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

FEB 20 2013

Mr. Ralph Pearce
Department of the Navy
Naval Facilities Engineering Command Southwest
1220 Pacific Highway, OPCE.RP
San Diego, CA 92132-5190

Re: EPA Concurrence on Final Third Five-Year Review Report, Operable Units 1 - 6
Marine Corps Logistics Base Barstow

Dear Mr. Pearce:

The U.S. Environmental Protection Agency (U.S. EPA) Region 9 has received and reviewed "Final Third Five-Year Review Report Operable Units 1 - 6 Marine Corps Logistics Base Barstow, California", dated December 17, 2012 (Barstow Final Five-Year Review). The Barstow Final Five-Year Review addresses completed and ongoing remedial actions taken pursuant to Superfund decision documents that have been completed to-date.

Based upon our review, U.S. EPA agrees with the findings, conclusions, and recommendations provided as they relate to protectiveness, and concurs with the Department of the Navy that the remedies for groundwater and soil remain protective of human health and the environment under the current land use at Barstow Marine Corps Logistics Base.

U.S. EPA looks forward to continued coordination with the Navy on cleanup activities at Barstow Marine Corps Logistics Base. If you have any questions concerning this matter, please contact Mary Aycock of my staff at (415) 972-3289.

Sincerely,

Michael Montgomery
Assistant Director, Superfund Division
Federal Facilities and Site Cleanup Branch

cc: Mr. Jim Bustamante, MCLB
Ms Soad Hakim, DTSC
Mr. Omar Pacheco, RWQCB

DEPARTMENT OF THE NAVY
NAVAL FACILITIES ENGINEERING COMMAND SOUTHWEST
1220 PACIFIC HIGHWAY
SAN DIEGO, CA 92132-5190

5090
Ser RAR00.GB/558
December 17, 2012

Phillip Ramsey
Attn: SFD-8-1
U.S. Environmental Protection Agency, Region IX
75 Hawthorne Street
San Francisco, CA 94105

Omar Pacheco, RPM
California Regional Water Quality Control Board
Lahontan Region - Victorville Branch Office
14440 Civic Drive, Suite 200
Victorville, CA 92392

Soad Hakim
Cal-EPA - Department of Toxic Substances
5796 Corporate Avenue
Cypress, CA 90630

Dear Mr. Ramsey, Mr. Pacheco, and Ms. Hakim:

The Department of the Navy is pleased to provide the enclosed Final Third Five-Year Review Report, Operable Units 1-6, Marine Corps Logistics Base Barstow, California. This deliverable is provided in the electronic and hard copy formats as stated on the attached distribution list. Please note that all regulatory comments and the Navy's responses to comments received on the Draft and Draft Final versions of the report are provided in Appendix H of the report.

If you have any questions, please contact Ralph Pearce at (619) 532-3768 or by email at Ralph.Pearce@navy.mil.

Sincerely,

GASTON BORDENAVE JR
By direction

Attachment: Distribution List

Enclosure: Final Third Five-Year Review Report, Operable Units 1-6, Marine Corps Logistics Base Barstow, California.

Copy to: Marine Corps Logistics Base
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Barstow, California 92311-5050

Commanding Officer
Naval Facilities Engineering Command, Southwest
ATTN: Diane Silva, Administrative Records
937 N. Harbor Drive
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San Diego, CA 92132-5181

2012 Final Third Five-Year Review Report
Operable Units 1 - 6, Marine Corps Logistics Base Barstow, California
DCN: ATJV-2610-0013-0030 December 11, 2012

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FINAL THIRD FIVE-YEAR REVIEW REPORT
OPERABLE UNITS 1 - 6

MARINE CORPS LOGISTICS BASE BARSTOW
BARSTOW, CALIFORNIA

ENVIRONMENTAL MULTIPLE AWARD CONTRACT (EMAC)
Contract Number N62473-09-D-2610
Contract Task Order 0013

DCN: ATJV-2610-0013-0030

Prepared for:

1220 Pacific Highway, Building 127, Room 112
San Diego, California 92132

Prepared by:

317 E. Main Street
Ventura, California 93001

11 December 2012

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ABBREVIATIONS AND ACRONYMS

%	percent
§	Section
1,1-DCE	1,1-dichloroethene
µg/L	micrograms per liter
AGMR	Annual Groundwater Monitoring Report
AGRA	AGRA Earth and Environmental, Inc.
amsl	above mean sea level
ARAR	applicable or relevant and appropriate requirement
AS/SVE	air sparging/soil vapor extraction
ATJV	AIS-TN&A JV
bgs	below ground surface
BMP	Base Master Plan
BEI	Bechtel Environmental, Inc.
BNI	Bechtel National, Inc.
CAOC	CERCLA Area of Concern
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CDHS	California Department of Health Services
CDPH	California Department of Public Health
CDWR	California Department of Water Resources
CFR	Code of Federal Regulations
COC	contaminants of concern
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethene
DDT	dichlorodiphenyltrichloroethane
DoD	Department of Defense
DON	Department of the Navy
DTSC	Department of Toxic Substances Control
ER	Environmental Restoration
ERFA	Extended RFA
FFA	Federal Facility Agreement
FS	Feasibility Study
ft/ft	feet per foot
FWENC	Foster Wheeler Environmental Corporation
GAC	granular activated carbon

ABBREVIATIONS AND ACRONYMS (CONTINUED)

GETS	Groundwater Extraction and Treatment System
GEW	groundwater extraction well
GIS	Geographic Information System
HERO	California Department of Toxic Substances Control, Office of Human and Ecological Risk
HHRA	Human Health Risk Assessment
IC	institutional control
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
IWTP	Industrial Wastewater Treatment Plant
J-E	Johnson-Ettinger (soil vapor exposure risk model)
JEG	Jacobs Engineering Group
LTGWMP	Long-term Groundwater Monitoring Plan
LUC	land use control
MCL	maximum contaminant level
MCLB	Marine Corps Logistics Base
MCMD	Marine Corps Maintenance Depot
MDAQMD	Mojave Desert Air Quality Management District
MEC	munitions and explosives of concern
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MTBE	methyl tert-butyl ether
NAVFAC SW	Naval Facilities Engineering Command Southwest
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NFA	no further action
NPL	National Priorities List
O&M	Operations and Maintenance
OCP	organochlorine pesticide
OEHHA	Office of Environmental Health Hazards Assessments
OHM	OHM Remediation Services Corporation
OTIE	Oneida Total Integrated Enterprises
OU	Operable Unit

ABBREVIATIONS AND ACRONYMS (CONTINUED)

PAH	polynuclear aromatic hydrocarbon
PCBs	polychlorinated biphenyls
PCE	tetrachloroethene (perchloroethene, perc)
pCi/L	picocuries per liter
PRG	Preliminary Remediation Goal
RA	remedial action
RAO	Remedial Action Objective
RAR	Remedial Action Report
RBC	risk-based criteria
RCRA	Resource Conservation and Recovery Act
RFA	RCRA facility assessment
RI	Remedial Investigation
ROD	Record of Decision
ROI	radius of influence
RPM	Remedial Project Manager
RSL	Regional Screening Level
RWQCB	Regional Water Quality Control Board
SAP	Sampling and Analysis Plan
SDVJV	SD Engineering and Construction Joint Venture
SVOC	semivolatile organic compound
TBC	to be considered
TCE	trichloroethene
TCRA	time-critical removal action
TEF	Technical and Economic Feasibility
TICs	tentatively identified compounds
TN&A	T N & Associates
TPH	total petroleum hydrocarbons
TPH-d	total petroleum hydrocarbons as diesel
TRPH	total recoverable petroleum hydrocarbons
TtEC	Tetra Tech EC, Inc.
TtFW	Tetra Tech FW, Inc.
URS	URS Corporation

ABBREVIATIONS AND ACRONYMS (CONTINUED)

URSGI	URS Group, Inc.
USC	United States Code
U.S. EPA	U.S. Environmental Protection Agency
UU/UE	unlimited use/unrestricted exposure
VOC	volatile organic compound
VPB	vertical profile boring
WDR	waste discharge requirement

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DECLARATION OF ACCEPTANCE FOR
OUS 1 – 6 THIRD FIVE-YEAR REVIEW REPORT – 2012
MARINE CORPS LOGISTICS BASE,
BARSTOW, CALIFORNIA

Pursuant to the delegation of the authority in Sections 2(d) and 11(g) of the Executive Order 12580, and U.S. Department of Defense Instruction 4715.7 of 22 April 1996, the U.S. Department of the Navy is the approval authority for Comprehensive Environmental Response, Compensation, and Liability Act Five-Year Reviews conducted at sites under its jurisdiction, custody, or control.

Michael L. Scalise
Colonel, U.S. Marine Corps
Commanding Officer

11 Dec 12
Date

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EXECUTIVE SUMMARY

Introduction

This report presents the results of the Third Five-Year Review for six operable units (OUs) located at the Marine Corps Logistics Base (MCLB) Barstow located near Barstow, California. This report has been prepared by the United States Department of the Navy (DON) in support of the Installation Restoration Program (IRP) being conducted at the MCLB Barstow. The IRP was developed by the Department of Defense (DoD) to clean up contamination at military facilities caused by past use, storage, handling, and disposal of hazardous and other potentially toxic substances. The review period of this report is October 2007 through September 2012, with a trigger review date of 19 December 2007.

Authority of Conducting Five-Year Reviews

The DON is the lead agency for conducting five-year reviews at the MCLB Barstow (the Base) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The DON has prepared this five-year review pursuant to CERCLA Section (§) 121(c) and the National Contingency Plan (NCP). In addition, the United States Environmental Protection Agency's (U.S. EPA's) Five-Year Review Guidance (U.S. EPA, 2001) and DON's policy for conducting CERCLA five-year reviews (DON, 2011) were extensively used in preparation of this five-year review report. The five-year review is required because hazardous substances, pollutants, or contaminants remain on Base above levels that allow for unlimited use and unrestricted exposure.

According to the NCP, five-year review reports are to be completed and signed within five years of the trigger date for a site when, upon the completion of the Remedial Actions (RAs) at a site, hazardous substances, pollutants, or contaminants will remain above levels that allow for unlimited use and unrestricted exposure. The OUs 1 and 2 Record of Decision (ROD) (JEG, 1998a), signed 22 April 1998, required the first statutory five-year review of these OUs to be completed by 22 April 2003. In accordance with DON's policy, the trigger date for the statutory five-year review of OUs 3 and 4 was 9 September 1998. The trigger date for the statutory five-year review of OUs 5 and 6 was 23 January 1998. To streamline and synchronize the five-year reviews of OUs 1 – 6, the first five-year review was completed and signed on 30 December 2002. The trigger date for subsequent five-year reviews of OUs 1 – 6 is the signature date of the prior five-year review. Hence the second five-year review was signed on 19 December 2007 (DON, 2007), and the Third Five-Year Review is due in December 2012. This approach is consistent with § 27.3 of the Federal Facility Agreement (FFA) between the DON, U.S. EPA Region 9, the California Department of Toxic Substances Control (DTSC), and the California Regional Water Quality Control Board - Lahontan Region (RWQCB-Lahontan Region).

Site Background and History

The MCLB Barstow is located in San Bernardino County, California, within the central Mojave Desert, approximately 135 miles northeast of Los Angeles. The MCLB Barstow consists of two

areas: the Yermo Annex, which is 7 miles east of Barstow, California, between Interstates 15 and 40; and the Nebo Main Base, which includes the Rifle Range, is 3.5 miles east of Barstow and intersected by Interstate 40.

In November 1989, the Base was placed on the CERCLA National Priorities List (NPL) due to the presence of soil and groundwater contamination. Soil and groundwater at the MCLB Barstow are currently being cleaned up under the IRP. The MCLB Barstow IRP follows federal and state regulations in its investigation and cleanup of Base contamination. The DON is the lead DoD authority responsible for conducting the site investigation and cleanup at the MCLB Barstow. The DON's investigation and cleanup efforts are being conducted in conjunction with the U.S. EPA, the Regional Water Quality Control Board – Lahontan Region (RWQCB-Lahontan Region), and the State of California Environmental Protection Agency's Department of Toxic Substances Control (DTSC).

The IRP divides the Base (Yermo Annex and Nebo Main Base) into seven OUs. Each OU is divided into a number of CERCLA Areas of Concern (CAOCs). OUs 1 and 2 pertain to groundwater contamination beneath the Yermo Annex and Nebo Main Base, respectively. Groundwater contamination is primarily due to dissolved volatile organic compounds (VOCs). OUs 3 and 5 pertain to soil contamination at the Yermo Annex, and OUs 4 and 6 pertain to soil contamination at Nebo Main Base. Soil contamination is primarily due to VOCs, metals, pesticides, polychlorinated biphenyls (PCBs), and polynuclear aromatic hydrocarbons (PAHs). RODs were signed for the following OUs: in 1997 for OUs 3 and 4; in 1998 for OUs 1 and 2 and OUs 5 and 6. RAs and landuse controls/institutional controls (LUCs/ICs) have been implemented at select CAOCs within OUs 1-6. The ROD for OU 7 is under development; therefore, OU 7 is not subject to five-year review.

Five-Year Review Questions

The Third Five-Year Review evaluates the remedies implemented at each of the CAOCs at OUs 1-6 by answering the following questions:

Question A: Is the remedy functioning as intended by the ROD(s)?

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and Remedial Action Objectives (RAOs) used at the time of the remedy selection still valid?

Question C: Has any other information come to light that could call in to question the protectiveness of the remedy?

Through the process of answering the review questions for each of the selected remedies at each OU, issues are identified, and a determination is made if the remedies are protective of human health and the environment. Recommendations and follow-up actions, with milestone dates for implementation, are made to address any concerns with short-term or long-term protectiveness.

The following Five-Year Review Summary forms provide a synopsis of the OUs, remedies in place, identified issues, protectiveness statements, and recommendations.

SITE IDENTIFICATION		
Site name (from WasteLAN) Marine Corps Logistics Base Barstow		
U.S. EPA ID (from WasteLAN) CA8170024261		
Region: 09	**State:** CA	**City/County**: Barstow / San Bernardino County

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: 12 / 08 / 98
Has site been put into reuse? ☒ YES ☐ NO	

REVIEW STATUS	
Reviewing agency: ☐ U.S. EPA ☐ State ☐ Tribe ☒ Other Federal Agency: U. S. Department of the Navy	
Author name: Ralph Pearce	
Author Title: Remedial Project Manager	**Author affiliation:** Naval Facilities Engineering Command, Southwest
Review period: October 2007 to September 2012	
Date(s) of inspection: 29 – 30 March 2012	
Type of review: ☒ Statutory ☐ Policy ☐ 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 (specify) _____	
Triggering action: ☐ Actual RA On-site Construction at OU__ ☐ Actual RA Start at OU #_____ ☐ Construction Completion ☒ Previous Five-Year Review Report ☐ Other (specify) _____	
Triggering action date: 12 / 19 / 2007	
Due date (five years after triggering action date): 12 / 19 / 2012	

(continued next page)

FIVE-YEAR REVIEW SUMMARY FORM – OU 1 (YERMO ANNEX)

OU 1 consists of CAOC 37, which is the groundwater at Yermo Annex. The remedy for OU 1 was established in the OUs 1 and 2 ROD signed in 1998. The ROD addresses three groundwater VOC plumes identified as the CAOC 26, Yermo North, and Yermo South plumes. The primary VOCs affecting groundwater are perchloroethylene (also called tetrachloroethene, perc, or PCE) and trichloroethene (TCE). Portions of the groundwater plumes extend off Base. These plumes are being remediated by the CAOC 16 and CAOC 26 air sparging/soil vapor extraction (AS/SVE) systems, and the Yermo Annex Groundwater Extraction and Treatment System (GETS). The GETS includes extraction wells, treatment of extracted groundwater through granular-activated carbon (GAC), and infiltration of treated water back into the aquifer. The remedial systems were installed during 1996 to 1998. The CAOC 26 AS/SVE system was shutdown in 1998 after meeting remedial objectives; the CAOC 16 AS/SVE system and GETS remain in operation. During the review period, only three to four extraction wells were required needed to be operated due to significant reductions in the Yermo plume area.

The OU 1 remedy also includes:

- Maintenance and monitoring of GAC treatment systems on two on-Base drinking water production wells and two off-Base private residential wells.
- Annual monitoring of groundwater VOCs at CAOCs 15/17, 16, 20, 23, 26, and 35.
- Groundwater monitoring to determine if dissolved metals, particularly chromium and nickel, are site-related contaminants in the CAOC 16 area.
- ICs incorporated in the Base Master Plan to prevent use of Base groundwater within contaminated zones, and
- Notification of San Bernardino County regarding off-Base migration of contaminated groundwater.

Issues Identified during the Third Five-Year Review:

1. The Yermo North plume remained stable during the review period; that is, the plume neither expanded nor retreated and the estimated plume mass did not change. The addition of two new extraction wells in 2010 and 2012 is anticipated to change the plume dimensions and center of mass due to improved hydraulic control. Soil vapor data in three multi-level monitoring wells installed at CAOC 16 indicate continued presence of VOCs with relatively stable concentrations over time. Conservative modeling indicates that the soil vapor VOCs do not pose an inhalation risk to on-Base persons (see OU 5 review). However, the presence of soil vapor VOCs and the stable Yermo North groundwater plume are indications of an ongoing contaminant source or sources that are not being effectively addressed by the current configuration of the remedy.
2. The Yermo North plume continued to be present off-Base during this five-year review period; however, the addition of two new extraction wells in 2010 and 2012 is anticipated to improve hydraulic control of the plume.
3. Obsolete remedial equipment may need to be replaced; additionally the relatively high energy costs associated with the CAOC 16 AS/SVE blower and compressor are not justified by the relatively low mass removal rates.
4. GAC treatment systems at off-Base private residential wells were regularly maintained. However, the Hodges' residence was reportedly unoccupied and the well inoperable since 2008

FIVE-YEAR REVIEW SUMMARY FORM – OU 1 (YERMO ANNEX)

Issues (continued):

but that condition has not been directly verified with the property owner.

5. Chromium and nickel in groundwater are detected above the respective mcls; however biofouling of wells may have affected reliability of the data. Recently implemented well-cleaning and updated sampling procedures are anticipated to result in a representative data set available for statistical analysis.

Recommendations and Follow-up Actions:

1. Engage the FFA to follow the process recommended in the OUs 1 and 2 ROD for evaluation of the existing OU 1 remedy (for optimization purposes).
2. Evaluate annually the effectiveness of the GETS in controlling migration of the Yermo North plume using multiple lines of evidence such as groundwater flow model, groundwater VOC concentrations at off-Base monitoring locations, and changes in plume characteristics.
3. Continue the Integrated Maintenance Plan to address remedial system and well repairs, upgrades, and maintenance to ensure optimal performance of existing systems, and continue system optimization measures to improve efficacy and reduce energy consumption.
4. Contact the off-Base property owner for Hodges residence and obtain access agreement to perform (at minimum) an inspection of the GAC treatment system.
5. Statistically evaluate dissolved chromium and nickel data in groundwater to determine if chromium and nickel are contaminants of concern (COCs) that require further investigation and/or remedial action.

Protectiveness Statement:

The remedial actions at OU 1 are currently protective of human health and the environment because of the ongoing operation of the GETS and the CAOC 16 AS/SVE system, the ICs that are in place, and the GAC treatment of two Yermo Annex drinking water production wells and two off-Base private residential wells. However, in order for the remedy to be protective in the long term the components and wells of the GETs and CAOC 16 AS/SVE systems continue to be maintained for optimal performance.

Other Comments:

The exposure assumptions, toxicity data, cleanup levels, and RAOs used for OU 1 at the time of the remedy selection are still valid. The U.S. EPA published updated toxicity data for TCE in 2011 which lowered exposure limits; however, the maximum contaminant level (MCL) for TCE in groundwater was not been revised. Because the OUs 1 and 2 ROD references the MCL for groundwater cleanup levels, the protectiveness of the selected remedy is not currently affected by the change in toxicity criteria for TCE. Additionally, the GAC treatment of on-Base and off-Base potable water wells and the Yermo Annex GETs removes TCE to below detectable limits; therefore the remedy-in-place is protective even considering the change in toxicity data for TCE.

FIVE-YEAR REVIEW SUMMARY FORM – OU 2 (NEBO MAIN BASE)
OU 2 consists of CAOC 38, which is the groundwater at Nebo Main Base. CAOC 38 includes two dissolved VOC plumes identified as Nebo North and Nebo South. The selected remedy for the Nebo North plume is AS/SVE treatment of VOCs in the source area, with natural attenuation to reduce contamination in groundwater downgradient of the source area. The Nebo North remedy also includes a "fail-safe" pump and treat system (Nebo GETS) to prevent off-Base migration. Operation of the Nebo GETS was not required during this review period. The Nebo North plume source area (former Building 50) was treated with AS/SVE until RAOs were met and the system was shutdown with regulatory approval in April 2011. The AS/SVE system is maintained in standby-mode and periodically operated to address rebound in soil vapor concentrations as a protective measure for groundwater. The Nebo North plume area has decreased significantly with only one well exhibiting VOC concentrations above the MCLs in 2011. The remedy selected for the Nebo South plume in the OU 2 ROD, signed in 2006, is AS/SVE to reduce soil vapor and groundwater VOC concentrations. A portion of the plume extended off-Base; however, off-Base groundwater concentrations have been below MCLs since at least 2003. Focused operation and major repairs of the AS/SVE system during the review period have resulted in significant reduction of the Nebo South plume. The OU 2 remedy also includes: • Monitoring associated with CAOC 7 (in the southern portion of Nebo Main Base); groundwater impacts related to this CAOC are now under consideration in the feasibility study for OU 7. • Monitoring for pesticides (specifically, dieldrin) in groundwater at CAOCs 1, 2, 3, and 14 in the northern part of Nebo Main Base; Pesticide monitoring ceased in 2009 due to long-term monitoring results indicating no detectable concentrations. • ICs/LUCs that prevent installation of drinking water wells within the plume areas at Nebo North and Nebo South, and that restrict use of the area around Nebo South area; The Base Master Plan (BMP) incorporates these ICs/LUCs. **Issues Identified during the Third Five-Year Review:** • The Nebo North GETS is no longer needed as the Nebo North plume is greatly diminished, is contained entirely on Base, and is unlikely to expand beyond the Base boundaries. A statistical analysis of Nebo North groundwater monitoring data, included in this report, indicates the shutdown criteria specified in the OUs 1 and 2 ROD have been met. This system is recommended for decommissioning. • Slight rebound of soil vapor VOC concentrations in the Nebo North source area indicates possible residual contaminant mass. • The Nebo South AS/SVE system may soon reach, or has reached, the limits of effectiveness of the system as designed. • VOCs in groundwater beneath CAOC 7 and in the central part of Nebo Main Base remain elevated; these groundwater areas are being considered under the OU 7 feasibility study. **Recommendations and Follow-up Actions:** • Continue monitoring the Nebo North source area and downgradient portion of the plume in accordance with the current monitoring plan to ensure the selected remedy remains protective.

FIVE-YEAR REVIEW SUMMARY FORM – OU 2 (NEBO MAIN BASE)

Recommendations (continued):

- The Nebo South AS/SVE system is near or at the limits of effectiveness; rebound testing (6 months to 12 months of temporary system shutdown) is recommended once the remaining groundwater plume is reduced to below MCLs. If groundwater COC concentrations remain below MCLs during and following the rebound test, perform a technical and economic feasibility study of continued operation of the system and seek FFA approval for permanent shutdown.

Protectiveness Statement:

The remedial actions at OU 2 (CAOC 38) are currently protective of human health and the environment because of the completion of Nebo North source area treatment and natural attenuation of the remaining plume, continued operation of Nebo South AS/SVE system, and the ICs/LUCs that are in place. However, for the remedies to be protective in the long term, the following activities or actions are required: continued monitoring of the Nebo North plume on an annual basis in accordance with the current sampling plan and continued maintenance/repair of the Nebo South AS/SVE system.

Other Comments:

- The exposure assumptions, toxicity data, cleanup levels, and RAOs used for OU 1 at the time of the remedy selection are still valid. The U.S. EPA published updated toxicity data for TCE in 2011; the updated data lowered exposure limits for TCE in human health risk assessments. However, the MCL for TCE in groundwater has not been revised. Because the OUs 1 and 2 ROD (1998) and OU 2 ROD (2006) reference the MCL for groundwater cleanup levels, the protectiveness of the selected remedies are not affected by the change in toxicity criteria for TCE.
- Groundwater impacts in the vicinity of isolated monitoring well NPZ-14, in southwestern Nebo Main Base, are being investigated and will be addressed under the OU 7 FS and ROD. Groundwater issues identified during the OU 7 Remedial Investigation (RI) of CAOC 10.38/10.39 Unit 7 will also be addressed under the OU 7 FS and ROD.
- Groundwater impacts downgradient from CAOC 7 Stratum 1 are being investigated and will be addressed under the OU 7 RI/FS and ROD.

FIVE-YEAR REVIEW SUMMARY FORM – OU 3 (YERMO ANNEX)
OU 3 consists of the shallow soils at Yermo Annex for which environmental data existed prior to the OU 3 RI and includes CAOCs 18, 20, 23, and 34. The selected remedies under the OUs 3 and 4 ROD (signed 1997) include LUCs for CAOCs 18, 20, 23, and 34 and concrete caps constructed at CAOCs 20 and 23. The LUCs are implemented through the Base Master Plan; the CAOC 20 and 23 caps are regularly maintained. Groundwater monitoring for CAOCs 20 and 23 is performed annually under OU 1. **Issues Identified during the Third Five-Year Review:** • Groundwater monitoring wells may be subject to biofouling that could impact data quality. • Data generated under the revised monitoring program should be evaluated for trends. **Recommendations and Follow-up Actions:** • Groundwater monitoring wells should be periodically cleaned and redeveloped to address biofouling (evaluation need annually). • Evaluate four consecutive years of radiological monitoring data in accordance with the OUs 3 and 4 ROD. **Protectiveness Statement:** The remedies are currently protective of human health and the environment because of the intact and maintained caps at CAOCs 20 and 23 as well as the LUCs that are in place. The exposure assumptions, toxicity data, cleanup levels, and RAOs used for OU 3 at the time of the remedy selection are still valid. There is no new data that could indicate the ineffectiveness of the remedies at this OU. **Other Comments:** The DON performed an evaluation of the previously-identified issue of gross alpha exceedances at CAOC 20 in 2009. The evaluation resulted in recommendations to: 1) revise the groundwater sampling procedure to include filtration of groundwater samples, 2) clean and redevelop turbid wells, and 3) replace gross alpha with tritium as more representative of radionuclides that could potentially originate from CAOC 20. The FFA regulators approved the recommendations, which were implemented beginning in 2010. Based on groundwater data to date, no contamination from CAOC 20 is suspected.

FIVE-YEAR REVIEW SUMMARY FORM – OU 4 (NEBO MAIN BASE)
OU 4 consists of the shallow soils at the Nebo Main Base for which environmental data existed prior to the OU 4 RI) and consists of CAOCs 2, 5, 9, and 11. No further action (NFA) was selected for the OU 4 CAOCs, with BMP modifications were incorporated for CAOCs 2, 5, and 11. **Issues Identified during the Third Five-Year Review:** None **Recommendations and Follow-up Actions:** None **Protectiveness Statement:** The OU 4 NFA remedy continues to be protective of human health and the environment because the LUCs for CAOCs 2, 5, and 11 are maintained. The exposure assumptions, toxicity data, cleanup levels, and RAOs used for this OU at the time of remedy selection are still valid. There are no new data that could indicate the ineffectiveness of the remedy at this OU. **Other Comments:** None

FIVE-YEAR REVIEW SUMMARY FORM – OU 5 (YERMO ANNEX)
OU 5 consist of the shallow soils at Yermo Annex for which data did not exist prior to the OU 5 RI and consists of CAOCs 15/17, 16, 19, 21, 22, 24, 25, 26, 27, 28, 29, 30, 31, 32, 35, and 36. CAOC 25 was eliminated from the RI as not requiring additional investigation/remediation. Remedies selected in the OUs 5 and 6 ROD for OU 5 are: • NFA for CAOCs 19, 22, 24, 27, 28, 29, 30, 31, 32 and 36. • NFA with BMP modifications for CAOCs 15/17, 21, and 26. • LUCs for CAOC 16, consisting of preservation of the existing hardstand. • A cap and LUCs for CAOC 35 Stratum 1 Zone 1, which is an inactive Class III Landfill located in the northeastern portion of the Yermo Annex. **Issues Identified during the Third Five-Year Review:** • For CAOC 16, observed cracking of the exterior cap appeared to affect only the surface of the concrete; therefore, short-term protectiveness is not affected. However, the concrete cap should be maintained to ensure long-term protectiveness. • For CAOC 35 Stratum 1 Zone 1, specific Operations and Maintenance (O&M) issues were identified regarding landfill cap erosion controls and survey of a settlement monument. • For CAOC 32 (Stratum 2), historical data indicate the potential presence of a soil contaminant (Aroclor 1242) above a newly-published risk-based screening level. • No other issues identified for the remaining CAOCs. **Recommendations and Follow-up Actions:** • For CAOC 16, continue maintenance of the concrete surface to ensure long-term protectiveness.

FIVE-YEAR REVIEW SUMMARY FORM – OU 5 (YERMO ANNEX)

- For CAOC 35 Stratum 1 Zone 1, continue cap monitoring and maintenance activities.
- For CAOC 32 (Stratum 2), add to the BMP a description of the site and the need to coordinate with Base Environmental Division for any changes to concrete cap in this area.

Protectiveness Statement:

The selected remedies at OU 5 currently protective of human health and the environment because the ongoing maintenance of CAOC 16 hardstand and CAOC 35 Stratum 1 Zone 1 landfill cap, as well as the implemented LUCs. The exposure assumptions, toxicity data, cleanup levels, and RAOs used for OU 5 at the time of remedy selection are still valid. There is no new data that could indicate the ineffectiveness of the remedies at this OU.

Other Comments: None

FIVE-YEAR REVIEW SUMMARY FORM – OU 6 (NEBO MAIN BASE)

OU 6 consists of the shallow soils at Nebo Main Base for which data did not exist prior to the OU 6 RI and includes CAOCs 1, 3, 4, 6, 7, 8, 12, 13, 14, and 33. Of these, CAOC 33 was eliminated from the RI as not requiring further investigation. The selected remedies under the OUs 5 and 6 ROD for this OU include:

- NFA for CAOCs 1, 3, 4, 6, 8, 12, 13, and 14; however modifications to the Base Master Plan for CAOCs 1, 3and 14 were required.
- A native soil cap and LUCs were selected and implemented at CAOC 7. The cap and LUCs are regularly maintained; groundwater monitoring is performed under OU 2.
- Groundwater cleanup at CAOC 6 ("Nebo South" plume) is covered under OU 2.

Issues Identified during the Third Five-Year Review:

- CAOC 7: The DON investigated conditions under the CAOC 7 Stratum 1 landfill cap in 2011 in response to persistent above-MCL detections of TCE in a downgradient monitoring well. The cap was evaluated and appears to be functioning as intended by the ROD; however, the presence of VOC-contaminated wastes and VOCs in soil vapor indicates the wastes are the likely source of the detected groundwater impacts.
- No other issues were identified.

Recommendations and Follow-up Actions:

- For CAOC 7 Stratum 1 consider appropriate response actions for VOC contamination of groundwater under the OU 7 feasibility study and incorporate into the OU 7 ROD.

Protectiveness Statement:

The selected remedies at OU 6 continue to be protective of human health and the environment because the ongoing maintenance of caps and implemented LUCs at CAOC 7. The exposure assumptions, toxicity data, cleanup levels, and RAOs used for this OU at the time of the remedy selection are still valid. There are no new data that could indicate the ineffectiveness of the remedies at this OU.

FIVE-YEAR REVIEW SUMMARY FORM – OU 6 (NEBO MAIN BASE)
Other Comments: None

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1.0 INTRODUCTION

1.1 OVERVIEW

The Department of the Navy (DON) is conducting environmental restoration activities at the Marine Corps Logistics Base, Barstow, California (the MCLB Barstow or the Base), as part of the Installation Restoration Program (IRP). The IRP was established by the Department of Defense (DoD) to identify, evaluate, and control the spread of contaminants from historical hazardous waste sites at military installations. The DON is the lead federal agency responsible for conducting the site investigation and cleanup at the MCLB Barstow. The DON's investigation and cleanup efforts are being conducted in conjunction with the U.S. Environmental Protection Agency (U.S. EPA), Region 9, Regional Water Quality Control Board – Lahontan Region (RWQCB - Lahontan Region), and the State of California Environmental Protection Agency's Department of Toxic Substances Control (DTSC) through a Federal Facility Agreement (FFA). All of these entities are collectively referred to as FFA Parties, and their representatives as FFA Remedial Project Managers (RPMs).

The MCLB Barstow is located in San Bernardino County, California, within the central Mojave Desert approximately 135 miles northeast of Los Angeles (Figure 1-1). The MCLB Barstow consists of two areas: the Yermo Annex, which is 7 miles east of Barstow between Interstates 15 and 40 (Figures 1-1 and 1-2); and the Nebo Main Base, which includes the Rifle Range, is 3.5 miles east of Barstow and intersected by Interstate 40 (Figures 1-1 and 1-3). Soil and groundwater at both Yermo Annex and Nebo Main Base have been impacted by contaminants and are being remediated under the IRP.

This Third Five-Year Review Report has been prepared by the Naval Facilities Engineering Command Southwest (NAVFAC SW) in accordance with the DON's Five-Year Review policy (DON, 2011) and U.S. EPA Comprehensive Five-Year Review Guidance (U.S. EPA, 2001). This report summarizes the status and evaluates the continued protectiveness of the remedies in place at the MCLB Barstow.

1.2 PURPOSE OF THE THIRD FIVE-YEAR REVIEW REPORT

The purpose of this Third Five-Year Review Report is to evaluate the implementation and performance of the remedies in place at the MCLB Barstow and to verify whether the remedies continue to remain protective of human health and the environment. This Report includes the methods, findings, and conclusions of the Third Five-Year Review Report. In addition, issues found during the review are identified, and recommendations to address them are presented in this Report. This Report also discusses how the issues identified during the Second Five-Year Review have been addressed.

Consistent with Executive Order 12580, the Secretary of Defense is responsible for ensuring that Five-Year Reviews are conducted at all qualifying DoD cleanup sites. The DON has prepared this Third Five-Year Review Report pursuant to Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Section 121 and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). CERCLA Section 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 Sections [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 NCP, 42 United States Code (USC), Section 9621(c), implementing regulations at 40 Code of Federal Regulations (CFR) Part 300.430(f)(4)(ii), provides:

> 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 initiation of the selected remedial action.

According to the *Navy/Marine Corps Policy for Conducting Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Five-Year Reviews* (DON, 2011a):

> a. A Five-Year Review shall be conducted at an Environmental Restoration (ER) site (Installation Restoration and Munitions Response) if the remedial action objectives (RAO) selected for a remedial action will result in any hazardous substances, pollutants, contaminants, or munitions and explosives of concern (MEC) remaining at the site above levels that allow for unlimited use/unrestricted exposure (UU/UE).
>
> b. If a remedial action will result in UU/UE, but the response action will not be completed within five years (if the first remedial site on an installation) or before the next Five-Year Review for other sites on the installation, then DON will conduct Five-Year Reviews during the remedial action operations (RAO) phase, as appropriate. When UU/UE is achieved, it will be documented in one subsequent Five-Year Review.

A Five-Year Review is required at the MCLB Barstow because hazardous substances, pollutants, or contaminants remain on Base above levels that allow for UU/UE. This is the Third Five-Year Review Report for the MCLB Barstow.

1.3 REVIEW INITIATION AND COMPLETION

The Third Five-Year Review process was initiated in January 2012 and will be completed by December 2012. The trigger for the MCLB Barstow five-year reviews is the date of the prior five-year review. In this case, the trigger date is the signature date of the Second Five Year Review, December 19, 2007 (DON, 2007a); therefore, the third five-year review period is December 20, 2007 through December 19, 2012.

1.4 DOCUMENT ORGANIZATION

This Five-Year Review Report is organized as follows:

Section 1.0 Introduction. Provides the purpose and authorization for conducting the Five-Year Review, states who conducted the review, the number of the review, when the review was initiated and completed, the review period, trigger and due dates.

Section 2.0 Site Organization and Chronology. Provides the MCLB Barstow IRP organization by Operable Unit (OU) and CERCLA Area of Concern (CAOC), and summarizes the site chronology.

Section 3.0 Background. For Yermo Annex and Nebo Main Base, describes the physical characteristics including regional setting, climate, geology, and hydrogeology. Due to the number of OUs and CAOCs reviewed, this section directs the reader to where to find additional background information in subsequent sections of the report.

Section 4.0 Remedial Actions. Provides a summary of selected remedies, remedy implementation, and ongoing system operations and maintenance (O&M). Due to the number of OUs and CAOCs reviewed, this section directs the reader to where to find remedial action information in subsequent sections of the report.

Section 5.0 Progress Since Last Review. Provides a summary of the prior review protectiveness statements, status of recommendations and follow-up actions from the last review, results of the implemented actions, and status of any other prior issues. Due to the number of OUs and CAOCs reviewed, this section directs the reader to where to find progress information in subsequent sections of the report.

Section 6.0 Five-Year Review Process. Describes the Five-Year Review process, including administrative components, who performs the review, schedule, community involvement, and the technical assessment process for each of the OUs.

Section 7.0 Yermo Annex – Technical Assessment. For each CAOC subject to five-year review at the Yermo Annex, describes the RAOs, selected remedies including institution controls (ICs) and land use controls (LUCs), implementation, and current status. Reviews issues identified during the prior and current Five Year Reviews. Presents the technical assessment of remedial progress and ICs/LUCs compliance, as applicable. Presents recommendations including follow-up actions to ensure protectiveness, including responsible parties and schedule. For CAOCs designated as no further action (NFA) with Base Master Plan (BMP) amendments, provides a review of any actions at those sites during the review period.

Section 8.0 Nebo Main Base – Five-Year Review. For each CAOC subject to five-year review at the Nebo Main Base, describes the RAOs, selected remedies including ICs/LUCs, implementation, and current status. Reviews issues identified during the prior and current Five Year Reviews. Presents the technical assessment of remedial progress and ICs/LUCs compliance, as applicable. Presents recommendations including follow-up actions to ensure protectiveness, including responsible parties and schedule.

For CAOCs designated as NFA with BMP amendments, provides a review of any actions at those sites during the review period.

Section 9.0 Issues and Recommendations. Provides a summary of the issues and recommended follow up actions, with milestone schedule for each OU.

Section 10.0 Summary and Protectiveness Statements. For each OU, provides a summary of the review findings and protectiveness statement.

Section 11.0 Next Review. Proposes the date for the next review.

Section 12.0 References. Provides a list of documents cited in this report.

2.0 SITE ORGANIZATION AND CHRONOLOGY

2.1 ORGANIZATION OF THE OPERABLE UNITS

To organize the site characterization and cleanup process, the MCLB Barstow has been divided into seven OUs, as follows:

OU 1 and OU 2 – address groundwater contamination at Yermo Annex and Nebo Main Base, respectively.

OU 3 and OU 4 – address soil contamination at Yermo Annex and Nebo Main Base, respectively, for which analytical data existed prior to the RI.

OU 5 and OU 6 – address soil contamination at Yermo Annex and Nebo Main Base, respectively, for which analytical data did not exist prior to the RI.

OU 7 – addresses contamination not covered by OUs 1-6.

2.2 RECORDS OF DECISION

Records of Decision (RODs) have been signed for OUs 1-6, as follows:

Operable Units 1 and 2, Final Record of Decision, Marine Corps Logistics Base, Barstow, California (OUs 1 and 2 ROD) (DON, 1998a).

OU 2 Nebo South: Final Record of Decision, Nebo South Groundwater – Operable Unit 2, Marine Corps Logistics Base, Barstow, California (OU 2 Nebo South ROD) (DON, 2006).

OUs 3 and 4: Operable Units 3 and 4, Final Record of Decision, Marine Corps Logistics Base, Barstow, California (OUs 3 and 4 ROD) (DON, 1997).

OUs 5 and 6: Operable Units 5 and 6, Final Record of Decision, Marine Corps Logistics Base, Barstow, California (OUs 5 and 6 ROD) (DON, 1998b).

OU 7: A ROD is anticipated to be completed by February 2014.

Each OU incorporates several hazardous waste areas termed CAOCs, as shown on Figure 2-1. The locations of CAOCs 1 through 38, and OUs 1-6, at the Yermo Annex and Nebo Main Base are shown on Figures 1-2 and 1-3, respectively. A summary of the MCLB Barstow OUs, related CAOCs, selected remedies (OUs 1 – 6), and summary of CAOC status in 2012 is presented in Table 2-1.

Cleanup actions are ongoing or have been completed at OUs 1-6, while OU 7 is in the remedial investigation/feasibility study (RI/FS) phase. Cleanup actions at the CAOCs can be broadly classified into the following three categories:

1. Requiring NFA;
2. Requiring ICs (also referred to as LUCs in this report) to protect human health and the environment; and
3. Requiring remedial action (RA).

Those CAOCs closed with NFA in their respective RODs do not require Five-Year Reviews. However, a number of CAOCs identified as NFA required modifications of the BMP for the MCLB Barstow. In general, modifications to the BMP consisted of including site history and the requirement that the MCLB Barstow Environmental Division be contacted prior to construction activities at these CAOCs. CAOCs with these modifications are subject to Five-Year Review.

Some of the CAOCs are further divided into strata (discrete lateral areas of contamination) and zones (vertical depths of contamination in soil). It should be noted that within boundaries of a number of CAOCs in OUs 3, 4, 5, and 6, the groundwater is being remediated or monitored under OU 1 (Yermo Annex) or OU 2 (Nebo Main Base).

The CAOCs, OUs to which they belong, and Five-Year Review requirements are summarized in Table 2-1 and illustrated on Figure 2-1. Five-Year Reviews are required for the following CAOCs: 1, 2, 3, 5, 6, 7, 11, 14, 15/17, 16, 18, 20, 21, 23, 26, 34, 35, 37, and 38.

In addition to the above list of CAOCs, the Five-Year Review addresses the following matters at the MCLB Barstow (associated with OUs 1 and 2):

- The OUs 1 and 2 ROD-required protection of on-Base drinking water wells (YDW-5, YDW-6, and YDW-7) at the Yermo Annex and two off-Base residential drinking water wells adjacent to the Yermo Annex. These protections are reviewed under OU 1 in Section 7.
- The potential presence of a source for chromium and nickel detected in groundwater in the northern portion of Yermo Annex. Reviewed under OU 1 in Section 7.
- Volatile organic compound (VOC) contamination found in groundwater in the southwestern portion of Nebo Main Base (well NPZ-14) and CAOC 10.38/10.39 Unit 7. These two areas are discussed briefly in Section 3.5.10, but are not reviewed as this area is being incorporated into OU 7, which is not yet under a ROD.

2.3 DESCRIPTION OF OPERABLE UNITS 1 - 6

2.3.1 OU 1 YERMO ANNEX GROUNDWATER

OU 1 consists of CAOC 37, which is the groundwater at Yermo Annex. The remedy for OU 1 was established in the OUs 1 and 2 ROD signed in 1998. The ROD addresses three groundwater VOC plumes identified as the CAOC 26, Yermo North, and Yermo South plumes. The primary VOCs affecting groundwater are perchloroethylene (also called tetrachloroethene, perc, or PCE) and trichloroethene (TCE). Portions of the groundwater plumes extend off Base. These plumes are being remediated by the CAOC 16 and CAOC 26 air sparging/soil vapor extraction (AS/SVE) systems, and the Yermo Annex Groundwater Extraction and Treatment System (GETS). The GETS includes extraction wells, treatment of extracted groundwater through granular-activated carbon (GAC), and infiltration of treated water back into the aquifer. The remedial systems were installed during 1996 to 1998. The CAOC 26 AS/SVE system was shut down in 1998 after meeting remedial objectives; the other two systems remain in operation.

During the review period, due to significant reductions in the CAOC 26 and Yermo South plumes, only three to four extraction wells were operated to meet the containment objectives.

The OU 1 remedy also includes:

- GAC treatment systems on two on-Base drinking water production wells and two off-Base residential wells. The GAC treatment systems are maintained and monitored on a regular basis.
- Groundwater monitoring for CAOCs under other OUs, specifically CAOCs 15/17, 16, 20, 23, 26, and 35. Monitoring is performed annually for these CAOCs.
- Monitoring to determine if dissolved metals, particularly chromium and nickel, are site-related contaminants in the CAOC 16 area. Monitoring is performed annually.
- An IC incorporated into the BMP to prevent use of Base groundwater within contaminated zones, and
- Notification of San Bernardino County regarding off-Base migration of contaminated groundwater.

2.3.2 OU 2 Nebo Main Base Groundwater

OU 2 consists of CAOC 38, which is the groundwater at Nebo Main Base. CAOC 38 includes two dissolved VOC plumes identified as Nebo North and Nebo South. The selected remedy for the Nebo North plume is AS/SVE treatment of VOCs in the source area, with natural attenuation to reduce contamination in groundwater downgradient of the source area. The Nebo North remedy also includes a "fail-safe" pump and treat system (Nebo GETS) to prevent off-Base migration; operation of the Nebo GETS was not required during the review period. The Nebo North plume source area (former Building 50) was treated with AS/SVE until RAOs were met and the system shutdown with regulatory approval in April 2011; the system is maintained in standby-mode and periodically operated to address rebound in soil vapor concentrations as a protective measure for groundwater. The Nebo North plume area has decreased significantly with only one well exhibiting VOC levels above the MCLs in November 2011.

The remedy selected for the Nebo South plume in the OU 2 ROD, signed in 2006, is AS/SVE to reduce soil vapor and groundwater VOC concentrations. A portion of the plume extended off-Base; however, off-Base groundwater concentrations have been below MCLs since at least 2003. Focused operation and major repairs of the AS/SVE system during the review period have resulted in significant reduction of the Nebo South plume.

The OU 2 remedy also includes:

- Monitoring associated with CAOC 7 (in the southern portion of Nebo Main Base); groundwater impacts related to this CAOC are now under consideration in the OU 7 FS.
- Monitoring for pesticides (specifically, dieldrin) in groundwater at CAOCs 1, 2, 3, and 14 in the northern part of Nebo Main Base. Pesticide monitoring was halted in 2009 due to long-term monitoring results showing no detectable concentrations.

- LUCs incorporated into the BMP that prevent installation of drinking water wells within the plume areas at Nebo North and Nebo South, and that restrict use of the area around Nebo South area.

2.3.3 OU 3 Yermo Annex Soils with Prior Data

OU 3 consists of the shallow soils at Yermo Annex for which environmental data existed prior to the RI and includes CAOCs 18, 20, 23, and 34. The selected remedies under the OUs 3 and 4 ROD (signed 1997) include LUCs for CAOCs 18, 20, 23, and 34 and concrete caps constructed at CAOCs 20 and 23. The LUCs are implemented through the BMP; the CAOCs 20 and 23 caps are regularly maintained. Groundwater monitoring for CAOCs 20 and 23 is performed annually under OU 1.

2.3.4 OU 4 Nebo Main Base Soils with Prior Data

OU 4 is the shallow soils at Nebo Main Base for which data existed prior to the RI and includes CAOCs 2, 5, 9, and 11. NFA was selected for the OU 4 CAOCs, although BMP modifications were incorporated for CAOCs 2, 5, and 11.

2.3.5 OU 5 Yermo Annex Soils

OU 5 consists of the shallow soils at Yermo Annex for which data did not exist prior to the RI and includes CAOCs 15/17, 16, 19, 21, 22, 24, 25, 26, 27, 28, 29, 30, 31, 32, 35, and 36. CAOC 25 was eliminated from the RI as not requiring further investigation. The remedies selected in the OUs 5 and 6 ROD for this OU include:

- NFA for CAOCs 19, 22, 24, 27, 28, 29, 30, 31, 32, and 36.
- NFA with BMP modifications for CAOCs 15/17, 21, and 26.
- LUCs for CAOC 16, consisting of preservation of the existing hardstand.
- A cap and LUCs were selected and installed for CAOC 35, Stratum 1 Zone 1 which is an inactive Class III Landfill, located in the northeastern portion of the Yermo Annex.

2.3.6 OU 6 Nebo Main Base Soils

OU 6 is the shallow soils at Nebo Main Base for which data did not exist prior to the RI and consists of CAOCs 1, 3, 4, 6, 7, 8, 12, 13, 14, and 33. Of these, CAOC 33 was eliminated from the RI as not requiring further investigation. The selected remedies under the OUs 5 and 6 ROD for this OU include:

- NFA for CAOCs 1, 3, 4, 6, 8, 12, 13, and 14; however modifications to the BMP for CAOCs 1 and 3 were required.
- A native soil cap and LUCs were selected and implemented at CAOC 7. The cap and LUCs are regularly maintained; groundwater monitoring is performed under OU 2.
- Groundwater cleanup at CAOC 6 ("Nebo South" plume) is covered under OU 2.

2.4 GOVERNING PLANS FOR REMEDIES IN PLACE

Groundwater monitoring at the Yermo Annex and Nebo Main Base is conducted in accordance with the *Draft Final Operable Units 1-6 Long-term Groundwater Monitoring Plan* (LTGWMP) (DON, 1998c), which has been updated and modified by the *Final Sampling and Analysis Plan, Marine Corps Logistics Base, Barstow, California, Revision 4* (SAP Revision 4) (AIS-TN&A JV [ATJV], 2012a).

The groundwater and soil vapor remediation systems at CAOC 37 (OU 1) at Yermo Annex are operated and maintained in general accordance with the *Draft Operation and Maintenance Manual, Groundwater Extraction, Treatment, and Recharge System and Air Sparging and Soil Vapor Extraction Systems Yermo Annex* (CAOC 37 O&M Manual) (OHM Remediation Services Corporation [OHM], 1999) and subsequent amendments.

The Nebo North GETS, a fail-safe system in case natural attenuation fails to stop plume migration, was not operated during the Third Five-Year Review period. The AS/SVE remediation system at Nebo North source met its RAOs and, with FFA approval, was shutdown in April 2011. However, the system was operated in April and September 2011 to address an increase in soil vapor concentrations in a limited area of the CAOC as a protective measure for groundwater (ATJV, 2012b).

The remediation system at Nebo South is operated and maintained in general accordance with the *Draft Operation and Maintenance Manual, CERCLA Area of Concern (CAOC 6) Air Sparge Soil Vapor Extraction System, Marine Corps Logistics Base, Barstow, California* (CAOC 6 O&M Manual) (OHM, 1996a).

The YDW-5 and YDW-6 drinking water well remediation systems are operated and maintained in general accordance with the *Final Operation and Maintenance Manual On Base Drinking Water Systems (YDW-5 and YDW-6), Yermo Annex, Marine Corps Logistics Base, Barstow, California* (Foster Wheeler Environmental Corporation [FWENC], 2003).

The caps at CAOCs 7 (Nebo Main Base) and CAOC 35 (Yermo Annex) are maintained in general accordance with the *Final Operations and Maintenance Manual, Closed Landfills at CAOCs 7 and 35* ("CAOCs 7 and 35 O&M Manual") (Bechtel National, Inc. [BNI], 1999).

The cap at CAOC 20 is maintained in accordance with Appendix A of the *Remedial Action Report, CAOCs 20 and 23, OUs 3 and 4* ("OUs 3 and 4 RAR") (DON, 2000).

The cap at CAOC 23 is maintained in general accordance with the *Maintenance Manual, Concrete Landfill Cap, CAOC 23, Yermo Annex, Marine Corp Logistics Base, Barstow, California* ("CAOC 23 O&M Manual") (AGRA Earth and Environmental, Inc. [AGRA], 1998).

2.5 OPERABLE UNIT CHRONOLOGIES

The chronology presented in Table 2-2 identifies significant events pertaining to OUs 1-6. The history of the IRP prior to the designation of OUs is also included. Additional Base history is available in the RODs or other documents available from the DON Administrative Record.

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3.0 BACKGROUND

3.1 HISTORY OF THE MCLB BARSTOW

The MCLB Barstow was originally established at the Nebo Main Base location as the United States Marine Corps Depot of Supplies, in December 1942, the Depot served as a storage site for supplies and equipment needed for Fleet Marine Forces in the Pacific theater during World War II. In October 1946, the base had outgrown its facilities and 2,000 acres of land approximately seven miles east of the Nebo Main Base were annexed from the United States Army (Yermo Annex).

In March 1961, the Depot Maintenance Activity was established at the Base. In November 1978, the Base was re-designated to its present title of the MCLB Barstow to emphasize its broad logistics support mission. In early 2006, the MCLB Barstow began a transition from military personnel to civilian contractors to free Marines for deployment; the Provost Marshal Office was augmented with a civilian police department, while many of the Marines stationed aboard the base have transferred to other commands. The MCLB Barstow consists of the Nebo Main Base and the Yermo Annex, both of which are used for the staging, storage, and maintenance of supplies and equipment used by the United States Marine Corps.

3.2 PRIOR INVESTIGATIONS AND REGULATORY ACTION

Beginning in the mid 1980's, the DON conducted a series of studies at the MCLB Barstow as part of the DON Assessment and Control of Installation Pollutants Program to determine the presence of contamination in soil and groundwater. An initial assessment study was conducted to evaluate past practices of hazardous waste handling, storage, and disposal and to identify areas representing a potential threat to human health and the environment. The initial assessment study identified 33 potential sites of contamination through record searches, employee interviews, and site surveys. These sites are referred to as CAOCs and are currently being addressed under the base CERCLA program.

On 15 November 1989, the EPA placed the MCLB Barstow on the National Priorities List due to the presence of soil and groundwater contamination on the Base. Environmental contamination at the MCLB Barstow is being addressed through the DoD IRP under the CERCLA with the exception of contamination associated with underground fuel tanks, which is being addressed outside the IRP under regulatory oversight of the RWQCB - Lahontan Region.

A FFA under CERCLA Section 120 was signed on 24 October 1990 by the DON, the U.S. EPA, the DTSC, and the RWQCB - Lahontan Region. The FFA provides a procedural framework for the signatories to ensure implementation of response actions to achieve appropriate cleanup levels.

A Resource Conservation and Recovery Act (RCRA) facility assessment (RFA) was begun in 1991 to comply with the schedule set forth in the 1990 FFA. The RFA process at the MCLB Barstow included a preliminary review, visual site inspection, and sampling visits to identify releases or potential releases that may require further action or investigation. The RFA was

completed in 1997; based on the findings of the RFA, an Extended RFA (ERFA) was performed from 2000 to 2001. Subsequent to the RFA/ERFA reports, seven OUs were established and the environmental investigation and cleanup activities were shifted to the CERCLA program. RI/FS were performed by the DON for OUs 1 – 6, leading to the RODs listed in Section 2.2.1 (the RI/FS is still in process for OU 7).

3.3 SITE PHYSICAL SETTING

This section describes the physical setting and conceptual site model of the Yermo Annex and Nebo Main Base. The MCLB Barstow location is shown on Figure 1-1, and the individual bases are shown on Figures 1-2 and 1-3.

