berm surface. Climatic conditions, soil particle distribution, and mass of lead added per unit time will determine the extent and degree of surface water lead transport.

Some useful lead migration mitigation techniques resulted from this demonstration. The addition of bentonite increased slope stability and decreased berm surface erosion. The erosion matting promoted vegetation. The end berms and range grading helped to manage storm water runoff. A detention pond is an effective means of controlling lead migration, but care should be taken, since its capture of lead makes it a potential point source, requiring a discharge permit. Some lead still exits the outlet pipe.

Physical and chemical treatment of the entire berm soil does not mitigate the lead transport from the concentrated areas in the bullet pockets and toes. These small soil volumes lie nearly directly on the range floor, where potential dissolved lead interacts little with treated soil. Pocket/toe soils are pulverized, unvegetated, and highly concentrated with lead, allowing surface water to carry these particles off range.

Figure 6 in the Fort Rucker final report uses surface soil composites on range floor and within the detention pond to show concentration trends. Sample points are plotted in the direction of range grading (left to right). The first two sample points (east wing and inlet) were taken from the range floor, i.e., moving toward the detention pond. The 10-, 40-, 80-, and 130-foot sample points were all within the detention pond, measured from the inlet toward the outlet that is in the direction of water flow. The last sample point (detention pond outlet) was actually outside the detention pond (see Figures 5-4 and 5-5).

Photo A

Photo C

Photo B

Figure 5-4. Water and sediments moving into, through, and out of detention pond. *Photo A* shows the inlet channel (and raised/covered ISSCO sampler) to the detention pond. *Photo B* shows the detention pond. The range gradient in the background channels water and sediment into the detention pond where the heaviest particles settle out as water moves toward the end of the pond (shown in the foreground). Slotted red pipe (*Photo B*) lets water exit the pond into riprap (*Photo C*), where any remaining suspended fine material exits with the water.

Photo A

Photo C

Photo B

Figure 5-5. Off-range sediment transport in March 1997. *Photo A* shows screening on the side of the PVC completely inundated with sediment. *Photo A* also shows small plumes of sediment exiting from open PVC, out of the sampling channel (under wood timbers) and onto the grassy area in between the targets and berm. Plume of light-colored sediment on the unvegetated range floor moves off range toward the detention pond in *Photo B*. Range sediments which were suspended in water enter the detention pond (*Photo C*) and settle out as water velocity decreases down the pond axis.

5.4 Fort Jackson Case Study (ongoing U.S. Army Environmental Center project)

Fort Jackson small arms range project objectives are as follows:

- improve storm water management,
- long-term range maintenance reduction,
- ease of future lead extraction from impact berm, and
- no increase in bullet ricochet/skip-over.

Several techniques are applied:

- Range regrading limits upstream storm water from washing over the berm front and range surface soils. Separating "clean" upstream water from "range runoff" is essential. This regrading decreases the storm water volumes and velocity. This lower velocity decreases the surface water transport of particulate lead. The berm face grade is limited to no more than 26° to limit erosion and increase structural stability.

- Soil amendments increase the potential to grow vegetation and the structural stability of soils, thus decreasing erosion. Top soil, chicken litter for additional organic matter as well as nutrients, pH adjustments using lime/calcium carbonate, and nitrogen fertilizer as needed were all added to range soils. In addition, soil amendments which include clay and organic matter mitigate the potential of vertical migration as an added bonus.

- Revegetation of berm faces and range floor (all barren areas), decreases erosion and storm water velocity, thus decreasing lead transport (Figure 5-6). Revegetation is the single most important improvement to bullet pocket stabilization as well as overall range management of lead transport.

Figure 5-6. Fort Jackson berm prior to modification (top) and after amendment and revegetation (bottom).

- Geotextile fabrics around bullet pockets are under evaluation for stabilization of soils adjacent to bullet pockets.

A year of monitoring is planned at Fort Jackson, to be completed in March 2004. Interim Army Small Arms Range Guidance based on all Army small arms ranges projects is being developed with the BMPs document expected in July 2004.

5.5 Naperville, Illinois Case Study

Naperville Sportsman Park, Naperville, Illinois
National Pollution Discharge Elimination System Permit

On October 13, 2000, the Naperville Park District, on behalf of its Sportsman's Park, became the first range to be issued a National Pollution Elimination Discharge System (NPDES) permit. The Clean Water Act requires an NPDES permit when any "pollutant" is discharged into "the water of the United States." The permit was issued by the Illinois Environmental Protection Agency (IEPA), which oversees the NPDES program in that state.

Several jurisdictions have determined that ranges meet the criteria contained in the Clean Water Act to warrant the need to obtain an NPDES permit if the range is shooting into water or wetlands. The impact or shot fall area need not be wet to qualify as a wetland.

The City of Naperville, the Naperville Park District, and the Naperville Sportsman's Park were sued in 1998 by a neighbor who was opposed to the range., The court ruled that an NPDES permit was required. The IEPA did not institute any action against the club and became involved after the court ruled that a permit was required. The parties named in the lawsuit spent many thousands of dollars on legal defense of the club and on scientific studies required to obtain a permit.

The Sportsman's Park had the only NPDES permit issued to an operating firing range in the United States as of the end of 2004. The permit requires that the trap range use steel shot and biodegradable targets, manage the litter created by the shotgun wads, and monitor water quality.

The club voluntarily suspended its operations during the litigation. As a result, many members canceled their membership. However, after reopening in 2001, the club successfully has rebuilt its membership and currently is throwing more targets than before the suit was filed. Many of the new members also are new to the shooting sports.

Clubs that shoot into waters or wetlands can avoid these huge costs, loss of membership, and potential closure by reorienting their ranges to avoid water or wetland areas or switching to nonlead ammunition. It is important to note that an NPDES permit still may be required, even if nonlead ammunition and biodegradable targets are used. However, it is likely that a permit will be easier to secure—and less expensive—if it obtained before lawsuits or agency actions are initiated.

5.6 New York Police Department Outdoor Firing Range Lead Stabilization Case Study

Introduction

The Rodman's Neck firing range is located on the southernmost portion of the Pelham Bay peninsula, which juts into Eastchester Bay. The City of New York developed and implemented an operations and maintenance plan on the Boy Range to demonstrate the effectiveness of economical lead recovery and lead-contaminated soil stabilization using a material named ECOBOND®.

Operations and Maintenance Procedure

The project demonstrated the ability to remove the bullet fragments using dry screening and treatment of the lead-contaminated soil to background levels so the soil levels can be reused on site. The lead recovery procedure allowed for 85% lead recovery and 90% soil reuse.

