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News From the Ordnance Center of Expertise and Design Center

April—June 1999 Vol. 6, No. 2

The ordnance box

by Col. Walter J. Cunningham, Commander, U.S. Army Engineering and Support Center, Huntsville

As penitence for going to graduate school, I was sent to a research laboratory. I was given the responsibility of creating a new research program. If there ever was a time to think outside the box, that was it. One of the things I noticed over time was the tendency to try to fit new requirements into an existing program and then to base our solutions on what we knew how to do—in effect, not thinking outside the box but taking the new problem and stuffing it into the old box. The only thing that was truly left outside the box was the optimal solution.

If, for example, we knew something about concrete, then all our new requirements miraculously had concrete solutions. This was particularly glaring when we tried to come up with mobile overhead cover for airborne units. As I recall, the air dropable concrete pillbox did not get many adherents at Fort Bragg.

> ***"As the risks go up, risk taking goes down. Most people do not think outside the box because they are the box."***

The clearance of unexploded ordnance (UXO) reminds me of my long-ago experience at the lab. There is a tendency to try to put UXO clearance into existing programs and processes. UXO clearance, however, requires its own solutions. Such solutions are outside the existing boxes of other programs. There are obviously similarities that can apply, but the way they must be put together to get anything remotely approaching safe, economical solutions requires us to create a separate program.

For a variety of reasons, various groups try to stuff the UXO clearance into one of two existing boxes. The first is the military operations box; the second is the hazardous waste box. While UXO clearance has aspects of both these boxes, it is a unique problem. If we are to efficiently reduce the risk to the public and protect the workforce, we will need solutions tailored to the UXO problem.

In the military operations box, UXO clearance is treated as a countermine operation. If you ask those involved, they will not see their actions in this light, but as a practical matter, this is what is happening. Much of the research and technology applied to UXO clearance are modifications of previous countermine programs, whether military or naval. However, the two problems are very different. Mines are shallow. They are intentionally deadly. We want very sensitive equipment to pick up every possible trace of the weapon. We want to mark the extent, usually so we can move around it. In some cases, we are attempting to find everything and mark the locations so that we can breach or clear it. There is a premium on finding the mines at a standoff. Speed is critical. The management structures in which the technologies are embedded are by and large tactical elements. Costs are ultimately measured in tactical efficiency and casualties.

Unexploded ordnance clearance is very different. UXO depths vary widely, and they can be very deep, particularly the heaviest and most dangerous. UXO was intended to be XO; its deadliness varies widely. We want discriminating technologies. We need to mark the extent of the UXO hazard, but UXO contamination tends to be larger, less predictable, and more random than mines. Standoff would be nice, but not at a premium. Finding everything that can harm the public is critical. We have the ability to tailor our technical and management processes. Costs are measured in risk reduction to the public and our workforce. Technologies and processes developed and optimized for countermine operations are almost certainly going to be sub-optimized, at best,

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Huntington District partners for success at Dolly Sods

by Kelley Wells, Huntington District

Dolly Sods, in northeastern West Virginia, is a popular hiking, fishing, camping, picnic, and hunting area. Operated by the U.S. Fish and Wildlife Service (USFWS), Dolly Sods is open to the public. An estimated 45,000 to 76,000 people visit Dolly Sods Wilderness annually. The many visitors, however, were not all aware of an unusual danger at the site: unexploded ordnance.

The Dolly Sods ordnance removal project was conceived as a result of a feasibility study in 1991 when ordnance was found in the West Virginia Maneuver Area. The Department of the Army had used the area for mountain training and maneuvers during World War II. Even though the area was searched and cleared by military explosive ordnance disposal teams after the war, at least twenty-one pieces of ordnance have been found in recent years.

Dolly Sods partnering meeting held on 11 May 1998 at the DNR Headquarters in Elkins, WV. Team Members pictured from left to right are Sara Schell, U.S. Forest Service; Mike Gifun, Huntsville Center; Ben Hodges, Human Factors Applications, Inc.; Elizabeth Schuppert, U.S. Forest Service; Wally Dean, Huntington District Corps of Engineers; Jim Rawson, WV Division of Natural Resources; Wren Wilson, Huntington District Corps of Engineers; Dave Wolfarth, Huntington District Corps of Engineers; Steve Hann, Huntington District Corps of Engineers.