3.3.1 CLIMATE

The Barstow area is characterized by intense summer heat; minimal rainfall and low humidity; strong winds; periodic thunderstorms; and flash floods. Factors that tend to moderate the weather in other areas of California are absent in the Mojave Desert, resulting in an extreme climate. Temperatures range from 12 to 114 degrees Fahrenheit annually. Winds near Barstow are primarily from the west at an average annual speed of approximately 11 miles per hour.

Annual average precipitation in the Barstow area is about 4 inches per year; however, considerable year-to-year variability results in the variable discharge conditions of the Mojave River and fluctuations in the groundwater table. Precipitation in the Mojave Desert occurs primarily with the passing of weakened winter fronts from the north and the periodic development of brief, localized thunderstorms during the summer. Periodic episodes of intense rainfall create flash flood conditions (referred to as flood flows) in the Mojave River and in the intermittent washes near the Nebo Main Base and Barstow (DON, 1998b).

3.3.2 TOPOGRAPHY

Regional topography near Barstow is dominated by broad, gently sloping surfaces formed by coalescing alluvial fans and the isolated fronts and peaks of the region's fault block mountains (DON, 1998b). Nebo Main Base was constructed near the Mojave River, where topography is relatively flat. The topographic surface at Nebo Main Base slopes north-northeast to the Mojave River. The topography overlying the Nebo Main Base North VOC groundwater plume is generally flat, with elevations between 2,025 and 2,050 feet above mean sea level (amsl) (Bechtel Environmental, Inc., [BEI] 2003).

The topography at Yermo Annex gently slopes to the south with the southern end of the facility over the Mojave River channel. To the west is Elephant Rock elevation 2,674 feet amsl and to the east is the town of Yermo. Interstate 15 runs along the north edge of the facility. Elevations at Yermo Annex range from 1,960 to 1,950 feet amsl.

3.3.3 GEOLOGY

The MCLB Barstow is within the Mojave Desert Geomorphic Province (DON, 1998b). This province is a wedge-shaped unit bounded by the Garlock Fault on the north and the San Andreas Fault on the southwest. The approximate eastern boundary is the Bristol-Granite

Mountains fault zone in the eastern Mojave Desert. At this diffuse boundary, the Mojave Desert merges with the Basin and Range Geomorphic Province.

Regional geology is characterized by the following stratigraphic units: a basement complex of pre-Tertiary granitic and metamorphic rocks; undifferentiated Tertiary continental volcanic and sedimentary rocks; Tertiary-Quaternary older and younger alluvial-fan deposits; Quaternary older alluvium; Quaternary younger and recent Mojave River alluvium.

Yermo Annex Geology

The Yermo Annex of the MCLB Barstow lies within the west/northwest-trending Barstow Basin, which is bounded by the Blackwater / Calico Faults to the northeast and by the Lenwood Fault to the southwest. Surface sediments throughout the basin typically consist of windblown sand and recent unconsolidated Quaternary alluvial deposits derived from the Mojave River or from adjacent highlands and Elephant Rock to the west. Underlying the shallow sediments are older alluvial fan deposits of poorly dated, possibly late Miocene to early Pleistocene age (Densmore et al., 1997).

The unconsolidated deposits underlying the Yermo Annex are essentially composed of a thick sequence (up to 600 feet) of alluvial fan deposits of gravel, sand, silt, and clay. The alluvial deposits vary in depth dependent upon bedrock and the distance to nearby mountain formations. Geophysical survey data and lithologic logging of deep exploratory boreholes performed during the RI identified the top of bedrock at approximately 600 feet below ground surface (bgs), as noted in the RI/FS Remedial Investigation Report for OUs 1 and 2 (Jacobs Engineering Group, Inc.[JEG], 1995a).

Underlying the unconsolidated deposits is a sequence of low permeability Tertiary volcanic and sedimentary rocks. The Tertiary rocks are underlain by the basement complex are composed of pre-Tertiary granitic and metamorphic rocks (Densmore et al., 1997).

Nebo Main Base Geology

The Nebo Main Base is located within the west-northwest-trending Barstow Basin roughly bounded by the Blackwater/Calico faults to the northeast and the Lenwood fault to the southwest. The northwest-trending Camp Rock-Harper Lake Fault Zone, which cuts through the Nebo Main Base area, extends from about 30 miles southeast of Nebo Main Base to just east of Harper Lake, about 15 miles to the northwest. The fault is defined by five northwest-trending, right-lateral, strike-slip branches in the area of Nebo Main Base. Regional geology is further described in the ROD report for OUs 5 and 6 (DON, 1998a).

Nebo Main Base geology is characterized by basement consisting of Paleozoic metamorphic rock, Mesozoic plutonic rock, and Miocene volcanic rock overlain by in some cases over 1000 feet of Plio-Pleistocene alluvial fan and fluvial deposits (Dudash, 2006). Based on lithologic data from deep borings drilled during the OUs 1 and 2 RI in the northwest portion of the Nebo Main Base (JEG, 1995) and other regional geologic information (United States Geological Survey, 1993), unconsolidated shallow sediments are interpreted to be several hundred feet thick.

3.3.4 HYDROGEOLOGY

The MCLB Barstow is located within the Mojave River Valley Basin hydrogeologic system, which consists of two primary aquifers: the regional aquifer composed of Pliocene and younger alluvial fan deposits and; the Mojave River aquifer composed of Pleistocene and younger river channel and floodplain deposits (California Department of Water Resources [CDWR], Planning and Local Assistance, 2004). The regional aquifer underlies and surrounds the floodplain aquifer. Most of the water from production wells in the area is from the Mojave River aquifer.

Yermo Annex Hydrogeology

The Yermo Annex is within the Yermo sub-basin of the Lower Mojave subunit (BNI 1998, and SOTA Environmental Technology, Inc., 2002). Two separate aquifers have been identified in the area surrounding the Yermo Annex, the regional aquifer, and the more localized Mojave River aquifer. Beneath the Yermo Annex, the Mojave River aquifer is generally composed of the saturated sediments that extend from the surface to a depth of approximately 200 feet bgs. This aquifer is underlain by a regional aquifer, which consists of the saturated sediments between approximately 200 feet bgs and bedrock at about 600 feet bgs beneath the eastern boundary of the Yermo Annex (Densmore et al., 1997). Hydrographs for select wells are shown on Figure 3-2.

Based on the November 2011 interpreted groundwater elevation contours for the Yermo Annex area with the GETS in operation, the general historical flow patterns for groundwater in the northern portion of the Yermo Annex is inferred to be generally west to east. In the east-central portion of the Yermo Annex, the groundwater flow direction is inferred to be from the west/southwest to east/northeast. Groundwater flow trends west to east in the west-central portion of the Yermo Annex. Groundwater elevation contours for November 2011 are presented on Figure 3-1. Groundwater flow direction was to the east in the southern portion and east-southeast in the northern portion of the Yermo Annex during May and November 2011. Hydraulic gradients ranged from 0.00053 (May 2011) to 0.00068 feet per foot (ft/ft) (November 2011) to the east and from 0.00060 (May 2011) to 0.00065 ft/ft (November 2011) to the east-southeast. The inferred groundwater flow patterns are consistent with the groundwater flow patterns observed historically.

Nebo Main Base Hydrogeology

The Nebo Main Base is located primarily within the Mojave River aquifer of the Mojave River Valley Basin. The Mojave River aquifer extends 50 to 200 feet deep in this basin, but is restricted to within about 1 mile of the active Mojave River channel (Stamos et al., 2001). Recharge of the aquifer is primarily by loss from the Mojave River (CDWR, 1967), which traverses the Base from west to east. The average thickness is estimated to be about 150 feet through this basin. Specific yield for this unit ranges from 23 percent (%) to 39% (Lines, 1996) and the average specific yield for this unit is approximately 27% in this basin (CDWR, 1967 and Lines, 1996).

The southern portion of Nebo Main Base may coincide with the regional aquifer composed of late Tertiary and younger unconsolidated to partially consolidated alluvial fan deposits up to

1,000 feet thick (Stamos and Predmore, 1995 and Lines, 1996). The permeability of these deposits decreases with depth (Stamos et al., 2001). Estimated average effective thickness in the Upper Mojave River Valley Groundwater Basin is about 300 feet thick (CDWR, 1967). Available information has indicated that specific yields and well yields are generally less for the fan unit compared to the floodplain unit, but suggest generally higher well yields for younger fan deposits and lower well yields for older fan deposits. The specific yields for this unit range from 4% to 25% with an estimated average of 10% (CDWR, 1967).

The groundwater flow patterns at the Nebo Main Base are significantly influenced by Mojave River and the Harper Lake-Camp Rock Fault (Figure 3-3). East of the fault, the groundwater flow was generally to the southeast, consistent with the flow direction of the Mojave River, with a relatively uniform hydraulic gradient of 0.0030 to 0.0032 ft/ft. West of the Harper Lake-Camp Rock Fault, a relatively complex groundwater flow pattern can be observed. Flow west of the fault is observed to be generally to the east-northeast in the southwest portion of the site with hydraulic gradients ranging from 0.0023 to 0.0168 ft/ft. The gradient in the northern area west of the Harper Lake-Camp Rock Fault tends to be flatter with a hydraulic gradient of 0.0019 ft/ft. Steeper hydraulic gradients in the southwest corner of Nebo Main Base appear to be influenced by the upland topography to the south and become less steep toward the middle of the Base. Hydrographs for select wells are shown on Figure 3-4.

3.4 DESCRIPTION AND HISTORY – YERMO ANNEX CAOCS

A total of 22 CAOCs were identified at Yermo Annex (Figure 1-2) (Table 2-1). Following is a brief summary of site descriptions, impacts to vadose zone and groundwater (if any), and RAs and/or BMP modifications for the Yermo Annex CAOCs with RAs, LUCs, and/or NFA with BMP modifications.

3.4.1 CAOCs 15/17 (OU 5)

CAOCs 15/17 are the Oil Storage/Spillage Area and Industrial Wastewater Treatment Plant (IWTP). Shallow soils at these CAOCs were impacted by low levels of metals, TCE, polychlorinated biphenyls (PCBs), total petroleum hydrocarbons (TPH), total petroleum hydrocarbons as diesel (TPH-d), and various pesticides. A time-critical removal action (TCRA) was conducted in 1993 to remove residual sludge. Mathematical modeling indicated that soil contamination would have limited potential impacts to groundwater.

A vertical profile boring advanced in the northeast corner of the CAOC to a depth of 292 ft bgs. VOCs were not detected in any of the soil samples; however, the highest TCE concentration in soil gas was detected at 122 ft bgs, indicating that vapors may have been originating from the groundwater (DON, 1998b). A near-surface soil gas survey indicated TCE and PCE concentrations decreased from south to north suggesting the source of these vapors was CAOC 16 (DON, 1998b) An NFA remedy was chosen for the CAOC, as documented in the OUs 5 and 6 ROD (DON, 1998b).

3.4.2 CAOC 16 (OU 5)

CAOC 16 is Building 573 and perimeter area (Marine Corps Maintenance Depot [MCMD]), located in the northeast portion of Yermo Annex. Soils at this CAOC were impacted by VOCs.

A hardstand in the form of a concrete cap ranging in thickness from 10 to 14 inches covers the entire area. The concrete cap greatly limits the potential for worker exposure to VOCs in soil gas (at shallow depths) and minimizes the potential for impact to groundwater (from soil/soil gas VOCs) due to infiltration. Therefore a LUC to preserve the hardstand was chosen as part of the remedy for soils at CAOC 16 (DON, 1998b). Groundwater beneath the CAOC is impacted by VOCs is being addressed under OU 1 (DON, 1998a). In addition, the vadose zone under CAOC 16 is being remediated under OU 1 via the CAOC 16 AS/SVE system. Potential nickel and chromium contamination of groundwater at CAOC 16 is also addressed under OU 1.

3.4.3 CAOC 18 (OU 3)

CAOC 18 is the former Sludge Waste Disposal Area. Soils at this CAOC are impacted by low levels of VOCs, semivolatile organic compounds (SVOCs), chlorinated pesticides, PCBs, petroleum hydrocarbons, metals, and polynuclear aromatic hydrocarbons (PAHs). Mathematical modeling indicated that soil contamination would have no potential impacts to groundwater. A NFA remedy with BMP modifications was chosen for this CAOC, as documented in the OUs 3 and 4 ROD (DON, 1997). The BMP modification includes description and history of soil impacts and specifies that any actions planned in the two strata of this CAOC be coordinated and reviewed by the Base Environmental Division (DON, 2010).

3.4.4 CAOC 20 (OU 3)

CAOC 20, the Second Hazardous and Low-Level Radiological Area, is located on the eastern side of the Yermo Annex. Soil contaminants included VOCs, SVOCs, metals, and pesticides. Mathematical modeling indicated that soil contamination would have limited potential impacts to groundwater. RAs selected at CAOC 20 include a combination of NFA with LUCs and a concrete cap, as documented in the OUs 3 and 4 ROD (DON, 1997). Groundwater monitoring of this CAOC is performed under OU 1.

3.4.5 CAOC 21 (OU 5)

CAOC 21, the Industrial Waste Disposal Area, is located on a flat, open, unpaved area near Gate 5 at the eastern perimeter of the Yermo Annex. This CAOC was originally under OU 3. Sampling indicated that low levels of chlorinated pesticides, VOCs, SVOCs, PCBs, metals, and petroleum hydrocarbons were present. A TCRA was conducted in 1997 to remove PCB-impacted soils (greater than 1 milligram per kilogram [mg/kg]). Mathematical modeling indicated that soil contamination would have very limited, if any, potential impacts to groundwater. A NFA remedy with BMP modifications was chosen for CAOC 21, as documented in the OUs 3 and 4 ROD (DON, 1997). The BMP modification included the history of soil impacts and stipulates that any changes in site use must be coordinated and reviewed by the Base Environmental Division (DON, 2010a).

3.4.6 CAOC 23 (OU 3)

CAOC 23, the Landfill Area, is located in the south/southeast corner of the Yermo Annex. Soils in the CAOC (outside the landfill) are impacted by low levels of VOCs. The landfill itself was not sampled. The selected remedy for CAOC 23 consisted of LUCs for some portions, and a

single layer cap or concrete pavement as documented in the OUs 3 and 4 ROD (DON, 1997). Groundwater at CAOC 23 is believed to have been impacted by VOCs and is monitored under OU 1.

3.4.7 CAOC 26 (OU 5)

CAOC 26, the Building 533 Waste Disposal Area, is located in the west-central portion of the Yermo Annex. Sampling indicates low levels of VOCs, SVOCs, pesticides, and metals above background levels. No PCBs were detected in any of the soil samples collected. A NFA remedy with BMP modifications was selected for this CAOC, as documented in the OUs 5 and 6 ROD (DON, 1998b). The BMP modification included a description of the CAOC and requirement that any actions or changes in site use will be coordinated through the Environmental Division. In addition to the soil samples, soil organic vapor surveys indicated that PCE concentrations in soil would impact groundwater. The residual vadose zone contamination was addressed by AS/SVE in combination with downgradient groundwater extraction wells. The CAOC 26 AS/SVE system was operated from December 1996 through December 1998. The system was shutdown with the FFA approval of the Final CAOC 26 Technical and Economic Feasibility Report (FWENC, 2001). Groundwater and soil vapor monitoring of CAOC 26 continues under OU 1.

3.4.8 CAOC 34 (OU 3)

CAOC 34, the PCB Storage Area (former Building S-345) is located on the eastern side of the Yermo Annex adjacent to the western side of the MCLB Barstow Effluent Disposal Pond (Building 426). The PCB Storage Area consisted of two separate concrete basins labeled Basin A (western basin) and Basin B (eastern basin). The basins were demolished and removed as a part of a TCRA in 1994. Sampling conducted prior to the RA indicated high levels of PAHs, phenol, organochlorine pesticides (OCPs), PCBs, and metals. TPH was present at low concentrations. The entire CAOC has been covered by concrete evaporation ponds. Mathematical modeling indicated that soil contamination would have very limited, if any, potential impacts to groundwater. An NFA remedy was selected for CAOC 34, as documented by the OUs 3 and 4 ROD (DON, 1997). Additionally, information regarding the contaminants in soil, specifically the low levels of benzo(a)pyrene detected in the surface soils at Stratum 1, were to be noted in the BMP. The BMP also stipulates that any changes in site use are to be reviewed by the Environmental Division.

3.4.9 CAOC 35 STRATUM 1 ZONE 1 (OU 5)

CAOC 35 Stratum 1 Zone 1, the capped and inactive Class III Landfill, is located in the northeastern portion of the Yermo Annex. VOCs, SVOCs, and pesticides were minimal at the surface. Subsurface samples indicated the presence of VOCs and SVOCs, including PAHs. TPH was present at high levels and PCB concentrations were high as well. These contaminants were all believed to be site-related. All metals present were at or below background level. Two modeling techniques were used to evaluate if groundwater would be affected. Results from the first model indicated that groundwater would be impacted by the contaminants within the landfill. A more refined evaluation was conducted which indicated that groundwater would not be affected. The remedy for the landfill is a single-layer native soil cap with NFA for remaining portions of the CAOC. Groundwater monitoring is performed under OU 1.

3.4.10 CAOC 37 (OU 1 GROUNDWATER)

CAOC 37 is the groundwater beneath the Yermo Annex. Groundwater contaminants include dissolved VOCs, primarily TCE and PCE; potential groundwater contamination by chromium and nickel is still under assessment. During initial environmental investigations at the Yermo Annex in the early 1990s, three dissolved VOC plumes were identified: CAOC 26 plume, Yermo North plume, and Yermo South plume (see Appendix D for historical plume maps). The contaminants of concern (COCs) consist of dissolved-phase VOCs, primarily TCE and PCE. The plumes, originating from different sources, were considered one merged plume for purposes of the response action. Since the merged VOC plume impacted the drinking water aquifer beneath the Yermo Annex, and extended off-Base, the DON determined that an initial response action was required. The current (2011) groundwater VOC plume extent is shown in Figure 3-5.

The initial response actions were to 1) add GAC treatment to on-Base drinking water production wells, 2) add GAC treatment systems to two off-Base private residential drinking water wells, and 3) begin hydraulic control of the identified groundwater plumes via installation of a GETS. The interim remedies were incorporated into the final remedy for OU 1 in the *OUs 1 and 2 ROD* (DON, 1998a). In addition, groundwater monitoring for CAOCs 15/17, 16, 20, 23, 26, and 35 (under OUs 3 and 5) is also included in OU 1.

3.5 DESCRIPTION AND HISTORY – NEBO MAIN BASE CAOCS

A total of 16 CAOCs requiring RA were identified at Nebo Main Base, as shown on Figure 1-3 (Table 2-1). Following is a brief summary for each of the Nebo Main Base CAOCs with RAs, LUCs, groundwater monitoring, and NFA with BMP modifications.

3.5.1 CAOC 1 (OU 6)

CAOC 1, the landfill north of the golf course, is located in the northern portion of the Nebo Main Base. Non-detectable or low concentrations of VOCs, SVOCs, organochlorine pesticide (OCPs), PCBs, metals, cyanide, and TPH-d were present in the samples collected at this site. Mathematical modeling indicated that residual dieldrin could migrate to the groundwater at concentrations that would contaminate or degrade the aquifer. To address this uncertainty, groundwater was monitored as a part of the OU 2 until 2009, when dieldrin monitoring was ceased in accordance with the Final Addendum 02 to Final Sampling and Analysis Plan, Revision 3 (Oneida Total Integrated Enterprises [OTIE], 2009b) and FFA concurrence (DTSC, 2010). A NFA remedy with BMP modifications was selected for CAOC 1, as documented by the OUs 5 and 6 ROD (DON, 1998b). The BMP modification includes the following items:

- a history of Strata 2 and 3,
- a description of the activities that occurred for flood control purposes,
- a legal description of the boundary of CAOC 1,
- a description of the low levels of pesticides and PAHs in surface soils, and

- a stipulation that any actions or changes in site use will be reviewed by the Environmental Division.

3.5.2 CAOC 2 (OU 4)

CAOC 2, the Pesticide Storage and Washout Area, is located on the north side of the Nebo Main Base. Soil samples indicated dichlorodiphenyltrichloroethane (DDT) and its breakdown products dichlorodiphenyldichloroethene (DDE) and dichlorodiphenyldichloroethane (DDD), in addition to various other pesticide and herbicide compounds with relatively low potential for vertical migration or subsurface transport of contaminants due to the silty and clayey soil at the washout area. Dieldrin concentrations were the only ones to exceed the residential soil risk-based criteria (RBCs). Fourteen metals exhibited concentrations that were statistically above background concentrations. All metals except thallium and lead were considered to be naturally occurring. Thallium and lead were considered potential site-related contaminants because they were commercially used in insecticides prior to 1965.

A TCRA was conducted at CAOC 2 from August to September 1994, during which 318 tons of soil were excavated and removed for off-site disposal. An NFA remedy with BMP modifications was selected for CAOC 2, as documented in the OUs 3 and 4 ROD (DON, 1997). The BMP modification included:

- A history of the CAOC,
- A description of the low levels of pesticides detected in the surface soils, and
- A stipulation that any actions planned or changes in site uses will be reviewed by the Environmental Division.

Mathematical modeling performed at CAOC 2 indicated that the contaminants remaining in the soils, specifically dieldrin could possibly migrate to the groundwater at concentrations that would contaminate or degrade the aquifer. To address this uncertainty, dieldrin in groundwater was monitored under OU 2; dieldrin monitoring was halted in 2009, after several years of non-detection, in accordance with the LTGMP (DON, 1998a), Final Addendum 02 to Final Sampling and Analysis Plan, Revision 3 (OTIE, 2009b) and FFA concurrence (DTSC, 2010).

3.5.3 CAOC 3 (OU 6)

CAOC 3, the Wastewater Disposal Area, is located in the northern portion of the Nebo Main Base, adjacent to the southern boundary of CAOC 1. Investigation results indicated non-detectable or low concentrations of VOCs, SVOCs, several pesticides, and extractable petroleum hydrocarbons in soils. All detected metals present were believed to be naturally occurring or present at concentrations of minor concern from a human health perspective. Mathematical modeling performed at CAOC 3 indicated that residual dieldrin in the soil could migrate to the groundwater at concentrations that would contaminate or degrade the aquifer. To address this uncertainty, groundwater was monitored as a part of OU 2. An NFA remedy with BMP modifications was selected for CAOC 3, as documented by the OUs 5 and 6 ROD (DON, 1998b). The BMP modification included:

- A history of the CAOC,

- A description of the low levels of pesticides detected in the surface soils, and
- A stipulation that any actions planned or changes in site uses will be reviewed by the Environmental Division.

3.5.4 CAOC 5 (OU 4)

CAOC 5, the Chemicals Storage Area, is located in the southeastern portion of the Nebo Main Base, north of the Drum Storage Area and Landfill (CAOC 7), and south of Joseph Boll Avenue. A variety of lower-level detections were present throughout the site including VOCs, SVOCs, OCPs, phenol, PCBs, TPH, PAHs, and metals. Mathematical modeling indicated that soil contamination would have no potential impacts to groundwater. A NFA remedy with BMP modifications was selected for CAOC 5, as documented in the OUs 3 and 4 ROD (DON, 1997). The BMP modification included:

- A history of the CAOC,
- A description of the low levels of pesticides detected in the surface soils,
- The presence of desert mix/dust suppression material, and
- A stipulation that any actions planned or changes in site uses will be reviewed by the Environmental Division.

3.5.5 CAOC 6 (OU 6)

CAOC 6, the original Trash Landfill, is located in the eastern portion of the Nebo Main Base, north of Interstate 40. Soil investigations conducted at CAOC 6 included analysis of VOCs, SVOCs, OCPs, PCBs, metals and cyanide in surface and subsurface samples. VOCs were not detected in any soil sample; the remaining organic analytes (SVOCs, OCPs, and PCBs) were generally not detected, or if detected, were at low concentrations below their respective risk-based levels (DON, 1998b). Metals were generally found to be consistent with background levels; cyanide was detected in some samples. The results of the risk assessments performed for CAOC 6 indicated risks within or below acceptable ranges; the ecological risk assessment did not find adverse impacts on ecological receptors (DON, 1998b).

Groundwater contamination by VOCs had been confirmed to exist beneath this CAOC and to have had migrated off-Base, impacting a private residential well located east of and adjacent to Nebo Main Base. A time-critical removal action performed by the DON in 1993 provided an alternate clean water supply to the affected residence. Additionally, an AS/SVE pilot study was being conducted at this site at the time of the OUs 5 and 6 ROD signing. Because remedial actions had been recommended in the OUs 1 and 2 ROD for VOC contaminants at CAOC 6, no further characterization of VOCs was recommended in the OUs 5 and 6 ROD (DON, 1998b).

An interim remedy for CAOC 6 consisting of a GETS was proposed in the OUs 1 and 2 ROD (DON, 1998a). This system was not implemented as it may have promoted off-Base migration of on-Base VOC contamination (DON, 2006). Rather, a pilot study for AS/SVE was proposed and accepted by the regulators. A number of vertical profile borings (VPBs) and other borings advanced in support of the AS/SVE Pilot Study indicated the presence of VOCs in soil gas at

CAOC 6 (TtEC, 2004). The AS/SVE system was installed September/October 1996 and operated since (OHM, 1995b). Following the success of pilot testing, the existing AS/SVE was selected as the final remedy and the Nebo South ROD was finalized (DON, 2006). The system continued in operation during this review period.

3.5.6 CAOC 7 (OU 6)

CAOC 7, the Drum Storage and Landfill Areas, is located in the southwest corner of the Nebo Main Base. The site consists of two separate landfill areas (western and eastern) with a former drum storage area located adjacent to the eastern landfill area. VOCs and SVOCs, OCPs, metals, and TPH-d were detected at low levels un soils. Impacts to groundwater were evaluated using mathematical modeling. Modeling indicated that lead and dieldrin detected at Stratum 1 may affect groundwater and that the projected concentrations of lead compounds in groundwater would be less than the projected concentration from background soils. Therefore, lead is not considered to have the potential to degrade water quality. A single-layer native soil cap with institutional controls (signs posted along the periphery) and groundwater monitoring was selected as the remedy for Strata 1 and 2. Additionally, the BMP was modified to stipulate that no breaching of the cap may occur, other than for cap maintenance activities, and any activities in these two strata must be coordinated through the Environmental Division (DON, 1998b, 2010a). Groundwater in the vicinity of CAOC 7 is monitored under OU 2.

Because there was the potential for minor surficial soil contamination to be present at Strata 3 and 4, the OUs 5 and 6 ROD (DON, 1998b) required that the BMP be amended to include a description of the history of the Strata, including the low levels of PCBs detected and a stipulation that any actions planned in the area should be coordinated and reviewed by the MCLB Barstow Environmental Division.

3.5.7 CAOC 11 (OU 4)

CAOC 11, the Fuel Burn Area, is located in the southwest portion of the Nebo Main Base between Interstate 40 to the north and the Base boundary to the south. Soil sample analysis indicated the presence of SVOCs, pesticides, TPH, and total recoverable petroleum hydrocarbons (TRPH). Mathematical modeling indicated that soil contamination would likely not impact groundwater. An NFA remedy with BMP modifications was selected for CAOC 11, as documented in the OUs 3 and 4 ROD (DON, 1997). The BMP modification included:

- A history of the CAOC
- A description of the low levels of pesticides detected in the soils, and
- A stipulation that any actions planned or changes in site uses will be reviewed by the Environmental Division.

3.5.8 CAOC 14 (OU 6)

CAOC 14 consists of the three major stormwater drainage channels that constitute the Nebo Main Base surface drainage system and four outfalls that discharge into the Mojave River.

During the remedial investigation of CAOC 14, each channel and outfall was inspected and sampled. No obvious sources such as drums, stains, or oily liquids were found. Other than

greases and oils associated with runoff from vehicle traffic areas, no ongoing releases were suspected to impact this CAOC. Samples were analyzed for VOCs, SVOCs, OCPs, PCBs, metals, cyanide, and TPH-d. VOCs were not present in the samples with the exception of a single detection, which was assumed to be the result of laboratory contamination. SVOCs were present; however, they were present at levels below residential RBC values. Pesticides were detected at varying levels throughout each of the samples. PCBs were detected in isolated samples. Metals detected in all samples were believed to be naturally occurring or present at concentrations of minor concern from a human health perspective.

The potential for impacts to groundwater from CAOC 14 was evaluated by mathematical modeling. The modeling results indicated that PAHs, PCBs, and pesticides could affect groundwater quality. All of the aforementioned contaminants are nonvolatile, insoluble, and adsorb easily to soil particles, and were expected to be relatively immobile. Further modeling analyses indicated that groundwater concentration of each of the contaminants would be below their respective RBCs and maximum contaminant levels (MCLs), except for dieldrin and gamma-chlordane. An NFA remedy with BMP modifications was selected for CAOC 14, as documented in the OUs 5 and 6 ROD (DON, 1998b). The BMP modification included:

- A history of the CAOC
- A description of the low levels of pesticides detected in the soils, and
- A stipulation that any actions planned or changes in site uses will be reviewed by the Environmental Division.

3.5.9 CAOC 38 (OU 2 GROUNDWATER)

CAOC 38 is the groundwater beneath the Nebo Main Base. It is impacted by dissolved phase VOCs at two defined locations: Nebo North and Nebo South, both of which are undergoing RA. The current extents of VOC groundwater plumes at the Nebo Main Base are shown on Figure 3-6.

Groundwater monitoring for CAOC 7 (OU 6) is also included in OU 2. Monitoring for potential pesticide contamination in groundwater at CAOC 14 ceased in 2009 based on several years of non-detection of these COCs.

The selected remedies for the Nebo North plume include AS/SVE treatment of the source area and natural attenuation of down-gradient VOCs. The Nebo North remedy also includes a fail-safe pump-and-treat system (Nebo North GETS) as a backup in case natural attenuation fails to stop plume migration. The GETS was not operated during the review period. The Nebo North AS/SVE system was installed in 2008 and operated until 2010, when it was shutdown with FFA regulatory concurrence (OTIE, 2011c). At Nebo South, the pilot study AS/SVE system was selected as the final remedy and incorporated into the OU 2 ROD (DON, 2006).

Since signing of the OUs 1 and 2 ROD additional areas of groundwater VOC contamination have been identified, as discussed below.

3.5.10 ADDITIONAL GROUNDWATER CONCERNS AT NEBO MAIN BASE

The following subsections discuss the additional groundwater issues at Nebo Main Base identified in the Second Five-Year Review. These groundwater issues are being further addressed under OU 7 and are not subject to this five-year review. However, for completeness, a brief description of the issues and a progress update is provided below.

CAOC 10.38/10.39 Unit 7

Under the OU 7 RI, groundwater contamination by TCE, PCE, and related breakdown products was identified in the area to the east of CAOC 10.38/10.39 Unit 7 (OTIE, 2010d) (Figure 3-7). Additional investigation of this area was performed during 2011 (Sealaska, 2012). The DON is in process of defining the source and extent of this contamination and will incorporate it under the OU 7 FS and OU 7 ROD. In the meantime, the DON is monitoring the area under the OU 2 long-term monitoring program.

Groundwater Contamination at NPZ-14

Piezometer NPZ-14 was installed in February 1992 for monitoring groundwater levels in the central portion of Nebo Main Base (JEG, 1992) and was later added to the OU 2 groundwater monitoring program (Figure 3-7). Beginning in November 2004, TCE concentrations rose above the MCL and have generally remained above the MCL suggesting an undefined upgradient source. A technical memorandum on TCE exceedances at NPZ-14 was prepared to evaluate possible sources of the TCE (TtEC, 2010a). However, no sources for chlorinated solvents upgradient of the piezometer could be identified based on the available historical data (TtEC, 2010a).

The DON has undertaken an investigation of the source and extent of TCE in the vicinity of NPZ-14 beginning in 2011. Three monitoring wells were installed during October 2011 (OTIE, 2012a) and three additional wells were installed during October to November 2012. The DON is considering appropriate responses to groundwater contamination of this area in the OU 7 FS and OU 7 ROD. In the meantime, the DON is monitoring the area under the OU 2 long-term monitoring program.

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4.0 REMEDIAL ACTIONS

A description of the selected remedies, remedy implementation, and ongoing system O&M is summarized by the individual Bases (Yermo Annex and Nebo Main Base), OUs, and CAOC review sections. A summary of OUs, CAOCs, and remedies is presented in Table 2-1. Additional information on remedial action in subsequent sections of this report, as follows:

- OUs 1, 3, and 5 (CAOCs 15/17, 16, 18, 20, 23, 34, and 37) at the Yermo Annex are reviewed in Section 7, with supporting documentation presented in Appendices D (OU 1) and E (OUs 3 and 5).
- OUs 2, 4, and 6 (CAOCs 1, 2, 3, 5, 7, 11, 14, and 38) at the Nebo Main Base are reviewed in Section 8, with supporting documentation in Appendix F (OU 2) and Appendix G (OUs 4 and 6).

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5.0 PROGRESS SINCE LAST REVIEW

The progress since the 2007 Five-Year Review including status of recommendations and follow-up, results of the implemented actions, and status of any other prior issues is provided in the following sections:

- OUs 1, 3, and 5 (CAOCs 15/17, 16, 18, 20, 23, 34, and 37) at the Yermo Annex are reviewed in Section 7, with supporting documentation presented in Appendices D (OU 1) and E (OUs 3 and 5).
- OUs 2, 4, and 6 (CAOCs 1, 2, 3, 5, 7, 11, 14, and 38) at the Nebo Main Base are reviewed in Section 8, with supporting documentation in Appendix F (OU 2) and Appendix G (OUs 4 and 6).

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6.0 FIVE-YEAR REVIEW PROCESS

The U.S. EPA's *Comprehensive Five-Year Review Guidance* (U.S. EPA, 2001) and DON Policy for Conducting CERCLA Statutory Five-Year Reviews (DON, 2011a) outline the Five-Year Review process and the elements required. This section of the document describes the process and presents the data reviewed.

6.1 ADMINISTRATIVE COMPONENTS

The required administration components include the notification of potentially interested parties of the initiation of process, identification of the Five-Year Review team, and schedule for the Five-Year Review.

6.1.1 NOTIFICATION OF POTENTIALLY INTERESTED PARTIES OF INITIATION OF REVIEW PROCESS

Public notices were placed in local newspapers to inform the public about the ongoing Third Five-Year Review process. The FFA signatories were notified prior to placing the public notices. Proofs of publication are included in Appendix A.

6.2 FIVE-YEAR REVIEW TEAM

This Five-Year Review was conducted by ATJV under contract N62473-09-D-2610, Contract Task Order 0013, for the NAVFAC SW. The NAVFAC SW RPM, Mr. Ralph Pearce, was responsible for the initiation and completion of this Five Year Review. Base access and interviews for the Five-Year Review were coordinated through Mr. Jim Bustamante, IRP Manager, The MCLB Barstow Environmental Division. Contact information for the aforementioned individuals is provided below:

Mr. Ralph Pearce, RPM
NAVFAC Southwest
1220 Pacific Highway
San Diego, CA 92132
(619) 532-3768

Mr. Jim Bustamante
Marine Corps Logistics Base Barstow
Environmental Division – IR Program
Building 196
Barstow, CA 92311-5050
(760) 577-6523

The Five-Year Review report was submitted to the FFA regulatory team for review and comment; comments were received and addressed by the DON under the FFA agreement process. Responses to comments are incorporated into Appendix H.

The FFA regulatory team includes the following:

Mr. Phillip Ramsey, RPM
U.S. EPA, Region 9
SFD-8-3, Attn: Phillip Ramsey
75 Hawthorne Street
San Francisco, CA, 94105

Ms. Soad Hakim, RPM
California Environmental Protection Agency
Department of Toxic Substances Control
5796 Corporate Avenue
Cypress, CA 90630

Mr. Omar Pacheco, RPM
California Regional Water Quality Control Board – Lahontan Region
Victorville Branch Office
14440 Civic Drive, Suite 200
Victorville CA 92392

6.3 OUTLINE OF COMPONENTS AND SCHEDULE OF FIVE-YEAR REVIEW

The Five-Year Review consists of the following tasks:

- Community involvement via the public notifications in the local newspapers
- Document review
- Data review
- Site inspections
- Technical assessments
- Five-year Review Report development and review

These tasks were accomplished during the January - November 2012 time period.

6.3.1 COMMUNITY INVOLVEMENT

Public notifications were placed in two local newspapers to inform the public about the Third Five-Year Review, including schedule for completion and how to access the Five-Year Report (Appendix A). Copies of the Third Five-Year Review Report will be placed into the Information Repository at the MCLB Barstow, which can be accessed by contacting Mr. Jim Bustamante at the Base Environmental Division at (760) 577-6523.

6.3.2 DOCUMENT REVIEW

This Five-Year Review consists of a review of relevant documents including annual O&M and monitoring reports, landfill cap repair reports, and well installation reports. A list of references cited in the subject Five-Year Review is included in Section 10.0. Other sections of this report,

specifically, Sections 7.0 and 8.0, include results from the review of the annual O&M and monitoring reports and other relevant documents.

6.3.3 DATA REVIEW AND EVALUATION

Monitoring, remedial systems O&M information, performance data and other information were reviewed for this Five-Year Review including the following:

- Groundwater monitoring data for OUs 1 and 2
- Soil vapor monitoring data for OUs 1 and 2
- O&M costs and performance data for four active remediation systems (see Section 6.5)
- O&M costs and performance data for four landfill cap systems (see Section 6.5)
- BMP amendments and Base Geographic Information System (GIS) data

6.3.4 FINDINGS FROM SITE INTERVIEWS, INSPECTIONS, AND INFORMATION REQUESTS

A site inspection of CAOCs was conducted March 29-30, 2012; an additional inspection of CAOCs 16 and 32 was performed on September 13, 2012. Information was gathered from the MCLB Barstow Environmental Division and the O&M contractors regarding the sites and systems.

Findings from the site inspection for those sites with site developments, defined as any construction altering the site since the last Five-Year Review, are summarized on Table 6-1. Site inspection photographs for CAOCs 16, 20, 23, and 35 at Yermo Annex, and CAOCs 6 and 7 at Nebo Main Base, are provided in Appendix B. As documented on Table 6-1, site development activities for these CAOCs were coordinated through the MCLB Barstow Environmental Division as required by the BMP.

Further information on activities at CAOCs with LUCs or BMP amendments is discussed in Section 7 for Yermo Annex and Section 8 for Nebo Main Base.

The information gathered from the MCLB Barstow Environmental Division and the O&M contractors has been incorporated into Sections 7 and 8.

6.4 TECHNICAL ASSESSMENT PROCESS

The technical assessment of the protectiveness of remedies implemented at the CAOCs is based on answering the following three questions:

Question A: Is the remedy functioning as intended by the RODs?

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of the remedy selection still valid?

Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

The technical assessment requires evaluation a number of considerations, as discussed below. A technical assessment was performed for CAOCs with remedies in place that require RA performance monitoring.

6.4.1 QUESTION A: IS THE REMEDY FUNCTIONING AS INTENDED BY THE ROD(S)?

The U.S. EPA's Comprehensive Five-Year Review Guidance (2001) identifies several areas that need to be considered when evaluating whether the remedy selected in the decision documents is functioning as designed. Areas of consideration include:

- Remedial Action Performance – Is the remedy operating as designed?
- System O&M – Will the system and current O&M activities maintain the effectiveness of the response actions?
- Cost of System O&M – How do planned costs compare to actual costs?
- Institutional Controls and Other Measures Implementation – Are these functioning as planned?
- Monitoring Activities – Do the current monitoring activities provide adequate information to determine the protectiveness and effectiveness of the remedy implemented?
- Optimization Opportunities – Are there areas for improvement?
- Early Indications of Potential Issues – Are there problems that could lead to the remedy being not protective or that suggest protectiveness is at risk unless changes are made?

6.4.2 QUESTION B: ARE THE EXPOSURE ASSUMPTIONS, TOXICITY DATA, CLEANUP LEVELS, AND RAOS USED AT THE TIME OF THE REMEDY SELECTION STILL VALID?

When evaluating the validity of the selected remedy, it is important to consider changes in standards, newly promulgated standards or "to be considered" (TBC) standards, changes in exposure pathways, changes in land use, or if any new contaminants and/or contaminant sources and/or remedy by-products have been identified.

6.4.3 QUESTION C: HAS ANY OTHER INFORMATION COME TO LIGHT THAT COULD CALL INTO QUESTION THE PROTECTIVENESS OF THE REMEDY?

The final question in conducting a technical assessment of the selected remedy includes the evaluation of any new information that may have become available that could call into question the protectiveness of the remedy selected. Situations include ecological risks, unidentified risks from natural disasters (for example, flooding), or land use changes.

In accordance with DON policy, if the Five-Year Review determines that the remedy or the RAOs are no longer protective, then the Five-Year Review Report will make recommendations concerning the steps necessary to achieve protectiveness (DON, 2011a).

6.4.4 ADDITIONAL CONSIDERATIONS/REVIEWS

For OU 1, the OUs 1 and 2 ROD required the additional evaluations be performed during the Five-Year Review:

- Evaluation of metals contamination in groundwater CAOC 16.

- Evaluation of the effectiveness of the AS/SVE and GETS in reducing groundwater and vadose zone contamination at CAOC 16 (although reduction of vadose zone contamination is not an RAO for CAOC 16) and the need for additional investigation.
- Evaluation of the effectiveness of the CAOC 26 AS/SVE system in reducing VOC levels in the shallow subsurface (this was not specifically required in the five-year review, but was required as part of the ROD). Because the CAOC 26 AS/SVE system was shut down in 1998 after achieving RAOs, the ongoing groundwater and soil vapor monitoring data were reviewed.

For OU 2, the Technical and Economic Feasibility Report for the Nebo North AS/SVE system (OTIE, 2011c) required the evaluation of the ongoing soil vapor and monitoring program for the Nebo North plume as part of this Five-Year Review.

The required additional evaluations for OU 1 and OU 2 were performed as part of this Five-Year Review and are discussed in the technical assessment report Sections 7.0 and 8.0, respectively.

The OUs 3 and 4 ROD (DON, 1997) and OUs 5 and 6 ROD (DON, 1998b) selected the No Action Alternative for several CAOCs. When selecting this alternative, the RODs specifically stated that the No Action Alternative does not involve institutional or engineering controls, containment, excavation, or treatment. However, at the conclusion of the selection reasoning, the RODs indicated that for certain CAOCs, the BMP should describe the history of the CAOC and specify that any actions planned in these areas or changes in the site use should be coordinated and reviewed by the MCLB Barstow Environmental Division. In this Five-Year Review, the phrase "NFA with BMP amendments" is used to refer to the No Action CAOCs where Environmental Division oversight is required to maintain the conditions of the NFA decision. The BMP was updated in 2010 and includes procedures to follow in evaluating changes to land use that may pose a risk to site workers (e.g., during construction activities) or substantially change the conditions supporting the NFA decision. The CAOCs with "NFA with BMP Amendments" were reviewed for any substantial changes in land use or site conditions in this Five-Year Review (see Sections 7.8 and 8.4 for Yermo Annex and Nebo Main Base affected CAOCs, respectively).

6.5 REVIEW OF OPERATIONS AND MAINTENANCE COSTS

The operations, maintenance, monitoring and repair costs were obtained for the CAOCs with construction-completed remedies; these included CAOCs 7, 20, 23, 26, 35, 37 and 38. The cost summaries including comparison with the original estimated costs under the ROD, last five-year review, and this review are summarized in Tables 6-2 (Yermo Annex) and 6-3 (Nebo Main Base). Due to the significant remedial equipment repairs and upgrades performed by the DON during the review period, these costs are generally shown separately. In prior reviews, the electrical costs for active remedial systems were paid by the MCLB Barstow and were not reported. This changed in 2008 when the IRP began to support those costs. The electrical costs are incorporated into the O&M average costs for this review. Further information

on the O&M costs for the remedial systems in place for OUs 1 and 2 is presented in Appendix D (see Technical Assessment D-2).

6.6 REVIEW OF EXPOSURE ASSUMPTIONS, TOXICITY DATA, CLEANUP LEVELS, AND RAOS

As part of the technical assessment, Question B (Section 6.4) asks specifically whether the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of the remedy are still valid. This review was conducted in accordance with the DON *Policy for Conducting CERCLA Statutory Five-Year Reviews* (DON, 2011a) and *U.S. EPA's Comprehensive Five-Year Review Guidance* (EPA, 2001). When evaluating this question, it is important to consider changes in standards, newly promulgated standards or TBC standards, changes in exposure pathways, changes in land use, or if any new contaminants and/or contaminant sources and/or remedy by/products have been identified.

Question B was addressed by OUs as grouped within the RODs. Applicable or relevant and appropriate requirements (ARARs) provided in the OUs 1 - 6 RODs were reviewed and evaluated to determine if any modifications of these ARARs had occurred that might affect the RAOs in the ROD or operation of the various groundwater treatment systems had occurred since the ROD was finalized. Chemical-specific ARARs including federal or state drinking water MCLs, published federal or state soil screening levels, and discharge limits in the RWQCB-Lahontan District Basin Plan and other RWQCB resolutions originally cited in the RODs were evaluated for revisions. Additionally, the Mojave Desert Air Quality Management District mass discharge limits were reviewed because these limits are used to evaluate compliance of the AS/SVE systems with air quality requirements. Supporting documentation for the review of toxicity data, cleanup levels, and RAOs is provided in Appendix C.

6.6.1 REVIEW OF EXPOSURE ASSUMPTIONS

Since the prior Five-Year Review, based on the technical assessments performed (Sections 7.0 and 8.0), there have been no significant changes in exposure pathways or land use that would negate or degrade the assumptions of the risk assessments performed to support selection of the RAOs.

The MCLB Barstow remains an active military facility. The ICs/LUCs are enforced and the MCLB Barstow Environmental Division reviews proposed construction or other changes on CAOCs where such activities could affect the selected remedy. The BMP was updated in 2010 to improve the clarity and coverage of the document for ICs/LUCs enforcement.

6.6.2 REVIEW OF TOXICITY DATA, CLEANUP LEVELS, AND RAOS

Current (as of May 2012) regional screening levels (RSLs) and promulgated standards were compared to the RAOs established in the RODs for OUs 1-6; details are provided in Appendix C.

Soil RSLs

For the soil COCs listed in the RODs, the 2004 Preliminary Remediation Goals (PRGs) were compared to the May 2012 RSLs (U.S. EPA, 2012a), with consideration of the DTSC Office of Human and Ecological Risk (HERO) guidance (DTSC, 2012). Tentatively identified compounds (TICs) were also reviewed. The evaluation of CAOCs with NFA is summarized in Tables C-1. The review found that:

- CAOC 32 Stratum 2 was the only CAOC with a NFA remedy and no BMP amendment that had a soil concentration of a COC exceeding a newly published RSL; specifically Aroclor-1242 (*see* OUs 5 and 6 ROD, Section 17.3.2). CAOC 32 Stratum 2 is located on the west side of the CAOC 16 hardstand and is covered with pavement and buildings. Because no direct exposure route is suspected, the NFA remedy is considered to be currently protective. However, to ensure long-term protectiveness, the BMP should be amended to note the potential presence of Aroclor 1242 at this location.

Groundwater MCLs and Tap Water RSLs

Documents published by the California Department of Public Health (CDPH) were consulted to identify COC MCLs that decreased when compared to the last five-year review, chemicals that are currently being analyzed for as an indicator for established COCs, or for compounds that were not of concern at the writing of the RODs (CDPH, 2011). The compounds for which any one of the above conditions apply are listed on Table C-5 in Appendix C.

There are no promulgated changes to the MCLs for the COCs identified in the OUs 1 and 2 RODs. The RAOs developed in the OUs 1 and 2 ROD were based on the MCLs. Therefore the groundwater RAOs based on the MCLs are still protective.

The 2004 tap water PRGs published by the U.S. EPA Region 9 were compared with the current U.S. EPA tap water RSLs for detected groundwater contaminants at the MCLB Barstow (Table C-6 in Appendix C).

Groundwater Discharge Limits

Treated groundwater from the Yermo Annex GETS is discharged back to the aquifer via infiltration galleries. The treated water is discharged in general compliance with the RWQCB-Lahontan Region order pertaining to Waste Discharge Requirement (WDR) for Land Disposal of Treated Groundwater. WDR Order Number 6-93-106A referenced in the prior five-year review was replaced by WDR Order Number R6T-2004-0015 (RWQCB, 2004).

Changes, as they pertain to the ROD requirements, are presented in Appendix C, Tables C-3 (detection limit and analytical method changes), C-4 (primary drinking water standards), C-5 (secondary drinking water standards), and C-6 (discharge standards). The revised discharge limits were incorporated into the Yermo Annex GETS monitoring program in the SAP Revision 4 (OTIE, 2012b).

Vapor Discharge Limits

According to Mr. Jim Bustamante, IRP Manager, Environmental Division, the MCLB Barstow, the Base is considered a major source by the Mojave Desert Air Quality District. The Federal

Operating Permit (number 08700587) for Yermo was renewed on March 24, 2010 and will expire on March 24, 2015 (Bustamante, 2012). The emission limits to the atmosphere from equipment in which organic solvents or materials containing organic solvents are listed in Part II.A.25 (Page II-15). The mass allowed to be emitted base-wide on an hourly and daily period were not changed in the renewed permit. Emission limits remain 39.6 lbs/day of photochemically reactive compounds and 600 lbs/day non-photochemically reactive compounds (Mojave Desert Air Quality Management District [MDAQMD], 2010).

6.6.3 NEW CONTAMINANTS OR CONTAMINANT SOURCES

No new contaminants or contaminant sources related to the MCLB Barstow operations were identified during the five-year review. However, two off-Base sources of contaminant impacted the MCLB Barstow groundwater during the review period and are briefly discussed in this section.

Perchlorate

Perchlorate contamination was discovered in the Nebo Main Base potable water system during routine sampling in 2010; by the November 2010 the source of the perchlorate was identified as a production well of the commercial water purveyor which supplies the Nebo Main Base. The perchlorate contamination was ultimately sourced to a private individual who disposed of perchlorate wastes on his property north of the City of Barstow, approximately 3 miles upgradient of the Nebo Main Base (RWQCB-Lahontan Region, 2011). The U.S. EPA Region 9 performed source characterization in 2011 - 2012 and will likely perform a removal action. The RWQCB-Lahontan Region was investigating the downgradient extent and possible other sources of perchlorate contamination during 2011 - 2012.

The DON is performing a study to assess the risks and develop contingency plans for further perchlorate impacts to the Base water supply. Quarterly monitoring of the MCLB Barstow monitoring wells has demonstrated the Base is not a perchlorate source as only trace level perchlorate concentrations have been found in on-Base monitoring wells (ATJV, 2012a, 2012b, 2012c). A perchlorate study report is anticipated to be completed by December 2012.

Methyl tert-Butyl Ether (MTBE)

The former MTBE plume in the southern half of the Yermo Annex was attributed to the Calnev Pipe Line Company, LLC; an active fuel handling facility located hydraulically upgradient and southwest of Yermo Annex. Additional background information on the MTBE plume is provided in the *Annual 2008 MTBE Data Summary Report, Yermo Annex* (TN&Associates, Inc. [TN&A], 2009).

Groundwater samples collected during semiannual and annual monitoring events at the Yermo Annex during the review period were analyzed for MTBE, which is part of the regular VOC analyte list. Because MTBE was not detected above the reporting limit of 2.0 microgram per liter (µg/L) in any well at the Base since 2006, separate reporting on the plume was ceased Additionally, the two 20,000 pound GAC vessels that were installed at the GETS as an

additional treatment step were removed in 2010 to save energy and operational costs. The DON continues precautionary MTBE monitoring on an annual basis.

6.6.4 REMEDY BY-PRODUCTS

The remedies in place include landfill covers, AS/SVE and groundwater pump and treat. Groundwater treatment is by GAC. The implemented remedies are not expected to produce by-products. In 2002, the California Department of Health Services (now CDPH) had expressed a concern regarding excess nitrate or nitrite from GAC treatment on the Yermo Annex drinking water production wells. This issue, now resolved, is discussed briefly below.

Excess Nitrate or Nitrite from GAC Treatment

The MCLB Barstow operates the YDW drinking water production wells and GAC treatment system under a permit from the CDPH; the permit requires monthly monitoring of VOCs. The MCLB Barstow added nitrate and nitrite analyses to the monthly monitoring program in 2002 in response to the CDHS stated concern that GAC treatment systems can generate excess nitrate or nitrite (CDHS, Southern California Drinking Water Field Operations Branch, correspondence dated April 30, 2002).

The long-term monitoring data for the YDW treatment system indicated nitrate and nitrite detected concentrations were well below the California action levels of 45 milligrams per liter (mg/L) (for nitrate as nitrate) and 1 mg/L (for nitrite as nitrogen) and were stable. Based on the data, nitrate/nitrite monitoring frequency was reduced by the MCLB Barstow to once per year beginning in 2012.

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7.0 YERMO ANNEX – TECHNICAL ASSESSMENT

7.1 OVERVIEW

CAOCs requiring five-year review include those with remedial actions, institutional controls, and NFAs with BMP modifications. At the Yermo Annex, the third five-year review covered CAOCs 37, 16, 20, 23, 35, 15/17, 18, 21, 23, 26, and 34 (Table 7-1). The technical review for each of the CAOCs with remedial actions (37, 16, 20, 23 and 35) is provided in Tables 7-2 through 7-6. The review tables have five parts corresponding to the review activities as follows:

- **Part 1:** Review of Remedial Action Objectives, Selected Remedies, Implementation, Status, and Changed Conditions Since ROD signing and Prior Review
- **Part 2:** Progress Since Last Review (2007)
- **Part 3:** Technical Assessment (Based on 2011 – 2012 Data, Site Inspection, Review of Relevant Documents, and Interviews). The three technical review questions are addressed in this part of the table.
- **Part 4:** Current Issues (Based on 2011 – 2012 Data, Site Inspection, Review of Relevant Documents, and Interviews). The potential for the identified issues to affect short-term and long-term protectiveness is also discussed.
- **Part 5:** Recommendations and Follow-up Actions (implementation by the DON with oversight by the FFA regulators); also included is a schedule and any relevant comments.

Supporting data, including data trends and evaluations, are presented in Appendices D and E.

The reviews of CAOCs with NFAs and BMP modifications are presented in Table 7-7 and discussed in Section 7.8; any activities or changes at these CAOCs during the prior five years are reviewed. A review of the dissolved metals question presented in the OUs 1 and 2 ROD is discussed in Section 7.9.

The following sections present a brief summary of the key findings of the technical assessment for each of the CAOCs reviewed.

7.2 CAOC 37 (OU 1) YERMO ANNEX GROUNDWATER

7.2.1 BACKGROUND

CAOC 37 is comprised of the contaminated groundwater plumes beneath the Yermo Annex, specifically, the Yermo North, Yermo South, and CAOC 26 comingled plumes. Of these originally identified plumes, only the Yermo North plume remains as a large contiguous VOC plume. The Yermo South and CAOC 26 plumes have declined or been remediated to below the groundwater cleanup goals in most portions of these plumes (see data trends and historical plume maps in Appendix D, D-1 RA Performance).

The selected remedies for CAOC 37 included groundwater extraction, ex-situ treatment of the extracted groundwater, recharge of treated groundwater back into the aquifer, and AS/SVE

systems for groundwater and vadose zone VOC mass removal. Groundwater cleanup standards are based on secondary and primary MCLs.

