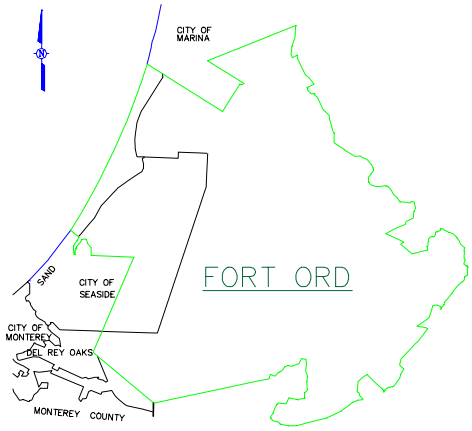

Shaw Environmental, Inc.
Total Environmental Restoration Contract
DACW05-96-D-0011
Task Order 11
783751

Submitted to:
U.S. Department of the Army
Corps of Engineers
1325 “J” Street
Sacramento, California 95814-2922

Submitted by:

Shaw Environmental, Inc.
P.O. Box 1698
Marina (Fort Ord), CA 93933

MACTEC

Draft Final
Post Remediation Risk Assessment
Seaside Parcels 1 through 4
Former Fort Ord, California
Revision 0

Draft Final
Post Remediation Risk Assessment
Seaside Parcels 1 through 4
Former Fort Ord, California
Revision 0

Prepared for

Shaw Environmental
P.O. Box 1698
Marina (Fort Ord), California 93933

On behalf of

Department of the Army
U.S. Army Corps of Engineers
Sacramento District
1325 J Street
Sacramento, California 95814-2922

MACTEC Project No. 4084075119 04

Nyree Melancon
Project Environmental Scientist

Bethany Flynn
Principal Geologist

June 27, 2008

MACTEC

MACTEC Engineering and Consulting, Inc.
5341 Old Redwood Highway, Suite 300
Petaluma, CA 94954 - (707) 793-3800

Draft Final
Post Remediation Risk Assessment
Seaside Parcels 1 through 4
Former Fort Ord, California
Revision 0

MACTEC Project No. 4084075119 04

This document was prepared by MACTEC Engineering and Consulting, Inc. (MACTEC) at the direction of Shaw Environmental, Inc. (Shaw) on behalf of the U.S. Army Corps of Engineers (USACE) for the sole use of the U.S. Department of the Army (Army), USACE, Shaw, and regulatory agencies, the only intended beneficiaries of this work. No other party should rely on the information contained herein without prior written consent of Shaw, the USACE and Army. This report and the interpretations, conclusions, and recommendations contained within are based, in part, on information presented in other documents that are cited in the text and listed in the references. Therefore, this report is subject to the limitations and qualifications presented in the referenced documents.

CONTENTS

TABLES

FIGURES

APPENDIX

LIST OF ACRONYMS

%	percent
ABBL	Arcadis BBL (formerly Blasland, Bouck and Lee, Inc. (BBL)
ADD	average daily dose
AF	adherence factor
Army	U.S. Department of the Army
ATSDR	Agency for Toxic Substances and Disease Registry
BRA	Baseline Risk Assessment
BRAC	Base Realignment and Closure
BERA	Baseline Ecological Risk Assessment
bgs	below ground surface
cal	caliber
Cal/EPA	California Environmental Protection Agency
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm^2	square centimeter
cm^2/event	centimeter squared per event
COPCs	Chemicals of Potential Concern
COPECs	Chemicals of Potential Ecological Concern
CPFs	cancer potency factors
CSEM	conceptual site exposure model
DI	daily intake
DTSC	Department of Toxic Substance Control
EPA	Environmental Protection Agency
EPCs	exposure point concentrations
ERA	Ecological Risk Assessment
FC	fraction contaminated
FFA	Federal Facility Agreement
FORA	Fort Ord Reuse Authority
GPS	global positioning system
HE	high explosive
HEAST	Health Effects Assessment Summary Tables
HHAG	Human Health Assessment Group
HHRA	Human Health Risk Assessment
HIs	Hazard Indexes
HLA	Harding Lawson Associates
HMX	cyclotetramethylenetetranitramine
HQ	hazard quotient
IRIS	Integrated Risk Information System
kg/mg	kilograms per milligram
LADD	lifetime average daily dose
LOAEL	lowest-observed adverse effect level
m	meter
mm	millimeter
MACTEC	MACTEC Engineering and Consulting, Inc.
MCWD	Marina Coast Water District
MEC	Munitions and Explosives of Concern

m^3/hr	cubic meters per hour
mg/cm^2	millimeters per square centimeter
mg/day	milligrams per day
mg/kg	milligrams per kilogram
mg/kg-day	milligrams per kilogram per day
mg/m^3	milligrams per cubic meter of air
MP/CID	Military Police/Criminal Investigation Division
N/A	not applicable
NOAEL	no-observed adverse effect level
NPL	National Priorities List
NRMA	National Resource Management Area
PETN	pentaerythritoltetranitrate
PM_{10}	Particulate matter of 10 micrometers in diameter or less
PRGs	Preliminary Remediation Goals
PRERA	Post Remediation Ecological Risk Assessment
PRHRA	Post-Remediation Health Risk Assessment
RAO	Remedial Action Objectives
RDX	cyclotrimethylen trinitramine
RI/FS	Remedial Investigation/Feasibility Study
RfDs	reference doses
RME	reasonable maximum exposure
ROD	Record of Decision
RRD	range related debris
RWQCB	Regional Water Quality Control Board
SA	surface area
SFs	slope factors
Shaw	Shaw Environmental & Infrastructure, Inc.
SOP	Standard Operating Procedures
TCL	target cleanup levels
UCL	upper confidence limit
µg/dL	micrograms lead per deciliter
µg/L	micrograms per liter
$\mu g/m^3$	micrograms of soil per cubic meter of air
USACE	U.S. Army Corps of Engineers

EXECUTIVE SUMMARY

This Draft Final (Revision 0) Post-Remediation Health Risk Assessment (PRHRA) for chemical contamination at Seaside transfer Parcels 1 through 4 (Seaside Parcels 1 through 4) a portion of Site 39 former Fort Ord, California, has been prepared to document chemical contamination risks following soil removal actions at four ranges within Seaside Parcels 1 through 4 as part of ongoing activities related to the investigation, remediation, realignment and closure of the former military base under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). This Draft Final version incorporates changes to the Draft based on comments received from the California Environmental Protection Agency Department of Toxic Substances Control and public comments from the Fort Ord Environmental Justice Network (FOJEN). Seaside Parcels 1 through 4 correspond to Historical Areas 112, 113, 114, and 115 (HA-112, 113, 114, and 115) , which include the development portions of Ranges 18, 19, 20, 21, 22, 23, 46, 48, (small arms or mixed use ranges), HA-50 (booby trap training area) and HA-59 (proposed small arms range). Remediation of chemical contamination in soil has been completed at the development portions of Ranges 18, 19, 21, and 46. The results of this PRHRA will be used to facilitate the transfer of Seaside Parcels 1 through 4 to Fort Ord Reuse Authority (FORA) for subsequent transfer to the City of Seaside. The City of Seaside plans to develop the Seaside transfer parcels as residential and mixed use development. Therefore, the goals of the PRHRA are to:

- Evaluate the potential human health risks and hazards associated with exposure to residual contaminants remaining in soil following remedial activities
- Evaluate the need for restricting residential land usage based on predicted risks to hypothetical residents from exposure to surface and subsurface soil contaminants
- Evaluate the potential ecological risks and hazards associated with exposure to residual contaminants remaining in soil following remedial activities.

This PRHRA does not address the physical risk associated with Munitions and Explosives of Concern (MEC). MEC removal to depth has been completed in the ranges subject to this evaluation (*Parsons, 2006*). The adequacy of the MEC removal action in terms of the physical risk will be evaluated in a separate munitions response Remedial Investigation/Feasibility Study.

Post-Remediation Health Risk Assessment

The receptors evaluated in the PRHRA included adult and child residents, construction workers, and landscape maintenance workers. For all receptors evaluated, the exposure to chemicals of potential concern (COPCs; antimony, copper and lead) via ingestion, inhalation of particulates, and dermal contact with soil were assessed to evaluate potential cancer risks and noncancer health hazards; however, lead was the only COPC that is carcinogenic, and was evaluated using a biokinetic model. Hazard indexes (HIs) were estimated to evaluate noncancer risks. The noncancer HIs for all of the scenarios are below U.S. Environmental Protection Agencies (EPA's) threshold. Exposure to lead was evaluated for all receptors at Seaside Parcels 1 through 4 using the California Environmental Protection Agency (Cal/EPA) LeadSpread model, version 7 (*Cal/EPA, 2000*). The estimated blood-lead levels for Seaside Parcels 1 through 4 are below the threshold level of 10 micrograms/lead per deciliter (µg/dL) of blood, indicating that the amount of risk due to an exposure to lead in soil is below the levels of concern established by Cal/EPA and EPA.

Based upon the conservative evaluation of potential risks and hazards under post-remediation conditions, adverse noncancer health effects and cancer risks are considered unlikely to be associated with future commercial or residential development at the Seaside parcels under the exposure conditions evaluated. In addition, due to the reduction in human health risks following the remediation of Ranges 18, 19, 21, and 46, a restriction on residential development is not recommended. No remediation of Ranges 20, 22, 23 and 48 was necessary based on the sampling results. However, soil analytical results from the development portions of Ranges 20, 22, 23 and 48 were included in the PRHRA; reconnaissance of HA-50, 59, and HA-112 through 115 did not indicate the potential for chemical contamination.

Post-Remediation Ecological Risk Assessment

A qualitative risk analysis was conducted for the ecological receptors for Seaside Parcels 1 through 4. The following ecological receptors are present and evaluated for Site 39: terrestrial plants, soil invertebrates, reptiles, aquatic life/amphibians, deer mouse, gray fox, mourning dove, red-tailed hawk, bushtit, and American robin. The threshold values that were developed in the Final Ecological Risk Assessment (ERA; *MACTEC/ABBL, 2007*) for lead were used in this qualitative risk analyses. As lead is the most prevalent chemicals of potential ecological concern (COPEC) and contributes the majority of risk at the Impact Area, remedial alternatives in the ERA were developed based on concentrations of lead in surface soil. The lead concentration ranges established in the ERA correspond to approximate

threshold concentrations based on protection of potential receptors at the Impact Area, ranging from protection of the most sensitive wildlife receptors (insectivorous and herbivorous birds and small mammals) to protection of less sensitive wildlife receptors (raptors, carnivorous mammals, plants, and invertebrates). The threshold values for lead that were developed for the ERA were compared to the lead concentrations in soil, and the calculated exposure point concentrations (EPC) for Seaside Parcels 1 through 4. The EPC that was calculated for Seaside Parcels 1 through 4 (67.47 milligrams per kilogram [mg/kg]) is more than 3 times below the lowest-observed adverse effect level (LOAEL) threshold value of 225 mg/kg. EPCs calculated for each Parcel were also well below 225 mg/kg. Since ecological receptors are not stationary (i.e., they roam while foraging, establishing or guarding habitat, etc.), and the Seaside Parcels will be developed by the City of Seaside as residential and mixed use development that will be of relatively low ecological habitat value, future site-related risks associated with exposure of ecological receptors to COPECs in site media are likely negligible.

1.0 INTRODUCTION

This Draft Final (Revision 0) Post-Remediation Health Risk Assessment (PRHRA) for chemical contamination at Seaside transfer parcels 1 through 4 (Seaside Parcels 1 through 4) a portion of Site 39 former Fort Ord, California, has been prepared by MACTEC Engineering and Consulting, Inc. (MACTEC) at the direction of Shaw E&I (Shaw) on behalf of the U.S. Department of the Army Corps of Engineers (USACE), Sacramento District. This version of the report incorporates comments from the DTSC and public received on the Draft report. Responses to DTSC and public comments are provided in Appendix A. Seaside Parcels 1 through 4 correspond to Historical Areas 112, 113, 114, and 115 (HA-112, 113, 114, and 115) , which include the development portions of Ranges 18, 19, 20, 21, 22, 23, 46, 48, (small arms or mixed use ranges), HA-50 (booby trap training area) and HA-59 (proposed small arms range). Remediation of chemical contamination in soil has been completed at the development portions of Ranges 18, 19, 21, and 46. This PRHRA is being conducted to document the post remediation risks within Seaside Parcels 1 through 4 as part of ongoing activities related to the investigation, remediation, realignment and closure of the former military base under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

Potential human health and ecological effects of chemicals detected in soil at Site 39 were originally evaluated on the basis of anticipated future land use in the Final Baseline Risk Assessment (BRA; *HLA, 1995a*), Baseline Ecological Risk Assessment (BERA; *HLA, 1995b*), and Final Ecological Risk Assessment for Site 39 Ranges, Habitat Areas, Impact Area (ERA; *MACTEC/ABBL, 2007*). The BRA and BERA were conducted as part of the Basewide Remedial Investigation/Feasibility Study (RI/FS; *HLA, 1995a, b*). The ERA was developed to supplement previous risk evaluations for Site 39 (including previous human health risk evaluations) and to guide risk management decision-making in the forthcoming Feasibility Study (*MACTEC/ABBL, 2007*). In the BRA, unacceptable risks to human health from exposure to beryllium, lead, and cyclotrimethylene trinitramine (RDX) were predicted based on an open space (i.e., habitat) future land use scenario. Unacceptable risks to ecological receptors were predicted from exposure to antimony, copper, lead, and cyclotetramethylenetetranitramine (HMX). Seaside Parcels 1 though 4 include only areas of antimony, copper, and lead contamination. This PRHRA does not address whether remedial action objectives (RAOs) have been met at each Historical Area. This issue has been addressed in the main body of the Confirmation Reports (*Shaw, 2003, 2005*).

