UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105

July 12, 2010

Ms. Angela Wimberly
Remedial Project Manager
Southwest Division Naval Facilities Engineering Command (SWDIV)
1220 Pacific Coast Highway
San Diego, CA 92132-5190

SUBJECT: FINAL FIVE-YEAR REVIEW REPORT, OU-1 AND OU-2, MARINE CORPS AIR STATION YUMA, ARIZONA

Dear Ms. Wimberly:

The United States Environmental Protection Agency (EPA) has reviewed the Final Five-Year Review Report dated June 2010. Based upon this review, EPA agrees with the overall findings, conclusions, and recommendations in the document that the remedies in place are protective in the short term. The remedies at Yuma currently protect human health and the environment because exposure pathways that may result in unacceptable risks are being controlled. However, in order for the remedies to be protective in the long-term, the following action needs to be taken:

> For OU-2, the document indicates that while Declaration of Environmental Use Restrictions (DEURs) have been proposed, they have not yet been registered with the State of Arizona. Consequently, it appears that these institutional controls (ICs) are not complete. Until the DEURs are in place, the lack of enforceable ICs presents a long-term protectiveness issue for the site. EPA notes that Yuma has appropriately identified this issue as a follow-up item in the document.

We appreciate the opportunity to work with you on this project and look forward to continued success at MCAS Yuma. If you have questions regarding this letter, please feel free to contact Martin Hausladen of this office at (415) 972-3007.

Sincerely,

for

Michael M. Montgomery
Assistant Director, Superfund Division
Federal Facility and Site Cleanup Branch

cc: Delfina Olivarez, ADEQ

FINAL

FIVE-YEAR REVIEW REPORT
OPERABLE UNITS 1 AND 2
MARINE CORPS AIR STATION
YUMA, ARIZONA

Contract No.: N68711-01-D-6009
Task Order: 008
DCN: BATL-6009-0008-0017

Prepared for:

Naval Facilities Engineering Command Southwest
1220 Pacific Highway
San Diego, California 92132-5190

Prepared by:

505 King Avenue
Columbus, Ohio 43201

June 2010

Signature Page

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Colonel Mark A. Werth — Date
Commanding Officer
MCAS Yuma
United States Marine Corps

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ABBREVIATIONS AND ACRONYMS

AAC	Arizona Administrative Code
ADEQ	Arizona Department of Environmental Quality
AOC	Area of Concern
ARAR	Applicable or Relevant and Appropriate Requirement
ARS	Arizona Revised Statutes
AS	air sparge
AS/SVE	air sparge/soil vapor extraction
ATSDR	Agency for Toxic Substances and Disease Registry
AWQS	Aquifer Water Quality Standards
bgs	below ground surface
BNI	Bechtel National, Inc.
CALA	Combat Aircraft Loading Area
Cal/EPA	California Environmental Protection Agency
CAOC	CERCLA Area of Concern
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfm	cubic feet per minute
CFR	Code of Federal Regulations
CHC	chlorinated hydrocarbon
COC	contaminant of concern
COPC	contaminant of potential concern
COPEC	contaminant of potential ecological concern
DCE	dichloroethene
DEUR	Declaration of Environmental Use Restrictions
DoD	United States Department of Defense
DON	United States Department of the Nay
ELCR	excess lifetime cancer risk
EMS	Environmental Management System
FFA	Federal Facility Agreement
FFAAP	Federal Facilities Agreement Assessment Program
FS	Feasibility Study
GAC	granular activated carbon
gpm	gallons per minute
HBGL	health-based guidance level
HI	hazard index
HQ	hazard quotient

ICs	institutional controls
ICP	institutional control plan
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
J&E	Johnson & Ettinger
JEG	Jacobs Engineering Group, Inc.
JSF	joint strike fighter
KTUA	Kawasaki, Theilacker, Ueno and Associates
LEPA	leading edge of the plume area
LTM	long-term monitoring
LUC	land use control
LUCIP	Land Use Control Implementation Plan
LUST	Leaking Underground Storage Tank
MCAS	Marine Corps Air Station
MCL	maximum contaminant level
MCLGs	maximum contaminant level goals
MNA	monitored natural attenuation
MRP	Munitions Response Program
NAVFAC	Naval Facilities Engineering Command
NCP	National Oil and Hazardous Substances Contingency Plan
NFA	No Further Action
NPL	National Priorities List
O&M	operation and maintenance
ODF	Ordnance Distribution Facility
OSWER	Office of Solid Waste and Emergency Response
OU	Operable Unit
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
POC	point of compliance
POTW	publicly owned treatment works
PRG	preliminary remediation goal
RA	Remedial Action
RAO	Remedial Action Objective
RBC	risk-based concentration
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RI	Remedial Investigation

ROD	Record of Decision
ROICC	Resident Officer in Charge of Construction
RPM	Remedial Project Manager
RSL	Regional Screening Level
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SRL	soil remediation level
STRAP	Source Treatment/Reduction Alternatives Plan
SVE	soil vapor extraction
SVOC	semi-volatile organic compound
SWDIV	Southwest Division Naval Facilities Engineering Command
TCE	trichloroethene
TLV	threshold limit value
TPH	total petroleum hydrocarbons
TRPH	total recoverable petroleum hydrocarbons
USBR	United States Bureau of Reclamation
U.S.C.	United States Code
USDA	United States Department of Agriculture
U.S. EPA	United States Environmental Protection Agency
UST	underground storage tank
VI	vapor intrusion
VOC	volatile organic compound
VCT	vertical circulation treatment
VEMUR	Voluntary Environmental Mitigation Use Restriction

EXECUTIVE SUMMARY

This report provides the results of the third Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) five-year review conducted for the Operable Units (OUs) at Marine Corps Air Station (MCAS) Yuma, Arizona. This review was conducted in accordance with the Department of the Navy's (DON's) *Navy/Marine Corps Policy for Conducting CERCLA Statutory Five-Year Reviews* (DON, 2004) and the United States Environmental Protection Agency (U.S. EPA) *Comprehensive Five-Year Review Guidance* (U.S. EPA, 2001). The purposes of this review are to evaluate the performance of the remedies implemented at OU-1 and OU-2 to ensure that they remain protective of human health and the environment, and to recommend actions for improvement if the remedies have not performed as designed or are no longer effectively protective.

This five-year review comprises document and data reviews, site inspections, station personnel interviews, regulatory comment reviews, and report development. Because these remedies would not result in site conditions suitable for unlimited use and unrestricted exposure (i.e., residential use) at the time of this five-year review and because the Records of Decision (RODs) for OU-1 and OU-2 were signed after October 17, 1986, the effective date of the Superfund Amendments and Reauthorization Act (SARA), this statutory review is required by and conducted according to the applicable laws. The scheduled completion date for this review is November 16, 2009, as dictated by the date when the previous five-year reviews for OU-1 and OU-2 were completed — November 16, 2004.

OU-1 was defined by a Federal Facilities Agreement (FFA) to include chlorinated hydrocarbon (CHC) groundwater plumes more than 10 ft below ground surface (bgs). The plumes were identified as Areas 1, 2, 3, 4, 5 and 6, with the largest plume in Area 1. OU-1 Areas 4 and 5 were later identified as fuel sites, rather than CERCLA sites, and were assigned to the state of Arizona's Leaking Underground Storage Tank (LUST) Program with oversight by the Arizona Department of Environmental Quality (ADEQ). The remedy selected for the remaining Areas of OU-1, as described in the ROD, consisted of a full-scale air sparge/soil vapor extraction (AS/SVE) system in the Building 230 "Hot Spot" of Area 1; a vertical circulation treatment (VCT) system in the leading edge of the plume area (LEPA) of Area 1; monitored natural attenuation (MNA) in Areas 1, 2, 3, and 6; and institutional controls (ICs) in the form of restrictions on groundwater use for all OU-1 areas. The OU-1 remedial action objectives (RAOs), as stated in the ROD, are to reach U.S. EPA maximum contaminant levels (MCLs) for the contaminated groundwater in Areas 1, 2, 3 and 6 and to prevent off-site migration of CHC concentrations at levels exceeding MCLs.

Groundwater monitoring has been performed for OU-1 areas on a quarterly basis since the signing of the ROD on October 5, 2000. Sampling has indicated that all plumes have been shrinking in size and concentration due to the implemented remedies, and that none of the plumes are migrating offsite. Areas 2, 3, and 6 have all achieved the MCL goals and have been closed with concurrence by U.S. EPA and ADEQ, and no further action (NFA) is required in these areas.

Active remediation systems were installed and operated in the Area 1 plume. A VCT system was operated in the LEPA from June 2000 to May 2003. The VCT system reduced CHC concentrations to meet MCLs and prevented any off-site migration of the plume at concentrations exceeding MCLs. The VCT system was placed in temporarily shutdown status in May 2003 after MCLs had been achieved and modeling indicated that groundwater would not reach the station boundary at concentrations exceeding the MCLs. Permanent shutdown of the VCT system occurred in December 2005 with concurrence by U.S. EPA and ADEQ.

An AS/SVE system was installed in the Building 230 vicinity to remediate the groundwater in the most highly contaminated area of OU-1. The AS/SVE system reduced the CHC "Hot Spot" in both size and magnitude such that modeling indicated that CHCs would not migrate offsite at concentrations greater than MCLs. The system was operated relatively continuously from November 1999 to May 2007 when it was placed in temporary shutdown status with concurrence by U.S. EPA and ADEQ.

MNA has been applied to all OU-1 areas through the development of a long-term monitoring (LTM) plan, as stipulated in the ROD. With the closure of OU-1 Areas 2, 3 and 6, the LTM plan has been revised to focus on monitoring the natural attenuation of CHCs in Area 1. The Area 1 plume will continue to be monitored until the CHC concentrations decrease below MCLs for a minimum of two years, at which point area closure may be requested.

ICs were required by the ROD to limit use and restrict exposure to any contaminated groundwater at OU-1 Areas 1, 2, 3 and 6. The ICs were established in the revised MCAS Yuma Master Plan and implemented through the Final Land Use Control Implementation Plan (LUCIP). MCAS Yuma Station Order 5090 (issued on January 10, 2002) formally directed tenants and contractors to incorporate the land use controls (LUCs) provided in the MCAS Yuma Master Plan and the Final LUCIP into their existing land use planning and management programs. The ICs established for OU-1 Area 1 are still effective and are to remain until Area 1 as a whole has met its cleanup goals (i.e., MCLs).

OU-2 was defined by an FFA to include soil contamination down to 10 feet bgs. The FFA identified 18 CERCLA Areas of Concern (CAOCs), 12 of which required NFA. Three of the remaining six were remediated to residential land use standards in 1999, with NFA required. The remaining three CAOCs (1, 8A and 10) were described in the Final OU-2 ROD as requiring ICs to prevent unlimited use and unrestricted exposure.

ICs, required by the ROD, were established in the revised MCAS Yuma Master Plan and implemented through the Final LUCIP. MCAS Yuma Station Order 5090 (issued on January 10, 2002) formally directed tenants and contractors to incorporate the LUCs provided in the MCAS Yuma Master Plan and the Final LUCIP into their existing land use planning and management programs. The ICs established for OU-2 remain effective. The MCAS Yuma Environmental Department continues to review and coordinate all plans for future activities at CAOCs 1, 8A, and 10, in consultation with U.S. EPA and ADEQ as necessary, to ensure continued compatibility with the ICs as specified in the OU-2 ROD.

The following U.S. EPA Five-Year Review Summary Form provides additional information regarding the review assessment results and future effectiveness of the remedy as implemented.

Five-Year Review Summary Form – Page 1

SITE IDENTIFICATION		
Site name: Marine Corps Air Station Yuma, Operable Units 1 and 2		
EPA ID: AZ0971590062 (MCAS Yuma)		
EPA Region: 09	**State:** AZ	**City/County:** Yuma / 027 Yuma
SITE STATUS		
NPL status: ☑ **Final** ☐ **Deleted** ☐ **Other (specify)**		
Remediation status (choose all that apply): ☐ **Under Construction** ☑ **Operating** ☐ **Complete**		
Multiple OUs? ☑ **YES** ☐ **NO**	**Construction completion date:** 16-Nov-1999	
Has site been put into reuse? ☐ **YES** ☑ **NO**		
REVIEW STATUS		
Lead agency: ☐ **EPA** ☐ **State** ☐ **Tribe** ☑ **Other Federal Agency** U.S. Department of the Navy		
Author name: Naval Facilities Engineering Command Southwest		
Author title:	**Author affiliation:** U.S. Department of Defense	
Review period: 16 November 2004 to 16 November 2009		
Date(s) of site inspection: 09 June 2009 to 11 June 2009 and 28 July 2009		
Type of review: ☑ **Post-SARA** ☐ **Pre-SARA** ☐ **NPL-Removal only** ☐ **Non-NPL Remedial Action Site** ☐ **NPL State/Tribe-lead** ☐ **Regional Discretion**		
Review number: ☐ **1 (first)** ☐ **2 (second)** ☑ **3 (third)** ☐ **Other**		
Triggering action: ☐ **Actual RA Onsite Construction at OU** ☐ **Actual RA Start** ☐ **Construction Completion** ☑ **Previous Five-Year Review Report** ☐ **Other (specify):** _____		
Triggering action date: 16 November 2004		
Due date *(five years after triggering action date)*: 16 November 2009		

Five-Year Review Summary Form – Page 2

Issues:

1	While base personnel have indicated the possibility of a future land use change for OU-2 CAOC 8A, documentation of that land use change is needed; should a change in land use be needed for OU-2 CAOC 8A, communication with the regulatory agencies, prior to the change, will occur as stipulated in the ROD.
2	U.S. EPA raised the following issue for OU-2: while DEURs have been proposed, they have not been registered with Arizona and thus the ICs are not complete (see Attachment 1).
3	U.S. EPA raised the following issue for OU-1: the most recent (June 2009) data presented in Figures 4-6 and 4-7 indicate that there has been recent plume migration in the LEPA and Hot Spot areas. The significance of this recent movement on remedy effectiveness needs to be evaluated.
4	An evaluation of the progress of an MNA remedy in meeting RAOs should be undertaken as part of every 5YR where MNA is the remedy. Since the transition to MNA was recently adopted for OU-1 Area 1, an evaluation was not performed for this five-year review.
5	Note that on January 7, 2010, U.S. EPA published draft guidance on Interim PRGs for dioxin in soil at CERCLA and RCRA sites. If adopted, this proposal will lower the dioxin PRG significantly. Please confirm the activities evaluated to address potential dioxin at CAOC 8A. If dioxin is a concern, we suggest that the 5YR include a discussion of this issue.
6	During the five-year review, inconsistencies were indentified between figures provided in the recently revised MCAS Yuma Master Plan (KTUA, 2007) and the Final LUCIP (SWDIV, 2002a).
7	The indoor air exposure pathway is incomplete for all three CAOCs in OU-2 based on current land use of these areas; thus, the ICs are appropriate. However, if these areas were to be redeveloped in the future for office and/or residential use, the ICs may not be protective.
8	U.S. EPA raised the following issue for OU-1 Area 1: the document should address any vadose zone contamination that may be of concern to the VI pathway.

Recommendations and Follow-up Actions:

1	While base personnel have indicated the possibility of a future land use change for OU-2 CAOC 8A, documentation of that land use change is needed; should a change in land use be needed for OU-2 CAOC 8A, communication with the regulatory agencies, prior to the change, will occur as stipulated in the ROD.
2	Evaluate the LUCIP and ensure that the plan is up-to-date, continues to provide effective processes for LUC implementation, and continues to provide long-term protectiveness. Also, discussions should be initiated between ADEQ, U.S. EPA, and Navy legal counsel to determine how to best address and resolve the DEUR issue.
3	Evaluate the progress of plume remediation and potential rebound, and review the AS/SVE shutdown criteria and make a recommendation regarding system operation.
4	An evaluation of MNA progress in subsequent five-year reviews should be performed, including modeling groundwater under the MNA scenario to predict when MNA would result in reaching MCLs.
5	U.S. EPA's dioxin reassessment has been developed and undergone review over many years with the participation of scientific experts in EPA and other federal agencies, as well as scientific experts in the private sector and academia. The Agency followed current cancer guidelines and incorporated the latest data and physiological/biochemical research into the assessment. The results of the assessment have currently not been finalized or adopted into state or federal standards. U.S. EPA anticipates that a final revision to the dioxin toxicity numbers may be released by the end of 2010. In addition, U.S. EPA/OSWER has proposed to revise the interim preliminary remediation goals (PRGs) for dioxin and dioxin-like compounds, based on technical assessment of scientific and environmental data. However, U.S. EPA has not made any final decisions on interim PRGs at the time of this five-year review. Therefore, the dioxin toxicity reassessment for this site (CAOC 8A) should be updated during the next Five-Year Review.
6	The DON and MCAS Yuma should reconcile the discrepancies between the figures in the Final LUCIP (SWDIV, 2002a) and the MCAS Yuma Master Plan (KTUA, 2007).
7	An evaluation of the ICs and the protectiveness of the LUCIP should be performed with regards to the VI pathway for all OU-2 CAOCs in the event of changes to the current land use status.
8	An analysis of soil gas data from previous soil investigations should be performed to compare to VI screening levels to ensure that the only potential VI source is groundwater.

Protectiveness Statement:
The remedy at OU-1 is currently and will continue to be protective of human health and the environment because of the implementation of remedial measures and control of exposure pathways that may result in unacceptable risks. These methods are being applied as follows:

1) Remediation systems were installed and operated in the Area 1 plume. A VCT system was operated in the LEPA from June 2000 to May 2003. The system has reduced CHC concentrations to near MCLs and contained any off-site migration of the plume in this area. An AS/SVE system was installed in the Building 230 area to remediate the groundwater in the most highly contaminated area of OU-1. The system operated relatively continuously between November 1999 and May 2007. The AS/SVE system has reduced the CHC "Hot Spot" in both size and magnitude such that the COCs will not migrate offsite at concentrations greater than MCLs.

2) MNA is currently applied at all active regions of Area 1. MNA has been demonstrated to reduce contaminant concentrations through natural processes and has indicated that the plumes are not migrating. Groundwater monitoring required for the MNA program has been implemented through the LTM plan for OU-1 at MCAS Yuma. Plumes will continue to be monitored through MNA of the LTM plan until they decrease in concentrations below MCLs.

3) ICs are in place to restrict exposure to any contaminated groundwater at Area 1 through MCAS Yuma Station Order 5090 (issued on January 10, 2002). This order formally directs tenants and contractors to incorporate the LUCs provided in the MCAS Yuma Master Plan and the Final LUCIP into their existing land use planning and management programs.

The MCAS Yuma Environmental Department will continue to review and coordinate all plans for future activities at OU-1 in consultation with U.S. EPA and ADEQ as necessary, to ensure application of the measures specified in the OU-1 ROD (Southwest Division Naval Facilities Engineering Command [SWDIV], 2000).

The remedy at OU-2 is currently and will continue to be protective of human health and the environment because exposure pathways that may result in unacceptable risks are being controlled as follows:

1) ICs are in place to restrict exposure to contaminants in soil at CAOCs 1, 8A and 10 through MCAS Yuma Station Order 5090 (issued on January 10, 2002). This order formally directed tenants and contractors to incorporate the LUCs provided in the MCAS Yuma Master Plan (Kawasaki, Theilacker, Ueno and Associates [KTUA], 2007) and the Final LUCIP (SWDIV, 2002a) into their existing land use planning and management programs.

2) The "modified Declaration of Environmental Use Restrictions (DEURs)" for CAOCs 1, 8A and 10 have been proposed to satisfy the requirements specified in the OU-2 ROD (Uribe & Associates, 1997b) for registration of the sites with the State of Arizona.

The MCAS Yuma Environmental Department will continue to review and coordinate all plans for future activities at CAOCs 1, 8A, and 10, in consultation with U.S. EPA and ADEQ as necessary, to ensure continued compatibility with the land use restrictions specified in the OU-2 ROD (Uribe & Associates, 1997b).

1.0 INTRODUCTION

1.1 Purpose of the Five-Year Review

The purpose of five-year reviews is to determine whether the remedy at a site is protective of human health and the environment. The methods, findings, and conclusions of reviews are documented in Five-Year Review reports. In addition, Five-Year Review reports identify issues found during the review, if any, and provides recommendations to address them.

1.2 Authority for Conducting this Five-Year Review

The United States Department of the Navy (DON) is preparing this five-year review pursuant to the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act (SARA) and the National Oil and Hazardous Substances Contingency Plan (NCP). CERCLA §121 states:

> *If the President selects a remedial action that results in any hazardous substances, pollutants, or contaminants remaining at the site, the President shall review such remedial action no less often than each five years after the initiation of such remedial action to assure that human health and the environment are being protected by the remedial action being implemented. In addition, if upon such review it is the judgment of the President that action is appropriate at such site in accordance with section [104] or [106], the President shall take or require such action. The President shall report to the Congress a list of facilities for which such review is required, the results of all such reviews, and any actions taken as a result of such reviews.*

The United States Environmental Protection Agency (U.S. EPA) and the DON interpret this requirement further in the NCP, Title 40 *Code of Federal Regulations* (CFR) Section (§) 300.430(f)(4)(ii) (implemented by 42 *United States Code* [U.S.C.] § 9621[c]), which states:

> *If a remedial action is selected that results in hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure, the lead agency shall review such action no less often than every five years after the initiation of the selected remedial action.*

1.3 Lead Agency Conducting the Five-Year Review

Consistent with Executive Order 12580, the Secretary of Defense is responsible for ensuring that five-year reviews are conducted at all qualifying Department of Defense (DoD) cleanup sites. The DON is the lead agency for conducting five-year reviews at Navy and Marine Corps installations. As such, the DON has conducted a five-year review of the remedial actions implemented at Operable Unit 1 (OU-1) and OU-2 at Marine Corps Air Station (MCAS) Yuma. This review was conducted from April 2009 through November 2009 in accordance with the following documents:

- *Navy/Marine Corps Policy for Conducting CERCLA Statutory Five-Year Reviews* (DON, 2004).
- *Comprehensive Five-Year Review Guidance* (U.S. EPA, 2001). (This guidance document includes the report template used in preparing this Five-Year Review Report.)

This report documents the results of the review. For the purposes of completing the five-year review, the DON tasked Battelle, under Task Order 008 of Contract Number N68711-01-D-6009, to provide site analysis and document development.

1.4 Five-Year Review Characteristics

This five-year review is a statutory review because:

- the remedies selected in the Record of Decision (ROD) for OU-1 and OU-2 do not result in site conditions being suitable for unlimited use and unrestricted exposure, and
- the RODs for OU-1 and OU-2 were each signed after October 17, 1986, the effective date of the SARA.

This is the third five-year review for the OUs at MCAS Yuma. The triggering action for this review was the completion of the previous five-year review dated November 16, 2004 (Southwest Division Naval Facilities Engineering Command [SWDIV], 2004). The first five-year review was completed on December 11, 2002 (SWDIV, 2002b) and was triggered by the development of institutional controls (ICs) established in the OU-2 ROD, which was signed on December 2, 1997 (Uribe & Associates, 1997b). The second five-year review was completed in 2004. The second five-year review was triggered by the start-up operations of the Remedial Action (RA) at OU-1; specifically the start up of an air sparge/soil vapor extraction (AS/SVE) system, described in Section 4.1.2.1. The AS/SVE system began operation on November 16, 1999 and represents the original triggering date of the OU-1 five-year review schedule. The second five-year review included a mid-sequence update to the first five-year review and was included in the first five-year review for OU-1 so that both OUs may be reviewed on the same five-year review schedule (SWDIV, 2004).

2.0 SITE CHRONOLOGY

This section summarizes events in the development of the Installation Restoration Program (IRP) at MCAS Yuma with emphasis on the history of contaminant detection, characterization, and remediation at OU-1 and OU-2. Table 2-1 presents these events in chronological order. Appendix A presents the list of all documents reviewed during this five-year review.

Table 2-1. Chronology of Significant Events

Event	Date
Initial Assessment Study was conducted to investigate past disposal practices at MCAS Yuma (Stearns, Conrad, Schmidt and Landau Associates, 1985a).	1985
MCAS Yuma was placed on Superfund National Priorities List (NPL).	02/1990
Site inspection was completed at MCAS Yuma (Malcolm Pirnie, Inc., 1990).	06/1990
The DON entered into a Federal Facilities Agreement (FFA) with U.S. EPA and Arizona Department of Environmental Quality (ADEQ). OUs were established, along with a schedule and framework for implementing environmental investigations and appropriate cleanup activities.	01/1992
Remedial Investigation (RI; Jacobs Engineering Group [JEG], 1996a) identified six groundwater plumes as CERCLA Areas of Concern (CAOC) for OU-1 and 18 CAOCs in near-surface soils of which 12 required no further action (NFA) for OU-2.	03/1996
Source Treatment/Reduction Alternatives Plan (STRAP) to address contamination in the Leading Edge Plume Area (LEPA) and Building 230 (Hot Spot) Area (JEG, 1996b).	04/1996
A soil sampling program for polycyclic aromatic hydrocarbons (PAHs) was performed at CAOC 10 (Uribe & Associates, 1996a) to better define the extent of the contaminants reported in surface soil during the RI.	08/1996
Feasibility Study (FS) of OU-2 (Uribe & Associates, 1996b) recommended RA for CAOCs 1, 4, 7, 8A, 9 and 10.	12/1996
Supplemental soil sampling program for PAHs was completed at CAOC 10 (Uribe & Associates, 1997a).	02/1997
Proposed Plan was issued for OU-2.	03/1997
Final ROD for OU-2 signed with ICs selected as the RA for CAOCs 1, 8A and 10 (Uribe & Associates, 1997b).	12/1997
OU-1 (FS) identified and evaluated remediation options for the six groundwater CAOCs (JEG, 1998a).	07/1998
Draft ROD prepared finalizing RAs and allowing construction and operation of remedial systems for OU-1 (JEG, 1998b).	09/1998
Full-scale AS/SVE system installed in the Building 230 part of OU-1 Area 1.	06-11/1999
Land survey conducted at OU-2 CAOCs 1, 8A and 10 for implementation of ICs.	07/1999
Final RA Report for OU-2 issued with recommended addendum to the MCAS Yuma Base Master Plan containing ICs and Voluntary Environmental Mitigation Use Restrictions (VEMURs) for CAOCs 1, 8A, and 10 (GEOFON, 1999).	09/1999
Full-scale AS/SVE system operation started in the Building 230 part of OU-1 Area 1.	11/1999
Full-scale vertical circulation treatment (VCT) system installed in the LEPA of OU-1 Area 1.	02-06/2000
Full-scale VCT operations started in the LEPA of OU-1 Area 1.	06/2000
Arizona Laws 2000, Chapter 225 amended *Arizona Revised Statutes* § 49-152 (Title 49, Chapter 1, Article 4) to eliminate VEMURs and replace them with Declarations of Environmental Use Restrictions (DEURs) as the appropriate document for recording a property's environmental land use restrictions with the state of Arizona.	07/2000
Temporary AS/SVE systems installed in OU-1 Areas 2 and 3.	09/2000
Final OU-1 ROD signed by DON, U.S. EPA, and ADEQ (SWDIV, 2000).	10/2000
MCAS Yuma Master Plan revised to include land use restrictions and recording of environmental-	09/2001

Table 2-1. Chronology of Significant Events (Continued)

Event	Date
use restrictions required in ICs for OU-1 and OU-2 (Kawasaki, Theilacker, Ueno and Associates [KTUA], 2001).	
Draft (Revision 1) Land Use Control Implementation Plan (LUCIP) was issued as an addendum to the MCAS Yuma Master Plan to provide additional ICs and steps for implementation and monitoring for OUs 1 and 2, Federal Facilities Agreement Assessment Program (FFAAP) Area of Concern A, and conditions for closure of Former Underground Storage Tanks (USTs) at the Former Exchange Gas Station.	12/2001
MCAS Station Order 5090 implemented LUCs provided in Draft LUCIP.	01/2002
Work Plan for Long-Term Monitoring (LTM) at OU-1 completed (Bechtel National, Inc. [BNI], 2002).	06/2002
Final Land Use Implementation Plan for MCAS Yuma OU-1 and OU-2 finalized, detailing ICs and monitoring (SWDIV, 2002a). The report formalizes the MCAS Yuma LUC agreement among DON, U.S. EPA, and ADEQ.	09/2002
First Five-Year Review completed for OU-2 (SWDIV, 2002b).	12/2002
OU-1 VCT system at Area 1 LEPA placed in temporary shutdown with concurrence from U.S. EPA and ADEQ.	05/2003
OU-1 Area 6 received NFA closure from U.S. EPA and ADEQ.	11/2003
OU-1 Area 6 wells were decommissioned.	03/2004
First Five-Year Review completed for OU-1 and an update included for OU-2 allowed both OUs to be placed on the same five-year review schedule (SWDIV, 2004).	11/2004
OU-1 VCT system at Area 1 LEPA placed in permanent shutdown with concurrence from U.S. EPA and ADEQ.	12/2005
OU-1 Area 3 received NFA closure from U.S. EPA and ADEQ.	02/2006
OU-1 Area 2 received NFA closure from U.S. EPA and ADEQ.	05/2006
OU-1 Area 2 wells were decommissioned.	08/2006
OU-1 Area 3 wells were decommissioned.	10/2006
OU-1 AS/SVE system at the Building 230 “Hot-Spot” placed in temporary shutdown with concurrence from U.S. EPA and ADEQ.	05/2007
OU-1 Area 1, 37 selected Area 1 wells decommissioned.	09/2007

3.0 BACKGROUND

This section describes the fundamental aspects of the station, providing a description of site characteristics. The purpose of this section is to identify the threat posed to the public and environment identified at the time of the OU-1 ROD (SWDIV, 2000) and OU-2 ROD (Uribe & Associates, 1997b), so that the performance of the remedy can be easily compared with the site conditions that the remedy was intended to address. Information provided by the OU-1 and OU-2 RODs regarding station history and site history have been updated in this section with information provided in the Remedial Action Reports, Semi-Annual Groundwater Monitoring Reports, the Final LUCIP (SWDIV, 2002a), and the revised Master Plan (KTUA, 2007).