Vadose zone cleanup standards are based on removal of VOCs from soils to levels that will not cause groundwater to exceed the groundwater cleanup standards. Section 2.8.3 of the OUs 1 and 2 ROD states:

> "The RAO for vadose zone cleanup at the MCLB Barstow is to remove contaminant mass in the subsurface soils to the degree necessary to 1) prevent further degradation of the groundwater above groundwater cleanup standards and 2) minimize the aquifer cleanup time. Vadose zone soils cleanup goals are source specific."

OUs 1 and 2 ROD Sections 2.8.4 (Criteria for "Shut-off" of AS/SVE Systems), 2.8.5 (Vadose Zone and Groundwater Modeling to Determine AS/SVE System "Shut-off"), and 2.8.6 (Determination of Asymptotic Conditions for "Shut Off" of AS/SVE Component of Groundwater Remedy) provide the specific analyses to be performed to determine if the vadose zone RAOs have been met by a selected remedy.

The OUs 1 and 2 ROD Sections 2.8.7 and 2.8.8 provide vadose zone source-specific cleanup goals for CAOCs 16 and 26. These cleanup goals are reviewed in detail in Sections 7.3 and 7.4 of this report, respectively. Monitoring is conducted to evaluate the effectiveness of the remedial actions and verify groundwater and vadose zone cleanup.

In addition to the selected remedies, under OU 1, groundwater monitoring is performed at CAOCs 20, 23 and 35, which are subject to landfill closure requirements. The technical assessment for CAOC 20, 23, and 35 including groundwater data are summarized in Tables 7-4, 7-5, and 7-6, respectively.

The OUs 1 and 2 ROD required groundwater sampling of dissolved metals at selected wells in the area of CAOC 16 to ascertain if these metals are naturally occurring or the result of Base activities. A summary of the review of this issue is presented in Section 7.9.

Additionally, under OU 1, certain LUCs are implemented to prevent the use of untreated groundwater for drinking water in the area of the plume above MCLs and to provide wellhead treatment of potentially impacted water supply wells. The LUCs and wellhead treatment measures are reviewed in Section 7.10.

Specific treatment system that were reviewed include the Yermo Annex GETS, CAOC 16 AS/SVE system, and CAOC 26 AS/SVE system, as shown on Figures 7-1, 7-2, and 7-3, respectively.

The OUs 1 and 2 ROD (DON, 1998a) states:

> "The RAO for groundwater cleanup shall be to achieve and maintain compliance with the groundwater cleanup standards throughout the groundwater contaminant plume. The groundwater RAO will be achieved through continued operation of the Yermo Annex plume groundwater pump and treat system and the AS/SVE system downgradient of CAOC 16. These systems serve the dual purpose of treating the

contaminated groundwater to achieve MCLs and containing the contaminated groundwater while the treatment is occurring. Institutional controls will also be implemented to prevent access to the contaminated groundwater until cleanup standards are achieved."

The OUs 1 and 2 ROD further specifies that the DON will evaluate the progress of the selected remedy for impacted groundwater at CAOC 16, once every 5 years, and submit the evaluation with the five-year review. That data evaluation is provided in Appendix D (see D-1 RA Performance) and summarized in the review Table 7-3.

7.2.2 SUMMARY OF TECHNICAL ASSESSMENT

The technical assessment for OU 1 is presented in Table 7.2, and includes:

- Review of the operations, maintenance, monitoring, and removal performance data for the Yermo GETS and CAOC 16 AS/SVE systems (the only two active remedial systems)
- Review of long-term trends in groundwater COC concentrations in specific key groundwater monitoring wells at the center of the Yermo North plume
- Review of long-term trends in groundwater COC concentrations and plume dimensions (Yermo North plume)
- Review of long-term trends in soil vapor COC concentrations (at CAOC 16 and CAOC 26)
- Modeling of the hydraulic capture zone for the updated groundwater extraction system.

7.2.3 SUMMARY OF FINDINGS

The technical review for the Yermo Annex GETS and CAOC 16 AS/SVE system (the two remaining active remedial systems at Yermo Annex) found that, other than periodic maintenance shutdowns, the systems were operated in accordance with the accepted O&M plan during the five-year review period. The DON completed numerous major and minor system and infrastructure repairs, replacements, and upgrades to address aging remedial system components. Significant among the repairs and upgrades completed were: installation of two new extraction wells (in 2010 and 2012) to improve hydraulic control and VOC mass removal; installation of new computer hardware and upgraded software; addition of remote telemetry; removal of two unneeded GAC treatment vessels; changeout of spent GAC; and GAC vessel inspection and repair. The reinvestment in the GETS and AS/SVE equipment will ensure the long-term protectiveness of the selected remedy.

The major issue identified during this review is the ability of the selected remedy to cost-effectively achieve the RAOs for groundwater. The original estimated OU 1 cleanup timeline (as stated in the ROD) was 30 years (1998 – 2028). As discussed in Appendix D-1, current data trends in groundwater monitoring locations in the center of the Yermo North Plume indicate that the 30-year timeline is unlikely to be achieved. Based on the available data, COC concentrations at the center of the Yermo North Plume are trending upward. The stability of the Yermo Annex plume and the persistence of soil vapor VOCs beneath CAOC 16 indicate the presence of a continued source of VOCs to groundwater. Data trends at key groundwater

monitoring locations for the Yermo North plume indicate that the 30-year timeline is unlikely to be achieved without more directly remediating the source.

The OUs 1 and 2 ROD (see ROD Section 2.8.7, pages 2-25 to 2-26) states that the following:

> "Evaluation of the progress of the selected remedy in meeting groundwater cleanup standards shall occur every 5 years as an FFA deliverable attached to the CERCLA Section 121(c) 5-year review report. The 5-year progress evaluation shall specifically consider the CAOC 16 groundwater monitoring well and vapor probe data. The signatory parties to this ROD will jointly evaluate whether the groundwater monitoring well and vapor probe data demonstrate that adequate progress is being made towards meeting cleanup goals at CAOC 16. If the FFA signatories determine that the remedial action is not resulting in adequate progress, the DON shall prepare a follow-up FFA deliverable report to be submitted to the FFA signatories addressing the following subjects.
>
> a) The potential need for additional remedial action at CAOC 16 (with supporting rationale, analysis, and documentation).
>
> b) An evaluation of the technical and economic feasibility of further investigation and remediation beneath Building 573 and the Building 573 hardstand to meet the RAO. This feasibility analysis will identify and evaluate one or more approaches to adequately characterize and remediate CAOC 16. The analysis shall evaluate the approaches against the nine NCP criteria: overall protection of human health and the environment; compliance with ARARs; long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; cost; state acceptance; and community acceptance. Evaluation of the implementability shall specifically include the impact of the approaches on Base operations, and any relevant technological advances. Discussion of the overall protection of human health criteria should include consideration of changes in land use. The evaluation of community acceptance shall specifically include social and economic impacts that the approaches may have on the surrounding community. Such impacts may include the consequences of any related degradation in the economic viability and competitiveness of the MCLB Barstow.
>
> c) Whether the basis for a CERCLA Section 121(d)(4)(C) "Technical Impracticability" waiver from attaining MCLs has been established (with supporting rationale, analysis, and documentation)."

Based on the technical assessment of CAOC 37 (OU 1), the selected remedy will probably not achieve groundwater RAOs within the ROD-estimated timeframe of 30 years. However, the Yermo GETS, CAOC 16 AS/SVE system, and LUCs will remain protective of human health and the environment if maintained and operated to current standards of practice.

The recommendation and follow-up action is to engage the FFA in the OUs 1 and 2 ROD-defined process for evaluation of the effectiveness of the Yermo North plume and evaluate if augmentation of the existing remedy is required to more effectively address this plume.

7.3 CAOC 16 (OU 5) MARINE CORPS MAINTENANCE DEPOT (MCMD)

7.3.1 SUMMARY OF THE TECHNICAL ASSESSMENT

CAOC 16 includes Building 573 and the surrounding concrete cover; the facility name was recently changed to the MCMD (formerly "Maintenance Center"). The selected remedy for CAOC 16 is LUCs to maintain the existing concrete hardstand, monitoring the physical and structural integrity of the concrete hardstand, and controlling and monitoring exposure pathways at CAOC 16. A regular maintenance program is implemented to maintain a stable surface environment, which will prevent organic vapors from escaping to the atmosphere, prevent direct contact with any soil contamination, and minimize infiltration of water to the subsurface.

The technical assessment of the CAOC 16 selected remedy included:

- an inspection of the hardstand on 29 March 2012
- interviews with the MCLB Barstow Environmental Division and review of available construction as-builts and Base GIS data on building construction on the hardstand during the review period,
- Johnson-Ettinger (J-E) modeling of selected 2007 - 2011 vapor data using conservative assumptions and the updated TCE risk criteria (U.S. EPA, 2012).

7.3.2 SUMMARY OF FINDINGS

The Third Five-Year Review technical assessment of CAOC 16 (Table 7-3) found the integrity of the concrete hardstand was maintained during the review period. A total of 8 structures were built on the hardstand during the review period during 2012. Of the completed buildings only one (Building 638) involved removal and replacement of the hardstand; the replacement floor was 12-inches of concrete (Table 7-8). Construction activities were coordinated with the MCLB Barstow Environmental Division. Field inspections and interviews conducted on 13-16 September 2012 confirmed that the hardstand was restored to original conditions (Appendix B). Based on the review findings, the hardstand was preserved in accordance with the ROD during construction of Building 638.

During the review period, one construction project impinging on the hardstand occurred within Building 573. A subsurface drain system was constructed in the weld shop section of Building 573. The existing 12-inch thick hardstand was saw-cut in an area measuring 52 feet long by 2 feet wide by 2 feet deep to accommodate a new 6-inch pipe and industrial floor drain that tied into the existing drainage system. While the trench was open, soil samples were collected for the purpose of evaluating the potential presence of contaminants and to provide information for health and safety screening purposes. Four soil samples from 3 feet bgs were analyzed for VOCs and one composite sample was analyzed for SVOCs and PCBs; no detectable concentrations were found. CAM 17 metals were also tested in the composite sample; trace

levels of metals were detected at levels considered to be background concentrations (IWS Environmental, 2011). The replacement flooring over the installed drain pipe was 12-inches thick, hence preserving the hardstand.

The effectiveness of the 10- to 12-inch thick concrete hardstand in preventing soil vapor intrusion into Buildings 573 and 579 was evaluated by modeling vapor concentration data from three soil vapor monitoring probes in the vicinity of the two buildings using the J-E vapor exposure model. The model report and outcome is presented in Appendix C. The California Office of Environmental Health Hazards Assessments (OEHHA) toxicity values were used in the model run. The model output indicated that the predicted excess lifetime cancer risks for the maximum PCE soil gas concentrations observed at depths of 60 and 140 feet exceeded the lower end of the U.S. EPA acceptable risk range of 10^{-4} to 10^{-6}; however all risk levels were well within the acceptable range. The non-cancer Hazard Quotient values were at least an order of magnitude lower than the threshold value of 1.0.

To provide information for risk management at the MCLB Barstow, the J-E vapor exposure model was also run using the toxicity values from the May 2012 Regional Screening Level tables (U.S. EPA, 2012a). The most recent U.S. EPA toxicity criteria have not been adopted by the Cal/EPA OEHHA; therefore the model was also run using the CalEPA criteria for PCE. The Inhalation Unit Risk and Reference Concentration for inhalation values represent the recently published toxicological profile for PCE and TCE (U.S. EPA, 2012b). The model output indicated that the predicted excess lifetime cancer risks were below the lower end of the EPA acceptable risk range of 10^{-4} to 10^{-6} and the non-cancer Hazard Quotient values were less than the threshold value of 1.0.

Based on conservative modeling, the selected remedy of preservation of the hardstand to prevent exposure to shallow soil vapors is functioning as intended by the ROD.

7.4 CAOC 26 (OU 5, OU 1)

7.4.1 Summary of the Technical Assessment

CAOC 26, the Building 533 Waste Disposal Area, is located in the west-central portion of the Yermo Annex. Sampling indicated low levels of VOCs, SVOCs, pesticides, and metals above background levels in the CAOC soils. An NFA remedy with BMP modifications was selected for this CAOC, as documented in the OUs 5 and 6 ROD (DON, 1998b). An AS/SVE system was installed and operated under OU 1 to address PCE concentrations in soil and groundwater.

The CAOC 26 AS/SVE system was installed in 1996, and was in operation from 1996 through 1998. In addition, four groundwater extraction wells connected to the Yermo GETS were installed in 1996 and were operated until 1998.

The technical assessment for the AS/SVE with groundwater pump-and-treat remedy for CAOC 26 under OU 1 is presented in Table 7-2; the assessment included:

- A review of groundwater and soil vapor monitoring data and trends from 2007 – 2011
- Review of records for maintenance of remediation equipment (system now shut down).

A technical assessment of the NFA with BMP Amendment remedy for the CAOC 26 surface is summarized in Table 7-7.

7.4.2 SUMMARY OF FINDINGS

The CAOC 26 remedy is currently protective of human health and the environment. The remedial system components (AS/SVE system and extraction wells) have been shut down since 1998 and are not actively maintained. Permanent decommissioning of the extraction wells (removal of downhole equipment and disconnection of electrical connection) and removal of above-ground remedial equipment from the AS/SVE compound is recommended.

7.5 CAOC 20 (OU 3)

7.5.1 SUMMARY OF THE TECHNICAL ASSESSMENT

The remedy at CAOC 20 consists of NFA with LUCs and a concrete cap. The concrete cap is maintained in accordance with the O&M Plan in Appendix A of the OUs 3 and 4 Removal Action Report (RAR) (DON, 2000). Groundwater is monitored under OU 1.

The technical assessment of CAOC 20 is presented in Table 7-4 and included:

- an inspection of the concrete cap on 29 March 2012
- a review of 2007 – 2011 annual O&M reports for this CAOC
- review of groundwater monitoring data and trends from 2007 - 2011

7.5.2 SUMMARY OF FINDINGS

The CAOC 20 cap is properly maintained. Groundwater COC concentrations are consistently below RAOs. Therefore, the CAOC 20 remedy appears to be functioning as intended by the ROD. Recommendations and follow-up actions include:

- Groundwater monitoring wells should be periodically cleaned and redeveloped to address biofouling that could impact data quality.
- Evaluate four consecutive years of radiological monitoring data in accordance with OUs 3 and 4 ROD.

The following provides a review of the changes to the groundwater monitoring program that were implemented in response to the issue identified in the 2007 Five-Year Review of elevated gross alpha groundwater concentrations. This information is taken from the SAP Revision 4.

CAOC 20 (OU 3), Second Hazardous and Low-Level Radiological Area, is on the eastern side of the Yermo Annex (Figures 1-2 and 7-4). CAOC 20 includes a low-level radiological waste disposal well capped by a concrete pad and surrounded by a chain-link fence. The radiological waste consisted of scrap luminescent dials. Although it is undocumented, the paint used to coat the dials could have contained radium, which historically was added to paints used on luminescent instruments. Documentation is not available regarding the exact quantity of radiological waste disposed at this site. In addition, 31 uncapped non-radioactive waste disposal wells are on the CAOC. These wells are approximately 30 feet deep and 4 feet in diameter. The non-radiological wastes consisted mainly of highly oxidizing bleaching powder.

Base records document that cans, drums, pails, and barrels of chlorinated lime, calcium hypochlorite, sodium carbonate, sodium sulfate, potassium hydroxide, waste electrolytic acid, and sodium-filled valves were disposed of in these wells. Additionally, cans of unknown content were disposed of in wells 24 and 25 (JEG, 1998). Depth to groundwater is more than 180 feet bgs.

Changes in the CAOC 20 radiological monitoring program were proposed in the *Final Technical Memorandum, Gross Alpha Exceedances in Groundwater at CAOC 20, Operable Unit 3, Yermo Annex, Marine Corps Logistics Base, Barstow, California* (TtEC, 2010). The recommended changes in the CAOC 20 radiological monitoring program was incorporated into the SAP Revision 4, which included adding tritium and removing gross alpha from the radiological analyses to meet the DQOs for this area. The DTSC in a letter dated 22 December 2009 concurred with the recommendations of the Technical Memorandum. The other analytes in the monitoring program remained the same as those in the original LTGWMP and included gross beta, radium-226, and radium-228.

7.6 CAOC 23 (OU 3)

7.6.1 Summary of the Technical Assessment

The remedy at CAOC 23 consists of NFA with LUCs and a concrete cap (Zone 1); Figure 7-4 provides the CAOC boundaries and cap location. The concrete cap is maintained in accordance with the O&M Plan in Appendix A of the OUs 3 and 4 RAR (DON, 2000). Groundwater is monitored under OU 1.

The technical assessment of CAOC 23, summarized in Table 7-5, included:

- inspection of the concrete cap on 29 March 2012
- review of 2007 through 2011 annual O&M reports for this CAOC.
- review of groundwater monitoring data from 2007 - 2011

7.6.2 Summary of Findings

The CAOC 23 Zone 1 concrete cap is properly maintained; surface cracks were repaired in 2008 and 2011. Groundwater COC concentrations were consistently below RAOs. Therefore, the CAOC 23 remedy appears to be functioning as intended by the ROD.

7.7 CAOC 35 STRATUM 1 ZONE 1 (OU 5)

7.7.1 Summary of the Technical Assessment

CAOC 35 Stratum 1 Zone 1, the inactive Class III Landfill, is located in the northeastern portion of the Yermo Annex. The remedy for the landfill is a single-layer native soil cap with NFA for remaining portions of the CAOC (Figure 7-5). The RAOs developed for CAOC 35 Stratum 1 Zone 1 include: minimize potential for disturbance of wastes, minimize the potential of future releases to groundwater, and attain landfill closure ARARs (*see* OUs 5 and 6 ROD, Section 3.6.1).

Through the installation of a cap, the remedy has met each of the RAOs. Groundwater monitoring is covered under OU 1.

The technical assessment (Table 7-6) of the CAOC 35 Stratum 1 Zone 1 selected remedy included:

- an inspection of the landfill cover on 29 March 2012
- a review of 2007 – 2011 annual O&M reports for this CAOC
- review of groundwater monitoring data from 2007 - 2011

7.7.2 SUMMARY OF FINDINGS

The CAOC 35 Stratum 1 Zone 1 landfill cover is properly maintained; the March 2012 inspection found the cap and fence at CAOC 35 Stratum 1 Zone 1 to be in good condition. The landfill fence has signs posted indicating the area is restricted. The cap is performing as intended to minimize the potential for the disturbance of the wastes, minimize the potential of future releases to groundwater, and attain landfill closure ARARs.

Some depressions and cracks formed in the cap and were repaired in one area in 2009 and then in a second area in 2010. Erosion occurs along the north fence line (outside the cap area) during heavy rainfall events. Backfilling was performed in response to erosion events. A recommendation to reduce the frequency of weed abatement activities from quarterly to once or twice a year was provided in the 2010 annual landfill O&M report (SD Engineering and Construction Joint Venture [SDVJV], 2011). The DTSC provided concurrence with the report without additional comments on May 19, 2011.

Groundwater monitoring for the CAOC was conducted under OU 1 annually during the review period. TCE and PCE concentrations in northerly downgradient wells YEP-2 and YEP-3 were consistently below MCLs during the review period. However, TCE and PCE were typically above the MCLs in potentially downgradient monitoring wells YS35-3 and YS35-4 (these wells may also reflect CAOC 16-sourced contamination). The groundwater exceedances detected in YS35-3 and YS35-4 will be captured by the Yermo GETS extraction wells, particularly GEW-17, and treated by the CAOC 16 AS/SVE system (OTIE, 2012d). Based on the available data, with consideration of the effectiveness of the CAOC 16/OU 1 remedy, the CAOC 35 Stratum 1 Zone 1 remedy is considered protective of human health and the environment.

7.8 YERMO ANNEX CAOCS WITH NFA AND BMP AMENDMENTS

7.8.1 SUMMARY OF THE TECHNICAL ASSESSMENT

CAOCs 15/17, 18, 21, 23 (Strata 5, 5[a]), 26, and 34 were closed under their respective RODs with NFA required except BMP modifications that included a description of the CAOCs and the stipulation that the MCLB Barstow Environmental Division review and coordinate any proposed land-use changes . The technical assessment of these sites is summarized in Table 7-7 and involved:

- Interview with the MCLB Barstow Environmental Division regarding any activities at these sites since 2007.

- Review of the BMP requirements.

7.8.2 SUMMARY OF FINDINGS

A new building, Building 601 (Non-Destructive Test Facility), was constructed over a portion of CAOC 15/17 in 2010 (Figure 7-6). The MCLB Barstow Environmental Division reviewed the proposed changed and confirmed that the new site conditions do not affect the NFA remedy. The status of CAOC 26 is reviewed in Section 7.4 and Table 7-3. There was no site activity at CAOCs 18, 21, 26, and 34 (Figure 7-6).

7.9 DISSOLVED METALS AT YERMO ANNEX

7.9.1 BACKGROUND

The OUs 1 and 2 ROD (DON 1998, Section 3.1.2 Inorganics) states:

> "Two metal analytes, nickel and chromium, were found to exceed MCLs and to be elevated relative to their statistically defined background levels in several wells near the highly industrial operations at Building 573 on the northern section of the Yermo Annex (i.e., wells YS34 1, YS35-1, YEP-1, YS16-4, and YS16-5). Three other metal analytes, antimony, thallium and aluminum, were also detected in this area at slightly elevated levels relative to their background concentrations…The RI yielded inconclusive answers to the questions of whether the concentrations of these five metals are naturally occurring or the result of Base activities. To resolve this issue, the Marine Corps and regulatory agencies have agreed to measure the concentrations of these five metals in a few selected groundwater monitoring wells for a minimum of four additional quarters (1 year). The MCLB Barstow has agreed to amend this ROD to address cleanup options if metals are determined to be a problem after this additional sampling."

Appendix D (D-3 Technical Assessment report) provides justification for permanent removal of aluminum, thallium, and antimony from the long-term monitoring program (as previously reported in the Final SAP Revision 4). Additionally, any further background metals sampling was determined to be unnecessary (Appendix D, D-3 Technical Assessment Report). The revised monitoring program, which implements recommendations from the Second Five-Year Review, includes only dissolved chromium and nickel in select wells in the CAOC 16 area.

7.9.2 SUMMARY OF THE TECHNICAL ASSESSMENT

Metals monitoring is performed under OU 1; the technical assessment summary is provided in Table 7-2. The technical assessment of this issue involved:

- Review of available chromium and nickel monitoring data and trends during the review period

7.9.3 SUMMARY OF FINDINGS

The 2007 - 2011 monitoring data for chromium and nickel were reviewed as part of the technical assessment. The 2011 annual monitoring locations and analytical results are shown on Figure 7-7. Due to inconsistencies in sampling methods over time (some samples filtered, some

not) and biofouling in certain wells (which affected data quality), the chromium and nickel data set generated during the review period was not consistent enough to allow statistical evaluation. The current monitoring program under the Final SAP Revision 4 provides that all metals samples be field filtered to provide a comparable data set. The DON cleaned and redeveloped a number of Yermo Annex monitoring wells in 2010 to address the turbidity issue. The conclusion of the technical assessment is that additional data collection is required before the OUs 1 and 2 ROD question on dissolved chromium and nickel can be answered. A comparable data set the can be statistically analyzed in accordance with the LTGWMP (JEG, 1998) procedures is anticipated to be available by 2014.

7.10 PROTECTION OF DRINKING WATER WELLS

7.10.1 BACKGROUND

The OUs 1 and 2 ROD, Section 3.6 (page 3-31) specifies:

> "To ensure that human health and the environment are protected in the future, institutional controls will be implemented that include access restrictions to prevent the on-Base use of untreated groundwater for domestic use, which includes ingestion, dermal contact and inhalation as routes of exposure. Wellhead treatment will be provided for any existing water supply wells that fall within the area of the plume exceeding MCLs. The DON will provide necessary information to appropriate county agencies identifying off-Base areas impacted by groundwater contamination exceeding MCLs. The DON will support county agencies with any technical information needed for the county to implement restrictions on construction and use of wells in the affected areas."

The Yermo Annex drinking water production wells active during the review period include YDW-5, YDW-6, and YDW-7. YDW-5 and YDW-6 have GAC adsorption systems that were installed since 1989 to treat extracted groundwater for VOCs, primarily TCE, 1,1-dichloroethene (1,1-DCE), and PCE (FWENC, 2003). YDW-7, which became operable in May 2008, is outside of the Yermo contaminant plume areas and does not have a treatment system. Monthly monitoring of VOCs is performed at the YDW-5 and YDW-6 GAC systems (influent, intermediate, and treated water) and YDW-7 (raw water); results are reported to the CDPH and are incorporated into the OUs 1 and 2 annual groundwater monitoring reports.

Additionally, the DON maintains GAC treatment systems on two off-Base private residential drinking water wells (Younts and Hodges properties) which are located approximately 1,300 and 1,500 feet east of the Yermo Annex boundary, respectively (Figure 7-1).

7.10.2 SUMMARY OF THE TECHNICAL ASSESSMENT

The technical assessment consisted of:

- Review of annual monitoring reports incorporating monthly GAC monitoring data for YDW-5, -6, and -7.
- Review of O&M reports on Yermo Annex and private residence GAC treatment systems.

- Review of correspondence between DON and San Bernardino County (providing required off-Base areas impacted by groundwater contamination exceeding MCLs).

7.10.3 SUMMARY OF FINDINGS

The GAC treatment systems on the YDW production wells and the private residences were properly maintained to prevent exposures to contaminated groundwater:

- The bag filters and bag filter housing at the Younts residence were replaced in February 2007. Although no breakthrough of the primary or secondary GAC vessels were detected, the DON replaced both GAC vessels at both the Younts and Hodges residences in August 2007 to meet the five-year maintenance requirement specified in the 2002 Five-Year Review (DON, 2002). The waste GAC was properly disposed (OTIE, 2010e).
- On 1 December 2009, the DON replaced the GAC at the YDW-5 drinking water treatment system. The Yermo Annex drinking water GAC adsorption system consists of two 20,000-pound GAC vessels (lead and lag). The carbon in the lead carbon vessel for well YDW-5 treatment system was changed out after analytical results indicated VOC breakthrough from this vessel. The waste GAC was properly disposed (OTIE, 2010e).
- The off-Base private residence of Hodges reportedly is not occupied since 2010 and the drinking water well is inoperable. The DON has not confirmed this information with the owner of the Hodges property and is relying on information from the neighbor, Mr. and Mrs. Yount on this account. The DON is in process of trying to contact the Hodges property owner and has not had access to the property since 2010.
- No other GAC replacements were necessary based on the YDW and Younts monitoring data. In accordance with the 2002 Five-Year Review recommendation, the Younts' GAC treatment system GAC was replaced in October 2012 (to be reported in the 2012 Annual Groundwater Monitoring Report [AGMR]).

The DON has informed San Bernardino County of the status of off-Base groundwater contamination above the MCLs by providing the annual groundwater monitoring reports to the County's public information officer. During the review period, the DON did not receive requests from the County for technical information to implement restrictions on construction and use of wells in the affected areas.

The DON maintains access agreements with all off-Base property owners with the MCLB Barstow-related monitoring wells or treatment systems. The DON also provides semiannual monitoring data letter reports to the Younts.

The BMP (Section 18) incorporates the restriction that any activities planned which may affect groundwater within OU 1 need to be reviewed by the Base Environmental Division. No new Base drinking water production wells were installed during the review period.

8.0 NEBO MAIN BASE – TECHNICAL ASSESSMENT

8.1 OVERVIEW

CAOCs at Nebo Main Base that require five-year review include those with remedial actions, LUCs, and NFAs with BMP modifications. At the Nebo Main Base, the Third Five-Year Review covers CAOC 38 (OU 2 groundwater, including Nebo North, Nebo South remedies) and CAOC 7 (Table 8-1). The remedial systems in place are shown on Figure 8-1.

The technical review for CAOCs 38 and 7 are provided in Tables 8-2 and 8-3, respectively. The review tables have five parts corresponding to the review activities as described in Section 7.1. A brief summary of the technical assessment and key findings for the two CAOCs reviewed is proved in Sections 8.2 and 8.3. Supporting data, including data trends, are presented in Appendices F (OU 2) and G (OUs 4 and 6).

The reviews of CAOCs with NFAs and BMP modifications are presented in Table 8-4 and discussed in Section 8.4; any activities or changes at these CAOCs during the prior five years is presented.

Additional groundwater issues identified in the Second Five-Year Review, and subsequently further investigated by the DON under OU 7, are discussed in Section 3.5.10.

8.2 NEBO MAIN BASE GROUNDWATER (CAOC 38)

8.2.1 BACKGROUND

CAOC 38 is the groundwater beneath the Nebo Main Base. It is impacted by dissolved phase VOCs in several locations. The OUs 1 and 2 ROD identified the Nebo North plume associated with Warehouse 2 (OU 7) and the Nebo South plume associated with CAOC 6 (OU 6). The primary COCs are TCE and PCE. The 2011 extents of the OU 2 groundwater plumes at the Nebo Main Base are shown on Figures 8-2 and 8-3.

Section 2.8.3 of the OUs 1 and 2 ROD (DON, 1998) states:

> "The RAO for vadose zone cleanup at the MCLB Barstow is to remove contaminant mass in the subsurface soils to the degree necessary to 1) prevent further degradation of the groundwater above groundwater cleanup standards and 2) minimize the aquifer cleanup time. Vadose zone soils cleanup goals are source specific."

OUs 1 and 2 ROD Sections 2.8.4 (Criteria for "Shut-off" of AS/SVE Systems), 2.8.5 (Vadose Zone and Groundwater Modeling to Determine AS/SVE System "Shut-off"), and 2.8.6 (Determination of Asymptotic Conditions for "Shut Off" of AS/SVE Component of Groundwater Remedy) provide the specific analyses to be performed to determine if the vadose zone RAOs have been met by a selected remedy. OUs 1 and 2 ROD, Section 2.8.9, provides the vadose zone source specific cleanup goal for the Nebo North plume.

The Nebo North AS/SVE system began operation in October 2007 and operated until March 2011, when it was shutdown with FFA regulatory concurrence (OTIE, 2011c). The

AS/SVE system is maintained so that it can be operated to address potential rebounds in soil vapor concentrations.

At Nebo South (CAOC 6), LUCs and an existing pilot study AS/SVE system was incorporated at the final remedy in the OU 2 ROD (DON, 2006). The OU 2 ROD established RAOs for the groundwater contaminants as the most stringent of the federal and state MCLs. The ROD also established RAOs for vadose zone cleanup for Nebo South as the removal of contaminant mass in the subsurface soils to the degree necessary to prevent further degradation of the groundwater above groundwater cleanup standards and minimize the aquifer cleanup time. Section 2.10.7 of the OU 2 ROD provides the criteria for shutoff of the Nebo South AS/SVE system.

The AS/SVE system was operated during the 2007 – 2012 review period. The LUC boundaries were marked in October 2011 through installation of site boundary markers and signs, a survey to establish horizontal coordinates, and updating of the MCLB Barstow GIS database to incorporate the LUC area boundaries.

8.2.2 SUMMARY OF THE TECHNICAL ASSESSMENT

The technical assessment for CAOC 38 (OU 2) is provided in Table 8-2 and included:

- Review of the operations, maintenance, monitoring, and removal performance data for the Nebo North and Nebo South (CAOC 6) AS/SVE systems
- Review of the need for continued maintenance in stand-by mode of the Nebo North GETS
- Review of long-term trends in groundwater and soil vapor VOC concentrations and plume dimensions as reported in the annual groundwater monitoring reports.
- Performance of vapor exposure risks for residual Nebo North VOC groundwater plume in the area Warehouses 3 and 4 (Appendix C).

8.2.3 SUMMARY OF FINDINGS

Both the Nebo North and Nebo South AS/SVE systems functioned as intended by the respective RODs during the Third Five-Year Review period. In both areas, groundwater VOC concentrations were significantly reduced.

- At Nebo North, vadose zone VOC concentrations were reduced to below levels that could threaten groundwater quality and the AS/SVE system was shutdown with regulatory concurrence. SVE only was resumed in April and September 2012 to address a slight rebound of soil vapor VOCs in two monitoring locations as a protective measure for groundwater.
- A statistical analysis of Nebo North monitoring well data, in accordance with OUs 1 and 2 ROD requirements, was performed as part of this review to assess the continued need for standby maintenance of the Nebo North GETS (Appendix F, F-1). The statistical analysis found the system is no longer needed and can be decommissioned.

- At Nebo South, the DON performed numerous system component repairs, including replacement of the air compressor. The operation of the AS/SVE system was focused on remaining groundwater plume areas resulting in significant (73%) reduction in plume size (areal extent) since 2007 (Appendix F, F-2). VOC concentrations in off-Base monitoring wells NEP-7, NEP-8, and NEP-9 were below MCLs during the review period and since 2006.
- The DON maintains access agreements with all off-Base property owners with the MCLB Barstow-related monitoring wells or treatment systems. The DON also provides semiannual monitoring data letter reports to CJR General Partnership, Hesperia, California (a holding company that owns the off-Base property adjacent to Nebo South).

Vapor exposure risks related to the selected remedy of natural attenuation of the residual Nebo North groundwater VOC plume were assessed using the J-E vapor exposure model and conservative assumptions. The model output indicated that the predicted excess lifetime cancer risks for the maximum estimated VOC soil gas concentrations (off-gassed from contaminated groundwater) observed at depths of 30 feet exceeded the lower end of the U.S. EPA acceptable risk range of 10^{-4} to 10^{-6}; however all risk levels were well within the acceptable range. The non-cancer Hazard Quotient values were at least an order of magnitude lower than the threshold value of 1.0. Therefore, the selected remedy of natural attenuation of the residual VOC groundwater plume does not appear to pose an inhalation exposure risk to building occupants of Warehouses 3 and 4. The model report and outcome is presented in Appendix C (C-2).

8.3 CAOC 7 (OU 6)

8.3.1 BACKGROUND

CAOC 7 was operated as the principal solid waste landfill for the MCLB Barstow from the early 1950s to 1964. Various chemicals from World War II and the Korean Conflict were stored and reportedly burned and disposed of as part of the landfill operation. Drums with unknown contents or believed to contain extremely hazardous materials were stored in a bermed area. These materials included caustic soda and various pesticides. Around 1958, a major fire reportedly occurred in the drum storage area, leading to a relatively large spill. The area was covered with approximately 2 feet of soil in 1964.

CAOC 7 consists of four strata (Figure 8-4):

- Stratum 1: The eastern L-shaped landfill disposal area, with each leg measuring approximately 50 by 750 feet (southeast corner of Nebo)
- Stratum 2: The western landfill disposal area, consisting of two separate trench areas; each trench area consists of two parallel trenches approximately 15 feet wide and ranging in length from 300 to 800 feet (south/central portion of Nebo)
- Stratum 3: A drum storage and spillage area measuring approximately 900 by 900 feet (northwest of Stratum 1). The selected remedy is NFA with BMP amendments.
- Stratum 4: The former playground area next to the amphibious vehicle test pond, also known as the "fish pond." The selected remedy is NFA with BMP amendments.

Groundwater monitoring is performed under OU 2 at CAOC 7 Strata 1 and 2. Most wells are sampled annually; however NSP-2, in which groundwater concentrations of TCE have exceeded the MCL, is sampled semi-annually.

8.3.2 Summary of the Technical Assessment

The technical assessment (Table 8-3) of the CAOC 7 remedy included:

- an inspection of the landfill cover on 29 March 2012
- a review of 2007 – 2011 annual O&M reports for this CAOC
- review of groundwater monitoring data from 2007 – 2011
- review of the results of the soil vapor investigation performed in October 2011

8.3.3 Summary of Findings

The CAOC 7 landfill caps are properly maintained in accordance with the CAOCs 7 and 35 O&M Manual (BNI, 1999). A summary of significant maintenance activities performed during the review period is provided in Table 8-3.

Since November 2007, TCE groundwater concentration in NSP-2, a downgradient monitoring well for CAOC 7 Stratum 1, have generally exceeded the MCL. Increases in TCE concentrations occurred following significant precipitation events during the winters of 2005/2006 and 2009/2010. TCE has not been reported in the well upgradient of CAOC 7 Stratum 1 (NS7-4), which indicated the landfill was the likely source of the TCE. In response, the DON began an evaluation of the remedy as required by the OUs 5 and 6 ROD.

A technical memorandum on the status and protectiveness of the CAOC 7 Stratum 1 landfill cap was finalized in 2010 (TtEC, 2010c). The memorandum reported the cap soil moisture data indicated conditions consistent with the arid site conditions. Based on the continued presence of groundwater TCE concentrations above the MCL at CAOC 7 Stratum 1, the DON installed two multi-leveled soil vapor wells through the landfill cap and an additional groundwater monitoring well upgradient and to the west of the cap in October 2011 (OTIE, 2012a). Soil vapor analytical results indicated concentrations of TCE and other VOCs were present at levels that could impact groundwater beneath the landfill cap. The DON is presently considering the appropriate response action, including performance of a soil vapor extraction pilot study. A final response action will be determined under the OU 7 Feasibility Study and ROD. In the meantime, the DON is monitoring the area under the OU 2 long-term monitoring program.

The CAOC 7 landfill caps (Stratum 1 and 2) are considered currently protective because of the restrictions on land use and the lack of exposure routes. Additional response action is required to ensure the long-term protectiveness of the CAOC 7 Stratum 1 remedy due to TCE concentrations exceeding the MCL in monitoring well NSP-2 and the presence of soil vapor VOCs that could be impacting groundwater quality (Figure 8-5).

8.4 REVIEW OF NFA CAOCS WITH BMP MODIFICATIONS

8.4.1 SUMMARY OF THE TECHNICAL ASSESSMENT

CAOCs closed with NFA except BMP modifications are reviewed in this section; these CAOCs include 1, 2, 3, 5, 7 (Strata 3 and 4), 11, and 14 at the Nebo Main Base. The BMP modifications include a description of the CAOCs and the specific ROD language requiring review and coordination of any significant land use changes (by the MCLB Barstow Environmental Division). Locations are provided on Figure 8-6. Groundwater monitoring was also performed at CAOCs 1, 2, 3, and 14 for the pesticide dieldrin until 2009. The Third Five-Year Review Report findings are summarized on Table 8-4.

The technical assessment (Table 8-4) involved:

- An interview with the MCLB Barstow Environmental Division regarding any activities at the CAOCs with BMP modification since 2007.
- Review of groundwater monitoring data for CAOCs 1, 2, 3, and 14.
- Review of the BMP requirements.

8.4.2 SUMMARY OF FINDINGS

There were no site activities occurring at CAOCs 1, 2, 3, 11 and 14 during the 2007 – 2011 review period. Long-term groundwater dieldrin data for CAOCs 1, 2, 3, and 14 show no detections of this pesticide; with FFA regulatory concurrence, dieldrin monitoring was ceased in 2009.

The MCLB Barstow Environmental Division reviewed and approved Disposition Services - Barstow Surplus Equipment Storage on CAOC 5 Stratum 1 - Lot 357A (Figure 8-7) beginning in 2009. Expansion of equipment storage to Lot 351 (east of Lot 357A) and Lot 352 South (south of I-40) was in discussion between Disposition Services - Barstow and the Environmental Division at the time of the review. Equipment storage of excess military equipment does not change or affect the NFA remedy.

The Environmental Division is reviewing potential solar array electrical cable runs that would cross CAOC 14 (probably below surface) at one or two locations on the west side of the Nebo Main Base. No effect on the NFA remedy is anticipated by the proposed cable crossing.

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9.0 ISSUES AND RECOMMENDATIONS

This section provides a summary of the issues identified and recommendations developed during the Third Five-Year Review process, as documented in Sections 7 and 8.

9.1 ISSUES IDENTIFIED DURING THE FIVE-YEAR REVIEW

The issues identified during the technical assessment of the Yermo Annex remedies in place are summarized in Table 9-1, and for Nebo Main Base in Table 9-2.

9.2 RECOMMENDATIONS AND FOLLOW-UP ACTIONS

The recommendations and follow-up actions for both Yermo Annex (OUs 1, 3 and 5) and Nebo Main Base (OUs 2, 4, and 6) are summarized Table 9-3.

CAOC 32 (OU 5) was not reviewed as part of the Third Five-Year Review, except during the review of exposure assumptions, toxicity data, cleanup levels, and RAOs (Section 6.6.2). CAOC 32 was the only CAOC with a NFA remedy and no BMP amendment with prior investigative data indicating soil concentrations of a COC exceeding a newly published RSL; specifically Aroclor-1242. This CAOC is located on the west side of the CAOC 16 hardstand; Stratum 2, where PCBs may be present in soil, is entirely covered with pavement and buildings. Because no direct exposure route is suspected, the NFA remedy is considered to be protective. However, to ensure long-term protectiveness, the BMP should be amended to note the potential presence of Aroclor 1242 at CAOC 32 Stratum 2 and a requirement for coordination with the Base Environmental Division for any activities that would affect the cover at this CAOC.

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10.0 SUMMARY AND PROTECTIVENESS STATEMENTS

This section provides a summary of the third five-year review and protectiveness statements for each of the OUs 1-6, based on the specific technical assessments presented in Sections 7 and 8.

10.1 OPERABLE UNIT 1

OU 1 consists of a single CAOC, 37, which is the groundwater at Yermo Annex and includes three dissolved plumes (CAOC 26, Yermo North, and Yermo South). It includes groundwater monitoring for soil CAOCs from other OUs, specifically CAOCs 20, 23, and 35. Remediation systems in place include:

- CAOC 26 AS/SVE and groundwater pump-and-treat system to reduce vadose zone and groundwater contamination (chlorinated VOCs) at CAOC 26 (systems inactive).
- CAOC 16 AS/SVE system to reduce vadose zone and groundwater contamination (chlorinated VOCs) at CAOC 16.
- Yermo Annex GETS to provide hydraulic containment of VOC-contaminated groundwater.
- GAC treatment systems at two on-Base and two off-Base drinking water wells.

10.1.1 SUMMARY OF REVIEW

A technical assessment was performed for OU 1 CAOC 37 including addressing each of the three questions:

Question A: Is the remedy functioning as intended by the RODs?

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of the remedy selection still valid?

Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

In addition, the OU 1 technical assessment included a review of metals in groundwater beneath CAOC 16, review of the effectiveness of the AS/SVE and GETS in addressing the Yermo North plume, and a review of the status of the CAOC 26 groundwater plume and monitoring program, as required by the OUs 1 and 2 ROD.

The technical assessment is detailed in Table 7-2, with a summary of issues and recommendations presented in Tables 9-1 and 9-3, respectively.

10.1.2 PROTECTIVENESS STATEMENT

Based on the technical assessment of remedies-in-place at CAOC 37 (the one CAOC in OU 1), the remedial actions at OU 1 are currently protective of human health and the environment because of the ongoing operation of the GETS and the CAOC 16 AS/SVE system as well as the ICs that are in place. Additionally GAC treatment on two Yermo Annex drinking water production wells and two off-Base private residential wells is maintained. However, in order

for the remedy to be protective in the long term, the remedial systems should continue to be maintained for optimal performance of the GETS and CAOC 16 AS/SVE system components and wells.

10.2 OPERABLE UNIT 2

The remedies in place at OU 2 (CAOC 38, Nebo Main Base groundwater) include the Nebo North GETS, Nebo North AS/SVE system with natural attenuation of downgradient groundwater COCs, the Nebo South (CAOC 6) AS/SVE system, and ICs/LUCs.

10.2.1 SUMMARY OF REVIEW

A technical assessment was performed for OU 2 CAOC 38 including addressing each of the three questions as stated in Section 10.1.1 above.

In addition, the OU 2 technical assessment included a review of the Nebo North monitoring program as required by the Technical and Economic Feasibility (TEF) report for shutdown of the Nebo North AS/SVE system. The technical assessment is detailed in Table 8-2, with a summary of issues and recommendations presented in Tables 9-2 and 9-3, respectively.

10.2.2 PROTECTIVENESS STATEMENT

The remedial actions at OU 2 (CAOC 38) are currently protective of human health and the environment because of the completion of Nebo North source area treatment and natural attenuation of the remaining plume, continued operation of Nebo South AS/SVE system, and the LUCs that are in place. However, in order for the remedies to be protective in the long term, the following activities or actions are required: continued monitoring of the Nebo North plume on an annual basis in accordance with the current sampling plan, and continued maintenance/repair of the Nebo South AS/SVE system to maintain optimal operations.

10.3 OPERABLE UNIT 3

OU 3 is the shallow soils at Yermo Annex (for which data existed prior to the RI) and includes CAOCs 18, 20, 23, and 34. Remedial measures in the form of caps were constructed at CAOCs 20 and 23.

10.3.1 SUMMARY OF REVIEW

A technical assessment was performed for OU 3 remedies-in-place at CAOCs 20 and 23 including addressing each of the three questions as stated in Section 10.1.1 above. The technical assessment is detailed in Tables 7-4 and 7-5, respectively, with a summary of issues and recommendations presented in Tables 9-1 and 9-3, respectively. For CAOCs 18 and 34, the technical assessment consisted of reviewing the BMP modifications and interviewing the Base IRP Manager regarding site activities. The technical assessment is provided in Table 7-7.

10.3.2 PROTECTIVENESS STATEMENT

The remedies are currently protective of human health and the environment because of the intact and maintained caps at CAOCs 20 and 23 as well as the LUCs that are in place. The

exposure assumptions, toxicity data, cleanup levels, and RAOs used for OU 3 at the time of the remedy selection are still valid. There is no new data that could indicate the ineffectiveness of the remedies at this OU.

10.4 OPERABLE UNIT 4

OU 4 is the shallow soils at Nebo Main Base (for which data existed prior to the RI) and consists of CAOCs 2, 5, 9, 10, and 11. Of these, CAOC 10 is now being evaluated under OU 7. NFA was required at the remaining CAOCs (although BMP modification was required for CAOCs 2, 5, and 11).

10.4.1 SUMMARY OF REVIEW

The technical assessment of OU 4 consisted of reviewing the BMP modifications for CAOCs 2, 5, and 11, with an interview of the Base IRP Manager on site activities. The technical assessment is detailed in Tables 8-4.

10.4.2 PROTECTIVENESS STATEMENT

The OU 4 NFA remedy continues to be protective of human health and the environment because the LUCs for CAOCs 2, 5, and 11 are maintained. The exposure assumptions, toxicity data, cleanup levels, and RAOs used for this OU at the time of remedy selection are still valid. There is no new data that could indicate the ineffectiveness of the remedy at this OU.

10.5 OPERABLE UNIT 5

OU 5 is the shallow soils at Yermo Annex and consists of CAOCs 15/17, 16, 19, 21, 22, 24, 25, 26, 27, 28, 29, 30, 31, 32, 35, and 36. Of these, CAOC 25 was eliminated from the RI/FS as not requiring additional investigation/remediation. NFA was selected at CAOCs 15/17, 19, 21, 22, 24, 26, 27, 28, 29, 30, 31, 32, and 36 (BMP modifications were required at CAOCs 15/17, 21 and 26). LUCs were selected for CAOC 16. Caps and LUCs were selected for CAOC 35 Stratum 1 Zone 1.

10.5.1 SUMMARY OF REVIEW

A technical assessment was performed for OU 5 including addressing each of the three questions as stated in Section 10.1.1 above for remedies-in-place at CAOCs 16 and 35. The technical assessment is detailed in Tables 7-3 and 7-6, respectively, with a summary of issues and recommendations presented in Tables 9-1 and 9-3, respectively. For CAOCs 15/17, 21 and 26, the technical assessment consisted of reviewing the BMP modifications and interviewing the Base IRP Manager regarding site activities. The technical assessment is provided in Table 7-7.

10.5.2 PROTECTIVENESS STATEMENT

The selected remedies at OU 5 continue to be protective of human health and the environment because the ongoing maintenance of CAOC 16 hardstand and CAOC 35 Stratum 1 Zone 1 landfill cap, as well as the implemented LUCs. The exposure assumptions, toxicity data, cleanup levels, and RAOs used for OU 5 at the time of remedy selection are still valid. There is no new data that could indicate the ineffectiveness of the remedies at this OU.

10.6 OPERABLE UNIT 6

OU 6 is the shallow soils at Nebo Main Base. It includes CAOCs 1, 3, 4, 6, 7, 8, 12, 13, 14, and 33. CAOC 33 was eliminated from the RI/FS as not requiring further investigation or remediation. NFA was selected for CAOCs 1, 3, 4, 6, 8, 12, 13, and 14. (BMP mods were required at CAOCs 1, 3, and 14. A native soil cap and LUCs were implemented at CAOC 7. Groundwater remediation at CAOC and monitoring of groundwater at CAOC 7 is covered under OU 2.

10.6.1 SUMMARY OF REVIEW

A technical assessment was performed for OU 6 including addressing each of the three questions as stated in Section 10.1.1 above for CAOC 7. The technical assessment is detailed in Table 8-3, with a summary of issues and recommendations presented in Tables 9-2 and 9-3, respectively. For CAOCs 1, 3, and 14, the technical assessment consisted of reviewing the BMP modifications and interviewing the Base IRP Manager regarding site activities. The technical assessment is provided in Table 8-4.

10.6.2 PROTECTIVENESS STATEMENT

The selected remedies at OU 6 continue to be protective of human health and the environment because the ongoing maintenance of caps and implemented LUCs at CAOC 7. The exposure assumptions, toxicity data, cleanup levels, and RAOs used for this OU at the time of the remedy selection are still valid. There is no new data that could indicate the ineffectiveness of the remedies at this OU.

10.7 OVERALL PROTECTIVENESS STATEMENT

Based on the third five-year review, the remedies for OUs 1-6 are currently protective of human health and the environment. For the selected remedies to remain protective in the long term the remedial systems and caps should continue to be maintained for optimal performance and the ICs/LUCs should continue to be implemented through the BMP with oversight by the Environmental Division of the MCLB Barstow.

11.0 NEXT REVIEW

The next Five-Year Review for OUs 1-6 is required by December 11, 2017, which is five years from the signature date of this review.

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Tables

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TABLE 2-1. SUMMARY OF CAOCs

CAOC	OU	Selected Remedy	Total Area (acres)	Areas Requiring BMP Modifications (acres)	Area of Formal LUCs (acres)	5-Yr Review Required?
1	6	NFA + BMP modification	38.09	Stratum 1 (7.76) Stratum 2 (25.88) Stratum 3 (4.45)	NA	Yes
2	4	NFA + BMP modification	1.87	Stratum 1 (0.01) Stratum 3 (1.86)	NA	Yes
3	6	NFA + BMP modification	57.4	Stratum 1 (39.31)	NA	Yes
4	6	NFA	4.3	NA	NA	No
5	4	NFA + BMP modification	47.7	Stratum 1 (28.43) Stratum 2 (15.23)	NA	Yes
6	6	NFA – groundwater under OU 2	10.1	NA	NA	Yes
7	6	Native soil cap, restriction on activities, groundwater monitoring (OU 2), precipitation infiltration monitoring at Strata 1 and 2, BMP modification at Strata 3 and 4.	30.7	Stratum 3 (17.41) Stratum 4 (0.14)	Stratum 1 (4.40) Stratum 2A (1.85) Stratum 2B (1.34)	Yes
8	6	NFA	0.6	NA	NA	No
9	4	NFA	0.6	NA	NA	No
10	4	NFA, now being evaluated under OU 7	0.6	NA	NA	No
11	4	NFA + BMP modification	3.49	CAOC 11 (3.49)	NA	Yes
12	6	NFA	0.3	NA	NA	No
13	6	NFA	0.1	NA	NA	No
14	6	NFA + BMP modification	24.8	Stratum 1 (13.72) Stratum 2 (0.62) Stratum 3 (0.35) Stratum 4 (0.25)	NA	Yes
15 / 17	5	NFA + BMP modification, groundwater monitoring under OU 1	16	CAOC 15 / 17 (15.98)	NA	Yes
16	5	Restriction on activities, groundwater under OU 1	47.69	NA	CAOC 16 (47.69)	Yes
18	3	NFA + BMP modification	5.2	Stratum 2 (0.48) (Stratum 3 (3.04)	NA	Yes
19	5	NFA	5.8	NA	NA	No
20	3	Limited Activities, groundwater monitoring (OU 1), precipitation infiltration monitoring, modification of concrete cap at Stratum 1. Limited Activities, groundwater monitoring (OU 1), precipitation, infiltration monitoring, drainage control (include Stratum 3).	2.6	NA	Stratum 1 (0.08) Stratum 2 (1.29)	Yes
21	5	NFA + BMP modification	9.96	CAOC 21 (9.96)	NA	Yes
22	5	NFA	4.1	NA	NA	No
23	3	LUC at Stratum 1, NFA at Strata 3, 4, 5, 5a. Concrete cap, groundwater monitoring (OU 1), Restriction of activities at Zone 1.	71.8	Stratum 5 (19.16) Stratum 5(a) (0.26)	Zone 1 (10.91)	Yes
24	5	NFA	5.5	NA	NA	No
25	5	NFA (determined prior to RI)	0.3	NA	NA	No
26	5	NFA + BMP modification, groundwater under OU 1	0.95	CAOC 26 (0.95)	NA	Yes
27	5	NFA	1.6	NA	NA	No
28	5	NFA	149.6	NA	NA	No
29	5	NFA	3	NA	NA	No
30	5	NFA	0.9	NA	NA	No
31	5	NFA	4.1	NA	NA	No
32	5	NFA	1.2	NA	NA	No
34	3	NFA + BMP modification	0.58	Stratum 1 (0.58)	NA	Yes
35	5	NFA at Strata 1 and 2, native soil cap, restriction on activities, groundwater monitoring (OU 1), precipitation infiltration monitoring at Zone 1.	27.9	NA	14.77	Yes
36	5	NFA	1.1	NA	NA	No
37	1	Groundwater extraction and treatment, AS/SVE systems, LUCs	Formal LUCs covering groundwater use			Yes
38	2	AS/SVE systems, natural attenuation, groundwater extraction and treatment, LUCs	Formal LUCs covering groundwater use			Yes

Notes:

1. CAOC 33, the Rifle Range Disposal Area, was approved for elimination from the RI/FS by the FFA signatories and is therefore not subject to the five-year review
2. NFA with BMP modifications and the formal LUCs areas are based on the legal descriptions included in the BMP as well as the respective RODs. Total CAOC areas were estimated based on the CAOC GIS data and information in the BMP.