Public impact

The clearance project has significantly reduced the amount of ordnance posing a hazard to the public in the most widely used areas. Below are the explosives that were found:

Wilderness Area:

- twelve high-explosive 81-mm mortars
- two high-explosive 60-mm mortars

North Area:

- one high-explosive 60-mm mortar
- one high-explosive 4.2-inch mortar
- six 4.2-inch mortars with FS smoke filler
- nineteen 4.2-inch inert mortars

Historically, at least one accident has occurred at the ordnance site. When Wallace Dean, a current Huntington District employee and team member, was hunting on the site as a young teenager, one of his friends found a live piece of ordnance and picked it up. The ordnance exploded, causing Wallace severe injury to his legs. Now that the cleanup effort has

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if not downright ineffective for UXO clearance.

In the hazardous waste box, UXO appears to be treated like any air or water quality problem. Both industry and government have organizations and processes in place to manage, regulate, and clean up other hazardous waste. Those organizations need to recognize the differences between the UXO clearance and hazardous waste cleanup. There is also common ground that if exploited effectively will ease the UXO burden. From the industry perspective, we need to create organizations that can effectively do and then integrate all the tasks necessary to clear an ordnance-contaminated site efficiently. From the government perspective, we need knowledgeable experts at every level. If, for example, mag and flag is approached like a variant of pump and treat, then we will be reworking the site for decades at exorbitant costs with little reduction in the actual risk to the public. In addition, there must be recognition of the risks to the workers as they clear a site. Dramatically increasing the chance of a tragic accident to eliminate a minor contamination that may have little practical impact on the environment or the health and safety of the public is unconscionable.

It is hard to expand our horizons and think outside our normal experience. This is understandable. Most situations do not manifestly require us to stretch our imaginations. This very human tendency is magnified if the task at hand is dangerous. As the risks go up, risk taking goes down. Most people do not think outside the box because they are the box. At this point in the evolution of the ordnance clearance program, we need to reverse those tendencies. ☐

Site investigator using a magnetometer to find metal-encased UXO at Dolly Sods, which is located in the West Virginia Maneuver Area.

concluded, there are fewer ordnance items at Dolly Sods along the trails most people travel. Their risk of becoming harmed is less.

Working with the community

Community involvement was increased through public meetings, news releases, and radio and newspaper interviews. The Corps of Engineers Huntington District and Huntsville Center team participated in a media day to explain the project actions and answer questions the media and public might have. Also, a public information repository, maintained in the U.S. Forest Service (USFS) office in Elkins, West Virginia, gave the public direct access to project files. Those actions helped maintain a good relationship with the public and provide an open forum for questions.

Partnering in action

Huntington worked to streamline the cleanup process. First, Huntington and Huntsville evaluated the 2.2-million-acre West Virginia Maneuver Area and found that Dolly Sods the was most likely area to contain ordnance posing a threat to the public. Dolly Sods encompasses 10,215 acres within West Virginia Maneuver Area. To decrease risk to the visiting public, 260 of Dolly Sods' most-used acres were cleared, including active trails, campsites, and cabin areas. By limiting clearance to the areas used by the public, costs were contained and environmental impact was limited while risk to the public was reduced.

To further streamline procedures, the Dolly Sods project was divided into two areas, the Wilderness and North Areas. Using the information from the Wilderness Area for reference, Huntington expedited the environmental assessment process through the North Area. This resulted in completion of the North Area removal action at least one year ahead of schedule. In addition, partnerships between Huntington District, the USFWS, USFS, West Virginia Department of Natural Resources, Huntsville Center, and the removal contractor streamlined other processes to improve the efficiency and effectiveness of the removal actions. For example, before the project began, the USFS arranged to mark the trails on which the contractor would be working. As a result, no time was lost between contract start date and the actual start of work.

