95th Air Base Wing
Edwards Air Force Base, California

Environmental Restoration Program

Record of Decision
Operable Unit 7
Chemical Warfare Materiel
Edwards AFB, California

Final

June 2009

ENVIRONMENTAL RESTORATION PROGRAM
RECORD OF DECISION
OPERABLE UNIT 7
CHEMICAL WARFARE MATERIEL

EDWARDS AIR FORCE BASE
CALIFORNIA

JUNE 2009

FINAL

Prepared for

95th AIR BASE WING
ENVIRONMENTAL RESTORATION DIVISION (95 ABW/EMR)
EDWARDS AIR FORCE BASE, CA 93524

and the

ERP PROGRAM OFFICE
AIR FORCE CENTER FOR ENGINEERING AND THE ENVIRONMENT/
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LIST OF ABBREVIATIONS AND ACRONYMS

<	less than
%	percent
§	section
µg/adsorbent	micrograms per adsorbent
µg/L	micrograms per liter
95 ABW/CEVR	95th Air Base Wing/Environmental Restoration Branch
95 ABW/EMR	95th Air Base Wing/Environmental Restoration Division
ABM	Aberdeen Bombing Mission
AF	Air Force
AFB	Air Force Base
AFCEE/ERD	Air Force Center for Environmental Excellence, Environmental Restoration Division
AFCEE/EXEW	Air Force Center for Engineering and the Environment/ Environmental Programs Execution – West
AFCEE/ISM	Air Force Center for Environmental Excellence/Installation Support, AFMC
AFFTC/EM	Air Force Flight Test Center, Environmental Management Directorate
AFFTC/EMR	Air Force Flight Test Center, Environmental Restoration Division
AFMC	Air Force Materiel Command
AFRL	Air Force Research Laboratory
AOC	area of concern
APG	Aberdeen Proving Ground
ARAR	Applicable or Relevant and Appropriate Requirement
ATSDR	Agency for Toxic Substances and Disease Registry
AVEK	Antelope Valley-East Kern
bgs	below ground surface
CAI	closed, abandoned, or inactive
Cal/EPA	California Environmental Protection Agency
CAS	Chemical Abstracts Service
CCR	California Code of Regulations
CDFG	California Department of Fish and Game
CDHS	California Department of Health Services
CDWR	California Department of Water Resources
CE	Civil Engineering
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
CESA	California Endangered Species Act
CFR	Code of Federal Regulations
Cl	chloride
cm/s	centimeters per second
CNS	chloroacetophenone (tear gas solution)
COC	contaminants of concern
CRWQCB	California Regional Water Quality Control Board

CWA	chemical warfare agent
CWC	California Water Code
CWM	chemical warfare materiel
CZ	Containment Zone
DAAMS	Depot Area Air Monitoring System
DCA	dichloroethane
DCB	dichlorobenzene
DCFM	dichlorodifluoromethane
DEM	diethyl malonate
DFRC	Dryden Flight Research Center
DMMP	dimethyl methyl phosphonate
DoD	Department of Defense
DTSC	Department of Toxic Substances Control
DWR	Department of Water Resources
EC	engineering control
ECBC	Edgewood Chemical Biological Center
EE/CA	engineering evaluation/cost analysis
EM	electromagnetic induction
EOD	Explosive Ordnance Division
EPA	Environmental Protection Agency
ERP	Environmental Restoration Program
ET	evapotranspiration
et seq.	*et sequentes* (and the following)
FID	flame ionization detector
FFA	Federal Facility Agreement
FS	Feasibility Study
FS	sulfur trioxide – chlorosulfonic acid smoke
ft/bgs	feet below ground surface
GA	tabun (ethyl N,N-dimethylphosphoramidocyanidate)
GB	sarin (isopropylmethyl phosphonofluoridate)
GIS	Geographic Information System
GP	General Plan
gpd	gallons per day
GPR	ground penetrating radar
GPS	global positioning system
H	mustard (bis [2-chloroethyl] sulfide)
H&S	health and safety
HB&A	Higginbotham/Briggs & Associates
HD	distilled mustard
HDX	High Melting eXplosive
HHRA	human health risk assessment
HI	Hazard Index

LIST OF ABBREVIATIONS AND ACRONYMS *(Continued)*

HSA	hollow stem auger
IC	institutional control
ID	identification
IM	incendiary bomb fill
INRMP	Integrated Natural Resources Management Plan
IP	induced polarization
IP/Res	induced polarization/resistivity
IRA	interim response action
KCEHSD	Kern County Environmental Health Services Department
L	lewisite
LUC	land use control
LUFT	leaking underground fuel tank
MAG	magnetic gradiometer
MARB	Munitions Assessment Review Board
MCL	Maximum Contaminant Level
MES	methyl salicylate
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MINICAMS®	Miniature Chemical Agent Monitoring System
MRBS	Munitions Residue Burial Site
MSL	mean sea level
N	nitrate
NA	not applicable
NASA	National Aeronautics and Space Administration
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
ND	not detected
NFI	No Further Investigation
NP	not promulgated
NPL	National Priorities List
OSWER	Office of Solid Waste and Emergency Response
OU	operable unit
PB	Precision Bombing
PB-Chem	Precision Bombing Chemical
PCB	polychlorinated biphenyl
PERA	Pre-scoping Ecological Risk Assessment
PHC	principal hazardous constituents
PID	photoionization detector
PIRA	Precision Impact Range Area
PRG	Preliminary Remediation Goal
PS	chloropicrin
PT1	incendiary bomb fill
RA	remedial action
RAB	Restoration Advisory Board

LIST OF ABBREVIATIONS AND ACRONYMS *(Continued)*

RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RDX	Research Department composition X or Royal Demolition eXplosive
RI	remedial investigation
ROD	record of decision
RPM	Remedial Project Manager
RTS	Report to Stakeholders
SARA	Superfund Amendments and Reauthorization Act
SO_4	sulfate
STL	Severn Trent Laboratories
SVOC	semivolatile organic compound
SWRCB	State Water Resources Control Board
TAMS	TestAmerica West Sacramento
TCB	trichlorobenzene
TCE	trichloroethene
TDL	total designated level
TDS	total dissolved solids
TEPH	total extractable petroleum hydrocarbons
TEU	U.S. Army Technical Escort Unit
TMB	trimethylbenzene
TRC	Technical Review Committee
TSDF	Treatment, Storage, and Disposal Facility
TVPH	total volatile petroleum hydrocarbons
UEH	unknown extractable hydrocarbon
USAF	United States Air Force
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UST	underground storage tank
USTI	Underground Storage Tank Investigation
UVH	unknown volatile hydrocarbon
UXO	unexploded ordnance
VOCs	volatile organic compounds
VR	visual reconnaissance

1.0 Part 1: Declaration

1.0 PART 1: DECLARATION

1.1 SITE NAME AND LOCATION

Edwards Air Force Base (AFB) (Base), Kern, Los Angeles, and San Bernardino Counties, California, United States Environmental Protection Agency (USEPA) Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) Identification Number: CA1570024504.

1.2 STATEMENT OF BASIS AND PURPOSE

This decision document presents the selected remedies for Operable Unit 7 (OU7), Chemical Warfare Materiel (CWM) at Edwards AFB, California, hereafter referred to as OU7 CWM, which were chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended by Superfund Amendments and Reauthorization Act (SARA) of 1986, and the CERCLA regulation National Oil and Hazardous Substances Pollution Contingency Plan (NCP). This decision document is based on documents contained in the Administrative Record File for OU7 CWM at Edwards AFB, 95th Air Base Wing, Environmental Management Directorate, 5 East Popson Avenue, Building 2650A.

The United States Air Force (USAF) and the USEPA are selecting the remedies contained in this Record of Decision (ROD) in concurrence with the California Environmental Protection Agency (Cal/EPA) Department of Toxic Substances Control (DTSC) and the California Regional Water Quality Control Board (Water Board), Lahontan Region to protect public health and welfare, and the environment.

1.3 ASSESSMENT OF OPERABLE UNIT 7, CHEMICAL WARFARE MATERIEL

This ROD addresses two sites located within OU7 CWM. These sites are:

- Site 426 - World War II Chemical Warfare Materiel Storage Yard.
- Site 442 - Known Explosive Ordnance Division (EOD) Burial Locations (which consists of three non-contiguous areas designated as Areas 1, 2, and 3).

For Site 426, the Remedial Project Managers (RPMs) have determined that no further action (see the Memorandum for Record, Appendix A), which would include the implementation of land use controls (LUCs), is necessary to protect public health or welfare or the environment because no constituents were found at the site above risk based cleanup levels acceptable for unrestricted use and unlimited exposure. All infrastructure associated with the former World War II Chemical Warfare Materiel Storage Yard that was considered potentially contaminated with CWM (i.e., soil and concrete) was removed during the interim response action. After it was determined that there were no constituents detected at concentrations above acceptable levels (see the Memorandum for Record, Appendix A), the infrastructure were stockpiled at designated areas on Base (Earth Tech, Inc. [Earth Tech] 2004b).

For Site 442, the selected remedial actions presented in this ROD are necessary to protect public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment. The site includes three known EOD burial locations that contain potentially hazardous intact munitions or munitions residue, possibly including CWM, chemical warfare agent (CWA), and industrial chemicals. Because of safety risks, soil samples were not collected within the limits of the burial trenches as delineated by geophysical methods (see Section 2.5.8). However, soil samples were collected from boreholes drilled adjacent to the burial locations, but only low levels of contaminants were detected in the samples, and the risk levels to human health and the environment are considered acceptable. Because the presence of buried CWM cannot be ruled out, remedial actions are necessary at these locations to reduce the probability of a future release of hazardous substances to groundwater, and to prevent potential direct exposure to future residents and industrial workers, which could result from contact with CWM.

1.4 DESCRIPTION OF THE SELECTED REMEDY

The regulatory agencies determined that no further remedy is required for Site 426 (see Section 1.3). The regulatory agencies further determined that a remedy is required for Site 442. The selected remedy for Site 442 is intended to be the final action for OU7 CWM, and is addressed independently of the other Operable Units (OUs) at Edwards AFB. The selected remedy includes the implementation of LUCs, berm construction to improve stormwater management, an enhanced cover system, and long-term management. The main components of the selected remedy include:

1. Adding additional soils to enhance the existing soil cover to contain the buried ordnance and prevent stormwater infiltration;

2. Performing grading in the trench areas to prevent stormwater ponding and to promote runoff;

3. Constructing a 2-foot-high berm wall at each burial location to prevent stormwater from running onto the burial trenches;

4. Installing fencing with locking gates that meets U.S. Fish and Wildlife Service standards for desert tortoise exclusion fencing around the perimeter of each area, constructing concrete dams at the gates, and warning signs posted on the fences to provide access controls;

5. Revegetating the disturbed areas with native plants;

6. Conducting visual inspections of the stormwater controls at least annually and repairing as needed;

7. Conducting visual inspections of the landfill cover at least annually and repairing as needed;

8. Collecting soil gas samples adjacent to the waste cells at least once every five years to confirm that volatile organic compound (VOCs) and CWAs or CWA degradation products have not been released;

9. Implementing and maintaining LUCs in perpetuity to prevent contact with the buried ordnance and prevent the unauthorized disposal of other types of waste; and

10. Reviewing the efficacy of the remedial action during Five-Year Reviews to ensure that any possible contamination from the buried ordnance is not migrating vertically to the groundwater.

1.5 STATUTORY DETERMINATIONS

The selected remedy is protective of human health and the environment, complies with Federal and State requirements that are applicable or relevant and appropriate to the remedial action, is cost effective, and uses permanent solutions and alternative treatment technologies to the maximum extent practicable.

The selected remedy for the known EOD burial locations at Site 442 does not satisfy the statutory preference for treatment as a principal element of the remedy because treatment of the buried ordnance at the site was not found to be practicable. The volume of buried debris, the hazardous nature of CWM that is potentially present at Site 442, and the absence of an identified area within the site where

elevated contaminant concentrations exist preclude a practicable remedy in which the ordnance could be safely excavated and the areas treated effectively. Although the selected remedy does not reduce the toxicity, mobility, or volume of CWM (if present) in the burial locations through treatment, implementing stormwater control measures that do not involve treatment will serve to reduce the potential mobility of potential contaminants within the waste cells.

A Five-Year Review will be conducted five years after implementation of the selected remedy at Site 442, and every five years thereafter, to determine whether the selected remedy continues to be protective of human health and the environment. The Five-Year Review results will be placed in the post-ROD Administrative Record File, which is located at the 95th Air Base Wing, Environmental Management Directorate, 5 East Popson Avenue, Building 2650A, Edwards AFB, California, 93524.

1.6 AUTHORIZING SIGNATURES AND SUPPORT AGENCY ACCEPTANCE OF THE SELECTED REMEDIES

The USAF and USEPA, with concurrence from Cal/EPA DTSC and the Water Board, Lahontan Region, have determined that Site 426 is suitable for future unrestricted use based on the completed cleanup actions performed at the site, and concur with the selected cleanup remedies for Site 442, Areas 1, 2, and 3.

Date 9/9/09

JERRY L. GANDY, Colonel, USAF
Commander, 95th Air Base Wing
Edwards Air Force Base, California

Date 9/16/09

MICHAEL M. MONTGOMERY
Assistant Director of Federal Facilities and Site Cleanup Branch
United States Environmental Protection Agency, Region 9

The Cal/EPA and the Water Board had the opportunity to review and comment on this Record of Decision, and our concerns are addressed.

Date 9/25/2009

ALLEN WOLFENDEN
Performance Manager
San Joaquin and Legacy Landfill Office
California Department of Toxic Substances Control

Date Oct 1, 2009

HAROLD SINGER
Executive Officer,
California Regional Water Quality Control Board, Lahontan Region

We the undersigned, having worked on the development of all phases of this document, hereby concur with the selected remedies in this ROD.

Date 9/9/09

AL DUONG
Remedial Project Manager
95 ABW/EMR
Edwards Air Force Base, California

Date 17 Sept '09

JAMES RICKS
Remedial Project Manager
Federal Facilities Cleanup Branch
U.S. Environmental Protection Agency, Region 9

Date 9/25/09

KEVIN DEPIES
Remedial Project Manager
Office of Military Facilities
California Department of Toxic Substances Control

Date 9-28-2009

JEHIEL W. CASS, P.E.
Remedial Project Manager
California Regional Water Quality Control Board, Lahontan Region

2.0 Part 2: Decision Summary

2.0 PART 2: DECISION SUMMARY

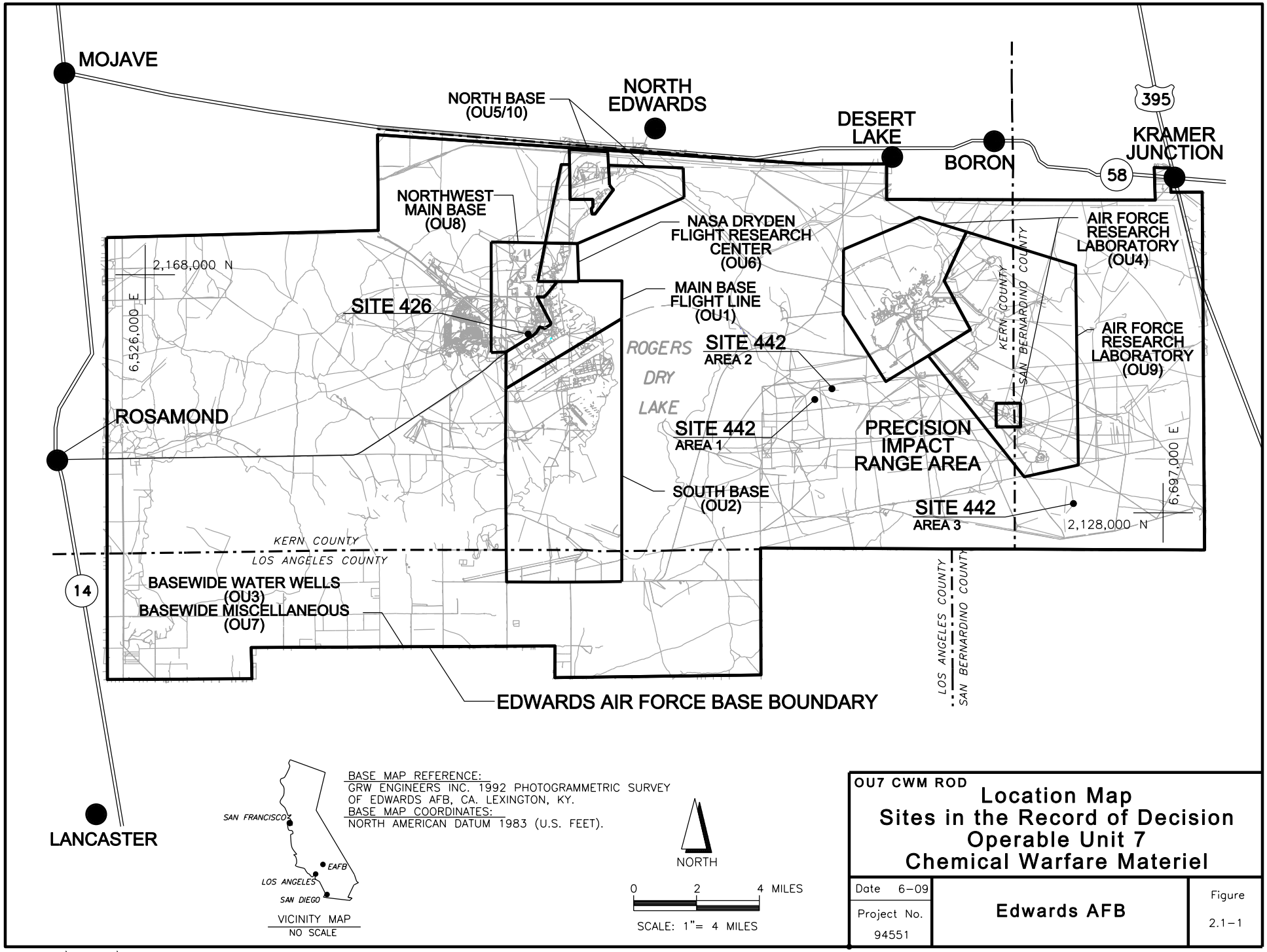
This decision summary provides an overview of the general characteristics for OU7 CWM at Edwards AFB, and more site-specific characteristics for the two sites in OU7 CWM that are included in this ROD. In addition, the decision summary describes the remedial alternatives evaluated for each site (if applicable), and a comparative analysis of those alternatives. The decision summary concludes with the identification of the selected remedy for a site (if applicable), and the statutory determinations supporting the selected remedy.

This decision summary incorporates the content recommended in *A Guide to Preparing Superfund Proposed Plans, Records of Decision, and Other Remedy Selection Decision Documents* (USEPA 1999). However, adjustments to the order of the recommended subsections were incorporated in this decision summary to accommodate the inclusion of site-specific information in the Site Characteristics subsection.

Details regarding the *CERCLA Proposed Plan for Operable Unit 7 (OU7), Chemical Warfare Materiel (CWM), Edwards Air Force Base, California* (Earth Tech 2008a), which addresses the two sites documented in this ROD, are provided in Section 2.3, Community Participation.

2.1 NAME, LOCATION, AND BRIEF DESCRIPTION OF OPERABLE UNIT 7, CHEMICAL WARFARE MATERIEL AT EDWARDS AIR FORCE BASE

Edwards AFB is located in southern California approximately five miles northeast of the city of Lancaster (Figure 2.1-1). The Base covers portions of Kern, Los Angeles, and San Bernardino Counties. The two sites addressed in this ROD are located in Kern County (Site 426 and Site 442, Areas 1 and 2) and San Bernardino County (Site 442, Area 3). Site 426 is located in the Northwest Main Base area, and the western part of the site is approximately 25 feet east of a dormitory occupied by military personnel. Site 442, Areas 1 and 2 are located in the West Range of the Precision Impact Range Area (PIRA), which covers a large portion of the eastern part of the Base. The PIRA boundary is fenced and posted with signs prohibiting unauthorized entry; access is controlled and monitored by PIRA Range Control. The nearest on-Base residential area to Site 442, Areas 1 and 2 is located approximately nine miles to the west-northwest, and the nearest residential areas off-Base are scattered



OU7 CWM ROD

Location Map
Sites in the Record of Decision
Operable Unit 7
Chemical Warfare Materiel

Date 6-09	Edwards AFB	Figure 2.1-1
Project No. 94551		

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rural dwellings seven or more miles south of Area 1 and the towns of Desert Lake and Boron approximately eight miles north-northeast of Area 2. Site 442, Area 3 is located in the East Range of the PIRA, and the nearest on-Base residential area is approximately 18 miles to the northwest, while the nearest residential areas off-Base are scattered rural dwellings three or more miles south of Area 3 and Kramer Junction approximately 11 miles to the north-northeast.

The USEPA CERCLIS identification number for Edwards AFB is CA1570024504. Edwards AFB was listed on the National Priorities List (NPL) on 30 August 1990. The lead agency for remedial investigation (RI) and remedial action (RA) at the facility is the USAF. Regulatory agencies providing support and oversight of the Environmental Restoration Program (ERP) at Edwards AFB include the USEPA Region 9, Cal/EPA DTSC, and the Water Board, Lahontan Region. The USAF, USEPA, DTSC, and the Water Board entered into a Federal Facility Agreement (FFA) for Edwards AFB in September 1990.

The two sites in OU7 CWM included in this ROD were former industrial facilities or known EOD burial locations. These sites fall into two categories:

- **No Further Action Site.** Site 426 is a former World War II CWM storage yard that has been recommended for no further action because no CWM or CERCLA-related wastes were found at the site; and following the interim response action the risks have been reduced to acceptable levels for unrestricted use and unlimited exposure.
- **Site with Known EOD Burial Locations.** Site 442 includes three known EOD burial locations (Areas 1, 2, and 3) that contain munitions debris, possibly including CWM, that require remedial action to prevent potential receptors from coming into direct contact with the buried munitions and to minimize future erosion of the cover soil.

2.2 SCOPE AND ROLE OF THE OPERABLE UNIT

OUs at Edwards AFB are used to group sites with similar site conditions and contaminants, and facilitate the administration of the ERP. OU7 is one of nine operable units designated at Edwards AFB (see Figure 2.1-1). Sites located within OU7 are designated as Basewide Miscellaneous Sites, which includes any potentially contaminated sites that are not located within another OU at the Base. However, sites potentially contaminated with CWM are being managed separately under the designation OU7 CWM because information in historical documents indicated that activities associated with CWM

may have occurred at the sites, potentially contaminating the sites with various types of CWA and/or their degradation products.

OU7 CWM was designated in order to identify and investigate former buildings, training facilities, maintenance facilities, and other storage areas on Base where activities associated with CWM may have occurred; and to remediate any soil and groundwater contamination that may pose a direct threat to human health or the environment. A total of 25 sites and two areas of concern (AOCs) were identified and investigated between 1996 and 2005.

Based on the results of the investigations, 23 sites and two AOCs were considered closed in the Site Investigation phase because they were found to pose no risk to human health and the environment.

The remaining two sites are documented in this ROD as follows:

- An interim response action was conducted at Site 426. The USAF, USEPA, Cal/EPA DTSC, and the Water Board agreed that no further action was required and that the results of the interim removal action be documented in the Proposed Plan and ROD.
- Site 442 consists of three non-contiguous areas (Areas 1, 2, and 3) with known EOD burial locations, which were evaluated to pose minimal risk to human health and the environment. However, the burial locations contain buried potentially hazardous intact munitions or munitions residue. The USAF, USEPA, Cal/EPA DTSC, and the Water Board agreed that the evaluation of remedial alternatives to mitigate the buried wastes was required for these sites.

2.3 COMMUNITY PARTICIPATION

Community members and local government agencies have been kept informed on ERP activities and have had opportunities for involvement in the decision-making process for the remediation of OU7 CWM sites throughout the CERCLA process. Highlights of the community involvement program are discussed below.

2.3.1 RESTORATION ADVISORY BOARD

The Edwards AFB Restoration Advisory Board (RAB) is a voluntary group that meets quarterly to facilitate the exchange of information and concerns between the on-Base and off-Base communities,

Federal and State regulatory agencies, and the Edwards AFB environmental cleanup program managers.

The RAB was formed in late 1994, replacing the Technical Review Committee (TRC), which was established after Edwards AFB was named to the NPL in 1990. The RAB has 14 appointed public representatives (two of which are alternates); a USAF Co-chair; and RPMs from Edwards AFB, the USEPA, Cal/EPA DTSC, and the Water Board, Lahontan Region. Off-Base communities represented on the RAB include Boron, California City, Lancaster, Mojave, North Edwards, and Rosamond. On-Base communities consist of Base Housing, Main Base Air Base Wing, Main Base Test Wing, National Aeronautics and Space Administration (NASA) Dryden Flight Research Center (DFRC), North Base, South Base, and the Air Force Research Laboratory (AFRL). One appointed public representative is elected by the group to serve as the Public Co-chair.

2.3.2 REPORT TO STAKEHOLDERS

The Report to Stakeholders (RTS), a monthly newsletter published by Edwards AFB, was developed for the RAB. The newsletter originally focused on hazardous waste cleanup at Edwards AFB, explaining how cleanup technologies work, providing status reports on key restoration activities, and introducing RAB members through in-depth interviews. The RAB members use the newsletter as a reference tool to educate their communities. In September 2004, the RTS began news coverage of other environmental activities at Edwards AFB to include conservation and compliance issues. Edwards AFB currently distributes 6,000 copies of the RTS every month. The public may also access the newsletter on the World Wide Web at the following site:

http://bsx.edwards.af.mil/environmental

2.3.3 ADMINISTRATIVE RECORD AND INFORMATION REPOSITORIES

The Administrative Record File is maintained at the 95th Air Base Wing, Environmental Management Directorate, 5 East Popson Avenue, Building 2650A, Edwards AFB, California 93524. In addition, copies of a subset of the data and documents contained in the Administrative Record File and a complete listing of all documents contained in the Administrative Record File are available for public review in information repositories located in the cities of Lancaster and Rosamond, as well as at Edwards AFB.

Edwards AFB Library
5 West Yeager Boulevard
Building 2665
Edwards AFB, CA 93524-1295
(661) 275-2665

Kern County Public Library
Wanda Kirk Branch
3611 West Rosamond Boulevard
Rosamond, CA 93560
(661) 256-3236

Los Angeles County Public Library
601 West Lancaster Boulevard
Lancaster, CA 93534
(661) 948-5029

2.3.4 COMMUNITY INVOLVEMENT

Public meetings were held at Edwards AFB prior to the implementation of the interim response actions at Site 426 in order to present the findings of the Engineering Evaluation/Cost Analysis (EE/CA) (Earth Tech 2001a), and to obtain public comments on the selected alternatives. A public meeting was also held at the Kern County Library, Wanda Kirk Branch in Rosamond, California, on December 19, 2000.

An overview of the Proposed Plan for OU7 CWM was presented at a RAB meeting held on May 15, 2008 at the Antelope Valley Inn in Lancaster, California. Notices of availability of the Proposed Plan were published in the Antelope Valley Press and Mojave Desert News (local area newspapers) on May 1, 2008 and May 29, 2008 and in the Desert Wings (a publication of the Edwards AFB Public Affairs Office) on May 2, 2008 and May 23, 2008. A public comment period was held from May 1 to June 16, 2008. During the public comment period, the RI report, the Feasibility Study (FS), and the Proposed Plan were made available to the public.

Public meetings were held on-and-off-Base on May 29, 2008 to present the Proposed Plan to a broader community audience. The on-Base meeting was held from 1100 to 1300 hours in Building 2650A, Conference Room 1, Edwards AFB, California. The off-Base meeting was held from 1730 to 1930 hours at West Boron Elementary School, 12300 Del Oro Street, Boron, California. No verbal or written public comments were received.

2.4 DECISION SUMMARY, SITE 426 – WORLD WAR II CHEMICAL WARFARE MATERIEL STORAGE YARD

2.4.1 SITE NAME, LOCATION, AND BRIEF DESCRIPTION

Site 426, the former World War II (WWII) Chemical Warfare Materiel Storage Yard, is located in the Northwest Main Base area of Edwards AFB, south of Popson Avenue and north of Rosamond Boulevard (Figure 2.4-1). Buildings 2518 and 2519 (part of a dormitory complex for enlisted military personnel built in the late 1990s) are partially inside the western boundary of Site 426, but are located approximately 25 feet west of the former features associated with the former Storage Yard. A restaurant building (Building 2412) and an older dormitory complex built in the 1950s (Buildings 2422 through 2425) are located approximately 300 feet north to 800 feet northwest of Site 426.

2.4.2 SITE GEOLOGY

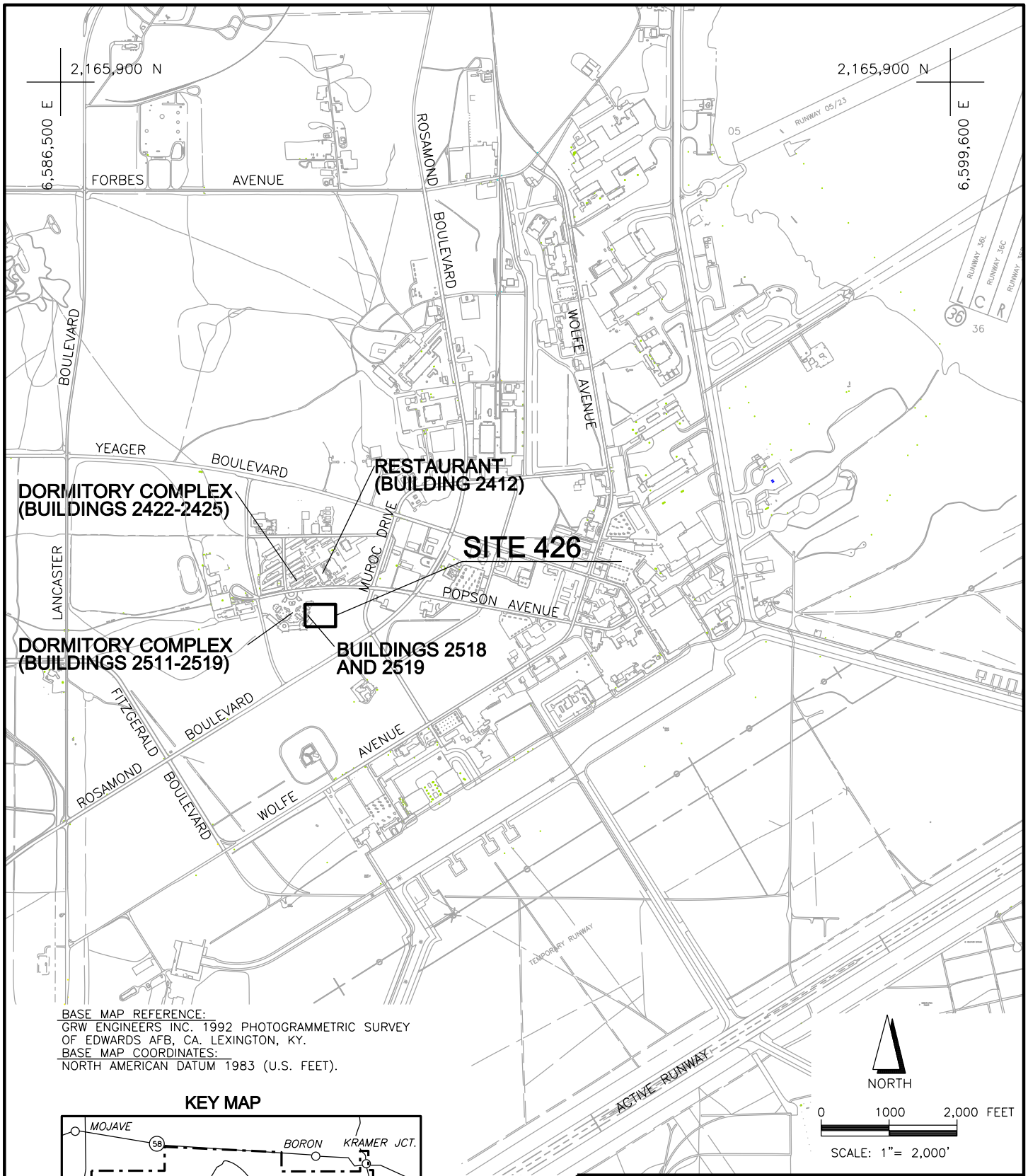
Site 426 is located in a low-relief saddle of a northwest-southeast trending ridge that slopes gently to the southeast. The elevation at the site is approximately 2,340 feet above mean sea level (MSL).

The geology at Site 426 consists of a thin veneer of fill material and alluvial sediments overlying weathered and competent granitic bedrock. Based on data collected from wells and boreholes drilled at the site, weathered bedrock is present at depths ranging from five feet below ground surface (bgs) to 17 feet bgs, and competent bedrock is present at depths ranging from 29 feet bgs to 35 feet bgs (Earth Tech 2006).

2.4.3 SITE HYDROGEOLOGY AND WATER SUPPLY

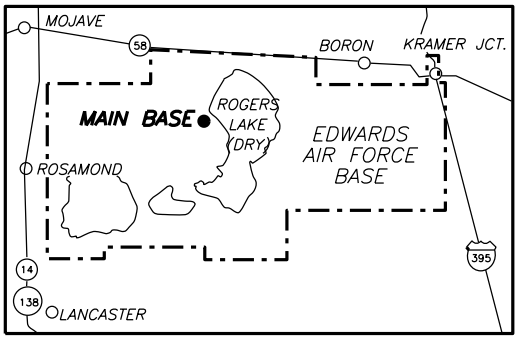
2.4.3.1 Hydrogeology

Groundwater at Site 426 is primarily in a relatively shallow aquifer, identified as the upper aquifer (Leighton and Phillips 2003), occurring in the fractured bedrock and thin alluvium of the Bissell Hills area. The aquifer is semi-confined, and flows into and is a source of recharge for the upper, middle, and lower aquifers (the Principal and Deep Aquifers of Londquist [1993] as reported in the *OU7 CWM RI SR* and *OU7 CWM FS* [Earth Tech 2006 and 2007a]). The shallow groundwater at the site occurs at depths ranging from nine feet bgs at the northwestern corner of the site to 23 feet bgs in the



BASE MAP REFERENCE:
GRW ENGINEERS INC. 1992 PHOTOGRAMMETRIC SURVEY OF EDWARDS AFB, CA. LEXINGTON, KY.
BASE MAP COORDINATES:
NORTH AMERICAN DATUM 1983 (U.S. FEET).

KEY MAP



OU7 CWM ROD

Location Map Site 426

Date 6-09	Edwards AFB	Figure 2.4-1
Project No. 94551		

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southeastern corner of the site. The shallow groundwater detected in the northwestern corner of the site may have been artificially induced by water used for irrigation or by leaks in the adjacent dormitory complex landscaping irrigation system. The groundwater flow direction is to the south and southeast (Earth Tech 2006).

2.4.3.2 Water Supply

Prior to the establishment of Edwards AFB in the 1940s, the water supply in the area was primarily from historic homestead water wells and was used for domestic and agricultural purposes. From the 1940s until early 1993, the water supply for the Base was primarily from groundwater production wells drilled and constructed by the Base.

Currently, the water supply for the Base comes from Base production wells (about 60 percent) and the Antelope Valley-East Kern (AVEK) Water Agency, a State water project contractor (about 40 percent). The Base contracted with AVEK to supply water to reduce groundwater withdrawals from the local aquifers in order to minimize land and lakebed subsidence. The detrimental effects of the subsidence include permanent loss of aquifer storage, increased flooding, cracks and fissures at land surface, damage to man-made structures, and intangible economic costs (Leighton and Phillips 2003). The formation of cracks and fissures on the surface of Rogers Dry Lake are of particular concern because they interfere with the use of the lakebed as an emergency landing surface for aircraft.

The closest Base water supply wells to Site 426 that provide potable water for beneficial uses (primarily industrial use) are located at the Graham Ranch Well Field approximately 4.1 miles to the southwest and South Base Well Field approximately 4.2 miles to the southeast.

Although groundwater in the upper aquifer in the Antelope Valley is considered a potential source of drinking water under State Water Resources Control Board (SWRCB) Resolution 88-63, in the area of Site 426, where groundwater occurs in weathered crystalline rocks (fractured bedrock), it is not considered a likely primary source of water for beneficial use because most wells completed in crystalline rock rely on fractures to obtain groundwater and are typically low yielding wells producing small quantities of groundwater (California Department of Water Resources [(CDWR] 2003).

2.4.4 SITE TOPOGRAPHY AND SURFACE DRAINAGE

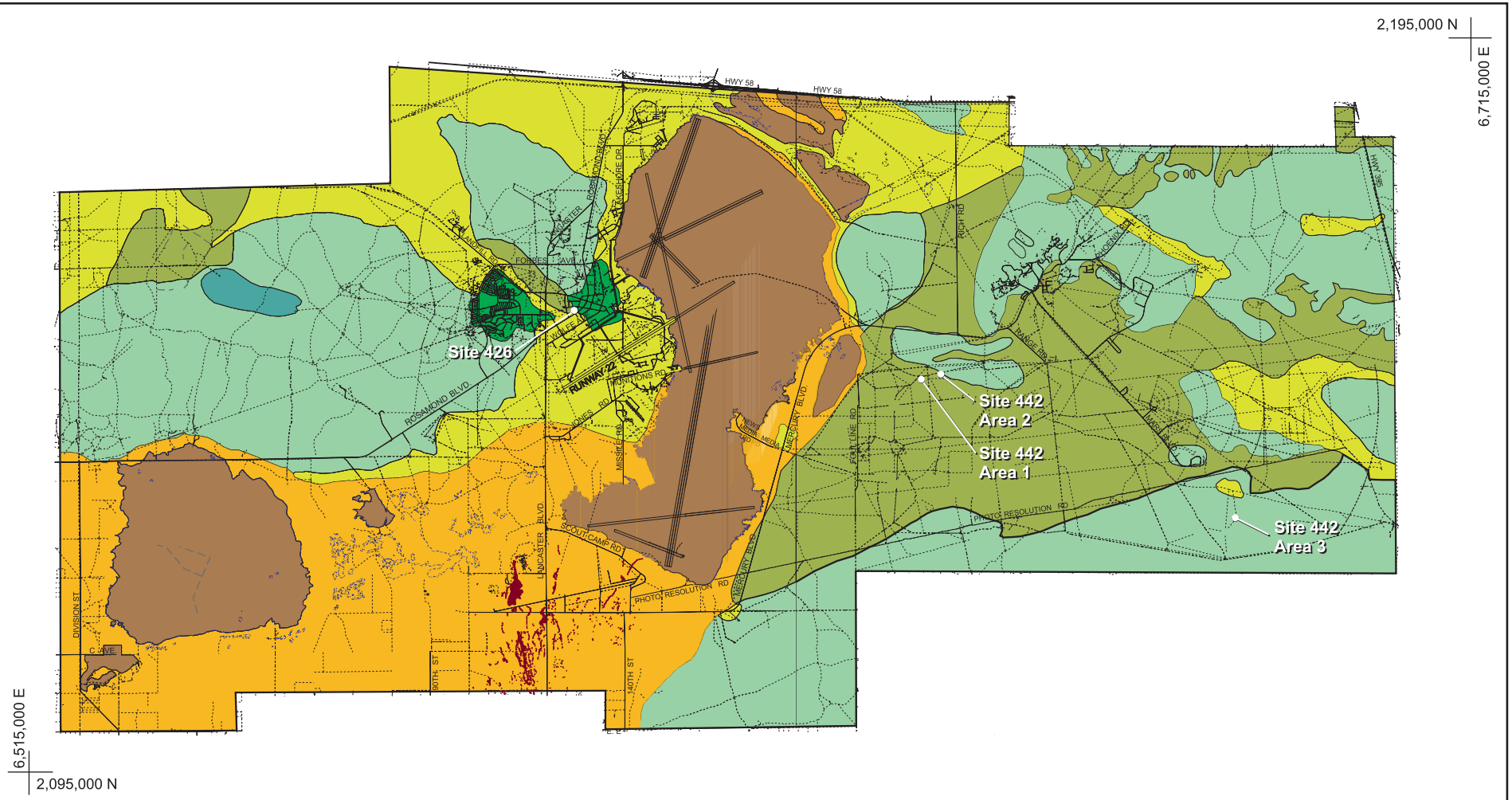
Local surface drainage is to the east along the eastern side of the site, and to the west along the western side of the site. However, the surface runoff eventually drains into Rogers Dry Lake, which is located approximately one mile to the east (see Figure 2.1-1) (Earth Tech 2006).