3.1 Station History

On February 21, 1928, Yuma County, Arizona, leased 640 acres of desert land near the city of Yuma from the federal government for use as an airfield. The airfield was established in the same year. Through the United States Bureau of Reclamation (USBR), Yuma County leased the acreage for 20 years with an option for an additional 20 years. In 1937, Yuma County constructed a small aircraft hangar and runway.

From l941 to 1946, the U.S. Army Air Corps leased the facility for pilot and bomber crew training. During this period, the facility was one of the busiest flight schools in the Army Air Corps. Flight activity ceased with the end of World War II, and the area was returned to the control of the USBR. In 1948, Yuma County obtained rights from the USBR to use the airfield, pursuant to Section l6 of the Federal Airport Act.

On July 7, 1951, the U.S. Air Force reactivated the site as a weapons proficiency center for fighter-interceptor units, and the site was declared a permanent Air Force installation in 1954. The Air Force reestablished joint use of the airfield with Yuma County in 1956.

In January 1959, the site and its associated range facilities were transferred to the DON. MCAS Yuma was then established on January 10, 1959 to maintain and operate the facilities and provide services and materials to support operations of the Marine Aircraft Wing and its subordinate units.

Since 1959, major improvements have included construction of a 13,300-foot-runway, development of the Instrumented Special Weapons System, and addition of a Tactical Aircrew Combat Training System. MCAS Yuma currently operates the airport facility as a joint military/civilian airport with the Yuma County Airport Authority.

3.2 Physical Characteristics

MCAS Yuma consists of approximately 4,800 acres located in the city and county of Yuma, Arizona (Figure 3-1). The station is located at an average elevation of 180 feet above mean sea level, on the northern portion of Yuma Mesa, and is approximately 60 to 70 feet above and 4 miles east of the Colorado River. MCAS Yuma is on the northern portion of the Yuma Mesa,

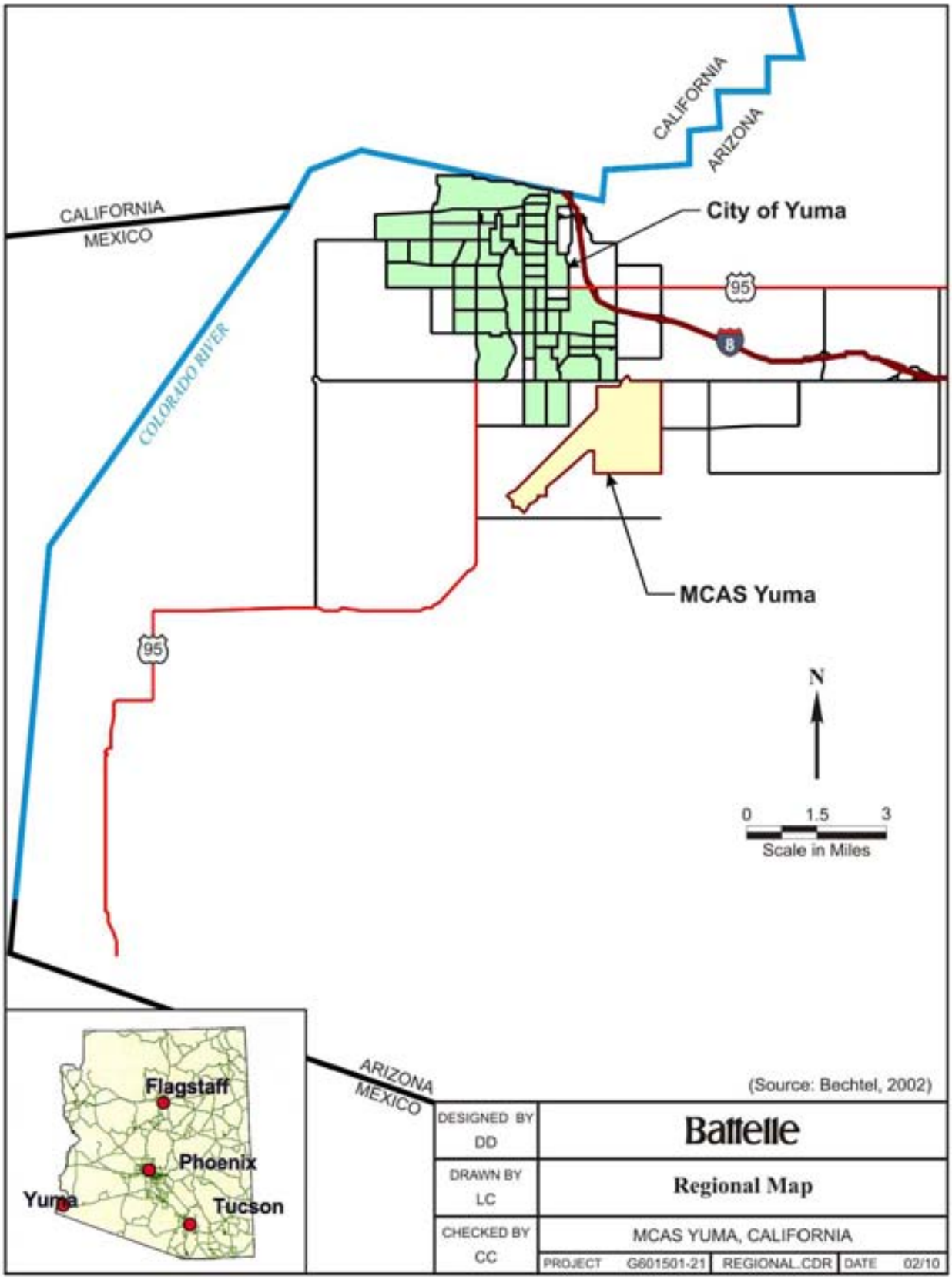

Figure 3-1. Regional Map

situated approximately 60 to 70 feet above the adjacent Colorado River Valley. Yuma Mesa is separated from the Colorado River Valley by a north-trending bluff approximately 5 miles west of MCAS Yuma. The climate is arid and the land type is desert. The following subsections describe the regional and local geology and hydrogeology associated with MCAS Yuma.

3.2.1 Geology. MCAS Yuma is on the northern portion of the Yuma Mesa, situated approximately 60 to 70 feet above the adjacent Colorado River Valley. Yuma Mesa is separated from the Colorado River Valley by a north-trending bluff approximately 5 miles west of MCAS Yuma. The climate is arid and the land type is desert.

Sedimentary deposits on Yuma Mesa are predominantly alluvial (stream) deposits interbedded with some aeolian (windblown) deposits in the upper 180 to 200 feet below ground surface (bgs). Most of the interbedded deposits consist of alluvium from Colorado River deposition that has been reworked by local ephemeral streams and sheetflow. The alluvium is highly variable and ranges in grain size from silt and fine sand up to very coarse gravel.

Locally at MCAS Yuma, silt and clay deposits form small discontinuous lenses that retard the vertical migration of groundwater. The primary stratigraphic units underlying MCAS Yuma are "younger alluvium" including minor aeolian sand and "older alluvium." The bottom of the older alluvium may extend more than 2,000 feet bgs in some areas. These alluvial units appear to directly overlie pre-Tertiary bedrock at MCAS Yuma.

Granitic bedrock crops out in the Yuma area as a series of north- to northwest-trending low hills known as the "Yuma Hills." The bedrock outcrops on and adjacent to the station indicate that relatively shallow bedrock zones exist in this region.

According to the Yuma Soil Conservation Service (U.S. Department of Agriculture [USDA], 1980), the principal soil type occurring at MCAS Yuma is Superstition Sand. This soil is deep and somewhat excessively drained. Permeability of the Superstition Sand is rapid and the available water capacity is low to moderate.

3.2.2 Hydrogeology. The principal stratigraphic units containing groundwater usable for agricultural and domestic applications are the alluvial deposits. These unconsolidated deposits are divided into (1) the upper fine-grained zone, (2) the coarse gravel zone, and (3) the wedge zone (Olmsted et al., 1973).

The upper, fine-grained zone includes the vadose zone and shallow groundwater and extends approximately 180 to more than 200 feet bgs. This zone comprises the majority of the younger alluvial stratigraphic unit and may include the upper portion of the older alluvium. The upper fine-grained zone represents alluvial and, to a lesser degree, aeolian deposits. The upper fine-grained zone consists of sand and silt with interbeds of sandy clay and sandy gravel.

Water quality in the upper fine-grained zone is highly variable, probably as a result of the shallow depth to water (40 to 80 feet) and the presence of irrigated agriculture in the area. Groundwater is generally unconfined in the upper fine-grained zone over much of Yuma Mesa. However, locally confined conditions associated with fine-grained lenses have been reported

(Olmsted et al., 1973). Figure 3-2 shows the distribution of the water table (i.e., groundwater surface contours) in the upper fine-grained zone across MCAS Yuma from the April-June 2009 groundwater monitoring report (Battelle, 2010).

Underlying the upper fine-grained zone is the coarse gravel zone, which includes the basal gravel of the younger alluvium and the upper coarse gravel of the older alluvium. In addition to gravel, the coarse gravel zone contains interbeds of sand and fine-grained lithologies. The coarse gravel zone is the most permeable groundwater reservoir in the Yuma area and provides the primary groundwater supply source. The top of this zone is approximately 180 to more than 200 feet bgs, and it ranges in thickness from 0 to 100 feet. Water quality in this zone is saline (Olmsted et al., 1973).

The wedge zone underlies the coarse gravel zone and makes up most of the older alluvium stratigraphic unit. This zone may extend to 2,000 feet bgs. Lithologies in the wedge zone range from gravel to clay with generally coarser lithologies in the upper portion (Olmsted et al., 1973). The wedge zone contains water that is generally fresher than the water in the overlying coarse gravel zone (Olmsted et al., 1973).

3.3 Land and Resource Use

MCAS Yuma is comprised of land use categories that are defined by specific uses or combinations of uses occurring in these areas. The station has 14 distinct land use categories or districts: air operations, aircraft maintenance, training, general maintenance, weapons, supply, public safety, administration, medical/dental, bachelor quarters, family housing, community support, recreation and communications/utilities. The following is a brief description of each district as provided by the MCAS Yuma Master Plan (KTUA, 2007):

Air Operations
Air operations include the airfield, taxiways, towways, parking aprons, flight equipment testing facilities, and air operations logistical facilities.

Aircraft Maintenance
Aircraft maintenance includes facilities generally located along the flight line, such as hangars, wash racks, engine test cells, and aircraft parts repair shops.

Training
The training land use primarily includes facilities that contain classrooms, lecture halls, educational workspaces/shops, and potentially specialized trainers and simulators.

General Maintenance
General maintenance includes facilities that provide varying levels of service to ground-based equipment and vehicles.

Weapons
The weapons land use includes a wide array of facility types, from the expansive area of the Combat Aircraft Loading Apron (CALA) to the confined area of an armory storeroom.

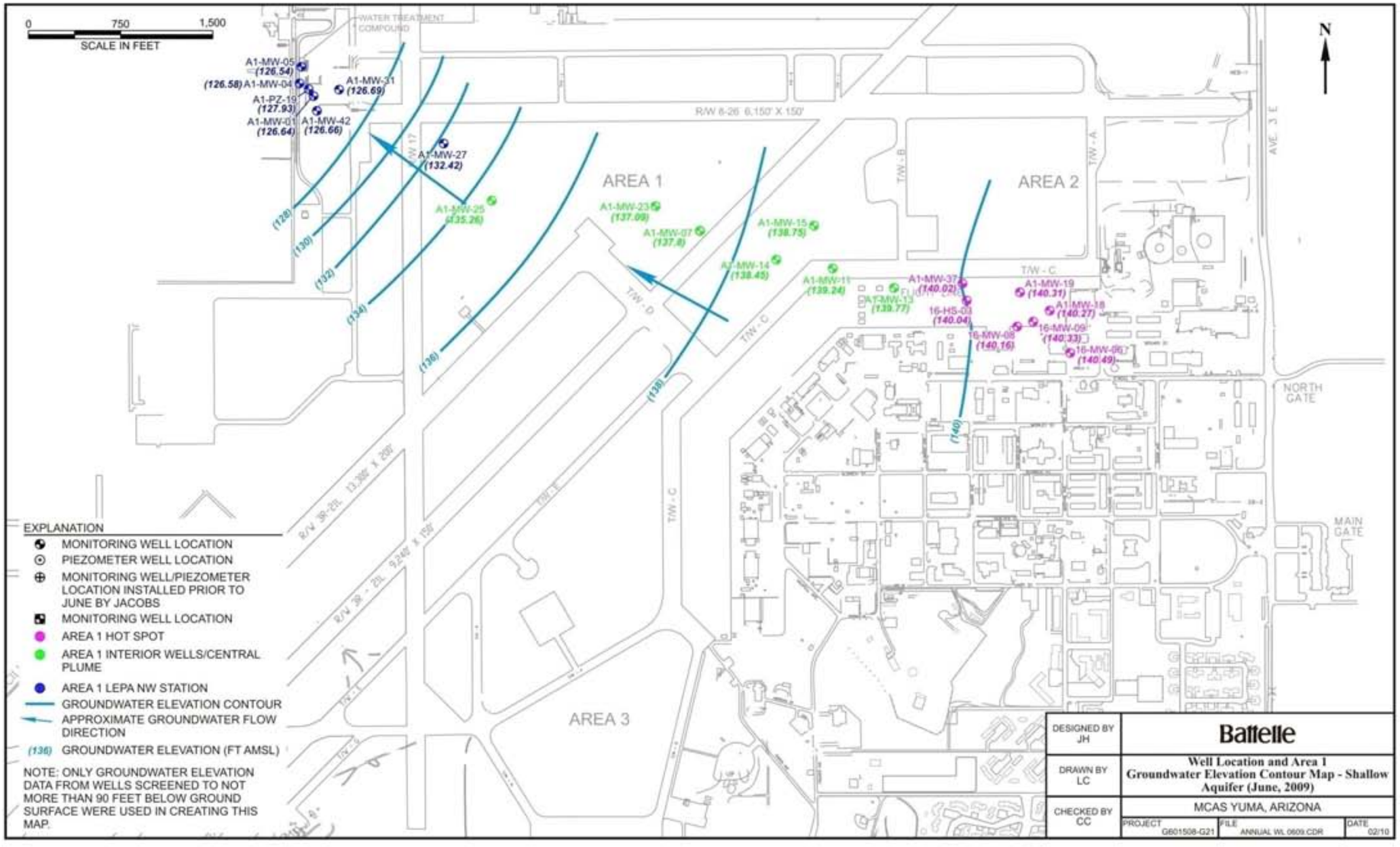

Figure 3-2. Groundwater Contour Map from the June 2009 Quarterly Report

Supply
Supply refers primarily to warehouse-type facilities and storage lots that serve as a staging area for materials either being redistributed elsewhere on base or awaiting use by a particular unit. The supply land use also includes fueling storage and dispensing facilities.

Public Safety
The public safety land use includes facilities used for the protection of physical assets and maintenance of order on an installation (e.g., police stations, fire stations, etc.).

Administration
Administration includes the facilities primarily composed of office spaces and other related functions to support all levels of command.

Medical/Dental
The medical/dental land use includes facilities provided for medical and dental services.

Bachelor Quarters
The bachelor quarters land use is almost entirely housing related, characterized by all types of barracks and the facilities that support them.

Family Housing
The family housing land use is comprised of on-base neighborhoods, including apartment-style and single family attached and detached homes.

Community Support
This land use includes facilities used by the base as a whole (e.g., library, exchange, recreation buildings, etc.).

Recreation
Recreational facilities may be considered a subset of the community support land use, although they are usually characterized by outdoor facilities (e.g., playing courts, fields, parks, etc.)

Communications/Utilities
This land use includes facilities used for the operation or oversight of the station's communications and utilities infrastructure (e.g., office space, equipment monitoring buildings, and the physical infrastructure).

Resource uses such as electrical, natural gas and water resources at MCAS Yuma are operated and maintained by the Installation and Logistics Department. The following is a brief description of the source(s) and distribution of each resource as provided by the MCAS Yuma Master Plan (KTUA, 2007):

Electrical
Electricity is provided by Arizona Public Service and Western Area Power Administration and is fed to the MCAS Yuma substation located near the centrally located MCAS Yuma water tower. Five overhead circuits distribute the power to various station components.

Natural Gas

Natural gas is purchased through the Defense Fuel Support Contract Program, which allows the station to competitively purchase gas from various suppliers at reduced rates. Gas is metered near the station boundary, south of the Main Gate, and is delivered by Southwest Gas Corporation lines to the station distribution system.

Water

Surface water is obtained from the USBR, which transports surface water from the Colorado River to the station via canals maintained by the Yuma Mesa Irrigation and Drainage District. Surface water is taken from a branch canal at the eastern boundary of the station and transported to the station's water treatment facility.

Groundwater is obtained through one on-base production well located at the water treatment facility. A new well was installed in February 2008, adjacent to an old production well that had been failing and is now used as a back-up well. Both wells are upgradient from the known groundwater contamination of the station. The water produced from the well is analyzed for volatile organic compounds (VOCs) and other potential contaminants in accordance with ADEQ requirements. The new well is currently producing approximately 650,000 gallons per day and the water produced is run through the water treatment facility where it is blended with surface water prior to station distribution (Shepherd, 2010). The nearest downgradient domestic wells are approximately 0.8 to 0.9 mile from the station boundary. The nearest municipal well is approximately 0.7 mile upgradient of the station.

The water treatment facility has three settling basins which have a total capacity of 7.5 million gallons of water. Water is processed via rapid sand filtration, clarification and disinfection with chlorine. Five electric pumps, with a total capacity of 6,500 gallons per minute, pump processed water into two elevated water storage tanks. The two tanks have a capacity of 500,000 gallons each. Water is distributed from the storage tanks through the station's water distribution network comprised of 6 to 16 inch pipes.

3.4 History of Contamination

During its 70 years of operation, MCAS Yuma has generated industrial wastes such as used oil, fuels, solvents, paint residues, battery acid, pesticides, herbicides, and polychlorinated biphenyls (PCBs). In the early years, some of these wastes were disposed in landfills, burn pits, and other areas located throughout MCAS Yuma. Construction and improvement activities also generated construction debris, which was disposed in undeveloped portions of MCAS Yuma.

It is believed that chlorinated hydrocarbons (CHCs) have occasionally been spilled on the ground surface during previous routine aircraft maintenance. It is also possible that tanks or drums of CHC solvents may have leaked onto the surface or into the subsurface in the past. CHCs could then have migrated into the groundwater through infiltration and percolation.

3.5 Initial Response

In 1985, the DON began evaluating its installations under the IRP (DON, 1992). Several studies were conducted at MCAS Yuma, including an Initial Assessment Study (Stearns, Conrad, Schmidt and Landau Associates, 1985a); the former Marine Wing Weapon Unit Site Characterization (Stearns, Conrad, Schmidt and Landau Associates, 1985b); a Confirmation Study, Verification Phase (Malcolm Pirnie, 1988); and a Site Inspection (Malcolm Pirnie, 1990). These early studies found the presence of various contaminants in the soil and chlorinated solvents in groundwater underlying MCAS Yuma, which led to its inclusion on U.S. EPA's NPL, or Superfund list, on February 21, 1990.

In 1990, following MCAS Yuma's listing on the NPL, the DON entered into an FFA with U.S. EPA and ADEQ to establish a framework and schedule for implementing environmental investigations and appropriate cleanup actions. The Final FFA was signed in January 1992. The FFA team agreed to subdivide the MCAS Yuma into two OUs (i.e., OU-1 and OU-2). Areas with potential groundwater contamination and soil contamination deeper than 10 feet bgs were designated as OU-1. 18 CAOCs, titled CAOC 1 through CAOC 18, containing potential soil contamination shallower than 10 feet bgs were designated as OU-2.

The OU-1 RI was conducted to determine areas of groundwater contamination that required either evaluation of remedial action or NFA as well as to assess the potential impacts of the contamination on human health and the environment (JEG, 1996a). The RI conducted for OU-2 investigated all 18 CAOCs and included human-health and ecological risk assessments to assess the potential impacts of the hazardous substances reported on both potential human and environmental receptors (JEG, 1996a).

3.6 Basis for Taking Action

The following subsections present a discussion of the RI findings and subsequent investigations performed for OU-1 and OU-2, respectively, which provide the basis for taking action.

3.6.1 Operable Unit 1. Based on the results of the OU-l RI, six areas of groundwater contamination were identified that exceeded maximum contaminant levels (MCLs) established by the U.S. EPA for drinking water standards. Four of the plume areas (Areas 1, 2, 3 and 6) that had CHC contamination were assigned to the DON's IRP under the CERCLA cleanup program. The two other areas of groundwater contamination, primarily containing fuel constituents, were assigned to the state of Arizona's Leaking Underground Storage Tank (LUST) Program. These non-CERCLA areas were located in the Fuel Farm (Area 4) and the Motor Transportation Pool (Area 5) (Bechtel, 2002). Subsequent to the RI, fuel constituents exceeding MCLs were identified at the Exchange Service Station (Subarea 5A), which was also investigated under the LUST Program (BNI, 2002). As Areas 4 and 5 and subarea 5A were part of the LUST Program and not associated with CERCLA, their inclusion in this five-year review is not required, and therefore no further discussion will be presented for these areas. Figure 3-3 shows the locations of OU-1 Areas 1, 2, 3, and 6 within MCAS Yuma and other general site characteristics (i.e., roads, fence lines, and buildings).

The OU-1 STRAP was conducted under the DON remedial action contract to evaluate the use of innovative in situ groundwater treatment technologies (JEG, 1996b). Based on the OU-1 RI and STRAP findings, remedial alternatives were evaluated for the CHC plumes in Areas 1, 2, 3, and 6 in the OU-1 FS (JEG, 1998a). In September 1998, a draft ROD for OU-1, which documented the remedial action plan for OU-1, including selected and contingent remedial actions for groundwater impacted by CHCs (JEG, 1998b), was prepared. In addition, the nature and extent of the primary CHC groundwater plumes were further investigated in several sampling phases (OHM Remediation Services Corp., 1996-1997; GEOFON, 2002).

The contaminants of concern (COCs) in the OU-1 CHC groundwater plumes consisted predominantly of 1,1-dichloroethene (DCE), trichloroethene (TCE), and tetrachloroethene (PCE) at levels exceeding the MCLs for U.S. EPA drinking water standards (i.e., 7 µg/L for 1,1-DCE, 5 µg/L for TCE, and 5 µg/L for PCE). The following subsections provide detailed information regarding the location, source and extent of CHC contamination in OU-1 Areas 1, 2, 3 and 6.

3.6.1.1 Area 1 Groundwater Plume. OU-1 Area 1 has been the largest CHC-contaminated groundwater plume, underlying an area of approximately 60 acres, and extending from the Building 230 area to the northwest station boundary (Figure 3-3). The Area 1 contamination was separated into the following three distinct plume regions subsequent to the RI: the "Hot Spot" plume near Building 230; the interior/central plume area near the northeast portion of the runway; and the LEPA near the northwest boundary of the station (Figure 3-3). The highest concentrations of groundwater contamination were identified northwest (downgradient) of the Building 230 area or "Hot Spot" with CHC concentrations detected at greater than 200 µg/L.

Two USTs were removed from the vicinity of the building, and the surrounding area has been paved. TCE was detected in soils beneath one of the USTs, which collected discharges from the floor drain of the Building 230 paint shop. Four dry wells, located within 200 feet of the building, were also identified and likely collected water from the vicinity of the building, allowing the water to infiltrate the soils and potentially into the groundwater. Although there is no conclusive evidence regarding the source of the Area 1 CHC plume, it appears to be related to activities associated with Building 230. Following the RI, results of passive and active soil-gas and vadose zone sampling suggested that there was no remaining source of CHCs in the vadose zone of the Building 230 area (SWDIV, 2000).

The Area 1 plume is limited to the upper portion of the unconfined aquifer; however, the plume appears to have a slight downward gradient from the Building 230 Hot Spot towards the LEPA (SWDIV, 2000). Based on groundwater sampling performed between 1998 and 1999, the extent of the Hot Spot was approximately 1,000 feet long by 400 feet wide. The maximum concentrations of TCE and PCE decreased during this time as well (SWDIV, 2000).

The subsurface lithology in the source area is relatively heterogeneous with sediment sizes including silts, fine to coarse sands, and gravels. Lithologic logging in the vicinity of Building 230 encountered several discontinuous clay lenses of a few inches up to 5 feet thick, which began approximately 30 feet bgs and were observed above and below the groundwater table

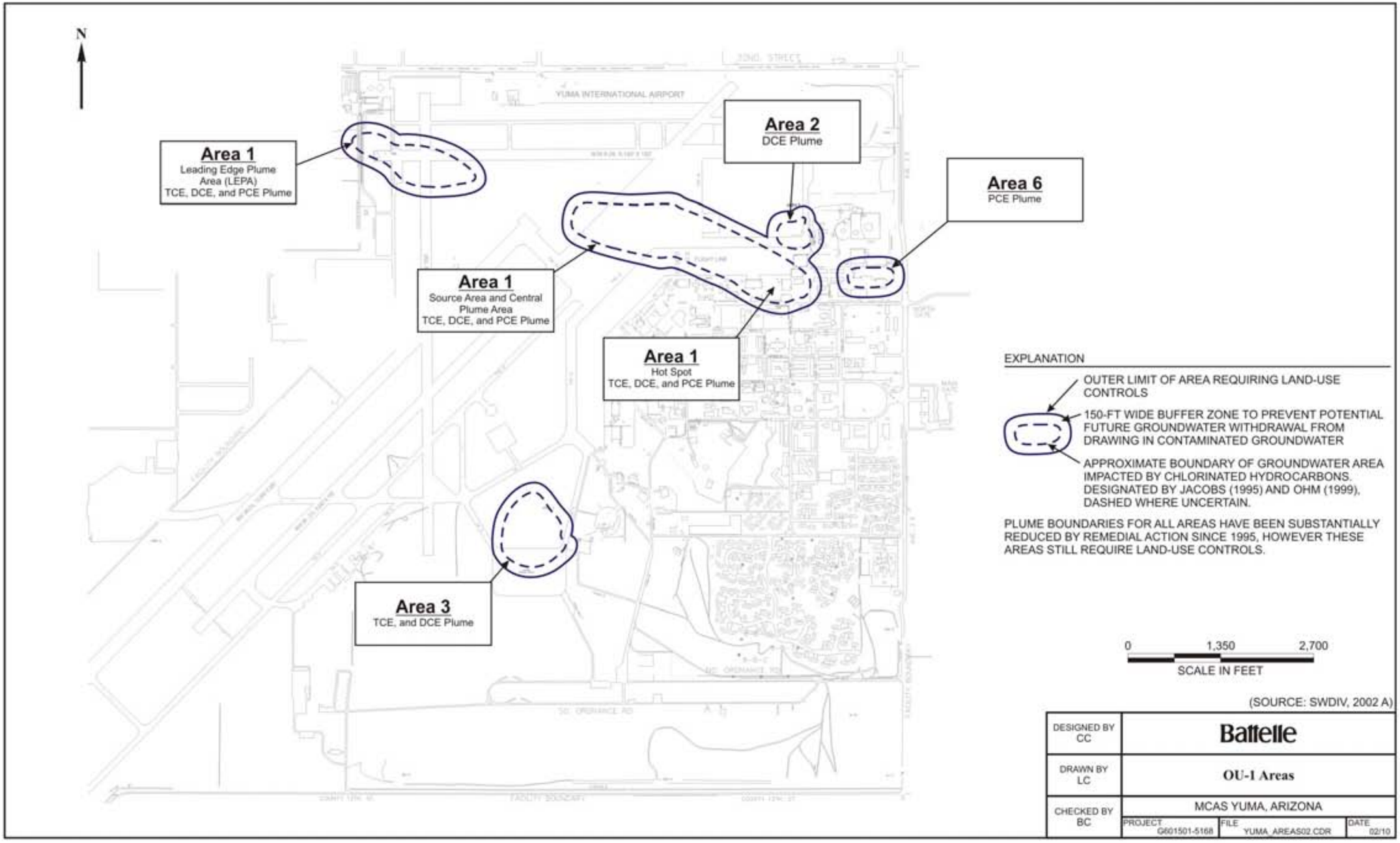

Figure 3-3. Location Map of OU-1 Areas

(SWDIV, 2000). The presence of these clay lenses suggested a limited vertical migration mechanism for contaminants in this area.

Additional groundwater sampling at the LEPA indicated concentrations of CHCs exceeding MCLs present to depths up to 180 feet bgs. Following the RI, CHCs were identified in groundwater beyond the western boundary of MCAS Yuma beneath property controlled by the Yuma Airport Authority. In September 1999, the horizontal and vertical extent of TCE- and DCE-impacted groundwater in the deep aquifer (30 to 190 feet below the groundwater table) had been fully delineated (OHM Remediation Services Corp., 1999a).