Abbreviations and Acronyms:

AS/SVE – air sparging/soil vapor extraction
BMP – Base Master Plan
CAOC – CERCLA Area of Concern
CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act
FS – Feasibility Study
LUC – land use control
NA – not applicable
NFA – no further action
OU – Operable Unit
RI – Remedial Investigation

Table 2-2. Chronology of Significant Events, MCLB Barstow Installation Restoration Program

DATE	SIGNIFICANT EVENT
1942	MCLB Barstow established at Nebo Main Base.
1946	Yermo Annex acquired.
1980	CERCLA enacted, DON implements the Installation Restoration Program.
Sept. 1983	Initial Assessment Study conducted.
1983	TCE found in groundwater production wells at the Yermo Annex.
1984 – 1986	Confirmation studies conducted.
1989	Groundwater production wells at Yermo Annex were connected to a GAC system.
Nov. 1989	MCLB Barstow is placed on the CERCLA National Priorities List.
Oct. 1990	MCLB Barstow enters into an FFA with the U.S. EPA, California Department of Toxic Substances Control, and the California Regional Water Quality Control Board. The FFA identified 7 OUs throughout the Base.
Aug. 1991	Preliminary Review/Visual Site Inspection Report completed.
Feb. – Dec. 1992	Phase I RI conducted for OU 1 and OU 2.
Mar. – Oct. 1992	Phase I RI conducted for OU 3 and OU 4.
1992	TCE detected above MCL in a private residence's drinking water well adjacent to Nebo Main Base. A TCRA was conducted to remove the well from service and connect the residence to the Base water supply system.
1993	TCRA was conducted to remove residual sludge at CAOC 15/17.
Jun. – Sept. 1994	Phase II RI conducted for OU 1 and OU 2.
Aug. – Sept. 1994	TCRA to remove 318 tons of impacted soil from CAOC 2 completed.
1995	TCE detected above MCL downgradient of Yermo Annex eastern boundary. A TCRA was conducted to provide residences with carbon treatment systems.
Oct. 1995	OU 1 and OU 2 RI Report completed.
1996	OU 1 and OU 2 FS Report completed.
1996	OU 1 and OU 2 Proposed Plan completed.
1996	OU 5 and OU 6 FS Report completed.
Feb. 1996	Phase I Ecological Risk Assessment conducted.
Aug. 1996	RI/FS for OU 3 and OU 4 completed.
Aug. 1996	Proposed Plan for OUs 3 and 4 completed.
Jun. 1997	OU 3 and OU 4 ROD signed.
Jul. – Aug. 1997	TCRA to remove PCB-impacted soils (>1 mg/kg) at CAOC 21.
1997	OU 5 and OU 6 Proposed Plan completed.
Jan. 1998	OU 5 and OU 6 ROD signed.
Apr. 1998	OU 1 and OU 2 ROD signed. The Nebo South portion under OU 2 was an interim ROD finalized subsequently during September 2007

Table 2-2. Chronology of Significant Events, MCLB Barstow Installation Restoration Program

DATE	SIGNIFICANT EVENT
1997 – Present	A non-time-critical removal action for groundwater containment and cleanup is being conducted at the Yermo Annex. Its purpose is to prevent further migration of contaminants beyond the Base boundary and accelerate groundwater cleanup.
September 1998	Actual remedial action started at OUs 3 and 4.
2002	First Five-Year Review conducted for OUs 1 through 6.
2005	OU 7 Remedial Investigation Report finalized
December 2005	Draft ESD Submitted for the Yermo Annex Off-Base Groundwater Extraction Wells (OU 1).
August 2006	Nebo South OU 2 Proposed Plan completed.
September 2006	Nebo South OU 2 Final ROD signed.
June 2007	Nebo South OU 2 Draft Land Use Control Remedial Design document submitted.
2007	Second Five-Year Review conducted for OUs 1 through 6.
2010	OU 7 Supplemental Remedial Investigation Report finalized
2007 - 2011	Nebo North source area treatment system operated until RAOs were met and shutdown was approved by FFA signatories (March 2011)
March – June 2010	Extraction well GEW-16 installed at Yermo Annex at base boundary to improve hydraulic control of Yermo North plume
July 2011	Memorandum to File to document post-ROD change in location of the Nebo North source area treatment system as a non-significant or minor change per U.S. EPA CERCLA guidance.
September – October 2011	Groundwater investigations at CAOC 10.38 Unit 7 and NPZ-14 area (OU 7 remedial investigations); installation of additional monitoring wells at CAOC 7 Stratum 1 (OU 6)
February – April 2012	Extraction well GEW-17 (replacing failed GEW-13) installed to improve capture of high-concentration zone of Yermo North plume
August 2012	Draft Feasibility Study for OU 7 submitted to FFA signatories
2012	Third Five-Year Review conducted for OUs 1 through 6

Abbreviations and Acronyms:

CAOC – CERCLA Area of Concern
CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act
DON – Department of the Navy
ESD – Explanation of Significant Differences
FFA – Federal Facility Agreement
FS – Feasibility Study
GAC – granular activated carbon
GEW – groundwater extraction well
MCL – maximum contaminant level
MCLB – Marine Corps Logistics Base
mg/kg – milligrams per kilogram
OU – Operable Unit
PCB – polychlorinated biphenyl
RI – Remedial Investigation
ROD – Record of Decision
TCE – trichloroethene
TCRA – time-critical removal action
U.S. EPA – United States Environmental Protection Agency

Table 6-1. Site Inspections Findings Summary For CAOCs With Site Development

CAOC	OU	Base	Description of Structure/Activity	Activity Period (Start – Completion Dates)	Activities in this area or changes in site use coordinated through and reviewed by the MCLB Barstow Environmental Department?
15/17	5	Yermo	Building 601 constructed on portion of CAOC	2010	Yes
16	5	Yermo	Buildings 563, 564, 574A, 574B, 638, 639 (see Table 7-3 for more information)	2009 - 2010	Yes
16	5	Yermo	Building 573, subfloor drain installed[1]	2011	Yes
23	3	Yermo	Surface regarding of a portion of the unpaved area	August 2011	Yes
32	5	Yermo	Building, paved area (within CAOC 16 hardstand), small unpaved area immediately west of hardstand	No activity[2]	N/A[2]
35	5	Yermo	Landfill Cap Repair	2009 and 2010	Yes
37	1	Yermo	Two replacement extraction wells and conveyance pipeline	GEW-16 - March-April 2010 GEW-17 - Jan-March 2012	Yes
5	4	Nebo	DRMO Equipment Storage	About Sept. 2009 - current	Yes
5	4	Nebo	Well Installation for OU 7 (Lots 327, 351)	2009 and 2011 (wells in use)	Yes
7	6	Nebo	Two soil vapor wells installed at Stratum 1 (southeast) capped landfill, and one groundwater monitoring well installed in Stratum 3 (adjacent to Stratum 1)	October 2011 (wells in use)	Yes

Notes:

[1] Access to Building 573 was restricted and not inspected during site visit; information based on review of report on soil sampling at this location (IWC, 2011) and other information provided by MCLB Barstow.

[2] CAOC 32 inspected in response to recommended inclusion of this CAOC in Base Master Plan (see Section 6.6.2)

TABLE 6-2. YERMO ANNEX, OUs 1, 3, and 5 OPERATION AND MAINTENANCE COSTS

CAOC	OU	O&M Item	Projected & Prior Costs	Actual Costs (2007 – 2012)	Comments
20	3	Cap maintenance and monitoring	**Original estimate in ROD:** $20,200 per year (for four years) **Last 5 Year Review Actual**: $10,000 per year (for four years)	Average $5,000 per year 2009 Repairs: $22,000	Monitoring costs covered under OU 1 groundwater monitoring.
23	3	Cap maintenance and monitoring	Original, Not estimated **Last 5 Year Review Actual**: $14,000 per year	Average $15,400 per year 2009 Repairs: $30,000	Monitoring costs covered under OU 1 groundwater monitoring.
35	5	Cap maintenance and monitoring	**Original estimate in ROD:** Not available (were part of total cost estimate of $1,432,215 for capital and O&M) **Last 5 Year Review Actual**: $14,000 per year	Average $24,500 per year March 2009 repair of depressions in cap: $209,000	Monitoring costs covered under OU 1 groundwater monitoring.
37	1	Operation of two AS/SVE systems and one GETS, groundwater monitoring	**Original estimate in ROD:** $1.2 Million per year **Last 5 Year Review Actual**: $696,000 per year	Average per year: $630,000 (O&M, monitoring, and electrical) Approximate Repairs 2007 – 2011: $1,247,500 (total)	One AS/SVE system (CAOC 26) is not in operation. Electrical costs were not previously available. Major upgrades and repairs remedial systems, including two new wells, resulted in relatively high costs during 2007 – 2012.

Abbreviations and Acronyms:

AS/SVE – air sparging/soil vapor extraction

CAOC – CERCLA Area of Concern

CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act

GETS – groundwater extraction and treatment system

O&M – Operations and Maintenance

OU – Operable Unit

ROD – Record of Decisions

TABLE 6-3. NEBO MAIN BASE, OUs 2, and 6 OPERATION AND MAINTENANCE COSTS

CAOC	OU	O&M Item	Projected & Prior Costs	Actual Costs (2007 – 2012)	Comments
7	6	Cap maintenance and monitoring	**Original estimate in ROD:** Not available (were part of total cost estimate of $1,273,080 for capital and O&M) **Last 5 Year Review Actual**: Maintenance: $11,000 per year	Average per year: $12,600	Monitoring costs covered under OU 2 groundwater monitoring.
38	2	Operation of two AS/SVE systems and one GETS, groundwater monitoring	**Original estimate in ROD:** $1.2 million per year **Last 5 Year Review Actual**: $274,000 (O&M, monitoring) per year (electrical not included)	Average per year: $361,000 (O&M, monitoring, and electrical) Approximate Repairs 2007 – 2011: $282,300 (total)	The Nebo North GETS was not operated during the review period. The Nebo North AS/SVE system operated from October 2007 – March 2011 and is now on standby operation with monthly O&M performed. The system was operated for 2 months during 2012. During most of the review period, the Nebo South AS/SVE was operated on a one month per quarter basis, with operations focused on residual plume areas. Numerous repairs and upgrades of Nebo South aging system components were performed during the review period.

Abbreviations and Acronyms:

AS/SVE – air sparge/soil vapor extraction

CAOC – CERCLA Area of Concern

CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act

GETS – groundwater extraction and treatment system

O&M – Operations and Maintenance

OU – Operable Unit

ROD – Record of Decision

Table 7-1. Yermo Annex – CAOCs Subject to Five-Year Review

OU	CAOC	CAOC Description	Remedy in Place	Review Summary Table
1	37	Yermo groundwater VOC plumes RAs plus monitoring	GETS, CAOC 16 AS/SVE System CAOC 26 AS/SVE System	Table 7-2
5	16	Building 573 and Underground Wastewater Piping System	ICs/LUCs to preserve concrete cover	Table 7-3
3	20	Second Hazardous and Low Level Radiological Area	Concrete Cap & ICs/LUCs	Table 7-4
3	23	Landfill Area with cap	Concrete Cap & ICs/LUCs	Table 7-5
5	35	Stratum 1 Zone 1 – Class III Landfill with cap	Landfill Cap & ICs/LUCs	Table 7-6
5	15/17	Oil Storage Spillage & Industrial Wastewater Treatment Plant Area	NFA with BMP amendment	Table 7-7
3	18	Sludge Waste Disposal Area	NFA with BMP amendment	Table 7-7
5	21	Industrial Waste Disposal Area	NFA with BMP amendment	Table 7-7
3	23	Landfill Area (Strata 5, 5a)	NFA with BMP amendment	Table 7-7
5	26	Building 533 Waste Disposal Area	NFA with BMP amendment (groundwater under OU 1)	Table 7-7
3	34	PCB Storage Area	NFA with BMP amendment	Table 7-7

Acronyms:

AS/SVE – Air Sparging and Soil Vapor Extraction System

BMP - Base Master Plan

CAOC – CERCLA Area of Concern

CERCLA - Comprehensive Environmental Response, Compensation, and Liability Act

GETS – Groundwater Extraction and Treatment System

ICs – Institutional Controls (Land Use Restrictions)

OU – Operable Unit

Table 7-2. CAOC 37 – Third Five-Year Review (OU 1 - Yermo Annex)

CAOC 37 – Part 1: Review of Remedial Action Objectives, Selected Remedies, Implementation, Status, and Changed Conditions		
Yermo Annex RAs and Monitoring	**Original Conditions, Investigations, and Responses**	**Changed Conditions Since ROD and Second Five-Year Review**
Applicable RODs	OUs 1 / 2 ROD (DON, 1998a)	None
Site Description and Figure References	OU 1 (CAOC 37) consists of contaminated groundwater beneath the Yermo Annex. During initial environmental investigations at the Yermo Annex, three dissolved VOC plumes were identified extents (see Figures D-2.2 – D-2.3 in Appendix D): CAOC 26 plume, Yermo North plume, and Yermo South plume. The contaminants of concern (COCs) consist of dissolved-phase VOCs, primarily trichloroethene (TCE) and tetrachloroethene (PCE). The plumes, originating from different sources, were considered one merged plume for purposes of the response action.	The CAOC 26 and Yermo South groundwater plumes have declined to below MCLs both on Base and in off-Base extents (see Figures D-2.2 – D-2.3 in Appendix D). The CAOC 26 remedial system was shutdown in 1998 when RAOs were met. Extractions wells related to the CAOC 26 and Yermo South plumes were shut down in 2002.
Basis of Response	Since the merged VOC plume impacted the drinking water aquifer beneath the Yermo Annex and impacted two off-Base residential wells, the DON determined that an initial response action was required. The initial response actions were to 1) add granular-activated carbon (GAC) treatment to on-Base drinking water production wells. GAC treatment systems were installed at the on-Base production wells YDW-5 and YDW-6 in 1989; 2) add GAC treatment systems to two off-Base private residential drinking water wells (Younts and Hodges) in 1995 and 3) begin hydraulic control of the identified groundwater plumes via installation of a groundwater extraction and treatment system (GETS). The GETS operated with 13 extraction wells when it was first installed in 1996, but now just 3 – 4 extraction wells are active. These response actions were incorporated into the final remedy for OU 1 in the OUs 1 and 2 ROD (DON, 1998a).	None (no changes to identified COCs or original basis of response).
Remedial Action Objectives	RAOs per the OUs 1 / 2 ROD: The selected RAOs for groundwater cleanup are the drinking water standards for specific VOCs (see Table 2-1, page 2-39, of the ROD), as follows: • The most stringent of federal and state MCLs • To be considered (TBC) risk-based criteria (RBC) where drinking water standards were not available (U.S. EPA Region 9 Preliminary Remediation Goals, August 1996).	No significant change in RAOs; see Appendix C for review of toxicity data changes.

Table 7-2. CAOC 37 – Third Five-Year Review (OU 1 - Yermo Annex)

CAOC 37 – Part 1: Review of Remedial Action Objectives, Selected Remedies, Implementation, Status, and Changed Conditions		
Yermo Annex RAs and Monitoring	**Original Conditions, Investigations, and Responses**	**Changed Conditions Since ROD and Second Five-Year Review**
Remedial Action Objectives (continued)	• Taste and odor objectives for toluene and xylenes as proposed by EPA, but not promulgated at the time of the ROD, as TBC standards (see Section 2.8.1 of the ROD). The RAO for vadose zone cleanup at MCLB Barstow is to remove contaminant mass in the subsurface soils to the degree necessary to 1) prevent further degradation of the groundwater above groundwater cleanup standards, and 2) minimize the aquifer cleanup time. Vadose zone soils cleanup goals are source specific.	
Selected Remedy	• For contaminated groundwater above MCLs: remediate via a pump and treat system that includes ex-situ GAC treatment and recharge of treated groundwater back into the aquifer (except directly beneath waste management areas/units). • Ensure hydraulic containment to prevent off-Base migration via extraction wells at the base boundary • Operate the existing AS/SVE systems for groundwater cleanup and vadose zone source removal at CAOC 26 and for groundwater VOC mass removal downgradient of CAOCs 16, 15/17, and 35. • Groundwater monitoring for CAOCs 20 and 23 (OU 3) is performed under OU 1. • Monitoring to determine if detected nickel and chromium concentrations in groundwater beneath CAOC 16 represent naturally occurring or anthropogenic, relative to OU-1 history.	None (selected remedies remain the same)
Remedy Implementation	• The OUs 1 / 2 ROD incorporated the existing groundwater extraction system including four on-Base wells at the CAOC 26 plume downgradient boundary and eight wells at the Base eastern boundary. An additional four off-Base wells at the MCL boundary were incorporated into the ROD. • Treatment of extracted groundwater was aboveground by granular activated carbon (GAC).	The four off-Base wells have not been installed as of 2012, as the off-Base portions of the plumes have reduced since 1996. Two new extractions wells were installed (2010, 2012) to improve hydraulic control of contaminated groundwater.

Table 7-2. CAOC 37 – Third Five-Year Review (OU 1 - Yermo Annex)

CAOC 37 – Part 1: Review of Remedial Action Objectives, Selected Remedies, Implementation, Status, and Changed Conditions		
Yermo Annex RAs and Monitoring	**Original Conditions, Investigations, and Responses**	**Changed Conditions Since ROD and Second Five-Year Review**
Remedy Implementation (continued)	• Treated groundwater was recharged back into the aquifer via two infiltration galleries located at the upgradient edge of the plume. • LUCs were implemented to restrict access to prevent the use of untreated groundwater for drinking water in the area of the plume above MCLs and • Wellhead treatment of potentially impacted water supply wells was implemented by incorporation of the existing GAC treatment on two on-Base production wells, and two off-Base private wells. • Air sparge from the AS/SVE systems was designed to discharge to the atmosphere after it has been filtered for organic compounds through GAC. Air discharges will comply with the discharge standards and requirements of the local air pollution control district. The Yermo Annex GETS, CAOC 16 AS /SVE system and CAOC 26 AS/SVE system are shown on Figure 7-1.	VOC emission rates remained well below the Mojave Desert Air Quality Management District (MDAQMD) maximum allowable levels (39.6 pounds/day for VOCs and 600 pounds/day for Freon) (DON, 2005) during the review period. The GAC soil vapor treatment vessels were taken off-line with FFA agreement in 2006. Monitoring of the AS/SVE system effluent vapor concentration continues on a monthly basis.
System Operations/ O&M	O&M of remedial systems is the responsibility of the DON under the IR Program. The OUs 1 / 2 ROD specified remedial monitoring to: • Monitor the effectiveness of the AS/SVE systems at CAOCs 16 and 26, as well as downgradient of CAOCs 16 and 15/17. • Monitor groundwater throughout the duration of the remedial action, which is estimated to take approximately 30 years, subject to evaluations of treatment effectiveness at 5-year intervals. • Monitor groundwater at CAOCs 20, 23 and 35 subject to landfill closure requirements. • Maintain GAC treatment on two Yermo Annex production wells, YDW-5 and YDW-6, including monthly monitoring and change-out GAC as needed. • Maintain GAC treatment on two off-Base private residential drinking water wells (Younts, Hodges) located east of Yermo Annex, including semiannual monitoring for VOCs and change-out GAC as needed or at least once every five years.	An Integrated Maintenance Plan (IMP) was implemented beginning in 2009 to facilitate identification and completion of repairs and upgrades to aging GETS and AS/SVE remedial equipment. Significant upgrades and two new extraction wells were completed during the review period improving the effectiveness of both systems. Two GAC vessels installed in 2002 to address MTBE from an off-Base source were determined to no longer be needed and were removed from the system in 2010.

Table 7-2. CAOC 37 – Third Five-Year Review (OU 1 - Yermo Annex)

CAOC 37 – Part 1: Review of Remedial Action Objectives, Selected Remedies, Implementation, Status, and Changed Conditions		
Yermo Annex RAs and Monitoring	**Original Conditions, Investigations, and Responses**	**Changed Conditions Since ROD and Second Five-Year Review**
System Operations/ O&M (continued)	• Sample groundwater quarterly for one year for five dissolved metals (nickel, chromium, antimony, thallium, and aluminum) at selected wells in the area of CAOC 16 to ascertain if these metals are naturally occurring or the result of Base activities.	Statistical analysis of antimony, thallium, and aluminum long-term monitoring data found no indication these metals are COCs; monitoring of these metals in OU 1 groundwater ceased in 2011 (SAP Ver. 4, 2012).
ICs/ LUCs	To ensure that human health and the environment are protected in the future, institutional controls will be implemented that include access restrictions to prevent the on-Base use of untreated groundwater for domestic use, which includes ingestion, dermal contact, and inhalation as exposure routes. Wellhead treatment will be provided for any existing water supply wells that fall within the area of the plume exceeding MCLs. The DON will provide necessary information to appropriate county agencies identifying off-Base areas impacted by groundwater contamination exceeding MCLs. The DON will support county agencies with any technical information needed for the county to implement restrictions on construction and use of wells in the affected areas. The development or use of contaminated groundwater for drinking water or domestic use without treatment is prohibited. The contaminated groundwater has been determined to be unsafe for drinking or domestic use as outlined in the ROD for OUs 1 and 2. Personnel planning to develop access to this contaminated groundwater must notify the Base Environmental Division. Any proposal for extraction and treatment of groundwater for use must ensure compliance with state and federal drinking water standards and be approved by the Base Environmental Division. Written concurrence of the FFA signatories is required before the DON takes any action at a CAOC that would be inconsistent with the prohibition against use of untreated groundwater at the Yermo Annex as drinking water. An amendment to the Base Master Plan to incorporate the ROD drinking water protection requirements was also required.	The Base Master Plan (BMP) was updated in February 2010 to include all ROD-specified amendments reflecting the groundwater access and water supply well design restrictions at the Yermo Annex (Sections 18.1 and 18.6 of the BMP). Yermo Annex production well YDW-7 was brought on-line in May 2008. This well was tested for VOCs in the raw water at start-up; since no VOCs were detected, this production well was considered beyond the Yermo Annex plume boundaries and no treatment was required. Monitoring for VOCs continues monthly.

Table 7-2. CAOC 37 – Third Five-Year Review (OU 1 - Yermo Annex)

CAOC 37 – Part 2: Progress Since Last Review (2007)				
Protectiveness statements from last review: The RAs at CAOC 37 under OU 1 were considered protective of human health and the environment. However, recommendations were made to ensure the remedy remained be protective in the long term, as stated below.				
Issue	**Recommendations/Follow-up Actions**	**Milestone Date**	**Action Taken and Outcome**	**Date of Action**
1. Effectiveness of GETS in containing the Yermo North Plume	Evaluate deepening of well GEW-8 to improve containment.	December 2008	GEW-8 and GEW-15 were evaluated for deepening. However, the DON decided to replace GEW-15 with new deeper extraction well GEW-16. Extraction well GEW-13 was noted to be failing due to declining groundwater levels; the DON decided to replace it with GEW-17 in an optimized location relative to the Yermo north plume center.	New extraction well installations completed: April 2010 (GEW-16) March 2012 (GEW-17)
	Evaluate the need for additional AS wells for the CAOC 16 system to augment the GETS.	December 2008	Available historical data were reviewed by the DON and presented to the FFA along with a discussion during the 1 December 2009 scheduled meeting.	Dec. 2009 with follow-up testing of CAOC 16 AS/SVE system in 2010
	Procure spare pumps for faster replacement in case of potential pump malfunctioning.	December 2008	Spare pumps were procured as needed; additionally the DON established the Integrated Maintenance Plan (IMP) for rapid RA system repair and upgrade needs.	Spare pumps procured as needed: 2007 - 2009 IMP established: October 2009
2. Aging system components (Yermo GETS and CAOC 16 AS/SVE)	Evaluate impact of replacing system components vs. service and repair of existing system components.	December 2008	The DON evaluated and subsequently performed extensive repairs and upgrades of remedial system components; established the IMP for future repairs.	IMP established: October 2009
3. Effectiveness of AS/SVE in reducing dissolved VOC concentrations at CAOC 16 and downgradient of CAOC 35	Evaluate the need for additional AS wells.	December 2008	The DON reviewed potential sources of VOCs at CAOC 16 with FFA regulators during June 2009 FFA meeting. The following additional actions were taken by DON: 1) performed rebound study during 8-month AS/SVE system shutdown during 2009-2010; 2) evaluated vacuum influence of existing CAOC 16 SVE system; 3) completed additional system/well repairs and upgrades to improve CAOC 16 AS/SVE efficiency (2009 – 2012).	1) Rebound system shutdown from Nov. 2009 – July 2010 (results reported in 2010 semiannual monitoring report); 2) SVE radius of influence testing Nov. – Dec. 2010 (reported in 2010 AGMR)

Table 7-2. CAOC 37 – Third Five-Year Review (OU 1 - Yermo Annex)

CAOC 37 – Part 1: Review of Remedial Action Objectives, Selected Remedies, Implementation, Status, and Changed Conditions		
Yermo Annex RAs and Monitoring	**Original Conditions, Investigations, and Responses**	**Changed Conditions Since ROD and Second Five-Year Review**
Other issues:	No other issues were identified that could affect the protectiveness of the remedy	

CAOC 37 – Part 3: Summary of Technical Assessment (Based on 2011 – 2012 Data, Site Inspection, Review of Relevant Documents, and Interviews)	
A. Is the remedy functioning as intended by the decision documents?	
Yermo GETS (extraction wells, GAC treatment, infiltration galleries)	• **Performance Standards**: Hydraulic control of the Yermo VOC plumes during 2007 – 2012 did not change significantly from the prior review period; the Yermo North VOC plume continued to extend off-Base as evidenced by off-Base monitoring well concentration data as far as 1,000 feet from the Base boundary. Hydraulic control is expected to improve with the operation of the two new extraction wells installed in 2010 (GEW-16 at the base boundary) and 2012 (GEW-17 near the source area). The existing Yermo Annex groundwater flow model was updated with the two new extraction wells and calibrated to May 2012 measured groundwater elevations. See Appendix D, D-2 Technical Assessment Report for model output. • **Monitoring:** Sampling of the GETS GAC is performed on a 60-day (influent and intermediate) and 90-day (effluent) schedule. The present schedule for GAC changeout and vessel inspections/repairs is July 2012, in accordance with the O&M Manual and present VOC concentrations detected at the intermediate location. • **O&M:** is performed on a continuous basis under an annually updated O&M Manual. The GETS system repairs and upgrades have improved overall system operational uptimes and efficiency as evidenced by an increase in measured VOC mass removal (see Appendix D, D-3 report). • **O&M costs**: Electrical costs were relatively high due to the nature of the remedy, pumping of groundwater from 185 or greater feet bgs to the surface followed by treatment and infiltration back into the aquifer. Optimized operation of only those extraction wells needed to meet the RAOs has been enacted to minimize operational costs. Refer to the O&M costs in Appendix D (D-3 report). • **Repair and upgrade costs** have been relatively high, due to the need to repair and upgrade aging system components, as recommended in the prior Five-Year Review. The installation of two new extraction wells (GEW-16 and 17) contributed to spikes in annual repair and upgrade costs, as shown in Appendix D (D-3 report). Presently the GAC vessels are exhibiting signs of possible failure (rust on exterior). Two of the GAC vessels were inspected and repaired in July 2012. • **Opportunities for Optimization**: The GETS has been optimized to improve both hydraulic containment and VOC mass removal by addition of two extraction wells (GEW-16 and GEW-17) within the plume boundaries during 2010 and 2012. In particular, GEW-17 was located in the highest concentration zone of the plume with the objective of improving plume capture (see recommendations in Part 5 of this summary). The presence of continued untreated source beneath CAOC 16 had

Table 7-2. CAOC 37 – Third Five-Year Review (OU 1 - Yermo Annex)

CAOC 37 – Part 3: Summary of Technical Assessment (Based on 2011 – 2012 Data, Site Inspection, Review of Relevant Documents, and Interviews)	
Yermo GETS (extraction wells, GAC treatment, infiltration galleries), (continued)	led to a relatively stable Yermo North plume (neither growing nor receding) during the Five-Year review period (Appendix D, D-2 Report). A key optimization measure would be to address the source, thus reducing the over-all remedial time-frame. • **Early indicators of potential remedy problems**: none identified • **ICs or other measures**: No new production wells were installed or are planned for installation at the Yermo Annex. During the site inspection, the IRP Manager noted that additional signage around the Yermo GETS infiltration galleries would prevent DRMO equipment from being parked there, potentially damaging the galleries.
CAOC 16 AS/SVE System	• **Performance standards**: Mass removal of vapor phase VOCs continues at a rate of approximately 100 pounds/year (total VOCs, primarily TCE and PCE). Mass removal data and trend graphs are provided in Appendix D (Graph D-1.1.6). The OUs 1 / 2 ROD required evaluation of the effectiveness of the AS/SVE system in reducing groundwater and vadose zone contamination at CAOC 16 and the need for additional investigation. As indicated by the vapor phase removal rate, VOC mass removal continues at a significant rate. The SVE wells are about 750 – 800 feet from Building 573 (Figure 7-2) and their estimated radius of influence (ROI) is 400 – 500 feet (2010 AGMR). In 2011 soil vapor monitoring data from wells YCW 16-1, 2, and 3, adjacent to Building 573, showed total VOC concentrations ranging from 0.17 to 312 ug/m^3. • **Monitoring**: Soil vapor samples for VOC analysis were collected from the CAOC 16 SVE system every 60 days from the air discharge point (GAC treatment was discontinued in 2006). Analytical results are reported in monthly air discharge reports submitted to the DON. The average removal rate of VOCs was approximately 0.55 pounds per day, which is below the MDAQMD discharge limit of 39.6 pound per day. • **O&M** is performed on a continuous basis under an annually updated O&M plan. CAOC 16 AS/SVE system upgrades and repairs have improved overall system operational uptimes and efficiency as evidenced by an increase in VOC mass removal rates (Appendix D, D-3 report). During the site inspection, some erosion around CAOC 16 AS/SVE wells located in the area north of CAOC 16 and east of CAOC 35 was noted. • **O&M Costs**: O&M costs are relatively reasonable and within range for an AS/SVE system; electrical costs are high due to the size of the air compressor and blower required for the deep wells and extent of the system. Refer to the O&M and monitoring costs for OU-1 (Appendix D, D-3 report). Repair and upgrade costs were reasonable and included repairs and upgrades to aging system components, as recommended in the prior Five-Year Review. AS/SVE system upgrades and sparge well cleanouts have improved overall system effectiveness. • **Opportunities for optimization**: More aggressive remediation of sub-building VOCs would likely reduce the overall CAOC 37 and CAOC 16 remedial time frames and ensure long-term protectiveness of the remedy. • **Early indicators of potential remedy problems**: none identified • **ICs or other measures**: Preservation of the hardstand (10- to 12-inch thick concrete cover) at CAOC 16 is required as a

Table 7-2. CAOC 37 – Third Five-Year Review (OU 1 - Yermo Annex)

CAOC 37 – Part 3: Summary of Technical Assessment (Based on 2011 – 2012 Data, Site Inspection, Review of Relevant Documents, and Interviews)	
	protective measure to prevent exposure to soil vapor). Appendix C, Technical Assessment Report –Review of Exposure Assumptions, Toxicity Data, Cleanup Levels, and RAOs for OU 1 through OU 6.
CAOC 26 AS/SVE System	The CAOC 26 AS/SVE system was shut-down in 1998 as the RAOs for the system were met; long-term monitoring continues on an annual and once-per-five-year basis, in accordance with the approved SAP. The RA system was not reviewed. • **Monitoring:** Since 1998, the CAOC 26 plume has significantly attenuated both in areal extent and concentrations of COCs in soil vapor and groundwater (data evaluation presented in 2010 Annual Groundwater Monitoring Report [OTIE, 2011b]). Consequently, the groundwater monitoring frequency was reduced from annual to once every five years at most CAOC 26 groundwater monitoring locations, as recommended in the Second Five Year Review (DON, 2007) and incorporated into the SAP Revision 4. Selected groundwater monitoring locations, however, continue to be sampled annually. Soil vapor monitoring at CAOC 26 was similarly reduced from annual to once every five years based on recent monitoring results (OTIE, 2011b). • **Opportunities for Optimization**: none identified. • **Early indicators of potential remedy problems**: none identified • **ICs or other measures**: see Table 7-7 for CAOC 26-specific BMP modifications
Yermo Annex production well treatment systems	• **Performance Standards**: The GAC treatment systems maintained on the Yermo Annex production wells (YDW-5 and YDW-6) are performing as designed to remove VOCs to non-detect levels in final treated water. Raw water is processed through two 20,000-lb GAC vessels in series. Monthly monitoring is performed on influent (raw water), intermediate (between lead and lag GAC vessels), and effluent (treated water entering the Base potable water system). Influent samples generally had low (below MCLs) or non-detected VOCs, primarily TCE and/or PCE. Intermediate samples were generally non-detect. If the intermediate samples indicated the presence of VOCs, plans for GAC replacement were made. COCs in treated water were consistently nondetect during the review period. • **Monitoring**: The costs for the monthly monitoring and GAC replacement are reasonable. Monthly monitoring of nitrates and nitrites was reduced to once per year. Nitrates/nitrite monitoring was originally performed to evaluate if the GAC was contributing these constituents to the treated water; after years of low nitrate/nitrite results, the SAP was revised to reduce the sampling frequency. • **O&M**: Regular drinking water system operations and O&M is the responsibility of the MCLB Barstow Public Works Division under the direction of the Base Water Resources Manager. Monthly monitoring of VOCs and GAC change-out is an IRP responsibility. The GAC in the lead vessel of YDW -5 was changed out during December 2009 in response to detections of VOCs in the intermediate samples; the new carbon vessel was configured to be the lag vessel to ensure clean water was delivered to the system. Production well YDW-6 was inoperable from August 2011 through May 2012 due to pump problems. • **Repair and upgrade costs**: No repairs were required other than GAC replacement at YDW-5. • **Opportunities for Optimization**: none identified.

Table 7-2. CAOC 37 – Third Five-Year Review (OU 1 - Yermo Annex)

CAOC 37 – Part 3: Summary of Technical Assessment (Based on 2011 – 2012 Data, Site Inspection, Review of Relevant Documents, and Interviews)	
	• **Early indicators of potential remedy problems**: none identified • **ICs or other measures**: No new production wells were installed or are planned for installation at the Yermo Annex.
Off-Base private residential well treatment systems	• **Performance Standards**: GAC treatment systems were maintained and semiannual monitoring performed on the two off-Base private residential wells (Younts and Hodges) during the review period. The Hodges residential well is reportedly non-operational since December 2008 and the property unoccupied since 2010. • **Monitoring**: Semi-annual monitoring was performed at the Younts in 2007 – 2012, and Hodges 2007 – May 2008. Sampling data of the influent, intermediate and effluent (treated water entering the household) show GAC treatment systems were functioning as intended to protect drinking water. Influent samples generally had low (below MCLs) TCE and/or PCE, with no other VOCs detected. Samples indicated no detectable VOC concentrations Intermediate and treated water. If the intermediate samples indicate the presence of VOCs, GAC replacement is scheduled. This instance did not occur during the review period. COCs in treated water were consistently nondetect during the review period. • **O&M:** The DON is responsible for treatment system O&M, monitoring, and GAC replacements. The off-Base owners are responsible for maintaining and operating their wells and well pumps. Regular planned GAC change-out at the once/five-year interval is scheduled for July 2012 at the Younts residence. To the DON's knowledge, the Hodges residence has been unoccupied and the well inoperable since 2010. • **Opportunities for Optimization**: none identified. • **Early indicators of potential remedy problems**: none identified • **ICs or other measures**: N/A. See LUCs/ICs section for relevant information.
LUCs/ICs	The OUs 1 and 2 ROD requires: • Implementation of ICs to prevent on-Base use of untreated groundwater for domestic use: The BMP (Section 18) includes the provision that any activities planned which may affect groundwater within OU 1 need to be reviewed by the Base Environmental Division. • The DON to provide monitoring information on off-Base groundwater exceeding the MCLs: The DON provided the 2010 Annual Groundwater Monitoring Report to San Bernardino County Public Information Officer, Mr. David Wert, on 20 April 2011. The 2010 AGMR identified the off-Base areas impacted by groundwater contamination exceeding MCLs. San Bernardino County did not request information or technical support for restrictions on construction and use of wells in the affected areas during the review period. To the DON's knowledge, no off-Base production wells were installed within the off-Base plume boundaries.

Table 7-2. CAOC 37 – Third Five-Year Review (OU 1 - Yermo Annex)

CAOC 37 – Part 3: Summary of Technical Assessment (Based on 2011 – 2012 Data, Site Inspection, Review of Relevant Documents, and Interviews)	
B. Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of the remedy still valid?	
Land-use and exposure assumptions remained unchanged during the 2007 – 2012 review period. Toxicity data for TCE was changed by the U.S.EPA in 2011; however, the cleanup levels for groundwater (MCLs) including for TCE were unchanged since 2007. The change in toxicity criteria for TCE does not affect the selected OU 1 (CAOC 37) groundwater remedy because the GAC treatment consistently reduces TCE concentrations to below detection limits in the treated water (for both the GETS and on-Base and off-Base drinking water wells). Therefore, the RAOs and selected remedies remain protective.	
C. Has any other information come to light that could call into question the protectiveness of the remedy?	
For the CAOC 37 RAs, no other information has come to light that could call into question the protectiveness of the remedy.	
Summary Of Technical Assessments	The RAs at CAOC 37 under OU 1 are performing or have performed as intended; the selected RAOs and remedies are still valid; no other information has come to light that calls into question the protectiveness of the remedy. Opportunities for optimization exist for enhanced source removal at CAOC 16.

CAOC 37 – Part 4: Current Issues (Based on 2011 – 2012 Data, Site Inspection, Review of Relevant Documents, and Interviews)	
Issues identified during the technical assessment and other five-year review activities (e.g., site inspection)	1. The GETS did not prevent off-Base contaminant migration during the review period; however, two extraction wells were added to the system in 2010 and 2012 to improve plume containment. 2. The Yermo North groundwater plume remained relatively stable during the 2007 – 2012 review period; plume stability indicates there is remaining VOC source beneath CAOC 16 and vicinity that is not being addressed by the in-place remedial system as currently configured. 3. Aging Yermo GETS and CAOC 16 AS/SVE system components may reduce remedial effectiveness; continued replacement, repairs, and upgrades may need to be performed to ensure long-term protectiveness of the remedy. 4. During the site inspection, some erosion around AS/SVE wells located in the area north of CAOC 16 and east of CAOC 35 was noted. Additionally, the IRP Manager noted that additional signage around the Yermo GETS infiltration galleries area would prevent DRMO equipment from being parked there, potentially damaging the galleries. 5. The off-base residential wells treatment systems were regularly maintained; however one residence belonging to Hodges was reportedly unoccupied and the well inoperable. This information was not directly verified with the property owner. 6. It has not yet been determined if chromium and/or nickel detected in Yermo Annex groundwater are site-related COCs per the OUs 1 / 2 ROD.

Table 7-2. CAOC 37 – Third Five-Year Review (OU 1 - Yermo Annex)

CAOC 37 – Part 4: Current Issues (Based on 2011 – 2012 Data, Site Inspection, Review of Relevant Documents, and Interviews)	
Determination of whether issues affect current or future protectiveness	Current protectiveness is not affected by the identified issues because of the operation, maintenance, and repairs of the remedial systems as well as on-going monitoring.
Discussion of unresolved concerns or items raised by support agencies and the community	Comments received from the FFA regulators on the Draft and Draft Final Third Five-Year Review Report were addressed by the DON as documented in Appendix H.
Other Comments, Considerations	• If hydraulic containment is improved, revisit the 2005 "Explanation of Significant Difference" for four off-Base extraction wells as specified in the OUs 1 and 2 ROD. • Energy use reduction strategies may be considered for the Yermo Annex AS/SVE system such as upgrades to more energy efficient equipment or optimized operational parameters.

CAOC 37 – Part 5: Recommendations and Follow-up Actions (implementation by DON under oversight authority of FFA)		
Recommendations / Follow-up Actions	**Schedule for Completion**	**Comments**
Engage the FFA in the OUs 1 and 2 ROD-defined process for evaluation of the effectiveness of the Yermo North plume and evaluate if augmentation of the existing remedy is required to more effectively address this plume.	Begin FFA discussions by July 2013	OUs 1 and 2 ROD section 2.8.7, pages 2-25 to 2-26 defines the review process for a technical and economic feasibility study of the existing remedy.
Evaluate once/year the effectiveness of the extraction well network in controlling migration of the Yermo North plume; optimize groundwater extraction rates to maximize plume control while reducing energy consumption	Include evaluations in Annual Groundwater Monitoring Reports, system optimization reports or O&M Manual updates.	Use multiple lines of evidence including COC concentrations, flow-modeling, mass removal rates, energy-consumption rates, and changes in plume dimensions and volume over time
Continue to address RA system and well repairs, upgrades, and maintenance as needed to maintain optimal system performance; continue system optimization measures to improve efficacy and reduce energy consumption	The integrated maintenance plan (IMP) is in place to ensure on-going repairs; perform OU 1 RA optimization review by May 2013	none
Repair erosion around AS/SVE wells located in the area north of CAOC 16 and east of CAOC 35. Add signage around the Yermo GETS infiltration galleries area to	Complete repairs and add signage by December 2013	none

Table 7-2. CAOC 37 – Third Five-Year Review (OU 1 - Yermo Annex)

CAOC 37 – Part 5: Recommendations and Follow-up Actions (implementation by DON under oversight authority of FFA)		
Recommendations / Follow-up Actions	**Schedule for Completion**	**Comments**
prevent any other use of the area.		
Formalize contact with Hodges residence owner to assess current well condition and occupancy status of this property.	By December 2012	none
Evaluate groundwater metals data statistically to determine if chromium and nickel are COCs and require further investigation and/or remedial action.	By July 2014 or as soon as sufficient comparable data are acquired for statistical evaluation	Perform in accordance with SAP Ver. 4 and LTGWMP

Acronyms and Abbreviations:
AGMR – Annual Groundwater Monitoring Report
AS/SVE – air sparge/soil vapor extraction
bgs – below ground surface
BMP – Base Master Plan
CAOC – CERCLA Area of Concern
CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act
COCs – contaminants of concern
DON – Department of the Navy
EPA – Environmental Protection Agency
FFA – Federal Facilities Agreement
GAC – granular activated carbon
GETS – Groundwater Extraction and Treatment System
GEW – groundwater extraction well
ICs – institutional controls
IMP – Integrated Maintenance Plan
MCL – maximum contaminant level
LUCs – land use controls
LTGWMP – Long Term Groundwater Monitoring Plan
MCLB – Marine Corps Logistics Base
MDAQMD – Mojave Desert Air Quality Management District
MTBE – methyl tertiary-butyl ether
N/A – not applicable

Table 7-2. CAOC 37 – Third Five-Year Review (OU 1 - Yermo Annex)

Acronyms and Abbreviations (continued)

O&M – Operation and Maintenance
OU – Operable Unit
PCE – tetrachloroethene
RA – remedial action
RAO – remedial action objectives
RBC – risk-based criteria
ROD – record of decision
ROI – radius of influence
SAP – Sampling and Analysis Plan
TBC – to be considered
TCE – trichloroethene
VOC – volatile organic compound
YDW – Yermo Drinking Water (well)

Table 7-3. CAOC 16 - Third Five-Year Review (OU 5 – Yermo Annex)

CAOC 16 – Part 1: Remedial Action Objectives, Selected Remedies, Implementation, Status, and Changed Conditions		
CAOC 16	**Information from the applicable ROD(s)**	**Changed Conditions Since ROD and Second Five-Year Review**
Applicable RODs	OUs 5 / 6 ROD (soils), OUs 1 / 2 ROD (groundwater)	None (no ROD amendments).
Site Description and Figure Reference	CAOC 16 consists of Building 573 and perimeter area, located in the northeast portion of Yermo Annex (Figure 7-2). Groundwater beneath the CAOC is impacted by VOCs is being addressed under OU 1.	Land use remains the same. Two new permanent structures and four modular or canopy structures were constructed on the hardstand since last review. Increased equipment storage on and adjacent to this CAOC was noted during the site inspection.
Basis of Response	Soils impacted by VOCs particularly TCE, PCE, and 1,1-DCE. A hardstand in the form of a concrete cap ranging in thickness from 10 to 14 inches covers the entire area. The concrete cap limits the potential for worker exposure to VOCs in soil gas (at shallow depths) and minimizes potential for impact to groundwater (from soil/soil gas VOCs) due to infiltration. Groundwater beneath CAOC 16 is contaminated with VOCs and potentially metals; remediation and monitoring of groundwater is addressed under CAOC 37 (OU 1) (See Table 7-2).	None (no changes to identified COCs or original basis of response).
Remedial Action Objectives	OUs 5 / 6 ROD: The RAOs are to limit the potential for worker exposure to VOCs in soil gas (at shallow depths) and minimize the potential for impact to groundwater (from soil/soil gas VOCs) due to infiltration.	None (no change to RAOs).
Selected Remedy	Under OUs 5 / 6 ROD: • Implement LUCs to preserve the existing 10 – 14-inch thick concrete hardstand covering the CAOC 16 area • Monitor the physical and structural integrity of the concrete hardstand, and • Control and monitoring of exposure pathways at CAOC 16. Under OUs 1 / 2 ROD: • AS/SVE and hydraulic containment to address VOC-contaminated groundwater	None (selected remedies remain the same). None (selected remedies remain the same).

Table 7-3. CAOC 16 - Third Five-Year Review (OU 5 – Yermo Annex)

CAOC 16 – Part 1: Remedial Action Objectives, Selected Remedies, Implementation, Status, and Changed Conditions		
CAOC 16	**Information from the applicable ROD(s)**	**Changed Conditions Since ROD and Second Five-Year Review**
Selected Remedy (continued)	• SVE to address VOCs in the vadose zone beneath CAOC 16 • Monitoring and evaluation of potential metals contamination of groundwater	
Remedy Implementation	The concrete hardstand was in place at the signing of OUs 5 / 6 ROD (for soil). CAOC 16 groundwater is included in OU-1 (CAOC 37), which is discussed in Table 7-2.	No change.
O&M	Maintenance of the hardstand is the responsibility of MCLB Barstow.	No change.
Base Master Plan Modifications	Sections 11.1 through 11.6 of the BMP were amended to state: • the physical and structural integrity of the concrete hardstand shall be maintained; • any excavation, damage, or removal of the concrete hardstand will be reported to the MCLB Barstow Environmental Department; and • If a change in land use is proposed that is inconsistent with the selected remedy for CAOC 16 or the land use recorded in the BMP for CAOC 16, the DTSC, the Water Board, and the U.S. EPA will be notified of such a change, along with an evaluation of what measures are necessary to protect human health and the environment. FFA concurrence will be obtained before such a change is made. The BMP amendments also describe the risk to human health and the environment that exists at CAOC 16; reference the MCLB Barstow OU 5 RI/ FS, and ROD; and provide a legal description (metes and bounds) of the boundaries of CAOC 16. The language in the BMP amendment also includes the title and dates of the related documents and their storage location.	BMP was updated in 2010.

Table 7-3. CAOC 16 - Third Five-Year Review (OU 5 – Yermo Annex)

CAOC 16 – Part 2: Progress Since Last Review (2007)	
Protectiveness statements from last review	The selected remedy for CAOC 16 is protective of human health and the environment.
Status of recommendations and follow-up actions from last review	None (for groundwater, see Table 7-2, CAOC 37 [OU-1]).
Results of implemented actions, including whether they achieved intended purpose	Not applicable.
Status of any other prior issues	No other issues identified

CAOC 16 – Part 3: Technical Assessment (Based on 2011 – 2012 Data, Site Inspection, Review of Relevant Documents, and Interviews)	
A. Is the remedy functioning as intended by the decision documents?	
LUC for preservation of the hardstand	• The LUCs for CAOC 16 are functioning properly. Since the last Five-Year Review, only one new construction project (Bldg. 638 machine shop) temporarily breached the hardstand to install footings. The hardstand was restored with the completion of the Bldg. 638 foundation in 2010. Refer to Table 7-8 for more information on construction and modifications to the hardstand. These projects were coordinated through and reviewed by the MCLB Barstow Environmental Division. • Within Building 573, one area of the floor was opened to replace a subfloor drain. Soil samples were collected and analyzed for VOCs, but none were detected. The concrete floor was restored to 10- to 12-inch thick specifications. • New construction on the hardstand is planned for 2012; however it will not change the basic function of the hard-stand, as a cap for the CAOC 16 area. Refer to Table 7-8 for more information on planned construction projects for 2012. • A site inspection on 29 March 2012 indicated the hard stand was generally intact. Cracks were observed in various locations; however, cracking is not thought to affect the basic integrity of the cap as only the upper two to three inches of pavement appeared to be affected. Photos from the site visit are included in Appendix B. • Based on the available information, the LUCs are functioning as intended by the ROD.
Hardstand to prevent exposure of workers to shallow depth VOC soil vapors and	• The hardstand and buildings present hard surfaces that will generally reduce infiltration to the subsurface, and thus reduce the potential for migration or dissolved phase transport. The continued

Table 7-3. CAOC 16 - Third Five-Year Review (OU 5 – Yermo Annex)

CAOC 16 – Part 3: Technical Assessment (Based on 2011 – 2012 Data, Site Inspection, Review of Relevant Documents, and Interviews)	
prevent VOC migration to groundwater Hardstand to prevent exposure of workers to shallow depth VOC soil vapors and prevent VOC migration to groundwater (continued)	presence of vapor phase VOCs at depth within the vadose zone indicates the potential for vapor-phase transport to the water table. • Potential exposure of workers to shallow soil vapors was assessed using the Johnson-Ettinger model, the 2007 - 2011 soil vapor data collected from the three YCW monitoring locations, and conservative assumptions (see Vapor Intrusion Modeling Report in Appendix C). The model outputs indicate that exposure risks were within the EPA acceptable risk range of 10^{-4} to 10^{-6} excess lifetime cancer risk, therefore the selected remedy (hardstand) is functioning as intended by the ROD.
B. Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of the remedy still valid?	
There have been no changes that impact the validity of technical assumptions, toxicity data, cleanup levels, and RAOs at CAOC 16. Soils at this CAOC were impacted by VOCs with predicted impacts to groundwater. Adequate soil characterization analytical data are not available due to the nature of the site (ongoing operations). Groundwater impacts are being evaluated under OU 1 (CAOC 37). The RAOs remain unchanged. Appendix C provides additional details on the review of changes in ARARs, toxicity data, and ARARs for CAOC 16.	
C. Has any other information come to light that could call into question the protectiveness of the remedy?	
No other information has come to light that would call into question the protectiveness of the remedy.	
Summary of Technical Assessment	The LUCs to preserve the CAOC 16 hardstand concrete cap are functioning as intended by the OUs 5 and 6 ROD. See Section 7.2 for further discussion on related groundwater issues.

CAOC 16 – Part 4: Issues (Based on 2011 – 2012 Data, Site Inspection, Review of Relevant Documents, and Interviews)	
Issues identified during the technical assessment and other five-year review activities (e.g., site inspection)	Surface cracking was observed at various locations on the concrete cap; according to Base personnel the cracking is an issue for day-to-day operations and funding is being sought to perform surface repairs.
Determination of whether issues affect current or future protectiveness	The observed cracking appeared to affect only the surface of the concrete; therefore, short-term protectiveness is not affected. However, the concrete cap should be maintained to ensure long-term protectiveness.
Discussion of unresolved concerns or items raised by support agencies and the community	Comments received and responses to comments are appended to this report (Appendix H).

Table 7-3. CAOC 16 - Third Five-Year Review (OU 5 – Yermo Annex)

CAOC 16 – Part 4: Issues (Based on 2011 – 2012 Data, Site Inspection, Review of Relevant Documents, and Interviews)	
Other comments, considerations	Related groundwater issues are discussed in Section 7.2 of this document.

CAOC 16 – Part 5: Recommendations and Follow-up Actions (implementation under oversight authority of FFA)			
Recommendations / Follow-up Actions	**Parties Responsible for Implementation**	**Schedule for Completion**	**Comments**
Complete necessary repairs to hardstand to ensure long-term protectiveness	MCLB Barstow Public Works	During next five year period	Public Works in process of securing funding for identified repairs

Acronyms and Abbreviations:

ARAR – Applicable Relevant and Appropriate Requirements

AS/SVE – air sparge/soil vapor extraction

BMP – Base Master Plan

CAOC – CERCLA Area of Concern

CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act

COCs – contaminants of concern

DTSC – Department of Toxic Substances Control

EPA – Environmental Protection Agency

FFA – Federal Facilities Agreement

ICs – institutional controls

LUCs – land use controls

MCLB – Marine Corps Logistics Base

O&M – Operation and Maintenance

OU – Operable Unit

PCE – tetrachloroethene

RAO – remedial action objectives

RI/FS – remedial investigation / feasibility study

ROD – record of decision

TCE – trichloroethene

VOC – volatile organic compound

Table 7-4. CAOC 20 - Third Five-Year Review (OU 5 – Yermo Annex)

CAOC 20 – Part 1: Remedial Action Objectives, Selected Remedies, Implementation, Status, and Changed Conditions		
CAOC 20	**Original Site Conditions, Response, Implementation**	**Changed Conditions Since ROD and Second Five-Year Review**
Applicable RODs	OUs 3/4 ROD (DON, 1998b) for cap and ICs/LUCs; OUs 1/2 ROD (DON, 1998a) for groundwater monitoring	None (no ROD amendments)
Site Description and Figure Reference	CAOC 20, the Second Hazardous and Low-Level Radiological Area, is located on the eastern side of the Yermo Annex (Figure 1-2). Soil contaminants included VOCs, SVOCs, metals, and pesticides. Mathematical modeling indicated that soil contamination would have limited potential impacts to groundwater. CAOC 20 consists of three strata (Figure 7-4): • Stratum 1 in the northwest corner of CAOC 20 and includes a radiological waste well and a 60-foot-by-60-foot area surrounding the well • Stratum 2 in the central portion of CAOC 20 and includes the non-radiological waste wells and the area between and surrounding the wells. • Stratum 3 in the northeastern portion of the CAOC between the convergence of the railroad tracks and includes areas of discoloration observed in aerial photographs. Determined as NFA by the OU 3/4 ROD. Groundwater sampling is conducted under OU1.	None (land use remains same; concrete cap maintained).
Basis of Response	Soils impacted by VOCs, SVOCs, metals, and pesticides; buried wastes with no direct analyses. The basis of the response was prevention of contaminant migration to groundwater and exposure to contaminants in excess of an ILCR of 1×10^{-6} and a Hazard Index of 1.0. While the calculated human health risk results for the soils in the area to be capped were below the acceptable risk range of 10^{-4} to 10^{-6}, uncertainties existed because of the lack of analysis of the buried waste itself.	None (no changes to identified COCs or original basis of response).
Remedial Action Objectives	OUs 3 / 4 ROD: The RAOs for Strata 1 and 2 of CAOC 20 are to limit the potential for exposure to, and disturbance of buried wastes, and to minimize the potential for future releases to groundwater.	None (no change to RAOs)
Selected Remedy	RAOs per the OUs 3 / 4 ROD: Relevant portions of the statutory determinations at CAOC 20 consist of the following:	None (selected remedy unchanged; on-going groundwater monitoring performed

Table 7-4. CAOC 20 - Third Five-Year Review (OU 5 – Yermo Annex)

CAOC 20 – Part 1: Remedial Action Objectives, Selected Remedies, Implementation, Status, and Changed Conditions		
CAOC 20	**Original Site Conditions, Response, Implementation**	**Changed Conditions Since ROD and Second Five-Year Review**
Selected Remedy (continued)	• Modification of the BMP (DON, 2010) to allow for limited activities only • Replacing an existing concrete cap to minimize rainwater infiltration • Drainage control, including grading and berms to reduce rainwater infiltration over the concrete cap, thereby further minimizing rainwater infiltration • Groundwater monitoring and vadose zone infiltration monitoring • LUCs for maintaining the existing concrete cap.	annually)
Remedy Implementation	The RAs were completed in 2000 and are discussed in detail in the OUs 3 / 4 ROD (DON, 2000). The neutron access probe for vadose zone infiltration monitoring at CAOC 20 was installed during a subsequent RA at CAOC 35, as noted in the OUs 5 and 6 RAR (DON, 2002). Data collected for CAOC 20 include soil moisture readings and groundwater monitoring results. Groundwater monitoring is conducted annually under the OU 1 long-term monitoring program (JEG, 1998). The initial groundwater analyte list per the ROD was VOCs, gross alpha, gross beta, Radium 226, and Radium 228, chromium and nickel.	There were no changes to the RA. The OUs 3 / 4 ROD requires that the CAOC 20 RAs be evaluated following every fourth year of monitoring for decisions on effectiveness and the need for additional actions. The first such analysis was performed as part of the Second Five-Year Review (DON, 2007). That analysis identified gross alpha exceedances in groundwater as a potential trigger for evaluation of the remedy; however, there were questions on data quality due to biofouling in wells and the representativeness of gross alpha of site conditions.
System Operations/ O&M	The concrete cap is maintained in accordance with the O&M Plan in Appendix A of the OUs 3 / 4 ROD (DON, 2000). Maintenance of cap is responsibility of the DON under the IR Program. Groundwater monitoring wells in the vicinity of CAOCs 20, 23, and 35 are shown on FigureA-1 in Appendix A.	The radiological monitoring program was revised in 2010 to eliminate gross alpha and add tritium to improve data representativeness (DON, 2010). The FFA approved the revision (see further discussion under Part 2 below). Well maintenance was also performed (Part 2).

