MILITARY MUNITIONS RESPONSE PROGRAM

DoD fully acknowledges its obligation to effectively respond to the hazards associated with unexploded ordnance. Our continued focus is to protect the health and safety of our citizens, sustain our environmental stewardship, continue effective communication with our stakeholders, and gain a thorough understanding of the gaps in our knowledge.

— Raymond F. DuBois, Deputy Under Secretary of Defense (Installations & Environment)

To attain the level of readiness necessary to deter adversaries and defend our nation, the Department of Defense (DoD) must develop, test, and deploy weapons systems and military munitions, and then train its personnel to use and maintain these systems. As a result, some properties that DoD has historically used to meet its defense mission are known or suspected to contain unexploded ordnance (UXO), discarded military munitions, and munitions constituents (MC). This chapter addresses property formerly used by DoD as ranges or for other munitions-related activities, such as demilitarization.

The Military Munitions Response program (MMRP) is designed to address the remediation of UXO, discarded military munitions, and MC located on defense sites. "Defense sites" is defined in 10 U.S.C. Section 2710 as "locations that are or were owned by, leased to, or otherwise possessed or used by the Department of Defense. The term does not include any operational range, operating storage or manufacturing facility, or facility that is used for or was permitted for the treatment or disposal of military munitions." The effect of this definition is to apply the MMRP to any location where there are UXO, discarded military munitions, or MC other than at the three types of excluded locations.

Since the inception of the Installation Restoration program (IRP) category of the Defense Environmental Restoration Program (DERP), DoD has addressed the environmental concerns associated with explosive contaminants at munitions manufacturing, processing, and demilitarization sites, as well as responses for military munitions incidental to IRP work. DoD will continue to conduct some incidental munitions response activities under the IRP category. Sites within the MMRP category, however, are those where the firing or disposal of munitions has occurred during training exercises and were not addressed under the IRP category. The primary concern at these sites is safety from explosive hazards.

The creation of the MMRP category under the DERP builds on DoD's accomplishments with the IRP. DoD's objectives for sites in the MMRP are similar to those for sites in the IRP. These objectives include:

- Identifying where, what kind, and to what extent UXO, discarded military munitions, or MC are present
- Determining both explosive safety hazards and toxicological hazards to human health and the environment
- Establishing goals and metrics to track and evaluate progress
- Setting priorities for conducting munitions response actions
- Planning, programming, and budgeting to effectively resource MMRP requirements
- Conducting necessary munitions response actions
- Developing and implementing effective MMRP-related technologies
- Ensuring the timely transfer of excess land to allow for alternative uses that are consistent with the munitions response completed.

As the DERP evolves to address emerging challenges, such as those associated with effectively conducting munitions responses, DoD updates the Annual Report to Congress to reflect these new requirements and developments. DoD initially introduced the MMRP category in the Fiscal Year 2001 (FY01) Annual Report. Through that report DoD both fulfilled the interim reporting requirements identified by Congress and established the mechanisms for reporting MMRP requirements in FY02. Similar to the format used for the IRP, DoD developed tables to show MMRP data at the installation level (Appendix C of this report) and provides additional narrative in this MMRP chapter to discuss reporting requirements, cleanup progress, and successes. DoD framed this reporting mechanism in FY01 on the IRP's foundation; in this fiscal year's report DoD builds on the framework put in place last year. This Annual Report for FY02, in whole, constitutes DoD's comprehensive plan for the MMRP, as required by the National Defense Authorization Act for Fiscal Year 2002.

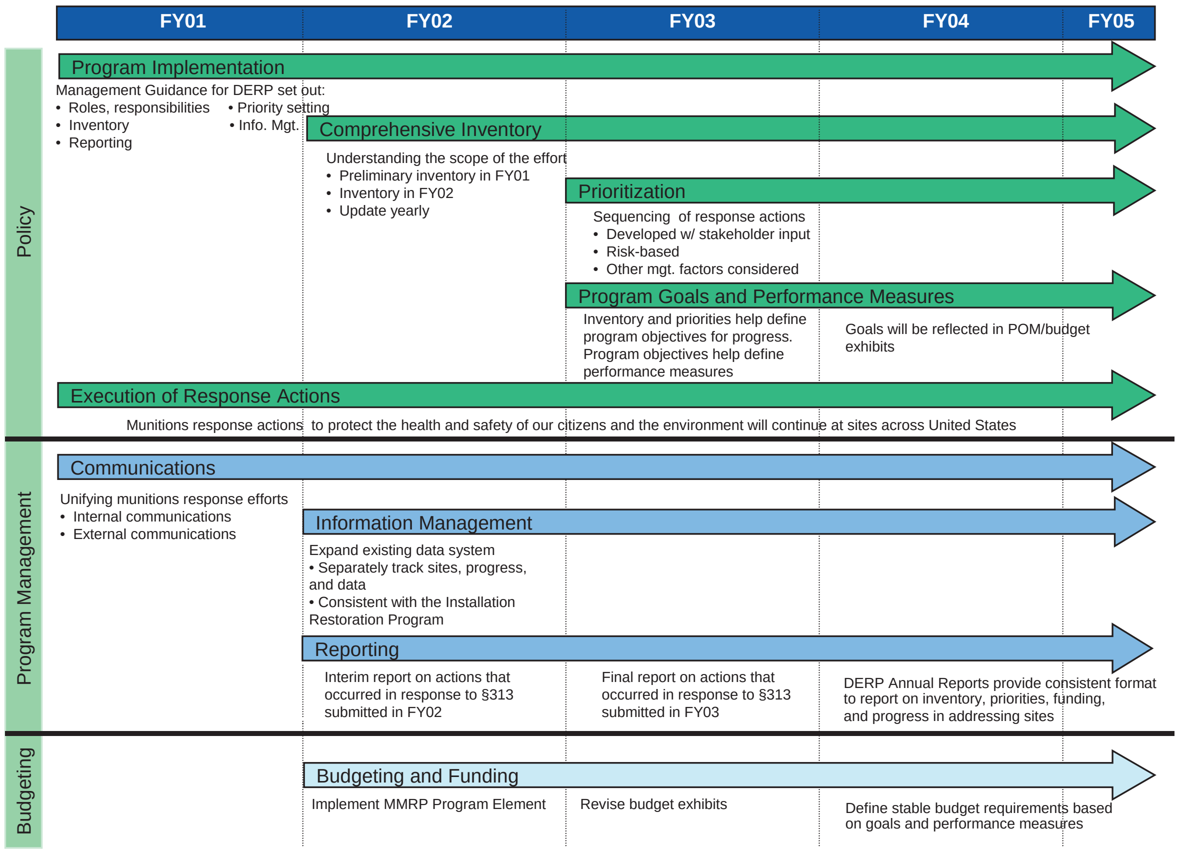
Following a Comprehensive Plan

In creating the MMRP category, DoD recognized the need for additional actions to fully implement effective munitions response. DoD developed a comprehensive plan setting the program's basic structure and implementing munitions response activities according to this framework. As shown in this chapter, DoD's comprehensive plan for the MMRP closely mirrors the strategy used to build and refine the IRP. The following sections discuss major areas of this comprehensive plan, including meeting policy requriements, managing the program, and accurately budgeting to effectively resource the MMRP. A summary of DoD's comprehensive plan and its major elements is shown in Figure 31.

Meeting Policy Requirements

Several elements integral to the success of the MMRP stem from requirements defined both by Congress and DoD. These elements include building a program framework, compiling a comprehensive inventory, developing a prioritization protocol for sequencing work at MMRP sites, and establishing program goals and performance measures. The policy requirements that formally set the MMRP in motion are similar to those of the IRP; those that are Congressionally defined are identified in Appendix G of this report.

Figure 31
Comprehensive Plan Timeline



Building a Framework for the MMRP

The September 2001 *Management Guidance for the Defense Environmental Restoration Program* described the MMRP's management structure, program policies, and initial requirements for conducting a munitions response. The major requirements for execution of the MMRP in the Management Guidance include:

- Developing an initial inventory of MMRP sites, or locations other than operational ranges, that may require a military munitions response, to be completed by September 30, 2002
- Acting to identify, characterize, track and report data related to the use of military munitions and munitions responses in a manner that is compatible with the IRP, and which supports inclusion in DoD's Restoration Management Information System (RMIS)

- Defining a new program element established for munitions response funding
- Defining the data elements necessary to develop credible cost estimates and support the MMRP
- Setting an interim prioritization process to assign to each defense site a relative priority for munitions responses.

Congress furthered the progress that DoD achieved with the DERP Management Guidance by enacting Sections 311 through 313 of the National Defense Authorization Act for Fiscal Year 2002.

These statutory requirements reinforced DoD's 2001 policy by tasking DoD to develop and maintain an inventory of defense sites that are known or suspected to contain UXO, discarded military munitions or MC. In defining "defense sites," Congress expressly excluded operational ranges. UXO are military munitions that have been prepared for action, deployed in such a manner as to constitute a hazard to operation, installations, personnel, or material, and remain unexploded either by malfunction, design, or any other cause. Discarded military munitions are military munitions that have been abandoned without proper disposal or removed from storage for the purpose of disposal. MC refers to any materials originating from UXO, discarded military munitions, or other military munitions, including explosive and nonexplosive materials, and emission, degradation, or breakdown elements of such ordnance or munitions. Congress directed DoD to make the initial MMRP site inventory available to the public by the end of May 2003, and update the inventory annually. Section 311 also advanced DoD's interim prioritization scheme, as established in the DERP Management Guidance, requiring DoD to develop a protocol for prioritizing defense sites for response activities in consultation with states and Tribes. This protocol is discussed in further detail later in this chapter.