Also, the presence of a threatened species, the Cheat Mountain salamander, created a dilemma. The work plan required a USFS representative to inspect the area where ordnance was found and move any salamanders to a safe location. However, the USFS office is at least two hours away from the site, and the contractor could not leave the ordnance site unprotected until the unexploded ordnance (UXO) was detonated. Sometimes a guard had to remain overnight, resulting in higher costs. In addition, none of the USFS employees had the OSHA training required to enter an area where ordnance had been located. To solve the problem, the partners decided to train one removal contractor to serve as the USFS representative and assure that the work plan was followed.

Partnering was effective again when the project was immobilized by inclement weather. A partnering meeting was held to discuss expectations and solve any problems before the project remobilized. This allowed for cultural resources training, endangered species training, and team building without additional effect on the schedule. Roles and responsibilities were also defined, enabling a smooth transition into the Dolly Sods North Area removal with everyone supportive of the action. Interagency partnering clearly improved the cleanup effort.

Working together within the Corps

Effective management techniques helped keep the program within schedule and budget. Project management team approval provided an easier flow of communication. Because Huntington was closer to the site, contracting officer representative (COR) authority was move from Huntsville to Huntington. Huntington also provided on-site oversight and monitoring and reported directly to the project manager and COR. The on-site representative also helped identify and solve potential problems to control costs.

Dolly Sods successes will be used to help other clearance projects across the country. A significant aid to the project was the partnering spirit, which lead to cooperation and effective problem solving. Team building exercises helped to strengthen the partnering mentality and establish strong relationships between all those involved. Also, defining the roles and responsibilities of each partner and voicing opinions about those responsibilities ensured that partners knew what was expected. When team roles and responsibilities are well defined, problems caused by poor communication and unanswered expectations decrease while the probability of team success increases. □

A walk in the woods: Pooh and Tigger find UXO together

by Betty Neff, U.S. Army Engineering and Support Center, Huntsville, Engineering Directorate

How can we efficiently locate and evaluate UXO-contaminated areas? Huntsville Center combines two technologies that add up to a winning solution.

No bush hogs, no tractors, no chainsaws—not even a Weedeater. As in the children's story, two companions simply take a quiet walk in the woods. That's one-way site investigators now gather sampling data on heavily vegetated ordnance sites. Say good-bye to grids. Say good-bye to flags. Thanks to improvements in global positioning system (GPS) technology and statistical sampling procedures, Huntsville Center created a new technique called Meandering Path Geophysical Investigations.

Meandering Path eliminates the need to cut vegetation before sampling data are gathered. With up to a third of investigation dollars devoted to vegetation clearance, this technique will save money that can be applied to other ordnance activities, including cleanup at high-priority sites.

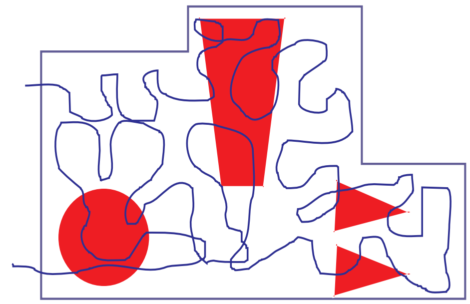
Traditional sampling methods are based on geometric grids that must be cleared of vegetation before investigation can even begin. Site investigators then scan the cleared grids with detection instruments, marking anomalies by hand with flags. Because Meandering Path does not depend on the geometric grid, trees and shrubs are not cut, wildlife is not disturbed, and ecological damage is minimized—all while saving money.

The reason? Advances in GPS software technology mean that satellite locks can be maintained to centimeter accuracy through heavier foliage than previously possible. Therefore, anomaly locations can be recorded under tree cover. Consequently, vegetation does not need to be removed before sampling data are gathered. Use of GPS also eliminates the need for flags, since GPS data generates maps that pinpoint the location of each anomaly and become a permanent record.

What's more, with this method, the traditional 100-by-100-foot grid is gone. Instead of rigid geometric grids, a fluid, "serpentine grid" is used. A safety escort and a geophysicist follow a loosely planned path designed to reduce distances between sample areas and to cover areas suspected of containing UXO. (See figure above.) That two-person team surveys for anomalies by walking a sensor over the equivalent area of a geometric grid. If the investigators come upon a tree or a briar patch, they just go around it, detecting as they go. The change in direction does not affect the randomness of the sampling, since an ordnance item is as likely to be on one side of a briar patch as on another.

