Range Sustainability Recommendations Based on Extensive Studies at Camp Edwards

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Abstract

Camp Edwards, located within the Massachusetts Military Reservation (MMR) is one of only a few ranges in the world exhaustively studied for environmental impacts. Impact Area training activities conducted since 1907 have included artillery, mortars, ground-to-ground rockets, air-to-ground rockets, and pyrotechnics. The Camp Edwards experience provides a depth of analysis unparalleled for determining the environmental impacts from certain types of military training. The studies conducted over the past seven years have identified the activities and mechanisms resulting in introduction of contaminants into the environment. The Impact Area range residue hypotheses evaluated include disposal/burial of munitions, open burn/open detonation (OB/OD), washout operations, low- and high order detonation, blow-in-place operations (BIP), corrosion of unexploded ordnance (UXO), and cracked or broken open UXO as a result of secondary detonations. The preliminary results indicate the processes releasing residues to the environment are low-order detonations, OB/OD, cracked or broken open UXO, BIP, corrosion of intact UXO, and high-order detonations. To date, no evidence of disposal/burial of rounds with explosive materials or washout facilities has been found in the Impact Area at Camp Edwards. Based on the training methodologies currently employed by the military and the fate-and transport behavior of the contaminants of concern, recommendations are made regarding best management practices for range sustainability. Implementation of the range sustainability recommendations could significantly reduce environmental impacts without impacting military readiness at training ranges across the U.S.

Introduction

Environmental investigations continue at Camp Edwards, which is located on the northern portion of the Massachusetts Military Reservation (MMR) located near Falmouth, MA (USA) on Cape Cod (Figure 1). A comprehensive site assessment has been underway since 1997. The MMR is a 21,000-acre facility. The Training Ranges and Impact Area at Camp Edwards encompass approximately 14,000-acres. The approximately 2,200 acre Impact Area contains artillery and mortar targets that have been used for training activities since 1908; however, the majority of activity at the MMR has occurred since 1935, and has included operations by the U.S. Army, U.S. Navy, U.S. Coast Guard, U.S. Air Force, MAARNG, U.S. Air National Guard, and Veterans Administration. The level of activity at the MMR has varied over its operational history. The most intensive U.S. Army activity occurred during World War II from 1940-1944

and during demobilization after the war. The firing of high explosive (HE) artillery rounds was discontinued in 1989. Low intensity training rounds (LITR) and inert and HE mortar rounds were fired until 1997 when a moratorium on artillery and mortar firing was established by the U. S. Environmental Protection Agency (USEPA). Surrounding the Impact Area are numerous firing ranges, artillery and mortar positions, and training areas (Figure 2). Site investigations, therefore, have addressed a variety of types of firing ranges, OB/OD (open burn/open detonation) sites, and firing positions.

Soils at the site consist of fine to coarse-grained sands overlying very coarse sands and gravels that reside at the top of the saturated zone (Ogden, 1998). Silt and clay comprise the base of the saturated zone, which overlies relatively impermeable bedrock located at a depth of 285 to 365 feet (ft) below ground surface. Depth-to-water over most of the site is approximately 100 ft. Camp Edwards Training Ranges and Impact Area lie directly over the Sagamore Lens, a major groundwater recharge area and the most productive portion of the Cape Cod Aquifer. The apex of the Sagamore Lens is located at the southeast corner of the Impact Area from which groundwater flows radially in all directions. The ocean bounds the aquifer on three sides. Except on extreme slopes, surface water runoff at Camp Edwards is virtually nonexistent due to the highly permeable nature of the soils and aquifer material (Figure 3).