The coarse gravel zone has not been investigated recently under the IR program. However, the OU-1 and OU-2 RI reports evaluated the potential for vertical migration of contamination. Groundwater at MCAS Yuma was identified as a separate OU, requiring a separate RI study and DQO development. However, groundwater was also identified as likely to be a medium of concern at individual OU-2 CAOCs. Therefore, the RI for OU-2 evaluated the potential for future groundwater contamination from subsurface soils. The OU-2 RI evaluated subsurface stratigraphy using cone penetrometer equipment, delineating the horizontal and vertical extent of clay lenses. The process provided a continuous lithologic profile of the subsurface, allowing cross sections and three-dimensional lithologic models to be constructed for each CAOC. Soil samples were also collected for testing such as grain-size distribution and hydraulic conductivity to provide supporting data for evaluating COPC mobility and to provide data for remedial design. Results of the lithologic logging were used to identify optimum soil sampling depths. The OU-1 RI was integrated with the groundwater-related information developed from the RI activities for OU-2. The OU-1 RI included installation of a well screened at a depth of 130 to 145 feet below groundwater surface to evaluate the potential for vertical flow of contamination and for the presence of DNAPL. In addition, wells were installed for the OU-1 RI at various depths in CAOCs to evaluate the vertical distribution of contaminants in the aquifer. Nested wells were also installed in Area 1 of OU-1 to determine the vertical extent of contamination. Groundwater data from the OU-1 RI showed the contamination is confined to the upper 20 to 30 feet of the water table. A subsequent study of perimeter well groundwater monitoring results (Jacobs, 1995) showed that the deeper zone of the upper fine-grained zone was not impacted by contamination.

All of the chemicals identified in Area 1 during the RI and subsequent investigations prior to the Final ROD that exceeded their respective background levels (except for: metals considered essential human nutrients; nonsite-related metals within naturally occurring background levels; and trihalomethanes historically detected in groundwater throughout the Yuma area) were evaluated as contaminants of potential concern (COPCs) in the human-health risk assessment. Table 3-1 lists the COPCs that exceeded MCLs and were major risk contributors in Area 1. The Area 1 risk assessment results for cancer (excess lifetime cancer risk [ELCR]) and noncancer (hazard index [HI]) were as follows:

- Residential exposure scenario based on 1995 RI data (JEG, 1996a)
  - ELCR: 4.72×10^{-3}
  - Cancer risk driver(s): 1,1-DCE (93.2% of risk) and TCE (6.4% of risk)
  - HI: 15.9

- Noncancer hazard driver(s): 1,1-DCE (19.5% of hazard) and TCE (78.6% of hazard)

- Residential exposure scenario based on August 1999 data (SWDIV, 2000)
  - ELCR: 1.75×10^{-3}
  - Cancer risk driver(s): 1,1-DCE (91.4% of risk) and TCE (8.6% of risk)
  - HI: 2.7
  - Noncancer hazard driver(s): 1,1-DCE (40.7% of hazard) and TCE (59.3% of hazard)

The cancer risk associated with groundwater exposure from Area 1 contamination, for the residential scenario from both datasets, exceeded the generally accepted range (10^{-6} to 10^{-4}). The HI exceeded the acceptable criterion of 1.0 in both datasets as well (SWDIV, 2000).

3.6.1.2 Area 2 Groundwater Plume. The OU-1 Area 2 contaminated groundwater plume was located northeast of the flight line along the easternmost taxiway, downgradient of the Fuel Farm Area and about 200 feet downgradient of Building 303, a jet engine testing cell (Figure 3-3). The footprint of the plume covered an area of approximately 4 acres and was confined on-station. Building 303 was associated with a suspected leach field, which is a possible source of the small plume in Area 2. The contamination at Area 2 consisted primarily of 1,1-DCE, however, CHCs were not detected in the vadose zone surrounding Area 2 and the source of contamination remains in question. A clay zone encountered about 80 feet bgs (i.e., 20 feet below the groundwater table) was thought to likely prevent significant downward migration of contaminants (SWDIV, 2000).

Table 3-1. OU-1 Area 1 Maximum Detected Concentrations of COPCs

Area 1 COPC	Maximum Reported Conc.[1]	Federal Primary Drinking Water Standards (MCLs)	Federal Maximum Contaminant Level Goals (MCLGs)	Arizona MCLs for Organic Chemicals	Arizona Numeric Aquifer Water Quality Standards (AWQS)	Required Cleanup Conc.[2]	Major Human Health Risk	Major Human Health Hazard
1,1-DCE	170	7	7	7	7	7	yes	yes
TCE	450	5	0	5	5	5	yes	yes
PCE	16	5	0	5	5	5	no	no

Based on summary information presented in Table 2-6 of the OU-1 ROD (SWDIV, 2000).
All concentrations in micrograms per liter (µg/L).
[1] Maximum reported concentrations were based on information from the RI (JEG, 1996a).
[2] Required cleanup concentrations based on the most conservative standards at the time of the investigation (i.e., MCLs based on Federal Drinking Water Standards).

The shallow, small plume of Area 2 centered on monitoring well FF-MW-24 had a maximum detected 1,1-DCE concentration of 210 µg/L reported in the RI (JEG, 1996a). The plume was relatively stable following the RI with no significant horizontal migration identified (SWDIV,

2000). 1,1-DCE concentrations were shown to decrease to 130 µg/L in June 1998 and to 26 µg/L in August 1999 (SWDIV, 2000).

All of the chemicals identified in Area 2 during the RI and subsequent investigations prior to the Final ROD that exceeded their respective background levels were evaluated as COPCs in the human-health risk assessment. Table 3-2 lists the contaminants that exceeded MCLs and were major risk contributors in Area 2. The Area 2 risk assessment results for cancer (i.e., ELCR) and noncancer (i.e., HI) were as follows:

- Residential exposure scenario based on 1995 RI data (JEG, 1996a)
  - ELCR: 4.6×10^{-3}
  - Cancer risk driver(s): 1,1-DCE
  - HI: 3.3
  - Noncancer hazard driver(s): 1,1-DCE
- Residential exposure scenario based on August 1999 data (SWDIV, 2000)
  - ELCR: 6.7×10^{-4}
  - Cancer risk driver(s): 1,1-DCE
  - HI: 0.5

The cancer risk associated with groundwater exposure from Area 2 contamination, for the residential scenario from both datasets, exceeded the generally accepted range (10^{-6} to 10^{-4}). The HI exceeded the acceptable criterion of 1.0 following the RI; however, as concentrations decreased in 1999, the HI dropped below the acceptable threshold (SWDIV, 2000).

Table 3-2. OU-1 Area 2 Maximum Detected Concentrations of COPCs

Area 2 COPC	Maximum Reported Conc.[1]	Federal Primary Drinking Water Standards (MCLs)	Federal Maximum Contaminant Level Goals (MCLGs)	Arizona MCLs for Organic Chemicals	Arizona Numeric Aquifer Water Quality Standards (AWQS)	Required Cleanup Conc.[2]	Major Human Health Risk	Major Human Health Hazard
1,1-DCE	180	7	7	7	7	7	yes	yes

Based on summary information presented in Table 2-6 of the OU-1 ROD (SWDIV, 2000).
All concentrations in micrograms per liter (µg/L).
[1] Maximum reported concentrations were based on information from the RI (JEG, 1996a).
[2] Required cleanup concentrations based on the most conservative standards at the time of the investigation (i.e., MCLs based on Federal Drinking Water Standards).

3.6.1.3 Area 3 Groundwater Plume. The OU-1 Area 3 contaminated groundwater plume was located north of the CALA near a former unlined fire training pit that was used from 1976 to 1985 to practice extinguishing various types of fires (Figure 3-3). The footprint of the plume covered an area of approximately 10 acres and was confined on-station. The contamination at Area 3 consisted primarily of TCE and 1,1-DCE. The detected CHC compounds in groundwater

were limited to the immediate vicinity of the former fire pit; they did not appear to have an upgradient source and were not migrating significantly downgradient.

The maximum concentrations of TCE and 1,1-DCE reported in the RI were 13 and 10.2 µg/L, respectively, at monitoring well W-5 (JEG, 1996a). The CHC concentrations decreased following the RI where groundwater monitoring results documented 1,1-DCE, TCE, and PCE concentrations dropped below the MCLs in 1999 at all Area 3 monitoring wells.

All of the chemicals identified in Area 3 during the RI and subsequent investigations prior to the Final ROD that exceeded their respective background levels were evaluated as COPCs in the human-health risk assessment. Table 3-3 lists the contaminants that exceeded MCLs and were major risk contributors in Area 3. The Area 3 risk assessment results for cancer (i.e., ELCR) and noncancer (i.e., HI) were as follows:

- Residential exposure scenario based on 1995 RI data (JEG, 1996a)
  - ELCR: 2.69×10^{-4}
  - Cancer risk driver(s): 1,1-DCE (96.8% of risk) and TCE (3.2% of risk)
  - HI: 0.6
- Residential exposure scenario based on August 1999 data (SWDIV, 2000)
  - ELCR: 1.43×10^{-5}
  - Cancer risk driver(s): 1,1-DCE (90.9% of risk) and TCE (9.1% of risk)
  - HI: 0.7

The cancer risk associated with groundwater exposure from Area 3 contamination, for the residential scenario, exceeded the accepted range (10^{-6} to 10^{-4}) following the RI, but was within the accepted range following the 1999 sampling. The HI was below the acceptable threshold of 1.0 for both datasets (SWDIV, 2000).

Table 3-3. OU-1 Area 3 Maximum Detected Concentrations of COPCs

Area 3 COPC	Maximum Reported Conc.[1]	Federal Primary Drinking Water Standards (MCLs)	Federal Maximum Contaminant Level Goals (MCLGs)	Arizona MCLs for Organic Chemicals	Arizona Numeric Aquifer Water Quality Standards (AWQS)	Required Cleanup Conc.[2]	Major Human Health Risk	Major Human Health Hazard
1,1-DCE	10.2	7	7	7	7	7	yes	no
TCE	12.8	5	0	5	5	5	no	no

Based on summary information presented in Table 2-6 of the OU-1 ROD (SWDIV, 2000).
All concentrations in micrograms per liter (µg/L).
[1] Maximum reported concentrations were based on information from the RI (JEG, 1996a).
[2] Required cleanup concentrations based on the most conservative standards at the time of the investigation (i.e., MCLs based on Federal Drinking Water Standards).

3.6.1.4 Area 6 Groundwater Plume. The OU-1 Area 6 contaminated groundwater plume was located south of the Central Receiving Warehouse (Building 328), where a small plume, primarily PCE, was detected in the vicinity of three suspected diesel-fuel USTs associated with former Building 335 (Figure 3-3). The original source of contamination, however, remains unknown. The footprint of the plume covered an area of less than 1 acre and was confined on-station. The maximum concentration of PCE reported in the RI was 7.1 µg/L at monitoring well 335-MW-04, however, the CHC plume was considered to be stable with respect to concentration and areal extent (SWDIV, 2000).

Elevated concentrations of total petroleum hydrocarbons (TPH) as diesel (14,000 milligrams per kilogram [mg/kg]) and as gasoline (770 mg/kg) were detected in the soil, but TPH was virtually absent in groundwater with only one monitoring well out of five having detected TPH (0.25 milligrams per liter [mg/L]).

Based on results from sampling conducted in April 1998, it appeared that the PCE concentration in well 335-MW-04 had fallen to 4 µg/L, while the PCE concentration in the nearby monitoring well 317-MW-01 was 9 µg/L. Further results from sampling conducted in October 1998 documented that the PCE concentration in well 335-MW-04 had fallen to 2 µg/L, while the concentration of PCE (7 µg/L) in well 317-MW-01 had dropped, but remained in excess of the MCL. Sampling conducted in August 1999 showed that the concentration of PCE in well 317-MW-01 was 8.6 µg/L. The Area 6 PCE concentrations remained essentially stable following the RI, at levels slightly in excess of the MCL, but less than the 10^{-4} risk level and the noncancer risk-based concentration (RBC).

All of the chemicals identified in Area 6 during the RI and subsequent investigations prior to the Final ROD, which exceeded their respective background levels, were evaluated as COPCs in the human-health risk assessment. Table 3-4 lists the contaminants that exceeded MCLs and were major risk contributors in Area 6. The Area 6 risk assessment results for cancer (i.e., ELCR) and noncancer (i.e., HI) were as follows:

- Residential exposure scenario based on 1995 RI data (JEG, 1996a)
  - ELCR: 8.60×10^{-6}
  - HI: 0.1
- Residential exposure scenario based on August 1999 data (SWDIV, 2000)
  - ELCR: 1.00×10^{-5}
  - HI: 0.1

The cancer risk associated with groundwater exposure from Area 6 contamination, for the residential scenario, was within the accepted range (10^{-6} to 10^{-4}) following the RI and the 1999 sampling. The HI was below the acceptable threshold of 1.0 for both datasets, as well (SWDIV, 2000).

Table 3-4. OU-1 Area 6 Maximum Detected Concentrations of COPCs

Area 6 COPC	Maximum Reported Conc.[1]	Federal Primary Drinking Water Standards (MCLs)	Federal Maximum Contaminant Level Goals (MCLGs)	Arizona MCLs for Organic Chemicals	Arizona Numeric Aquifer Water Quality Standards (AWQS)	Required Cleanup Conc.[2]	Major Human Health Risk	Major Human Health Hazard
PCE	7.1	5	0	5	5	5	no	no

Based on summary information presented in Table 2-6 of the OU-1 ROD (SWDIV, 2000).
All concentrations in micrograms per liter (µg/L).
[1] Maximum reported concentrations were based on information from the RI (JEG, 1996a).
[2] Required cleanup concentrations based on the most conservative standards at the time of the investigation (i.e., MCLs based on Federal Drinking Water Standards).

3.6.2 Operable Unit 2. Based on the results of the RI conducted across the 18 CAOCs of OU-2, the FFA team agreed that 12 of the CAOCs required NFA. The six remaining CAOCs (i.e., CAOCs 1, 4, 7, 8, 9 and 10) required remedial actions (JEG, 1996a). The results of the ecological risk assessment conducted as part of the RI (JEG, 1996a) indicated that chemicals detected in the soil and surface water did not pose a significant risk to ecological receptors at MCAS Yuma. With the exception of migratory birds that were observed in the air over MCAS Yuma, no state or federally listed threatened or endangered species were known to be present at MCAS Yuma. No critical habitats or habitats of endangered species were found to be affected by contaminants of potential ecological concern (COPEC) at OU-2.

The FS conducted for the remaining six CAOCs (Uribe & Associates, 1996b) focused on remedial action for CAOCs 4, 7, and 9, where surface disposal of asbestos-bearing waste was confirmed, which would allow unrestricted use of the sites. Remediation to residential land use standards was completed in 1999 for OU-2 CAOCs 4, 7, and 9 (GEOFON, 1999); therefore, these CAOCs and the 12 OU-2 CAOCs that achieved NFA status are not required to be included in further discussion.

A discussion of the remaining OU-2 CAOCs (i.e., CAOCs 1, 8A and 10), including site description, history of contamination, response actions, and the basis for taking remedial action, is provided below. The COCs of the remaining Areas of OU-2 are PAHs and PCBs and do not represent a source of contamination for any OU-1 areas. Figure 3-4 shows the locations of OU-2 CAOCs 1, 8A and 10 within MCAS Yuma and other general site characteristics (i.e., roads, fence lines, and buildings).

3.6.2.1 CERCLA Area of Concern 1. CAOC 1 consists of the pre-1960 flight line (tarmac, runways, aprons, and taxiways) and associated aircraft-maintenance hangar facilities. This site is located within the footprint of the existing flight line in the north-central portion of MCAS Yuma and occupies approximately 170 acres (Figure 3-4). In the 1940s, used oil was routinely drained from aircraft engines directly to the ground surface on which the aircraft were parked. In the 1950s, 1960s, and 1970s, waste oil was used for dust control around hangars, taxiways, and apron edges. The RI focused on the flight line areas where source areas of contamination were

expected to be found, such as aircraft and vehicle wash racks, oil/water separators, fuel storage bladder locations, dry wells, miscellaneous stained soil areas, and maintenance and storage yards (JEG, 1996a).

The results of the RI revealed the widespread detection of total recoverable petroleum hydrocarbons (TRPH) in surface soils and localized occurrences around the flight line. PAHs were also reported in localized surface soils. PCBs, formerly used as coolant for electric transformers, were reported at the northern edge of the flight line and existing wash rack. Solvents, containing VOCs and semi-volatile organic compounds (SVOCs), pesticides and metals, were reported in shallow soil samples throughout the flight line (Uribe & Associates, 1997b). The results of the investigation did not reveal significant soil contamination in the areas of the specific units included in the investigation (e.g., drywells, oil/water separators, wash racks, etc.). PAHs were the major COPCs posing unacceptable health risk to exposure from CAOC 1 soils.

All of the chemicals identified at CAOC 1 during the RI, including metals that exceeded their respective background levels (i.e., arsenic, beryllium, and cadmium), were evaluated as COPCs in the human-health risk assessment as industrial and residential land use scenarios. Table 3-5 lists the maximum detected concentrations of the COPCs, identifies the residential and industrial risk-based criteria used in the RI, and identifies the threshold limit values (TLVs) established for metals within the soils of CAOC 1. The CAOC 1 risk assessment results for cancer (i.e., ELCR) and noncancer risk (i.e., HI) were as follows:

- Residential exposure scenario
  - ELCR: 2.19×10^{-4}
  - Risk driver(s): PAHs, 83 percent of the cancer risk
- Industrial exposure scenario
  - ELCR: 6.48×10^{-5}
  - Cancer Risk driver(s): PAHs, 90 percent of the cancer risk
  - HI: 1.86
  - Noncancer Risk driver(s): metals

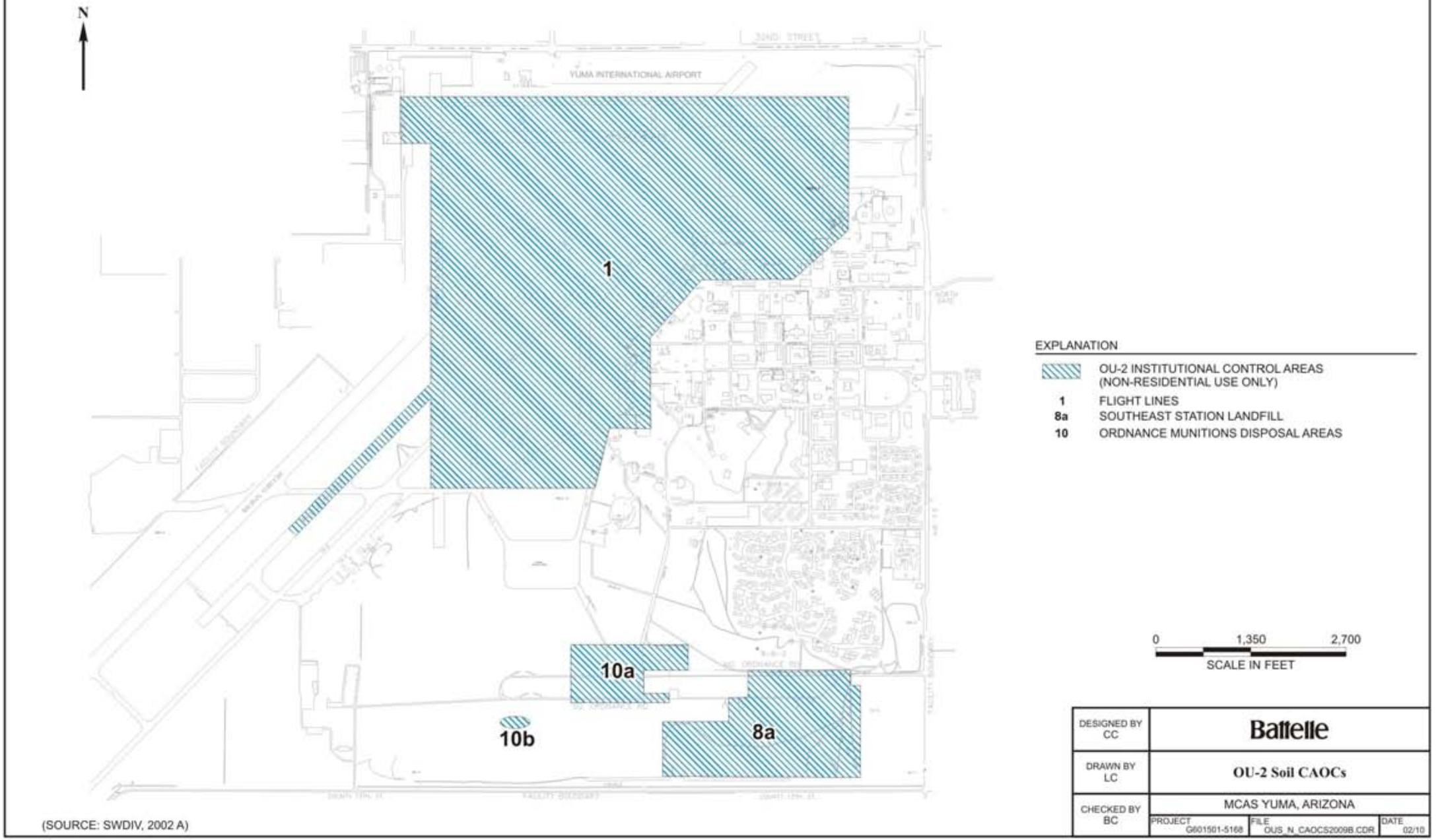

Figure 3-4. Location Map of OU-2 CERCLA Areas of Concern

Table 3-5. OU-2 CAOC 1 Maximum Detected Concentrations of COPCs

CAOC 1 COPC	Maximum Reported Conc.[1]	Residential Risk-Based Criteria		Industrial Risk-Based Criteria		TLV
		Cancer	Noncancer	Cancer	Noncancer	
VOCs						
2-Butanone	2.31	--	2,770	--	3,070	na
Chloromethane	0.11	3.17	--	5.82	--	na
Methylene Chloride	0.16	6.44	1,930	12	1,930	na
Xylene	0.09	--	1,930	--	1,930	na
SVOCs						
1-Methyl-2-Pyrrolidinone	0.16	NA	NA	NA	NA	na
2-Cyclohexen-1-Ol	0.1	NA	NA	NA	NA	na
2-Cyclohexen-1-One	0.095	NA	NA	NA	NA	na
2-Methylnaphthalene	54	--	608	--	608	na
2-Pentanone, 4-Hydroxy-4-Methyl	9.8	NA	NA	NA	NA	na
7H-Benz(DE)Anthracen-7-One	1.7	NA	NA	NA	NA	na
9,10-Anthracenedione	1.6	NA	NA	NA	NA	na
Acenaphthene	0.034	--	55.6	--	55.6	na
Acenaphthylene	0.045	NA	NA	NA	NA	na
Anthracene	0.26	--	1.76	--	1.76	na
Benzo(e) Pyrene	0.17	NA	NA	NA	NA	na
Benzo(a) Anthracene	3.6	0.391	--	1.23	--	na
Benzo(a) Pyrene	4.5	0.0391	--	0.123	--	na
Benzo(b) Fluoranthene	10	0.391	--	1.23	--	na
Benzo(g,h,i) Perylene	2	NA	NA	NA	NA	na
Benzo(k) Fluoranthene	4.2	3.91	--	12.3	--	na
Benzo(b) Naphtho(2,3-D)Furan	0.18	NA	NA	NA	NA	na
Bis(2-Ethylhexyl) Phthalate	2.7	20.4	780	64.1	6,400	na
Butyl Benzyl Phthalate	0.25	--	7,800	--	64,000	na
Carbazole	0.77	14.3	--	44.9	--	na
Chrysene	5.6	39.1	--	123	--	na
Cyclopenta(def) Phenanthrenon	0.62	NA	NA	NA	NA	na
Di-n-Octylphthalate	0.24	--	780	--	6,400	na
Di-n-Butylphthalate	1.78	--	3,900	--	32,000	na
Dibenzo(a,h) Antracene	0.97	0.0391	--	0.123	--	na
Dibenzofuran	0.05	NA	NA	NA	NA	na
Ethanone, 1-Oxiranyl	0.071	NA	NA	NA	NA	na
Ethylene Glycol	170	--	78,000	--	100,000	na
Fluoranthene	8.3	--	1,560	--	12,800	na
Fluorene	0.044	--	47.6	--	47.6	na
Hexanedioic Acid, Bis(2-Ethyl)	5.1	NA	NA	NA	NA	na
Indeno (1,2,3-cd) Pyrene	2.5	0.391	--	1.23	--	na
Naphthalene	70	--	124	--	124	na
Phenanthrene	2.3	--	42	--	42	na
Phenol	0.064	--	18,700	--	100,000	na
Pyrene	8	--	1,170	--	9,600	na
Total Petroleum Hydrocarbons						
Diesel	5,100	--	--	--	--	na
Gasoline	48	--	--	--	--	na
Total Petroleum Hydrocarbons	4,200	--	--	--	--	na

Table 3-5. OU-2 CAOC 1 Maximum Detected Concentrations of COPCs (Continued)

CAOC 1 COPC	Maximum Reported Conc.[1]	Residential Risk-Based Criteria		Industrial Risk-Based Criteria		TLV
		Cancer	Noncancer	Cancer	Noncancer	
Pesticides and PCBs						
4,4-DDD	0.21	0.935	--	2.63	--	na
4,4-DDE	0.14	0.66	--	1.86	--	na
4,4-DDT	0.026	0.66	15.6	1.86	113	na
aldrin	0.000088	0.0132	0.973	0.0371	6.76	na
aroclor 1254	0.02	0.0473	--	0.176	--	na
aroclor 1260	0.39	0.0473	--	0.176	--	na
dieldrin	0.014	0.014	1.56	0.0395	11.3	na
endosulfan II	0.015	--	1.56	--	11.3	na
endosulfan sulfate	0.013	--	1.56	--	11.3	na
endrin	0.0067	--	9.37	--	67.6	na
endrin aldehyde	0.0097	--	9.37	--	67.6	na
endrin ketone	0.018	--	9.37	--	67.6	na
heptachlor epoxide	0.0065	0.0247	0.406	0.0694	2.93	na
alpha-benzene hexachloride	0.00027	0.0453	--	0.143	--	na
alpha-chlordane	0.17	0.173	1.87	0.486	13.5	na
delta-benzene hexachloride	0.0063	0.158	--	0.499	--	na
gamma-chlordane	0.14	0.173	1.87	0.486	13.5	na
methoxychlor	0.063	--	156	--	1,130	na
Metals						
Aluminum	26,200	--	71,100	--	100,000	20,800
Arsenic	16	0.302	21.3	1.9	399	8.59
Barium	437	--	1,520	--	12,400	187
Beryllium	0.43	0.129	356	0.859	6,650	1.97
Cadmium	6.2	26.5	35.6	45.4	665	1.04
Chromium	32.2	--	71,100	--	100,000	49.2
Cobalt	16.6	--	4,540	--	29,600	12.2
Copper	47.1	--	2,630	--	49,200	15.4
Lead[2]	102	--	--	--	--	15.8
Manganese	727	--	136	--	1,180	319
Mercury	1.3	--	21	--	382	nd
Nickel	39.3	--	1,420	--	26,600	19.5
Selenium	0.59	--	356	--	6,650	2.26
Silver	42.1	--	356	--	6,650	1.15
Thallium	0.5	--	4.98	--	93.1	4.21
Vanadium	56.7	--	498	--	9,310	37.7
Zinc	101	--	21,300	--	100,000	37.9

Based on summary information presented in Tables 2-1 through 2-5 of the OU-2 ROD (Uribe & Associates, 1997b).
All concentrations in milligrams per kilogram (mg/kg).

-- indicates that this constituent did not have cancer and/or noncancer toxicity.
NA indicates that no toxicity data were available at the time of the RI.
na indicates that a TLV was not applicable for the constituent.
nd indicates that no data were obtained for the TLV calculations.
XX indicates that the maximum detected concentration of the constituent exceeded this criterion.

[1] Maximum reported concentrations were based on information from the RI (JEG, 1996a).
[2] U.S. EPA Region IX residential and industrial soil screening levels for lead were 400 and 1,200 mg/kg at the time of the RI, respectively. Concentrations below these values were not considered to impact health.

The cancer risk for the residential scenario exceeded the generally accepted range (10^{-6} to 10^{-4}), which precluded unrestricted exposure or residential land use. The cancer risk for the industrial scenario was within the acceptable range; therefore, no restrictions were needed for this land use. The HI exceeded the acceptable criterion of 1.0 (primarily attributed to metals); however, none of the individual target organs or organ systems HI values exceeded the criterion (JEG, 1996a).

3.6.2.2 CERCLA Area of Concern 8A. CAOC 8A is located in the southeastern portion of MCAS Yuma, between North Ordnance Road and the southern MCAS Yuma property line (Figure 3-4). CAOC 8A is the site of a former landfill and surface disposal areas. The site is vacant land, except for ordnance and munitions storage bunkers on the portion of the site within the Ordnance Distribution Facility (ODF). During the RI, this area was investigated as part of the greater CAOC 8. CAOC 8 was a 68-acre area used primarily for the disposal of municipal wastes generated at MCAS Yuma from 1953 to 1961 (Uribe & Associates, 1997b). A portion of the area was also used for rubble disposal and as a borrow area for fill soil. The wastes were burned prior to disposal in 10 to 20 disposal pits at CAOC 8A. The waste streams potentially associated with this disposal area include vehicle- and fuel-related wastes, used oils, solvents, paints, thinners, pesticides, and herbicides. The disposal pits were backfilled and no longer provide an opportunity for direct human exposure to contaminated soil. The CAOC 8A landfill is inactive, and no disposal or other use is authorized for the site. The portion of the site within the ODF is used for ordnance and munitions storage within storage bunkers.

Drilling within the landfill at CAOC 8A was not performed during the RI because of potential drilling hazards and difficult drilling conditions caused by buried construction debris. Therefore, the landfill investigation was directed at evaluating the exposure scenario for the present site conditions and future (capped) conditions. The analytical results from the RI surface soil sampling and analysis program for CAOC 8 indicated the presence of TRPH, PAHs, PCBs, solvents, pesticides and metals. These contaminants were generally found in the portion of CAOC 8 assigned to CAOC 8A (i.e., south of North Ordnance Road). Low levels of TCE, PCE, xylenes and methane were also detected in soil gas samples. PCBs detected in surface soil at CAOC 8A were the major COPC posing a potential human risk.

