Final
Track 3 Impact Area Munitions Response Area Munitions Response Remedial Investigation/Feasibility Study Former Fort Ord, California

Volume I of 2

Remedial Investigation

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FIGURE

TABLES

PLATES

CSUMB	California State University Monterey Bay
ctg	Cartridge
CWM	Chemical Warfare Material

D

DA	Department of the Army
DDESB	Department of Defense Explosives Safety Board
D/Div	Division
DEM	Digital elevation map
DMM	Discarded Military Munitions
DoD	Department of Defense
DOI	Department of Interior
DQO	Data Quality Objectives
DRMO	Defense Reutilization and Marketing Office
DRO	Del Rey Oaks
DTSC	California Department of Toxic Substances Control

E

E&D	Engineering and Demolitions
EC	Engineering Control
EE/CA	Engineering Evaluation/Cost Analysis
EFMB	Expert Field Medical Badge
EM	Engineer Manual
ENGR/Engr	Engineer
EOD	Explosive Ordnance Disposal
EPA	U.S. Environmental Protection Agency
EPW	Evaluation of Previous Work
ERA	Ecological Risk Assessment
ESA	Endangered Species Act
EVAC	Evacuation
EVOC	Emergency Vehicle Operation Center

F

F	Fahrenheit
FA	Field Artillery
FAAF	Fritzsche Army Airfield
FBTA	Field Battalion Training Area
FF	Field fortification
FFA	Federal facility agreement
FM	Field Manual
FORA	Fort Ord Reuse Authority
FRC	Former Range Control
FS	Feasibility Study
Ft	feet (or foot)
FTS	Field Test Site

G

GDA	Guard Duty Area, Gun Defended Area
GIS	Geographical Information System

GPS	Global Positioning System
GTC	Geotechnical Consultants, Inc.

H

ha	hectare
HA	historical area
Harding ESE	formerly known as Harding Lawson Associates (HLA)
HC	hexachlorethane
HCP	Habitat Conservation Plan
HCRS	Heritage Conservation and Recreation Service
HE	High Explosive
HEAT	High Explosive Antitank
HEDP	High Explosive Dual Purpose
HFA	Human Factors Applications, Inc.
HHCA	Hand-to-Hand Combat Area
HLA	Harding Lawson Associates
HMP	Habitat Management Plan
HMX	cyclotetramethlene-tetranitramine
HTW	Hazardous and Toxic Waste
H_2Hz	hertz

I

IC	Institutional Control
IT	IT Corporation
ITRC	Interstate Technology and Regulatory Council
ITT	Individual Tactical Training

K

KO	Contracting Officer

L

LAW	light antitank weapon
lbs	pounds
LDSP	Land Disposal Site Plan
LE	Low Explosive
LUC	Land Use Controls

M

m	meter
MACTEC	MACTEC Engineering and Consulting, Inc. (formerly Harding ESE)
MAG	Magnetometer
MC	Munitions Constituents
MCPD	Monterey County Planning Department
MCX	Mandatory Center of Expertise
MD	Munitions Debris
MEC	Munitions and Explosives of Concern
MG	Machine gun
mg/kg	milligrams/kilogram
MILES	Multiple Integrated Laser Engagement System

mm	millimeter
MM	Military Munitions
MMRP	Military Munitions Response Program
MOCO	Monterey County
MOUT	Military Operations in Urban Terrain
MPC	Monterey Peninsula College
mph	miles per hour
MR	Munitions Response
MP	Mortar Position
MRA	Munitions Response Area
MRS	Munitions Response Site
MSL	mean sea level
MTR/MORT	Mortar

N

NA	Not available
NAV	Navigation
NAVSCOLEOD	Naval School, Explosive Ordnance Disposal

O

OB/OD	Open burn/open detonation
ODDS	Ordnance Detection and Discrimination Study
OE	Ordnance and Explosives
OEW	Ordnance and Explosive Waste
ORAGS	Oak Ridge Airborne Geophysical System
ORNL	Oak Ridge National Laboratory
OU	OperableUnit

P

PA/SI	Preliminary Assessment/Site Inspection
Parsons	Parsons Infrastructure & Technology Group Inc.
Pd	Probability of detection
PDA	personal digital assistant
PTA	Physical Training Area

Q

QA	Quality Assurance
QA/QC	Quality Assurance/Quality Control
QC	Quality Control
QC/QA	Quality Control/Quality Assurance

R

RA	Risk Assessment
RAC	Risk Assessment Code
RAO	Remedial Action Objectives
RCRA	Resource Conservation and Recovery Act
RDX	Cyclotrimethylene trinitramine
RGT	Rifle Grenade Training
RI	Remedial Investigation

RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
RDX	Cyclotrimethylene trinitramine
RR	Recoilless rifle
RRD	Range-Related Debris
RRTA	Recoilless Rifle Training Area
RSOP	Reconnaissance, Selection, and Occupation of Position
RSP	Render Safe Procedures
RWQCB	Regional Water Quality Control Board

S

SAA	Small Arms Ammunition
SAP	Sampling and Analysis Plan
SAW	Semi-automatic weapon
SCA	special case areas
SEA	Seaside
SGD	Staal, Gardner & Dunne, Inc.
Shaw	Shaw Environmental, Inc.
SOP	Standard Operating Procedure
SOW	Scope of Work
SQD	Squad
SS/GS	SiteStats/GridStats
ST	Service Test, possibly
SUMP	Site Use Management Plan
SUXOS	Senior UXO Supervisor

T

TCRA	Time Critical Removal Action
TEM	time-domain electromagnetics
TERC	Total Environmental Restoration contract
TIP	Technical information paper
TM	Technical Manual
TNG	Training
TNT	Trinitrotoluene
TOW	Tube-launched, optically-tracked, wire-guided
TP	target practice
TPA	triethylaluminum
TPH	total petroleum hydrocarbons
TS	Training Site

U

USA	USA Environmental, Inc.
USACE	U.S. Army Corps of Engineers
USAEDH	U.S. Army Design Engineering and Support Center, Huntsville
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Department of the Interior, Fish and Wildlife Service
UXB	UXB International, Inc.
UXO	Unexploded Ordnance

W

WGBA	Watkins Gate Burn Area
WP	White phosphorous
WWI	World War I
WWII	World War II

GLOSSARY

Closed Range:	A military range that has been taken out of service and either has been put to new uses that are incompatible with range activities or is not considered by the military to be a potential range area. A closed range is still under the control of a Department of Defense (DoD) component. Source: (3).
Discarded Military Munitions (DMM):	Military munitions that have been abandoned without proper disposal or removed from storage in a military magazine or other storage area for the purpose of disposal. The term does not include unexploded ordnance, military munitions that are being held for future use or planned disposal, or military munitions that have been properly disposed of consistent with applicable environmental laws and regulations. (10 U.S.C. 2710(e)(2) (6)). For the purposes of the Basewide Munitions Response Program being conducted at the former Fort Ord, DMM does not include small arms ammunition .50 caliber and below.
Engineering Control (EC):	A variety of engineered remedies to contain and/or reduce contamination, and/or physical barriers intended to limit access to property. Some examples of ECs include fences, signs, guards, landfill caps, soil covers, provision of potable water, slurry walls, sheet pile (vertical caps), pumping and treatment of groundwater, monitoring wells, and vapor extraction systems. Source: (1).
Expended:	The state of munitions debris in which the main charge has been expended leaving the inert carrier. Source: (2).
Explosive Ordnance Disposal (EOD) Personnel	Military personnel who have graduated from the Naval School, Explosive Ordnance Disposal (NAVSCOLEOD); are assigned to a military unit with a Service-defined EOD mission; and meet Service and assigned unit requirements to perform EOD duties, EOD personnel have received specialized trining to address explosive and certain Chemical Agent (CA) hazards during both peacetime and wartime. EOD personnel are trained and equipped to perform Render Safe Procedures (RSP) on nuclear, biological, chemical, and conventional munitons, and on improvised explosive devices. Source (8).
Explosive Soil:	Explosive soil refers to mixtures of explosives in soil, sand, clay, or other solid media at concentrations such that the mixture itself is explosive. (a) The concentration of a particular explosive in soil necessary to present an explosion hazard depends on whether the particular explosive is classified as "primary" or "secondary." Guidance on whether an explosive is classified as "primary" or "secondary" can be obtained from the Ordnance and Explosives Mandatory Center of Expertise (OE MCX) or Chapters 7 and 8 of TM 9-1300-214, Military Explosives. (b) Primary explosives are those extremely sensitive explosives (or mixtures thereof) that are used in primers, detonators, and blasting caps. They are easily detonated by heat, sparks, impact, or friction. Examples of primary explosives include Lead Azide, Lead Styphnate, and Mercury Fulminate.

	(c) Secondary explosives are bursting and boostering explosives (i.e., they are used as the main bursting charge or as the booster that sets off the main bursting charge). Secondary explosives are much less sensitive than primary explosives. They are less likely to detonate if struck or when exposed to friction or electrical sparks. Examples of secondary explosives include Trinitrotoluene (TNT), Composition B, and Ammonium Picrate (Explosive D). (d) Soil containing 10 percent or more by weight of any secondary explosive or mixture of secondary explosives is considered "explosive soil." This determination was based on information provided by the USACE as a result of studies conducted and reported in USACE Report AMXTH-TE-CR 86096. (e) Soil containing propellants (as apposed to primary or secondary high explosives) may also present explosion hazards. (ER 1110-1-8153). Source (5).
Feasibility Study (FS):	An evaluation of potential remedial technologies and treatment options that can be used to clean up a site. Source: (2).
Impact Area:	The impact area consists of approximately 8,000 acres in the southwestern portion of former Fort Ord, bordered by Eucalyptus Road to the north, Barloy Canyon Road to the east, South Boundary Road to the south, and North-South Road to the west. Source: (2).
Institutional Control (IC):	A legal or institutional mechanism that limits access to or use of property, or warns of a hazard. An IC can be imposed by the property owner, such as use restrictions contained in a deed, or by a government, such as a zoning restriction. Source: (1).
Land Use Controls (LUC):	LUC are physical, legal, or administrative mechanisms that restrict the use of, or limit access to, real property, to manage risks to human health and the environment. Physical mechanisms encompass a variety of engineering remedies to contain or reduce contamination and/or physical barriers to limit access to real property, such as fences or signs. Source: (6).
Magnetometer:	An instrument used to detect ferromagnetic objects. Total field magnetometers measuring the strength of the earth's natural magnetic field at the magnetic sensor location. Gradient magnetometers, sensitive to smaller near-surface metal objects, use two sensors to measure the difference in magnetic field strength between the two sensor locations. Vertical or horizontal gradients can be measured. Source: (2).
Military Munitions Response Program (MMRP):	DoD-established program to manage the environmental, health and safety issues presented by Munitions and Explosives of Concern (MEC). Source: (2).

Military Munitions:	Military munitions means all ammunition products and components produced for or used by the armed forces for national defense and security, including ammunition products or components under the control of the DoD, the Coast Guard, the Department of Energy, and the National Guard. The term includes confined gaseous, liquid, and solid propellants, explosives, pyrotechnics, chemical and riot control agents, smokes, and incendiaries, including bulk explosives and chemical warfare agents, chemical munitions, rockets, guided and ballistic missiles, bombs, warheads, mortar rounds, artillery ammunition, small arms ammunition, grenades, mines, torpedoes, depth charges, cluster munitions and dispensers, demolition charges, and devices and components thereof. The term does not include wholly inert items, improvised explosive devices, and nuclear weapons, nuclear devices, and nuclear components, other than non nuclear components of nuclear devices that are managed under the nuclear weapons program of the Department of Energy after all required sanitization operations under the Atomic Energy Act of 1954 (42 U.S.C. 2011 et seq.) have been completed. (10 U.S.C. 101(e)(4)). Source: (7).
Munitions Constituents (MC)	Any materials originating from unexploded ordnance (UXO), DMM, or other military munitions, including explosive and nonexplosive materials, and emission, degradation, or breakdown elements of such ordnance or munitions (10 U.S.C. 2710 (e) (3)). Source: (6).
Munitions Debris:	Remnants of munitions (e.g., fragments, penetrators, projectiles, shell casings, links, fins) remaining after munitions use, demilitarizations, or disposal. Source: (7).
Munitions and Explosives of Concern (MEC):	Distinguishes specific categories of military munitions that may pose unique explosives safety risks, such as: UXO, as defined in 10 U.S.C. 101 (e) (5); discarded military munitions, as defined in 10 U.S.C. 2710 (e) (2); or munitions constituents (e.g., TNT, Cyclotrimethylene trinitramine [RDX]), as defined in 10 U.S.C. 2710 (e) (3), present in high enough concentrations to pose an explosive hazard. Source: (7). For the purposes of the Basewide Munitions Response Program being conducted for the former Fort Ord, MEC does not include small arms ammunition .50 caliber and below.
Munitions Response Area (MRA):	Any area on a defense site that is known or suspected to contain UXO, DMM, or MC. Examples are former ranges and munitions burial areas. A MRA comprises of one or more munitions response sites. Source: (7).
Munitions Response Site (MRS):	A discrete location within a MRA that is known to require a munitions response. Source: (7).

Mortar:	Mortars typically range from approximately 1 inch to 11 inches in diameter or larger, and can be filled with explosives, toxic chemicals, white phosphorus or illumination flares. Mortars generally have thinner metal casing than projectiles but use the same types of fuzing and stabilization. Source: (1).
MEC Sampling:	Performing MEC searches within a site to determine the presence of MEC. Source: (2).
Operating Grids:	Typically, 100-foot by 100-foot parcels of land as determined by survey and recorded by Global Positioning System (GPS), marked at each corner with wooden stakes. Sites are divided into operating grids prior to the commencement of work by brush removal or OE sweep teams. A single grid may be occupied by only one team at any time, and the grid system facilitates the maintenance of safe distances between teams. They are identified sequentially using an alpha-numeric system (e.g., E-5). Source: (2).
Projectile:	An object projected by an applied force and continuing in motion by its own inertia, as a bullet, bomb, shell, or grenade. Also applied to rockets and to guided missiles. Source: (4).
Range-Related Debris:	Debris, other than munitions debris, collected from operational ranges or from former ranges (e.g., target debris, military munitions packaging and crating material). Source: (6).
Remedial Investigation (RI):	Exploratory inspection conducted at a site to delineate the nature and extent of chemicals, and in this case OE, present at the site. Source: (2).
Removal Depth:	The depth below ground surface to which all ordnance and other detected items are removed. Source: (2).
SiteStats/GridStats:	Programs developed by QuantiTech for the Huntsville Corps of Engineers to predict the density of ordnance on sites with spatially random dispersal of ordnance. Source: (2).
Technology-Aided Surface Removal:	A removal of UXO, DMM, or chemical warfare material (CWM) on the surface (i.e., top of the soil layer) only, in which the detection process is primarily performed visually, but is augmented by technology aide (e.g., hand-held magnetometers or metal detector) because vegetation, the weathering of UXO, DMM or CWM, or other factors make visual detection difficult. Source: (2).
Track 0 Areas	Areas of the former Fort Ord that contain no evidence of munitions and explosives of concern (MEC) and have never been suspected of having been used for military munitions-related activities of any kind. This definition has been clarified in the *Explanation of Significant Differences, Final Record of Decision, No Action Regarding Ordnance-related Investigations (Track 0 ROD), former Fort Ord, California (March 2005)* to include areas not suspected as having been used for military munitions-related activities of any kind, but where incidental military munitions have been discovered.
Track 1 Sites	Sites at the former Fort Ord where military munitions were suspected to have been used, but based on the results of the MR RI/FS each site falls into one of the following three categories: Category 1: There is no evidence to indicate military munitions were used at the site (i.e., suspected training did not occur);

	or Category 2: The site was used for training, but the military munitions items used do not pose an explosive hazard (i.e., training did not involve explosive items); or Category 3: The site was used for training with military munitions, but military munitions items that potentially remain as a result of that training do not pose an unacceptable risk based on site specific evaluations conducted in the Track 1 OE RI/FS. Field investigations identified evidence of past training involving military munitions, but training at these sites involved only the use of practice and/or pyrotechnic items that are not designed to cause injury. In the unlikely even that a live item of the type previously observed at the site is found, it is not expected that the item would function by casual contact (i.e., inadvertent and unintentional contact).
Track 2 Sites	Sites at the former Fort Ord where MEC items were present, and MEC removal has been conducted (i.e., Parker Flats MRA).
Track 3 Sites	Track 3 Sites are those areas where MEC is suspected or known to exist, but investigations are not yet complete or need to be initiated, or (2) any area identified in the future. Source: (2).
Transferred Range:	A military range that is no longer under military control and has been leased, transferred, or returned to another entity, including Federal entities. This includes a military range that is no longer under military control but was used under the terms of a withdrawal, executive order, special-use permit or authorization, right-of-way, public land order, or other instrument issued by the Federal land manager. Source: (3).
Transferring Range:	A military range that is proposed to be leased, transferred, or returned from the DoD to another entity, including Federal entities. This includes a military range that is used under the terms of a withdrawal, executive order, special-use permit or authorization, right-of-way, public land order, or other instrument issued by the Federal land manager. An active range will not be considered a "transferring range" until the transfer is imminent. Source: (3).
Unexploded Ordnance (UXO):	Military munitions that (A) Have been primed, fuzed, armed, or otherwise prepared for action; (B) Have been fired, dropped, launched, projected, or placed in such a manner as to constitute a hazard to operations, installations, personnel, or materials; and (C) Remain unexploded, whether by malfunction, design, or any other cause. (100 U.S.C. 101 (c)(5)). Source: (7). For the purpose of the Basewide Munitions Response Program being conducted for the former Fort Ord, UXO does not include small arms ammunition .50 caliber and below.
UXO Technician	Personnel who are qualified for and filing Department of Labor, Service Contract Act, and Directory of Operations contractor positions of UXO Technician I, UXO Technician II, and UXO Technician III.

UXO- Qualified Personnel	Personnel who have performed sucessufully in military EOD positions, or are qualified to perform in the following Department of Kabor, Service Contract Act, Directory of Operations contractor positions: UXO Technician II, UXO Technicain III, UXO Safety Officer, UXO Quality Control Specialist, or Senior UXO Supervisor.

Sources:

(1) Compendium of Department of Defense Acronyms, Terms, and Definitions: The Interstate Technology and Regulatory Council (ITRC) Work Group (Unexploded Ordnance Work Team), December 2000.

(2) Non-standard definition developed to describe Fort Ord-specific items, conditions, procedures, principles, etc. as they apply to issues related to the MEC cleanup.

(3) Management Guidance for the Defense Environmental Restoration Program published by the office of the Under Secretary of Defense (Installations and Environment), September 2001.

(4) "Unexploded Ordnance (UXO): An Overview", October 1996. DENIX.

(5) Ordnance and Explosives Response Engineer Manual (EM) 1110-1-4009. U.S. Army Corps of Engineers, June 23, 2000.

(6) Memorandum for the Assistant Chief of Staff for Installation Management, Subject: Munitions Response Terminology (April 21, 2005).

(7) Federal Register/Volume 70. No. 192/Wednesday, October 5, 2005/Rules and Regulations, 32 CFR Part 179, Munitions Response Site Prioritization Protocol, Department of Defense, Final Rule. October 2005.

(8) Department of Defense Explosive Safety Board Technical Paper 18 (Minimum Qualification for Unexploded Ordnance [UXO]. Technicians and Personnel). December 20, 2004.

1.0 INTRODUCTION

The former Fort Ord is located near Monterey Bay in northwestern Monterey County, California (Plate 1). Since 1917, portions of the former Fort Ord were used by Army units for maneuvers, target ranges, and other purposes. Military munitions were fired into, fired upon, or used on the facility in the form of artillery and mortar projectiles, rockets and guided missiles, rifle and hand grenades, practice land mines, pyrotechnics, bombs, and demolition materials. As a result, a wide variety of conventional munitions and explosives of concern (MEC), both unexploded ordnance (UXO) and discarded military munitions (DMM) items have been encountered at sites throughout the former Fort Ord.

MEC distinguishes specific categories of military munitions that may pose unique explosives safety risks, such as: UXO, as defined in 10 U.S.C.101(e)(5); discarded military munitions, as defined in 10 U.S.C. 2710(e)(2); or munitions constituents (e.g., TNT, Cyclotrimethylene trinitramine [RPX]), as defined in 10 U.S.C. 2710(e)(3), present in high enough concentrations to pose an explosive hazard. Small arms ammunition that is .50 caliber and below is not being considered as MEC under the Track 3 Munitions Response Remedial Investigation/Feasibility Study (RI/FS) or Basewide Munitions response (MR) RI/FS Program. Site assessment, site characterization, remedial design, and remediation activities to address the presence of small arms ammunition .50 caliber and below and explosive munitions constituents at the former Fort Ord are being conducted under the Basewide Range Assessment Program (BRA*; IT, 2001*).

On behalf of the U.S. Army Corps of Engineers (USACE) - Sacramento District, MACTEC Engineering and Consulting, Inc. (MACTEC) has prepared this Draft Final Track 3 Impact Area Munitions Response Area RI/FS for the portion of the Impact Area that is currently designated for transfer to Bureau of Land Management (BLM) as Habitat Reserve in the Installation-Wide Multispecies Habitat Management Plan (HMP) including the Eucalyptus Fire Area and the Watkins Gate Burn Area (Plate 2). The Impact Area MRA includeds two areas previously evaluated in the Interim Action program; a southern portion of Ranges 43-48, and Range 30A. These areas were evaluated as part of the Track 3 Impact Area MRA. When selected in the Track 3 Record of Decision (ROD), the preferred alternative recommended in this RI/FS is intened to serve as the final remedy for these two Interim Action areas. In effect, the Track 3 ROD will amend the 2002 Interim Action ROD regarding the southern portion of Ranges 43-48 and Range 30A. This Final report was revised based on comments received on the draft final report. The comments and associated responses are provided in Appendix F to this report. The RI/FS addresses only the physical hazards to humans from MEC. The chemical hazards are being addressed under the BRA program. Areas of the historical Impact Area that are identified for development, MRS-15 SEA 01 through MRS-15 SEA 04, MRS-15 DRO 01, DRO 01A, DRO 02 and DRO 02A; MRS-15 MOCO 01 and 02; MRS-46; MRS-47; the Monterey Peninsula College (MPC) designated portions of MRS-Ranges 43 through 48 including a small development portion and area designated as Habitat Reserve, BLM Headquarters (MRS-35) including Parcel F1.12; and the Military Operations in Urban Terrain (MOUT) (MRS-28) are not evaluated in this report.

Track 3 Sites are those areas where: (1) MEC are suspected or known to exist, but investigations are not yet complete or need to be initiated, or (2) any suspected or known areas identified in the future. The Impact Area MRA qualifies as for Track 3 because MEC exist and actions have not been completed.

1.1 Description of the MR RI/FS Program

The MR RI/FS program is described in detail in the Final OE RI/FS Work Plan (*Army, 2000a*). The MR RI/FS is being conducted pursuant to the Comprehensive Environmental Response, Compensation, and

Liability Act (CERCLA). The MR RI/FS only addresses the physical or explosive risk from MEC. The potential soil contamination from small arms and military munitions ranges is being addressed under the BRA (*IT, 2001*). Elements of the Basewide MR program included a literature review, preparation of a Sampling and Analysis Plan (SAP) for additional MEC characterization activities, evaluation of previous MEC contractors work, performance of an Ordnance Detection and Discrimination Study (ODDS), identification of Applicable or Relevant and Appropriate Requirements (ARARs), evaluation of risks, development of long-term risk management measures, a community relations plan, and a health and safety plan.

The information gathered and evaluated during the literature review and the Basewide MR RI/FS is being used to categorize all areas of the former Fort Ord according to actions that have been taken or where actions are identified as necessary to mitigate MEC hazards. Four categories of sites have been identified, Track 0 through Track 3. Definitions of the site categories are presented in the glossary. The information being evaluated to form decisions includes, but is not limited to, the knowledge of the site, the quality of the available information, the work completed, and the intended future land uses. The above types of information have been used to prepare the Track 3 MR RI/FS.

1.2 Track 3 Impact Area MR RI/FS

This section describes the elements and the purpose of the Track 3 Impact Area Munitions Response Area (Impact Area MRA) RI/FS.

1.2.1 Elements of the Track 3 MR RI/FS

The Track 3 Impact Area MR RI/FS is divided into three main parts, the RI, the risk assessment (RA), and the FS. Each of these parts is described below.

