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Ordnance • Explosives environment

News From the Ordnance Center of Expertise and Design Center

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Measuring protectiveness: recurring reviews at cleared sites

by Rob Wilcox, OE Team, Huntsville Center

Risk, or potential for harm, at an ordnance site is only half the problem. Measuring protectiveness completes the equation.

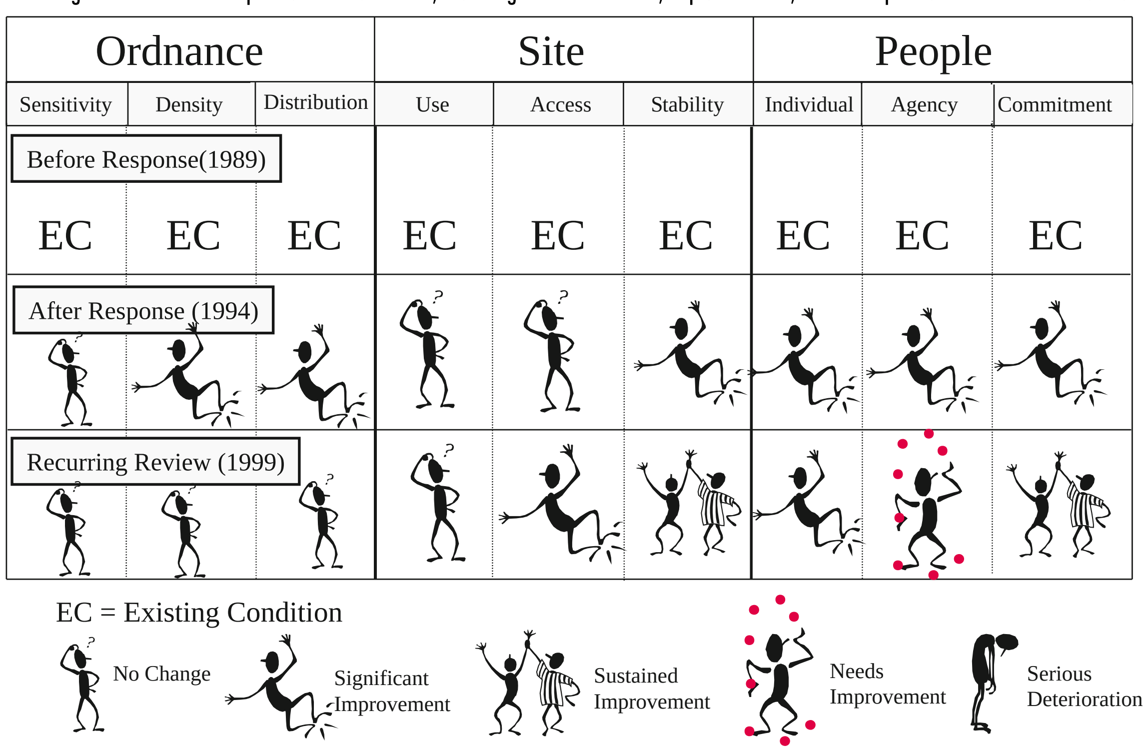
Potential for an ordnance accident stems from many conditions: ordnance sensitivity, ordnance density, ordnance distribution, site stability, site use, site access, institutional behavior and commitment, and individual behavior and commitment.

Those conditions lead to decisions for response actions on ordnance sites. How much to dig, how deep to dig, whether to dig, what institutional controls to recommend are all determined by site conditions. During site investigation and characterization, those of us with responsibility for formerly used defense sites (FUDS) use existing conditions to measure the potential for harm. (See chart below.) Using such data, we respond with technology, manpower, support for local programs, money, and commitment. We map, we clear, we educate.

Then we go away until conditions change or it's time for review of protectiveness. Over time, the earth shifts, the rain falls, and plans change. Conditions change. How, then, do we measure protectiveness after a response action?