Table 1 lists the number of samples by media and site collected from the inception of the Impact Area Groundwater Study through August 30, 2003. Over 25,000 individual samples have been collected at Camp Edwards from various operable units. The seven major areas of study include; the Impact Area, Demolition Area 1 (Demo 1), Demolition Area 2 (Demo 2), Southeast Ranges, Gun and Mortar Firing Positions, Bourne Public Water Supply area, and the Northwest Corner. Each of the areas are discussed in greater detail in the following sections. All other samples are included in the "Other" category. These include samples collected at Training Areas, Small Arms Ranges, Background samples and other miscellaneous areas at Camp Edwards.

	Impact Area	Demo 1	Demo 2	SE Ranges	G&M Range	Phase IIB Sites	Bourne	NW Corner	Other	Total
Surface Soil (0-2 ft)	3,376	348	106	2,278	902	1,857	3	126	824	9820
Deep Soil > 2 ft	688	366	0	273	2	8	0	0	234	1571
GW Well	2,029	817	45	1,009	195	169	683	20	4,293	9260
GW Profile	1,533	581	16	1,399	159	211	340	94	761	5094
Total	7,626	2,112	167	4,959	1,258	2,245	1,026	240	6,112	25,745

Table 1. Location, media, and number of environmental samples collected at Camp Edwards from August 1, 1997 to August 30, 2003.

Impact Areas

The gun and mortar positions were used to fire 75 mm, 105 mm, 155 mm and 8-inch artillery rounds, and 60 mm, 81 mm, 3-inch and 4.2-inch HE mortars, illumination, smoke and white phosphorous mortars into the Impact Area. Therefore, UXO and munition debris can be found in the Impact Area. The assessment of the data indicates the source term for groundwater is confined to an area of approximately 330 acres (AMEC, 2001a). The source of the contaminants appears to be the result of low order detonations and cracked rounds from secondary impacts (Pennington et al. 2002). More than 3,500 soil samples have been collected to date. The predominant contaminants observed were hexahydro-1,3,5-tetranitro-1,3,5-triazine (RDX), octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX), 2-amino-4,6-dinitrotoluene (2a-DNT), 4-amino-2,6-dinitrotoluene (4a-DNT) in soil (Figure 4) and RDX, HMX, and perchlorate in groundwater (Figure 5). A total of 319 monitoring wells at 126 locations have been installed within and downgradient of the Impact Area (AMEC, 2001b). In excess of 1,000 groundwater profile and 1,500 groundwater monitoring well samples have been collected and analyzed for explosives and VOCs.

Based on the exhaustive study of the Impact Area the following recommendations are possible activities that could be implemented for operational ranges to minimize environmental impacts;

Open Burn/Open Detonation – Explosive Ordnance Training

Demolition and Explosive, Ordinance, and Demolition (EOD) training at Demolition Areas 1 (Demo 1) {Figure 6}and 2 (Demo 2) as well as open burning/open detonation (OB/OD) operations began sometime in the mid-1970s and included the destruction of various types of ordnance using explosive charges of Composition C4 (C4), TNT, and detonation-cord. As part of a comprehensive site reconnaissance, chunks of C4 and other residual munitions were found on the ground surface and removed in accordance with approved procedures. Over 600 soil samples have been collected at Demo 1 (Figure 7). The following explosive and propellant compounds have been repeatedly detected in soil and groundwater (Figure 8) at Demo 1: perchlorate, RDX, HMX, 2a-DNT, 4a-DNT, 2,4,6-trinitrotolune (TNT), and 2,4-dinitrotoluene (2,4-DNT)){AMEC, 2003 and 2002).

Based on several studies of demolition areas the following guidelines are recommended;

- Locate future OB/OD areas away from sensitive environmental resources, if possible
- Remove UXO and munition debris after each training exercise,
- Design OB/OD or EOD training areas so that activities are conducted on an impermeable barrier such as clay or concrete, and

The Known Distance (KD) Rocket Range is comprised of approximately 98 acres of land to the southeast of the Impact Area. The range consists of a 25 m rifle range with 55 firing points, a 365-m distance rifle range with 20 firing points, two firing points for Dragon missiles, and 90 mm recoilless rifle training, and one firing point for TOW missiles (Ogden, 2000a). A portion of the range has also been used for helicopter

gunship, machine gun, and grenade launcher training. Information from an interview indicates live tank gunnery was also performed in this area.

