

# The Cost of Cleaning Up Unexploded Ordnance

## How Clean Is Clean?

Since the end of the Cold War, the Department of Defense has closed almost 100 major military bases and many smaller ones. Closed bases are either turned to other governmental purposes at the national, state, or local level, or, in some cases, sold to individuals or companies in the private sector. Regardless of the purpose the land may be put to, these installations must all go through a process of environmental restoration to ensure the safety of the eventual users. This restoration pertains not only to the contamination caused by toxic substances, but also to a hazard unique to military bases: unexploded ordnance (UXO), which occurs when the munitions used in military training or weapons testing do not explode as designed. UXO includes such items as artillery shells, bombs, rockets, hand grenades, and so forth. Clearing the land of UXO is an expensive, time-consuming, and often contentious process. One of the problems contributing to the complexity of UXO remediation is that it is difficult to estimate the costs of clearing the land. Researchers from RAND Arroyo Center explored the issues related to the cost of cleaning up UXO, focusing specifically on how changes in the cleanup protocols affect costs. The results of their research appear in *Unexploded Ordnance Cleanup Costs: Implications of Alternative Protocols*.

### UXO Cleanup Is Controversial

Several organizations play important roles in the UXO cleanup of any installation. The Department of Defense (DoD) and the military services bear the primary responsibility for the cleanup, but the Environmental Protection Agency also has a key role. Equally important are the eventual users of the land and concerned citizens' groups. The process can be quite contentious because of differing opinions on cleanup standards. Unlike air and water pollution, no accepted standard exists for

### Key findings

- No accepted standard exists for clearing unexploded ordnance from closed military bases, so each site must be separately negotiated.
- Depending on the cleanup protocol (depth of clearance, number of metal detector scans), costs can vary widely.
- The budget implications of protocol choice are significant, with costs ranging into billions of dollars.
- Baseline standards need to be established and cost estimation tools need to be improved.

cleaning up UXO. Thus, DoD and the Army take a site-specific approach, which entails negotiating at each site the depth to which the UXO will be cleared and how that will be done. The organizations that have a stake in the process have been unable to agree on a standard depth or cleanup protocol. Some organizations want to clear only the UXO lying on the surface, while others want the land cleared of all UXO down to a depth of several feet.

The technology available for locating UXO aggravates the disagreements. Metal detectors are the only tools available for finding UXO. As their name implies, they detect metal under the ground—any metal. They signal the presence of dud artillery rounds, but they also detect inert pieces of metal, e.g., shrapnel, hubcaps, belt buckles, and rocks with high iron content. Although analysis of the signals can increase the probability of identifying UXO, the only way to know for sure is to dig up the piece of metal. Furthermore,

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the detectors will miss some metal, including UXO, due to the way it sits in the ground or the skill of the individual operator. Typically, contractors initially scan a site to map the locations of buried metal, analyze the data to identify the metal most likely to be UXO, rescan the site, and dig up suspicious items. But because there is some risk that this process will leave UXO behind, not all accept it as sufficient.

### Estimating the Cost of Cleaning Up UXO

Arroyo researchers wanted to explore how changes in UXO cleanup (clearance depth, number of surveys with metal detectors, and amount of excavation) could affect costs. To do so, they used a cost-estimation tool called Remedial Action Cost Engineering Requirements (RACER), a software program widely used across DoD to estimate the cost of environmental remediation activities. Although the model had some shortcomings, the researchers were able to adapt it to do a cost analysis.

The analysis looked at the effects of three protocols on the total cost of cleaning up a 7,000-acre site that used to be a multipurpose training range. Protocol 1, favored by the Army, involves surveying the area with metal detectors and then digging up every metal anomaly to depths of one, two, or four feet.

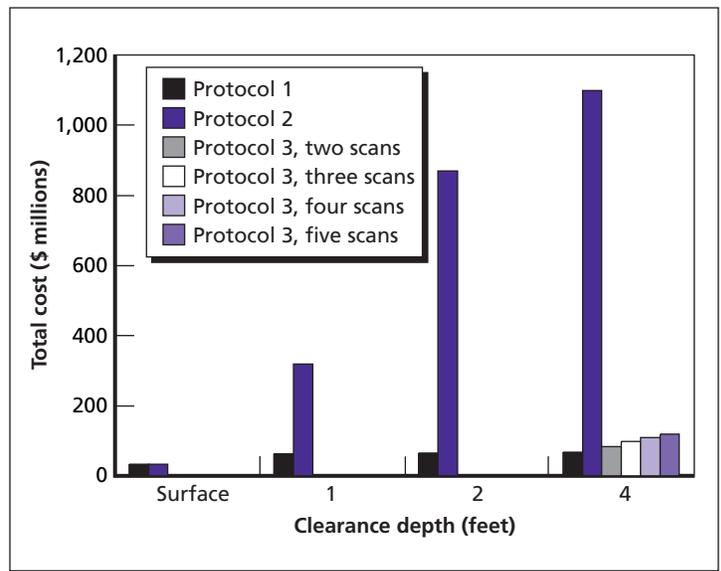
Protocol 2, suggested by officials of the state for areas that will be developed for residential purposes, involves excavating all the soil in affected areas and sifting it to remove any UXO. Under this proposal, the excavation would proceed at one-foot intervals, with a metal detector survey before each excavation. Arroyo cost analysis assumed excavation to a depth of four feet.