The RI (Volume 1) presents background information including a description of the site, the site history, a description of the military munitions potentially present based on historical use of the area, history of MEC investigations, nature and extent of MEC, and a conceptual site model based on the existing data. As part of the conceptual site model, the anticipated future reuse for the site is identified and potential receptors are presented.

The information used in preparation of the RI included historical training maps, aerial photographs, MR contractor after action reports (AARs), technical information papers (TIPs), aerial geophysics report, the archives search reports (ASRs), the ODDS report, field training manuals, and interviews. References for each of the sources used are provided in the RI section.

Information from historical training maps and aerial photographs was integrated into the project Geographical Information System (GIS). Data were integrated into the GIS according to procedures described in the Standard Operating Procedures (SOPs) prepared for the project (Appendix A).

The RA was conducted based on the data set for MRS-Ranges 43 through 48. This data set was selected for use because it expected to represent a worst-case area for the Impact Area and data were available for both surface removal and subsurface removal. Separate risk analyses, “both baseline and after action” scenarios are presented for the identified reuse. The baseline risk represents the risk assuming that no response have taken place, therefore, all of the items discovered to date remain at the site, for comparison purposes. The after action risks represent the anticipated worst-case state of the Impact are following either a surface removal or removal to depth. The results of the RA are provided in Section 4.0 of the RI.

The FS (Volume II) describes the remedial action objectives (RAOs) for the site, background information, development of ARARs, and presents the screening and development of alternatives to support the reuse of the Impact Area. The FS also includes an evaluation and comparison of alternatives for remediation, and the preferred alternatives for the Impact Area MRA.

1.2.2 Purpose

The RI/FS process as outlined in the U.S. Environmental Protection Agency (USEPA) guidance (*EPA, 1988*) represents the methodology that the Superfund program has established for characterizing the nature and extent of risk posed by contaminated sites, and for evaluating potential remedial options. The purpose of the Track 3 Impact Area MR RI/FS is to: (1) describe the site conditions and nature and extent of MEC based on available data; (2) to complete a risk assessment for the Impact Area based on information from the removal completed at MRS-Ranges 43 through 48; and (3) complete a FS for the Impact Area MRA.

1.3 Report Organization

The Track 3 Impact Area RI/FS is organized as follows:

Volume 1 – Remedial Investigation/Risk Assessment

Section 1 – Introduction. This section provides the background information on the Track 3 process. The purpose of this report is also included in this section.

Section 2 – Background. This section presents the Fort Ord military munitions-related history, describes the physical setting, and presents background information on the Basewide MR RI/FS program.

Section 3 – Track 3 Impact Area Remedial Investigation (RI). This section presents a description of the site, the history of the site use and investigation, an assessment of the data quality, the nature and extent of contamination, and a conceptual site model, including the anticipated future use of the site.

Section 4 – Risk Assessment. This section presents the results of the risk assessment.

Section 5 – Conclusions and Recommendations. This section presents the conclusions and recommendations based on the RI and RA.

Section 6 – References. A list of references for pertinent documents cited in the report is presented.

Volume 2 – Feasibility Study

Section 1 – Introduction. Section 1 describes the purpose and objectives of the FS and presents background information.

Section 2 – Remedial Action Objectives. Section 2 describes the objectives of the MEC cleanup. It presents the application of the risk assessment results, and potential ARARs.

Section 3 – Identification and Screening of Remedial Technologies. Section 3 identifies, describes, and screens stand-alone technologies that will be considered as components for the development of remedial alternatives.

Section 4 – Development of Remedial Alternatives. This section describes the rationale for combining stand-alone technologies to develop a range of remedial alternatives.

Section 5 – Evaluation and Comparison of Remedial Alternatives. This section presents the evaluation and comparison of alternatives using the nine CERCLA criteria. The preferred alternative is identified.

Section 6 – Approval Process. This section describes the steps to the ROD including the proposed plan and community involvement activities.

Section 7 – References. This section provides a list of references for pertinent documents cited in the report.

2.0 BACKGROUND

This section provides a summary of the former Fort Ord military munitions-related history, a description of its physical setting, the background of the Basewide MR RI/FS, and background of the Track 3 Impact Area MRA investigations and removals.

2.1 Historical Use

Military training at the former Fort Ord began in approximately 1917 with the purchase of over 15,000 acres by the Army and designated as an artillery range (*Cozzens, 1922*). The initial land purchase included the Impact Area. The property was used as a maneuver and training area primarily for the 11th Cavalry and the 76th Field Artillery stationed at the Presidio of Monterey. During the spring and summer months the 30th Infantry Regiment stationed at the Presidio of San Francisco participated in maneuvers as did other Army Reserve and National Guard Units (*HLA, 2000a*). By 1933 the Camp Ord Military Reservation was established and was comprised of three camps, Camp Clayton, Camp Ord, and Camp Huffman. Camp Huffman was located within the Impact Area MRA. In 1940, the 7th Infantry Division was activated and Fort Ord was named a permanent Army post. Other divisions that were activated at Fort Ord following the 7th Division included the 4th Division, the 5th Division and the 6th Division. In 1957 Fort Ord became a United States Army Infantry Training Center, serving in this capacity until 1974. In October 1974, the 7th Infantry Division was reactivated at Fort Ord. The 7th Division was converted to a light division in 1983. The former Fort Ord was selected in 1991 for Base Realignment and Closure (BRAC), and was officially closed in September 1994.

2.1.1 History of Military Munitions Use within the Impact Area

Although Fort Ord maps older than 1945 are limited, military munitions found within the Impact Area are consistent with military munitions available for use prior to 1940. World War I (WWI) -era military munitions found during sampling and removal actions include Stokes mortars, Livens projectiles, and 37 and 75millimeter (mm) projectiles, which were available for use prior to World War II (WWII). A review of archival film footage of training at Fort Ord in 1936 shows troops training with small arms weapons, howitzers, and Livens projectors. A 1945 training facilities map indicates that several ranges and training areas had been established within the Impact Area including an antitank range, anti-aircraft range, a close combat course, small arms ranges, mortar range, infiltration course, practice and live hand grenade range, booby trap training area, bazooka demonstration area, and a moving vehicle range. Ranges were added to the Impact Area throughout the 1950s. Ranges identified on 1950s-era training maps included 60mm and 81mm mortar ranges, 57mm recoilless rifle range, rocket launcher range, rifle grenade range, small arms ammunition ranges, and hand grenade assault, infiltration, close combat, and small arms firing courses. By the early 1960s, the position of the Impact Area ranges remained relatively static. Ranges identified on the 1960s –era training maps included small arms ammunitions ranges, 90 and 106mm recoilless rifle sub-caliber range, a 40mm grenade range, mortar range, 3.5-inch rocket range, 90mm recoilless and M72 light antitank weapon (LAW) range, high explosive (HE) hand grenade range, close combat and infiltration courses, and an explosive ordnance disposal range. Based on the items discovered at the site both practice and HE items were used during training. Documentation including training facilities maps, range control records, and range regulation standard operating procedures from the 1970s, 1980s, and 1990s indicate that military munitions allowed on the Impact Area ranges included small arms ammunition, hand grenades, 60mm, 81mm and 4.2-inch mortars and mortar sub-caliber

devices, 14.5mm sub-caliber devices (artillery), Dragon missiles, 90mm and 20mm projectiles, anti-tank rockets and sub-caliber devices, 40mm grenades, anti-personnel mines, C4 and TNT.

Range use ceased in 1994 at the time of Base Closure with the exception of the MOUT and at Range 36A which was used for a short period of time in support of Time Critical Removal Actions (TCRAs). The MOUT is not included in this report. Additional details on range history and military munitions authorized for use or potentially used on the ranges are provided in Section 3.5.

2.1.2 Summary of Existing MR Program

Since BRAC listing and closure of Fort Ord in 1991, the Army had been conducting a munitions response to MEC that consists of implementing and documenting munitions responses in areas with imminent hazards. These removal actions have not only reduced imminent hazards but have also provided information about the type of MEC and level of hazard at each of the sites that can be used in the Basewide MR RI/FS.

Work performed for the existing MR program has been conducted in accordance with the following documents:

- TCRAs have been implemented as described in the *Fort Ord Ordnance and Explosive Waste Time-Critical Removal Action Memorandum* (*Army, 1994*).

- Non-time-critical removal actions are being addressed according to the *Final Action Memorandum, Phase 2 Engineering Evaluation/Cost Analysis, Ordnance and Explosives Sites, Former Fort Ord, Monterey County, California* (*Army, 1999*). The *Action Memorandum, Phase 2 Engineering Evaluation/Cost Analysis* (EE/CA) identifies and describes the rationale for continuing with MEC removal actions at MRSs while the Basewide MR RI/FS is being conducted and addresses recommendations for future MEC removal actions.

- All removal actions have been implemented in accordance with the Land Disposal Site Plan (LDSP), LDSP amendments, and explosive safety submissions, which have been approved by the Department of Defense Explosives Safety Board (DDESB). These plans are required to describe the nature, extent, and types of known or suspected MEC contamination, the proposed future use of each area, and procedures for mitigating MEC hazards in a manner compatible with the proposed land reuse and in accordance with DoD safety standards.

Other elements of the MR program implemented prior to the Basewide MR RI/FS include the following:

- **Archives Search Program** – MRSs were identified and listed in the 1997 *Draft Revised Archive Search Report* (ASR; *U.S. Army Engineer Division, Huntsville [USAEDH], 1997a*), which is an update of previous ASRs (*USAEDH, 1993; 1994*). A preliminary site reconnaissance was conducted as part of the ASR to further identify/characterize potential MRSs; the results are contained in the 1997 ASR.

- **Site Investigation/Sampling** – Based on the 1993 ASR, several MRSs were identified for investigation. Human Factors Applications, Inc., and USA Environmental, Inc. performed sampling.

- **Phase 1 Engineering Evaluation/Cost Analysis (Phase I EE/CA; *USAEDH, 1997b*) and the Phase 2 Engineering Evaluation/Cost Analysis (Phase 2 EE/CA; *Army, 1998b)*** – The Phase 1 and Phase 2 EE/CAs were developed to describe the munitions response to MEC and management

activities for sites known or suspected to contain MEC. The Phase 1 EE/CA addressed 29 MRSs and subsites (*USAESCH, 1997*). The Phase 2 EE/CA addressed the remaining MRSs, including future sites (*Army, 1998b*).

Elements of the MR Program implemented as part of the Basewide MR RI/FS include the following:

- **Draft Final Literature Review Report, Ordnance and Explosives, Remedial Investigation/Feasibility Study, Former Fort Ord, California (*HLA, 2000a*)** – This report was the first step in evaluating existing MEC related information for the former Fort Ord as part of the MR RI/FS program.

- **Draft Final Ordnance and Explosives Remedial Investigation/Feasibility Study Work Plan, Former Fort Ord, California (*USACE, 2000*)** – The RI/FS Work Plan describes the overall process for implementing the CERCLA process for Munitions Response Sites at the former Fort Ord and introduces the management of sites within the 4 tracks (Tracks 0 through 4).

- **Record of Decision, Interim Action for Ordnance and Explosives at Ranges 43-48, Range 30A, and Site OE-16, Former Fort Ord, California (*Army, 2002b*)** – This ROD describes the Interim Action for removal of MEC at two areas within the Impact Area and one area just to the north of the Impact Area. The interim action includes vegetation removal through prescribed burns and removal of all detectable MEC to depth. The action within MRS-Ranges 43 through 48 is documented in the Draft Final Ranges 43 through 48 Technical Information Paper (*Parsons, 2006*).

- **Record of Decision, No Further Action Related to Munitions and Explosives of Concern - Track 1 Sites, No Further Remedial Action with Monitoring for Ecological Risks from Chemical Contamination at Site 3 (*Army, 2005*)** – This ROD addresses sites at the former Fort Ord that were suspected to have been used for military training with military munitions, but based on the Track 1 Ordnance and Explosives Remedial Investigation/Feasibility Study (*MACTEC, 2004*), each site falls into one of three categories (Categories 1 through 3) and require no further action. The ROD also outlines a "plug in" process by which an Approval Memorandum will be prepared that presents the rationale for designating future sites as Track 1 sites. When approved by the regulatory agencies, the Approval Memorandum will become the decision document for the specific Track1 site. Seventeen sites were identified for no further action as part of the Track 1 ROD. Several other groups of sites have also been identified as Track 1 sites and have proceeded through the Track 1 "plug in" process.

- **Final Track 2 Munitions Response, Remedial Investigation/Feasibility Study, Parker Flats Munitions Response Area, Former Fort Ord, California *(MACTEC, 2006b)*** – This is the first RI/FS prepared for Track 2 sites which are sites where MEC items were present, and MEC removal has been conducted. The MRA consists of 13 MRS sites.

2.2 Physical Setting

The following sections summarize the location and general physical setting of the Impact Area MRA, including intended land uses.

2.2.1 Location

The historical Impact Area MRA is located in the southwestern portion of the former Fort Ord. The area covers approximately 8,000 acres and is bounded by Eucalyptus Road to the North, Barloy Canyon Road

to the east, South Boundary Road to the south, and General Jim Moore Boulevard to the west (Plate 2). The firing ranges were located approximately along the perimeter of the historical Impact Area such that weapons firing was generally directed toward the center of the Impact Area (Plates 3 and 4).

The Impact Area MRA consists of 6,560 acres of the 8,000 acre historical Impact Area that is currently designated for transfer to BLM as Habitat Reserve. Portions of the historical Impact Area not included in the Impact Area MRA include the MOUT which will continue to be used as a training facility, the northern and western edges of the historical Impact Area that are desinated for development, and a portion of the habitat reserve in MRS-Ranges 43-48 that is not designated to be transferred to BLM (Plate 2).

2.2.2 General History

The Impact Area MRA was reportedly used since 1917 for training exercises using military munitions. Munitions that have been fired into, fired upon, or used at the Impact Area include artillery and mortar projectiles, rockets and guided missiles, rifle and hand grenades, practice land mines, pyrotechnics, bombs, small arms ammunition, and demolition materials. The earliest ranges present in the Impact Area were located predominantly in the northern and western portions of the Impact Area. The firing points for the ranges on the north side were adjacent to Eucalyptus Road. The firing points for the ranges on the western side were mostly located several thousand feet inland from General Jim Moore Boulevard. Most of the ranges present on the western side of the Impact Area were abandoned by 1958 and the firing points for the ranges that remained active were moved to locations closer to General Jim Moore Boulevard. By 1961, numbers beginning with 18, had been assigned to some of the ranges following the numbering scheme already in use at the beach trainfire ranges (designated 1 through17). A training map from 1964 indicates that by this date all of the ranges within the Impact Area were consecutively numbered. The locations and limits of the individual ranges have not changed appreciably since that time. At the time of base closure, twenty-eight of thrity ranges (numbered 18 through 48) were active or considered operational.

2.2.3 Land Use

The former Fort Ord consists of both developed land (approximately 8,000 acres) and undeveloped land (approximately 20,000 acres). The developed areas include the East Garrison, the Fritzsche Army Airfield (FAAF), and the Main Garrison. The Impact Area MRA is primarily undeveloped.

2.2.3.1 Developed Land

The Impact Area MRA does not include developed land other than access road and trails. Developed areas adjacent to the Impact Area MRA include an active training area, MOUT facility located in the northeastern portion of the Impact Area and the BLM headquarters.

2.2.3.2 Undeveloped Land

The Impact Area MRA is primarily undeveloped land in the inland portions of the former Fort Ord. The Impact Area MRA is primarily left in its natural state, with only minor development of support facilities associated with training that occurred at the firing ranges (e.g., access roads, observation towers, targets, trenches, bunkers, etc.).

2.2.3.3 Future Land Use

The future land uses presented in this section are primarily based upon the Fort Ord Reuse Authority (FORA) March 1997 Fort Ord Base Reuse Plan (*FORA, 1997*), the July 1995 USACE and BLM Site Use Management Plan (SUMP) (*USACE, 1995b*) and the Installation-Wide Multispecies Habitat Management Plan (HMP), (*USACE, 1997*). Since base closure, the Army has been coordinating with the BLM regarding the management of habitat reserve within the former Impact Area. The 1995 SUMP and 1997 HMP outline agreements on conceptual reuse and management of the Impact Area based on MEC cleanup expectations at the time. Since then, BLM has provided several updates on its plans for reuse and habitat management. These documents include the 2004 draft Proposed Mangement Plan (*BLM and Army, 2004*), 2006 Proposed Resource Management Plan/Final Environmental Statement, and 2006 draft Habitat Conservation Plan (HCP) ([*Zander, 2007*]; provided as part of the BLM comments to the draft Track 3 MR RI/FS,).

The Reuse Plan identified approximately 20 land-use categories at Fort Ord (*FORA, 1997*) including habitat management, open space/recreation, institutional/public facilities, commercial, industrial/business park, residential, tourism, mixed use, and others. The SUMP identified three unique future reuse designations within the Impact Area MRA. These designations include unrestricted/BLM areas, limited-access areas, and restricted/administration areas. Anticipated future uses within each designation are described below:

- Unrestricted/BLM areas: Construction of facilities, habitat restoration, and maintenance of access routes.

- Limited-access areas: Recreation access, notification uses, and habitat restoration.

- Restricted/administration areas: Habitat monitoring and habitat enhancement.

A general goal of the HMP is to promote preservation, enhancement, and restoration of habitat and populations of HMP species while allowing development on selected properties on the former Fort Ord, which promotes economic recovery after base closure. Most parcels designated for development are intended for economic recovery and have no restrictions in terms of habitat management. Other development parcels are obligated to implement certain guidelines outlined in the HMP. Parcels designated as habitat management or habitat corridors have specific management guidelines and restrictions prescribed by the HMP; these mitigations are designed to offset the habitat loss that would occur in designated development areas present outside the Impact Area MRA. On a basewide level, implementations of the HMP is required to comply with the federal Endangered Species Act and Biological Opinions for the disposal and reuse of the former Fort Ord.

The HMP (*USACE, 1997*), East Garrison and Parker Flats Land Use Modification Assessment (*Zander, 2002*), and the Revised Attachment A – HMP map (*March 2006*) presents the revised boundaries of the habitat reserve areas and describes special land-use controls and habitat monitoring requirements for target species within the HMP Reserve and Development Areas. Boundaries for habitat reserve to be managed by BLM were also revised. For the habitat reserve in the Impact Area, certain management actions and mitigation measures are prescribed in the HMP and biological opinions (*USFWS, 1999, 2002, and 2005*) for predisposal actions (environmental cleanup and munitions response). These include minimizing disturbances in the habitat, conducting employee education program, habitat monitoring, and vegetation burning in support of munitions response in maritime chaparral habitat. Post-disposal management guidelines are also outlined in the HMP for the habitat reserve areas in the Impact Area,

including habitat restoration, enhancement and monitoring, access control, controlled burning and an allowance for development-oriented use in as much as 2 percent of the Natural Resource Management Area – a portion of the Impact Area being transferred to BLM.

BLM recently provided the draft HCP to the Army. The draft HCP describes the projected land uses, existing habitat features, species covered by the plan, and the resource conservation and management activities that are anticipated for property that will be transferred to BLM. The draft HCP discusses the types of activities that will be allowed including:

- Route, road, and trail management and maintenance;
- Habitat enhancement;
- Fuelbreak construction and management;
- Use of admentistrative areas;
- Aquatic monitoring and educational programs;
- Species specific monitoring and habitat enhancement; and
- Recreational access on established routes.

It is the intent of this RI/FS to evaluate and propose a cleanup alternative that would support the implementation of the post-disposal management guidelines required by the HMP that are applicable to the habitat reserve within the Impact Area.

2.2.4 Site Features

The following section summarizes site features at the former Fort Ord.

2.2.4.1 Climate

The discussion on climate provided below provides general climate information. It is expected that more detailed climate information will be provided in work plans that would be prepared for specific actions that may be taken in the fuure. The area's climate is characterized by warm, dry summers and cool, rainy winters. The Pacific Ocean is the principal influence on the climate at the former Fort Ord, and the source of fog and onshore winds that moderate temperature extremes.

Temperature

Daily ambient air temperatures typically range from 40 to 70 degrees Fahrenheit (F), but temperatures in the low 100s have occurred. Thick fog is common in the morning throughout the year. Winds are generally from the west.

Rainfall

The average annual rainfall of 18 inches occurs almost entirely between November and April. Because the predominant soil is permeable sand, runoff is limited and streamflow occurs only intermittently and within the very steep canyons in the eastern portion of the Impact Area.

Winds

The winds are generally from the west (a sea breeze) due to the proximity to Montery Bay (*Nuss, 2003*). During 2006 the average monthly wind speed measured at Fort Ord ranged from 7.5 to 11.4 miles per hour (mph) with maximum monthly wind gusts ranging from 25 to 48 mph. (*Renard, 2007*).

Additional information on mixing heights and weather patterns at Fort Ord are provided in Nuss, 2003.

2.2.4.2 Ecological Setting

The former Fort Ord is located on California's central coast, a biologically diverse and unique region. The range and combination of climatic, topographic, and soil conditions at the former Fort Ord support many biological communities. Initial field surveys were conducted from 1991 through 1994 to provide detailed site-specific, as well as basewide, information regarding plant communities, botanical resources, observed and expected wildlife, and biological resources of concern. Plant communities were mapped for the whole base as described in the *Draft Basewide Biological Inventory, Fort Ord, California* (*HLA, 1992*). Additional flora and fauna monitoring and reporting has occurred since 1994 to document the affects to rare, threatened, and endangered species as the result of the Army predisposal actions.

Several of the former Fort Ord plant communities have been combined for simplification. The 11 plant communities described at former Fort Ord sites include coast live oak woodland (coastal and inland); central maritime chaparral; central coastal scrub; grassland; developed/landscaped/ruderal and disturbed dunes; dune scrub; iceplant mats; riparian forest; wetlands (including vernal pools and freshwater marsh); and coastal strand. Central maritime chaparral is the most extensive natural community at the former Fort Ord, occupying approximately 12,500 acres in the south-central portion of the base. Oak woodlands are widespread at the former Fort Ord and occupy the next largest area, about 5,000 acres. Grasslands, located primarily in the southeastern and northern portions of the base, occupy approximately 4,500 acres. The other community types generally occupy less than 500 acres each. Approximately 4,000 acres of the above-mentioned plant communities occur in partially developed areas or areas identified for development. The remaining approximately 4,000 acres of the base are considered fully developed and not defined as ecological communities.

Plate 5 shows the Fort Ord plant communities that are present within the Track 3 Impact Area MRA. The dominant community is the central maritime chaparral that covers about 6,066 acres of the Impact Area MRA. Other communities include the inland coast woodland community that comprises about 199 acres of the site, the grassland community (about 256 acres), and the wetland community that comprises about 24 acres of the site. A small portion of the site has been developed. Listed species present in the Impact Area MRA include the California tiger salamander (*Ambystoma californiense*), sand gilia (*Gilia tenuiflora* ssp. *arenaria*), California goldfields (*Lasthenia conjugens*), Monterey spineflower (*Chorizanthe pungens* var. *pungens*), and Seaside bird's beak (*Cordylanthus rigidus* var. *litteralis*) including critical habitat designated for Monterey spineflower.

Among the more than 260 vertebrates known to occur or potentially occur at the former Fort Ord some are considered special-status species, as documented in the Fort Ord *Draft Basewide Biological Inventory, Fort Ord, California*, dated December 8, 1992. These wildlife species, in addition to plant species and native biological communities, are collectively called special status natural resources. They receive various levels of protection under local, state, or federal laws, regulations, and codes. The closure and disposal of former Fort Ord is considered a major federal action that could affect several species of concern and other rare species listed by the California Department of Fish and Game and/or the California Native Plant Society or listed as threatened or endangered under the federal Endangered Species Act

(ESA). The U.S. Department of the Interior, Fish and Wildlife Service (USFWS) final Biological Opinion for the Disposal and Reuse of Fort Ord (*USFWS, 1993*) required that a HMP be developed and implemented to reduce the incidental take of listed species and loss of habitat that supports these species.

Other subsequent biological opinions (*USFWS, 1999, 2002,and 2005)* addressed reasonable and prudent measures to mitigate impacts to listed species and critical habitat for species such as the California tiger salamander, California goldfields, and Monterey spineflower. The HMP (*USACE, 1997*), the Biological Opinions mentioned above, as well as an Assessment (*Zander, 2002*), a Memorandum of Understanding (*BLM/Army, 2004*), and a *Revised Attachment A - Habitat Management Plan Map* (*USACE, 2005*) establish the guidelines for the conservation and management of wildlife and plant species and habitats that largely depend on former Fort Ord land for survival.