The human-health risk assessment subdivided CAOC 8, based on current and anticipated future land use, into CAOC 8A and CAOC 8B, and evaluated each separately. CAOC 8B is the MCAS Yuma residential housing area located between North Ordnance Road and Loesch Street. The assessment estimated the human-health risks at CAOC 8B for both the industrial and residential scenarios to be within the acceptable range (JEG, 1996a). Table 3-6 lists the maximum detected concentrations of the COPCs, identifies the residential and industrial risk-based criteria used in the RI, and identifies the TLVs established for metals within the soils of CAOC 8A. The RI risk assessment results for CAOC 8A were as follows:

- Residential exposure scenario
  - ELCR: 9.94×10^{-5}
  - HI: 0.35
  - Risk driver(s): PAHs and PCBs; with 74 percent of the cancer risk attributed to Aroclor 1254 (a PCB, reported at three sample locations)

Table 3-6. OU-2 CAOC 8A Maximum Detected Concentrations of COPCs

CAOC 8A COPC	Maximum Reported Conc.[1]	Residential Risk-Based Criteria		Industrial Risk-Based Criteria		TLV
		Cancer	Noncancer	Cancer	Noncancer	
SVOCs						
1-Methyl-2-Pyrrolidinone	0.13	NA	NA	NA	NA	na
Benzo(a) Anthracene	0.2	0.391	--	1.23	--	na
Benzo(a) Pyrene	0.24	0.0391	--	0.123	--	na
Benzo(b) Fluoranthene	0.42	0.391	--	1.23	--	na
Benzo(g,h,i) Perylene	0.035	NA	NA	NA	NA	na
Benzo(k) Fluoranthene	0.2	3.91	--	12.3	--	na
Bis(2-Ethylhexyl) Phthalate	0.387	20.4	780	64.1	6,400	na
Chrysene	0.27	39.1	--	123	--	na
Di-n-Butylphthalate	4.038	--	3,900	--	32,000	na
Fluoranthene	0.344	--	1,560	--	12,800	na
Indeno (1,2,3-cd) Pyrene	0.074	0.391	--	1.23	--	na
N-Nitrosodiphenylamine	0.049	58.2	--	183	--	na
Phenanthrene	0.14	--	42	--	42	na
Pyrene	0.344	--	1,170	--	9,600	na
Total Petroleum Hydrocarbons						
Diesel	860	--	--	--	--	na
Pesticides and PCBs						
4,4-DDD	0.00805	0.935	--	2.63	--	na
4,4-DDE	0.0079	0.66	--	1.86	--	na
4,4-DDT	0.0023	0.66	15.6	1.86	113	na
aldrin	0.00248	0.0132	0.973	0.0371	6.76	na
aroclor 1254	4.045	0.0473	--	0.176	--	na
dieldrin	0.0695	0.014	1.56	0.0395	11.3	na
endosulfan I	0.00136	--	1.56	--	11.3	na
endosulfan II	0.0027	--	1.56	--	11.3	na
endosulfan sulfate	0.00098	--	1.56	--	11.3	na
endrin	0.04176	--	9.37	--	67.6	na
endrin aldehyde	0.0174	--	9.37	--	67.6	na
endrin ketone	0.01142	--	9.37	--	67.6	na
alpha-chlordane	0.05873	0.173	1.87	0.486	13.5	na
beta-benzene hexachloride	0.00041	0.158	--	0.499	--	na
gamma-chlordane	0.00756	0.173	1.87	0.486	13.5	na
gamma-benzene hexachloride (lindane)	0.00072	0.173	9.37	0.486	67.6	na
Metals						
Aluminum	11,700	--	71,100	--	100,000	7,770
Antimony	8.5	--	28.4	--	532	6
Arsenic	4.7	0.302	21.3	1.9	399	9.68
Barium	160	--	1,520	--	12,400	133
Beryllium	0.14	0.129	356	0.859	6,650	0.28
Cadmium	1.2	26.5	35.6	45.4	665	0.8
Chromium	15.7	--	71,100	--	100,000	10.6
Chromium VI	0.22	4.07	356	6.97	6,650	nd
Cobalt	6.5	--	4,540	--	29,600	6.12
Copper	582	--	2,630	--	49,200	21.7
Lead[2]	659	--	--	--	--	8.79

Table 3-6. OU-2 CAOC 8A Maximum Detected Concentrations of COPCs (Continued)

CAOC 8A COPC	Maximum Reported Conc.[1]	Residential Risk-Based Criteria		Industrial Risk-Based Criteria		TLV
		Cancer	Noncancer	Cancer	Noncancer	
Manganese	278	--	136	--	1,180	137
Mercury	0.17	--	21	--	382	nd
Nickel	14.9	--	1,420	--	26,600	6.7
Selenium	0.98	--	356	--	6,650	1.89
Silver	10.2	--	356	--	6,650	1.47
Thallium	0.5	--	4.98	--	93.1	6.76
Vanadium	28	--	498	--	9,310	22.6
Zinc	58.9	--	21,300	--	100,000	28.0

Based on summary information presented in Tables 2-1 through 2-5 of the OU-2 ROD (Uribe & Associates, 1997b).
All concentrations in milligrams per kilogram (mg/kg).
-- indicates that this constituent did not have cancer and/or noncancer toxicity.
NA indicates that no toxicity data were available at the time of the RI.
na indicates that a TLV was not applicable for the constituent.
nd indicates that no data were obtained for the TLV calculations.
XX indicates that the maximum detected concentration of the constituent exceeded this criterion.
[1] Maximum reported concentrations were based on information from the RI (JEG, 1996a).
[2] U.S. EPA Region IX residential and industrial soil screening levels for lead were 400 and 1,200 mg/kg at the time of the RI, respectively. Concentrations below these values were not considered to impact health.

  - Lead: detected at 659 milligrams per kilogram (mg/kg) in surface soil, which exceeded the U.S. EPA Region 9 residential soil screening value of 400 mg/kg and caused lead to be identified as a potential residential health risk (Uribe & Associates, 1997b).

- Industrial exposure scenario
  - ELCR: 3.02×10^{-5}
  - Cancer Risk driver(s): PAHs and PCBs
  - HI: 0.41

Because soil sample results were not available for the landfill contents, exposure to the landfill contents was not assessed for CAOC 8A. The cancer risk estimate for residential exposure at the site surface was at the high end of the generally acceptable range. Exposure to surface soil did not pose an unacceptable level of risk under an industrial land use scenario. Based on both this information and that the risks associated with exposure to the landfill interior are not known, U.S. EPA, ADEQ, and the DON made a risk management decision to restrict the use of CAOC 8A to the current use (inactive landfill and industrial use of former surface disposal areas) and prohibit any land use that could potentially disturb the contents of the landfill (Uribe & Associates, 1997b).

3.6.2.3 CERCLA Area of Concern 10. CAOC 10, consisting of subareas 10A and 10B (Figure 3-4), is located within the secured and existing ODF (CAOC 10A) and the fenced area adjacent to CAOC 8A (CAOC 10B) in the southeastern portion of MCAS Yuma. CAOC 10 was used during World War II as a shooting range for bomber gun crews. Since the early 1950s, ordnance materials have been stored in the magazines around the central portion of the Ordnance

Loop (North and South Ordnance Roads). The area has also been used for surface tank and drum storage. Surface spills, including liquid residues from ordnance-mixing operations, have been reported within this area. CAOC 10 continued to be used for the storage and handling of ordnance as part of the station's ordnance distribution facility. Suspected waste associated with this area includes used oils, ordnance waste associated with nitroaromatics, fuel-related wastes, and metals.

The primary finding of the RI field sampling and analysis program was TRPH, PAHs in surface soil, and one lead result reported above the site background concentration. PAHs were detected in surface soil at four locations during the RI. The risk assessment results from CAOC 10 indicated both the industrial and residential exposure scenarios had potential cancer risk within the generally accepted range; benzo(a)pyrene, a PAH, contributed 74 percent of the cancer risk for the residential exposure scenario.

The risk assessment results for CAOC 10 were later revised with results from additional soil sampling for PAHs conducted in August 1996 (Uribe & Associates, 1996a) and February 1997 (Uribe & Associates, 1997a). The August 1996 sample results showed one to two orders of magnitude higher total PAH concentrations, which led to supplemental soil sampling to fully define the extent of PAHs in the soil areas then designated as CAOCs 10A and 10B (Uribe & Associates, 1997a). Initially, this second risk assessment used RBCs calculated during the RI with 1993 U.S. EPA-approved dermal exposure factors, instead of the promulgated 1996 dermal exposure factors. Recalculating the RBCs using the dermal exposure factors valid for 1996 resulted in RBCs for PAHs that were identical to the 1996 U.S. EPA preliminary remediation goals (PRGs). Using the recalculated RBC values to estimate human health risk for CAOC 10 yielded the following results:

- Residential exposure scenario
  - ELCR: 2.9×10^{-4}
  - Risk driver(s): PAHs, greater than 74 percent of the cancer risk
- Industrial exposure scenario
  - ELCR: 7.0×10^{-5}
  - Cancer Risk driver(s): PAHs

The recalculated cancer risk for residential exposure exceeded the generally acceptable range, whereas the cancer risk for industrial exposure was in the middle of the range. For this reason, the risk for the site was considered potentially higher than acceptable for unrestricted exposure or residential land use, but acceptable for industrial land use. Table 3-7 lists the maximum detected concentrations of the COPCs, identifies the residential and industrial risk-based criteria used in the RI, and identifies the TLVs established for metals within the soils of CAOC 10.

Table 3-7. OU-2 CAOC 10 Maximum Detected Concentrations of COPCs

CAOC 10 COPC	Maximum Reported Conc.[1]	Residential Risk-Based Criteria		Industrial Risk-Based Criteria		TLV
		Cancer	Noncancer	Cancer	Noncancer	
SVOCs						
Acenaphthene	0.166	--	55.6	--	55.6	na
Anthracene	0.388	--	1.76	--	1.76	na
Benzo(a) Anthracene	2.718	0.391	--	1.23	--	na
Benzo(a) Pyrene	2.197	0.0391	--	0.123	--	na
Benzo(b) Fluoranthene	3.482	0.391	--	1.23	--	na
Benzo(g,h,i) Perylene	0.322	NA	NA	NA	NA	na
Carbazole	0.19	14.3	--	44.9	--	na
Chrysene	2.873	39.1	--	123	--	na
Di-n-Butylphthalate	3.359	--	3,900	--	32,000	na
Fluoranthene	4.132	--	1,560	--	12,800	na
Fluorene	0.044	--	47.6	--	47.6	na
Indeno (1,2,3-cd) Pyrene	1.531	0.391	--	1.23	--	na
Naphthalene	0.112	--	124	--	124	na
Phenanthrene	1.746	--	42	--	42	na
Pyrene	4.057	--	1,170	--	9,600	na
TPH						
Total Petroleum Hydrocarbons	25	--	--	--	--	na
Pesticides and PCBs						
4,4-DDE	0.002	0.66	--	1.86	--	na
dieldrin	0.00079	0.014	1.56	0.0395	11.3	na
endrin	0.00137	--	9.37	--	67.6	na
beta-benzene hexachloride	0.00067	0.158	--	0.499	--	na
Metals						
Aluminum	5,290	--	71,100	--	100,000	6,310
Arsenic	3.9	0.302	21.3	1.9	399	8.99
Barium	85.3	--	1,520	--	12,400	184
Beryllium	0.67	0.129	356	0.859	6,650	0.28
Cadmium	1.7	26.5	35.6	45.4	665	1.64
Chromium	11.2	--	71,100	--	100,000	25.1
Cobalt	3.7	--	4,540	--	29,600	7.31
Copper	5.5	--	2,630	--	49,200	5.83
Lead[2]	31	--	--	--	--	6.79
Manganese	176	--	136	--	1,180	157
Nickel	6.8	--	1,420	--	26,600	9.83
Selenium	0.63	--	356	--	6,650	1.9
Silver	0.78	--	356	--	6,650	1.14
Vanadium	22.3	--	498	--	9,310	26.9
Zinc	157	--	21,300	--	100,000	30.2

Based on summary information presented in Tables 2-1 through 2-5 of the OU-2 ROD (Uribe & Associates, 1997b).

All concentrations in milligrams per kilogram (mg/kg).

-- indicates that this constituent did not have cancer and/or noncancer toxicity.

NA indicates that no toxicity data were available at the time of the RI.

na indicates that a TLV was not applicable for the constituent.

nd indicates that no data were obtained for the TLV calculations.

XX indicates that the maximum detected concentration of the constituent exceeded this criterion.

[1] Maximum reported concentrations were based on information from the RI (JEG, 1996a).

[2] U.S. EPA Region IX residential and industrial soil screening levels for lead were 400 and 1,200 mg/kg at the time of the RI, respectively. Concentrations below these values were not considered to impact health.

4.0 REMEDIAL ACTIONS

This section discusses the results of events identified in the chronology, listed in Section 2, that define the remedies for OU-1 and OU-2, from the signing of the RODs to the present. The section discusses remedy selection, remedy implementation, and remedy performance, and identifies any changes to or problems associated with the components of the remedy. Table 4-1 provides a summary list of all sites including the type of site, the current status, and the past and present remedial actions associated with OU-1 and OU-2.

Table 4-1. Summary of IR Sites Associated with OU-1 and OU-2

Site ID	Operable Unit	Type of Site	Current Status (Active or Closed [Year Closed])	Remedial Actions Taken
Area 1	OU-1	Groundwater	Active	ICs, AS/SVE, VCT, MNA,
Area 2	OU-1	Groundwater	Closed [2006]	ICs, temporary AS/SVE, MNA
Area 3	OU-1	Groundwater	Closed [2006]	ICs, temporary AS/SVE, MNA
Area 6	OU-1	Groundwater	Closed [2003]	ICs, MNA
CAOC 1	OU-2	Soil	Active	ICs
CAOC 2	OU-2	Soil	Closed [1996]	NFA
CAOC 3	OU-2	Soil	Closed [1996]	NFA
CAOC 4	OU-2	Soil	Closed [1999]	Asbestos Remediation
CAOC 5	OU-2	Soil	Closed [1996]	NFA
CAOC 6	OU-2	Soil	Closed [1996]	NFA
CAOC 7	OU-2	Soil	Closed [1999]	Asbestos Remediation
CAOC 8A	OU-2	Soil	Active	ICs
CAOC 8B	OU-2	Soil	Closed [1996]	NFA
CAOC 9	OU-2	Soil	Closed [1999]	Asbestos Remediation
CAOC 10A	OU-2	Soil	Active	ICs
CAOC 10B	OU-2	Soil	Active	ICs
CAOC 11	OU-2	Soil	Closed [1996]	NFA
CAOC 12	OU-2	Soil	Closed [1996]	NFA
CAOC 13	OU-2	Soil	Closed [1996]	NFA
CAOC 14	OU-2	Soil	Closed [1996]	NFA
CAOC 15	OU-2	Soil	Closed [1996]	NFA
CAOC 16	OU-2	Soil	Closed [1996]	NFA
CAOC 17	OU-2	Soil	Closed [1996]	NFA
CAOC 18	OU-2	Soil	Closed [1996]	NFA

4.1 Remedial Actions for Operable Unit 1

This section discusses the remedy selection, the remedy implementation, and the remedy performance for OU-1 and identifies any changes to or problems with the components of the remedy.

4.1.1 OU-1 Remedy Selection. This section describes the purpose for remediation, the remedial alternatives developed and evaluated in the OU-1 FS (JEG, 1998a) against the nine

CERCLA evaluation criteria for remedial alternatives, and the remedy selected in the Final ROD (SWDIV, 2000).

4.1.1.1 OU-1 Remedial Action Objective. Remedial action objectives (RAOs) for all of the OU-l groundwater CHC plumes included containment of all the plumes within the facility boundary and to reduce groundwater contamination to meet applicable drinking water standards. Groundwater RAOs applicable for VOCs were established to ensure that any person exposed in the future would not be exposed to unsafe levels of CHCs. These RAOs were based on detailed analysis of chemical-specific applicable or relevant and appropriate requirements (ARARs) and health risk-based criteria that were consistent with the beneficial uses of the affected aquifer at the time of remediation and of its projected use.

4.1.1.2 OU-1 Applicable or Relevant and Appropriate Requirements. Federal drinking water standards were identified in the OU-1 ROD as applicable or relevant and appropriate chemical-specific requirements for the remediation of OU-1 groundwater plumes. The U.S. EPA had promulgated MCLs under the Safe Drinking Water Act (SDWA) to protect public health from contaminants that may be in drinking water sources (40 CFR, Part 141). Although these requirements were applicable only at the tap for water provided directly to 25 or more people or that would be supplied to 15 or more service connections, they were relevant and appropriate since the state of Arizona had designated all aquifers in the state as potential sources of drinking water (unless reclassification is obtained). Nonzero maximum contaminant level goals (MCLGs) were also relevant and appropriate to remedial actions that were required to meet drinking water standards. Federal MCLs and nonzero MCLGs were, therefore, chemical-specific ARARs for meeting RAOs.

State MCLs were the maximum permissible levels for treated groundwater delivered to users of water systems (§§ R18-4-205 and R18-4-211). They were applicable since the state of Arizona had designated all aquifers in the state to be potential sources of drinking water (Arizona Revised Statutes [ARS] § 49 through 224B). However, no state MCL equivalents (i.e., Aquifer Water Quality Standards [AWQS] for the State of Arizona) were more stringent than the federal MCLs or nonzero MCLGs.

While none of the groundwater extraction and treatment alternatives transfer treated groundwater to a public water-supply agency, the groundwater could be considered as a potential future drinking water supply. If the treated groundwater is to be used as a potable water supply, it would be considered an off-site, post-remedy activity and would have to comply with all legal drinking water requirements in existence at the time the water is used.

Portions of the Resource Conservation and Recovery Act (RCRA) groundwater protection standards contained in ARS Title 49 (Laws Relating to Environmental Quality) and Arizona Administrative Code (AAC) Title 18 were considered to be relevant and appropriate for the groundwater plumes being addressed by OU-l remedial actions because the hazardous constituents being addressed were similar or identical to those found in RCRA hazardous waste. In addition to concentration limits for groundwater, a groundwater-quality monitoring program was required to demonstrate the effectiveness of a corrective action program (40 CFR 264.100).

Discharge by industrial users to a publicly owned treatment works (POTW) was considered an off-site activity, which required compliance with the substantive and procedural requirements of the federal pretreatment program (40 CFR Part 403). In general, the discharges could not cause either a violation of any requirement of the POTW's National Pollutant Discharge Elimination System permit or prevention of sewage sludge use or disposal.

The SDWA provided federal authority over injection wells (42 U.S.C. § 300f et seq.). The Federal Underground Injection Control Plan prohibits injection wells such as those located at OU-l from causing a violation of primary MCLs in the receiving waters and adversely affecting human health (40 CFR § 144.12). The federal reinjection regulation states that contaminated groundwater that has been treated may be reinjected into the formation from which it was withdrawn if such reinjection was conducted pursuant to a CERCLA cleanup and was approved by the U.S. EPA (40 CFR § 144.13). These regulations were applicable to any OU-l treated groundwater that was reinjected into the aquifer.

RCRA Section 3020 was also applicable to the OU-l remedial actions. The RCRA states that the ban that prohibits the disposal of hazardous waste into a formation that contains an underground source of drinking water does not apply to the injection of contaminated groundwater into the aquifer if:

(1) such injection is part of a response action under CERCLA;

(2) such contaminated groundwater is treated to substantially reduce hazardous constituents before such injection; and

(3) such response action would, upon completion, be sufficient to protect human health and the environment (42 U.S.C. § 6939b).

Arizona's Aquifer Protection Permit Program would apply to the reinjection of treated groundwater (ARS § 49-243). Under this program, MCAS Yuma would implement best available demonstrated control technology, processes, operating methods, or other alternatives and include, where practicable, a technology permitting no discharge of pollutants; the facility must not cause or contribute to a violation of aquifer water quality standards at the applicable point of compliance (POC), or further degrade aquifer water quality with respect to a pollutant at the POC if the quality of the aquifer already violates the applicable aquifer water-quality standard for that pollutant.

4.1.1.3 OU-1 Selected Remedy. Twelve remedial alternatives were developed for OU-1 to address a range of responses from no action to active removal of contaminants from the groundwater. All of the alternatives were based on the Area 1 plume, which was the primary plume area requiring remediation. In the Hot Spot where the highest concentrations of VOCs were reported (i.e., downgradient of Building 230), more aggressive alternatives to decrease the contaminant mass in the source area (in addition to plume containment) were included to provide options that would reduce the overall timeframe required to meet the RAOs. Eight alternatives were retained for detailed analyses in the FS for OU-l (JEG, 1998a).

The selected remedy as defined in the Final OU-1 ROD (SWDIV, 2000) consisted of "containment of the LEPA by VCT, Hot Spot removal by AS/SVE, with ICs and potential

monitored natural attenuation (MNA) if the treatment systems do not reduce COC concentrations to MCLs" for the Area 1 plume and "ICs and MNA" for the Area 2, 3 and 6 plumes. The DON developed decision-making processes to evaluate the requirements for implementing contingency alternatives for both of the OU-1 selected remedies as well.

The major components of the selected Area 1 remedy included the following:

- Implement a groundwater containment/treatment system at the LEPA using a VCT system to prevent further off-site migration.
- Treat the groundwater at the Hot Spot in the vicinity of Building 230 with an AS/SVE system to reduce contaminant mass in the area and accelerate remediation time for the entire plume.
- Transport, regenerate, recycle, and/or dispose of spent granular activated charcoal (GAC) units associated with the operation of the VCT and AS/SVE systems.
- Perform groundwater modeling to demonstrate that VOC concentrations will reach the base boundary equal to or less than MCLs. If so demonstrated, then MNA will be performed to verify VOCs are approaching MCLs.
- Implement ICs to restrict access to contaminated groundwater. Amend the MCAS Yuma Master Plan to reflect groundwater access and use restrictions, including contamination that has moved off MCAS Yuma, and established mechanisms to control changes that would not interfere with or adversely affect remedial actions.
- Implement an LTM plan, which includes MNA of COCs in the portions of Area 1 where active remediation (i.e., remedial system operations) was not taking place, and evaluate the results to determine the effectiveness of the selected remedies.
- Implement an institutional control plan (ICP) to facilitate training and education of personnel involved with the enforcement of the required ICs. The ICP documents all of the required institutional and engineering controls as well as details the procedures for any required monitoring programs. The ICP also documents procedures for the review of digging and building permits, establishes procedures for ensuring regular checks and balances are in place, includes provisions for annual review (and updates as necessary) of the MCAS Yuma Master Plan, and provides for inspection and enforcement measures to ensure that the required ICs are correctly implemented and enforced. Additionally, the ICP establishes procedures that require the regulatory agencies to be notified in the event any major change in land use is proposed.
- Remediate all contaminated groundwater to MCLs (i.e., 7 µg/L for 1,1-DCE, 5 µg/L for TCE, and 5 µg/L for PCE).
- Terminate system operation (refer to Termination Criteria below).

The major components of the selected Area 2, 3 and 6 remedy included the following:

- Implement ICs on MCAS Yuma.

- Implement a LTM plan that includes MNA of COCs (i.e., 1,1-DCE, TCE and PCE) in selected groundwater monitoring wells.
- Close areas when COCs achieve MCLs for two consecutive years (refer to Termination Criteria below).

To ensure protection of human health and the environment, ICs were required to restrict access to OU-1 contaminated groundwater and prevent its use on MCAS Yuma. The DON was required to provide county agencies with information of any off-station groundwater contamination associated with Area 1 at the time of the ROD.

Stipulations were provided in the ROD for written concurrence to be obtained from the FFA team for any actions taken that were inconsistent with the prohibited groundwater use. Also, if the DON intended to excess the property, it must notify the ADEQ and U.S. EPA in advance of the execution of any transfer. The DON would again consult with the ADEQ and U.S. EPA in revisiting the existing land use classification and restrictions for the areas involved to determine if the foreseeable future land use would differ from the assumptions made at the time of the ROD. A reevaluation of the ICs would be performed if necessary at that time.

The MCAS Yuma Master Plan was required to be amended to: prohibit the use of groundwater from OU-1; describe the risk to human health and the environment of contaminated groundwater use; and, reference the OU-1 ROD.

4.1.1.4 OU-1 Termination Criteria. Criteria for termination of the groundwater containment/treatment systems for OU-1 Area 1 were defined in the ROD (Sections 2.13.1.4. and 2.13.2. of SWDIV, 2000) and summarized below.

Selected monitoring wells located both upgradient and downgradient of the groundwater treatment systems would be monitored during the remedial action in accordance with the LTM plan. The DON would evaluate the results to verify that the remedial systems were effectively containing and treating the plume and, in the case of AS/SVE, to verify that the systems were effectively reducing contaminant mass in the treatment area. The groundwater containment/treatment systems would remain in operation until one of the following criteria was reached:

(1) Representative groundwater concentrations measured in the designated wells upgradient and downgradient of the VCT system had achieved groundwater cleanup standards (MCLs).

(2) Remaining CHC concentrations in Area 1 groundwater would reach the station boundary at concentrations equal to or less than MCLs. (This would require groundwater modeling results indicating that remaining contaminants above MCLs would reach the station boundary at concentrations equal to or less than MCLs followed by MNA to remedy the remaining VOCs). Modeling would be performed only after CHC concentrations upgradient and downgradient of the VCT system had reached MCLs. After MCLs were attained and the VCT system had been temporarily

shut down, if CHCs rebounded above MCLs, modeling would be performed to determine whether CHCs would reach the station boundary at or below MCLs.

(3) The AS/SVE system was no longer removing mass (i.e., asymptotic condition was permanently reached) after system optimization. Modeling of the Hot Spot would also be required, indicating CHCs would reach the station boundary at or below MCLs to terminate operation of the VCT well system.

The DON would demonstrate the above conditions through collection of groundwater samples from the monitoring wells designated in the LTM plan. When the monitoring data indicated that any of the above conditions had been met, the DON could propose a temporary shutdown of the remediation system. Shutdown would be subject to U.S. EPA and ADEQ concurrence. The groundwater LTM program would continue for a period of up to 2 years. If it was demonstrated in this period that the representative groundwater concentrations of CHCs met the groundwater cleanup standards, the parties agreed that the system operation would be shut down permanently.

If, during temporary shutdown of the remediation system, monitoring wells upgradient from the base boundary indicated a rebound in VOC concentrations to above MCLs, operation of the remediation system would be restarted. The DON could then attempt to demonstrate through groundwater modeling that remaining groundwater contaminants would reach the station boundary at concentrations equal to or less than MCLs. Groundwater modeling results would be subject to U.S. EPA and ADEQ concurrence. If demonstrated, the DON could then propose permanent shutdown of the remediation system, subject to U.S. EPA and ADEQ concurrence. MNA of the Area 1 plume would be implemented to confirm VOCs were approaching MCLs. If MNA was not progressing adequately, the remediation system would be operated as needed.

If it was determined that criteria 1 and 2 could not be met, the DON would demonstrate that VOCs in groundwater had been removed to the extent technically and economically feasible as set forth in item 3, by analyzing the following:

(1) Whether the mass removal rate was approaching asymptotic levels after temporary shutdown periods and appropriate system optimization,

(2) The additional cost of continuing to operate the system at concentrations approaching asymptotic mass levels,

(3) Whether discontinuing the system would significantly prolong the time to attain the groundwater cleanup standard.

The criteria for closure at Areas 2, 3 and 6 included demonstration that MCLs had been met at the sites through at least two years of quarterly groundwater monitoring as specified in the LTM plan. If monitoring indicated that MCLs had not been met in accordance with these criteria, the groundwater monitoring would continue until MCLs were achieved. When monitoring indicated that VOC concentrations had decreased to MCLs, the LTM program would continue for a minimum of two additional years. If there was no significant rebound in VOC concentrations above MCLs, the DON could propose that the LTM program be terminated.

Discontinuation of the LTM as well as closure of the individual OU-1 areas (i.e., Areas 1, 2, 3 and 6) would require U.S. EPA and ADEQ concurrence. ICs for each area would also be maintained until the individual areas had met the closure criteria with concurrence by U.S. EPA and ADEQ. Following the closure of an individual area, the ICs for that area would no longer be required. Five-Year Reviews would also be required for all active areas undergoing remediation until cleanup standards (i.e., MCLs) have been achieved.

4.1.2 OU-1 Remedy Implementation. The following sections discuss the steps taken post-ROD to implement the remedies selected for OU-1 Area 1 (containment plus Hot Spot removal by AS/SVE) and Areas 2, 3 and 6 (ICs and MNA) at MCAS Yuma.

4.1.2.1 Area 1 Containment and Removal Systems. Implementation of the remedy for OU-1 began with the installation of the AS/SVE system in the Building 230 area of OU-1 Area 1 in June 1999. The AS/SVE system combined two technologies: an air sparge (AS) system and a soil vapor extraction (SVE) system. The AS system was composed of 46 AS wells, configured in five banks (i.e., Rows 29, 39, 49, 59, and 70; shown in Figure 4-1), designed to inject air into the phreatic (or saturated) zone to strip VOCs from groundwater. The SVE system was composed of 15 SVE wells designed to create a vacuum in the vadose (or unsaturated) zone, capture the sparge air and soil vapor, and remove the stripped contaminants from the subsurface. The contaminated vapor stream would then be treated above ground using a GAC system prior to discharge to the atmosphere.

A blower rated at 400 cubic feet per minute (cfm) was installed to deliver the injection air to the AS wells, while the SVE system used a separate blower, rated at 500 cfm, to extract sparge air and soil vapors from the extraction wells. The injection and extraction blowers, the vapor treatment system, and associated equipment were contained in a treatment compound located west of Building 230. The operation of the AS/SVE system is described in detail in the Addendum to the Final Operation and Maintenance (O&M) Manual (Battelle, 2004c). The AS/SVE system began operation on November 16, 1999, which represents the triggering action of the five-year review process. A schematic diagram of the AS/SVE system is included in Appendix B1.