An armored personnel carrier target is located approximately midway downrange of the KD Range cleared area. Based on damage to the target and the amount of ordnance debris in the immediate vicinity, it is presumed to be the primary range target. Visible debris from fired rockets and missiles includes portions of housings, fins, and electronic circuitry. Nitroglycerin and NC are the primary propellants used in anti-tank rockets. At the rocket firing positions, NG can be expected because of the rocket back-blast.

For the KD Range, more than 300 soil samples were collected at firing points and targets. Nitroglycerin was the most widespread explosive/propellant compound detected, mainly at the firing points. Some RDX, HMX, and TNT was observed in soil samples surrounding the primary target. Groundwater samples did not indicate the presence of explosive or propellant contaminants. Based on several studies of rocket ranges (Ogden, 2001) the following guidelines are recommended;

- Remove UXO and munition debris around the target areas after each training exercise,
- Design rocket firing points and targets so that activities are conducted on an impermeable barrier such as clay or concrete, and
- Consider the application of lime on an annual basis using standard agriculture application rates.

Conclusions

The DoD should consider developing a range sustainability doctrine for Army ranges. This manual should consist of activities that can be implemented to maintain range sustainability, which would include a program to periodically clean the ranges of UXO, OE Scrap, and other munition debris. Currently, the Air Force implements a routine range maintenance program, including the recovery of munitions on the range. A program similar to the Air Force's could be developed for Army ranges.

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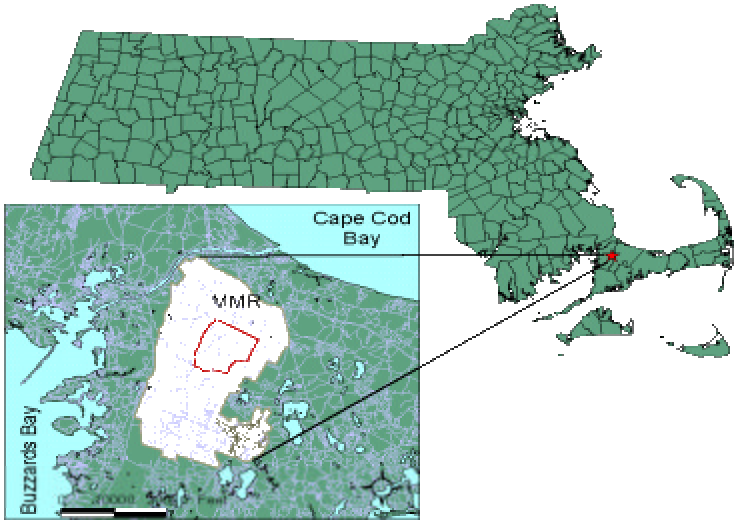


Figure 1. Location of Camp Edwards.