Two of the eleven plant communities at Fort Ord are considered rare or declining and of highest inventory priority by the California Department of Fish and Game (CDFG; *CDFG, 1997*): central maritime chaparral and valley needlegrass grassland.

Special-status wildlife that occur or potentially occur at Fort Ord include one invertebrate, one reptile, two amphibians, 11 birds, and two mammals. The greatest diversity of wildlife species occurs in chaparral communities that potentially host special status wildlife species such as California black legless lizard *(Anniella pulchra nigra),* Monterey dusky footed woodrat *(Neotoma macrotis luciana),* coast horned lizard *(Phrynosoma coronatum),* golden eagle *(Aquila chrysaetos)* and loggerhead shrike *(Lanius ludovicianus).*

Special status wildlife species potentially occurring in the inland coast live oak woodland community include California tiger salamander, California black legless lizard, dusky-footed woodrat, American badger *(Taxidea taxus),* Cooper's hawk *(Accipiter cooperii),* and yellow warbler *(Dendroica petechia).*

In the grassland community, special status wildlife species are potentially represented by American badger, California tiger salamander, California horned lark *(Eremophilia alpestris actia),* golden eagle, northern harrier *(Circus cyaneus),* loggerhead shrike, tricolored blackbird *(Agelaius tricolor),* prairie falcon *(Falco mexicanus)* and burrowing owl *(Athene cunicularia hypugaea).*

Special status wildlife species possibly occurring in the wetland community include Monterey ornate shrew *(Sorex ornatus salarius),* sharp-shinned hawk *(Accipiter striatus),* Cooper's hawk, Northern harrier, yellow warbler, tricolored blackbird, California tiger salamander, California red-legged frog *(Rana aurora draytoni),* Southwestern pond turtle *(Emmys marmorata pallida),* and California linderiella *(Linderiella occidentalis).*

From 1994 to the present, baseline and follow-up surveys have been conducted for habitats identified in the HMP that are potentially affected by Army predisposal activities. These data are presented in annual monitoring reports from 1994 through 2005 (*HLA, 1994, 1995b, 1996, 1997, 1998, 1999a, 2000b; Harding ESE, 2001, 2002; MACTEC, 2003, 2004; Parsons, 2005*).

2.2.4.3 Topography and Surface Waters

The topography of the Impact Area MRA consists of low rolling hills in the western and central portions, and more rugged terrain comprising several canyons and ridges to the east. The predominant topography of the Impact Area reflects morphology typical of the dune sand deposits that underlie the western and central portions of the Impact Area MRA. Elevations range from approximately 200 feet mean sea level (MSL) to 900 feet MSL. Runoff is minimal in the western and central portions of the Impact Area due to

the high rate of surface water infiltration into the permeable dune sand; consequently, well-developed natural drainages are absent throughout much of this area. However, limited erosion has been observed primarily where roads were carved into slopes. In these areas, small gullies are present, but generally end shortly after the topography flattens out. Closed drainage depressions typical of dune topography are common. The eastern portion of the Impact Area is characterized by relatively well-defined, eastward-flowing drainage channels within narrow, moderately to steeply sloping canyons. Runoff is into the Salinas Valley.

2.2.5 Geologic and Hydrogeologic Conditions

This section summarizes subsurface conditions at the former Fort Ord, emphasizing the conditions within the Impact Area MRA.

2.2.5.1 Geology

The geology over the majority of the Impact Area is Pleistocene-age dune deposits that are up to 250 feet thick. The dune deposits form the characteristic low rolling hills seen in the western and central portions of the Impact Area. The geology in the eastern portion of the Impact Area includes Pliocene to Pleistocene alluvial fan, lake, and flood deposits of the Paso Robles Formation and Pleistocene sand and gravel deposits of the Aromas sand.

2.2.5.2 Hydrogeology

The Salinas Basin and the Seaside Basin are the two main hydrogeologic structures underlying the former Fort Ord. The Salinas Basin underlies approximately the northern one-third of the former Fort Ord; the Seaside Basin underlies approximately the southern two-thirds of the installation including the Impact Area. Only the Seaside Basin is discussed here.

The Seaside Basin reportedly consists of the following four aquifers, from depth to ground surface: the Monterey Formation aquifer, the Santa Margarita Formation aquifer, the Paso Robles Formation aquifer, and a perched aquifer (*GTC, 1986*).

The Monterey Formation consists of marine siltstone and shale that is known to yield water from fractures. Water-supply wells in the city of Seaside produce water primarily from the Santa Margarita Formation aquifer, which pinches out beneath Seaside. The Paso Robles Formation aquifer is confined or semi-confined and is found beneath the Seaside Clay unit of the Paso Robles Formation. The Paso Robles aquifer is a major water-bearing unit in the Seaside Basin.

An unconfined, perched aquifer overlies the Seaside Clay unit of the Paso Robles Formation and may occur in one or more of the following units: Recent Alluvium, the Aromas Sand, and the upper member of the Paso Robles Formation.

2.3 MR RI/FS Background

This section identifies the regulatory background for the MR program and presents information on the MR investigations conducted within the Impact Area MRA. A description of the Basewide Range Assessment program, which addresses the potential for chemical contamination (munitions constituents) related to military munitions, is also provided in this section.

2.3.1 Regulatory Background

Since the base was selected for BRAC in 1991 and was officially closed in September 1994, MEC removal actions have been performed and documented in preparation for transfer and reuse of the former Fort Ord property. Limited removal actions began in 1993. The munitions response to MEC at identified MRSs continued after base closure because the expanded reuse of the former Fort Ord increased the possibility of the public being exposed to MEC hazards. The Army performed its activities pursuant to the President's authority under the CERCLA Section 104, as delegated to the Army in accordance with Executive Order 12580 and in compliance with the process set out in CERCLA Section 120. The regulatory agencies (USEPA and the California Department of Toxic Substances Control [DTSC] under the California Environmental Protection Agency [Cal/EPA]) were provided copies of work plans and after action reports for review. The agencies had the opportunity to provide input during MEC investigation and removal actions; however, the removal actions were completed by the Army using its delegated removal authority under CERCLA.

In November 1998, the Army agreed to evaluate MEC at the former Fort Ord in an MR RI/FS consistent with CERCLA. The Basewide MR RI/FS, which the Army is preparing to address MEC hazards on the former Fort Ord, will include input from the community and will require regulatory agency review and approval. The Basewide MR RI/FS will evaluate past removal actions as well as recommend future remedial actions deemed necessary to protect human health and the environment under future uses.

In April 2000, an agreement was signed between the Army, USEPA, and DTSC to evaluate MEC at the former Fort Ord subject to the provisions of the Fort Ord Federal Facility Agreement (FFA). The signatories agreed that the FFA provided the appropriate framework and process to address the Army's MEC activities. The signatories also agreed that one or more operable units should be established to expidite site investigation and selection of response actions. The FFA was originally signed in 1990 by the Army, USEPA, California Department of Health Services (the oversight responsibility is now assumed by DTSC), and the Regional Water Quality Control Board (RWQCB). The FFA established schedules for performing remedial investigations and feasibility studies, and requires that remedial actions be completed as expeditiously as possible.

In addition to the regulatory participation by the USEPA and DTSC described above, consultation with the USFWS on remediation of MEC has been completed, resulting in a biological opinion including incidental take limits. If the Track 3 RI/FS results in impacts to HMP species not previously considered, the Army will consult with the USFWS in accordance with the Endangerded Species Act.

The Basewide MR RI/FS will contain a comprehensive evaluation of all MEC-related data for the entire former Fort Ord and will evaluate long-term response alternatives for cleanup and risk management of MEC.

2.3.2 Impact Area MR RI/FS Investigations Background

MEC-related field investigations, sampling, and removal activities were conducted at the Track 3 Impact Area by Army's MR contractors according to contractual and/or work plan requirements in place at the time the work was conducted. Although formal data quality objectives (DQOs) were not established at the time much of the work was completed, the purpose and objectives of the work conducted at the sites were based on contractual and/or work plan requirements. The approved investigation methodologies are summarized below, and are evaluated further in Section 3.3.2.

The munitions response investigation and removal work conducted at the former Fort Ord focused on addressing explosive safety. According to the USACE Military Munitions Safety Specialist for the Sacramento District, when non-military munitions related debris was found it was removed from the excavation and inspected for explosive hazards and for the presence of hazardous wastes. If MEC or hazardous wastes were identified, they were removed and disposed of following the appropriate requirements. After the waste material was inspected, the non-hazardous debris was left in place or removed.

Four primary contractors performed munitions response to MEC at the Track 3 Impact area: (1) Human Factors Applications, Inc. (HFA), (2) CMS Environmental, Inc., (CMS), now known as USA Environmental, Inc. (USA), (3) Parsons Infrastructure & Technology Group, Inc. (Parsons), and (4) Shaw Environmental, Inc. (Shaw).

Human Factors Applications, Inc. (HFA) – December 1993 through June 1994

Background

HFA was contracted by the U.S. Army Corps of Engineers Huntsville Division (CEHND) in late 1993 to provide munitions response to MEC services at Fort Ord. HFA's objective was to determine the presence or absences of MEC at 16 sites distributed throughout Fort Ord. The sites were identified by the U.S. Army Corps of Engineers, St. Louis Division, and reported in the 1993 Archives Search Report. If MEC was discovered, it was reported to the CEHND Safety Specialist who was responsible for determining whether the site was to be declared contaminated with MEC. HFA performed sampling operations at Fort Ord from December 1993 through June 1994. HFA was also contracted to perform a removal action at a portion of MRS-31.

Impact Area Investigations

Review of the HFA After Action Report (*HFA, 1994*) indicates that 80 grids were established in and around the southeastern portion of the Impact Area MRA. Of the 80 grids established, three grids were sampled; however, all of the sampled grids were outside of the Impact Area MRA boundary. The exact locations of the established grids, and whether they were within the Impact Area MRA, are not known.

General Requirements

HFA performed work according to the Fort Ord-Phase 1 Work Plan and Accident Prevention Plan dated December 16, 1993 (*HFA, 1993*). The work plan describes the procedures that were followed during all aspects of work including surface and subsurface characterization activities and the quality control plans and reporting.

CMS Environmental, Inc (CMS) / USA Environmental (August 1995 through 2000)

Background

CMS was issued a contract by the CEHND in 1995 to perform munitions response to MEC at selected sites within the former Fort Ord. The contract was revised on January 31, 1997 (*CMS, 1997*). In June 1998, CMS was sold, and the name of the company became USA. In July 1998, USA began to conduct work on Fort Ord as a subcontractor to CMS. In September 1998, the sale was complete and USA became the prime contractor. USA also worked at former Fort Ord as a MR subcontractor to Parsons since 2000.

Impact Area Investigations

CMS/USA conducted the following activities within the Impact Area:

- 100 percent grid sampling;
- Four foot clearance of Impact Area roads and trails; and
- Four foot and surface clearance of fuel breaks (areas cleared of high vegetation to retard the progress of fires).

Each of these activities is described in detail in Section 3.3.1.

General Requirements

CMS/USA performed work according to three different work plans. The first work plan was dated July 21, 1995 (*CMS, 1995*) and covered work completed prior to September 30, 1997. The second work plan was completed in September 1997 (*CMS, 1997*) and covered work completed prior to completion of a revised work plan in April 2000 (*USA, 2000c*). The work plans outlined the general procedures that were to be followed during site preparations, sampling (both sitestat/gridstat (SS/GS)) and 100 percent grid sampling), and removal actions. The plans also described the procedures that would be used for all MEC demolitions and the quality control/quality assurance program.

Parsons

Background

Parsons was issued the contract to perform Military Munitions Response Program activities at the former Fort Ord by the U.S. Army Corps of Engineers, Sacramento District on July 14, 2000. Parsons has performed work at the former Fort Ord since 2000.

Impact Area Investigations

Parsons conducted the following activities within the Impact Area:

- Fuel break clearance (subsurface and surface);
- Visual surface removal in accessible areas (no vegetation removal) within Ranges 43-48;
- Visual surface removal within the Ranges 43-48;
- Subsurface removals within MRS-Ranges 43 through 48 including both analog and digital removals;
- Visual surface removal within the Watkins Gate Burn Area;
- Visual surface removal in accessible areas (no vegetation removal) within Mortar Alley;
- Visual surface removal in accessible areas (no vegetation removal) within Range 30A; and
- Digital geophysical mapping within the Watkins Gate Burn Area.

Each of these activities is described in detail in Section 3.3.1.

General Requirements

Parsons performed work within the Impact Area according to the Programmatic Work Plan (*Parsons, 2004a*). The Programmatic Work Plan was originally prepared in May 2001 with the second edition published in May 2004. The Programmatic Work Plan describes the procedures, methods, resources, and Quality Control/Quality Assurance (QC/QA) that Parsons and its subcontractors use while performing work under contract DACA05-00-D-003. Site-specific work plans were also prepared to document site-specific procedures and requirements.

Shaw Environmental, Inc.

Background

Shaw Environmental, Inc. (Shaw) performs MMRP work at the former Fort Ord under the Total Environmental Restoration Contract (TERC) No. DACW05-96-0011. The work is being performed according to site specific work plans.

Impact Area Investigations

Shaw completed the following activities within the Impact Area:

- Time Critical Removal Action (TCRA) at the Eucalyptus Fire Area (surface removal); and
- Munitions response at Range 36A.

Each of the activities is described in detail in Section 3.3.1.

General Requirements

Shaw performed the TCRA at the Eucalyptus Fire Area in accordance with the Final Work Plan, Time Critical Removal Action and Ordnance and Explosives Reconnaissance, Eucalyptus Fire Site, Former Fort Ord, Rev 0 (*Shaw, 2003*). The work plan described the procedures, methods, and Quality Assurance/Quality Control (QA/QC) that Shaw used while performing the work at the Eucalyptus Fire Area. Work at Range 36A is being performed according to the Draft Final Work Plan, Range 36A Munitions Response, Former Fort Ord, California which is included as Volume 2 of the Draft Final RCRA Closure Plan, Range 36A (*Shaw, 2005*).

Basewide Range Assessment

MACTEC and Shaw Environmental have been performing an evaluation of the potential for chemical exposures related to military munitions training throughout the former Fort Ord. The investigations are being conducted according to the Basewide Range Assessment Work Plan (*IT, 2001*), and the Basewide Range Assessment Sampling and Analysis Plan (*MACTEC/Shaw, 2003*). These documents outline the process for conducting evaluations throughout the Former Fort Ord for potential munitions constituents related to military munitions training. The BRA also evaluates the potential for chemicals such as total petroleum hydrocarbons (TPH), which could be associated with flame thrower training or flame field expedient training.

The results of the Basewide Range Assessment are detailed in the Basewide Range Assessment Comprehensive Report which is currently out as REV 1C (*MACTEC/Shaw, 2006*). The Basewide Range Assessment was an outgrowth of the work conducted at Site 39 during the 1994 Basewide Remedial Investigation/Feasibility Study, and was conducted to address munitions constituients across the former Fort Ord. The BRA was initiated to evaluate areas not identified during the initial Basewide RI/FS and to provide a framework for evaluating areas within the historical Impact Area through collection of additional site reconnaissance and sampling data. A framework for evaluation of additional areas within the Impact Area for munitions constituents using data collected during MEC removal activities was also established. Plate 6 shows areas of the Impact Area that were evaluated during the BRA through either site reconnaissance walks or collection of soil samples for analysis of metals and or explosives. Plate 6 also shows features mapped as part of the BRA that are related to military munitions training such as targets, range fan markers, and firing points.

The results of the work conducted during the Site 39 investigation (1994 Basewide RI/FS) indicated that impacts to groundwater are not expected, because impacts to soil are generally identified only in the surface and near surface, and groundwater is generally at depths greater than 100 feet below ground surface. The primary focus of the BRA is to evaluate the potential for metals and explosives contamination in soil, and to evaluate potential remedial actions for chemical contamination related to military munitions training.

3.0 TRACK 3 IMPACT AREA REMEDIAL INVESTIGATION (RI)

3.1 Track 3 Impact Area Munitions Response Site Description

The Impact Area MRA is located in the southwestern portion of the former Fort Ord. The area covers approximately 6,560 acres. The Impact Area MRA includes all of MRS-BLM, and a portion of MRS-Ranges 43 through 48. It does not include the development areas on the outer edges of the historical Impact Area, the MPC development parcels, the MPC Habitat Reserve parcels, the MOUT or BLM Headquarters, (MRS-15 SEA 01 through 04; MRS-15 DRO 01, MRS-15 DRO 01A, MRS-DRO 02, MRS15 -DRO 02A, MRS-15 MOCO1, MRS-MOC02, MRS-46, MRS-35, MRS-28, or MRS-47 [Plate 2]).

The Impact Area MRA is within the former Fort Ord Impact Area and was previously the location of the Fort Ord Range Complex, which was used for live fire training exercises with a variety of weapons. At the time of base closure, twenty-eight of thrity ranges (numbered 18 through 48) were active or considered operational. The ranges were positioned around the perimeter of the Impact Area, with firing directed toward the center of the Impact Area at targets that were positioned down range.

The Impact Area MRA evaluated in this RI/FS includes two areas previously evaluated in the Interim Action program: a southern portion of Ranges 43-48, and Range 30A. The 2002 Interim Action ROD selected interim remedial actions for these areas, consisting of vegetation clearance via prescribed burning, MEC remediation via surface and subsurface removal, and MEC detonation with engineering controls. Subsurface MEC removal depths were to be determined in the site-specific work plans based on the type of MEC, the typical depth at which the MEC type is found, planned reuse of the specific areas within the Interim Action site, and the capabilities of the geophysical detection equipment selected as best suited for site conditions by the site geophysicist (*Army, 2002b*).

The site-specific work plan for the Interim Action at Ranges 43-48 identified MEC removal to depth in the entire 500-acre site, based on detection-and-removal of individual anomalies using dual-instrument approach. Areas around targets were expected to contain high density of metallic clutter that would preclude successful implementation of geophysical investigation. Because cleanup of such areas would likely involve methods that could significantly impact the habitat, the site-specific work plan included a process for documenting such areas and making recommendations to USACE, and the Army would consult with the regulatory agencies regarding those recommendations (*Parsons, 2003*). The interim action was conducted from October 2003 to December 2005 and the final report on the completed activities was issued in January 2007. The report identified several areas within Ranges 43-48 where removal-to-depth was not completed, including areas of high metallic clutter (*Parsons, 2007*). The portion of MRS-Ranges 43-48 that is also part of the Impact Area MRA includes some of these areas where subsurface removal was not conducted (see Section 3.3.1 for additional information). The evaluation of the preferred alternative for the Track 3 Impact Area MRA doubles as the follow-on evaluation of this portion of the Interim Action site, Ranges 43-48. The preferred alternative is consistent with the actions taken at the Ranges 43-48 site.

Implementation of the interim remedy in Range 30A was suspended due to the high wildfire risk associated with prescribed burning in this part of the Impact Area MRA. Range 30A is approximately 388 acres, and contains as well as is surrounded by areas of healthy Central Maritime Chaparral vegetation, which is highly flammable and has not recently burned. Under the Interim Action program, the site would be surrounded by a 45-foot primary fuel break, and burned in one large prescribed burn.

Drawing from the lessons learned from the Ranges 43-48 prescribed burn, the Army has determined that remedial actions in that vicinity of the Impact Area MRA should be sequenced so that the area between Range 30A and the base boundary is burned and cleaned up first, thus creating a larger fuel break in the process, before taking action in Range 30A. The preferred alternative for the Track 3 Impact Area MRA provides for removal to depth in selected areas, including areas of high density metallic clutter associated with sensitive-type munitions –- a type of area specifically suspected to exist in Range 30A. Therefore, the preferred alternative is not inconsistent with the previously-selected interim remedy.

For these reasons, the remedy that is recommended for the Track 3 Impact Area MRA, when selected in the Track 3 ROD, will serve as the final remedy for the these two Interim Action areas. In effect, the Track 3 ROD will amend the 2002 Interim Action ROD regarding the southern portion of Ranges 43-48 and Range 30A.

3.2 Track 3 Impact Area MRA Munitions Response Site History and Development

The initial use of the historic Impact Area began in approximately 1917 when the U.S. Government purchased more than 15,000 acres of land and designated it as an artillery range (*Cozzens, 1922*). Cavalry and artillery troops stationed at the Presidio of Monterey, along with infantry troops stationed at the Presidio of San Francisco, conducted training activities within the Impact Area. Although no training maps from this time period have been found, pre-WW II-era military munitions have been removed during response actions within the Impact Area. These include Livens projectiles, Stokes mortars, and 37 and 75mm projectiles.

By 1945 eighteen ranges and training areas had been established within the boundaries of the Impact Area. Table 3.1 presents information on ranges established in the 1940s and 1950s. These ranges included an antitank range, anti-aircraft range, a close combat course, small arms ranges (rifle and machine gun), mortar range, infiltration course, hand grenade range, booby trap training area, bazooka demonstration area, and a moving vehicle range (*Army, 1945*). Ranges were added to the Impact Area throughout the 1950s. During the 1940s and the early 1950s, the firing points for the ranges on the north side of the Impact Area were adjacent to Eucalyptus Road. The firing points for the ranges on the western side were mostly located several thousand feet inland from General Jim Moore Boulevard (Plate 3).

Ranges identified on 1950s-era training maps included 60mm and 81mm mortar ranges, a 57mm recoilless rifle range, a rocket launcher range, a rifle grenade range, small arms ammunition ranges, and hand grenade assault, infiltration, close combat, and small arms firing courses (*Army, 1956, 1957, and 1958*). The majority of the ranges present on the western side of the Impact Area were abandoned by 1958 and the firing points for the ranges that remained active were pulled back to locations closer to General Jim Moore Boulevard (Plate 3).

By 1961 the Impact Area ranges had been assigned numbers following the numbering scheme already in use at the beach trainfire ranges. Table 3.2 presents information on ranges established between 1961 and base closure. A training map from 1964 indicates that by this time all of the ranges within the Impact Area were consecutively numbered (*Army, 1964).* It is also during this time period that the position of the Impact Area ranges remained relatively static and the locations and limits of the individual trainfire ranges have not changed appreciably since that time. Ranges identified on the 1960s –era training maps included small arms ammunition ranges, a 90mm and 106mm recoilless rifle sub-caliber range, a 40mm grenade range, a mortar range, a 3.5-inch rocket range, a 90mm recoilless and M72 LAW range, a hand

grenade range, close combat and infiltration courses, and an explosive ordnance disposal range (*USACE, 1968*).

The configuration of the Impact Area ranges remained relatively constant throughout the 1970s, 1980s and 1990s (*Army, 1976, 1987, 1992*). Additionally, the type of weapons that were being used at each of the ranges also remained relatively constant. Documentation including training facilities maps, range control records, and range regulation standard operating procedures from this time period, indicate that military munitions authorized for use at the Impact Area ranges included small arms ammunition, hand grenades, 60mm, 81mm and 4.2-inch mortars and mortar sub-caliber devices, 14.5mm sub-caliber devices (artillery), Dragon missiles, 90mm and 20mm projectiles, LAW rockets and sub-caliber devices, 40mm grenades, claymore mines, C4 and TNT. At the time of base closure twenty-eight of thirty ranges (numbered 18 through 48) were active or considered operational within the Impact Area (*Army, 1992*).

In addition to Ranges identified within the Impact Area, four artillery firing points located outside the Impact Area were identified from former Range Control files and training facility drawings. Range control records and interviews indicate the firing points were used by artillery units utilizing 105mm howitzers and were fired at targets within the Impact Area. According to interviews with range control personnel conducted in 1994, these areas experienced light use from 1978 to 1982 (*HLA, 1994*); however, the firing points continued to be listed on range control documents dated 1984, 1987, and 1992. According to the former Range Control Officer present during the periods of firing point use, all rounds fired from the firing points landed in the target area within the Impact Area (*HLA, 2000a*).

3.3 Military Munitions Response Program Investigations

Several investigations in support of, and independent of, the Fort Ord military munitions response program have been conducted within the Impact Area. These include sampling, TCRAs, road and trail clearance, clearances conducted to support of the establishment of fuel breaks, and Interim Actions. Table 3.3 lists the investigations and the number of MEC and either number or pounds of munitions debris removed during the investigations.