Section 312 requires DoD to create a program element specifically for funding munitions responses. This separate program element, which DoD adopted in 2001, is intended to ensure that DoD can identify and track munitions response funding. The creation of the MMRP program element not only assists DoD in the planning and execution of the MMRP, but also helps Congress make more informed budgetary decisions in support of the program. Additionally, the separate program element for the MMRP is intended to allow DoD to manage MMRP funding while minimizing impacts to the IRP.

Section 313 directs DoD to provide a comprehensive assessment of UXO, discarded military munitions, and MC in the FY02 DERP Annual Report to Congress that includes:

- Separate estimates of the aggregate projected costs of the remediation of UXO, discarded military munitions, and MC at operational ranges and all other defense sites
- A comprehensive plan for addressing the remediation of UXO, discarded military munitions, and MC at defense sites, including an assessment of the funding required and the period of time over which such funding will be required
- An assessment of the technology currently available for the remediation of UXO, discarded military munitions, and MC and an assessment of the impact of improved technology on the cost of such remediation and a plan for the development and use of such improved technology.

DoD has fulfilled the requirements as directed by Congress—the aggregate projected cost estimates and technology assessment can be found later in this chapter, and this FY02 Annual Report constitutes DoD's comprehensive plan for addressing military munitions at MMRP sites. Section 313 also required an interim assessment; this requirement was fulfilled by the FY01 Annual Report to Congress.

Compiling a Comprehensive Inventory of MMRP Sites

To accurately determine the scope of effort required for the MMRP, DoD developed a comprehensive inventory of sites or locations other than operational ranges that may require a military munitions response. In the same manner that DoD developed its IRP inventory, the MMRP inventory will continue to be updated yearly as the program matures. This inventory serves as the basis for the other elements of the MMRP.

During FY02, DoD identified sites known or suspected to contain UXO or discarded military munitions and sites known or suspected to be impacted by MC for inclusion in its MMRP inventory. As of the end of FY02, DoD has identified 2,307 sites. This is an increase of 553 sites since DoD reported its interim inventory in FY01. As is the case in the IRP, MMRP sites are categorized according to their status in the response process as of the end of FY02—undergoing investigation or cleanup (in-progress), awaiting future work, or having achieved response complete (RC). Figures 32 and 33 illustrate the status of sites at active and base realignment and closure (BRAC) installations, respectively. No MMRP sites on active installations have reached the RC milestone. DoD will continue to identify and address MMRP sites at its active and BRAC installations in the future.

Addressing munitions response projects on formerly used defense site (FUDS) properties continues to be a high DoD priority to ensure the public is protected from potential safety hazards that may be present on property DoD no longer controls. Through FY02 DoD identified 1,691 FUDS projects eligible for cleanup under the MMRP, which represents over 73 percent of the sites in the MMRP inventory. Figure 34 illustrates the status of FUDS properties in the MMRP at the end of FY02.

Figure 32
Active Installations MMRP Site Status**
(as of September 30, 2002)

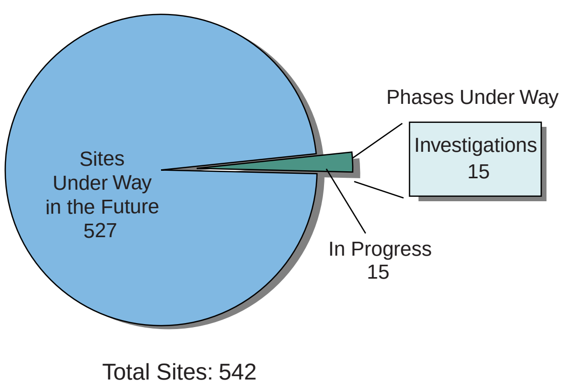
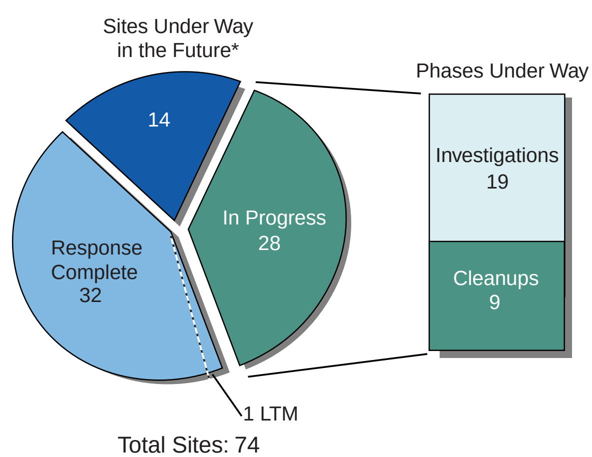
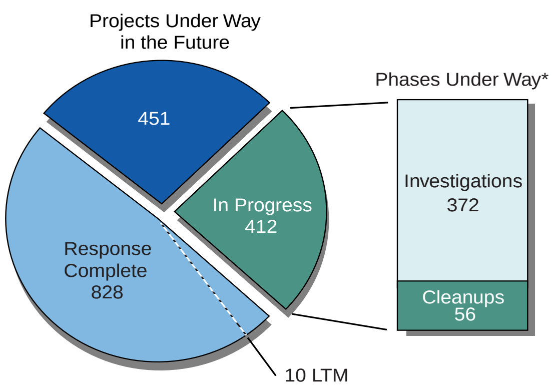


Figure 33
BRAC Installations MMRP Site Status
(as of September 30, 2002)



*Includes sites with future preliminary assessment starts and sites that are between phases.
**"Active installations" refers solely to areas other than operational ranges.

Figure 34
FUDS Properties MMRP Site Status
(as of September 30, 2002)



Total = 1,691

*Phases Under Way may not add up to Projects in Progress because some sites have multiple phases under way.

The risks posed at defense sites vary greatly. Many sites reach the RC milestone directly from investigation, when it is determined that the site does not pose a risk to human health or the environment that requires a munitions response, where as other sites must go through all phases of the munitions response to achieve RC. At some sites, access restrictions may suffice as a remedy following the investigation, due to technical impracticability or community concerns about ecological damage. Figures 35 and 36 illustrate the number of BRAC sites and FUDS projects achieving RC from both investigation and cleanup over the last four fiscal years.

Alternatively, some sites are found to require an immediate response, where the risk requires mitigation in an accelerated timeframe. At these sites, DoD normally conducts an interim action to address any immediate risks to human health and the environment.

Figure 35
BRAC MMRP Sites With Response Complete

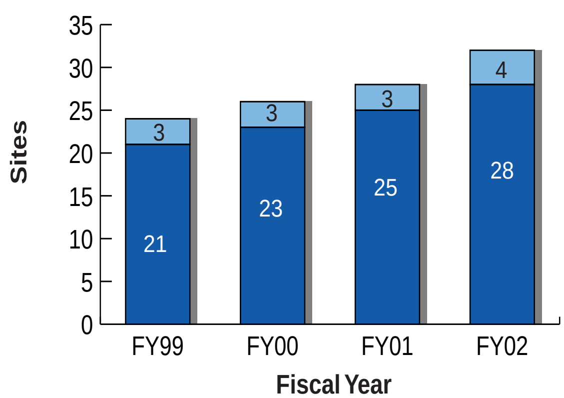
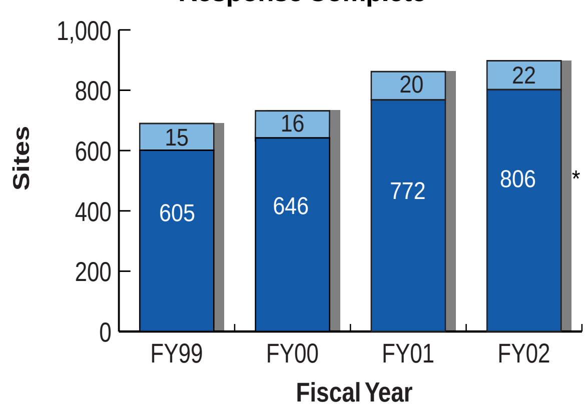
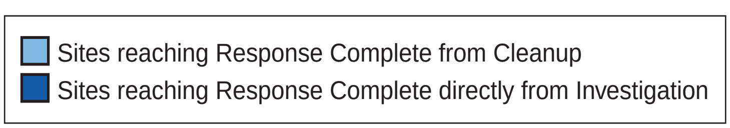


Figure 36
FUDS MMRP Projects With Response Complete





* Includes 1 site that had IRAs conducted prior to the completion of the studies.

Figures 37 and 38 show the number of interim actions completed at MMRP sites on BRAC installations and FUDS properties. DoD has not completed any interim actions at active installations.

DoD continues to develop its inventory as new information becomes available. The complete installation-level inventory can be found in Appendix C of this report. A Web-based version of the inventory, which will provide additional information such as site-level data and site maps, will be available by mid-2003.

Figure 37
Cumulative Interim Actions Completed at BRAC MMRP Sites

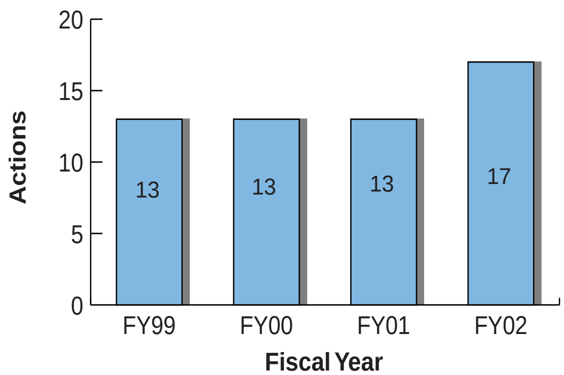
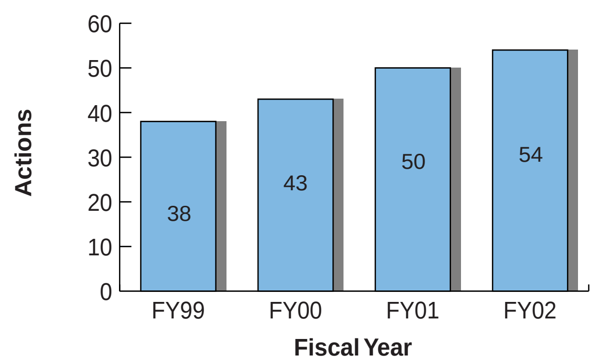


Figure 38
Cumulative Interim Actions Completed at FUDS MMRP Projects



Developing a Site Prioritization Protocol

In February 2002, DoD began developing, in consultation with representatives of states and Tribes, a proposed protocol for assigning a relative priority to each site in the MMRP. Similar to the Relative Risk Site Evaluation process for IRP sites, described in Chapter 3 of this report, this site prioritization protocol is intended to help ensure that DoD first addresses those sites that pose the greatest risk to human health and the environment, recognizing that resources are limited. The relative priority assigned to each site will serve as the primary factor for sequencing munitions responses under the MMRP category. DoD recognizes that other factors, such as economic, programmatic, and stakeholder concerns, may impact sequencing decisions.