On the basis of discussions among MACTEC, the Army, the USACE, and regulatory agency representatives, the purpose of this PRHRA is to facilitate the closure of Site 39, Seaside Parcels 1 through 4 at Fort Ord with respect to risks related to residual metals in soil. It does not address the physical risk associated with Munitions and Explosives of Concern (MEC). MEC removal to depth has been completed in the ranges subject to this evaluation (*Parsons, 2006*)). The adequacy of the MEC removal action in terms of the physical risk will be evaluated in a separate munitions response Remedial Investigation/Feasibility Study. The results of this PRHRA will be used to facilitate the transfer of Seaside Parcels 1 through 4 to Fort Ord Reuse Authority (FORA) for subsequent transfer to the City of Seaside. Therefore, the goals of the PRHRA are to:

- Evaluate the potential human health risks and hazards associated with exposure to residual contaminants remaining in soil following remedial activities;
- Evaluate the need for restricting residential land usage based on predicted risks to hypothetical residents from exposure to surface and subsurface soil contaminants; and
- Evaluate the potential ecological risks and hazards associated with exposure to residual contaminants remaining in soil following remedial activities.

The approach for conducting the PRHRA is consistent with the BRA/BERA/ERA. The approach is consistent with PRHRA/ Post Remediation Ecological Risk Assessment (PRERA) methods used at other Sites, (Sites 16/17, 31, *HLA, 1998a,b*; Site 3, *HLA, 1998c, 1999a,* Site 39, Ranges 24, 25, and 26, *HLA, 2000*). The PRHRA is conducted in accordance with U.S. Environmental Protection Agency (EPA), California Environmental Protection Agency (Cal/EPA), and USACE human health risk assessment guidance, which includes the following documents:

- *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part A) (EPA, 1989)*
- Chapter 2, Use of Soil Concentration Data in Exposure Assessment, in *Supplemental Guidance for Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities (Cal/EPA, 1992)*
- *Exposure Factors Handbook (EPA, 1997a)*

- *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), Final (EPA, 2004a)*

- *Risk Assessment Handbook - Human Health Evaluation Manual (USACE, 1995)*

- *Risk Assessment Guidance for Superfund (RAGS), Volume I, Human Health Evaluation Manual. Part D: Standardized Planning, Reporting, and Review of Superfund Risk Assessment (EPA, 1998b).*

Methods described in the PRHRA differ from methods generally followed in risk assessments in several important ways:

- Only chemicals detected in soil are evaluated, and

- Chemicals of potential concern (COPCs) and chemicals of potential ecological concern (COPECs) are limited to metals associated with significant risks at small arms ranges as determined at Site 3 and Site 39 *(HLA, 1999a, 2000).*

Seaside Parcels 1 through 4 include ranges at Fort Ord for which PRHRA are required.

This PRHRA is organized as follows:

- Section 2.0 Background, describing Fort Ord, CERCLA-related activities at the installation, Site 39, and Seaside Parcels 1 through 4. The original BRA and remedial activities are also described.

- Section 3.0 Data Evaluation, describing the data set used for the PRHRA.

- Section 4.0 Exposure Assessment, describes the conceptual site model, exposure point concentrations, exposure assumptions, and intake estimates.

- Section 5.0 Toxicity Assessment, describes noncancer reference doses and cancer slope factors.

- Section 6.0 Lead Evaluation, describes the Cal/EPA LeadSpread model and exposure assumptions used.

- Section 7.0 Human Health Risk Characterization, provides a quantitative evaluation of the estimated noncancer hazards and estimated blood-lead levels to potential receptors.

- Section 8.0 Uncertainty Analysis, qualitatively discusses uncertainties in the risk assessment process.

- Section 9.0 Post-Remediation Ecological Risk Assessment, provides a qualitative evaluation of potential risk to ecological receptors.

- Section 10.0 Summary and Conclusions, provides a summary of the results of the PRHRA.

- Section 11.0 Literature Cited.

2.0 BACKGROUND

The former Fort Ord is adjacent to Monterey Bay in northwestern Monterey County, California, approximately 80 miles south of San Francisco (Figure 2-1). The former Army facility consists of approximately 28,000 acres adjacent to the cities of Seaside, Sand City, Monterey, and Del Rey Oaks to the south and Marina to the north. The Southern Pacific Railroad and Highway 1 pass through the western part of Fort Ord, separating the beachfront portions from the rest of the base.

In February 1990, EPA placed Fort Ord on the National Priorities List (NPL) of Superfund sites. In July 1990, the United States Army, EPA, Cal/EPA Department of Toxic Substance Control (DTSC), and the Regional Water Quality Control Board (RWQCB) of Cal/EPA (Central Coast Region) signed a Federal Facility Agreement (FFA). In 1991, the basewide RI/FS began, and Fort Ord was placed on the Base Realignment and Closure (BRAC) list. In 1997, the basewide Record of Decision (ROD) was signed. This required removal of lead-contaminated soil at Site 39 in areas with greater than 10 percent spent ammunition to meet a remedial action objective for lead of 1,860 milligrams per kilogram (mg/kg). Since the ROD was completed, the Fort Ord Reuse Plan was modified to include residential and mixed use development along the southern and western perimeter of Site 39 (Figure 2-1). Historical Areas 112, 113, 114, and 115, which include portions of Ranges 18, 19, 20, 21, 22, 23, 46, 48, HA-50, and HA-59 are within parcels designated for development (Seaside Parcels 1 through 4).

In response to the change in the Fort Ord Reuse Plan to include residential and mixed use development along the southern and western perimeters of Site 39, additional site characterization was implemented on portions of individual small arms ranges designated for residential or mixed use development. Additional site characterization activities, intended to be used as the basis for determining additional cleanup requirements on a range-specific basis, are discussed in the *Draft Final Additional Soil Characterization – Site 39, Work Plan, Former Fort Ord, California (HLA, 1999b)*. Results of the additional characterization at HA-112, 113, 114, and 115, which include the development portions of Ranges 18, 19, 20, 21, 22, 23, 46, 48, HA-50, and HA-59, are summarized in Section 2.3 of this document.

The following sections provide a general description of HA-112, 113, 114, and 115 (Section 2.1), summarize the findings of the BRA (Section 2.2) and BERA and ERA (Section 2.3) for Site 39, summarize additional site characterization activities at HA-112, 113, 114, and 115 (Section 2.4), and describe remedial activities and post-remedial sampling (Section 2.5).

2.1 Description of Seaside Parcels 1 through 4

Seaside Parcels 1 through 4 (HA-112 through 115) are located in the southwestern portion of the former Fort Ord within the historical Impact Area, Site 39 (Figure 2-2). Site 39 comprises an area of approximately 8,000 acres which was used as small arms ranges and high explosive target areas. The majority of Site 39 (6,830 acres) is designated habitat reserve as part of National Resource Management Area (NRMA). The NRMA contains most of the high impact areas of Site 39. A risk evaluation of the habitat reserve portion of Site 39 is presented in the ERA (*MACTEC/ABBL, 2007*) and is not included in the current risk assessment. This risk assessment only addresses Seaside Parcels 1 through 4 (HA-112 through 115) and portions of Ranges 18, 19, 20, 21, 22, 23, 46, 48, HA-50, and HA-59 within the Seaside Parcels 1 through 4 boundaries. The City of Seaside plans to develop the Seaside transfer parcels as residential and mixed-use development.

2.1.1 Seaside Transfer Parcels

Seaside Transfer Parcels are bounded by former Fort Ord Boundary to the west adjacent to the city of Seaside, Eucalyptus Road to the north-northwest, MRS-15 DRO 01 to the south, and borders the proposed NRMA to the east (Figure 2-2).

2.1.2 Former Land Uses

The current risk assessment focuses only on the specific portions of each range that lie within Seaside Parcels 1 through 4. Information regarding the past use of each parcel is summarized below.

Seaside 1 (HA-112) – HA-112 (Seaside 1) is located on the western edge of the former Impact Area adjacent to General Jim Moore Boulevard (Figure 2-3). The development portions of Ranges 21, 22, and 23 (HA-21D, -22D, and -23D) are within the HA-112 boundaries, and are summarized below.

- Range 21 was a small arms range with a berm or backstop. Range 21 is not present on maps or air photos dated before 1968. Evidence of previous ranges cannot be seen on the 1965 air photo mosaic. The use of the range appears to have been consistent. The 1973 Range Standard Operating Procedures (SOPs) indicate that it was a 10 meter (m) Machine Gun Range, later a 25m Zero Range was added (1980 through 1993; *MACTEC, 2006*). Weapons authorized for use at Range 21 included the M-60 machine gun and the M-14 and M-16 rifles (*Army, 1973 and 1980*).

- Range 22 was a long distance range without a berm. Range 22 is not present on historical maps or aerial photos dated before 1984. Historical documents indicate that the range was used for 50-caliber machine gun firing. Circa 1990 documents also indicate that the range may have been used for 400-meter to 700-meter-range sniper qualification. Targets and areas of greater-than-10-percent bullet density were observed; however, no greater than 10 percent spent small arms accumulation areas were mapped within the development portion of the range. Relatively few 50-caliber slugs were identified, although a rusted vehicle body (used as a target) showed a high number of impacts from 50-caliber projectiles. Range related debris (RRD) was identified in various locations, some of which included empty ammo boxes and other miscellaneous scrap (*MACTEC, 2006*).

- Range 23 was used for various training purposes since at least 1945, and as a range from at least the mid-1950s onward. Initially, Range 23 was listed as a Trainfire Range Complex, and eventually became a Rifle Squad Tactical Range in 1965. An area south of the Rifle Squad Tactical Range was later used as a Dragon Tracking Range (HA-23M). Downrange activity was reportedly limited to 700 meters due to the presence of safety fans associated with adjacent ranges. Small arms ammunition and MEC that were used at Range 23 include 5.56 millimeter (mm) and 7.62mm small arms ammunitions, and 40mm practice grenades. Based on interview records, (*Army, 1980*) additional MECs found within the HA-23H/HA-23M boundaries include 40mm high explosive (HE) grenades, and Claymore mines. None of these items were identified during site reconnaissance or sampling. Based on the historical use, this range is identified as a mixed-use range (*MACTEC, 2006*). Only a small corner of the range falls within Seaside 1.

Seaside 2 (HA-113) – HA-113 is located just north of HA-112 on the western edge of the former Impact Area adjacent to General Jim Moore Boulevard (Figure 2-4). The development portions of Ranges 19, 20 (HA-19D, -20D), and HA-59D are within the HA-113 boundaries, and are summarized below.

- Range 19 was a long distance small arms range without a berm. Range 19 is shown on maps dating back to 1956, and is labeled as Range 19 since 1961. The range fan changed shape slightly in some years, but the range location has remained consistent. Use of the range is documented in SOPs and on training maps as a Trainfire Record Fire Range from 1973 to base closure. Weapons authorized for use on Range 19 included the M-16 and M-14 rifles (*Army, 1973 and 1980*). Review of 1960 and 1965 air photo mosaics shows a similar vegetation pattern as is seen today. It appears that some type of training, possibly including the use of small arms, took place in the area of Range 19 in the 1940s

and possibly early 1950s based on review of aerial photographs. The specific type of training activities performed in the area during the 1940s and 1950s are not known (*MACTEC, 2006*).