Soil Characterization

The City of New York had Consulting Engineers perform soil characterization at the Rodman's Neck range (Table 5-1). The highest TCLP/Synthetic Precipitation Leaching Procedure (SPLP) leachable lead concentrations were observed in samples collected from the lower berm of the Charlie and Eddie Ranges and the flat and lower berm of the Albert and Frank Ranges. The majority of the samples collected from these areas exhibited leachable lead concentrations in excess of the TCLP Project Action Level (PAL) of 5.0 ppm and SPLP PAL of 0.172 ppm.

In contrast, TCLP and SPLP leachable lead concentrations for the majority of the samples collected from the Boy Range after treatment were found to be well below the TCLP and SPLP PALs in spite of the facts that soil within the range was treated over six months prior to sampling and the range is used on a daily basis. The sample results for the Boy Range demonstrate that the removal and recycling of lead fragments along with treatment of soil effectively reduces the leachability of lead present in the soil. Application of the stabilization material did not have any adverse impacts such as hardening of the soil matrix. Hardening of the soil matrix during previous maintenance efforts may have several adverse effects such as creating ricochets and drainage problems.

Table 5-1. Treatment results at New York Police Department outdoor firing range, Rodman's Neck, Bronx, New York

Firing Range Sample	Pretreatment TCLP lead	Treatment TCLP	Pretreatment SPLP lead	Treatment SPLP lead
West side #1	788	0.005 ppm	20	0.035 ppm
West side #2	788	0.270 ppm	20	0.031 ppm
East side #1	280	0.104 ppm	15	0.0469 ppm
East side #2	280	0.0545 ppm	15	0.0176 ppm

Project Action Level for TCLP lead is <5.0 ppm.
Project Action Level for SPLP lead is <0.172 ppm.

Conclusions

Based on the success of the maintenance and operation procedures, Consulting Engineers recommended to the City of New York that the lead fragment removal and recycling along with the lead stabilization technology be used to treat other ranges to meet BMPs and to save money.

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APPENDIX A

Acronyms

Acronyms

BMP	best management practice
CFR	Code of Federal Regulations
COTS	commercial, off-the-shelf
DEP	(Massachusetts) Department of Environmental Protection
DoD	U.S. Department of Defense
EMP	environmental management plan
EPA	U.S. Environmental Protection Agency
ERDC	(U.S. Army) Engineer Research and Development Center
ESP	Environmental Stewardship Plan
ESTCP	Environmental Security Technology Certification Program
GOAL	(Massachusetts) Gun Owners' Action League
IEPA	Illinois Environmental Protection Agency
LSI	(Massachusetts) Lead Shot Initiative
MIC	metastable intermolecular compound
NASR	National Association of Shooting Ranges
NPDES	National Pollution Elimination Discharge System
NRCS	Natural Resources Conservation Service
NSSF	National Shooting Sports Foundation
OSHA	Occupational Safety and Health Administration
PAH	polycyclic aromatic hydrocarbons
PAL	project action level
PBZ	personal breathing zone
PEL	permissible exposure limit
PIMS	phosphate-induced metal stabilization
RCRA	Resource Conservation and Recovery Act
REST	Range Evaluation Software Tool
SACON	shock-absorbing concrete
SDZ	surface danger zone
SPLP	Synthetic Precipitation Leaching Procedure
TCLP	Toxic Contaminant Leaching Procedure
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey

APPENDIX B

Glossary

GLOSSARY

absorption – the act of taking in or soaking up.

adsorption – the process that removes dissolved metals from the water column through binding the ions to the surface of a sediment particle.

acids – pH below 7.0. Under acid conditions, leads tend to dissolve and adhere to particles. The lower the pH, the more acidic the conditions and the more lead tends to dissolve.

agglomerate – to form into rounded masses.

alkaline – not acidic, basic, pH above 7.0. Under moderately alkaline conditions, lead tends to adhere tightly to soil and other particles; however, under strong alkaline conditions lead mobilization may be increased.

aesthetics – appearance. An aesthetically pleasing range looks well-managed and attractive.

ammunition – one or more loaded cartridges consisting of a primed case and propellant, with or without one or more projectiles.

backstop – a structure specifically constructed to stop and store projectiles fired on a range.

baffle – a barrier to intercept projectiles and/or reduce, redirect, or suppress sound. Baffles are used overhead, alongside, or at ground level to restrict or intercept errant or off-target shots. Use of baffles and backstops reduces the surface danger zone to the immediate limits of the range containment area.

berm – a wall of earthen materials that separates two physical features. Can be a manmade or natural feature. In the context of this manual, a berm would be a (generally manmade) mound or wall of earth that would delineate the back and/or sides of a firing range.

buffer – solutions the resist changes of hydrogen ion (H^+) concentrations. In surface water, dissolved specific ions (bicarbonate and carbonate) are in equilibrium with the carbon dioxide in the atmosphere (gas) and dissolved in water. Together they act like a buffer: this means the pH of water won't change even if acid or base is added (within limits) to a solution.

bullet trap – a device designed to trap and capture bullets and fragments.

cartridge – a single round of ammunition consisting of the case, primer, and propellant, with or without one or more projectiles. Also applies to a shot shell.

firing lane – the area within which a firearm is fired. It consists of firing and target lines and left and right limits of fire.

firing line – the base line to a range to which the targets are parallel to, from where firearms are discharged and forward of which no one is permitted during fire.

firing position (point) – an area directly behind the firing line having a specific width and depth that is occupied by a shooter, equipment, and, if appropriate, an instructor or coach.

foreground – the area between the firing line and the backstop berm (and between the side berms) at an outdoor rifle/pistol range.

green ammunition – lead-free bullet or shot.

ground baffle – a device on the range floor designed to intercept and stop ricocheting projectiles. May be used on backstop areas where the slope does not positively contain bullets.

impact area – the area behind a backstop bullet trap or shot fall zone directly behind the target where bullets are expected to impact the shotgun pellets land. The term may also refer to the part of the surface danger zone area downrange of an outdoor range where bullets will impact if not intercepted by a backstop.

no-blue-sky rule – jargon that applies to baffled ranges only. It refers to the placement of a series of overhead baffles in such a manner that no "blue sky" can be seen from the firing line.

noise baffle – a sound suppression barrier constructed using sound-absorbing materials. Noise baffles may be designed to either absorb (stop) and/or reflect sound.

pollutant – as defined by the Clean Water Act, "dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions...wrecked or discarded equipment...discharged into the water."

primer – a cartridge ignition component consisting of brass or gilding metal cup, priming mixture, anvil and foil disc, which fires the cartridge when struck with sufficient force.

projectile – an object propelled from a firearm by the force of rapidly burning gases or other means.

safety baffle – vertical or angled barrier to prevent a projectile from traveling into an undesired area or direction. Used to reduce the surface danger zone to prevent bullets from leaving the ranges property between the backstop and berms.

saltation – (geology) the leaping movement of sand or soil particles as they are transported in a fluid medium over an uneven surface.

shot fall zone – the area at a trap, skeet, or sporting clays range on which spent shot falls. The shot fall zone as discussed in this manual should not be confused with the similarly shaped but somewhat larger safety zone.

target line – a line parallel to the firing line along which targets are placed.