3.3.1 History of Investigations

Grid Sampling

An initial evaluation to determine the scope of future munitions response in the Impact Area was conducted in 1997 and 1998. As part of this evaluation, grid sampling was performed within selected areas of the Impact Area to collect data regarding the type, depth, and distribution of military munitions present. Grid sampling is a method whereby 100 percent of the geophysical anomalies identified within a designated grid (typically 100- by 100-foot) are investigated. Each 100- by 100-foot grid was sampled to a depth of 4 feet (all anomalies detected were investigated to a depth of 4 feet and deeper anomalies were investigated as directed by a USACE UXO Safety Specialist). All sample grids were geophysically searched using a Schonstedt Model GA-52/Cx magnetometer. The initial sampling of the Impact Area included the investigation of twenty grids located within small arms ammunition firing ranges 18, 19, 21, 39 and 46 (Site OE-15A). MEC and munitions debris removed from the sample grids included practice and illuminating projectiles, practice and smoke producing hand grenades, practice rockets, blasting caps and a rifle fired smoke grenade (*USA, 2000a*).

The second phase of Impact Area grid sampling included the investigation of forty-one grids located in the areas behind the range firing lines and between the ranges fans (Site OE-15B). MEC and munitions

debris removed from the sample grids included practice and HE projectiles and projectile fuzes, practice hand grenades and practice hand grenade fuzes, rifle-fired smoke grenades, a HE antitank (HEAT) guided missile, HEAT rockets, and practice anti-personnel mines (*USA, 2000b*).

Removal Actions on Impact Area Roads and Trails

To facilitate safe travel within the Impact Area during field sampling activities, removal actions were performed on portions of eight access roads and thirty-two dirt roads and trails in 1997 and 1998. The objective was to remove all MEC and munitions debris to a depth of at least 4 feet (all anomalies detected were investigated to a depth of 4 feet and deeper anomalies were investigated as directed by a USACE UXO Safety Specialist). The road clearances were comprised of contiguous 15- by 110-foot grids. All investigations were geophysically searched using a Schonstedt Model GA-52/Cx magnetometer. MEC and munitions debris removed from the roads and trails included practice, HE and shrapnel projectiles, practice and HE rockets, projectile and rocket fuzes, antitank and practice rifle-fired grenades, incendiary and smoke hand grenades, hand grenade fuzes, rifle fired and hand held signals, and a claymore mine (*USA, 2001a*).

Fuel-Break Removal

To prevent the spread of accidental fires and to manage controlled burns within the Impact Area fuel breaks were cut around portions of the Impact Area perimeter. Because the cutting of vegetation may affect federally listed species, the Army coordinated the cutting of fuel breaks with the U.S. Fish and Wildlife service. At this time, three phases of fuel break removals have been completed. The initial fuel break removal was conducted in 1998 (*USA, 2001b*). Prior to conducting a removal action within the fuel breaks, the vegetation was mechanically and/or manually removed. Brush cutting was conducted by UXO technicians or by laborers escorted by UXO technicians. The objective of the fuel break removal was to remove all MEC and munitions debris to a depth of at least 4 feet (all anomalies detected were investigated to a depth of 4 feet and deeper anomalies were investigated as directed by a USACE UXO Safety Specialist). The fuel breaks were comprised of contiguous 30- by 110-foot grids. The fuel breaks were geophysically searched using a Schonstedt Model GA-52/Cx magnetometer. MEC and munitions debris removed from the Impact Area fuel breaks included practice, HE, smoke and illuminating projectiles, practice, HEAT and incendiary rockets, HEAT missiles, antitank and practice rifle-fired grenades, smoke producing hand grenades, hand grenade fuzes, practice mines, ignition cartridges and pyrotechnics (i.e., signals and pyrotechnic mixtures) (*USA, 2001b*).

The Navy Fire Department, who was responsible for fire management at the former Fort Ord until October 2001, conducted a fire risk assessment of the Impact Area and recommended that the Impact Area be divided into defensible polygons. When Fort Ord was active, the Army maintained a system of roads and fuel breaks that allowed fire fighter vehicle access, and to prevent or slow the spread of wild fires. Over time, many of the fuel breaks had become overgrown or inaccessible. In accordance with the Navy Fire Department's fire risk assessment of the Impact Area it was recommended that the existing network of fuel breaks be re-established. The first phase of fuel break maintenance included re-establishing the fuel breaks adjacent to the main roads located around the perimeter of the Impact Area and re-establishing some of the interior fuel breaks. The second phase of fuel break maintenance involved the re-establishment of interior fuel breaks (*Parsons, 2001*). Initially it was determined that fuel breaks would consist of a 15-foot wide central road cleared to a depth of 4 feet and a 15-foot wide surface clearance on either side (45 foot total width). In some areas, the width of the road area cleared to a 4-foot depth was 20 feet (50 foot total width). The fuel breaks were comprised of contiguous 45- by 100-foot or 50- by 100-foot grids. The vegetation within the fuel breaks was cut and masticated in place using a

combination of mechanical and manual methods. The 15 or 20-foot wide central portion of the fuel breaks were geophysically searched using a Schonstedt Model GA-52/Cx magnetometer. A surface removal was performed on the 15-foot wide areas on either side of the central portion. Phase 3 prepared 10 fuel breaks for use as defensible polygon fuelbreaks. This work included a subsurface removal along the entire 45-foot width of Riso Ridge Road and 15-foot wide corridors on each of the other nine existing internal fuel breaks. The MEC and munitions debris found included practice, HE, smoke, and illuminating projectiles, and projectile fuzes (Fort Ord Military Munitions database).

A 200-foot wide surface reconnaissance was also completed along South Boundary Road to allow for firefighting along the Southern boundary of the Impact Area. No MEC item was found. Small arms were found during the reconnaissance.

Time Critical Removal Actions

To address the imminent threat to the public posed by the presence of MEC on the ground surface TCRAs were performed at several locations including three areas within the Impact Area (MRS-15 Mortar Alley, MRS-15 Range 30A, MRS-Ranges 43 – 48). These TCRAs consisted of visual surface sweeps conducted on the trails, paths, and accessible areas at these three locations. The TCRAs are summarized below.

MRS-15 Mortar Alley

The TCRA at MRS-15 Mortar Alley was conducted in November and December 2001 (*Parsons, 2002a*). The surface removal was performed without the use of geophysical equipment and no vegetation was removed. The field crews walked open areas and trails visually searching for MEC and munitions debris. Only areas that were relatively clear of vegetation were searched. The field crews used personal digital assistants (PDAs) and GPS to record site data, navigate the site, and record the locations of any MEC and munitions debris that were observed. The surface removal operations covered approximately fifty percent of the 26-acre site. MEC items found and removed included 4.2-inch and 81mm HE mortars, an HE 40mm grenade, and a 75mm shrapnel projectile. Munitions debris found and removed consisted predominantly of 81mm practice mortars and several 60mm practice mortars (*Parsons, 2002a*). Based on the presence of MEC and munitions debris on the ground surface it is believed that additional MEC is present in the subsurface.

MRS-15 Range 30A

The TCRA at MRS-15 Range 30A was conducted in November and December 2001 (*Parsons, 2002b*). The surface removal was performed without the use of geophysical equipment and no vegetation was removed. Following the investigation at MRS-15 Mortar Alley, the scope of the investigation was changed to include only those areas that were wide enough for bicycle travel. The field crews walked open areas and trails visually searching for MEC and munitions debris. Only areas that were relatively clear of vegetation were searched. The field crews used PDAs and GPS to record site data, navigate the site and record the locations of any MEC and munitions debris that was observed. The surface removal operations covered approximately 1 percent of the 391-acre site. MEC items found and removed included 60mm practice mortars, 81mm HE, practice and illumination mortars, HE and practice 40mm grenades, 75mm shrapnel projectiles, a 37mm low explosive projectile, and a 155mm shrapnel projectile. Munitions debris found and removed consisted predominantly of 81mm practice mortars and two 60mm practice mortars (*Parsons, 2002b*). Additionally, 7,252 pounds of munitions debris was also removed. Based on the presence of MEC and munitions debris on the ground surface, it is believed that additional MEC is present in the subsurface.

MRS-Ranges 43 through 48 TCRA

A TCRA was performed over the Ranges 43-48 area from August to December 2001 to remove MEC, munitions debris, and range-related debris from the surface of the site. No vegetation clearance was performed and the removal only occurred in the open and accessible areas (*Parsons, 2002c*). Approximately 35 percent of the area was covered. The TCRA was performed to reduce the public safety threat to the nearby populations due to the site proximity and accessibility. During the TCRA, 2,334 MEC items and 133 munitions debris items were removed. The MEC removed included 35mm subcaliber M73 practice rockets, 66 mm M72 series HEAT and M74 triethyalumunum (TPA) incendiary rockets, 84mm M136 HEAT projectiles, 40mm HE projectiles, 90mm HE projectiles, 60mm M49 series HE and M50 series target practice (TP) projectiles, 81mm M43 series projectiles, 57mm M306 series projectiles, M231 Dragon guided missiles and rocket motors from M222 Dragon guided missiles.

MRS-Ranges 43 through 48 Interim Action

This section summarizes the Interim Action completed at MRS-Ranges 43 through 48. It presents a brief history of the action and summarizes the completed actions and results.

History

Based on the results of previous sampling completed within the MRS-Ranges 43 through 48 boundary, it was determined that an interim removal action be completed. The Army prepared a proposed plan identifying the preferred alternative (prescribed burning, surface and subsurface removal, and detonation with engineering controls). A ROD documenting the final selection of the alternative was signed in September 2002.

Interim Action

The Interim Action included the following activities:

- Preparatory Actions such as relocating surface debris, vegetation cutting, fire prevention work and range target identification and limited removal and path clearance;
- Prescribed burning to clear vegetation;
- Grid Installation;
- Visual Surface removal to identify and remove any MEC; munitions debris (MD) and range-related debris (RRD) 2 inches or larger were also removed;
- Additional target removal;
- Geophysical walk through to identify the geophysical instrument that should be used for the digital survey;
- Geophysical transect sampling to identify the general site conditions;
- Seeding of quality control/quality assurance (QC/QA) items;

- Analog removal using a Schonstedt GA-52Cx (a Handspring Visor PDA was used to view and input data including the location and quantities of MEC encountered);
- Digital geophysical mapping and processing;
- Reacquisition of anomalies and excavation;
- Sifting of soil to remove MEC in 14 acres of Range 45; and
- Quality Control (QC) and Quality Assurance (QA) inspections.

During the Interim Action surface removal over 3,000 subcaliber practice rockets, almost 600 HE projectiles including 57mm M306 series, HE, 60mm M49 series HE mortars, 75mm M48 projectiles, 40mm and M381 HE projectiles, missiles, hand grenades, and illumination signals were found and removed.

During the Analog removal, over 3,000 MEC items were identified and removed, including 40mm HE projectiles, 37mm HE and low explosive (LE) projectiles, 81mm and 60mm HE mortars, 75mm HE projectiles, 57mm HE projectiles, signals and fuzes.

An additional 440 MEC items were identified as a result of the digital geophysical mapping and anomaly excavations. MEC items identified included 60mm and 81mm HE mortars, 40mm projectiles, both HE and practice, 57mm HE projectiles, flares and fuzes (*Parsons, 2006*). Table 3.4 represents the number of MEC items identified during each of the above phases.

During the MRS-Ranges 43 through 48 Interim Action, areas of the site were identified as "special case areas" (SCAs). SCAs were defined for the Ranges 43 through 48 Interim Action as an area in an MRS in which MEC removal cannot be completed within the scope of work due to metallic clutter or obstructions that compromise instrument performance or technician safety or because the removal process would cause a serious adverse impact to the habitat. Areas identified as SCAs include nearly 139 acres of Range 48 that contained numerous targets and dense munitions debris. MEC and munitions debris identified within Range 48 during surface removals include practice and HE mortars, 57mm projectiles, subcaliber LAW rockets, 66mm LAW rockets, rifle grenades (mostly practice), 37mm and 75mm projectiles, and small arms. The TIP indicates that a combined approach using a dual-tool method with multiple areas requiring significant excavation in combination with mechanical sifting would be required. Other SCAs include 15 acres of Range 47 and 19 acres of Range 44. In addition, due to the time and funding constraints not all of the subsurface removal process was completed in several areas; these areas were designated non-completed areas include approximately 56 acres in the central and southern portions of the MRS (*Parsons, 2007*). Additional information about the SCAs and non-completed areas in Ranges 43-48 is included in Appendix G.

Watkins Gate Burn Area

In October of 2003 a prescribed burn was conducted within MRS-Ranges 43 through 48. The prescribed burn jumped the fuel break on the west side of MRS-Ranges 43 through 48 and unintentionally burned approximately 1,000 acres of dense maritime chaparral (Watkins Gate Burn Area [WGBA]). The fire in the WGBA exposed hundreds of MEC items on the ground surface (*Parsons, 2004b*). The WGBA is in close proximity to residential neighborhoods (approximately 600 feet). Trespassing incidents have occurred in the Impact Area in the past. To mitigate the threat associated with the presence of MEC on the ground surface, a TCRA was completed across the surface of the WGBA in December 2003 through

March 2004. The TCRA involved establishing search grids (1,000-feet [ft] by 1,000-ft) within the WGBA. Sweep teams, consisting of crews walking side by side, searched the path visually locating MEC on the surface of the open and accessible portions of the grids. In locations that were previously identified as historical ranges and suspected of being heavily contaminated with MEC, UXO Safety Specialists searched the areas prior to the sweep. If the ground surface was obscured by burned vegetation, thick layers of ash or other debris, a Schonstedt model GA-52/Cx magnetometer was authorized to be used to locate items (*Parsons, 2004b*); although, the instrument was not used at the site. As part of the TCRA range targets including tanks, armored personnel carriers (APCs) and other vehicles exposed by the fire were also removed. Each target was inspected by a UXO Safety Specialist prior to removal. The ground surface of the target location was also inspected. Four-hundred ninety-nine MEC items and 68,590 pounds (lbs) of munitions debris were removed under the TCRA. Approximately 19 percent of the MEC removed was HE, the majority of which were projectiles.

Digital Geophysical Transects Sampling

Following the TCRA at WGBA non-intrusive geophysical transect sampling was performed to collect subsurface data that could be used to help plan future response actions in the WGBA. The transect sampling was performed by towing three Geonics EM61-MK2 time-domain metal detectors behind a tracked all-terrain vehicle. The 100- by 100-foot grids were sampled in passes of approximately 100 feet in length. Grids in the unburned portion of the WGBA (approximately 95 acres) and approximately 6 percent of the burned grids that contained thick manzanita were not surveyed (Plate 2). The results of the transect sampling indicate that the majority of the WGBA (approximately 89 percent) had light anomaly densities (between 0 and 0.02 anomalies per foot). Approximately 5 percent of the WGBA had light to medium densities (between 0.02 and 0.04 anomalies per foot) and two large areas contained medium to high densities of anomalies (*Parsons, 2005*). One of the two areas that were identified as containing medium to high anomaly densities corresponds to an area where projectiles and mortars were recovered during the TCRA. The firing point for these munitions is believed to have been Range 48 (*Parsons, 2005*). In the second medium- to high-density area, a large number of 60mm mortars were recovered during the TCRA. A large number of "pop-out pins" were identified in one of the Range 18 sample grids and this may have been the firing point for the 60mm mortars (*USA, 2000a*). The "pop-out" pin is a fuze safety device that is partially released from the fuze upon the mortar firing. The pin rides up the bore of the mortar until it clears the muzzle whereupon it is ejected from the fuze. Two other smaller areas that also contained medium to high anomaly densities were recorded. These locations include an area where several thousand pounds of mostly 3.5-inch rocket debris were recovered and an area that contains practice antitank rifle grenades (*Parsons, 2005*).

Eucalyptus Fire Area

In July 2003, an accidental fire burned approximately 644 acres including approximately 367 acres in the northeast corner of the Impact Area. To take advantage of the vegetation removal provided by the fire a TCRA, a visual surface sweep for the presence of military munitions, was conducted from October 2003 to May 2004. The purpose of the TCRA was to locate and remove any MEC identified and munitions debris (over 2-inches in size) from the ground surface (*Shaw, 2005*). The sweep teams consisted of crews walking side-by-side and spaced 4 to 8 feet apart visually searching the ground for military munitions. The sweep team was followed by a GPS operator who recorded the path of the center of the sweep line, as well as any MEC items found. MEC items found and removed included pyrotechnics (flares and signals), simulators (projectile, grenade, artillery, and explosive boobytrap), hand grenades (smoke, practice, fragmentation and civilian offensive) and hand grenade fuzes (practice and HE), rifle-fired antitank grenades, 40mm projectiles (HE, signals, illumination, smoke and practice), practice and HE 40mm

cartridges, a rocket fuze, and two Japanese manufactured HE mortars. The visual surface sweep did not include the use of geophysical instruments except in the survey grids where the 40mm HE grenades were found. In that area, a subsurface investigation to a depth of 6-inches was conducted using the Schonstedt GA-52/Cx magnetometer and a Whites Classic I, Model 800-0303 metal detector. Approximately 29,300 pounds of munitions debris 2 inches or greater in size was also removed. Munitions debris consisted primarily of 3.5-inch practice rockets (expended), practice hand grenades (expended), hand grenade fuzes (expended), dummy rockets (expended), and signals (expended).

Ordnance Detection and Discrimination Study

The ODDS was developed to evaluate the commercially available MEC detection instruments and systems available and their ability to detect and discriminate between MEC and munitions debris and range related debris at the former Fort Ord.

As part of this study, test plots were established within the Impact Area MRA for testing the effectiveness of the instruments in detecting and discriminating inert munitions debris items below the ground surface (Seeded Test). Prior to installation of the test plots MEC removal was completed. The removal included sweeping with the Schonstedt GA-52/Cx and digital data surveys. During the removal operation 14 MEC and 251 munitions debris items were identified and removed.

An additional phase of the ODDS was to complete field trials of the instruments. Four field trial sites were selected within the Impact Area. The field trials involved digital geophysical mapping of the grids using the EM61, EM61-HH, G-858, GEM-3, and the MTDAS. In addition, the sites were also analog surveyed using Schonstedt magnetometers. Following the surveys, all anomalies were excavated and either 10 by 10 or 100 by 100 foot grids were sifted as part of the QC program. The field trial sites are shown on Plate 2 and the results are as follows:

- FTS-1 (Range 37) – 69 munitions debris items and no MEC were discovered. Four 100 by 100 grids were surveyed.
- FTS-2 (Range 31) – 156 munitions debris items and eight MEC were discovered. Four 100 by 100 feet grids were surveyed.
- FTS-5 (Range 26) – 13 munitions debris items and no MEC were discovered. Four 100 by 100 feet grids were surveyed.
- FTS-6 (Badger Flats) – 31 munitions debris and two MEC were discovered. Four 100 by 100 feet grids were surveyed.

The result of the ODDS study are presented in *Ordnance Detection & Discrimination Study (ODDS) Report, Volume I-IV (Parsons, 2002d).*

Range 36A

Range 36A was permitted as an open burn/open detonation (OB/OD) area. The range was reportedly used from sometime in the 1940s through October 1992 (*Shaw, 2005*). Range 36A is currently undergoing clean closure associated with potential chemical residue as part of a RCRA closure process. The Army recently completed a munitions response to address the possibility the MEC may be present at Range 36A. During the digital geophysical mapping phase of the response, numerous metallic anomalies were identified indicating that more metallic debris was potentially buried on the site than previously

suspected. Based on this information, trenching was conducted to determine the nature of the anomalies. Based on the trenching information it is suspected that Range 36A may have been used primarily as an EOD training area rather than primarily as an OB/OD area. The results also indicated that most of the metallic debris is located within 6 inches of the surface. Based on these initial results, the Army prepared a field work variance and following agency approval, conducted additional investigation of the magnetic anomalies. No MEC was identified during the additional investigation. The results of the MR investigation are presented in Volume II of the Draft RCRA Closure Certification Report for Range 36A (*Shaw, 2007*).

3.3.2 Data Quality Assessment

This section presents a review of the quality control measures that were implemented as part of the investigations completed within the Impact Area described above. It also summarizes the data management processes that were in place when the data were collected and stored for later use.

As described above, four contractors completed work within the Track 3 Impact Area MRA site boundaries. A description of the QC/QA completed by three of the four contractors is presented below, along with an assessment of the programs. Based on review of existing data, it appears that HFA did not investigate any grids within the Impact Area MRA; therefore, information on HFA QC/QA is not provided below.

3.3.2.1 CMS/USA Environmental

The QC/QA programs that were in place for the USA Environmental work were based on three different work plans. The first work plan dated July 21, 1995 covered work completed before September 1997 (*CMS, 1995*). Work completed after September 1997 was completed under September 30, 1997 work plan (*CMS, 1997*). The work plan was revised again in 2000 (*USA, 2000c*). All three work plans established quality control programs including criteria for employee qualifications, training, equipment calibration and testing, and QC auditing procedures. A brief description of the results of the QC/QA for work completed by USA within the Impact Area is provided below.

MRS-15A

Sampling at MRS-15A was conducted from October 20 through November 19, 1997. As stated in the USA Work Plan (*Appendix F, USA, 1997*) the QC Audit effort consisted of a magnetometer inspection (Schonstedt GA-52Cx) of at least 10 percent of each grid. The pass/fail criteria for each grid was zero UXO items encountered. No QC failures occurred during this work. Formal QA inspections were not conducted for this work; however, informal inspections were conducted and no deficiency reports were written as part of the QA.

MRS-15B

Sampling at MRS-15B was conducted between October 27, 1997 and February 24, 1998. As stated in the (*Appendix F, USA, 1997*) work plan the QC Audit effort consisted of a magnetometer inspection (Schonstedt GA-52Cx) of at least 10 percent of each grid. No QC failures occurred during this work. In addition, no deficiencies were written as part of the USACE QA.

Roads and Trails and Fuel Break Clearance

Road, trail, and fuel break clearance was conducted in 1997 and 1998. As part of this work, daily operational checks and QC inspections were preformed. All grids passed the initial QC. The pass/fail criteria used in this work was modified to include both identification of any UXO items and identification of 5 or more metallic anomalies. All grids passed the QC inspection. In addition, all grids passed the 10 percent USACE QA inspection.

3.3.2.2 Parsons

Field Operations QA/QC

Parsons prepared a programmatic work plan that described the QC program for work conducted at the former Fort Ord. The programmatic work plan established a QC Geophysicist who was fully responsible for overseeing and documenting all QC preformed with respect to Fort Ord digital geophysical surveys performed by Parsons. QC steps included equipment management, weekly instrument checks (instrument standardization), daily instrument checks (instrument standardization), positioning control checks, static checks, battery signal strength checks, audio response checks, field data quality checks, cable shake test, and metal-fee operator checks during the digital geophysical surveys, download checks, field records check, data quality checks, office review of field forms, instrument standardization checks, data sample spacing checks, instrument drift checks, processed data checks, data deliverable checks, database checks, and dig sheet checks as part of the digital geophysical data processing, field verification of geophysical data versus intrusive results, verification of anomaly removal during intrusive actions and after completion of initial survey, field analog QC surveys, impromptu field team checks for adherence to field QC procedures, and daily quality control reporting as part of geophysical surveys. Site specific work plans were prepared for some of the work elements preformed within the Impact Area. The work element specific work plans sometimes specified criteria for QC audits.

A brief description of the QC/QA activities conducted for work completed by Parsons within the Track 3 Impact Area boundaries is provided below.

Mortar Alley Limited Surface Removal

Review of the Technical Information Paper documenting this limited surface removal in accessible areas does not indicate whether any formal QC or QA inspections were preformed.

MRS-30A Limited Surface Removal

Review of the Technical Information Paper documenting this limited surface removal in accessible areas does not indicate whether any formal QC or QA inspections were performed.

Watkins Gate Burn Area – Surface Removal

The QC requirements for the Watkins Gate Burn surface removal stated that inspectors would check a minimum of 10 percent of grid; if MEC, MEC-like item, or 20 pieces of debris of notable size were encountered, that portion of the grid would fail, and surface removal would begin again. QA requirements were a visual inspection of 10 percent of each grid. If MEC or MEC-like items were found the surface removal would need to be preformed again.

The Technical Information Paper for the surface removal stated that there were no QC or QA failures.

Watkins Gate Burn Area Digital Geophysical Transect Sampling

The QC requirements for the digital geophysical transect sampling followed the requirements outlined in the technical letter describing the procedures for the Watkins Gate Burn Area digital geophysical transect sampling. The requirements included review of processed data to make sure it complied with the requirements provided in the technical letter.