The VCT system consisted of four injection wells and four extraction wells located in the LEPA of OU-1 Area 1 (Figure 4-2). Submersible pumps in each extraction well were designed to extract groundwater at a flowrate of 30 to 40 gallons per minute (gpm). The extracted groundwater was pumped through various holding tanks and bag filters before being treated with GAC. The VCT GAC was designed to remove organic chemicals (e.g., 1,1-DCE, TCE, PCE, etc.) from the groundwater. After the water had passed through the GAC units, the treated water would be pumped back into the aquifer through the four injection wells, each at a flowrate of 40 gpm. The operation of the VCT system is described in detail in the Addendum to the Final O&M Manual (Battelle, 2004c). The VCT system began operation on June 16, 2000. A schematic diagram of the VCT system is included in Appendix B2.

4.1.2.2 OU-1 Long Term Monitoring Plan. The LTM plan was initiated in 1999 (OHM Remediation Services Corp., 1999b) and was finalized in June 2002 (BNI, 2002). The LTM plan formalized the list of monitoring wells that would be sampled on an annual, semi-annual, and

quarterly basis; outlined the groundwater monitoring and sampling methods to be used; and established a schedule of reporting the monitoring results. One of the plan objectives was to select monitoring wells necessary to assess the status of the groundwater plumes. Many of the wells at MCAS Yuma were installed for site characterization and for RI and FS studies. Consequently, many wells have demonstrated non-detection and offer no meaningful information on plume status. The LTM plan evaluated the well layout and identified wells necessary to track contamination. The plan originally called for sampling in 31 wells on a quarterly basis and 63 wells on a semiannual basis. Most of the wells were clustered in the Building 230 area, where contamination levels were highest, and the LEPA area, where the possibility of off-station migration existed.

4.1.2.3 MCAS Yuma Master Plan. The MCAS Yuma Master Plan contains a detailed review of all physical conditions, resources, and tenant commands present at MCAS Yuma and the planned development of the station in the foreseeable future. The MCAS Yuma Master Plan was developed to support the MCAS Yuma mission and implement the station's strategic plan. In order to control the areas of potential risk from exposure to groundwater contamination at OU-1 Areas 1, 2, 3 and 6 and ensure that future land use would not result in unacceptable levels of risk to human health or the environment, the necessary restrictions were presented in a revision to the MCAS Yuma Master Plan. The MCAS Yuma Master Plan was revised in September 2001 (KTUA, 2001) and again in November 2007 (KTUA, 2007) to contain the ICs for OU-1 as identified in the Final OU-1 ROD (SWDIV, 2000). Figure 3-3 (based on Figure 5-16 of the updated MCAS Yuma Master Plan [KTUA, 2007]) shows the locations of the OU-1

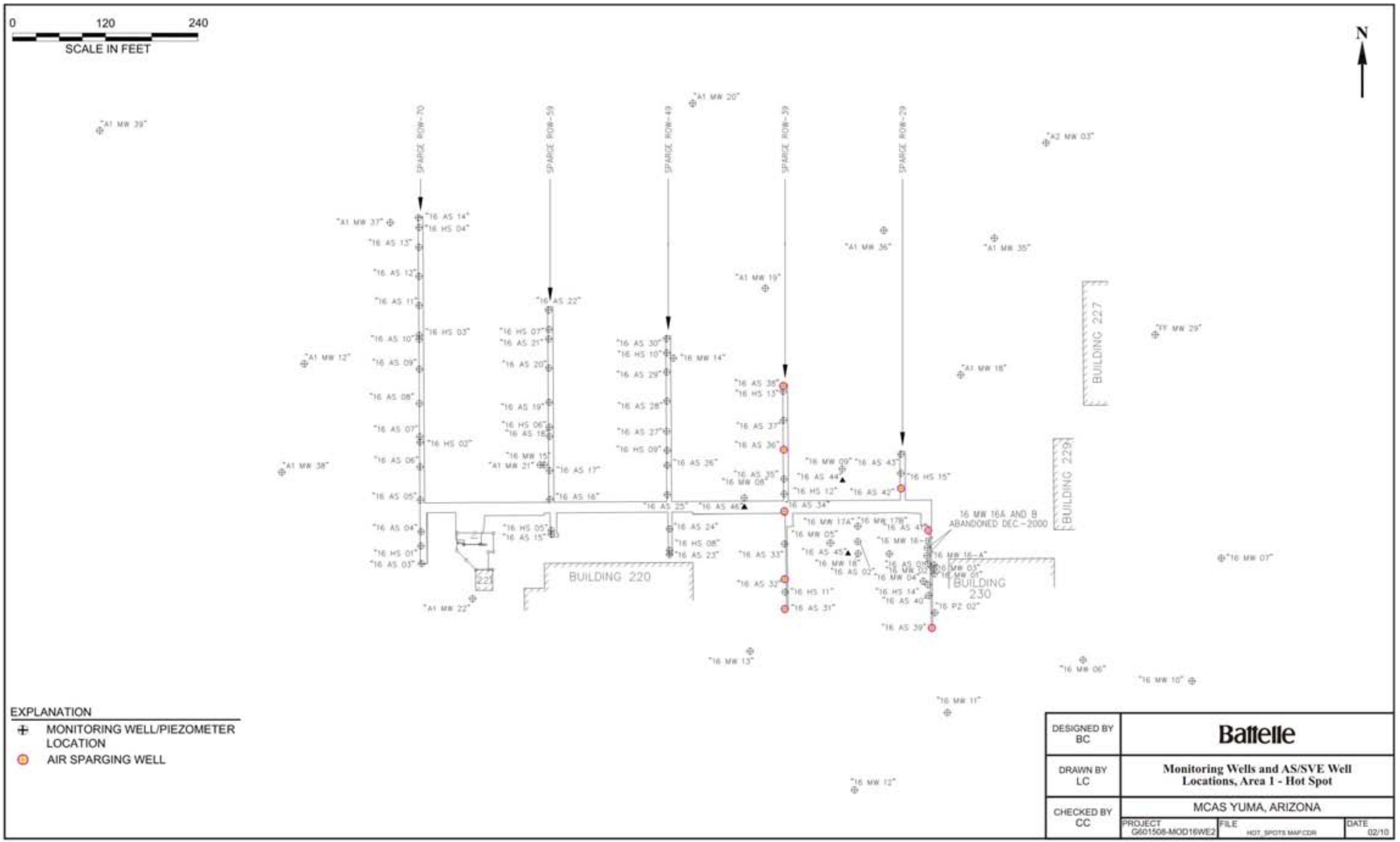

Figure 4-1. OU-1 Area 1 Hot Spot Monitoring Well and AS Well Map

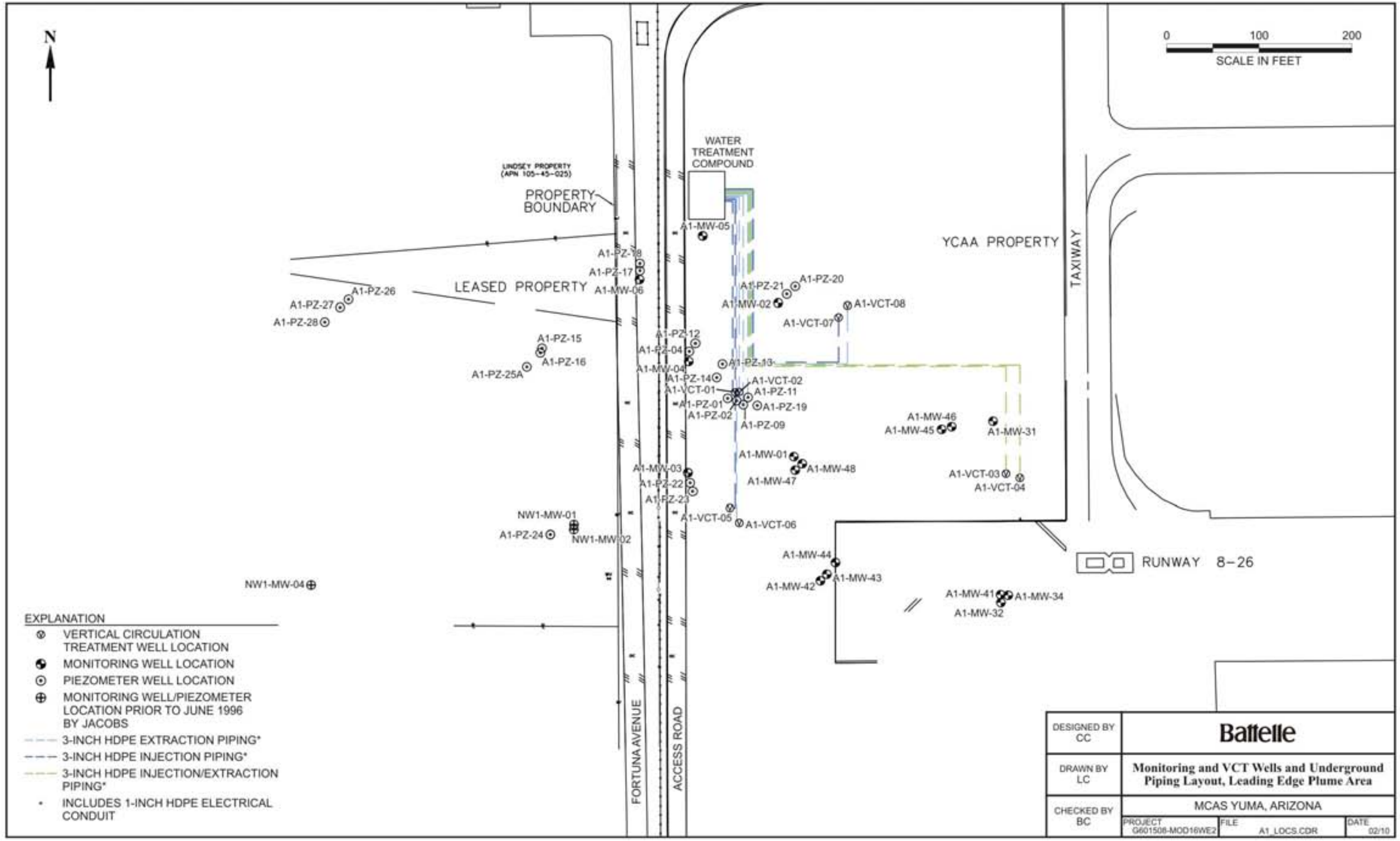

Figure 4-2. OU-1 Area 1 LEPA Monitoring Well and VCT Well Map

areas and the boundaries of the required ICs.

4.1.2.4 Land Use Control Implementation Plan. The Final LUCIP was issued in September 2002 (SWDIV, 2002a) and addressed all DON, U.S. EPA, and ADEQ comments on the Draft (Revision 1) LUCIP that was issued on December 20, 2001 (Appendix B3). MCAS Yuma Station Order 5090 was issued on January 10, 2002, informing station tenants of the land use restrictions for OU-1 and implementing the other LUCs provided in the Draft LUCIP (Appendix B4). The Draft (Revision 1) LUCIP was originally issued as an addendum to the Master Plan to provide steps for implementation and monitoring of ICs at OU-1 and other station areas. Figure 3-3, based on Figure 2-1 of the Final LUCIP (SWDIV, 2002a), shows the locations of the OU-1 areas and the boundaries of the required ICs.

As stated in the ROD (SWDIV, 2000), LUCs were applied to OU-1 as follows:

- LUCs implemented at OU-1 are to remain throughout the duration of the remedial actions to restrict the use of contaminated groundwater.
- LUCs are not required for soil excavation for utility trenches or building construction.
- MCAS Yuma tenants and assigned organizations will comply with all of the LUCs in force at MCAS Yuma.
- MCAS Yuma tenants and assigned organizations will not use contaminated groundwater underlying the designated plume areas for any purpose including but not limited to: drinking water, irrigation, fire control, dust control, or any other activity.
- MCAS Yuma tenants and assigned organizations will not damage or interfere in any way with groundwater monitoring wells, remedial treatment systems, and/or sampling efforts. Access to monitoring wells, remedial treatment systems, and sampling efforts will be permitted to regulatory agency personnel and individuals specifically contracted by the DON and the MCAS Yuma Environmental Department to perform activities related specifically to the use and maintenance of such wells, systems, and sampling efforts. Access to monitoring wells, remedial treatment systems, and sampling efforts will not be permitted to other MCAS personnel unless specifically authorized by the MCAS Yuma Environmental Department. Access will be required for equipment, including trucks, small loaders, and drill rigs. Alteration or destruction of monitoring wells or remedial treatment systems will require approval from the MCAS Yuma Environmental Department, U.S. EPA, and ADEQ.
- Within 5 working days of discovery, MCAS Yuma tenants and assigned organizations will provide the MCAS Yuma Environmental Department with written notice of failure to comply with the LUCs.
- No later than December 31 of each year, MCAS Yuma tenants and assigned organizations will provide a written report to the MCAS Yuma Environmental Department describing compliance with prohibition of the use of groundwater underlying designated plume areas. A Station Order has been developed to ensure tenant commands comply with LUCs and the Station Order will define requirements for reporting to the MCAS Yuma Environmental Department. In addition, the Station Order will establish authority to enforce by the MCAS Yuma Commanding Officer.

Along with the LUC components bulleted above, OU-1 areas are surrounded by fencing which effectively limit access to the areas.

4.1.3 OU-1 System Operations & Maintenance. This section discusses the O&M activities associated with the remedial systems and the LTM program for OU-1.

4.1.3.1 Area 1 AS/SVE System O&M. The AS/SVE system began operation on November 16, 1999 and operated relatively continuously, except for maintenance and monitoring interruptions, until May 9, 2007, when the system was placed on temporary shutdown, with U.S. EPA concurrence. Before November 2002, the system was operated in a phased approach, whereby the sparged air was alternately directed into the different sparge rows of the well field. Typically, Rows 29, 39, and 59 (see Figure 4-1) were operated together, and Rows 49 and 70 were operated together for alternating 1-month periods. This injection pattern was used to increase the effectiveness of the system by allowing reestablishment of the natural groundwater gradient at the rows that were not operating, thus allowing groundwater to move through the well field. During the time period between November 2002 and temporary system shutdown in May 2007, air injection was focused on the eastern portion of the site, where elevated contaminant concentrations were persistent. This air injection was through Rows 29, 39, and 49 in an attempt to enhance VOC removal in the area. Soil vapor samples were periodically collected and analyzed by U.S. EPA method TO-14 prior to the GAC treatment to monitor system performance, demonstrate air emission compliance, and calculate the cumulative VOC mass removed.

On August 16, 2006, the DON submitted a letter to U.S. EPA and ADEQ, proposing temporary shutdown of the AS/SVE system of Area 1. The request was supported by a technical memorandum demonstrating that the AS/SVE system was no longer removing sufficient mass to justify the continued operation of the system. Further, the technical memorandum described how the temporary shutdown requirements of the ROD (SWDIV, 2000) had been satisfied. Concurrence for shutdown of the Area 1 AS/SVE system was received from U.S. EPA on January 8, 2007 (Appendix B5). The Navy submitted a second letter to ADEQ, with the U.S. EPA concurrence attached, stating that ADEQ concurrence with temporary shutdown of the AS/SVE system would be assumed unless ADEQ responded otherwise within 10 days. No response was received from ADEQ.

The AS/SVE system was placed in temporary shutdown on May 9, 2007 and currently remains in temporary shutdown status. Based on soil vapor sampling associated with the AS/SVE system, approximately 79 lb of COCs were removed from the subsurface between system startup and temporary shutdown. The total mass removal rate remained relatively consistent between January 2002 and temporary shutdown.

4.1.3.2 Area 1 VCT System O&M. The VCT system began operation on June 16, 2000 and operated relatively continuously except for routine maintenance and monitoring, such as replacement of filters and pumps. In September 2002, it was noted that injection well VCT-01 and extraction well VCT-06 were not operational due to a collapsed well casing and a faulty pump, respectively (see Figure 4-2). Consequently, the system was operated in three injection

wells and three extraction wells from September 2002 to May 2003. Process water samples, both influent and effluent, were collected during VCT system operation. MCLs were never exceeded in the effluent samples.

On February 24, 2003, the DON submitted a letter to U.S. EPA and ADEQ, proposing the temporary shutdown of the VCT system at the LEPA of Area 1. The request was supported by a technical memorandum describing how temporary shutdown requirements of the ROD had been satisfied for the VCT system at the LEPA. Concurrence for the temporary shutdown of the VCT system was received from U.S. EPA on April 24, 2003, and from ADEQ on April 25, 2003 (Appendix B6). The VCT was placed in temporary shutdown on May 6, 2003, following concurrence by U.S. EPA and ADEQ.

The analytical results from the influent and effluent water samples were used to calculate VOC mass removal by the VCT system. In May 2003 (when the system was placed in temporary shutdown), an estimated 10.7 lb of total mass had been removed from the 136,591,146 gallons of extracted groundwater since system startup. Recent activities associated with the Area 1 VCT system are provided in Section 5.1.3.

On September 6, 2005, the DON submitted a letter to U.S. EPA, proposing permanent shutdown of the VCT system of Area 1. The request was supported by a technical memorandum demonstrating that the COCs in groundwater in the vicinity of the VCT system had remained at or below MCLs for a period greater than 2 years. Groundwater modeling had also demonstrated that remaining CHC concentrations would not migrate off-station above the MCLs. The letter described how the permanent shutdown requirements of the ROD (SWDIV, 2000) had been satisfied. Concurrence for shutdown of the Area 1 VCT system was received from U.S. EPA on December 1, 2005 (Appendix B7). The VCT system was permanently shutdown in December 2005 and currently remains in the permanent shutdown status.

4.1.3.3 Area 1 Groundwater Monitoring. Groundwater monitoring has been performed in Area 1 since remedial actions began. The LTM program has maintained quarterly monitoring events whereby select wells have been monitored for standard water quality parameters and MNA parameters. During the monitoring events, groundwater samples have been collected for laboratory analysis of VOC concentration using U.S. EPA method 8260. The sampling results have been described in quarterly progress and groundwater reports since system startup in 1999.

OHM Remediation Services Corp. initially installed and operated the remedial systems of Area 1 in 1999 and provided groundwater monitoring through September 2000. GEOFON, Inc. was responsible for OU-1 environmental activities from October 2000 to September 2001. Terra Vac assumed responsibility for OU-1 environmental activities from October 2001 to September 2002. Battelle was contracted to perform environmental activities from October 2002 through September 2009. Most recently, Trevet, Inc. has been contracted for the continued groundwater monitoring program beginning in December 2009. The quarterly, semiannual and annual reports are reviewed by the MCAS Yuma Environmental Department and regulators. If any significant changes in plume status are detected, additional wells may be sampled.

Historical and current concentrations of 1,1-DCE, TCE, and PCE in the Hot Spot and LEPA areas of OU-1 Area 1 are shown in Figures 4-3 and 4-4, respectively, while Figure 4-5 shows the current (June 2009) sampling results for the COCs at wells throughout Area 1. Concentrations exceeding the MCL for each COC on the historical and current maps are highlighted in yellow. Figure 4-6 presents a contour map of 1,1-DCE concentrations at Area 1, with a time-series of contours based on semi-annual sampling event results from June 2003, 2005, 2007, and 2009. Similar time-series contours of TCE concentrations are presented in Figure 4-7. Contour maps were not prepared for PCE due to the consistent, below-MCL concentrations observed throughout the five-year review period. Recent activities associated with the Area 1 LTM plan, including the current groundwater sampling schedule, are provided in Section 5.1.3.

4.1.3.4 Area 1 Groundwater Modeling. Groundwater fate and transport modeling was updated for the Area 1 plume to evaluate the effects of the VCT and AS/SVE remediation systems on the behavior of the plumes (BNI, 2002; Battelle, 2004a). An eight-layer flow model that simulated the geologic and hydrologic conditions at the site was prepared. Natural attenuation processes were included in the model using site-specific monitoring and sampling data. In general, the models confirmed historical monitoring results showing that the plumes are slow-moving and are decreasing in size and magnitude. Predictive simulations demonstrated that the plumes would not migrate offsite at concentrations greater than MCLs (Battelle, 2004a).

4.1.3.5 Area 2 Groundwater Monitoring. The Area 2 plume consisted of an isolated zone of mainly 1,1-DCE in the groundwater at low concentrations near the MCL. MNA was selected as the remedy for the Area 2 plume. The LTM program (BNI, 2002) originally monitored 12 wells at the site to evaluate contaminant concentrations and identify and monitor other chemical indicators associated with MNA. Monitoring was performed on a quarterly basis from March 1998 to March 2006, under various contractors (see Area 1 Groundwater Monitoring above). In addition to the MNA activities, a small temporary AS/SVE system was installed in the Area 2 plume in September 2000, but was deemed unnecessary due to the low CHC concentrations.

On March 12, 2006, the DON submitted a letter to U.S. EPA and ADEQ, proposing site closure and an end of LTM at Area 2. The request was supported by a technical memorandum describing how the closure requirements of the ROD had been satisfied at Area 2. Verbal concurrence for closure of Area 2 was received from U.S. EPA on March 30, 2006, followed by a letter dated May 23, 2006 (Appendix B8). The Navy submitted a second letter to ADEQ, with the U.S. EPA concurrence attached, stating that ADEQ concurrence with closure of Area 2 would be assumed unless ADEQ responded otherwise within 10 days. No response was received from ADEQ.

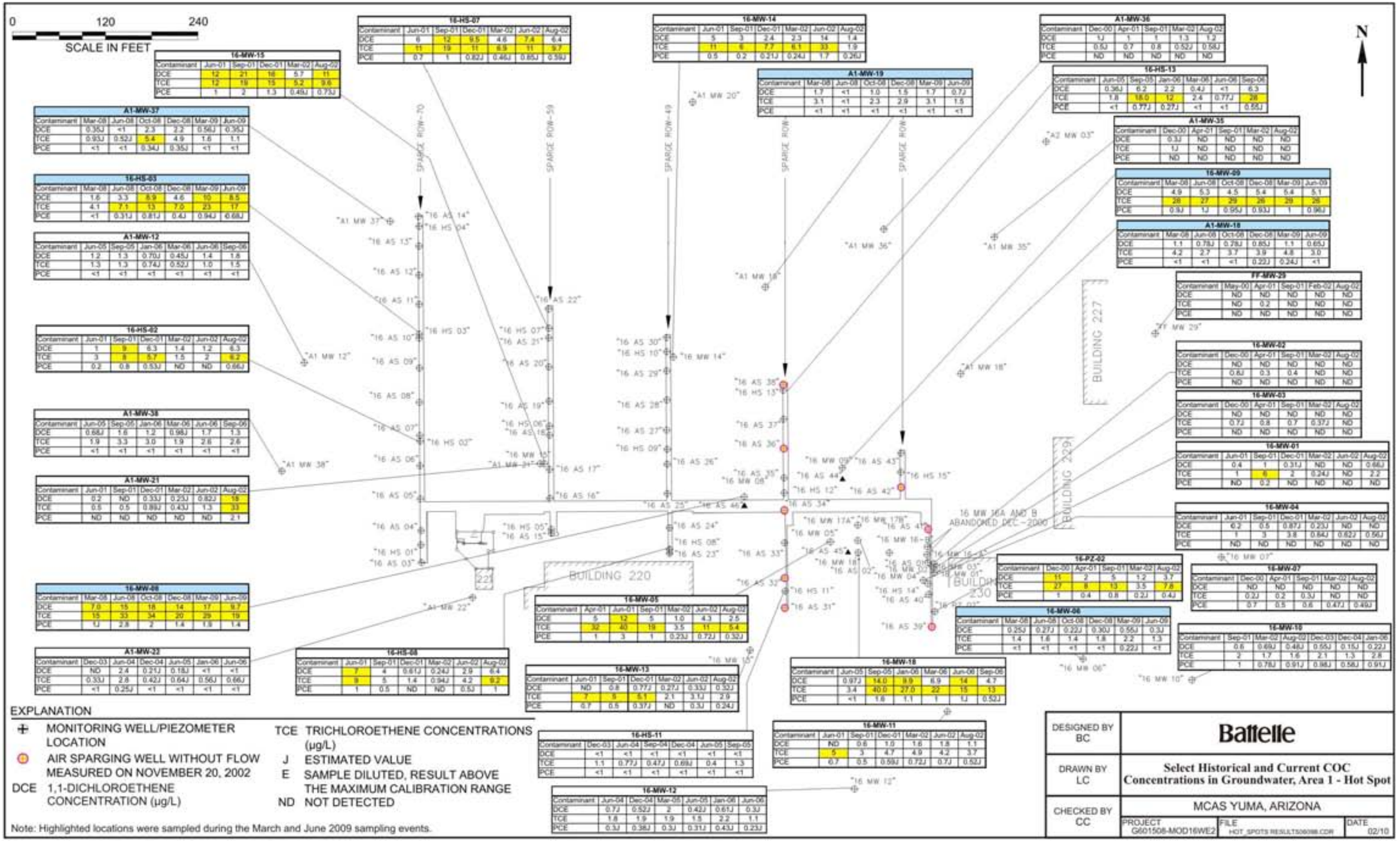

Figure 4-3. Historical Concentrations of 1,1-DCE, TCE, and PCE in the OU-1 Area 1 Hot Spot

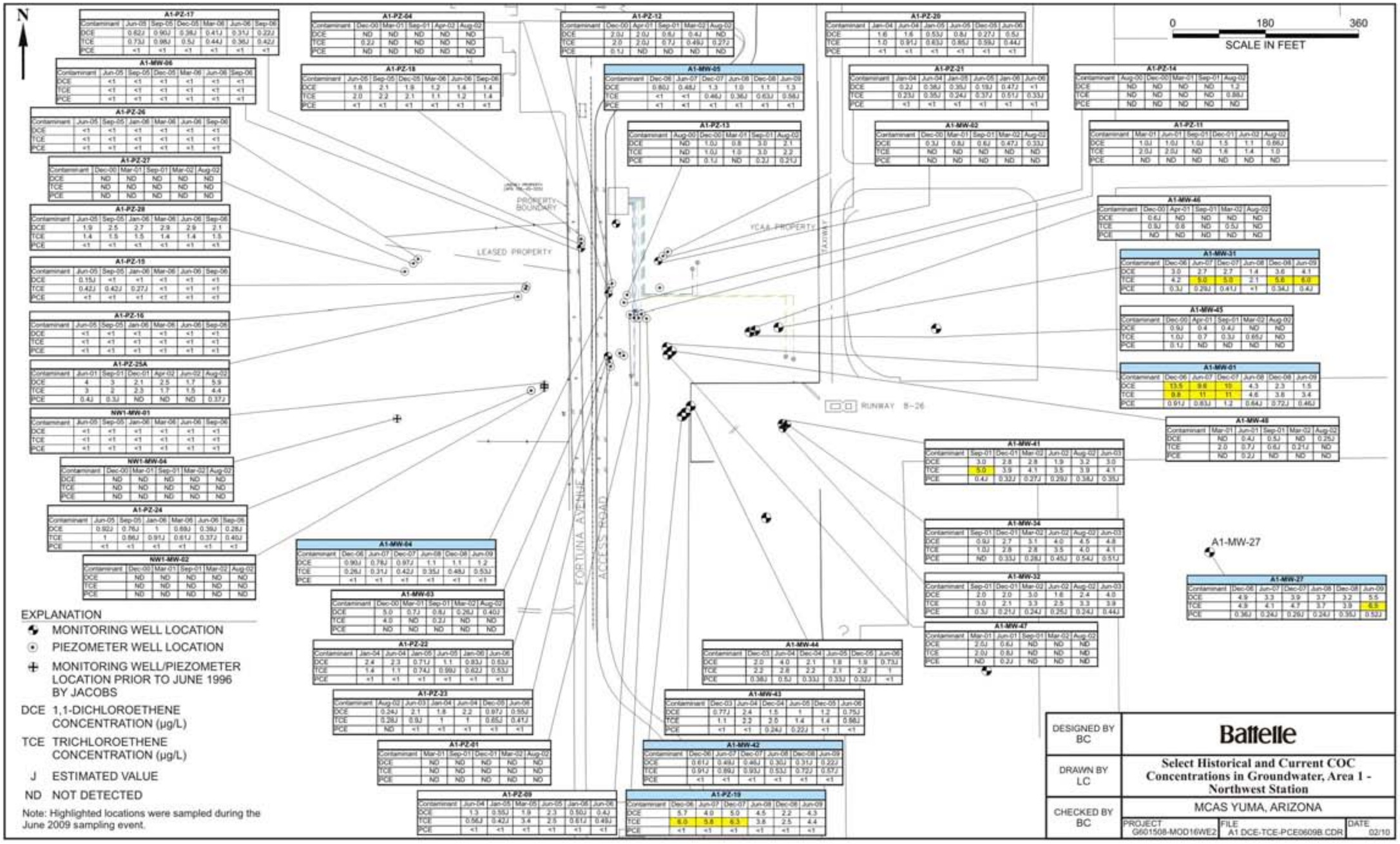

Figure 4-4. Historical Concentrations of 1,1-DCE, TCE and PCE in the OU-1 Area 1 LEPA