When finalized, the protocol will replace DoD's interim tool for prioritizing MMRP sites, the Risk Assessment Code, that the U.S. Army Corps of Engineers developed to prioritize munitions responses at FUDS. The relative priority assigned to each site by the protocol will be based primarily on an evaluation of site conditions relating to the following potential explosive and environmental hazards that may be present due to the past munitions-related activites: explosive hazards posed by military munitions or explosives and health and environmental hazards posed by MC.

DoD has considered numerous factors during the efforts to develop the site prioritization protocol, including:

- Whether the UXO, discarded military munitions, or MC are known or suspected to be present
- The type of UXO, discarded military munitions, or MC thought to be on the site
- Whether public access to the defense site is controlled, and the effectiveness of these controls
- The potential for direct human contact with UXO, discarded military munitions, or MC at defense sites
- Whether a response action has been or is being undertaken at the defense site
- Whether the site is under DoD control and the planned or mandated date from DoD control
- The extent of any documented incidents involving UXO, discarded military munitions, or MC at or from the defense site
- The potential for MC to contaminate drinking water or to be released into the air
- The potential for destruction of sensitive eco-systems and damage to natural or cultural resources from future cleanup actions.

DoD published an Advanced Notice of the proposed protocol development process in the Federal Register on March 20, 2002. Through this notice, DoD requested early input from stakeholders, including the public, state and local governments, Tribes, and other Federal agencies, on the factors that should be considered in the development of the protocol and the methods used to prioritize defense sites. DoD also sponsored meetings with Tribes, state regulators, and other Federal agencies to ensure their concerns were addressed during the protocol's development. DoD will publish the proposed protocol in the Federal Register and provide a formal 60-day public comment period. Following consideration of submitted comments, DoD will finalize the protocol and apply it to the sites listed in the MMRP inventory.

For more information on the MMRP Site Prioritization Protocol, visit

https://www.denix.osd.mil/MMRP

DoD guidance requires Components to document the relative priority assigned to each defense site in the Management Action Plan (MAP) for the installation or FUDS property. Components will also include the priority with other information on the site in the MMRP inventory and update the priority to reflect any new information that becomes available. Further, each DoD Component will solicit input from and provide site inventory and prioritization information to stakeholders.

Upon its completion, DoD will use the protocol as the basis for its MMRP risk management strategy, in the same manner as the relative-risk site evaluation is used in the IRP. The site prioritization protocol will set the framework for the MMRP by establishing a structure to help determine the sequence in which munitions responses should be conducted. As it is finalized and applied to the MMRP inventory, DoD will develop goals and metrics to ensure the future progress of this program, similar to the relative risk reduction goals for the IRP.

Establishing Program Goals and Performance Metrics

As MMRP sites are prioritized, DoD will work to develop and implement program goals and performance metrics to measure progress in completing work at MMRP sites. Similar to the IRP, the MMRP category will have both goals to move through the phases of the program and goals to address the sites with greatest risk first. DoD will begin developing the program progress goals in FY03 based on the site-level cost data found in DoD's MMRP inventory; the risk-based goals will be developed based on the prioritization of sites under DoD's MMRP site prioritization protocol.

Focus on the Field

FUDS

Unique Approach to Munitions Response Saves Time and Money

At the former Boise Barracks in Boise, Idaho, the U.S. Army Corps of Engineers (USACE) removed unexploded ordnance (UXO) and discarded military munitions from over 1,000 acres of terrain for less than half of the estimated cost. These savings were realized through the unique approach of USACE's contractor.

Terrain cleared of ordnance and explosives at the former Boise Barracks.

The contractor streamlined the surveying process for this project by using a working grid for surveying the property that was 100 times larger than the standard working grid typically used in the removal of UXO and discarded military munitions. This action also allowed surface clearance crews to cover much longer distances without interruption. In addition, the sweep team doubled its coverage area by spacing team members 10 feet apart rather than the standard five feet.

After the contractor passed several quality control and assurance inspections, USACE determined that this innovative strategy was successful. The fixed price of the contract provided substantial savings over the initial estimated cost, while still allowing USACE to achieve surface clearance on 1,000 acres and subsurface clearance on 50 acres of trails. Additionally, display cases, brochures, and posters were prepared to highlight the cleanup success.

The process of establishing MMRP goals and metrics mirrors the development and use of the management goals and metrics used in the IRP and incorporated in DoD's Financial Management Regulation and President's Budget exhibits. DoD will use these program goals and performance metrics to accurately plan, program, and budget for stable funding to complete MMRP requirements. Continuously evaluating the program's goals and metrics will help DoD build on the existing foundation to meet the future challenges the MMRP will face.

Managing the Program

DoD has demonstrated success in the IRP, and will continue this progress in the MMRP. By building the MMRP through forward thinking policies and guidance, establishing an inventory, determining a risk-based approach to addressing sites, and creating goals and performance metrics—the same steps taken to create the IRP—DoD has assembled the framework for the MMRP on a proven foundation. Through effective program management, including increased stakeholder participation and outreach, inclusive data collection and site tracking, and consistent and thorough reporting, DoD will continue to build the MMRP on the success of the IRP.

Communicating with Stakeholders

The MMRP will promote DoD's and other stakeholders' understanding of the challenges associated with military munitions response activities and further their effective conduct and management. One way in which DoD is encouraging participation of the other stakeholders is by working with Environmental Protection Agency (EPA), the states, Tribes, and other Federal agencies to establish a munitions response committee (MRC) to address issues related to munitions responses and attempt to develop consensus-based policy to guide munitions responses. The MRC also worked in consultation with representatives of states and Tribes to complete the MMRP sites prioritization protocol.

Managing Programmatic Information

To track the additional data required for the MMRP, DoD modified its RMIS, updating the data structure to include MMRP data elements required by statute, as well as those called for in DoD guidance. In addition to the data discussed above, these data elements include:

- A unique identifier for each site
- A record of the location, boundaries, and extent of each site
- Current land owners, and
- Land use controls or restrictions.

In turn, each Component modified its data collection procedures to record and provide these data in support of the MMRP inventory requirements. DoD continues to update its RMIS as new information becomes available.

Reporting on Program Progress

As previously noted, Congress asked DoD to provide an interim assessment of its MMRP; this requirement was fulfilled by the FY01 Annual Report. In this report for FY02, DoD fulfills its remaining obligations under the statutory requirements. As the site-level MMRP inventory is updated, sites are prioritized, funding is budgeted, and work is executed, DoD will report its progress and initiatives accordingly.

Budgeting

Like the well-established IRP, the MMRP category requires predictable funding levels for accurate planning and program execution, as well as for estimation of future costs and activities. Without the required amount of funding, sites identified in the MMRP inventory cannot be properly addressed and their risks effectively mitigated. To ensure proper funding levels are attained, DoD engages in a budgeting that is closely tied to program planning and execution, as discussed in Chapter 2 of this report. The creation of the MMRP program element helps DoD manage MMRP funding and allows Congress to make more informed budgetary decisions in support of the program.

FY02 Financial Status and Progress

The cost-to-complete (CTC) estimates derived as a result of the budgeting process are based on DoD's available site-level data and provide the most accurate picture of anticipated cost trends for addressing MMRP requirements, serving as DoD's site-level estimates of CTC restoration activities at its MMRP sites. Figures 39 and 40 show DoD's estimated funding requirements for munitions responses by budget year and phase. DoD demonstrates its commitment to addressing MMRP concerns by continuing to increase the resources available for reducing risks at these sites. As the MMRP matures and new sites are identified, DoD's CTC estimates will improve to provide an even more accurate picture of program requirements.

Figure 39
Active Installation and FUDS Property MMRP Cost-to-Complete Estimates by Phase Category, FY03-Complete*† (in $000)

Phase	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10-Complete
Investigation	36,058	28,304	18,075	16,801	12,465	38,581	59,225	1,844,970
IRA	5,560	2,460	1,575	459	0	0	0	25,961
RD	167	160	179	626	54	220	168	49,885
RA-C	30,962	38,196	48,851	56,127	63,195	58,367	69,291	8,023,178
RA-O	0	0	0	0	0	0	0	1,476
LTM	472	0	0	0	0	0	0	1,222,184
Total	**73,219**	**69,120**	**68,680**	**74,013**	**75,714**	**97,168**	**128,684**	**11,167,654**

*Does not include program management, DTRA, other miscellaneous costs, and IRP funding. IRP funding is shown in Chapter 3 of this report.
†"Active installations" refers solely to areas other than operational ranges.

Figure 40
BRAC Installation MMRP Cost-to-Complete Estimates by Phase Category, FY03-Complete* (in $000)

Phase	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10-Complete
Investigation	3,475	0	1,629	250	25	0	115	537
IRA	0	0	0	0	0	0	1,824	0
RD	0	65	0	0	0	0	100	291
RA-C	17,004	7,077	8,464	2,634	2,728	2,518	11,135	325,329
RA-O	0	0	0	0	0	0	0	652
LTM	135	85	553	528	528	1,211	912	2,700
Total	**20,614**	**7,227**	**10,646**	**3,412**	**3,281**	**3,729**	**14,086**	**329,509**

*Does not include program management, other miscellaneous costs, and IRP funding. IRP funding is shown in Chapter 3 of this report.