- Range 20 may have been active during the late 1960s through early 1970s. It is shown on training maps from 1967, 1968, and 1972, but is not shown on training maps from 1964 or earlier, and is not evident on aerial photos from 1965 or 1966. Range SOPs from 1973 through 1992 do not list Range 20 as an active range and do not provide evidence that Range 20 was used for small arms or other training (*MACTEC, 2006*).

- HA- 59 was identified as M-1, Table IX on a 1956 Range Construction Priority Map. It is not known if this range was ever constructed and it is not shown on subsequent 1950s era maps. This range was located closer to General Jim Moore Boulevard than other ranges. Reconnaissance activities did not indicate the presence of a range in this area (*MACTEC, 2006*).

Seaside 3 (HA-114) – HA-114 is located just north of HA-113 on the northern edge of the former Impact Area adjacent to Eucalyptus road (Figure 2-5). The far western part of HA-18D, which is discussed below, is within the HA-114 boundaries.

Seaside 4 (HA-115) – HA-115 is located just to the east of HA-114 on the northern edge of the former Impact Area adjacent to Eucalyptus road (Figure 2-6). The eastern portion of HA-18D, HA-48D, HA-46D, and HA-50D are within the HA-115 boundaries, and are summarized below.

- Range 18 was a long distance range without a berm. Range 18 is shown on maps dating back to 1961 and is present on the 1960 photo mosaic. The configuration of the range fan does not appear to have changed since 1960 and the range is labeled as Range 18 from 1960 through base closure in 1993. Range use is documented as Record Range from 1973 to present. Weapons authorized for use at Range 18 included the M-14 and M-16 rifles (*Army, 1973 and 1980*). A 1945 map shows "30 caliber (cal) AA Practice", "Dummy Grenade", and "Machine Gun 30 cal" ranges in the southern (inland from current position) portion of the range. Evidence of these ranges is present on the 1947, 1949, and 1951 aerial photographs, and the 1960 and 1965 aerial photo mosaics (*MACTEC, 2006*).

- Range 46 was located in the northern part of the historical Impact area and was used as Pistol Range, Military Police/Criminal Investigation Division (MP/CID) Qualification course, night record fire, and 10 meter machine gun range from as early as the 1960s, and possibly as early as 1958. Range control records from 1973 through 1993 indicate that the range was used as a MP/CID qualification course

through much of that period (*Army, 1973 and 1991*). This range contained a berm that was located just to the north of the habitat/development boundary within the habitat reserve (*MACTEC, 2006*).

- Range 48 was used as a mortar range from at least the mid-1940s onward. It was used as a weapons demonstration range from the mid-1960s until 1975, and as a sniper range from about 1982 until 1990. From 1990 until 1993, it was used as an anti-tank weapons range. MEC items either found or listed as having been used on Range 48 includes, 40mm high-explosives, 66mm incendiary rockets, 60mm, 81mm, and 4.2-inch mortars, Stokes mortars, pyrotechnic devices from other countries, Claymore mines, 90mm and 106mm recoilless rifles, Dragon wire-guided missiles, 5.56 and 7.62mm bullets, and 14.5mm subcaliber rounds (*MACTEC, 2006*). Target areas for larger munitions are not within Seaside Parcel 4.

- HA-50 was identified as a Booby Traps Training Area on a 1945 training facilities map (*Army, 1945*). The training area is not present on the circa 1954 map (*Army, 1954*). Evidence of cleared areas in the site vicinity are visible on 1949 and 1951 aerial photographs. Expended blank casings, 50-caliber links, and concrete debris were found in the site vicinity during reconnaissance. No evidence of a range including targets, firing lines, or fighting positions was encountered (*MACTEC, 2006*).

Several metals are associated with spent ammunition. For the evaluation conducted for Site 3 *(HLA, 1995a, b, and 1999a)* concentrations of antimony, chromium, copper, lead, tin, and zinc were found at elevated levels in soils with high densities of spent ammunition at the surface. Although MEC may be present, although not expected, at these HAs, as discussed previously, this evaluation does not address the physical risks of MEC. No evidence of target areas for explosive MEC items were identified within the Seaside 1 through 4 parcels; therefore, explosive compounds are not evaluated in this assessment.

2.2 Summary of Baseline Health Risk Assessment for Site 39

Potentially complete exposure pathways and possible receptors were identified in the BRA on the basis of future land use plans known at the time (*HLA, 1995a*) and the results of limited site characterization activities. Site characterization activities were limited when the RI/FS was conducted because of the presence of MEC. Many areas, including the Inland Ranges were not fully characterized. On the basis of previous and assumed future land uses and the limited information on the distribution of soil contamination detected in the RI/FS, potential risks and hazards were estimated for all of Site 39 (including the Seaside Parcels 1 through 4). Available future land use plans at the time indicated that Site

39 was not expected to be developed for residential, industrial, or commercial use, but rather recreational, educational, and natural resource oriented use. The presence of potential future onsite receptors was assumed to be limited due to these proposed land uses and the presence of MEC. A future onsite habitat management worker was assumed to have more exposure to site-related chemicals than other potential receptors and was, therefore, quantitatively evaluated for potential exposure to soil and groundwater via the following exposure pathways:

- Incidental ingestion of soil
- Dermal contact with soil
- Inhalation of airborne dust
- Ingestion of groundwater as drinking water.

Current offsite resident receptors (child and adult) were also quantitatively evaluated for potential exposure to soil via inhalation of dusts.

COPCs selected for quantitative evaluation in the BRA for Site 39 soil were 2-amino-4,6-dinitrotoluene, 4-amino-2,6-dinitrotoluene, antimony, arsenic, beryllium, cadmium, copper, cyclotetramethylenetetranitramine (HMX), lead, nickel, RDX, and 2,4,6-trinitrotoluene. For groundwater, antimony, arsenic, beryllium, mercury, and nitrate were selected as COPCs.

Results of the BRA for Site 39 are summarized below for all receptors:

- Soil: Total multi-pathway Hazard Indexes (HIs) for all receptors were equal to or below 1 for both the average and reasonable maximum exposure (RME) scenarios. Estimated multipathway cancer risks were below or within EPA's target risk range of 10^{-6} to 10^{-4} for both average and RME scenarios.
- Groundwater: HIs for the habitat management worker receptor were below 1 for the average and RME scenarios. Cancer risks were within EPA's target risk range of 10^{-6} to 10^{-4}.
- Results of the lead exposure evaluation indicated that all estimated 99th percentile blood-lead levels were below the target blood-lead level of 10 micrograms lead per deciliter of blood (µg/dL).

As discussed previously, the risk estimates presented in the RI/FS were based on limited site characterization data. Further evaluations of risk were to be conducted as additional data were collected.

2.3 Previous Ecological Risk Assessments

Two ecological risk assessments were conducted for Site 39, the BERA, which was conducted by Harding Lawson Associates (HLA) in 1995, and the ERA, which was conducted by MACTEC and Arcadis BBL (ABBL) in 2007 for the habitat area of Site 39. The two ecological risk assessments are summarized below.

2.3.1 Summary of Baseline Ecological Risk Assessment

The BERA for Site 39 was also conducted using limited site characterization data (*HLA, 1995b*). Additionally, because of the presence of MEC, site-specific biota data could not be collected. Biota data collected for areas of Sites 16 and 31 were considered somewhat representative of conditions at Site 39 (similar contaminants and habitat types). Eight types of plant communities were identified at Site 39 in the BERA: Central maritime chaparral, coast live oak woodland, landscaped, seasonally wet grassland, upland ruderal, valley needle grassland, vernal pool, and wet ruderal. Special-status plant species identified in the BERA included: Monterey spineflower, kellog's horkelia, Monterey manzanita, sandmat manzanita, Monterey ceanothus, and sand gilia. Special-status animal species observed or expected included: dusky-footed woodrat, golden eagle, northern harrier, California horned lizard, cooper's hawk, sharp-shined hawk, black shouldered kite, burrowing owl, black and/or silver legless lizard, California tiger salamander, southwestern turtle, and American badger. Receptors evaluated in the BERA included: terrestrial plants, the leaf litter community (i.e., soil invertebrates), black legless lizard, deer mouse, gray fox, and mourning dove.

COPECs in surficial and shallow soil evaluated in the BERA included 11 metals (antimony, arsenic, beryllium, cadmium, chromium, copper, lead, nickel, selenium, silver, and zinc), bis-2-ethylhexylphthalate, 2-amino-dinitrotoluene, HMX, pentaerythritoltetranitrate (PETN), pentachlorophenol, RDX, and tetryl. Adverse effects on ecological receptors were predicted for deer mice, with the majority of the risks attributed to elevated concentrations of lead and HMX (hazard quotients of 27 and 4, respectively). Adverse effects were found to be unlikely for the other receptors evaluated. As discussed previously, the evaluation conducted for the BERA was based on limited data.

2.3.2 Summary of the Ecological Risk Assessment

The ERA was conducted at Site 39, in the area that is to remain as habitat, in order to evaluate potential ecological risk under a baseline scenario and to evaluate various potential remediation scenarios to reduce the risks. The potential remediation scenarios were developed based on an assessment of habitat quality and distribution of COPEC concentrations. Since the BERA, comprehensive site characterization activities, including soil sampling, bullet mapping, and habitat quality mapping have been conducted and are ongoing at the historical Impact Area (*MACTEC/ABBL, 2007*). Additional chemical data were collected from plants, soil invertebrates, reptiles, and small mammals. Seven types of plant communities were identified at Site 39 in the ERA: Central maritime chaparral, coast live oak woodland, landscaped, upland ruderal, valley needle grassland, vernal pool, and wet ruderal. Special-status plant species identified in the ERA included: Monterey spineflower, sand gilia, Seaside bird's-beak, toro manzanita, sandmat manzanita, Monterey ceanothus, Eastwood's goldenbush, Hooker's Manzanita, Yadon's piperia, and Contra Costa goldfields. Special-status animal species observed or expected included: California red-legged frog, California black legless lizard, California tiger salamander, tricolored blackbird, southwestern pond turtle, Monterey ornate shrew, and California linderiella (fairy shrimp). Receptors evaluated in the ERA included: terrestrial plants, the leaf litter community (i.e., soil invertebrates), reptiles (representative of black legless lizard), aquatic life/amphibians, deer mouse, gray fox, mourning dove, red-tailed hawk, bushtit, and American robin.

The ERA focused on chemical contamination associated with military training within the historical Impact Area. The primary chemical contaminants associated with small arms ranges include antimony, copper, and lead, which were identified as COPECs. The ERA identified the habitat portion of Ranges 21, 24, 36, 38, 48, 57, 58, and 60 as areas with minimal risks and areas with no significant contamination. However, the habitat portions of Ranges 18, 19, 22, 23, 26, 27, 27A, 28, 29, 34, 37, 39/40, 43/44/45, and 46 have areas that pose a significant risk to ecological receptors. Due to the areas with significant risks, threshold values were developed for lead, since it is the most prevalent COPEC and contributes the majority of the risk at the Impact Area. The threshold values that were developed, which are further discussed in Section 9.1, are based on protection of potential receptors at the Impact Area. Remedial alternatives were developed for these ranges based the threshold values.

2.4 Site Characterization Summary

This section summarizes the field activities and the results of the characterization activities performed at Seaside 1 through 4 (HA-112 through HA-115), which include the development portions of Ranges 18, 19, 20, 21, 22, 23, 46, 48, HA-50, and HA-59. The discussion provides a chronology of the work completed beginning with site characterization and then describes the removal actions completed at four of the ranges

2.4.1 Field Activities

The characterization activities proposed at Ranges 18, 19, 21, 22, 23, and 46 were presented in the *Draft Final Additional Soil Characterization-Site 39 Work Plan, Former Fort Ord, Californi*a (*HLA, 1999b*). Proposed activities included sampling at all six ranges and analysis of samples for lead and antimony. Lead and antimony were selected for analysis because they were detected above their respective EPA Region IX Preliminary Remediation Goals (PRGs; *EPA, 1999*) during a pilot study performed in November 1998 (*HLA, 1999c*). Metals analyzed in the pilot study were selected based on information from the evaluation of contaminants in soil at Site 3. Chromium, zinc, copper, and tin were also analyzed for during the pilot study. Copper was detected above Fort Ord background levels in several samples. Zinc was detected above background in one greater than 10 percent ammunition cover area sample. Chromium was not detected above background in any samples (background information are not available for tin).