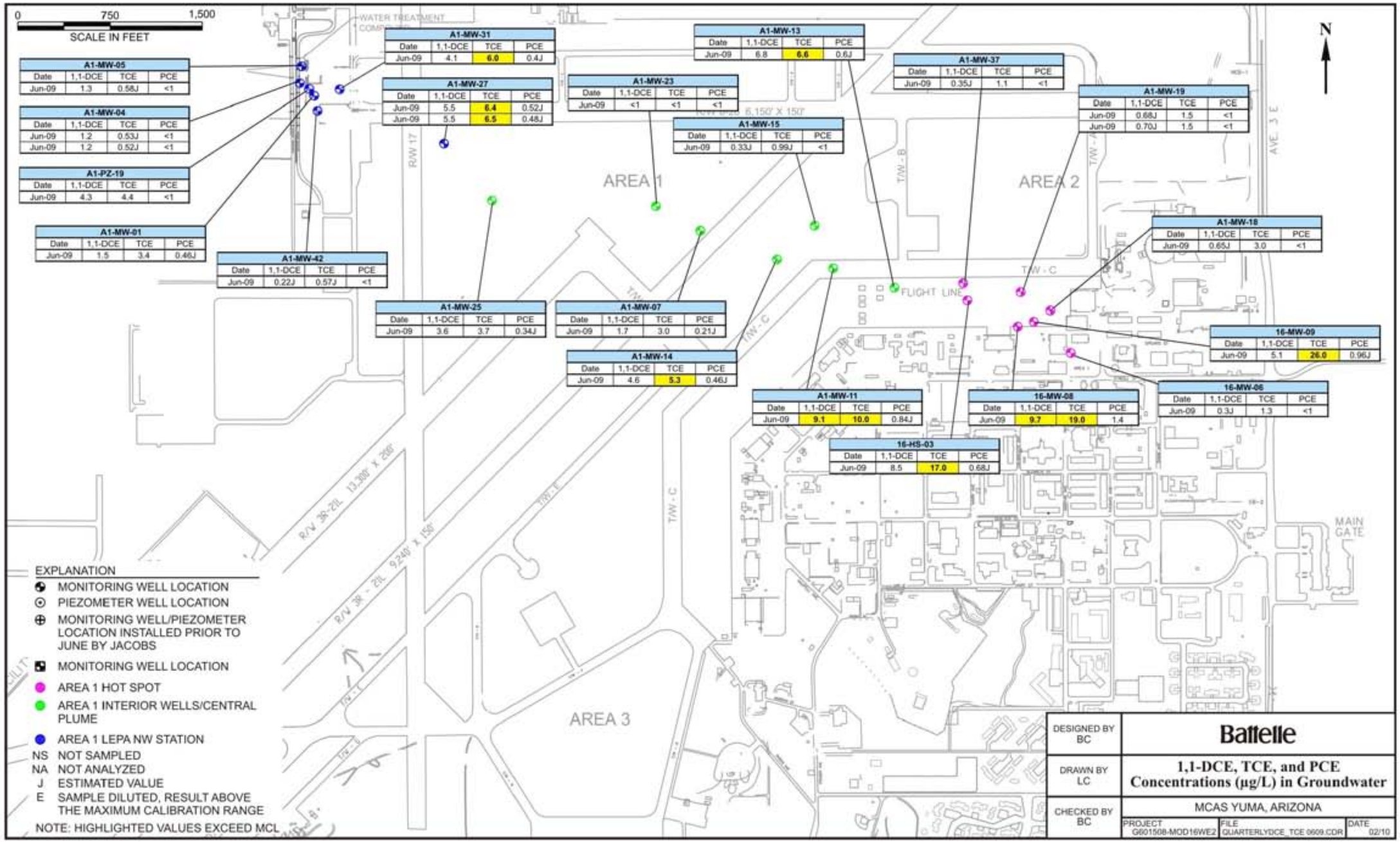

Figure 4-5. Current Concentrations of 1,1-DCE, TCE and PCE in OU-1 Area 1

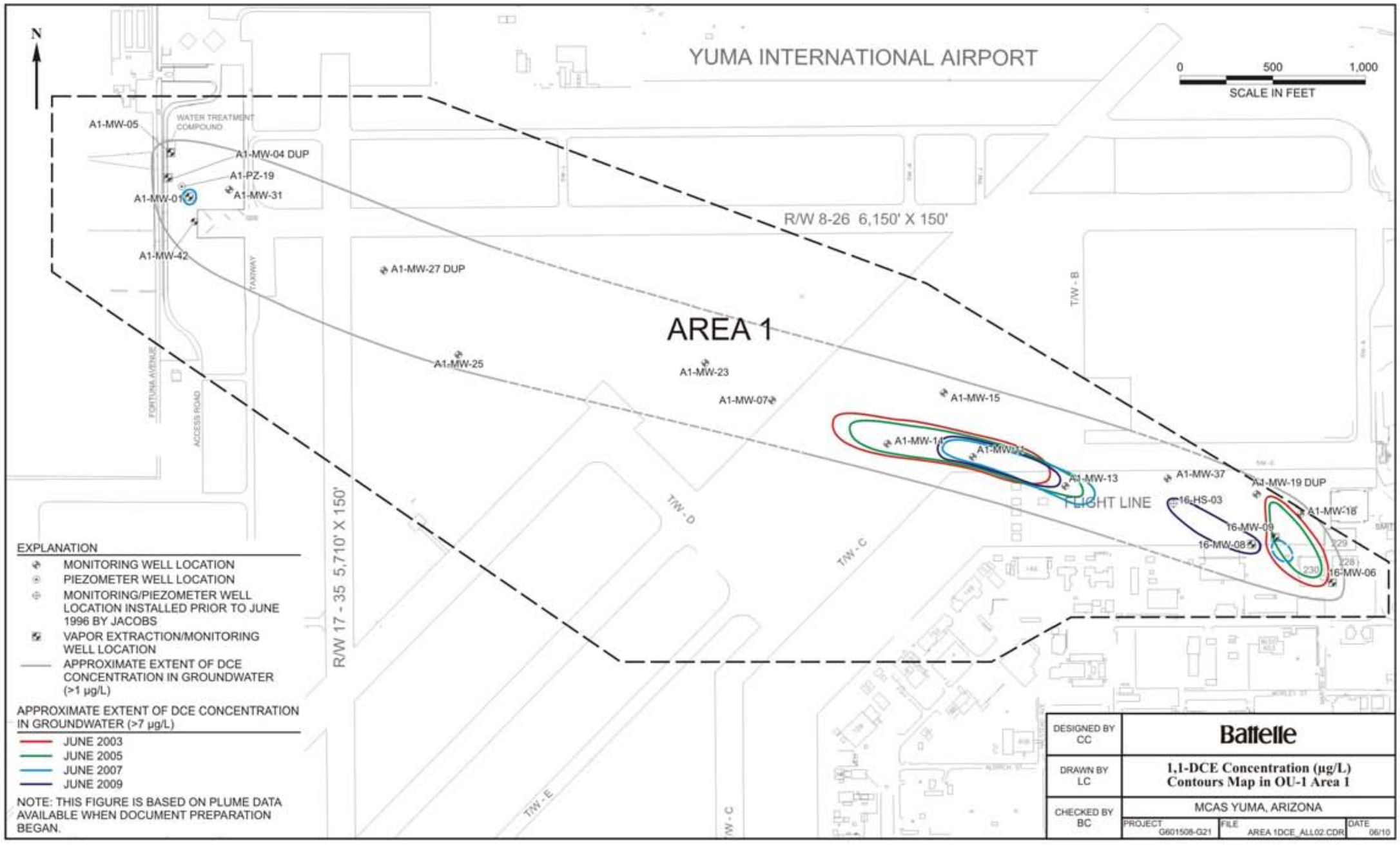

Figure 4-6. Current and Historical Contour Map of 1,1-DCE Concentrations in OU-1 Area 1

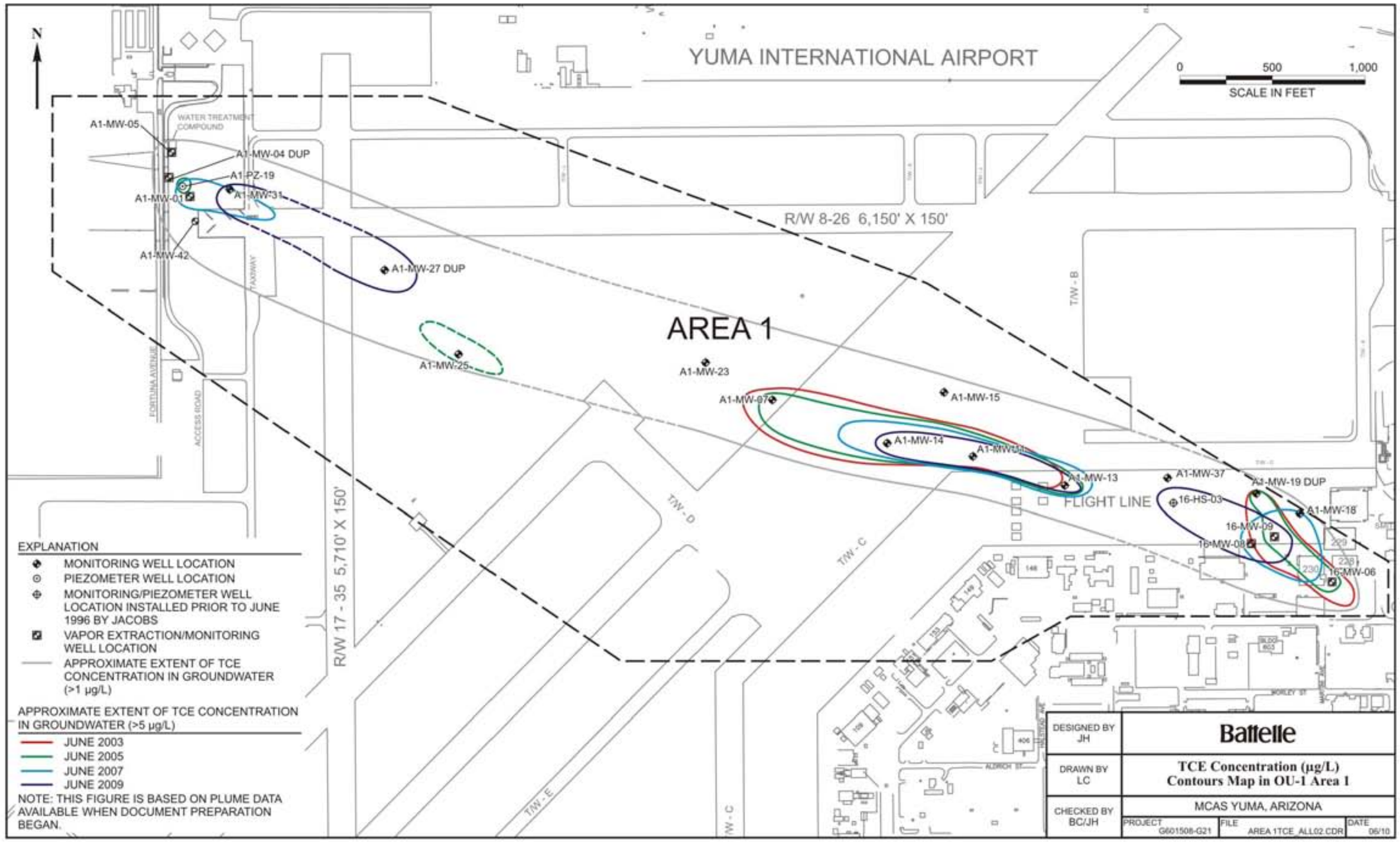

Figure 4-7. Current and Historical Contour Map of TCE Concentrations in OU-1 Area 1

Following the concurrence from U.S. EPA, Area 2 was considered closed with NFA required. All Area 2 wells were decommissioned between August 2, 2006 and August 11, 2006 as outlined in the *Well Abandonment Report for Wells at Area 2, Area 3 and Subarea 5A, Marine Corps Air Station Yuma, AZ* submitted on 20 November 2006 (Battelle, 2006b).

4.1.3.6 Area 3 Groundwater Monitoring. The Area 3 plume consisted of TCE and 1,1-DCE in groundwater at low concentrations near MCLs. MNA was selected as the remedy for the Area 3 plume. The LTM program (BNI, 2002) originally monitored 10 wells at the site to evaluate contaminant concentrations and identify and monitor other chemical indicators associated with MNA. Monitoring was performed on a quarterly basis from March 1998 to December 2005, under various contractors (see Area 1 Groundwater Monitoring above). In addition to the MNA activities, a small temporary AS/SVE system was installed in the Area 3 plume in September 2000, but was deemed unnecessary due to the low CHC concentrations.

Following the identification of free product in Area 3 monitoring well A3-MW-07 in December 2001, the DON developed a two-phased approach for investigation of the free product in a Technical Memorandum submitted to the ADEQ and U.S. EPA on January 6, 2004. The first phase of the investigation was completed in 2004 and included document review, free product sampling and analysis, a free product removal action, and post-removal monitoring. The findings of the first phase of the investigation were documented in the *Report for Investigation of the Presence of Free Product, Monitoring Well A3-MW-07, Marine Corps Air Station (MCAS) Yuma, AZ* (Battelle, 2004d). The information gathered during the first phase of the investigation indicated that further investigation was necessary, and the report recommended that the second phase of the investigation (as described in the Technical Memorandum of January 2004) should be implemented.

A work plan was finalized in February 2005 (Battelle, 2005a) and described the actions to be performed under the second phase of the investigation in greater detail than was originally provided in the Technical Memorandum and the Phase I report. The objectives of the second phase of the investigation were to further delineate the contamination and determine the source of free product found within well A3-MW-07 by: performing a down-well video survey of the well; conducting a geophysical survey to identify any undiscovered drums, tanks or pipelines; collecting vadose zone soil and shallow groundwater samples from 15 locations near the well; and analyze soil and groundwater samples for VOC and TPH concentrations.

The results of the second-phase investigation at MCAS Yuma Area 3 adequately delineated the subsurface contamination and determined the source of free product found within well A3-MW-07. Because no set MCLs were exceeded in the groundwater, the contamination was found at three to four orders of magnitude greater within the soil than the water, and the contamination reached the water table mainly through a conduit created by A3-MW-07; therefore, it was recommended that well A3-MW-07 be abandoned to prevent further contamination from migration through the slotted screened interval and into the groundwater. It was indicated that following the conduit removal, the contamination would be isolated from the water table by a 1 to 4 ft layer of impermeable clay. Further, it was found that, pending the abandonment of A3-MW-07, the results from the investigation warranted the recommendation for site closure for Area 3 at MCAS Yuma. The findings of the second phase of the investigation were documented

in the *Final Second Phase Investigation of the Presence of Free Product, Monitoring Well A3-MW-07, Marine Corps Air Station (MCAS) Yuma, AZ* (Battelle, 2005c).

On December 14, 2005, the DON submitted a letter to U.S. EPA and ADEQ, proposing site closure and an end of LTM at Area 3. The request was supported by a technical memorandum describing how the closure requirements of the ROD had been satisfied at Area 3. The U.S. EPA concurred with site closure in a letter dated February 9, 2006 (Appendix B9). The Navy submitted a second letter to ADEQ on February 15, 2006, with U.S. EPA concurrence attached, stating that ADEQ concurrence with closure of Area 3 would be assumed unless ADEQ responded otherwise within 10 days. No response was received from ADEQ.

Following the concurrence from U.S. EPA, Area 3 was considered closed with NFA required. All Area 3 wells were decommissioned between October 3, 2006 and October 6, 2006 as outlined in the *Well Abandonment Report for Wells at Area 2, Area 3 and Subarea 5A, Marine Corps Air Station Yuma, AZ* (Battelle, 2006b).

4.1.3.7 Area 6 Groundwater Monitoring. The Area 6 plume contamination consisted primarily of PCE in groundwater at low concentrations near MCLs. MNA was selected as the remedy for the Area 6 plume. The LTM program (BNI, 2002) originally monitored five wells at the site to evaluate contaminant concentrations and identify and monitor other chemical indicators associated with MNA. Monitoring was performed on a quarterly basis from March 1998 to October 2003, under various contractors (see Area 1 Groundwater Monitoring above).

On September 3, 2003, the DON submitted a letter to U.S. EPA and ADEQ, proposing site closure and an end of LTM at Area 6. The request was supported by a technical memorandum describing how the closure requirements of the ROD had been satisfied at Area 6. A concurrence letter from ADEQ (Appendix B10), dated October 21, 2003, agreed with closing the site and ending LTM in Area 6. The U.S. EPA also agreed with site closure in a memo dated November 20, 2003 (Appendix B10). The DON awarded a contract for the abandonment of the Area 6 monitoring wells to Battelle on March 23, 2004. Recent activities associated with Area 6 are provided in Section 5.1.3.2.

4.1.3.8 Annual System Operations/O&M Costs. Table 4-1 provides the annual system O&M costs for the previous five-years. The total cost values for each time period reflect costs for O&M of the AS/SVE and VCT systems, groundwater monitoring, and preparation of the quarterly progress and groundwater monitoring reports. Costs for work performed beyond these parameters (including well decommissioning activities) are not included in Table 4-1. The decrease in annual costs after 2007 is due to the shutdown of the AS/SVE system in May 2007 and the subsequent end of full-time, on-site staffing.

Table 4-2. Annual System Operation and Maintenance Costs

Dates		Total Annual Costs[1]
From	To	
July 2004	June 2005	$350,000
July 2005	June 2006	$355,000
July 2006	September 2007	$368,000
October 2007	September 2008	$203,000
October 2008	September 2009	$201,000

[1] Total costs are rounded to the nearest $1,000.

4.2 Remedial Actions for Operable Unit 2

This section discusses the remedy selection, the remedy implementation, and the remedy performance for OU-2 and identifies any changes to or problems with the components of the remedy.

4.2.1 OU-2 Remedy Selection. This section describes the purpose for remediation, the remedial alternatives developed and evaluated in the OU-2 FS (Uribe & Associates, 1996b) against the nine CERCLA evaluation criteria for remedial alternatives, and the remedy selected in the ROD (Uribe & Associates, 1997b).

4.2.1.1 OU-2 Remedial Action Objective. The RAO for OU-2 CAOCs 1, 8A and 10 is to minimize the potential for unacceptable human-health risk that could result from a change in land use (Uribe & Associates, 1996b). The RAO was determined as a final result of the human-health risk assessments conducted for each site in the RI (JEG, 1996a) and FS (Uribe & Associates, 1996b). The results indicated that potentially unacceptable cancer risk levels could result from residential land use and unrestricted exposure to surface and shallow subsurface soil at the three sites. However, the cancer risk for the current and anticipated future land use scenario, as areas of industrial land use, was estimated to be within the U.S. EPA acceptable range.

4.2.1.2 OU-2 Applicable or Relevant and Appropriate Requirements. Arizona's Soil Remediation Standards are identified in the OU-2 ROD as relevant and appropriate chemical-specific requirements for the remediation of soil at CAOCs 1, 8A and 10. These rules are relevant and appropriate, but not applicable because the remedial action is being conducted under federal law (e.g., CERCLA) and not as one of the state of Arizona's regulatory programs. For more information, see the OU-2 ROD (Uribe & Associates, 1997b) and the rules as summarized in ARS Title 49, §§ 151 and 152, and the AAC Title 18, Chapter 7, Article 2, Soil Remediation Standards (§§ R18-7-201 through R18-7-209). These rules allow for soil remediation to one of three standards as follows:

- Remediation to background levels;
- Remediation to health-based guidance levels (HBGLs) presented in Appendix A Soil Remediation Levels (SRLs) of AAC Title 18, Chapter 7, Article 2; or

- Remediation to levels derived from a site-specific risk assessment.

In addition, at sites where soil remediation does not meet residential standards or background levels, but rather industrial or site-specific standards, the rules previously required the submittal of a VEMUR. However, in July of 2000, subsequent to the signing of the OU-2 ROD, Arizona's Soil Remediation Standards were amended. The amended rules eliminated the VEMUR and replaced it with a DEUR as the appropriate document for recording a property's environmental land use restrictions with the state of Arizona (see Arizona Laws 2000, Chapter 225 amending ARS § 49-152 [Title 49, Chapter 1, Article 4]). Because soils at CAOCs 1, 8A and 10 meet industrial, but not residential cleanup standards, and because these state rules were determined to be relevant and appropriate in the OU-2 ROD, the DON has proposed "modified DEURs" for CAOCs 1, 8A and 10 in the Final LUCIP to fulfill the substantive requirements of ARS § 49-152. Table 4-2 identifies the HBGLs for ingestion of soil contaminants for COPCs at CAOC 1, 8A and 10 as presented in Appendix A (SRLs) to AAC Title 18, Chapter 7, Article 2 (updated June 1995).

Table 4-3. Health Based Guidance Levels (HBGLs) for Ingestion of COPCs in Soil at OU-2 CAOC 1, 8A and 10

OU-2 COPC	Cancer Group	Residential Oral HBGL (mg/kg)	Non-Residential Oral HBGL (mg/kg)
Acenaphthene	ND	7,000.0	24,500.0
Acenaphthylene (PAH)	D	7,000.0	24,500.0
Anthracene (PAH)	D	35,000.0	122,500.0
Benz[a]anthracene (PAH)	B2	1.1	4.6
Benzo[a]pyrene (PAH) (BaP)	B2	0.19	0.80
Benzo[b]fluoranthene (PAH)	B2	1.1	4.6
Benzo[k]fluoranthene (PAH)	B2	1.1	4.6
Chrysene (PAH)	B2	110.0	462.0
Dibenz[a,h]antracene (PAH)	B2	0.11	0.46
Fluoranthene (PAH)	D	4,700.0	16,450.0
Fluorene (PAH)	D	4,700.0	16,450.0
Indenopyrene (PAH)	B2	1.1	4.6
Naphthalene (PAH)	D	4,700.0	16,450.0
Polychlorinated biphenyls (PCBs)	B2	0.18	0.76
Polychlorinated biphenyls	ND	8.2	28.7
Pyrene (PAH)	D	3,500.0	12,250.0

Table derived from Table 2-8 of the OU-2 ROD (Uribe & Associates, 1997b).
Cancer groups are as follows:
B2 Probable human carcinogen
D Not classifiable as to human carcinogenicity
ND No data available

4.2.1.3 OU-2 Selected Remedy. Two remedial alternatives were developed and evaluated in the FS for OU-2 (Uribe & Associates, 1996b) to address the RAO for CAOCs 1, 8A, and 10: no action and ICs. The no action alternative presented an acceptable risk to human health as long as the current land use remained industrial; however, without controls in place to prevent

unrestricted use, future land use could lead to unacceptable levels of human-health risk. Taking public comment on the OU-2 Proposed Plan into consideration, the ROD proposed ICs as the preferred remedy for the three OU-2 CAOCs.

The selected remedy as defined in the ROD consisted of ICs restricting land use of CAOC 1 and CAOC 10 to industrial/commercial use and CAOC 8A to the current use and prevent any activities that may disrupt and expose the landfill interior. The ICs would be implemented through the MCAS Yuma Master Plan (former Base Master Plan), which will reference the OU-2 ROD. The ICs identified in the ROD are as follows:

- Restrict land use at CAOCs 1 and 10 to industrial/commercial use.
- Restrict land use at CAOC 8A to current use and prevent any activities that may disrupt and expose the landfill interior.
- Provide a legal description of site boundaries and a site map for each site.
- Execute and record a VEMUR with the state of Arizona for each site.
  - The VEMUR would contain language clarifying that it was executed and recorded by the federal government "for itself only, and not as a covenant running with the land". In addition, it would clarify that:
    a. No interest in real property on behalf of the state of Arizona is created by the VEMUR or by any notice of cancellation of the VEMUR pursuant to ARS § 49-152, and
    b. The signature of an authorized representative of the ADEQ on the document acknowledges that the remediation of the property was conducted in accordance with the provisions of ARS § 49-152.
- Any future activities planned for the area must be coordinated with and reviewed by the MCAS Yuma Environmental Department, including official consultation with the DON, in consultation with U.S. EPA and ADEQ as necessary.

A change in land use from industrial to residential use would require reevaluation of the remedy for CAOCs 1 and 10. For CAOC 8A, a change in land use that would involve activities that may lead to disruption of the site surface and exposure of the landfill contents would require the reevaluation of the remedy for compatibility with the desired activity. The remedy could be changed pursuant to CERCLA §§ 120 and 121 and NCP § 300.430(f)(4)(iii), and further investigation could be undertaken to determine if remediation is required and if the ROD must be amended.

If the DON intended to excess the property to a nonfederal entity, it must notify the ADEQ and U.S. EPA in advance of the execution of any transfer. The DON would again consult with the ADEQ and U.S. EPA in revisiting the existing land use classification and restrictions for the CAOCs involved to determine if the foreseeable future land use would differ from the assumptions made at the time the original remediation action decision was made. A reevaluation of the ICs would be performed if necessary at that time.

4.2.2 OU-2 Remedy Implementation. The ROD for OU-2 identified ICs for CAOCs 1, 8A and 10. The following subsections discuss the steps taken post-ROD to implement ICs for CAOCs 1, 8A and 10 at MCAS Yuma.

4.2.2.1 OU-2 Remedial Action Report. The Final Remedial Action Report for OU-2 (GEOFON, 1999) included an information summary and ICs for CAOCs 1, 8A and 10 in a recommended addendum to the MCAS Yuma Base Master Plan. A VEMUR application package containing a summary of pertinent site conditions and legal description of the site boundaries was included as a part of the addendum. A land survey of CAOCs 1, 8A and 10 was used to produce the legal descriptions and site maps (Don Peterson Engineers, 1999).

4.2.2.2 MCAS Yuma Master Plan. The MCAS Yuma Master Plan contains a detailed review of all physical conditions, resources, and tenant commands present at MCAS Yuma and the planned development of the station in the foreseeable future. The MCAS Yuma Master Plan was developed to support the MCAS Yuma mission and implement the station's strategic plan. In order to control the areas of potential risk from exposure to soil contamination at OU-2 CAOCs 1, 8A and 10 and ensure that future land use would not result in unacceptable levels of risk to human health or the environment, the necessary restrictions were presented in a revision to the MCAS Yuma Master Plan. The MCAS Yuma Master Plan was revised in September 2001 (KTUA, 2001) and again in November 2007 (KTUA, 2007) to contain the ICs for OU-2 as identified in the ROD and specified in the Master Plan addendum provided in the Final Remedial Action Report for OU-2 (GEOFON, 1999). Figures 5-17 and 5-18 of the updated MCAS Yuma Master Plan (KTUA, 2007) provide the locations of the OU-2 site areas for which ICs would apply and what the controls are.

The MCAS Yuma Master Plan does not include a map of CAOC 8A showing the locations of the former disposal areas, as recommended in the ROD, or a map of the locations of PAHs in soil reported for CAOC 10. However, the site boundaries given for CAOCs 8A and 10 (as CAOCs 10A and 10B) in the Master Plan, for which the listed ICs apply, do incorporate corresponding areas of significance for both sites. Figure 3-4 shows the boundaries of the three CAOCs for which ICs are implemented as they appear in both the revised MCAS Yuma Master Plan (KTUA, 2007) and the Final LUCIP (SWDIV, 2002a).

4.2.2.3 Land Use Control Implementation Plan. The Final LUCIP was issued in September 2002 (SWDIV, 2002a) and addressed all DON, U.S. EPA, and ADEQ comments on the Draft (Revision 1) LUCIP that was issued on December 20, 2001 (Appendix B3). MCAS Yuma Station Order 5090 was issued on January 10, 2002, informing station tenants of the land use restrictions for OU-2 and implementing the other LUCs provided in the Draft LUCIP (Appendix B4). The Draft (Revision 1) LUCIP was originally issued as an addendum to the Master Plan to provide steps for implementation and monitoring of ICs at OU-2 and other station areas. The document also contained complete VEMUR application packages for CAOCs 1, 8A and 10. The Draft LUCIP noted that recordation of a VEMUR had been achieved previously for the MCAS Yuma FFAAP Area of Concern (AOC) A.

The ICs for OU-2 were subsequently updated in the Final LUCIP to provide "modified DEURs" for CAOCs 1, 8A and 10 as follows (see Section 3 of the Final LUCIP; SWDIV, 2002a):

ICs will restrict the land use of CAOCs 1 and 10 to industrial/commercial use and CAOC 8A to its current use (inactive landfill/surface disposal area). ICs for these CAOCs may be recorded in DEURs in accordance with and substantially in the form set out in ARS § 49-152. ICs will also restrict the land use of FFAAP AOC A to industrial/commercial use. ICs for this AOC are recorded as a VEMUR in accordance with and substantially in the form set out in ARS § 49-152. The VEMUR for AOC A was in place prior to the revision of ARS § 49-152, wherein VEMURs were changed to DEURs. The VEMUR and DEURs (if recorded) each contain language clarifying that they were executed and recorded by the federal government "for itself only, and not as a covenant running with the land." In addition, they clarify the following:

a. The parties agree that no interest in real property on behalf of the state of Arizona either is created by this VEMUR or DEUR or by any notice of cancellation of this VEMUR or DEUR pursuant to ARS § 49-152.

b. Changes in activities or land use in these CAOCs or FFAAP AOC A will be coordinated through and reviewed by the MCAS Yuma Environmental Department. In the event that the Navy/Marine Corps plans any future changes in land use at CAOCs 1, 8A or 10 or at the FFAAP AOC A, the DON, in consultation with U.S. EPA and ADEQ, would reevaluate the ICs in light of the intended land use. If the change in land use is not compatible with the ICs, the ICs may be changed pursuant to CERCLA §§ 120 and 121 and the NCP § 300.430(f)(4)(iii), and the ROD for OU-2 may be amended. If the Navy/Marine Corps plans to excess the property to a nonfederal entity, it will notify ADEQ and U.S. EPA in advance of the execution of any such transfer. The Navy/Marine Corps will consult with ADEQ and U.S. EPA in revisiting existing land use classifications/restrictions for the CAOC or FFAAP AOC A (or, in the alternative, the remedial action selection) to determine whether the foreseeable future land use differs from the assumptions made at the time the original remedial action decision was made. At that time, the Navy/Marine Corps, in consultation with ADEQ and U.S. EPA, will undertake a reevaluation of the appropriate ICs and determine if engineering controls and/or other remedial action are necessary.