2.4.5 SITE ECOLOGICAL SETTING

Site 426 is located in Land Use Management Area C (Developed Area [Housing/Commercial/ Industrial]) as designated in the Integrated Natural Resources Management Plan (INRMP) for Edwards AFB (USAF 2002). Management Area C comprises Main Base, North Base, South Base, the National Aeronautics and Space Administration (NASA) Dryden Flight Research Center, and the Main Base Active Landfill. Biotic habitats in the Main Base area, where Site 426 is located, include zonal xerophytic saltbush scrub, creosote bush scrub, and Joshua tree woodlands; and azonal urban/developed areas (USAF 2002) (Figure 2.4-2). However, the land at Site 426 is highly disturbed due to past interim response actions (see Section 2.4.9), and the results of a Pre-scoping Ecological Risk Assessment (PERA) conducted by the USAF (2004b) concluded that there was no habitat for ecological receptors at the site. Additionally, data in the Base Geographic Information System (GIS) shows that no endangered, threatened, or sensitive flora or fauna species have been identified in the vicinity of Site 426.

2.4.6 SITE LAND USE AND DEMOGRAPHICS

Site 426 is currently undeveloped open terrain. The population in the area of Site 426 consists of military personnel and civilian workers. The military personnel live in dormitory-style quarters west and northwest of Site 426. Air Force personnel live in a newer dormitory complex (Buildings 2511 to 2519) completed in 1997, and two of the dormitories (Buildings 2518 and 2519) are located partially inside the western boundary of Site 426. Marine and Air Force personnel also live in four older dormitory buildings (Buildings 2422 to 2425) built in the 1950s and located approximately 450 feet to 800 feet northwest of Site 426. On average there are approximately 750 personnel living in the dormitories at any given time. During the daytime, civilians work at a restaurant (Building 2412) located approximately 300 feet north of the site and at the dormitories.



Habitats and Plant Communities

- Xerophytic Saltbush Scrub
- Urban/Developed Areas
- Playa
- Mesquite Woodland
- Joshua Tree Woodland
- Halophytic Saltbush Scrub
- *Hymenoclea-Lycium*
- Creosote Bush Scrub

Explanation:

- Paved Roads
- Unpaved Roads
- Base Boundary

North

Scale 1 inch = 4 miles

0 1 2 3 4

BASE MAP REFERENCE:
GRW Engineers Inc. 1992 Photogrammetric Survey of Edwards AFB, CA. Lexington, KY

BASE MAP COORDINATES:
North American Datum 1983 (U.S. Feet)

Source: USAF (2002)

OU7 CWM ROD

Habitats and Plant Communities at Edwards AFB

Date 6-09	Edwards AFB	Figure 2.4-2
Project No. 94551		

2.4.7 SITE HISTORY AND ENFORCEMENT ACTIVITIES

A more complete discussion of the history and activities occurring at Site 426 is provided in *Environmental Restoration Program, Remedial Investigation Summary Report, Chemical Warfare Materiel Sites, Operable Unit No. 7, Edwards Air Force Base, California* (*OU7 CWM RI SR*) (Earth Tech (2006), and is briefly summarized below.

Before World War II, the area at Site 426 was undeveloped land located approximately 1.6 miles west of the town of Muroc. Muroc was a small agricultural community that was abandoned during the establishment of Muroc Army Air Field, which eventually became Edwards AFB. In February 1988, a visual survey was conducted in the area of Site 426 for the State of California - The Resources Agency, Department of Parks and Recreation. Three concrete pads, buried water pipes, a system of irrigation ditches, and dead locust trees were features described during the visual survey.

In May 1993, a possible homestead water well (designated as Well 10/10-35B1) was described during a field reconnaissance of historic water wells for the Basewide Water Well Closure Program (Earth Tech 1995b). At that time, a tar-like substance was observed on a concrete pad located near the possible water well. During further field reconnaissance at the possible homestead water well in February 1995, an underground storage tank (UST) containing waste oil (subsequently designated as UST M139) was found beneath the concrete pad.

In July 1995, the UST and a concrete valve box with associated piping were excavated and removed as part the Underground Storage Tank Investigation (USTI) Program (Earth Tech 1998). The UST was a 5,000-gallon concrete tank containing approximately 3,000 gallons of waste oil, which was removed and containerized for transport to an off-site disposal facility. The UST, valve box, and piping were pressure washed, and the UST and valve box were broken into fragments for transport to an off-site hazardous waste facility. The piping, concrete fragments from the UST and valve box, and excavated soil were transported to the McKittrick Waste Disposal Site, McKittrick, California. The containerized waste oil and wash rinseate were transported to DeMenno/Kerdoon, Compton, California for disposal. The removed UST location was designated as Site 419 in 1997. Site 419 is a non-CERCLA petroleum-only site located within the boundary of OU7 CWM Site 426 that was investigated and cleaned up as part of the ERP for OU7 Basewide Miscellaneous sites (Earth Tech 2001b and 2004c);

and therefore, is not addressed in this ROD. On 10 August 2004, the Kern County Environmental Health Services Department (KCEHSD) closed Site 419 to further action.

Research of archival documents and historic aerial photographs indicated that the features found during the field reconnaissance were not associated with a homestead site, but with the WWII CWM Storage Yard (Site 426). The WWII CWM Storage Yard (often identified as a "Toxic Gas Yard" in archival documents) was constructed in late 1942 and encompassed approximately 1.6 acres. By October 1946, the yard was no longer in use, and was subsequently demolished. According to maps obtained from the 95th Civil Engineering Squadron at Edwards AFB, no buildings have been constructed in the area of the former Toxic Gas Yard since that time.

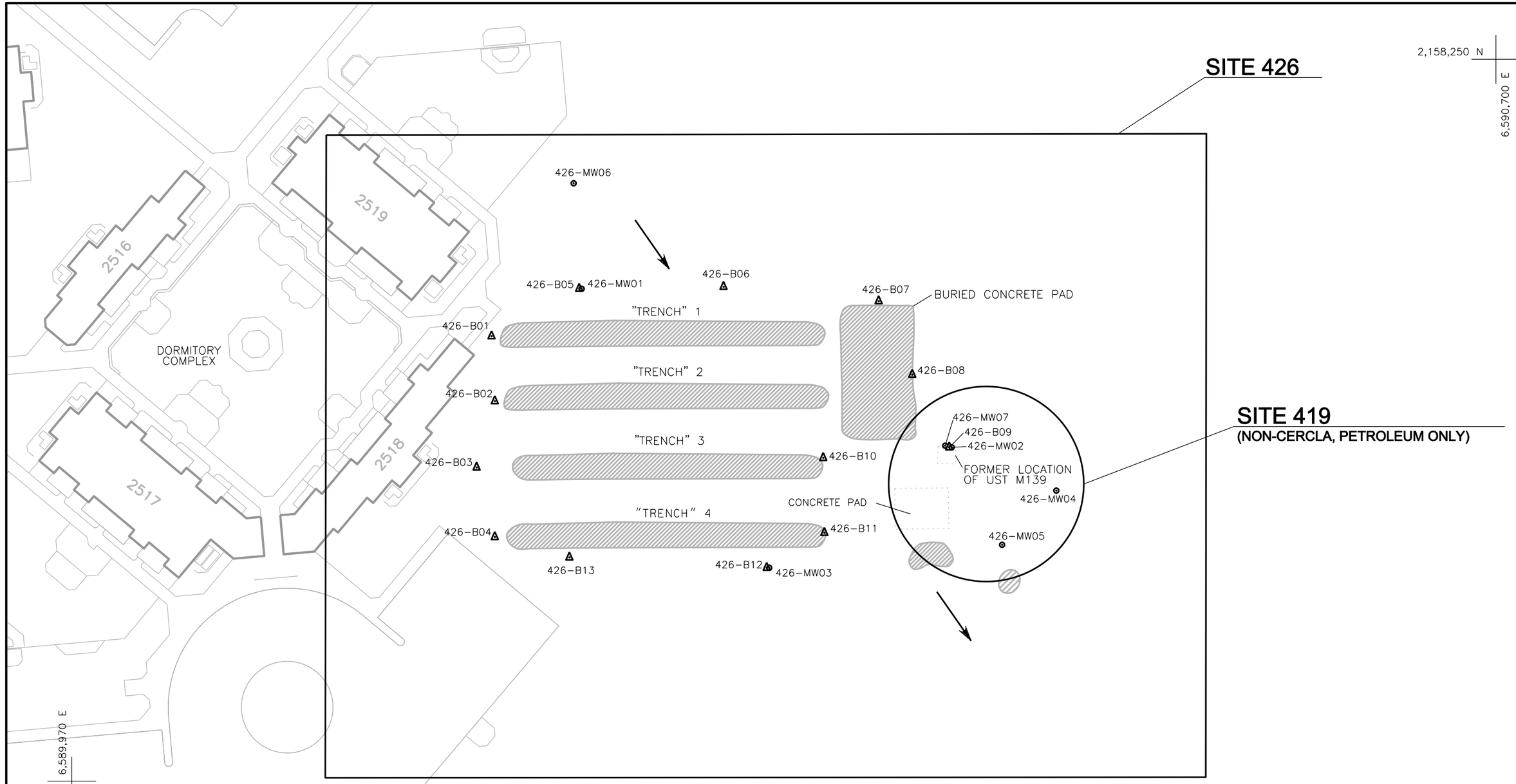
Archival records indicate that CWAs and industrial chemicals may have been stored and/or disposed at the former CWM Storage Yard. The CWAs may have included mustard (H), distilled mustard (HD), and lewisite (L). The industrial chemicals may have included tear gas (CNS), gasoline-based incendiaries (napalm, incendiary bomb fill [IM and PT1]), thermite, and smoke (FS).

2.4.8 REMEDIAL INVESTIGATIONS

A brief summary of the remedial investigations conducted at Site 426 include the following:

- Geophysical surveys were conducted in 1996 and 1997 using electromagnetic, magnetic, and ground penetrating radar (GPR) geophysical techniques. The surveys identified numerous geophysical anomalies including four buried "trenches" presumably containing metal objects and debris (Figure 2.4-3). Each "trench" was estimated at 150 feet to 160 feet long by 12 feet wide, and the "trenches" were spaced approximately 23 feet apart. Based on the geophysical data, the "trenches" were covered with approximately four feet of soil. A rectangular anomaly located approximately 10 feet east of the two northernmost "trenches" was interpreted as a concrete foundation. Numerous other anomalies were identified throughout the survey area, but were interpreted as either existing utilities or small metal objects.

- In July 1997, Computer Sciences Corporation conducted an active soil gas survey at seven sampling points along three of the four buried "trenches." The objective of the survey was to determine whether petroleum hydrocarbon wastes were disposed in the "trenches." The soil gas samples were collected at depths of 5 feet bgs to 10 feet bgs and analyzed for hydrocarbons using a gas chromatography screening method. All sample results were below reporting limits.



BASE MAP REFERENCE:
GRW ENGINEERS INC. 1992 PHOTOGRAMMETRIC SURVEY OF EDWARDS AFB, CA. LEXINGTON, KY.
BASE MAP COORDINATES:
NORTH AMERICAN DATUM 1983 (U.S. FEET).

OU7 CWM ROD

Reference Map Site 426

Date 6-09	Edwards AFB	Figure 2.4-3
Project No. 94551		

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- In October 1997, Radian conducted a passive soil gas survey to detect CWA or CWA degradation products. Passive soil gas samples were collected at the ground surface from 25 locations distributed over the four "trenches." Possible mustard degradation products (1,4-thioxane and 1,4-dithiane) were detected in 15 of the 25 soil gas samples.

- In January 1997, four boreholes were drilled approximately 10 feet west of the four "trenches" identified by the geophysical survey (see Figure 2.4-3). Analysis of the soil samples collected from the boreholes was used to determine whether CWA was present in the vicinity of the planned dormitory complex, which was constructed later in 1997. Thirty soil samples were collected from the boreholes at 3-foot or 5-foot intervals. Air monitoring did not detect any CWA during the drilling activities, or during the on-site mobile laboratory analysis of the soil samples. No CWA or CWA degradation products were detected.

- In March 2000, nine additional boreholes were drilled and sampled to determine whether CWA was present in soils in the vicinity of the four "trenches". The boreholes were located north (two boreholes), south (two boreholes) and east (five boreholes) of the four "trenches" identified by the geophysical survey (see Figure 2.4-3). Soil samples were collected in the boreholes at 5-foot intervals. The soil samples collected were screened on-site using a Miniature Chemical Agent Monitoring System (MINICAMS®) and Depot Area Air Monitoring System (DAAMS) tubes, and sent to an off-site laboratory for analysis of CWA, CWA degradation products, petroleum hydrocarbons, VOCs, and metals. CWA and CWA degradation products were not detected during laboratory analysis of the soil samples. However, unknown extractable hydrocarbons (UEH) and unknown volatile hydrocarbons (UVH) were detected in soil samples collected from the former location of UST M139 at concentrations exceeding their respective leaking underground fuel tank (LUFT)-derived target cleanup goals. These residuals were addressed under the USTI program (Earth Tech 2004c).

- In February and March 2000, Earth Tech conducted passive soil gas surveys to determine whether mustard degradation products were released at the "trenches." The survey used two different passive soil gas survey techniques (Gore-Sorber® and EMFLUX®). The Gore-Sorber® technique was used at 43 soil gas sample locations at Site 426, and at three background soil gas sample locations. The EMFLUX® technique was used at 10 soil gas sample locations; each EMFLUX® sample location corresponded to a Gore-Sorber® sample location to allow for the direct comparison of the sample results. CWAs were not detected in any of the soil gas samples. However, potential mustard degradation products (1,4-thioxane and 1,4-dithiane) were detected in five EMFLUX® soil gas samples, including one soil gas sample collected at the background location. CWA degradation products, including 1,4 thioxane and 1,4-dithiane were not detected in any of the Gore-Sorber® soil gas samples. Fuel-related aromatic hydrocarbons were detected in the soil gas samples collected using both passive soil gas survey techniques.

- In March 2000, Bakhtar Associates (2000) conducted a GPR survey at Site 426 using U.S. Air Force EarthRadar technology. The survey was conducted at the previously identified "trenches" using a small tractor with a platform-mounted GPR and global positioning system (GPS), and a pair of skid-like dipole antenna. Interpretation of the survey results indicated that the average depth to the buried material was approximately three feet bgs to four feet bgs, with a maximum depth of approximately nine feet bgs.

- In August 2000, Zonge Engineering & Research Organization, Inc. (2001) conducted a geophysical survey at Site 426 using induced polarization (IP) and resistivity techniques. The resistivity survey indicated that the bottom of the "trenches" ranged from three feet bgs to 10 feet bgs. In some areas, IP anomalies were identified below the "trenches," possibly indicating that leachate fluids percolated into the soil. Interpreting the depths of the "trenches" using IP was complicated by the deeper anomalies.

- Three groundwater monitoring wells (426-MW01 through 426-MW03) were installed in March 2000. Groundwater samples were collected and screened on-site for CWA, and then sent to an off-site laboratory for analysis. Laboratory analysis did not detect CWA or CWA degradation products in the groundwater samples. Benzene (a fuel-related hydrocarbon) was detected in one monitoring well (426-MW02), which is now associated with Site 419, a non-CERCLA petroleum-only site located within the boundary of Site 426 that is not addressed in this OU7 CWM ROD.

- Three additional groundwater monitoring wells (Wells 426-MW04 through 426-MW06) were installed in November 2000. CWA and CWA degradation products were not detected in the groundwater samples collected from the wells. Although UEH was detected in two of the monitoring wells (Wells 426-MW04 and 426-MW05), the wells are downgradient of the non-CERCLA Site 419, a petroleum-only contaminated site located within the boundary of Site 426. The source of the UEH was evaluated to be former UST M139 at Site 419.

A more detailed discussion of the remedial investigations conducted at Site 426 is included in the *OU7 CWM RI SR* (Earth Tech 2006).

2.4.9 INTERIM RESPONSE ACTIONS

From June to October 2002, an interim response action was conducted at Site 426 to remove and evaluate the debris (possibly including CWM) that was presumably buried in the "trenches" at the former Toxic Gas Yard. The excavation team conducting the activities at the site during the interim response action consisted of personnel from Earth Tech, the U.S. Army Technical Escort Unit (TEU), and the U.S. Army Edgewood Chemical Biological Center (ECBC).

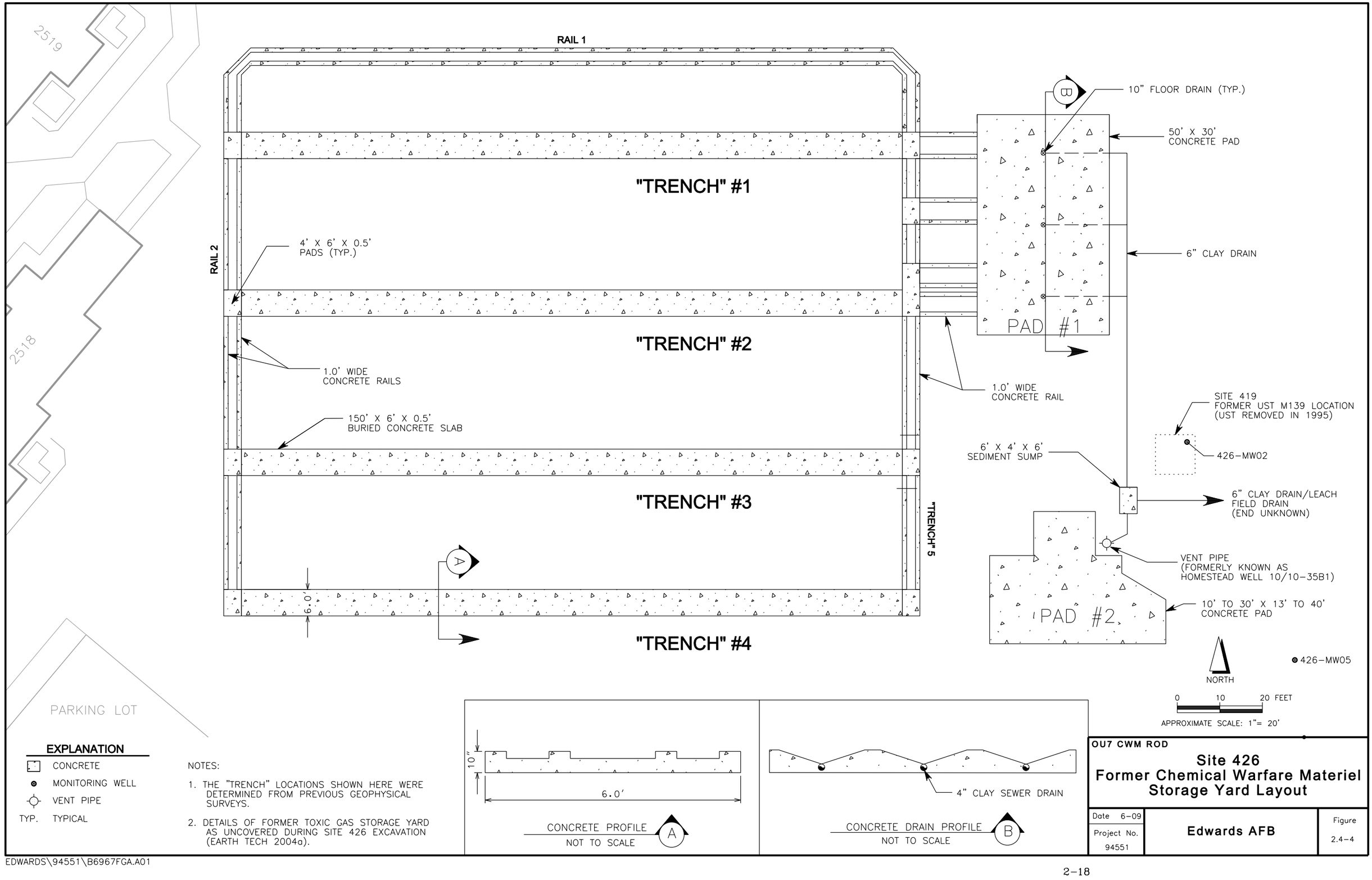
The excavations were accomplished using a trackhoe under a movable vapor containment system equipped with an air conditioning system and air exhaust/filtration system. Stringent health and safety

protocols, including a comprehensive air monitoring program, were followed during the interim response action to ensure the health and safety of site personnel and the population in the area of Site 426 and Main Base in the event a release of CWA or other hazardous contaminants occurred.

No evidence of CWM was encountered during the interim response action. Each of the four east-west trending linear features ("trenches") observed on the aerial photographs and delineated during the geophysical surveys were subsequently identified as concrete rail lines that were 150 feet long, six feet wide, and six inches thick (with four inch thick rails) (Figure 2.4-4). A fifth north-south trending "trench" was also identified as a concrete rail system with two sets of tracks. The tracks were about 125 feet long, four feet wide (total for both tracks), and one foot thick. These north-south trending rail tracks circled the east-west trending rail lines to the north (Rail 1) and continued to the south (Rail 2) on the western side of the "trenches." Two concrete pads (Pads 1 and 2) were also located east of the concrete railway system. Pad 1 was a rectangular foundation approximately 50 feet long (north to south) and 30 feet wide (east to west). Pad 2 was an irregularly-shaped pad that ranged in length from approximately 13 feet to 40 feet (east to west) and ranged in width from approximately 10 feet to 30 feet (north to south).

This infrastructure associated with the former Toxic Gas Yard (concrete rails, concrete pads, floor drains, sumps, and clay leach field piping) was removed during the interim response action. The windblown and alluvial silts and sands that covered the concrete rail system and pads were also removed during the excavations. The thickness of the overburden ranged from approximately 1.5 feet at the eastern end of the site to 3.5 feet at the western end. The soils below the rails and pads were excavated until weathered bedrock was encountered (at depths ranging from approximately six feet at the eastern end of the "trenches" to eight feet at the western end of the site).

All soil samples collected during the interim response action were screened for mustard and lewisite by the ECBC Monitoring Branch laboratory. After ECBC confirmed that no CWA was present, soil samples were shipped to Severn Trent Laboratories, Inc. (STL) in West Sacramento, California (STL Sacramento) (now TestAmerica West Sacramento [TAMS]) for analysis of CWA degradation products, VOCs, total extractable petroleum hydrocarbons (TEPH), metals, and cyanide.



EXPLANATION

- CONCRETE
- MONITORING WELL
- VENT PIPE
- TYP. TYPICAL

NOTES:

1. THE "TRENCH" LOCATIONS SHOWN HERE WERE DETERMINED FROM PREVIOUS GEOPHYSICAL SURVEYS.
2. DETAILS OF FORMER TOXIC GAS STORAGE YARD AS UNCOVERED DURING SITE 426 EXCAVATION (EARTH TECH 2004a).

CONCRETE PROFILE A
NOT TO SCALE

CONCRETE DRAIN PROFILE B
NOT TO SCALE

OU7 CWM ROD

Site 426
Former Chemical Warfare Materiel Storage Yard Layout

Date 6-09	Edwards AFB	Figure 2.4-4
Project No. 94551		

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The headspace screening of the excavated soil and concrete did not detect any CWA contamination, or elevated concentrations of other industrial contaminants. The soils were ultimately disposed on vacant land on the PIRA. The concrete was transported to an approved debris stockpile at South Base for recycling.

Site 426 was restored to near original conditions after the excavations were backfilled and the excavated material removed. After the site was graded, Envirotac II® (a soil stabilizer) was applied to control dust and erosion at the site. Site restoration activities were completed in December 2002.

Details of all activities conducted during the interim response action are presented in *Environmental Restoration Program, Interim Removal Action Report, Site 426, World War II Chemical Warfare Materiel Storage Yard, Operable Unit No. 7, Edwards AFB, CA* (Earth Tech 2004b).

Because no CWA or CWA degradation products were detected in groundwater samples collected after the interim response action at Site 426 (Earth Tech 2004b), and no petroleum-related constituents were detected at concentrations exceeding their respective Maximum Contaminant Levels (MCLs) in groundwater samples collected after the interim response action at Site 419 (Earth Tech 2004c), all groundwater monitoring wells at these sites were destroyed in accordance with procedures agreed to by the KCEHSD (1989 and 1993).

2.4.10 NATURE AND EXTENT OF RESIDUAL SITE CONTAMINATION

No residual contaminants remain at the site that would limit exposure or restrict use.

2.4.11 SUMMARY OF SITE RISKS

2.4.11.1 Human Health Risk

After the interim response action was completed at Site 426, the USAF calculated the potential risk to human health if hypothetical future residents or industrial workers are exposed to soils or groundwater at the site through ingestion, inhalation, or skin contact. The results of the human health risk assessment (HHRA) for Site 426 are summarized in Table 2.4-1. The potential cancer risks and noncancer Hazard Indexes (HIs) for hypothetical future residents, industrial workers, and construction workers exposed to the soil and groundwater at Site 426 were evaluated to be acceptable to all receptors

TABLE 2.4-1. SUMMARY OF HUMAN HEALTH RISK ASSESSMENT RESULTS – SITE 426

Potential Exposure Pathway	Exposure Medium	Cancer Risk[a]	Primary Risk Drivers[b]	Noncancer Hazard Index[c]	Primary Risk Drivers[b]
Residential (Hypothetical future)	Soil	$1x10^{-6}$	None	0.44	None
	Groundwater	$6x10^{-7}$	NA	Vanadium - alimentary, kidney, and respiratory systems: 0.90[e] Nitrate - methemoglobinemia: 0.68[e]	None
	Indoor Air	NA	NA	NA	NA
Industrial	Soil	$5x10^{-7}$	None	0.03	None
	Groundwater[d]	NA	NA	NA	NA
	Indoor Air	NA	NA	NA	NA
Construction Worker	Soil	$8x10^{-9}$	None	0.01	None
	Groundwater	$7x10^{-13}$	NA	<0.001	NA
	Indoor Air	NA	NA	NA	NA

Notes:

[a] To manage risks from known or suspected carcinogens, the United States Environmental Protection Agency (USEPA 1980) has developed the following exposure range: more than one additional cancer case for 10,000 people is unacceptable (i.e., greater than $1x10^{-4}$); one additional cancer case for 10,000 to one million people is considered generally acceptable (i.e., between $1x10^{-4}$ and $1x10^{-6}$); and one additional cancer case for one million or more people is considered acceptable (i.e., less than $1x10^{-6}$). However, if multiple contaminants are present and multiple pathways of exposure exist, the higher end of the range should be used to establish cleanup goals.

[b] As determined by the Human Health Risk Assessment (Earth Tech 2004d). "None" indicates that there are no primary risk drivers because the total risk is characterized as generally acceptable or acceptable according to the USEPA (1980) exposure range. If a constituent is shown as a primary risk driver, the number in parentheses is the percentage of the risk accounted for by the constituent.

[c] A Hazard Index less than 1 is considered generally acceptable (USEPA 1991).

[d] No industrial risk for groundwater calculated during the risk assessment process (Earth Tech 2004d).

[e] Results expressed on a target organ basis per Memorandum for Record, Revised Calculation of Noncancer Hazard for Groundwater at Site 426 (USAF 2008).

< less than

NA not applicable; no exposure pathway identified during the risk assessment (Earth Tech 2004d).

because the cancer risks are less than 1 x 10^{-6} and the HIs are less than 1. A more comprehensive discussion of the HHRA for this site is presented in the *Environmental Restoration Program, Human Health Risk Assessment, Basewide Miscellaneous and Chemical Warfare Materiel Sites, Operable Unit 7, Edwards AFB, CA* (*OU7 CWM HHRA*) (Earth Tech 2004e).

2.4.11.2 Ecological Risk

A PERA was conducted at Site 426 by the USAF (2004b). Although Site 426 is located in an area with biotic habitats that include zonal xerophytic saltbush scrub, creosote bush scrub, and Joshua tree woodlands, there is no habitat at the site as a result of past construction and development activities. Based on the results of the assessment, it was concluded that no further ecological investigation was required for Site 426 because there was no habitat, potential for off-site transport of contamination, or complete exposure pathways.

2.4.11.3 Threat to Groundwater or Surface Water

No residual contaminants remain at Site 426 that would constitute a threat to groundwater. There are no surface waters in the vicinity of Site 426.

2.4.12 STATUTORY DETERMINATIONS

The RPMs concurred in the Memorandum for Record (see Appendix A) that no further investigation (NFI) is required for soil and groundwater at Site 426 because no chemical warfare agents or degradation products were detected in any of the soil samples.

2.4.13 DOCUMENTATION OF SIGNIFICANT CHANGES FROM THE PROPOSED PLAN

There are no significant changes from the Proposed Plan.

2.5 DECISION SUMMARY, SITE 442 – KNOWN EXPLOSIVE ORDNANCE DIVISION BURIAL LOCATIONS

2.5.1 SITE NAME, LOCATION, AND BRIEF DESCRIPTION

Site 442, Areas 1, 2, and 3 are Known Explosive Ordnance Division Burial Locations. Areas 1 and 2 are located in the West Range of the PIRA, approximately three miles west of PIRA Range Control

(Downfall) and approximately one mile south of Mercury Boulevard (Figure 2.5-1). Area 3 is located within the East Range of the PIRA, approximately two miles south-southeast of Haystack Butte and one mile north of the southern Base boundary.

Site 442, Area 1 is approximately 4.6 acres (Figure 2.5-2). Four dirt roads, visible on aerial photographs dating from 1942 to 1952, once provided access to the site. Currently, the roads are overgrown with vegetation, and one of the access roads is barely discernible. Near the entrance to Area 1, a weathered sign marked "EXPLOSIVE AREA" was found lying on the ground surface. In addition, a sign with no distinguishable markings was located at the site. Scattered surface debris at Area 1 includes ordnance scrap, links from .50-caliber metallic link-belts, and canvas parts of cargo parachutes. The ground surface appears to have been disturbed and cleared of vegetation at some time in the past.

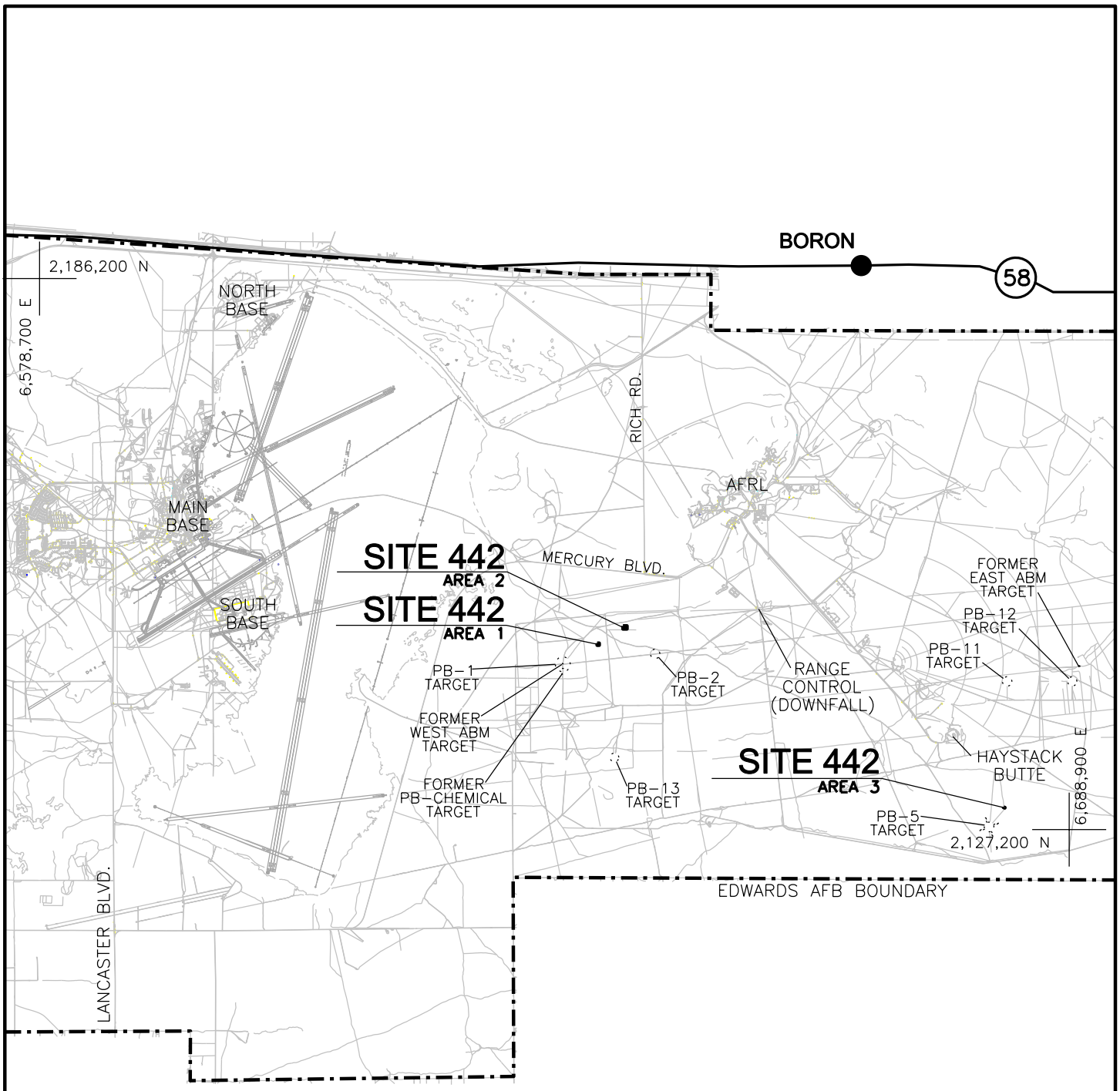
Site 442, Area 2 is approximately 8.3 acres (see Figure 2.5-2). The site is posted with a small weathered aluminum sign marked "BOMB BURIAL." Several steel fence posts delineate the perimeter of the burial area. A former homestead water well (destroyed in May 2003 [Earth Tech 2004d]) and concrete foundation are located near the entrance to the site.

Site 442, Area 3 (Figure 2.5-3) is approximately 0.5 mile northeast of the center of Precision Bombing (PB) Target PB-5 and encompasses approximately 0.2 acres.

2.5.2 SITE GEOLOGY AND SEISMOLOGY

2.5.2.1 Geology

Site 442, Areas 1 and 2 are located on a gently sloping alluvial plain at elevations approximately 2,500 feet above MSL. Based on the results of the borehole drilling at the site, the subsurface geology at Site 442, Areas 1 and 2 consists of unconsolidated alluvium underlain by granitic bedrock. The weathered granitic bedrock occurs at depths ranging from 60 feet bgs in Area 2 to greater than 200 feet bgs in Area 1. The alluvium at Site 442, Areas 1 and 2 is comprised of silty sands, gravelly sands, and gravels (Earth Tech 2007a).



BASE MAP REFERENCE:
GRW ENGINEERS INC. 1992 PHOTOGRAMMETRIC SURVEY OF EDWARDS AFB, CA. LEXINGTON, KY.
BASE MAP COORDINATES:
NORTH AMERICAN DATUM 1983 (U.S. FEET).