Quality control for the geophysical transects included QC Geophysicist observation of the data collection team to ensure they were following the procedures outlined in the Technical Letter work plan. The QC Geophysicist also reviewed data prior to delivery to the USACE to check that the processor complied with requirements**.**

Ranges 43 through 48 Visual Surface Removal prior to Burn

According to the work plan for the MRS-ranges 43 through 48 surface removal, a visual QC inspection covering a minimum of 10 percent of the swept area of each 1,000-ft grid was required. If more than three UXO or UXO-like items are found at the surface in the swept areas, the area would be re-swept. The Technical Information Paper reporting the results of the clearance does not have information on QC activities preformed. This area was re-swept as part of the surface removal following the burn; therefore, all of the area received additional clearance following this initial sweep.

Fuel Break Maintenance within the Impact Area

According to the Fuel Break Maintenance report, QC was performed on at least 10 percent of the 4-ft removal section and the surface removal sections of each fuel break. Four-foot removal sections were inspected using a Schonstedt magnetometer. Four-foot removal sections also included monitoring by burying inert military munitions seed items (based on the most probable munitions) for the inspected area. Sixty items were buried and all 60 items were found.

Quality Assurance involved a 10 percent sweep of each of the 4-ft removal sections. No UXO or UXO-like items were found during the QA sweep.

43-48 Removal to Depth

The QC requirements for the MRS-Ranges 43 through 48 Interim Action are documented in the Technical Information Paper (*Parsons, 2007*). The QC activities included a 10 percent QC survey with a Schonstedt magnetometer of all completed grids, inspection of backhoe excavations, daily field audits and data audits, and seeding of QC/QA items prior to beginning the analog and digital removal actions. The results of the QC/QA procedures are presented below.

Analog 10 Percent QC

Parsons UXO QC specialist inspected a minimum of 10 percent of each completed grid or partial grid using a Schonstedt GA/52-Cx magnetometer. During the inspections, one expended MK II practice hand grenade was found in one grid. The grid received a second analog removal as a result of the discovery. The grid was then checked again and no MEC or MD was found. No MEC or MEC like items were found during the QC check of the other 1,207 grids or partial grids.

Backhoe Inspection QC

Following completion of backhoe excavations, the UXO QC specialist performed an inspection of the excavation site utilizing the same type of geophysical equipment used by the excavation team. During the inspection of one backhoe excavation, a MK II practice hand grenade was found at the base of a sifted soils pile. Discovery of the item constituted a grid failure. As a result of the grid failure, all screened debris at the excavation site was visually and physically checked.

Seeding of QC Items

The QC check using seeded items included seeding of 121 inert ordnance items at various depths below the ground surface prior to the analog removal and seeding of 123 inert ordnance items prior to the digital geophysical mapping. In addition, 5 seed items were placed in the stockpile awaiting sifting operations.

During the analog removal, 98 of the seeded items were recovered. Of the 23 non-recovered items, 12 were determined to be undetectable, and 11 were considered missed. During the digital geophysical mapping phase, 111 of the seeded items were recovered. Of the 12 non-recovered items, nine were determined to be undetectable, and three were considered missed. All five seed items placed in the sifting stockpile were found.

Analog QA Inspection

Following the QC of each grid, the government also checked a minimum of 10 percent of each grid passed by Parsons using a Schonstedt magnetometer. No MEC items were found during the QA inspections.

The analog QA required inspection of at least 10 percent of each removal to depth grid within the Ranges 43-48 site.

Ordnance Detection and Discrimination Study

Quality Control during the field trials involved twice-daily function testing of the digital geophysical tool, testing performance of instrument over “mini plots” where seeded items were buried, and review of field documentation and data.

Following excavations at the field trial sites, additional QC/QA was performed. The QC included both analog and digital surveys to ensure that all locations selected for excavation had been completed and to determine if any detectable items remained at the site.

The final QC step involved excavation of 10-foot by 10-foot plots to a depth of 4 feet and four of the Field Trial Sites (FTS-3, FTS-4, FTS-5 and FTS-6), and excavation of 100-foot by 100-foot grids at FTS-1 and FTS-2. Military munitons items recovered during the QC sifting were one MD item at FTS-5 and one MD item at FTS-6.

Data Management QC/QA

All data was managed according to the requirements identified in the programmatic work plan (*Parsons, 2004a*). Quality control checks of the data prior to delivery to the USACE included checks of data completeness, quality, and format.

Parsons, the MR contractor between 2001 and 2006, performed a 100 percent QC review of the CMS data set. This evaluation included a review of the field grid records and the former Fort Ord Munitions Response database. The USACE implemented a QA review of ten percent of the data reviewed by Parsons. The QA review included a comparison of the data set with the data set reported in the pertinent AAR.

3.3.2.3 Shaw Environmental

Eucalyptus Fire Area Visual Surface Removal

Quality Control activities performed during the work completed at the Eucalyptus Fire Area removal included the following:

- Physically walking each grid at least once with coverage of 10 to 20 percent;
- Physically walking some grids twice, due to vegetation, with coverage of 15 to 25 percent;
- Observing field activities to verify compliance with required procedures;
- Reviewing field documentation; and
- Reviewing project data from GIS and verifying data verses field conditions.

All but 3 grids passed the initial QC process. The grids that failed QC were swept again and QC was performed a second time. No other QC variances were reported during the project.

In addition to the QC activities performed by Shaw, The USACE preformed the following QA activities:

- Monitoring subcontractor field practices including announced and extemporaneous, unobtrusive observations;
- Reviewing and observing field ground control and GPS procedures;
- Independent examination of data files and anomaly maps; and
- Physically walking of at least 10 percent of each grid at least once.

No QA failures were reported for this project.

Data Management QC/QA

All field data was managed according to the Final Eucalyptus Fire Work Plan (*Shaw, 2005*). Data collection procedures included the use of either electronic data collection systems with pre-defined data dictionaries, or hard copy field forms. At the end of the field day, hard copies of the electronic forms were made as appropriate and all field forms were reviewed and verified for completeness. Following review, the data were loaded into the project database.

Following Shaw QC of the data, the data was transferred to the USACE where it under went additional QA.

3.3.3 Data Usability

Review of after action reports for work completed within the Impact Area MRA also indicates that the QA/QC procedures used were appropriate and followed the requirements identified in the programmatic or site specific work plans. Review also indicates that there were very few QC or QA failures. It should also be noted that the most complete data set and the data set that most closely reflects current removal technology is the Ranges 43 through 48 data set. The Ranges 43 through 48 removal action involved more field QA/QC and data management QC than previous actions.

Based on the QA/QC processes described above and a review of the after action reports associated with the activities performed within the Impact Area MRA, the existing Impact Area MRA data are of sufficient quality for use in the RI, RA, and FS.

3.3.4 Basewide Range Assessment

The BRA is being conducted at the former Fort Ord, including the Impact Area, to gather data that will be used to evaluate the potential for chemical contamination at suspected small arms and multi-use ranges and training areas at the former Fort Ord. Each of these suspect areas is identified as a historical area (HA). As part of the BRA, the site assessment process includes conducting literature reviews, site reconnaissance and mapping, and site investigation sampling. The results of the assessment will be used to determine whether the areas may be recommended for the remedial phase that includes site characterization, risk evaluation, and remedial action.

Although the Fort Ord BRA is not part of the MR program, many of the DQOs identified for the Site Assessment Phase of the BRA investigation are the same DQOs established for the site reconnaissance phase of the current MR site investigation program being implemented at the former Fort Ord (*Parsons, 2001*). Both programs include using the results of the site inspections to determine if additional work (i.e., sampling for MEC and chemicals associated with MEC) is necessary. The Fort Ord BRA was conducted in accordance to the Basewide Range Assessment Work Plan (*IT, 2001*). Revision 1C of the Final Comprehensive Basewide Range Assessment Report was issued in November 2006 (*MACTEC/Shaw, 2006*).

Much of the Impact Area, including most of the individual historical range fans within the Impact Area (HA-18 through 76) were investigated as part of the BRA through either site reconnaissance or soil sampling activities or both. Site reconnaissance completed as part of the BRA was conducted by a two-person team that included a UXO-qualified personnel and a second member trained in MEC recognition. Prior to conducting the site reconnaissance, historical features were identified from training maps and aerial photographs and their locations entered into a GPS unit (waypoints). The team then conducted the site visit that included navigating to each of the waypoints. The path of the site walk was recorded digitally with a GPS unit. The following features or items were required to be mapped if present based on a visual search of the site as part of the BRA reconnaissance: (1) targets; (2) firing lines; (3) range fan markers; (4) survey bench marks; (5) areas of stained soil that could indicate the presence of petroleum hydrocarbon or bulk explosives contamination; (6) MEC or munitions debris; (7) potential sample locations based on a) the presence of spent ammunition (lead; accumulations of 1 to 10 percent and areas exceeding 10 percent), or b) accumulations of MEC or munitions debris; (8) other training related features (e.g., fighting positions, fox holes, etc.); and (9) areas of thick vegetation that could limit access to the investigation area. In addition to the Site Reconnaissance activities, over 3,000 soil samples have been collected within the Impact Area and analyzed for potential chemicals of concern. Plate 6 presents the information collected during the BRA. The information collected as part of the site reconnaissance and

soil sampling has been added to the project GIS and was used to further the interpretation of the nature and extent of MEC contamination within the Impact Area (Section 3.5).

3.4 FTO Battelle – Oak Ridge National Laboratory (ORNL) Airborne Geophysical Survey

A low-altitude helicopter survey was performed over a 2,562 hectare (6,332 acre) portion of the historical Impact Area (Impact Area MRA and surrounding area to the north and west) between January 29 and February 17, 2005. The survey did not include the far eastern portion of the Impact Area MRA due to the steep terrain. The survey objective was to assess the effectiveness of using airborne geophysical surveying to detect and map surface and buried "UXO". A secondary objective was to identify soil resistivity variations that might be associated with contaminants.

The geophysical survey was performed jointly by Battelle and Oak Ridge National Laboratory (ORNL). The geophysical methods used were magnetics and time-domain electromagnetics (TEM). Magnetic surveying was performed over the entire 2,562-hectare (ha) main survey area, while TEM surveying was performed within the main survey area at two smaller areas totaling 72 ha or 178 acres in size. The geophysical instruments were deployed using the Oak Ridge Airborne Geophysical System (ORAGS) mounted on a Bell 2006 Long Range helicopter. The procedures and results of the survey are described in more detail in Appendix C.

The results of the survey were reported by Battelle in the Draft Final Report, Airborne Geophysical Survey, Fort Ord, California, January 29 – February 17, 2005 (*Battelle, 2005*). Battelle indicated the ORAGS survey was successful in delineating areas of greater and lesser ordnance contaminations over the roughly 2,562 ha surveyed at Fort Ord, however, "detection of single isolated items … cannot be achieved with these data.…" Accordingly, Battelle concluded "airborne data are not suitable for declaring an area free of contamination (because) some MEC types fall below the detection threshold of the system and only a percentage of other ordnance types will be detected". Plate 15 presents the results of the survey along with MEC and munitions debris removed during site investigations to-date. It is possible that the results of the aerial geophysical survey could be used in conjunction with removal data to indicate areas where higher densities of MEC could be present. As stated above, the information should not be used to declare an area free of contamination.

3.5 Nature and Extent of Munitions and Explosives of Concern

This section describes the nature and extent of MEC based on currently available data. The sources used to develop this section include historical training maps and aerial photographs, MEC Contractor After Action Reports, Technical Information Papers, Site Walks, and The Airborne Geophysical Survey Report, and Archive Search Reports. Information on training practices and potential distribution of items was developed from Technical Manuals and other historical documents.

3.5.1 Training Practices

Training practices are discussed below to provide information on the types of military munitions that may have been used at the site and the possible location of MEC possibly remaining at the site.

Pre World War II Training

Little documentation on pre World War II (WWII) training activities at the former Fort Ord is available. Footage from a 1938 film entitled *A year on a Calvary Post, 1938 – 11th Calvary, Presidio, Monterey, California*, National Archives footage from 1940 and topographic maps from 1918, 1933, and 1938 were available for review. A set of aerial photographs from 1941 was also used in the review, as were the results of sampling and removal actions conducted within the historical Impact Area. Some of the information is based on technical data presented in The American Arsenal (*Hogg, 2001*). The types of training likely to have occurred included 37mm training, 75mm training, practice Stokes mortar training, Livens projector (smoke only) training, and 60mm and 81mm mortar training. All of these items have been identified during sampling and removal actions within the Impact Area.

World War II Training

Training conducted during the early 1940s is not documented on any existing training maps; however, a 1945 training map is available that documents the types of training that were occurring within the historical Impact Area at that time. The documented ranges in use in 1945 included the Austin Anti-tank range (2.36- inch rocket training), a bazooka demonstration range (2.36-inch rockets), practice and live hand grenade training ranges, an infiltration course, a close combat course, a mortar range, a booby trap training area, a 30 caliber anti-aircraft range, machine gun transition, submachine gun, carbine (rifle), and rifle transition small arms ranges, a moving vehicle range, and a squad problems and company problems training areas. A large portion of the site is labeled as an Impact Area on the 1945 training map (Plate 3).

The types of military munitions and the maximum range of the munitions that would likely have been used at the ranges are shown below.

Range	**Military Munitions that may have been used**	**Maximum Range**
Austin Anti-Tank Range	HE and Practice 2.36- inch rockets, 3.5-inch rockets, pyrotechnics	200 to 600 yards for 2.36-inch rocket, 945 yards for 3.5-inch rocket M29A2.
Bazooka Demonstration Range	HE and Practice 2.36-inch rockets, 3.5-inch rockets	200 to 600 yards for 2.36-inch rocket.
30 Caliber Anti-aircraft	30 caliber small arms	2,000 to 5,500 yards.
Live Hand Grenade Range	MK II Fragmentation Grenades, offensive MK IIIA1 hand grenades, grenade fuzes	NA, Average throwing distance – MK II 30m, MK III A1 40m. Frag danger zone 150meters (m).
Practice Hand Grenade Range	MK II Practice Hand Grenades, M205 and M10 series hand grenade fuzes	NA, Throwing distance – 30m.
Mortar Range	60mm and 81mm HE and practice mortars, 60mm illumination mortars	300 to 1,985 yards for 60mm, 2,558 to 3,288 yards for 81mm.

Range	Military Munitions that may have been used	Maximum Range
Infiltration Course	Small arms ammunition, demolition charges, smoke grenades	See small arms below. Demolition charges and smoke grenades would be expected to have been used within the range fans.
Booby Traps	Possibly simulators	NA
Machine gun courses	Small arms ammunition, 30 caliber, 50 caliber, 22 caliber	.30 caliber 2,000 to 5,500 yards. 50 caliber 6,000 to 7,200 yards, 22 caliber 1,500 yards.
Rifle and carbine courses	Small arms ammunition 30 caliber, 22 caliber	.30 caliber 2,000 to 5,500 yards, 22 caliber 1,500 yards.
Squad Problems	Unknown	NA
Company Problems	Unknown	NA
Close Combat Course	Small arms	.30 caliber 2,000 to 5,500 yards. .50 caliber 6,000 to 7,200 yards, .22 caliber 1,500 yards.
Moving Vehicle Range	Unknown	NA
Artillery Training	105mm, 155mm, and 8-inch projectiles (fired from points outside the Impact Area)	105mm: approximately 4,040 to 12,600 yards; 155mm: approximately 4,200 to 16,000 yards; 8-inch: approximately 5,900 to 18,510 yards.

NA=Not Available

Although not identified by specific ranges, 37mm, 57mm, 75mm, 105mm, and 8-inch MEC and munitions debris items have been identified within the Impact Area, suggesting that training within the site also involved use of these WWII era munitions.

1950s Training

Based on training maps from the mid- to late 1950s, ranges present within the Impact Area included 60 and 81mm mortar ranges (likely both practice and HE), a 57mm recoilless rifle range, a rifle grenade range, a high explosive hand grenade range, a hand grenade assault range, an infiltration range, a close combat range, a rocket launcher course, a field firing range, an antitank range and small arms firing courses and ranges.

The types of military munitions and the maximum range of the munitions that would likely have been used at the ranges are shown below.

Range	**Military Munitions that may have been used**	**Maximum Range**
Mortar Range	60mm and 81mm mortars, both HE and practice	300 to 1,985 yards for 60mm, 2,558 to 3,288 yards for 81mm.
Rifle Grenade Ranges	HE and practice rifle grenades, M29 Practice	M29 150 yards.
Hand Grenade Assault Range	Practice hand grenades	NA, Locations would vary depending on the course.
Infiltration Range	Small arms, demolition charges, smoke grenades	Demolition charges and smoke grenades would be expected to have been used within the range fans.
Close Combat Range	Small arms	30 caliber 2,000 to 5,500 yards. .50 caliber 6,000 to 7,200 yards, .22 caliber 1,500 yards, 7.62mm 4,100 meters, 5.56mm 3,100 meters.
57mm Recoilless Rifle Range	57mm M306 Series HE projectile, M306A1 target practice projectile, M307 series HEAT projectile, and M308 series smoke (white phosphorous)	M306 HE 6,575 meters, M306A1 TP 6,570 meters. M307 HEAT 6,364 meters, M308 series smoke 400 meters.
Rocket Launcher	3.5-inch rockets	M29A2 945 yards.
Combat in Cities	Small arms	See close combat range above.
Anti Tank Range	3.5-inch rockets	945 yards for M29A2 and M30 rockets.
High Explosive Hand Grenade	M26, MK II	NA, Average throwing distance 30 meters for MK2, 40 meters for M26. Frag danger zone 150m.
Field Firing Ranges	Unknown	NA
Artillery Training	105 mm, 155mm, and 8-inch projectiles (fired from points outside the Impact Area)	105mm: approximately 4,040 to 12,600 yards; 155mm: approximately 4,200 to 16,000 yards; 8-inch: approximately 5,900 to 18,510 yards.

NA – Not Available

1960s to Base Closure, Training

Ranges identified on the 1960s training maps included small arms training ranges, a rocket launcher range, recoilless rifle ranges, weapons demonstration ranges, close combat courses, infiltration courses, high explosive hand grenade ranges and hand grenade assault courses, mortar ranges, grenade launcher ranges, and squad defense and squad battle ranges, M72 LAW rocket and 90mm subcaliber ranges, and squad and platoon attack ranges. Slight changes to the range configurations occurred during the 1970s and 1980s; however, the types of weapons used for training in the Impact Area did not vary. A helicopter attack range was established in the eastern part of the Impact in the mid-1980s. Prior to this time period the range was used as a day/night combat course. In the 1990s the helicopter range was used as a live fire exercise range. Authorized types of ammunition for the live fire exercise range included small arms ammunition and 40mm target practice.

The types of military munitions and the maximum range of the munitions that would likely have been used at the ranges from the 1960s until base closure are shown below.

Range	**Military Munitions that may have been used**	**Maximum Range**
Small Arms Ranges	5.56mm, 7.62mm, .50 caliber, .45 caliber .38 caliber	1,300m for .45 caliber to 4,100m for 7.62mm.
Rocket Launcher Range (Early 1960s)	3.5-inch rockets	M29A2 945 yards.
Close Combat Course	Small Arms	7.62mm 4,100m, 5.56mm 3,100m.
High Explosive Hand Grenade Range	M26, M69	NA, Maximum throwing distance - 25m, Frag danger zone 150m.
106 and 90mm recoilless rifle Range	106mm, 90mm recoilless rifles, subcaliber	90mm 100-2,200m 106mm 1,800 to 6,900m.
Mortar Range	60mm, 81mm, 4.2-inch	Minimum range HE- 300m. Maximum range 60mm 2,558m for 81mm 3,288 yards.
Grenade Launcher Range	M79 and M203, Claymore mines, HE and practice ammunition, M433 HE-DP	Maximum range 450m, minimum range 130m.
90mm/M72 Service Firing	M72 LAW Rockets, 35mm subcaliber rockets, 90mm Recoilless rifle (Target Practice)	90mm 100-2,200m M72 66mm HEAT, 1,000 meters. 35mm subcaliber M73 – 1,150m.
MK19 Gunnery Range	40mm HE, TP, and High Explosive Dual Purpose (HEDP)	2,200m maximum range for the M430 HEDP and M918 practice.
50 caliber and Weapons Demonstration Range	M-72 LAW, 90mm Recoilless Rifle, AT-4, M47 Dragon, M202 Rocket Launchers. 50 caliber	90mm 100-2,200m M72 66mm HEAT, 1,000 meters. 35mm subcaliber M73 – 1150m M47 Dragon 1000m.

Range	Military Munitions that may have been used	Maximum Range
Attack Helicopter Gunnery Range	20mm, 7.62mm, 40mm (semi automatic weapons)	Target limit is 2/3 maximum range of 4,600m for 20mm, 2,100m for 40mm grenades, and 4,100 m for 7.62mm.
Squad Attack	M16 rifles, semi-automatic weapons (SAW), and M 60 MG, M781 40mm practice	4,100m for 7.62mm, 3,100 for 5.56mm, and 400m for M781.
Platoon Attack	M16, SAW, M60, 90mm recoilless rifle (RR), LAW Subcaliber, M79/203 40mm TP	7.62mm 4,100m, 5.56mm 3,100m, 400m 40mm target practice.
Moving Target	M72 LAW Subcaliber, 90mm and 106mm (no service ammo) subcaliber, 14.5 subcaliber, 60mm, 81mm,	35mm subcaliber M73 – 1,150m.
Platoon Live Fire Course	Mortars, M-16 rifle, SAW, M-60, machine gun (MG) and M203, LAW, AT-4, ¼ pound demolitions, fragmentation hand grenades, tracer ammunition	Mortars – 300 yards to 1,288 yards, LAW-1,000m.
Infiltration Course	Small Arms, demolition charges, smoke grenades	Demolition charges and smoke grenades would be expected to have been used within the range fans.
Hand Grenade Assault Range	Practice hand grenades	NA, locations of grenades would vary depending on the course.
Automatic Rifle and Army Training and Evaluation Program (ARTEP)	5.56mm, 7.62 MG, M60, LAW 35mm subcaliber, 40mm target practice	35mm subcaliber M73 – 1,150m, 7.62mm 4,100m, 5.56mm 3,100m, 400m 40mm target practice.
Sniper Training	5.56mm, 7.62mm M60, MG, LAW, 90mm Sub-Cal, 40mm TP	35mm subcaliber M73 – 1150m, 7.62mm 4,100m, 5.56mm 3,100m, 400m 40mm target practice.
Artillery Training	105mm, 155mm, and 8-inch projectiles (fired from points outside the Impact Area)	105mm: approximately 4,040 to 12,600 yards; 155mm: approximately 4,200 to 16,000 yards; 8-inch: approximately 5,900 to 18,510 yards.

NA= Not available

The types of Ranges in use from the 1960s through the base closure are shown on Plate 4.

Expected MEC Distribution

Based on the types of ranges and locations of the ranges used during the history of Fort Ord, the following distribution of MEC would be anticipated.

Mortars

Mortar ranges and firing points have been located in the northern and northwestern portion of the Impact Area since at least 1945. Maps are not available for the time period prior to 1945. Based on the location

of the mortar ranges and maximum range of the mortars it is anticipated that both practice and HE 81mm, 60mm, and 4.2-inch mortars would be present in the northwestern to central portion of the Impact Area.

Rocket Launchers Shoulder-Launched Weapons

The following types of rockets are expected to be present within the Impact Area based on review of historical training maps.

2.36-inch Rocket Launcher (Bazooka)

Based on the 1945 training map, a 2.36-inch rocket range was present in the northeast part of the Impact Area. 2.36-inch rockets were also likely used at the Austin Anti-tank range. Based on these range configurations HE 2.36-inch rockets would be expected in localized areas down range from the two identified ranges.

3.5-inch Rocket Launcher

Based on the 1950s training maps a 3.5-inch rocket range was present in the western part of the Impact Area, and also in the northern part of the impact area. The maximum range of the 3.5-inch rocket is 945 yards; therefore, the rockets would be expected within 1,000 yards of the firing line at both of the identified ranges.

LAW Rocket Launcher

A M72 Service LAW rocket range was identified on late 1960s through base closure maps in the north central portion of the Impact Area (Range 44). It is anticipated that LAW rockets would be found down range of the Range 44. Other ranges where LAW rockets were authorized for firing included Range 43 (Squad Patrol), and Range 48 (Anti-armor HE and Subcaliber).

Subcaliber LAW Rockets (35mm)

The 35mm subcaliber LAW rockets were authorized for use at Ranges 24, 28, 31, 43, 41, and 44 (*Army, 1984 and 1991*). It is anticipated that 35mm subcaliber rockets would be found down range at each of these ranges.