Protectiveness continued on page 7

How do we measure protectiveness after a response action? The Tierrasanta and the Murphy Canyon Naval Housing recurring review may offer some answers. The chart below shows the conditions used to measure protectiveness at that site. Those conditions fall under three categories: ordnance, site, and people. After the clearance was completed in 1994, the existing conditions that were altered were measured, resulting in an evaluation of protectiveness. In 1999, recurring review measures, depicted below, show that protectiveness is still effective.



Navy divers confirm no public risk at Nansemond Piers

by Sandy McAnally, Engineering Directorate, Huntsville Center

When questions arose concerning the possibility of unexploded ordnance along two piers at the now defunct Nansemond Ordnance Depot, an area known as Pig Point, VA, the Army called in the Navy. U.S. Army Engineering and Support Center, Huntsville and Norfolk District teamed with the U.S. Navy to resolve those questions.

In March 1999, dive teams from Yorktown Naval Weapons Station and Little Creek Naval Amphibious Base responded to the Corps of Engineers' request to search for and locate unexploded ordnance below the abandoned piers in the Nansemond and James Rivers.

The Navy optimized this partnering opportunity as a training exercise. "We get to practice search techniques and if we find something, it keeps stuff from washing upon beaches during a storm," said Chief Petty Officer Rob Paulette, a member of the Yorktown Detachment, in an interview during the two-day search.

Led by Senior Chief Richard Graves and Lt. Richard Hayes, three seven-man teams of explosives experts and EOD-trained divers completed the search of the two piers using Mk29 ordnance locators and Garret Sea Hunter metal detectors. The equipment permitted a search to a depth of 2 feet below the riverbed. One dive team was assigned to a World War II pier, while two other teams swept each side of the World War I pier. Corps of Engineers Norfolk District coordinated the 30-foot-wide search around the periphery of both piers.

Navy EOD specialists, using metal detectors and ordnance locators, walk four abreast during a grid sweep around a World War II pier at Nansemond Depot. Navy divers also conducted an underwater search around the remains of a World War I pier, finding fishing weights, lawn chairs, and other debris, but no explosives.

Because of shallow water around the World War II pier, divers used a sweep method that consisted of four men abreast equipped with ordnance locators and one line supervisor to direct the four men. They laid out 100-foot distance lines parallel to the pier and used a 30-foot line perpendicular to the pier to create 100- by 30-foot search grids. The supervisor arbitrarily placed a large metal object in each grid to ensure that the equipment was working and that the searchers were alert.

The search of the remains of the World War I pier used two methods, the sweep and the jackstay. The jackstay consisted of two 30-foot weighted standing legs perpendicular to the pier and a 100-foot running line parallel to the pier. With the running line for a guide, the diver began his swim from one end of the 100-foot line to the other using an ordnance locator. The 100-foot line was also a guide for the return path that slightly overlapped the first path. Divers continued this pattern until the entire 100- by 30-foot grid was searched. In shallow water, the divers switched to the sweep method, ensuring comprehensive coverage of the entire area.

Although historical data identified the possibility of debris from an explosion on the World War I pier many years ago, there has been no evidence of unexploded ordnance washed on the shores. However, Kirk Stevens, the Norfolk project manager, says that when questions on public safety arise, "answering those questions quickly and thoroughly is very important." As Corps officials expected, the teams finished the search empty-handed, except for a 6-ounce lead fishing weight and a couple of lawn chairs.

Stevens' assessment of the partnership included a fourth partner—the public. "Overall, the investigation went very smoothly. The local fisherman did not object to closing the World War II pier currently used as a public fishing pier. And the Navy's specialists were very professional. I would use them again and again."

The partnering project proved very successful for everyone, according to Glenn Earhart of Huntsville Center. "The Navy used our help request as a training exercise for their EOD teams. The quick response coordinated by Norfolk District resolved the EPA's and the State of Virginia's concerns about ordnance and explosives potential at the site, and the Corps of Engineers saved program dollars because no formal contract was awarded for the underwater investigation." ☐

Reducing clearance cost, time at Range 65, Fort Dix

by Carol Youkey, OE Team, Huntsville Center

Among the items found at Fort Dix were consolidated demolition shot consisting of a 60-mm illumination mortat (on top) and a 35-mm subcaliber practice rocket (on the bottom). Cost savings using geophysical mapping was nearly $28,000 per acre.