EXPLANATION

ABM ABERDEEN BOMBING MISSION
PB PRECISION BOMBING

NORTH

0 1 2 3 MILES

SCALE: 1"= 3 MILES

OU7 CWM ROD

Location Map Site 442 Areas 1, 2, and 3

Date 6-09	Edwards AFB	Figure 2.5-1
Project No. 94551		

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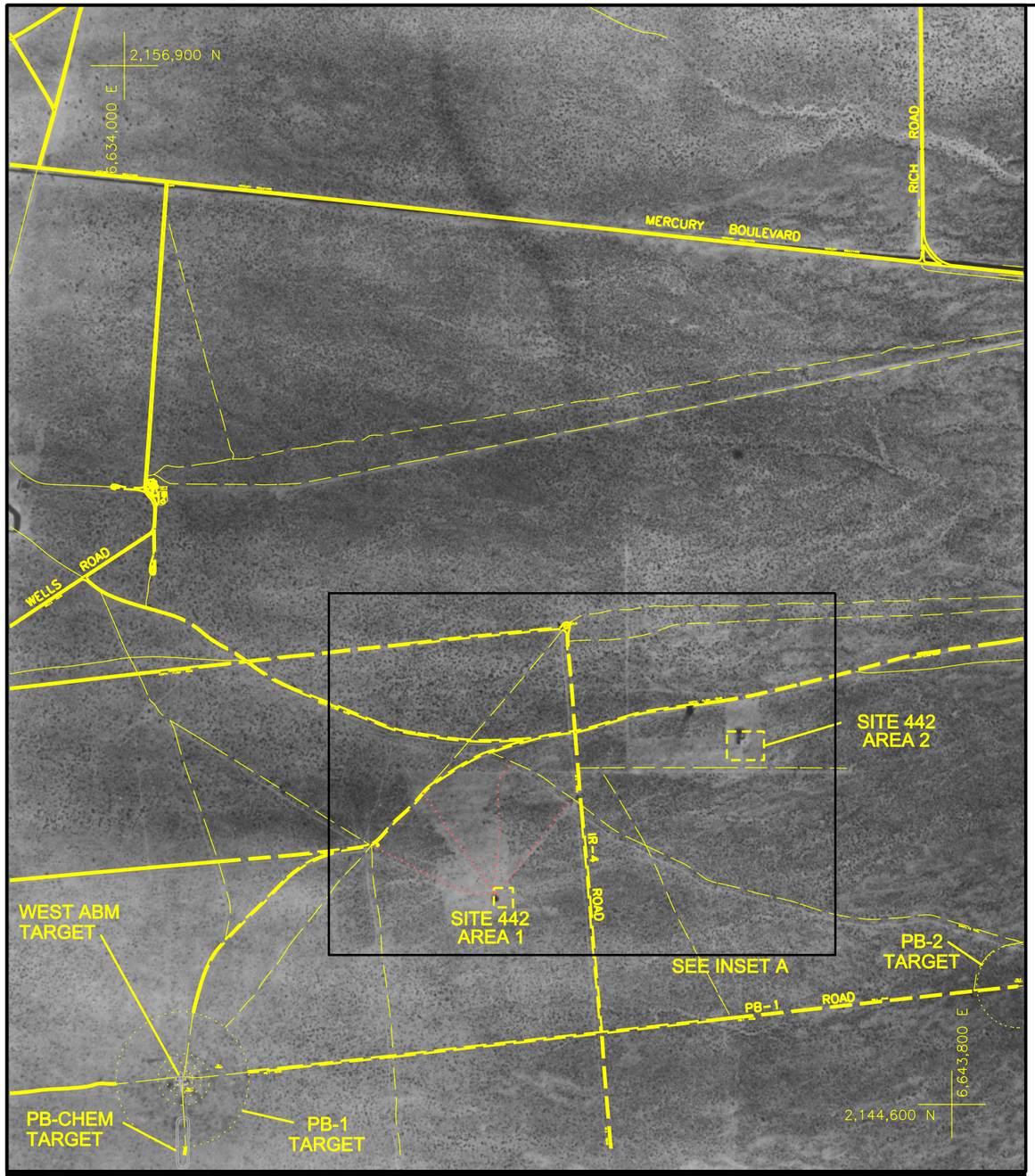

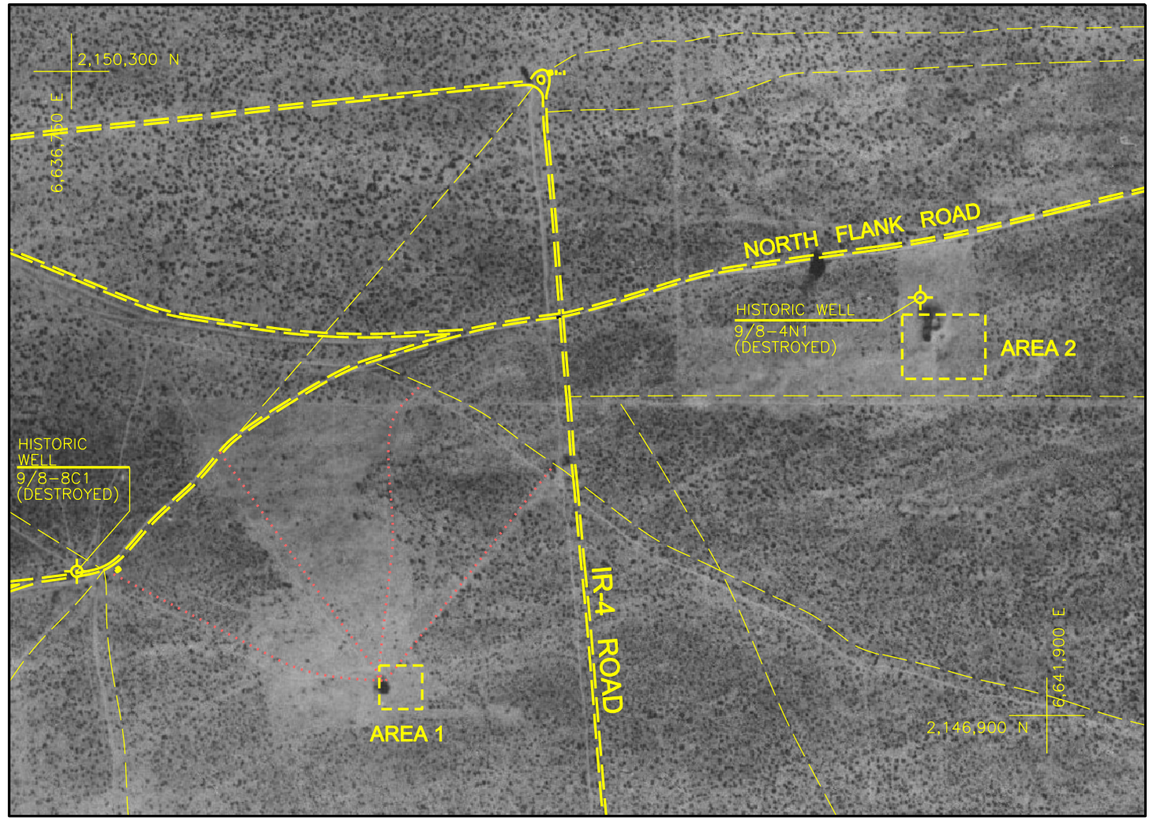

INSET A

EXPLANATION

PB PRECISION BOMBING
PB-CHEM PRECISION BOMBING CHEMICAL

SOURCE:
U.S. DEPARTMENT OF AGRICULTURE
PRODUCTION AND MARKETING ADMINISTRATION
KERN COUNTY, CALIFORNIA, ABL SERIES,1952

NORTH
0 800 1600 FEET
SCALE: 1"= 1600'

EXPLANATION

- CURRENT SITE CONDITIONS (ROADS & STRUCTURES)
- TRAIL (1942 TO 1952)
- SITE BOUNDARY
- HISTORIC WELL

NORTH
0 400 800 FEET
SCALE: 1"= 800'

BASE MAP REFERENCE:
GRW ENGINEERS INC. 1992 PHOTOGRAMMETRIC SURVEY OF EDWARDS AFB, CA. LEXINGTON, KY.
BASE MAP COORDINATES:
NORTH AMERICAN DATUM 1983 (U.S. FEET).

OU7 CWM ROD

1952 Aerial Photograph Site 442 Areas 1 and 2

Date 6-09	Edwards AFB	Figure 2.5-2
Project No. 94551		

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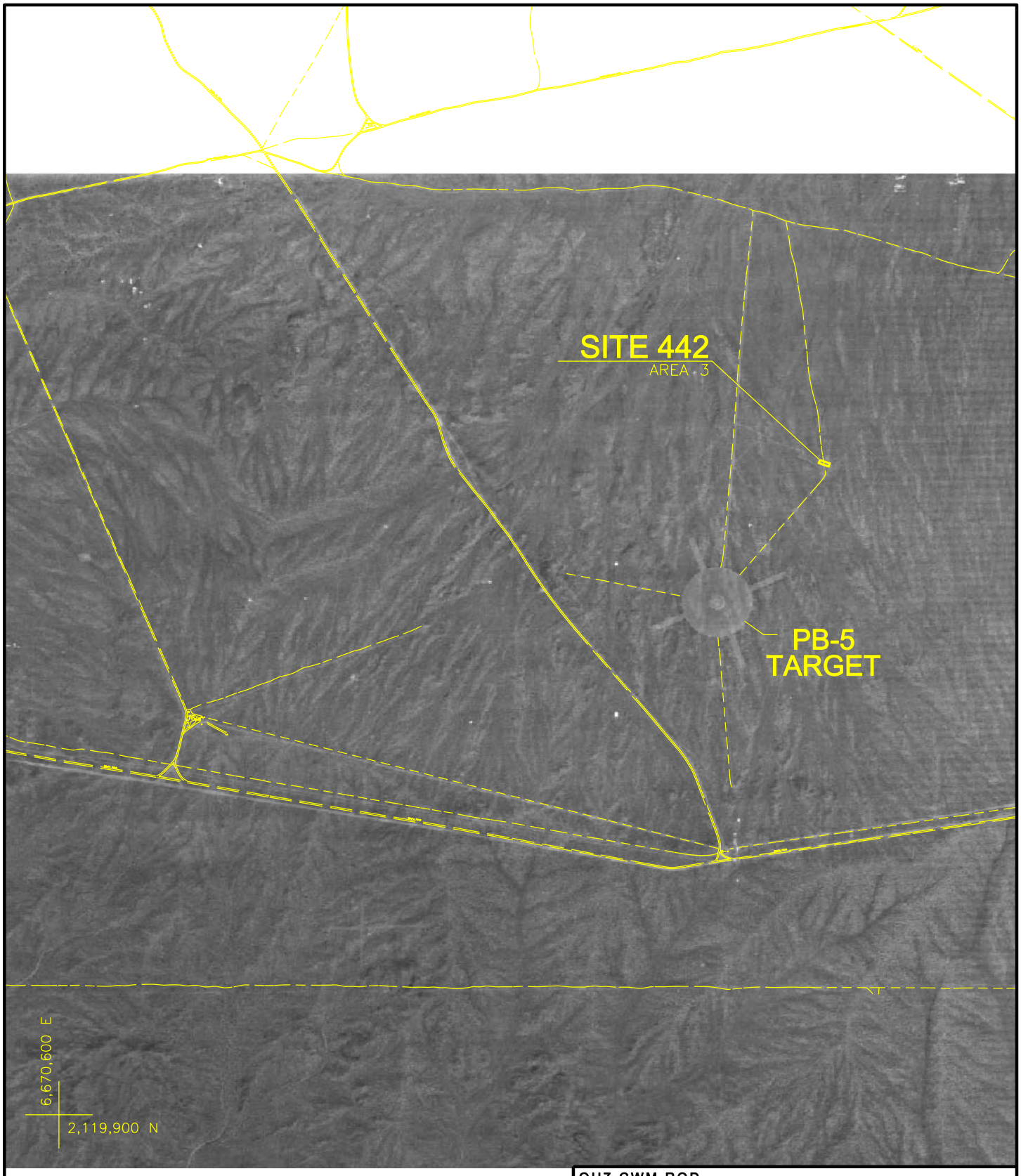

EXPLANATION

PB PRECISION BOMBING

NORTH

0 1000 2000 FEET

SCALE: 1"= 2,000'

OU7 CWM ROD

1963 Aerial Photograph
Site 442
Area 3

Date 6-09	Edwards AFB	Figure 2.5-3
Project No. 94551		

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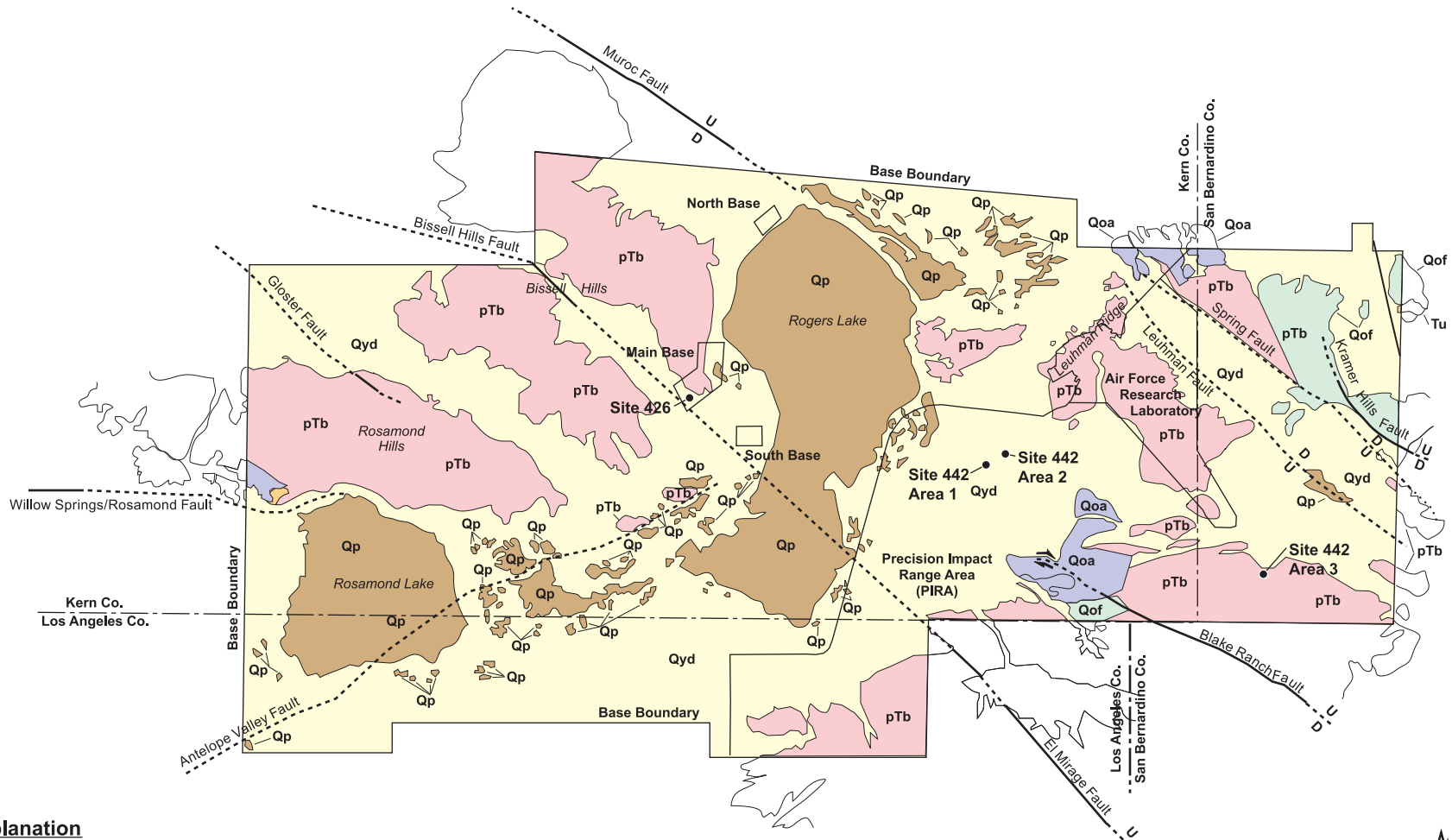
Site 442, Area 3 is located on the northwest flank of a low relief hill at an elevation approximately 3,015 feet above MSL. Quaternary alluvial deposits (sands and gravels) cover most of the area, although occasional outcrops of Tertiary bedrock (quartz monzonite) are observed. Based on the results of borehole drilling at the site, the subsurface geology at Site 442, Area 3 is comprised primarily of unconsolidated alluvial silty sands, with minor amounts of rock fragments (weathered bedrock) and clay. The silty sands overlay weathered and competent quartz monzonite bedrock. The thickness of the unconsolidated alluvial deposits is approximately 30 feet, but is variable throughout the area based on the occasional bedrock outcrops (Earth Tech 2007a).

2.5.2.2 Seismology

This region of Southern California is seismically active. The San Andreas Fault Zone is located approximately 30 miles southwest of Site 442. Major earthquakes (magnitude 5 or greater) recorded near Edwards AFB in the last 15 years include the Landers and Big Bear earthquakes in June 1992 and the Mojave earthquake in July 1992.

Three principal faults are mapped in the area northeast of Site 442; the Spring Fault; the Kramer Hills Fault; and the Leuhman Fault (Figure 2.5-4). The Spring Fault and Kramer Hills Fault are generally parallel, northwest-trending, high angle faults. Movement on the two faults is not well understood, but is thought to be primarily in the vertical direction with relatively little total displacement. The rocks between the faults are downthrown (i.e., graben blocks) relative to the uplifted rocks northeast of the Kramer Hills Fault and southwest of the Spring Fault (i.e., horst blocks). Alluvial deposits conceal the surface trace of the Leuhman Fault, but it is inferred that the fault trends parallel to the Spring Fault and Kramer Hills Fault (Dibblee 1967, Roy F. Weston 1986, and Rewis 1995).

The northwest-trending Blake Ranch Fault is located approximately 2.5 miles southwest of Site 442, Area 3. Although no major seismic activity has been recorded recently in proximity to Area 3, this region of Southern California is seismically active. The San Andreas Fault zone is located approximately 30 miles southwest of Site 442, Area 3.



Explanation

Symbols

- Geologic contact
- County line
- Fault, dashed where approximately located Dotted where concealed
- Edwards AFB boundary

Valley Fill Deposits

- Qyd — Recent alluvium and dune sand
- Qoa — Older alluvium, fanglomerate, gravel, sand, silt and clay
- Qp — Quaternary playa deposits, clay and silt, thin saline crust in places
- Qof — Older alluvial fan deposits, fanglomerate, unspecified

Bedrock

- Tu — Tertiary, undifferentiated sedimentary and volcanic rock. Includes sandstone conglomerate, shale, lake deposits, volcanic rocks, and tuff-breccia. Yield small quantities of water to wells.
- pTb — Pre-Tertiary basement complex. Quartz monzonite, granite, schist, gneiss, and other metamorphic rocks, undifferentiated. Locally highly fractured along faults. May yield small quantities of water from fractures or where deeply weathered.

From Roy F. Weston, Inc. (1986), Dibblee (1967), and Rewis (1995).

OU7 CWM ROD

Generalized Geologic Map of Edwards AFB

Date 6-09	Edwards AFB	Figure 2.5-4
Project No. 94551		

2.5.3 SITE HYDROGEOLOGY AND WATER SUPPLY

2.5.3.1 Hydrogeology

The main aquifer system at Edwards AFB is the Antelope Valley closed alluvial basin (Rewis 1995), which is comprised of several subbasins. Site 442, Area 1 is located in the Lancaster Subbasin, while Area 2 is located in a recharge area for the Antelope Valley Basin (CDWR 2003) (Figure 2.5-5). The aquifer system in the Lancaster Subbasin consists of three aquifers, the upper, middle, and lower aquifers, which were identified on the basis of the hydrologic properties, age, and depth of the unconsolidated deposits (Leighton and Phillips 2003). Based on an extrapolation of existing data, the groundwater in the vicinity of Site 442, Area 1 is in the middle aquifer (Leighton and Phillips 2003), which is considered a primary source of drinking water under SWRCB Resolution 88-63.

During groundwater sampling in February 2003, the depths to groundwater in Site 442, Areas 1 and 2 were 209 feet bgs and 191 feet bgs, respectively. Based on the depth to water in these monitoring wells, and using extrapolated aquifer data collected from wells in OUs 4 and 9, the direction of groundwater flow is to the west toward Rogers Dry Lake (Figure 2.5-6).

Based on the results of the borehole drilling, Site 442, Area 3 is located in an area of shallow bedrock and low groundwater yield (see Figure 2.5-5). Groundwater occurs at a depth in excess of 250 feet bgs. Based on available data for the eastern PIRA, the direction of groundwater flow in the vicinity of Site 442, Area 3 is to the north-northeast (Earth Tech 2007a).

2.5.3.2 Water Supply

Historically, potable water for the AFRL (located approximately 3.3 miles northeast of Site 442, Area 2) was supplied by two production well fields: Mary's Well Field (including Wells 1, 2, and 3) and the Lower Well Field (including Wells A, B, C, and D) (Earth Tech 2007a). Both well fields are located east of Rogers Dry Lake, in the eastern portion of the Lancaster Subbasin (Figure 2.5-7). Since late 1997, AFRL has purchased a portion of its potable water supply from the AVEK Water Agency, which runs a pipeline from Boron to AFRL. Well production records for 2002 show that the four wells in the Lower Well Field produced a combined total of approximately 22 million gallons, or 36 percent of the water supply, while AVEK supplied approximately 39 million gallons, or 64 percent of the water

2,197,000 N

6,700,500 E

SITE 426

ROSAMOND–BISSELL AREA

ROGERS DRY LAKE

SITE 442 AREA 1

SITE 442 AREA 2

AIR FORCE RESEARCH LABORATORY

GRAHAM RANCH WELL FIELD

SOUTH BASE WELL FIELD

LOWER WELL FIELD

HI VISTA AREA

ROSAMOND LAKE

SOUTH TRACK WELL FIELD

SITE 442 AREA 3

EDWARDS AIR FORCE BASE BOUNDARY

6,524,500 E

2,104,000 N

EXPLANATION

AFB	AIR FORCE BASE
DWR	DEPARTMENT OF WATER RESOURCES
LUC	LAND USE CONTROL
USGS	UNITED STATES GEOLOGICAL SURVEY
⌖	BASE SUPPLY WELL

6-44 ANTELOPE VALLEY BASIN

- RECHARGE AREA
- LANCASTER SUBBASIN (USGS)
- NORTH MUROC SUBBASIN (USGS)

6-46 FREMONT VALLEY BASIN

- RECHARGE AREA
- GLOSTER SUBBASIN (USGS)
- CHAFFE SUBBASIN (USGS)

6-41 MIDDLE MOJAVE RIVER VALLEY BASIN

- RECHARGE AREA

6-47 HARPER VALLEY BASIN

- RECHARGE AREA

NORTH

0 6000 12000 FEET

SCALE: 1"= 12000'

NOTES: 1. HYDROLOGIC UNITS BASED ON DWR BULLETIN 118 (CDWR 2003).
2. USGS SUBBASIN BOUNDARIES FROM USGS (2005) FACT SHEET.

OU7 CWM ROD

Antelope Valley Groundwater Basin (DWR Basin No. 6-44) with USGS Subbasins

Date 6-09	Main Base Edwards AFB	Figure 2.5-5
Project No. 94551		

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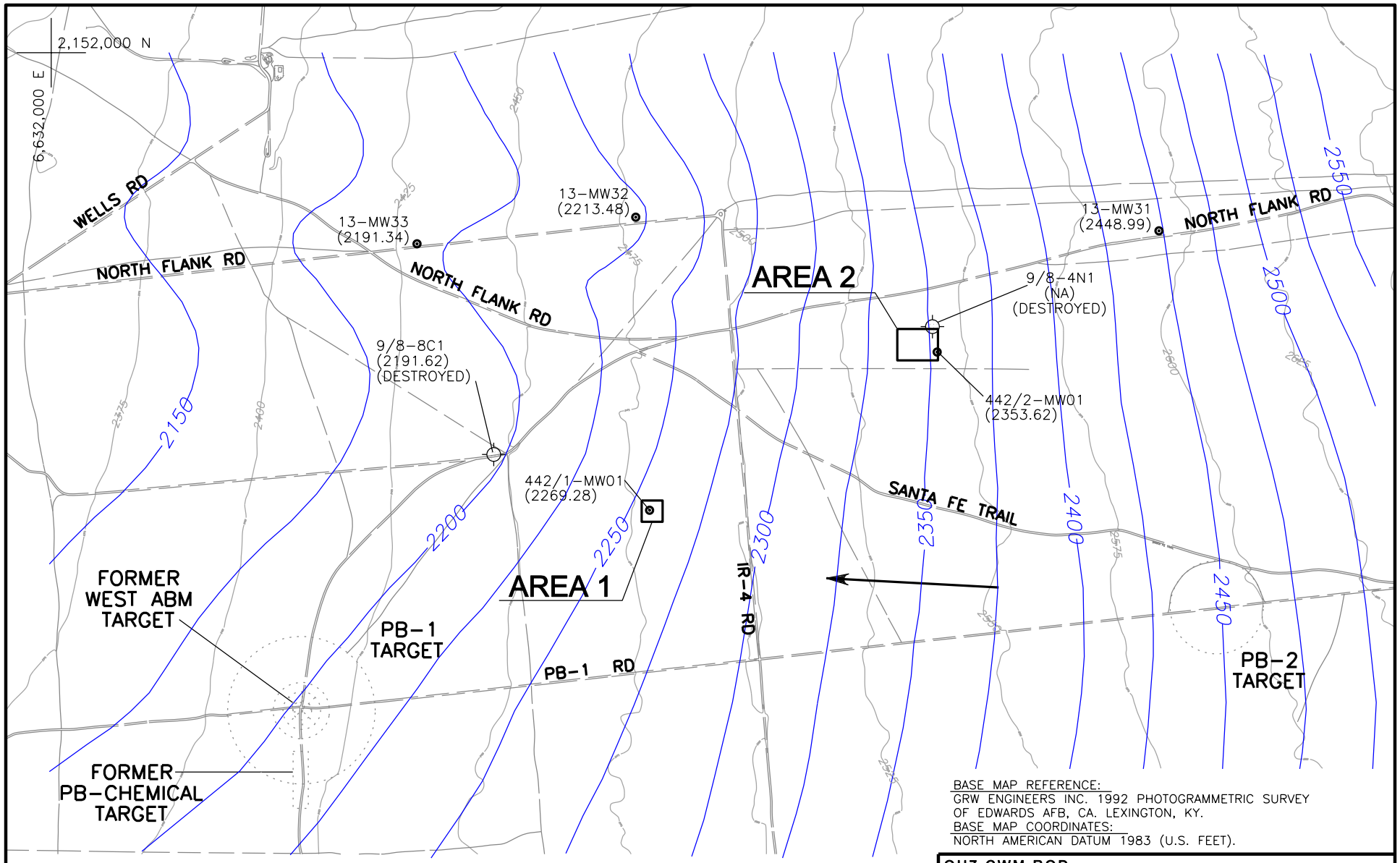

OU7 CWM ROD

Groundwater Elevation Map
Site 442
Areas 1 and 2

Date 6-09	Edwards AFB	Figure 2.5-6
Project No. 94551		

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2,175,600 N

6,611,300 E

OU4

OU9

ROGERS DRY LAKE

TEST AREA 1-100

TEST AREA 1-125

TEST AREA 1-90

TEST AREA 1-14

TEST AREA 1-120

TEST AREA 1-115

TEST AREA 1-40

LEUHMAN RIDGE

TEST AREA 1-32

TEST AREA 1-21

TEST AREA 1-30

TEST AREA 1-110

TEST AREA 2-10

TEST AREA 1-36

TEST AREA 2-5

MERCURY BLVD

MARS BLVD

WELL 2 9/8-6H2

WELL 1 9/8-6H1

WELL 3 9/8-6J1

MARY'S WELL FIELD (INACTIVE)

WELLS RD

NORTH FLANK RD

13-MW31

13-MW32

13-MW33

9/8-4N1 (DESTROYED)

SITE 442 (AREA 2)

9/8-8C1 (DESTROYED)

PB-1 TARGET

SITE 442 (AREA 1)

PB-2 TARGET

FORMER WEST ABM TARGET

FORMER PB-CHEMICAL TARGET

TEST AREA 1-38

TEST AREA 1-39

TEST AREA 1-42

OU4

TEST AREA 1-46

TEST AREA 1-52

PB-11 TARGET

MERCURY BLVD

WELL B 9/9-15J1

WELL A 9/9-14P2

WELL D 9/9-13N1

WELL C 9/9-23B1

LOWER WELL FIELD

SOUTH AIR FORCE RESEARCH LABORATORY CONTAINMENT ZONE GROUNDWATER LAND USE CONTROL COMPLIANCE BOUNDARY

TEST AREA 1-56

6,686,400 E

2136,600 N

PB-13 TARGET

EXPLANATION

- OPERABLE UNIT (OU) BOUNDARY
- MONITORING WELL
- SITE BOUNDARY
- HISTORIC WELL
- BASE SUPPLY WELL
- SOUTH AFRL CONTAINMENT ZONE AND GROUNDWATER LAND USE CONTROL COMPLIANCE BOUNDARY

ABM ABERDEEN BOMBING MISSION
PB PRECISION BOMBING

BASE MAP REFERENCE:
GRW ENGINEERS INC. 1992 PHOTOGRAMMETRIC SURVEY OF EDWARDS AFB, CA. LEXINGTON, KY.
BASE MAP COORDINATES:
NORTH AMERICAN DATUM 1983 (U.S. FEET).

NORTH

0 2500 5000 FEET

SCALE: 1"= 5000'

OU7 CWM ROD

Location of Well Fields in the Vicinity of Site 442, Areas 1 and 2

Date 6-09	Edwards AFB	Figure 2.5-7
Project No. 94551		

EDWARDS\94551\B7173FGA.A01

supply (Earth Tech 2008b). The three wells in Mary's Well Field have been inactive since at least 1997. The nearest off-Base water supply well is located approximately 7.5 miles north of Site 442, Areas 1 and 2.

As shown on Figure 2.5-7, Site 442, Area 2 is located within the South AFRL Containment Zone (CZ) as defined in the *Record of Decision, South Air Force Research Laboratory, Operable Units 4 and 9, Edwards Air Force Base, California* (Earth Tech 2007b). Groundwater data collected from two rounds of sampling at Area 2 (see Section 2.5.10.3) indicate that groundwater below Area 2 is not contaminated. Modeling indicates that future migration of the contamination in the groundwater at the South AFRL within the CZ could pose a potential risk to human health if the groundwater were used for drinking water purposes.

There are no on-Base water supply wells used for beneficial purposes (i.e., municipal, agricultural, industrial, or freshwater replenishment) in the vicinity of Site 442, Area 3. The nearest known off-Base water supply well used for beneficial purposes is located approximately 5.7 miles to the southeast of Area 3.

2.5.4 SITE TOPOGRAPHY AND SURFACE DRAINAGE

Site 442, Areas 1 and 2 are located on a gently sloping alluvial plain at elevations approximately 2,500 feet above MSL. Local surface drainage is to the west toward Rogers Dry Lake, which is located approximately four miles west of Site 442, Areas 1 and 2. Site 442, Area 3 is located on the northwest flank of a low relief hill at an elevation approximately 3,015 feet above MSL. The topography and surface drainage at Site 442, Area 3 slopes north-northeast toward a small, topographically open basin of gentle relief.

2.5.5 SITE ECOLOGICAL SETTING

The land at Site 442, Areas 1 and 2 is slightly disturbed to moderately disturbed. Site 442, Areas 1 and 2 are located in the Air Force Desert Tortoise Management Zone 1 (USAF 2002). The major zonal habitat in the area is described as Joshua tree woodlands (see Figure 2.4-2). The Joshua tree is not a Federal or State endangered or threatened species.

The land surface at Site 442, Area 3 is slightly disturbed to moderately disturbed. Site 442, Area 3 is located in the U.S. Fish and Wildlife Service Fremont-Kramer Desert Tortoise Critical Habitat Unit and Air Force Desert Tortoise Management Zone 3 (USAF 2002). The desert tortoise is listed as a

Federal and State threatened species. The major zonal habitat in the area is described as creosote bush scrub (see Figure 2.4-2).

2.5.6 SITE LAND USE AND DEMOGRAPHICS

Site 442, Areas 1, 2, and 3 are located in Land Use Management Area B (Precision Impact Range Area) as designated in the INRMP for Edwards AFB (USAF 2002). Land Use Management Area B covers a large portion of the eastern part of the Base. The area is primarily used to test aircraft targeting equipment and for practice in precision bombing. It is also used for aircraft flight-testing, explosive ordnance disposal, and the placement of communication equipment. Other activities and uses in the PIRA are scheduled around the Range use, are severely restricted, and occur occasionally. The long range plan contained in the Base General Plan (GP) (Higginbotham/Briggs & Associates [HB&A] 2001) states that the future land use in this Management area will continue to be for industrial purposes.

The land at Site 442, Areas 1 and 2 is undeveloped open terrain. The nearest facility continuously staffed with personnel working on Base is PIRA Range Control (Downfall) (Building 9505) located approximately 2.7 miles east-northeast of Site 442, Area 2. The closest active targets (Targets PB-1 and PB-2) are not used for live fire; munitions are dropped with spotting charges. Site 442, Area 1 is 0.7 miles northeast of Target PB-1, and 1.1 miles west-northwest of Target PB-2. Site 442, Area 2 is 1.4 miles northeast of Target PB-1, and 0.7 miles northwest of Target PB-2. The nearest live fire target (Target PB-13) is located 3.5 miles south of Site 442, Area 1. Due to the distances from these targets, the likelihood of an accidental impact at Site 442, Areas 1 and 2 from a bomb dropped by an aircraft intending to use these nearby targets is low.

The land at Site 442, Area 3 is undeveloped open terrain. The nearest facility continuously staffed with personnel working on Base is PIRA Range Control (Downfall) (Building 9505), which is located approximately 6.4 miles northwest of Site 442, Area 3. The closest active targets (Targets PB-11 and PB-12) are not used for live fire; munitions are dropped with spotting charges. Site 442, Area 3 is 2.5 miles south of Target PB-11, and 2.8 miles southwest of Target PB-12. Due to the distances from these targets, the likelihood of an accidental impact at Site 442, Area 3 from a bomb dropped by an aircraft intending to use these targets is low.

2.5.7 SITE HISTORY AND ENFORCEMENT ACTIVITIES

2.5.7.1 History of Site 442, Areas 1 and 2

Based on features observed on available aerial photographs, Site 442, Areas 1 and 2 were apparently active from 1942 to 1952. Site 442, Areas 1 and 2 may have been associated with activities that took place at two nearby former bombing targets that were active during that time period, the Precision Bombing Chemical (PB-Chem) Target (Site 430) and West Aberdeen Bombing Mission (ABM) Target (Site 431) (see Figure 2.5-2). The PB-Chem and West ABM targets were under the control of the ABM, a detachment from the U.S. Army's Aberdeen Proving Ground (APG), Maryland, which was tasked with the testing of CWM. The former bombing targets are also observed on the 1942 aerial photographs.

In the late 1980s, canisters (initially thought to contain H) were found near the current Target PB-1; however, the contents were determined to be an oily liquid. In mid-1992, a suspected chemical bomb was found near the southwestern corner of the current Target PB-1; however, the bomb fill was not determined. Base EOD personnel detonated the ordnance in place.

2.5.7.2 History of Site 442, Area 3

Site 442, Area 3 may have been associated with activities that took place at Target PB-5. Bomber crews stationed at March Field, Riverside, California, and later at Muroc Army Air Field, used Target PB-5 for day and night bombing practice during the 1940s. An August 1949 memorandum stated that Target PB-5 was heavily bombed with mostly M38A2 practice bombs, some of which were filled with high explosives or incendiaries. By 1957, Target PB-5 may have been inactive according to a standard operating procedure manual for the bombing and gunnery ranges at Edwards AFB. The manual showed the location of Target PB-5, but made no reference to activities conducted at the target, whereas activities conducted at other targets on the PIRA were described (Earth Tech 2006). However, based on analysis of aerial photographs taken during the 1960s, an observed change in the configuration of the target center suggests that Target PB-5 was active during this period.

The nearest target to Site 442, Area 3 that was formerly under the control of the ABM (the East ABM Target) is located 3.3 miles northeast of Area 3. Burial trenches that may have been associated with the

East ABM Target have not been located; therefore, it is possible that CWM dropped at the East ABM Target may have been disposed at Site 442, Area 3.

A September 1994 memorandum, which lists the status of unexploded ordnance (UXO) contamination at several Air Force Bases (including Edwards AFB), reported that chemical and non-conventional munitions were found at several target areas (Weston Solutions, Inc. 2003). An attachment entitled *"Targets within the Precision Impact Range Area (PIRA)"* reported that canisters with H agent were found near Target PB-5; however, there was no information on the exact location where the canisters were found or how they were disposed.

Target PB-5 is inactive and is not maintained (i.e., grubbed or graded). However, the target outline is visible on recent aerial photographs and is recognizable during site reconnaissance.

2.5.7.3 Chemical Warfare Agents and Industrial Chemicals Associated with Site 442

Based on archival research, several different types of CWA and industrial chemicals may have been tested as fill material in bombs dropped at the targets associated with the burial trenches at Site 442, Areas 1 and 2 as shown in Table 2.5-1 and indicated below (Earth Tech 2007a):

- **Mustard and Lewisite -** Supply credit reports from 1940 for Muroc Army Air Field show that CWAs mustard (H) (bis [2-chloroethyl] sulfide) (55 tons) and lewisite (L) (dichloro-2-chlorovinyl arsine) (80 tons) were planned for shipment to the Base. The likely use of these materials was as bomb fill. A 1945 high altitude bombing report indicates that 12 H-filled bombs were dropped at Muroc Army Air Field, and 11 were recovered.

- **Incendiaries -** Napalm and thermite bomb drop locations are listed on a 1953 test facilities map, which also indicates areas where mustard bombs were detonated. Several memoranda from 1942 to 1945 relate to the use of incendiary bombs at Muroc Army Air Field. A 1946 memorandum requests delivery of 90 white phosphorus-filled bombs to the ABM at Muroc Army Air Field.

- **Nerve Agents -** Several archival documents from 1952 to 1955 discuss ballistic tests of non-persistent gas (sarin [GB] [isopropylmethyl phosphonofluoridate]) cluster bombs at Edwards AFB. None of the documents mention that live agent was used in the tests. In addition, there was no mention in any of the archival documents of what simulants were used in the testing; however, known nerve simulants include methyl salicylate (MES), dimethyl methyl phosphonate (DMMP), and diethyl malonate (DEM) (GEOMET Technologies, LLC 2008).

TABLE 2.5-1. CHEMICAL WARFARE AGENTS AND INDUSTRIAL CHEMICALS POTENTIALLY PRESENT AT SITE 442, AREAS 1, 2, AND 3

Analyte	Symbol	CAS No.
Chemical Warfare Agents		
Distilled mustard (bis[2-chloroethyl]sulfide)	HD	505-60-2
Lewisite (2-chlorovinyldichloroarsine)	L	541-25-3
Sarin (isopropyl methylphosphonoflouridate)	GB	107-44-8
Tabun (ethyl N,N-dimethylphosphoramidocyanidate)	GA	77-81-6
Industrial Chemicals		
Chloropicrin (trichloronitromethane)	PS	76-06-2
Cyanogen chloride	CC/CK	506-77-4
Explosives and explosive residues	-	
2-amino-4,6-dinitrotoluene	-	35572-78-2
4-amino-2,6-dinitrotoluene	-	19406-51-0
1,3-dinitrobenzene	-	99-65-0
2,4-dinitrotoluene	-	121-14-2
2,6-dinitrotoluene	-	606-20-2
HMX (octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine)	-	2691-41-0
nitrobenzene	-	98-95-3
nitroglycerin	-	55-63-0
2-nitrotoluene	-	88-72-2
3-nitrotoluene	-	99-08-1
4-nitrotoluene	-	99-99-0
pentaerythritol tetranitrate	-	78-11-5
RDX (cyclotrimethylenetrinitramine)	-	121-82-4
tetryl	-	479-45-8
1,3,5-trinitrobenzene	-	99-35-4
2,4,6-trinitrotoluene (TNT)	-	118-96-7
Hydrogen cyanide	AC	74-90-8
Incendiary (gasoline + isobutyl methacrylate polymer thickeners)	IM	-
Incendiary (gasoline + magnesium)	PT1	-
Phosgene (carbon dichloride)	CG	75-44-5
Tear gas (chloroacetophenone and chloropicrin in chloroform)	CNS	532-27-4
Thermite (trivalent iron + aluminum)	-	-
White phosphorus	WP	7723-14-0
Mercury	Hg	7439-97-6
Chemical Warfare Agent Degradation Products		
Thiodiglycol	TDG	111-48-8
1,4-dithiane	DT	505-29-3
1,4-oxathiane	OT	15980-15-1
2-chlorovinyl arsonous acid	CVAA	85090-33-1
Lewisite oxide	LO	3088-37-7
Vinyl chloride	-	75-01-4
Diisopropylmethylphosphonate	DIMP	1445-75-6
Dimethylmethylphosphate	DMMP	756-79-6
Isopropyl methylphosphonic acid	IMPA	1832-54-8
Methylphosphonic acid	MPA	993-13-5

Notes:

CAS Chemical Abstracts Service
HDX High Melting eXplosive
RDX Research Department composition X or Royal Demolition eXplosive

Archival research also indicates that canisters with mustard agent were found near Target PB-5 and that incendiaries may have been tested as fill material in bombs dropped at the target, which is near the known burial location at Site 442, Area 3 (Earth Tech 2007a).