APPENDIX C

Comprehensive Template for an Environmental Management Plan

COMPREHENSIVE TEMPLATE FOR AN ENVIRONMENTAL MANAGEMENT PLAN

1.0 Introduction

The XYZ Club, Inc. is located at 123 X Road in Blanktown, Florida…

1.1 Mission Statement

The XYZ Club, Inc. is committed to…

1.2 Purpose

The purpose of this Environmental Stewardship Plan (i.e., the Plan) is to:

- identify issues of potential environmental concern that may exist;
- identify, evaluate, and prioritize appropriate actions to manage these issues;
- list short- and long-term action items and the steps needed for implementation;
- develop and implementation schedule;
- identify ways to measure the Plan's success; and
- annually evaluate the progress made towards achieving our environmental stewardship goals; etc.

1.3 Goals

- Avoid shooting over and into water and wetlands.
- Prevent off-site migration of lead through groundwater and surface water runoff.
- Conduct lead recovery.
- Discourage ingestion of lead by wildlife.
- Maintain soil pH between 6.5 and 8.5 in the shot fall zone.

2.0 Site Assessment

2.1 Description of Ranges and Support Facilities

The XYZ Club has an x position Trap Range, a y position Skeet Range, a z position Sporting Clays Course, and a q position Small Arms Range. These ranges are located in a rural setting and are oriented away from residential areas and surface water bodies.

[Briefly describe each range, its dimensions, orientation, vegetative cover, numbers of shooters and targets used per year, wildlife usage, etc.]

2.2 Existing Environmental Conditions

[Describe the most significant environmental issues associated with the ranges. Refer to figures, tables, the results of surveys, inspections, professional opinions, etc.]

2.2.1 Trap and Skeet Fields

2.2.2 Sporting Clays Course

2.2.3 Rifle and Black Powder Range(s)

2.2.4 Outdoor Handgun Range(s)

3.0 Trap (and) Skeet Field(s)

3.1 Action Plan

3.1.1 Potential Management Alternatives

Alternative 1: Achieve all of the environmental goals identified simultaneously.

Alternative 2: Work on one goal this year and address all other later.

Alternative 3: Choose a few goals that can be implemented immediately and begin planning longer-term alternatives.

Alternative 4: Vegetate sparse grass area of trap/skeet field.

Alternative 5: Reorient trap field to avoid lead shot entering wetlands.

Alternative 6: Reorient sporting clays stations to maximize the overlap of falling shot into the open field where it can be more easily recovered for recycling.
Alternative 7: Limit use of the trap/skeet range to only those stations that do not have wetland area within the shot fall zone.
Alternative 8: Apply lime to shot fall zones if soil test results indicate this step would be beneficial.
Alternative 9: Prepare fields for lead reclamation.
Alternative 10: Get bids for lead reclamation project.
Alternative 11: Conduct lead reclamation within the trap/skeet shot fall zones.
Alternative 12: Conduct lead reclamation within the berm of the small arms range.
Alternative 13: Conduct lead reclamation within the sporting clays shot fall zone.
Alternative 14: Change mowing frequency to closely mow grass in shot fall zones.
Alternative 15: Construct lean-tos at backstop berms.
Alternative 16: Construct a lime lined drainage swale for storm water management.
Alternative 17: List additional Best Management Practices that may be appropriate to your club.

3.1.2 Selection of Management Alternatives to be Implemented

[Describe the process by which the above alternatives will be, or were, selected (incorporate range managers, the membership, and outside consultants as applicable).]

3.1.3 Alternatives Selected

Based on the stewardship goals of the Plan, the benefits provided, and the current availability of funds, the following priorities were chosen for the current calendar year.
Alternative x:
Alternative y:
Alternative z:
These choices were made to address the most pressing concerns and the most easily resolved issues and to initiate management practices that would create longer-term environmental benefits. In order to achieve the goals of the Plan, the following actions are necessary.
a) Management Actions: [assign personnel responsible for initiating, conducting, and completing the alternatives selected above.]
b) Operational Actions: [collect soil samples for pH analysis, consult with USDA’s Natural Resources Conservation Service and/or the county Cooperative Extension Service regarding best suited vegetative management recommendations.]
c) Construction Actions: [do site preparation work, get bids, institute mowing and vegetative management recommendations, reorient shooting position as appropriate.]

3.2 Plan Implementation

3.2.1 Schedule for Implementation

Winter/Spring: [pH survey, contact local officials for vegetation management recommendations, reorient shooting positions as appropriate, realign shooting positions as appropriate.]
Summer/Fall: [prepare site for reclamation project, apply lime/fertilizer/seed, get bids for berm lean-tos/reclamation. As a rule of thumb, 50 pounds of lime per 1,000 square feet should raise soil pH by 1 once the residual acidity is overcome.]

3.2.2 Responsibilities

[i.e.: the trap/skeet chairman/chairmen will… The club treasurer will… The membership will provide the labor to…]

4.0 Rifle, Black Powder, and Outdoor Handgun Range(s)
4.1 Action Plan
4.1.1 Potential Management Alternatives Alternative 1: Achieve all of the environmental goals identified simultaneously. Alternative 2: Work on one goal this year and address all other later. Alternative 3: Choose a few goals that can be implemented immediately and begin planning longer-term alternatives. Alternative 4: Culvert the stream through the shooting ranges. Alternative 5: Vegetate the backstop berm(s) to minimize erosion. Alternative 6: Construct a lime lined drainage swale for storm water management. Alternative 7: Apply lime to the berm and foreground if pH test determines it is necessary. Alternative 9: Begin planning a lead reclamation project. Alternative 10: Change mowing frequency to closely mow grass in shot fall zones. Alternative 11: Construct lean-tos at berms. Alternative 12: List additional Best Management Practices that may be appropriate to your club.
4.1.2 Selection of Management Alternatives to be Implemented [Describe the process by which the above alternatives will be, or were, selected (incorporate club officers, the membership, and outside consultants as applicable).]
4.1.3 Alternatives Selected Based on the stewardship goals of the Plan, the benefits provided, and the current availability of funds, the following priorities were chosen for the current calendar year. Alternative x: Alternative y: Alternative z: These choices were made to address the most pressing concerns and the most easily resolved issues and to initiate management practices that would create longer-term environmental benefits. In order to achieve the goals of the Plan, the following actions are necessary. a) Management Actions: [assign personnel responsible for initiating, conducting, and completing the alternatives selected above.] b) Operational Actions: [collect soil samples for pH analysis, consult with USDA's Natural Resources Conservation Service and/or the county Service Forester regarding best suited vegetative management recommendations.] c) Construction Actions: [do site preparation work, get bids, institute mowing and vegetative management recommendations, reorient shooting position as appropriate.]
4.2 Plan Implementation
4.2.1 Schedule for Implementation Winter/Spring: [pH survey, contact local officials for vegetation management recommendations, reorient shooting positions as appropriate, realign shooting positions as appropriate.] Summer/Fall: [prepare site for reclamation project, apply lime/fertilizer/seed, get bids for berm lean-tos/reclamation.]
4.2.2 Responsibilities [i.e.: the small arms range chairman/chairmen will… The club treasurer will… The membership will provide the labor to…]