Technical advantages for Meandering Path include more efficient sector analysis and better visual representation. When sampling traditional geometrical grids, the large uninvestigated areas between grids can contribute to statistical uncertainty. With Meandering Path, however, that uncertainty is diminished by reducing distance between paths. Predictions, therefore, can be stated with more confidence.

Huntsville Center has always looked for methods to reduce the sampling area while still obtaining adequate data for accurate site characterization. Meandering Path is



The diagram above shows a typical path investigators would follow when characterizing an ordnance site using Meandering Path Geophysical Investigations. A safety escort and a geophysicist collect data along a loosely planned path using new GPS equipment to guide the investigation and locate anomalies. The red areas represent UXO contamination. Meandering Path was developed to reduce the need to clear vegetation from sampling grids. The new process can save up to one third of investigation costs.

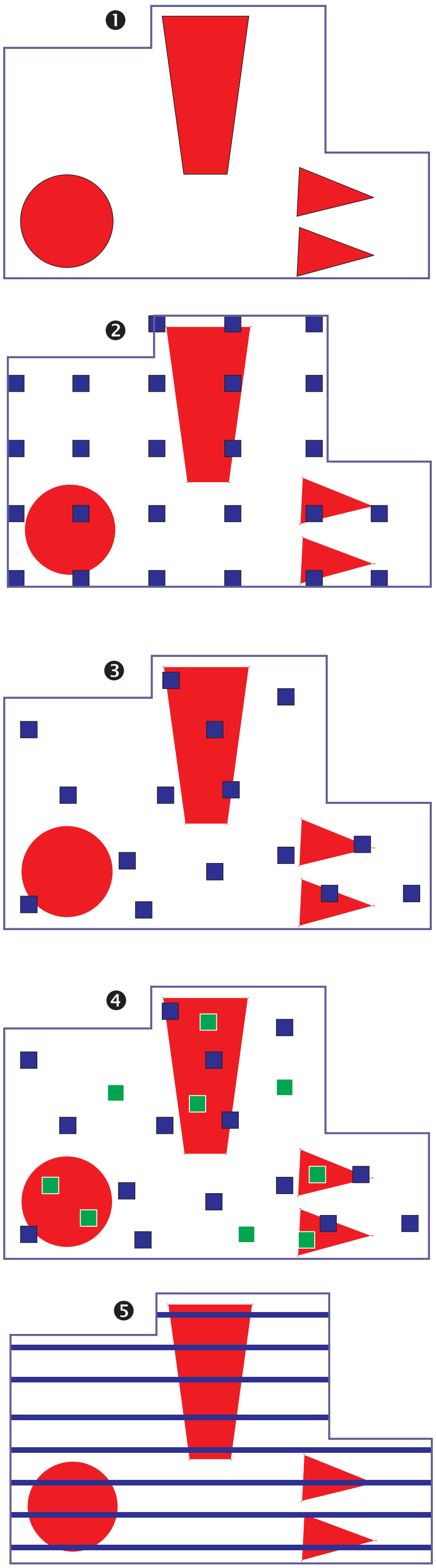
just the latest in a series of site characterization improvements. (See page 5.) Early on, through fixed-pattern sampling, the sample area typically consisted of 10% of the total area.

With the development of ordnance and explosives statistical tools, such as SiteStats/GridStats, site investigators could sample a smaller area with the same statistical accuracy. For example, when combined with statistical analysis, random-pattern sampling and hybrid-grid sampling reduce the sampling area to less than 5%. Still, those techniques may require vegetation clearance in order to access the required sampling areas.

By combining new GPS technology with digital geophysical mapping, Huntsville Center found a method that reduces costs where vegetation is a concern. The Center expects Meandering Path Geophysical Investigations to become a standard approach in the OE site characterization toolbox.

For more information on Meandering Path, contact Roger Young at Roger.Young@hnd01.usace.army.mil. □

Site characterization toolbox grows, improves



Meandering Path Geophysical Investigation (page 4) is the latest site characterization innovation. The diagrams [left] show improvements Huntsville Center has made in sampling techniques over the years. The red areas are UXO contamination; blue squares or strips are sampling areas.