As a result of the Base Realignment and Closure process, Range 65 at Fort Dix, NJ, was designated for renovation in 1997 for use by Reserves components. The renovation required installation of new targets, reshaping drainage areas, and excavation of a 7-acre borrow area. New York District's design/construction team recognized the importance of providing an ordnance and explosives (OE) clearance before their contractor began work. Upon New York's recommendation, the Fort Dix Directorate of Public Works (DPW) contacted Huntsville Center for assistance in planning and executing the clearance.

Only the areas to be excavated were planned for clearance, and the Fort Dix DPW arranged for surface sweeps of the entire range by the explosives ordnance disposal (EOD) unit. The areas to be excavated totaled 25 acres over about 30 locations.

The ordnance contractor mobilized in September 1997 and began the location surveying work to stake out the 30 separate parcels. After clearance efforts began, workers proceeded more slowly than expected because of the high number of metallic contacts encountered. Although a lot of metal was expected, actual contacts in the field were even more than estimated.

The detection equipment selected by the contractor was the hand-held Schonstedt magnetometer. At the time of the contract award, this equipment was believed to be the best available for the conditions at Fort Dix. In fact, the Schonstedts did detect a large number of live and inert ordnance items during the period from September through December 1997. The problem, however, was that over 70,000 investigations, or digs, had to be made to recover the 131 unexploded ordnance (UXO) items and the 707 practice rounds. Also, because of the underground metallic density and the audio-only feature of the magnetometers, several grids failed both the contractor's quality control process and the government's quality assurance checks. That meant rework. The entire process proved so time consuming that project funds were expended and work stopped on December 11, 1997, after 13 of the 25 acres were cleared.

About the same time, Huntsville Center's geophysical team reported a successful trial with OE detection using much-improved analysis software, along with existing mapping hardware. The geophysical team recommended applying the improved process to the remainder of Range 65 and estimated that the cost to complete the project would be much less than with the Schonstedt.

The project team decided to geophysically map the 7-acre borrow area, although 90% had previously been cleared with Schonstedts. Through geophysical mapping, 13 inert items were located in the borrow area, which had already been cleared to a depth of 18 inches with magnetometers. Also, the 12 remaining uncleared acres were mapped. All geophysical mapping, investigations, and ordnance removal of the remaining areas were completed in less than one month.

Project costs using the two different technologies varied significantly. The cost of clearance using Schonstedt magnetometers exceeded $34,000 per acre, while geophysical mapping was only $6,283 per acre. The cost difference was, of course, related to the reduction in the number of investigations, or digs, that were needed, since the geophysical mapping technology was able, in many cases, to discard non-ordnance items from the dig list. In fact, where 70,241 digs were made during the magnetometer searches, only 12,280 were made after geophysical mapping identified anomalies to be investigated. Furthermore, the non-ordnance scrap recovered during the mapping process was only 1,126 pounds as compared to 11,405 pounds of scrap recovered during the magnetometer process. Also, the number of hours expended to detect and remove ordnance dropped from 8,935 to 1,619 using geophysical mapping, even though a comparable number of acres were searched.

In summary, changing technologies during this range clearance project proved to be both successful and cost effective.

Civil engineer Carol Youkey has been an ordnance project manager at Huntsville Center since 1995. She is a registered professional engineer and land surveyor in Alabama. ☐

Test site baselines performance of detection instruments

by Denis Michael Reidy, Ph.D., E-OIR Measurements, Inc., Spotsylvania, VA

False alarm and detection rates can seem like opposite ends of a seesaw when measuring the performance of handheld instruments used for mine and unexploded ordnance detection. As might be expected, higher detection performance generally results in increased false alarms incidents. While this tradeoff is inevitable, determining the extent of the tradeoff between false alarm and detection rates is important when exploring ways to improve a system's performance.