5.0 Sporting Clays Course

5.1 Action Plan

5.1.1 Potential Management Alternatives

5.1.2 Selection of Management Alternatives to be Implemented

5.1.3 Alternatives Selected

5.2 Plan Implementation

5.2.1 Schedule for Implementation

5.2.2 Responsibilities

6.0 Measuring Success (to refer to the document for the type of activities used to measure success, so that the EMP could be tailored to specific range conditions) By monitoring the impact or success of the Plan, the club is best prepared to make whatever changes may be necessary to reinforce success and make the most of environmental stewardship efforts.

6.1 Vegetation

[The density of vegetation growth should be measured throughout the growing season, especially in areas of sparse growth where steps have been taken to increase the vegetative cover. This is can be done by taking periodic photographs (e.g., once a month) from the same places to document the impact of the Plan.]

6.2 Wildlife

[Keep a log of visual observations made regarding the frequency of range usage by the variety of species in your area.]

6.3 Soil and Runoff pH

[Track soil and runoff pH through semiannual monitoring and adjust the amount of lime applied to different areas of the range to maintain a pH level that will prevent lead from dissolving (i.e., a pH of 6.5–8.5).]

6.4 Erosion

[Again, keeping a photographic record of problem areas best prepares your club to document achievements and adjust the Plan as appropriate.]

7.0 Plan Review and Revisions

Continue to monitor the environment and review the Plan on an annual basis. Update the Plan as needed and set goals for subsequent years. Make recommendations for future club officers to consider when updating the Plan and in setting goals (tell them what worked, what didn't work, and what still needs to be done).

FIGURES

[Insert site location map here] Typically, a site location map is cut from a USGS topographic map of the club's area. The club should be centered on the map. Indicate the property boundaries and layout of the range.

[Insert other figures as necessary to support the text] Other figures may include an aerial photograph, and sketches of the club property in general and/or specific ranges in particular.

Example:

Appendix A

Information from USDA, Natural Resources Conservation Service [and/or county Cooperative Extension Service] [concerning soil and vegetation management recommendations]

Appendix B (etc.)
[For other supporting documentation as needed.]

APPENDIX C
Record Keeping

APPENDIX D

RECORD-KEEPING AND EVALUATION

Evaluation of the success of an Environmental Stewardship Plan should occur one or more times per year. Keeping the Plan current will help the range make midcourse corrections where necessary and document the results from the previous year's initiatives. The focus of the evaluation should be to determine whether the Environmental Stewardship Plan has been implemented as intended, the problems (if any) encountered, and what types of adjustments should be made to the plan for the future. In addition, it will be useful to monitor the environmental benefits that have resulted from implementation of management and engineering actions. This will demonstrate the effectiveness of the actions that have been taken. Just as with other aspects of business, record-keeping is essential for evaluation of the Environmental Stewardship Plan. Typical records that may be useful in evaluating the effectiveness of a plan may include:

- Range "inspections" by range manager.
- Photographs of preexisting conditions versus conditions after environmental improvements have been implemented ("before" and "after" photographs).
- Log of actual implementation dates, problems addressed, associated costs, conditions, problems encountered and follow-up actions.
- Frequency of changed operational practices (i.e., mowing on poorly vegetated soils) and observed results.
- Comparison of changes in operational costs related to changed procedures; and
- Frequency and type of environmentally related complaints from customers or the public.

Quantitative measurement of environmental improvements will most likely be beyond the capabilities of range operators and need not be sought unless they are necessary to support legal proceedings. In these cases, support from outside consultants may be in order. Local universities or nonprofit groups with an environmental research interest may also represent a viable source of assistance. Examples of record-keeping forms and logs are included below.

DOCUMENT IMPORTANT INFORMATION FOR EACH PLANNED IMPROVEMENT:
FACILITY NAME:____________________
Lime and Phosphate Addition Form
Date:__________ Employee_____________
Time:__________
Type of Lime:____
Source of Lime:____
Type of Soil Amendment:____
Source of Soil Amendment:____
Firing Lane Location of Lime Addition:
____
____
____
____
Amount of Lime Added at each Firing Lane:
____
____
____

____
Firing Lane Location of Soil Amendment:
____
____
____
____
Amount of Soil Amendment Added at each Firing Lane:
____
____
____
____
Notes:____
____
pH Testing Form
Year______
Date Method Firing Lane No. pH Action Taken
Range Log for each Firing Lane
Firing Lane__________
Date Organization Ammunition Type Rounds Fired
Total

APPENDIX D

Response to Comments

RESPONSE TO COMMENTS

Section 1.2, Para. 2, Sent. 1—Should EMP be a part of the overall Range Management Plan?

> **See Section 4, paragraph 3 states "A plan to listen to the concerns of neighbors provides an opportunity to discuss both the safety and environmental programs incorporated into the operating plans for the range."**

Installations should probably consider these practices in designing ranges and in developing their site-specific environmental management system (EMS). However, there may be good reasons why whether there is any substantial risk. As an example, the decision tree for the management plan on page 57 does not address the "no action" alternative if there are no real issues.

> **No further action has been included in the decision tree, which is now Figure 2-1. After considering all of the potential environmental issues, if there is nothing that potentially presents a risk, then no further action can be chosen.**

Section 2.0—The lead pathway and fate in the environment discussion is presented in both Sections 2 and 4.2. This seems redundant.

> **It is redundant in concept, but it is appropriate in both since the introduction explains overall fate and transport as it relates to exposure and Chapter 4 addresses fate and transport as it relates to specific environmental characteristics.**

Pages 11–14: These two pages discuss the distribution of shot at trap and skeet ranges. There are a couple of statements that should be verified. First that maximum shot fall is directly related to elevation above sea level. I do not think this has as much effect as indicated. Second, the assumption that normal skeet loads do not travel as far as trap loads. I think this is an erroneous assumption. The maximum shot fall distances need to be clarified with the following variables in mind. Maximum shot distance will be based on shot size, powder load, gun barrel length, gun choke, vertical angle the shot was fired, and local terrain. I do not believe normal trap and skeet loads differ as much as indicated. Also, most trap and skeet shooters reload their own shells. Shot distance should come from published ballistic tables, including reloading manuals. I also think they will be the same for trap and skeet.