Preliminary visual reconnaissance and mapping of the surface distribution of spent ammunition at Ranges 18, 19, 21, 22, 23, and 46 were completed in November and December 1998. The mapping consisted of traversing each range and estimating the occurrence and the percentage of surface area covered by spent ammunition similar to the mapping conducted for Site 3 (*HLA 1995a, b, 1998c, 1999b*) where four bullet cover "zones" were identified. Because of the thick vegetation in some areas of Site 39, only the greater than 10 percent areas (red zones) were generally mapped. Global positioning system (GPS) technology was used to define and map the distribution of spent ammunition. Other features that were mapped include the range fan boundaries, target boxes, firing lines, and fuel breaks, where present.

In order to evaluate existing concentrations of metals in soil at the above sites, soil sampling was recommended. Hand dug test pits were completed for collection of soil samples and for visual observation of the distribution of bullets below ground surface. A combination of biased and random sampling approaches were selected based on the results of the visual mapping and results of a pilot study

completed in November and December 1998 (*HLA, 1999c*). Samples were collected as necessary from 0, 1, and 2 feet below ground surface (bgs). The sample locations are shown on Figures 2-7 through 2-12.

Reconnaissance and mapping were performed at Range 20 in June 1999 and May 2001 because the range appears on historical usage maps. Although no significant evidence of historical range use was observed, because the range is listed in historical documentation, a random sampling program was implemented for this site to verify that metals impacted soil was not present. Samples were analyzed for antimony, copper, and lead because of the site was identified as a small arms range. Sample locations are shown on Figure 2-13.

Reconnaissance of the portion of Range 48 that falls within the development parcel was completed in June 1999. The habitat portion of the range was not mapped due to the high quantity of MEC remaining on the range. Soil samples were collected in July 2001. Samples were analyzed for lead, copper, and antimony based on historic use of the site as a small arms range. Sample locations are shown on Figure 2-14.

Reconnaissance and mapping were performed at HA-50 in October 2001 and reconnaissance activities were conducted at HA-59. The results of the field activities for the development portions of Ranges 18, 19, 20, 21, 22, 23, 46, 48, HA-50 and HA-59 are discussed below.

2.4.2 Results

This section summarizes the results of the field activities by range. The goal of the sampling was to identify areas where lead concentrations in soil exceeded the EPA Region IX residential PRG for lead of 400 mg/kg.

Range 18

Range 18 sampling indicated that lead concentrations in soil exceeded the Region IX residential PRG of 400 mg/kg, primarily adjacent to the target lines. Based on this information, Shaw conducted additional sampling in 2002 to further characterize the site for remediation (*Shaw, 2002*). The sampling results are discussed further in Section 2.5.

Range 19

Range 19 sampling indicated that lead concentrations in soil exceeded the Region IX residential PRG of 400 mg/kg, primarily adjacent to the target lines. Based on this information, Shaw conducted additional

sampling in 2002 to further characterize the site for remediation (*Shaw, 2002*). The sampling results are discussed further in Section 2.5.

Range 20

The ground surface visibility at Range 20 was limited in several areas by very dense vegetation; however, portions of the site were open and accessible for mapping and sampling. No firing lines or target areas were evident on the range, except for one possible target that was identified in May 2001. Bullet accumulations of less than one percent were mapped in small areas within the habitat area of Range 20, primarily on an access road that runs along the north side of the range. These accumulations are down-range from Range 19 and may be the result of training associated with that range. Car debris was mapped in the area between Ranges 20 and 21. Several spent ammunition accumulation areas of greater than 10 percent were identified within the habitat area of Range 20 that overlap with the development portion of Range 19 (*MACTEC, 2006*). No areas of spent ammunition accumulations were identified within the development portion of Range 20. Nine soil samples were collected from the development portion of Range 20. Antimony was not detected in any of the samples, but copper and lead were detected in all of the samples. All copper and lead concentrations were below Fort Ord background concentrations (18.2 mg/kg and 51.8 mg/kg, respectively) and their Region IX PRGs (3,100 mg/kg and 400 mg/kg). Based on the reconnaissance and sampling results, Range 20 was identified for no further action. All soil sample results were incorporated into the data set for the PRHRA.

Range 21

At Range 21 a firing line, firing points, a berm and spent small arms ammunition areas of less than 1 percent, 1 to 10 percent, and greater than 10 percent were mapped during reconnaissance. In the vicinity of the firing points the spent small arms ammunition concentrations were 1 to 10 percent. The berm, which was located to the east of the firing line, was 15 to 20 feet tall. The berm and the adjacent area behind it include an area with greater than 10 percent lead concentrations on the ground surface. In the development portion of Range 21, sampling indicated that lead concentrations in soil exceeded the EPA residential PRG of 400 mg/kg, primarily on the berm that served as a backstop for the range and within a relatively small area behind the berm. Based on the sampling data, the range was identified for remediation. As part of the remediation activities, a portion of the berm and soil in excess of 400 mg/kg were removed, which is discussed further in Section 2.5.

Range 22

Reconnaissance activities conducted within the development portion of the range did not identify areas with greater than 10 percent spent small arms ammunitions accumulations; therefore, Range 22 was sampled according to a grid pattern. Twenty-four locations were sampled within the development portion of the range. Lead was detected in 12 of the 24 samples at concentrations up to 26.2 mg/kg. Copper was detected in all samples at a maximum concentration of 103 mg/kg. Antimony was not detected in any of the samples. Results of the sampling indicated that lead concentrations were below Fort Ord background concentrations (51.8 mg/kg) for all 24 sample location. Three sampling locations had copper concentrations greater than background concentrations (18.2 mg/kg); however, all copper concentrations were below the Region IX PRG of 3,100 mg/kg. All soil sample results were incorporated into the data set for the PRHRA.

Range 23

Access to a large portion of the range is limited due to thick vegetation. Site reconnaissance performed in 1999 found no fixed firing points, which was expected due to the tactical nature of range use. Some areas of bullet densities greater than 10 percent were observed within the habitat reserve portion of the range. Five biased locations were sampled in the development portion of Range 23 based on the results of the site reconnaissance. The samples were analyzed for antimony and lead. The five soil samples did not have detectable concentrations of antimony; however, lead was detected in all samples at concentrations ranging from 33.6 to 435 mg/kg. Because the concentrations were below the Region IX PRG in 4 of the 5 samples and the concentrations in the fifth sample were just above the Region IX PRG, remediation was not conducted (*MACTEC, 2006*). All soil samples were incorporated into the data set for the PRHRA.

Range 46

The Range 46 sampling results indicated that lead concentrations exceeded the Region IX PRG of 400 mg/kg at Range 46, primarily on the berm that served as a backstop for the range and within a relatively small area behind the berm (*MACTEC, 2006*). As part of the remediation activities, the berm and soil in excess of 400 mg/kg were removed, which is discussed further in Section 2.5.

Range 48

Results of the reconnaissance indicated that a firing line and two rows of targets were present within the development portion of Range 48. Empty casings, links, two observation towers, a weapons' cleaning

area, two rows of small arms targets, and a mess area were also identified, however, no MEC was identified in the development portion of Range 48. The concentrations of antimony, copper, and lead in the soil samples that were collected during July 200l were below their Region IX PRGs (31 mg/kg, 3,100 mg/kg, and 400 mg/kg, respectively), however, three soil samples exceeded the background levels for antimony, 19 for copper, and five for lead. The highest concentration of copper used for the PRHRA data set was detected in a surface soil sample which was located between the two rows of targets. All soil samples were incorporated into the data set for the PRHRA.

HA-50

During mapping and site reconnaissance of HA-50 expended blank casings, 50-caliber links, and concrete debris were found in the site vicinity, however, no evidence of a booby trap training area was identified (*MACTEC, 2006*).

HA-59

Reconnaissance activities conducted for HA-59 did not indicate there was a range located in this area. It is possible that this range was never constructed.

2.5 Remedial Activities and Post-Remediation Sampling

According to the ROD, remedial activities at Site 39 were designed to be protective of human health and the environment under the land reuse plan proposed at the time of signature (habitat management area). Soil and debris were to be remediated to the risk-based target cleanup levels (TCLs). The results of the site characterization activities at Ranges 18, 19, 21, and 46 indicate that lead was present in soil above Region IX PRGs in areas designated for mixed use, which include residential housing. Based on site characterization results presented above, Ranges 18, 19, 21, and 46 were recommended for remediation. Remediation activities are described below.

Ranges 18 and 19

Remedial activities began in 1999 and continued from August 4 through October 16, 2002 for Range 18, and from September 3 through 12, 2002 for Range 19. Soil containing accumulated spent ammunition and residual lead were removed along target lines and at target boxes. Excavations ranged from 1 to 3 feet below ground surface. Soil surrounding target boxes was excavated over an area approximately 20 feet wide (10 feet on either side of the target box), extending 10 feet in front of each target, and 20 feet

behind each target box (*Shaw, 2005*). Approximately 24,900 cubic yards of soil was removed from the 12 acres that comprise the development portion of Range 18. Approximately 1,400 cubic yards of soil was removed from 0.7 acre that comprises the development portion of Range 19.

Confirmation soil samples were collected from below each of the target boxes, and approximately 10 feet behind the location of the removed target boxes. Samples were also collected from the bottom of the target line excavation and from the target line excavation sidewalls in order to verify the width of the target line excavations. Confirmation samples were also collected from the haul roads, stockpiles, and decontamination areas. Confirmation samples that showed elevated concentrations of lead were over-excavated. Over-excavation samples were collected from the bottom of the excavation at the same horizontal location as the original confirmation sample, following the removal of the soil with elevated concentrations of lead (*Shaw, 2005*). Soil samples were analyzed for antimony, copper, and lead.

Approximately 653 soil samples, including duplicates, were collected from Range 18 and analyzed. Antimony, copper, and lead concentrations were below Region IX PRGs of 31 mg/kg, 3,100 mg/kg, and 400 mg/kg, respectively for all samples. After remedial activities, approximately 69 soil samples, including duplicates, were collected from Range 19. Antimony, copper, and lead concentrations were below Region IX PRGs of 31 mg/kg, 3,100 mg/kg, and 400 mg/kg, respectively. The confirmation soil sample results and results from soil samples that were not removed during remediation at Ranges 18 and 19 were incorporated into the data set for PRHRA.

Ranges 21 and 46

Remedial activities were conducted between September 1999 and November 2000 for Range 21 and from September through October 1999 for Range 46. Soil containing accumulated spent ammunition and residual lead was removed from the areas identified for remediation during site characterization. Excavation at Range 21 extended approximately 2 feet below ground surface on the flat portion of the range and 3 feet below ground surface on the berm. Excavation at Range 46 extended approximately 1 foot below ground surface on the flat portion of the range and 3 feet below ground surface on the berm for Range 46. Trenching was done in the berm area of Range 21 to investigate whether the berm was reworked and rebuilt causing the burial of spent ammunition. Trenching showed the berm was not reworked (*Shaw, 2003*). Approximately 9,600 cubic yards of soil was removed from 4.2 acres that comprise the development portion of Range 21. Approximately 3,900 cubic yards of soil was removed from 1.2 acres that comprise the development portion of Range 46.

Confirmation soil samples were collected on a 50-ft grid and along the excavation perimeter. Biased sample locations, which were identified by the Army, were collected after excavation from random areas or from areas that had discolored soil. Confirmation samples were also collected from the haul roads, stockpiles, and decontamination areas. Confirmation samples that showed elevated concentrations of lead were over-excavated. Following the removal of the soil with elevated concentrations of lead, over-excavation samples were collected from the center of each sidewall and the center of the bottom of the excavation at the same horizontal location as the original confirmation (*Shaw, 2003*). Soil samples were analyzed for antimony, copper, and lead.

Approximately 184 soil sample locations, including duplicates, were analyzed from Range 21. All antimony and copper concentrations were below Region IX PRGs of 31 mg/kg and 3,100 mg/kg, respectively. Two sampling locations at Range 21 exceeded the Region IX PRG of 400 mg/kg for lead at concentrations of 410 mg/kg and 570 mg/kg. Approximately 81 soil sample locations, including duplicates, were analyzed from Range 46. All antimony, copper, and lead concentrations were below Region IX PRGs of 31 mg/kg, 3,100 mg/kg, and 400 mg/kg, respectively. All confirmation sample results and results from soil samples that were not removed during remediation at Ranges 21 and 46 were incorporated into the data set for PRHRA.

3.0 DATA EVALUATION

This section describes the data set for Seaside Parcels 1 through 4. On the basis of regulatory requirements, the PRHRA evaluates only exposure to soil. Groundwater was not determined to be adversely impacted at Site 39 (*HLA, 1995a*) and will not be evaluated herein. The chemicals evaluated in this assessment are considered relatively immobile and groundwater in the area is deep (130 feet bgs).