In fact, quantifying that false alarm/detection rate tradeoff is one purpose of the new pilot site launched by Joint Unexploded Ordnance Coordinating Office (JUXOCO) in April 1998. Unlike operational test sites, the JUXOCO site, located in Fort A.P. Hill, VA, was developed to overcome problems in determining baseline performance of handheld detection systems. The Fort A.P. Hill test site was specifically designed to lessen several of the most perplexing difficulties of comparing sensor performance.

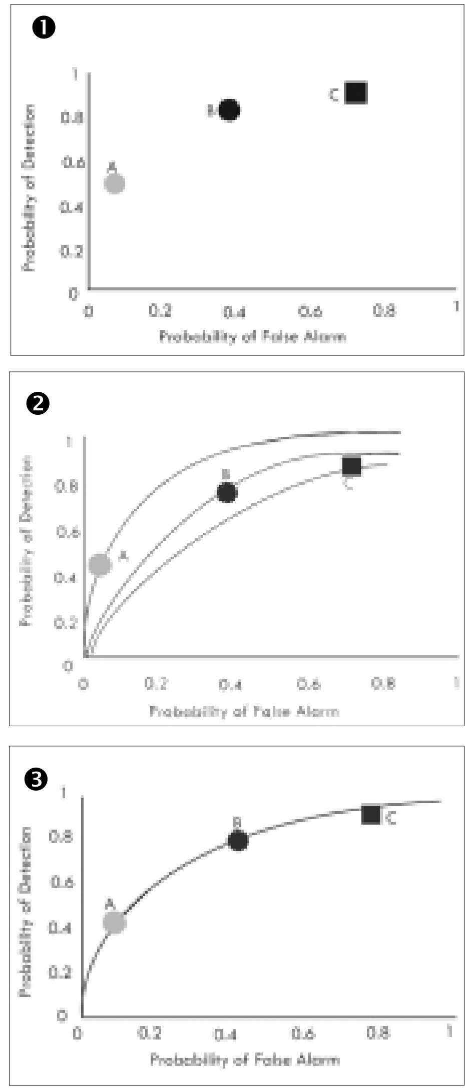
High false alarm rates can significantly impact the efficiency of clearance operations. For that reason, the goal has long been to improve the capability of detecting targets while at the same time significantly reducing the number of false alarms. To improve capability, a baseline of detection versus false alarm performance is first needed. Traditionally, establishing baseline performance of a detection system involves creating a receiver operating characteristic (ROC) curve. A ROC curve is simply a plot of the relationship between a system's detection performance and its false alarm performance.

Ideally, such ROC curves are generated from successive collection runs over a known target field, each at different sensor (receiver) sensitivity or threshold settings. For each collection run, the number of correct detections divided by the number of actual targets is plotted against the number of false alarms divided by the total number of possible false alarms. The resulting plotted points then form a ROC curve that can be used to predict the probability of false alarm (P_{fa}) for any probability of detection (P_d) for that system at that site.

Unfortunately, the very nature of detection system operation makes traditional ROC curve generation difficult.

The first problem is rooted in the equation for probability of false alarm (P_{fa}). P_{fa} is calculated by dividing the number of actual false alarms by the total number of opportunities for false alarms. Because the search often covers a relatively large area, it is difficult to determine the number of opportunities for false alarms. As a result, ROC-like curves are sometimes generated using false alarm rate (FAR) in place of the probability of false alarm.

False alarm rate is the number of false alarms for a given collection run divided by some measure, such as the area covered by the sensor. The use of a FAR provides some relative measurement of the false alarm performance for a sensor system covering a specified area on a given collection run. Even so, it does not provide a very accurate measure of a sensor system's true performance because of the inherent inability to control the actual area covered by the system. Also, while an operator may physically walk over a specified area, it is unlikely that the sensor head is actually covering precisely that area—it could be less, or even more if there is significant overlapping. Finally, the FAR is not necessarily independent of the actual number of targets. Changing the size of the target set can change the measured ROC, even though the site and detection systems have not changed.