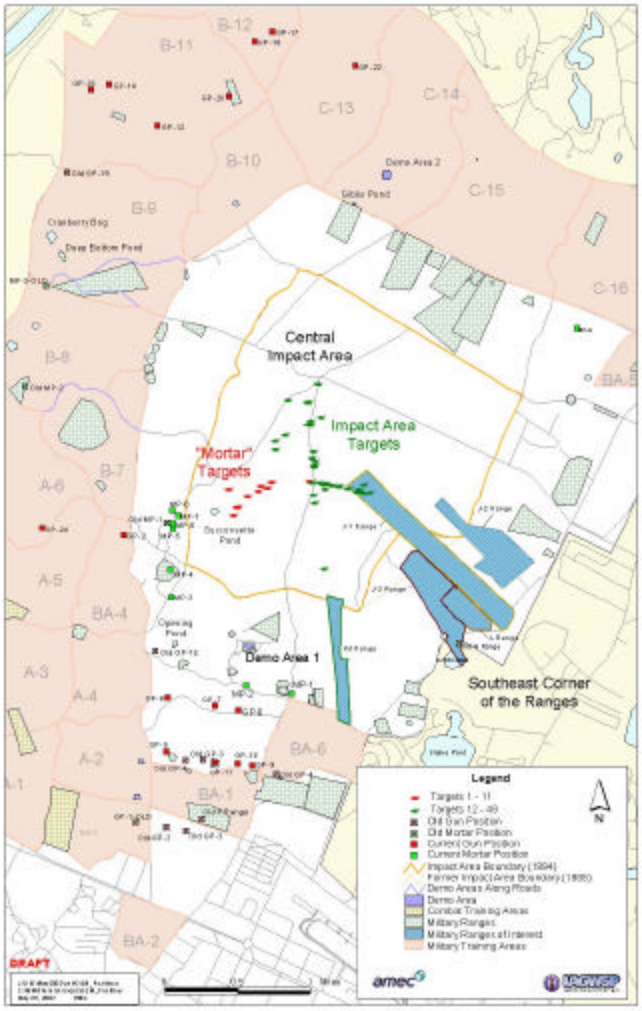


Figure 2. Location of areas of interest at Camp Edwards.

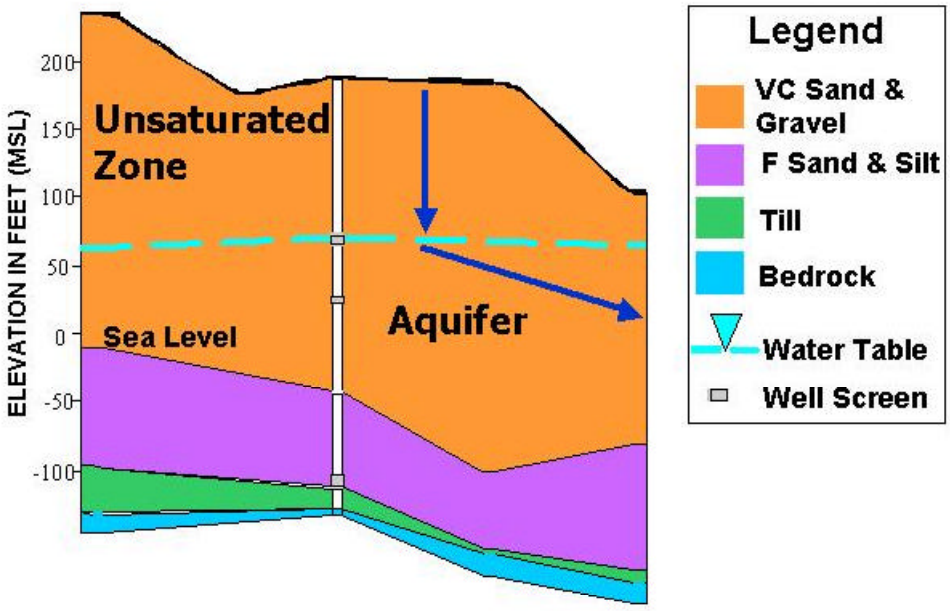


Figure 3. Generalized Lithologic Cross-Section for the site.