2.5.8 REMEDIAL INVESTIGATIONS

RIs conducted at Site 442, Areas 1, 2, and 3 include archival and aerial photograph research, site reconnaissance surveys, geophysical surveys, passive soil gas surveys, borehole drilling and soil sampling, monitoring well installation and groundwater sampling, and soil cover investigations at the suspected burial locations. No intrusive sampling was conducted within the waste cells due to the hazardous nature of the suspected contents within the waste cells. A more complete discussion of the remedial investigations conducted are presented in the *OU7 CWM RI SR* (Earth Tech 2006) and in *Environmental Restoration Program, Feasibility Study, Site 442 – Area 1, 2, and 3, Operable Unit No. 7, Chemical Warfare Materiel, Edwards AFB, CA (OU7 CWM FS)* (Earth Tech 2007a). A brief summary of the remedial investigations conducted at Site 442, Areas 1, 2, and 3 include the following:

- Earth Tech and Base EOD personnel visited the former Target PB-5 in July 1999. At the observation point northeast of the target, a large area north of the remnants of the observation tower was clear of vegetation. The EOD representative stated that a trench was excavated at this location, filled with munitions, and subsequently backfilled. This trench was designated as the PB-5 Munitions Residue Burial Site (MRBS) (current location of Site 442, Area 3).

- A site reconnaissance survey of Site 442, Areas 1 and 2 was conducted in August 1999. The suspect areas identified on aerial photographs appeared graded, highly disturbed, and void of vegetation. At Site 442, Area 1, four dirt roads (observed on aerial photographs) that once provided access to the site were overgrown. A weathered sign marked "EXPLOSIVE AREA" was found lying on the ground surface near the entrance to the area. In addition, a sign with no distinguishable markings was found. Scattered surface debris at the site includes ordnance scrap, links from .50-caliber metallic link-belts, and canvas parts of cargo parachutes. Site 442, Area 2 was posted with a small weathered aluminum sign marked "BOMB BURIAL." A former homestead water well (Well 9/8-4N1) and a concrete foundation are located near the entrance to the site. Several steel fence posts delineate the perimeter of the burial area. The ground surface at both areas appeared to have been disturbed and cleared of vegetation at some time in the past.

- A magnetic gradiometer (MAG) reconnaissance survey was conducted at Site 442, Areas 1 and 2 in January and February 2000. At Site 442, Area 1, a total of 346 anomaly markers were placed on the ground during the survey. The mapped locations of the markers show a

spread-out scatter pattern that suggests the traces of a work yard where Range residue may have been sorted for disposal. At Site 442, Area 2, a total of 1,360 anomaly markers were placed on the ground during the survey. The mapped locations of the markers show a pattern that is most dense in an east-west band across the central part of the area.

- Detailed (gridded) MAG and electromagnetic induction (EM) surveys of Site 442, Areas 1 and 2 were conducted in April 2000. For Site 442, Area 1, the MAG survey showed two trench-like anomalies located in the southern half of Site 442, Area 1. The trench-like anomalies have lengths of approximately 160 feet and 200 feet (or more). The EM survey showed the same anomalies, but less complete, probably due to surface debris on site. The GPR survey showed that the eastern anomaly might be an accumulation of small metal scraps that may have been graded into a windrow. For Site 442, Area 2, the MAG and EM surveys identified five anomalies that resemble burial trenches, and two smaller anomalies (each interpreted as a few pieces of buried metal).

- A passive soil gas survey was conducted at Site 442, Areas 1 and 2 in July and August 2001 using the Gore-Sorber® passive soil gas technique. The primary objective of the passive soil gas survey was to evaluate the presence of CWA degradation products or other toxic chemicals at the site. In addition, background samples (i.e., samples most likely free of CWA) were collected at locations upgradient of the site to allow for the direct comparison of the sample results, and to evaluate the presence of false positives. The soil gas samples collected were analyzed for VOCs and semivolatile organic compounds (SVOCs), CWA degradation products, and explosives.

- In September 2001, three boreholes were drilled at Site 442, Area 1 and 15 boreholes were drilled at Site 442, Area 2. Boreholes were drilled adjacent to, not within, the waste disposal cells. Soil samples were field-screened by the mobile laboratory using a MINICAMS® for H and L, a photoionization detector (PID) for chloropicrin (PS), and a flame ionization detector (FID) for VOCs. Samples were analyzed for H, L, GB and tabun (GA) (Ethyl N,N-dimethylphosphoramidocyanidate); TEPH; total volatile petroleum hydrocarbons (TVPH); VOCs; CWA degradation products; explosives; metals and other elements; mercury; and cyanide.

- In December 2001, an induced polarization/resistivity (IP/Res) survey was conducted in Areas 1 and 2 to estimate the depth of the interpreted burial trenches. For Site 442, Area 1, based on the IP/Res survey, the estimated depth of the trench is 12 feet to 15 feet bgs, and the estimated thickness of soil cover over the buried debris is less than two feet. For Site 442, Area 2, based on the IP/Res survey, the estimated depth to the bottom of the buried debris in each of the three east west trenches is 10 feet bgs and the estimated thickness of the soil cover is four feet or less. For the north-south trench, the estimated depth to the bottom of the buried debris is 12 feet to 15 feet bgs, and the estimated thickness of the soil cover is less than two feet. The estimated depth to the bottom of the buried debris in the smaller anomalies is four to six feet bgs, and the estimated thickness of the soil cover is less than two feet.

- In December 2002, two groundwater monitoring wells were installed; one at Site 442, Area 1 and one at Site 442, Area 2. The wells were installed to determine the depth of groundwater at Site 442, Areas 1 and 2, and to evaluate whether the groundwater was contaminated due to the buried munitions in the trenches. Groundwater was encountered at a depth of 209 feet bgs at Site 442, Area 1 and 191 feet bgs at Site 442, Area 2. Groundwater samples were collected from both wells in February and August 2003. Groundwater samples were analyzed for TEPH; TVPH; VOCs; CWA degradation products; explosives; metals and other elements; mercury; cyanide; anions; and perchlorate.

- From March 2003 to May 2003, a visual reconnaissance (VR) survey was conducted at the former PB target areas potentially associated with Site 442, Areas 1 and 2 (Earth Tech 2003). Based on archival research, these former target areas (the PB-Chem Target and the West ABM Target) were used by the ABM for the testing of CWM in the 1940s and 1950s. The purpose of the VR survey was to evaluate whether ordnance fragments visible on the surface at these former target areas were, or potentially could be, the result of CWM testing. Munitions that were designed to hold CWA, but no live CWA-filled items, were found during the VR survey. Items that were characterized as CWM and potential CWM were found predominantly in the center portion of the West ABM Target. An intact M125A1 bomblet that was designed to hold 2.6 pounds of non-persistent gas (typically GB) was found approximately 0.85 miles east of the former West ABM Target. The bomblet was reported to Base EOD personnel, and later evaluated by the U.S. Army TEU. After the U.S. Army Munitions Assessment Review Board (MARB) stated their position that the bomblet was filled with water, it was detonated in place by Base EOD personnel. Additionally, six UXO or potential UXO items were found in the area of the former West ABM Target. The locations of these UXO items were reported to the Base EOD for evaluation and disposal, and were subsequently blown in place by Base EOD personnel.

- In April 2003, Earth Tech personnel conducted a site reconnaissance survey of Site 442, Area 3. A shallow, northwest-southeast trending depression, clear of vegetation and approximately 120 feet by 200 feet in area, was observed in the area north of the remnants of an observation tower. A signpost marked "BOMB BURIAL" and several shallow sinkholes were observed at the northwest end of the shallow depression. A second signpost was found approximately 100 feet northwest of the shallow depression. Although badly faded, the words "...BURIAL" and "DO NOT REMOVE..." were faintly legible on the second sign. Another shallow depression and a 4-foot high mound of soil were located southwest of the burial location. This depression may have been a borrow pit. Debris was scattered throughout the area including bomb fragments, remnants of a parachute, cans and glass bottles, glass debris, a tire, wood debris, metal strapping, wiring, and imported gravel.

- In August 2003, Spectrum Geophysics conducted MAG, EM, and GPR geophysical surveys at Site 442, Area 3 to locate the suspected buried trench, delineate its boundaries, and estimate the depth of fill. A complex series of northwest-southeast trending anomalies were identified in an area approximately 145 feet long and 30 feet wide. A signpost at the site marked "BOMB BURIAL" coincided with the detected southeastern extent of the anomalous area. The source of the geophysical anomalies was interpreted to be buried

metal objects in a backfilled trench. As indicated by the signpost, the buried metal objects are presumably munitions, possibly including CWM. The estimated depth of the trench could not be determined, but the soil covering the buried debris was estimated to be three feet to four feet thick.

- In September and October 2003, a VR survey was conducted in the area around former Target PB-5 (located southwest of Site 442, Area 3) (Earth Tech 2004a). The purpose of the VR survey was to locate and describe any potential CWM ordnance or CWM scrap materials visible on the ground in the area of former Target PB-5, which may have been used by the ABM in the 1940s and 1950s for the testing of CWM. Two items found in the vicinity of former Target PB-5 were evaluated as potential CWM ordnance components or CWM scrap materials. The items found were consistent with the box-type fin associated with the M102, M102A1, and M103A1 tail fins found on M70 persistent gas bombs. A suspect area devoid of vegetation was also characterized as an area potentially associated with CWM. Additionally, four UXO or potential UXO items were found in the area around former Target PB-5. The locations of these UXO items were reported to the Base EOD for evaluation and disposal, and were subsequently blown in place by Base EOD personnel.

- In July 2004, a passive soil gas survey was conducted at Site 442, Area 3. The primary objective of the passive soil gas survey was to evaluate whether CWA degradation products or other toxic chemicals were released into the subsurface as a result of the buried munitions residue at the PB-5 MRBS. A total of 22 soil gas modules (including duplicates) were deployed, retrieved, and analyzed. The soil gas modules were deployed in two evenly spaced linear rows along the length of the buried trench delineated during the geophysical survey. In addition, one background sample (i.e., a sample most likely free of CWA) was collected from a location near the site to allow for the direct comparison of the sample results, and to evaluate the presence of false positives. The soil gas samples collected were analyzed for CWA degradation products, explosives, and industrial chemicals.

- In July 2004, four boreholes were drilled at Site 442, Area 3 using hollow stem auger (HSA) drilling techniques. The boreholes were drilled at the mid-point of each side, outside the area of suspected buried debris, and at each end of the suspect trench delineated during the geophysical survey. The soil samples were analyzed for HD, L, GA, and GB, TEPH, TVPH, VOCs, CWA degradation products, explosives, metals and other elements, mercury, cyanide, and perchlorate.

- In August 2004, an attempt was made to install one groundwater monitoring well (442/3-MW01) at Site 442, Area 3. The borehole for the proposed groundwater monitoring well was drilled at the location of a former soil borehole (442/3-B01) on the north side (downgradient) of the trench identified as the PB-5 MRBS. The borehole was drilled and logged for lithology to a depth of 250 feet bgs using the air rotary drilling technique. Soil samples were not collected during drilling. After allowing the borehole to sit open for 24 hours, no groundwater was encountered. Consequently, after receiving approval from the RPMs, the monitoring well was not installed and the borehole was backfilled with grout.

- In October 2004, Earth Tech conducted a soil cover investigation at Site 442, Areas 1, 2, and 3 in order to assess the effectiveness of the existing soil cover in protecting human health and the environment. The investigation included geophysical surveys using GPR to evaluate the thickness of the soil cover and sampling for geotechnical properties of the soils covering the buried debris. The results of GPR surveys to evaluate the thicknesses of the existing soil cover at the three Areas indicated that the depths to the shallowest buried objects ranged from 0.5 feet to 3 feet bgs. However, it should be noted that the detected objects were interpreted to be small pieces of debris in the soil cover and that the depth to significant buried debris (such as intact bomb casings) was considered to be at or below the maximum depth of GPR penetration at these Areas, which was evaluated to be approximately four feet bgs to five feet bgs. The geotechnical test results showed that the soils covering the buried debris at all three Areas are classified as silty sands with hydraulic conductivities ranging between 6.59×10^{-5} centimeters per second (cm/s) and 7.52×10^{-4} cm/s. Geotechnical samples were collected at each trench to a depth of 30 inches without encountering debris.

2.5.9 INTERIM RESPONSE ACTIONS

No interim response actions have been performed at Site 442.

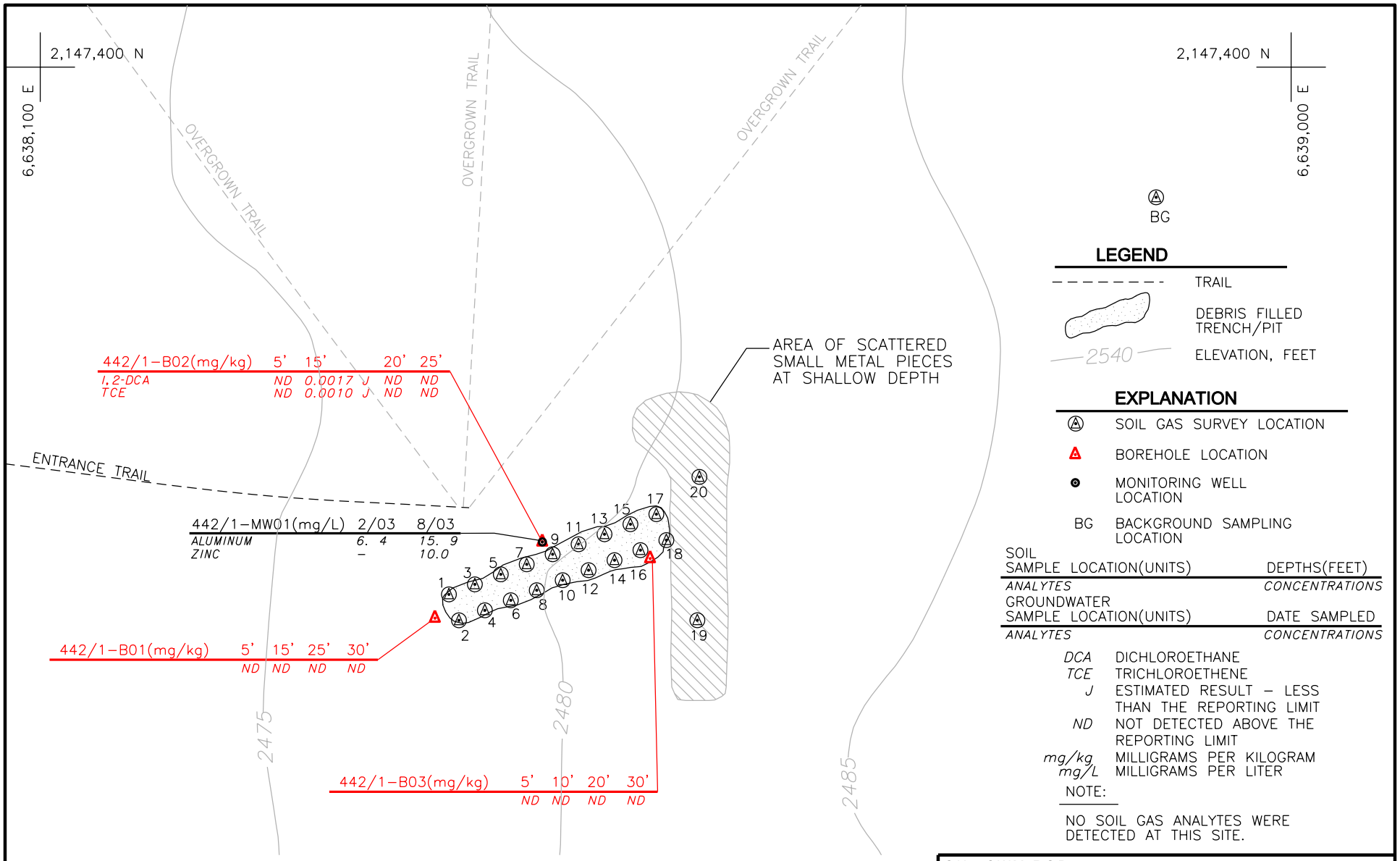
2.5.10 NATURE AND EXTENT OF RESIDUAL SITE CONTAMINATION

The following subsections summarize the results of the previous RIs conducted to characterize the soil gas, soil, and groundwater contamination at Site 442, Areas 1, 2, and 3. The results of the soil gas, soil, and groundwater sampling are shown on Figures 2.5-8 through 2.5-10. The complete analytical results from the RIs are presented in the *OU7 CWM RI SR* (Earth Tech 2006).

2.5.10.1 Soil Gas

Passive soil gas samples were collected over and around the burial trenches at Site 442, Areas 1, 2, and 3 using Gore-Sorber® techniques. Samples were analyzed for CWA degradation products, VOCs, SVOCs, and explosives. Soil gas samples were taken in lieu of soil samples over the burial trench locations to reduce the possibility of unearthing CWA and to avoid having to transport soils that could potentially be contaminated with CWA to an off-site laboratory.

A total of 88 soil gas locations were sampled at Site 442, Areas 1 and 2. Eighteen soil gas modules were deployed in and around the suspected trench at Site 442, Area 1. In addition, two soil gas modules were deployed in an area of shallow metallic debris, and one soil gas module was deployed



BASE MAP REFERENCE:
GRW ENGINEERS INC. 1992 PHOTOGRAMMETRIC SURVEY OF EDWARDS AFB, CA. LEXINGTON, KY.
BASE MAP COORDINATES:
NORTH AMERICAN DATUM 1983 (U.S. FEET).

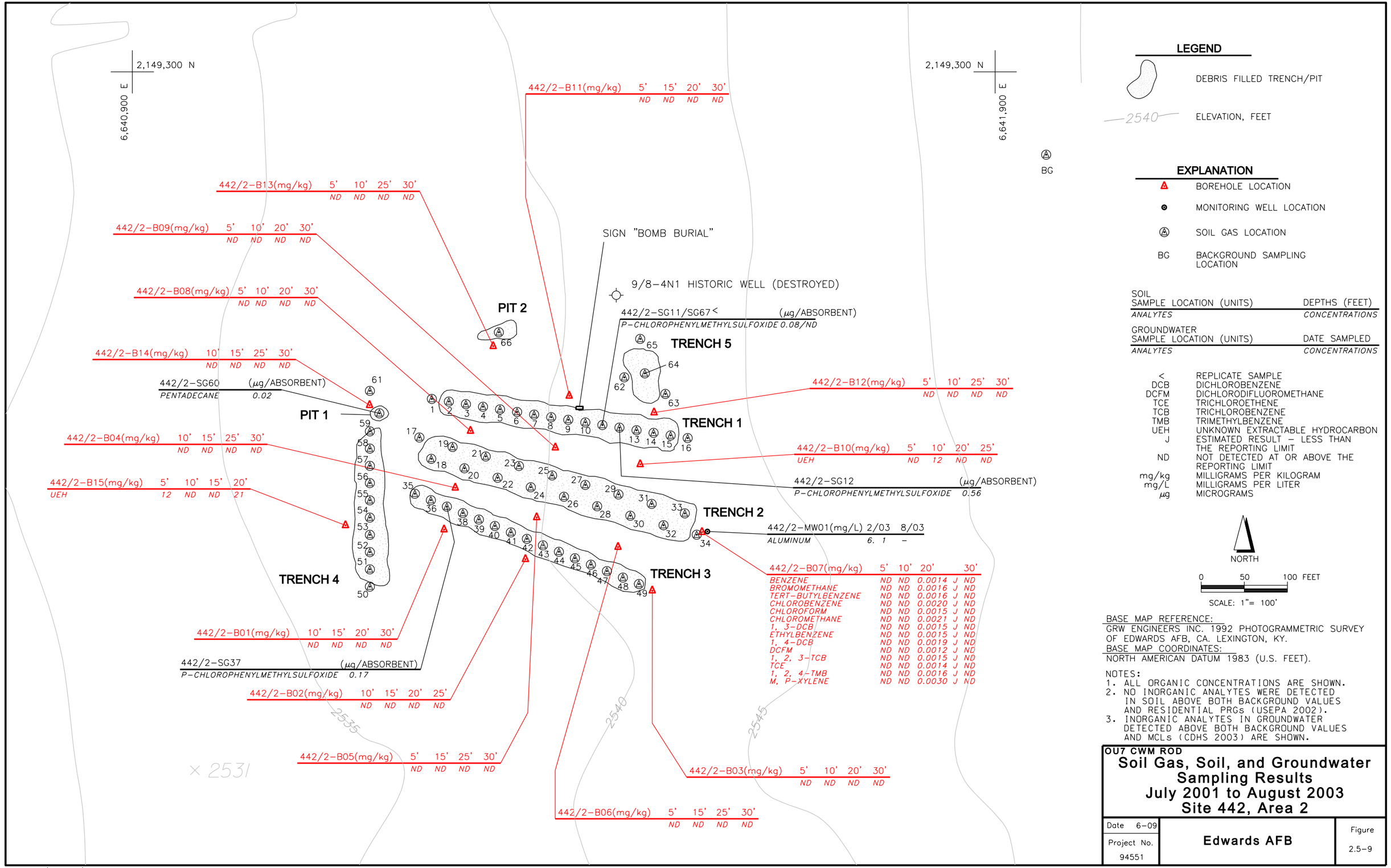
NOTES:
1. ALL ORGANIC CONCENTRATIONS ARE SHOWN.
2. NO INORGANIC ANALYTES WERE DETECTED IN SOIL ABOVE BOTH BACKGROUND VALUES AND RESIDENTIAL PRGs (USEPA 2002).
3. INORGANIC ANALYTES IN GROUNDWATER DETECTED ABOVE BOTH BACKGROUND VALUES AND MCLs (CDHS 2003) ARE SHOWN.

OU7 CWM ROD

Soil Gas, Soil, and Groundwater Sampling Results July 2001 to August 2003 Site 442, Area 1

Date 6-09	Edwards AFB	Figure 2.5-8
Project No. 94551		

EDWARDS\94551\B6961FGA.A01



LEGEND

DEBRIS FILLED TRENCH/PIT

2540 ELEVATION, FEET

EXPLANATION

- BOREHOLE LOCATION
- MONITORING WELL LOCATION
- SOIL GAS LOCATION
- BG BACKGROUND SAMPLING LOCATION

SOIL
SAMPLE LOCATION (UNITS) DEPTHS (FEET)
ANALYTES *CONCENTRATIONS*

GROUNDWATER
SAMPLE LOCATION (UNITS) DATE SAMPLED
ANALYTES *CONCENTRATIONS*

<	REPLICATE SAMPLE
DCB	DICHLOROBENZENE
DCFM	DICHLORODIFLUOROMETHANE
TCE	TRICHLOROETHENE
TCB	TRICHLOROBENZENE
TMB	TRIMETHYLBENZENE
UEH	UNKNOWN EXTRACTABLE HYDROCARBON
J	ESTIMATED RESULT – LESS THAN THE REPORTING LIMIT
ND	NOT DETECTED AT OR ABOVE THE REPORTING LIMIT
mg/kg	MILLIGRAMS PER KILOGRAM
mg/L	MILLIGRAMS PER LITER
µg	MICROGRAMS

NORTH

0 50 100 FEET

SCALE: 1"= 100'

BASE MAP REFERENCE:
GRW ENGINEERS INC. 1992 PHOTOGRAMMETRIC SURVEY OF EDWARDS AFB, CA. LEXINGTON, KY.

BASE MAP COORDINATES:
NORTH AMERICAN DATUM 1983 (U.S. FEET).

NOTES:
1. ALL ORGANIC CONCENTRATIONS ARE SHOWN.
2. NO INORGANIC ANALYTES WERE DETECTED IN SOIL ABOVE BOTH BACKGROUND VALUES AND RESIDENTIAL PRGs (USEPA 2002).
3. INORGANIC ANALYTES IN GROUNDWATER DETECTED ABOVE BOTH BACKGROUND VALUES AND MCLs (CDHS 2003) ARE SHOWN.

OU7 CWM ROD

Soil Gas, Soil, and Groundwater Sampling Results July 2001 to August 2003 Site 442, Area 2

Date 6-09	Edwards AFB	Figure 2.5-9
Project No. 94551		

EDWARDS\94551\B6962FGA.A01

2,129,808.4 N

2,129,808.4 N

6,681,677.9 E

6,682,177.9 E

3010

3015

3020

3025

GEOPHYSICAL SURVEY BOUNDARY

STEEL FENCE POST
ILLEGIBLE SIGN

TRENCH ANOMALY

442/3-MW01
(MONITORING WELL NOT INSTALLED;
BOREHOLE BACKFILLED WITH GROUT)

442/3-B01 (mg/kg) 0' 5' 10' 25'
ND ND ND ND

442/3-B04 (mg/kg) 0' 15' 20' 30'
ND ND ND ND

STEEL FENCE POST
"BOMB BURIAL" SIGN

442/3-SG05 (mg/ABSORBENT)
P-CHLORO 0. 04

442/3-SG11 (mg/ABSORBENT)
P-CHLORO 0. 04

442/3-B02 (mg/kg) 0' 10' 15' 20'
ND ND ND ND

442/3-B03 (mg/kg) 0' 10' 20' 30'
ACETONE 0. 011 ND ND ND

442/3-SG19 (mg/ABSORBENT)
TOLUENE 0. 02

442/3-SG17 (mg/ABSORBENT)
TOLUENE 0. 02

MOUND

MOUND

CONCRETE FOOTING OF
DEMOLISHED OBSERVATION TOWER

CENTER OF FORMER TARGET PB-5
2,571 FT, 218° TRUE

NORTH

0 25 50 FEET

SCALE: 1"= 50'

BASE MAP REFERENCE:
GRW ENGINEERS INC. 1992 PHOTOGRAMMETRIC SURVEY OF EDWARDS AFB, CA. LEXINGTON, KY.
BASE MAP COORDINATES:
NORTH AMERICAN DATUM 1983 (U.S. FEET).

NOTES:
1. ALL ORGANIC CONCENTRATIONS ARE SHOWN.
2. NO INORGANIC ANALYTES WERE DETECTED IN SOIL ABOVE BOTH BACKGROUND VALUES AND RESIDENTIAL PRGs (USEPA 2002).

EXPLANATION

- ATTEMPTED MONITORING WELL LOCATION
- SOIL GAS LOCATION
- BOREHOLE LOCATION (JULY 2004)
- BURIAL TRENCH
- TRAIL
- 3020 — ELEVATION CONTOUR LINE (5-FOOT INTERVAL)
- INTERPRETED DIRECTION OF GROUNDWATER FLOW

BOREHOLE I.D. DEPTH
ANALYTE VALUE (mg/kg)

SOILGAS I.D. DEPTH
ANALYTE VALUE (µg/ADSORBENT)

mg/kg	MILLIGRAMS PER KILOGRAM
µg	MICROGRAMS
P-CHLORO	P-CHLOROPHENYLMETHYLSULFONE
J	ESTIMATED RESULT. LESS THAN THE REPORTING LIMIT
ND	NON-DETECT ABOVE REPORTING LIMIT
°	DEGREES
FT	FEET
MRBS	MUNITIONS RESIDUE BURIAL SITE
PB	PRECISION BOMBING (TARGET)

2,129,077.7 N

OU7 CWM ROD

Soil Gas and Soil Sampling Results July 2004 Site 442, Area 3 (PB-5 MRBS)

Date 6-09 Project No. 94551	Edwards AFB	Figure 2.5-10

EDWARDS\94551\B6960FGA.A01

400 feet northeast of the suspected trench and designated as a background location believed to be free of CWA contamination (see Figure 2.5-8). Sixty-six soil gas modules were deployed in and around the suspected trenches at Site 442, Area 2. One soil gas module was deployed approximately 500 feet northeast of the trenches at Site 442, Area 2 and designated as a background location believed to be free of CWA contamination (see Figure 2.5-9).

No analytes were detected in the soil gas samples collected at Site 442, Area 1. At Site 442, Area 2, trace amounts of p-chlorophenylmethylsulfoxide were detected at three locations, and pentadecane was detected at one location. The chemical p-chlorophenylmethylsulfoxide is a pesticide produced at Rocky Mountain Arsenal shortly after the Army stopped producing H gas. The reason for its presence at Site 442 is not known. The pentadecane is a petroleum hydrocarbon.

At Site 442, Area 3, CWA degradation products were not detected in the soil gas modules. The pesticide p-chlorophenylmethylsulfone was detected at a concentration of 0.04 micrograms per adsorbent (μg/adsorbent) in the soil gas modules collected at two sample locations (see Figure 2.5-10). Toluene was detected at a concentration of 0.02 μg/adsorbent in the soil gas modules collected at two other sample locations. Undecane (two samples), tridecane (one sample), and pentadecane (one sample) were also reported at estimated concentrations below the method detection limit.

2.5.10.2 Soil

For the soil analytical results discussed below, the maximum concentrations of the organic contaminants detected in the soil samples were compared to their respective calculated total designated levels (TDLs), residential PRGs, and industrial PRGs. The maximum concentrations of the inorganic constituents detected in the soil samples were compared to their respective calculated background concentrations, calculated TDLs, and residential and industrial PRGs.

Because OU7 CWM covers such a large area with a diverse range of soil types and groundwater conditions, calculating background values characteristic of each CWM site was not considered practical. Instead, background values were calculated for selected OUs (OUs 1, 2, 4, 5, 9, and 10) that represent the range of soil types and groundwater conditions at the Base, and which could then be applied to the nearest OU or site where background values were not specifically developed. These calculated background concentrations for the selected OUs were developed in a process approved by the

RPMs, and using techniques consistent with USEPA guidance (Earth Tech 1995a). For Site 442, the background concentrations used are the calculated 95% upper confidence limits for OUs 4 and 9, the closest OUs to the site (Earth Tech 2000).

PRGs are risk-based concentrations that are intended to assist in initial screening-level evaluations of chemical constituents in the media of concern.

The TDL for a constituent is calculated to determine whether a solid waste (e.g., contaminated soil) may pose a threat to the water quality at a site (California Regional Water Quality Control Board [CRWQCB] 1989). TDL methodology is based on the primary MCL of the constituent, the leaching potential of the constituent to reach groundwater, and the environmental attenuation factor (i.e., the potential for the attenuation or reduction of the concentration of the constituent), and is calculated as follows:

TDL (in mg/kg) = Primary MCL (in mg/L) x Leachability Factor x Attenuation Factor

Where: mg/kg is milligrams per kilogram and mg/L is milligrams per liter.

If the constituent concentrations in the soil at a site exceed the TDL, the soil is classified as a "designated waste" and is directed to waste management units, which isolate the waste from the environment.

For all Areas of Site 442, the TDLs for the organic contaminants detected in the soil samples collected at the site were calculated using a leachability factor of 10 and an environmental attenuation factor of 100. The TDLs for the inorganic constituents detected in the soil samples were calculated using a leachability factor of 100 and an environmental attenuation factor of 100. The leachability factors and environmental attenuation factors selected were based upon information presented in The Designated Level Methodology for Waste Classification and Cleanup Level Determination (CRWQCB 1989). The leachability factors are typical values for organic and inorganic constituents. The environmental attenuation factors are based on an average degree of protection for water quality from reasonable worst-case conditions.

Site 442, Areas 1 and 2

The maximum concentrations of the organic contaminants detected in soil samples collected at Site 442, Areas 1 and 2 are shown in Table 2.5-2 in comparison to their respective calculated TDLs and residential PRGs. Because no organic compounds exceeded residential PRGs, industrial PRGs are not shown on the table. The maximum concentrations of the inorganic contaminants detected in soil samples collected at Site 442, Areas 1 and 2 are shown in Table 2.5-3 in comparison to their respective calculated background concentrations, calculated TDLs, and residential PRGs. Because no inorganic constituents exceeded both residential PRGs and background concentrations, industrial PRGs are not shown on the table.

Field screening and laboratory analyses did not detect any CWA, CWA degradation products, or explosives in any of the soil samples collected from the boreholes at Site 442, Areas 1 and 2.

At Site 442, Area 1, estimated concentrations (i.e., concentrations below the laboratory reporting limit) of 1,2-dichloroethane (0.0017 mg/kg) and trichloroethene (TCE) (0.0010 mg/kg) were detected in soil samples collected at Borehole 442/1-B02 (see Figure 2.5-8). Acetone (a common laboratory contaminant) was detected at a maximum concentration of 8.1 mg/kg in Borehole 442/1-B03.

At Site 442, Area 2, an unknown extractable hydrocarbon (UEH) was detected at a concentration of 12 mg/kg in Borehole 442/2-B10, and at concentrations of 12 mg/kg and 21 mg/kg in Borehole 442/2-B15. TCE was detected at an estimated concentration of 0.0014 mg/kg in Borehole 442/2-B07 (see Figure 2.5-9). Several other VOCs were also detected in the soil from Borehole 442/2-B07, but at estimated concentrations below their respective reporting limits. None of the VOCs were detected at concentrations that exceeded their respective calculated TDLs (if applicable) or residential and industrial PRGs.

Of the inorganic analytes detected in the soil samples collected at Site 442, Areas 1 and 2, only arsenic was detected at concentrations that exceeded its respective residential and industrial PRGs; however, the maximum concentration detected is below the calculated background concentration for arsenic in soil and the calculated TDL value. Cadmium, total chromium, cobalt, nickel, and sodium were detected at maximum concentrations that exceeded their respective calculated background concentrations in soil, but

TABLE 2.5-2. MAXIMUM CONCENTRATIONS OF ORGANIC CONTAMINANTS DETECTED IN SOIL COMPARED TO CALCULATED TDLs AND RESIDENTIAL PRGs - SITE 442, AREAS 1 AND 2

Analyte	Maximum Concentration (mg/kg)	Location ID of Maximum Concentration	Sample Depth (ft bgs)	No. of Detections/ Total No. of Samples	Calculated TDL Value [a] (mg/kg)	No. of Samples Exceeding Calculated TDL Value/Total No. of Samples	2002 Residential PRG [b] (mg/kg)	No. of Samples Exceeding Residential PRG/Total No. of Samples [c]
Petroleum Hydrocarbons								
UEH	21	442/2-B15	20	3/81	-	-	NP	-
Volatile Organics								
acetone*	8.1	442/1-B03	10	50/81	-	-	1,600	0/81
benzene*	0.0014 J	442/2-B07	20	1/117	1	0/117	0.6	0/117
bromomethane*	0.0016 J	442/2-B07	20	1/81	-	-	3.9	0/81
tert-butylbenzene*	0.0016 J	442/2-B07	20	1/81	-	-	390	0/81
chlorobenzene*	0.0020 J	442/2-B07	20	1/81	70	0/81	150	0/81
chloroform*	0.0015 J	442/2-B07	20	1/81	80	0/81	0.94 [d]	0/81
chloromethane*	0.0021 J	442/2-B07	20	1/81	-	-	1.2	0/81
1,3-dichlorobenzene*	0.0015 J	442/2-B07	20	1/81	-	-	16	0/81
1,4-dichlorobenzene*	0.0019 J	442/2-B07	20	1/81	5	0/81	3.4	0/81
dichlorodifluoromethane*	0.0012 J	442/2-B07	20	1/81	-	-	94	0/81
1,2-dichloroethane*	0.0017 J	442/1-B02	15	1/81	0.5	0/81	0.28	0/81
ethylbenzene*	0.0015 J	442/2-B07	20	1/117	300	0/117	8.9	0/117
methylene chloride*	0.0024 J	442/2-B07	20	1/81	5	0/81	9.1	0/81
1,2,3-trichlorobenzene*	0.0015 J	442/2-B07	20	1/81	-	-	NP	-
trichloroethene (TCE)*	0.0014 J	442/2-B07	20	2/81	5	0/81	0.053	0/81
1,2,4-trimethylbenzene*	0.0016 J	442/2-B07	20	1/81	-	-	52	0/81
m- & p-xylene*	0.0030 J	442/2-B07	20	1/81	1,750	0/81	270	0/81

Notes:

Analytes included in this table are compared to the 2002 USEPA PRGs (USEPA 2002) because the 2002 PRGs were used in the *Human Health Risk Assessment, Basewide Miscellaneous and Chemical Warfare Materiel Sites, Operable Unit 7, Edwards Air Force Base, California* (Earth Tech 2004b).

* Analyte carried forward in the risk assessment process.

[a] TDL (mg/kg) = Primary MCL (mg/L) x Leachability Factor (10) x Attenuation Factor (100) (CRWQCB 1989).

[b] USEPA Region IX PRGs (USEPA 2002).

[c] All detected concentrations are also below the 2002 Industrial PRGs.

[d] CAL-Modified PRG (USEPA 2002).

-	not applicable
CDHS	California Department of Health Services
CRWQCB	California Regional Water Quality Control Board
ft bgs	feet below ground surface
ID	identification
MCL	maximum contaminant level; more stringent of the Federal or State primary MCL (CDHS 2003)
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
NP	not promulgated
PRG	preliminary remediation goal
TDL	total designated level
UEH	unknown extractable hydrocarbon
USEPA	United States Environmental Protection Agency

Data Qualifier:

J Estimated result. Result is less than reporting limit (laboratory-assigned data qualifier).

TABLE 2.5-3. MAXIMUM CONCENTRATIONS OF INORGANIC CONSTITUENTS DETECTED IN SOIL COMPARED TO CALCULATED BACKGROUND CONCENTRATIONS, CALCULATED TDLs, AND RESIDENTIAL PRGs - SITE 442, AREAS 1 AND 2

Analyte	Maximum Concentration (mg/kg)	Location ID of Maximum Concentration	Sample Depth (ft bgs)	No. of Detections/ Total No. of Samples	Calculated Background Concentration [a] (mg/kg)	No. Samples of Exceeding Background/ Total No. of Samples	Calculated TDL Value [b] (mg/kg)	No. Samples of Exceeding Calculated TDL Value/Total No. of Samples	2002 Residential PRG [c] (mg/kg)	No. Samples of Exceeding Residential PRG/Total No. of Samples [d]
Metals and Other Elements										
aluminum	17,300	442/2-B06	30	81/81	24,280	0/81	10,000	7/81	76,000	0/81
arsenic	9.1	442/1-B01	30	81/81	24.1	0/81	100	0/81	0.39	81/81 [e]
barium	122	442/2-B07	30	81/81	590	0/81	10,000	0/81	5,400	0/81
beryllium	0.87	442/2-B06	30	28/81	0.9	0/81	40	0/81	150	0/81
cadmium*	1.3	442/2-B13	30	1/81	0.66	1/81	50	0/81	37	0/81
calcium	58,300	442/2-B12	10	81/81	88,000	0/81	-	-	NP	-
chromium, total*	25.1	442/2-B08	30	81/81	11.6	8/81	500	0/81	210	0/81
cobalt*	6.9	442/2-B06	30	3/81	6.4	1/81	-	-	900	0/81
copper	20.2	442/2-B09	30	81/81	35.6	0/81	-	-	3,100	0/81
iron	16,500	442/2-B06	30	81/81	17,026	0/81	-	-	23,000	0/81
lead	6.1	442/2-B06	30	81/81	11.3	0/81	-	-	150 [f]	0/81
magnesium	7,860	442/2-B06	30	81/81	15,695	0/81	-	-	NP	-
manganese	363	442/2-B06	30	81/81	596	0/81	-	-	1,800	0/81
nickel*	10.1	442/2-B06	30	48/81	9.9	1/81	1,000	0/81	1,600	0/81
potassium	4,030	442/2-B06	30	80/81	7,444	0/81	-	-	NP	-
sodium	1,190	442/2-B09	20	79/81	1,150	1/81	-	-	NP	-
vanadium	34.4	442/2-B06	30	81/81	69.7	0/81	-	-	550	0/81
zinc	45.6	442/2-B06	30	81/81	66.6	0/81	-	-	23,000	0/81

Notes:

Analytes included in this table are compared to the 2002 USEPA PRGs (USEPA 2002) because the 2002 PRGs were used in the *Human Health Risk Assessment, Basewide Miscellaneous and Chemical Warfare Materiel Sites, Operable Unit 7, Edwards Air Force Base, California* (Earth Tech 2004d).