Figures 41 and 42 show DoD's estimated CTC for munitions responses by phase category and Component based on the inventory completed. As of the end of FY02, only the Defense Logistics Agency (DLA) had identified no MMRP sites at its active installations. Air Force and DLA have identified no MMRP sites at their BRAC installations. DoD's CTC estimates presented above serve as the site-level estimates for sites in the inventory Congress requested in Section 311 of 10 U.S.C. 2710. The Resource Conservation and Recovery Act (RCRA) and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) proposals contained in the Department's Readiness and Range Preservation Initiative (RRPI) only apply to operational ranges and, if enacted, will not have an impact on DoD's environmental financial liability or the DERP.

Figure 41
Active Installation and FUDS Property MMRP Cost-to-Complete Estimates by Phase Category and Component, FY03-Complete*† (in $000)

Phase	Army	Navy	Air Force	DLA	FUDS	Total
Investigation	142,704	78,231	126,887	0	1,706,657	2,054,479
IRA	0	31,051	0	0	4,964	36,015
RD	0	1,396	0	0	50,063	51,459
RA-C	425,919	179,844	322,779	0	7,459,625	8,388,167
RA-O	0	1,476	0	0	0	1,476
LTM	56,289	40,624	256,016	0	869,727	1,222,656
Total	**624,912**	**332,622**	**705,682**	**0**	**10,091,036**	**11,754,252**

*Does not include program management, DTRA, other miscellaneous costs, and IRP funding. IRP funding is shown in Chapter 3 of this report.
†"Active installations" refers solely to areas other than operational ranges.

Figure 42
BRAC Property MMRP Cost-to-Complete Estimates by Phase Category and Component, FY03-Complete* (in $000)

Phase	Army	Navy	Air Force	DLA	Total
Investigation	4,177	1,854	0	0	6,031
IRA	1,824	0	0	0	1,824
RD	391	65	0	0	456
RA-C	354,877	22,012	0	0	376,889
RA-O	652	0	0	0	652
LTM	5,596	1,056	0	0	6,652
Total	**367,517**	**24,987**	**0**	**0**	**392,504**

*Does not include program management, other miscellaneous costs, and IRP funding. IRP funding is shown in chapter 3 of this report.

Figures 43 and 44 show each Component's planned ER and BRAC funding for munitions responses at defense sites for FY01, FY02, FY03 and FY04. These costs are for investments at other than operational ranges. As sites are prioritized and program goals and performance metrics are established, the Components will invest their MMRP funding accordingly to appropriately address the risks at these sites. Detailed installation-level information on DoD's anticipated funding needs for the MMRP can be found in Appendix C of this report.

Figure 43
Planned Investments for Munitions Response at Active Installations and FUDS Properties, FY01-FY04†† (in $000)

ER	FY01	FY02	FY03	FY04
Army*	10,042	9,982	10,000	10,000
Navy**	6,945	7,997	8,000	8,000
Air Force	0	0	0	0
FUDS†	58,162	59,992	76,155	64,120
Sub Total	**75,149**	**77,971**	**94,155**	**82,120**

Figure 44
Planned Investments for Munitions Response at BRAC Installations, FY01-FY04 (in $000)

BRAC	FY01	FY02	FY03	FY04
Army	38,347	33,837	11,178	2,520
Navy***	0	915	9,436	4,707
Air Force****	0	0	0	0
Sub Total	**38,347**	**34,752**	**20,614**	**7,227**

*In addition to Environmental Restoration (ER) account investments, Army executed $12.0 million in FY01 and $35.9 million in FY02 in the Operations & Maintenance (O&M), Army Appropriation at Massachusetts Military Reservation (MMR). Army will execute $76.2 million and $65.5 million in FY03 and FY04, respectively, in the O&M, Army Appropriation at MMR.

**In addition to ER investments, Navy executed $60.0 million in FY01 and $66.9 million in FY02 in the O&M, Navy Appropriation at Kaho'olawe. Navy will execute $25.0 million in FY03 in the O&M, Navy Appropriation at Kaho'olawe.

***Navy is funding military munitions response activities for Adak Naval Air Facility, Mare Island Naval Shipyard, and South Weymouth Naval Air Station with BRAC IRP funding. This funding is reflected in Appendix B of this report.

****No MMRP category sites were identified at Air Force BRAC installations. The Air Force addressed the UXO risks incidental to IRP sites through the IRP category.

†FUDS totals include funds for Archive Search Reports.

††"Active installations" refers solely to areas other than operational ranges.

High and Low Cost Estimates

In addition to the site-level estimates provided in Figures 41 and 42, Congress asked DoD to provide projected low and high program estimates of cost for addressing UXO, discarded military munitions, and MC at operational ranges and all defense sites. In response to this statutory requirement, DoD prepared the *Guidance on Estimating Low and High Aggregate Projected Costs for the Remediation of Unexploded Ordnance, Discarded Military Munitions, and Munitions Constituents.* This guidance provided the Components with explicit instructions for the development of these low and high program estimates for operational ranges, which do not fall within the definition of defense sites or within the scope of the DERP, and for all defense sites.

The guidance required each Component to submit low and high estimates for addressing UXO, discarded military munitions, and MC. The Components supported their estimates by submitting a summary of the information used to prepare the estimates, including the number of ranges, the number of acres anticipated to contain a high density of UXO,discarded military munitions, and MC, and the number of acres anticipated to contain a low density of UXO,discarded military munitions, and MC. Figure 45 shows the low and high estimates submitted to fulfill this one-time requirement.

Figure 45
Aggregate Low and High Cost Estimates for Addressing UXO, Discarded Military Munitions, and Munitions Constituents (in billions of dollars)

	Operational Ranges		Other Than Operational Ranges	
	Low Estimate	High Estimate	Low Estimate	High Estimate
UXO and Discarded Military Munitions	15	83	8	21
Munitions Constituents	1	82	<1	14

For MMRP sites, the guidance required that each Component submit aggregate CTC estimates—a site-level, low, and high estimate for UXO and discarded military munitions; and a site-level, low, and high estimate for MC. The Annual Report to Congress already reports the site-level CTC estimates for MMRP sites in Appendix C, however this year aggregate low and high program cost estimates are also reported to satisfy the one-time Congressional reporting requirement in Section 313 of 10 U.S.C. 2710. DoD estimates that total costs to address risks from UXO, discarded military munitions, and MC at operational ranges will be between $16 billion and $165 billion; estimated costs to address UXO, discarded military munitions, and MC at MMRP sites (i.e., other than operational ranges) will be between $8 billion and $35 billion.

DoD's guidance outlines specific assumptions, as directed in the statutory requirement, to be applied to the low and high cost estimates. These assumptions address:

- Any public uses after the remediation is completed
- The extent of the remediation required to make the site available for use
- The technologies to be applied to achieve such a level of remediation.

DoD used the assumptions outlined in the guidance to develop all low and high cost estimates. However, under the guidance, the Components could apply different assumptions when site-specific information indicated that different assumptions should be used, either at a program-level or a site-level, to yield more accurate cost estimates.

Whenever different assumptions were used, the Component justified their use. For instance, in cases where sufficient data was not available to support the development of cost estimates using the assumptions outlined in the guidance, DoD selected and documented the alternative assumptions used. Army, Navy, and FUDS each followed an alternative assumption; these variances are identified in Appendix G of this report.

Although the guidance outlined consistent assumptions for cost estimates, it adopted a decentralized approach to developing the numbers to ensure that site-specific knowledge would be used to develop the most appropriate and accurate cost estimates. DoD's *Guidance on Estimating Low and High Aggregate Projected Costs for the Remediation of Unexploded Ordnance, Discarded Military Munitions, and Munitions Constituents* is included in its entirety in Appendix G of this report.

Evaluating the Impact of Technology

The MMRP technology evaluation summarizes the munitions response technology currently available, assesses the impact of improved technology on the cost of munitions responses, and outlines a plan for the development and use of improved technology. Using this assessment, DoD provides Congress with an accurate picture of how technology can benefit the MMRP and identify the areas in which munitions response technology can be improved.

Since there are fundamental physical differences between munitions (i.e. UXO and discarded military munitions) and MC, the discussion of munitions response science and technology is divided into two categories: munitions technology, which includes those systems used to locate, detect, discriminate, recover, and destroy UXO and discarded military munitions; and MC science and technology, which includes the systems used in sampling and analysis of environmental media and the systems used to remediate releases of MC. In addition, the discussion of MC science and technology addresses the state of the current knowledge base related to the toxicological and environmental distribution, fate, and transport of MC.

Munitions Technology Currently Available

The type and complexity of the technologies used at different points in conducting a munitions response to UXO or discarded military munitions reflect the different activities that occur throughout the response process. Throughout the course of a munitions response to UXO or discarded military munitions, multiple systems or technologies are needed to:

- Identify and characterize areas where UXO are thought to be present;
- Detect UXO and record a geographic reference of that location;
- Discriminate UXO from innocuous materials (e.g., scrap metal, geological formations);
- Excavate or recover UXO; and
- Destroy or neutralize recovered UXO.

In addition, technologies are used for long-term monitoring, post-response reviews, and assessing the quality of the munitions response. The technology required for each of these activities is not necessarily unique to the MMRP; the systems used may be used in the IRP.

Area Identification and Characterization

All munitions response activities to address UXO require characterization of the site to identify probable areas (e.g. target or impact areas, firing points on ranges, burial sites) critical to developing and executing an efficient, comprehensive, and cost effective response. At very large sites, such as former ranges, characterization may show that UXO or discarded military munitions are present on only a small fraction of the total acreage. Planning and implementing a response by simply assuming an equal distribution of munitions over the entirety of a site can prove to be an inefficient use of resources. This kind of approach has led to the extremely high cost estimates seen in the past.