The figures above demonstrate the problem of single point generation when devloping ROC curves. At figure ❶ , three sensor systems may generate very different P_d/P_{fa} performances. However, with only single performance points, it is impossible to determine if these three points represent sensors operating on three different ROC curves as in figure ❷, or whether the sensors are all really on the same ROC curve but were each run with different operator thresholds as in figure ❸.

The second problem with developing a ROC curve for detection systems is that since an operator is interpret-

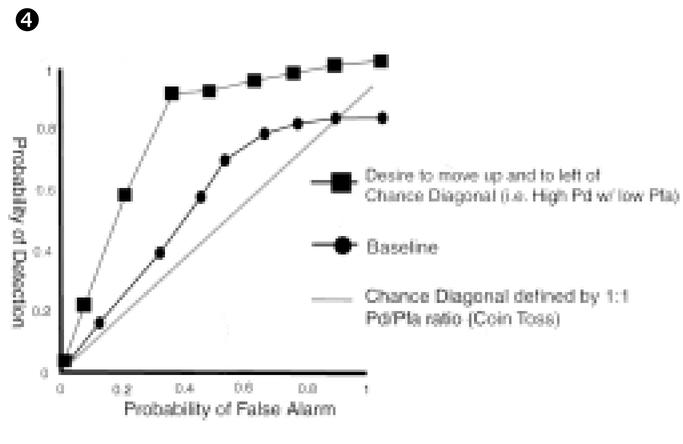


Figure ❹ illustrates the concept of an improved ROC curve using advanced algorithm techniques. By diminishing problems associated with false alarm rate, the JUXOCO test site can be a benchmark control for handheld detector system performance, a protocol control for testing, and a method to create accurate ROC curves for detector

ing the results from the detector system, realistically, only a single point relating P_d and P_{fa} can be generated. This is because there is generally no way of precisely controlling and varying the operator's threshold for detection such that a reliable ROC curve can be established. Single performance points, while useful in operational scenarios replicating the real world, are not a very useful way of quantitatively comparing the baseline performance of sensor systems. For example, three sensor systems may generate very different P_d/P_{fa} performances (figure ❶). However, with only single performance points, it is impossible to determine if these three points represent sensors operating on three different ROC curves (figure ❷) or whether the sensors are all really on the same ROC curve but were each run with different operator thresholds (figure ❸).

Such problems make it extremely difficult to objectively compare the performance of current detection systems. Therefore, the pilot site was designed to determine an actual probability (percent) of false alarm (P_{fa}) instead of a false alarm rate (FAR). Of the site's 980 grids, approximately 100 grids contain targets. Therefore, for each test, 880 grids will be opportunities for false alarms. In that way, the test site controls and stabilizes both opportunities for targets and opportunities for false alarms.

Detectors deployed at the pilot site will only collect data at specific points where either mine targets are buried or no mine targets exist. Each discrete area or node where sensor data is collected will be considered a decision opportunity; that is, at this discrete location, the system either declares a target or it does not. Since only the no-target grid areas (containing either clutter or a blank area) can be falsely identified as targets, the total opportunities for false alarms are determined by summing the number of discrete grid areas where no targets exist. The P_{fa} is then calculated by dividing the total number of false alarms that occurred during a run by the number of opportunities for false alarm for that run.

The first tests were performed last year on the U.S. Army's standard handheld metallic mine detector (AN/PSS-12) and the Geophex GEM-3 detector. Also, better algorithm techniques have been applied to the Geophex GEM-3 detector. Results so far show significant reduction in the P_{fa}, while maintaining the same P_d. Figure ❹ illustrates the concept of an improved ROC curve using advanced algorithm techniques.

By diminishing problems associated with false alarm rate, the JUXOCO test site can be used in three ways:

- As a benchmark control for handheld detector system performance.
- As protocol control for testing, since all detection systems at the test site are deployed through the same test parameters.
- To create accurate receiver operating characteristic (ROC) curves for detector sensitivity.

Future plans for the site include a change in the test layout. The change will be introduced in stages, to preserve the ability to use the site to acquire data collections during the year as well as preserve as much continuity for ongoing efforts as possible. Meanwhile the site will be expanded to allow greater flexibility for vehicle-borne detector systems. In addition, smaller unexploded ordnance and sub-munitions will be included to augment the largely landmine-based target set. The clutter objects will be similarly enhanced through the addition of radar specific clutter objects.