* Analyte carried forward in the risk assessment process.

[a] Background level calculated for OUs 4 and 9 (The Earth Technology Corporation 1995).

[b] TDL (mg/kg) = Primary MCL (mg/L) x Leachability Factor (100) x Attenuation Factor (100) (CRWQCB 1989).

[c] USEPA Region IX PRGs (USEPA 2002).

[d] All detected concentrations are below the 2002 Industrial PRGs except where noted.

[e] The arsenic concentrations in 80 of 81 samples also exceed the 2002 Industrial PRG for arsenic (1.6 mg/kg).

[f] CAL-Modified PRG (USEPA 2002).

-	not applicable	mg/kg	milligrams per kilogram
ft bgs	feet below ground surface	mg/L	milligrams per liter
CDHS	California Department of Health Services	NP	not promulgated
CRWQCB	California Regional Water Quality Control Board	PRG	preliminary remediation goal
ID	identification	TDL	total designated level
MCL	maximum contaminant level; more stringent of the Federal or State primary MCL (CDHS 2003)	USEPA	United States Environmental Protection Agency

the concentrations do not exceed their respective calculated TDLs (if applicable) or residential and industrial PRGs. Aluminum was detected at concentrations that exceeded the calculated TDL (in seven of 81 samples); however, the maximum detected concentration did not exceed the calculated background concentration or the residential and industrial PRGs for aluminum in soil.

Site 442, Area 3

The maximum concentrations of the organic contaminants detected in soil samples collected at Site 442, Area 3 are shown in Table 2.5-4 in comparison to their respective calculated TDLs and residential PRGs. Because no organic compounds exceeded residential PRGs, industrial PRGs are not shown on the table.

The maximum concentrations of the inorganic contaminants detected in soil samples collected at Site 442, Area 3 are shown in Table 2.5-5 in comparison to their respective calculated background concentrations, calculated TDLs, and residential PRGs. Because no inorganic constituents exceeded both residential PRGs and background concentrations, industrial PRGs are not shown on the table.

Based on the analytical results, no CWA or CWA degradation products were detected in any of the soil samples. Acetone, a common laboratory contaminant, was detected at an estimated concentration below the laboratory's reporting limit in one soil sample collected at Borehole 442/3-B03. Other organic contaminants detected in the soil samples are qualified as probable laboratory contaminants.

Of the inorganic analytes detected in the soil samples collected at Site 442, Area 3, only arsenic was detected at concentrations that exceeded its respective residential and industrial PRGs; however, the maximum detected concentration is below the calculated background concentration for arsenic in soil and the calculated TDL value. Total chromium (in two of 16 samples), iron (in one of 16 samples), and zinc (in one of 16 samples) were detected at concentrations that exceeded their respective calculated background concentrations in soil, but the concentrations did not exceed their respective calculated TDLs (if applicable), or their respective residential and industrial PRGs.

2.5.10.3 Groundwater

The maximum concentrations of the organic and inorganic contaminants detected in the groundwater samples collected from Monitoring Wells 442/1-MW01 (Site 442, Area 1) and 442/2-MW01 (Site 442,

TABLE 2.5-4. MAXIMUM CONCENTRATIONS OF ORGANIC CONTAMINANTS DETECTED IN SOIL COMPARED TO CALCULATED TDLs AND RESIDENTIAL PRGs - SITE 442, AREA 3

Analyte	Maximum Concentration (mg/kg)	Location ID of Maximum Concentration	Sample Depth (ft bgs)	No. of Detections/ Total No. of Samples	Calculated TDL Value [a] (mg/kg)	No. of Samples Exceeding Calculated TDL Value/Total No. of Samples	2002 Residential PRG [b] (mg/kg)	No. of Samples Exceeding Residential PRG/Total No. of Samples [c]
Volatile Organics								
acetone	0.011 J	442/3-B03	0	1/16	-	-	1,600	0/16
1,2,3-trichlorobenzene	0.0013 J (UJ1)	442/3-B01	0	2/16	-	-	NP	-
1,2,4-trichlorobenzene	0.0011 J (UJ1)	442/3-B01	0	1/16	5	0/16	650	0/16
Semivolatile Organics								
naphthalene	0.0016 J (UJ1)	442/3-B01	0	2/16	-	-	56	0/16

Notes:

Analytes included in this table are compared to the 2002 USEPA PRGs (USEPA 2002) because the 2002 PRGs were used in the *Human Health Risk Assessment, Basewide Miscellaneous and Chemical Warfare Materiel Sites, Operable Unit 7, Edwards Air Force Base, California* (Earth Tech 2004d).

[a] TDL (mg/kg) = Primary MCL (mg/L) x Leachability Factor (10) x Attenuation Factor (100) (CRWQCB 1989).

[b] USEPA Region IX PRGs (USEPA 2002).

[c] All detected concentrations are also below the 2002 Industrial PRGs.

-	not applicable	mg/kg	milligrams per kilogram
CDHS	California Department of Health Services	mg/L	milligrams per liter
CRWQCB	California Regional Water Quality Control Board	NP	not promulgated
ft bgs	feet below ground surface	PRG	preliminary remediation goal
ID	identification	TDL	total designated level
MCL	maximum contaminant level; more stringent of the Federal or State primary MCL (CDHS 2003)	USEPA	United States Environmental Protection Agency

Data Qualifier:

J	Estimated result. Result is less than reporting limit (laboratory-assigned data qualifier).
(UJ1)	Blank contamination. Contaminant level in the method blank is below reporting limit (data validation assigned qualifier).

TABLE 2.5-5. MAXIMUM CONCENTRATIONS OF INORGANIC CONSTITUENTS DETECTED IN SOIL COMPARED TO CALCULATED BACKGROUND CONCENTRATIONS, CALCULATED TDLs, AND RESIDENTIAL PRGs - SITE 442, AREA 3

Analyte	Maximum Concentration (mg/kg)	Location ID of Maximum Concentration	Sample Depth (ft bgs)	No. of Detections/ Total No. of Samples	Calculated Background Concentration [a] (mg/kg)	No. of Samples Exceeding Background/ Total No. of Samples	Calculated TDL Value [b] (mg/kg)	No. of Samples Exceeding Calculated TDL Value/Total No. of Samples	2002 Residential PRG [c] (mg/kg)	No. of Samples Exceeding Residential PRG/Total No. of Samples [d]
Metals and Other Elements										
aluminum	9,100	442/3-B04	0	16/16	24,280	0/16	10,000	0/16	76,000	0/16
arsenic	17.0	442/3-B04	30	16/16	24.1	0/16	100	0/16	0.39	16/16 [e]
barium	191	442/3-B01	5	16/16	590	0/16	10,000	0/16	5,400	0/16
calcium	23,000	442/3-B04	0	16/16	88,000	0/16	-	-	NP	-
chromium, total*	14.0	442/3-B04	20	16/16	11.6	2/16	500	0/16	210	0/16
cobalt	5.1	442/3-B03	0	1/16	6.4	0/16	-	-	900	0/16
copper	11.5	442/3-B04	0	15/16	35.6	0/16	-	-	3,100	0/16
iron*	17,100	442/3-B03	0	16/16	17,026	1/16	-	-	23,000	0/16
lead	4.6	442/3-B04	0	16/16	11.3	0/16	-	-	150 [f]	0/16
magnesium	6,010	442/3-B02	15	16/16	15,695	0/16	-	-	NP	-
manganese	452	442/3-B03	20	16/16	596	0/16	-	-	1,800	0/16
nickel	8.3	442/3-B03	0	5/16	9.9	0/16	1,000	0/16	1,600	0/16
potassium	3,970	442/3-B02	15	16/16	7,444	0/16	-	-	NP	-
sodium	808	442/3-B02	15	6/16	1,150	0/16	-	-	NP	-
vanadium	39.9	442/3-B02	15	16/16	69.7	0/16	-	-	550	0/16
zinc*	67.9	442/3-B02	15	16/16	66.6	1/16	-	-	23,000	0/16

Notes:

Analytes included in this table are compared to the 2002 USEPA PRGs (USEPA 2002) because the 2002 PRGs were used in the *Human Health Risk Assessment, Basewide Miscellaneous and Chemical Warfare Materiel Sites, Operable Unit 7, Edwards Air Force Base, California* (Earth Tech 2004d).

* Analyte carried forward in the risk assessment process.

[a] Background level calculated for OUs 4 and 9 (The Earth Technology Corporation 1995).

[b] TDL (mg/kg) = Primary MCL (mg/L) x Leachability Factor (100) x Attenuation Factor (100) (CRWQCB 1989).

[c] USEPA Region IX PRGs (USEPA 2002).

[d] All detected concentrations are below the 2002 Industrial PRGs except where noted.

[e] The arsenic concentrations in the 16 samples also exceed the 2002 Industrial PRG for arsenic (1.6 mg/kg).

[f] CAL-Modified PRG (USEPA 2002).

-	not applicable
CRWQCB	California Regional Water Quality Control Board
ft bgs	feet below ground surface
ID	identification
MCL	maximum contaminant level; more stringent of the Federal or State primary MCL (CDHS 2003)
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
NP	not promulgated
PRG	preliminary remediation goal
TDL	total designated level
USEPA	United States Environmental Protection Agency

Area 2) in February and August 2003 are shown on Table 2.5-6 in comparison to their respective calculated background concentrations in groundwater (if applicable) and primary MCLs in drinking water.

Laboratory analyses did not detect CWA, CWA degradation products, fuels, VOCs, perchlorate, or explosives in the groundwater samples collected from Monitoring Wells 442/1-MW01 and 442/2-MW01.

Of the inorganic analytes detected in the groundwater samples collected from Monitoring Wells 442/1-MW01 and 442/2-MW01 (see Figures 2.5-8 and 2.5-9), only aluminum was detected at a maximum concentration that exceeded its respective calculated background concentration in groundwater and primary MCL in drinking water (California Department of Health Services [CDHS] 2003). Molybdenum was detected at a maximum concentration that exceeded its calculated background concentration, but a primary MCL for molybdenum was not promulgated by the CDHS in 2003.

The elevated concentrations of metals in groundwater are believed to be naturally occurring due to groundwater flowing through and dissolving minerals in the weathered granitic bedrock at the site. The bedrock is characterized as quartz monzonite, an ignenous rock with a high percentage of feldspar (aluminum oxide is a major component in feldspar). In addition, there are no known anthropogenic sources (i.e., caused by humans) of these metals at the site.

2.5.10.4 Area of Impacted Soil

Because none of the organic contaminants detected in soil were at concentrations exceeding the residential PRGs, and no inorganic contaminants were detected at concentrations exceeding both the background concentrations and the residential PRGs, there are no areas of impacted soil at Site 442.

2.5.10.5 Volume of Impacted Groundwater

No organic contaminants other than acetone, a common laboratory contaminant, were detected in groundwater. The only inorganic constituents detected above background concentrations were aluminum and molybdenum; however, as discussed in Section 2.5.10.3, these metals are evaluated to be naturally occurring. For these reasons, there are no areas of impacted groundwater at Site 442.

TABLE 2.5-6. MAXIMUM CONCENTRATIONS OF ORGANIC AND INORGANIC CONTAMINANTS DETECTED IN GROUNDWATER COMPARED TO CALCULATED BACKGROUND CONCENTRATIONS AND PRIMARY MCLs - SITE 442, AREAS 1 AND 2

(Page 1 of 2)

Analyte	Unit	Maximum Concentration	Location ID of Maximum Concentration	Sampling Date of Maximum Concentration	No. of Detections/ Total No. of Samples	Calculated Background Concentration[a]	No. of Samples Exceeding Background/ Total No. of Samples	Maximum Contaminant Level (MCL) [b]	No. of Samples Exceeding MCL/Total No. of Samples
Volatile Organics									
acetone	µg/L	3.0 J (J3)	442/2-MW01	08/21/2003	2/5	-	-	NP	-
General Inorganics									
bromide	mg/L	0.74	442/1-MW01	02/10/2003	2/3	-	-	NP	-
chloride (as Cl)	mg/L	327	442/1-MW01	02/10/2003	3/3	3,260	0/3	250/500/600 [c]	2/3
nitrogen, nitrate (as N)	mg/L	1.2	442/1-MW01	02/10/2003	3/3	-	-	10	0/3
sulfate (as SO_4)	mg/L	226	442/1-MW01	02/10/2003	3/3	2,420	0/3	250/500/600 [c]	0/3
Metals and Other Elements									
aluminum*	mg/L	15.9	442/1-MW01	08/22/2003	4/4	3.7	3/4	1	3/4
arsenic	mg/L	0.043	442/1-MW01	08/22/2003	4/4	0.081	0/4	0.01	4/4
barium	mg/L	0.054	442/1-MW01	08/22/2003	3/4	0.11	0/4	1	0/4
calcium	mg/L	20.3	442/1-MW01	08/22/2003	4/4	262	0/4	NP	-
chromium, total	mg/L	0.043	442/1-MW01	08/22/2003	3/4	2.7	0/4	0.05	0/4
copper	mg/L	0.040	442/1-MW01	08/22/2003	3/4	0.05	0/4	1 [d]	0/4
iron	mg/L	16.9	442/1-MW01	08/22/2003	4/4	109	0/4	0.3 [d]	4/4
magnesium	mg/L	8.7	442/1-MW01	08/22/2003	4/4	590	0/4	NP	-
manganese	mg/L	1.0	442/1-MW01	08/22/2003	4/4	2.8	0/4	0.05 [d]	3/4
molybdenum*	mg/L	0.35	442/1-MW01	08/22/2003	4/4	0.19	1/4	NP	-
nickel	mg/L	0.059	442/1-MW01	08/22/2003	2/4	0.65	0/4	0.1	0/4
potassium	mg/L	25.2	442/2-MW01	08/21/2003	4/4	52.9	0/4	NP	-
sodium	mg/L	370	442/1-MW01	02/10/2003	4/4	1,670	0/4	NP	-

TABLE 2.5-6. MAXIMUM CONCENTRATIONS OF ORGANIC AND INORGANIC CONTAMINANTS DETECTED IN GROUNDWATER COMPARED TO CALCULATED BACKGROUND CONCENTRATIONS AND PRIMARY MCLs - SITE 442, AREAS 1 AND 2

(Page 2 of 2)

Analyte	Unit	Maximum Concentration	Location ID of Maximum Concentration	Sampling Date of Maximum Concentration	No. of Detections/ Total No. of Samples	Calculated Background Concentration[a]	No. of Samples Exceeding Background/ Total No. of Samples	Maximum Contaminant Level (MCL) [b]	No. of Samples Exceeding MCL/Total No. of Samples
Metals and Other Elements (continued)									
vanadium	mg/L	0.072	442/1-MW01	02/10/2003	3/4	0.09	0/4	NP	-
zinc*	mg/L	10.0	442/1-MW01	08/22/2003	4/4	0.83	1/4	5 [d]	1/4

Notes:

* Analyte carried forward in the risk assessment process.

[a] Source: Earth Tech (1999 rev. 2000).

[b] Source: CDHS 2003 (more stringent of the Federal or State Primary MCL).

[c] Secondary MCL Ranges - Recommended/Upper/Short Term (CDHS 2003).

[d] Secondary MCL (CDHS 2003).

- not applicable
µg/L micrograms per liter
CDHS California Department of Health Services
ID identification
MCL maximum contaminant level
mg/L milligrams per liter
NP not promulgated

Data Qualifiers:

J Estimated result. Result is less than reporting limit (laboratory-assigned data qualifier).
(J3) Extraction or analysis out of holding time (data validation assigned qualifier).

2.5.10.6 Extent and Contents of Debris-filled Trenches

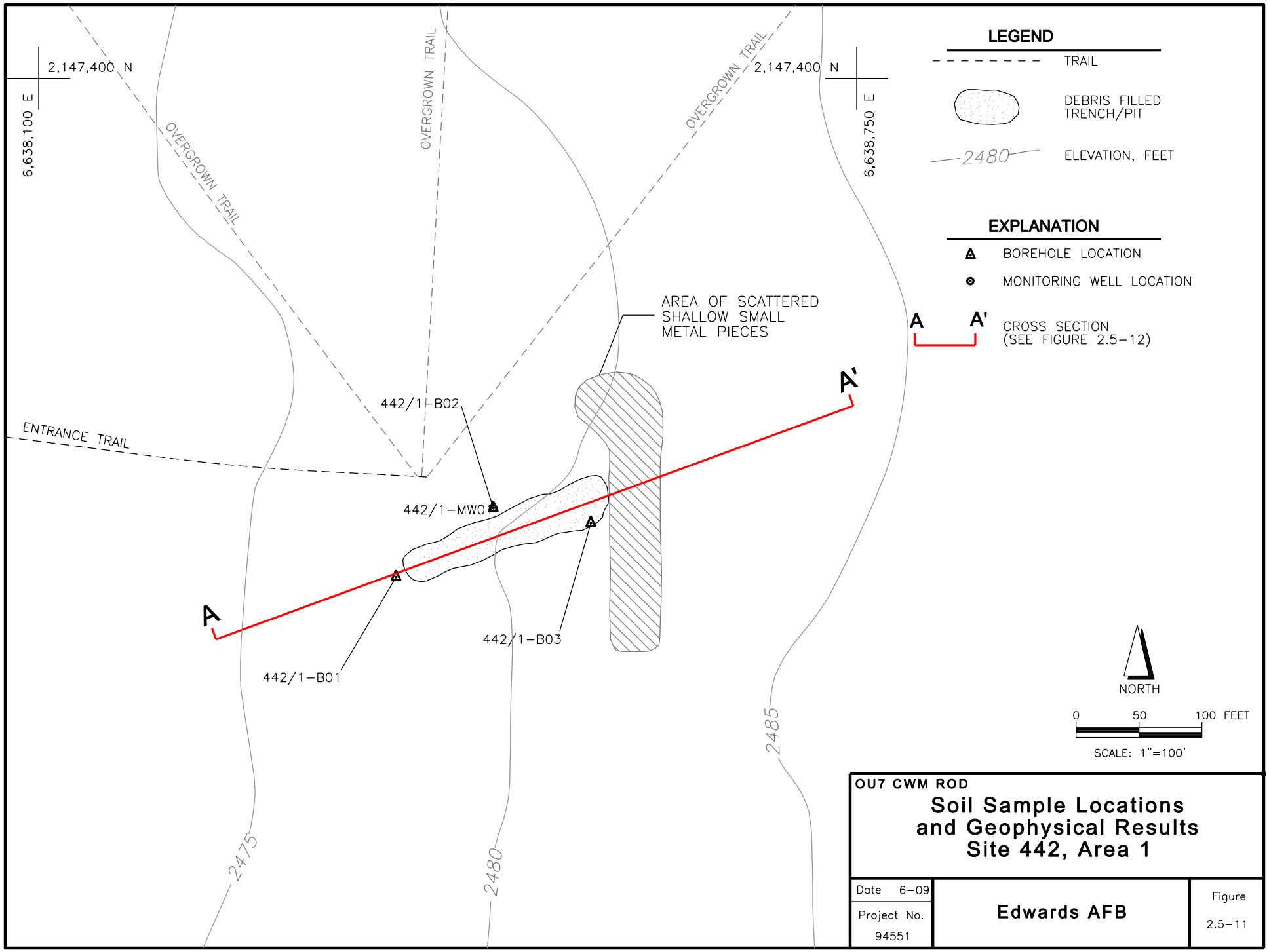
Based on the results of the geophysical surveys at Site 442, Areas 1, 2, and 3, one anomalous area at Site 442, Area 1 (Figures 2.5-11 and 2.5-12), seven anomalous areas at Site 442, Area 2 (Figures 2.5-13 and 2.5-14), and one anomalous area at Site 442, Area 3 (Figures 2.5-15 and 2.5-16) were identified that may contain buried debris. The estimated areal extent and volume of the debris in each area is as follows, assuming an average trench depth of 15 feet:

- Site 442, Area 1 – Area: 5,150 square feet; Volume: 2,900 cubic yards.
- Site 442, Area 2 – Area: 39,250 square feet; Volume: 21,800 cubic yards.
- Site 442, Area 3 – Area: 3,600 square feet; Volume: 2,000 cubic yards.

The GPR survey data collected in October 2004 indicates that cover soils over the debris-filled trenches are at least four feet thick; however, small pieces of metal may be mixed with the cover soil at depths ranging from 0.5 feet bgs to 3 feet bgs. Geotechnical samples were collected at each trench to a depth of 30 inches without encountering debris; therefore, the cover thickness is evaluated to be a minimum 30 inches thick based on direct observation. Geotechnical testing data indicates the cover soils are composed primarily of silty sands with hydraulic conductivities ranging as follows:

- Site 442, Area 1 – 6.59×10^{-5} cm/s to 7.52×10^{-4} cm/s.
- Site 442, Area 2 – 9.09×10^{-5} cm/s to 2.13×10^{-4} cm/s.
- Site 442, Area 3 – 3.09×10^{-4} cm/s to 3.37×10^{-4} cm/s.

The results of archival research and the VR surveys indicate that it is possible that CWM and live CWA may be present in the burial trenches at Site 442; however, it is more likely that the majority of the buried debris is non-toxic. Target/Range management practices in the 1940s and 1950s on Air Force facilities would have included periodic surface clearances of the target areas and known areas where errant bomb drops had occurred to locate and destroy (blown in place) unexploded bombs/munitions that would be a hazard to Range operators. Bomb/munitions debris would have been recovered for disposal. Debris such as bomb fins, practice bomb carcasses, fragments, expended rocket motors, etc. would be collected and stored at areas on the Range, or buried somewhere on the facility that was used

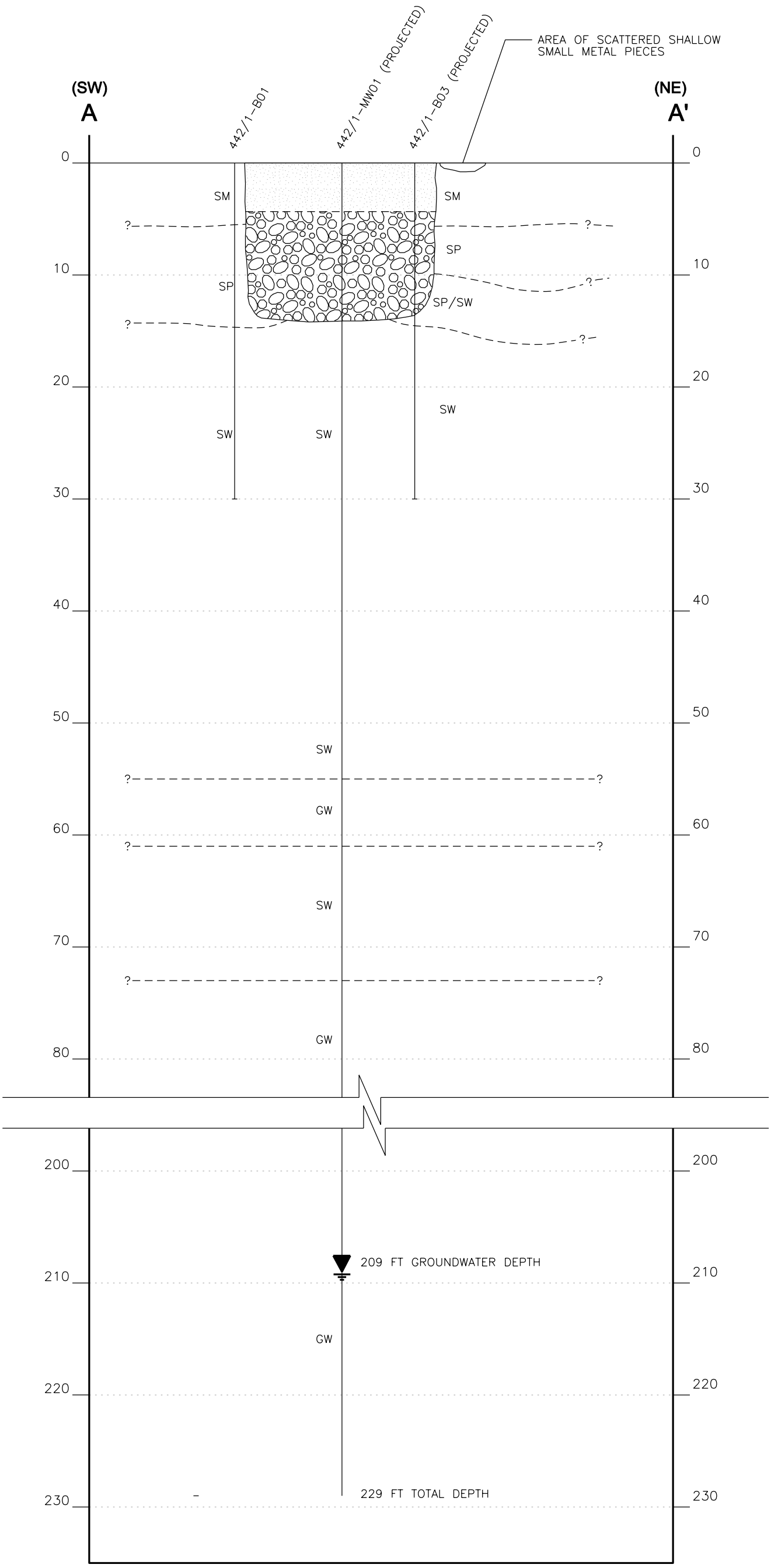


OU7 CWM ROD

Soil Sample Locations and Geophysical Results Site 442, Area 1

Date 6-09	Edwards AFB	Figure 2.5-11
Project No. 94551		

EDWARDS\94551\B6959FGA.A01



NOTE:

SEE PLAN MAP (FIGURE 2.5-11) FOR LOCATION

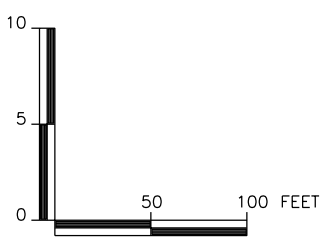
EXPLANATION

SM SILTY SAND
SP POORLY-GRADED SAND
SW WELL-GRADED SAND
GW WELL-GRADED GRAVELS

ARTIFICIAL FILL

TRENCH DEBRIS

ESTIMATED EXTENT BASED ON GEOPHYSICAL DATA



HORIZONTAL SCALE: 1"= 100'
VERTICAL SCALE: 1"= 10'

OU7 CWM ROD

Cross Section A-A'
Site 442, Area 1

Date 6-09	Edwards AFB	Figure 2.5-12
Project No. 94551		

EDWARDS\94551\B6996XSA.A01

2,149,300 N

6,640,900 E

2,149,300 N

6,641,900 E

442/2-B11

442/2-B13

A'

9/8-4N1 HOMESTEAD WELL (ABANDONED)

SIGN "BOMB BURIAL"

442/2-B09

PIT 2

442/2-B08

442/2-B14

442/2-B12

PIT 1

TRENCH 1

442/2-B04

442/2-B10

442/2-B15

TRENCH 2

442/2-MW01

442/2-B07

TRENCH 4

TRENCH 3

442/2-B01

442/2-B03

442/2-B05

A

442/2-B02

442/2-B06

2535

2540

2545

× 2531

LEGEND

DEBRIS FILLED TRENCH/PIT

2540 ELEVATION, FEET

EXPLANATION

BOREHOLE LOCATION

MONITORING WELL LOCATION

A A' CROSS SECTION (SEE FIGURE 2.5-14)

NORTH

0 50 100 FEET

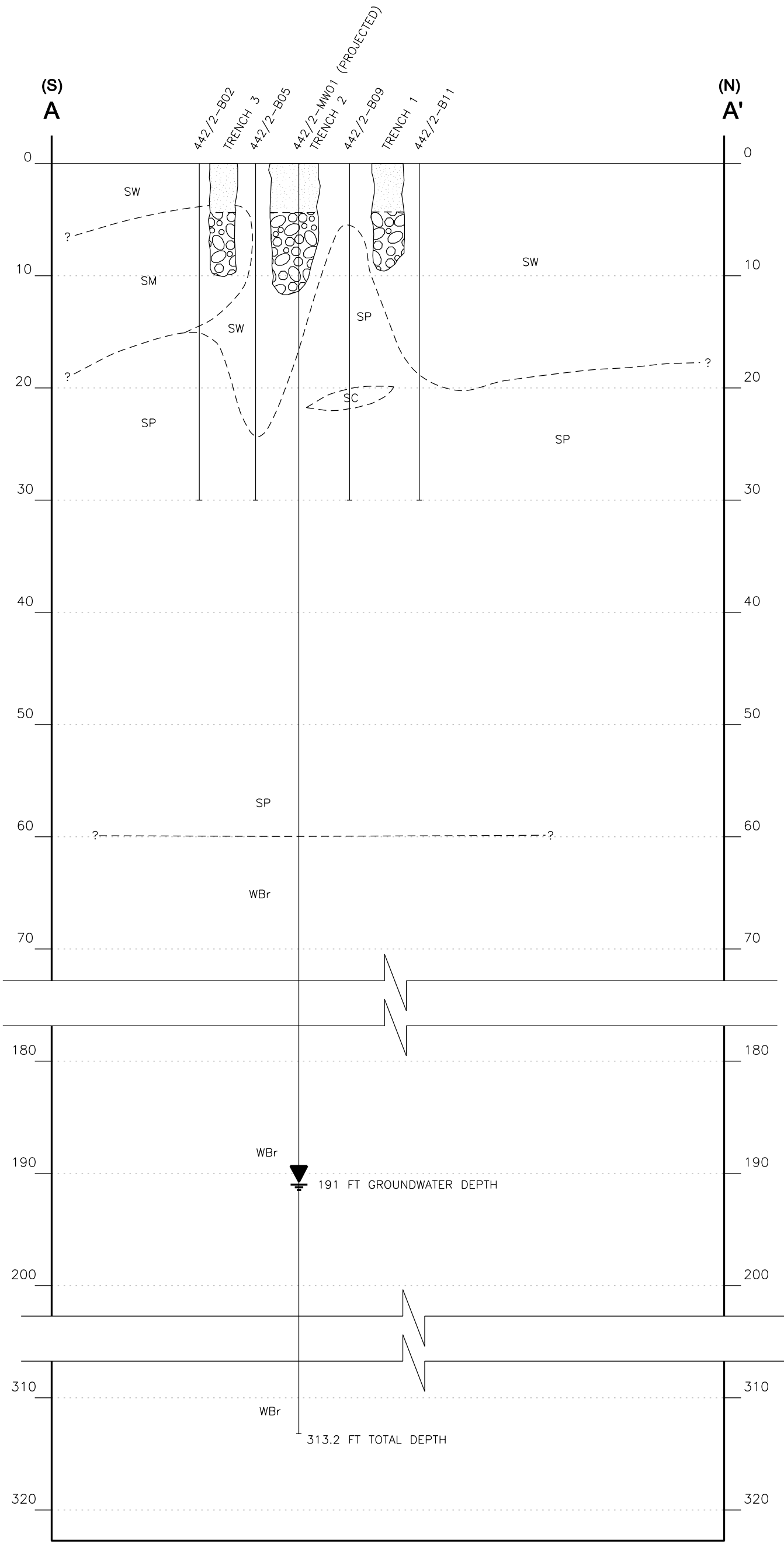
SCALE: 1"= 100'

OU7 CWM ROD

Soil Sample Locations and Geophysical Results Site 442, Area 2

Date 6-09	Edwards AFB	Figure 2.5-13
Project No. 94551		

EDWARDS\94551\B6957FGA.A01



EXPLANATION

SM	SILTY SAND
SW	WELL-GRADED SAND
SP	POORLY-GRADED SAND
SC	CLAYEY SAND
WBr	WEATHERED BEDROCK

ARTIFICIAL FILL

TRENCH DEBRIS

ESTIMATED EXTENT BASED ON GEOPHYSICAL DATA

10
5
0
50
100 FEET

HORIZONTAL SCALE: 1"= 100'
VERTICAL SCALE: 1"= 10'

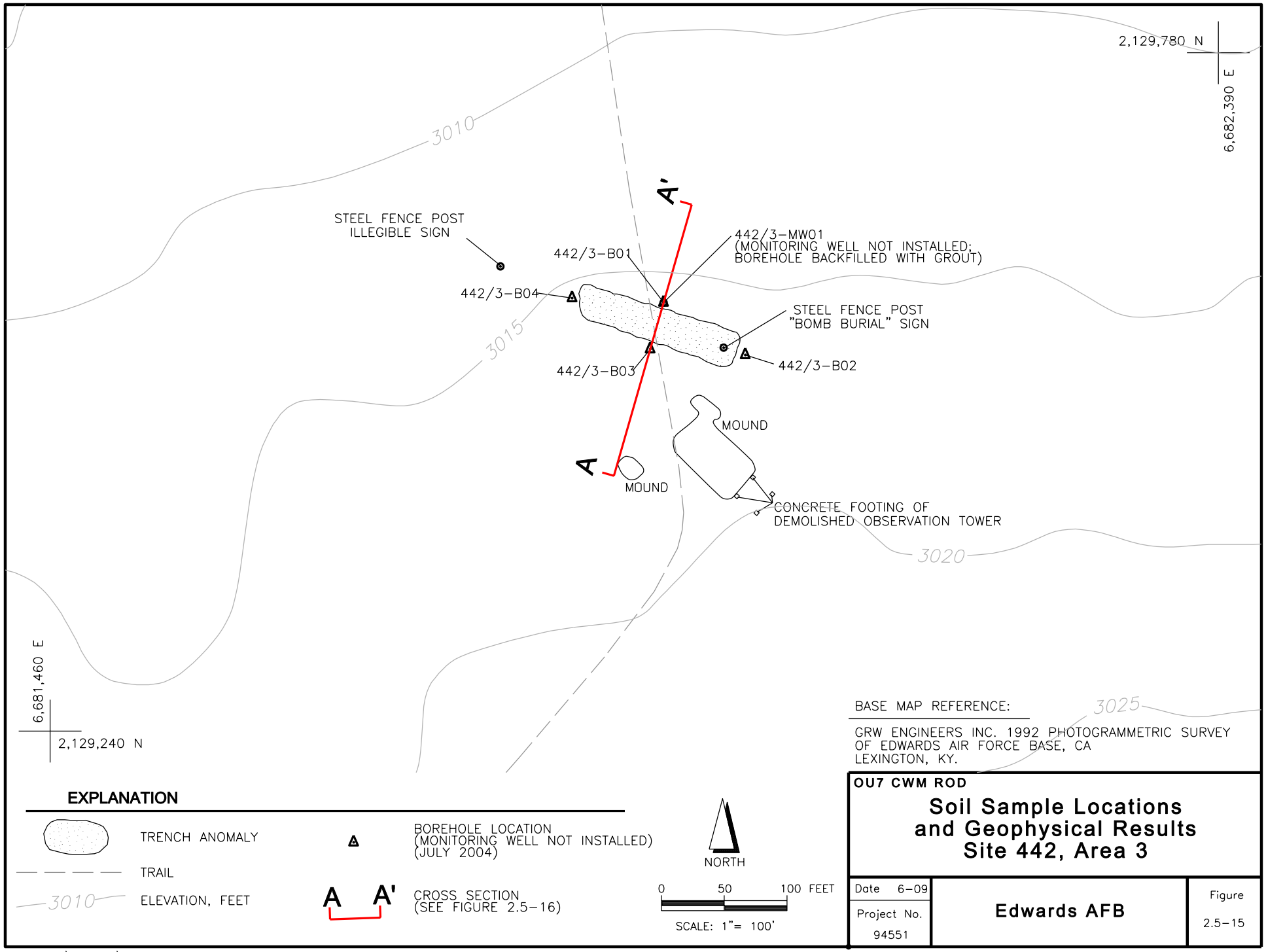
NOTE:
SEE PLAN MAP (FIGURE 2.5-13) FOR LOCATION

OU7 CWM ROD

Cross Section A-A'
Site 442, Area 2

Date 6-09	Edwards AFB	Figure 2.5-14
Project No. 94551		

EDWARDS\94551\B6956XSA.A01



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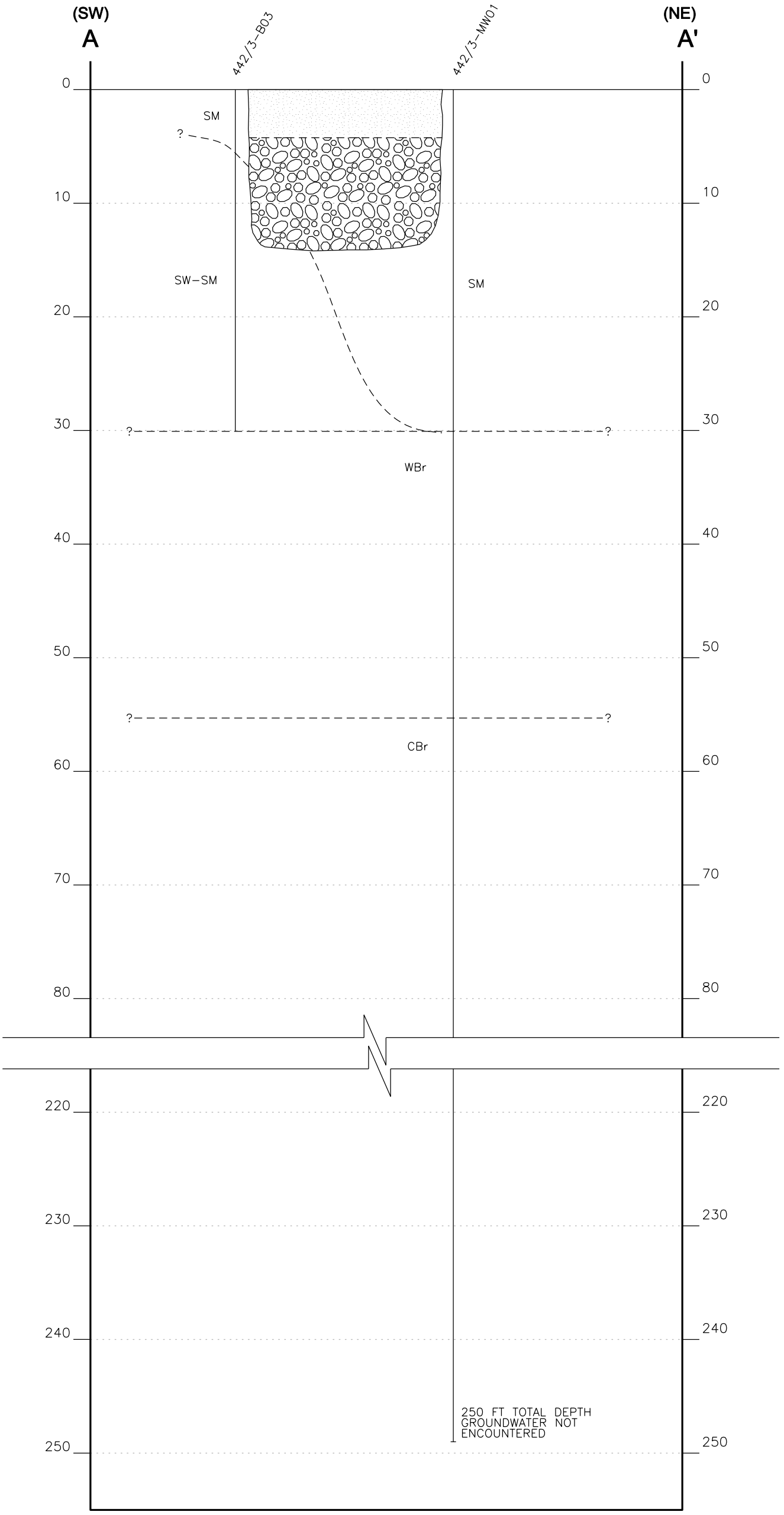


NOTE:

SEE PLAN MAP (FIGURE 2.5-15) FOR LOCATION

EXPLANATION

SM	SILTY SAND
SW	WELL-GRADED SAND
WBr	WEATHERED BEDROCK
CBr	COMPETENT BEDROCK

ARTIFICIAL FILL

TRENCH DEBRIS (DEPTH ASSUMED TO BE APPROXIMATELY 15 FEET BELOW GROUND SURFACE)

10
5
0
50
100 FEET

HORIZONTAL SCALE: 1"= 100'
VERTICAL SCALE: 1"= 10'

OU7 CWM ROD

Cross Section A-A'
Site 442, Area 3

Date 6-09	**Edwards AFB**	Figure 2.5-16
Project No. 94551		

2-62

EDWARDS\94551\B6958XSA.A01

the least. Historically and currently, munitions that could contain hazardous fillers are not normally transported off the target due to the hazard to the Range clearance crews, but are blown in place (Earth Tech 2007a).