The current approach to assessing an area for UXO involves the use of statistical tools, professional judgment, historical records investigation, and information derived from the characterization of a fraction of the site using visual surface sweeps and detection technologies. By contrast, the technologies discussed in the following sections are focused almost exclusively on detecting subsurface UXO or discarded military munitions.

Detection

After areas of probable UXO presence have been identified, the next step in conducting a munitions response involves locating UXO. When UXO are on the surface this is a relatively simple task, but finding subsurface UXO or UXO in thick vegetation is much more challenging. Detection of surface UXO is presently performed primarily through visual searches, or technology-aided (e.g. use of simple hand-held analog systems) surface sweeps in areas of thick vegetation. This method requires trained personnel to walk the entire area, visually scanning for UXO. Although this technique is slow, labor-intensive, and can be quite costly when addressing large areas or areas with rough terrain, it is effective and to date no single system with a distinct performance advantage has emerged. Two main technologies comprise the UXO detection technology baseline. These are simple analog systems and digitally recorded, geo-referenced systems. There is currently no baseline technology available for wide-area assessment or for underwater detection of UXO.

Multi-Sensor Towed Array Detection System is an example of the newer generation of vehicle towed systems.

Simple Analog Systems

Until recently, the primary method for detecting UXO involved personnel scanning an area of land with a simple analog system, such as a hand-held magnetometer that senses disturbances in the local magnetic field caused by the presence of ferrous metal and translates this disturbance into an audio signal that is interpreted by the operator. When the signal indicating an electromagnetic field disturbance is heard, the operator marks the location with a small pin flag—resulting in this technique being termed "mag and flag." Later, all marked locations are excavated to find any material at these flagged locations.

Although simple analog systems are widely used, this technology has many limitations. For example, in the application of these simple systems, no sensor data is recorded for subsequent analysis, and the decision to mark a location is based solely on the operator's instantaneous and subjective analysis of the audio signal. Also, in a vast majority of cases, the items recovered prove to be innocuous pieces of metal —experience has shown that for every UXO removed approximately 100 innocuous items or empty holes may be excavated. In addition, these systems are unable to detect deeply buried UXO, and their overall effectiveness is highly dependent on operator performance. These systems are relatively inefficient, capable of scanning only small areas of land at a given time. This slows the process of detecting potential UXO, particularly over vast areas. Despite the limitations on this technology, these systems do have some advantages in that they are readily available at a low cost, and can be useful when vegetation or difficult terrain make the use of more advanced systems infeasible. They are also useful in reacquiring UXO originally detected by other methods.

Digitally Recorded, Geo-referenced Systems

More advanced than simple analog systems are digitally recorded, geo-referenced sensor technologies, whose improved capabilities represent the results of recent efforts to develop UXO better detection and discrimination technologies. These UXO detection systems can digitally record information from sensor signals and reference that data to the position of the detected anomaly on the site. These improvements provide a permanent record of the data collected and allow subsequent computer modeling analysis of the data. These systems also cover a larger amount of surface area than simple analog systems, capable of scanning up to several dozen acres per day.

Digitally recorded, geo-referenced geophysical technologies, such as simple time-domain electromagnetic induction (EMI) and cesium vapor magnetometers, are considered the current sensor technology baseline. Combinations of different sensor technologies and the use of more complex EMI sensor systems are emerging as the next step in the evolution of UXO detection technology. This advanced sensor technology is currently available with a wide range of properties and performance characteristics that can be matched with site-specific conditions. The primary difference among these various configurations is their usefulness given differences (e.g. vegetation, terrain, type of munitions used) in site specific conditions. Each also has a particular application (e.g., magnetometers can detect only munitions components containing ferrous metal) and each is useful only under specific conditions (e.g., vehicle mounted systems usually cannot be used in dense vegetation). A number of advanced versions are currently under development. The systems currently used in the field are primarily restricted to total field magnetometers and single axis, single time-gate EMI systems.

Although digitally recorded, geo-referenced technologies are a significant improvement over simple analog systems, there are still several factors currently limiting the utility of these systems. For example, if the geo-referencing is done through the use of a global position system (GPS), the system must be able to obtain a signal from the GPS satellites, which can be difficult if the system is operating in an area with dense overhead cover, such as a forest. Additionally, current digitally recorded, geo-referenced technologies are not as light or deployable as the older simple analog systems and can be unreliable in rough terrain.

Wide-Area Assessment

One of the most significant challenges in conducting munitions responses is the size of the area to be investigated. Such areas can range from less than one acre to tens of thousands of acres. In larger sites, wide-area detection technologies can have a significant impact on both the identification and characterization of areas (e.g. target or impact areas) where it is most probable that UXO will be detected.

Presently, the baseline of available UXO technologies does not include wide area assessment technologies. Developmental work on airborne wide area screening technology is ongoing, with helicopter-borne total field magnetometer systems emerging as a powerful and cost-effective tool for open, large-area surveys. The primary benefit of aircraft-borne systems is the coverage of large areas in a shorter timeframe, due to the high speed and wide detection swath of these systems.

Helicopter-borne detection systems are emerging as a cost-effective tool for characterizing large areas.

Underwater Detectors

There is a no baseline technology for underwater UXO detection, partly because few underwater assessments or production surveys have been undertaken. Limited experience and a number of technical challenges need to be overcome in this area. These technical challenges include, but may not be limited to: including navigation, station keeping, and sensor deployment in water. The few systems employed to date include towed side-scan sonar, magnetometer systems, and simple EMI systems.

Discrimination

The increased use of digital recording and geo-referenced sensors allows for the use of sophisticated processing techniques to conduct further analyses of collected data. Investments in systems for post-collection data processing now allow the generation of detailed maps showing sensor responses across the areas covered. More importantly, the data collected is now being analyzed in an effort to discriminate UXO from innocuous materials with similar sensor signatures. Advancements in discrimination technologies will help make UXO response activities more focused and efficient. In the studies performed at Jefferson Proving Ground (JPG), Indiana, the use of post-processing systems showed it was possible, when certain conditions are available, to correctly discriminate UXO from innocuous metal items roughly half the time.

So far no single system has emerged as having a distinct performance advantage. Each of the systems available has a unique set of properties and performance characteristics that must be matched to site-specific conditions. At times, a mix of technologies must be used to address the entirety of the site. The current baseline technology for discrimination of UXO from innocuous items is computer-based post-processing of digital data, which allows the operator to identify the location, depth, and approximate size of the object being investigated. As the baseline for detection systems moves beyond the first generation of digital systems, discrimination tools will also advance. Currently, on simple sites where only a limited number of munitions types had been used, discrimination based on simple features such as size allows for a discrimination of UXO from innocuous items. The key to reducing the cost and improving the effectiveness of UXO responses lies in improved discrimination.

Recovery

One of the most common methods of addressing UXO is to recover the munitions item intact for destruction or neutralization. Given the nature of UXO, this process is inherently hazardous, conducted in close proximity to the UXO. As a result, when implementing a munitions response that involves UXO recovery, the primary objective is to conduct the recovery in a manner that minimizes potential hazards to the public, response personnel, and to any nearby property, while at the same time attempting to minimize any environmental impacts.

Unintentional encounters with UXO are extremely hazardous.

In most cases, response personnel manually excavate and recover individual UXO in order to minimize the potential for accidental disturbance and unintended detonation; in some areas, however, such as near the center of an impact area, recovery work is extremely hazardous and can be very costly and time consuming. While there is some use of standard small–scale earthmoving equipment, the ability to use larger, more powerful devices is extremely limited due to the increased potential for both accidental detonation of UXO and an unacceptable environmental impact. Access problems caused by property owner-imposed restrictions, geographical features, or by environmental impact concerns can also restrict the ability to use such devices to retrieve or remove UXO. Likewise, there are no specialized systems for the recovery of UXO in water or dredged sediments. Therefore, the current baseline technology for recovering UXO is manual excavation of single items with, or without, the assistance of small-scale earthmovers.

Destruction

The final step in the munitions response process is to destroy or neutralize recovered UXO. The current technology baseline for UXO destruction is destruction in place by open detonation. If it is determined that a munition can be moved with an acceptable degree of risk, it may be relocated to another area for disposal. When moving UXO poses an unacceptable risk, then destruction in place by open detonation is the safest option for disposal. During destruction in place, an explosive charge or perforator is used to destroy the UXO either through the direct action of donor explosive or by causing sympathetic detonation of the explosive charge in the UXO. Often sandbags or water-filled blivets are used to mitigate blast effects (e.g., blast overpressure or fragment flight).

In the few cases where the on-site munitions or emergency response specialist (i.e., military Explosives and Ordnance Disposal (EOD) personnel) determines that in-place detonation may not be possible because of of an imminent and substantial endangerment to the public or critical facilities, EOD personnel may apply specialized technologies. However, even under these circumstances measures must be taken to protect the public and critical facilities from an unintentional detonation. In cases where the risk to move discovered munitions is acceptable, specialized technologies may be used in the detonation of recovered munitions. This technology is limited. For example, concerns about the potential for release of metals, unconsumed explosive compounds, or other organic compounds to the environment have prompted the use of a confined detonation system at the Massachusetts Military Reservation for those munitions that could be moved.

Munitions Constituent Science and Technology

In addition to the concerns about UXO at defense sites, there is concern about the potential for releases of MC from UXO and other military munitions. There are over 200 chemicals associated with military munitions and their degradation and combustion products. Of these chemicals there are 20 that are of greatest concern due to their widespread use and potential environmental impact. These 20 chemicals are shown in Figure 46.