Because COPCs for human receptors were initially identified as part of the site investigations discussed in Section 2.4, further COPC/COPEC selection was not conducted in this assessment. The COPC/COPECs identified were antimony, copper, and lead.

3.1 PRHRA Data Set

As discussed in Section 2.5, the development portions of Ranges 18, 19, 21, and 46 were remediated. To evaluate these ranges, pre-remediation data from soil sampling locations that were not excavated during remedial activities, as well as data from post-remediation samples, were used in the PRHRA. Because the development portions of Ranges 22, 23, and 48 were not remediated, they were evaluated in the PRHRA using data collected during the initial site investigations. Soil data from 0 to 6 inches bgs were collected during post-remediation sampling activities with an occasional sample collected at 1 to 2 feet bgs. Site characterization samples were taken from 0, 1, and 2 feet bgs depth intervals, as discussed in Section 2.4. Because of the nature of contamination at the site (metals from spent ammunition in surface soils), concentrations are expected to be highest in the top 2 feet of soil. Consequently, pre-remediation and post-remediation samples from 0 to 2 foot bgs were compiled for the PRHRA data set. The data used in this PRHRA are shown on Table 3-1. The sample locations are shown on Figures 2-7 through 2-14. Soil outside of the ranges and historical areas within Seaside Parcels 1 through 4 were not sampled because there was no evidence of range activities (i.e., berms, target boxes, fining lines, fuel breaks, fan boundaries, and spent ammunition or MECs) during site characterization (*MACTEC, 2006*). Therefore, the data from the soil samples that were collected from Ranges 18, 19, 21, 22, 23, 46, and 48 were assumed representative of the potentially impacted soils for Seaside Parcels 1 through 4 and combined as one data set. Elevated metals are not anticipated in Seaside Parcels 1 through 4 outside of the historical ranges.

Antimony was detected in 509 samples out of 1,052 samples. The highest concentration of antimony was 22 mg/kg located in Range 18, which is above the background concentration of 8.2 mg/kg but below the

Region IX PRG of 31 mg/kg. Copper was detected in 975 samples out of 1,036 samples. The highest concentration of copper was 1,040 mg/kg located in Range 48, which is above the background concentration of 18.2 mg/kg but below the Region IX PRG of 3,100 mg/kg. Lead was detected in 814 out of 1,052 samples. The highest concentration of lead was 570 mg/kg located in Range 21, which is above the background concentration of 51.8 mg/kg and the Region IX PRG of 400 mg/kg.

3.1.1 Duplicate Samples

Duplicate samples were also collected for selected soil samples. For duplicate samples, the following criteria were used to select the results to be applied in the PRHRA:

- Where all results were reported as non-detect, the most conservative (i.e., highest) reporting limit was used in the PRHRA;
- Where all results were reported as detected, the highest of the results was used in the PRHRA; and
- Where there were both detected and non-detected results, the highest detected result was used in the PRHRA.

3.2 Data Validation and Confirmation

Pre-remediation and post-remediation data were validated consistent with procedures specified in the Former Fort Ord Complex *Draft Final Chemical Data Quality Management Plan* (*HLA, 1997*) and the *Final Draft Contractor Quality Control Plan and Sampling and Analysis Plan, Basewide Soil Remediation Sites, Fort Ord, California* (*IT, 1998*), respectively. The detection limits, quantitation limits, and data qualifiers for all of the chemicals analyzed were reviewed to assess the usability of the data for risk assessment. All the detection limits for the U-qualified values for the COPCs were below their PRGs. All COPC data were found usable for the PRHRA/PRERA; no data points were rejected as R-qualified.

4.0 EXPOSURE ASSESSMENT

This section describes the potential receptors and exposure pathways selected for quantitative risk characterization. Exposure assumptions (or factors), equations used to estimate dose for the selected receptors, and methods used to derive exposure point concentrations are also described.

4.1 Conceptual Site Exposure Model

A conceptual site exposure model (CSEM) was developed to facilitate the analysis of potentially complete exposure pathways within Seaside Parcels 1 through 4. The CSEM schematically represents the relationship between chemical sources and receptors at a site, and identifies potentially complete and significant pathways through which receptors may be exposed to the COPCs. The CSEM is presented in Figure 4-1.

A complete exposure pathway consists of four components (*EPA, 1989*):

- A source and mechanism of chemical release (e.g., release to the subsurface);
- A retention or transport medium (e.g., dust);
- A receptor at a point of potential exposure to a contaminated medium (e.g., resident); and
- An exposure route at the exposure point (e.g., inhalation of particulates).

If any of these four components are not present, then an exposure pathway is considered incomplete and is not evaluated further. If all four components are present, a pathway is considered complete. In addition to the distinction between complete and incomplete pathways, complete exposure pathways can be further delineated into those expected to be insignificant and those that may be significant. The two types of potentially complete pathways are discussed below:

- Potentially Complete but Insignificant Exposure Pathways. Exposure pathways in this category meet all four requirements to be considered complete. However, these pathways are not expected to contribute significantly to the overall exposure for a receptor, due to the nature of the particular fate and transport mechanisms that comprise the pathway. For this reason, the potential health impacts associated with these types of pathways are evaluated qualitatively but not quantified in this risk assessment.

- Potentially Complete and Significant Exposure Pathways. A potentially complete and significant exposure pathway is comprised of fate and transport mechanisms and exposure characteristics that tend to result in more substantial exposures than complete but insignificant pathways. These pathways comprise the majority of exposure, and as such potential health effects associated with these pathways are quantified in the risk assessment.

The potential receptors and potentially complete exposure pathways for the site are discussed in the sections below.

4.1.1 Potential Receptors

The receptors quantitatively evaluated at Seaside Parcels 1 through 4 were identified on the basis of the current anticipated future land use and the need to assess whether restriction of future residential land use is necessary. The proposed land use plans for the Seaside Parcels indicate that the parcel will be primarily residential with areas of mixed uses.

As discussed in Section 2.1, portions of Ranges 18, 19, 20, 21, 22, 23, 46, 48, HA-50, and HA-59 are located within the Seaside 1 through 4 transfer parcels. The remaining portions of the above ranges are located in the habitat reserve portions of Site 39 and are not included in this PRHRA. Receptors evaluated in the PRHRA include:

- Construction workers to assess potential risks associated with future development/construction activities;
- Landscape maintenance workers; and
- Adult and child residents who can potentially live at the site to evaluate the need for land use restrictions.

The conceptual site model for human health (Figure 4-1) illustrates the selected receptors for the PRHRA. Exposures to ecological receptors are unlikely to be significant because Seaside Parcels 1 through 4 are designated to be developed as residential areas with areas of mixed use that will provide only limited habitat for ecological receptors that are adapted to urbanized areas. Ecological exposures in these developed areas are unlikely to be significant.

4.1.2 Exposure Pathways

An individual may have direct contact with surface soil or subsurface soil that is brought to the surface as part of construction or landscaping activities (significant grading of the site is expected due to site redevelopment). If chemicals are present in soil, they may be absorbed through direct pathways such as inadvertent soil ingestion and dermal contact with soil. Additionally, soil particulates can be suspended in air and inhaled by receptors. Exposure to vapors emitted from soil is not expected to be significant at the site because volatile chemicals have not been detected. Accordingly, for all receptors, the exposure pathways identified as potentially complete at Seaside Parcels 1 through 4 are as follows:

- Incidental soil ingestion
- Dermal exposure to soil
- Inhalation of suspended soil particulates.

These pathways were, therefore, quantitatively evaluated in the PRHRA. The potential exposure pathways for each receptor are illustrated in the conceptual site model (Figure 4-1). The ingestion of home-grown produce pathway is also evaluated in the PRHRA for lead only, using the LeadSpread model version 7 (*Cal/EPA, 2000*).

4.2 Exposure Point Concentrations (EPCs)

The EPA defines EPCs as the representative chemical concentrations a receptor may contact at an exposure area over the exposure period (*EPA, 1989*). The typical concept of human exposure at a site or within a defined exposure area is that individuals contact the contaminated medium on a periodic and random basis. Because of the repeated nature of such contact, the human exposure does not really occur at a fixed point but rather at a variety of points with equal likelihood that any given point within the exposure area will be the contact location on any given day. Thus, the EPCs should be the arithmetic averages of the chemical concentrations within the exposure area. To account for uncertainty in estimating the arithmetic mean concentration, EPA recommends that an upper confidence limit (UCL) be used to represent the EPC, as described in subsection 4.2.1. The data used to establish the EPCs for the COPCs are listed in Table 3-1. As recommended in EPA guidance, one-half the reporting limit was used as a proxy concentration for each non-detect sample for the COPCs.

For this PRHRA, two types of EPCs were estimated. Soil EPCs were calculated to evaluate the ingestion and dermal contact exposure pathways. Air EPCs for airborne dust were calculated from the soil EPCs.

4.2.1 Soil Exposure Point Concentrations

The EPA (*1989*) recommends using an estimate of the UCL on the mean as an EPC for prolonged exposures where it is appropriate to group data. Three types of 95 percent UCLs were calculated in this PRHRA for each COPC (Table 4-1): (1) arithmetic 95 percent UCL on the mean (*Gilbert, 1987*); (2) 95 percent UCL by Land's method (*Gilbert, 1987*); and (3) bootstrap-t estimate of the 95 percent UCL (*Manly, 1997*). The equations are provided below for each method. More detailed information on these methods can be found on EPA's website at: http://www.epa.gov/superfund/programs/risk/ragsa/ucl.pdf.

Arithmetic 95 Percent UCL (*Gilbert, 1987*) for a Normal Distribution

$$Arithmetic 95\%UCL = \bar{x} + t_{(\alpha, n-1)} \times \frac{SD}{\sqrt{n}}$$

Where:

$\bar{x}$ =	sample mean
$t_{(\alpha, n-1)}$ =	t score for alpha level (alpha and degrees of freedom = n-1), from table published in Gilbert (*1987*)
SD =	sample standard deviation
n =	number of samples

95 Percent UCL by Land's method (*Gilbert, 1987*) for a Lognormal Distribution

$$Land's 95\%UCL = e^{\bar{x} + 0.5sy^2 + \frac{sy \times H}{\sqrt{n-1}}}$$

Where:

e =	constant (base of the natural log, equal to 2.718)
$\bar{x}$ =	minimum variance unbiased estimator of the sample mean
sy =	minimum variance unbiased estimator of the sample variance
H =	H value, determined from a table derived by Land and published in Gilbert (*1987*)
n =	number of samples

Bootstrap-t Estimate of the 95 Percent UCL (*Manly, 1997*) for a Non-Parametric Distribution

The bootstrap-t method cannot be explained by an equation, but is rather a process used to derive the 95 percent UCL using an advanced computer program. A detailed explanation of the bootstrap-t can be found in Section 4.7 of *ProUCL Version 4.0 Technical Guide*, EPA/600/R-07/041 (*EPA, 2007a*), available on-line at: http://www.epa.gov/esd/tsc/images/proucl4technical.pdf. The bootstrap-t method is used for non-parametric data sets (i.e., data sets that do not fit a normal or log-normal distribution). A bootstrap-t, also known as a bootstrap-pivot algorithm, was used to estimate the bootstrap-t 95 percent UCL in accordance with the following four steps: 1) The data set was randomly re-sampled with replacement to create a synthetic sample of the same size as the original data set; 2) The arithmetic mean, standard error and "T" value for the synthetic data set were calculated according to Section 3.6 of Manly (*1997*); 3) Steps 1 and 2 were performed 500,000 times and the resulting "T" values were ranked; and 4) The 95th percentile value of the 500,000 "T" values created during Step 3 was selected and used in Equation 3.12 of Manly (*1997*) to derive the bootstrap-t estimate of the 95 percent UCL on the mean of the original data set.

For non-detect samples, a concentration equal to one-half of the sample-specific reporting limit was used in the 95 percent UCL calculations.

The Shapiro-Wilk W-test (*Algorithm R94, Appl. Statist., 1995*) was conducted for each COPC within each data set to determine if the data set was normally or log-normally distributed with 95 percent confidence. Based on the results of the W-test, the EPC for each COPC within each data set was derived as follows:

- If the W-test for normality did not fail, the data set was assumed to be normally distributed. The EPC was selected as the lesser of the arithmetic 95 percent UCL on the mean and the maximum detected value.

- If the W-test for normality failed and the W-test for log-normality did not fail, the data set was assumed to be log-normally distributed. The EPC was selected as the lesser of the Land's 95 percent UCL on the mean and the maximum detected value.

- If both the W-test for normality and the W-test for log-normality failed, the data set was assumed to be neither normally nor log-normally distributed. The EPC was selected as the lesser of the bootstrap-t estimate of the 95 percent UCL on the mean and the maximum detected value.