❶ In full-coverage sampling, 100% of a site would be sampled. This method is not used because it is cost prohibitive, slow, and can be devastating to the environment. For example, at $2,500 per acre, a typical 30,000-acre site investigation would cost $75M and need 50-60 geophysical crews to finish investigation work within one year. Those numbers do not include any ordnance recovery work, only investigation. The Corps of Engineers' entire annual budget for UXO recovery is about $75M.

❷ Fixed-patten sampling became the first alternative to full-coverage. Sampling data are gathered from grids spaced evenly over the site. With fixed-pattern, typically 10% of the total site is sampled.

❸ Random-pattern sampling combined with statistical analysis reduces the sampling area from 10% to less than 5%. The method, however, sometimes leaves holes in the data.

❹ Hybrid-grid sampling addresses random-pattern deficiencies by adding biased grids (light blue) to the random ones. Biased grids ensure that areas with known contamination are sampled. They also fill large unsampled areas left between random grids.

❺ Transect sampling is particularly suited to boundary location, i.e., for identifying where impact areas end. Also requiring a 1-5% sample area, transect sampling is not good for investigating in heavy vegetation. ☐

Range rule update

by Jim Manthey, U.S. Army Engineering and Support Center, Huntsville, OE Team

The Department of Defense (DOD) team developing the Range Rule is hard at work addressing comments resulting from the public comment period. The comment response package and a revised Range Rule should be completed in the next two months. The comment response package and the revised rule will then be staffed and coordinated throughout DOD.

Additional tasks to be conducted before final rule promulgation are completion of the National Environmental Policy Act (NEPA) programmatic environmental assessment and an interim Range Rule Risk Methodology (R3M).

The development of the interim R3M procedure is being conducted as a partnership between DOD, the Environmental Protection Agency (EPA), state regulators, and other stakeholders. The interim R3M will be a qualitative decision process based upon the evaluation of the nine decision basis criteria from the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). The interim R3M will be published this summer.

The completion of an interim R3M is an EPA requirement for promulgation of the Range Rule. The R3M validation requirements are causing a delay to the promulgation schedule. The Range Rule is now anticipated to be finalized in mid-2000.

A registered professional civil engineer working at Huntsville Center, Jim Manthey serves on the Army Management and the Department of Defense teams developing the Range Rule.

Bury it, blow it: underground detonation process standardized, approved

by Betty Neff, U.S. Army Engineering and Support Center, Huntsville, Engineering Directorate

In the beginning, all intentional detonation procedures were approved site-by-site, safety-plan-by-safety-plan. To streamline that lengthy approval process, Huntsville Center developed standardized detonation procedures. One-time approval sets permanent requirements for safe intentional detonation. Even more, those procedures solve the problem of over designing barricades based on generic fragment throw distances. By calculating safe, minimal distances for specific munitions, Huntsville Center not only establishes safe standards but reduces ordnance cleanup costs and cycle time. Buried munitions disposal was the first of intentional detonation procedures approved by the Department of Defense Explosives Safety Board (DDESB) in November 1998.

While other standardized engineering controls are limited to 155-mm rounds or smaller, the buried munitions disposal process has been approved for all intentional detonations. With this method, clearance workers bury the ordnance item before detonating it instead of erecting a structure for protection against fragment hazards. If the item is already underground, more earth is added to meet the requirements.

The trick, of course, is to bury the item just deep enough or cover it with just enough dirt to prevent hazardous munitions fragments.

When munitions are buried for detonation, the soil acts as a barricade, slowing fragments and reducing exclusion zones. If, however, the munition is too shallow, the energy release is relatively close to the surface and the explosion vents to the atmosphere, causing a crater. Hazardous fragments and soil would then be thrown from the center of the explosion.

With deep enough burial, though, the energy release forms a void, or camouflet, beneath the earth; the earth absorbs the energy and fragments and the explosion is contained. What remains is a cavern, or underground pocket, as shown in the figure.