Figure 46: Munitions Constituents of Greatest Concern

Trinitrotoluene (TNT)
1,3-Dintrobenzene
Nitrobenzene
2,4-Dinitrotoluene
2-Amino-4,6-Dinitrotoluene
2-Nitrotoluene
2,6-Dinitrotoluene
4-Amino-2,6-Dinitrotoluene
3-Nitrotoluene
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)
2,4-Diamino-6-nitrotoluene
4-Nitrotoluene
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)
2,6-Diamino-4-nitrotoluene
Methylnitrite
Perchlorate
1,2,3-Propanetriol trinitrate (Nitroglycerine)
Pentaerythritoltetranitrate (PETN)
1,3,5-Trinitrobenzene
N,2,4,6-Tetranitro-N-methylaniline (Tetryl)
(White Phosphorus)

Many of these compounds have been an environmental concern to DoD for more than 20 years. Compounds such as trinitrotoluene (TNT) may be found in the soil and groundwater at former ammunition manufacturing and at former load, assemble, and pack plants. DoD has recently identified the potential for MC to be released at locations such as former ranges, open burning/open detonation sites, and burial pits. Prior to the development of the MMRP, these sites were addressed as part of the IRP.

The current understanding of the causes, distribution, and potential impact of releases of MC is quite limited. In addition, the current technology for characterizing, treating, and monitoring releases of MC, especially over extremely larges areas, is also quite limited in terms of usefulness and effectiveness.

To effectively address releases of MC, DoD must advance MC-related science and technology to gain an understanding of:

- The types of contamination that is associated with different activities,
- The distribution, fate and transport of MC once they are released into the environment,
- The human and ecological impacts of releases of MC,
- Cost-effective strategies to characterize and monitor potential MC contamination, and
- Cost-effective means to treat or contain MC releases into the environment.

Focus on the Field

ARMY

Phytoremediation Cleans Up Groundwater at Aberdeen Proving Ground

The J-Field area at Aberdeen Proving Ground is located at the southernmost end of the Gunpowder Neck Peninsula in Harford County, Maryland. Specific activities at J-Field date back to when the Army began testing high explosives and chemical munitions. Between 1940 and the 1970s, the Army used J-Field for the disposal of many types of chemical agents, high explosives and chemical wastes, which were burned and detonated in open pits and trenches. Hydrocarbon fuels, such as diesel fuel, often were used to produce more complete combustion of the waste materials. Data collected indicate that nerve agents, adamsite, riot control agents, white phosphorous, and mustard gas were disposed of at J-Field. The Army also used various chlorinated solvents as decontaminating agents within the pits. Army investigations have detected significant levels of volatile organic compounds (VOCs) in the groundwater at the toxic burning pits area and range.

The Army planting trees at the Aberdeen Proving Ground phytoremediation grove.

The U.S. Army's Directorate of Safety, Health, and Environment, the U.S. Environmental Protection Agency (EPA) Region III, and EPA's Environmental Response Team Center worked together to examine innovative treatment technologies as options for cleanup activities at J-Field. The Army implemented a pilot-scale phytoremediation study in 1996, which successfully provided hydraulic containment of the groundwater plume and mass removal of VOCs. A final Record of Decision was signed in FY02, with phytoremediation playing a major role in the remedial action selected for the site.

Currently, the phytoremediation grove at J-Field consists of over 600 trees, including hybrid poplars, tulip trees, silver maples, loblolly pines, willows, and oaks. J-Field is the first Army facility that has selected the innovative remedy of phytoremediation as part of a CERCLA Record of Decision. Estimated cost savings for using phytoremediation versus conventional groundwater treatment is over $16.7 million.

Several notable groups have visited the J-Field phytoremediation grove. These visitors include the EPA Groundwater Forum, Italian Ministry of Defense delegates, members of Maryland Department of the Environment, German educators on an exchange program through a local community college, and graduate classes from the University of Maryland.

Sources Fate and Transport of Munitions Constituents

The lack of knowledge concerning sources of MC and the limited ability to quantify the extent and magnitude of potential MC releases severely limits DoD's ability to assess the risks and future liabilities associated with MC. Until quite recently, no systematic investigations had been conducted to gain a clear understanding of how MC releases occur and migrate into the environment on ranges. At present there is no consensus concerning the mechanisms that can lead to an MC release, the processes by which MC migrate into the environment, or the quantity and frequency of such releases.

Understanding MC fate and transport in the environment is critical to planning investigations, conducting risk assessments, and implementing any required remedial activities. There are several well-established models for chemical fate and transport through soil and groundwater. These models require specific information about each chemical to model its movement and determine its effect on the environment. Presently there is no standard MC data set for these models. Although there is a growing body of data, gaps in certain chemical, biological, and toxicological properties of MC remain.

Human and Ecological Impacts

An assessment of the human health risks posed by a release of MC requires an understanding of the potential effects of those chemicals on humans. For most MC, either no benchmark values for health risks exist, or extremely conservative benchmark values have been adopted due to the limited scientific data available.

To fully assess the risks associated with MC, there must also be an understanding of how an MC release can impact ecological receptors, such as small mammals, birds, fish, amphibians, and reptiles. An ecological risk assessment requires a knowledge of both the direct impact of MC to these receptors, and the potential for indirect effects, such as transfer of contamination across trophic levels and bioaccumulation. Significant progress in assessing these issues has been made in the last several years, but due to the large number of chemicals and receptors that must be considered, there are still significant data gaps.

Site Characterization and Monitoring

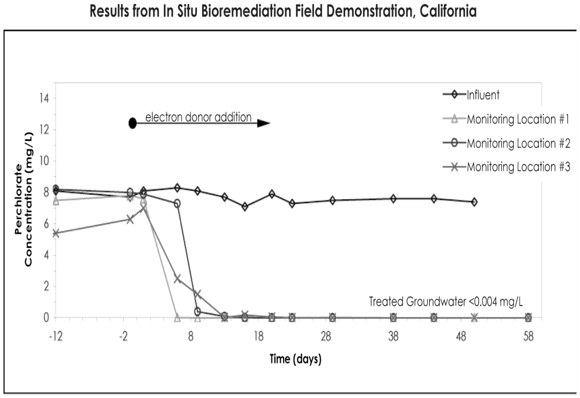
The baseline technologies for characterizing and monitoring MC in soil and groundwater consist of the devices used in standard laboratory methodologies and sampling techniques. Standardized laboratory analysis methods are available for most MC, with the exception of some of the less common transformation products, and involve the collection, transportation, and testing of samples. Costs for sampling and analysis can range from $200 to $1,000 per sample.

On-site characterization methods are emerging as a result of recent DoD investment in this area and are being used more frequently in site investigations. These field test methods provide a rapid and cost-effective alternative to laboratory analysis, but are available only for the more common MC.

Using Innovative Technology to Address Complex Challenges

In situ bioremediation shows tremendous promise for remediating perchlorate-contaminated groundwater. Results below demonstrate that when an electron donor is added to groundwater, local bacteria are able to rapidly break down perchlorate to below regulatory levels. This technology is relatively simply to implement and can result in substantial life cycle cost savings over pump and treat technologies. It is currently being demonstrated at multiple DoD sites across the country.

Results from In Situ Bioremediation Field Demonstration, California



Currently there is no standardized sampling strategy for characterizing MC contamination over large areas. The approach developed and accepted by regulators for characterizing industrial hazardous waste sites may not be appropriate for MC over large areas, as any MC present are expected to be highly dispersed and have an extremely heterogeneous distribution.

Treatment and Containment

The baseline technologies for treating MC in groundwater are pump-and-treat systems. These systems extract the contaminated groundwater, treat it in an aboveground system, and either re-inject the treated water or discharge it to a surface body of water. For most MC filtration through activated carbon is the standard ex-situ treatment, but a number of alternative in-situ treatment approaches are emerging due to DoD investments. These investments may significantly reduce the costs associated with the current ex-situ pump-and-treat methods.

Until the early 1990s, the baseline for treating MC in soils was excavation followed by incineration. DoD has developed a number of alternative ex-situ treatments, such as composting and soil washing, which are much more cost effective. At present, there is no standard approach for in-situ treatment or containment of MC in soil, which would greatly aid the cleanup of large areas of contamination.

Munitions Response Research, Development, Testing, and Evaluation

DoD has two principle objectives in striving to advance the state of the technologies used to conduct munitions responses. First, these efforts seek to enhance the overall effectiveness of munitions responses, improve the safety of response personnel, and increase overall protection of human health and the environment. Second, these efforts seek to reduce the costs associated with the MMRP and increase program efficiency.

The plan for investments in UXO technologies and MC science and technology from FY01 through FY04 are summarized in Figure 47. In this period, DoD seeks to continue its investment in advancing the state of UXO technology. Figures 48 and 49 show the distribution of the FY02 investment to each of the technology development objectives for both UXO and MC, respectively.

Technology Development Objectives

To provide focus for the technology development programs, DoD has established six objectives specific to munitions technology development and five objectives specific to MC technologies. These objectives do not represent single endpoints in the technology development process, but rather describe classes of technologies required to meet specific operational needs.