2.5.11 CONCEPTUAL SITE MODEL

The conceptual site model illustrating the potential risk from contaminant migration and exposure pathways for Site 442, Areas 1, 2, and 3 is shown on Figure 2.5-17. Factors influencing the distribution of contaminants and completed pathways that present risk to human heath and biota are described in greater detail below.

Contaminant Sources

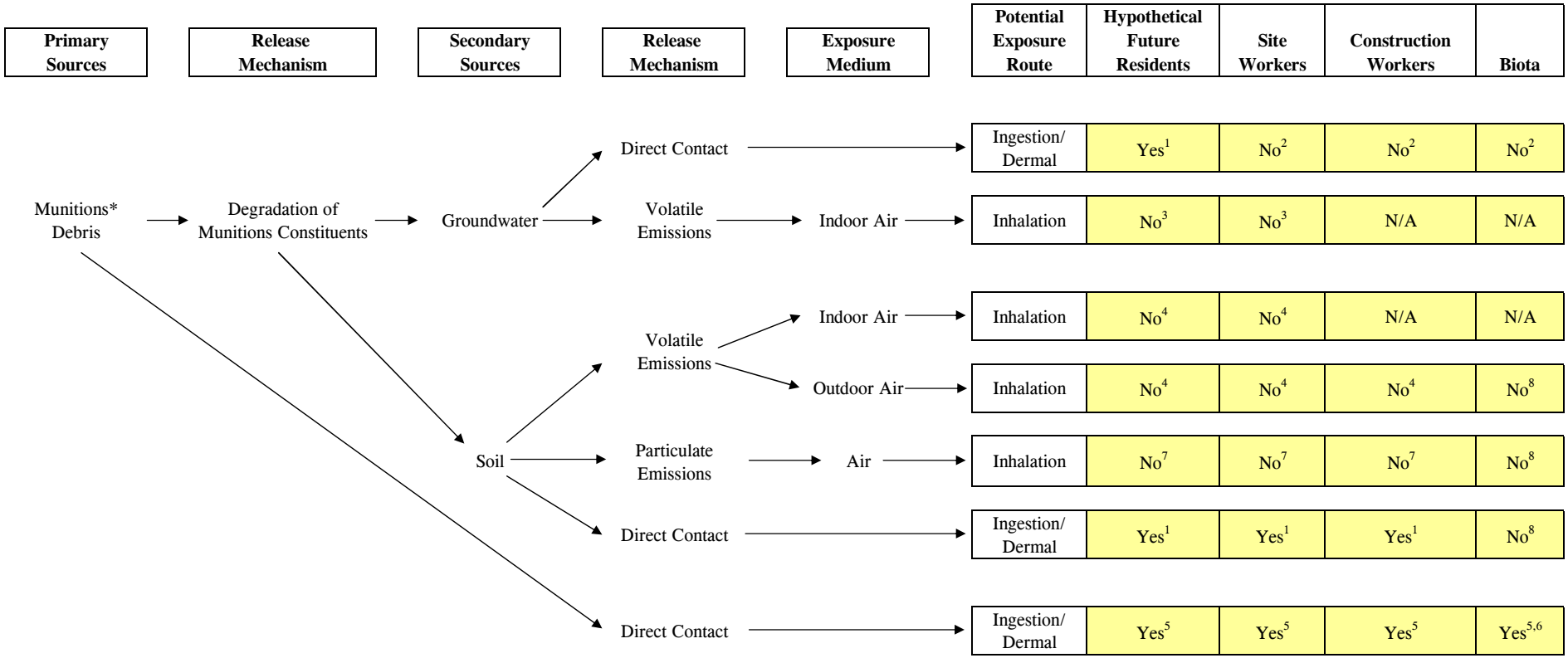
Bomb fills that may have been used at the bombing targets associated with Site 442, Areas 1, 2, and 3 include the chemical agents mustard, lewisite, and sarin, and the industrial chemicals napalm, thermite, and white phosphorus. These contaminants or their degradation products (see Table 2.5-1) may be present as residuals adhering to bomb casings or soil surrounding bomb casings, or as fill in an intact bomb casing.

Factors Controlling the Distribution of Contaminants

The fate and transport properties of CWA and other industrial chemicals potentially present in the burial trenches have been reviewed by Munro et al. (1999) and the U.S. Army (2001). Based on the below discussion, CWA and industrial chemicals potentially present in the burial trenches have a low probability of migrating to groundwater.

The CWA sarin is highly volatile, readily hydrolyzed, and considered non-persistent in soils. Mustard and lewisite can also rapidly volatilize off soils. Although mustard and lewisite are rapidly hydrolyzed, the rate of hydrolysis is limited by their slow rate of solubility. Therefore, because of their low solubility in water and ease of hydrolysis once dissolved, it is unlikely that mustard and lewisite will be transported through soil into groundwater. However, when exposed to a small amount of water intermediate hydrolysis products can form a polymeric coating on droplets of mustard that may retard hydrolysis, and the coated droplets may be considered fairly persistent in the environment. Mustard and lewisite can also be degraded microbially.

FIGURE 2.5-17. CONCEPTUAL SITE MODEL - SITE 442, AREAS 1, 2, AND 3



* It is not known if, or when, chemical warfare materiel (CWM) may have been buried at the known munitions burial locations at Site 442 - Areas 1, 2, and 3.

[1] Pathway potentially complete; however, risk is within acceptable limits (see Tables 2.5-7 and 2.5-8).

[2] No complete pathway; depth to groundwater greater than 190 feet below ground surface at Site 442 - Areas 1 and 2, and groundwater was not encountered to 250 feet below ground surface at Site 442 - Area 3.

[3] No complete pathway, volatile organic compounds not detected in groundwater.

[4] Gases from the degradation of munitions constituents (including chemical warfare agents) not detected in soil gas survey modules during remedial investigations; volatile organic compounds only sporadically detected in soil.

[5] Not specifically evaluated; however, the presence of hazardous wastes cannot be ruled out.

[6] Pathway only complete for burrowing animals.

[7] Pathway potentially complete; however, risk within acceptable limits (pathway included in PRGs for soil [see Tables 2.5-2 through 2.5-5]).

[8] No complete exposure pathways receptors (USAF 2004a).

N/A not applicable, not a valid pathway

It is also unlikely that other industrial chemicals remaining as residuals on spent munitions would impact groundwater. Chloropicrin, cyanogen chloride, and phosgene, like sarin, are highly volatile, are readily hydrolyzed, and considered non-persistent in soils. Napalm contains gasoline and polymer thickeners. Any residual napalm remaining on spent munitions would likely be biodegraded aerobically prior to impacting the groundwater. Iron and aluminum oxides from the degradation of residual thermite would have low mobility in the alkaline soils present at Site 442. The primary route of loss for white phosphorus in soils is through oxidation, which usually occurs rapidly (Agency for Toxic Substances and Disease Registry [ATSDR] 1997). However, the rate of oxidation will be slower if a protective phosphorus oxide coating forms and encapsulates the white phosphorus. The encapsulated white phosphorus will not be transported to groundwater, but is a hazard if crushed by soil disturbance (digging, excavations, etc.) or foot traffic because it will ignite spontaneously upon drying and exposure to air.

It should also be noted that the debris within the burial trenches may have been buried for as long as 50 years, and data do not indicate that a release from the trenches has occurred to date. Such a release, if it had occurred, would likely have been detected by soil gas sampling, groundwater sampling, or soil samples collected adjacent to the waste cells during the remedial investigation. Even if a release did occur, the depths to groundwater are greater than 190 feet bgs at Areas 1 and 2 and greater than 250 feet bgs at Area 3, reducing the probability that the release would reach groundwater. The high evaporation rate and low stormwater infiltration volume, resulting from the arid climate at Edwards AFB, limit the downward migration of contaminants.

Exposure Pathways

There is no current risk to receptors from surface exposure to CWA because there is no CWA currently on the surface of the site. However, there is a risk to hypothetical future residents or future construction workers from intact munitions or munitions residue encountered during excavation activities. Any CWA unearthed during future construction activities or by burrowing animals would vaporize in the ambient air, creating a short term risk to human health and the environment. Industrial chemicals such as chloropicrin, cyanogen chloride, phosgene, and gasoline-based incendiaries would behave similarly. White phosphorous, if exposed to air, will ignite spontaneously. Potential future exposure to burrowing animals will be reduced because the cover over the burial areas will be at least six feet deep, there is no evidence that any CWA have been released in the burial areas, and measures will be taken to restrict colonization of the covers by burrowing animals.

2.5.12 SUMMARY OF SITE RISKS

2.5.12.1 Human Health Risk

The results of the HHRA for Site 442 are summarized in Tables 2.5-7 and 2.5-8. The potential cancer risks and noncancer HIs for hypothetical future residents, industrial workers, and construction workers exposed to the soil at Site 442, Areas 1, 2, and 3 were evaluated to be acceptable to all receptors.

The potential cancer risks and noncancer HIs for hypothetical future residents exposed to the groundwater at Site 442, Areas 1, 2, and 3 were assessed. At Site 442, Areas 1 and 2, no suspected cancer-causing contaminants were detected in the groundwater; therefore, a potential cancer risk was not estimated. The noncancer HI for hypothetical future residents is 3.4, which is considered unacceptable (because the HI is greater than 1). However, the HI may be overstated because the constituents that accounted for most of the risk value (molybdenum and zinc) exceeded their respective calculated background concentrations in only one of four groundwater samples collected. These metals are believed to be naturally occurring because molybdenum and zinc are not associated with CWM or other munitions in quantities that would impact groundwater. If the impact of these metals is not considered, the HI would be 0.44 based on the maximum detected concentration of aluminum in groundwater.

At Site 442, Area 3, groundwater was not encountered in a borehole drilled to 250 feet bgs; therefore, potential cancer risk and noncancer HI values were not calculated.

The potential cancer risks and noncancer HIs to industrial and construction workers from the groundwater at Site 442, Areas 1, 2, and 3 were not calculated because groundwater was not encountered at depths shallower than 190 feet bgs, and workers are unlikely to come in contact with groundwater.

A more comprehensive discussion of the HHRA for this site is presented in the *OU7 CWM HHRA* (Earth Tech 2004e).

TABLE 2.5-7. SUMMARY OF HUMAN HEALTH RISK ASSESSMENT RESULTS – SITE 442, AREAS 1 AND 2

Potential Exposure Pathway	Exposure Medium	Cancer Risk[a]	Primary Risk Drivers[b]	Noncancer Hazard Index[c]	Primary Risk Drivers[b]
Residential (Hypothetical future)	Soil	$2x10^{-7}$	None	0.05	None
	Groundwater	*	None	3.4[d]	Molydenum (57%) Zinc (27%)
	Indoor Air	NA	NA	NA	NA
Industrial	Soil	$8x10^{-8}$	None	0.005	None
	Groundwater	NA	NA	NA	NA
	Indoor Air	NA	NA	NA	NA
Construction Worker	Soil	$1x10^{-9}$	None	0.002	None
	Groundwater	NA	NA	NA	NA
	Indoor Air	NA	NA	NA	NA

Notes:

[a] To manage risks from known or suspected carcinogens, the United States Environmental Protection Agency (USEPA 1980) has developed the following exposure range: more than one additional cancer case for 10,000 people is unacceptable (i.e., greater than $1x10^{-4}$); one additional cancer case for 10,000 to one million people is considered generally acceptable (i.e., between $1x10^{-4}$ and $1x10^{-6}$); and one additional cancer case for one million or more people is considered acceptable (i.e., less than $1x10^{-6}$). However, if multiple contaminants are present and multiple pathways of exposure exist, the higher end of the range should be used to establish cleanup goals.

[b] As determined by the Human Health Risk Assessment (Earth Tech 2004d). "None" indicates that there are no primary risk drivers because the total risk is characterized as generally acceptable or acceptable according to the USEPA (1980) exposure range. If a constituent is shown as a primary risk driver, the number in parentheses is the percentage of the risk accounted for by the constituent.

[c] A Hazard Index less than 1 is considered generally acceptable (USEPA 1991).

[d] The Hazard Index may be overstated because the primary risk drivers exceeded their respective calculated background concentrations in only one of four groundwater samples collected. Molybdenum and zinc are believed to be naturally occurring because they are not associated with chemical warfare materiel or other munitions in quantities that would impact groundwater. If the impact of these metals is not considered, the HI would be 0.436 based on the maximum detected concentration of aluminum in groundwater.

* Acetone (a common laboratory contaminant) was the only volatile organic compound detected in groundwater; therefore, no analytes were carried forward in the risk assessment process (Earth Tech 2004d).

% percent

NA not applicable; no exposure pathway identified during the risk assessment (Earth Tech 2004d).

TABLE 2.5-8. SUMMARY OF HUMAN HEALTH RISK ASSESSMENT RESULTS – SITE 442, AREA 3

Potential Exposure Pathway	Exposure Medium	Cancer Risk[a]	Primary Risk Drivers[b]	Noncancer Hazard Index[c]	Primary Risk Drivers[b]
Residential (Hypothetical future)	Soil	$7x10^{-8}$	None	0.73	None
	Groundwater	NA	NA	NA	NA
	Indoor Air	NA	NA	NA	NA
Industrial	Soil	$3x10^{-8}$	None	0.17	None
	Groundwater	NA	NA	NA	NA
	Indoor Air	NA	NA	NA	NA
Construction Worker	Soil	$5x10^{-10}$	None	0.07	None
	Groundwater	NA	NA	NA	NA
	Indoor Air	NA	NA	NA	NA

Notes:

[a] To manage risks from known or suspected carcinogens, the United States Environmental Protection Agency (USEPA 1980) has developed the following exposure range: more than one additional cancer case for 10,000 people is unacceptable (i.e., greater than $1x10^{-4}$); one additional cancer case for 10,000 to one million people is considered generally acceptable (i.e., between $1x10^{-4}$ and $1x10^{-6}$); and one additional cancer case for one million or more people is considered acceptable (i.e., less than $1x10^{-6}$). However, if multiple contaminants are present and multiple pathways of exposure exist, the higher end of the range should be used to establish cleanup goals.

[b] As determined by the Human Health Risk Assessment (Earth Tech 2004d). "None" indicates that there are no primary risk drivers because the total risk is characterized as generally acceptable or acceptable according to the USEPA (1980) exposure range. If a constituent is shown as a primary risk driver, the number in parentheses is the percentage of the risk accounted for by the constituent.

[c] A Hazard Index less than 1 is considered generally acceptable (USEPA 1991).

NA not applicable; no exposure pathway identified during the risk assessment (Earth Tech 2004d).

2.5.12.2 Ecological Risk

The Scoping Ecological Risk Assessment (USAF 2004a) recommended that no further ecological investigation was required at Site 442 because the contaminants of potential ecological concern were evaluated and present no complete exposure pathways to ecological receptors.

2.5.12.3 Threat to Groundwater or Surface Water

Because the buried debris in the trenches at Site 442, Areas 1, 2, and 3 may contain hazardous substances, there is a potential for impact to the groundwater. However, as previously stated in Section 2.5.3, the groundwater under Site 442, Areas 1, 2, and 3 is deep (approximately 209 feet bgs, 191 feet bgs, and greater than 250 bgs, respectively); therefore, the potential for any hazardous substances leaching into the groundwater at these Areas is low. Surface water may be present at these Areas only briefly during storm events; there is no permanent standing water in the vicinity of Site 442, Areas 1, 2, and 3.

2.5.13 REMEDIAL ACTION OBJECTIVES

Although there are no current risks associated with known contaminants at the site, Remedial Action Objectives (RAOs) were developed to protect human health and the environment from a potential future release of CWM. These RAOs are to:

1. Prevent human and ecological receptors from direct contact with buried debris and hazardous chemicals potentially present in the debris;

2. Prevent human and ecological receptors from potential future inhalation or ingestion of hazardous chemicals which could potentially migrate to air or groundwater if containerized hazardous chemicals were present in the buried debris, and these containers were to degrade and leak; and

3. Prevent hazardous chemicals potentially contained within the buried debris from impacting groundwater.

2.5.14 DESCRIPTION OF ALTERNATIVES

Four alternatives were evaluated to address the buried debris at Site 442. A more comprehensive discussion of the alternatives is presented in the *OU7 CWM FS* (Earth Tech 2007a). A clean closure alternative was not evaluated in the *OU7 CWM FS*, but was considered in a separate memorandum

(USAF 2007). Based on the analysis in the memorandum, the cost to remove all debris from Site 442 is approximately $26 million. Based on the high cost compared to other alternatives, the alternative was not carried forward.

The four alternatives considered are:

1. **No Action.** The NCP requires that this alternative be used as a baseline to be compared to other alternatives. This alternative assumes that No Further Action will be taken at Site 442, Areas 1, 2, and 3. Access to Site 442 is currently limited to personnel authorized by Range Control to enter the PIRA. This alternative has no cost.

2. **Land Use Controls.** This alternative includes the continued implementation of LUCs, which would include access controls and administrative controls or LUC boundaries. Consistent with RAO #1, access controls would include the installation of fences with locking gates that meet U.S. Fish and Wildlife Service standards for desert tortoise exclusion fencing around the perimeter of each area, and warning signs posted on the fences. UXO-qualified personnel will assist during the design and installation of the perimeter fences to ensure: (1) fences are positioned to enclose all known EOD burial locations at Areas 1, 2, and 3; (2) areas where the fences are installed are cleared of potential munitions items; and (3) potential munitions items are not disturbed by subsurface excavation to install the fences. The Air Force, under this alternative, would enforce land use restrictions for Site 442 in the Base GP including a prohibition of unrestricted use at the site (e.g., homes, daycare centers, schools, hospitals, etc.), and instructions and orders issued by the Commanding Officer to govern conduct, actions, and activities with respect to the site. These land use restrictions would be documented in the Base GIS, which is annotated with LUC information and which 95 ABW/EMR must consult before issuing digging permits. This alternative would cost an estimated $1.8 million over 32 years.

3. **Land Use Controls and Stormwater Controls.** This alternative includes the use of LUCs listed under Alternative 2 and the installation of stormwater controls. Consistent with RAOs #2 and #3, a 2-foot-high reinforced concrete berm wall would be constructed at each area to prevent stormwater from running onto the burial trenches. The concrete berm wall is a more effective drainage control device than a ditch, because a ditch would eventually fill with soil and debris transported by wind or stormwater flows. The materials deposited in the ditch would need to be removed to prevent stormwater from crossing the ditch and running onto the trenches, thus incurring additional maintenance costs and reduced performance as compared to the berm wall. Low spots in the existing cover would be filled with native soils including excavated soils from the construction of the concrete berm wall. The cover would then be graded to drain. After the grading is complete, any areas devoid of vegetation would be revegetated. UXO-qualified personnel will assist during the installation of the concrete berm walls and subsurface footings to ensure: (1) areas where the concrete berms are installed are cleared of potential munitions items; (2) potential munitions items are not disturbed by subsurface excavation to install the berm walls and

footings; and (3) limited grading does not disturb any potential munitions items. This alternative would cost an estimated $2.3 million over 32 years.

4. **Land Use Controls, Stormwater Controls, and Enhanced Cover System (Selected Alternative).** This alternative includes the LUCs and stormwater controls listed under Alternative 3 and the installation of enhanced soil cover systems at each area. Consistent with RAOs #2 and #3, the enhanced soil cover would include the placement of an additional cover layer (using on-Base soils) over the existing soil cover. Costing in the FS assumed an additional 30-inch thick soil layer would be installed; however, infiltration modeling using UNSAT-H (see Section 2.5.15 and Appendix C) indicates that 12 to 24 additional inches of cover may be sufficient. This alternative would also include the construction of drainage systems to prevent stormwater run-on and to direct runoff away from the enhanced soil cover systems. After the construction of the enhanced soil cover systems at each area, any disturbed areas would be revegetated. This alternative would cost an estimated $3.9 million over 32 years.

It should be noted that the estimated costs for Alternatives 2, 3, and 4 cover a time period of 32 years, which includes two years to design and install the alternative remedy.

2.5.15 COMPARATIVE ANALYSIS OF ALTERNATIVES

The comparative analysis of the alternatives for Site 442 is presented in Tables 2.5-9 and 2.5-10, and is briefly discussed below.

Overall Protection of Human Health and the Environment

All of the active alternatives would provide adequate overall protection of human health and the environment through the use of LUCs. In addition, Alternatives 3 and 4 provide enhanced protection from a future release of contaminants potentially contained within the debris-filled trenches to groundwater. Alternative 3 provides enhanced stormwater controls that would minimize infiltration into the trenches by diverting precipitation off site, thereby reducing the potential for contaminant migration. In addition to providing stormwater controls, Alternative 4 provides additional protection from stormwater infiltration by including an enhanced landfill cover (see UNSAT-H Modeling discussion under "Compliance with Applicable or Relevant and Appropriate Requirements" subsection). However, groundwater sampling data indicates there has been no impact to groundwater through infiltration under existing conditions, so the benefit of the enhanced cover system predicted by modeling cannot be confirmed.

TABLE 2.5-9. COMPARATIVE ANALYSIS OF ALTERNATIVES - SITE 442, AREAS 1, 2, AND 3
(Page 1 of 3)

CERCLA Criteria [a]	ALTERNATIVE 1 No Action	ALTERNATIVE 2 Land Use Controls	ALTERNATIVE 3 Land Use Controls and Stormwater Controls	ALTERNATIVE 4 Land Use Controls, Stormwater Controls, and Enhanced Cover System (Selected Alternative)
Threshold Criteria				
Overall Protection of Human Health and the Environment	Does not prevent contact with potentially contaminated soils or contaminated or explosive munitions debris that may be present within the burial trenches. Existing land use controls may degrade in the future if not maintained.	LUCs (access and administrative controls) would reduce the possibility of inadvertently excavating contaminated soil or contaminated or explosive munitions debris that may be present in the burial trenches.	LUCs (access and administrative controls) would reduce the possibility of inadvertently excavating contaminated soil or contaminated or explosive munitions debris that may be present in the burial trenches. Stormwater controls would reduce the potential for exposure to COCs that may be present in the burial trenches by reducing the potential of the COCs to migrate to groundwater.	LUCs (access and administrative controls) would reduce the possibility of inadvertently excavating contaminated soil or contaminated or explosive munitions debris that may be present in the burial trenches. Stormwater controls and an enhanced cover system would reduce the potential for exposure to COCs that may be present in the burial trenches by reducing the potential of the COCs to migrate to groundwater.
Compliance with ARARs	Not applicable, no action proposed, ARARs do not apply.	Alternative would be compliant with location-specific ARARs and action-specific ARARs for LUCs under 22 CCR, but not with all action specific ARARs for landfill closure under 22 CCR and 27 CCR.	Alternative would be compliant with location-specific ARARs and action-specific ARARs for LUCs under 22 CCR, but not with all action specific ARARs for landfill closure under 22 CCR and 27 CCR.	Alternative would be compliant with location-specific ARARs and action-specific ARARs for LUCs under 22 CCR, and all action specific ARARs for landfill closure under 22 CCR and 27 CCR.
Balancing Criteria				
Long-Term Effectiveness and Permanence	Does not reduce the potential in the long-term for exposure to potentially contaminated soils or contaminated or explosive munitions debris that may be present within the burial trenches.	Reduces the potential in the long-term for exposure to contaminated soils or contaminated or explosive munitions debris that may be present within the burial trenches through the use of LUCs.	Stormwater controls would reduce the potential for exposure to COCs that may be present in the burial trenches by reducing the potential of the COCs to migrate to groundwater. Reduces the potential in the long-term for exposure to contaminated soils or contaminated or explosive munitions debris that may be present within the burial trenches through the use of LUCs.	Stormwater controls and an enhanced cover system would reduce the potential for exposure to COCs that may be present in the burial trenches by reducing the potential of the COCs to migrate to groundwater. Reduces the potential in the long-term for exposure to contaminated soils or contaminated or explosive munitions debris that may be present within the burial trenches through the use of LUCs.

TABLE 2.5-9. COMPARATIVE ANALYSIS OF ALTERNATIVES - SITE 442, AREAS 1, 2, AND 3
(Page 2 of 3)

CERCLA Criteria [a]	ALTERNATIVE 1 No Action	ALTERNATIVE 2 Land Use Controls	ALTERNATIVE 3 Land Use Controls and Stormwater Controls	ALTERNATIVE 4 Land Use Controls, Stormwater Controls, and Enhanced Cover System (Selected Alternative)
Balancing Criteria *(Continued)*				
Reduction of Toxicity, Mobility, and Volume through Treatment	Not applicable if no COCs are present in the buried debris. If COCs are present in the buried debris, treatment is required to satisfy this criterion, but is considered impractical because of the volume of buried debris and the hazardous nature of CWM that is potentially present. The only reduction of toxicity that would occur is by natural processes.	Not applicable if no COCs are present in the buried debris. If COCs are present in the buried debris, treatment is required to satisfy this criterion, but is considered impractical because of the volume of buried debris and the hazardous nature of CWM that is potentially present. The only reduction of toxicity that would occur is by natural processes.	Not applicable if no COCs are present in the buried debris. If COCs are present in the buried debris, treatment is required to satisfy this criterion, but is considered impractical because of the volume of buried debris and the hazardous nature of CWM that is potentially present. The only reduction of toxicity that would occur is by natural processes. Stormwater controls not involving treatment would reduce the mobility of contaminants.	Not applicable if no COCs are present in the buried debris. If COCs are present in the buried debris, treatment is required to satisfy this criterion, but is considered impractical because of the volume of buried debris and the hazardous nature of CWM that is potentially present. The only reduction of toxicity that would occur is by natural processes. Stormwater controls not involving treatment and an enhanced cover system would reduce the mobility of contaminants.
Short-Term Effectiveness	Existing LUCs reduce short-term risks to Base workers.	Enhancing LUCs will further reduce short-term risks. Minimal risk to construction workers associated with fence construction if geophysical clearance of fence posthole locations is conducted.	Enhancing LUCs will further reduce short-term risks. Minimal risk to construction workers associated with fence and berm construction if geophysical clearance of fence posthole and berm footing locations is conducted. Risk to equipment operators during cover repair can be mitigated if potholes in the existing cover are filled prior to regrading the site. .	Enhancing LUCs will further reduce short-term risks. Minimal risk to construction workers associated with fence and berm construction if geophysical clearance of fence posthole and berm footing locations is conducted. Risk to equipment operators during cover construction can be mitigated if potholes in the existing cover are filled prior to applying additional cover and regrading the site.
Implementability	Not applicable, no activities proposed.	This alternative can readily be implemented.	This alternative can readily be implemented.	This alternative can readily be implemented.
Cost				
Escalated Cost [b]	None	$1,753,000	$2,329,000	$3,886,000
Present Value Cost [c]	None	$841,000	$1,193,000	$2,241,000
Modifying Criteria				
Regulatory Agency Acceptance	Not acceptable	Not acceptable	Not acceptable	Acceptable

TABLE 2.5-9. COMPARATIVE ANALYSIS OF ALTERNATIVES - SITE 442, AREAS 1, 2, AND 3
(Page 3 of 3)

CERCLA Criteria [a]	ALTERNATIVE 1 No Action	ALTERNATIVE 2 Land Use Controls	ALTERNATIVE 3 Land Use Controls and Stormwater Controls	ALTERNATIVE 4 Land Use Controls, Stormwater Controls, and Enhanced Cover System (Selected Alternative)
Community Acceptance	No public comments specific to this alternative.	No public comments specific to this alternative.	No public comments specific to this alternative	No public comments specific to this alternative.

Notes:
[a] Source: USEPA (1999).
[b] Escalated cost is in 2007 dollars.
[c] Present value cost is in 2007 dollars (assumes a 7 percent discount factor).

ARARs applicable or relevant and appropriate requirements
CCR California Code of Regulations
CERCLA Comprehensive Environmental Response, Compensation, and Liability Act
CFR Code of Federal Regulations
COCs contaminants of concern
CWM chemical warfare materiel
LUCs land use controls

TABLE 2.5-10. COSTS OF THE ALTERNATIVES - SITE 442, AREAS 1, 2, AND 3

Cost in 2008 dollars	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Timeframe[a]	NA	32 years	32 years	32 years
Area 1				
Design	NA	$11,000	$21,000	$28,000
Capital	$0	$139,000	$198,000	$300,000[d]
Operation and Maintenance	NA	$174,000	$252,000	$400,000
Five-Year Review (Periodic)	NA	$198,000	$198,000	$198,000
Escalated Cost[b]	$0	$522,000	$669,000	$926,000
Present Value Cost[c]	$0	$229,000	$310,000	$445,000
Area 2				
Design	NA	$11,000	$21,000	$52,000
Capital	$0	$163,000	$363,000	$1,250,000[d]
Operation and Maintenance	NA	$174,000	$252,000	$400,000
Five-Year Review (Periodic)	NA	$198,000	$198,000	$198,000
Escalated Cost	$0	$546,000	$834,000	$1,899,000
Present Value Cost	$0	$249,000	$445,000	$1,241,000
Area 3				
Design	NA	$17,000	$27,000	$36,000
Capital	$0	$296,000	$348,000	$427,000[d]
Operation and Maintenance	NA	$174,000	$252,000	$400,000
Five-Year Review (Periodic)	NA	$198,000	$198,000	$198,000
Escalated Cost	$0	$685,000	$826,000	$1.061,000
Present Value Cost	$0	$363,000	$438,000	$555,000
Totals for Areas 1, 2, and 3				
Design	NA	**$39,000**	**$69,000**	**$116,000**
Capital	**$0**	**$598,000**	**$909,000**	**$1,977,000**[d]
Operation and Maintenance	NA	**$522,000**	**$756,000**	**$1,200,000**
Five-Year Review (Periodic)	NA	**$594,000**	**$594,000**	**$594,000**
Escalated Cost	**$0**	**$1,753,000**	**$2,329,000**	**$3,886,000**
Present Value Cost	**$0**	**$841,000**	**$1,193,000**	**$2,241,000**

Notes:

[a] Includes time to produce design documents, install capital improvements, and implement the remedy for 30 years.

[b] Escalated cost is the inflationary adjustment from current dollars to the future estimated cost when the work is performed.

[c] Present value is the amount of money that would need to be invested in the present to cover the total cost of the project, assuming an interest rate of 7 percent, which was used in the *Feasibility Study, Site 442 – Area 1, 2, and 3, Operable Unit No. 7, Chemical Warfare Materiel, Edwards AFB, CA (OU7 CWM FS)* (Earth Tech 2007a).

[d] Cost estimates in the *OU7 CWM FS* (Earth Tech 2007a) assumed 30 inches of additional cover soils would be required to isolate the waste. Modeling using UNSAT-H (see Appendix C) predicts a lesser quantity of soils (12 to 24 additional inches) would be required to isolate the waste. The actual required cover thickness and associated costs will be determined in the Remedial Action Work Plan.

NA not applicable

As recommended by United States Environmental Protection Agency (2000), cost estimates for each alternative are to be within an accuracy range of –30 to +50 percent. The complete cost estimates can be found in the *OU7 CWM FS* (Earth Tech 2007a).

Compliance with Applicable or Relevant and Appropriate Requirements

All active alternatives would be compliant with location-specific Applicable or Relevant and Appropriate Requirements (ARARs) identified for the remedial actions at Site 442 (see Section 2.5.19 and Appendix B, Table B-1 for a full listing and discussion of ARARs). To assess whether Alternatives 3 and 4 would be compliant with cover requirements for solid waste landfills under California Code of Regulations (CCR) Title 27, the unsaturated vertical flow model UNSAT-H, Version 3.01 (Fayer 2000) was used to evaluate stormwater infiltration through the soil covering the debris-filled trenches at Areas 1, 2, and 3 under existing site conditions (Alternative 3) and predict performance of engineered landfill cover systems (Alternative 4). A State prescriptive cover was also modeled for comparative purposes. Model assumptions and detailed results are contained in Appendix C.

Existing conditions at Site 442, Areas 1, 2, and 3 were modeled using site-specific soil data from each location. Soil from each Area can generally be characterized as well-graded sand with very little gravel and fines. The soil cover thickness at Site 442 Areas 1, 2, and 3 was estimated to be 48 inches based on the data from GPR surveys conducted at each Area. A 90 percent bare area was used to model the relatively sparse vegetation conditions typical at Site 442.

Preliminary cover designs were modeled using site-specific soil data from each location. The following cover configurations were modeled:

- Evapotranspiration (ET) Landfill Cover – Two configurations were modeled. In the first, a 12-inch thick layer of soil obtained from each of the three sites would be placed on the existing 48-inch thick soil cover at Site 442 Areas 1, 2, and 3. The hydraulic conductivity of the onsite soils used for additional cover was averaged for each site to reflect blending of the soils that would take place during cut and fill operations. In the second version, the 12-inch thick layer of soil was replaced with a 24-inch thick layer of soil. All other model conditions remained the same.

- State Prescriptive Landfill Cover – A State prescriptive landfill cover as defined in CCR Title 27, Section 21090 was modeled. First, a 12-inch-thick clay layer with a hydraulic conductivity of 1×10^{-6} cm/s would be placed over the existing soil cover. Next, a 12-inch-thick horizontal drainage layer with a hydraulic conductivity of 5.80×10^{-3} cm/s would be placed over the clay layer. Last, a 12-inch-thick vegetative soil cover with a hydraulic conductivity of 1.90×10^{-4} cm/s would be placed over the drainage layer.

A comparison of the existing soil cover model results to the enhanced cover model results indicates that the predicted stormwater infiltration rates through the existing soil cover (with an estimated four feet of total thickness) is between 0.04 and 0.22 inches per year. The predicted infiltration rates if 12 inches of additional locally obtained soil cover materials are added is between 0.03 and 0.15 inches per year, and if 24 inches of additional cover materials are added is between 0.02 and 0.06 inches per year. These ET cover infiltration rates compare favorably with the State prescriptive cover model, which predicts infiltration rates of between 0.02 and 0.04 inches per year.

It is therefore concluded that the existing cover (Alternative 3) may not be compliant with State prescriptive standards. Alternative 4 would be equivalent to State prescriptive cover standards.

Long-Term Effectiveness and Permanence

All active alternatives provide long-term protectiveness of human health and the environment through the use of LUCs. In addition, Alternatives 3 and 4 reduce the long-term potential for stormwater infiltration into the trenches, which would reduce the potential of contaminants migrating to groundwater.

Reduction of Toxicity, Mobility, and Volume through Treatment

Alternatives 1 and 2 do not reduce the toxicity, mobility, or volume of waste through treatment. Although Alternatives 3 and 4 do not reduce the toxicity or volume of waste through treatment, they do reduce the potential mobility of contaminants potentially present in the waste through cover improvements and stormwater controls that do not involve treatment.

Short-Term Effectiveness

Existing LUCs currently reduce the short-term risk to Base workers and visitors, and prevent unauthorized access to the PIRA. All active alternatives provide enhanced engineering and administrative LUCs which will further reduce the risk to Base workers and visitors, and provide additional protection from unauthorized access. The engineering LUCs (fence and berm) and cover enhancements can be accomplished in a manner to reduce risk to construction workers through the use of safety procedures such as clearance of working areas by UXO-trained personnel, and by geophysical clearance of all areas where intrusive work will be performed for all alternatives.

Implementability

All alternatives can readily be implemented. Goods and services to perform the site improvements are readily available. However, it should be noted that properly briefed and trained personnel would be required to escort any project personnel on the PIRA unless the Chief of PIRA Operations (Downfall) grants unescorted entry for a limited (project specific) period of time. Project personnel would be required to successfully complete an initial and annual ground and explosive safety training program to be granted unescorted entry. In addition, work on PIRA could be interrupted if PIRA is closed due to Base mission-related test activities.

Cost

As shown in Tables 2.5-9 and 2.5-10, Alternatives 2, 3, and 4 have progressively increasing costs. Notably, the present value cost for Alternative 4 is almost twice the cost of Alternative 3.

Regulatory Acceptance

Based on comments received on the Proposed Plan, Alternative 2 was not acceptable to the regulators because it is not adequately protective of groundwater. Alternatives 3 and 4 were considered acceptable. However, after further review, Alternative 3 was evaluated to be not acceptable because it does not fully comply with ARARs (see "Compliance with Applicable or Relevant and Appropriate Requirements" discussion).

Community Acceptance

The Proposed Plan and fact sheets were made available to the public during a public comment period, and meetings were held to receive public input on the alternatives presented in the Proposed Plan. Because no comments were received for any alternatives in the Proposed Plan during the public comment period or meetings, it is assumed that the selected remedy is acceptable to the community.