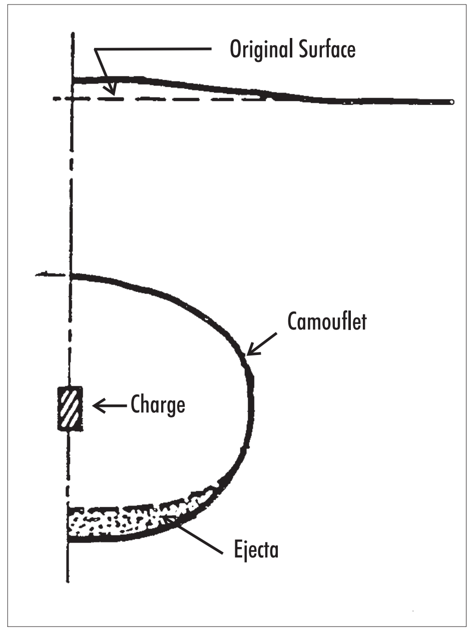
The drawback of camouflet formation is that the underground pocket must be opened, trapped gases released, and the cavern filled with soil in order to complete the procedure and render the area safe.

Although burial calculations can be made by hand, they are quite complex and must be calculated for each soil type. That's why Huntsville Center developed the buried explosion module (BEM). BEM is a computer program that efficiently determines safe burial depth, thereby simplifying and standardizing fragment calculations for specific munitions.

When developing the module, Dr. Michelle Crull, Huntsville Center BEM developer, assumed a density of one-half for all soils—a conservative estimate. Using that density, BEM efficiently calculates munition fragment speed, fragment trajectory, and soil fragment distance through a series of equations to determine safe burial depth.

Munition fragment speed

First, BEM calculates fragment weights and initial fragment velocity in accordance with TM 5-1300, *Structures to Resist the Effects of Accidental Explosions*, and HND-ED-CS-S-98-1, *Methods for Predicting Primary Fragmentation Characteristics of Cased Explosives*. If the depth of burial is zero, BEM assumes a depth of burial of 0.1 foot, the fragment does not pass through any soil, and the velocity of the fragment equals the initial velocity. Otherwise, the fragment velocity as it exits the soil is calculated in accordance with Department of Energy/Technical Information Center (DOE/TIC) 11268, *A Manual for the Prediction of Blast and Fragment Loadings On Structures*.



If the munition is buried at just the right depth, the blast from intentional detonation is contained underground and a camouflet, or cavern, forms as shown above. Buried explosion module (BEM) is a computer program that efficiently determines safe burial depth. After the detonation, the underground pocket must be opened, trapped gases released, and the cavern filled with soil in order to complete the procedure and render the area safe.

Fragment trajectory

Next, using the fragment velocity, BEM then calculates the line-of-sight angle from the depth of burial to the edge of the crater to determine the start angle for TRAJ, which is a trajectory program for personal computers. Then, BEM calculates the true crater in accordance with DOE/TIC 11268. With the fragment velocity, the fragment weight, and start angle, TRAJ calculates trajectory, that is, the maximum horizontal range of the fragment.

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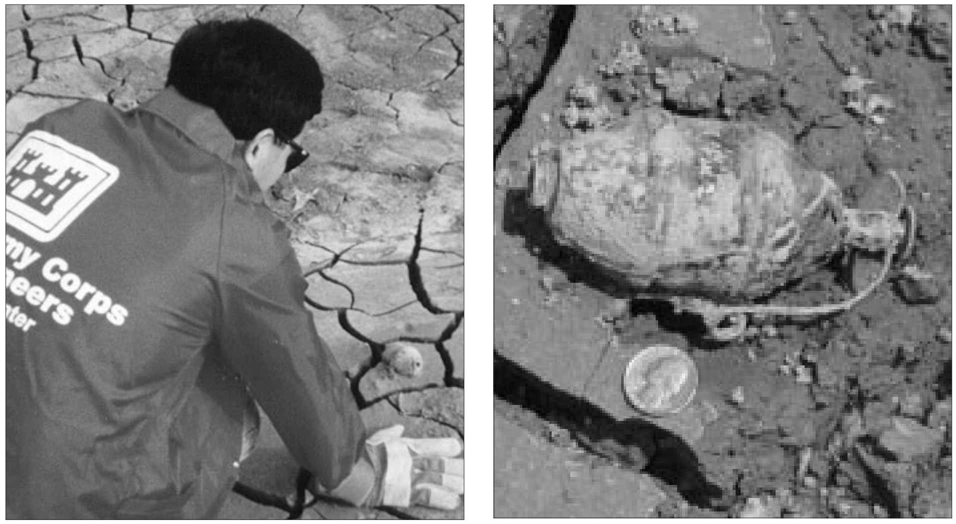
FBI turns to Corps of Engineers for help with UXO