For CAOCs 1 and 10 and FFAAP AOC A, a change in land use from industrial to residential use would require a reevaluation of the ICs. For CAOC 8A, a change in land use involving any activities that may disrupt and expose the landfill interior would require a reevaluation of the ICs. At the time of these future activities, further investigation may be undertaken to determine whether remediation is required and whether the ROD must be amended.

In the event that OU-2 property is excessed, MCAS Yuma shall notify the transferee or lessee of the land use controls (LUCs) described in this section, and Naval Facilities Engineering Command (NAVFAC) Southwest shall include the restrictions, as shown in Figure 2-2 of the LUCIP, in the transfer or lease. Such

notification will be provided at least 45 days in advance of the property transfer or lease conveyance. MCAS Yuma shall comply with § 120(h)(3) of CERCLA in any such transfers (LUCIP Appendix C; SWDIV, 2002a). Transfer or lease of real property out of federal control will follow guidance included in the DoD memorandum, Interim Policy on Land Use Controls Associated With Environmental Restoration Activities (DoD, 2000, as amended) (LUCIP Appendix D; SWDIV, 2002a).

Along with the LUC components listed above, OU-2 areas are surrounded by fencing which effectively limits access to the areas.

5.0 PROGRESS SINCE PREVIOUS FIVE-YEAR REVIEW

This section provides the protectiveness statements from the previous five-year review, any recommendations and follow-up actions identified in the previous five-year review, and the results of implemented actions taken towards resolving the issues including whether they achieved the intended effect. The following subsections identify the progress for OU-1 and OU-2 separately.

5.1 Progress for Operable Unit 1

The following provides the OU-1 protectiveness statement from the five-year review dated November 2004 (SWDIV, 2004), identifies the recommended follow-up actions, and summarizes the results of actions taken.

5.1.1 OU-1 Protectiveness Statement from the 2004 Five-Year Review. "The remedy at OU-1 is currently and will continue to be protective of human health and the environment because of the implementation of remedial measures and control of exposure pathways that may result in unacceptable risks. These methods are being applied as follows:"

(1) "Remediation systems were installed and operated in the Area 1 plume. A VCT system was operated in the LEPA from June 2000 to May 2003. The system has reduced CHC concentrations to near MCLs and contained any off-site migration of the plume in this area. An AS/SVE system was installed in the Building 230 area to remediate the groundwater in the most highly contaminated area of OU-1. The system has operated relatively continuously from November 1999 to present. The AS/SVE system has reduced the CHC Hot Spot in both size and magnitude such that the COCs will not migrate offsite at concentrations greater than MCLs."

(2) "MNA will be applied at all areas to demonstrate the reduction of contaminant concentrations through natural processes and ensure that the plumes are not migrating. Groundwater monitoring required for the MNA program will be implemented through the LTM plan for OU-1 at MCAS Yuma. Plumes will continue to be monitored until they decrease in concentrations below MCLs."

(3) "ICs are in place to restrict exposure to any contaminated groundwater at Areas 1, 2, and 3 through MCAS Yuma Station Order 5090 (issued on January 10, 2002). This order formally directs tenants and contractors to incorporate the LUCs provided in the MCAS Yuma Master Plan and the Final LUCIP into their existing land use planning and management programs."

"The MCAS Yuma Environmental Department will continue to review dig/building permits at Areas 1, 2, and 3" (SWDIV, 2004).

5.1.2 Previous Issues, Recommendations and Follow-up Actions for OU-1. Table 5-1 lists the issues that were identified for the OU-1 areas during the last five-year review (SWDIV, 2004). Table 5-2 summarizes the recommendations and follow-up actions as stated in the last five-year review (SWDIV, 2004).

Table 5-1. Issues Identified During the Previous Five-Year Review

Issues	Affects Current Protectiveness (Yes/No)	Affects Future Protectiveness (Yes/No)
A petroleum sheen was observed in well A3-MW-07 in Area 3. The contamination was first noticed on December 28, 2001 and confirmed in subsequent events. Analysis of the substance indicates that it is mostly diesel contamination that may be related to the materials used in the fire training area. There is no evident source to the contamination, and petroleum hydrocarbon chemicals are not present in surrounding wells. The sheen is isolated and not an immediate threat to human health due to institutional controls on groundwater.	No	No

Table 5-2. Recommendations and Follow-up Actions from the Previous Five-Year Review

Recommendations/Follow-Up Actions	Affects Current Protectiveness (Yes/No)	Affects Future Protectiveness (Yes/No)
Investigate the petroleum hydrocarbon contamination found at Area 3 to evaluate its potential impact on groundwater in Area 3. Continue the monitoring and remediation of the contamination if necessary.	No	No

5.1.3 Actions Taken at OU-1 Since the Previous Five-Year Review. The following subsections identify the actions taken across all of the areas of OU-1 during the past five years. The actions taken to address the recommendations given in Table 5-2 are provided below as well as other actions that have occurred at OU-1, which were not identified in the previous five-year review.

5.1.3.1 Summary of Actions Taken in Response to Previous Five-Year Review Recommendations. Table 5-3 provides a summary of the actions taken to address the recommendations provided in the previous five-year review (SWDIV, 2004).

Table 5-3. Summary of Actions Taken in Response to Previous Five-Year Review Recommendations

Recommendations/ Follow-Up Actions	Party Responsible	Milestone Date	Actions Taken and Outcome	Date of Action
Investigate the petroleum hydrocarbon contamination found at Area 3 to evaluate its potential impact on groundwater in Area 3. Continue the monitoring and remediation of the contamination if necessary.	DON	06-Jan-2004	First phase investigation	12-Nov-2004
			Second phase investigation	15-Nov-2005
			Area 3 closure	09-Feb-2006
			Area 3 Well Abandonment	20-Nov-2006

5.1.3.2 Area 1 Actions Taken

AS/SVE System

As stated in Section 4.1.3.1, the DON proposed temporary shutdown of the AS/SVE system of Area 1 in August 2006 and received concurrence from U.S. EPA and ADEQ (Appendix B5). The AS/SVE was placed in temporary shutdown on May 9, 2007 and currently remains in temporary shutdown status. Based on soil vapor sampling associated with the AS/SVE system, approximately 79 lb of COCs were removed from the subsurface between system startup(November 16, 1999) and temporary shutdown (May 9, 2007). The total mass removal rate remained relatively consistent between January 2002 and temporary shutdown.

VCT System

As stated in Section 4.1.3.2, following the temporary shutdown of the VCT system in May 2003, the DON proposed permanent shutdown of the VCT in September 2005 and received concurrence from U.S. EPA and ADEQ (Appendix B7). The VCT system was permanently shut down in December 2005 and currently remains in the permanent shutdown status. In May 2003, when the system was placed in temporary shutdown, an estimated 10.7 lb of total mass had been removed from the 136,591,146 gallons of extracted groundwater since system startup.

LTM

On July 25, 2006, the DON submitted a letter to U.S. EPA and ADEQ, proposing changes to the LTM plan for OU-1 groundwater contamination, of which only Area 1 monitoring wells remained applicable (see actions taken for Areas 2, 3 and 6 below). The request was supported by a technical memorandum proposing the reduction of sampling frequency and the reduction of the monitoring wells sampled. Concurrence for the changes to the LTM was received from U.S. EPA on January 8, 2007 (Appendix B11). The Navy submitted a second letter to ADEQ, with the U.S. EPA concurrence attached, stating that ADEQ concurrence with the proposed LTM changes would be assumed unless ADEQ responded otherwise within 10 days. No response was received from ADEQ.

Following U.S. EPA concurrence, the LTM plan was modified to sample groundwater on the schedule listed in Table 5-4. The revised groundwater-monitoring schedule was implemented during the annual monitoring event in December 2006. Currently, 21 wells are monitored on an annual, semi-annual, and quarterly basis. Thirty-seven monitoring wells were decommissioned in Area 1 between July and September 2007 as indicated in the *Draft Report for Abandonment of Monitoring Wells at Area 1, MCAS Yuma, AZ* (Battelle, 2007). The wells were decommissioned in accordance with Arizona Department of Water Resources substantive requirements after CHCs were demonstrated to be below their MCLs for the minimum required time of two years.

Table 5-4. Revised Groundwater Monitoring Schedule for MCAS Yuma

Subareas of OU-1 Area 1 Groundwater Contamination	Quarterly VOCs	Semi-Annual VOCs	Annual VOCs	Annual Natural Attenuation Parameters[1]
Area 1 "Hot Spot" Building 230 Area	A1-MW-18	A1-MW-18	A1-MW-18	A1-MW-18
	A1-MW-19	A1-MW-19	A1-MW-19	
	A1-MW-37	A1-MW-37	A1-MW-37	A1-MW-37
	16-MW-06	16-MW-06	16-MW-06	16-MW-06
	16-MW-08	16-MW-08	16-MW-08	16-MW-08
	16-MW-09	16-MW-09	16-MW-09	
	16-HS-03	16-HS-03	16-HS-03	16-HS-03
Area 1 Interior Wells Central Plume Area		A1-MW-07	A1-MW-07	A1-MW-07
		A1-MW-11	A1-MW-11	
		A1-MW-13	A1-MW-13	
		A1-MW-14	A1-MW-14	A1-MW-14
		A1-MW-15	A1-MW-15	
		A1-MW-23	A1-MW-23	
		A1-MW-25	A1-MW-25	
Area 1 "LEPA" Northwest Station Boundary Area		A1-PZ-19	A1-PZ-19	
		A1-MW-01	A1-MW-01	A1-MW-01
		A1-MW-04	A1-MW-04	
		A1-MW-05	A1-MW-05	
		A1-MW-27	A1-MW-27	A1-MW-27
		A1-MW-31	A1-MW-31	
		A1-MW-42	A1-MW-42	

Sampling schedule derived from LTM Technical Memorandum (Battelle, 2006a).
[1]Natural attenuation parameters: chloride, ferrous iron, sulfate, nitrate, pH, dissolved oxygen, redox potential.

5.1.3.3 Area 2 Actions Taken. As stated in Section 4.1.3.5, the DON proposed site closure and the end to LTM at Area 2 in March 2006 and received concurrence from U.S. EPA and ADEQ (Appendix B8). Following the concurrence, Area 2 was considered closed with NFA. All Area 2 wells were decommissioned in August 2006 as outlined in the *Well Abandonment Report for Wells at Area 2, Area 3 and Subarea 5A, Marine Corps Air Station Yuma, AZ* (Battelle, 2006b).

5.1.3.4 Area 3 Actions Taken. As stated in Section 4.1.3.6, following the identification of free product in Area 3 monitoring well A3-MW-07 in December 2001, the DON developed a two-phased approach for investigation of the free product in January 2004. The first phase of the investigation, completed in 2004 (Battelle, 2004d), indicated that further investigation was necessary and that the second phase of the investigation should be implemented.

The second-phase investigation (Battelle, 2005c) found that no MCLs were exceeded in the groundwater, but soil contamination was three to four orders of magnitude greater than the water. The second-phase investigation also determined that the contamination had reached the water table mainly through a conduit created by monitoring well A3-MW-07. It was recommended that well A3-MW-07 be abandoned to prevent further contamination from migration through the slotted screened interval and into the groundwater. In doing so, the contamination would be

isolated from the water table by a 1 to 4 ft layer of impermeable clay. Further, it was found that, pending the abandonment of A3-MW-07, the results from the investigation warranted the recommendation for site closure for Area 3 at MCAS Yuma.

The DON proposed site closure and the end to LTM at Area 3 in December 2005 and received concurrence from U.S. EPA and ADEQ (Appendix B9). Following the concurrence, Area 3 was considered closed with NFA required. All Area 3 wells were decommissioned in October 2006 as outlined in the *Well Abandonment Report for Wells at Area 2, Area 3 and Subarea 5A, Marine Corps Air Station Yuma, AZ* (Battelle, 2006b).

5.1.3.5 Area 6 Actions Taken. As stated in Section 4.1.3.7, following concurrence from U.S. EPA and ADEQ, Area 6 was considered closed with NFA in November 2003 (Appendix B10). All Area 6 wells were decommissioned between March 24, 2005 and March 31, 2005 as outlined in the *Well Abandonment Report for Wells at Area 6 and Subarea 5A, Marine Corps Air Station Yuma, AZ* (Battelle, 2005b).

5.2 Progress for Operable Unit 2

This section provides the protectiveness statements from the previous five-year review, the status of recommendations and follow-up actions from the previous five-year review, and the results of implemented actions taken towards resolving the issues including whether they achieved the intended effect. The following subsections identify the progress for OU-1 and OU-2 separately.

5.2.1 OU-2 Protectiveness Statement from the 2004 Five-Year Review. The remedy at OU-2 is currently and will continue to be protective of human health and the environment because exposure pathways that may result in unacceptable risks are being controlled as follows:

(1) ICs are in place to restrict exposure to contaminants in soil at CAOCs 1, 8A, and 10 through MCAS Yuma Station Order 5090 (Appendix B4). This order formally directed tenants and contractors to incorporate the LUCs provided in the MCAS Yuma Master Plan and the Final LUCIP (Appendix B3) into their existing land use planning and management programs.

(2) The "modified DEURs" for CAOCs 1, 8A, and 10 have been proposed to satisfy the requirements specified in the OU-2 ROD for registration of the sites with the state of Arizona.

The MCAS Yuma Environmental Department will continue to review dig/building permits.

5.2.2 Previous Issues, Recommendations and Follow-Up Actions for OU-2. No issues were identified for OU-2 during the previous five-year review (SWDIV, 2004). Consequently, no recommendations or follow-up actions were proposed for OU-2.

5.2.3 Actions Taken at OU-2 Since the Previous Five-Year Review. No actions have taken place within the protected areas defined by OU-2 CAOCs 1, 8A and 10 within the past five years.

6.0 FIVE-YEAR REVIEW PROCESS

This section provides a description of the activities performed during the five-year review process for MCAS Yuma OU-1 and OU-2, as well as a summary of the findings of each step in the process when appropriate.

6.1 Administrative Components of the Five-Year Review Process

Responsibilities for this OU-1 and OU-2 five-year review were developed by the DON and the MCAS Yuma Environmental Department. Table 6-1 summarizes the people involved in the five-year review process.

Table 6-1. Five-Year Review Participants

Name	Title	Organization
Angela Wimberly	Remedial Project Manager	NAVFAC Southwest
Derral VanWinkle	Interim Remedial Project Manager	NAVFAC Southwest
Chris Coonfare	Project Manager	Battelle
Damon DeYoung	Task Manager	Battelle
Dan Nail	IRP Manager	MCAS Yuma Environmental Department
Joe Britain	Environmental Engineer	MCAS Yuma Environmental Department
Chris Kost	EMS Coordinator	MCAS Yuma Environmental Department
Dave Rodriguez	Environmental Director	MCAS Yuma Environmental Department
Jeremy Nevin	ROICC	MCAS Yuma
Joellen Meitl	Project Manager	ADEQ
Delfina C. Olivarez	Project Manager	ADEQ
Martin Hausladen	Project Manager	U.S. EPA

The review team consisted of Chris Coonfare (Battelle) as the primary investigator for the review and Dan Nail (MCAS Yuma Environmental Department) as the station contact responsible for arranging access to Environmental Department documents and to station resources and personnel. Components identified in advance with those responsible for the review included:

- Document review
- Data review
- Site inspection
- Local interviews, and
- Five-year review report development and review.

These components were later modified to include U.S. EPA and ADEQ interview responses. The five-year review, including site inspections and interviews, was conducted between April 2009 and February 2010.

6.2 Community Notification and Involvement

MCAS Yuma personnel and the greater Yuma, Arizona, community were informed of the start of the review in April 2009 in a public notice sent to base personnel and printed in the local area newspaper:

- *The Sun* (Yuma and regional paper) Sunday, May 10, 2009
- MCAS Yuma Basewide E-mail Newsletter Friday, April 3, 2009

The notice stated the purpose of the five-year review at OU-1 and OU-2 under CERCLA; described the remedy for contaminated groundwater at OU-1 and contaminated soils at OU-2; and identified the types of COCs present. The restriction of future groundwater and soil use was identified, as necessary, to prevent unacceptable human-health risk that could result if the sites were used for residential purposes. The notice stated that the ICs for OU-1 and OU-2 were implemented through the Base Master Plan which was issued in September 2001. The public notice is included in Appendix B12.

A second public notice and a fact sheet are planned to notify the community of the findings upon completion of the Five-Year Review Report. In addition, the fact sheet will be sent to regulatory agency personnel and those community representatives who indicated interest in prior mailings concerning environmental restoration activities at MCAS Yuma. The Five-Year Review Report for OU-1 and OU-2 will also be made available at the Yuma County Public Library, 350 South Third Avenue, Yuma, Arizona 85364-3897.

The local community was not directly involved in the five-year review process, because ICs are currently implemented only within the station to limit groundwater use by station tenants. Remedial actions have contained off-site plume migration. During the earlier phases of site RI and remedy selection and evaluation, interested community representatives had the opportunity to provide input on the remedial action. The project was managed to allow exchange of information and partnership among the community, DON, U.S. EPA, and State of Arizona regulatory agencies by reviewing and commenting on technical documents relating to the ongoing environmental cleanup at MCAS Yuma. With remedial activities well underway at OU-1 and OU-2, public interest in CERCLA proceedings has declined.

6.3 Document Review

This five-year review for OU-1 and OU-2 consisted of a review of relevant documents issued prior to and since the construction of the remedial systems (see Appendix A for the complete list of documents reviewed). The documents reviewed included the OU-1 and OU-2 RODs, the Final LUCIP, the MCAS Yuma Master Plan, technical memorandums, remediation progress reports, groundwater-monitoring reports, discharge reports, monitoring well inspections required by the LUCIP, aerial photographs, and compliance documents maintained by the MCAS Yuma Environmental Department. Most documents have focused on remediation system operation and groundwater monitoring. These reports summarize the AS/SVE and VCT systems O&M and emissions monitoring.

During the review process, some inconsistencies were indentified between figures provided in the recently revised MCAS Yuma Master Plan (KTUA, 2007) and the Final LUCIP (SWDIV, 2002a). Specifically, Figure 5-17 of the Master Plan does not show all CAOCs of OU-2 (i.e., CAOC 10B is not represented) and CAOC 1 does not have the correct boundaries as shown in Figure 2-3 of the Final LUCIP. Also, Figure 5-18 should represent all ICs of OU-1 and OU-2 and thus should present a merging of Figures 2-1 and 2-3 of the Final LUCIP; however, Figure 5-18 does not show some of the OU-1 IC areas (e.g., Area 3).

6.4 Data Review

The data review included examination of groundwater-monitoring information, risk assessment information, and regulatory standards to identify any changes to the protectiveness of the selected remedies. The most recent sampling data were used in a screening evaluation of potential change in human-health risk for the areas discussed in detail in Section 7.1.2 of this report.

Review of groundwater-level surveys indicates that there were no major changes in hydraulic gradient direction or magnitude over the review period, although the water table continues to decline overall. It should be noted that if levels decrease below AS well screen intervals, the AS/SVE system will be ineffective. Furthermore, if the levels decrease below monitoring well screen intervals, the LTM program will be ineffective. However, a number of wells are present at great enough depths to deem the LTM program effective for the foreseeable future. Water-quality parameters have also shown only minor changes outside zones where the remediation systems were applied. In general, the plumes have not shown any significant movement or expansion that would indicate any significant changes in the groundwater system.

Overall, contaminant concentrations have declined at OU-1 over the past five years. Table 6-2 summarizes and compares the maximum detected concentration of COCs in Area 1 from the June 2009 sampling event, the most recent semi-annual monitoring event, and the March 2004 sampling event, the results of which were reported in the last five-year review. Chemical concentrations were near MCLs in the Area 1 central/interior plume and LEPA. The only chemical detected at levels significantly higher than its MCL was TCE in the Building 230 “Hot Spot” area.

Following the temporary shutdown of the AS/SVE system slight rebound of COC concentrations was observed in the western portion of the Hot Spot plume. Two wells (i.e., wells 16-HS-03 and 16-MW-08) that were below the 1-1, DCE MCL (7 µg/L) in June 2007 have shown an increase in concentrations to levels above the MCL in June 2009 (Figure 4-6). Similarly, one well (i.e., well 16-HS-03) that was below the TCE MCL (5 µg/L) in June 2007 has shown an increase in concentration to a level above the MCL in June 2009 (Figure 4-7). This migration of 1,1-DCE and TCE to the west-northwest is likely due to the reestablishment of the natural hydraulic gradient in the absence of the AS/SVE system influence. However, even with slight rebound following the AS/SVE temporary shutdown in May 2007, the plume concentrations appear to have stabilized over the past two years (see Figure 4-3) and are substantially lower than the concentrations reported in the previous five-year review (Table 6-2).

Table 6-2. Summary of Maximum Groundwater Concentrations Detected in the March 2004 and June 2009 Monitoring Events

OU-1 Area 1	Maximum Concentration in Groundwater (µg/L)					
	1,1-DCE		TCE		PCE	
	2004[a]	2009[b]	2004[a]	2009[b]	2004[a]	2009[b]
"Hot Spot"	20	9.7	62	26	2.4	1.4
Central/Interior	13	9.1	10	10	<1	<1
LEPA	7.5	5.5	6.3	6.5	<1	<1
MCLs[c]	*7*		*5*		*5*	

[a] Groundwater monitoring data from March 2004 reported in the previous five-year review (SWDIV, 2004).
[b] Groundwater monitoring data from June 2009 (Battelle, 2010).
[c] MCLs based on U.S. EPA National Primary Drinking Water Regulations (U.S. EPA, 2009a).

6.5 Site Inspection

The purpose of the site inspections is to review and document current site conditions at the areas and evaluate visual evidence regarding the protectiveness of the remediation systems, monitoring equipment, and ICs. This effort included inspection of the monitoring wells used to assess the groundwater plumes and review of the monitoring documents concerning OU-1. The U.S. EPA *Comprehensive Five-Year Review Guidance* (U.S. EPA, 2001) provides a site inspection checklist, as well as the report template used for the development of this report. The modified site inspection checklists completed during the site inspection for each area are provided to document site conditions in Appendix C. Site photographs are included in Appendix E.

6.5.1 OU-1 Site Inspection. Inspections at OU-1 Area 1 were conducted between June 9 and June 11, 2009 by personnel from Battelle and the MCAS Yuma Environmental Department. The Area 1 plume extends across a large portion of the MCAS Yuma flight line area from the Building 230 area (Hot Spot) to the northwestern border of the station (LEPA). The site inspection for the Area 1 plume consisted of inspection of the AS/SVE system, the VCT system, monitoring wells associated with the area, and general land use. The AS/SVE system and the VCT system were not in operation during the inspection as both systems had reached their shutdown criteria. Monitoring wells were in good condition. The site is contained within the station, and much of Area 1 is located within the flight line area. No activity that would be considered inconsistent with industrial land use was noted at Area 1. Details on the Area 1 inspection are provided in Appendix C.

6.5.2 OU-2 Site Inspection. Inspections at OU-2 CAOCs 1, 8A, and 10 were conducted on July 28, 2009 by personnel from Battelle and the MCAS Yuma Environmental Department to document any changes since the last five-year review. Inspection of the status of OU-2 CAOCs 1, 8A, and 10 indicated that there were no land use changes since the last five-year review. No activity that would be considered inconsistent with industrial land use was noted at the areas. All areas are located in restricted areas with fencing and secured gates. Details on the OU-2 inspection are provided in Appendix C.

6.6 Interviews

Individuals responsible for or familiar with current activities at OU-1 and OU-2 or with activities that took place over the past 5 years were interviewed between July 2009 and February 2010 (Appendix D). An interview documentation form listing the name, title, and organization of the interviewee, along with the date and location where the interviews took place, is provided in Appendix D1; the interview records documenting the interviews are provided in Appendices D2 through D9.

All personnel interviewed noted no significant changes to site conditions or land use at the areas over the past 5 years. A summary presentation of additional observations made during the review's site inspections, personnel interviews, and regulatory agency comments is given below.

Derral VanWinkle, October 21, 2009
Derral VanWinkle is the NAVFAC Southwest Interim Remedial Project Manager (RPM) for MCAS Yuma. Mr. VanWinkle directs OU-1 remediation activities for the Navy. The complete interview record for Mr. VanWinkle is provided in Appendix D2.

- Exposure assumptions presented in the ROD are still valid, although the approach to calculation of the vapor exposure route has changed.
- The toxicity data provided in Tables 2-7 and 2-8 of the OU-1 ROD are likely no longer valid. The slope factors and chronic RfDs for 1,1-DCE, TCE, PCE have changed since publication of the ROD for OU-1 9 years ago. However, even if the slope factors or RfDs have become more conservative since the ROD was signed, the cleanup goals (MCLs) are not risk-based. It is possible that achieving the MCLs will leave a greater risk than originally published in the ROD. This should be explored in more detail in the five-year review.
- No information has come to light that would call into question the remedy's protectiveness. The results indicate that the remedies have prevented any further off-site migration of COCs, and appear to have reduced concentrations to levels meeting the clean-up goals in most areas without significant rebound. Monitoring is currently being conducted to demonstrate that rebound has not significantly occurred such that there would be a threat to human health through migration of the chemicals off base.

Dan Nail, July 28, 2009
Mr. Nail is the IRP Manager for MCAS Yuma Environmental Department in charge of coordinating environmental activities for OU-1. The complete interview record for Mr. Nail is provided in Appendix D3.

- Remediation of COAC 8 will need to be considered, since the southern portion of the base will house a new squadron of fighter jets within the next few years.

Joe Britain, July 28, 2009
Joe Britain is an environmental engineer for the MCAS Yuma Environmental Department. Mr. Britain was mainly involved in engineering support and land use controls at the station. The complete interview record for Mr. Britain is provided in Appendix D4.

- A big concern for MCAS Yuma is still ultimate remediation for CAOC 8 (landfill) due to upcoming joint strike fighter (JSF) construction in that area of base proper.

Chris Kost, August 14, 2009
Mr. Kost is the Environmental Management System (EMS) coordinator at the MCAS Yuma Environmental Department. Mr. Kost worked with OHM Remediation Services Corp. and IT Corp. during OU-1 remediation construction projects. The complete interview record for Mr. Kost is provided in Appendix D5.

- Concern is raised regarding the CAOC 8 and the upcoming JSF construction in the area.

David Rodriguez, August 6, 2009
Mr. Rodriguez is the director of the MCAS Yuma Environmental Department. The complete interview record for Mr. Rodriguez is provided in Appendix D6.

- COAC 8 priority has been elevated. The space will be critical for the introduction of the JSF at MCAS Yuma. In addition, the Munitions Response Program (MRP) sites will also require remediation for same JSF reasons.

Jeremy Nevin, October 28, 2009
Mr. Nevin was the Resident Officer in Charge of Construction (ROICC) until June 2009 and supervised construction projects at the station. The complete interview record for Mr. Nevin is provided in Appendix D7.

- No construction projects required coordination with the MCAS Yuma Environmental Department during the past 5 years.

Joellen Meitl, February 10, 2010
Ms. Meitl is a Project Manager in the Federal Projects Unit of the ADEQ. The complete interview record for Ms. Meitl is provided in Appendix D8.

- It should be verified that the OU-1 groundwater cleanup goals are based on the more conservative of the U.S. EPA MCLs and the Arizona AWQS.

Delfina Olivarez, February 10, 2010
Ms. Olivarez is a Project Manager in the Federal Projects Unit of the ADEQ. The complete interview record for Ms. Olivarez is provided in Appendix D9.

- CAOC 8A shows enough visible ground debris to cause concern of hazardous windblown emissions. Previous reports do not state/address any air analysis work of OU-1 and OU-2 done at MCAS Yuma.

Martin Hausladen

Mr. Hausladen is a Project Manager in the Federal Facilities Superfund Division of the U.S. EPA. No comments were received to the five-year review interview questions prior to the development of this report.

7.0 TECHNICAL ASSESSMENT

The technical assessments for OU-1 and OU-2 are independently presented in the following subsections.

7.1 Technical Assessment of Operable Unit 1

The technical assessment for OU-1 presented in this section describes how each of the three key assessment questions was answered for OU-1. The discussion presented here is a framework for the protectiveness determination that explains the conclusions of the review, based on the information presented in the previous section.

7.1.1 Question A: Is the Remedy for OU-1 Functioning as Intended by the Decision Documents?

Yes; a review of documents, site inspections, and interviews of station personnel indicates that the remedies for OU-1 are functioning to protect human health through implementation of the remedial systems and ICs on land and groundwater use. The subsections below provide further detail regarding the remedy efficacy.

7.1.1.1 AS/SVE Performance. The AS/SVE system for Area 1 operated relatively continuously in the Hot Spot area of Building 230 from November 1999 to May 2007. The system was designed to reduce CHC concentrations in the Hot Spot by injecting air into the subsurface in AS wells and recovering the vapors in the SVE wells. Since 1998, maximum TCE concentrations in the Hot Spot have been reduced from 290 µg/L in 1998 to 26 µg/L in June 2009 (see Figures 4-3 and 4-5). Maximum 1,1-DCE concentrations have been reduced from 300 µg/L in 1998 to 9.7 µg/L in June 2009 (see Figures 4-3 and 4-5). The system has removed approximately 79 lb of volatile chemicals from the groundwater. The overall size of the plume in the Hot Spot has also decreased substantially. This information suggests that the AS/SVE system has functioned as intended in remediation of the groundwater plume in the Building 230 area. Consequently, temporary shutdown of the AS/SVE system was approved by U.S. EPA and ADEQ in 2007.

7.1.1.2 VCT Performance. The VCT system operated relatively continuously in the LEPA area from June 2000 to May 2003. The system was designed to reduce CHC concentrations and contain the plume in the LEPA area by withdrawing contaminated groundwater and re-injecting treated water into the aquifer. Monitoring data indicated that CHC concentrations in the LEPA area were sustained below MCLs, so the system was shut down on May 6, 2003. Monitoring of the groundwater continued as part of the LTM during the temporary shutdown period. Permanent shutdown of the VCT system was approved in December 2005 with concurrence from U.S. EPA and ADEQ, following two years of groundwater monitoring performed subsequent to the 2003 temporary shutdown approval.