Protocol 3 represents a compromise between 1 and 2. It calls for carrying out protocol 1 and then surveying the entire area again with a metal detector to find any UXO missed on the first sweep. More than two surveys might be needed. Some UXO might still be missed because of its size, depth, or orientation, but this process would increase the probability of detection. The cost analysis assumed excavation to a depth of four feet, meaning that search crews would dig down to four feet where UXO was detected.

The figure shows the results of the cost analysis for the various protocols. As can be seen, the cost differences among the alternatives are large. The most expensive alternative (protocol 2, with excavation to four feet) would cost DoD \$1.1 billion if implemented across all of the site. This option is more than 30 times as expensive as the least costly alternative (protocol 1 with surface clearance only), which would cost \$35 million. The compromise approach of conducting multiple searches with metal detectors without completely excavating the soil would cost \$84 million if the entire site were scanned twice and \$120 million if it were scanned five times. The total cost of surveying the entire site five times is about one-tenth that required for the excavation-and-sifting approach. Unfortunately, at present, no quantitative technique exists to determine how much additional risk is reduced by one protocol compared with another, and thus it is not possible to evaluate the relative effectiveness of the three protocols.

The budgetary implications of these findings are significant. For example, the entire budget available in fiscal year 2004 for cleaning

### Cost Differences Among Alternative UXO Cleanup Protocols at Case Study Site



up all types of environmental contamination at all Army installations closed since the end of the Cold War is \$57 million. The cost of cleaning up the site studied in this analysis to any depth below the surface—even using the least costly protocol—exceeds this entire annual budget, which is intended to cover many other installations and kinds of environmental contaminants.

### Recommendations

The cost estimation process needs to improve if DoD is to develop effective plans for cleaning up UXO. Arroyo researchers recommend that DoD take the following steps:

1. Continue efforts to develop a uniform strategy for UXO cleanup cost estimation. A feasible way to reach this goal is to modify RACER's OE [ordnance and explosives] Removal Action Module and to establish a standard way of implementing RACER.
2. Work with contractors to improve RACER's ability to estimate UXO cleanup costs. This improvement would include giving the model additional capabilities such as estimating the cost of searching to different depths, considering how different soil types affect costs, and options for the methods of clearing vegetation (e.g., controlled burn) and excavating (e.g., backhoe).
3. Conduct an exercise to calibrate and validate the modified RACER OE Removal Module. Once initial modifications are completed, the OE Removal Module should be validated by checking it against actual cost data for a variety of different types of UXO sites, applying additional modifications as necessary.

Arroyo researchers also made some recommendations about managing UXO sites. Because no existing technology can guarantee that all UXO has been located, regulators and the military have had difficulty agreeing on what UXO clearance process is sufficient to protect the public. The federal government should prepare a plan for developing baseline UXO clearance standards to end the stalemates that have arisen at many installations among regulators,

community members, and the military. In particular, they recommend that the federal government take the following actions:

1. Designate an executive agency (the Army Corps of Engineers, EPA, or both) to develop baseline standards for UXO clearance. The standards should be tied to future land use and should be flexible enough to accommodate unique situations but broad enough to recognize the many similarities across sites.
2. Establish a publicly accessible database of UXO accidents in the United States. As the database matures, the information it

contains could be used to update UXO clearance standards. The database should include all domestic UXO incidents, both those that involve explosive ordnance disposal contractors and military personnel and those that involve civilians.

3. Consider the funding implications of different choices about “how clean is clean enough” for UXO remediation. Given the many uncertainties in calculating UXO cleanup costs, new studies would be required to assess how different UXO clearance standards affect costs. ■

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This research brief describes work overseen by RAND Arroyo Center and documented in *Unexploded Ordnance Cleanup Costs: Implications of Alternative Protocols*, by Jacqueline MacDonald and Carmen Mendez, MG-244-RC (available at <http://www.rand.org/publications/MG/MG244/>), 2005, 108 pp., \$20.00, ISBN: 0-8330-3774-9. MG-244-RC is also available from RAND Distribution Services (phone: 310.451.7002; toll free: 877.584.8642; or email: [order@rand.org](mailto:order@rand.org)). The RAND Corporation is a nonprofit research organization providing objective analysis and effective solutions that address the challenges facing the public and private sectors around the world. RAND's publications do not necessarily reflect the opinions of its research clients and sponsors. **RAND**® is a registered trademark.

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