Plans also include acquiring three or four high-quality detectors available in today's market, instrumenting them, and comparing their detection performance with the PSS-12 at the same site with the same targets. The following instruments are being considered: Minelab F1A-6, Vallon 1620C, Guartel MD 8, Foerster Minex (2FD 4.400.01). Tests for new sensors, such as quadrupole resonance and perhaps other chemical sensors, are also being considered.

Ultimately, the Unexploded Ordnance Center of Excellence hopes to expand these and other standardized test protocols in support of a national series of test sites at which this type of baseline testing of detectors may be performed.

Denis Michael Reidy currently provides coordination for detector testing and for test standards and guidelines being developed by JUXOCO at Fort Belvoir. A geophysicist by training, he has been involved actively in the research and development of sensors and systems for detecting and locating subsurface munitions over the past ten years. ☐

Wayne's world of OE safety: three facets of risk

COMMENTARY

by Wayne Galloway, Chief, OE Safety Team, Huntsville Center

As I mentioned in my previous newsletter article, I believe that the ordnance community is open to risk and liability in three main safety areas of concern:

- Clearing ordnance and explosives (OE) from sites.
- Transferring cleared land.
- Moving and releasing OE residue resulting from clearance.

Of the three, clearance is probably *the most dangerous*, just ask the two individuals injured on a project at Fort Drum and the individuals that went back in to complete the work. Clearance workers are continually exposed to personal risk and harm when excavating in areas thought to contain unexploded ordnance (UXO).

The second area, the transferring of the property after clearance, is probably *the most difficult* because of the safety concerns of the receiving parties and their concurrence in acceptable clearance levels, resources, cost, time, and so on.

The third concern is the moving and releasing of OE residue from site clearances, i.e., turning over the scrap. This concern is probably *the most deficient* of the three.

Now that's a bold and scary statement. It scared me, if you know what I mean. Before I need to look for another job, let me explain this. This statement comes only from "Wayne's World of OE" consisting of just me, myself, and I. (I like those guys.) It's just my observation and opinion. It's not meant to promote, offend, or step on any toes or such. So don't get excited over this, other than to just think about. Also, I want you to let me know what you think about it. If you're still with me, I'll explain. Although I think this area is deficient, I think it can be fixed, if we will only do it.

The problem comes from the loss of chain-of-custody control after site residue leaves government possession. When the Corps of Engineers completes all the various levels of on-site inspections—including quality assurance inspections by the federal government, the government contractor certifies in a signed document (in our case, a DD Form 1348) that a load of site residue is free from explosive hazard. After certification, this residue is transferred to private metal recyclers, either directly from the Corps of Engineers or through the Defense Reutilization Marketing Office (DRMO). DRMO or the recyclers then have our DD Forms 1348 with our certification.

Once we've turned the residue over, it is no longer in our control and will be removed from the site. Once residue leaves the site, it might go directly to a recycler or get sold and may become consolidated with other range scrap, and it gets resold again and again. Yet our Form 1348 may still be passed along as certification that the scrap is free from explosive hazard—even when it has been mixed with other ordnance residue. At that point, the Form 1348 no longer has any meaning as to the state of the residue. The contractor, the Corps of Engineers, and DOD are placed at risk and could be potentially liable for such commingled scrap. If there is an explosive hazard, it's now in the private sector.

Whether there is injury or not, this is a weakness in the process. If there are items that resemble ordnance items, they can become a problem, even if they are inert, simply because they look like dangerous items.

This problem can be corrected, however, by controlling the process for handling site residue. This material should be processed only by selected, approved, and qualified ordnance scrap recycling dealers. Such dealers would have to provide accepted chain-of-custody control until the scrap has been smelted. That process would be assured (checked) by the federal government. Until the residue is completely broken down, it cannot be consolidated or commingled without breaking chain of custody control—from site to grave so to speak. A process such as this would protect the public, scrap dealers, our contractors, DRMO, the Corps, and DOD. We wouldn't release this material until it is deemed to no longer be an ordnance item.