Table 4-1 provides the results of the W-test, the estimated 95 percent UCLs, and the EPC for each COPC and data set for soil.

4.2.2 Air Exposure Point Concentrations from Airborne Dust

EPCs for metals sorbed to airborne dust were derived by multiplying the EPCs in soil (in mg/kg) by the mean annual concentration of respirable particles with a mean diameter of less than or equal to 10 microns (PM_{10}) for the California Standard in micrograms of soil per cubic meter of air (i.e., 20 $\mu g/m^3$) and a unit conversion factor in kilograms per microgram (*CARB, 2005*). EPCs for air are provided in Table 4-1.

4.3 Exposure Assumptions

The PRHRA used single point estimates for each of the input exposure assumptions to develop single point dose estimates for each scenario. Daily intake values were calculated using exposure factors associated with the RME scenario. An RME, as defined by EPA, is the "highest exposure that is reasonably expected to occur" and is estimated using a combination of average and upper bound values of human exposure factors (*EPA, 1989*). Exposure assumptions are provided in Table 4-2.

4.3.1 Exposure Time, Exposure Frequency, and Exposure Duration Parameters

The exposure time and frequency parameters for the construction and landscape maintenance worker receptors are based on a standard work schedule of 8 hours per day, 250 days per year. An exposure duration of one year for the construction worker is used (*DTSC, 2005*). For the landscape maintenance worker, an exposure duration of 25 years (*EPA, 1991; Cal/EPA, 1992*) is assumed.

Exposure time and frequency parameters of 24 hours per day, 350 days per year are used for residential receptors (*Cal/EPA, 1992*). For the adult resident, an exposure duration of 24 years is assumed (*Cal/EPA, 1992*). An exposure duration of 6 years is used for the child resident receptor (*EPA, 1997a; Cal/EPA, 1992*).

4.3.2 Inhalation Rates

The *Exposure Factors Handbook* recommends inhalation rates for a variety of receptors (*EPA, 1997a*). For children of 6 to 8 years, an RME inhalation rate of 0.42 cubic meters per hour (m^3/hr) is recommended. Because this is the highest inhalation rate for a child within the age range of 1 through 6 years evaluated in the risk assessment, this value is used as a conservative estimate of inhalation for child resident receptor. For the residential adult, the inhalation rate is assumed to be 0.83 m^3/hr, which is consistent with Cal/EPA guidance (*1992*). For the construction worker, the inhalation rate of 2.5 m^3/hr is used, based upon heavy outdoor work. For the landscape maintenance worker, the inhalation rate of 1.5 m^3/hr is used, based on moderate activity (*EPA, 1997a*).

4.3.3 Dermal Contact Factors

The following sections provide a description of the exposure factors specific to the dermal contact pathway.

Soil-to-Skin Adherence Factor. The recommended soil-to-skin adherence factor (AF) for the residential adult scenario is 0.07 millimeters per square centimeter (mg/cm^2) (*EPA, 2004a*). This is based on the body-part-specific and activity-specific adherence factors presented in Kissel et al. (*1996*) and Holmes et al. (*1998*). The activity pattern selected to be representative of the average urban suburban resident is the outdoor gardener. This scenario is considered to represent the most likely residential activities, since it includes such activities as weeding, pruning, picking fruit, digging small irrigation trenches, and cleaning up. The weighted adherence factor for this scenario was calculated using the equation below, where SA = surface area:

$$WeightedAF = \frac{SA_1 \times AF_1 + SA_2 \times AF_2 + \ldots SA_i \times AF_i}{SA_1 + SA_2 + \ldots SA_i}$$

Weighted AFs were used to account for the differences in AF for each body part. The AFs for the activity scenarios described in Kissel et al. (*1996*) and Holmes et al. (*1998*) are calculated using the methodology described above.

The recommended AF for the residential child scenario is 0.2 mg/cm^2 (*EPA, 2004a*), and is used to represent a sensitive population with activity patterns that could contribute to increased exposure. The adherence factor is taken from observations of children at play.

The AF value for the landscape maintenance worker (0.04 mg/cm^2) is based on the weighted average soil adherence for a landscaper/rockery, and the value for the construction worker (0.1 mg/cm^2) is based on the weighted average soil adherence for a construction worker (*EPA, 2004a*).

Dermal Surface Area. The adult resident, construction worker, and landscape maintenance worker are conservatively assumed to wear a short-sleeved shirt, shorts, and shoes for the entire exposure duration. For such an individual, the exposed skin surface is limited to the head, hands, forearms, and lower legs. This corresponds to a surface area of 5,700 square centimeter (cm^2). The recommended SA for the child resident exposed to contaminated soil is 2,800 cm^2, which includes the head, hands, forearms, lower legs, and feet (*EPA, 2004a*).

4.3.4 Fraction Contaminated Parameter

A fraction contaminated (FC) parameter was applied to the PRHRA, which assumes that receptors may or may not be directly exposed to contaminated soil, due to the mobility of receptors or physical barriers such as landscaping. A FC of 1 indicates that the receptor can potentially be exposed to all (or 100 percent) of contaminated soil, whereas a FC of 0.5 assumes that a receptor will be exposed to only 50 percent of contaminated soil. For residents, and construction and landscape maintenance workers, the FC is assumed to be 1.

4.3.5 Chemical-Specific Absorption Fractions

All chemicals were assumed to have an oral absorption fraction (fraction ingested) of 1.0 (i.e., 100 percent) for soil. Chemical-specific dermal absorption factors were obtained for all COPCs in soil for the evaluation of dermal contact exposures. Cal/EPA guidance (*Cal/EPA, 1994*) was the source of these factors for residents, construction, and landscape maintenance workers. Dermal absorption factors are compiled in Table 4-2.

For evaluating inhalation exposures, chemicals associated with airborne particulates were assumed to be 100 percent bioavailable.

4.3.6 Soil Ingestion Rates

The RME soil ingestion values identified for assessing residential exposures are 200 milligrams per day (mg/day) for a residential child and 100 mg/day for a residential adult (*Cal/EPA, 1994*). The soil

ingestion rate of 100 mg/day, based on a non-residential commercial/industrial outdoor worker, is used for the landscape maintenance worker and of 330 mg/day for a construction worker (*DTSC, 2005*).

4.4 Intake Estimates

EPA and Cal/EPA-DTSC recommended procedures and exposure assumptions were used to estimate the daily intake (DI), or average daily dose, for each soil pathway evaluated in the PRHRA (*EPA 1991, 1997a; Cal/EPA, 1992*). A DI represents an estimate of a chemical dose that a receptor might receive on a daily basis. DI was calculated for each COPC and each exposure pathway. DI is defined as the average amount of chemical systematically absorbed by the body over a given period of time. For noncarcinogenic effects, the DI is averaged over the period of exposure and is referred to as the average daily dose (ADD). For carcinogenic effects, the DI is averaged over a lifetime and is referred to as the lifetime average daily dose (LADD). The general equations employed to estimate the doses for each exposure pathway considered in the PRHRA are described in the following sections. Standard exposure factors recommended by EPA (*1989, 1991, 1997a*) and Cal/EPA (*1992*) were used to estimate the DIs.

4.4.1 Intake Estimates for Inhalation of Airborne Dust

The chronic DI for the inhalation of airborne dust exposure pathway was calculated according to the following equation:

$$DI = \frac{EPC \times IR_{inh} \times ET \times EF \times ED}{BW \times AT}$$

where:

DI	=	Daily intake (milligrams per kilogram per day [mg/kg-day]);
EPC	=	Exposure point concentration of COPC in air (mg/m^3);
IR_{inh}	=	Inhalation rate (cubic meter per hour [m^3/hr]);
ET	=	Exposure time (hours/day);
EF	=	Exposure frequency (days/year);
ED	=	Exposure duration (years);
BW	=	Body weight (kilograms);
AT	=	Averaging time (days; toxic effect assessment-determined variable, ED x 365 for noncarcinogens; 70 years x 365 for carcinogens).

Table 4-2 presents the exposure assumptions used in the equation. The estimated DIs for inhalation of airborne dust for each COPC and data set are presented in Table 4-3.

4.4.2 Intake Estimates for Dermal Contact with Soil

The chronic DI for dermal contact with soil exposure pathway was calculated according to the following equation:

$$DI = \frac{EPC \times CF \times SA \times AF \times ABS \times FC \times EF \times ED}{BW \times AT}$$

where:

DI	=	Daily intake (mg/kg-day);
EPC	=	Exposure point concentration of COPC in air (mg/kg);
CF	=	Conversion factor (kilograms per milligram [kg/mg]);
SA	=	Skin surface area (centimeter squared per event [cm^2/event]);
AF	=	Soil to skin adherence factor (milligrams per centimeter squared [mg/cm^2]);
ABS	=	Absorption factor (unitless);
FC	=	Fraction contaminated (unitless);
EF	=	Exposure frequency (days/year);
ED	=	Exposure duration (years);
BW	=	Body weight (kilograms);
AT	=	Averaging time (days; toxic effect assessment-determined variable, ED x 365 for noncarcinogens; 70 years x 365 for carcinogens).

Table 4-2 presents the exposure assumptions used in the equation. The estimated DIs for dermal contact with soil for each COPC and data set are presented in Table 4-4.

4.4.3 Intake Estimates for Soil Ingestion

The chronic DI for soil ingestion exposure pathway was calculated according to the following equation:

$$DI = \frac{EPC \times CF \times IR_{ing} \times FI \times EF \times ED}{BW \times AT}$$

where:

DI	=	Daily intake (mg/kg-day);
EPC	=	Exposure point concentration of COPC in air (mg/kg);
CF	=	Conversion factor (kg/mg);
IR_{ing}	=	Ingestion rate (milligrams per day [mg/day]);
FI	=	Fraction ingested (unitless);
EF	=	Exposure frequency (days/year);
ED	=	Exposure duration (years);
BW	=	Body weight (kilograms);
AT	=	Averaging time (days; toxic effect assessment-determined variable, ED x 365 for noncarcinogens; 70 years x 365 for carcinogens).

Table 4-2 presents the exposure assumptions used in the equation. The estimated DIs for soil ingestion for each COPC and data set are presented in Table 4-5.

5.0 TOXICITY ASSESSMENT

This section presents the toxicity assessment for the COPCs evaluated in the PRHRA. Toxicity assessment includes identification of the types of toxicity potentially associated with each COPC (i.e., noncarcinogenic and carcinogenic or cancer causing effects) and the chemical-specific dose-response relationships. The dose-response relationship characterizes the relationship between the dose of a chemical and the probability of an adverse health effect in an exposed population.

The following sections discuss the criteria used to evaluate the potential for noncarcinogenic and carcinogenic effects of the COPCs.

5.1 Noncancer Reference Doses

In deriving dose-response criteria for assessing the potential for noncancer health effects from exposure to chemicals, it is assumed by regulatory agencies that noncancer health effects occur only after a threshold dose is reached. This threshold dose is usually estimated by regulatory agencies from the no-observed adverse effect level (NOAEL) or the lowest-observed adverse effect level (LOAEL) determined from chronic (i.e., long-term) animal studies or human epidemiological studies. The NOAEL is defined as the highest dose at which no adverse effects are observed, while the LOAEL is defined as the lowest dose at which adverse effects are observed.

Uncertainty factors or safety factors are applied to the NOAEL or LOAEL observed in animal studies or human epidemiologic studies to establish "reference doses" (RfDs). A chronic RfD is an estimate of a dose level that is not expected to result in adverse health effects in persons exposed for a lifetime, even among the most sensitive members of the population (e.g., children and the aged).

Cal/EPA does not promulgate noncancer toxicity criteria for human health effects, except within the AB 2588 Air Toxics "Hot Spots" program. Therefore, RfDs developed by EPA were used to evaluate noncarcinogenic health hazards in the PRHRA. The RfDs used in the PRHRA were compiled from EPA's Integrated Risk Information System (IRIS; *EPA, 2007b*). If values were not provided in IRIS for a particular chemical, the Health Effects Assessment Summary Tables (HEAST; *EPA, 1997b*) were consulted, as suggested in EPA's risk assessment guidelines (*EPA, 1989*).

For purposes of this assessment and consistent with EPA (*1989*) guidance, the oral RfDs were used to represent the dermal RfDs. Where inhalation toxicity criteria were not available, oral toxicity criteria were used. The RfDs for the COPCs at Seaside Parcels 1 through 4 are listed in Table 5-1.