> **Shot distance has come from published ballistic tables and verified by SAAMI.**

Section 2.1.3, Para. 3—Expand this section by providing additional guidance such as: "Recommend posting a simple placard at the range noting potential presence of lead and recommendations to avoid eating in the area and to wash hands and face following working or shooting at the range."

> **Accepted.**

Section 2.1.3, Para. 3—Expand this section by providing additional guidance such as: "Medical surveillance (periodic blood lead levels) should only be considered for those where measured environmental lead levels in conjunction with sufficient exposure would lead to predictable elevated blood lead levels in a chronically exposed member. Industrial hygienists as needed can quantify lead exposures. Intermittent users should not be in a medical surveillance program. The OSHA-mandated lead surveillance program is not an incidental program and medical surveillance for lead should not be taken lightly. Placing personnel in lead surveillance without performing appropriate environmental lead monitoring is a frequent and costly mistake."

> **The team will revisit the wording around the medical surveillance issue; however, this specific wording was rejected by the team because the reference to OSHA and associated citations are more accurate. The recommended language may lead to an inaccurate interpretation by range operators that blood lead testing is a broad recommendation. We have many levels of environmental sophistication on small arms firing ranges and this type of detail could confuse and alienate the reader, thus jeopardizing the useful nature of the overall document.**

Sections 2.2 and 3.5 depict the use of bullet containment traps to assist in lead recovery. Note that the use of hard bullet traps increases ricochet and usually requires the need to increase the surface danger zone for the range. This should be considered prior to installation of a hard trap on an outdoor range. Similar ricochet concerns exist with the baffled ranges also depicted. Consider for development of BMPs.

> **Language and additional examples of bullet traps have been included.**

Section 2.4, Para. 2, Sent. 1 and 2—Change second paragraph to: "The sound at the muzzle of a shotgun firing a typical clay-shooting cartridge reaches some 140-150 decibels (dB). For comparison, normal speech is around 50-60 dBA (A = weighted scale to approximate human hearing for steady state noise) and clapping hands up to around 80 dB. Sound levels above 140 dB for many people become painful."

Accepted.

In April 2000, President Clinton signed Executive Order (EO) 13148 "Greening the Government through Leadership in Environmental Management" that established a five-year Environmental Management System (EMS) implementation goal for all Federal Facilities. EO 13148 requires an EMS at all appropriate federal facilities by December 31, 2005. Developing and implementing an EMS is required at all Army installations. Evaluating and resolving environmental concerns associated with small arms ranges would be subject to the installation EMS.

Additional steps, even more protective than the recommendations suggested in the ITRC document, do not necessarily conflict.

The International Organization for Standardization developed the ISO-14001 standard to provide a set of internationally recognized criteria for EMSs. The Army has chosen to use the ISO-14001 standard as a model for implementing EMSs at Army installations.

No conflicts with ISO-14001 in the document.

Section 3.3—Throughout the document, alternative non-lead ammunition is mentioned as an available management technique. Section 3.3 specifically mentions frangible type of projectile. Environmental impact considerations for long-term use of frangible projectiles include the release of copper and the inability to recover intact projectiles in the environment. Frangible ammunition does work well in indoor ranges with containment bullet stops. Consider including this discussion on environmental impacts of frangible projectiles.

This section has been revised accordingly.

Section 3.4.2, Para. 5—How does an earthen berm reduce lead mobility? Adding more soil to a berm does not alter the transport characteristics of lead. The conductivity of the soil and/or ground has to be reduced to slow transport via leaching to ground water. Surface runoff is another problem all together. Consider clarifying this idea.

The term "mobility" has been replaced by the phrase "solute transport." A berm slope can redirect rain water, thereby reducing percolation. The berm concentrates the shot, thereby allowing recovery and recycling, and the shot is now separated from the groundwater table by nearly the thickness of the berm. Solute transport must migrate through the berm material below as well as the soils, sand, or rock above the water table.

Section 3.6 (page 33 lead recovery techniques)—"It should be noted that to ensure that lead is not considered "discarded" or "abandoned" on your range within the meaning of the RCRA statute, periodic lead management activities should be planned for and conducted." The foregoing is contrary to the Munitions Rule, and this statement should be modified or deleted.

There is no contradiction because the Range Rule is incomplete.

Section 3.6.1.1, (Page 34)—While sifting for lead shot appears to be the best method, it may prove to be too difficult. The soil will have to be broken up into very fine particles. Clarify, elaborate?

Crushing is a possibility that must obviously be factored into the cost of the operation.

Section 3.7.1, Pg. 37, Last Para., Last Sent.—Be careful with use of the word "treatment." This has very definite RCRA/CERCLA meaning.

The term "treatment" has been removed. It add little to the statement since stabilization is discussed earlier in the text.

Page 16, Clay Targets—I have read on clay target boxes that they are toxic or may be harmful to swine. This may need to be clarified.

The language in Section 3.11.2 has been clarified regarding the findings of Baer et al. in the 1995 report.

Section 4.0—Environmental Management Planning. DoD recommends that consideration be given to moving this section to the front. Doing so might help to give the message clearly that one sets up an EMS, does an assessment, etc., first. Then, the document could offer some practical alternatives. Perhaps even all the technical alternatives could be an appendix, while the other materials could be the main part of the document?

The team has considered this in the past and feels it is important to build a foundation of knowledge and understanding before performing the task. The team has modified Figure 1-1.

Recommend deleting Appendix B, captioned "Environmental Law and Regulations," in its entirety. If it is to remain in the document, DoD believes that a much higher level of legal review would be required, potentially the DoD Office of General Counsel, as several of the specific paragraphs make broad statements of jurisdictional applicability that in fact may be counter to DoD positions in pending litigation and elsewhere. A few specific problems with Appendix B are shown in succeeding comments and recommendations.

This section (Appendix B) has been removed.

The Army has developed *The Army Training Range Aspect and Impact Methodology* to support and be an integral component of the installation-wide EMS. It provides appropriate, range-specific guidance on completing the assessment of environmental aspects and impacts (environmental exposures), and provides criteria to help characterize their relative significance. The methodology ensures that the installation's EMS addresses range environmental issues while focusing on its mission priorities. The systematic identification of potentially significant environmental aspects provides the basis for setting environmental objectives and performance standards, and for structuring the Army's environmental management programs, operational controls and other system components that are necessary for the orderly, complete and reliable management of significant environmental exposures associated with the operation of its small arms ranges. The guidance titled "Aspect and Impact Methodology for Army Training Ranges" can be found at www.denix.gov.

Thank you for the suggestion.