M202 Rocket Launcher - Flash

The M202 Flash is lightweight shoulder fired rocket launcher with a maximum effective range of 500 meters. The launcher is reusable and is capable of firing 1 to 4 66mm rockets semi-automatically at a rate of one rocket per second (*Army, 2002a*). Each rocket consists of a warhead with thickened pyrophoric agent, a fuze, and rocket motor. The pyrophoric agent (triethylaluminum) burns spontaneously when exposed to air. The M202 was authorized for use during various periods of time at Ranges 44, 45 and 48 (*Army, 1980 and 1991*).

Recoilless Rifles

57mm

Based on the circa 1954 training map, a 57mm recoilless rifle range was located in the northwest part of the Impact Area. The maximum range for the 57mm projectile is approximately 6,500 meters. 57mm

projectiles HE and practice could be found down range of the 57mm recoilless rifle range and could extend into the center of the Impact Area. In addition, M307 series HEAT projectiles and M308 series smoke (white phosphorous) could be found downrange.

84mm AT-4

The M136 AT-4 recoilless rifle, designed in the late 1980s, is a shoulder-launched light anti-armor weapon. This weapon was authorized for use during various periods of time at Ranges 43, 44, and 48 (*Army, 1991 and 1992*). The maximum effective range for the M136 AT4 is 300 meters with a minimum range (to be used during training) of 30 meters (*Army, 2006*). It is expected that the largest concentration of high explosive antitank warheads (MEC) would be located in close proximity to the targets at these ranges.

90mm

90mm subcaliber ammunition was authorized for use on the Platoon Attack course (Range 31), the ARTEP Range (Range 24), the Anti-Armor Sub-caliber range (Range 41), and the Recoilless Rifle/Rocket Launcher M47 Dragon Range (Range 44A). The minimum identified range for the 90mm was 100m with a maximum range of 2,200m. Based on this range, 90mm projectiles could be found just down range of the authorized ranges to about 2,000m down range.

106mm

Subcaliber 106mm recoilless rifles were identified for use at Range 41. According to the 1992 Standard Operating Procedures (*Army, 1992*), two firing lines were available for 106mm subcaliber firing. The minimum range identified for the 106mm subcaliber round was 450 meters and the maximum range 700m. Based on this information, it is expected that 106mm subcaliber items could be found down range at Range 41 from about 450 to 700m.

M47 Dragon Guided Missile

The M47 Dragon is a shoulder-fired medium antitank guided missile. Use of this weapon began in the mid-70s and according to Fort Ord range data was authorized for use during various periods of time at Ranges 44, 44A, 48 and possibly Range 31 (*Army, 1980, 1982, 1991 and 1992*). The maximum effective range for the Dragon is 1,000 meters with a minimum range of 65 meters (*Army, 1990*). It is expected that the largest concentration of high explosive antitank warheads (MEC) would be located in close proximity to the targets at these ranges.

High Explosive Hand Grenade Ranges

A live hand grenade range was located in the northwestern part of the impact area based on the 1945 training map. After the 1940s, the live hand grenade range was located in the northeast part of the Impact Area. It is expected that high explosive hand grenades would be confined to area identified on the 1945 training map and the area identified on the 1950s through 1990s training maps. According to the 1992 *Standard Operating Procedures* (SOPs), fragmentation grenades were also authorized for use at Range 43. According to the Range 43 SOP, all grenades were to be thrown into the designated bunkers and were not authorized for throwing into other parts of the range. Because hand grenades are thrown, they would not be expected down range, but would be confined to small areas.

Practice Hand Grenades

Practice hand grenades are used for training in the care, handling and throwing of fragmentation hand grenades. Practice hand grenade bodies do not contain high-explosive filler, but some models may contain a small, separate black powder charge (*Army, 1977c*). Practice hand grenades utilize a pyrotechnic delay-igniting fuze. Fuze models commonly used in practice hand grenades include M205A1, M205A2, and M228. Ranges where practice and high explosive hand grenades or ranges where hand grenades may have been used during training were identified on historic training maps from the 1950s to 1960 (Plate 3). Practice hand grenades may have also been used at ranges where high explosive hand grenades were authorized for use from the 1960s until base closure (Ranges 28, 31, 35, 36, and 43; *Army, 1973, 1991*). Because practice hand grenades can only be thrown about 30 to 40 meters depending on the model, they would be expected to be localized near the targets and not be found further down range.

Rifle Grenades

Rifle grenade ranges were located in the northeastern portion of the Impact Area in the 1950s and late 1960s. Prior to the 1950s no rifle grenade ranges were identified within the Impact Area, and no rifle grenade ranges were present on training maps dated after the early 1960s. It is expected that rifle grenades could be present in the northeast portion of the Impact Area. The maximum range for the M29 rifle grenade is 150 yards; therefore, it is expected that rifle grenades would be found toward the outer part of the impact area, most likely within the fans shown on the 1950s and early 1960s training maps.

40mm Projectiles

Practice

According to the 1984 and 1991 Fort Ord Range/Training Area Operating Procedures and Usage Guide (*Army, 1984,1991,and 1992*), practice 40mm projectiles were authorized for use at ranges 23, 24, 28, 29,30, 30A, 31, 32, 35, and 45 (Plate 4). It is suspected that 40mm projectiles could be present down range within the fans of these ranges. The maximum range of the 40mm practice projectiles is 400m for models that were authorized for use on all ranges except Range 30A. Therefore, it is suspected that the projectiles would be found within 400m of the furthest firing point. It is likely that most will be found near established targets. The maximum range for the 40mm practice ammunition used at Range 30A (M918) was 2,200 meters; therefore, it is possible that at Range 30A, the MK19 Gunnery Range, the 40mm projectiles could be found further down range.

High Explosive

High explosive 40mm projectiles were authorized for use at Ranges 30A, 45, and possibly at Range 47 (*Army, 1992*). The M79 and M203 grenade launchers were authorized for use on Ranges 45 and possibly during the 1960s at Range 47. The MK 19 Mod 3 machine gun was authorized for use at Range 30A. The MK 19 Mod3 fires the M430 40mm projectile. The maximum range for the M430 40mm projectile is 2,200 meters. Based on the above information it is expected that high explosive 40mm projectiles could be found down range to 400m past the firing point at Ranges 45 and 47 and up to 2,200 meters past the firing points at Range 30A. It is expected that the greatest concentrations of 40mm projectile UXO and munitions debris would be associated with the targets. High explosive 40mm projectiles were also authorized for use on Range 32, the Attack Helicopter range, that was active in the 1980s. It is expected that the greatest concentrations of 40mm projectiles would be associated with the targets.

Fuzes

Fuzes that might be found within the Impact Area include the M48 series point detonating fuze that is used primarily to detonate smoke, white phosphorous (WP) ammunition in 75mm, 90mm and 4.2 inch calibers (*Army, 1977b*) and 75mm HE M48, 75mm HE M41A1, and 105mm HE M1 (*Hogg, 2001*). Other fuzes that could be present include hand grenade fuzes, and other fuzes associated with projectiles found within the Impact Area.

3.5.2 Site Features

The western and central portions of the Impact Area MRA consist of low rolling hills and closed depressions; the ground surface generally slopes to the west and northwest throughout most of the area. Seasonal wetlands are present within some of the depressions. In the eastern portions of the site, the terrain is more rugged and consists of ridges rising up to 600 feet above the canyon bottoms. Elevations range from approximately 900 feet above MSL in the southeast to approximately 200 feet above MSL in the southwest.

At some of the individual ranges, the ground surface between the firing line and the target area is generally flat and may slope slightly up or down to the targets. Hills and ridges are sometimes found between or down range of the identified ranges.

Physical features indicative of military munitions training found within the Impact Area include developed firing lines and firing points, observation towers, fixed targets, silhouettes, track-mounted moving targets, pneumatic and electric pop-ups, automobiles, trucks, tanks, armored personnel carriers, and earthen berms. Range boundary markers are also present on many of the individual ranges.

Fuel breaks are present throughout the site. Fuel breaks consist of roads and trails that are drivable and used for interior access, and receive periodic vegetation cutting. The width of the fuel break is variable.

3.5.3 Nature and Extent

This section discusses the nature and extent of MEC and munitions debris within the Impact Area based on the existing sampling and removal data, and compares the data with the expected distribution based on historical training maps and other documents. The distribution is discussed based on type of munitions identified during removal actions and investigation completed to date. The distribution is not, in general, broken down to the level of individual models. Plates 7 through 12 presents the distribution of items found during investigations completed to date. The patterns shown on Plates 7 through 12 as areas where MEC are in general likely to be present, are based on limited available sampling and removal data and historical information. The areas shown are considered approximate and may either over or underestimate the area in which MEC may be found.

3.5.3.1 Spatial Distribution

The following is a discussion of the spatial distribution of MEC and munitions debris found within the Impact Area MRA. This distribution discussion is based on review of data obtained during visual surface removals conducted over more than 1,500 acres, subsurface removals over about 90 acres of roads and trails, and 100 percent subsurface grid sampling over 9.5 acres. The locations of MEC and munitions debris identified during the sampling and removal actions are shown on Plates 7 through 14. Plate 2 presents the locations of the surface removals, subsurface sampling grids, and the subsurface roads and

trails removals. The roads and trails cross much of the Impact Area and although they do not represent a true transect layout where transects are placed at a constant fixed distance, they do provide useful data in that they cross through the center of the Impact Area and through many of the historical range fans.

Mortars

The types of mortars identified within the Impact Area MRA include HE, practice, and illumination. The distribution is discussed below. Following the discussion on the spatial distribution, a section on the potential vertical distribution of items is presented.

Practice and High Explosive Mortars

Large concentrations of practice and HE 81mm mortars, mostly munitions debris, have been identified in the southeastern portion of the Impact Area, just to the north of MRS-47, in an area identified as Mortar Alley. A visual surface removal was conducted in this area and the distribution is presented on Plate 7. This distribution represents only items found on the surface based on visual evidence without any vegetation removal.

81mm and 60mm mortars (primarily expended practice) are also concentrated along Riso Ridge extending to the north and to the west of mortar alley along Mercury Road. A second area along Riso Ridge is present near the intersection of Hawkeye Road. This area is just to the south of the down range area of Range 34, which was authorized for mortar fire in the 1980s. 81mm practice mortars are also present on Orion Road south of Broadway Avenue, which is down range of Range 42, which was authorized for mortar fire in the 1970s through base closure.

60mm and 81mm practice mortars, both munitions debris (MD) and MEC, are also present within the boundaries of Range 48, which was identified as a mortar range on 1940s and 1950s era maps. A small concentration of mortars, primarily 60mm practice, both MD and MEC, was also identified down range of Range 18. A mortar range was identified within the boundaries of Range 18 on 1950s era training maps.

Two areas of 3-inch trench mortars (Stokes) were identified just outside of the Track 3 Impact Area boundary during removal operations within MRS-15 SEA3 and MRS-15 SEA4. It is possible that Stokes mortars could be present within the Track 3 Impact Area boundaries adjacent to these areas.

With the exception of the Stokes mortars found to the west of the Track 3 Impact Area and the mortars found in the far southeast part of the impact area, the distribution of mortars based on available sampling and removal data appears to correspond well with the expected distribution based on historical range information. Training maps are not available for the time period when Stokes mortars would have been used and it is possible that the mortars found in the southeastern part of the Impact Area were also fired prior to the earliest available training maps (*1945*).

Illumination Mortars

Illumination mortars are present along Orion Road from the intersection of Broadway south to, and past, the intersection with Watkins Gate Road and along Watkins Gate Road toward the west. They were also found in grids where removals were conducted as part of the preparation of the ODDS test site. Smaller accumulations are also present near and along Mercury Road in the southeastern part of the Impact Area. Most of the Illumination Mortars are found in the center of the Impact Area, which would be expected based on the use of the mortars for illumination purposes. A few illumination mortars were also identified adjacent to Range 26.

Plate 7 shows areas where the different types of mortars identified within the Impact Area would likely be found; however these areas should be considered approximate and it is possible that mortars could be found outside the likely areas.

Rifle Grenades

A small number of rifle grenades have been identified in the northeastern portion of the site in the vicinity of the area where a designated rifle grenade range was present on the 1950s and early 1960s training maps. Plate 8 shows the distribution of rifle grenades found during sampling and removal actions and presents an approximate area where rifle grenades could be present based on existing information. It appears that there are rifle grenades within the boundaries of Range 37.

Three M9 HE rifle grenades (MEC) were also detected in the far northeastern portion of the Impact Area northeast of the MOUT. These rifle grenades were found on the surface during the Eucalyptus Fire visual surface removal. Available training maps do not show a rifle grenade range in this area; however, based on the discovery of several rifle grenades on the surface in this area, it is possible that a range existed in this area.

A small accumulation of M9 and M11 rifle grenades is also present in the northwestern part of the site. Available training maps do not show a range fan in this location; however, based on the distribution of rifle grenades in the northwestern part of the site, it is possible that a range existed in the area.

M22 Rifle smoke grenades, mostly munitions debris, were also discovered during removal actions at MRS-DRO 01 just to the west of the Track 3 Impact Area boundaries suggesting use in the area. It is possible that additional rifle smoke grenades are present within the Impact Area at Range 26.

Hand Grenades

The majority of hand grenades identified in the Impact Area during sampling and removal were found in the northwestern portion of the site (Plate 8). MK II practice hand grenades, a MK II fragmentation grenade, and associated fuzes were identified. A practice hand grenade range and a live hand grenade range were identified on a 1945 training map in the area where the MK II grenades were found.

In addition, several white phosphorous hand grenades, and a MK III offensive hand grenade were identified north of Broadway Avenue. No corresponding training areas were identified on available historical training maps; however based on the presence of several grenades on the surface, it is possible that this area was used for hand grenade training.

The remainder of the hand grenades and grenade fuzes identified, are generally found on the outer edges of the Impact Area, within the MOUT and in the northeast near areas identified for high explosive hand grenade training and for hand grenade confidence course in the 1950s and 1960s.

40mm Projectiles

Three primary areas have been identified where HE 40mm projectiles were found during sampling and removal actions. The first area is located in the northern tip of the site consisting of Ranges 47 and 45. Both of these ranges were identified as M79 grenade launcher ranges. Range 47 was used from the mid-1960s until the early to mid-1970s. Range 45 was established by the mid-1970s and used until base closure. 40mm projectiles identified within the Range 47 fan include M381 and M382 40mm projectiles. M381, M385, and M386 40mm projectiles have been identified within Range 45 (Plate 9).

The second area is down range of Range 30A. Range 30A was identified as a MK 19 Mod A3 40mm machine gun range in the 1990s. MEC and munitions debris identified during down range fuel break clearance and visual surface removal on the range included M918 40mm practice and M430 40mm HE. These items would be expected at this range based on identification as a 40mm machine gun range. 40mm munitions debris and MEC found on Nowhere Road fall within the 2,200m range of the projectiles. Two areas within Range 30A have been identified as high density areas. It is possible that high concentrations of metallic debris or sensitively fuzed items could be present in these areas. The identified areas are approximate in both size and location (Plate 9). Additional 40mm MEC and munitions debris is likely between the firing line at Range 30A and down range to Watkins Gate Road (Plate 9).

The third area is along Riso Ridge near the intersection of Hawkeye Road. This is down range of Range 32 that was used as a Helicopter Range in the 1980s. Numerous 40mm cartridge cases with the projectiles removed and several M383 40mm HE projectiles were identified along the road. It should be noted that helicopter firing positions are present in this area, but the targets are located further inland. Several HE M381 40mm projectiles were also discovered near Range 34. The 40mm HE projectiles discovered near Riso Ridge could be the result of the helicopter firing, or may have another source. It is expected that additional 40mm HE projectiles could be present near the targets used for the helicopter training.

Practice 40mm projectiles have been identified just outside the Impact Area boundaries within the boundaries of Ranges 24, 26, and the MOUT. Projectiles found within the MOUT and Range 26 are primarily smoke items used for signaling. Several 40mm practice projectiles of unknown model were identified at Range 24 along with several 40mm smoke projectiles (Plate 9).

75mm Projectiles

The majority of the 75mm projectiles (MEC and munitions debris) identified during sampling and removal actions are present on roads running through the central part of the Impact Area and in the southwestern part of the Impact Area along Phoenix Road (Plate 10). 75mm projectiles have not been identified, except as single occurrences, is in the northeastern part of the Impact Area (Plate 10). The types of 75mm projectiles found within the Impact Area include mostly MK 1 Shrapnel, with lesser amounts of M48 HE, MK 1 HE, and M41A1 HE items. 75mm projectiles were available for use prior to 1945, which is the date of the earliest available training map; therefore, historical information on firing points and ranges that may have been used is not available. Based on the distribution of 75mm projectiles discovered to date, and the lack of historical range information, it is possible that 75mm projectiles could be found throughout the Impact Area, with lower concentrations expected in the northeastern part of the site.

37mm Projectiles

The types of 37mm projectiles detected within the Impact Area include the low explosive MK II, the low explosive MK I, and the armor piercing tracer M51 series. The armor piercing M51 series 37mm projectiles were found on both Phoenix Road and Nowhere Road in the southwestern part of the site (Plate 10). They were also found on and near Impossible Canyon Road in the eastern part of the site. Low explosive 37mm projectiles were found in the northern and central part of the site during fuel break removal and during removal as part of the ODDS and Mortar Alley visual surface removal. 37mm projectiles were also found in the southern part of the site. Additional 37mm projectiles found in the southern part of the site include the target practice M63 MOD 1 and the M59 armor piecing. 37mm projectiles were available for used prior to 1945, which is the date of the earliest available training map;

therefore, historical information on 37mm firing points and ranges prior to 1945 is not available. Based on the distribution of 37mm projectiles discovered to date, and the lack of historical range information, it is possible that 37mm projectiles could be found throughout the Impact Area (Plate 10).

Rockets

Five different types of rockets have been discovered and removed from the Impact Area; the 2.36-inch rocket, (both high explosive and practice), the 3.5-inch rocket, the 66mm M72 series LAW rocket, the 66mm M74 incendiary rocket, and the 35mm M74 subcaliber rocket. The distribution of each of the different types of rockets is presented on Plate 11 and described below:

2.36-inch Rocket

The largest concentration of 2.36-inch rockets identified to date is just outside the Impact Area MRA boundary at Range 26. An antitank range was present in the current location of Range 26 in the 1940s based on the 1945 training map. It is likely that the rockets found in this area were the result of use in the 1940s as an antitank range. 2.36-inch rockets have also been identified within the boundaries of Range 37 and on Chinook Road, which is down range of Range 37 (Plate 11). Based on review of historical training maps, a rocket launcher range is present in this area on a 1956 training map; therefore, it is possible that the rockets were the result of use of this range. Two 2.36-inch practice rockets were found within Range 42, which is near an area identified as a Bazooka Demonstration Range on the 1945 training map. It is possible that these rockets were related to the training in 1945. Based on the distribution of 2.36-inch rockets identified to date, it is possible that additional 2.36-inch rockets could be present in and around Range 26, Range 42, and Range 37. It is also possible that 2.36-inch rockets could be present in other parts of the Impact Area, based on the discovery of 2.36-inch rockets within the boundaries of Range 48 and Watkins Gate Road.

3.5-inch Rockets

A large accumulation of 3.5-inch practice rockets (munitions debris) was identified in the northwestern part of the site. These rockets are not shown on the map because they were identified as part of the visual surface removal at Watkins Gate Burn Area and individual locations of munitions debris were not identified in this effort. 3.5-inch rockets (munitions debris) were also identified during removal actions on Broadway Road, which runs adjacent to the 1950s range. Additional areas where 3.5-inch rockets were identified included an area along Evolution Road (Range 48). 3.5-inch rocket motors (munitions debris) were found on Chinook Road down range of Range 37, and on Impossible Canyon Road and Hawkeye Road. These locations are down range of a rocket launcher range shown on a 1956 training map. 3.5-inch rockets were also identified within MRS-15 DRO 1 near Range 25. It is possible that additional 3.5-inch rockets are present within the Track 3 Impact Area boundaries near this location. 3.5-inch rockets have not been identified in the southeastern part of the Impact Area. Based on the distribution of 3.5-inch rockets identified to date, it appears that 3.5-inch rockets are most likely present within of near range fans identified on historical training maps (Plate 11); however, it is possible that additional areas of 3.5-inch rocks could be present within the Impact Area.

66mm LAW Rockets

During removal actions, 66mm LAW rockets were found within the Range 44 and Range 45 and Range 48. Lesser numbers of LAW rockets were also found within Range 43 and near Range 46. Range 44 was authorized as a M72 LAW Rocket Service Fire range from 1960s through base closure. The maximum range for the 66mm rocket was 1,000 meters, so it is not expected that the 66mm rockets would be

present past about 1,000 meters down range of the firing points. Based on the presence of 66mm LAW rockets at Range 48, it is possible that 66mm rockets were also authorized for firing at Range 48. Based on the occurrence of 66mm rockets and the maximum range of the rockets, it is expected that the majority of the 66mm rockets would be present within the boundaries of the Ranges 43 through 48 Burn Area (Plate 11). Because the LAW rocket was not in use prior to the establishment of the range configurations in the 1960s, which were mostly unchanged until base closure, it is unlikely that 66mm rockets would be present outside of the Ranges 43 through 48 Area.

35mm Sub caliber Rockets

Sub caliber 35mm rockets were found at Ranges 24, 28, 41, 43, 44, 45, and 48 during sampling and removal actions. Based on review of available Range SOPs from the 1970s through 1992 sub caliber 35mm rockets were authorized for fire at Ranges 24, 28, 31, 41, 43, and 44. This corresponds fairly well with the distribution identified during removal and sampling actions. Little in the way of removal actions has been completed in Range 31, which may account for why 35mm sub caliber LAW rockets have not been found at the Range 31. The presence of 35mm sub caliber LAW rockets at Range 48 suggests that they were authorized for use at the range in the past. Because the maximum range for the 35mm sub caliber rocket is only 1,100 meters, it is expected that they would be found within about 1,000 meters of the Impact Area boundaries and would not be expected in the central portion of the Impact Area (Plate 11).

57mm Recoilless Rifle

Two areas with 57mm projectiles are evident based on sampling and removal actions conducted within the Impact Area (Plate 12). The first area is down range of Range 48, which is in the vicinity of a 1950s range labeled Mortar and 57mm firing. The second area is down range of Ranges 43, 44, and 45. These ranges are in the vicinity of ranges identified as field firing ranges on 1950s training maps. According to the Policies and Procedures for Firing Ammunition for Training, Target Practice, and Combat the minimum range to impact for 57mm recoilless rifles is 250 to 300 meters (*Army, 1983*). The maximum range for the 57mm recoilless rifle is 4,600 meters (*Army, 1983*). It appears that the 57mm projectiles discovered to date fall within these ranges, with the majority of items located 500 to 1,500 meters down range. A few 57mm projectiles have also been detected further down range to the maximum range of the item.

AT-4 Recoilless Rifle Projectiles

Numerous AT-4 84mm high explosive antitank recoilless rifle projectiles were found during sampling and removal actions within the area identified as Ranges 43-48 and adjacent areas. The majority of the AT-4 discovered to date are within the boundaries of Ranges 44 and 48. Based on a review of available range SOPs from the 1970s through 1992, AT-4 recoilless rifles were authorized for use at Ranges 43, 44, and 48. Because the maximum effective range for the projectiles fired from the AT-4 recoilless rifle is 300 meters. As shown on Plate 10, the majority of these projectiles are found down range at Ranges 43, 44, and 48 within 300 meters of the firing points (Plate 12).

Dragon Missiles

Practice Dragon missiles (MEC and munitions debris) were found during sampling and removal actions in the area identified as Ranges 43-48. Based on the review of available range SOPs from the 1970s through 1992, Dragon missiles were authorized for use at Ranges 44, 44A, 48, and possibly Range 23M. Because the maximum effective range for the Dragon missile is 1,000 meters, it is expected that the

majority of these missiles would be found down range at Ranges 44 and 48 within 1,000 meters of the firing points.

M48 and M1907 Fuzes

M48 and M1907 fuzes are present throughout the central portion of the Impact Area extending from the northern tip of the Impact Area toward MRS-47 (Plate 13). The fuzes are also present along the roads in the southern half of the Impact Area.

The M48 is a point detonating fuze used primarily to detonate smoke and WP 75mm, 90mm, and 4.2-inch projectiles (*Army, 1977b*). It is expected that additional concentrations of live fuzes (MEC) would be expected in the vicinity of targets on ranges where smoke and WP 75mm, 90mm and 4.2-inch projectiles were used. The possibility also exists that live fuzes may also be present near the locations where the projectiles were fired from (firing points).