7.1.1.3 Groundwater Modeling. Groundwater modeling was performed to ensure that the remediation systems selected for the Area 1 plume would work as intended and prevent any migration of the Area 1 plume (BNI, 2002; Battelle, 2004a). The movement and behavior of the plume was simulated with groundwater flow and transport models in light of the effects of the

remediation systems. The model suggested that the LEPA plume would not migrate and would be reduced to below MCLs by approximately 2003. This was confirmed by groundwater monitoring, which showed evidence that the LEPA plume was reduced to MCLs (Battelle, 2004b). The modeling also showed that the reductions in plume concentrations at the Building 230 Hot Spot caused by the AS/SVE system would limit plume expansion. Furthermore, predictive simulations indicated that the plume would not migrate offsite and would be reduced to MCLs approximately by the year 2020.

7.1.1.4 Monitored Natural Attenuation. MNA was the selected remedy for OU-1 Areas 1, 2, 3 and 6. The plumes were monitored for contaminants and MNA chemical indicators. Overall, the monitoring has indicated that the plumes are decreasing in size and magnitude through natural processes. Following the temporary shutdown of the AS/SVE system, slight rebound of COC concentrations has been observed in the western portion of the Hot Spot of the Area 1 plume. This migration of 1,1-DCE and TCE to the west-northwest, as shown in Figures 4-6 and 4-7, is likely due to the reestablishment of the natural hydraulic gradient in the absence of the AS/SVE system influence. However, the plume concentrations appear to have stabilized since 2007 (see Figure 4-3) and are substantially lower than the concentrations reported in the previous five-year review (Table 6-2). Overall, Area 1 continues to show reduction in CHC concentrations indicating that natural attenuation has been effective (see Figures 4-3 and 4-4). Areas 2, 3 and 6 have been granted NFA closure and the monitoring wells have been decommissioned. These successful closures indicate that the remedy for Areas 2, 3, and 6 has worked as intended.

7.1.1.5 Implementation of Institutional Controls. ICs were selected for all areas of OU-1 to limit the use of groundwater. The MCAS Yuma Master Plan was updated in September 2001 (KTUA, 2001) with the ICs for Areas 1, 2, 3, and 6 in OU-1. The MCAS Yuma Master Plan has subsequently been revised (KTUA, 2007). The final LUCIP, issued in September 2002 (SWDIV, 2002a), was developed to provide the details for implementing LUCs for OU-1, and included a description of the ICs and access and notification provisions (Appendix B3). The LUCs were also formally implemented for MCAS Yuma by Station Order 5090, which directed tenants and contractors to incorporate the LUCs into existing land use planning and management systems. The MCAS Yuma Station Order 5090 was signed in January 2002 (Appendix B4). ICs will be maintained for each OU-1 groundwater plume area until each area has met its closure criteria, as stated in the ROD and summarized in Section 4.1.1.4 of this report.

The final LUCIP also provides for ADEQ access to the sites, prior notification, and reevaluation of the remedy in the event a change to the land use is proposed. The final LUCIP states that ADEQ will be notified in advance if the property associated with these areas is identified as excess by MCAS Yuma and proposed for transfer out of federal ownership.

Annual compliance reports have not been submitted from the MCAS Yuma tenants for this five-year review period. However, within OU-1, MCAS Yuma tenants do not have access to groundwater water resources. The only mechanism for exposure to groundwater is through extraction via groundwater wells. The MCAS Yuma dig permit approval process (which must proceed through the MCAS Yuma Environmental Department) successfully maintains control over the installation of any groundwater wells. No groundwater extraction wells, with the

exception of the wells used for environmental remediation, have been installed in the areas within OU-1.

MCAS Yuma Environmental Department personnel routinely visit the secured areas in the course of their regular duties.

7.1.2 Question B: Are the Exposure Assumptions, Toxicity Data, Clean-up levels, and Remedial Action Objectives Used at the Time of Remedy Selection Still Valid?

Yes; the following subsections discuss the information evaluated in answering this question on the basis of human-health and ecological risk assessment, federal and state regulations evaluated as potential ARARs for the remedial action, and achievement of the RAO.

7.1.2.1 Changes in Standards. The U.S. EPA MCLs for 1,1-DCE, TCE, and PCE remain unchanged since the development of the OU-1 ROD as is shown in U.S. EPA's National Primary Drinking Water Regulations (U.S. EPA, 2009a).

7.1.2.2 Changes in Exposure Pathways. Vapor intrusion (VI) calculations were not established in the OU-1 ROD and have not been performed in previous five-year reviews. Using the U.S. EPA Johnson & Ettinger (J&E) Model (Version 3.1; 02/04) to calculate the VI risks and hazards of groundwater left in place at concentrations equal to the MCLs for the three COCs of OU-1 Area 1, all COCs pose a risk less than or equal to the 1×10^{-6} threshold and have an associated hazard quotient (HQ) of less than 1 (assuming a conservative soil type of loamy sand). These calculated risks and hazards indicate that the established cleanup goals (i.e., U.S. EPA MCLs) are protective of human health through the VI pathway. Table 7-1 highlights the VI risks and hazards for OU-1 COCs. Table 7-2 identifies the toxicity and concentrations used in the J&E Model for the OU-1 VI calculations. The depth to groundwater used in estimating the VI risk was 60 ft bgs.

Table 7-1. OU-1 Estimated Vapor Intrusion Risk Based on Soil Type

OU-1 COC	Loamy Sand		Sandy Loam	
	Risk	HQ	Risk	HQ
1,1-DCE	NA	4E-3	NA	2E-3
TCE	2E-7	5E-4	1E-7	3E-4
PCE	1E-6	2E-3	5E-7	9E-4

Table 7-2. OU-1 COC Toxicity Values Used in the J&E Model

OU-1 COC	Inhalation Unit Risk ($\mu g/m3)^{-1}$	Source	Inhalation Reference Concentration (mg/m^3)	Source	MCL[1] (µg/L)
1,1-DCE	NA	--	0.2	U.S. EPA IRIS	7
TCE	2.0E-06	Cal/EPA	0.6	ATSDR[2]	5
PCE	5.9E-06	Cal/EPA	0.27	Cal/EPA	5

NA Not Available

[1] MCLs were used as "Initial Groundwater Concentrations" in the J&E Model to estimate VI risk and hazards.

[2] Source was provided on U.S. EPA Integrated Risk Information System (IRIS) Web site.

The calculated RBC for TCE in groundwater that poses a risk to industrial workers at a distance of 100 ft from the vapor source (a condition met by all buildings in Area 1) is 33 µg/L. Since TCE concentrations within the Hot Spot are below this concentration, the risk through a VI pathway is currently acceptable. Similar results for PCE exist in Area 1.

7.1.2.3 Changes in Toxicity and Other Contaminant Characteristics. The cancer slope factor and/or oral reference dose (RfD) have changed for the three COCs of OU-1 since the ROD was signed. Toxicity criteria were selected according to the U.S. EPA (2003) Office of Solid Waste and Emergency Response (OSWER) Directive 9285.7-53, which recommends a hierarchy of human health toxicity values for use in risk assessments at Superfund sites. The hierarchy is as follows:

(1) U.S. EPA's IRIS;

(2) U.S. EPA's Provisional Peer-Reviewed Toxicity Values (Office and Development, National Center for Environmental Assessment, Superfund Health Risk Technical Support Center); and

(3) other sources of information, such as toxicity values from the State of California's Environmental Protection Agency (Cal/EPA) and the Agency for Toxic Substances and Disease Registry's (ATSDR's) minimal risk levels for noncarcinogenic constituents

Per U.S. EPA (2009b), noncancer toxicity values for TCE were not selected, but rather, cancer-risk considerations were used to dominate the evaluation of TCE as they are protective of noncancer risks as well. Table 7-3 summarizes the changes that have been made to the cancer slope factors and oral RfDs for the three COCs of OU-1 Area 1. Recent toxicity reports have been developed for PCE and TCE. However, these reports are in a draft form however and represent a non-citable reference per U.S. EPA direction.

Table 7-3. Summary of Toxicity Changes to the OU-1 COCs

OU-1 COC	Oral Slope Factor $(mg/kg\text{-}day)^{-1}$		Source	Oral Reference Dose (RfD) (mg/kg-day)		Source
	New	Previous		New	Previous	
1,1-DCE	NA	NA	--	5.0E-02	9.0E-03	U.S. EPA IRIS
TCE	5.9E-02	NA	Cal/EPA	NA	NA	U.S. EPA, 2009b
PCE	5.4E-01	NA	Cal/EPA	NU	1.0E-02	U.S. EPA IRIS

Cal/EPA Office of Environmental Health Hazard Assessment's toxicity values [available at http://www.oehha.ca.gov/risk/ChemicalDB/index.asp]
U.S. EPA IRIS Accessed December 2009 [available on IRIS at http://www.epa.gov/iris]
NU Not Updated
NA Not Available

Based on the increased concentration of the 1,1-DCE oral RfD, the current remediation goals (i.e., U.S. EPA MCLs) remain protective of human health. The oral slope factors for TCE and PCE have been established since the last five-year review. For the current review, the U.S. EPA Regional Screening Levels (RSLs) (U.S. EPA, 2009b) for tap water for TCE and PCE were used to assess the protective nature of the current remediation goals. The RSLs are 2 µg/L for TCE and 0.1 µg/L for PCE, both below the 5 µg/L MCL for each compound. However, since the ICs in place at OU-1 prevent a completed exposure pathway from groundwater, the RSLs do not require a modification of the remedial goal. As an ARAR, MCLs remain the remedial goal.

7.1.2.4 Expected Progress Towards Meeting RAOs. The RAOs for all of the OU-l groundwater CHC plumes are: 1) the containment of all plumes within the facility boundary, and 2) the reduction of groundwater contamination to meet applicable drinking water standards (i.e., U.S. EPA MCLs). The selected remedies have successfully contained all contaminated plumes to within the MCAS Yuma facility boundaries and MNA has demonstrated the continued reduction of CHC concentrations. Three of the four OU-1 areas (i.e., Areas 2, 3 and 6) have met the MCLs and have been subsequently closed with NFA. Area 1 remains under MNA through which declining CHC concentrations are expected to continue.

7.1.3 Question C: Has any Other Information Come to Light That Could Call Into Question the Protectiveness of the Remedy?

No; no additional information has been found that suggests that the remedy selected for OU-1, as currently defined in the ROD (SWDIV, 2000), may not be protective. The selected remedy has been effective as long as groundwater is not used from the sites where RAOs have not been achieved.

7.2 Technical Assessment of Operable Unit 2

The technical assessment for OU-2 presented in this section describes how each of the three key assessment questions was answered for OU-2 CAOCs 1, 8A and 10. The discussion presented here is a framework for the protectiveness determination that explains the conclusions of the review, based on the information presented in the previous section.

7.2.1 Question A: Is the Remedy for OU-2 Functioning as Intended by the Decision Documents?

Yes; a review of documents, site inspections, and interviews of station personnel indicates that the remedy for OU-2 CAOCs 1, 8A and 10 is functioning to protect human health through implementation of ICs on land use. The subsections below provide further detail regarding the remedy efficacy.

7.2.1.1 Remedial Action Performance. The selected remedy as defined in the ROD consisted of ICs restricting land use of CAOC 1 and CAOC 10 to industrial/commercial use and CAOC 8A to its current use as an inactive former landfill as well as prevent any activities that may disrupt and expose the landfill interior. The land surfaces are secured by fencing with locked gates and access to CAOCs 1, 8A and 10 is restricted to MCAS Yuma Environmental Department personnel and MCAS Yuma security personnel. No station activity is currently proceeding at the CAOCs. These measures are functioning to protect human health.

7.2.1.2 Implementation of Institutional Controls. The MCAS Yuma Master Plan was updated in September 2001 (KTUA, 2001) with the ICs for CAOCs 1, 8A and 10 of OU-2. The MCAS Yuma Master Plan has subsequently been revised (KTUA, 2007). The final LUCIP, issued in September 2002 (SWDIV, 2002a), was subsequently developed to provide the details for implementing LUCs for OU-2, and included a description of the ICs and access and notification provisions (Appendix B3). The LUCs were also formally implemented for MCAS Yuma by Station Order 5090, which directed tenants and contractors to incorporate the LUCs into existing land use planning and management systems. The MCAS Yuma Station Order 5090 was signed in January 2002 (Appendix B4).

The final LUCIP also provides for ADEQ access to the sites, prior notification, and reevaluation of the remedy in the event a change to the land use is proposed. The final LUCIP states that ADEQ will be notified in advance if the property associated with these areas is identified as excess by MCAS Yuma and proposed for transfer out of federal ownership.

Annual compliance reports have not been submitted from the MCAS Yuma tenants for this five-year review period. However, OU-2 is effectively isolated from human contact by secured fencing. Any activity within CAOCs 8A and 10 of OU-2 must be coordinated with MCAS Environmental Department personnel. There are no tenants within CAOCs 8A and 10 as well. OU-2 CAOC 1 is within the flight line access control area and all locations with base tenants present are paved, thus preventing contact with OU-2 CAOC 1 soils.

MCAS Yuma Environmental Department personnel routinely visit the secured areas in the course of their regular duties.

7.2.2 Question B: Are the Exposure Assumptions, Toxicity Data, Clean-up Levels, and Remedial Action Objectives (RAOs) used at the Time of Remedy Selection Still Valid?

Yes; the following subsections discuss the information evaluated in answering this question on the basis of human-health and ecological risk assessment, federal and state regulations evaluated as potential ARARs for the remedial action, and achievement of the RAO.

7.2.2.1 Changes in Standards. Arizona's Soil Remediation Standards are identified in the OU-2 ROD as chemical-specific ARARs for the remediation of soil at CAOCs 1, 8A and 10. ARS Title 49, as implemented in AAC Title 18, Chapter 7, Article 2 requires that soils be remediated to either: 1) background levels; 2) HBGLs; or 3) site-specific risk assessment based levels. HBGLs listed in Appendix A of AAC Title 18, Chapter 7, Article 2 have been updated and included in Table 7-4, with a comparison of the HBGLs given in the ROD (which were last updated in June 1995).

7.2.2.2 Changes in Exposure Pathways. VI calculations were not established in the OU-2 ROD and have not been performed in previous five-year reviews. Of the COPCs present in OU-2 CAOCs 1, 8A, and 10, naphthalene is the only one where VI may be a potential concern for future workers and only in CAOCs 1 and 10. The U.S. EPA J&E soil VI model (ver 3.1) was used to estimate the noncarcinogenic health hazard for potential exposure to naphthalene in indoor air. Table 7-5 summarizes the HQs for naphthalene in CAOCs 1 and 10 based on the maximum concentration of naphthalene detected in soil in these

Table 7-4. Revised Health Based Guidance Levels for Ingestion of COPCs in Soil at OU-2 CAOC 1, 8A and 10

OU-2 COPC	Cancer Group		Residential Oral HBGL (mg/kg)		Non-Residential Oral HBGL (mg/kg)	
	1995[a]	2007[b]	1995[a]	2007[b]	1995[a]	2007[b]
Acenaphthene	ND	nc	7,000.0	3,700	24,500.0	29,000
Acenaphthylene (PAH)	D	na	7,000.0	na	24,500.0	na
Anthracene (PAH)	D	nc	35,000.0	22,000	122,500.0	240,000
Benz[a]anthracene (PAH)	B2	ca	1.1	0.69	4.6	21
Benzo[a]pyrene (PAH) (BaP)	B2	ca	0.19	0.069	0.80	2.1
Benzo[b]fluoranthene (PAH)	B2	ca	1.1	0.69	4.6	21
Benzo[k]fluoranthene (PAH)	B2	ca	1.1	6.9	4.6	210
Chrysene (PAH)	B2	ca	110.0	68	462.0	2,000
Dibenz[a,h]antracene (PAH)	B2	ca	0.11	0.069	0.46	2.1
Fluoranthene (PAH)	D	nc	4,700.0	2,300	16,450.0	22,000
Fluorene (PAH)	D	nc	4,700.0	2,700	16,450.0	26,000
Indeno[1,2,3-cd]pyrene (PAH)	B2	ca	1.1	0.69	4.6	21
Naphthalene (PAH)	D	nc	4,700.0	56	16,450.0	190
Polychlorinated biphenyls (PCBs) (high risk)	B2	ca, nc	0.18	0.25	0.76	7.4
Polychlorinated biphenyls (low risk)	ND	ca, nc	8.2	3.9	28.7	37
Pyrene (PAH)	D	nc	3,500.0	2,300	12,250.0	29,000

[a] 1995 data given in Tables 2-8 of the OU-2 ROD (Uribe & Associates, 1997b) (also shown in Section 4.2.1.2. of this document).

[b] 2007 data derived from Appendix A to ARS Title 18, Chapter 7, Article 2 updated March 30, 2007.

Cancer Groups are as follows:

- B2 Probable human carcinogen
- D Not classifiable as to human carcinogenicity
- ND No data available
- Ca carcinogen
- nc noncarcinogen
- na not available

CAOCs. An HQ of 1 is deemed acceptable by U.S. EPA and ADEQ. Table 7-6 summarizes the input parameters used to estimate the health hazard.

The HQ for naphthalene in CAOC 1 exceeds the regulatory threshold of 1 for each building scenario, but the HQ is below 1 for CAOC 10. Given that the soil data are more than 10 years old and that naphthalene (as well as the other PAHs) was detected in surficial soil samples associated with the washrack area (an uncovered area exposed to the elements) it is unlikely that the concentrations that may currently be present in CAOC 1 surficial soil would be as high as 70 mg/kg. Historical concentrations of naphthalene in soil in all other sampling locations within CAOC 1 would not be associated with an HQ above 1. Furthermore, receptors are not anticipated to have continuous exposure to the maximum concentration, and U.S. EPA recommends use of exposure point concentrations representative of average site concentrations. If further evaluation was performed, an average value (i.e., 95% upper confidence limit of arithmetic mean) would be used and the resulting HQ would be lower than that calculated here.

Table 7-5. Estimated Vapor Intrusion HQs for Naphthalene at OU-2 CAOCs 1 and 10

Building Size	OU-2 CAOCs	Maximum Concentration Detected (mg/kg)	HQ
32 ft x 32 ft x 10 ft	CAOC 1	70	44
	CAOC 10	0.112	0.07
64 ft x 64 ft x 10 ft	CAOC 1	70	16
	CAOC 10	0.112	0.025

Table 7-6. Input Parameters Used in the J&E Model to Evaluate the Vapor Intrusion Pathway for OU-2 CAOCs 1 and 10

Parameters	Input Value
Average soil/groundwater temperature (degrees C)	20
Depth below grade to bottom of floor (cm)	15
Depth below grade to top of contamination (cm)	15
Depth below grade to bottom of contamination (cm)	305
Soil stratum	A
Thickness of soil stratum (cm)	15
SCS soil type	LS
Soil vapor permeability (cm^2)	Calculated
Soil dry bulk density (g/cm^3)	1.62
Soil total porosity (unitless)	0.39
Soil water-filled porosity (unitless)	0.076
Soil organic carbon fraction (unitless)	0.002
Floor thickness (cm)	15
Soil building pressure differential ($g/cm\text{-}sec^2$)	40
Length of structure (cm)	1000 and 2000[a]
Width of structure (cm)	1000 and 2000[a]
Height of structure (cm)	305
Floor-wall seam crack width (cm)	0.1

Table 7-6. Input Parameters Used in the J&E Model to Evaluate the Vapor Intrusion Pathway for OU-2 CAOCs 1 and 10 (Continued)

Parameters	Input Value
Indoor air exchange rate (1/h)	0.828
Average vapor flow rater into building (L/m)	5
Target cancer risk level (unitless)	1×10^{-6}
Target noncancer Hazard Quotient (unitless)	1
Exposure Frequency (days)	250
Exposure Duration (years)	25

[a] Two building sizes were evaluated to account for the different sizes of buildings that are present within the OU-2 areas.

7.2.2.3 Changes in Toxicity and Other Contaminant Characteristics. A toxicity investigation of all COPCs for OU-2 CAOCs was not performed as the ICs that are currently present, as set forth in the Final LUCIP (SWDIV, 2002a) and MCAS Yuma Master Plan (KTUA, 2007), do not allow for a complete exposure pathway to site contaminants. The ICs continue to effectively protect human health and the environment.

7.2.2.4 Expected Progress Towards Meeting RAOs. The RAO for OU-2 CAOCs 1, 8A and 10 is to minimize the potential for unacceptable human-health risk that could result from a change in land use (Uribe & Associates, 1996b). The continued isolation of OU-2 CAOCs, by way of ICs, remains an effective means of meeting the RAO.

7.2.3 Question C: Has Any Other Information Come to Light That Could Call Into Question the Protectiveness of the Remedy? No; no additional information has been found to suggest that the remedy selected for OU-2 CAOCs 1, 8A, and 10, as currently defined in the ROD (Uribe & Associates, 1997), may not be protective. The selected remedy has been effective as long as ICs are maintained. While base personnel have indicated the possibility of a future land use change for OU-2 CAOC 8A, documentation of that land use change is needed; should a change in land use be needed for CAOC 8A, communication with the regulatory agencies, prior to the change, will occur as stipulated in the ROD.

8.0 ISSUES

This section presents issues that have been raised in the past five years. Table 8-1 identifies the site operations, conditions, or activities that may currently prevent the remedy from being protective, or may prevent it from being protective in the future.

Table 8-1. Issues Regarding Remedy Protectiveness

Issue Number	Issues	Affects Current Protectiveness (Yes/No)	Affects Future Protectiveness (Yes/No)
1	While base personnel have indicated the possibility of a future land use change for OU-2 CAOC 8A, documentation of that land use change is needed; should a change in land use be needed for OU-2 CAOC 8A, communication with the regulatory agencies, prior to the change, will occur as stipulated in the ROD.	No	Yes
2	U.S. EPA raised the following issue for OU-2: while DEURs have been proposed, they have not been registered with Arizona and thus the ICs are not complete (see Attachment 1).	No	Yes
3	U.S. EPA raised the following issue for OU-1: the most recent (June 2009) data presented in Figures 4-6 and 4-7 indicate that there has been recent plume migration in the LEPA and Hot Spot areas. The significance of this recent movement on remedy effectiveness needs to be evaluated.	No	Yes
4	An evaluation of the progress of an MNA remedy in meeting RAOs should be undertaken as part of every 5YR where MNA is the remedy. Since the transition to MNA was recently adopted for OU-1 Area 1, an evaluation was not performed for this five-year review.	No	Yes
5	Note that on January 7, 2010, U.S. EPA published draft guidance on Interim PRGs for dioxin in soil at CERCLA and RCRA sites. If adopted, this proposal will lower the dioxin PRG significantly. Please confirm the activities evaluated to address potential dioxin at CAOC 8A. If dioxin is a concern, we suggest that the 5YR include a discussion of this issue.	No	Yes
6	During the five-year review, inconsistencies were indentified between figures provided in the recently revised MCAS Yuma Master Plan (KTUA, 2007) and the Final LUCIP (SWDIV, 2002a).	No	Yes
7	The indoor air exposure pathway is incomplete for all three CAOCs in OU-2 based on current land use of these areas; thus, the ICs are appropriate. However, if these areas were to be redeveloped in the future for office and/or residential use, the ICs may not be protective.	No	Yes
8	U.S. EPA raised the following issue for OU-1 Area 1: the document should address any vadose zone contamination that may be of concern to the VI pathway.	No	Yes

9.0 RECOMMENDATIONS AND FOLLOW-UP ACTIONS

No recommendations are needed at this point in the remediation of the OUs at MCAS Yuma as the remedial systems and ICs currently in place are effectively protecting human health and the environment.

Table 9-1. Recommendations and Follow-up Actions following the Five-Year Review

Issue Number	Recommendations and Follow-up Actions	Party Responsible	Oversight Agency	Milestone Date	Affects Protectiveness (Yes/No; Current and/or Future)
1	While base personnel have indicated the possibility of a future land use change for OU-2 CAOC 8A, documentation of that land use change is needed; should a change in land use be needed for OU-2 CAOC 8A, communication with the regulatory agencies, prior to the change, will occur as stipulated in the ROD.	DON	U.S. EPA	To be determined	Yes; Future
2	Evaluate the LUCIP and ensure that the plan is up-to-date, continues to provide effective processes for LUC implementation, and continues to provide long-term protectiveness. Also, discussions should be initiated between ADEQ, U.S. EPA, and Navy legal counsel to determine how to best address and resolve the DEUR issue.	DON	U.S. EPA and ADEQ	2015	Yes; Future
3	Evaluate the progress of plume remediation and potential rebound, and review the AS/SVE shutdown criteria and make a recommendation regarding system operation.	DON	U.S. EPA	Ongoing	Yes; Future
4	An evaluation of MNA progress in subsequent five-year reviews should be performed, including modeling groundwater under the MNA scenario to predict when MNA would result in reaching MCLs.	DON	U.S. EPA	2015	Yes; Future

Table 9-1. Recommendations and Follow-up Actions following the Five-Year Review (Continued)

Issue Number	Recommendations and Follow-up Actions	Party Responsible	Oversight Agency	Milestone Date	Affects Protectiveness (Yes/No; Current and/or Future)
5	U.S. EPA's dioxin reassessment has been developed and undergone review over many years with the participation of scientific experts in EPA and other federal agencies, as well as scientific experts in the private sector and academia. The Agency followed current cancer guidelines and incorporated the latest data and physiological/biochemical research into the assessment. The results of the assessment have currently not been finalized or adopted into state or federal standards. U.S. EPA anticipates that a final revision to the dioxin toxicity numbers may be released by the end of 2010. In addition, U.S. EPA/OSWER has proposed to revise the interim preliminary remediation goals (PRGs) for dioxin and dioxin-like compounds, based on technical assessment of scientific and environmental data. However, U.S. EPA has not made any final decisions on interim PRGs at the time of this five-year review. Therefore, the dioxin toxicity reassessment for this site (CAOC 8A) should be updated during the next Five-Year Review.	DON	U.S. EPA	2015	Yes; Future
6	The DON and MCAS Yuma should reconcile the discrepancies between the figures in the Final LUCIP (SWDIV, 2002a) and the MCAS Yuma Master Plan (KTUA, 2007).	DON	U.S. EPA	2015	Yes; Future
7	An evaluation of the ICs and the protectiveness of the LUCIP should be performed with regards to the VI pathway for all OU-2 CAOCs in the event of changes to the current land use status.	DON	U.S. EPA	2015	Yes; Future
8	An analysis of soil gas data from previous soil investigations should be performed to compare to VI screening levels to ensure that the only potential VI source is groundwater.	DON	U.S. EPA	2015	Yes; Future

10.0 PROTECTIVENESS STATEMENTS

Protectiveness statements for OU-1 and OU-2 are independently presented in the following subsections.

10.1 Protectiveness Statement for Operable Unit 1

The remedy at OU-1 is currently and will continue to be protective of human health and the environment because of the implementation of remedial measures and control of exposure pathways that may result in unacceptable risks. These methods are being applied as follows:

(1) Remediation systems were installed and operated in the Area 1 plume. A VCT system was operated in the LEPA from June 2000 to May 2003. The system has reduced CHC concentrations to near MCLs and contained any off-site migration of the plume in this area. An AS/SVE system was installed in the Building 230 area to remediate the groundwater in the most highly contaminated area of OU-1. The system operated relatively continuously between November 1999 and May 2007. The AS/SVE system has reduced the CHC "Hot Spot" in both size and magnitude such that the COCs will not migrate offsite at concentrations greater than MCLs.

(2) MNA is currently applied at all active regions of Area 1. MNA has been demonstrated to reduce contaminant concentrations through natural processes and has indicated that the plumes are not migrating. Groundwater monitoring required for the MNA program has been implemented through the LTM plan for OU-1 at MCAS Yuma. Plumes will continue to be monitored through MNA of the LTM plan until they decrease in concentrations below MCLs.

(3) ICs are in place to restrict exposure to any contaminated groundwater at Area 1 through MCAS Yuma Station Order 5090. This order formally directs tenants and contractors to incorporate the LUCs provided in the MCAS Yuma Master Plan (KTUA, 2007) and the Final LUCIP (SWDIV, 2002a) into their existing land use planning and management programs.

The MCAS Yuma Environmental Department will continue to review and coordinate all plans for future activities at OU-1 in consultation with U.S. EPA and ADEQ, as necessary, to ensure application of the measures specified in the OU-1 ROD (SWDIV, 2000).

10.2 Protectiveness Statement for Operable Unit 2

The remedy at OU-2 is currently and will continue to be protective of human health and the environment because exposure pathways that may result in unacceptable risks are being controlled as follows:

(1) ICs are in place to restrict exposure to contaminants in soil at CAOCs 1, 8A and 10 through MCAS Yuma Station Order 5090. This order formally directed tenants and contractors to incorporate the LUCs provided in the MCAS Yuma Master Plan

(KTUA, 2007) and the Final LUCIP (SWDIV, 2002a) into their existing land use planning and management programs.

(2) The "modified DEURs" for CAOCs 1, 8A and 10 have been proposed to satisfy the requirements specified in the OU-2 ROD (Uribe & Associates, 1997b) for registration of the sites with the State of Arizona.

The MCAS Yuma Environmental Department will continue to review and coordinate all plans for future activities at CAOCs 1, 8A, and 10, in consultation with U.S. EPA and ADEQ as necessary, to ensure continued compatibility with the land use restrictions specified in the OU-2 ROD (Uribe & Associates, 1997b).

11.0 NEXT REVIEW

The next five-year review for MCAS Yuma OU-1 and OU-2 will be due in 2015, five years from the date on which this document is signed. Consecutive five-year reviews will be required as long as site groundwater and land conditions remain that do not allow for unlimited use and unrestricted exposure.