Table 7-4. CAOC 20 - Third Five-Year Review (OU 5 – Yermo Annex)

CAOC 20 – Part 1: Remedial Action Objectives, Selected Remedies, Implementation, Status, and Changed Conditions		
CAOC 20	**Original Site Conditions, Response, Implementation**	**Changed Conditions Since ROD and Second Five-Year Review**
ICs/LUCs	Land use restrictions have been placed on CAOC 20. Activities are limited to surface uses such as equipment storage. Additional actions, including drainage control to promote surface water runoff and minimize standing water directly above the areas of buried wastes, as well as installation of an upgradient and downgradient monitoring well, were completed in June 1999 (DON, 2000). As documented in Section 2.2.8 of the final ROD (DON, 1997), the following language establishes the restriction on certain types of land use at CAOC 20: "To ensure that human health is protected in the future, no excavation of soils (e.g., in the course of construction or maintenance of building or utility facilities) within CAOC 20 Strata 1 and 2 may occur below a 5-foot depth unless prior approval of the FFA signatories is obtained. The maintenance of railroad tracks adjacent to CAOC 20 is not affected by these limitations. If an excavation below the 5-foot level in CAOC 20 Strata 1 and 2 is proposed, the DTSC, RWQCB, and EPA must be provided with written notification of such a proposed action. "	BMP was updated in 2010.

Table 7-4. CAOC 20 - Third Five-Year Review (OU 5 – Yermo Annex)

CAOC 20 – Part 2: Progress Since Last Review (2007)	
Protectiveness statements from last review:	Due to exceedances of the RAO for gross alpha, upon consultation with the FFA signatories, additional investigations were determined to be necessary to further evaluate gross alpha in groundwater. If it is determined that the source of the exceedances is CAOC 20, a re-evaluation of the remedy for CAOC 20 may be required. Appropriate action will need to be proposed after consultation with the FFA signatories.
Status of recommendations and follow-up actions from last review	The CAOC 20 monitoring program was evaluated during 2009 – 2010 as a prelude to any further investigation. The evaluation resulted in recommendations to clean and redevelop turbid wells to improve data quality, filter groundwater samples for radiological analyses, and replace gross alpha with tritium as more representative of the radionuclides that could originate from CAOC 20 (DON, 2010b). The revision was accepted by the DTSC on 22 December 2009. The recommendations were implemented beginning in 2010. Monitoring data from 2010 and 2011 annual monitoring events indicated tritium was not detected above the detection limit.
Results of implemented actions, including whether they achieved intended purpose	The evaluation of the CAOC 20 monitoring program and implemented follow-up actions meet the intended purpose of the ensuring proper monitoring of CAOC 20 groundwater.
Status of any other prior issues	No other prior issues identified.

CAOC 20 – Part 3: Technical Assessment (Based on 2011 – 2012 Data, Site Inspection, Review of Relevant Documents, and Interviews)	
A. Is the remedy functioning as intended by the decision documents?	
Cap Maintenance and Performance	A review of the annual operation and maintenance reports for the CAOC 20 cap (TerraVac, 2007; SES-TECH, 2008 and 2009; SDV, 2011; Sealaska, 2012) indicated that the cap and fence are in good working condition. Landfill cap maintenance activities were as follows: • As part of regular O&M, inspections were conducted to check for the presence of concrete cracks in the joint sealer. During the September 2008 landfill inspection, one 10-foot crack was repaired with an elastomeric waterproof sealant. • In March 2009, improvements were made to the 12-inch PVC drain pipe under the railroad tracks by adding a rip-rap apron. Erosion control measures were also implemented, including grading washouts, reconstruction of the drainage swale and placement of erosion control materials (jute, geotextile fabric, and float rock). • The moisture monitoring gauges were replaced in August 2010, and a new circuit board/data processor was installed

Table 7-4. CAOC 20 - Third Five-Year Review (OU 5 – Yermo Annex)

CAOC 20 – Part 3: Technical Assessment (Based on 2011 – 2012 Data, Site Inspection, Review of Relevant Documents, and Interviews)	
Cap Maintenance and Performance (continued)	in January 2012. • Soil moisture is monitored on a regular basis using the installed soil moisture monitoring system. In addition, a rainfall gauge measures rainfall at regular intervals. Soil moisture and rainfall gauge data are downloaded bimonthly and reported in the annual report. The measured soil moisture content was relatively constant, and little to no variability over time was observed at each point, indicating that the cap is functioning effectively. • A visual inspection of the cap performed on March 29, 2012 found the cap to be in good shape with no visible cracks or defects; a fence surrounds the cap and was found to be in good shape. The visual inspection record is provided in Appendix B. O&M costs are minimal, primarily associated with removal of debris in the channel and moisture monitoring. The remedy is cost effective and utilizes a permanent solution. The fence around the site is intact and in good repair. Based on the O&M reports, and site inspection, the concrete cap and fence at CAOC 20 are in good working condition.
Groundwater Monitoring Results	As a part of the Five-Year Review process, the OUs 3 / 4 ROD (DON, 1997) requires that the RA for CAOC 20 be re-evaluated following the fourth year of monitoring for decisions on the effectiveness of the RAO and the potential need for additional actions. If the monitoring indicates a statistically significant release at CAOC 20, an appropriate action is to be proposed after consultation with the FFA regulators. The evaluation of 2007 through 2011 data is discussed below. • Historical concentration trends for TCE and PCE are presented Appendix E for the wells in the vicinity of CAOC 20 (upgradient well YS20-1; cross-gradient well YS20-2; and downgradient well YIMW-5 as shown on Figure 3-1. Historical data for these wells indicate relatively stable TCE and PCE concentrations below MCLs for wells YS20-1 and YS20-2 (Appendix E, Graphs E-1.1). TCE and PCE concentrations for the samples collected from well YIMW 5 were not detected at the respective detection limit since March 2003. • Radiological analyte trends are presented in Appendix E. Previous trends in gross alpha are no longer reported or evaluated. No significant or readily identifiable concentration trends for gross beta or radium isotopes 226, or 228 have been observed in CAOC 20 wells since November 2004. Radiological analytes, where detected, were below respective RAOs (Appendix E, Graphs E-1.2). • YS20-1 and YS20-2 were cleaned and redeveloped in October 2010 to reduce biofouling and improve data quality. The November 2011 data indicated dissolved chromium and nickel concentrations at YS20-1 exceeded the RAOs. For YS20-2, only dissolved nickel concentration exceeded the RAO. However, continued elevated turbidity measurements in these wells could indicate non-representative conditions in the wells and surrounding aquifer. Additionally YS20-1 had only 3 feet of water in the screen, which could reduce sample quality. • Based on the CAOC 20 groundwater monitoring data, the selected RA is meeting the RAOs.

Table 7-4. CAOC 20 - Third Five-Year Review (OU 5 – Yermo Annex)

CAOC 20 – Part 3: Technical Assessment (Based on 2011 – 2012 Data, Site Inspection, Review of Relevant Documents, and Interviews)	
Institutional Controls	The LUC that is in place at Stratum 1 of CAOC 20 is restricted use of the site. No activities were observed that would have violated the LUC. No new uses of groundwater were reported and/or observed.
B. Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of the remedy still valid?	
Because the site conditions, surrounding land use, and potential receptors have not changed since the time of the remedy, the exposure assumptions are still valid. Soils at this CAOC were impacted by low levels of VOCs, SVOCs, metals, and pesticides, with predicted low probability of impacts to groundwater. The Second Five-Year Review analyzed the impact of a lowered PRG (now RSL) for arsenic in soils. The change was found to have no impact on the protectiveness of the remedy and arsenic was determined to be naturally occurring. Appendix C provides additional details on the review of changes in screening criteria and MCLs for this CAOC.	
C. Has any other information come to light that could call in to question the protectiveness of the remedy?	
No other information has come to light that would call into question the protectiveness of the remedy.	
Summary Of Technical Assessments	Based on the technical evaluation, the remedy at CAOC 20 appears to be performing effectively to meet the RAOs for this area. Optimization measures included well maintenance and revisions to the monitoring program as discussed above.

CAOC 20 – Part 4: Issues (Based on 2011 – 2012 Data, Site Inspection, Review of Relevant Documents, and Interviews)	
Issues identified during the technical assessment and other five-year review activities (e.g., site inspection)	1. No prior or current issues identified with the cap. 2. Groundwater monitoring wells exhibit high turbidity which could indicate biofouling that could impact data quality.
Determination of whether issues affect current or future protectiveness	The identified well maintenance issue does not affect current or future protectiveness of the remedy.
Discussion of unresolved concerns or items raised by support agencies and the community	Comments received and responses to comments are appended to this report (Appendix H).
Other Comments	None

Table 7-4. CAOC 20 - Third Five-Year Review (OU 5 – Yermo Annex)

CAOC 20 – Part 5: Recommendations and Follow-up Actions (implementation under oversight authority of FFA)			
Recommendations / Follow-up Actions	**Parties Responsible for Implementation**	**Schedule for Completion**	**Comments**
Groundwater monitoring wells should be periodically cleaned and redeveloped to address biofouling that could impact data quality	DON	Annual evaluation of wells with history of biofouling; address under OU 1 O&M program as needed.	none
Evaluate four consecutive years of radiological monitoring data in accordance with OUs 3 /4 ROD	DON	Evaluate 2010 – 2013 annual monitoring data; complete by July 2014	Use statistical methods identified in OUs 3 / 4 ROD

Acronyms and Abbreviations:

AGMR – Annual Groundwater Monitoring Report

ARAR – Applicable Relevant and Appropriate Requirements

AS/SVE – air sparge/soil vapor extraction

bgs – below ground surface

BMP – Base Master Plan

CAOC – CERCLA Area of Concern

CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act

COCs – contaminants of concern

DON – Department of the Navy

DTSC – Department of Toxic Substances Control

EPA – Environmental Protection Agency

FFA – Federal Facilities Agreement

ICs – institutional controls

IMP – Integrated Maintenance Plan

LTGWMP – Long Term Groundwater Monitoring Plan

LUCs – land use controls

MCLB – Marine Corps Logistics Base O&M – Operation and Maintenance

OU – Operable Unit

PCE – tetrachloroethene

RAO – remedial action objectives

RAR – Remedial Action Report

RI/FS – remedial investigation / feasibility study

ROD – record of decision

SAP – Sampling and Analysis Plan

TCE – trichloroethene

VOC – volatile organic compound

Table 7-5. CAOC 23 - Third Five-Year Review (OU 3 – Yermo Annex)

CAOC 23 – Part 1: Remedial Action Objectives, Selected Remedies, Implementation, Status, and Changed Conditions		
CAOC 23	**Original Site Conditions, Response, Implementation**	**Changed Conditions Since ROD and Second Five-Year Review**
Applicable RODs	OUs 3/4 ROD (DON, 1998b) for caps and ICs/LUCs; OUs 1/2 ROD (DON, 1998a) for groundwater monitoring.	None (no ROD amendments)
Site Description and Figure Reference	CAOC 23, the Landfill Area, is an irregular L-shaped area located in the south/southeast corner of the Yermo Annex between the railroad tracks and the industrial operations' perimeter fence (Figure 1-2). CAOC 23 consists of six strata (Figure 7-4): • Strata 1: General storage area located in the northeastern portion of CAOC 23 • Stratum 2: Trenches around the southwestern perimeter of CAOC 23 • Stratum 3: A second general storage area in the north-central portion of CAOC 23 • Stratum 4: Waste management area located in the south-central portion of CAOC 23. • Stratum 5: A potential waste burial area. • Stratum 5a: PCB-hit area in the western portion of CAOC 23. The southern portion of Stratum 1 and all of Stratum 2 (the only areas where landfilling occurred) were combined to form CAOC 23, Zone I. The remaining strata, including the northern portion of Stratum 1, and Strata 3, 4, 5, and 5a were declared NFA per the ROD (DON, 1997).	None (land use remains same; concrete cap maintained).
Basis of Response	Soils in the CAOC (outside the landfill) are impacted by low levels of VOCs. The landfill itself was not sampled.	None (no changes to identified COCs or original basis of response).
Remedial Action Objectives	RAOs per the OUs 3 / 4 ROD: Relevant portions of the statutory determination for CAOC 23, Zone I (Section 1.5 of the OUs 3 and 4 ROD [DON 1997]) are as follows: • Minimize the potential for disturbance of wastes, • Minimize potential future releases to groundwater,	None (no change to RAOs)

Table 7-5. CAOC 23 - Third Five-Year Review (OU 3 – Yermo Annex)

CAOC 23 – Part 1: Remedial Action Objectives, Selected Remedies, Implementation, Status, and Changed Conditions		
CAOC 23	**Original Site Conditions, Response, Implementation**	**Changed Conditions Since ROD and Second Five-Year Review**
Remedial Action Objectives (continued)	• Attain landfill closure ARARs, and • Provide a final remedy that minimizes impacts to existing Defense Reutilization Materials Office (DRMO) facilities.	
Selected Remedy	OUs 3 / 4 ROD: For Strata 1, 2, and 4: • In-place abandonment of a water line • Deep dynamic compaction of soil • Installation of a concrete cap at Zone 1, which is defined as Stratum 2 and the southern portion of Stratum 1 (see Figure 4-3) • Groundwater monitoring and vadose zone infiltration monitoring. For Strata 3, 5, and 5a: • NFA with BMP modifications (brief description of the history of CAOC 23 Strata 5 and 5a, statement that low levels of PCBs and pesticides were detected in the soils, and coordination of any proposed actions or changes in site use by the MCLB Barstow Environmental Department).	None (selected remedy unchanged; on-going groundwater monitoring performed annually)
Remedy Implementation	The RAs were completed in 2000 and are discussed in detail in the OUs 3 and 4 RAR (DON, 2000). In addition, four of the five geophysical anomalies at CAOC 23 (four at Stratum 1 and one at Stratum 4) (Figure 7-4) were excavated and consolidated at the CAOC 35 Landfill prior to installation of a cap at that CAOC. The fifth anomaly could not be found when resurveyed by geophysical methods. It may have been a surface interference that was moved when the Defense Reutilization Materials Office (DRMO) moved from the area. Groundwater monitoring is conducted annually under OU 1 long-term monitoring program. It should be noted that Section 2.3.8 of the OUs 3 and 4 ROD (DON, 1997) calls for vadose zone monitoring, but none is required in Section 2.3.6.3 of the same ROD; therefore no vadose zone infiltration monitoring is performed beneath the concrete cap or elsewhere at this CAOC.	None (no further RA undertaken)

Table 7-5. CAOC 23 - Third Five-Year Review (OU 3 – Yermo Annex)

CAOC 23 – Part 1: Remedial Action Objectives, Selected Remedies, Implementation, Status, and Changed Conditions		
CAOC 23	**Original Site Conditions, Response, Implementation**	**Changed Conditions Since ROD and Second Five-Year Review**
System Operations/ O&M	The concrete cap is maintained in accordance with the CAOC 23 O&M Manual (AGRA, 1998); monitoring consists of annual groundwater sampling under OU 1.	No significant changes since last review
Base Master Plan modifications	The BMP Sections 3.1 through 3.6 were amended to state that any actions planned for this area or changes in site use were required to be coordinated and reviewed by the MCLB Barstow Environmental Department. If a change in land use is proposed that is inconsistent with the selected remedy for CAOC 23 or the land use recorded in the BMP for CAOC 23, the FFA regulators will be notified of such a change, and concurrence will be obtained before such a change is made.	BMP was updated in 2010

CAOC 23 – Part 2: Progress Since Last Review (2007)	
Protectiveness statements from last review	Remedial measures at CAOC 23 were considered protective of human health and the environment.
Status of recommendations and follow-up actions from last review	No recommendations or follow-up actions were proposed
Results of implemented actions, including whether they achieved intended purpose	N/A
Status of any other prior issues	No issues were identified.

Table 7-5. CAOC 23 - Third Five-Year Review (OU 3 – Yermo Annex)

CAOC 23 – Part 3: Technical Assessment (Based on 2011 – 2012 Data, Site Inspection, Review of Relevant Documents, and Interviews)	
A. Is the remedy functioning as intended by the decision documents?	
Cap Maintenance and Performance Cap Maintenance and Performance (continued)	The installation of the concrete cap allows each of the RAOs to be met. The concrete cap functions as a barrier against contact with the buried waste and restrictions against breaching the cap will verify that this function is maintained in the future. The cap also functions to prevent precipitation from percolating into the buried solid wastes. The concrete cap has provided a better working surface for the existing equipment storage land use. Landfill maintenance and monitoring activities at CAOC 23 are performed quarterly, in accordance with the ROD and the CAOC 23 O&M Manual (AEE, 1998). Landfill monitoring activities consist of concrete cap and joint sealer inspection, weed control, and inspection of perimeter fence and protective gravel cover. In addition, annual groundwater monitoring is performed under OU1 (to determine if there is any impact to groundwater from CAOC 23). The cap is surveyed annually for settling. A review of the annual operation and maintenance reports for the CAOC 23 cap (TerraVac, 2007; SES-TECH, 2008 and 2009; SDVJV, 2011; Sealaska, 2012) indicated that the cap and fence are in good working condition. Landfill cap maintenance activities were as follows: • During the January 2008 landfill inspection, one 40-foot crack, and one 20-foot crack in the landfill were repaired with an elastomeric waterproof sealant. • In March 2009, a 15-foot crack in the southwest portion of the cap was sealed. Erosion control measures were also implemented, including grading washouts, reconstruction of the drainage swale and placement of erosion control materials (jute, geotextile fabric, and float rock). • Eleven (11) settlement monitoring points were installed and surveyed in April 2009. Settling does not appear to be an issue of concern, based on a January 2011 survey (SDV, 2011). O&M costs are minimal; the remedy is cost effective and utilizes a permanent solution.
Groundwater Monitoring Results	Fourteen (14) monitoring wells in the vicinity of CAOC 23 are sampled annually for VOCs. The monitoring program is adequate for evaluation of remedy effectiveness. Groundwater concentration trends from wells in the vicinity of CAOC 23 were reviewed. TCE and PCE concentration trends for several wells in the vicinity of CAOC 23 shown in Figure E-2 in Appendix E indicate the following: • TCE and PCE concentrations upgradient (YS23-11, YS23-12, and YS23-13) and downgradient (YS23-14, YS23-15, YS23-16, YS23-17, YS23-19) of CAOC 23 are relatively stable and below MCLs. • Fluctuating TCE concentrations with a slight overall increasing trend can be observed in well YS23-18. However, TCE concentrations did not exceed the MCL. Based on the groundwater data, levels of COCs in groundwater are below MCLs, as discussed in Section 7.2. The remedy is therefore performing effectively.

Table 7-5. CAOC 23 - Third Five-Year Review (OU 3 – Yermo Annex)

CAOC 23 – Part 3: Technical Assessment (Based on 2011 – 2012 Data, Site Inspection, Review of Relevant Documents, and Interviews)	
ICs/LUCs	The LUCs for CAOC 23 are functioning properly. The activities within the area observed during the Site Inspection on 29 March 2012 are consistent with the use of the cap as a laydown area for DRMO. No activities were observed that would have violated the LUCs.
B. Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of the remedy still valid?	
Because the site conditions, surrounding land use, and potential receptors have not changed since the time of the remedy, the exposure assumptions, toxicity data, cleanup levels, and RAOs are still valid.	
C. Has any other information come to light that could call in to question the protectiveness of the remedy?	
No other information has come to light that would call into question the protectiveness of the remedy.	
Summary of Technical Assessments	Based on the technical evaluation, the remedy at CAOC 23 appears to be performing effectively to meet the OUs 3 / 4 ROD RAOs for this area. No optimization measures were identified.

CAOC 23 – Part 4: Issues (Based on 2011 – 2012 Data, Site Inspection, Review of Relevant Documents, and Interviews)	
Issues identified during the technical assessment and other five-year review activities (e.g., site inspection)	1. Cracks in the concrete cap surface were repaired in 2008 and 2009. The cap was found to be in good condition during the Five Year Review inspection. 2. With respect to groundwater monitoring, concentrations of COCs are below RAOs at CAOC 23. Therefore, no changes to the remedy need be considered.
Determination of whether issues affect current or future protectiveness	The selected remedy at CAOC 23 remains protective of human health and the environment.
Discussion of unresolved concerns or items raised by support agencies and the community	Comments received and responses to comments are appended to this report (Appendix H).
Other Comments/Considerations	None

CAOC 23 – Part 5: Recommendations and Follow-up Actions (implementation under oversight authority of FFA)
No recommendations are made.

Table 7-5. CAOC 23 - Third Five-Year Review (OU 3 – Yermo Annex)

Acronyms and Abbreviations:

ARAR - Applicable or Relevant and Appropriate Requirements
bgs – below ground surface
BMP – Base Master Plan
CAOC – CERCLA Area of Concern
CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act
COCs – contaminants of concern
DON – Department of the Navy
EPA – Environmental Protection Agency
FFA – Federal Facilities Agreement
ICs – institutional controls
LUCs – land use controls
LTGWMP – Long Term Groundwater Monitoring Plan
OU – Operable Unit
PCE – tetrachloroethene
RA – remedial action
RAO – remedial action objectives
ROD – record of decision
SAP – Sampling and Analysis Plan
TCE – trichloroethene
VOC – volatile organic compound

Table 7-6. CAOC 35 Stratum 1 Zone 1 - Third Five-Year Review (OU 5, OU 1 - Yermo Annex)

CAOC 35 – Part 1: Remedial Action Objectives, Selected Remedies, Implementation, Status, and Changed Conditions		
CAOC 35	**Original Site Conditions, Response, Implementation**	**Changed Conditions Since ROD and Second Five-Year Review**
Applicable RODs	OUs 5 / 6 ROD, OUs 1 / 2 ROD	None (no ROD amendments).
Site Description and Figure Reference	CAOC 35, the capped and inactive Class III Landfill, is located in the northeastern portion of the Yermo Annex, as shown in Figure 7-5.	None (land use remains same; concrete cap maintained).
Basis of Response	VOCs, SVOCs, and pesticides were minimal in surface samples, while subsurface samples indicated the presence of VOCs and SVOCs, including PAHs. TPH and PCB were present at high levels. These contaminants were all believed to be site-related. All metals present were at or below background level. A modeling evaluation indicated that groundwater would probably not be affected by the landfill.	None (no changes to identified COCs or original basis of response).
Remedial Action Objectives	OUs 5 / 6 ROD: The RAO for the CAOC 35 Zone 1 (OU 5) remedy is to minimize water infiltration and potential future impact to groundwater, limit potential human exposure to buried waste, and maintain landfill closure ARARs	None (no change to RAOs).
Selected Remedy	OUs 5 / 6 ROD: The major components of the selected remedy at CAOC 35 include: • Installation of a 3-foot native soil cover • Installation of a 6-inch rock cover over the native soil cover and a 6-foot fence (with finer mesh at the bottom to prevent desert tortoises from entering) • Installation of soil moisture monitors • Restriction of land use activities in the area (sign postage and institutional controls) OUs 5 and 6 RA Report (DON, 2002) noted that the remedy was determined to be "operating properly and successfully" by the DON and all FFA Parties.	None (selected remedy unchanged). Crack and depression repairs were performed in 2009 and 2010. Note that groundwater monitoring is performed under OU 1.

Table 7-6. CAOC 35 Stratum 1 Zone 1 - Third Five-Year Review (OU 5, OU 1 - Yermo Annex)

CAOC 35 – Part 1: Remedial Action Objectives, Selected Remedies, Implementation, Status, and Changed Conditions		
CAOC 35	**Original Site Conditions, Response, Implementation**	**Changed Conditions Since ROD and Second Five-Year Review**
Remedy Implementation	The RA (cap construction) was completed in January 2001 (OU 5 and 6 RAR, DON 2002). The neutron access probe for vadose zone infiltration monitoring at CAOC 35 was installed in January 2001 (OUs 5 and 6 RA Report, DON 2002). Quarterly monitoring of the CAOC 35 cap. Groundwater monitoring is conducted under the OU 1 long-term monitoring program.	There were no changes to the RA.
System Operations/ O&M	The soil cap is maintained in accordance with the CAOC 7 and 35 O&M Manual (BNI, 1999). O&M of the cap involves routine inspections of the surface; weed eradication; and monitoring of soil moisture, rainfall, and settlement. Groundwater monitoring is performed under the OU 1 long-term monitoring program (see Table 7-2).	There were no changes to O&M of the cap. Crack repair was performed in 2009 and 2010. There are some monitoring technical issues that are discussed below in Part 3.
Base Master Plan Modifications	If a change in land use is proposed that is inconsistent with the selected remedy for CAOC 35 or the land use recorded in the BMP for CAOC 35, the DTSC, the Water Board, and the U.S. EPA will be notified of such a change, and concurrence will be obtained before such a change is made.	The BMP was updated in 2010.

Table 7-6. CAOC 35 Stratum 1 Zone 1 - Third Five-Year Review (OU 5, OU 1 - Yermo Annex)

CAOC 35 – Part 2: Progress Since Last Review (2007)	
Protectiveness statements from last review	The selected remedy at CAOC 35 is considered protective in the short term as additional measures are required to address the observed increase in groundwater concentrations.
Status of recommendations and follow-up actions from last review	There were no recommendations or follow-up actions from the 2007 Five-Year Review (DON 2007).
Results of implemented actions, including whether they achieved intended purpose	N/A
Status of any other prior issues	No other prior issues identified.

CAOC 35 – Part 3: Technical Assessment (Based on 2011 – 2012 Data, Site Inspection, Review of Relevant Documents, and Interviews)	
A. Is the remedy functioning as intended by the decision documents?	
Cap Maintenance and Performance	A review of the "Annual Operation and Maintenance Reports for the CAOCs 7, 20, 23, AND 35" (2007 through 2011) indicated that inspection and maintenance of the monolithic cap and chain-link fence were performed quarterly over the five year review period. Some depressions and cracks formed in the cap and were repaired in one area in 2009 and then in a second area in 2010. Presently the cap and fence at CAOC 35 are in good condition. Erosion occurs along the north fence line (outside the cap area) during heavy rainfall events. Backfilling was performed in response to erosion events. A recommendation to reduce the frequency of weed abatement activities from quarterly to once or twice a year was provided in the 2010 Annual Report for the Long-Term Monitoring Activities at CAOCs 7, 20, 23, and 35. The DTSC provided concurrence with the report without additional comments on May 19, 2011. Monthly rainfall and soil moisture data is collected and reported in the Annual Operation and Maintenance Reports. Soil moisture beneath the cap remained relatively low through the review period. The "corrected" soil moisture data ranged 3.68 to 3.80 percent. However, a slight decrease in moisture content is usually noted during dry season, which seems to be correlated with the rainfall. There were some missing data from 2011 that is attributed to a malfunctioning instrument computer board. The circuit board/data processor at CAOC 35 was replaced in January 2012 to assure accurate data collection. The annual settlement monument survey data indicates some differential settlement has occurred. The presence of depressions and cracks (repaired in 2009 and 2010) support this statement. The last settlement survey performed in January 2011 showed a decrease in elevation by 0.07 ft at Monument #1 (previously it had remained consistent for 4 years) and 0.23 ft at Monument #2 (previously it showed a consistent decrease of 0.01 ft each year) in comparison to the baseline elevations established in 1999. However, in 2002, J.D. Cole & Associates reported that the corner of the

Table 7-6. CAOC 35 Stratum 1 Zone 1 - Third Five-Year Review (OU 5, OU 1 - Yermo Annex)

CAOC 35 – Part 3: Technical Assessment (Based on 2011 – 2012 Data, Site Inspection, Review of Relevant Documents, and Interviews)	
Cap Maintenance and Performance (continued)	concrete pad for CAOC 35 Monument #1 had been damaged, therefore skewing the original survey results (Terra Vac, 2007). So it's unclear whether Monument #1 is still damaged and could have moved. Therefore, re-establishment of the baseline survey and repair of Monument #1 (if necessary) is recommended. A visual inspection of the cap performed on March 29, 2012 found the cap to be in good shape with no visible cracks or defects; the surrounding fence surrounds the cap was also found to be in good condition. O&M costs are minimal, primarily associated with removal of trash from the fence lines and moisture monitoring. The remedy is cost effective and utilizes a permanent solution.
Groundwater Monitoring Results	Groundwater monitoring wells in the vicinity of CAOC 35 are shown in Figure 7-5. TCE and PCE concentration trends for several CAOC 35 monitoring wells presented in Figure E-3 in Appendix E. The figure indicates the following: • TCE and PCE concentrations up-gradient of the cap (wells YS35-8 and YS15-2) are relatively stable and below MCLs with one exception: well YS15-2 reported 5.1 µg/L in 2005. • TCE and PCE levels in wells located downgradient of the cap, including YEP-2 and YEP-3, are relatively stable and generally below MCLs. • TCE and PCE levels in YS35-3 have been above MCLs during the review period, but were actively remediated to below MCLs via AS/SVE (refer to CAOC 16) and hydraulic capture (refer to CAOC 37, GETS) in the latest sampling event in Nov 2011. PCE and TCE concentrations in YS35-4, though above MCLs, have been decreasing since 2010.
Institutional Controls	The LUC that is in place at CAOC 35 is restricted use of the site. No activities were observed that would have violated the LUC. No new uses of groundwater were reported and/or observed.
B. Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of the remedy still valid?	
Because the site conditions, surrounding land use, and potential receptors have not changed since the time of the remedy, the exposure assumptions are still valid. There have been no changes that impact the validity of technical assumptions, toxicity data, cleanup levels, and RAOs at this CAOC. Soils at this CAOC were impacted by VOCs, SVOCs, PAHs, TPH, and PCBs, with relatively limited (predicted) impacts to groundwater. A review of the OUs 5 and 6 ROD (DON, 1998b) indicates that the only change to toxicity data or cleanup levels for soil is a lowered PRG for arsenic. This change has no impact on the protectiveness of the remedy because arsenic was determined to be at background levels (BEI, 2003). In addition, the PRG decrease did not cause any soils that were not already above the PRGs to be above the PRGs. These changes do not affect the RAOs. Appendix C provides additional details on the review of changes in ARARs, toxicity data, and RAOs for this CAOC.	
C. Has any other information come to light that could call in to question the protectiveness of the remedy?	
During the third five-year review, no other information has come to light that could call into question the protectiveness of the CAOC 35 remedy	

Table 7-6. CAOC 35 Stratum 1 Zone 1 - Third Five-Year Review (OU 5, OU 1 - Yermo Annex)

CAOC 35 – Part 3: Technical Assessment (Based on 2011 – 2012 Data, Site Inspection, Review of Relevant Documents, and Interviews)	
Summary of Technical Assessments	The RAOs developed for CAOC 35 (OU 5) include: minimize water infiltration and potential future impact to groundwater, limit potential human exposure to buried waste, and maintain landfill closure ARARs. Groundwater monitoring for the CAOC has been conducted under OUs 1 and 2; monitoring data for downgradient wells YEP-2, YEP-3 continue to have non-detect or below MCL concentrations of VOCs. However, TCE and PCE levels in potentially downgradient wells, YS35-3, and YS35-4, have exceeded MCLs during the review period (these wells are also downgradient of CAOC 16). The MCL exceedances are being addressed by the CAOC 16 AS/SVE system and through hydraulic capture (refer to CAOC 37, GETS). Therefore the CAOC 35 remedy is protective of human health and the environment.

CAOC 35 – Part 4: Issues (Based on 2011 – 2012 Data, Site Inspection, Review of Relevant Documents, and Interviews)	
Issues identified during the technical assessment and other five-year review activities (e.g., site inspection)	1. Degradation of the fence post foundations noted on the north side of cap. 2. Damage to Settlement Monument #1 could skew the original survey results and requires resurvey. 3. Groundwater COCs exceeding MCLs are noted potentially downgradient of CAOC 35.
Determination of whether issues affect current or future protectiveness	Assuming the identified maintenance issues are addressed and groundwater capture/treatment continues under OU 1, the identified issues will not affect the current or future protectiveness of the remedy.
Discussion of unresolved concerns or items raised by support agencies and the community	Comments received and responses to comments are appended to this report (Appendix H).
Other comments/considerations: None.	

Table 7-6. CAOC 35 Stratum 1 Zone 1 - Third Five-Year Review (OU 5, OU 1 - Yermo Annex)

CAOC 35 – Part 5: Recommendations and Follow-up Actions (implementation under oversight authority of FFA)			
Recommendations / Follow-up Actions	**Parties Responsible for Implementation**	**Schedule for Completion**	**Comments**
1. Implementation of erosion best management practices to prevent degradation of the fence post foundations on north side of cap.	DON	Integrate in annual O&M program	none
2. Re-establish settlement monument baseline survey due to past damage to Monument #1.	DON	Before next cap survey event	none
3. Continue to monitor and treat COCs in groundwater downgradient of CAOC 35.	DON	Ongoing	Groundwater monitoring and treatment is performed under OU 1.

Acronyms and Abbreviations:

µg/L micrograms per liter
ARAR – applicable or relevant and appropriate requirement
AS/SVE – air sparge/soil vapor extraction
bgs – below ground surface
BEI – Bechtel Environmental, Inc.
BMP – Base Master Plan
BNI – Bechtel National, Inc.
CAOC – CERCLA Area of Concern
CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act
COCs – contaminants of concern
DoD – Department of Defense
DON – Department of the Navy
DTSC – Department of Toxic Substances Control
EPA – Environmental Protection Agency
FFA – Federal Facilities Agreement
GETS – Groundwater Extraction and Treatment System
ICs – institutional controls

Table 7-6. CAOC 35 Stratum 1 Zone 1 - Third Five-Year Review (OU 5, OU 1 - Yermo Annex)

Acronyms and Abbreviations (continued):

IMP – Integrated Maintenance Plan
LUCs – land use controls
LTGWMP – Long Term Groundwater Monitoring Plan
MCL – maximum contaminant level
MCLB – Marine Corps Logistics Base
N/A – not applicable
O&M – Operation and Maintenance
OU – Operable Unit
PAH – polynuclear aromatic hydrocarbon
PCB – polychlorinated biphenyl
PCE – tetrachloroethene
PRG – Preliminary Remediation Goal
RA – Remedial Action Report
RAO – remedial action objectives
RAR - Remedial Action Report
RBC – risk-based criteria
ROD – record of decision
ROICC – Resident Officer in Charge of Construction
SVOC – semivolatile organic compound
TCE – trichloroethene
TPH – total petroleum hydrocarbons
VOC – volatile organic compound

Table 7-7. Yermo Annex – Status of CAOCs with No Further Action and BMP Amendments

CAOC Description (see Figures 7-5 and 7-6 for Locations)	BMP Modifications[1]	2007 – 2012 Status[2]
CAOC 15/17 (OU 5)		
CAOCs 15/17 are the Oil Storage/Spillage Area and Industrial Wastewater Treatment Plant located in the northern part of Yermo Annex. Activities at CAOC 17 consisted of defueling operations and storage of an estimated 4,000 drums of waste oil and new lubricating oil. Primary waste operations at CAOC 15 consisted of defueling operations, emptying bilge waters contaminated with fuel, and storing waste oil; several releases of contaminated water and waste oil were documented. CAOC 17 consists of 14 evaporation basins associated with the wastewater treatment plant; overfills and spillages from the basins were documented. CAOC 17 partially overlaps CAOC 15. Shallow soils at these CAOCs were impacted by low levels of metals, TCE, PCBs, TPH (diesel range), and various pesticides. A TCRA was conducted in 1993 to remove residual sludge. Mathematical modeling indicated that soil contamination would have limited potential impacts to groundwater. A NFA remedy was chosen for the two CAOCs, as documented in the OUs 5 and 6 ROD (DON, 1998a). Because the incremental carcinogenic human health risks at this CAOC exceeded 1 x 10^{-6},a BMP amendment was required for information and future planning purposes.	**Total CAOC area**: 15.98 acres **Area requiring BMP Modification**: 15.98 acres **BMP Modifications, Sections 12.1 – 12.6**: • a history of the CAOC • low levels of PCBs, hexavalent chromium, and PAHs were detected in surface soils, and • Requirement that any actions planned or changes of onsite uses will be reviewed by the Environmental Division. • Description and map of area requiring BMP modification	The Environmental Division reviewed and approved construction of Building 601 on CAOC 15/17 Stratum 6. Soil tested prior to construction for VOCs; non-detect results. Construction completed October 2010. No other actions on the CAOC during the review period.
CAOC 18 (OU 3)		
CAOC 18 is the former Sludge Waste Disposal Area located in the eastern side of Yermo Annex. Soils at this CAOC are impacted by low levels of VOCs, SVOCs, chlorinated pesticides, PCBs, petroleum hydrocarbons, metals, and PAHs. Mathematical modeling indicated that soil contamination would have no potential impacts to	**Total CAOC area:** 5.2 acres **Area requiring BMP Modification**: Stratum 2 (0.48 acres); Stratum 3 (3.04 acres) **BMP Modifications, Sections 4.1 -4.6**: • A history of the CAOC	No actions were undertaken at CAOC 18 during the review period.

Table 7-7. Yermo Annex – Status of CAOCs with No Further Action and BMP Amendments

CAOC Description (see Figures 7-5 and 7-6 for Locations)	BMP Modifications[1]	2007 – 2012 Status[2]
(CAOC 18 [OU 3], continued) groundwater. A NFA remedy with BMP modifications was chosen for this CAOC, as documented in the OUs 3 and 4 ROD (DON, 1997).	• A description of the low levels of soil contaminants, and • Requirement that any actions planned or changes of onsite uses will be reviewed by the Environmental Division.	
CAOC 21 (OU 5)		
CAOC 21, the Industrial Waste Disposal Area, is located on a flat, open, unpaved area near Gate 5 at the eastern perimeter of the Yermo Annex. This CAOC was originally under OU 3. Sampling indicated that low levels of chlorinated pesticides, VOCs, SVOCs, PCBs, metals, and petroleum hydrocarbons were present. A TCRA was conducted in 1997 to remove PCB impacted soils. Mathematical modeling indicated that soil contamination would have very limited, if any, potential impacts to groundwater. A NFA remedy with BMP modifications was chosen for CAOC 21, as documented in the OUs 3 and 4 ROD (DON, 1997).	**Total CAOC area:** 9.96 acres **Area requiring BMP Modification:** 9.96 acres **BMP Modifications, Sections 13.1 – 13.6** • A history of the CAOC, • A description of the low levels of contaminants, and • Requirement that any actions planned or changes of onsite uses will be reviewed by the Environmental Division.	No actions were undertaken at CAOC 21 during the review period.
CAOC 23 (OU 3) Strata 5, 5(a)		
CAOC 23, known as the Landfill Area, is an irregular L-shaped area located at the south to southeast corner of the Yermo Annex that is sited between the railroad tracks (that serve the warehouse areas) and the industrial operations' perimeter fence. CAOC 23 was divided into six strata: Strata 1 and 3 are general storage areas located in the northeastern and north-central portions of the CAOC 23. The trenches that comprise Stratum 2 are located around the southwestern perimeter. Stratum 4 consists of the waste management area located in the south-central area of CAOC 23. Stratum 5, the potential waste burial area, and Stratum 5a, the PCB-impacted area, are sited in the western	**Total CAOC area:** 60 acres **Area requiring BMP Modification:** 60 acres **BMP Modifications, Sections 3.1 – 3.6 (for Stratum 5 and 5a):** • A history of the CAOC, • A description of pesticides and PCBs soil contaminants, and • Requirement that any actions planned or changes of onsite uses will be reviewed by the Environmental Division.	Surface grading was performed by the Base in 2011 in the NFA portion of the CAOC (Stratum 5/5A) to clear and level the area for military equipment storage. Additionally, footings for solar panel arrays were installed in a portion of Stratum 5/5A during 2012. These activities were coordinated with Base Environmental.

Table 7-7. Yermo Annex – Status of CAOCs with No Further Action and BMP Amendments

CAOC Description (see Figures 7-5 and 7-6 for Locations)	BMP Modifications[1]	2007 – 2012 Status[2]
(CAOC 23, continued portion of CAOC 23. Because the residual risk at Strata 5 and 5a exceeds 1 x 10^{-6}, the ROD requires that any actions**)** planned in these two strata that change the site use must be coordinated and reviewed by the Base Environmental Division. (A concrete cap installed at CAOC 23 Zone 1 is separately evaluated in Table 7-5).		
CAOC 26 (OU 5)		
CAOC 26, the Building 533 Waste Disposal Area, is located in the west-central portion of the Yermo Annex. Sampling indicated low levels of VOCs, SVOCs, pesticides, and metals above background levels. No PCBs were detected. An NFA remedy with BMP modifications was selected for this CAOC, as documented in the OUs 5 and 6 ROD (DON, 1998b). PCE contamination of the vadose zone and groundwater is addressed under OU 1 (see Table 7-2).	**Total CAOC area:** 0.95 acres **Area requiring BMP Modification:** 0.95 acres **BMP Modifications, Sections 14.1 through 14.6**: • A history of the CAOC, and • Requirement that any actions planned or changes of onsite uses will be reviewed by the Environmental Division.	No actions were undertaken at CAOC 26 during the review period. The Base has requested removal of the old remedial equipment from this area (see recommendations, Table 9-1).
CAOC 34 (OU 3) Stratum 1		
CAOC 34, the PCB Storage Area (former Building S-345) is located on the eastern side of the Yermo Annex adjacent to the western side of the MCLB Effluent Disposal Pond (Building 426). Stratum 1 is the area covered by former concrete basins and adjacent soils. Stratum 2 is the soils within the basins and Stratum 3 is the concrete basins themselves. Stratum 1 requires BMP modification. The PCB Storage Area consisted of Basin A (western basin) and Basin B (eastern basin), which were demolished and removed as a part of a TCRA in 1994. Sampling conducted prior to the RA indicated high levels of PAHs, phenol, organochlorine pesticides (OCPs), PCBs, and metals. TPH was present at low concentrations. The entire CAOC has been covered by concrete evaporation ponds. Mathematical modeling	**Total CAOC area:** 0.58 acres **Area requiring BMP Modification:** **BMP Modifications, Sections 5.1 – 5.6** • A history of the CAOC • A description of the low levels of the contaminants in soil, specifically the low levels of benzo[a]pyrene detected in the surface soils at Stratum 1, and • Requirement that any actions planned or changes of onsite uses will be reviewed by the Environmental Division.	No actions were undertaken at CAOC 34 during the review period.

Table 7-7. Yermo Annex – Status of CAOCs with No Further Action and BMP Amendments

CAOC Description (see Figures 7-5 and 7-6 for Locations)	BMP Modifications[1]	2007 – 2012 Status[2]
(CAOC 23, continued indicated that soil contamination would have very limited, if any, potential impacts to groundwater. An NFA remedy was selected for CAOC 34, as documented by the OUs 3 and 4 ROD (DON, 1997).		

Notes

1. February 2010 Updated Operable Units 1, 2, 3, 4, 5, and 6 Institutional Controls/Land Use Controls Section for MCLB Barstow Base Master Plan
2. Based on interviews with Mr. Jim Bustamante, IRP Manager, MCLB Barstow Environmental Division, conducted during January 2012 and April 26, 2012; site inspections conducted 29 March 2012.

Acronyms and Abbreviations:

BMP – Base Master Plan

CAOC – CERCLA Area of Concern

CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act

DON – Department of the Navy

IR – Installation Restoration

IRP – Installation Restoration Program

MCLB – Marine Corps Logistics Base

NFA – No Further Action

OU – Operable Unit

PAH - polynuclear aromatic hydrocarbon

PCB – polychlorinated biphenyl

RA - remedial action

ROD – Record of Decision

SVOC - semivolatile organic compound

TCE – trichloroethene

TCRA - Time-Critical Removal Action

TPH - total petroleum hydrocarbons

VOC - volatile organic compound

Table 7-8. CAOC 16 - New Construction on Hardstand Since 2007

BUILDING No.	BUILDING NAME	BLDG Area (sq. ft.)	YEAR BUILT	Type of Construction	Hardstand removed?	Thickness of new floor (inches)[1]
563	Decontamination Facility	2000	2010	Block foundation on top of hardstand	no	n/a
564	Breakroom[2]	400	2009	Modular on hardstand	no	n/a
574A	Personnel Support (Modular)	2400	2010	Modular on hardstand	no	n/a
574B	Multi-Purpose Facility (Modular)	5460	2010	Modular on hardstand	no	n/a
638	Machine Shop	22564	2010	New construction	Yes	12-in thick floor 24-in footings
639	Warehouse	2400	2010	bolted to the hardstand	no	n/a
602	Armored Vehicle Repair	n/a	2012	New construction[3]	no	existing floor 36-in footings
603	Light Armored Vehicle Repair	n/a	2012	New construction[3]	no	existing floor 36-in footings

Notes:

1. Sources: MCLB Barstow Environmental Division and MCLB Barstow Public Works; verified by contractor field engineer by visual inspection of building plans
2. Unable to verify construction of this building
3. Buildings constructed in late 2012; see related inspection/interview form in Appendix B for detail

Table 8-1. Nebo Main Base – CAOCs with Five-Year Review

OU	CAOC	CAOC Description	Remedy in Place	Review Summary Table
2	38	Nebo North plume	GETS (hydraulic control), AS/SVE (source area), Natural Attenuation (down-gradient plume)	Table 8-2
2	38	Nebo South (CAOC 6 soils were closed with NFA; groundwater is addressed under OU 2)	AS/SVE	Table 8-2
6	7	Strata 1 and 2: Drum Storage and Landfill Area Stratum 3: Former Drum Storage Area Stratum 4: Recreational Area	Strata 1 and 2 – landfill caps Strata 3 and 4: ICs/LUCs	Table 8-3
6	1	Landfill North of the Golf Course	NFA with BMP amendment	Table 8-4
4	2	Pesticide Storage and Washout Area	NFA with BMP amendment	Table 8-4
6	3	Wastewater Disposal Area	NFA with BMP amendment	Table 8-4
4	5	Chemical Storage Area (Strata 1 and 2)	NFA with BMP amendment	Table 8-4
6	7	Strata 3 and 4	BMP Amendment	Table 8-4
4	11	Fuel Burn Area	NFA with BMP amendment	Table 8-4
6	14	Drainage Channels and Mojave Riverbed Outfalls	NFA with BMP amendment	Table 8-4

Acronyms and Abbreviations:

AS/SVE – Air Sparging and Soil Vapor Extraction System
BMP - Base Master Plan
CAOC – CERCLA Area of Concern
CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act
GETS – Groundwater Extraction and Treatment System
ICs – Institutional Controls
IRP – Installation Restoration Program
LUCs – land use controls
NFA – no further action
OU – Operable Unit
ROD – Record of Decision

Table 8-2. CAOC 38 - Third Five-Year Review (OU 2 – Nebo Main Base)

CAOC 38 – Part 1: Review of Remedial Action Objectives, Selected Remedies, Implementation, Status, and Changed Conditions		
Nebo Main Base RAs, Monitoring	**Original Conditions, Investigations, and Responses**	**Changed Conditions Since ROD and Second Five-Year Review**
Applicable RODs	OUs 1 / 2 ROD (DON, 1998a) Nebo North RA and interim remedy for Nebo South; OU 2 ROD (DON, 2006) for Nebo South plume.	The Nebo North source area location was modified by documenting a Minor Change to the OUs 1 / 2 ROD (DON, 2011). The selected remedy of AS/SVE did not change; the source area location is now identified as former Building 50 (CAOC 10.12, OU 7).
Site Description and Figure References	CAOC 38 is the groundwater beneath the Nebo Main Base. It is impacted by dissolved phase VOCs in several locations. The OUs 1 / 2 ROD identified the Nebo North plume associated with Warehouse 2 (CAOC 3, OU 7) and the Nebo South plume associated with CAOC 6 (OU 6). The primary COCs are trichloroethene (TCE) and tetrachloroethene (PCE). The Nebo Main Base is shown on Figure 1-3; plume extents are shown on Figures 8-1 through 8-3. OU 2 includes groundwater monitoring for capped landfills under CAOC 7 (OU 6) and for pesticides (specifically, dieldrin) in groundwater at CAOCs 1, 2, 3, and 14 in the northern part of Nebo Main Base.	Since ROD signing, two additional areas of VOC contaminated groundwater have been identified. Groundwater contamination at monitoring well NPZ-14 and CAOC 10.38/10.39 Unit 7 is being addressed under OU 7 (Appendix F-3); these areas are not subject to Five-Year Review, but are discussed in Section 3.5.10 of the report.
Basis of Response, Interim Response Actions	Prior to approval of the OUs 1 / 2 ROD, groundwater VOC concentrations at Nebo Main Base were determined to pose a threat to human health and the environment. Two interim response actions were taken to address groundwater VOCs, as follows: • A pilot-study groundwater extraction and treatment system (GETS) was installed at the northern edge of Nebo Main Base to prevent off-site migration of the Nebo North plume, if needed. • A time-critical removal action (TCRA) was performed in June 1989 in response to the Nebo South VOC plume extending off-site and impacting a private residence's well (Figure 8-3). The private well was taken out of service and the residence connected to the Base potable water system (JEG, 1993).	None (no changes to identified COCs or original basis of response). Notes: The Nebo North GETS system was tested but has never been operated. The private residence has been vacant since circa 2006; the property was owned by a holding company and unoccupied during the review period.

Table 8-2. CAOC 38 - Third Five-Year Review (OU 2 – Nebo Main Base)

CAOC 38 – Part 1: Review of Remedial Action Objectives, Selected Remedies, Implementation, Status, and Changed Conditions		
Nebo Main Base RAs, Monitoring	**Original Conditions, Investigations, and Responses**	**Changed Conditions Since ROD and Second Five-Year Review**
Remedial Action Objectives	RAOs per the OUs 1 / 2 ROD: The selected RAOs for groundwater cleanup are the drinking water standards for specific VOCs (see Table 2-1, page 2-39, of the ROD), as follows: • The most stringent of federal and state MCLs • To be considered (TBC) risk-based criteria (RBC) where drinking water standards were not available (U.S. EPA Region 9 PRGs, August 1996). • Taste and odor objectives for toluene and xylenes as proposed by EPA, but not promulgated at the time of the ROD, as TBC standards (see Section 2.8.1 of the ROD). The RAO for vadose zone cleanup at MCLB Barstow is to remove contaminant mass in the subsurface soils to the degree necessary to 1) prevent further degradation of the groundwater above groundwater cleanup standards, and 2) minimize the aquifer cleanup time. Vadose zone soils cleanup goals are source-specific.	None (no change to RAOs) See Section 6.6 and Appendix C for review of exposure assumptions, toxicity data, cleanup levels, and RAOs.
Selected Remedy	**Nebo North:** • For the contaminated groundwater above MCLs within OU 2, the selected remedy for Nebo North consists of remediation of the vadose zone using AS/SVE, natural attenuation of the contaminant plume, fail-safe pump-and-treat of the groundwater with concentrations above drinking water standards, and institutional controls. • To ensure that human health and the environment are protected in the future, the ROD states that institutional controls will be implemented that include access restrictions to prevent the on-base use of untreated groundwater for domestic use, which includes ingestion, dermal contact, and inhalation as exposure routes. Wellhead treatment will be provided for any existing water supply wells that fall within the area of the plume exceeding MCLs. • The DON will provide necessary information to appropriate county agencies identifying off-Base areas impacted by groundwater contamination exceeding	None (selected remedies remain the same)

Table 8-2. CAOC 38 - Third Five-Year Review (OU 2 – Nebo Main Base)

CAOC 38 – Part 1: Review of Remedial Action Objectives, Selected Remedies, Implementation, Status, and Changed Conditions		
Nebo Main Base RAs, Monitoring	**Original Conditions, Investigations, and Responses**	**Changed Conditions Since ROD and Second Five-Year Review**
Selected Remedy (continued)	MCLs. The DON will support county agencies with any technical information needed for the county to implement restrictions on construction and use of wells in the affected areas. **Nebo South - final remedy in OU 2 ROD (DON, 2006):** • AS/SVE to remove VOCs from groundwater and the vadose zone in the source area. • LUCs, including access restrictions to prevent the use of untreated groundwater for drinking water in the area of the plume above MCLs. Other Remedy components under the OUs 1 / 2 ROD: • No new drinking water wells should be installed within the plume areas at Nebo North and Nebo South.	None (selected remedy remains the same)
Remedy Implementation	**Nebo North**: The Nebo North AS/SVE system began operation in October 2007 and operated until March 2011, when it was shut down with FFA regulatory concurrence (OTIE, 2011b). The AS/SVE system is maintained so that it can be operated to address potential rebounds in soil vapor concentrations. **Nebo South**: Operation of the existing pilot study AS/SVE system was continued along with related monitoring. Due to the low concentrations of VOCs in the influent stream and the VOC effluent emission rate falling well below the Mojave Desert Air Quality Management District's allowable levels of 39.6 lbs/day (DON, 2005) GAC replacement for the CAOC 6 AS/SVE system was discontinued. The soil vapor VOC concentrations are monitored to determine if there is a need for GAC treatment. The final LUC boundaries as determined in the OU 2 ROD (DON, 2006) and LUC Remedial Design document (DON, 2009a) were implemented in 2011 through installation of site boundary markers and signs, a survey to establish horizontal coordinates, and updating of the MCLB Barstow GIS database to incorporate the	N/A (system implemented during current review period) No change to remedy implementation

Table 8-2. CAOC 38 - Third Five-Year Review (OU 2 – Nebo Main Base)

CAOC 38 – Part 1: Review of Remedial Action Objectives, Selected Remedies, Implementation, Status, and Changed Conditions		
Nebo Main Base RAs, Monitoring	**Original Conditions, Investigations, and Responses**	**Changed Conditions Since ROD and Second Five-Year Review**
	LUC area boundaries.	
System Operations/O&M/ Monitoring	**Nebo North**: • O&M performed on an on-going basis in accordance with the O&M Manual for OUs 1 and 2, Addenda 5 through 7 (OTIE, 2010a; OTIE, 2011a; OTIE, 2011d). • Monitor the vadose zone and evaluate effectiveness of AS/SVE. • Monitor groundwater throughout the duration of the RA, estimated to take approximately 15 years, subject to evaluations of treatment and cost-effectiveness at 5-year intervals. **Nebo South**: • O&M performed on an on-going basis in accordance with the O&M Manual for OUs 1 and 2, Addenda 5 through 7 (OTIE, 2010a; OTIE, 2011a; OTIE, 2011d). • Monitor soil vapor in the vadose zone to measure the effectiveness of AS/SVE system operation. • Monitor groundwater at off-site wells on the adjacent property (Figure 8-3) • Monitor groundwater during operation of the AS/SVE system. Evaluate treatment and cost-effectiveness at 5-year intervals until RAOs are met.	**Nebo North:** With AS/SVE system shutdown in 2011, the monitoring program was reduced to annual sampling at selected wells. **Nebo South:** System operations were optimized to target residual plume mass; once groundwater concentrations decreased to MCLs, operation of the related AS/SVE wells were operated in standby mode.
ICs/LUC	BMP (Amended 2010), Section 19.4.1 states: "The development or use of contaminated groundwater for drinking water or domestic use without treatment is prohibited. The contaminated groundwater has been determined to be unsafe for drinking or domestic use as outlined in the ROD for OUs 1 and 2. Personnel planning to develop access to this contaminated groundwater must notify the Base Environmental Division. Any proposal for extraction and treatment of groundwater for treatment and use must ensure compliance with state and federal drinking water standards and be approved by the Base Environmental Division."	None Note: Nebo Main Base receives its potable water from an off-site private water purveyor; former production wells are not used except for irrigation of the on-Base golf course.