Ordnance residue should no longer be thought of as scrap, but as a possible hazard to life and considered as sensitive material until it no longer is considered ordnance residue and is only melted down scrap. Although I consider this concern as the most deficient, it would be quicker to fix than the other two concerns, and it can be done with a change of attitude and process. We should not let this material out of our control into these various scrap yards until we are assured it has been properly processed. This is fixable, we just have to do it.

Now that I have gone around the bush, and around the forest, to get to a few points that I feel are concerns of safety for the OE community, what is it that you think? That is, what this is all about—what you think and do. Let me know how you feel about these concerns sometime. Thanks for the opportunity. Thanks for the time. ☐

Why use statistics?

by Arkie Fanning, Engineering Directorate, Huntsville Center

Statistical analysis is used in various ways in the evaluation of ordnance and explosives (OE) and unexploded ordnance (UXO) for characterization of OE sites. Presented below are pro and con views on using statistics. Of course, the primary purpose of using statistics is that statistical analysis is much less expensive than 100% evaluation. But there are other reasons:

Advantages of using statistics

✓*Statistics are valid.* Statistical analysis, when done correctly, provides the same information that can be obtained from 100% investigation.

✓*Statistical analysis is faster.* It takes much less time to evaluate a sector using statistical tools than investigating 100% of the sector.

✓*Statistical analysis enables faster and more efficient decision making.* Because statistics provides the correct information, decision makers are able to make decisions within a shorter timeframe.

✓ *Statistical analysis aids in prioritization of budget and resources.* Using statistics helps the investigative team determine where best to use limited resources to most efficiently reduce the amount of UXO or risk at a site.

✓*Statistical analysis is less expensive.* It does not make sense to gather more information than is necessary for a fair decision. Being 100% certain there is no UXO is very expensive. Often, it is impossible to obtain a sufficient budget to show that there is no UXO in a sector. The statistical approach then can provide decision makers with the information they need.

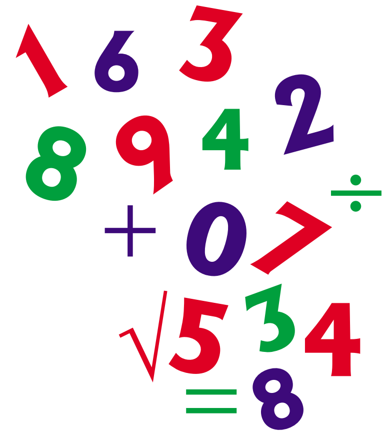
Together, these advantages allow needed risk mitigation actions to begin sooner.

Disadvanatges of using statistics

✓*Statistical analysis carries levels of uncertainty.* To account for this uncertainty, a confidence limit (usually 90%) is used. The following statement is normally made: The amount of UXO in the sector is between 0 and 0.4/acre. In that statement, 0 represents the left tail of the confidence interval (10%) and 0.4 represents the right tail (90%). Only 10% of the time will the amount of UXO be greater than 0.4/acre (if the data are gathered correctly). That also means that 10% of the time there will be more than 0.4/acre. But is that critical? The decision to remove UXO or to conduct other UXO response actions at the site is made based on *all* NCP criteria and not just the risk or the amount of UXO. If there were actually 0.5/acre, would that, in fact, mean that a different decision would be made? Remember, statistics are only a small part of the information used in decision making.

✓*Statistical analysis is sometimes difficult to explain.* The statistics used in ordnance investigations are very technical and can be difficult to translate into laymen's terms.

✓*Statistics are affected by many factors.* Stating that there is between 0 and 0.4/acre assumes that many design criteria have been met. For instance, it assumes that the sample is representative of the population, the technology is capable of providing a correct sample, and the statistics were calculated correctly. If any of those are not true, the statistical answer may be incorrect.