The document can serve as a guide for management and operators of small arms ranges to consider for the sustainability of their ranges. However, there is serious concern that endorsement by the Army or DoD might be construed to mean that these practices should or will be implemented at all ranges. Many factors are involved in the decision process for implementation as each site has specific characteristics that need to be considered. It may be inappropriate to implement these practices at ranges where the risks are relatively small. Additionally implementation will require a substantial increase in funding and could impact readiness.

We hope to alleviate some of these fears through the disclaimer.

Tracer ammunition is often fired on military small arms ranges. To a lesser extent, incendiary ammunition is sometimes fired. Both types of ammunition are prone to starting range fires which could have a detrimental impact on vegetation and sensitive wildlife.

Good point and applicable to more than simply military ranges. The team will add language to note this type of ammunition.

Some established small arms ranges were used in the past for other than small arms firing. They may contain dangerous UXO (40MM grenade duds for example), which might have an effect on current range maintenance.

Indeed this is a concern, and all military ranges should evaluate the history of their range before any activity is conducted on the site.

This is a superb document, which obviously reflects well upon the knowledge of the authors, reviewers and team members. It is also a much needed document due to the general lack of knowledge on the part of state and federal regulators, the shooting public, the military and law enforcement regarding the environmental and health consequences related to small arms ranges. While range safety precepts have been developed for many decades, environmental challenges may not be so well understood. The content and format of the document addresses the major environmental and health concerns very well.

Thank you.

1.0 Introduction First paragraph first sentence—I would add law enforcement after military, separating it from government environmental agencies, since they are a major segment of the shooting community.

Change accepted.

1.0 Introduction Third paragraph second sentence—Why is non-exploding here and does that includes tracers and incendiary? Obviously most small arms ammo is non-exploding, however some military 50 cal may be exploding or incendiary and others may be tracer. The growth of 50 cal sporting rifles and use of surplus military ammo may introduce some of these ammo types to civilian ranges.

We are covering only "most" ammo. We are not covering incendiary or tracer rounds. This scope has been clarified in the document.

1.1 Problem Statement Second paragraph second sentence—I would eliminate the reference to "Soviet" ammunition as fulminate of mercury is common in older ammunition of any country of origin and some modern percussion caps.

Agreed. It has been removed.

1.1 Problem Statement, Fourth paragraph second sentence—This statement seems misleading to me. Most states have a resource conservation and Recovery Act (RCRA) equivalent, which covers ranges as generators of hazardous waste (i.e. lead, whether it is released into the environment or not. For those states, which do not have a RCRA equivalent statute, EPA will regulate the ranges under RCRA. The fact that most states statutes probably do not specifically mention ranges is of no moment.

If the range is not a generator of "waste," RCRA does not apply until a waste is generated above conditionally exempt amount. If there is no documented release, the Clean Water Act does not require corrective measure, and RCRA cannot require corrective action. The document now contains the following statement, "Lead is not considered a hazardous waste subject to RCRA at the time it is discharged from a firearm because it is used for its intended purpose. As such, shooting lead shot (or bullets) may not be regulated nor is a RCRA permit required to operate a shooting range."

2.0 Potential Environmental Issues at Ranges Table 2-1—Add Antimony Sulfide from 5% to 30% is used in most primer compounds" Add, "Bismuth is used for lead shot replacement."

Accepted. Done.

2.0 Potential Environmental Issues at Ranges Page 7—Add two questions. "Are there animals or birds that feed on the ranges when not is use?" "What is the pH of the rain?" (Acid rain causes the lead bullets or shot to form lead oxide, which dramatically increases transport.)

Animals and birds on the site are defined by habitat. The last bullet identifies water or wetlands as the habitat that would attract waterfowl and thereby expose them to lead if lead is deposited in the habitat. Establishing the pH of the soil better defines the capacity of the soil and soil moisture to stabilize the lead in the soil. The pH of the rain may contribute although it may also be buffered by limestone ($CaCO_3$) in the soil. Soil pH is a more direct measurement than rain.

2.0 Potential Environmental Issues at Ranges Last Paragraph last sentence page 7—I would eliminate, "The user is cautioned that…" The caution seems to relate to the second phrase, i.e. that cleanup sampling is more detailed and requires a larger scale that confirmatory sampling. If the caution is necessary, consider rearranging the sentence.

The team feels that we must reinforce a distinction between cleanup of closed ranges and limited investigations to understand the range environment, including pathways. The caution is warranted, and the suggestion is rejected.

2.0 Potential Environmental Issues at Ranges Third Bullet page 10—Add, Copper from jackets or cores and tin from lead alloys can act as an herbicide, reducing the vegetative cover and allowing more erosion.

Language added.

2.3.1 Human Health and Exposure, First paragraph, Third sentence, page 11—Add, Lead can also have serious effects on adults who drink alcoholic beverages due to a synergistic effect. Suicidal tendencies and gray looking skin are warning signs of lead poisoning.

The following language has been added. "This manual does not cover many of the serious health effects caused by exposures to lead and lead poisoning, and the reader is encouraged to access other sources of more detailed information on those subjects."

2.3.1 Human Health and Exposure, Second paragraph, first sentence, page 11—Change to read. "Exposure to lead at outdoor shooting ranges can occur by three main pathways: Inhalation and incidental ingestion and drinking water. Many ranges are in rural areas where people use well water. In sandy areas, heavy metals can easily migrate down 400 feet or more and reach many drinking water aquifers.

Since "drinking water contaminated by lead" is an example of incidental ingestion, not another pathway, the phrase has not been added.

2.3.1 Human Health and Exposure, First partial paragraph, page 12—Add, Windblown lead dust can stick to lips and licking lips can also cause substantial ingestions, particularly in dry and hot areas. For Ranges which provide firearms and or cleaning facilities, solvents used to remove lead from bores present another human and environmental exposure pathway.

The team does not feel we need to go into this level of detail. At the end of paragraph 2 on page 12 the following has been added at the end of the final sentence: "and is a good reference for any personal protective equipment recommendations."

2.3.1 Human Health and Exposure, Third paragraph, page 12—Add "Range workers (and frequent shooters) should be particularly alert to other potential lead exposure in their routines, such as gardening near roadways, lead paint or soldered pipes in their houses and work that involves soldering, casting bullets or sinkers. The lead body burden is cumulative."

The following language has been added: "This document is intended to address the minimization of potential exposures to lead associated with shooting ranges. It is not a general discussion of health effects stemming from exposures to lead, nor is it intended as a manual on range safety. The reader is encouraged to access other sources of more detailed information on those subjects."

2.1.4 Lead in Plants and Crops, First partial paragraph, page 13—Add, "Some plants have been bioengineered to hyper-accumulate lead and could be planted on ranges. Mowing these plants periodically can remove large amounts of lead."