Figure 47
UXO AND MC RDT&E Investments FY01-FY04

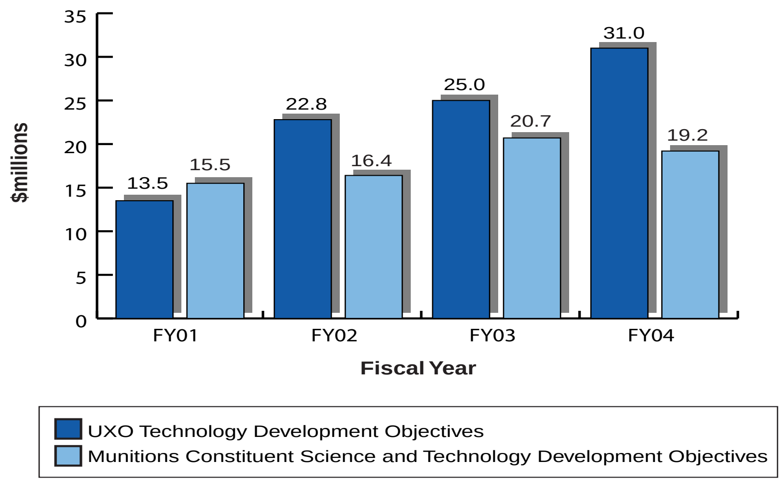


Figure 48
RDT&E Funding for MC, FY02
(percentage by funding)

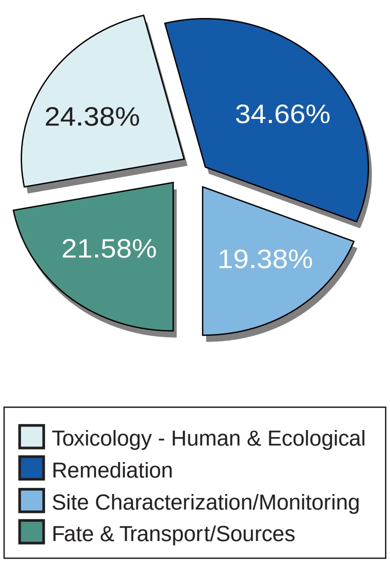
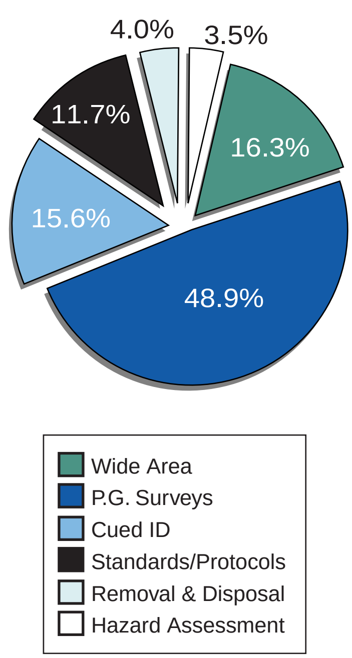


Figure 49
RDT&E Funding for UXO, FY97-FY02
(millions of dollars)
Does not include Directed Adds



Munitions Technology Development Objectives

- Wide-Area Assessment. Wide-area assessment technology can rapidly identify the areas within sites that require detailed characterization. Costs in dollars per acre covered for wide-area assessment are much lower than costs for detailed characterization, as the existing wide-area assessment systems are primarily airborne platforms that allow rapid coverage of large areas. It is important to note that these systems are not suitable for all terrains, currently only capable of detecting large objects or dense clusters of small objects, and they are unable to provide the high degree of detection efficiency and geo-location accuracy. Future developmental activities are focused on extending the use of these systems to a wide variety of terrain and improving their ability to detect smaller munitions.

- Production Ground Surveys. Production ground surveys currently involve the use of sensors to detect and locate UXO. Following collection, the data from the sensors is analyzed using computer modeling and simulation software. Significant progress has been made in improving detection capabilities, however, discrimination between UXO and innocuous materials with similar sensor signatures has not seen the same level of improvement. New sensor concepts with advanced detection and discrimination capabilities are in development. When coupled with similar efforts to improve the post-collection processing systems, these systems should lead to even greater improvement in detecting UXO more efficiently and effectively.

- Cued Identification. This objective focuses on the development of enhanced descrimination technology. After production ground surveys identify general areas that may contain UXO, cued identification is used to definitively identify the exact location of the item. Cued identification is a key element in discriminating between UXO and innocuous materials with similar sensor signatures, and is a critical feature of efforts to reduce the inefficiencies caused by poor discrimination.

- Standards and Protocols. This objective is focused on developing standardized methods for the collection, management, and evaluation of geophysical data. It includes the establishment of standardized test facilities and protocols that enable the evaluation of detection systems under reproducible conditions. These facilities would also aid in generating valuable data to support further development and optimization of these systems.

- Recovery and destruction. This objective is focused on developing systems that will improve the safety and efficiency of UXO recovery and destruction activities. Developing tools for the treatment of residues, mass clearance of highly contaminated areas, and removal and destruction of UXO in all site environments are of primary interests.

An example of UXO that may present MC concern.

- Decision Tools. This objective is focused on developing methods to guide and evaluate actions throughout the UXO-munitions response process. Developing statistical assessment tools, quality control tools, and hazard assessment tools are of primary interests.

Munitions Constituent Technology Development Objectives

- Sources of Contamination. This objective is focused on developing a greater understanding of MC releases, including the range activities that are associated with MC releases, the size, form, frequency and distribution of those releases, and how MC initially migrate into the environment. An assessment of potential sources of MC and a characterization of the associated releases are being conducted using laboratory simulations, computer modeling, and controlled firings on ranges and test chambers.

- Fate and Transport. This objective is focused on developing predictive tools for the movement and life of MC in soil, sediment, groundwater, surface water, and the marine environment. A wide variety of physical, chemical, and biological data is essential to understand the fate and transport of chemicals released into the environment, including physiochemical properties and process descriptors such as solubility and dissolution, adsorption coefficients, and half-lives. Much of this data has been identified over the last few years and final gaps are currently being filled. By building an understanding of how these materials move and are transformed in the environment, reliable risk assessments can be developed as can protocols to mitigate the impacts. This knowledge will support the development and design of sustainable training and testing ranges.

- Human and Ecological Toxicity. This objective is focused on developing standardized and accepted toxicity benchmarks for all munitions constituents. The majority of the chemicals used in explosives and propellants, along with their degradation products, lack sufficient toxicology and health effects data to establish clean-up standards or drinking water standards. Toxicity benchmarks and drinking water health advisory levels have been proposed for many MC, with the MC of greatest concern likely to have standards promulgated in the next few years.

- Site Characterization and Monitoring. This objective addresses the need for sampling protocols and technology designed to characterize and monitor MC on ranges. Sampling protocols designed to characterize ranges are under development, but must be tested in coordination with the regulatory community to ensure acceptance. Also under development are technologies designed to decrease the cost of groundwater and soil monitoring and innovative approaches specifically designed to characterize the large areas typical of ranges. Advances in sensor design,electronics miniaturization and wireless communication are being utilized to develop the next generation of tools.

- Treatment and Containment. The focus of this objective is to develop in-situ treatment and containment techniques for soil and groundwater. When MC are released into the environment, treatment or containment technologies are required to prevent unacceptable exposure. Ranges will also require techniques that are applicable for large areas and approaches that prevent MC from migration off ranges. Cost-effective treatment and containment of munitions constituents in groundwater and soil are being developed.

Additional information on these technology development objectives is provided in Appendix G of this report.

The Impact of Investments on Munitions Response Technology

A comprehensive evaluation of the impact of technology investment requires detailed information on the characteristics of military munitions response sites (e.g., topography, vegetation, soil type, expected future land use), and data on the specific technologies under consideration, as well as an extensive data set on the costs associated with ongoing or recently completed response actions. Because this level of detail is not available, the information presented here shows the nature of the impact that can result from investing in new technologies without attempting to quantify expected impacts and cost savings.

The impacts of advancing the state of current technology vary from direct predictable cost reductions to improved efficiency, and are expected to include:

- Increases in the efficiency of remediaiton systems leading directly to improved cleanup and decreasing unit costs;
- Improvements in the overall effectiveness of a system which impacts subsequent tasks or that causes a change in the total life cycle costs and long-term management requirements;
- Changes in the UXO response process due to the introduction of new technologies; and
- Overall improvements in program performance, efficiency, and confidence which impacts cost, schedule and management.

Unit costs and expected performance depend on the complexity and size of the site as well as the future land use and cleanup goal. Independent of these variables, though, reviews of the costs associated with UXO responses identified three variables as consistently having the greatest overall impact on cost. These variables include:

- The acreage requiring detailed surface and subsurface investigation,
- The number of anomalies requiring intrusive investigation per acre, and
- The total duration of a response.

Technology targeted to specifically address these site variables can significantly impact the overall cost of munitions responses. Technology is expected to have a significant impact on the quality of cleanup that can be achieved, which will reduce risks and free up land for alternative uses. Improved technology can also impact long-term costs by minimizing long-term management requirements at a site and reducing the need to return to sites where the response has been completed.

The following sections discuss the ways through which an investment in technology can advance the current technology baseline for site characterization, detection and descrimination, recovery and destruction, and long-term management of military munitions response sites.

Impact of Technology on Site Characterization

There is usually a wide variation in the distribution of UXO across a munitions response site, ranging from areas with little potential for UXO presence to areas where UXO is almost certainly present. Understanding the distribution of UXO across a site allows a tailored approach to site characterization, focusing munitions response activity on the areas with the highest probability of UXO contamination, rather than spending resources to scrutinize the entire site.

The use of advanced technology with enhanced UXO detection precision can minimize the area requiring detailed investigation which reduces munitions response costs. To achieve a reduction in response area, advances must be made in: (1) statistical protocols to aid in the planning of detailed site investigation, (2) wide-area airborne technology that can accurately assess larger land areas, and (3) sensors and software to improve detection and discrimination.

Statistical tools will put the process of area reduction on a firm scientific basis. Using these tools with the existing baseline detection and discrimination technology should yield significant cost savings. Wide-area airborne technology offers the potential to perform surveys over the majority of terrain at costs estimated to be much lower than experienced with current systems. As previously stated, this technology is already emerging for flat and open terrain and has detection performance sufficient for area reduction for medium to large ordnance. Combining these two tools should allow

Focus on the Field

FUDS

U.S. Army Corps of Engineers Successfully Removes Ordnance from Former Erie Army Depot

For almost 50 years, the U.S. Army used the 96,000-acre Erie Army Depot for testing and evaluating munitions, including firing live and inert ordnance into Lake Erie. Since 1966, the property has been the home of the Erie Industrial Park and the Toussaint Gun Club and has served as a popular tourist and local fishing area.