5.2 Cancer Slope Factors

In contrast to noncancer effects, chemicals considered to be carcinogenic are treated by regulatory agencies as if any dose, no matter how small, is associated with some risk for developing cancer. In other words, the dose-response curve used for carcinogens (for regulatory purposes) only predicts zero risk when there is zero dose, thereby implying a non-threshold mechanism for all potential carcinogens. The carcinogenic potential of each chemical is assessed using slope factors (SFs) or cancer potency factors (CPFs) which represent the upper-bound estimate of the probability of an individual developing cancer, per unit intake of chemical over a 70-year lifetime. At Seaside Parcels 1 through 4, the only COPC that is considered to be carcinogenic is lead, which is not evaluated using SF/CPFs, as described below. Antimony and copper are not considered carcinogenic and therefore, do not have SF/CPFs (Table 5-1).

An important component of the toxicity assessment is an evaluation of the weight-of-evidence for human carcinogenic potential of each chemical. In assessing carcinogenicity, the Human Health Assessment Group (HHAG) of EPA classifies chemicals into one of the following groups, according to the weight-of-evidence from epidemiologic and animal studies (*EPA, 1997b*):

- Group A – Human carcinogen (sufficient evidence of carcinogenicity in humans).
- Group B – Probable human carcinogen (B1-limited evidence of carcinogenicity in humans; B2-sufficient evidence of carcinogenicity in animals with inadequate or lack of evidence in humans).
- Group C – Possible human carcinogen (limited evidence of carcinogenicity in animals and inadequate or absent human data).
- Group D – Not classifiable as to human carcinogenicity (inadequate or no evidence).
- Group E – Evidence of noncarcinogenicity for humans (no evidence of carcinogenicity in adequate studies).

Generally, quantitative carcinogenic risks are evaluated only for chemicals identified as Group A or B, and, on a case-by-case basis, for Group C chemicals. Lead is the only COPC identified as a carcinogen

and is classified as a Group B2 carcinogen. However, due to the unique chemical properties of lead, the quantification of cancer risks is associated with uncertainty due to receptor physiology and exposure conditions that influence the absorption, release, and excretion of lead. Because of the uncertainty with the models used to calculate slope factors, EPA has determined that, at this time, it is inappropriate to use a numerical estimate for the evaluation of lead cancer risks. Therefore, lead is evaluated differently than other chemicals using biokinetic modeling to estimate a blood-lead concentration, as described in Section 6.0.

6.0 LEAD EVALUATION

Exposure to lead was evaluated for all receptors at Seaside Parcels 1 through 4 using the Cal/EPA LeadSpread model, version 7 (*Cal/EPA, 2000*). The LeadSpread model was used to estimate blood lead concentrations that result from exposure to lead through dietary intake, drinking water, soil and dust ingestion, inhalation, and dermal contact. The LeadSpread model incorporates background exposures to lead in air, drinking water, and food; user-defined media concentrations; and default and user-defined exposure assumptions. The model also processes empirically derived toxicokinetic relationships to estimate blood-lead concentrations. The LeadSpread model addresses possible exposures to lead via inhalation of airborne dust and air, incidental ingestion of soil, dermal contact with soil, ingestion of drinking water, and ingestion of food. The food ingestion component can include ingestion of home-grown produce.

6.1 Exposure Assumptions

Environmental site-specific assumptions were incorporated into the LeadSpread model where applicable. The soil lead concentration used in the model was the EPC that was derived from site-specific soil concentrations as discussed in Section 4.2. The default concentration of suspended soil particulates (1.5 $\mu g/m^3$) was replaced with the California Standard PM_{10} concentration of 20 $\mu g/m^3$ (*CARB, 2005*). Lead was not detected in any samples that were collected by the Marina Coast Water District (MCWD) in 2006, which provides water service to the communities at Fort Ord and Seaside (*MCWD, 2006*). Therefore, a concentration of 15 micrograms per liter (µg/L) of lead in drinking water was used in the model because the default value for the model and the action level for MCWD are the same. Default values for lead concentrations in air (0.028 $\mu g/m^3$) and percentage of ingested home-grown produce (7 percent) were used.

The LeadSpread model provides default exposure assumptions for child, adult, and occupational receptors. However, the PRHRA evaluated construction worker and landscape maintenance worker receptors, which are not available in the LeadSpread model. Therefore, site-specific exposure assumptions were applied to the LeadSpread model for these receptors. Site-specific exposure frequencies, skin surface areas, soil adherence factors, soil ingestion rates, and breathing rates, presented in Section 4.3, were input into the LeadSpread model for these receptors as shown on the LeadSpread worksheet Table 6-1.

7.0 HUMAN HEALTH RISK CHARACTERIZATION

This section of the PRHRA provides a quantitative evaluation of estimated noncancer hazards and estimated blood-lead levels to potential receptors from exposure to COPCs in soil at Seaside Parcels 1 through 4. Noncancer hazard indices are summarized in Table 7-1. Estimated blood-lead levels are presented in Table 6-1. Quantitative cancer risks were not calculated for any of the COPCs in this PRHRA because antimony and copper are only associated with noncancer effects and lead was evaluated using the LeadSpread model.

7.1 Estimated Noncancer Health Effects

A hazard quotient (HQ) is estimated to evaluate each COPC individually for each exposure pathway. The HQ is the site-related ADD divided by the RfD, which represents the acceptable daily intake. The hazard quotients are then added for all chemicals for all pathways for each receptor. The sum of the HQs is referred to as the "hazard index" (HI). If the HI is less than 1, a noncancer hazard is not considered likely to exist under the exposure conditions evaluated, even among the most sensitive members of the population, including children (where applicable) and the aged.

Based on RME assumptions, the estimated HIs for each receptor are summarized in the following table:

Summary of Hazard Indices

Receptors	**Seaside Parcels 1 through 4**
Child Resident	$1.0x10^{-1}$
Adult Resident	$1.1x10^{-2}$
Construction Worker	$2.5x10^{-2}$
Landscape Maintenance Worker	$7.7x10^{-3}$

Because these values are well below 1, residual chemicals at the site are considered unlikely to pose a significant noncancer health hazard for potential receptors evaluated on the basis of future recreational, commercial, and residential land use, and the exposure conditions evaluated.

7.2 Lead Modeling

The LeadSpread model uses site-specific data and biokinetic modeling to estimate blood-lead concentrations. It is assumed that all receptors will be exposed to background lead concentrations in drinking water, air, and food, in addition to site-specific lead concentrations in site soil. For the residential scenario, lead uptake via ingestion of homegrown produce is also assessed. Estimated blood-lead concentrations are compared to a target blood-lead concentration of 10 µg/dL. This concentration represents a LOAEL based on findings by the Agency for Toxic Substances and Disease Registry (ATSDR).

The 99th percentile of calculated blood-lead levels for each receptor is compared to the target blood-lead level of 10 µg/dL to determine if adverse health effects may be expected. Results of the blood-lead modeling using the EPCs are summarized in Table 6-1.

The estimated 99th percentile blood-lead levels for each receptor are summarized as follows:

Receptors	**Seaside Parcels 1 through 4**
Child Resident	7.0
Adult Resident	4.0
Construction Worker	4.2
Landscape Maintenance Worker	3.5

The 99th percentile blood-lead levels above, are all below the target blood-lead level of 10 µg/dL, indicating that lead at Site 39, Seaside Parcels 1 through 4 soil is unlikely to pose a hazard to future receptors.

8.0 UNCERTAINTY ANALYSIS

Uncertainty is inherent in many aspects of the risk assessment process. Because direct measurements are not available for many of the criteria upon which the risk estimates are dependent (e.g., air concentrations, human exposure parameters, and low dose criteria), conservative assumptions and methodologies are employed to eliminate the possibility of underestimating risk. Some of the major factors in uncertainty are qualitatively discussed below.

8.1 Potential for Presence of Additional Chemicals

The evaluated sites at Fort Ord have undergone much characterization over the last few years. A range of laboratory analytical methods has been used to assess the presence of pesticides, solvents, semivolatile compounds, metals, and petroleum hydrocarbons. These analytical methods represent the gamut of chemicals that have toxicological significance. Accordingly, it is unlikely that potentially toxic chemicals that are present at the site were not detected by these methods.

8.2 Evaluation of Chemicals That May Not Be Associated with Site Releases

The chemicals detected at the site and evaluated in the PRHRA possibly represent natural or anthropogenic background. Metals in soil can result from (1) naturally occurring (background) rocks and minerals, (2) anthropogenic sources (i.e., resulting from human activities, but not related to a particular site), or (3) activities or release from a site.

8.3 Uncertainty of Exposure Pathways and Future Land Uses

The estimation of cancer risks and noncancer hazards are conditional on the proposed future land use occurring. In order to assess the risks from a variety of possible conditions, a number of scenarios were evaluated at each site, covering residential, commercial, and construction exposures. The residential and commercial land use evaluation is consistent with planned future land use. Each of the exposure scenarios evaluated is consistent with the current proposed land use for the Seaside parcel. Evaluation of the residential scenario provides an assessment that is protective for a wide range of future land uses. Because risks for the residential scenario are within EPA's acceptable risk range, the site does not pose risks for other possible receptors. The exposure scenarios evaluated in the PRHRA assume that each

receptor would spend all of their exposure time on one or all of the three ranges located within the Seaside parcel. Because the development portions of Ranges 18, 19, 20, 21, 22, 23, 46, 48, HA-50, and HA-59 are only a fraction of the larger Seaside parcel, it is unlikely to assume that any one receptor would spend all of their time on any one range. Therefore, the risk assessment is likely to overestimate the potential risks to all receptors that may use the Seaside parcels.

8.4 Exposure Point Concentrations

Exposure assumptions are single point estimates used to develop the dose estimates for each scenario. They are based on information that is highly conservative in nature and are intended to overestimate exposure in order to be protective of sensitive members of the population. Many exposure assumptions (i.e., ingestion rates and breathing rates) are based on studies of populations and are intended to be representative of 95 percent of the population. In most cases, the use of this assumption would only moderately overestimate exposure and the resulting risks.

8.5 Lead Evaluation

The lead evaluation using the LeadSpread model is likely to overestimate the potential risk to all of the receptors that may use the Seaside parcels due to the water ingestion pathway. This pathway assumes that the receptors will be consuming water from the Seaside parcels. As discussed in Section 6.1, drinking water for the site is provided by the MCWD and a concentration of 15 µg/L was used in the model. This drinking water concentration contributes 41 percent (%) to the overall blood estimate for child resident receptor to maximum contribution of 71% to the overall blood estimate for landscape maintenance worker.

9.0 POST-REMEDIATION ECOLOGICAL RISK ASSESSMENT

A qualitative risk analysis was conducted for the ecological receptors for Seaside Parcels 1 through 4. As discussed in Section 2.3, the following ecological receptors are present and evaluated in the BERA and ERA for Site 39: terrestrial plants, soil invertebrates, reptiles, aquatic life/amphibians, deer mouse, gray fox, mourning dove, red-tailed hawk, bushtit, and American robin. The ERA prepared by MACTEC/ABBL evaluated ingestion of soil and ingestion of food items that have taken up COPECs as exposure pathways, but did not evaluate ingestion of dust and dermal exposure as exposure pathways because it was found that they were not significant exposure pathways. The threshold values that were developed in the ERA for lead were used in this qualitative risk analyses. The threshold concentrations and development of the threshold concentrations for lead are discussed below. Threshold values were not developed for antimony and copper because they do not contribute significantly to the overall ecological risks at the Impact Area.

Although aquatic life/amphibians were evaluated in the BERA and ERA and the California tiger salamander buffer extends into the southern portion of HA-112, they were not qualitatively evaluated in this ecological assessment. They were not qualitatively evaluated due to the lack of surface water at Seaside Parcels 1 through 4. In addition, the results of the ERA indicated that there were no elevated risks to aquatic life/amphibians specifically the California tiger salamander in areas where ponds were present.

9.1 Threshold Concentrations for Lead

As lead is the most prevalent COPEC and contributes the majority of risk at the Impact Area, remedial alternatives in the ERA were developed based on concentrations of lead in surface soil. The lead concentration ranges established in the ERA correspond to approximate threshold concentrations based on protection of potential receptors at the Impact Area, ranging from protection of the most sensitive wildlife receptors (insectivorous and herbivorous birds and small mammals) to protection of less sensitive wildlife receptors (raptors, carnivorous mammals, plants, and invertebrates). The threshold concentrations for lead were estimated by back-calculating acceptable lead concentrations in soil for each wildlife receptor, assuming a target lead HQ of one using the baseline risk estimates and EPCs presented in the ERA, respectively. The ratio of the baseline EPC to the HQ was calculated for each concentration range and each receptor and the range of thresholds evaluated to develop the lead concentration ranges in soil. In developing the range of threshold values, the focus was on the LOAEL-based values which are more

representative of population level risks. LOAEL-based values ranged from approximately 225 mg/kg to 10,300 mg/kg for all receptors except the bushtit. NOAEL-based thresholds ranged from approximately 110 mg/kg to 5,500 mg/kg, for all but the bushtit. The lowest thresholds were based on the American robin since insectivorous birds drive the assessment of risks for lead. The bushtit was not used because risks to the bushtit are predicted at the background levels of lead (*MACTEC/ABBL, 2007*).