Table 8-2. CAOC 38 - Third Five-Year Review (OU 2 – Nebo Main Base)

CAOC 38 – Part 2: Progress Since Last Review (2007)	
Protectiveness statements from last review	**Nebo North**: The Nebo North plume has decreased in extent with several wells showing overall decrease in VOC levels. As of September 2007, the GETS has not been in operation because the plume has been shrinking. The remedy at Nebo North was considered protective of human health and the environment. **Nebo South**: The remedy was considered to be protective of human health and the environment in the short term. However, aging AS/SVE system components could impact long-term protectiveness by reducing remedial system effectiveness.
Status of recommendations and follow-up actions from last review	**Nebo North**: No recommendations were determined because the system was being installed during 2007. **Nebo South**: • **2007 Recommendation**: In order to address the aging CAOC 6 AS/SVE system components, evaluate the possibility of replacing system components and the associated impact versus continuing to service and repair the existing system components. • **2012 Update**: An Integrated Maintenance Plan (IMP) was implemented by the DON beginning in 2009 to facilitate identification and completion of remedial equipment repairs and upgrades. During the review period, numerous minor equipment repairs were completed along with one major upgrade – replacement of the malfunctioning old air compressor with a new, more energy-efficient model.
Results of implemented actions, including whether they achieved intended purpose	**Nebo North**: The AS/SVE system performed as intended to treat the Nebo North plume source. **Nebo South**: Repairs and upgrades improved remedial efficiency as intended, resulting in rapid declines in plume area and groundwater concentrations.
Status of any other prior issues	**Nebo North and Nebo South:** No other prior issues were identified. **Other Groundwater at Nebo Main Base:** • **2007 Recommendation:** The prior review recommended investigations into the persistent detections of TCE above the MCL at monitoring well NPZ-14. • **2012 Update:** During the review period, the DON reviewed historical site information and data for possible upgradient sources (Appendix F-3); however, no clear historical source was identified. The DON installed three additional monitoring wells in the vicinity of NPZ-14 in October 2011. Additional investigations are planned during 2012. This area of impacted groundwater and any sources identified will be incorporated into the OU 7 ROD.

Table 8-2. CAOC 38 - Third Five-Year Review (OU 2 – Nebo Main Base)

CAOC 38 – Part 3: Technical Assessment (Based on 2011 – 2012 Data, Site Inspection, Review of Relevant Documents, and Interviews)	
A. Is the remedy functioning as intended by the decision documents?	
Nebo North - AS/SVE in source area; natural attenuation; GETS for hydraulic control	• **Performance Standards**: The Nebo North AS/SVE system (October 2007 – March 2010) functioned as intended to reduce vadose zone and groundwater VOC concentrations in the plume source area (Appendix F provides supporting documentation). The Nebo North GETS has not been in operation since 1996 as the plume has been shrinking and contingency containment measures have not been needed. • **Monitoring:** The groundwater and soil vapor monitoring program was updated in the 2012 SAP and includes annual monitoring of selected wells in the source area and down-gradient extent. The monitoring well network and monitoring frequency appears to be sufficient for meeting project quality objectives. The 2011 monitoring data indicated only one monitoring well within the Nebo North plume with VOC concentrations slightly above the MCLs. Natural attenuation is expected to continue to function as intended to further reduce the presence of VOCs. • **O&M**: The Nebo North AS/SVE system was shut down in March 2011 but is maintained on a monthly basis in standby mode. The regular O&M program ensures the system can be restarted if necessary to address rebound in concentrations. In April and September 2012, the SVE system was restarted with focused operation in the northern part of the site to address a slight rebound in VOC concentrations in that area. The restart was done as a protective measure for groundwater, which has concentrations that remain below MCLs. • **O&M Costs**: Operational costs are reduced as the system is maintained in standby mode. Estimated operational costs for Nebo North are provided in Table 6-3; an analysis of O&M costs for OUs 1 and 2 is provided in Appendix D (D-3). • **Optimization**: As the AS/SVE system is in standby mode, no review of optimization opportunities was performed. The Nebo North GETS may be considered for permanent shutdown as the long-term groundwater COC concentration trends indicate this system is no longer needed as a contingency measure. An analysis of the data, as required by the ROD for assessing extraction system shutdown, is provided in Appendix F (F-1 Technical Assessment Report). • **Early indicators of potential remedy problems:** None identified.
Nebo South (CAOC 6) – AS/SVE	• **Performance Standards**: The Nebo South AS/SVE system was operated cyclically (one month per quarter) during most of the review period and is functioning as intended. System repairs and optimization measures improved VOC mass removal rates during the review period as compared to the prior period. The extent of the Nebo South TCE plume has decreased by 73% since 2007 and VOC levels in a majority of the wells have decreased well below MCLs. The rate of removal has declined due to the decrease in VOC mass in soil and groundwater. Appendix F provides the supporting documentation and analysis. • **Monitoring:** Monitoring activities are performed semiannually (off-base and boundary wells) and annually (on-base and off-base

Table 8-2. CAOC 38 - Third Five-Year Review (OU 2 – Nebo Main Base)

CAOC 38 – Part 3: Technical Assessment (Based on 2011 – 2012 Data, Site Inspection, Review of Relevant Documents, and Interviews)	
Nebo South (continued)	wells). Soil vapor is sampled only periodically or "as needed" based on very low concentrations produced by the SVE portion of the system. Off-Base groundwater is currently not used; off-Base groundwater monitoring data indicate TCE and PCE concentrations have been below MCLs since 2006 (see NEP-7, NEP-8, NEP-9 trend graphs in Appendix F). • **O&M**: The Nebo South AS/SVE system is maintained on a regular basis to keep the system functioning as intended. The mass removal rates have "flat-lined," indicating the system is approaching the limits of effectiveness. • **O&M Costs**: Operational costs are within range for an AS/SVE system. Estimated operational costs for Nebo South are provided in Table 6-3; an analysis of O&M costs for OUs 1 and 2 is provided in Appendix D (D-3 Report). Replacement of the air compressor in July 2011 caused an increase in O&M costs for that year; improved system performance is anticipated with this system upgrade. • **Optimization**: The DON has focused AS/SVE operations on remaining impacted areas, shutting down wells once groundwater concentrations fall below MCLs. No other opportunities for optimization were identified during the review. See the CAOC 6 AS/SVE system performance graph in Appendix F; only 19.2 pounds of total soil vapor VOCs have been removed since system startup. • **Early indicators of potential remedy problems:** None identified.
LUC/Institutional Controls:	• No new groundwater supply wells have been installed (or planned for installation) on or off Base within the boundaries of the Nebo South plume. • The LUC boundaries of CAOC 6 were demarcated and signs posted in October 2011; surveyed boundaries were entered into the Base GIS system in May 2012.
B. Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of the remedy still valid?	
Land-use and exposure assumptions remain unchanged. Toxicity data for TCE was changed by the U.S.EPA in 2011; however, the cleanup levels for groundwater (MCLs) including for TCE were unchanged since 2007. The change in toxicity criteria for TCE does not affect the selected remedy because the cleanup levels for groundwater (MCLs) remain relevant and unchanged since 2007. The RAOs remain protective. Appendix C provides a review of the relevant toxicity data changes.	
C. Has any other information come to light that could call in to question the protectiveness of the remedy?	
No other information has come to light that could call into question the protectiveness of the OU 2 remedies.	
Summary Of Technical Assessments	The RAs at CAOC 38 under OU 2 are performing or have performed as intended; the selected RAOs and remedies are still valid; no other information has come to light that calls into question the protectiveness of the remedy.

Table 8-2. CAOC 38 - Third Five-Year Review (OU 2 – Nebo Main Base)

CAOC 38 – Part 4: Issues (Based on 2011 – 2012 Data, Site Inspection, Review of Relevant Documents, and Interviews)	
Issues identified during the technical assessment and other five-year review activities (e.g., site inspection)	**Nebo North plume:** • Relatively low-concentration rebound of soil vapor VOCs was observed at the former wash stand area after one year of system shutdown; system restarted in April and September 2012 to address the rebound. Groundwater concentrations have remained below MCLs or non-detect in the treatment area in 2011 (one year after AS/SVE operation stopped). • The overall plume is significantly reduced and expected to continue to attenuate • The Nebo North GETS is no longer needed to be maintained in "standby mode" based on statistical analysis of groundwater VOC trends. **Nebo South AS/SVE system:** • The system may be approaching the limits of remedial effectiveness (See Appendix F for supporting data); the Nebo South plume has been significantly reduced and off-site VOC concentrations were below the MCLs during the review period.
Determination of whether issues affect current or future protectiveness	**Nebo North source area:** • Current or future protectiveness is not affected because the Nebo North AS/SVE system was operated until the RAOs were met and the potential utility of the system had been fully realized. Natural attenuation is expected to address the downgradient extent of the plume which is reduced to one monitoring well with slightly above MCL concentrations of PCE. **Nebo South AS/SVE system:** • Current or future protectiveness is not affected because of continued operation of the Nebo South AS/SVE system until RAOs are met and the FFA concurs with system shutdown.
Discussion of unresolved concerns or items raised by support agencies and the community	Comments received and responses to comments are appended to this report (Appendix H).
Other Comments, Considerations	• None

Table 8-2. CAOC 38 - Third Five-Year Review (OU 2 – Nebo Main Base)

CAOC 38 – Part 5: Recommendations and Follow-up Actions (implementation under oversight authority of FFA)			
Recommendations / Follow-up Actions	**Parties Responsible for Implementation**	**Schedule for Completion**	**Comments**
Permanently shut-down the Nebo GETS as the Nebo North plume has been significantly reduced, is contained entirely on the Base, and is unlikely to expand since the source area has been treated.	FFA regulatory review and approval; DON implementation	Upon FFA approval, determine a schedule	A statistical evaluation of Nebo North monitoring well data was performed and is presented in Appendix F (F-1 Report); the evaluation is consistent with the requirements of the OUs 1 and 2 ROD to determine system shutdown.
Continue monitoring of the Nebo North source area and downgradient portion of the plume in accordance with the current monitoring plan to ensure the selected remedy remains protective	DON	Annual monitoring	None
The Nebo South AS/SVE system is near or at the limits of effectiveness; rebound testing (6 months to 12 months of temporary system shutdown) is recommended once the remaining groundwater plume is reduced to below MCLs. If groundwater COC concentrations remain below MCLs during and following the rebound test, perform a technical and economic feasibility study of continued operation of the system and seek FFA approval for permanent shutdown.	DON, with FFA review and concurrence	Schedule to be determined based on additional monitoring data	None

Acronyms and Abbreviations:

AS/SVE – air sparge/soil vapor extraction

BMP – Base Master Plan

CAOC – CERCLA Area of Concern

Table 8-2. CAOC 38 - Third Five-Year Review (OU 2 – Nebo Main Base)

Acronyms and Abbreviations (continued):

CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act

DON – Department of the Navy

ESD – Explanation of Significant Differences

FFA – Federal Facility Agreement

GAC – granular activated carbon

GETS – groundwater extraction and treatment system

IC – institutional control

IMP – Integrated Maintenance Plan

LUC – land use control

MCL – maximum contaminant level

MCLB – Marine Corps Logistics Base

O&M – Operations and Maintenance

OU – Operable Unit

PCE - tetrachloroethene

RA – Remedial Action

RAOs – remedial action objectives

ROD – Record of Decision

TCE – trichloroethene

TEF – technical and economic feasibility

VOCs – volatile organic compounds

Table 8-3. CAOC 7 (OU 6) – Third Five-Year Review

CAOC 7– Part 1: Review of Remedial Action Objectives, Selected Remedies, Implementation, Status, and Changed Conditions		
Landfill Caps, ICs/LUCs	**Original Conditions, Investigations, and Responses**	**Changed Conditions Since ROD and Second Five-Year Review**
Applicable RODs	OUs 5/6 ROD (DON, 1998b) for caps and ICs/LUCs; OUs 1/2 ROD (DON, 1998a) for groundwater monitoring.	No changed surface conditions
Site Description and Figure References	CAOC 7 was operated as the principal solid waste landfill for MCLB Barstow from the early 1950s to 1964, and is located in the southeast portion of Nebo Main Base (Figure 1-3). Various chemicals from World War II and the Korean conflict were stored and, when possible, were reportedly burned and disposed of as part of the landfill operation. Drums with unknown contents or that were believed to contain extremely hazardous materials were stored in a bermed area. These materials included caustic soda and various pesticides. Around 1958, a major fire reportedly occurred in the drum storage area, leading to a relatively large spill. The area was covered with approximately 2 feet of soil in 1964. CAOC 7 consists of four strata (Figure 8-4): • Stratum 1: The eastern L-shaped landfill disposal area, with each leg measuring approximately 50 by 750 feet (southeast corner of Nebo) • Stratum 2: The western landfill disposal area, consisting of two separate trench areas; each trench area consists of two parallel trenches approximately 15 feet wide and ranging in length from 300 to 800 feet (south/central portion of Nebo) • Stratum 3: A drum storage and spillage area measuring approximately 900 by 900 feet (northwest of Stratum 1). Declared NFA per OU 5/6 ROD. • Stratum 4: The former playground area next to the amphibious vehicle test pond, also known as the "fish pond." Declared NFA per OU 5/6 ROD. Under OU 2, monitoring wells were installed in the vicinity of CAOC 7. Groundwater samples indicated that concentrations of VOCs were detected at or below their respective MCLs. It was noted that the landfill might have been a source of VOCs in the past, but there was uncertainty about a possible continuing release.	

Table 8-3. CAOC 7 (OU 6) – Third Five-Year Review

CAOC 7– Part 1: Review of Remedial Action Objectives, Selected Remedies, Implementation, Status, and Changed Conditions		
Landfill Caps, ICs/LUCs	**Original Conditions, Investigations, and Responses**	**Changed Conditions Since ROD and Second Five-Year Review**
Basis of Response, Interim Response Actions	VOCs and SVOCs, OCPs, metals, and TPH-d were detected at low levels. Impacts to groundwater were evaluated using mathematical modeling. Modeling indicated that lead and dieldrin detected at Stratum 1 may affect groundwater and that the projected concentrations of lead compounds in groundwater would be less than the projected concentration from background soils. Therefore, lead is not considered to have the potential to degrade water quality.	Groundwater impacted with TCE at concentrations greater than the MCL was first identified in November 2004 at NSP-2, a monitoring well located downgradient of Stratum 1 landfill cap.
Remedial Action Objectives	RAOs per the OUs 5 / 6 ROD: Relevant portions of the statutory determination for CAOC 7, Strata 1 and 2 (Section 1.5 of the OUs 5 and 6 ROD [DON 1998b]) are as follows: "The selected remedies for CAOC 7 Strata 1 and 2…use permanent solutions and alternative remediation technologies to the maximum extent practicable… Because hazardous substances remain in place at CAOC 7 Strata 1 and 2,… reviews will be conducted within 5 years of the start of the remedial actions at these CAOCs to ensure that the remedy continues to adequately protect human health and the environment. These selected remedies are protective of human health and the environment, comply with federal and state requirements that are legally applicable or relevant and appropriate to the remedial actions, and are cost-effective."	None (no change to RAOs)
Selected Remedy	OUs 5 / 6 ROD: • Strata 1 and 2: A single-layer native soil cap with institutional controls (signs posted along the periphery), and precipitation infiltration and groundwater monitoring. Other Remedy components under the OUs 1 / 2 ROD: • Monitoring of groundwater related to Strata 1 and 2 landfill caps is performed under OU 2.	An evaluation of additional remedial alternatives and/or enhancements to current remedy is being conducted as part of the preparation of the OU 7 Feasibility Study.

Table 8-3. CAOC 7 (OU 6) – Third Five-Year Review

CAOC 7– Part 1: Review of Remedial Action Objectives, Selected Remedies, Implementation, Status, and Changed Conditions		
Landfill Caps, ICs/LUCs	**Original Conditions, Investigations, and Responses**	**Changed Conditions Since ROD and Second Five-Year Review**
Remedy Implementation	As discussed in Section 4.3.5, the remedy selected at CAOC 7 (native soil cap monolithic) under the OUs 5 and 6 ROD (DON, 1998b) has been implemented successfully.	None
RA Operations/ O&M / Monitoring	The landfill caps are maintained in accordance with the Final Operations and Maintenance Manual, Closed Landfills at CAOCs 7 and 35 (Bechtel, 1999). Groundwater monitoring is performed under OU 2 on a semiannual and annual basis. Section 4.6.3 of the OUs 5 and 6 ROD (DON 1998b) states the following: "If any detection(s) in the first 5 years is above an MCL, then annual monitoring will be continued. After a detection above an MCL, if the next three consecutive annual monitoring events indicate that contaminant concentrations are above an MCL, then the remedy for the site will be reevaluated for compliance with the threshold criteria, and if necessary, the selected remedy will be revised or enhanced with the concurrence of the FFA signatories."	Beginning in November 2004, TCE groundwater concentration in NSP-2, a downgradient monitoring well for CAOC 7 Stratum 1, have generally exceeded the MCL. TCE has not been reported in the well upgradient of CAOC 7 (NS7-4), which indicated the waste under the capped landfill was the likely source of the TCE. In response, the DON began an evaluation of the remedy as required by the OUs 5 and 6 ROD. As such, an evaluation of additional remedial alternatives and/or enhancements to current remedy is being conducted as part of the preparation of the OU 7 Feasibility Study.
ICs/LUC	**Sections 1.4 and 4.0 of the OUs 5 and 6 ROD (DON 1998b), and Section 10.0 of the BMP (DON, 2010)** • A history of CAOC 7 Strata 3 and 4, • A description of the low levels of PCBs detected in surface soils, and • A stipulation that any actions planned or changes in site uses will be reviewed by the Environmental Division.	None. Note: Nebo Main Base receives its potable water from an off-site private water purveyor; former production wells are not used except for irrigation of the on-Base golf course.

Table 8-3. CAOC 7 (OU 6) – Third Five-Year Review

CAOC 7 – Part 2: Progress Since Last Review (2007)				
Protectiveness statements from last review:	The remedy for CAOC 7 (OU 6) is considered protective in the short-term because there is no evidence of current exposure. However, in order for remedy to remain protective in the long-term, the required actions included further assessment of the VOC detections at monitoring wells NSP-2 (down-gradient from CAOC 7 Stratum 1).			
Recommendations and follow-up actions from last review (Status Update)				
Issue	**Recommendations/Follow-up Actions**	**Milestone Date**	**Action Taken and Outcome**	**Date of Action**
TCE Concentrations in one downgradient well (NSP-2) have exceeded the MCL over the past three events. If TCE exceeds the MCL during the next groundwater monitoring event, a remedial revaluation may be required.	If TCE concentration from the next groundwater monitoring event exceeds the MCL, re-evaluate the remedy for the site for compliance with the threshold criteria, and if necessary, revise or enhance the selected remedy with the concurrence of the FFA signatories.	December 2008	The DON increased monitoring at NSP-2 to semi-annually and evaluated the performance of the Stratum 1 landfill cap as a follow-up action to the second five-year review. Additionally, the DON decided to investigate the cause of the NSP-2 MCL exceedance by collecting soil vapor samples from beneath the cap, and adding a groundwater monitoring well upgradient of the cap. In 2011, two soil vapor multi-screened monitoring wells were installed through the Stratum 1 landfill cap and sampled for VOCs (four screened depths per well). The additional groundwater monitoring well was installed within CAOC 7 Stratum 3, upgradient of NSP 2 and the cap. A sample of buried waste material was collected and found to be contaminated with VOCs. Data from the new vapor monitoring wells indicates the presence of VOCs in waste materials and soil vapors beneath the cap. The soil vapor concentrations extend to near the water table, indicating the buried waste is the likely source of the detected TCE in NSP-2. The DON is considering an SVE pilot study for VOC mass removal at Stratum 1.	Semiannual monitoring: 2009 – ongoing; Landfill cap evaluation: December 2009 (Tetra Tech, 2010C); Well installation: October 2011 (ATJV, 2012); soil vapor and groundwater sampling in November 2011, May 2012, and October/November 2012
Status of any other prior issues	No other issues identified.			

Table 8-3. CAOC 7 (OU 6) – Third Five-Year Review

CAOC 7 – Part 3: Technical Assessment (Based on 2011 – 2012 Data, Site Inspection, Review of Relevant Documents, and Interviews)	
A. Is the remedy functioning as intended by the decision documents?	
Stratum 1 Landfill Cap	• Based on the functional review of the Stratum 1 landfill cap, significant percolation of precipitation through the cap is not occurring. Soil moisture data is monitored on a regular basis using a soil moisture monitoring system. In addition, a rainfall gauge measures rainfall at regular intervals. Soil moisture and rainfall gauge data are downloaded bimonthly. Measured soil moisture contents are relatively constant at Stratum 1 at below 10%, and little to no variability over time was observed at each point (URS, 2003; TerraVac, 2004, 2005, and 2007; SES-TECH 2008 and 2009; SDV 2011; Sealaska 2012), indicating that the cap is functioning effectively. • Groundwater monitoring data indicated persistent concentrations of TCE in downgradient monitoring well NSP-2 during the majority of the review period (data trends provided in Appendix G). TCE concentrations exceeded the MCL in six out of seven samples collected semi-annually during the review period. NSP-2 is screened from 183 feet to 203 feet bgs; the water table was last measured at 185 feet bgs in November 2011 (ATJV, 2012). • Soil vapor samples of the vadose zone beneath the cap in November 2011 indicated the presence of elevated VOCs beneath the waste material and in declining concentrations with depth to above the water table. The soil vapor data indicate that migration of VOCs to the water table via soil vapor is likely occurring and causing the TCE contamination detected at NSP-2.
Stratum 2 Landfill Cap	Landfill cap O&M activities are performed quarterly in accordance with the ROD and the O&M Manual. O&M activities include: Inspection of the protective gravel cover and perimeter fence, weed eradication, and download of soil moisture and rainfall data. General maintenance activities were as follows: o In 2008, repairs were made to desert tortoise fencing, and washouts along the perimeter road. A monument settlement survey was conducted in September 2008. • Based on the functional review of the Stratum 2 landfill cap, significant percolation of precipitation through the cap is not occurring. As described for Stratum 1, soil moisture and rainfall data are regulatory monitored at Stratum 2. The measured soil moisture content was relatively constant at Stratum 2, and little to no variability over time was observed at each point (URS, 2003; TerraVac, 2004, 2005, and 2007; SES-TECH 2008 and 2009; SDVJV 2011; Sealaska 2012), indicating that the cap is functioning effectively. • Based on the available groundwater data, the remedy at Stratum 2 is performing as intended; however, only limited groundwater monitoring locations and no soil vapor data were available for this review.
Strata 3 & 4 ICs/LUCs	• The LUCs for Strata 3 and 4 are functioning as intended by the OUs.

Table 8-3. CAOC 7 (OU 6) – Third Five-Year Review

CAOC 7 – Part 3: Technical Assessment (Based on 2011 – 2012 Data, Site Inspection, Review of Relevant Documents, and Interviews)	
B. Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of the remedy still valid?	
Land-use and exposure assumptions remain unchanged; toxicity values for PCE changed but did not result in a change to the MCL; the cleanup levels for groundwater (MCLs) remain relevant and unchanged since 2007; therefore, the RAOs remain protective.	
C. Has any other information come to light that could call in to question the protectiveness of the remedy?	
No other information has come to light that could call into question the protectiveness of the CAOC 7 remedies.	
Summary Of Technical Assessments	The CAOC7 Stratum 1 landfill cap has prevented precipitation from entering the landfill wastes (based on routine moisture monitoring data), which was the intent of the cap design. However, the cap has not prevented migration of vapor-phase VOCs to the groundwater table, leading to TCE concentrations above the MCL downgradient of the cap. The lack of a completed exposure pathway (to human receptor from soil vapors or groundwater) indicates limited short-term concerns; however, long-term protectiveness of human health and the environment are not ensured. The remedies for Stratum 2, 3, and 4 are functioning as intended, and therefore are protective of human health and the environment.

CAOC 7 – Part 4: Issues (Based on 2011 – 2012 Data, Site Inspection, Review of Relevant Documents, and Interviews)	
Issues identified during the technical assessment and other five-year review activities (e.g., site inspection)	• Continued presence of TCE at above MCL concentrations in groundwater down-gradient of Stratum 1 landfill cap; • The presence of VOCs in soil vapor in the vadose zone beneath the Stratum 1 cap, distributed vertically to the groundwater table. • The presence of VOCs and other contaminants in capped waste material in direct contact with underlying soils with subsequent migration of volatile contaminants via vapor transport.
Determination of whether issues affect current or future protectiveness	• The presence of VOCs in the vadose zone is an issue primarily for contamination of groundwater; because no other land uses are allowed at CAOC 7, the soil vapor exposure route is currently incomplete. • Protectiveness of the selected remedy to address soil vapor and/or groundwater will be considered during the OU 7 Feasibility Study.
Discussion of unresolved concerns or items raised by agencies and community	Comments received and responses to comments are appended to this report (Appendix H).

Table 8-3. CAOC 7 (OU 6) – Third Five-Year Review

CAOC 7 – Part 4: Issues (Based on 2011 – 2012 Data, Site Inspection, Review of Relevant Documents, and Interviews)	
Other Comments, Considerations	The DON is considering an SVE pilot study using the existing vapor monitoring wells at CAOC 7 Stratum 1 cap

CAOC 7 – Part 5: Recommendations and Follow-up Actions (implementation under oversight authority of FFA)			
Recommendations / Follow-up Actions	**Parties Responsible for Implementation**	**Schedule for Completion**	**Comments**
Continue remedy evaluation at CAOC 7 in accordance with OUs 5 / 6 ROD and alternatives to address soil vapor and groundwater impacts in the OU 7 FS process.	DON, with FFA input and approvals	Draft OU 7 Feasibility Study anticipated by July 2012.	The DON is considering a pilot study for SVE to determine mass removal rates with that technology.

Acronyms and Abbreviations:

AGMR – Annual Groundwater Monitoring Report

AS/SVE – air sparge/soil vapor extraction

bgs – below ground surface

BMP – Base Master Plan

CAOC – CERCLA Area of Concern

CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act

COCs – contaminants of concern

DON – Department of the Navy

EPA – Environmental Protection Agency

FFA – Federal Facilities Agreement

ICs – institutional controls

IMP – Integrated Maintenance Plan

LUCs – land use controls

LTGWMP – Long Term Groundwater Monitoring Plan

Table 8-3. CAOC 7 (OU 6) – Third Five-Year Review

Acronyms and Abbreviations (continued):

MCL – maximum contaminant level

MCLB – Marine Corps Logistics Base

O&M – Operation and Maintenance

OU – Operable Unit

PCE – tetrachloroethene

RA – remedial action

RAO – remedial action objectives

RBC – risk-based criteria

ROD – record of decision

SAP – Sampling and Analysis Plan

TCE – trichloroethene

VOC – volatile organic compound

Table 8-4. Nebo Main Base – CAOCs with No Further Action and Groundwater Monitoring and/or BMP Amendments

CAOC Description (see Figure 8-6 for Locations)	BMP Modifications[1]/Groundwater Monitoring[2]	2007 – 2012 Status[3]
CAOC 1 (OU 6)		
CAOC 1 is a closed landfill located north of the golf course in the northern portion of the Nebo Main Base. Non-detectable or low concentrations of VOCs, SVOCs, OCPs, PCBs, metals, cyanide, and TPH-d were present in the samples collected at this site. A NFA remedy with BMP modifications was selected for CAOC 1, as documented by the OUs 5 and 6 ROD (DON, 1998b). Mathematical modeling indicated that residual dieldrin could migrate to the groundwater at concentrations that would contaminate or degrade the aquifer. To address this uncertainty, groundwater was monitored for dieldrin as a part of the OU 2.	**Modifications in Section 15.0 of the BMP** • a history of Strata 2 and 3, • a description of the activities that occurred for flood control purposes, • a legal description of the CAOC boundary, • the low levels of pesticides and PAHs detected in surface soils, and • A stipulation that any actions or changes in site use will be reviewed by the Environmental Division.	**Site Actions:** No actions were undertaken at CAOC 1 during of this review period.
	Groundwater Monitoring: Groundwater monitoring for dieldrin was performed annually at monitoring wells MW-F, NS2-1, and NS2-2 in the northern part of Nebo Main Base. Groundwater was monitored for dieldrin was performed annually until 2008, when dieldrin monitoring was ceased in accordance with the Long-term Groundwater Monitoring Plan (LTGMP) (DON, 1998a), Final Addendum 02 to Final Sampling and Analysis Plan, Revision 3 (OTIE, 2010b) and FFA concurrence (DTSC, 2010).	**Groundwater Monitoring:** Dieldrin was not detected above the reporting limit in annual samples from 2005 – 2008.
CAOC 2 (OU 4)		
CAOC 2 is a former Pesticide Storage and Washout Area located on the north side of the Nebo Main Base. Soil samples indicated the presence of DDT and its breakdown products, DDE and DDD, in addition to various other pesticide and herbicide compounds with relatively low	**Modifications in Sections 6.0 of the BMP** • A history of the CAOC, • A description of the low levels of pesticides detected in the surface soils, and • A stipulation that any actions planned or changes	**Site Actions:** No actions were undertaken at CAOC 2 during of this review period.

Table 8-4. Nebo Main Base – CAOCs with No Further Action and Groundwater Monitoring and/or BMP Amendments

CAOC Description (see Figure 8-6 for Locations)	BMP Modifications[1]/Groundwater Monitoring[2]	2007 – 2012 Status[3]
(CAOC 2 continued) potential for vertical migration or subsurface transport of contaminants due to the silty and clayey soils. Dieldrin concentrations were the only ones to exceed the residential soil risk-based criteria (RBCs). Fourteen metals exhibited concentrations that were statistically above background concentrations. All metals except thallium and lead were considered to be naturally occurring. Thallium and lead were considered potential site-related contaminants because they were commercially used in insecticides prior to 1965. A TCRA was conducted at CAOC 2 from August to September 1994, during which 318 tons of soil were excavated and removed for off-site disposal. A NFA remedy with BMP modifications was selected for CAOC 2, as documented in the OUs 3 and 4 ROD (DON, 1997). Mathematical modeling performed at CAOC 2 indicated that dieldrin could possibly migrate to the groundwater at concentrations that would contaminate or degrade the aquifer. To address this uncertainty, dieldrin was monitored under OU 2.	in site uses will be reviewed by the Environmental Division.	
	Groundwater Monitoring: Groundwater monitoring for dieldrin was performed annually at monitoring wells MW-F, NS2-1, and NS2-2 in the northern part of Nebo Main Base beginning in 1998. After several years of non-detects, dieldrin monitoring was ceased in accordance with the Long-term Groundwater Monitoring Plan (LTGMP) (DON, 1998a), Final Addendum 02 to Final Sampling and Analysis Plan, Revision 3 (OTIE, 2010b) and FFA concurrence (DTSC, 2010).	**Groundwater monitoring:** Dieldrin was not detected above the reporting limit in annual samples from 2005 – 2008.
CAOC 3 (OU 6)		
CAOC 3 is a former Wastewater Disposal Area located in the northern portion of the Nebo Main Base, adjacent to the southern boundary of CAOC 1. A NFA remedy with BMP modifications was selected for CAOC 3, as documented by the OUs 5 and 6 ROD (DON, 1998b). Investigation results indicated non-detectable or low concentrations of VOCs, SVOCs, several pesticides, and extractable petroleum hydrocarbons in soils. All detected metals present were believed to be naturally occurring or	**Modifications in Sections 16.0 of the BMP** • A history of the CAOC, • A description of the low levels of pesticides detected in the surface soils, and • A stipulation that any actions planned or changes in site uses will be reviewed by the Environmental Division.	**Site Actions:** No actions were undertaken at CAOC 3 during of this review period.

Table 8-4. Nebo Main Base – CAOCs with No Further Action and Groundwater Monitoring and/or BMP Amendments

CAOC Description (see Figure 8-6 for Locations)	BMP Modifications[1]/Groundwater Monitoring[2]	2007 – 2012 Status[3]
CAOC 3 (continued) present at concentrations of minor concern from a human health perspective. Mathematical modeling performed at CAOC 3 indicated that residual dieldrin in the soil could migrate to the groundwater at concentrations that would contaminate or degrade the aquifer. To address this uncertainty, dieldrin was monitored under OU 2.	**Groundwater Monitoring**: Groundwater monitoring of dieldrin and other pesticides was performed annually at monitoring wells MW-F, NS2-1, and NS2-2 in the northern part of Nebo Main Base beginning in 1998. After several years of non-detects, dieldrin monitoring was ceased after 2008 in accordance with the Long-term Groundwater Monitoring Plan (LTGMP) (DON, 1998a), Final Addendum 02 to Final Sampling and Analysis Plan, Revision 3 (OTIE, 2010b) and FFA concurrence (DTSC, 2010).	**Groundwater monitoring:** Dieldrin monitoring for dieldrin stopped after 2008; no other groundwater monitoring for this CAOC performed.
CAOC 5 (OU 4) (see also Figure 8-7)		
CAOC 5, the Chemicals Storage Area, is located in the southeastern portion of the Nebo Main Base, north of the Drum Storage Area and Landfill (CAOC 7), and south of Joseph Boll Avenue. A NFA remedy with BMP modifications was selected for CAOC 5, as documented in the OUs 3 and 4 ROD (DON, 1997). A variety of lower-level detections were present throughout the site including VOCs, SVOCs, OCPs, phenol, PCBs, TPH, PAHs, and metals. Mathematical modeling indicated that soil contamination would have no potential impacts to groundwater.	**Modifications in Sections 7.0 of the BMP** • A history of the CAOC, • A description of the low levels of pesticides detected in the surface soils, • The presence of desert mix/dust suppression material, and • A stipulation that any actions planned or changes in site uses will be reviewed by the Environmental Division.	**Site Actions:** Environmental Division reviewed and approved DRMO Surplus Equipment Storage on Stratum 1 - Lot 351, beginning in Fall 2009. Expansion of storage to Lot 357 was in discussion at time of this review. The DON performed OU 7 investigative activities that included the installation of several monitoring wells within the CAOC 5 boundary in 2009 and 2011. The locations of the wells were coordinated with the Environmental Division.
CAOC 7 (OU 6) Strata 3 and 4		
CAOC 7 is the Drum Storage and Landfill Areas in the	**Modifications in Sections 10.0 of the BMP**	The DON performed OU 7 investigative activities that included

Table 8-4. Nebo Main Base – CAOCs with No Further Action and Groundwater Monitoring and/or BMP Amendments

CAOC Description (see Figure 8-6 for Locations)	BMP Modifications[1]/Groundwater Monitoring[2]	2007 – 2012 Status[3]
(**CAOC 7 continued**) southwest portion of Nebo Main Base. CAOC 7 was operated as the principal solid waste landfill for the Base from the early 1950s to 1964. Strata 1 and 2 are under landfill covers and are discussed in Section 8.3 of the main text. Stratum 3 is a drum storage and spillage area identified during the aerial photograph review measuring approximately 900 by 900 feet. Stratum 4 is the former playground area next to the amphibious vehicle test pond also known as the "fish pond." The playground next to the fish pond was identified as a sampling stratum because of the potential impact to the area from landfill activities. However, the recreation equipment has since been removed, thus minimizing the exposure potential in this area.	• A history of the CAOC, • A description of the low levels of metals, VOCs, and SVOCs detected in the surface soils, • A stipulation that any actions planned or changes in site uses will be reviewed by the Environmental Division.	the installation of a monitoring well in Stratum 3 of CAOC 7. The location of the well was coordinated with the Environmental Division.
CAOC 11 (OU 4)		
CAOC 11, the Fuel Burn Area, is located in the southwest portion of the Nebo Main Base between I-40 to the north and the Base boundary to the south. Soil sample analysis indicated the presence of SVOCs, pesticides, TPH, and total recoverable petroleum hydrocarbons (TRPH). Mathematical modeling indicated that soil contamination would likely not impact groundwater. A NFA remedy with BMP modifications was selected for CAOC 11, as documented in the OUs 3 and 4 ROD (DON, 1997).	**Modifications in Sections 8.0 of the BMP** • A history of the CAOC, • A description of the low levels of pesticides detected in the surface soils, and • A stipulation that any actions planned or changes in site uses will be reviewed by the Environmental Division.	**Site Actions:** No actions were undertaken at CAOC 11 during of this review period.
CAOC 14 (OU 6)		
CAOC 14 consists of the three major stormwater drainage channels that constitute the Nebo Main Base surface drainage system and four outfalls that discharge into the Mojave River.	**Modifications in Sections 17.0 of the BMP** • A history of the CAOC, • A description of the low levels of pesticides detected in soils, and	**Site Actions:** No actions were undertaken at CAOC 14 during of this review period.

Table 8-4. Nebo Main Base – CAOCs with No Further Action and Groundwater Monitoring and/or BMP Amendments

CAOC Description (see Figure 8-6 for Locations)	BMP Modifications[1]/Groundwater Monitoring[2]	2007 – 2012 Status[3]
(**CAOC 14, continued**) During the remedial investigation of CAOC 14, each channel and outfall was inspected and sampled. Samples were analyzed for VOCs, SVOCs, OCPs, PCBs, metals, cyanide, and TPH-d. VOCs were not present in the samples with the exception of a single detection, which was assumed to be the result of laboratory contamination. SVOCs were present; however, they were present at levels below residential risk-based concentrations (RBCs). Pesticides were detected at varying levels throughout each of the samples. PCBs were detected in isolated samples. Metals detected in all samples were believed to be naturally occurring or present at concentrations of minor concern from a human health perspective. The potential for impacts to groundwater from CAOC 14 was evaluated by mathematical modeling, which indicated that groundwater concentration of each of the detected soil contaminants would be below their respective RBCs and maximum contaminant levels (MCLs), except for dieldrin and gamma-chlordane in the northern portion of Nebo. To address this uncertainty, pesticides were monitored under OU 2. NFA remedy with BMP modifications was selected for CAOC 14, as documented in the OUs 5 and 6 ROD (DON, 1998b).	• A stipulation that any actions planned or changes in site uses will be reviewed by the Environmental Division.	The Environmental Division is reviewing potential electrical cable runs that would cross CAOC 14 (probably below surface) at one or two locations on the west side of the Nebo Main Base. No effect on the NFA remedy is anticipated by the proposed cable crossing.
	Groundwater Monitoring: Groundwater monitoring of dieldrin and other pesticides was performed annually at monitoring wells MW-F, NS2-1, and NS2-2 in the northern part of Nebo Main Base beginning in 1998. After several years of non-detects, dieldrin monitoring was ceased after 2008 in accordance with the Long-term Groundwater Monitoring Plan (LTGMP) (DON, 1998a), Final Addendum 02 to Final Sampling and Analysis Plan, Revision 3 (OTIE, 2010b) and FFA concurrence (DTSC, 2010).	**Groundwater monitoring:** Dieldrin monitoring for dieldrin stopped after 2008; no other groundwater monitoring for this CAOC performed.

Notes:

1. February 2010 Updated Operable Units 1, 2, 3, 4, 5, and 6 Institutional Controls/Land Use Controls Section for MCLB Barstow Base Master Plan
2. Draft Final Operable Units 1-6, Long-Term Groundwater Monitoring Plan. July 1998; Sampling and Analysis Plans for Operation and Maintenance of Yermo Annex and Nebo Main Base Groundwater Remediation Systems, MCLB, Barstow, California (1998 through 2012)
3. Based on interviews with Mr. Jim Bustamante, IRP Manager, MCLB Barstow Environmental Division, conducted during January 2012 and March-April 2012; site inspections conducted 29 March 2012.

Table 8-4. Nebo Main Base – CAOCs with No Further Action and Groundwater Monitoring and/or BMP Amendments

Acronyms and Abbreviations:

BMP – Base Master Plan

CAOC – CERCLA Area of Concern

CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act

DDT - dichlorodiphenyltrichloroethane

DDE - dichlorodiphenyldichloroethene

DDD - dichlorodiphenyldichloroethane

DON – Department of the Navy

FFA – Federal Facility Agreement

IRP – Installation Restoration Program

MCL – maximum contaminant level

MCLB – Marine Corps Logistics Base

OU – Operable Unit

PCB – polychlorinated biphenyl

RBC – Risk Based Concentrations

RI – Remedial Investigation

ROD – Record of Decision

SVOCs – semivolatile organic compounds

TCRA – time critical removal action

TPH – total petroleum hydrocarbons

TRPH - total recoverable petroleum hydrocarbons

VOCs – volatile organic compounds

Table 9-1. Issues Identified at Yermo Annex

CAOC	OU	Issues Identified During Five-Year Review	Do the identified issues affect short-term protectiveness?	Do the identified issues affect long-term protectiveness?
CAOCs with Remedial Systems and/or Caps in Place				
37	1	The Yermo North plume was relatively stable during the five-year review period. While improved hydraulic control is expected with installation of two new extraction wells, the presence of a continuing source beneath CAOC 16 and vicinity is suspected. Persistent VOC concentration in soil vapor monitoring wells adjacent to Building 573 in another indication of source. The CAOC 16 SVE system has removed approximately 650 lbs of total VOCs during 2007 - 2011, and the performance curve indicates continued climb in the mass removal rate. The radii of influence of the existing SVE wells do not extend as far as Building 573 thus the current SVE system is not optimal for reducing VOC mass from beneath the building. During the site inspection, some erosion around AS/SVE wells located in the area north of CAOC 16 and east of CAOC 35 was noted. Additionally, the IRP Manager noted that additional signage around the Yermo GETS infiltration galleries area would prevent DRMO equipment from being parked there, potentially damaging the galleries.	No, short-term protectiveness is provided by the continued operation of the remedies in place for CAOC 37 groundwater. On-Base and off-Base drinking water supplies are protected by GAC systems.	The remedies in place for CAOC 37 groundwater, if properly maintained, will continue to be protective of human health and the environment.
16	5	The CAOC 16 hardstand is maintained as intended by the ROD; surface cracks in the hardstand are scheduled for repairs by MCLB Barstow during 2012. Conservative modeling of soil vapor VOC concentrations at Building 573 does not indicate a concern for vapor intrusion exposure (Appendix D, D-1). However, VOC migration to groundwater may not be prevented by the hardstand due to vapor-phase migration of VOCs.	No, short-term protectiveness is provided by current remedy	No, long-term protectiveness is provided by current remedy.
20	3	The cap is maintained as required and no groundwater impacts have been identified related to this CAOC.	N/A	N/A

Table 9-1. Issues Identified at Yermo Annex

CAOC	OU	Issues Identified During Five-Year Review	Do the identified issues affect short-term protectiveness?	Do the identified issues affect long-term protectiveness?
23	3	None; cap is maintained as required and no groundwater impacts have been identified related to this CAOC.	N/A	N/A
35	5	Identified issues include needed improvements in best management practices to prevent fence post erosion and resurveying of a broken survey monument. Also noted is the continued presence of VOCs in groundwater exceeding the MCLs in two monitoring wells potentially downgradient of CAOC 35 (these wells are also downgradient of CAOC 16).	No, shot-term protectiveness is ensured by cap maintenance.	No, long-term protectiveness is ensured by the maintained cap and the OU 1 groundwater treatment systems.
CAOCs with No Further Action and Base Master Plan Amendments				
15/17	5	None	N/A	N/A
18	3	None	N/A	N/A
21	3	None	N/A	N/A
26	5	AS/SVE system is obsolete and is recommended to be removed.	No, short-term protectiveness is provided by current remedy	No, long-term protectiveness is provided by current remedy.
34	3	None	N/A	N/A

Abbreviations and Acronyms:

AS/SVE – air sparging/soil vapor extraction
CAOC – CERCLA Area of Concern
CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act
DRMO – Defense Reutilization Materials Office
GETS – Groundwater Extraction and Treatment System
N/A – not applicable
O&M – Operations and Maintenance
OU – Operable Unit
VOC – volatile organic compound

Table 9-2. Issues Identified at Nebo Main Base

CAOC	OU	Issue	Currently Affects Protectiveness	Affects Future Protectiveness
1	6	None	N/A	N/A
2	4	None	N/A	N/A
3	6	None	N/A	N/A
5	4	None	N/A	N/A
7	6, 7	CAOC 7 (Stratum 1 landfill cap). A remedy evaluation was required by the OUs 5 and 6 ROD due to persistent exceedances of TCE in downgradient monitoring well (NSP-2). An evaluation of the cap indicated it was performing as intended by the ROD to prevent infiltration of moisture. However, additional investigation identified VOCs in soil vapor under the landfill cap to approximately 185 feet below ground surface. The DON is considering appropriate response actions to the subsurface VOC impacts at CAOC 7 Stratum 1 under the OU 7 ROD (anticipated to be finalized by March 2014).	No, there are no known groundwater receptors, and the cap is maintained.	Yes – potential future protectiveness issues if not addressed
11	4	None	N/A	N/A
14	6	None	N/A	N/A
38	2	Relatively low-concentration rebound of soil vapor VOCs was observed at the former wash stand area after one year of system shutdown; system restarted in April and September 2012 to address the rebound as a protective measure for groundwater. Groundwater concentrations have remained below MCLs or non-detect in the treatment area in 2011 (one year after AS/SVE operation stopped). The overall plume is significantly reduced and expected to continue to attenuate.	No, RAOs continue to be met by current remedy.	No, assuming continued monitoring and appropriate response action if required.
		The Nebo North GETS is no longer needed based on statistical analysis of long-term monitoring data and can be permanently decommissioned.	No	No
		Nebo South (CAOC 6). Significant plume reduction was achieved during the review period. The system is nearing the limits of effectiveness. If groundwater concentrations fall below MCLs, perform rebound testing for 6 – 12 months and, if groundwater COCs remain below MCLs, consider performing Technical and Economic Feasibility study for system shutdown.	No	No

Table 9-2. Issues Identified at Nebo Main Base

Abbreviations and Acronyms:

AS/SVE – air sparging/soil vapor extraction
CAOC – CERCLA Area of Concern
CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act
GETS – groundwater extraction treatment system
MCL – maximum contaminant level
N/A – not applicable
OU – Operable Unit
ROD – Record of Decision
TCE – trichloroethene
VOC – volatile organic compound

Table 9-2. Issues Identified at Nebo Main Base

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Table 9-3. Issues and Recommendations Summary

CAOC	OU	Issue	Recommendations/Follow-up Actions	Milestone Date	Other Considerations
37	1	The Yermo North plume remained stable during the review period; that is, the plume neither expanded nor retreated and the estimated plume mass did not change. The addition of two new extraction wells in 2010 and 2012 is anticipated to change the plume dimensions and center mass due to improved hydraulic control. Soil vapor data in three multi-level monitoring wells installed as part of the OU 1 remedy continue to show soil vapor VOC concentrations beneath CAOC 16. Conservative modeling shows the soil vapor VOCs are not an inhalation risk to on-site workers (see OU 5 review). However, the presence of soil vapor VOCs and the stable Yermo North groundwater plume are indications of an on-going contaminant source or sources that are not being effectively addressed by the current configuration of the remedy.	Engage the FFA to follow the process recommended in the OUs 1 and 2 ROD for evaluation of the existing OU 1 remedy (for Yermo North plume). As part of that process, consider life-cycle cost analysis of existing versus amended approach, additional investigation and/or pilot studies to identify source(s) beneath CAOC 16, and appropriate amended remedial response actions.	Begin FFA discussions by July 2013	OUs 1 and 2 ROD Section 2.8.7, pages 2-25 to 2-26 defines the review process for a technical and economic feasibility study of the existing remedy.
37	1	The Yermo North plume continued to be present off-Base during this five-year review period; however, the addition of two new extraction wells in 2010 and 2012 is anticipated to improve hydraulic control.	Evaluate once/year the effectiveness of the extraction well network in controlling migration of the Yermo North plume; optimize groundwater extraction rates to maximize plume control while reducing energy consumption	Include evaluations in Annual Groundwater Monitoring Reports, system optimization reports or O&M Manual updates.	Use multiple lines of evidence including COC concentrations, flow-modeling, mass removal rates, energy-consumption rates, and changes in plume dimensions and volume over time. If hydraulic containment is improved, and the plume is captured completely on Base, revisit the 2005 "Explanation of Significant Difference" for four off-Base extraction wells as specified in the OUs 1 and 2 ROD.
37	1	Aging remedial equipment may need to be replaced; additionally the relatively high energy costs associated with the CAOC 16 AS/SVE blower and compressor are not justified by the relatively low mass removal rates	Continue the Integrated Maintenance Plan to address remedial system and well repairs, upgrades, and maintenance to ensure optimal performance of existing systems, and continue system optimization measures to improve efficacy and reduce energy consumption.	The IMP is in place to ensure on-going repairs; perform OU 1 RA optimization review by May 2013	Energy use reduction strategies may be considered for the CAOC 16 AS/SVE system such as upgrades to more energy efficient equipment or optimized operational parameters.
37	1	During the site inspection, some erosion around AS/SVE wells located in the area north of CAOC 16 and east of CAOC 35 was noted. Additionally, the IRP Manager noted that additional signage around the Yermo GETS infiltration galleries area would prevent DRMO equipment from being parked there, potentially damaging the galleries.	Repair erosion around AS/SVE wells located in the area north of CAOC 16 and east of CAOC 35. Add signage around the Yermo GETS infiltration galleries area to prevent any other use of the area.	Complete repairs and add signage by December 2013	None
37	1	The off-base residential wells treatment systems were regularly maintained; however one residence belonging to Hodges was reportedly unoccupied and the well inoperable. This information was not directly verified with the property owner.	Contact the off-site property owner for Hodges residence and obtain access agreement to perform (at minimum) an inspection of the GAC treatment system	By December 2012	None
37	1	Chromium and/or nickel in groundwater have not yet been determined to be site-related contaminants; however, recently implemented well-cleaning and updated sampling procedures are anticipated to result in a representative data set available for statistical analysis.	Evaluate groundwater metals data statistically to determine if chromium and nickel are COCs and require further investigation and/or remedial action.	By July 2014 or as soon as sufficient comparable data are acquired for statistical evaluation	Perform in accordance with SAP Ver. 4 and LTGWMP
38	2	Permanently shut-down the Nebo GETS as the Nebo North plume has been significantly reduced, is contained entirely on the Base, and is unlikely to expand since the source area has been treated.	Decommission Nebo North GETS; the ROD-specified shut-down criteria have been met and the system is no longer needed.	Upon FFA approval, determine a schedule	A statistical evaluation of Nebo North monitoring well data was performed and is presented in Appendix F (F-1 Report); the evaluation is consistent with the requirements of the OUs 1 and 2 ROD to determine system shutdown.
38	2	Slight rebound of soil vapor VOC concentrations in the Nebo North source area indicates possible residual contaminant mass.	Continue monitoring of the Nebo North source area and downgradient portion of the plume in accordance with the current monitoring plan to ensure the selected remedy remains protective.	Annual monitoring	None
38	2	The Nebo South AS/SVE system may soon reach or has reached the limits of effectiveness of the system	Nebo South AS/SVE system is near or at the limits of effectiveness; perform rebound testing (6 months to 12 months of temporary system shutdown; consider the technical and economic feasibility study.	Schedule to be determined based on additional monitoring data	None
38	2	Groundwater impacts in the vicinity of isolated monitoring well NPZ-14, in southwestern Nebo Main Base, are being investigated and will be addressed under the OU 7 Feasibility Study and ROD. Groundwater issues identified during the OU 7 Remedial Investigation of CAOC 10.38/10.39 Unit 7 will also be dealt with under the OU 7 FS and ROD.	None	N/A	The Draft OU 7 Feasibility Study is was submitted to the FFA in August 2012.
18, 20, and 34 (1)	3	No issues identified	None	N/A	An evaluation of the previously-identified issue of gross alpha exceedances at CAOC 20 was performed by the Navy in 2009 – 2010. The outcome of the evaluation, as approved by the FFA regulators, was to revise the groundwater sampling procedure to include filtration of groundwater samples, clean and redevelop turbid wells, and replace gross alpha with tritium as more representative of radionuclides that could potentially originate from CAOC 20. Based on groundwater data to date, no contamination from CAOC 20 is suspected
23 Strata 3, 5, 5a	3	Surface grading for equipment storage and solar panel footings installed at CAOC 23 Strata 5/5A under Environmental Division oversight per the BMP	None	N/A	None
2, 5, 9, and 11	4	No issues identified	None	N/A	None
15/17, 21, 35(2E)	5	No issues identified.	None	N/A	None

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Table 9-3. Issues and Recommendations Summary

CAOC	OU	Issue	Recommendations/Follow-up Actions	Milestone Date	Other Considerations
16	5	Observed cracking of the exterior cap appeared to affect only the surface of the concrete and is scheduled for repair by the Base; therefore, short-term protectiveness is not affected.	Repair existing surface cracks on hardstand; continue maintenance of the concrete surface to ensure long-term protectiveness	During next five year period	None
26	5	The remedial system components (AS/SVE system and extraction wells) have been shutdown since 1998 and are not actively maintained.	Permanent decommissioning of the extraction wells (removal of downhole equipment, and safety shutdown of electrical) and removal of above-ground remedial equipment from the AS/SVE compound is recommended.	During next five year period	None
35	5	Specific O&M issues were identified regarding landfill cap erosion controls and resurvey of a settlement monument.	During routine O&M, address the identified issues including the implementation of erosion controls and resurvey of a settlement monument.	During routine O&M	None
1, 3, 4, 6, 8, 12, 13, and 14	6	No issues identified.	None	N/A	Groundwater cleanup and monitoring at CAOC 6 is proceeding under OU 2 (Nebo South)
7	6	The DON investigated conditions under the CAOC 7 Stratum 1 landfill cap in 2011 in response to persistent above-MCL detections of TCE in a downgradient monitoring well. The cap was evaluated and appears to be functioning as intended by the ROD to prevent infiltration of moisture; however, the presence of VOC-contaminated wastes and VOCs in soil vapor beneath the Stratum 1 cap indicates the wastes are the likely source of the detected groundwater impacts	For CAOC 7 Stratum 1 consider appropriate response actions for sub-landfill impacts under the OU 7 feasibility study and incorporate into the OU 7 ROD.	The OU 7 Feasibility Study is anticipated to be finalized in Februrary 2013; the OU 7 ROD is anticipated to be finalized in March 2014.	The DON is considering an SVE pilot study using the existing vapor monitoring wells at CAOC 7 Stratum 1 cap