Summary

Alternative 3 is the lowest cost alternative that is currently protective of human health and the environment. However, it is not acceptable to the Water Board because the existing cover does not perform equivalently to the State Prescriptive Cover (Title 27).

Alternative 4 provides equivalent protection from stormwater infiltration as the State Prescriptive Cover; and therefore is in full compliance with ARARs.

Based on the evaluation of alternatives, the implementation of Alternative 4 is selected.

2.5.16 PRINCIPAL THREAT WASTES

Any CWM item that is buried within Site 442 would be considered a principal threat waste. The presence of principal threat wastes has not been verified through excavation or chemical testing due to the hazards involved in these activities.

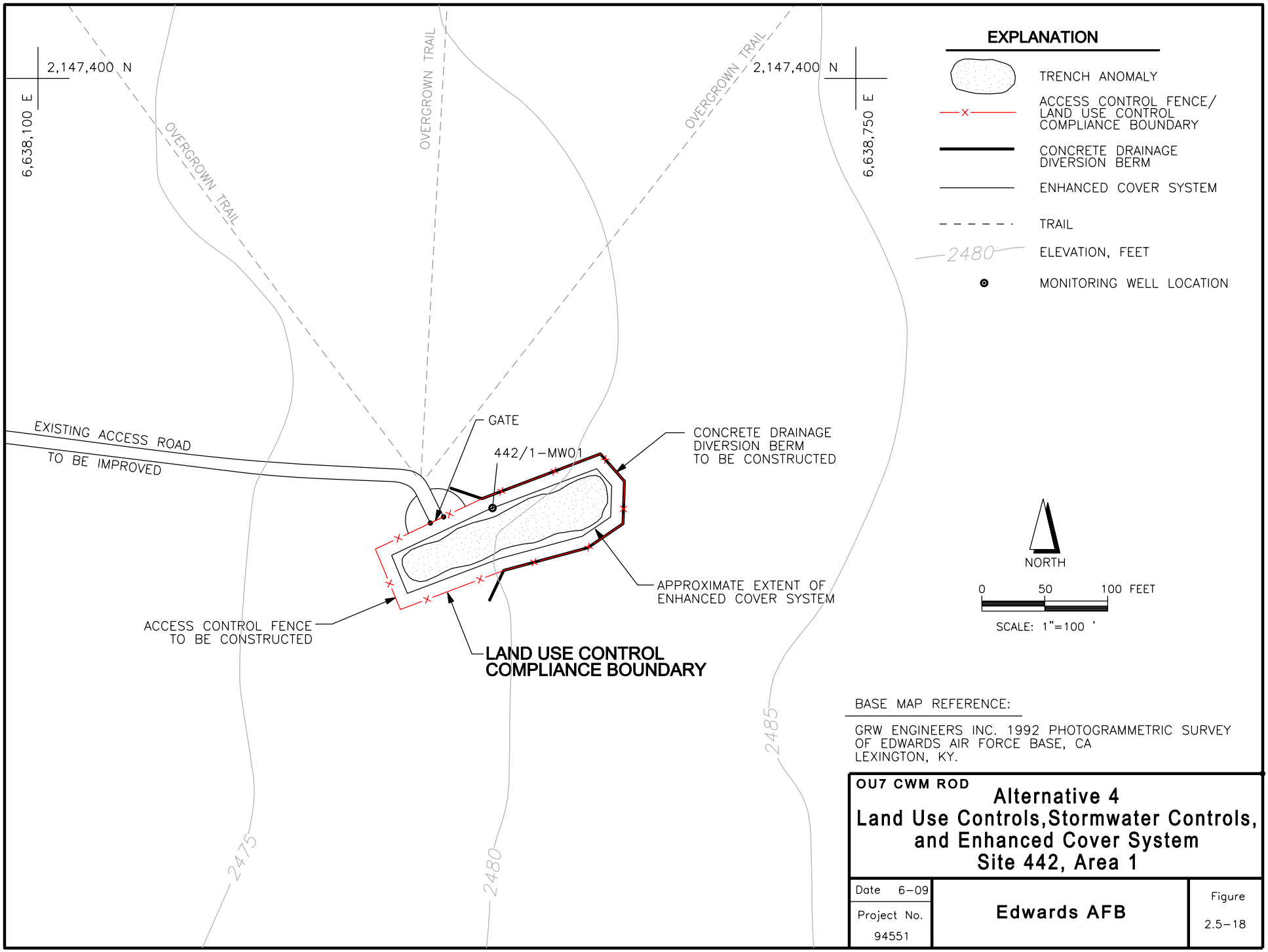
2.5.17 SELECTED REMEDY

The USAF and USEPA, with concurrence from Cal/EPA DTSC and the Water Board, Lahontan Region, selected Alternative 4 for Site 442. Figures 2.5-18 through 2.5-20 show the conceptual layout for the selected remedy for each of the burial areas. Figure 2.5-21 is a conceptual design cross section of the selected remedy showing the buried debris-filled trench, general locations of proposed grading to eliminate ponding, security fence and subsurface tortoise fence, and proposed concrete stormwater diversion berm.

The USAF, USEPA, and Cal/EPA DTSC concur with the selected remedy because it is the only alternative that is protective of human health and the environment, complies with ARARs, and is acceptable to the regulators because it is protective of the groundwater resource. The selected remedy would cost an estimated $3.6 million during the first 32 years of site operation. The Water Board concurs with the selected remedy because it meets the technical requirements of California water quality law, plans, and policies.

The selected remedy is intended to be the final action for OU7 CWM, and is addressed independently of the other OUs at Edwards AFB. The main components of the selected remedy include:

1. Adding additional soils to enhance the existing soil cover (which is estimated to be four feet to five feet thick) to contain the buried ordnance and prevent stormwater infiltration. The thickness of the required additional soil layer to meet standards equivalent to the State Prescriptive Standard as described in CCR Title 27, Section 21090 will be determined by performing a study of the properties of the existing soil cover and potential available soils and then conducting stormwater infiltration modeling(addresses RAOs #1 and #3).



BASE MAP REFERENCE:

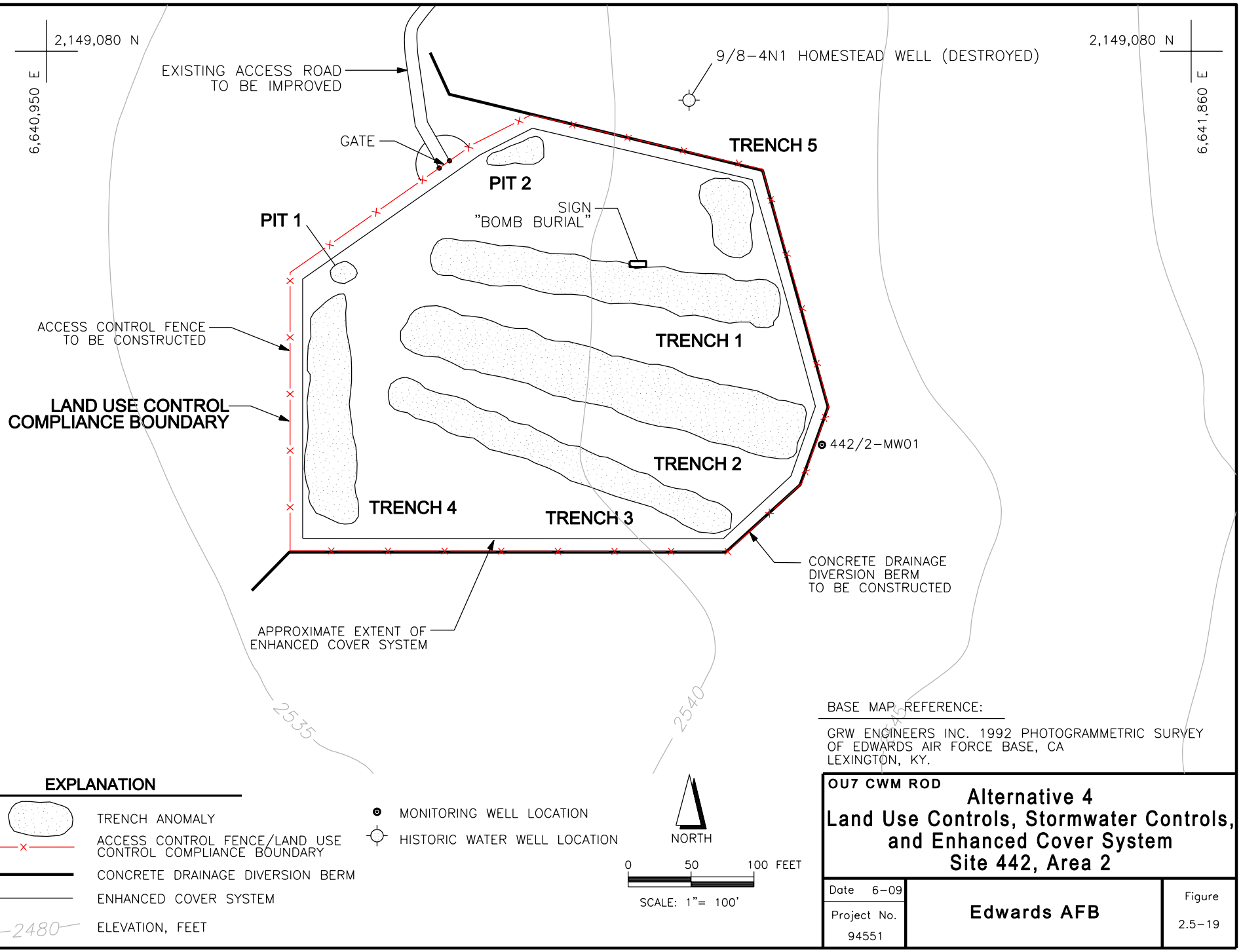
GRW ENGINEERS INC. 1992 PHOTOGRAMMETRIC SURVEY
OF EDWARDS AIR FORCE BASE, CA
LEXINGTON, KY.

OU7 CWM ROD

Alternative 4
Land Use Controls, Stormwater Controls, and Enhanced Cover System
Site 442, Area 1

Date 6-09	Edwards AFB	Figure 2.5-18
Project No. 94551		

EDWARDS\94551\B6953FGA.A01



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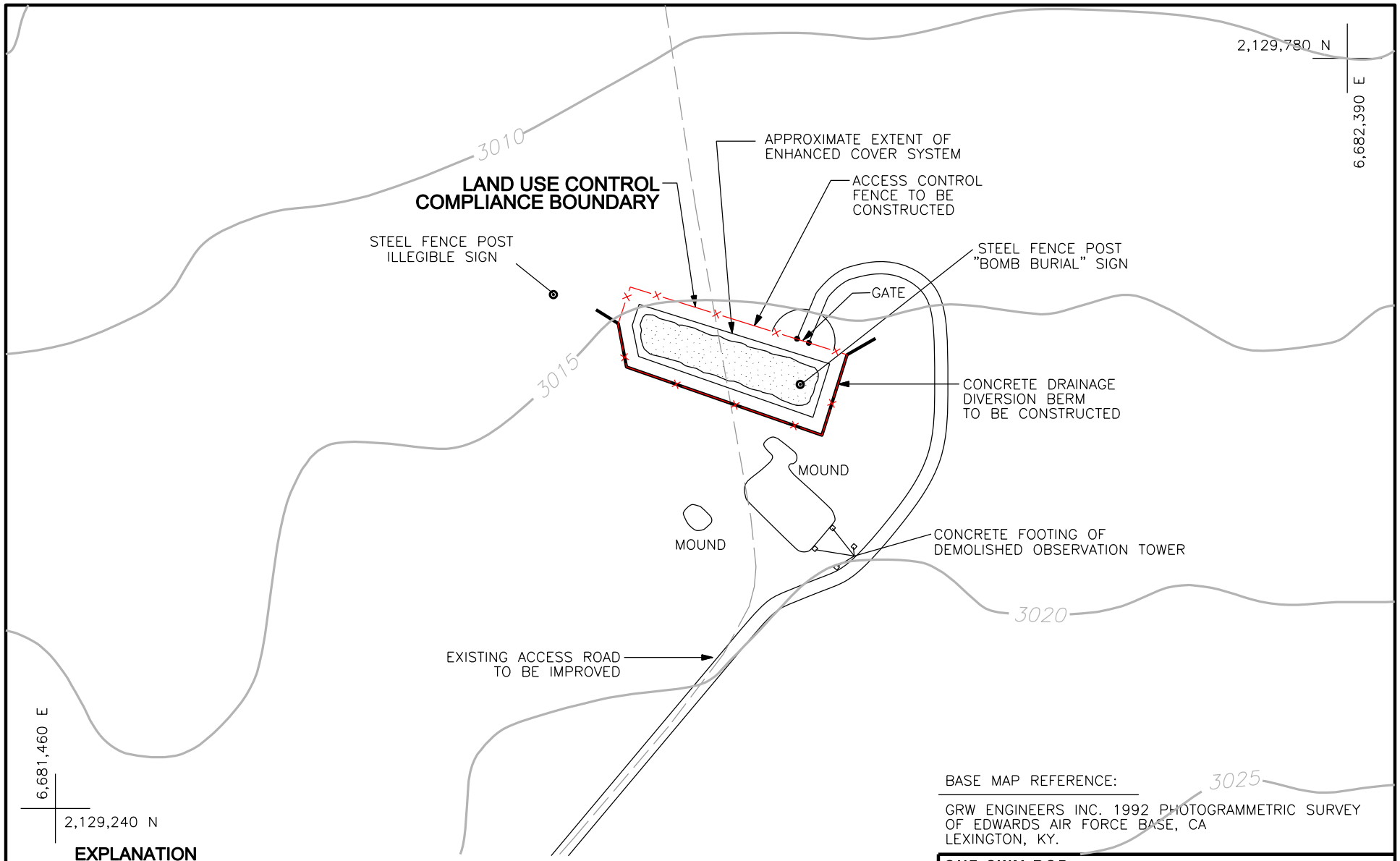

BASE MAP REFERENCE:

GRW ENGINEERS INC. 1992 PHOTOGRAMMETRIC SURVEY OF EDWARDS AIR FORCE BASE, CA LEXINGTON, KY.

OU7 CWM ROD

Alternative 4 Land Use Controls, Stormwater Controls, and Enhanced Cover System Site 442, Area 3

Date 6-09	Edwards AFB	Figure 2.5-20
Project No. 94551		

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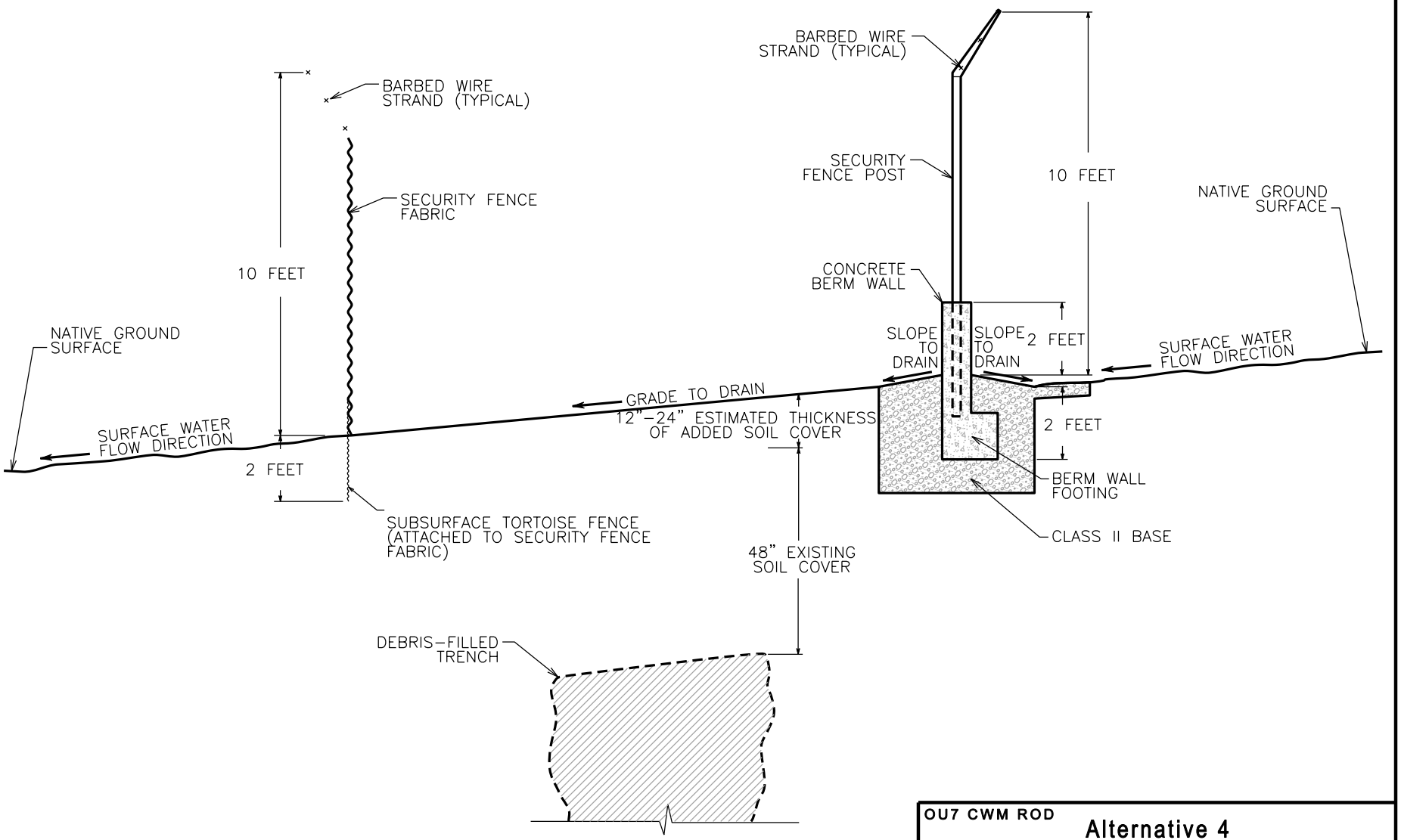

NOTE:
DRAWING NOT TO SCALE

OU7 CWM ROD

Alternative 4
Land Use Controls, Stormwater Controls, and Enhanced Cover System
Conceptual Design Cross Section

Date 6–09	Edwards AFB	Figure 2.5–21
Project No. 94551		

EDWARDS\94551\B7160FGA.A01

2. Performing grading in the trench areas to prevent stormwater ponding and to promote runoff (addresses RAO #3).

3. Constructing a 2-foot-high berm wall at each burial location to prevent stormwater from running onto the burial trenches (addresses RAO #3).

4. Installing tortoise-proof fences with locking gates around the perimeter of each area, constructing concrete dams at the gates, and warning signs posted on the fences to provide access controls (addresses RAO #1).

5. Revegetating the disturbed areas with native plants (addresses RAO #3).

6. Conducting visual inspections of the stormwater controls at least annually. Breaches of the concrete berm wall will be repaired as needed (addresses RAO #3).

7. Conducting visual inspections of the landfill cover at least annually to ensure it continues to isolate the waste and is protective of groundwater quality and repairing as needed. Visual inspections will also be conducted after heavy precipitation events in which greater than one inch of rainfall occurs in a 24-hour period, unless it can be demonstrated that the cover is sufficiently stable to withstand these events. The post-rainfall inspections may be discontinued if a qualified engineer has determined that little-to-no significant erosion has occurred after three successive events. The discontinuations of the post-rainfall inspections will be documented in the five-year review.

8. Conducting visual inspections and post-closure maintenance of the landfill cover and fencing at least annually to prevent colonization of the landfill by burrowing animals. Holes and fissures in the landfill cover will be filled, and repairs to the fencing will be made. Any sensitive species found in burrows within the landfill boundary will be relocated under the supervision of a qualified biologist. If burrowing animals continue to colonize the landfill, measures to restrict colonization will be evaluated, including but not limited to the addition of a base rock layer over the landfill cover. If required to restrict colonization efforts, the Air Force will consult with Cal/EPA DTSC to determine the most appropriate additional remedy component (addresses RAOs #1, #2, and #3).

9. Collecting soil gas samples adjacent to the waste cells at least once every five years to confirm that CWAs, CWA degradation products, or VOCs have not been released. If CWA or CWA degradation products are detected in the passive soil gas and the detections are confirmed, additional investigations including air perimeter monitoring would be conducted. Additional LUCs and enhanced containment alternatives would be developed if the perimeter monitoring results indicated that any detectable release of CWA had occurred. If VOCs are detected, additional investigations including groundwater sampling may be conducted to evaluate if there has been a release to groundwater (addresses RAOs #2 and #3).

10. Implementing and maintaining LUCs, which include both institutional controls (ICs) and engineering controls (ECs), in perpetuity to prevent contact with the buried ordnance and prevent the unauthorized disposal of other types of waste. A more complete discussion of the procedures to be used to implement the ICs (items [i] through [v]) is contained in Section 2.5.18 of this ROD. The Air Force shall provide additional details regarding the ECs (items [vi] and [vii]), and health and safety procedures required to install the ECs in a Remedial Action Work Plan to be submitted in accordance with the FFA schedule. The Remedial Action Work Plan is an enforceable primary document under Section 7.3 of the FFA. A listing of the ICs and ECs to be enforced for Site 442 follows:

    i. No structures designed for occupancy will be constructed within the LUC area boundaries (addresses RAOs #1 and #2).

    ii. Only Air Force authorized personnel will be allowed within the LUC area boundaries (addresses RAOs #1 and #2).

    iii. Signs will be posted that warn that the areas may contain hazardous munitions, prohibit unauthorized dumping, and prohibit digging within the LUC area boundaries unless monitored by authorized EOD personnel (addresses RAOs #1 and #2).

    iv. The Air Force shall prohibit unauthorized dumping and prohibit digging within the LUC area boundaries unless monitored by EOD personnel (addresses RAOs #1 and #2).

    v. The installation of groundwater extraction wells and consumption of groundwater will be prohibited within the footprint of each area of Site 442 (addresses RAOs #2 and #3).

    vi. Fencing will be erected around each burial area to prevent unauthorized access. The fences will follow the LUC area boundaries (addresses RAOs #1 and #2).

    vii. Infrastructure related to the remedy, including, but not limited to landfill cover, fencing, stormwater controls, and monitoring wells will be protected by ICs from activities that may negatively impact their ongoing maintenance, effectiveness and safety (addresses RAOs #1, #2, and #3).

11. Reviewing the efficacy of the remedial action during Five-Year Reviews to ensure that any possible contamination from the buried ordnance is not migrating vertically to the groundwater (addresses RAO #3).

2.5.18 LAND USE CONTROLS IMPLEMENTATION AND ADMINISTRATION

The Air Force is committed to implement, monitor, maintain, and enforce remedies that protect human health and the environment in accordance with CERCLA and the NCP.

2.5.18.1 General Requirements

LUC measures to be used at Site 442 are in accordance with specific provisions of CCR Title 22, Section 67391.1 that were determined by the Air Force to be relevant and appropriate requirements. Subsections (a), (b), and (e)(2) in CCR Title 22, Section 67391.1 provide that if a remedy at property owned by the Federal government will result in levels of hazardous substances remaining on property at levels unsuitable for unrestricted use and unlimited exposure, and it is not feasible to record a land use covenant (as is the case with Site 442), then the ROD is to clearly define and include limitations on land use and other IC mechanisms to ensure that future land use will be compatible with the levels of hazardous substances remaining on the property.

The Air Force will implement the following measures at Site 442:

1. Include in the GP for Edwards AFB any specific restrictions required for Site 442, a statement that restrictions are required because of the presence of pollutants or contaminants, the current land users and uses of the site, the geographic control boundaries, and the objectives of the land use restrictions.

2. The Air Force shall not modify or terminate LUCs, implementation actions, or modify land use without approval from the USEPA, Cal/EPA DTSC, and Water Board. The Air Force shall seek prior concurrence before any anticipated action that may disrupt the effectiveness of the LUCs or any action that may alter or negate the need for LUCs.

3. The Air Force is responsible for implementing, maintaining, reporting on, and enforcing the LUCs. Although the Air Force may later transfer these procedural responsibilities to another party by contract, property transfer agreement, or through other means, the Air Force shall retain ultimate responsibility for remedy integrity.

4. The Air Force will notify the USEPA, Cal/EPA DTSC, and Water Board as soon as practicable but no longer than 10 days after discovery of any activity that is inconsistent with the IC objectives or use restrictions, or any other action that may interfere with the effectiveness of the ICs. The Air Force will notify the USEPA, Cal/EPA DTSC, and Water Board regarding how the Air Force has addressed or will address the breach within 10 days of sending the USEPA, Cal/EPA DTSC, and Water Board notification of the breach.

5. The Air Force shall notify the USEPA, Cal/EPA DTSC, and Water Board 45 days in advance of any proposed land use changes that are inconsistent with LUC objectives or the selected remedy.

6. Whenever the Air Force transfers real property that is subject to LUCs and resource use restrictions to another Federal agency, the transfer documents shall require that the Federal

transferee include the LUCs, and applicable resource use restrictions, in its resource use plan or equivalent resource use mechanism. The Air Force shall advise the recipient Federal agency of all obligations contained in the ROD, including the obligation that a State Land Use Covenant will be executed and recorded pursuant to CCR Title 22, Section 67391.1 in the event the Federal agency transfers the property to a non-Federal entity.

7. Whenever the Air Force proposes to transfer real property subject to resource use restrictions and LUCs to a non-Federal entity, it will provide information to that entity in the draft deed and transfer documents regarding necessary resource use restrictions and LUCs, including the obligation that a State Land Use Covenant will be executed and recorded pursuant to CCR Title 22, Section 67391.1. The signed deed will include LUCs and resource restrictions equivalent to those contained in the State Land Use Covenant and this ROD.

8. The Air Force will provide notice to the USEPA, Cal/EPA DTSC, and Water Board at least six months prior to any transfer or sale of Site 442 so that the USEPA, Cal/EPA DTSC, and Water Board can be involved in discussions to ensure that appropriate provisions are included in the transfer terms or conveyance documents to maintain effective LUCs. If it is not possible for the facility to notify the USEPA, Cal/EPA DTSC, and Water Board at least six months prior to any transfer or sale, then the facility will notify the USEPA, Cal/EPA DTSC, and Water Board as soon as possible but no later than 60 days prior to the transfer or sale of any property subject to LUCs. In addition to the land transfer notice and discussion provisions above, the Air Force further agrees to provide the USEPA, Cal/EPA DTSC, and Water Board with similar notice, within the same time frames, of Federal-to-Federal transfer of property. The Air Force shall provide a copy of the executed deed or transfer assembly to the USEPA, Cal/EPA DTSC, and Water Board.

9. The Air Force will address as soon as practicable any activity that is inconsistent with LUC objectives or use restrictions or any other action that may interfere with the effectiveness of LUCs, but in no case will the process be initiated later than 30 days after the Air Force becomes aware of the activity.

10. Monitoring of the environmental use restrictions and controls will be conducted annually by the Air Force. The monitoring results will be included in a separate report or as a section of another environmental report, if appropriate, and provided to the USEPA, Cal/EPA DTSC, and Water Board. The annual monitoring reports will be used in preparation of the Five-Year Review to evaluate the effectiveness of the remedy.

11. The annual monitoring report, submitted to the regulatory agencies by the Air Force, will evaluate the status of the ICs and how any IC deficiencies or inconsistent uses have been addressed. The annual evaluation will address whether the use restrictions and controls referenced above were communicated in the deed(s), whether the owners and State and local agencies were notified of the use restrictions and controls affecting the property, and whether use of the property has conformed to such restrictions and controls.

It is understood that the Air Force is responsible for remedy implementation and ensuring integrity of the remedy, including monitoring, maintaining, and enforcing the identified controls. If the Air Force determines that it cannot meet specific LUC requirements, it is understood that the remedy may be reconsidered and that additional measures may be required to ensure the protection of human health and the environment.

In addition, to assure the USEPA, Cal/EPA DTSC, Water Board, and the public that the Air Force will fully comply with and be accountable for the performance measures identified herein, the Air Force will submit to the USEPA, Cal/EPA DTSC, and Water Board in a timely manner an annual monitoring report on the status of LUCs and/or other remedial actions, including the operation and maintenance and monitoring thereof, and how any LUC deficiencies or inconsistent uses have been addressed. The report will also be filed in the Information Repositories. The report will not be subject to approval and/or revision by the USEPA, Cal/EPA DTSC, and Water Board. The annual monitoring reports will be used in preparation of the Five-Year Reviews to evaluate the effectiveness of the remedy and will verify that State and local agencies were notified of the use restrictions and controls affecting the property and that the use of the property has conformed to such restrictions and controls.

2.5.18.2 Implementation Procedures

Only USAF-approved projects are allowed on Base and they must be covered by one of the following documents: AFFTC Form 5926 (Civil Engineering [CE] Work Clearance Request) and/or AF Form 332 (CE Work Request). AFFTC Form 5926 is required for any project that involves mechanical soil excavation or drilling, such as digging trenches for underground lines, excavating soil for building foundations, or drilling to install groundwater monitoring wells.

Documentation of LUCs and Restricted Areas

All areas requiring LUCs will be documented in the GP and the Base GIS after this ROD is approved and authorized by the supporting regulatory agencies. The GP includes general information about LUCs and incorporates the GIS, which contains site-specific LUC information by reference. Restrictions required by the ROD will either be entered into the GIS or incorporated by reference to an external document such as an LUC implementation work plan.

Until a site is cleaned to acceptable levels suitable for unrestricted use and unlimited exposure, the GP will reflect the restrictions on development and land use. Upon completion of a remedial action at a site, the GP will be updated to modify the site-specific use restrictions as appropriate.

The footprints of areas impacted with chemicals of concern are documented in the GIS from ERP documents. LUC boundaries for Site 442 will be based on the fence boundaries for the three Areas that comprise Site 442.

The Air Force shall notify the USEPA and the State in advance of any changes to the GP and internal administrative procedures that would affect the LUCs.

Enforcement Process

Any project requiring change in land use designation and/or construction requires approval by the appropriate Environmental Management Office to ensure compliance with the GP. Environmental Management has primary responsibility to ensure that LUCs are enforced and that the appropriate Air Force offices are notified of any subsequent changes to the LUCs. However, the Installation Commander has the ultimate responsibility for the enforcement of LUCs.

AF Form 332, the CE Work Request, must be submitted and approved before the start of any construction project on Edwards AFB. Approval of this form involves the comparison of the construction site with the constraints in the GP and GIS, including the identification of LUCs that are applicable to the construction site. The Work Request serves as the document for communicating any construction constraints to the appropriate offices. Any constraints at the site result in the disapproval of the form unless the requester makes appropriate modifications to the construction plans. The CE Work Management Office is responsible for the final approval of proposed construction projects through the Configuration Control Board review process.

AFFTC Form 5926, the EAFB CE Work Clearance Request, will be used for any project that involves mechanical soil excavation. The requester submits AFFTC Form 5926 to CE Customer Service, and it is circulated to appropriate offices for review of needed safety procedures. Approval of this form involves the comparison of the site with the constraints in the GP and GIS, including the

identification of LUCs that are applicable to the excavation site. The CE Real Estate Office is responsible for the final approval of excavation projects through the permit review process.

In addition, because these are restricted access areas, prior approval is required from Edwards AFB Range Operations before site visits or intrusive work is performed.

2.5.19 STATUTORY DETERMINATIONS

The following sections discuss how the selected remedy meets the statutory requirements.

Protection of Human Health and the Environment

The selected remedy will protect human health and the environment by preventing unauthorized access to and prevent direct contact with the buried debris present at the site through LUCs and the repair and maintenance of the cover materials, and by protecting groundwater by minimizing the infiltration of stormwater into the landfill.

Compliance with ARARs

The selected remedy will comply with all Federal and State ARARs identified for the remedial action (Appendix B, Table B-1). The buried debris in the trenches at Site 442, Areas 1, 2, and 3 is a solid waste as described under the Military Munitions Rule (see Appendix B, Table B-1, Item No. 6), and is therefore subject to ARARs as stipulated below. Further more, if the military munitions solid waste is also hazardous waste, Resource Conservation and Recovery Act (RCRA) Subtitle C regulations are ARARs.

Chemical-Specific ARARs. No chemical-specific ARARs are associated with Site 442, Areas 1, 2, and 3.

Location-specific ARARs. Because Site 442, Areas 1, 2, and 3 have already been moderately disturbed, and no eligible cultural resources have been identified in these Areas, most Federal and State regulations governing the protection of wildlife, historical, or archeological resources are not ARARs. However, because endangered or threatened species are present in these Areas, and there is a possibility that migrating birds may be present, the following are listed as ARARs:

- Federal Endangered Species Act (Table B-1, Item No. 1);
- California Endangered Species Act (Table B-1, Item No. 2);

- Wildlife Species/Habitats (Table B-1, Item No. 3);
- Protected Birds (Table B-1, Item No. 4);
- Protected Mammals (Table B-1, Item No. 5);
- Protected Amphibians and Reptiles (Table B-1, Item No. 6); and
- Rare Native Plants (Table B-1, Item No. 7).

Field activities associated with the selected remedy for Site 442, Areas 1, 2, and 3 (i.e., construction, monitoring, and maintenance of the engineered LUCs and stormwater controls) will be coordinated with Base biologists to ensure the protection of sensitive plant and wildlife species.

Action-specific ARARs.

- Sources of Drinking Water Policy (Table B-1, Item No. 8) – The Air Force agrees with the designation of the current and potential use of the groundwater at Site 442 as drinking/domestic use. By controlling the infiltration of surface water into the debris-filled trenches, the selected remedy is protective of groundwater as required by SWRCB Resolution 88-63.

- Land Use Controls (Table B-1, Item No. 9) – As discussed in Section 2.5.14, LUCs are included as part of the selected remedy because hazardous substances may remain in the trenches at Site 442 at levels unsuitable for unrestricted use and unlimited exposure. In the event of transfer of property to a non-Federal entity that includes the LUC boundaries at Site 442, a land use covenant with Cal/EPA DTSC would be required. Therefore, the cited requirements are relevant and appropriate to the selected remedy. LUCs will be administered during the implementation of the selected remedy as indicated in Section 2.5.18 of this document and in the *Basewide Land Use Control Implementation Plan* (Earth Tech 2007c).

- Military Munitions Rule (Table B-1, Item No. 10) – Section 107 of the Federal Facilities Compliance Act of 1992 required the USEPA to issue a ruling, in consultation with the Department of Defense (DoD) and the States, that determines whether conventional and chemical military munitions are a hazardous waste under RCRA and that also identifies the party or parties responsible for providing protective storage and transportation of the hazardous waste. In response, the USEPA (1997) finalized regulations (the "Military Munitions Rule") that identifies when conventional and chemical military munitions become a hazardous waste under RCRA.

The definition of military munitions is set forth in 40 CFR, Part 260, Section 260.10. Under 40 CFR, Part 266, Subpart M, Section 266.202, Definition of Solid Waste, the USEPA established the regulatory definition of solid waste as it applies to three specific categories of military munitions: (1) munitions used for their intended purpose; (2) unused munitions; and (3) used or fired munitions. These definitions are described below:

In Section 266.202(a), a military munition is not a solid waste for regulatory purposes under the following circumstances: (1) a munition is used for its intended purpose, which includes a munition used for the training of military personnel; a munition used for research, development, testing, and evaluation; and a munition destroyed during range clearance operations at active and inactive ranges; and (2) an unused munition, or component thereof, is being repaired, reused, recycled, reclaimed, disassembled, reconfigured, or otherwise subjected to materials recovery activities.

In Section 266.202(b), an unused munition is considered a solid waste for regulatory purposes when any of the following occurs: (1) the unused munition is abandoned by being disposed of, burned, detonated (except during its intended use), incinerated, or treated prior to disposal; (2) the unused munition is removed from storage for purposes of disposal or treatment prior to disposal; (3) the unused munition is deteriorated, leaking, or damaged to the point that it may no longer be put back into serviceable condition and it cannot be reasonably recycled or used for other purposes; or (4) the unused munition has been determined to be a solid waste by an authorized military official.

In Section 266.202(c), used or fired munitions are a solid waste for regulatory purposes when they are removed from their landing spot and either: (1) managed off-range (i.e., transported off-range and stored, reclaimed, treated, or disposed); or (2) disposed on-range (i.e., buried or disposed in a landfill). In both cases, when the used or fired munition is a solid waste, it is potentially subject to regulation as a hazardous waste. In addition, munitions that land off-range and are not promptly retrieved are considered statutory solid waste.

The USEPA conditionally exempts from the RCRA Manifest Requirements and Container Marking Requirements any waste non-chemical military munitions that are shipped from one military owned or operated Treatment, Storage, and Disposal Facility (TSDF) to another in accordance with DoD military munitions shipping controls. The USEPA also conditionally exempts from the RCRA Subtitle C storage regulations any waste non-chemical military munitions subject to the jurisdiction of the DoD Explosives Safety Board storage standards (U.S. Department of Defense 2004).

Based on the above discussion, the contents of the burial trenches at Site 442 are considered a solid waste for regulatory purposes because they are used or fired munitions that were disposed on the Range. Therefore, Section 266.202(c) of the Military Munitions Rule is considered an action-specific ARAR for Site 442.

- Definition of and Criteria for Identifying Hazardous Wastes (Table B-1, Item No. 11) – The criteria contained in this ARAR will be used to define if any waste inadvertently

uncovered by the selected remedy is hazardous, extremely hazardous, or a hazardous waste of concern.

- Ignitable, Reactive, or Incompatible Wastes (Table B-1, Item No. 12) – Precautions will be taken during the implementation of the selected remedy to prevent disturbance of any hazardous waste that potentially could be present in the burial trenches to prevent a release of hazardous materials.

The following regulations governing hazardous waste landfills under CCR Title 22, Division 4.5, Chapter 14, Article 2 were determined to be relevant and appropriate for Site 442 because hazardous wastes could be present at the site:

- General Inspection Criteria for Hazardous Waste Landfills (Table B-1, Item No. 13) – LUCs, stormwater controls, and the cover over the burial trenches implemented as a result of the selected remedy will be inspected according to this ARAR to identify problems in time to correct them before they harm human health or the environment.

- Seismic and Precipitation Design Standards for Hazardous Waste Landfills (Table B-1, Item No. 14) – The facilities in the selected remedy will be designed to continue to contain the waste after a 24-hour precipitation storm or the maximum credible earthquake. In addition, the facilities will be inspected as soon as feasible after these events, and repairs will be made if required.

- Surveying Requirements for Hazardous Waste Landfills (Table B-1, Item No. 15) – Permanently surveyed benchmarks will be installed at each cell location.

- Closure and Post-Closure Care for Hazardous Waste Landfills (Table B-1, Item No. 16) – The remedy specifies closure-in-place for the remaining wastes at Site 442. The contents of each waste cell are presumed to contain hazardous wastes not expected to be readily mobile. The groundwater monitoring program requirements are not required unless there is physical evidence of a release.