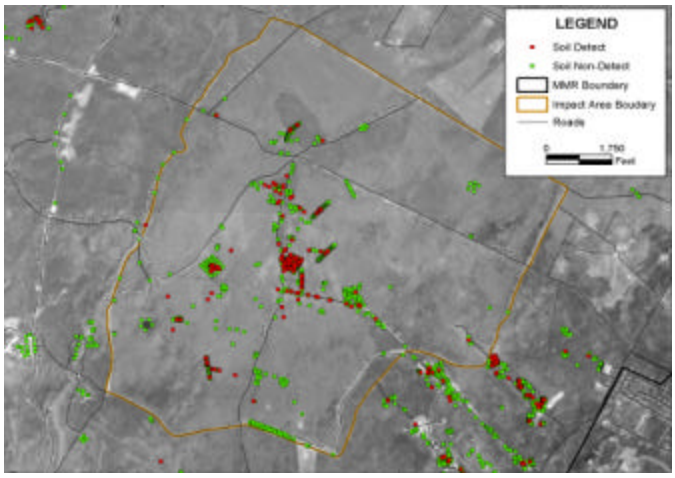
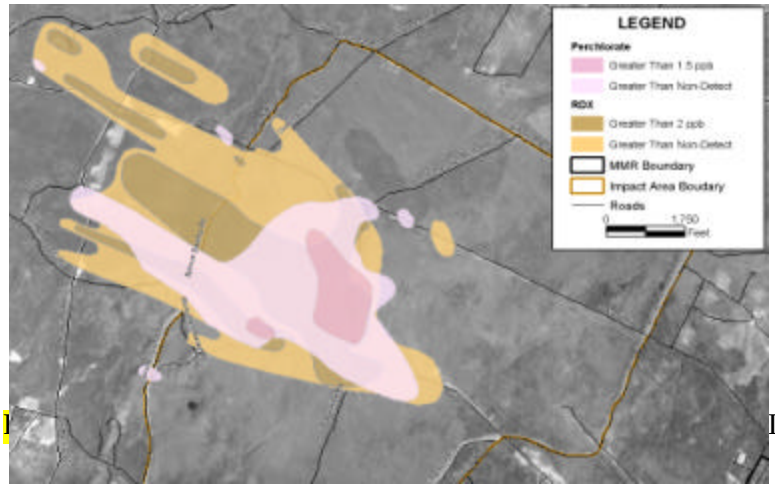


Figure 4. Explosive Soil Detections in the Impact Area



Impact Area

Figure 6. Demolition Area 1

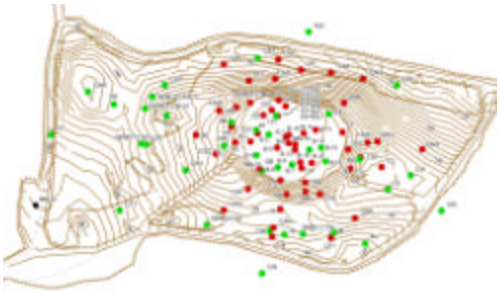
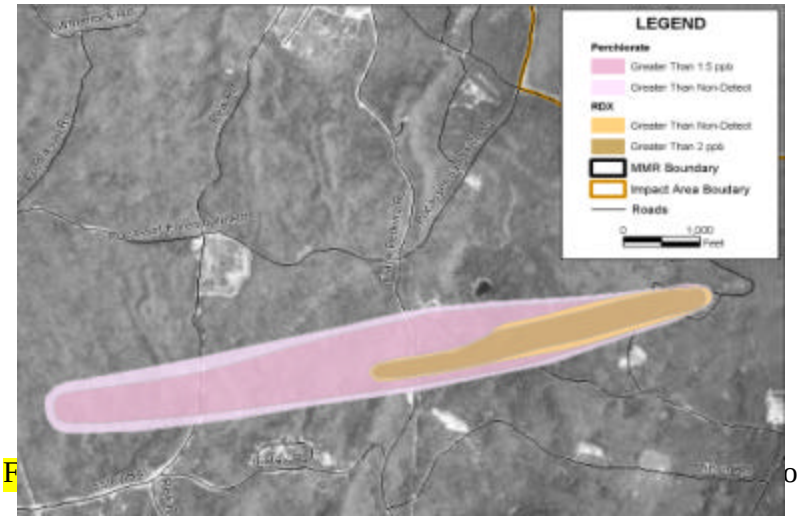


Figure 7. Explosive Soil Detections at Demo 1



F o Area 1