Acronyms and Abbreviations :
AS/SVE – air sparge/soil vapor extraction
BMP – Base Master Plan
CAOC – CERCLA Area of Concern
CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act
COCs – contaminants of concern
FFA – Federal Facilities Agreement
GETS - groundwater extraction and treatment system
ICs – institutional controls
IMP - Integrated Maintenance Plan
LTGWMP – Long Term Groundwater Monitoring Plan
LUCs – land use controls
MCLB – Marine Corps Logistics
O&M – Operation and Maintenance
OU – Operable Unit
PCE – tetrachloroethene
RAO – remedial action objectives
ROD – record of decision
SAP - Sampling and Analysis Plan
TCE – trichloroethene
VOC – volatile organic compound

Table 9-3. Issues and Recommendations Summary

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Figures

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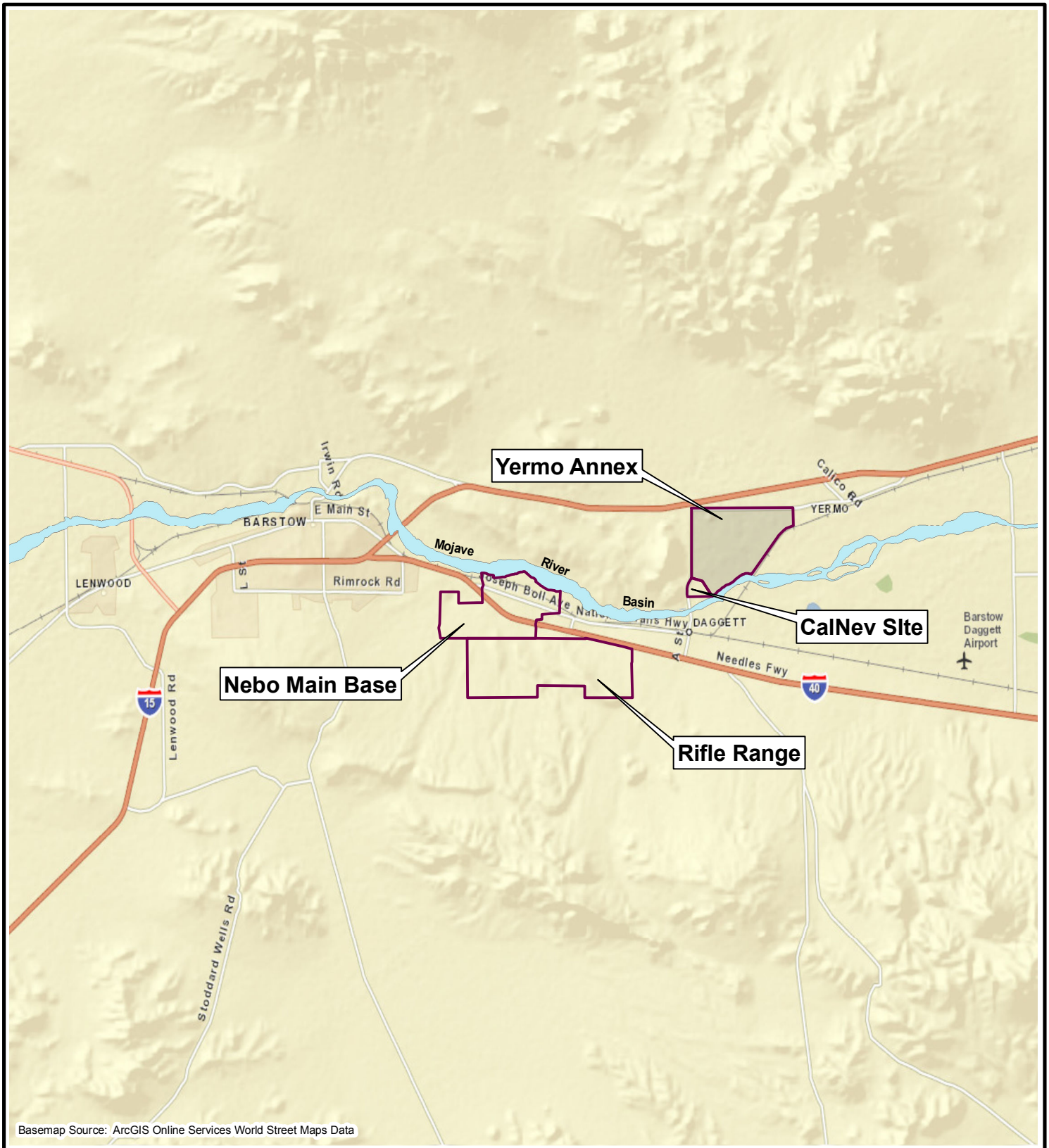
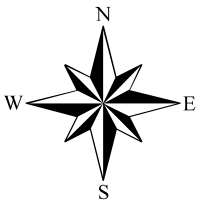




Scale in Miles

0 2 4

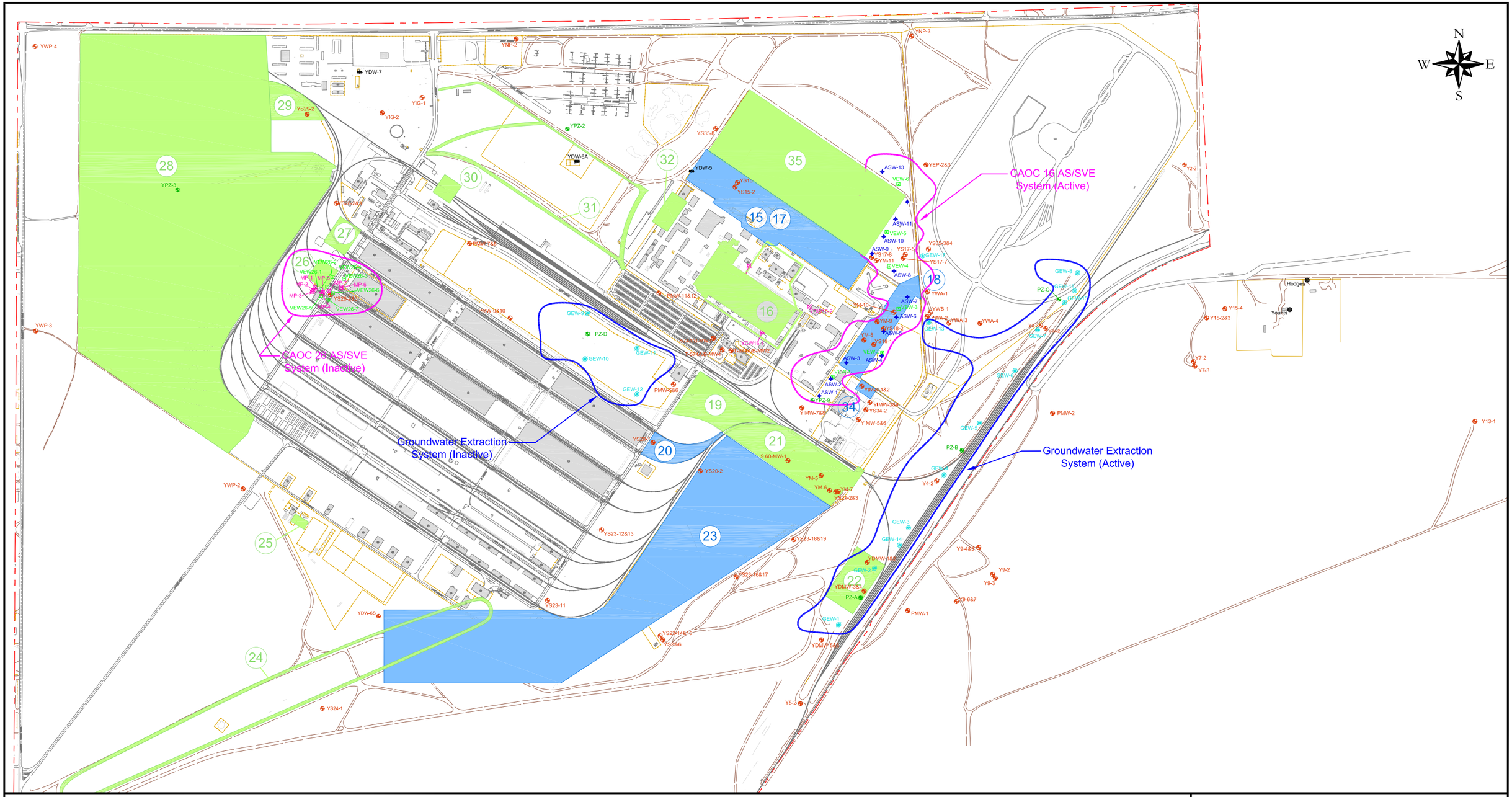
Figure 1-1
MCLB Barstow Vicinity Map

Marine Corps Logistics Base
Barstow, California

AIS-TN&A Joint Venture

Date:
March 20, 2012

File:
Figure 1-1 - MCLB Barstow Vicinity Map.mxd



Legend

- Paved Road
- Dirt Road
- Railroad Tracks
- Fence Line
- Base Boundary
- Operable Unit 3 (CAOC ##)
- Operable Unit 5 (CAOC ##)
- YMP-2 Groundwater Monitoring Well
- YPZ-2 Piezometer
- YDW-5 Base Groundwater Supply Well
- GEW-3 Groundwater Extraction Well (Active)
- GEW-2 Groundwater Extraction Well (Inactive)
- VEW-1 Vapor Extraction Well
- ASW-1 Air Sparge Well
- YCW16-1 Combination Well
- Younts Residential Well

Notes

1) CAOC - CERCLA Area of Concern
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act

Approximate Scale in Feet

0 900 1800

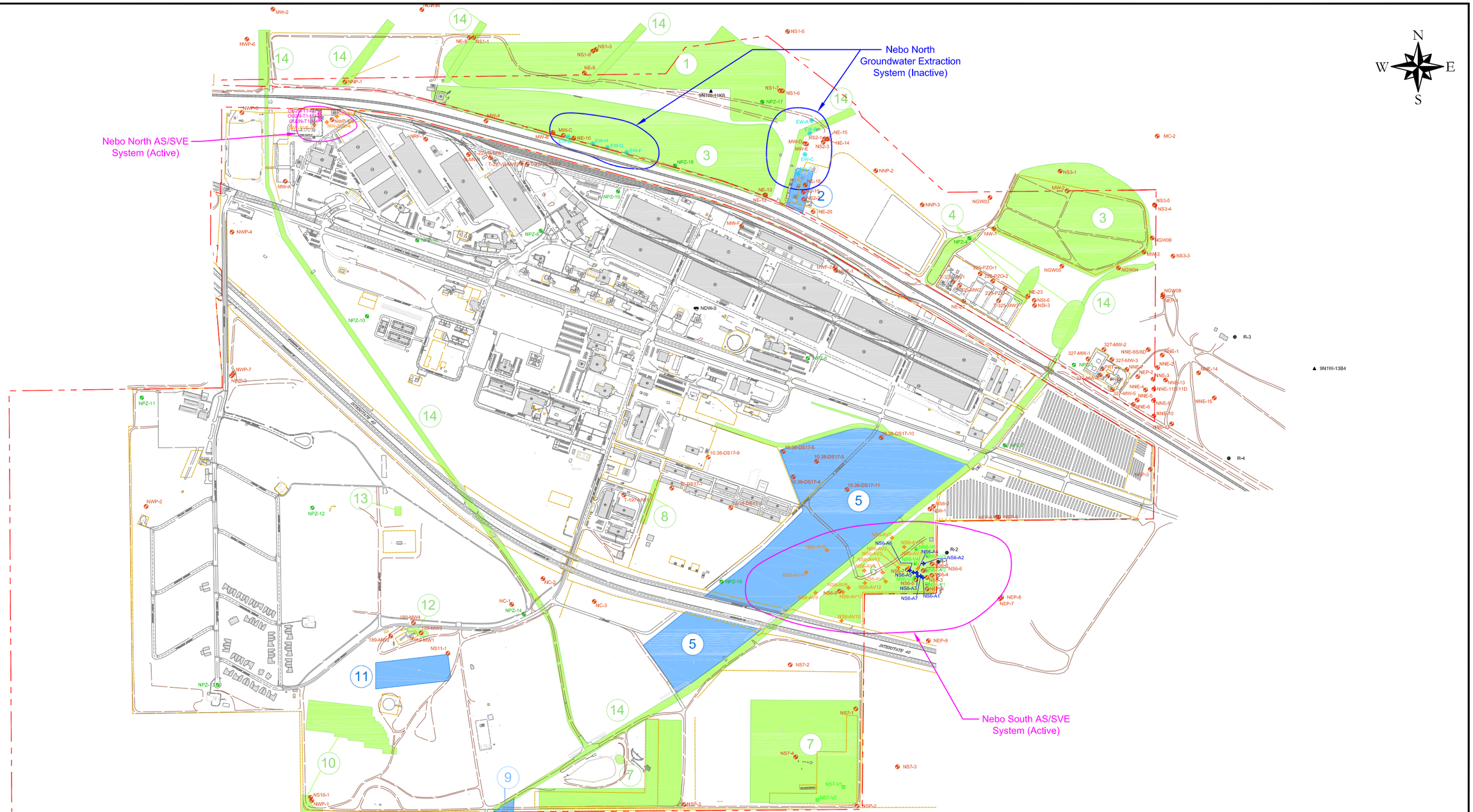
Figure 1-2
Site Map with CAOCs

Yermo Annex
Marine Corps Logistics Base
Barstow, California

AIS-TN&A Joint Venture

Date: May 4, 2012

File: Barstow_5yrRev.dwg



Legend

- Paved Road
- Dirt Road
- Railroad Tracks
- Fence Line
- Base Boundary
- Operable Unit 4 (CAOC ##)
- Operable Unit 6 (CAOC ##)
- NEP-1 Groundwater Monitoring Well
- NPZ-4 Piezometer
- NDW-6 Base Groundwater Supply Well
- EW-B Groundwater Extraction Well (Active)
- NS6-V4 Vapor Extraction Well
- NS6-A7 Air Sparge Well
- NS6-AV7 Vapor Extraction/Air Sparge Well
- 9N1W-11K6 USGS Well
- R-1 Residential Well

Notes

1) CAOC - CERCLA Area of Concern
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act

Approximate Scale in Feet

0 900 1800

Figure 1-3
Site Map with CAOCs

Nebo Main Base
Marine Corps Logistics Base
Barstow, California

AIS-TN&A Joint Venture

Date: May 4, 2012

File: Barstow_5yrRev.dwg

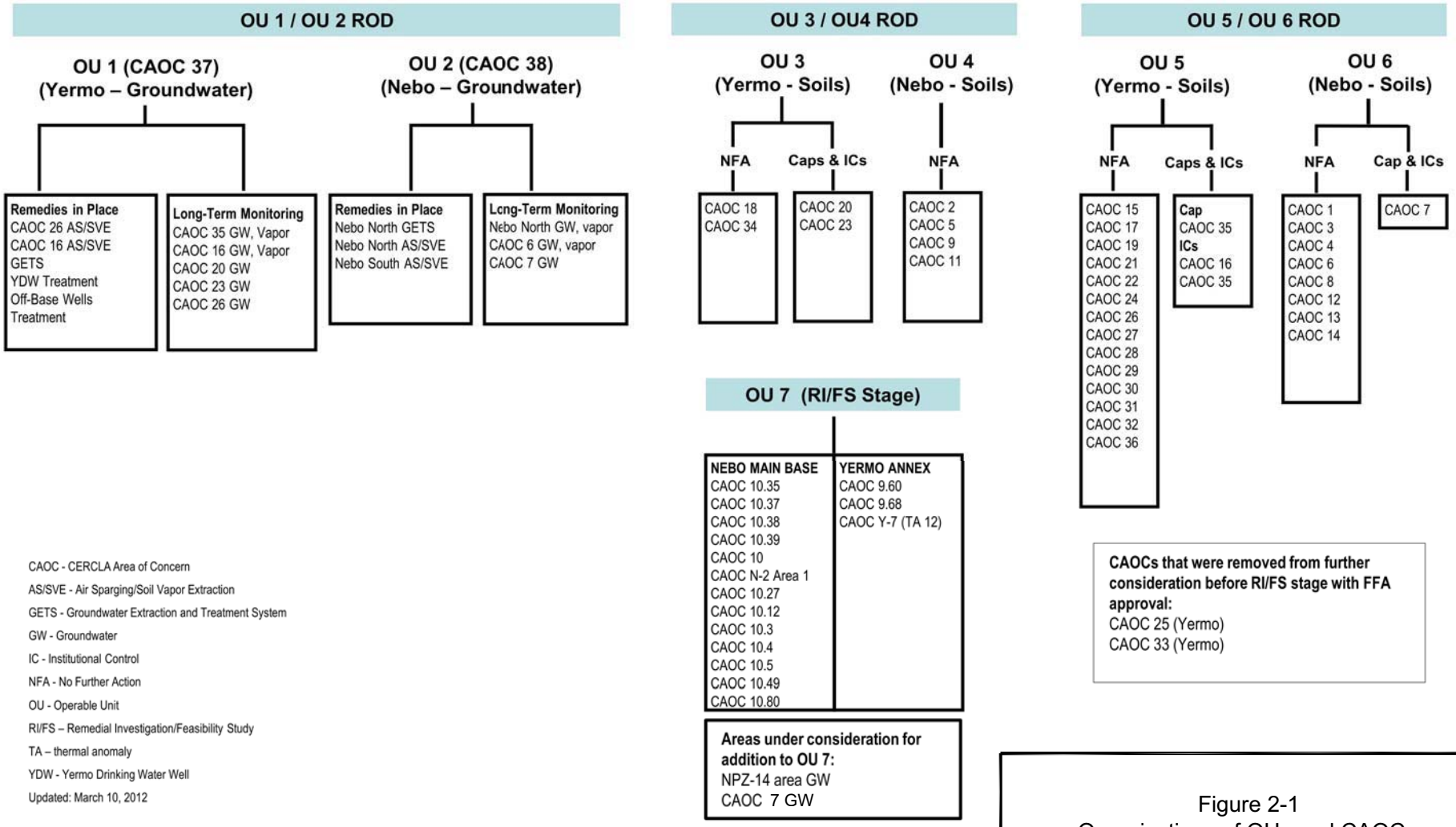


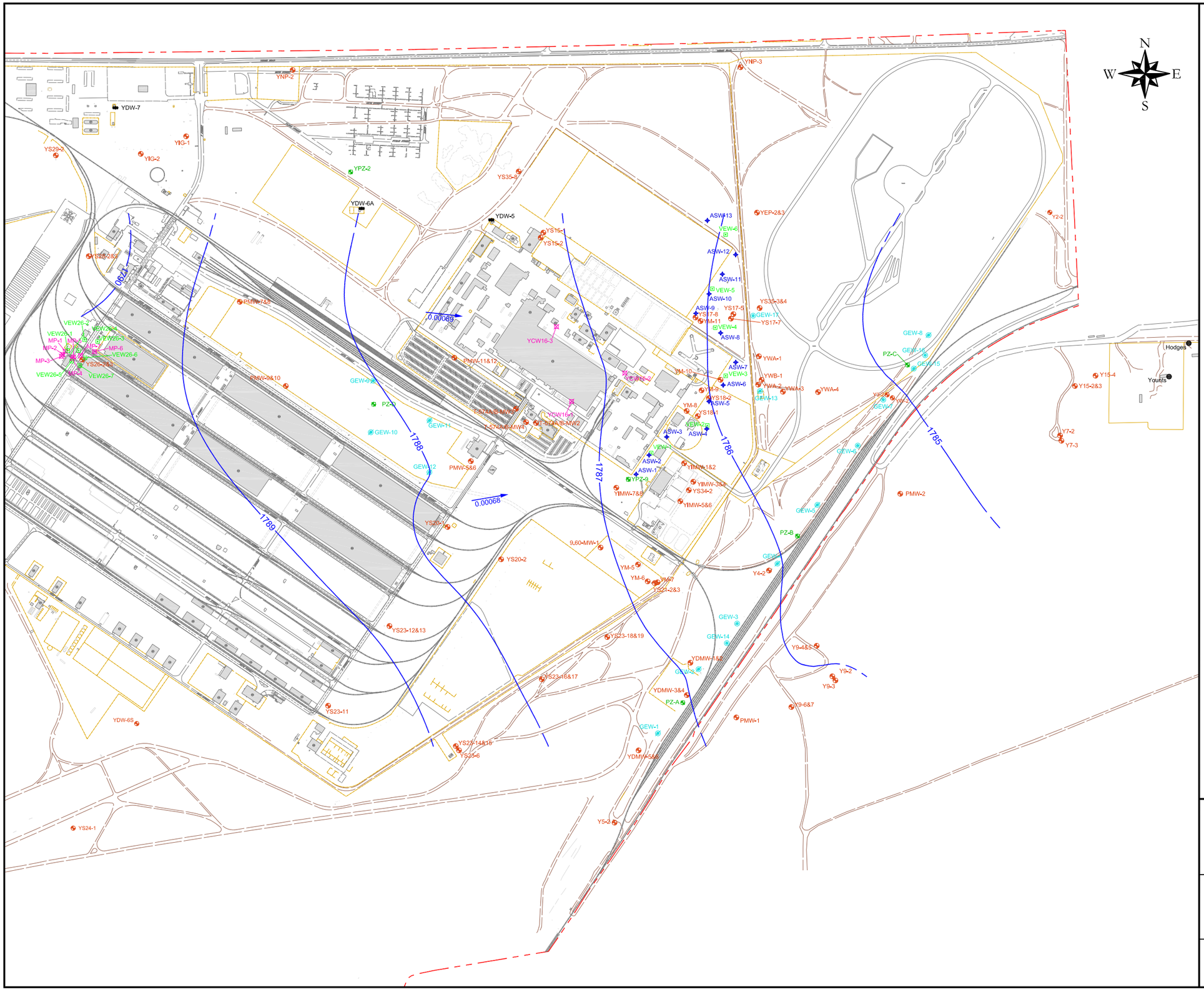
Figure 2-1
Organizations of OUs and CAOCs

Marine Corps Logistics Base
Barstow, California

AIS-TN&A Joint Venture

Date: May 9, 2012

File: Barstow_5yrRev.dwg



Legend

- Paved Road
- Dirt Road
- Railroad Tracks
- Fence Line
- Base Boundary
- Groundwater Elevation Contour, 1-foot Interval (Dashed Where Approximate)
- Groundwater Flow Direction (With Approximate Gradient in ft/ft)
- YMP-2 Groundwater Monitoring Well
- YPZ-2 Piezometer
- YDW-6 Base Groundwater Supply Well
- GEW-3 Groundwater Extraction Well (Active)
- GEW-2 Groundwater Extraction Well (Inactive)
- VEW-1 Vapor Extraction Well
- ASW-1 Air Sparge Well
- YCW16-1 Combination Well
- Younts Residential Well

Notes

1) Groundwater elevation contours were drawn using only monitoring wells with water levels within the screened interval. Water levels from extraction wells were not used for contouring.

2) GEW-7, 13, & 16 were online during gauging.

3) For groundwater elevations at selected monitoring wells, refer to Table 5-1.

4) GETS = Groundwater Extraction Treatment System
ft/ft = feet per feet

Approximate Scale in Feet

0 800 1600

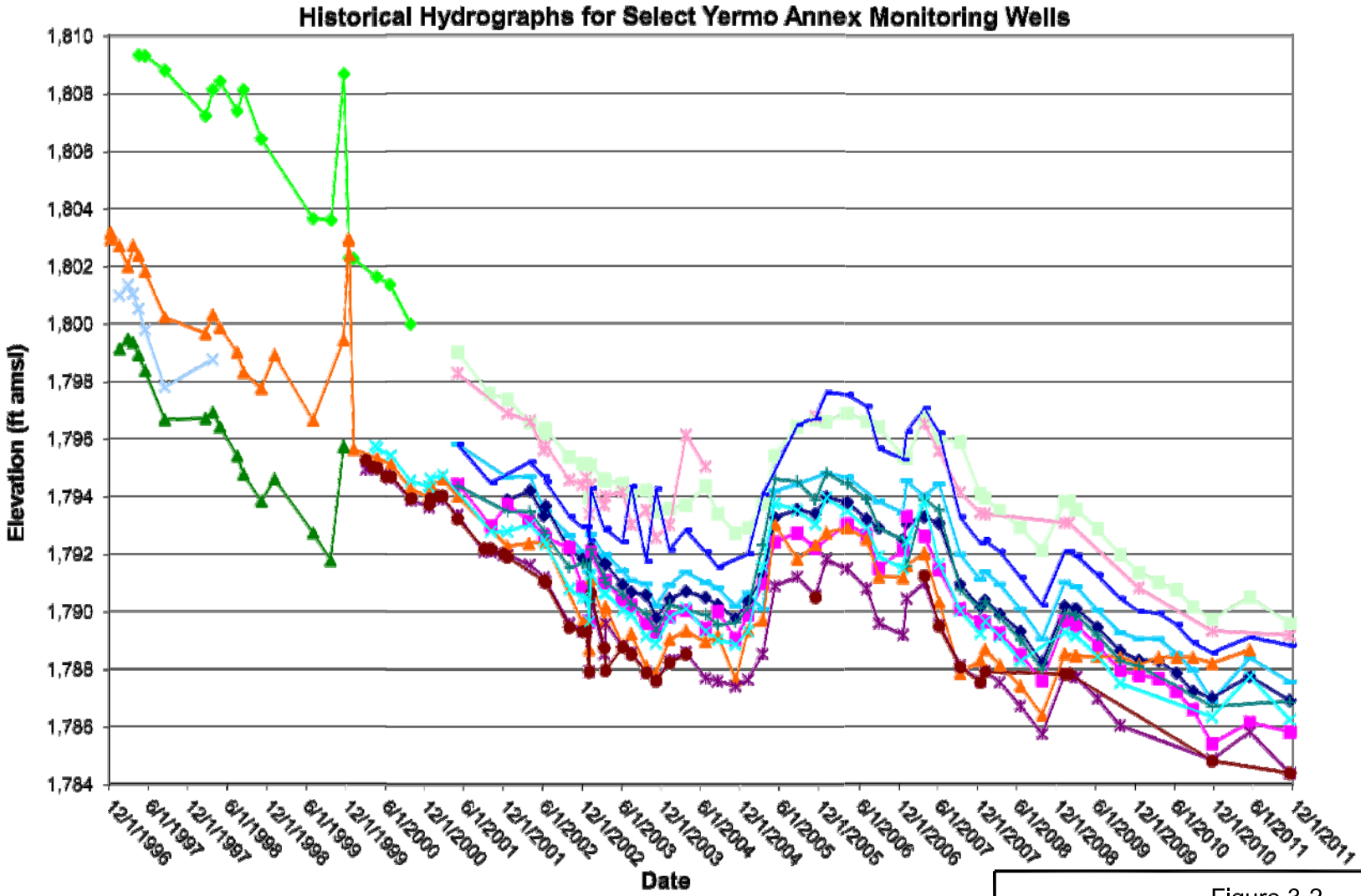
Figure 3-1
Groundwater Elevation Map
(November 2011)

Yermo Annex
Marine Corps Logistics Base
Barstow, California

AIS-TN&A Joint Venture

Date: May 4, 2012

File: Barstow_5yrRev.dwg



Legend

YS26-1* | YS26-2 | YS26-3 | PMW-11 | YCW-16-2 | YEP-2 | PZ-C
Y15-1* | Y15-2 | Y15-3 | YS23-12 | YS21-2 | Y9-1* | Y9-2

* = Well has been abandoned and replaced with a deeper nested well set.

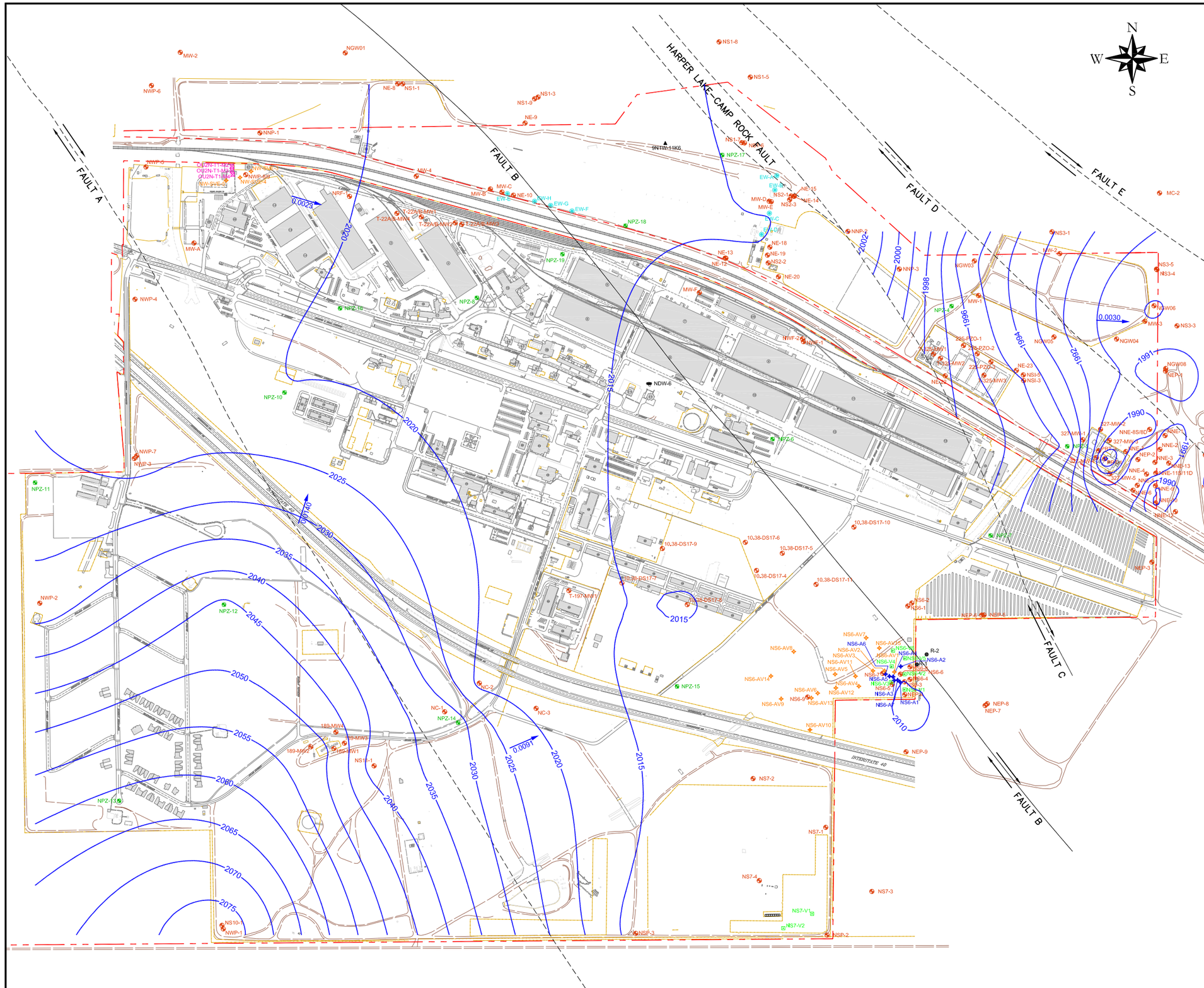
Figure 3-2
Hydrographs for Select Monitoring Wells,
Yermo Annex (2011)

Yermo Annex
Marine Corps Logistics Base
Barstow, California

AIS-TN&A Joint Venture

Date: May 11, 2012

File: Barstow_Hgraphs.dwg



Legend

- Paved Road
- Dirt Road
- Railroad Tracks
- Fence Line
- Base Boundary
- Groundwater Elevation Contour
- Groundwater Flow Direction (With Approximate Gradient in ft/ft)
- NEP-1 Groundwater Monitoring Well
- NPZ-4 Piezometer
- NDW-6 Base Groundwater Supply Well
- EW-B Groundwater Extraction Well (Inactive)
- NS6-V4 Vapor Extraction Well
- NS6-A7 Air Sparge Well
- NS6-AV7 Vapor Extraction/Air Sparge Well
- 9N1W-11K6 USGS Well

Notes

1) Groundwater elevation contours were drawn using only monitoring wells with water levels within the screened interval.

2) For groundwater elevations at selected monitoring wells, refer to Table 8-1.

3) ft/ft = feet per feet

Approximate Scale in Feet

0 800 1600

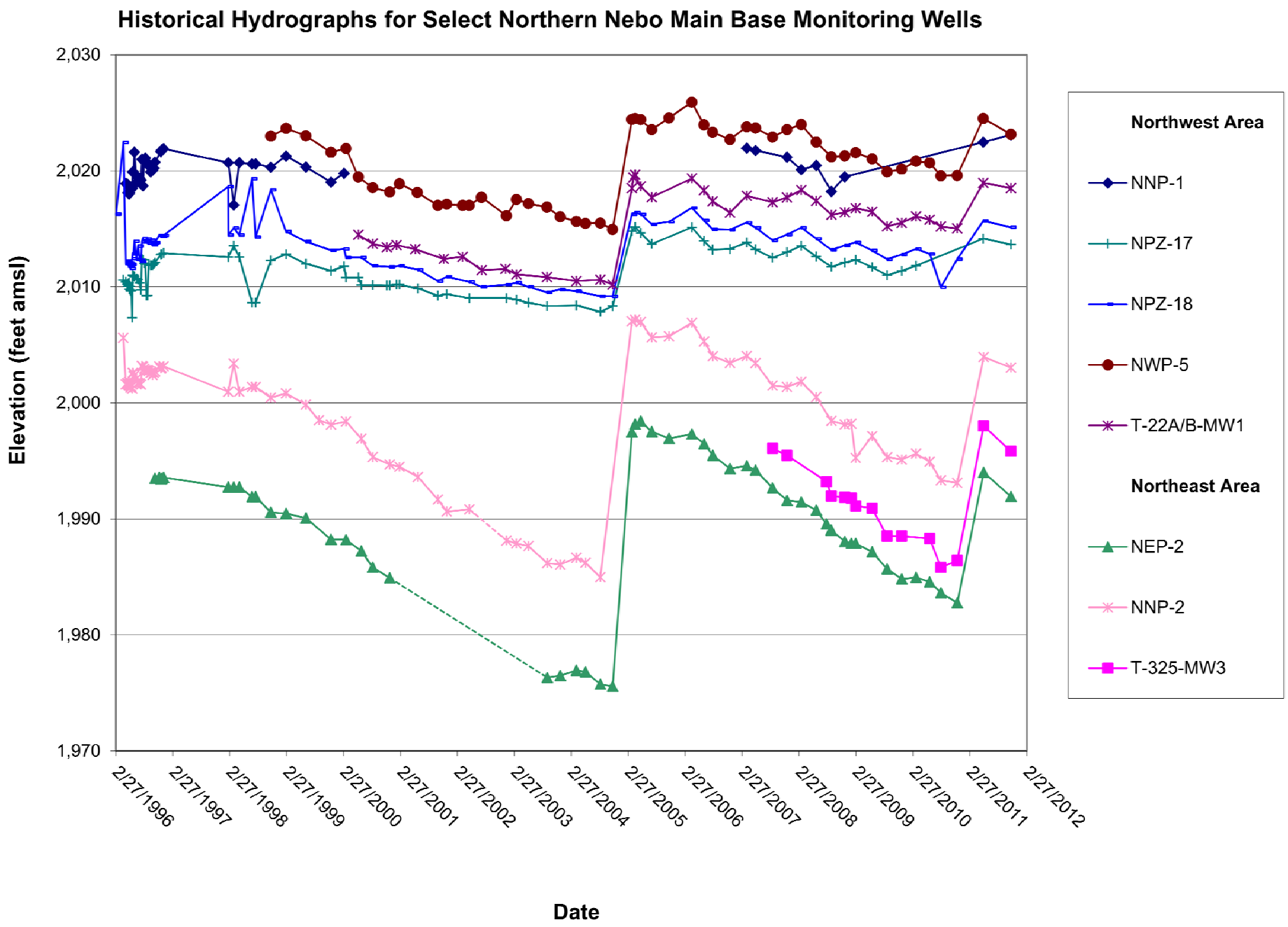
Figure 3-3
Groundwater Elevation Map
(November 2011)

Nebo Main Base
Marine Corps Logistics Base
Barstow, California

AIS-TN&A Joint Venture

Date: May 4, 2012

File: Barstow_5yrRev.dwg



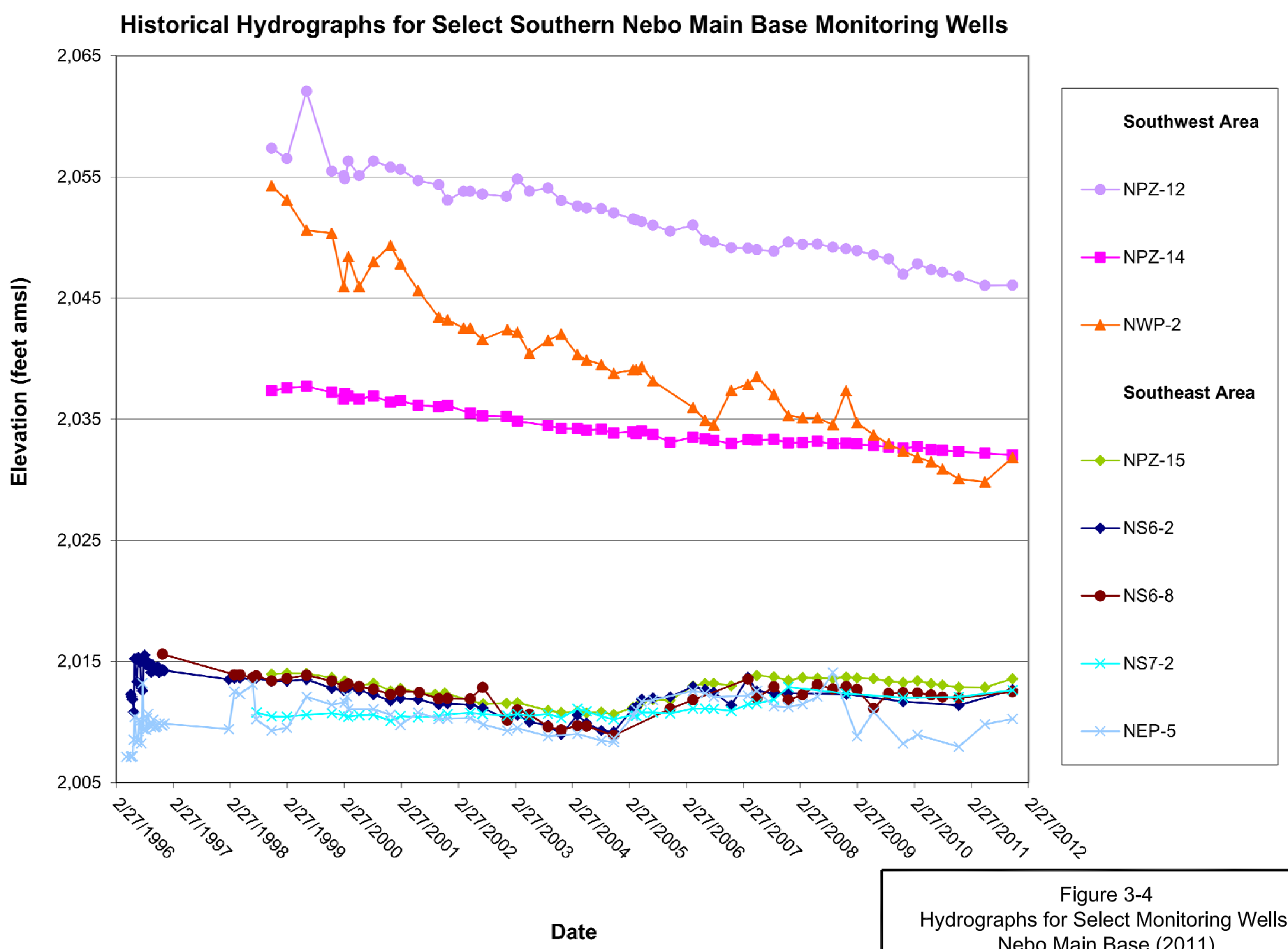


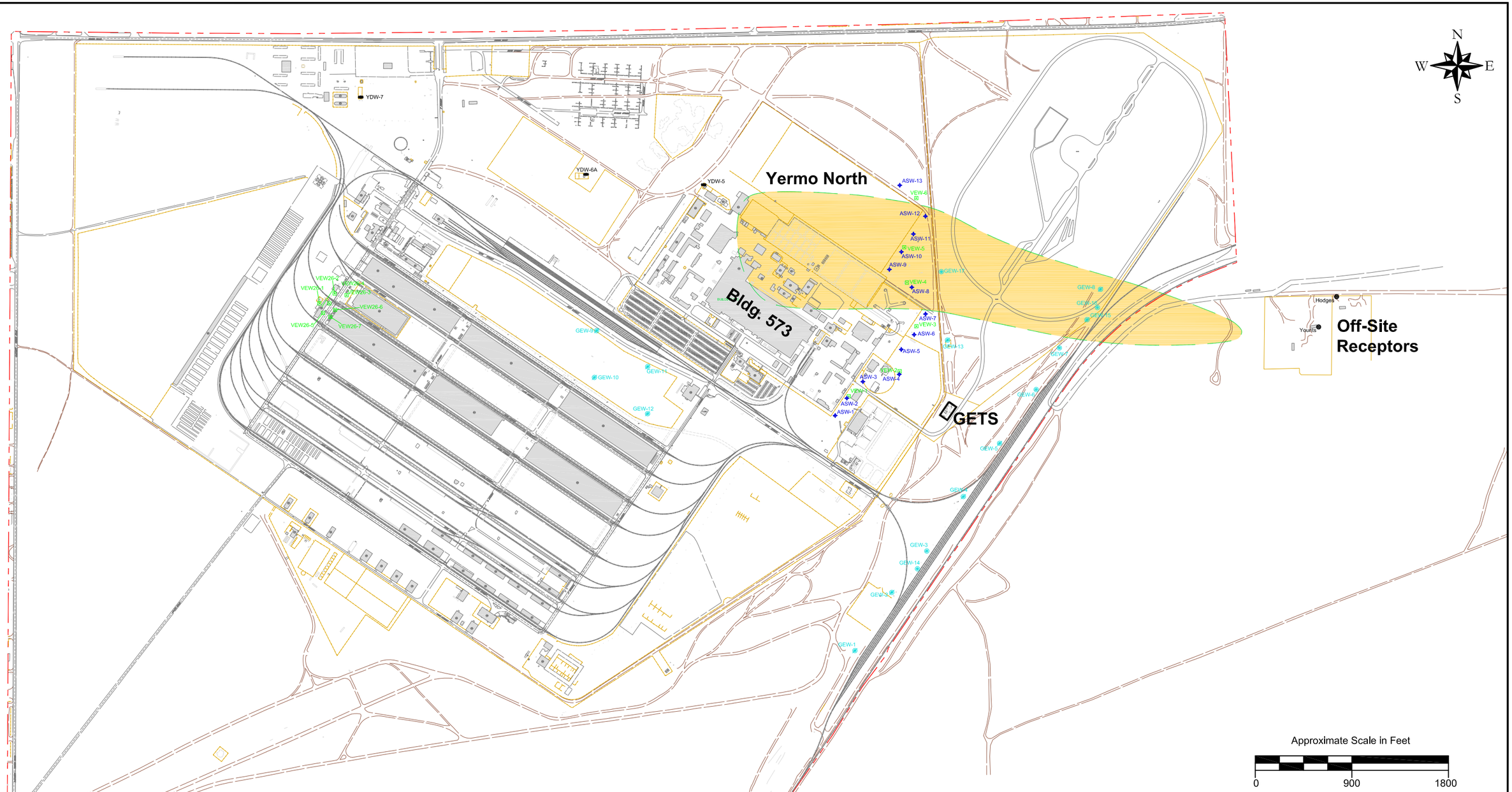
Figure 3-4
Hydrographs for Select Monitoring Wells,
Nebo Main Base (2011)

Yermo Annex
Marine Corps Logistics Base
Barstow, California

AIS-TN&A Joint Venture

Date: May 11, 2012

File: Barstow HGraph.dwg



Legend

- Paved Road
- Dirt Road
- Railroad Tracks
- Base Boundary
- YDW-5 Base Groundwater Supply Well
- GEW-3 Groundwater Extraction Well (Active)
- GEW-2 Groundwater Extraction Well (Inactive)
- VEW-1 Vapor Extraction Well
- ASW-1 Air Sparge Well
- Younts Residential Well
- Approximate OU1 Groundwater VOC Plume

Notes

1) Analytical results used to delineate the OU1 groundwater plume are a combination of wells sampled during the November 2011 event and May 2012 event.

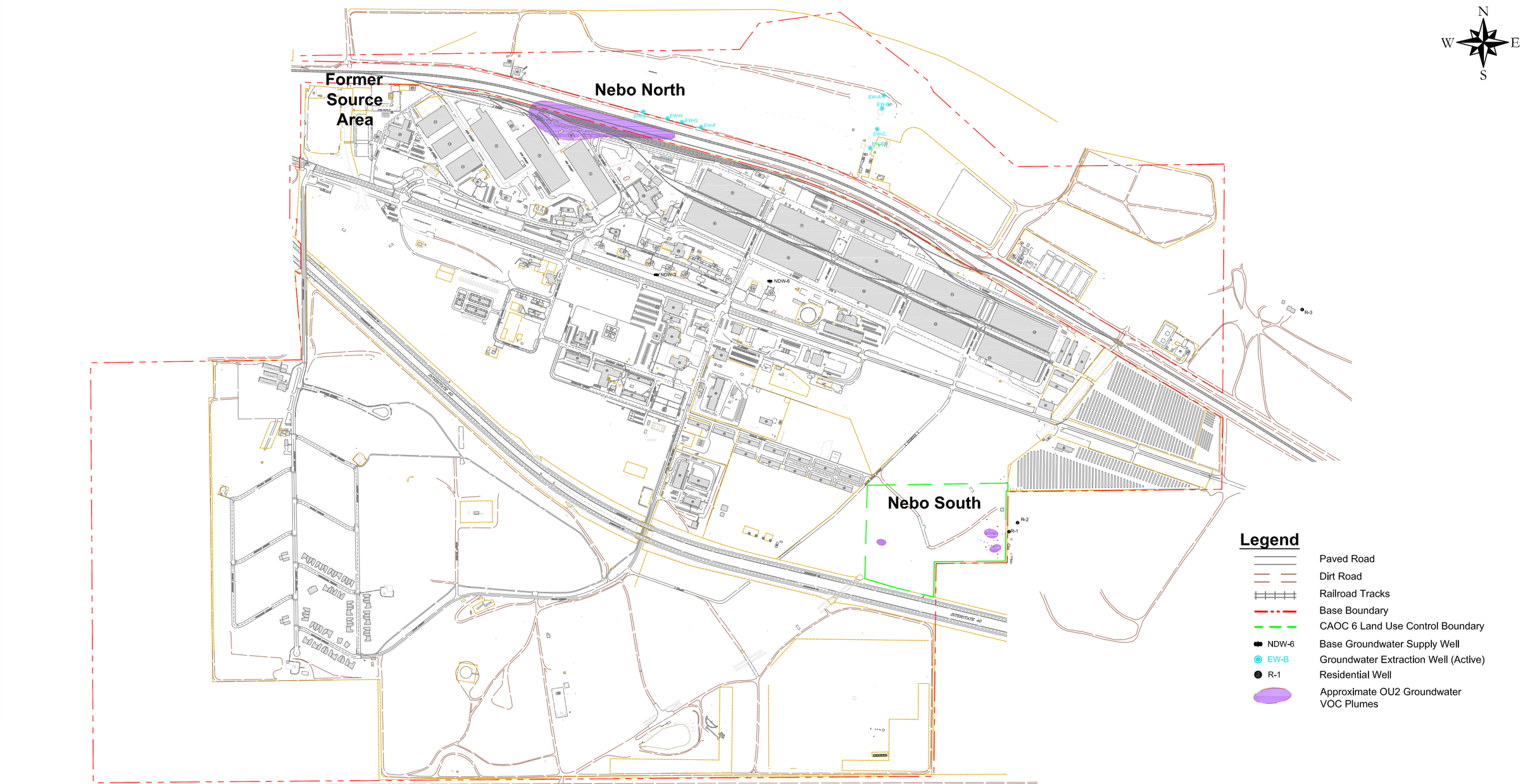
Figure 3-5
Groundwater VOC Plume Extent
(November 2011)

Yermo Annex
Marine Corps Logistics Base
Barstow, California

AIS-TN&A Joint Venture

Date: December 4, 2012

File: Barstow_5yrRev.dwg



Notes

1) Analytical results used to delineate the OU2 groundwater plumes are a combination of wells sampled during the November 2011 event and May 2012 event.

Approximate Scale in Feet

0 900 1800

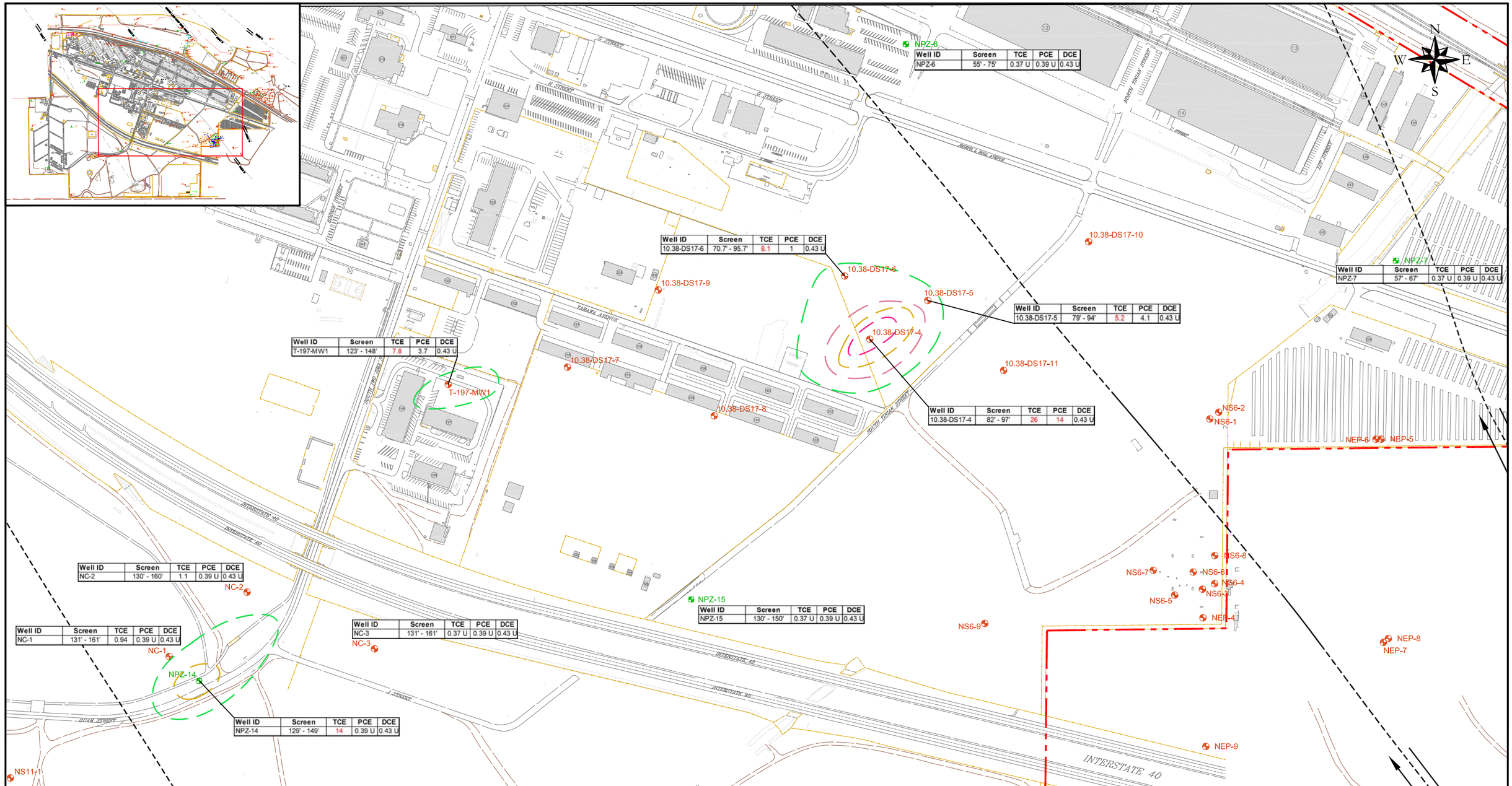
Figure 3-6
Groundwater VOC Plumes Extent
(November 2011)

Nebo Main Base
Marine Corps Logistics Base
Barstow, California

AIS-TN&A Joint Venture

Date: December 4, 2012

File: Barstow_5yrRev.dwg



Legend

- Paved Road
- Dirt Road
- Railroad Tracks
- Fence Line
- Base Boundary
- MW-B — Groundwater Monitoring Well
- NPZ-8 — Piezometer
- —5— Approximate TCE Isoconcentration Contour (ug/L)
- —10 Approximate TCE Isoconcentration Contour (ug/L)
- —5— Approximate PCE Isoconcentration Contour (ug/L)
- —10 Approximate PCE Isoconcentration Contour (ug/L)

Monitoring Well Sample

Well Screen Interval — Analyte

Well ID	Screen	TCE	PCE	DCE
T-197-MW1	123' - 148'	7.8	3.7	0.43 U

Concentration (ug/L)

Red Result indicates an MCL excedence

Notes

1) Analytical results shown in ug/L (micrograms per liter) are a combination of wells sampled during the November 2011 event and May 2012 event.