Plant accumulation requires dissolution of the lead. This might be a sensitive balance to prevent lead from continuing to the water table. It might be particularly dangerous in areas where the water table is very close to the surface.

2.5 Shooting Sound Suggest at the end of the section—The lower the frequency noise of a muzzle blast strikes the hair cells in the cochlea at a particular location. Without hearing protection these hairs will be damaged over time. These hairs are connected to the nerves that transmit sound to the brain. Muzzle brakes often worsen the effect by directing some of the blast (and attending noise) rearward toward the shooter and sometimes sideways toward the next shooter. The damage to the hair cells in the cochlea will eventually cause deafness for the particular frequency. That frequency often corresponds to the frequency heard in some consonant and may produce a type of deafness that makes it difficult to hear speech, while higher pitched sounds can still be heard clearly.

Interesting; however, not part of this document. We don't want to minimize the importance of hearing protection; however, we have had to draw some limits. Thank you for the comment.

3.0 Best Management Practices, First paragraph, First sentence—I believe the least expensive and only way to control metal (lead) migration on shotgun ranges is to use steel shot. There is no appreciable difference, since there will be no competitive differences and steel shot is cheaper. Modern bores can handle steel shot and modern plastic cup wads protect all bores with the lighter skeet loads. In parts of the country with acid rain (Now most of the country) lead will rapidly migrate into groundwater and/or surface water. In arid regions, wind will cause abrading of lead shot and migration of lead dust. This there is no effective way to prevent lead migration from shotgun ranges. Therefore, I would exclude shotgun ranges and rewrite the first sentence to relate only to rifle/pistol ranges.

Some differ in their evaluation of steel and other alternative shot material. We leave it to the operator to exercise appropriate management techniques.

3.0 Best Management Practices, Third bullet—Add, "Some fertilizers contain arsenic which may add to the heavy metal contamination."

This should be a consideration when adding fertilizer to any media, not specifically ranges.

3.0 Best Management Practices, Fourth bullet—Add, "Carefully check berm for rocks, which may cause ricochets." This is noted on page 32.

Change accepted.

3.2 Alternative Shot Material, First paragraph, Third sentence, page 25—I disagree with this sentence, "For shooting clay targets, there is no current ideal replacement in terms of cost and performance." The only realistic disadvantage with using steel shot is comparing a record of 999 out of 1,000 targets set with lead shot to 993 out of 1,000 with steel shot. In other words, while there might be some disadvantage for clays at 35+ yards, all shooters have the same disadvantage. Since we're not dealing with cripples as in a hunting ban on lead shot, I don't think the team should parse the issue.

The comment is well taken. We have changed the text "ideal" to "perfect."

3.5.2 Berm Construction and Maintenance, First partial paragraph, page 33—Add, "natural hills are formed by surface water flow (or perhaps wind) and may have to be managed more carefully."

Hills are the result of erosion. This does not necessarily mean erosion is still active and will unnecessarily transport lead. Slopes are the issue of control regardless of their development.

3.6.1.1 Sifting and Raking—I do not see that raking would be an effective shot recovery technique on ranges covered with vegetative cover such as grasses. Is this realistic? I would add a section on vacuuming, which seems to be a far better alternative.

Sifting may involve shoveling material from the surface. Raking may not mean the traditional garden rake. It is realistic on smaller ranges. See Section 3.15 for vacuuming case study.

3.7 Stabilization of lead shot and bullets in the soils—Where the method chosen is to continue to allow lead shot and the BMP selected is to stabilize the lead in the soil, the deed should be annotated to prevent incompatible future use such as farming or housing, that could open an exposure pathway.

That is a function of a closed range. Abandoned lead at a closing range will be subject to waste generation and disposal requirements. See SMART-1, *Characterization and Remediation of Soils at Closed Small Arms Firing Ranges* (ITRC 2003a, www.itrcweb.org).

3.9 Vegetative Cover Fourth paragraph—Plants such as marigolds which contain insecticide, will deter insects from eating the vegetative cover and thereby ingesting lead which can escalate up the food chain.

Thank you for the suggestion. Many plants can act as natural barriers to pests.

3.10 Management Alternatives for Erosion—Two additional thoughts. We used coconut fiber logs to control erosion at an old range, with good success. Second, where the berm is manmade, placing it in a direction so that the backside is toward the prevailing bad weather (wind direction) can be helpful.

Thank you. Range orientation is an important management practices.

3.11.1 Cartridge Cases and Wads—Plastic wads, which form shot cups (most commercial ammunition), chafe off a considerable amount of lead from the shot. This is readily observable on the white plastic cups as black or gray spots. This lead dust is easily washed off by rain. Therefore, a second reason exists to clean the litter.

This is true. Even though this may not cause the soils to fail leach tests, they are an easily controllable source of some lead on the range. "These should be collected and containerized to prevent migration and potential exposure."

Population density—During deliberations in deciding a small range (now a park) cleanup in southeast DC, a risk assessment found that children playing in the park would only increase their blood levels by 3. The clinical standard for plumbism is 10 u/dl, therefore the responsible party advocated that cleanup wasn't necessary. A survey of the blood lead levels of surrounding children found that 10% had blood lead levels >7u/dl, thus playing on the range would add enough body burden to give them a lead poisoning, supporting a clean up decision. If a range were in an area of heavy lead exposure for animals or man, such as downwind from a smelter, then the additional body burden should be considered in deciding BMPs.

The following language has been added in several locations in the document to refer the reader to more in-depth information on consequences of lead exposure: "This document is intended to address the minimization of potential exposures to lead associated with shooting ranges. It is not a general discussion

of health effects stemming from exposures to lead, nor is it intended as a manual on range safety. The reader is encouraged to access other sources of more detailed information on those subjects."

Video Practice ranges—Law enforcement and the military might consider virtual reality ranges for much of their shooting practice, just like pilots train in simulators.

Thank you.

Toxic Table—List toxics issues with other range metals contaminants such as tungsten, epoxy, arsenic, antimony, etc. While lead is the current culprit, we don't want to replace it with something worse.

Correct. All metals must be managed in the amounts most commonly used at ranges to prevent problems. See last sentence in Section 1.1.

Unburned explosive residues are a big issue on artillery and bombing ranges. The Massachusetts Military Reservation Range has contaminated many of the wells in Cape Cod with explosive residue. For reasons unknown to me, shells which detonate properly often leave large chunks of undetonated explosive behind. Small arm ammo also leaves behind unburned powder. One can actually see the unburned powder cleaning a shotgun or 22. Many double-based powders are nitroglycerine and nitrocellulose. Some of these residues are toxic and more importantly water soluble. This might be another area to consider.

Appropriate text/edits made to reflect your concerns.