The M1907 M combination fuze was used on 75mm and 155mm shrapnel projectiles. Because these projectiles were generally used prior to the 1940s (WWI era) the location of their use at the former Fort Ord is not documented. 75mm projectiles (primarily 75mm shrapnel projectiles) have been found throughout the Impact Area with the heaviest concentrations found in the central and southwestern portions. As was expected, many of the M1907 M combination fuzes are found in the same general areas as the 75mm shrapnel projectiles.

Pyrotechnics

A variety of pyrotechnics may have been used during training activities including flares, signals, and simulators (*Army, 1977a*). Pyrotechnic signals and flares include those used for illumination, warning and signaling purposes. These items may have been used at the impact area to train troops in their handling and use, or employed to illuminate targets under simulated nighttime battlefield training. Simulators that may have been used in the impact area include detonation, projectile (ground burst or air burst), hand grenade, artillery flash, and booby trap. Pyrotechnic simulators are used to simulate battlefield conditions during training. Ranges where pyrotechnics are commonly employed include combat courses, infiltration courses, and booby trap training areas. However, because pyrotechnics are used in a wide variety of training activities their presence at most of the impact area ranges is expected (Plate 14).

Other Projectiles

105mm, 155mm, and 8-inch projectiles have been found within the Impact Area. Most of the items were found during fuel break clearances and road and trail clearances. It is anticipated that these items were associated with firing from points outside the Impact Area (Plate 14).

3.5.3.2 Vertical Distribution

This section describes the suspected vertical distribution of MEC items within the Impact Area MRA. It is not broken down into individual types of items as the aerial distribution was, and relies on the geophysical information collected following the Watkins Gate Burn Area surface removal, limited sampling results, the MRS-Ranges 43 through 48 Interim Action Removal to Depth information and the fuel break clearance results. The following describes the vertical distribution of items by area.

Watkins Gate Burn Area

Review of the digital geophysics EM survey conducted by Parsons following the visual surface removal indicates the presence of 2 areas with high numbers of anomalies per linear foot of survey (Plate 16). The results of the survey indicate the potential for more subsurface items to be present in the areas with high anomalies per foot, than in areas with lower anomaly per foot densities.

The first high-density area is located adjacent to Range 48 and down range of Range 18 within the Range fan for the 1950s era Mortar Range No 2. The second area is to the south, in the vicinity of the 1945 rifle transition course, 1950s era Machine Gun Table No. 2, and a demonstration range present in the 1960s.

Based on the results of the survey, it is likely that subsurface MEC, possible mortars, are present in the area adjacent to Range 48, and that MEC is present in the southern part of the Watkins Gate Burn Area, possible related to items used at the Demonstration Range in the 1960s.

It should be noted that the digital geophysics results represent the potential for subsurface MEC and can be used as a guide to identify areas with greater potential for accumulations of MEC. However, because no anomalies were dug as part of the survey, it is not possible to determine the density of subsurface MEC in the high-density areas, or in other areas of the site.

Fuel Breaks

Three phases of fuel break clearance were completed within MRS-BLM. During the first phase 110.7 acres under went a surface removal and 7.23 acres under went a subsurface clearance. During the second phase, a surface removal was completed on 131.08 acres and a subsurface removal was completed on 25.15 acres. The third phase involved surface removal over 12.1 acres and subsurface removal over 58.8 acres.

During the Phase 3 Fuel Break investigation, 150 items were removed from the subsurface and a total of 8 items were removed from the surface. Based on this action the calculated subsurface density of MEC is 2.55 items per acre. This represents only a small portion of the Impact Area MRA, but does give an estimate of the potential subsurface MEC density in parts of the Impact Area MRA.

MRS-Ranges 43 through 48 Interim Action

Review of the information provided in the Ranges 43 through 48 Interim Action Technical Information Paper indicates that over 9,000 MEC items were removed. A breakdown of the data by depth indicates that over half the MEC was found on the surface. Of the remaining MEC, most is found within 1 foot below ground surface (bgs). The number of MEC items continues to drop with less than 1 percent found between 3 and 4 feet bgs.

Based on the review of the above information, it appears that the majority of the subsurface MEC items found within the Impact Area including all of MRS-Ranges 43 through 48 are present within 1 foot of the surface, with lower quantities present below one foot. It should also be noted that in areas that have not been widely used for travel, there is the potential for MEC items on the surface to exceed one item per acre.

3.6 Conceptual Site Model

Conceptual site models (CSMs) are generally developed during the preliminary site characterization phase of work to provide a basis for the sampling design and identification of potential release (functioning of the MEC item; e.g., detonation) and exposure pathways. CMSs usually incorporate information regarding the physical features and limits of the areas of concern (the site), nature and source of the contamination (in this case MEC), and exposure pathways (potential scenarios that may result in contact with MEC).

The CSM for the Track 3 Impact Area MRA is based on currently available site-specific removal data and general information including literature reviews, aerial photographs, maps, training manuals; available field and technical manuals (FMs and TMs), field observations, and the information shown on Plates 5 through 14. The CSMs address training practices that occurred within the Impact Area MRA. The types of training that are known to have occurred or potentially occurred are detailed in Section 3.5, which describes the nature and extent of MEC within the Impact Area MRA based on existing data. This information is summarized below and is depicted on Plate 17.

3.6.1 Training Practices and Likely Distribution of MEC

Plate 17 presents generalized diagrams which depict the types of training that was likely occurring during different eras within the Impact Area MRA. Additional details on the types of training including information on ranges where the items could have been used, and maximum ranges of the weapons is provided in Section 3.5.1. A summary of the types of training that likely occurred is provided below.

Training through the 1940s as shown on Plate 17 involved bazooka training at the Austin Anit-tank range, Stokes mortar and 60mm and 81mm mortar training, both practice and live hand grenade training, rifle grenade training, and training with 37mm and 75mm projectiles and small arms training. The figure depicts some of the areas where this training may have occurred; however, historical training maps are not available prior to 1945, so it is possible that the training depicted on the plate could have occurred in other locations within the Impact Area.

During the 1950s the west side of the Impact Area was used for small arms training, mortar training and 3.5-inch rocket training. Recoilless rifle training occurred in ranges along the northern Impact Area boundaries. Hand grenade and rifle grenade ranges were located in the northeastern part of the Impact Area. Available training maps do not show training areas within the southeastern part of the Impact Area.

Training from the 1960s until base closure included small arms training, primarily on the western portion of the Impact Area MRA, a rocket launcher range, recoilless rifle ranges, weapons demonstrations ranges, close combat courses, mortar ranges and grenade launcher ranges.

Plates 7 through 14 show the areas of the Impact Area where different types of MEC are likely to be encountered based on historical information and available sampling and removal data. It is possible that MEC could be encountered outside of the areas shown on these plates because actions have not been completed in most of the Impact Area. It is expected that the highest concentrations of the MEC will be located within historic range fans around former targets. Based on review of depth distribution data presented in Section 3.5.3.2 it appears that the majority of the subsurface MEC is within one foot below ground surface.

3.6.2 Identified Reuse

The currently identified future recipient of this property is the BLM. BLM is currently preparing a habitat conservation plan for the former Fort Ord, in coordination with Fort Ord Reuse Authority and other property recipients, that identifies activities anticipated to occur. The draft HCP identifies the types of activities that would be allowed including:

- Route, road, and trail management and maintenance;
- Habitat enhancement;
- Fuel Break construction and management;
- Use of administrative areas;
- Aquatic monitoring and educational programs;
- Species specific monitors and habitat enhancement;
- Recreational access on established routes.

3.6.3 Potential Human Exposure Pathways – Physical Hazards

Plate 17 presents a conceptual site model showing previous use and proposed reuse of the Impact Area. This model shows the types of activities that occurred while the Impact Area was in use that resulted in the presence of MEC, the expected exposure pathways, and the types of activities that are anticipated in the future. It is possible that the receptors identified below could come in contact with MEC present at the site. The potential receptors based on the identified potential reuses above include trespassers, surface only receptors, shallow intruding receptors, deeper intruding receptors, and construction workers. A brief description of each of the potential exposure pathways related to the receptors is presented below.

- **Trespassers** – It is anticipated that the trespasser could currently come in contact with surface MEC by walking on the site and possibly with subsurface MEC if the trespasser dug into the ground. The area is currently fenced and monitored to discourage trespassing. The trespasser is expected to enter the site more than once a month but less than once per week, and spend up to 6 hours per day on site.

- **Surface only Receptors** – Surface only receptors are not expected to intrude below the ground surface. The receptor group includes firefighters conducting prescribed burning, habitat monitors performing surface only activities such as performing plant counts and monitoring of animal species and invasive weed control through spraying, and public users engaged in hiking and habitat viewing,. The surface only receptor could be on site as often as 5 days per week, and spend up to 8 hours per day on site. The surface only receptor could come in contact with MEC remaining on the surface in the course of performing the the above activities.

- **Shallow Intruding Receptors** – Shallow intruding receptors could intrude up to 1 foot bgs. The receptor group may include biking and equestrian visitors, and habitat workers installing stakes up to 1 foot bgs. The shallow intruding receptor could be exposed to MEC both on the surface and to a depth of 1 foot bgs. The shallow intruding could be on site as often as 5 days per week, and spend up to 8 hours per day on site. Shallow intruding receptors could come in contact with MEC remaining

on the surface and MEC in the shallow subsurface while walking on the surface or by intruding below the surface while installing stakes or recreating.

- **Deeper Intruding Receptors** – Deeper intruding receptors include habitat workers conducting trail maintenance, invasive weed control and planting, and firefighters who could be creating fuel breaks and responding to wildfires. It is expected that the deeper intruding receptors could intrude to 3 feet bgs. The deeper intruding receptor could be on site as often as 5 days per week, and spend up to 8 hours per day on site. Deeper intruding receptors could come in contact with MEC remaining on the surface and MEC below the surface while performing the above activities.

- **Construction Worker** – Construction workers would perform activities associated with construction of parking areas with restrooms, and preparation of interpretive displays. They could also perform construction of new roads within the Impact Area. The construction worker would likely be a receptor during the initial development of the area. Following the initial development, construction is not expected to be as intensive. It is expected that the construction worker could be exposed to both surface and subsurface MEC. It is anticipated that the construction worker could intrude below the surface to 5 feet. The construction worker may be on site up to 5 days per week.

3.6.4 Potential Human Exposure Pathways – Chemical Hazards

The potential for exposure to chemical hazards within the Impact Area is being addressed under the Basewide Range Assessment program and are described in detail in the Draft Final Comprehensive Basewide Range Assessment Report. It is expected that contact with shallow soil would be the most likely exposure route for chemicals within the Impact Area. Chemicals of concern addressed as part of the BRA include metals and explosives. Petroleum hydrocarbons were also identified as chemicals of concern on two ranges. Sampling for explosives in soil was conducted in 1994 as part of the Basewide RI/FS. The resulting FS identified remedial units for explosives at only 5 ranges (Ranges 30A, 36, 44, 45, and 48). Results of previous studies indicate that the migration of contamination to deep soil and groundwater is not expected; therefore, exposure to explosive compounds through contact with groundwater was eliminated as a pathway.

The risks associated with the potential exposures described above are being addressed as part of the BRA and are not discussed further. This RI including the risk assessment presented in Section 4.0 evaluates only the physical hazards associated with MEC.

4.0 RISK ASSESSMENT

This section presents the results of the MEC risk assessment that addresses the explosive hazards associated with MEC in the Impact Area MRA. It also provides a summary of the status of the assessment of chemical risks to human health and the environment. The risks associated with chemical hazards are being addressed as part of the Basewide Range Assessment, which is a component of the Hazardous Toxic Waste (HTW) RI/FS program, separate from the Munitions Response RI/FS program.

4.1 MEC Risk Assessment Physical Hazards

The MEC risk assessments for Fort Ord provide a qualitative description of the risks of a receptor encountering a MEC item. Because the nature of these types of risk assessments is largely qualitative, a specific protocol was developed to evaluate current and future MEC risks to humans at Fort Ord. The Fort Ord Ordnance and Explosives Risk Assessment Protocol (protocol) (*Malcolm Pirnie, 2002*) was developed through the combined effort of the Army, DTSC, and U.S. Environmental Protection Agency (EPA), and allows for a comparative review of MEC risks at impacted sites. Unlike typical risk assessments that evaluate potential exposures to hazardous substances in environmental media, the protocol does not calculate a numerical probability of adverse effects or a hazard index. Rather, it relies on an *a priori* assumption that any encounter with MEC will result in an adverse effect, and provides a qualitative description of the risk based on the likelihood of encountering a MEC item combined with the potential of the item to cause a serious injury if detonated. The Army is required to conduct a MEC risk assessment as part of the RI/FS process for munitions response sites at Fort Ord. The protocol is used to develop and allow for a comparative evaluation of various remedial alternatives in the FS.

The output of the risk assessment consists of an overall MEC Risk Score designated by the letters A through E, with A representing the lowest risk and E representing the highest risk. The scores are supported by a brief narrative describing the assumptions used in developing the input factors. A summary of the protocol and the scoring tables is provided below.

The explosive risks to plants and animals are not addressed in the risk assessment protocol. The Army has been evaluating and managing the habitat at the former Fort Ord, as well as investigation and cleaning up MEC, since the base was listed for closure in the early 1990's. Based on many years of site experience, the presence of MEC in the Impact Area MRA does not appear to be a concern in terms of physical risks to ecological receptors. Several iterations of biological resource evaluations and many years of habitat monitoring show that the ecological environment is healthy and thriving. The site was used as a multi-range impact area for over 80 years, yet it still supports high diversity of plants and animals, including species considered rare, threatened and endangered. Based on Base Realignment and Closure Cleanup Team (BCT) concurrence, the explosive risks to plants and animals are not addressed in this document.

4.1.1 Data and Data Usability

The data quality assessment for Track 3 Impact Area MRA is presented in Section 3.3.3. Usable data is defined as those data with sufficient quality for use in the decision-making process.

Selection of Data Set

The data available for performing the Risk Assessment for the Impact Area MRA is limited to that collected during:

- Surface removals performed within the Watkins Gate Burn Area (about 1,005 acres) and the Eucalyptus Fire Area (367 acres);

- Surface and subsurface removals performed for the fuel breaks and roads and trails established in the MRA (about 295 acres of surface removal and 133 acres of subsurface removal); and

- The data from the MRS-Ranges 43 through 48 interim action (499 acres of surface removal and 272 acres of subsurface removal within the historical Impact Area). It is suspected, based on historical information, that MRS-Ranges 43 through 48 may represent one of the highest MEC density areas within the historical Impact Area. It should be noted that only a portion of MRS-Range 43 through 48 is included within the Track 3 Impact Area MR RI/FS boundaries because the Track 3 Impact Area only includes the portion of the historical Impact Area that is currently designated for transfer to BLM and that most of the subsurface removal occurred outside of the area addressed in the RI/FS (Plate 2).

Based on discussions with the BCT at an August 30, 2005 meeting , it was decided that the full removal data set from Ranges 43 through 48 Interim Action could be used for this risk assessment because: (1) the subsurface removal data set is larger than is available within the footprint of the Impact Area MRA, (2) the high density of items present on both the surface and the subsurface would result in a conservative risk score, and (3) because the other subsurface data set within the Impact Area MRA is limited to removals within fuel breaks and on roads and trails; most of the fuel breaks were maintained as access roads during the time the Impact Area was active and would have received at least some level of maintenance and clearance for safe travel, and may thus not be representative of the density of items within the majority of the Impact Area MRA. The Ranges 43 through 48 Interim Action data are also considered a high quality data set because the subsurface removal involved both an analog and digital geophysical survey. While the risk assessment itself utilizes data from Ranges 43 through 48 to estimate MEC density and subsequent risks to each type of receptor, the results are then conservatively considered to be representative of the entire Impact Area. The data are considered conservative because it most likely overestimates the density of items between range fans. In addition, although this risk assessment includes a component referred to as a "baseline" risk assessment, this designation is not completely accurate because MEC detected during the various response actions have been removed from the site.

The data identifying the density of the different MEC hazard types (Type 1 through Type 3) with Type 1 representing the lowest hazard and Type 3 representing the highest hazard, found in Ranges 43 through 48 is provided in Table B12. The data set used to estimate the surface density included the data from the visual surface sweep completed in accessible areas before the burn and the results of the surface sweep conducted across the entire 499 acres following the burn. The subsurface data set included the data from removal to depth operations (272 acres). MEC hazard types are further described below, and are presented in Table 4.11. These data serve as the basis for identifying munitions type and density for the various depth intervals evaluated in the risk assessment.

As noted above, the data set from removal at Ranges 43 through 48 is considered conservative for estimating occurrence of MEC in most other parts of the Impact Area. The data for MRS-Ranges 43 through 48 may be representative of portions of the Impact Area that were heavily used (inside the main impact area or within range fans), but likely do not represent the density in areas between ranges, or areas

used for shorter periods of time than was the case for MRS-Ranges 43 through 48. The actual MEC densities could also be higher than observed in the Ranges 43 through 48 data set because the removal to depth was not completed in some special case areas that may represent the even higher subsurface densities of metallic debris and UXO. Special case areas within MRS- Ranges 43 through 48 were defined as areas in an MRS in which MEC removal cannot be completed within the scope of work due to metallic clutter or obstructions that compromise instrument performance or technician safety or because the removal process would cause a serious adverse impact to the habitat. Approximately 300 acres within the Impact Area MRA have been identified as potential high density areas that may require special removal actions; however, the acreage of high density areas could be more or less than the current estimate.

Data Usability

It should be noted that all data in the MMRP database has gone through the database QC/QA during which MEC data is verified against the original grid sheets, and appropriate updates and corrections have been made. Ranges 43 through 48 Interim Action data has gone through this database QC/QA process and has been loaded into the MMRP database. The dataset used for the risk assessment is provided in Appendix B as Tables B11 anad B12.

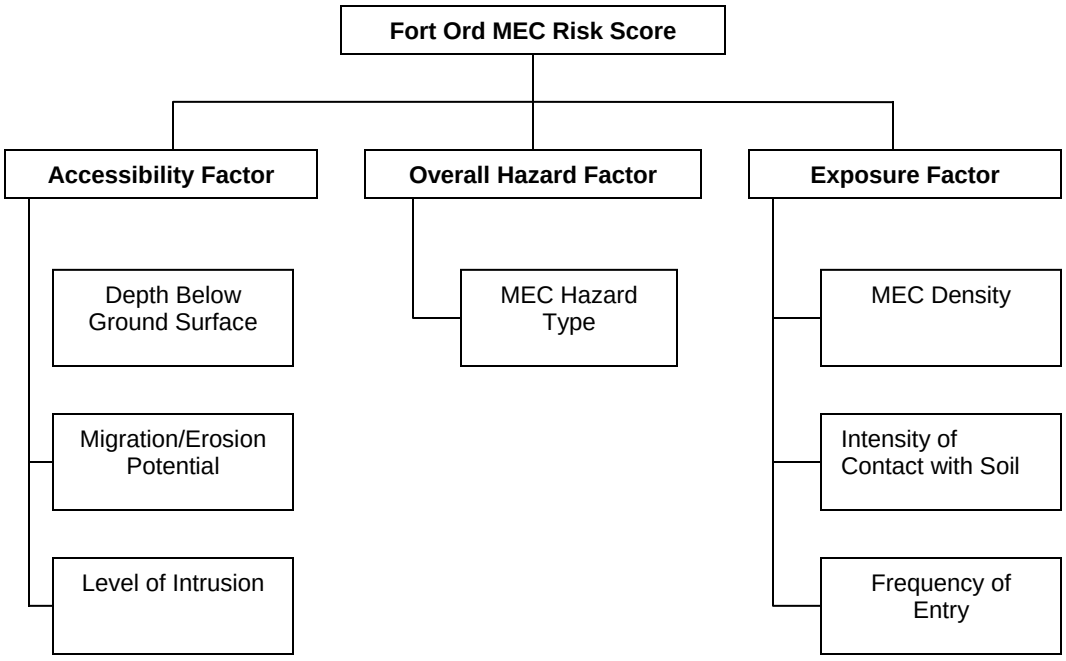
4.1.2 Description of Receptors

The proposed reuses for the Track 3 MRA are discussed in Section 2.2.3.3, and include native habitat for ecological species, and non-motorized recreational uses (hiking, biking, and equestrian). Receptors expected to be associated with the planned reuses have been divided into five main groups that include trespassers, surface only receptors, shallow intruding receptors, deeper intruding receptors, and construction workers. The grouping of receptors by intrusion depth, with the exception of the trespasser and the construction worker, was discussed with the EPA and DTSC on June 26, 2006. The receptors were grouped to simplify the results of the risk assessment. Intrusion depth was used to group the receptors because it was a common input parameter for a number of potential receptors and has a significant impact on the results of the risk assessment. A description of each receptor evaluated in the Track 3 Impact Area MRA risk assessment, and the associated activities and exposure assumptions are presented in Table 4.1.

4.1.3 Discussion of MEC Risk Assessment Protocol

As discussed above, the Fort Ord MEC Risk Assessment Protocol is a qualitative risk assessment approach, with seven qualitative and quantitative input factors. Two matrices combine six of the input factors into scores for accessibility and exposure. A third matrix combines the scores for accessibility and exposure with overall hazard (the seventh input factor) into a qualitative score for estimating MEC risk. The seven input factors are shown below in Figure 1.

Figure 1: Fort Ord MEC Risk Assessment Protocol Process



4.1.3.1 Definition of Input Factors and Assumptions

The following sections discuss each of the input factors and matrices used to determine an overall MEC risk score, and are adapted from the Fort Ord Ordnance and Explosives Risk Assessment Protocol (*Malcolm Pirnie, 2002*).

Accessibility Factor

The accessibility factor reflects how likely the MEC would be accessible to receptors. Three factors are considered; (1) depth of MEC below ground surface (Table 4.2), (2) the level, or depth, of soil intrusion by the receptor (Table 4.3), and (3) the migration/erosion potential, which evaluates whether the apparent depth of MEC items will decrease over time as a consequence of soil erosion (Table 4.4). This potential is estimated using the Universal Soil Loss Equation, and is assumed to be less than 3/100 inches per year for the Impact Area MRA. This is consistent with that estimated for the Parker Flats MRA (*Malcolm Pirnie, 2005*). This is a reasonable estimate for soil loss for areas of established vegetation even shortly after a burn; however, higher rates of erosion could be expected in disturbed areas such as roads and excavation areas.

A score is assigned for each factor using the established criteria, and these input factors are combined to produce an overall score for the accessibility factor using the scoring matrix presented in Table 4.5.

Exposure Factor

The exposure factor (Table 4.10) assesses the likelihood that someone will be exposed to the MEC when in the exposure area. Three input factors are evaluated: (1) MEC density, (2) intensity of contact with soil; and (3) frequency of entry. MEC density is based on the number of MEC items per acre, and is assessed to the level of intrusion for the specific receptor. MEC densities for the Impact Area MRA (based on the data collected at MRS-Ranges 43 through 48), for each depth interval and by MEC hazard classification, are summarized in Table 4.7. As stated above, Type 1 items represent the lowest hazard and Type 3 items represent the greatest hazard. MEC Density scores are presented in Table 4.7.

The intensity of contact with soil (Table 4.8) represents an hours-per-day assessment of the receptor's contact with soil. The frequency of entry (Table 4.9) evaluates the number of entries per year, month, and week based on a person-days-per-year approach. Thus, the frequency of entry is the same if one person visits the site one day each month for a year or if 12 people visited the site for one day during the year. The exposure duration is fixed at one year for all receptors and the number of exposures during that year is evaluated. MEC density, intensity of contact with soil, and frequency of entry are combined in an overall Exposure Factor Scoring Matrix (Table 4.10) to an overall score for the exposure factor.

Overall Hazard Factor

The overall hazard factor is an assessment of the inherent hazard of the specific MEC item, and must be determined by UXO-trained personnel. The overall hazard factor relates to the MEC Hazard Type score that considers the energetic material present in the MEC item and functioning of the item, and assumes that all items are fuzed and portable. It also considers the portability of an item. The scoring is based on both the likelihood of the MEC to cause an injury, and the severity of the injury. Based on the factors identified above, 4 possible scores for the MEC Hazard factor are possible and are presented in Table 4.11. The scores range from 0 to 3, with 0 assigned to inert items and 3 representing the highest hazard. In August 2005, the explosive hazard risk code classifications were updated. This updated information was used in selecting the hazard factors used in this risk assessment.

Overall MEC Risk

The overall MEC risk is determined by combining the accessibility, exposure, and overall hazard factors in a matrix to yield (Table 4.12) an overall risk score designated by the letters A through E, where A represents the lowest risk, and E represents the highest risk. In addition to the letter score, accompanying narrative will explain the assumptions used in calculating the risk score. It should be noted that the risk score represents the highest risk level for the receptors and does not necessarily represent the expected risk.