✓*Statistics cannot prove the negative.* It is impossible to use statistics to prove there is no UXO in a sector. One can provide very high confidence values, but to be 100% sure there are no UXO, all of the area must be investigated. In the end, the decision to use statistics is usually justified based on cost. The budget for most sites would be astronomical for complete evaluation of all potential OE sectors. However, it is important to realize that there are many factors that affect the ultimate statistic and that statistics are only as good as the assumptions made and the process used to collect the data.

Arkie Fanning is a registered professional engineer with a specialty in operations research. He is the developer of UXO Calculator, the replacement for SiteStats/GridStats. Those statistical tools are part of the ordnance site characterization process used by the Corps of Engineers. □

Protectiveness *continued from page 1*

Tierrasanta and the Murphy Canyon Naval Housing area, the first ordnance clearance sites, offer some answers, since they are also the first sites to undergo recurring review.

Consistent with CERCLA principles, the recent Tierrasanta review investigated the ordnance clearance conducted between November 1990 and April 1994 on former Camp Elliott. During that timeframe, the U.S. Army Engineering and Support Center, Huntsville cleared ordnance on 1,900 acres containing heavy brush. Site workers located and removed more than 4,800 ordnance items. In addition, institutional controls in the form of education programs and local land deed policies were established to support the clearance action.

Protectiveness *continued on page 8*

Prospect Workshop

Ordnance Response Projects at Chemical Warfare Materiel (CWM) Sites

To reserve a space in this workshop session or to obtain additional information, call Ms. Joy Rodriguez at 256-895-7448 no later than 3 December 1999. A DD Form 1556 should be completed with all approvals and faxed to 256-895-7497. Reporting instructions to attendees will be issued upon receipt of an allocated space.

This workshop is for staff-level project managers and technical engineering disciplines, safety and occupational health professionals, and management personnel involved in cleanup activities on CWM sites under the Defense Environmental Restoration Program. These sites consist of fomerly used defense sites, installation restoration, and base realignment and closure sites. This workshop provides an overview of information concerning the Corps' role and the role of other activities and agencies in the cleanup of CWM sites.

This workshop consists of classroom instruction on the regulatory requirements for cleanup of CWM sites; the roles and responsibilities of the Corps and other activities and agencies; CWM agents and their impact; ordnance identification; decontamination procedures; analytical methodology for soil and water; degradation by-products; strategies for sampling; air-monitoring equipment including operation, maintenance, and use; contents of the safety submission; downwind hazard methodology; medical support requirements; technical escort unit operations plans; protective action plans and required exercises; personnel protective equipment, storage, transportation, and disposal considerations.

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Protectiveness *continued from page* 7

Five years later, the review focused on the active and somewhat exclusive community in northeast San Diego, CA. The objective of the investigation was to determine if the response action was still protective of public safety.

With protectiveness the standard for determining potential for harm at Tierrasanta, conditions became the yardstick of acceptability. Existing condition before response served as the baseline as follows:

- Before the ordnance project began, there was a condition at the project site. The condition was unacceptable.
- After the project was done, there was a condition at the project site. The condition was acceptable.
- Therefore, if we can maintain or improve that difference, the condition will remain acceptable.

For Tierrasanta, condition measurements fall into three categories: ordnance, site, and people. Each category covers three conditions as shown in the chart on page 1. Not all conditions can be influenced by a response, however. For example, nothing can be done to change the sensitivity of the ordnance itself.

The baseline was the unacceptable existing condition in 1989, before response. The acceptable conditions established through the response action were reviewed for change with goal of maintaining or improving conditions.

As shown in the chart on page 1, the review concluded that the Tierrasanta ordnance clearance completed in April 1994 is still protective of public safety. Institutional controls currently in place are, for the most part, effective. There was no ordnance exposure problem from erosion, new construction, recreational or other activities, storm damage, or land-use changes. Also, measures show sustained improvement in the stability of the site because vegetation that matured since 1994 is both preventing erosion and keeping the public out.

Recommendations for improvement fall mostly under agency commitment and include increased public education for community schools, libraries, and parents; a city habitat management plan for replacing possible vegetation loss; and another site review in five years.☐

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