The ranges of thresholds derived in the ERA were rounded to approximate the range of thresholds calculated and the values roughly correspond to receptors and endpoints as follows (*MACTEC/ABBL, 2007*):

- 225 mg/kg: approximates the LOAEL-based threshold concentration protective of insectivorous birds (based on the American robin);
- 450 mg/kg: approximates the NOAEL-based threshold concentration protective of insectivorous mammals and the LOAEL-based threshold concentration protective of herbivorous birds;
- 910 mg/kg: approximates the NOAEL-based threshold concentration protective of raptors (carnivorous birds) and the LOAEL-based threshold concentration protective of insectivorous mammals;
- 1,860 mg/kg: approximates the NOAEL-based threshold concentration protective of herbivorous small mammals, the benchmark value to invertebrates, and the LOAEL-based threshold concentration protective of raptors, and is also the ROD cleanup level based on protection of human health (recreational visitor); and
- Greater than 1,860 mg/kg: lead concentrations greater than the ROD cleanup level based on protection of human health (recreational visitor); the NOAEL for plants and carnivorous mammals (gray fox) are roughly twice the 1,860 mg/kg value.

9.2 Threshold Values versus Site Concentrations

The threshold values for lead that were developed for the ERA as discussed above were compared to the lead concentrations in soil and the calculated EPC for Seaside Parcels 1 through 4 presented in Table 4-1. One soil sample was above the NOAEL threshold value of 450 mg/kg and 83 soil samples were above the LOAEL threshold value of 225 mg/kg. The EPC that was calculated for Seaside Parcels 1 through 4 (67.47 mg/kg) is more than 3 times below the LOAEL threshold value of 225 mg/kg. In response to

comments on the Draft report, EPCs for each individual Seaside Parcel were also calculated and ranged from 24.78 to 100.2 mg/kg. Even the highest calculated EPC is 2 times below the LOAEL threshold value of 225 mg/kg. These calculations are provided as an attachment to the Response to Comments provided in Appendix A. Since ecological receptors are not stationary (i.e., they roam while foraging, establishing or guarding habitat, etc.), and the Seaside Parcels will be developed by the City of Seaside as residential and mixed use development that will be of relatively low ecological habitat value, future site-related risks associated with exposure of ecological receptors to COPECs in site media are likely negligible.

10.0 SUMMARY AND CONCLUSIONS

This section summarizes the projected future uses, exposure scenarios considered, and the results and conclusions of the PRHRA for the portions of Site 39 that are scheduled to be transferred to the City of Seaside (Seaside Parcels 1 through 4). The future land uses for the transfer parcels include residential and mixed use. For the purposes of this assessment, Seaside Parcels 1 through 4 was evaluated together for a sitewide analysis.

10.1 Post-Remediation Health Risk Assessment

The receptors evaluated in the PRHRA included adult and child residents, construction workers, and landscape maintenance workers. For all receptors evaluated, the exposure to COPCs (antimony, copper and lead) via ingestion, inhalation of particulates, and dermal contact with soil were assessed to evaluate potential cancer risks and noncancer health hazards. The estimated HIs and incremental cancer risks are presented in Tables 4-3 through 4-5 and 7-1. As discussed in Section 7.1, the noncancer HIs for all of the scenarios are below EPA's threshold (i.e., an HI of 1). The estimated blood-lead levels for Seaside Parcels 1 through 4 are below the threshold level of 10 μg/dL blood (Table 6-1), indicating that the amount of risk due to an exposure to lead in soils is below the levels of concern established by Cal/EPA and EPA. As discussed in Section 8.0, the uncertainties in the PRHRA method would tend to overestimate rather than underestimate risks and hazards.

Based upon the conservative evaluation of potential risks and hazards under post-remediation conditions, adverse noncancer health effects and cancer risks are considered unlikely to be associated with future commercial or residential development at the Seaside parcels under the exposure conditions evaluated. In addition, due to the reduction in human health risks following the remediation of Ranges 18, 19, 21, and 46, a restriction on residential development is not recommended.

10.2 Post-Remediation Ecological Risk Assessment

A qualitative risk analysis was conducted for ecological receptors potentially present at Seaside Parcels 1 through 4. As discussed in Section 2.3, the following ecological receptors are present and evaluated in the BERA and ERA for Site 39: terrestrial plants, soil invertebrates, reptiles, aquatic life/amphibians, deer mouse, gray fox, mourning dove, red-tailed hawk, bushtit, and American robin. The threshold values that were developed in the ERA for lead were used in the qualitative risk analyses. Based on a comparison of

threshold values (225 mg/kg protective of insectivorous birds and 450 mg/kg protective of insectivorous mammals and herbivorous birds) with residual lead concentrations remaining in soil (67.47 mg/kg) at Seaside Parcels 1 through 4 (maximum of 100.2 mg/kg at Seaside 4), and consideration of the habitat value under the future residential/mixed land use scenario, ecological risks are predicted to be negligible and no further action is recommended.

11.0 LITERATURE CITED

Algorithm R94, Appl. Statist, 1995. *Applied Statistics, Series C of the Journal of the Royal Statistical Society*, Blackwell Publishing, Ltd., Oxford UK. 44(4).

California Air Resource Board (CARB), 2005. *Ambient Air Quality Standards*. November 29.

California Environmental Protection Agency (Cal/EPA), 1992. *Supplemental Guidance for Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities*. Department of Toxic Substances Control.

_____, 1994. *Preliminary Endangerment Assessment Guidance Manual*. Department of Toxic Substances Control.

_____, 2000. Lead Risk Assessment Spreadsheet, Version 7. Department of Toxic Substances Control. Preliminary Version.

Department of Toxic Substance Control (DTSC), 2005. *Recommended DTSC Default Exposure Factors for Use in Risk Assessment at California Military Facilities.* Human and Ecological Risk Division (HERD). October 27.

Gilbert, R.O., 1987. *Statistical Methods for Environmental Pollution Monitoring*. New York, Van Nostrand Reinhold Co.

Harding Lawson Associates (HLA), 1995a. *Basewide Remedial Investigation/Feasibility Study, Fort Ord, California. Volume III, Baseline Human Health Risk Assessment.* Final. October.

_____, 1995b. *Basewide Remedial Investigation/Feasibility Study, Fort Ord, California, Volume IV, Baseline Ecological Risk Assessment*. Final. October.

_____, 1997. *Draft Final Chemical Data Quality Management Plan, Former Fort Ord, California*. July 22.

_____, 1998a. *Technical Memorandum, Draft Final Work Plan, Post-Remediation Health Risk Assessment, Sites 12, 16, and 17, Fort Ord, Monterey County, California*. October 27.

_____, 1998b. *Technical Memorandum, Draft Work Plan, Post-Remediation Risk Assessment, Site 31, Former Fort Ord, Monterey County, California*. October 26.

_____, 1998c. *Draft Final Additional Ecological Risk Evaluations, Site 3 – Beach Trainfire Ranges, Fort Ord, California*. September.

_____, 1999a. *Technical Memorandum, Draft Final Work Plan, Post-Remediation Risk Assessment, Site 3, Former Fort Ord, Monterey County, California*. October 5.

_____, 1999b. *Draft Final Additional Soil Characterization – Site 39, Work Plan, Former Fort Ord, California*. Contract No. DACA05-86-C-0241.

_____, 1999c. *Pilot Study, Site 39 Small Arms Ranges, Former Fort Ord, Monterey, California*.

_____, 2000. *Appendix B, Draft Post-Remediation Risk Assessment Site 39, Ranges 24, 25, and 26, Fort Ord, California*. February 28.

Holmes, K.K., J.H. Shirai, K.Y. Richter, and J.C. Kissel, 1998. Field Measurement of Dermal Soil Loadings in Occupational and Recreational Activities. *Journal of Soil Contam*. In Press.

International Technology, Inc. (IT), 1998. *Final Draft Contractor Quality Control Plan and Sampling and Analysis Plan, Basewide Soil Remediation Sites, Fort Ord, California*. August.

Kissel, J., K. Richter, and R. Fenske, 1996. *Field Measurements of Dermal Soil Loading Attributable to Various Activities: Implications for Exposure Assessment*. *Risk Analysis*. 16(1): 116-125.

MACTEC Engineering and Consulting, Inc. (MACTEC), 2006. *Draft Final Comprehensive Basewide Range Assessment Report, Former Fort Ord, California*. Revision 1C. November 24.

MACTEC Engineering and Consulting, Inc. and Arcadis BBL (MACTEC/ABBL), 2007. *Final Ecological Risk Assessment for Site 39 Ranges Habitat Areas, Impact Area, Former Fort Ord, California*. Revision 1. October 31.

Manly B.F.J., 1997. *Randomization, Bootstrap and Monte Carlo Methods in Biology.* Second Edition. Chapman and Hall, London, UK, 1997. ISBN 0-412-72130-9.

Marina Coast Water District (MCWD), 2006. *2006 Consumer Confidence Report, for Central Marina and Ord Community*. http://www.mcwd.org.

Parsons, 2006. *Final Technical Information Paper, MRS-SEA.1-4, Time Critical Removal Action and Phase 1 Geophysical Operations*. February 11.

Shaw Environmental & Infrastructure, Inc. (Shaw), 2002. *Sampling and Analysis Plan, Characterization and Remediation Confirmation, Site 39, Ranges 18 and 19, Former Fort Ord, California*. August 1.

_____, 2003. *Draft Final Remedial Action Confirmation Report Site 39, Ranges 21 and 46, Basewide Remediation Sites, Former Fort Ord, California*. January.

_____, 2005. *Draft Final Remedial Action Confirmation Report Site 39, Ranges 18 and 19, Basewide Remediation Sites, Former Fort Ord, California*. February.

United States Army (Army), 1945. *Training Facilities, Fort Ord and Vicinity, California*. Revised August 1945.

_____, 1954. *Training Areas That Cannot Be Used At Same Time: (As Presented In Use).* Circa 1954.

_____, 1973. *U.S.A.I.C. and Fort Ord Reg 350-5, Range Data and Special Instructions.* April 27.

_____, 1980. *Range Regulations, Fort Ord Regulation 350-5, H.Q. 7th Infantry Division and Fort Ord Californi*a. September 9.

_____, 1991. *Fort Ord / Training Area Operating Procedures and Usage Guide.* June.

United States Army Corps of Engineers (USACE), 1995. *Risk Assessment Handbook – Human Health Evaluation Manual*. Volume I. EM200-1-4. June 30.

U.S. Environmental Protection Agency (EPA), 1989. *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A)*. Office of Emergency and Remedial Response. EPA/540/1-89/002.

_____, 1991. *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors.* Publication 9285.6-03. Office of Emergency and Remedial Response. NTIS PB91-921314.

_____, 1997a. *Exposure Factors Handbook.* Office of Research and Development. EPA/600/P-95/002FA.

_____, 1997b. *Health Effects Assessment Summary Tables (HEAST).* Office of Solid Waste and Emergency Response.

_____, 1998a. *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual, Supplemental Guidance for Dermal Risk Assessment, Interim Guidance*. Internal Draft. Office of Emergency and Remedial Response.

_____, 1998b. *Risk Assessment Guidance for Superfund (RAGS). Volume I, Human Health Evaluation Manual. Part D: Standardized Planning, Reporting, and Review of Superfund Risk Assessments*. Office of Solid Waste and Emergency Response. EPA/540/F-97/036. January.

_____, 1999. *Region IX Preliminary Remediation Goals (PRGs)*. Stanford J. Smucker, Regional Toxicologist. October 1.

_____, 2003. *Draft Final Guidelines for Carcinogen Risk Assessment*. EPA/630/P-03/001A. February.

_____, 2004a. *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment)*. Final. EPA/540/R/99/005. July.

_____, 2004b. *Region 9 Preliminary Remediation Goals*. San Francisco, California. October 20.

_____, 2007a. *ProUCL Version 4.0 Technical Guide*. EPA/600/R-07/041. April.

_____, 2007b. Integrated Risk Information System (IRIS). Website address: www.epa.gov/iris.