by Bob DiMichele, U.S. Army Engineering and Support Center, Huntsville, PAO

Sometimes you come across a circumstance where you just scratch your head and wonder where you can go to get help. The FBI recently faced that type of situation when it came across a possible unexploded grenade at the bottom of a pond in rural southwestern Tennessee. The agents just didn't know where to call to safely remove the grenade. They found out that the Corps of Engineers' Huntsville Center could solve the problem.

The FBI had been investigating a case in which an individual had bought a 60-acre farm in Tennessee with cash. That type of all-cash purchase garnered interest from the FBI and an investigation found that the cash could be tied to illegal activities. So, the FBI confiscated the property. In doing so, it came across some less than typical farmhouse items such as automatic weapons, grenade launchers, and antique swords. An informant told the FBI that the former owner of the property threw some hand grenades into a pond.

The FBI planned to auction the property and needed to be certain it was safe for sale. But, the FBI doesn't handle military explosives. So, the agents had the pond drained and called for a military explosive ordnance disposal (EOD) team. However, a problem developed. The grenades couldn't be readily found. If any grenades were actually there, they had sunk into the mud in the bottom of the pond and were not accessible for disposal. Army EOD doesn't search for items that are potential unexploded ordnance; it responds to located items.



Greg Bayuga, ordnance safety specialist at Huntsville Center, carefully examines the area surrounding a partially buried grenade in the bottom of a drained pond. Enlarged in the photo on the right is the lone fuzed grenade uncovered in the bottom of a drained pond during an FBI investigation.

The FBI looked for an organization that holds specialized expertise in removing old munitions buried beneath the ground. They turned to the ordnance expertise of the U.S. Army Engineering and Support Center in Huntsville, Alabama.

Greg Bayuga and John Younghans, both ordnance safety specialists at Huntsville Center, were able to provide a Corps of Engineers' response to this unexploded ordnance site. In this case, the circumstances didn't require an immediate response. The FBI had made sure the site was secure. Therefore, Bayuga and Younghans, waited for several days of heavy rain to pass.

Bayuga said the pond, which was about 40 yards by 30 yards in size, had sufficient time to dry and that the soil was ideal for searching for unexploded

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BEM continued from page 6

Soil fragment distances

Finally, BEM calculates the maximum ejecta radii, which are the distances that soil fragments will travel. The BEM equation is based on 2-inch diameter or larger soil chunks and maximum soil throw distances.

Application of BEM results

Because of the nature of the equations, BEM calculations will never result in a final fragment velocity and corresponding fragment range of zero. However, with crater formation, a burial depth may be found where the fragment range will be less than the soil ejecta range. In that case, there is no added benefit to burying the munition any deeper to reach the depth at which a camouflet is formed. That point is the safe burial depth, since validation results show that BEM calculations are conservative.

More information on buried munitions disposal can be accessed through Huntsville Center's website, http://www.hnd.usace.army.mil. Then select "Product Lines," "Ordnance and Explosives," "Technology," and "Analytical Tools." □

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munitions. The search didn't take long.

Bayuga and Younghans arrived the afternoon of May 3 and began their ordnance search using a magnetometer. Almost immediately, Younghans found a hand grenade. He said, "Even though the magnetometer told you were it was, you couldn't see it until you were right on top of it. The grenade had just blended into the mud."

The munition was unusual, according to Bayuga. It was a fuzed Danish fragmentation grenade. The next day, they systematically searched the entire pond without finding any more unexploded ordnance and the 717th Ordnance Company, EOD, from Fort Campbell, Ky., safely detonated the lone grenade in place.

The result, however, far outweighed the effort, Bayuga said. The project was a small one by any terms—cost, time, or number of munitions, but the results were large and came in the form of improved public safety as well as a grateful customer at the FBI. ☐

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