Overall MEC Risk Score	**A**	**B**	**C**	**D**	**E**
	Lowest	Low	Medium	High	Highest

4.1.4 MEC Risk Assessment Results

This section describes the results of both the baseline risk for each identified receptor, and after action risk. The baseline risk assumes that no removal has occurred. After Action Risk for two cleanup scenarios were evaluated: (1) surface removal; and (2) removal to depth.

4.1.4.1 Baseline Risks

A summary of the input factors and MEC baseline risk for each receptor is presented in Table 4.13. For each receptor, the risk posed by each MEC Hazard Classification is scored separately and the highest of the three scores will be used as the overall score for the receptor. The baseline MEC risk assessment results for each receptor are presented in Tables 4.14 through 4.18. The tables present the results and a brief description of the inputs used to generate the resultant score. The baseline results ranged from a D (high risk) to E (highest risk) for all receptors depending on the MEC hazard type. Exposure to MEC hazard Type 1 items resulted in a D for all receptors, while exposure to Type 3 and Type 2 MEC items resulted in a score of E.

4.1.4.2 After Action Risks

Two hypothetical remedial scenarios were evaluated to determine the potential for risk reduction; (1) a surface removal, and (2) a removal to depth of MEC. The after action risk assessments are considered hypothetical because they are based on assumed accessibility factors and exposure factors. The risk assessment also assumes that any encounter with MEC will results in an adverse outcome. More information on the uncertainties of the After Action risk analysis is provided in Section 4.1.5. For the removal to depth, it is assumed that 100 percent of the detected MEC will be removed. However, due mainly to the limitations of detection equipment, it is difficult to confirm the removal efficiency for depths below 1 foot. Therefore, it was assumed that MEC could remain below one foot when calculating the after action risks.

After Action Risks Surface Removal

For the surface removal after action risk calculation, it was assumed that 100 percent of the MEC on the surface was removed. A summary of the inputs and results for the surface removal scenario is presented in Table 4.19. Additional information on the inputs factors for each receptor are presented in Tables 4.20 through 4.24. A MEC depth below ground surface score of “7” was used to calculate the risk for all receptors including the surface only receptor. Based on the protocol, a surface only receptor could have received a MEC depth below ground surface score of one based on removal of all MEC to the depth of intrusion. Although a MEC removal was conducted below the ground surface, a conservative score MEC depth below ground surface of “7” was selected. The MEC depth below ground surface score of “7” indicates no MEC on the surface, but MEC below the ground surface.The only improvement in overall risk score from the Baseline analysis is for the surface only receptor, because the surface only receptor is not expected to intrude below the surface. The overall risk for the surface only receptor is reduced from an E to a C (medium risk). All other receptors are expected to intrude below the surface; therefore, the risk score remains an E (highest risk). Although there is no reduction in risk score for intruding receptors as a result of a surface removal, a small decrease in risk would be anticipated because the potential for a surface encounter with MEC would be eliminated.

After Action Risks Subsurface Removal

Calculation of the After Action Risks for a subsurface removal is based on assumptions that: (1) all detected MEC items will be removed regardless of depth, (2) nearly all MEC in the zero to one foot bgs interval is expected to be removed, and (3) it is likely that some MEC below one foot remains because it is not detectable. The third assumption suggests that it is possible that MEC could remain below 1 foot even after a removal to depth, and, as a result, a MEC depth below ground surface score of "6" was selected for performing the risk assessment for receptors that intrude below 1 foot. This assumption was used to support decision making with regard to remedial alternative selection and comparison in the FS. The use of a "6" for receptors below 1 foot and use of a "1" for MEC below ground surface is based on BCT concurrence for use of this assumption for the Track 2 Parker Flats site. It should be noted that this is also a valid assumption according to the Risk Assessment Protocol for considering remedial alternatives in the feasibility study.

It is true that the protocol states that a score of one for depth below ground surface is likely to occur when considering remedial alternatives. For the removal to depth scenario where all detected MEC items are removed according the data quality objectives, using a score of 1 for depth below ground surface and 1 for MEC density for all depths would result in a score of "A" (lowest risk) for all receptors. Although this is an approach that could be used, the MR BCT did not feel that a score of "A" (lowest risk) is appropriate scoring for the Impact Area MRA for deeper depth intervals.

A very high density of MEC was observed at MRS- Ranges 43 through 48 during Interim Action. This indicates that the MEC density in the rest of the Impact Area MRA could be as high as that encountered at Ranges 43 through 48. In over 150 acres of Ranges 43 through 48, removal to depth using geophysical detection technology was not completed during the Interim Action due to the presence of high concentrations of metallic debris, which made it impossible to identify individual anomalies to investigate. These areas would require a different approach in order to complete a subsurface MEC removal. In the periphery of such areas, the density of debris is still very high. Though it has been shown that detection technologies can reliably detect most shallow subsurface MEC items, there may still be concerns about the ability of the best available technology to detect MEC items at depth. In addition, because the site was used as a multi-range impact area for decades, the possibility of Type 3 MEC items remaining in the subsurface cannot be ruled out. Therefore, an after-action scoring of "A" (lowest risk) was considered inappropriate for receptors intruding below 1 foot depth.

An alternative approach, also allowable under the Fort Ord Risk Assessment Protocol, was therefore used for calculating the risk for receptors that would intrude below one foot. Similar to the application of the protocol for the Parker Flats MRA, the MEC depth below ground surface and MEC density input factors were selected based on calculated after-action MEC density below the 1 foot depth.

MEC densities below 1 foot were calculated by assuming a detection efficiency of 32 percent, the percent detection for all seeded items used for calculating the residual density of items remaining at Parker Flats (*Malcolm Pirnie, 2005*). The seeded items used in the calculation included both items seeded as part of the ODDS and those used as part of the QA/QC process for removal actions conducted within the Impact Area development parcels. It should be noted that the detection efficiency percentage is based on small numbers of seeded items covering a limited number of munitions types in different depth intervals. This small sample size increases the uncertainty of the detection efficiency estimate. It should also be noted that instrument detection efficiency is typically better at shallower depth and drops as the depth of the target increases. In addition, the seeded items data set for removals below 1 foot remains limited because most of the seeded items used for QC/QA during the MRS-Ranges 43 through 48 Interim Action were

buried within 1 foot below ground surface. Based on a detection efficiency of 32 percent, the following residual MEC densities were calculated:

Item Type	**Number of Items detected below 1 feet during the MRS Ranges 43 through 48 removal to depth Interim Action**	**Number of Acres**	**Calculated Residual Density per acre**	**MEC Density Input Score for intrusion below 1 foot**
Type 1	418	286	3.11	3
Type 2	21	286	0.16	3
Type 3	76	286	0.56	3

A summary of the input factors and results for the subsurface removal to depth are presented in Table 4.25. Additional information on specific input factors for each receptor are presented in Tables 4.26 through 4.30. It should be noted that the most conservative scores were used for each input score. For example, for the shallow intruding receptor, the intensity of contact and frequency of entry scores for a habitat monitor were used because the habitat worker would be expected to more frequently enter the site and spend more time in contact with the soil each day than a recreational user. The surface only receptor and the shallow intruding receptor show improvements in overall risk scores between the surface only removal and the removal to depth. The surface only receptor score improves from a C to an A and the shallow intruding receptor improves from an E to an A. Although no improvement in overall risk scores is calculated for the deeper intruding receptors, it should be noted that the majority of items found within the Ranges 43 through 48 Interim Action were found in the top foot and the densities of items are much lower below 1 foot. Therefore, the removal to depth should result in a reduction of risk for deeper intruding receptors. Because the more conservative input scores were used for each receptor, it is possible that a receptor included in a particular group could have a lower risk score than the calculated score. For example, if a residential receptor were included in the group that could intrude below 1 foot, the resident would not have as high an intensity of contact with soil as the habitat worker which could result in a lower risk score. However, based on the inputs to the protocol, it is expected that all receptors intruding below 1 foot would have a risk score of E (highest) or D (high). It should be noted that any completed subsurface removal action would reduce the risk to intruding receptors; however because Type 3 MEC items are present in the subsurface within the Impact Area MRA, the risk score for deeper intruding receptors remains an E. If BCT-approved work plans are used for future work and the work meets established DQOs, it would be expected that MEC density and depth below ground surface scores of 1 could be used as factors. If these factors are used, the risk score for the deeper intruding receptor and construction worker would improve to an A from an E.

4.1.5 Uncertainty

This section addresses the uncertainties in the risk assessment related to data used in the risk assessment, input scores, and assumptions about the uses of the land by future receptors.

4.1.5.1 Data

This section addresses the uncertainties related to the data set used in the risk assessment. It is suspected that the MRS-Ranges 43 through 48 dataset may represent one of the highest MEC density areas present within the historical Impact Area based on the length of use (from at least 1945 through base closure), and the types of military munitions that were used (mostly HE). It is expected that areas between range fans and behind the firing lines of historical ranges would have lower MEC densities than were present within Ranges 43 through 48. This data set was selected in part because the work was conducted according to an agency approved work plan as would occur in future Impact Area MRA remedial actions. It is anticipated that future remedial actions within the Impact Area MRA will be conducted to meet DQOs established in BCT approved work plans. In addition, the use of seeded items for QC and QA more represents possible QA/QC procedures that could be used in future remedial actions.

The data used in performing this risk assessment may not represent all areas of the Impact Area MRA as noted above. As part of the post-remediation confirmation report, it is anticipated the risk assessment will be reviewed and modified as appropriate using the data set from the completed removal action to obtain a more accurate post remediation risk score.

4.1.5.2 Input Scores

The following section address uncertainties related to some of the input scores including the Migration/Erosion Potential, the Level of Intrusion, the Frequency of Entry, and the Intensity of Contact with Soil. Most of the uncertainties are similar to those identified in the Parker Flats Risk Assessment (*Malcolm Pirnie, 2005*).

Migration/Erosion Potential

The same Erosion Potential Score was used for this risk assessment as was used for the Parker Flats MRA risk assessment (*Malcolm Pirnie, 2005*) based on similar soil, vegetation cover, and topographic conditions through most of the site. It is possible that erosion in the far eastern part of the site could be higher than assumed for Parker Flats due to the steeper terrain and the soil type present. Erosion could also be higher in areas where soil is disturbed such as excavation areas and along roads and trails. Erosion is expected to be low in well vegetated areas. Use of the lowest input factor could result in an underestimation of the overall risk.

Level of Intrusion

The level of intrusion score is based on an assumed depth of soil intrusion by the receptor based on expected behavior. If a receptor intrudes to less than the assumed depth, the risk would be overestimated, and if a receptor intruded greater than the assumed depth, the risk would be underestimated.

Frequency of Entry and Contact with Soil

The frequency of entry factor depends on assumptions about the behavior of receptors that access the site. The Frequency of entry factor is a measure of the number of times per year that a receptor (one or more persons) will be in the area. If people were to visit the site more times per year than assumed in the risk assessment, then the overall risk for that receptor would underestimate the actual risk. The opposite is also true, that if people were to visit the site fewer times than assumed in the risk assessment, then the overall risk would be overestimated.

Intensity of Contact with Soil

The intensity of contact with soil factor is a measure of the length of time the receptor will have contact with the exposure medium (in this case, soil). It is difficult to evaluate the activities that will occur in the future, and what will be the intensity of contact with the soil. As with the Frequency of Entry uncertainties, if the receptor spends more time in contact with the soil than assumed, the overall risk for the receptor would be underestimated, and if the receptor were to spend less time in contact with the soil, the overall risk score could be overestimated.

4.1.5.3 Future Receptors

The assumptions made for future receptors directly impact the input scores as noted above. One of the primary uncertainties for use by future receptors is whether surface only receptors would be allowed to travel off established roads and trails and whether the activities of some visitors would allow for intrusion (i.e., bike riding and equestrian activities). If higher intensity use is proposed, risk should be evaluated for that use.

4.2 Human Health Risk Assessment Chemical Hazards

The potential for risk to human receptors from the exposure to chemicals associated with MEC is being addressed as part of the BRA program. The BRA is a continuation of the work originally completed during the Basewide RI/FS (*HLA, 1995a*).

During the Basewide RI/FS the historical Impact Area was investigated for munitions constituients related to small arms ammunition use and larger military munitions. Investigation of chemical contamination (munitions constituients including metals, explosive compounds, and total petroleum hydrocarbons) was conducted at military munitions targets within specific ranges inside the limits of the historical Impact Area. As described previously, the Impact Area MRA is the portion of the historical Impact Area that is currently designated for transfer to BLM. The results of the investigation indicated that explosive compounds and metals are generally present in near surface soil and are present primarily in ranges that show evidence of heavy use, such as demolished targets and visible accumulations of unexploded ordnance and munitions debris. The occurrence of explosive compounds in the subsurface soil was sporadic, and concentrations were generally below reporting limits. When levels of explosives were elevated, there was an accompanying elevation in metals. Areas of the historical Impact Area were also investigated for the presence of hydrocarbons related to the use of flammable substances in training operations. Ranges investigated for hydrocarbons included Range 33 and Range 40A. Following the completion of the soil sampling, a human health risk assessment was performed. The results of the risk assessment were used to prepare an FS for the site. A ROD addressing chemical contamination for the historical Impact Area (Site 39 in the Basewide RI/FS) was signed in 1997 (*Army, 1997a*). The selected remedial action for soil related to explosives was excavation of soil containing the explosive RDX at concentrations above 0.5 milligrams/kilogram (mg/kg) and beryllium concentrations above 2.8 mg/kg. Based on the results of the risk assessment remediation of other explosive compounds in soil was not recommended. It is anticipated that remediation of soil above the cleanup goals noted above will be protective of human health.

Following the Basewide RI/FS and completion of the ROD, changes were made to the reuse plan for portions of the Impact Area. This resulted in reevaluation of portions of the Impact Area under the Basewide Range Assessment Program. As part of this program, additional samples were collected from several identified historical ranges. The results of this sampling are being evaluated under the BRA to

determine if any changes to the human health cleanup goals presented in the Basewide RI/FS and Basewide ROD (*Army, 1997*) are necessary. The primary focus of the BRA for areas within the historical Impact Area is to further characterize the extent of explosive compound and lead contamination related to military training and to collect data for assessment of the risk to ecological receptors from munitions constituients as described below.

4.3 Ecological Risk Assessment Chemical Hazards

Ecological risks were first addressed as part of the Basewide RI/FS (*HLA, 1995a*). As stated above in Section 4.2, the remedial action selected in the Basewide ROD included excavation of soil containing RDX above 0.5 mg/kg. The RAOs were however, only developed for the protection of human health. For ecological receptors, potentially unacceptable risks were predicted for metals and cyclotetrramethlene-tetranitramine (HMX), but RAOs were not developed. The ROD required that a post remediation risk assessment be performed following implementation of the remedial action for human health. As part of the BRA, it was determined that the ecological risk assessment should proceed prior to completion of the remediation specified in the ROD. An Ecological Risk Assessment (ERA) for Small Arms Ranges was completed in 2005 to address the potential for ecological risks associated with heavy metals at small arms ranges within the impact area. Based on comments received from the USEPA, the DTSC, and CDFG on the ERA, an addendum proposing ecological risk screening levels for explosive compounds was developed (*MACTEC, 2006b*).

The addendum presents screening levels for explosive compounds developed consistent with guidance from EPA (*1997*). The overall objective of the addendum was to develop screening levels for explosive compounds and evaluate existing data for exposure media (i.e., soil) to determine whether more detailed evaluations of potential risks associated with explosive compound are warranted. In addition, if there is evidence that MEC found in the subsurface has released chemicals of concern into the subsurface soils, these specific locations will also be evaluated to determine if sampling is necessary (*MACTEC/Shaw, 2007*).

The addendum concluded that Ranges 33, 36, 43, 44, 45, and 48 required further evaluation, and presents an approach for evaluating other areas of the historical Impact Area that may be identified in the future. This work will continue under the BRA and Site 39.

4.4 Conclusions

The following conclusions can be made based on the results of the risk assessment.

- The Baseline Risks for all receptors are highest risk (E). This score is based on the types and densities of MEC removed during the MRS-Ranges 43 through 48 Interim Action. It is suspected that the MRS-Ranges 43 through 48 dataset may represent one of the highest MEC desity areas present within the historical Impact Area based on the length of use (from at least 1945 through base closure), and the types of military munitions that were used (mostly HE).

- The After Action Risks associated with a visual surface removal are highest risk (E) for all intruding receptors and a medium risk (C) for surface only receptors. It was assumed that all MEC encountered on the surface would be removed.

- The After Action Risks associated with a removal to depth for all receptors intruding below 1 foot remain highest risk (E). For surface only receptors and shallow intruding receptors, those intruding

less than 1 foot, the risk is lowest (A). These risks were calculated assuming that all detected MEC would be removed. Due to limitation of detection capability of any detection equipment, it was assumed that (1) all MEC on the surface is removed, (2) nearly all MEC in the top 1 foot is removed, and (3) some MEC below 1 foot is removed.

- Although surface removal and removal to depth would result in eliminating many MEC items from the site and reducing the possibility of future exposures, it is not possible to verify all MEC items were removed to all depths. Therefore, a possibility remains that an intruding receptor could encounter a MEC item. The results of the risk assessment indicate that after-action risk scores would remain in the high range for those receptors exhibiting intrusive activities. Therefore, land use controls will be evaluated as part of remedial alternatives to support safe reuse activities (e.g., habitat monitoring, invasive weed control, prescribed burning and associated fire management). These land use controls will allow for proper management of the habitat reserve in accordance with HMP (*USACE, 1997*), the USFWS Biological Opinions (*USFWS, 1999, 2002, 2005*), an Assessment (*Zander, 2002*), a Memorandum of Understanding (*BLM/Army, 2004*), and a Revised Attachment A Habitat Management Plan Map (*USACE, 2005*). The HMP and these additional requirements establish the guidelines for the conservation and management of wildlife and plant species and habitats that largely depend on former Fort Ord land for survival.

- Based on the risk assessment, it is anticipated that unrestricted intrusive activities will be unacceptable after conducting either surface removal or removal to depth. Note that a potential residential receptor that could be expected to have intrusive activities as deep as 4 to 5 feet would have similar risk scores as a construction worker (after action risk is E). Therefore, an unrestricted land use, typically represented by a residential exposure scenario by the regulatory agencies, would be unacceptable. Appropriate land use controls would be necessary for proper management of any potential residual risks. As described in Section 2.2, the objective of the remedy is to support the reuse of the Impact Area MRA as a habitat reserve. The HMP (and other documents cited above) designates the entirety of the Impact Area MRA as a Natural Resource Management Area. The Fort Ord Reuse Plan (as updated) designates the entirety of the Impact Area MRA as a Habitat Reserve.

5.0 CONCLUSIONS AND RECOMMENDATIONS

This section presents the conclusions and recommendations for the Impact Area MRA RI based on the review and analysis of the data associated with historical information and sampling and removal data. It also presents summarizes the conclusions of the RA presented in Section 4.0.

5.1 Conclusions

5.1.1 Site Use and Development

Based on the results of the literature review, sampling, and removal actions, the site appears to have been used for the following types of training:

- Artillery training using 37mm and 75mm projectiles (HE, LE, and practice), Stokes mortar, 60mm, 81mm mortar, and Livens projectors training prior to WWII.

- Recoilless Rifle using 57mm ammunition, practice, HE, and white phosphorous, and illumination 60mm and 81mm mortar, practice and high explosive hand and rifle grenade, 2.36-inch rocket, booby traps, and small arms training in the 1940s.

- Mortar training using 81mm and 60mm mortars (HE, practice, illumination), 57mm recoilless rifle, anti-tank training using 3,5-inch rockets, practice and HE hand grenade training, and small arms training in the 1950s.

- Training from the 1960s to base closure included LAW rocket, grenade launcher, small arms, 60mm and 81mm practice and HE mortars including 4.2-inch mortars, 106mm and 90mm recoilless rifle, Dragon missile, helicopter gunnery, and high explosive hand grenade. Claymore mines were authorized for use at two ranges. Two EOD ranges were also present in the Impact Area.

- Artillery training using 105mm projectiles was authorized in the 1980s and 1990s. It appears based on MEC identified during MEC sampling that 155mm and 8-inch projectiles were also fired into the Impact Area MRA.

Development of the Impact Area is summarized below:

- No evidence of established range areas within the Impact Area in present on early 1940s aerial photographs; suggesting that specific training areas within the Impact Area had not been developed.

- Beginning in the 1940s, established range areas were identified. Most of the ranges were located on the northern and just in from the western boundaries of the site.

- Additional ranges were added to the site in the 1950s, with the greatest concentration still on the western and northern boundaries. Hand grenade training areas were moved from the western portion of the Impact Area to the northeastern part of the site.

- By the 1960s, the western ranges present in the 1950s, appear to have been mostly abandoned, and ranges established further to the west closer to General Jim Moore Blvd. Additional ranges were also

added along the southern boundary of the site. Facilities within the Impact Area included limited roads and trails, parking areas, and range towers and latrines.

5.1.2 Data Usability

Based on review of the contractor after action reports and the QA/QC processes described in the RI the data collected during the sampling and removal actions performed within the Impact Area MRA was considered usable for preparation of the RI, RA, and FS.

5.1.3 Nature and Extent of Contamination

The following describes the nature and extent of MEC within the Impact Area MRA based on existing information:

- In general, the spatial distribution of MEC removed todate within the Impact Area is similar to what would be expected based on available historical information; the largest concentration of MEC occur mostly within and down range of ranges identified on historical training maps. For example, mortars are found within ranges identified for mortar training and 40mm projectiles are found within grenade launcher ranges. Munitions that do not fall within range fans include 37mm and 75mm projectiles. These items were used prior to 1945, which is the date of the earliest available training maps.

- Review of the vertical distribution information indicates that most of the MEC occurs within 1-foot bgs. Concentrations of MEC drop off quickly below 1 foot. It is anticipated that concentrations of MEC at depth in high density MEC areas will also decrease significantly below 1 foot; however, becase removal to depth have not been accomplished in the high density "special case areas" the depth distribution in "special case areas" is unknown.

5.1.4 Risk Assessment

- The Baseline Risks for all receptors are the highest risk (E).

- The After Action Risks for implementation of a visual surface removal are highest (E) for all intruding receptors. The risk for a surface only receptor is medium (C).

- The After Action Risk for implementation of a removal to depth for a surface only receptor and a shallow intruding receptor (intrusion of less than 1 foot) are lowest (A), and remain highest (E) for all other deeper intruding receptors.

5.2 Recommendations

The data provided in this RI are of sufficient quality and can be used to prepare a feasibility study for this site. The results of the risk assessment can be used as a tool in comparison of the nine criteria in the feasibility study.

- Although surface removal and removal to depth would result in eliminating many MEC items from the site and reducing the possibility of future exposures, it is not possible to verify all MEC items were removed to all depths. Therefore, a possibility remains that an intruding receptor could encounter a MEC item. The results of the risk assessment indicate that after-action risk scores would remain in the high range for those receptors exhibiting intrusive activities. Therefore, land use

controls will be evaluated as part of remedial alternatives to support safe reuse activities (e.g., habitat monitoring, invasive weed control, prescribed burning and associated fire management). These land use controls will allow for proper management of the habitat reserve in accordance with HMP (*USACE, 1997*), the USFWS Biological Opinions (*USFWS, 1999, 2002, 2005*), an Assessment (*Zander, 2002*), a Memorandum of Understanding (*BLM/Army, 2004*), and a Revised Attachment A Habitat Management Plan Map (*USACE, 2005*). The HMP and these additional requirements establish the guidelines for the conservation and management of wildlife and plant species and habitats that largely depend on former Fort Ord land for survival.

- Based on the risk assessment, it is anticipated that unrestricted use that would allow unrestricted intrusive activities will be unacceptable after conducting either surface removal or removal to depth. Note that a potential residential receptor that could be expected to have intrusive activities as deep as 4 to 5 feet would have similar risk scores as a construction worker (after action risk is E). Therefore, an unrestricted land use, typically represented by a residential exposure scenario by the regulatory agencies, would be unacceptable. Appropriate land use controls would be necessary for proper management of any potential residual risks. As described in Section 2.2, the objective of the remedy is to support the reuse of the Impact Area MRA as a habitat reserve. The HMP (and other documents cited above) designates the entirety of the Impact Area MRA as a Natural Resource Management Area. The Fort Ord Reuse Plan (as updated) designates the entirety of the Impact Area MRA as a Habitat Reserve.

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