Searching for UXO at the former Erie Army Depot.

In May 2002, the U.S. Army Corps of Engineers (USACE), Louisville District, began a time-critical removal action at the property to remove high concentrations of ordnance remaining from the depot's former activities from the beachfront and surrounding waters. Following a meeting with the local community and the Ohio Environmental Protection Agency, the USACE worked with area marina and other business owners to develop a plan for the removal. Because of the area's popular fishing season and associated tourism, the USACE delayed the removal and, in the interim, worked with the community to increase awareness of the work to be performed. The USACE distributed fliers, local newspapers and television stations carried news stories, and a notice was provided to mariners to ensure the safety of boaters and residents. To further reduce the impact on the community, ordnance removal was restricted to off-peak and low-tourism hours.

UXO recovered in a low-water area.

Although the removal proved much more difficult than originally envisioned, the removal team overcame the obstacles through close partnership with stakeholders. By mid-August, the removal team had collected and disposed of over 3,000 items and sent approximately 13 tons of scrap metal for recycling. The USACE partnership with regulatory agencies and continual involvement with local stakeholders minimized the impact on the surrounding area—no boats were ever delayed from entering Lake Erie due to the removal project.

To increase the effectiveness of future ordnance removal actions, the USACE began a mobility study to track the movement of any remaining ordnance in Lake Erie. From the data gathered in this study, the USACE aims to develop a long-term strategy to address any future removal actions that may be needed.

DoD to focus its resources on those areas where the majority of UXO is present. At moderate to large sites, which can extend over thousands of acres, a significant portion of the total site may not need to undergo more detailed investigation.

Impact of Technology Investment on Improved Detection and Discrimination

As with the size of the site, the number of anomalies at a site suspected of being UXO has a significant overall effect on response costs. The current practice is to assume that every anomaly detected is a potential UXO and recover the item. Experience at many sites has shown that for every UXO removed, approximately 100 innocuous items that posed no explosive hazard are recovered. With the cost for recovering a subsurface anomaly usually exceeding $200 each, this current practice is a highly ineffective use of resources. Developing the ability to avoid recovering a large number of innocuous items will yield significant savings.

In order to reduce this inefficiency, DoD has focused its investment on the development of technology with advanced sensor design, enhanced geo-referencing capabilities, improved sensor platforms, and more sensitive discrimination capabilities to more effectively distinguish UXO from innocuous items. Given the site-specific nature of the ratio of UXO to innocuous items, it is imprudent to attempt to estimate the total costs that may be saved by this investment; however, every time recovery of an innocuous item is avoided, those resources remain available to recover UXO.

Finally, it is crucial to recognize that improvements in detection and discrimination technology will improve the quality of the clearance. The primary benefit already being recognized is an increase in the protectiveness of the responses using the new technology. For example, the testing conducted at Jefferson Proving Ground showed a 15 percent increase in the average likelihood of detecting subsurface UXO, and blind comparisons between the newer technology and traditional “mag and flag” show even larger improvement. Yet, in difficult sites with high clutter or terrain issues, even the best current systems can leave a significant residual risk due to undetected UXO. Although it is highly unlikely that any technology will ever yield a 100 percent detection rate at every site, improvements are still required for these sites if this land is to be developed for alternate uses.

Impact of Technology Investment on the Recovery and Destruction Phases of a Response

In the area of UXO recovery and destruction the impact of new technology is not expected to be as dramatic as those discussed above. Given the current baseline of technology (i.e., manual excavation or use of small scale earthmoving equipment) when the investment results in new technologies coming into use, there will likely be at least a transient increase in costs, simply because of the move to the use of the a more advanced system. The same observation is true for destruction technologies, since the current baseline (i.e., detonate in place) does not involve the use of any system beyond the donor explosive. Nevertheless, development of mass area clearance technologies for heavily impacted areas can significantly reduce the costs of clearance. Although these areas constitute a small portion of the total acreage, the total cost of clearance of these areas, although uncertain at present, is still expected to be a significant. Similarly, issues of recovering UXO in dredged sediments are restricted to a limited number of sites; yet each one can have a significant cost impact, which can be avoided by improved detection and recovery technologies. The critical objective in planning these investments is, therefore, to ensure that the new technology has benefits that justify the investment.

Impact of Technology on Response Duration and Long-term Management

Advanced technology can aid in the overall management and reduce the total cost through improved efficiencies and shorter project duration. The investments being made in technology should cause responses to proceed more rapidly. As all projects have certain fixed costs, decreasing the time required to execute the project will result in some cost savings.

There are additional long-term costs impacts that are difficult to quantify at the present time. Under various environmental laws (e.g., the Comprehensive Environmental Response Compensation and Liability Act (CERCLA)), unless a site is remediated to a degree that allows unrestricted use, there is a requirement to monitor the site on a recurrent basis to ensure the continued effectiveness of the response. Under CERCLA, monitoring occurs as needed and, at a minimum, is assessed during the five-year review.

Focus on the Field

NAVY

Munitions and Explosive Cleanup at Naval Weapons Station Seal Beach Reduces Risk and Adds New Wetland in the Process

The Navy recently removed more than 24,000 tons of soil and debris from the Naval Weapons Station (NWS) Seal Beach, California, to protect base personnel, the public, and the environment from potential hazards associated with abandoned munitions.

NWS Seal Beach encompasses 5,000 acres of land, including over 900 acres of saltwater marsh designated as a National Wildlife Refuge (NWR). Through investigations, the Navy determined that a four-acre area on the NWR (IRP Site 5), which was used as a munitions disposal site from the early 1950s to the early 1980s, contained abandoned munitions, munitions-related, and explosive-related materials scattered across and buried below the surface.

Recreated wetlands area at NWS Seal Beach.

The Navy used special site inspection and quality control processes to locate munitions and munitions constituents in the landfill. Of the more than 37,000 tons of soil and debris excavated and screened for contamination, the Navy found approximately 13,000 tons clean for reuse on base. The remaining soil, contaminated primarily with lead and debris, was transported off-site by rail for disposal. By transferring the contaminated soil by train, the Navy reduced the number of dump trucks needed for the project by over 95 percent. The City of Seal Beach, the surrounding community, and regulatory agencies were very pleased with the Navy's initiative to eliminate over one thousand trucks that would have otherwise driven through the city, emitting diesel exhaust to the environment. In addition, the use of rail was more cost effective than trucks, resulting in a cost savings of approximately $100,000.

Overall, the project team successfully located and disposed of over 750 high explosives munitions, and 615 munitions-related items. The Navy also recovered over twelve 55-gallon drums of small arms, which were shredded or crushed before recycling. Upon completion of the project, the Navy returned approximately 4.1 acres at Site 5 to wetland habitat. As a result, NWS Seal Beach is the only DoD installation with an NWR located on-base, an accomplishment highly praised by the U.S. Fish and Wildlife Service, Friends of Seal Beach National Wildlife Refuge, the Restoration Advisory Board (RAB), and the surrounding community. The project was well received by regulatory agencies and the public due to the teamwork and proactive approach of the project management team, which included representatives from the Navy, its contractors, regulatory agencies, and the RAB.

Even with the advances in detection capabilities that have resulted from the technology investment made to date, there is some potential that one or more UXO will remain undetected at a site. As a result, DoD expects to incur long-term management costs at most, if not all, munitions response sites. The specific requirements for this long-term management will probably differ from site to site, primarily due to the differing effectiveness of the responses implemented. In addition, should a response fail to meet the objectives established in the selection document (e.g., Record of Decision), additional response activities will be required.

The continued improvement in detection, discrimination, and recovery technologies help reduce the uncertainty associated with implementing responses. Simply put, with new technologies finding more UXO, there is less chance that undetected items will remain. In the future, this may reduce the effort associated with specific requirements for long-term management at munitions response sites, and greatly increase the likelihood the response will remain effective over time. In addition to increasing the overall protectiveness of these responses new technologies offer the opportunity to improve the overall efficiency of the program and reduce total life-cycle costs.

Expected Impacts Resulting from Munitions Constituents Science and Technology Investments

Investments in advancing the understanding of the sources of munitions constituent releases and expanding the understanding of the physiochemical and toxicological properties are required if DoD is to be able to determine there is an unacceptable risk to human health or the environment. Where such a risk exists, DoD must be able to implement a protective, efficient, and cost-effective solution.

A scientific understanding of sources of MC, their fate, and their transport will allow DoD to identify those activities that can lead to releases and predict the ranges at which there is a possibility of off-range exposure. It is expected that the results of this research will show that only a limited number of activities can lead to releases of concern and that only under certain environmental conditions can these pose a risk off-site. It will also allow DoD to focus on those activities and ranges where a real risk exists and prevent or mitigate potentially costly future cleanup requirements.

Currently, the required cleanup concentrations for many munitions constituents vary widely across the country. These cleanup concentrations are often set at extremely conservative levels, which necessitates expensive remediation. A major contributor to the lack of consistency and the currently required cleanup levels is the limited human and ecological toxicity data. Relatively small shifts in drinking water standards can have impacts of billions of dollars to DoD environmental costs. The absence of quality toxicology data inevitably leads to an inefficient use of resources and does not allow DoD to ensure that human health and the ecosystem are protected.

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As DoD continues to identify munitions response sites and further characterize the potential hazards at these sites, DoD will be able to refine the existing elements of the MMRP and introduce improved methods and requirements for conducting munitions responses at its MMRP sites. With the allocation of more resources to this new program, DoD is better able to understand the challenges presented by munitions response sites and, using past environmental restoration work as a blueprint for success, work toward developing a successful program to address these challenges. As with past environmental restoration efforts, DoD looks forward to working with all stakeholders to identify solutions that best protect the public and the environment from the hazards associated with military munitions.