The following regulations governing solid waste landfills under CCR Title 27 were determined to be relevant and appropriate for Site 442 (a waste management unit) because it requires the cover to be protective of groundwater, and has provisions governing closed, abandoned, or inactive units (units inactive as of November 27, 1984) as defined under Section 20080(g):

- Closure and Post-Closure Maintenance Requirements for Solid Waste Landfills (Table B-1, Item Nos. 17 and 18) – The cover in the selected remedy will be at least as protective as the State Prescriptive Cover described in Section 21090. The final closure and post-closure maintenance plan will be developed as part of the Remedial Action Work Plan for Site 442, and the final cover design will be demonstrated to comply with this standard.

- Groundwater Monitoring Programs for Solid Waste Landfills (Table B-1, Item No. 19) – The selected remedy will follow the groundwater programs described in this ARAR in the event that there is physical evidence of a release.

- Vadose Zone Monitoring Requirements for Solid Waste Landfills (Table B-1, Item No. 20) – The selected remedy will include soil gas sampling every five years to assess whether VOCs have been released into the environment that may potentially threaten groundwater.

Cost Effectiveness

The selected alternative is the lowest cost remedy that is protective of human health and the environment and complies with ARARs.

Utilization of Permanent Solutions and Alternative Treatment Technologies

The selected alternative does not incorporate permanent solutions or alternative treatment technologies but provides the best balance of tradeoffs among short-term effectiveness, long-term effectiveness and permanence, implementability, and cost. It is expected to be permanent and effective over the long term as long as routine maintenance of the fence, cover, and erosion control features is performed, and the LUCs are enforced.

Preference for Treatment as a Principal Element

Because treatment of the potential contaminant source at the site (i.e., buried CWM) was not found to be practicable, this remedy does not satisfy the statutory preference for treatment as a principal element of the remedy. The size of the burial areas, extremely hazardous nature of the munitions potentially buried at the site, and the fact that no specific areas at the site with elevated contaminant concentrations have been identified, preclude a remedy in which contaminants could be excavated and treated effectively.

Five-Year Review Requirements

Five-Year Reviews will be required as long as the LUCs are in place to ensure the remedy continues to remain effective.

2.5.20 DOCUMENTATION OF SIGNIFICANT CHANGES FROM THE PROPOSED PLAN

Alternative 3, which included stormwater controls and re-grading of the site but not the requirement that the final cover perform to State Prescriptive design standards contained in CCR Title 27, was selected as the preferred alternative in the Proposed Plan. However, at the request of Cal/EPA and the Water Board, Alternative 4 is the selected remedy in this ROD because it contains enhanced cover provisions that comply with State Prescriptive design standards.

2.6 REFERENCES

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Part 3: Responsiveness
Summary

3.0 PART 3: RESPONSIVENESS SUMMARY

This Responsiveness Summary is intended to provide a summary of information about the views of the public regarding both the remedial alternatives and general concerns about OU7 CWM submitted during the public comment period. An overview of the Proposed Plan for OU7 CWM was presented at a RAB meeting held on May 15, 2008 at the Antelope Valley Inn in Lancaster, California. Notices of availability of the Proposed Plan were published in the Antelope Valley Press and Mojave Desert News (local area newspapers) on May 1, 2008 and May 29, 2008 and in the Desert Wings (a publication of the Edwards AFB Public Affairs Office) on May 2, 2008 and May 23, 2008. A public comment period was held from May 1 to June 16, 2008. During the public comment period, the RI report, the Feasibility Study (FS), and the Proposed Plan were made available to the public.

Public meeting were held on-Base and off-Base on May 29, 2008 to present the Proposed Plan to a broader community audience. The on-Base meeting was held from 1100 to 1300 hours in Building 2650A, Conference Room 1, Edwards AFB, California. No public comments were received during the public meetings.

Appendix A

APPENDIX A

MEMORANDUM FOR RECORD
OPERABLE UNIT 7
CHEMICAL WARFARE MATERIEL

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE FLIGHT TEST CENTER (AFMC)
EDWARDS AIR FORCE BASE, CALIFORNIA

MEMORANDUM FOR RECORD 10 March 2004

FROM: AFFTC/EMR
5 E. Popson Avenue
Edwards AFB CA 93524-8060

SUBJECT: No Further Investigation (NFI) Status for Site 426, World War II Chemical Warfare Materiel Storage Yard, Operable Unit 7, Edwards AFB, California.

1. This office has reviewed the Interim Removal Action (IRA) Report for Site 426 (November 2003). No residual soil contaminants remain from any chemical warfare activities that may have occurred at Site 426. No chemical warfare agents or degradation products were detected in soil samples. Based on the analytical results presented in the IRA report, this office is satisfied that the investigation is complete. Based on laws and regulations in place at the time of this action, this site will be classified as requiring no further investigation of soil and groundwater.

2. It is important to note that this letter does not relieve Edwards AFB of further responsibilities mandated under CERCLA, the California Health and Safety Code, and the California Water Code if additional or previously unidentified contamination at the subject site causes or threatens to cause pollution, or is found to pose a significant threat to public health and the environment.

3. For questions or comments, please call Mr. David Steckel at (661) 277-1474.

4. We, the undersigned, concur with the above selected determination of NFI for Site 426.

David E. Steckel 10 MAR 04
DAVID E. STECKEL Date
Remedial Project Manager
U.S. Air Force

Sheryl Lauth 3/10/04
SHERYL LAUTH Date
Remedial Project Manager
U.S. Environmental Protection Agency
Region 9

John A. O'Kane Jr. 3/10/04
JOHN A. O'KANE, JR. Date
Remedial Project Manager
California Department of Toxic Substances
Control, Region 1

Elizabeth T. Lafferty 3/10/04
ELIZABETH T. LAFFERTY Date
Remedial Project Manager
California Regional Water Quality Control
Board, Region 6

APPENDIX B

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS FOR OPERABLE UNIT 7, CHEMICAL WARFARE MATERIEL

Table B-1 Applicable or Relevant and Appropriate Requirements – Site 442

TABLE B-1. APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS – SITE 442

Item No.	Requirement	Citation	Federal or State Requirement	Description	ARAR Determination	Comments
Chemical-specific ARARs						
There are no chemical–specific ARARs associated with this site.						
Location-specific ARARs						
1	Endangered Species Act of 1973, Section 7(c)	50 CFR 200 and 402	Federal	Requires formal consultation with the USFWS if activities have the potential to alter the natural environment of listed endangered and threatened species.	Relevant and appropriate	Endangered or threatened species and/or critical habitat are found at Edwards AFB. Site 442 Area 3 is located in the USFWS Fremont-Kramer Desert Tortoise Critical Habitat Unit. Site 442 Areas 1 and 2 are located in areas with “dense” populations of desert tortoise, but are not considered to be critical habitat. The Base INRMP details, or incorporates by reference, the management practices to be followed at sites with desert tortoise habitat.
2	California Endangered Species Act	California Fish and Game Code, Div. 3, Ch. 1.5, Article 1, Sections 2050-2055; Article 3, Section 2080; 14 CCR, Div. 1, Subdivision 3, Ch. 6, Article 1, Sections 670.2, 670.5, and 783 et. seq.	State	Establishes species, subspecies, and varieties of native California plants or animals as endangered, threatened, or rare. Prohibits the taking, importation, or sale of any species, or any part thereof, of an endangered species or a threatened species. Prohibits releases and/or actions that would have a deleterious effect on species or their habitat. Contains provisions concerning CDFG coordination and consultation with State and Federal agencies and with project applicants. 14 CCR Section 670.1 provides a listing of the plants of California to be declared endangered, threatened or rare. 14 CCR Section 670.5 provides a listing of the animals of California to be declared endangered or threatened. 14 CCR Section 783 et. seq. provides the implementation regulations for the California Endangered Species Act.	Relevant and appropriate	Potentially relevant and appropriate if there are endangered or threatened species in the area that could be affected if actions are not taken to conserve the species, and where State law has a listing that is more stringent than the Federal Endangered Species Act and Migratory Bird Treaty Act. State listed species known to occur in the vicinity of Site 442 include desert tortoise, Mohave ground squirrel, and Swainson’s hawk. As stated in Air Force Instruction 32-7064, dated 17 September 2004, State-protected species will be protected when practicable and the appropriate State authority will be contacted if conflicts arise. The State may provide procedures for minimization of impacts and harm to species.

TABLE B-1. APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS – SITE 442

Item No.	Requirement	Citation	Federal or State Requirement	Description	ARAR Determination	Comments
3	Wildlife Species/Habitats	California Fish and Game Code; Div.3, Ch. 1, Section 2000; Div. 4, Part 1, Ch. 1, Section 3005, Part 2, Ch.1, Sections 3511 and 3513; and Div. 9, Ch.1, Section 12000 et seq. 14 CCR, Div. 1, Subdivision 2, Ch. 1, Section 250; Ch. 7, Section 507; Subdivision 3, Ch. 1, Section 650	State	Prohibits the taking of birds and mammals, except as otherwise provided in the Fish and Game Code and 14 CCR, including taking by poison. Section 3511 provides that it is unlawful to take or possess any of the following fully protected birds: (a) American peregrine falcon; (b) Brown pelican; (c) California black rail; (d) California clapper rail; (e) California condor; (f) California least tern; (g) Golden eagle; (h) Greater sandhill crane; (i) Light-footed clapper rail; (j) Southern bald eagle; (k) Trumpeter swan; (l) White-tailed kite; (m) Yuma clapper rail.	Relevant and appropriate	Potentially relevant and appropriate to the extent that such fully protected birds or their habitat occur on or near Site 442. Fully protected birds including American peregrine falcon, Golden eagle, and White-tailed kite are known to occur in the vicinity of Site 442. As stated in Air Force Instruction 32-7064, dated 17 September 2004, State-protected species will be protected when practicable and the appropriate State authority will be contacted if conflicts arise. The State may provide procedures for minimization of impacts and harm to species.
4	Protected birds	California Fish and Game Code Div. 4, Part 2, Ch. 1, Sections 3503 and 3503.5 and Ch. 3, Section 3800	State	Section 3503 requires that action must be taken to avoid the take or destruction of the nest or eggs of any bird. This section prohibits the take, possession, or needless destruction of the nest or eggs of any bird, except as otherwise provided by this code or any regulation made pursuant thereto. Section 3503.5 prohibits the take, possession, or destruction of any birds in the orders of Falconiformes or Strigiformes (birds-of-prey) or to take, possess, or destroy the nest or eggs of any such bird except as otherwise provided by this code or any regulation adopted pursuant thereto. Section 3800 requires that action must be taken to prevent the take, possession, or destruction of any non-game birds or their eggs. This section prohibits the take of nongame birds, except in accordance with regulations of the commission, or when related to mining operations with a mitigation plan approved by the department. This section further provides requirements concerning mitigation plans related to mining.	Relevant and appropriate	Potentially relevant and appropriate to the extent that nongame birds, birds-of-prey or their nests and eggs are located on or near Site 442. Bird-of-prey species may be found on or near Site 442 include Burrowing owl, Prairie falcon, White-tailed kite, Short-eared owl, and Swainson's hawk. As stated in Air Force Instruction 32-7064, dated 17 September 2004, State-protected species will be protected when practicable and the appropriate State authority will be contacted if conflicts arise. The State may provide procedures for minimization of impacts and harm to species.

Item No.	Requirement	Citation	Federal or State Requirement	Description	ARAR Determination	Comments
5	Protected mammals	California Fish and Game Code Div. 4, Part 3, Ch. 2, Section 4000 et. seq ; Ch. 3, Section 4150; Ch. 8, Section 4700; Ch. 10, Section 4800 et. seq.; 14 CCR, Div. 1, Subdivision 2, Ch. 5, Section 460	State	Actions must be taken to assure that no fully protected mammals are taken or possessed at any time. Section 4000 et. seq. provides that a fur-bearing mammal may be taken only with a trap, a firearm, bow and arrow, poison under a proper permit, or with the use of dogs. The Code identifies fur-bearing mammals as the following: pine marten, fisher, wolverine, mink, river otter, gray fox, cross fox, silver fox, red fox, kit fox, raccoon, beaver, badger, and muskrat. Section 4150 requires that action must be taken to avoid the take or possession of nongame mammals. Nongame mammals are those occurring naturally in California which are not game mammals, fully protected mammals, or fur-bearing mammals. These mammals, or their parts, may not be taken or possessed except as provided in this code or in accordance with regulations adopted by the commission. Section 4700 prohibits the take or possession of any of the fully protected mammals or their parts. The following are fully protected mammals: (a) Morro Bay kangaroo rat; (b) Bighorn sheep except Nelson bighorn sheep; (c) Northern elephant seal; (d) Guadalupe fur seal; (e) Ring-tailed cat; (f) Pacific right whale; (g) Salt-marsh harvest mouse (h) Southern sea otter; (i) Wolverine. Section 4800 et. seq. requires that action must be taken to avoid injuring, taking, possessing or transporting any mountain lion. Mountain lions are specially protected mammals in California. It is unlawful to take, injure, possess, transport, or sell any mountain lion or any part or product thereof. Violation of this section is a misdemeanor. 14 CCR Section 460 makes it unlawful to take fisher, martin, river otter, desert kit fox, and red fox.	Relevant and appropriate	Potentially relevant and appropriate if regulated mammals and/or their habitat are located on or near Site 442. Desert kit fox, Badger, Ring-tailed cat, and Mountain lions may be present on or near Site 442. As stated in Air Force Instruction 32-7064, dated 17 September 2004, State-protected species will be protected when practicable and the appropriate State authority will be contacted if conflicts arise. The State may provide procedures for minimization of impacts and harm to species.

TABLE B-1. APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS – SITE 442
(Page 4 of 9)

Item No.	Requirement	Citation	Federal or State Requirement	Description	ARAR Determination	Comments
6	Protected amphibians and reptiles	California Fish and Game Code Div. 5, Ch. 1, Section 5000 et. seq. 14 CCR, Div. 1, Subdivision 1, Ch. 5, Section 40.	State	Section 5000 makes it unlawful to sell, purchase, harm, take, possess, or transport any tortoise or parts thereof, or to shoot any projectile at a tortoise. This does not apply to the taking of any tortoise when authorized by the department for education, scientific, or public zoological purposes. 14 CCR Section 40 makes it unlawful to capture, collect, intentionally kill or injure, possess, purchase, propagate, sell, transport, import, or export any native reptile or amphibian, or parts thereof unless under special permit from the department issued pursuant to 14 CCR Sections 650, 670.7, or 783 of these regulations, or as otherwise provided in the Fish and Game Code or these regulations.	Relevant and appropriate	Site 442 Area 3 is located in the USFWS Fremont-Kramer Desert Tortoise Critical Habitat Unit. Site 442 Areas 1 and 2 are located in areas with "dense" populations of desert tortoise, but are not considered to be critical habitat. The Base INRMP details, or incorporates by reference, the management practices to be followed at sites with desert tortoise habitat. Numerous reptile species may be present at Site 442 including Sidewinder, Desert rosy boa, Horned lizard, Long-nosed leopard lizard, and Desert iguana. As stated in Air Force Instruction 32-7064, dated 17 September 2004, State-protected species will be protected when practicable and the appropriate State authority will be contacted if conflicts arise. The State may provide procedures for minimization of impacts and harm to species.
7	Rare native plants	California Fish and Game Code Div. 2, Ch. 10, Section 1908 14 CCR, Div. 1, Subdivision 3, Ch. 3, Section 670.2	State	Action must be taken to conserve native plants; there can be no releases and/or actions that would have a deleterious effect on species or habitat. Section 1908 imposes a substantive requirement by forbidding any person to take rare or endangered native plants. 14 CCR Section 670.2 provides a listing of the plants of California that have been declared to be Endangered, Threatened or Rare.	Relevant and appropriate	Potentially relevant and appropriate to the extent that there are rare or endangered plants at Site 442. Rare plants known to occur in the vicinity of Site 442 include Barstow woolly sunflower (Eriophyllum mohavense), Lancaster milk-vetch (Astragalus preussi var. laxiflorus), Red rock poppy (Eschscholzia minutifolia ssp. twisselmannii), Alkali mariposa lily (Calochortus striatus), and Desert cymopterus (Cymopterus deserticola). As stated in Air Force Instruction 32-7064, dated 17 September 2004, State-protected species will be protected when practicable and the appropriate State authority will be contacted if conflicts arise. The State may provide procedures for minimization of impacts and harm to species.
Action-specific ARARs						
8	Sources of Drinking Water Policy	SWRCB Resolution No. 88-63; Porter-Cologne Water Quality Act (CWC Sections 13000, 13140, 13240); H&S Code Section 25356.1.5(a)	State	Resolution 88-63 has been incorporated into all Regional Board Basin Plans, including the Lahontan Region Water Board Basin Plan. This resolution designates all groundwater and surface waters of the State as drinking water except where the TDS is greater than 3,000 ppm, the well yield is less than 200 gpd from a single well, the water is a geothermal resource or in a wastewater conveyance facility, or the water cannot reasonably be treated for domestic use using either best management practices or best economically achievable treatment practices.	Applicable	The Air Force agrees with the designation of the potential future use of the groundwater at Site 442 as drinking/domestic use.

TABLE B-1. APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS – SITE 442
(Page 5 of 9)

Item No.	Requirement	Citation	Federal or State Requirement	Description	ARAR Determination	Comments
9	Land Use Controls	22 CCR, Div. 4.5, Ch. 39, Section 67391.1; California Civil Code, Div. 3, Part 1, Title 3, Section 1471(a) through (f)	State	Requires that if a remedy will result in hazardous substances remaining on a property at levels unsuitable for unrestricted use and unlimited exposure, the limitations or controls are clearly set forth and defined in the response action decision document, and that the decision document include an implementation and enforcement plan. In the event of a property transfer, requires the State to enter into restrictive Land Use Covenants with land-owners and their successors, with exceptions for Federal-to-Federal property transfers.	Relevant and appropriate	Institutional controls will be required at Site 442 as long as the buried debris remains in place. Although it is not contemplated that property at Site 442 will be transferred, in the event that such property is transferred, the AF and the State have agreed to follow the procedure laid out in the Basewide Land Use Control Implementation Plan. EPA agrees that the substantive portions of the regulation referenced are ARARs. EPA specifically considers sections (a), (d), (e), and (f) of 22 CCR, Section 67391.1 to be ARARs for this ROD. DTSC's position is that all of the State regulation is an ARAR.
10	Military Munitions Rule	40 CFR, Part 260, Section 260.10; Part 266, Subpart M, Section 266.202 (Military Munitions Rule: Hazardous Waste Identification and Management; Explosives Emergencies; Manifest Exemption for Transport of Hazardous Waste on Right-of-Ways on Contiguous Properties [EPA–530-Z-95-013]).	Federal	The USEPA finalized the "Military Munitions Rule" that identifies when conventional and chemical military munitions become a hazardous waste under RCRA.	Applicable	"Military munitions" are defined in Section 260.10. Section 266.202 defines whether a military munition is a solid waste. The contents of the burial trenches at Site 442 are considered a solid waste for regulatory purposes because they are used or fired munitions that were disposed on the Range.
11	Definition of and Criteria for Identifying Hazardous Wastes	22 CCR Div 4.5 Ch. 11 Articles 1, Sections 66261.2-3, Article 3 Sections 66261.21 and.23, Article 5 Sections 66261.100-.101, 66261.110, 66261.111	State	Defines wastes that are subject to regulation as a RCRA or California hazardous waste. Defines criteria for designating a waste an extremely hazardous waste. Requires reporting of hazardous waste of concern in the event it is discovered to be missing.	Relevant and appropriate	Although testing of the waste at Site 442 was not feasible for safety reasons, the possible presence of CWA makes it prudent to manage the site as though hazardous waste, extremely hazardous waste, or hazardous waste of concern may be present and to avoid release(s) during construction activities.

TABLE B-1. APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS – SITE 442
(Page 6 of 9)

Item No.	Requirement	Citation	Federal or State Requirement	Description	ARAR Determination	Comments
12	Ignitable, Reactive or Incompatible Wastes	22 CCR, Div. 4.5, Ch. 14, Article 2, Section 66264.17(b)	State	Requires the owner of a facility that disposes ignitable or reactive waste to take precautions to prevent reactions which generate extreme heat or pressure, fire or explosions, or violent reactions; or produce uncontrolled flammables posing a risk of fire or explosions, or toxic mists, fumes, dusts or gasses in sufficient quantities to threaten human health or the environment, damage to the structural integrity of the facility, or through like means threaten human health or the environment.	Relevant and Appropriate	Precautions will be taken during the implementation of the selected remedy to prevent disturbance of any hazardous waste that potentially could be present in the burial trenches to prevent a release of hazardous materials.
13	General Inspection Requirements for Hazardous Waste Landfills	22 CCR, Div. 4.5, Ch. 14, Article 2, Section 66264.15(a)	State	Requires that the owner or operator inspect the disposal facility for malfunctions and deterioration, operator errors, and discharges which may be causing or may lead to: (1) release of hazardous waste constituents to the environment; or (2) a threat to human health. The owner or operator must conduct these inspections often enough to identify problems in time to correct them before they harm human health or the environment.	Relevant and Appropriate	The selected remedy requires that the facility be inspected on at least an annual basis to maintain the integrity of the land use controls, stormwater controls, and cover.
14	Seismic and Precipitation Design Standards for Hazardous Waste Landfills	22 CCR, Div. 4.5, Ch. 14, Article 2, Section 66264.25	State	Facilities subjected to this chapter and all covers systems and drainage control systems shall be designed to function without failure resulting from a 24-hour probable maximum precipitation storm and to withstand the maximum credible earthquake.	Relevant and Appropriate	The facilities in the selected remedy will be designed to continue to contain the waste after a 24-hour precipitation storm or the maximum credible earthquake. In addition, the facilities will be inspected as soon as feasible after these events, and repairs will be made if required.
15	Surveying Requirements for Hazardous Waste Landfills	22 CCR, Div. 4.5, Ch. 14, Article 2, Section 66264.309(a)	State	Requires establishment of permanently surveyed benchmarks at each cell location with horizontal and vertical controls.	Relevant and Appropriate	Permanently surveyed benchmarks will be installed at each cell location.

TABLE B-1. APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS – SITE 442
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Item No.	Requirement	Citation	Federal or State Requirement	Description	ARAR Determination	Comments
16	Closure and Post-Closure Care for Hazardous Waste Landfills	22 CCR, Div. 4.5, Ch. 14, Article 2, Section 66264.310(a), (b)(1, 4 & 5)	State	(a) At final closure of the landfill or upon closure of any cell, the owner or operator shall cover the landfill or cell with a final cover designed and constructed to: (1) prevent the downward entry of water into the closed landfill throughout a period of at least 100 years; (2) function with minimum maintenance; (3) promote drainage and minimize erosion or abrasion of the cover; (4) accommodate settling and subsidence so that the cover's integrity is maintained; (5) accommodate lateral and vertical shear forces generated by the maximum credible earthquake so that the integrity of the cover is maintained; (6) have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present; and (7) conform to the provisions of subsections (e) through (r) of Section 66264.228, except that the Department shall grant a variance from any requirement of subsections (e) through (r) which the owner or operator demonstrates to the satisfaction of the Department is not necessary to protect public health, water quality or other environmental quality. (b) After final closure, the owner or operator must comply with all post-closure requirements contained in Sections 66264.117 through 66264.120, including maintenance and monitoring throughout the post-closure care period specified in the permit under Section 66264.117. The owner or operator must: (1) maintain the integrity and effectiveness of the final cover, including making repairs to the cap as necessary to correct the effects of settling, subsidence, erosion, or other events; (4) prevent run-on and run-off from eroding or otherwise damaging the final cover; (5) protect and maintain surveyed benchmarks used in complying with Section 66264.309.	Relevant and Appropriate	The selected remedy will comply with the general provisions of these sections. The landfill cover will be designed in accordance with Title 27, Section 20080.

Item No.	Requirement	Citation	Federal or State Requirement	Description	ARAR Determination	Comments
17	Closure and Post-Closure Maintenance Requirements for Solid Waste Landfills	27 CCR, Ch. 1, Article 1, Section 20080 (b, c, and g)	State	Allows for engineered alternatives to the State Prescriptive Cover that afford equivalent protection against water quality impairment. Allows for demonstration that meeting the equivalent protection requirement is unreasonably and unnecessarily burdensome, or will cost substantially more than alternatives which meet the criteria, or is impractical and will not promote attainment of applicable performance standards. Defines Closed, Abandoned, or Inactive (CAI) units as waste management units which were closed, abandoned, or inactive on or before November 27, 1984.	Relevant and Appropriate	Title 27 is considered relevant and appropriate for design of the cover to be placed over the burial trenches at Site 442, a waste management unit, because it requires the cover to be protective of groundwater. During preparation of the Remedial Action Work Plan, a technical evaluation, which will include an evaluation of the thickness and hydraulic conductivity of the existing cover of each area, will be performed to assess if the existing cover isolates the waste and is protective of groundwater quality. During the Remedial Action phase, necessary improvements or repairs to the landfill cover will be made, including, but not limited to, addition of cover materials and grading the site to drain to prevent ponding or exposure of previously buried material, and to assure the cover will continue to isolate the waste and protect the groundwater at least as well as would a final cover built in accordance with applicable State prescriptive standards under Title 27, Section 21090(a)(1-3). In this particular case, Site 442 will be treated as a CAI unit because all wastes were deposited prior to November 27, 1984, and closure will comply with California Code of Regulations, Title 27, Section 21090(a)(1) through (a)(4).
18	Closure and Post-Closure Maintenance Requirements for Solid Waste Landfills	27 CCR, Ch. 3, Subchapter 5, Article 2, Section 21090(a)(1) – (a)(4)	State	Requires alternative final cover designs to isolate the waste in the unit from precipitation and irrigation waters at least as well as a final cover built in accordance with: (1) Foundation Layer – consisting of at least two feet of appropriate material compacted to optimum moisture content; (2) Low Hydraulic Conductivity Layer – consisting of at least one foot of soil with no waste placed on top of the foundation layer and compacted to attain a hydraulic conductivity of 1×10^{-6} cm/s with a plan to protect the cover layer integrity from foreseeable damage; (3) Erosion Resistant Layer – consisting of either (a) vegetative layer of at least one foot of soil capable of sustaining plants, is initially planted, and replanted as needed, or (b) mechanical layer that is erosion and ultraviolet light resistant; and (4) Cover Maintenance Plan – that includes, as a minimum, (a) periodic leak search, (b) periodic identification of other problems, (c) prompt cover repair, and (d) vegetation maintenance.	Relevant and Appropriate	The final closure and post closure maintenance plan will be developed as part of the Remedial Action Work Plan for Site 442. The final cover design will be demonstrated to comply with this standard.
19	Groundwater Monitoring Programs for Solid Waste Landfills	27 CCR, Ch. 3, Subchapter 3, Article 1, Section 20385	State	Specifies provisions for conducting detection monitoring, evaluation monitoring, and corrective action programs. Defines the required monitoring programs and their triggers.	Relevant and Appropriate	The remedy specifies closure-in place for the remaining wastes at Site 442. The contents of each waste cell are presumed to contain hazardous wastes not expected to be readily mobile. The groundwater monitoring program requirements are not required unless there is physical evidence of a release.

TABLE B-1. APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS – SITE 442
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Item No.	Requirement	Citation	Federal or State Requirement	Description	ARAR Determination	Comments
20	Vadose Zone Monitoring Requirements for Solid Waste Landfills	27 CCR, Ch. 3, Subchapter 3, Article 1, Section 20415 (d).	State	Requires discharger to establish an Unsaturated Zone Monitoring System.	Relevant and Appropriate	Due to the arid nature of the site conditions, the remedy specifies that soil gas samples instead of soil liquid samples will be collected at least once every five years to establish whether volatile organic compounds have been released into the environment that may threaten groundwater.

Notes:

AF	Air Force
AFB	Air Force Base
ARAR(s)	Applicable or Relevant and Appropriate Requirement(s)
Basin Plan	Water Quality Control Plan for Lahontan Region
CAI	Closed, Abandoned, or Inactive
CCR	California Code of Regulations
CDFG	California Department of Fish and Game
CESA	California Endangered Species Act
CFR	Code of Federal Regulations
Ch.	Chapter
cm/s	centimeters per second
CWA	Chemical Warfare Agent
CWC	California Water Code
Div.	Division
EPA	Environmental Protection Agency
et seq.	*et sequentes* (and the following)
gpd	gallons per day
H&S	health and safety
INRMP	Integrated Natural Resources Management Plan
ppm	parts per million
RCRA	Resource Conservation and Recovery Act
ROD	Record of Decision
SWRCB	State Water Resources Control Board
TDS	total dissolved solid
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service

Appendix C

APPENDIX C

WASTE TRENCH INFILTRATION EVALUATION USING THE UNSAT-H MODEL – SITE 442, AREAS 1, 2, AND 3

APPENDIX C

WASTE TRENCH INFILTRATION EVALUATION USING THE UNSAT-H MODEL – SITE 442, AREAS 1, 2, AND 3

The water balance model UNSAT-H, Version 3.01 (Fayer 2000) was used to evaluate stormwater infiltration under existing site conditions and predict performance of engineered landfill cover systems for the Edwards Air Force Base Site 442 waste trenches. Climatic data from the years 1977 through 1986 was used to provide conservative modeling estimates. These years had the highest annual precipitation for a consecutive ten-year period for available rainfall data (1942 to 2008). Daily precipitation data for the weather station located in Mojave, California was obtained from http://weather-warehouse.com. Temperature and wind speed data were obtained from the Edwards Air Force Base (AFB) weather station database, available at the internet site https://bsx.edwards.af.mil/weather/noframes.htm. Cloud cover and solar radiation data for Palmdale, California, were obtained from the California Irrigation Management Information System (CIMIS) internet site, http://www.cimis.water.ca.gov. There was no single database that included all the climatic data for the ten-year period used to model landfill cover conditions. The climatic data was compiled for entry into the UNSAT-H model.

Soil data required for input into the UNSAT-H model includes hydraulic conductivity, initial suction head, soil moisture retention, initial soil water content, and van Genuchten parameters. Soil data input for hydraulic conductivity was measured in the laboratory using American Society for Testing and Materials (ASTM) Method D5084. Suction head, plant growth, and initial soil water content were assumed based on recommendations from the UNSAT-H manual. Soil moisture retention is a function of the hysteresis. The hysteresis model within UNSAT-H is a function of the van Genuchten function. The Van Genuchten parameters are calculated directly from the maximum amount of air that becomes entrapped when the soil is wetted, and α, which is a parameter that describes the imbibition curve. The Van Genuchten function within UNSAT-H describes non-hysteretic hydraulic properties. The soil properties of the UNSAT-H conceptual model are assumed to be independent of temperature deep below the surface soil.

Vegetation data required for input into the UNSAT-H model includes root biomass distribution, leaf area index, biomass, growing season, and percent bare area. This data was assumed based on native plant community types and climatic conditions for the Mojave Desert region and published data (Desert

Research Institute 2004). A 90 percent bare area was used to model the relatively sparse vegetation conditions typical of Site 442.

EVALUATION OF EXISTING CONDITIONS AND ENGINEERED LANDFILL COVERS

Existing Conditions at Site 442 - Areas 1, 2, and 3 were modeled using site-specific soil data from each location. Soil from each area can generally be characterized as well-graded sand with very little gravel and fines (the average fines content is less than 16.6 percent and the average gravel content is less than 6.2 percent). The soil cover thickness at Site 442 - Areas 1, 2, and 3 was estimated to be 48 inches based on the data from a ground penetrating radar survey conducted at the sites. A thickness of 48 inches was used in the model to represent the soil cover depth expected at the site.

In addition, preliminary engineered cover designs were modeled using site specific soil data from each location. The following three engineered landfill cover configurations were modeled:

1 and 2. Evapotranspiration Landfill Cover – 12-inch and 24-inch thick layers of soil obtained from the vicinity of each of the three sites would be placed on the existing 48-inch thick soil cover at Site 442 Areas 1, 2, and 3. The hydraulic conductivity of the onsite soils was averaged for each site to reflect blending of the soils that would take place during cut and fill operations during infrastructure construction.

3. State Prescriptive Landfill Cover - First, a 12-inch thick clay layer with a hydraulic conductivity of 1×10^{-6} cm/s would be placed over the existing soil cover. Next, a 12-inch thick horizontal drainage layer with a hydraulic conductivity of 5.80×10^{-3} cm/s would be placed over the clay layer. Last, a 12-inch thick vegetative soil cover with a hydraulic conductivity of 1.90×10^{-4} cm/s would be placed over the drainage layer.

The hydraulic conductivities used for each individual model run are shown in Table 1. The modeling results for existing conditions are shown in Table 2. The hydraulic conductivity of the onsite soils used for additional cover was averaged for each site to reflect blending of the soils that would take place during cut and fill operations from access road and berm walls construction. Annual and total percolation rates shown in Table 2 are averaged for each area from the individual model runs shown in Table 1.

TABLE 1. SUMMARY OF HYDRAULIC CONDUCTIVITIES USED FOR UNSAT-H MODEL RUNS - SITE 442

Layer Configuration (inches)	Existing Cover (48-inch thick soil layer)	Blended on site borrow soils (12 and 24 inches) over existing cover	State Prescriptive Cover (12-inch erosion resistant layer[typical value]/12-inch clay layer [typical]/24-inch foundation layer [existing])
Location	Saturated Hydraulic Conductivity (cm/s)		
Area 1/HB01	6.59×10^{-5}	$4.09 \times 10^{-4}/6.59 \times 10^{-5}$	$1.90 \times 10^{-4}/1.00 \times 10^{-6}/6.59 \times 10^{-5}$
Area 1/HB02	7.52×10^{-4}	$4.09 \times 10^{-4}/7.52 \times 10^{-4}$	$1.90 \times 10^{-4}/1.00 \times 10^{-6}/7.52 \times 10^{-4}$
Area 2/HB01	9.09×10^{-5}	$1.32 \times 10^{-4}/9.09 \times 10^{-5}$	$1.90 \times 10^{-4}/1.00 \times 10^{-6}/9.09 \times 10^{-5}$
Area 2/HB02	1.24×10^{-4}	$1.32 \times 10^{-4}/1.24 \times 10^{-4}$	$1.90 \times 10^{-4}/1.00 \times 10^{-6}/1.24 \times 10^{-4}$
Area 2/HB03	1.02×10^{-4}	$1.32 \times 10^{-4}/1.02 \times 10^{-4}$	$1.90 \times 10^{-4}/1.00 \times 10^{-6}/1.02 \times 10^{-4}$
Area 2/HB04	2.13×10^{-4}	$1.32 \times 10^{-4}/2.13 \times 10^{-4}$	$1.90 \times 10^{-4}/1.00 \times 10^{-6}/2.13 \times 10^{-4}$
Area 3/HB01	3.09×10^{-4}	$3.23x\ 10^{-4}/3.09 \times 10^{-4}$	$1.90 \times 10^{-4}/1.00 \times 10^{-6}/3.09 \times 10^{-4}$
Area 3/HB02	3.37×10^{-4}	$3.23 \times 10^{-4}/3.37 \times 10^{-4}$	$1.90 \times 10^{-4}/1.00 \times 10^{-6}/3.37 \times 10^{-4}$

Notes:
cm/s centimeters per second
HB hand boring

TABLE 2. SUMMARY OF SITE 442 COVER UNSAT-H MODELING RESULTS

Location	Year [2]	Average Annual Percolation (inches) [1]			
		Existing Cover (48-inch thick soil layer)	Existing Cover (48 inches thick) with additional 12-inch thick layer of on site soil	Existing Cover (48 inches thick) with additional 24-inch thick layer of on site soil	State Prescriptive Cover (24-inch foundation layer, 12-inch thick clay layer, 12-inch thick erosion resistant layer)
Area 1	1977	0.36	0.53	0.46	0.36
	1978	1.41	0.64	0.10	0.00
	1979	0.00	0.00	0.00	0.00
	1980	0.00	0.00	0.00	0.00
	1981	0.00	0.00	0.00	0.00
	1982	0.00	0.00	0.00	0.00
	1983	0.47	0.36	0.02	0.00
	1984	0.00	0.00	0.00	0.00
	1985	0.00	0.00	0.00	0.00
	1986	0.00	0.00	0.00	0.00
	Total	2.24	1.54	0.58	0.37
Area 2	1977	0.18	0.20	0.20	0.18
	1978	0.26	0.05	0.00	0.00
	1979	0.00	0.00	0.00	0.00
	1980	0.00	0.00	0.00	0.00
	1981	0.00	0.00	0.00	0.00
	1982	0.00	0.00	0.00	0.00
	1983	0.00	0.02	0.00	0.00
	1984	0.00	0.00	0.00	0.00
	1985	0.00	0.00	0.00	0.00
	1986	0.00	0.00	0.00	0.00
	Total	0.44	0.28	0.20	0.18
Area 3	1977	0.36	0.50	0.44	0.37
	1978	1.69	0.61	0.03	0.00
	1979	0.00	0.00	0.00	0.00
	1980	0.00	0.00	0.00	0.00
	1981	0.00	0.00	0.00	0.00
	1982	0.00	0.00	0.00	0.00
	1983	0.12	0.26	0.00	0.00
	1984	0.00	0.00	0.00	0.00
	1985	0.00	0.00	0.00	0.00
	1986	0.00	0.00	0.00	0.00
	Total	2.18	1.38	0.47	0.37

Notes:

[1] Annual and total percolation rates are averaged for each area from individual model runs.

[2] Rainfall data for the years 1977 to 1986 was used. These years had the highest annual precipitation for a consecutive ten-year period for available rainfall data (1942 to 2008).

CONCLUSIONS

UNSAT-H predictions of the hydraulic performance of the four landfill cover configurations are as follows:

- Existing Conditions (48 inches of existing soil cover) – between 0.04 and 0.22 inches per year.
- Evapotranspiration Landfill Cover (12 inches of soil placed over 48 inches of existing cover) – between 0.03 and 0.15 inches per year.
- Evapotranspiration Landfill Cover (24 inches of soil placed over 48 inches of existing cover) – between 0.02 and 0.06 per year.
- State Prescriptive Landfill Cover – between 0.02 and 0.04 inches per year.

The arid climate of Site 442 reduced the amount of soil water loss from plant transpiration and increased evaporation rates. In general, drainage rates predicted by the model runs decreased as soil water retention properties increased. The predicted drainage rates for the Existing Conditions model are attributed to the limited soil water retention properties of the existing well-graded sand with very little gravel and fines in combination with a relatively low percentage of vegetation. In general, the predicted drainage rates for the Evapotranspiration Landfill Cover model were less than the Existing Conditions model because of the addition of the soils to the existing cover. The mixture of soil from Site 442 - Areas 1, 2, and 3 improved the soil water retention properties as compared to the existing landfill cover soil. The predicted drainage rates for the State Prescriptive Landfill Cover were generally the lowest of the three landfill cover systems modeled. The decrease in drainage rates can be attributed to the increase in water retention properties of the clay. However, the clay layer used in a State Prescriptive Landfill Cover is subject to desiccation in arid environments, which will compromise its effectiveness over time.

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