Size and amount of firing at a range—The shooting club ranges used two weeks before hunting season to sight in rifles is a far different scenario from military ranges which fires 10,000 rounds a day. Perhaps some distinction should be made with respect to BMPs.

The following has been added at the end of Section 3.1: "It should noted that range use (shooting regularity, intensity, etc.) has an effect on the environmental management of a facility. Many things are range specific according to use."

Use of smaller caliber ammo or lighter weight bullets—Perhaps smaller gauge shotguns (410-28) could be used on shotgun ranges, particularly those ranges that supply the guns. Using 120 grain bullets instead of 180 grain bullets would reduce the heavy metal contamination at a ranges by 30%.

We understand the concept; however, smaller caliber and smaller bullet size have other consequences also. 410 have a higher wound rate. Smaller projectiles may have a higher velocity, resulting in fragmentation, deeper penetration in berms, higher ricochet, etc.

Smaller gauge shotguns (410-28) also reduce sound. Also most ranges are fenced in to prevent kids, etc. from wandering onto the range by accident (either drawn by the shooting or entering before opening time) ivy (grapes, mile and minute etc.) can be planted on the fence to reduce the noise.

We do not think we should to go into what guns to use. Plantings are not an effective range control practice.

Page 20—Section on Cartridge and Wads at the top of the page is a duplication of information found at the bottom of page 19.

Correction completed.

...very useful document. I found it very informative. Congratulations to you and your team.

Thank you.

We would like to review the regulatory section of the document when it is completed.

There is no regulatory section in this document simply because the operation of a firing range is not overseen by any regulatory authority unless (1) it generates a waste and transports it off site or (2) there is a documented release to the environment. The team supports a voluntary program to reduce and prevent pollution using this guide.

The Illinois EPA did not fully agree with ITRC's earlier guidance document on the characterization and remediation of soils at small arms ranges because it did not include regulatory flexibility for individual states. We recommend that the ITRC take our previous comments regarding the need for regulatory flexibility into account when they form the section on regulatory compliance.

The team supports a voluntary program to reduce and prevent pollution using this guide, but states can choose other approaches to assure environmental protection at ranges.)

Executive Summary—The opening paragraph emphasizes the potential for migration of contaminants off-site; however, there is no discussion of the direct contact impact (i.e., inhalation and ingestion exposure) to humans using the operating firing range. This omission is repeated throughout the text. The human health exposure pathway should be mentioned as of equal concern when developing an Environmental Management Plan (EMP).

The following has been added to the Executive Summary at the end of Paragraph 1: "This document is intended to address the minimization of potential exposures to lead associated with shooting ranges. It is not a general discussion of health effects stemming from exposures to lead, nor is it intended to be a manual on range safety. The reader is encouraged to access other sources of more detailed information on these subjects."

Section 2.0: Potential Environmental Issues at Ranges, Figure 2-1, Decision Tree—There is no pathway presented for considering direct contact to humans using the operating range. This should likely take preference over wildlife, and therefore, a diamond before "Is Wildlife an Issue?" should be included to reflect the discussion presented in Section 2.1.3. The dust/air quality issue should be placed under the direct contact to humans.

Immediate or acute exposure is not depicted as are chronic or long-term exposure in the diagram.

Section 2.1.6: Wildlife and Habitat Concerns. Section 2.0—Makes an abrupt transition from discussing general issues associated with fate and transport to a discussion of lead. It has been found that copper may be a risk driver for water fowl where lead shot enters surface water. In addition, arsenic may be a problem in impacted soil. A small discussion of these other contaminants should be included. While it should be acknowledged that lead is the primary contaminant of concern, the impression should not be given that if exposure to, and transport of, lead is controlled then all environmental problems will be solved.

Copper has been included as a related metal in earlier sections.

Section 3.6: Metal Recovery Techniques for Berm Maintenance—Since this is an EMP document, it would be beneficial to range operators to have a list of contacts for lead recycling operations, such as a generic web site for lead recycling associations, etc.

Please see the list of references in Chapter 1.

Section 3.6.1.1 Sifting and Raking—The text box in this section indicates that proper personnel protection equipment (PPE) should be used when workers come into contact with lead-impacted soil. However, no discussion is included to the effect of what this protection would entail. A separate subsection within Section 2.0 on PPE would probably be beneficial for a range operator to know (i.e., dust mask, gloves, disposable Tyvek suit, etc.).

The team feels this guidance should not describe what to use, just suggest they contact lead exposure/poisoning prevention sources for details.

Section 3.9: Vegetative Control—At the bottom of page 42, a suggestion is made to contact state wildlife agencies for a list of plants not attractive to wildlife. Are there any websites that provide a comprehensive list of these agencies throughout the U.S., and if so, can it be included within the document? Any outside references would be helpful to range operators in finding the resources needed to design and implement the EMP.

See www.itrcweb.org for a listing of all state Web sites. Each can lead you to related state, county, and federal agencies helpful in this and other areas.

Section 3.15: Emerging Technologies, Sulfur-Based Stabilization Technology, Sulfitech Compound—Please provide a reference for the EPA study cited at the end of page 61.

Adequate supporting testing documentation has not been provided as of this printing and the section has been deleted.

Section 4.2: General Environmental Conditions—Possible copper and arsenic contamination should be briefly mentioned here.

Good point. The following has been added at the end of the section: "Other metals may become the environmental concern at a site and should not be ignored or assumed not to pose a potential problem see Table 2-1."

Section 4.4: Management Plan Development—On Table 4-3, Template for an Environmental Management Plan, it may be prudent to condense Section 3.0 through 5.0 into one section, so that the EMP outline is not too long and daunting. The different range types are discussed in the text, and it should be implicit to the range operators that they will need to develop an action plan and plan implementation for each type of range

The range type is an important function of lead dispersal and should drive much of the investigation. Comment rejected.

Section 2.1.1, Soil Cover—Include the words "and fine-grained sediment" into the first sentence. Add the following sentences, "Organic carbon also reduces oxidized forms of lead into lead sulfides, which are relatively immobile in anoxic environments. Therefore, thicker organic-rich soil covers generally result in lower concentrations of lead in groundwater and pore moisture."

Changes adopted.

Section 2.1.2, Transport—In the "Precipitation" section, include the idea of lead transport through sediments.

Suggested language was adopted to include lead sediment transport.

Section 2.1.6, Wildlife and Habitat Concerns—Add language to recognize the significance of soil ingestion as an impact on terrestrial invertebrates and aquatic benthic organisms.

Suggested language adopted.

Section 3.15, Phytoremediation of Lead-Contaminated Soil—Add the following sentence to the end of "Implications": "Caution must be taken as this technology may result in an increased risk of groundwater contamination from EDTA or increased soluble metals produced via soil acidification."

The suggested sentence has been added.

APPENDIX E

ITRC Contacts, Fact Sheet, and Product List

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