2) VOC = Volatile Organic Compound
TCE = Trichloroethene
PCE = Tetrachloroethene
DCE = 1,1-Dichloroethene
J = Estimated Value
U = Not Detected (value indicates reporting limit)
CAOC - CERCLA Area of Concern
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act

Approximate Scale in Feet

0 350 700

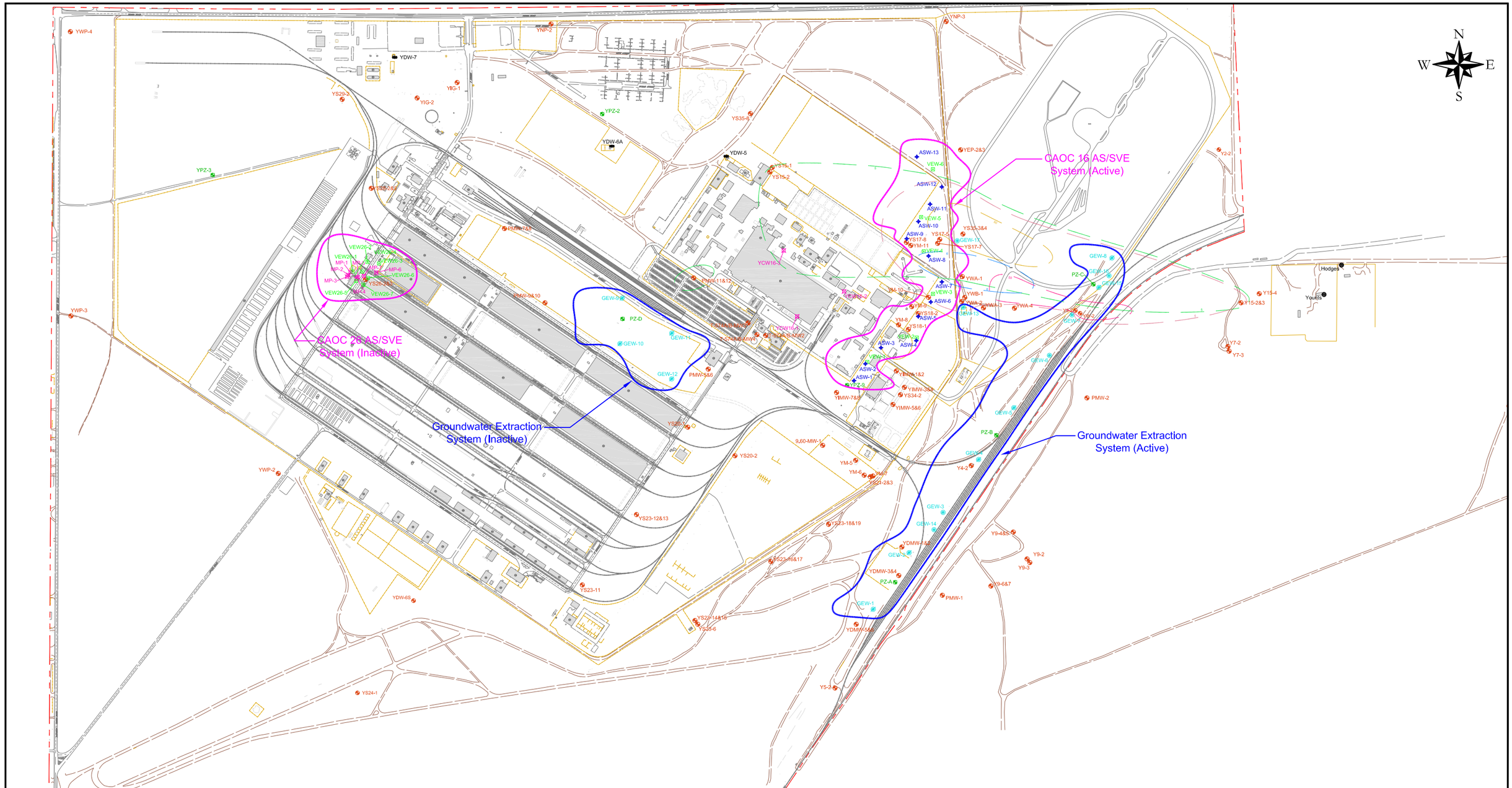
Figure 3-7
Select VOC Concentrations in Groundwater, NPZ-14 and CAOC 10.38/10.39 Unit 7 Monitoring Wells (2011, 2012)

Nebo Main Base
Marine Corps Logistics Base
Barstow, California

AIS-TN&A Joint Venture

Date: May 4, 2012

File: Barstow_5yrRev.dwg



Legend

- Paved Road
- Dirt Road
- Railroad Tracks
- Fence Line
- Base Boundary
- YMP-2 Groundwater Monitoring Well
- YPZ-2 Piezometer
- YDW-5 Base Groundwater Supply Well
- GEW-3 Groundwater Extraction Well (Active)
- GEW-2 Groundwater Extraction Well (Inactive)
- VEW-1 Vapor Extraction Well
- ASW-1 Air Sparge Well
- YCW16-1 Combination Well
- Younts Residential Well
- 5 Approximate TCE Isoconcentration Contour (ug/L)
- 50 Approximate TCE Isoconcentration Contour (ug/L)
- 5 Approximate PCE Isoconcentration Contour (ug/L)
- 50 Approximate PCE Isoconcentration Contour (ug/L)
- 6 Approximate DCE Isoconcentration Contour (ug/L)

Notes

1) Analytical results shown in ug/L (micrograms per liter) for the wells sampled during the 2011 Annual Groundwater Monitoring Event.

2) TCE = Trichloroethene
PCE = Tetrachloroethene
DCE = 1,1-Dichloroethene
CAOC = CERCLA Area of Concern
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
OU = Operable Unit

Approximate Scale in Feet

0 900 1800

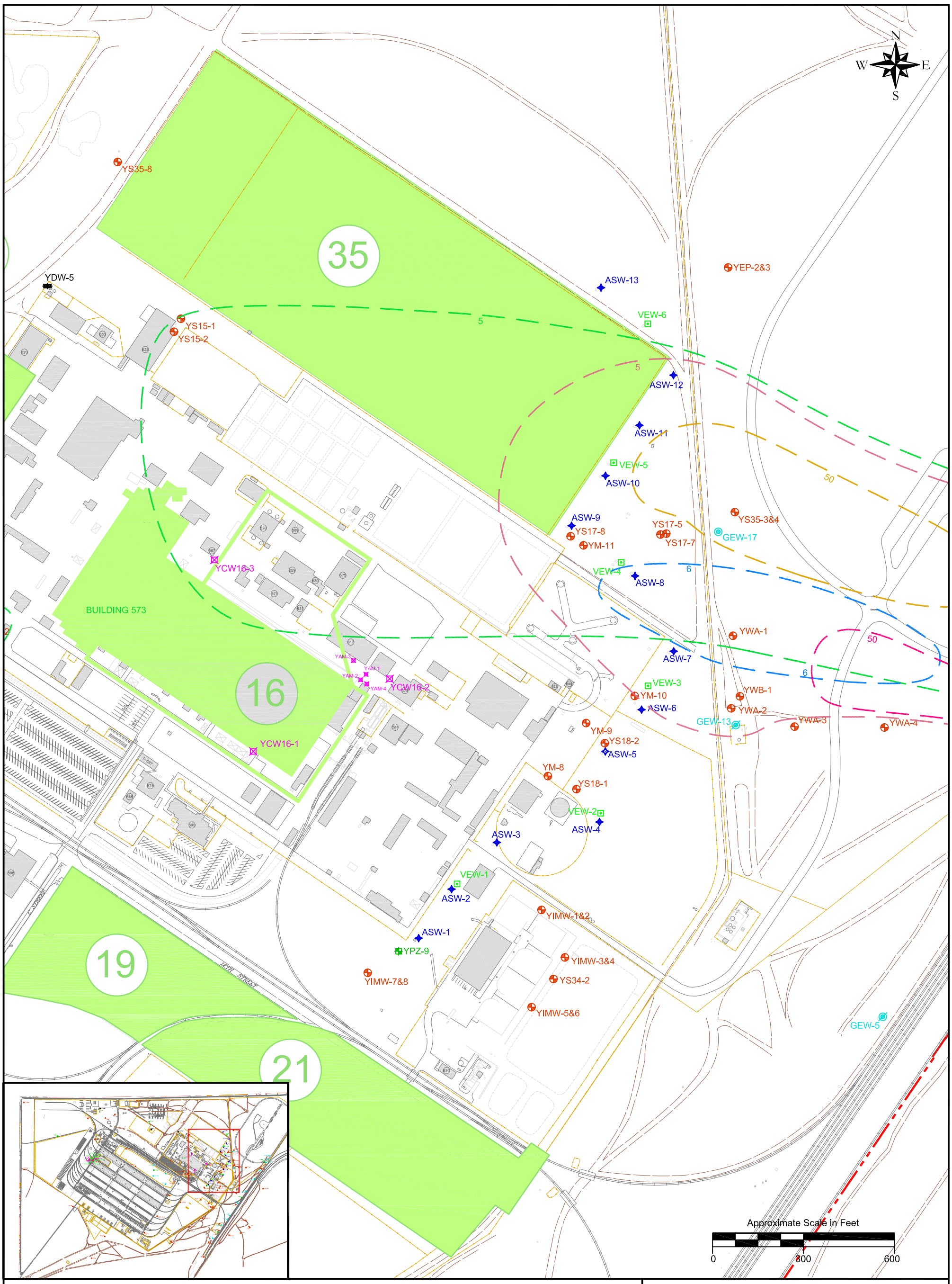
Figure 7-1
OU 1 (CAOC 37) Groundwater Plumes and Remediation Systems

Yermo Annex
Marine Corps Logistics Base
Barstow, California

AIS-TN&A Joint Venture

Date: May 4, 2012

File: Barstow_5yrRev.dwg



Legend

- Paved Road
- Dirt Road
- Railroad Tracks
- Fence Line
- YMP-2 Groundwater Monitoring Well
- YPZ-2 Piezometer
- GEW-13 Groundwater Extraction Well (Active)
- VEW-1 Vapor Extraction Well
- ASW-1 Air Sparge Well
- YCW16-1 Combination Well
- 5 Approximate TCE Isoconcentration Contour (ug/L)
- 50 Approximate TCE Isoconcentration Contour (ug/L)
- 5 Approximate PCE Isoconcentration Contour (ug/L)
- 50 Approximate PCE Isoconcentration Contour (ug/L)
- 6 Approximate DCE Isoconcentration Contour (ug/L)

Notes

1) Analytical results shown in ug/L (micrograms per liter) for the wells sampled during the 2011 Annual Groundwater Monitoring Event.

2) TCE = Trichloroethene
PCE = Tetrachloroethene
DCE = 1,1-Dichloroethene
CAOC = CERCLA Area of Concern
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
AS/SVE = Air Sparge / Soil Vapor Extraction

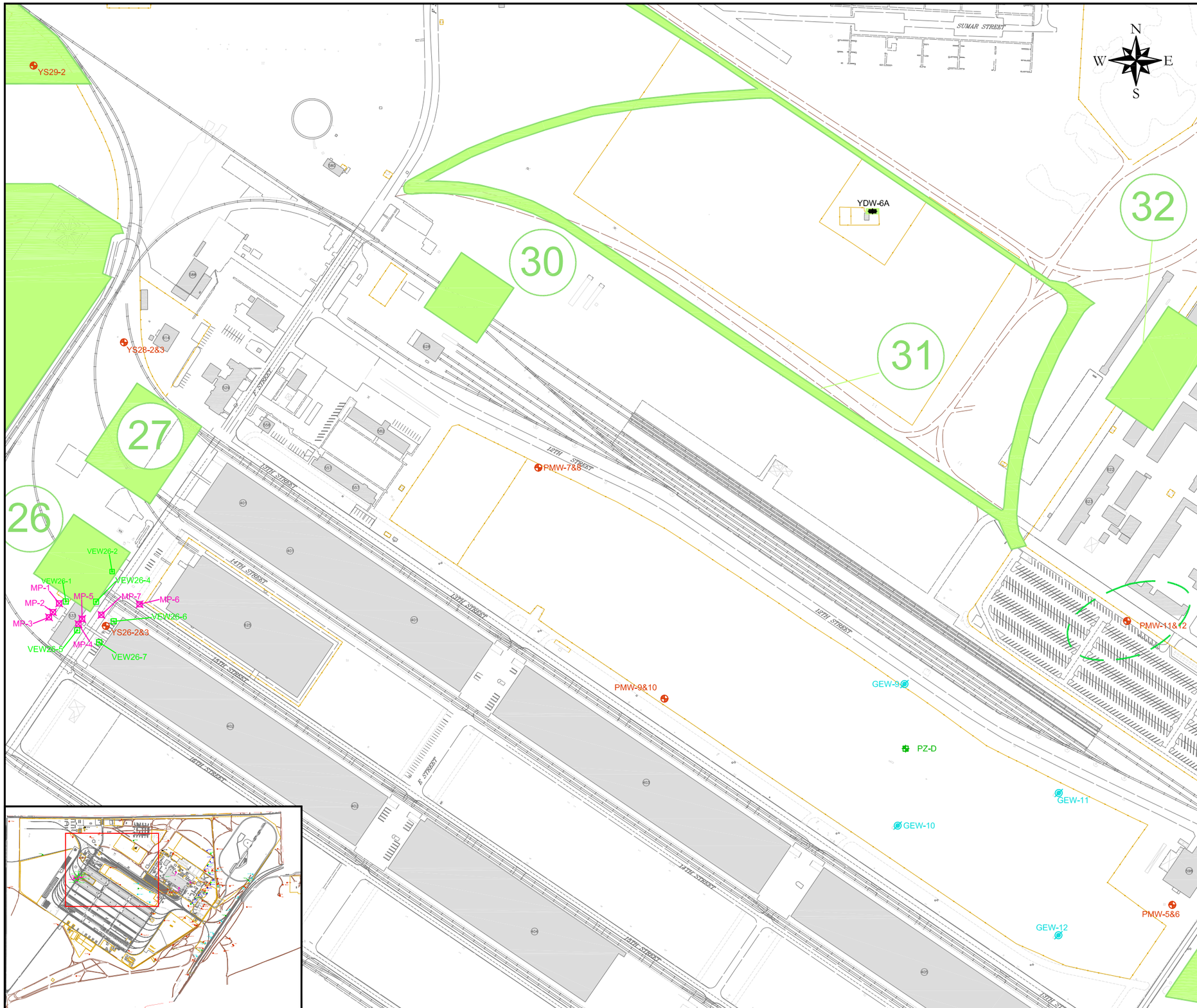
Figure 7-2
CAOC 16 AS/SVE System

Yermo Annex
Marine Corps Logistics Base
Barstow, California

AIS-TN&A Joint Venture

Date: May 4, 2012

File: Barstow_5yrRev.dwg



Legend

- Paved Road
- Dirt Road
- Railroad Tracks
- Fence Line
- YS29-2 Groundwater Monitoring Well
- PZ-D Piezometer
- GEW-9 Groundwater Extraction Well (Inactive)
- VEW26-1 Vapor Extraction Well
- MP-4 Combination Well
- YDW-6A Base Groundwater Supply Well
- —5— Approximate TCE Isoconcentration Contour (ug/L)

Notes

1) Analytical results shown in ug/L (micrograms per liter) for the wells sampled during the 2011 Annual Groundwater Monitoring Event.

2) TCE = Trichloroethene
CAOC = CERCLA Area of Concern
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
AS/SVE = Air Sparge / Soil Vapor Extraction

Approximate Scale in Feet

0 300 600

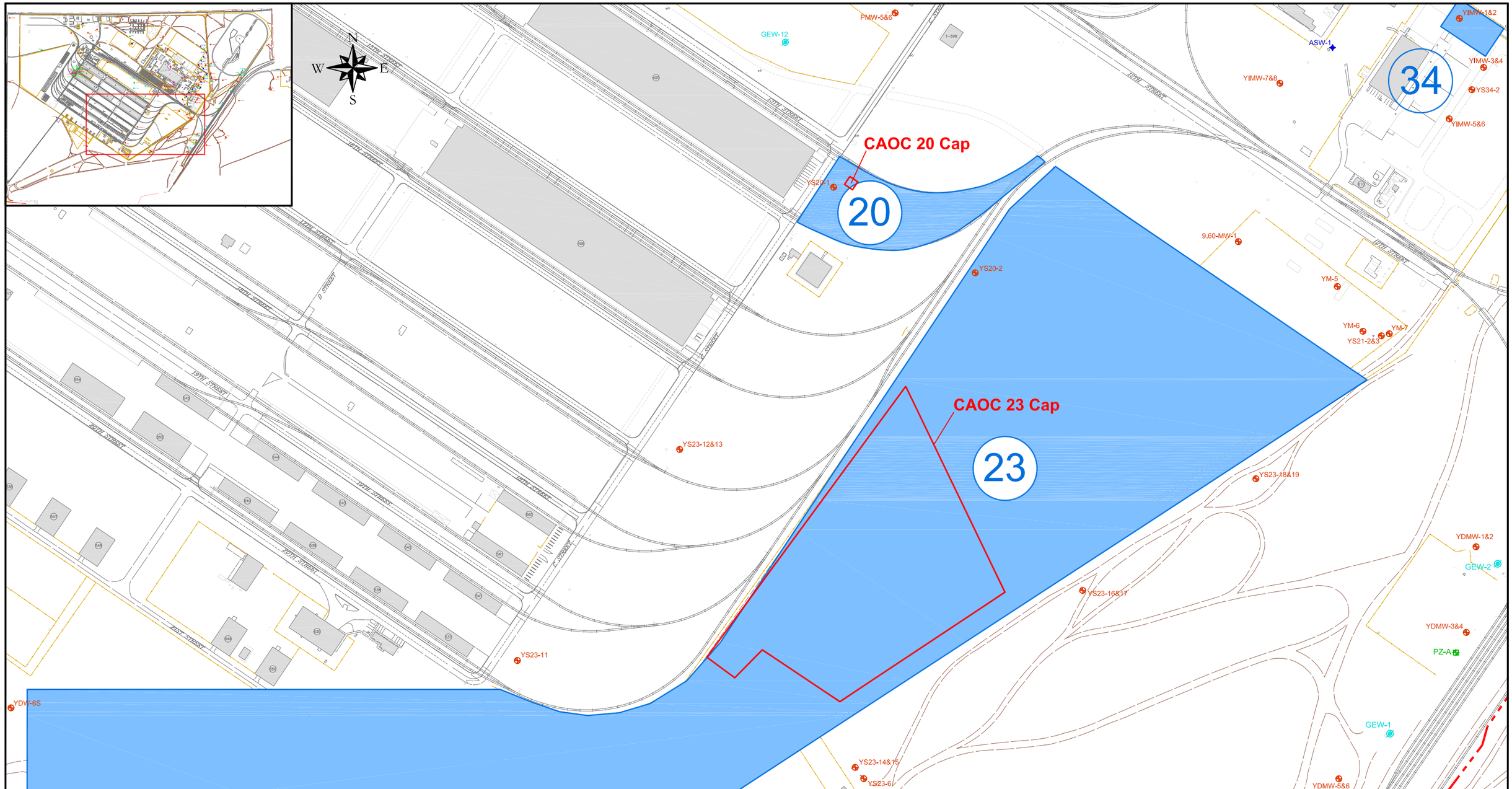
Figure 7-3
CAOC 26 AS/SVE System

Yermo Annex
Marine Corps Logistics Base
Barstow, California

AIS-TN&A Joint Venture

Date: May 4, 2012

File: Barstow_5yrRev.dwg



Legend

- Paved Road
- Dirt Road
- Railroad Tracks
- Fence Line
- YS23-11 Groundwater Monitoring Well
- PZ-A Piezometer
- GEW-1 Groundwater Extraction Well (Inactive)

Notes

1) CAOC - CERCLA Area of Concern
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act

Approximate Scale in Feet

0 300 600

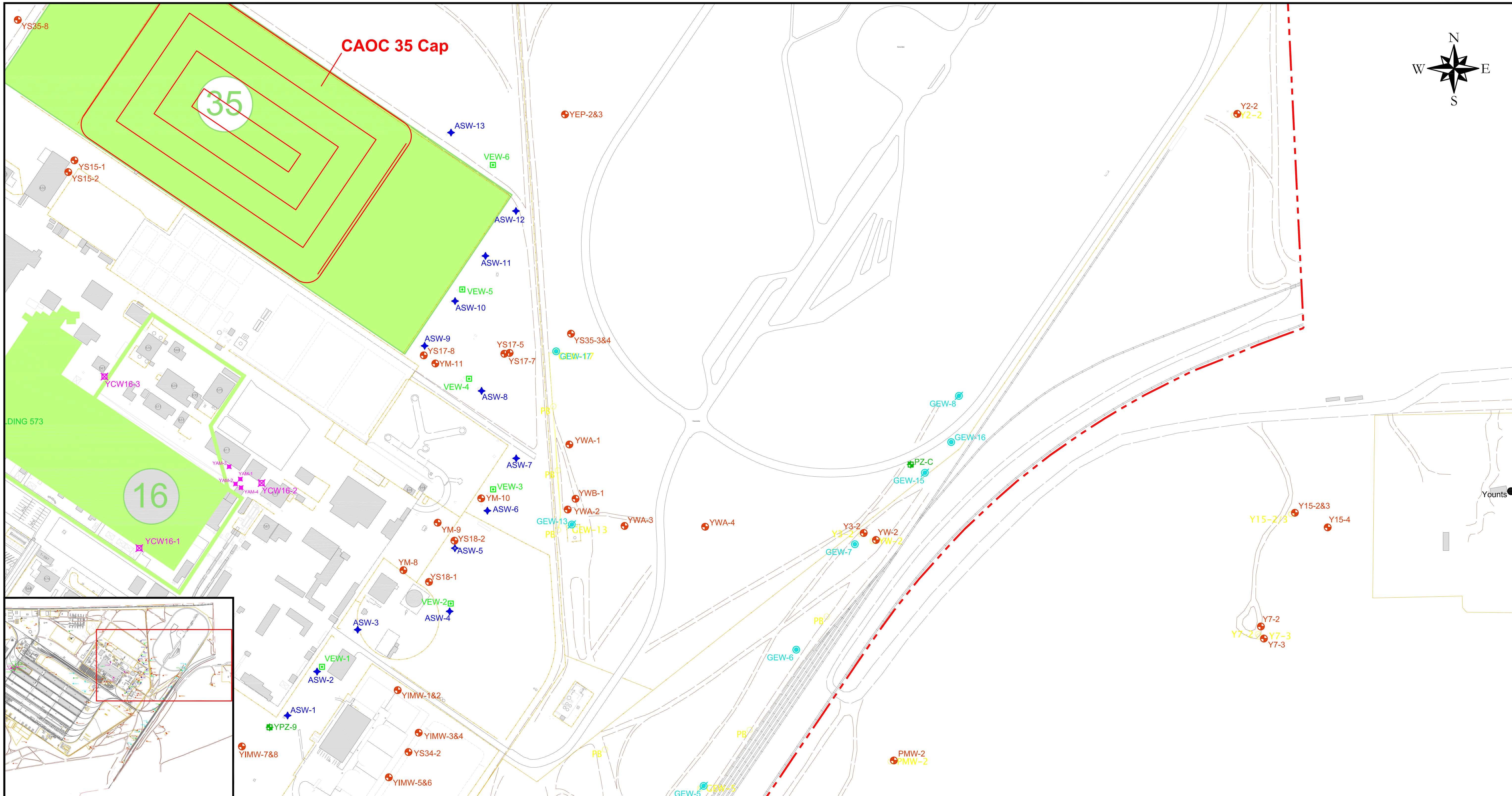
Figure 7-4
CAOCs 20 and 23 Caps

Yermo Annex
Marine Corps Logistics Base
Barstow, California

AIS-TN&A Joint Venture

Date: May 4, 2012

File: Barstow_5yrRev.dwg



Legend

Paved Road	
Dirt Road	
Railroad Tracks	
Fence Line	
YMP-2	Groundwater Monitoring Well
YPZ-2	Piezometer
GEW-17	Groundwater Extraction Well (Active)
GEW-5	Groundwater Extraction Well (Inactive)
VEW-1	Vapor Extraction Well
ASW-1	Air Sparge Well
YCW16-1	Combination Well
Younts	Residential Well

Notes

1) CAOC - CERCLA Area of Concern
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act

Approximate Scale in Feet

0 350 700

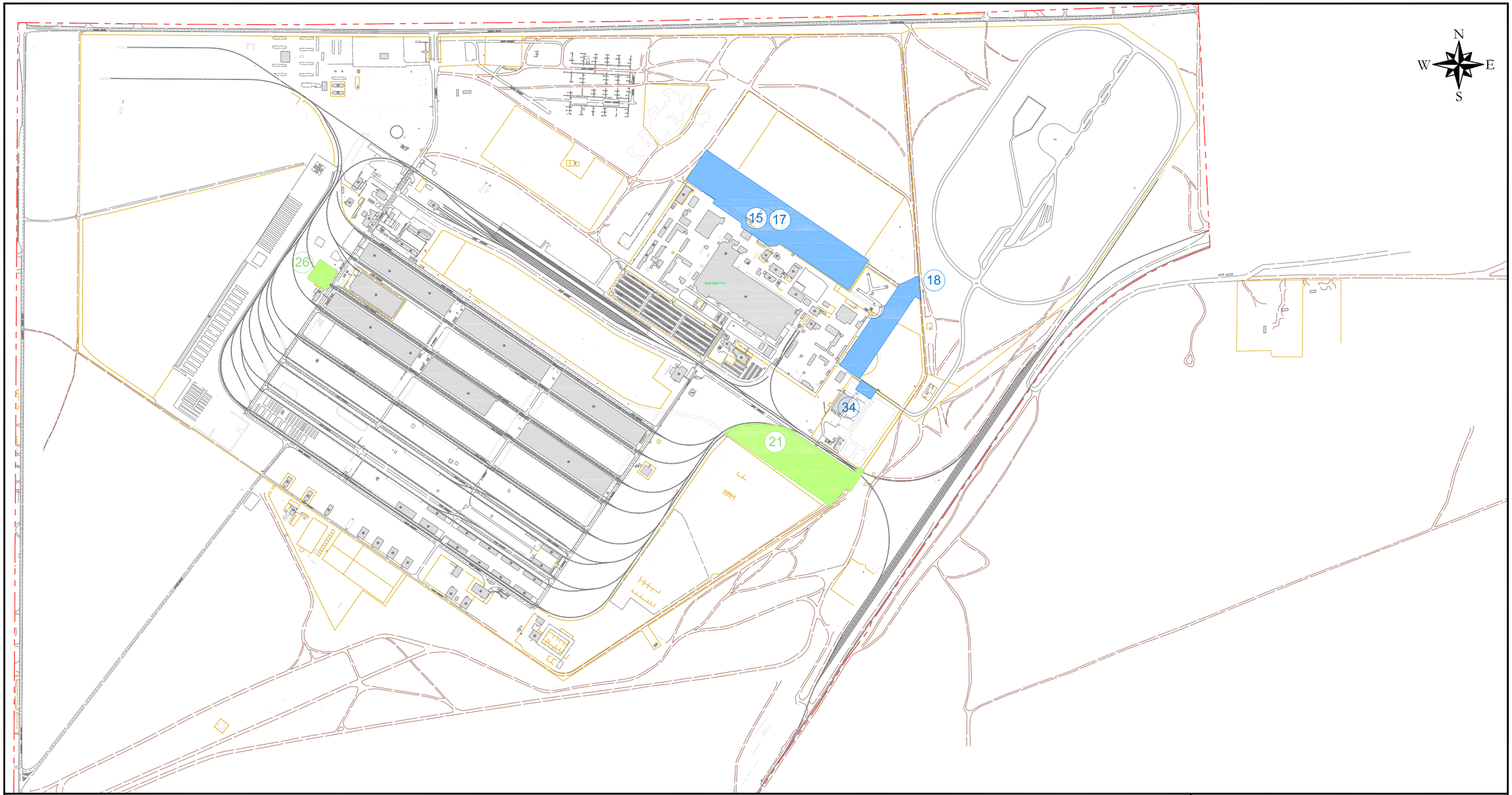
Figure 7-5
CAOC 35 Stratum 1 Zone 1 Cap

Yermo Annex
Marine Corps Logistics Base
Barstow, California

AIS-TN&A Joint Venture

Date: May 4, 2012

File: Barstow_5yrRev.dwg



Legend

- Paved Road
- Dirt Road
- Railroad Tracks
- Fence Line
- Base Boundary
- 18 Operable Unit 3 (CAOC ##)
- 26 Operable Unit 5 (CAOC ##)

Notes

1) CAOC - CERCLA Area of Concern
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act

Approximate Scale in Feet

0 900 1800

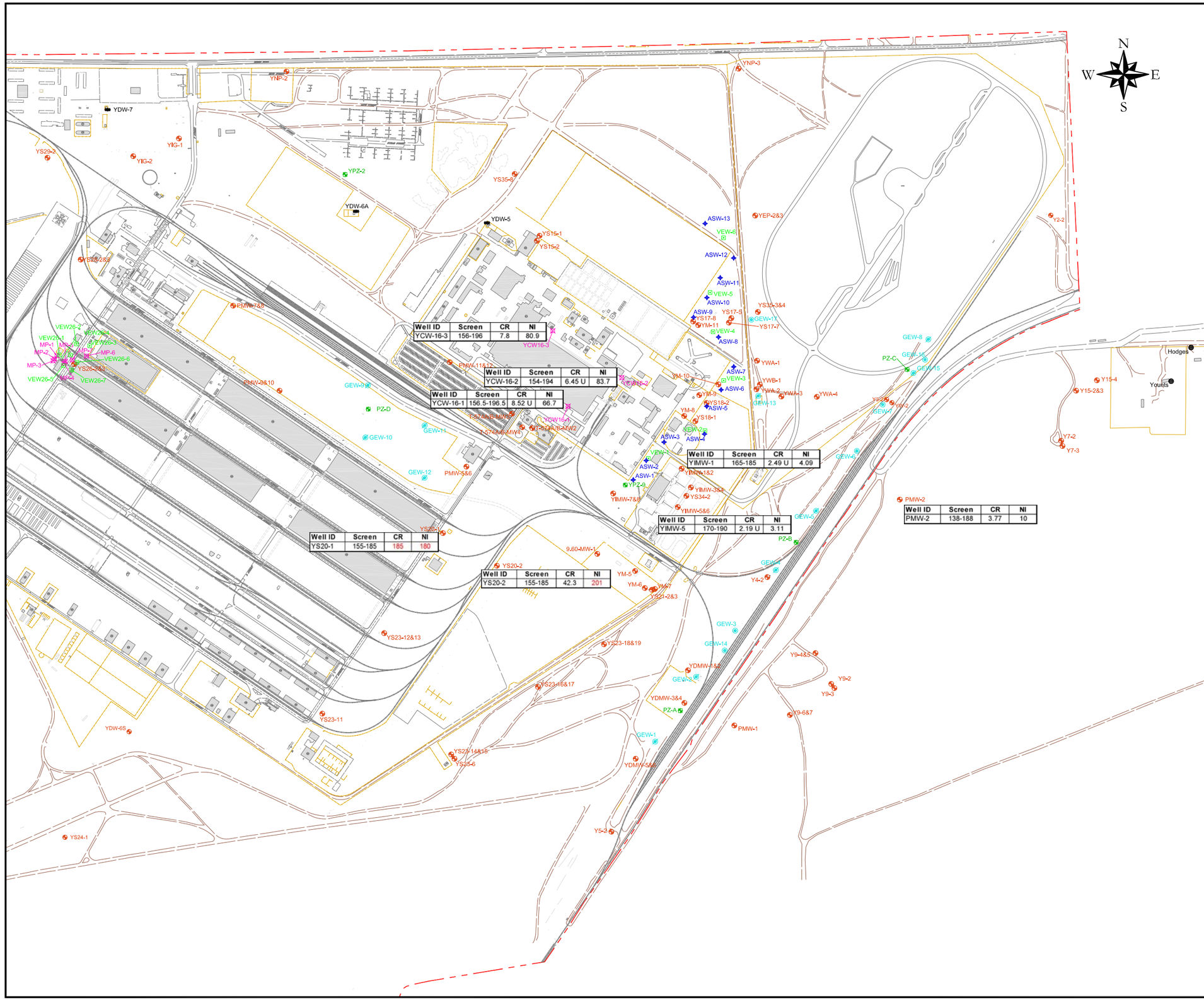
Figure 7-6
CAOCs 15/17, 18, 21, 26, and 34: No Further Action with Base Master Plan Modifications

Yermo Annex
Marine Corps Logistics Base
Barstow, California

AIS-TN&A Joint Venture

Date: September 4, 2012

File: Barstow_5yrRev.dwg



Legend

- Paved Road
- Dirt Road
- Railroad Tracks
- Fence Line
- Base Boundary
- YMP-2 Groundwater Monitoring Well
- YPZ-2 Piezometer
- YDW-6 Base Groundwater Supply Well
- GEW-3 Groundwater Extraction Well (Active)
- GEW-2 Groundwater Extraction Well (Inactive)
- VEW-1 Vapor Extraction Well
- ASW-1 Air Sparge Well
- YCW16-1 Combination Well
- Younts Residential Well

Screen Interval (ft bgs) — Analyte

Well ID	Screen	CR	NI
YS20-1	155-185	185	180

Red Result indicates an MCL excedence

Notes

1) Analytical results shown in ug/L (micrograms per liter) for the wells sampled during the 2011 Annual Groundwater Monitoring Event.

2) Cr = Chromium (MCL = 50 ug/L)
Ni = Nickel (MCL = 100 ug/L)
MCL = Maximum Contaminant Level
J = Estimated Value
U = Not Detected (value indicates reporting limit)

Approximate Scale in Feet

0 800 1600

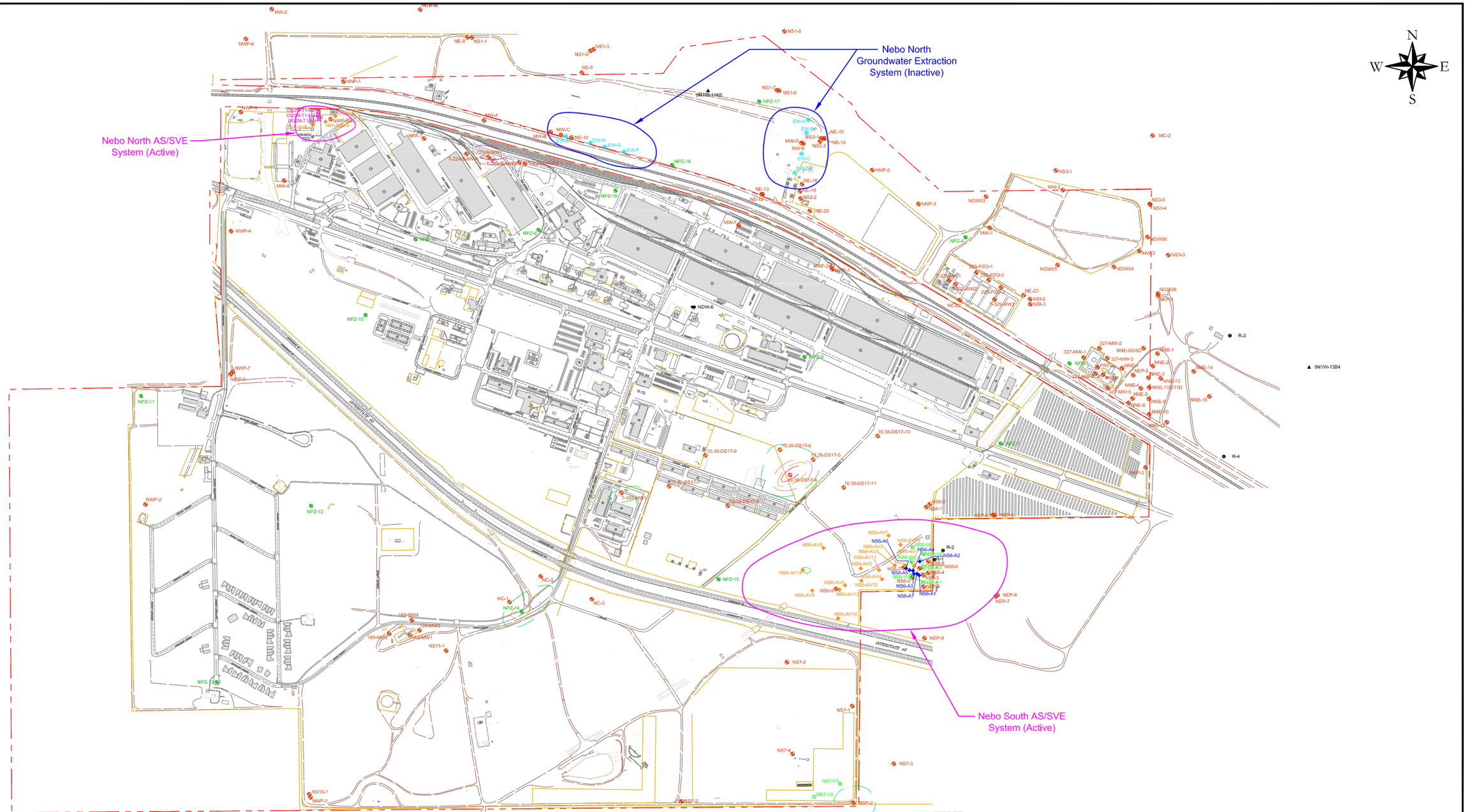
Figure 7-7
Chromium and Nickel in Groundwater
(2011 Annual)

Yermo Annex
Marine Corps Logistics Base
Barstow, California

AIS-TN&A Joint Venture

Date: May 4, 2012

File: Barstow_5yrRev.dwg



Legend

	Paved Road	NS6-V4	Vapor Extraction Well
	Dirt Road	NS6-A7	Air Sparge Well
	Railroad Tracks	NS6-AV7	Vapor Extraction/Air Sparge Well
	Fence Line	9N1W-11K6	USGS Well
	Base Boundary	R-1	Residential Well
NEP-1	Groundwater Monitoring Well	5	Approximate TCE Isoconcentration Contour (ug/L)
NPZ-4	Piezometer	10	Approximate TCE Isoconcentration Contour (ug/L)
NDW-6	Base Groundwater Supply Well	5	Approximate PCE Isoconcentration Contour (ug/L)
EW-B	Groundwater Extraction Well (Active)	10	Approximate PCE Isoconcentration Contour (ug/L)

Notes

1) Analytical results shown in ug/L (micrograms per liter) are a combination of wells sampled during the November 2011 event and May 2012 event.

2) TCE = Trichloroethene
PCE = Tetrachloroethene
DCE = 1,1-Dichloroethene
CAOC = CERCLA Area of Concern
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
OU = Operable Unit

Approximate Scale in Feet

0 900 1800

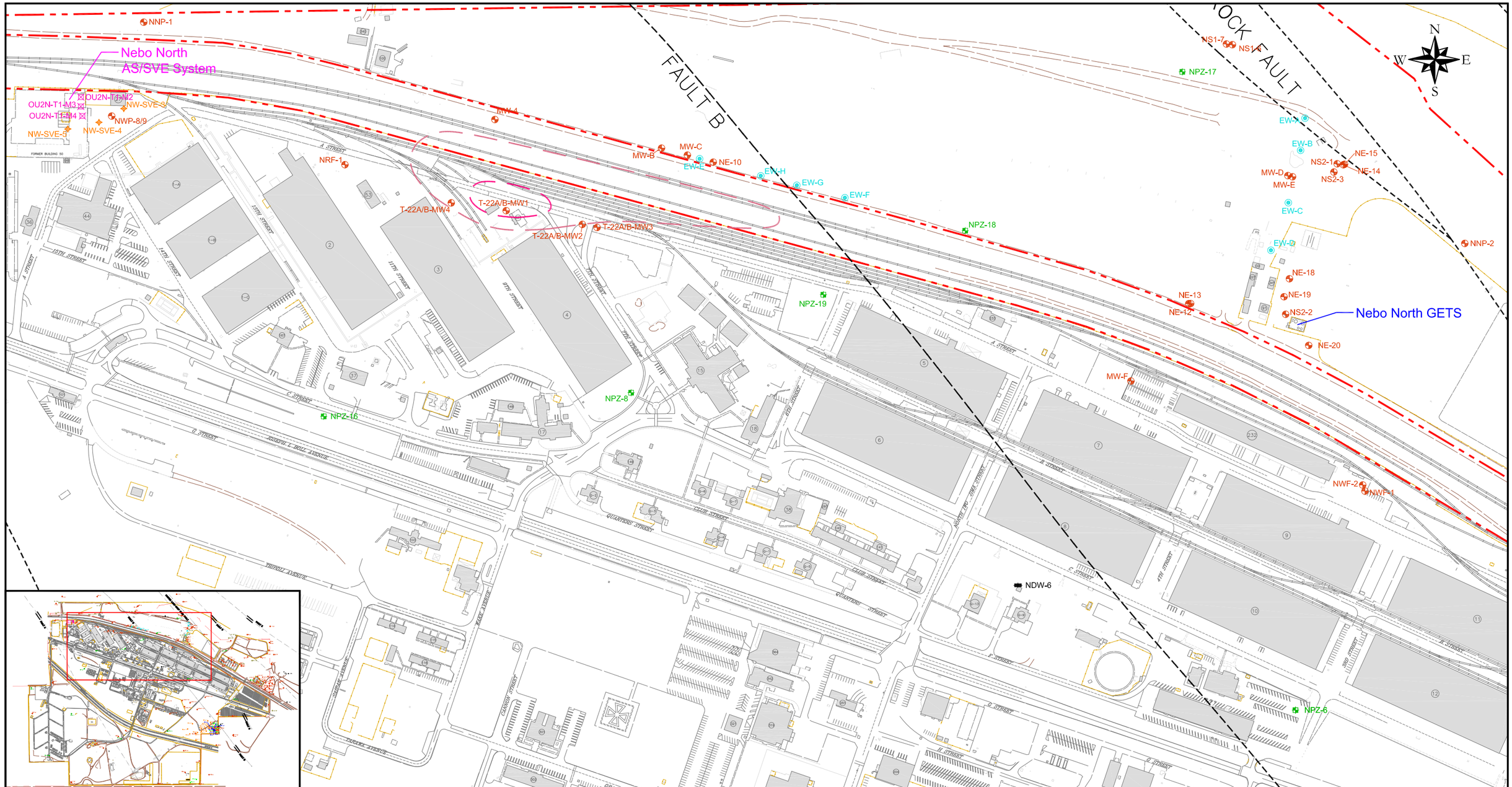
Figure 8-1
OU2 (CAOC 38) Groundwater Plumes and Remediation Systems

Nebo Main Base
Marine Corps Logistics Base
Barstow, California

AIS-TN&A Joint Venture

Date: May 4, 2012

File: Barstow_5yrRev.dwg



Legend

	Paved Road	MW-B	Groundwater Monitoring Well
	Dirt Road	NPZ-8	Piezometer
	Railroad Tracks	NDW-6	Base Groundwater Supply Well
	Fence Line	EW-B	Groundwater Extraction Well (Inactive)
	Base Boundary	NW-SVE-3	Vapor Extraction Well
		OU2N-T1-M2	Combination Well

Notes

1) GETS = Groundwater Extraction Treatment System
AS/SVE = Air Sparge / Soil Vapor Extraction

Approximate Scale in Feet

0 350 700

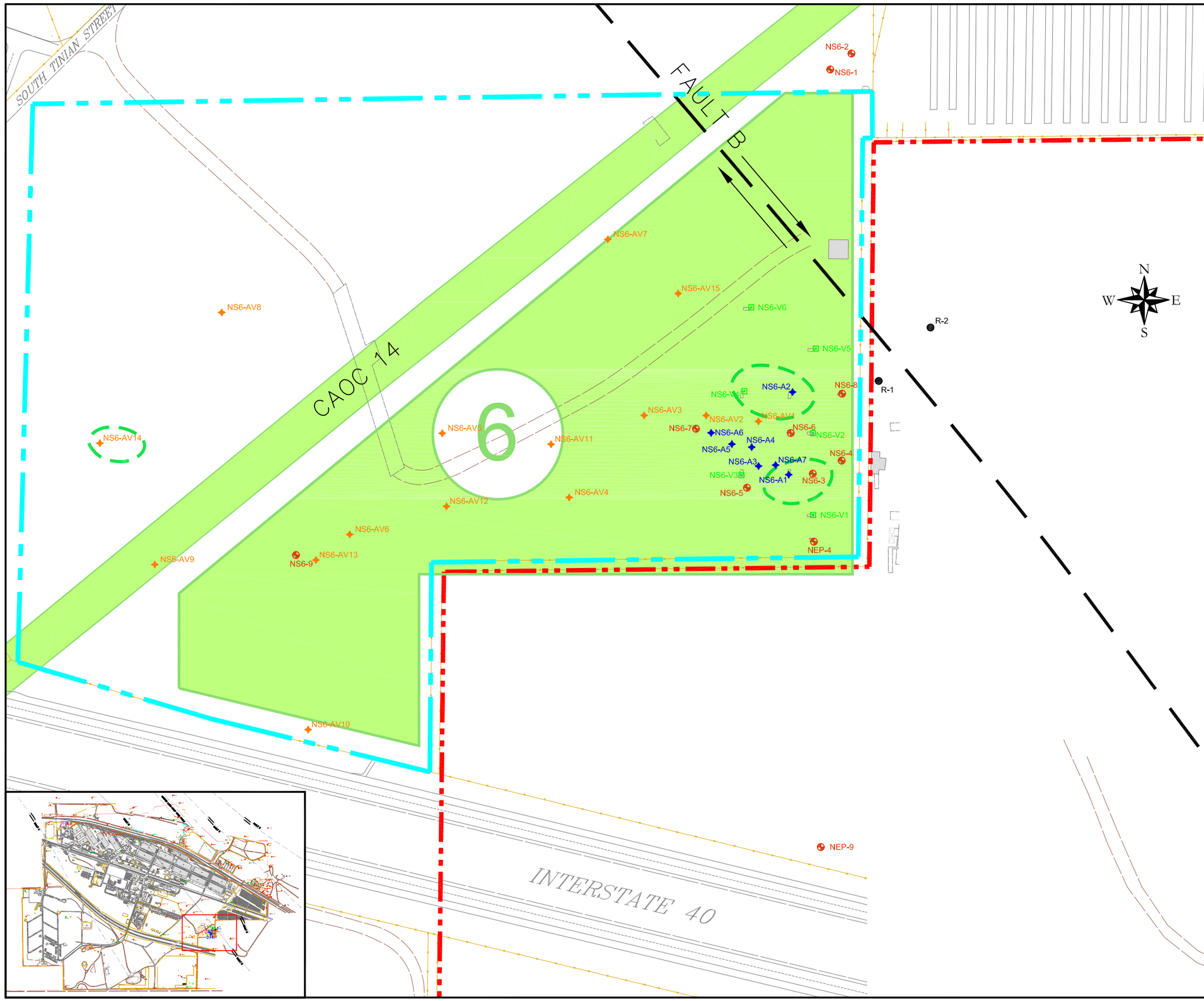
Figure 8-2
Nebo North AS/SVE System, GETS, and 2011 Isoconcentration Contours

Nebo Main Base
Marine Corps Logistics Base
Barstow, California

AIS-TN&A Joint Venture

Date: May 11, 2012

File: Barstow_5yrRev.dwg



Legend

- Paved Road
- Dirt Road
- Fence Line
- Base Boundary
- CAOC 6 Land Use Control Boundary
- NEP-1 Groundwater Monitoring Well
- NS6-V4 Vapor Extraction Well
- NS6-A7 Air Sparge Well
- NS6-AV7 Air Sparge/Vapor Extraction Well
- R-1 Residential Well
- Operable Unit 6 (CAOC ##)
- 5 Approximate TCE Isoconcentration Contour (ug/L)

Notes

1) CAOC - CERCLA Area of Concern
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
AS/SVE = Air Sparge / Soil Vapor Extraction
TCE = Trichloroethene

Approximate Scale in Feet

0 150 300

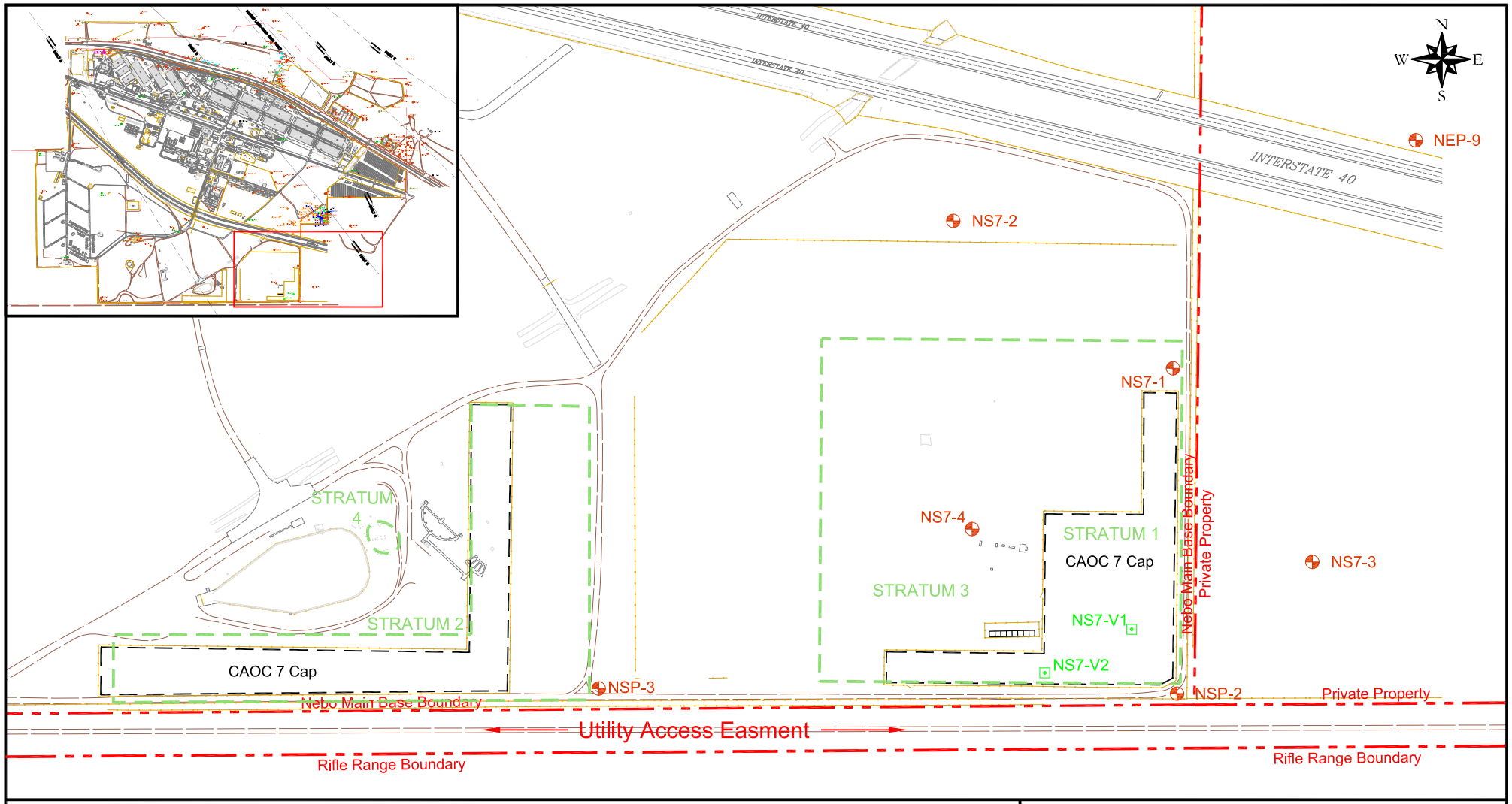
Figure 8-3
Nebo South (CAOC 6) AS/SVE System and 2011 Isoconcentration Contours

Nebo Main Base
Marine Corps Logistics Base
Barstow, California

AIS-TN&A Joint Venture

Date: May 4, 2012

File: Barstow_5yrRev.dwg



Legend

- Paved Road
- Dirt Road
- Fence Line
- Base Boundary
- CAOC 7 Boundary
- NSP-3 Groundwater Monitoring Well
- NS7-V1 Vapor Extraction Well

Notes

1) CAOC - CERCLA Area of Concern
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act

Approximate Scale in Feet

0 400 800

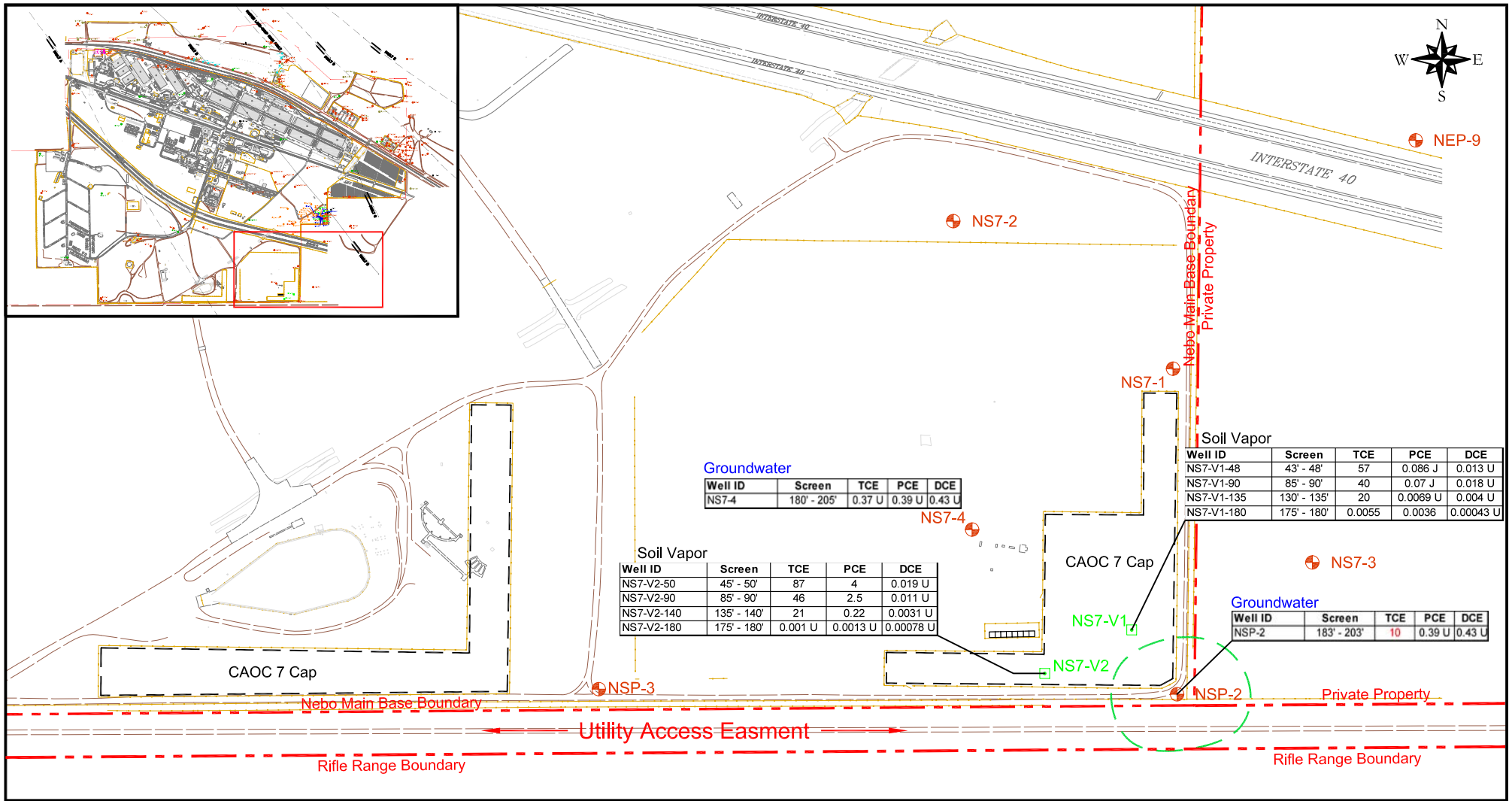
Figure 8-4
CAOC 7 Strata

Nebo Main Base
Marine Corps Logistics Base
Barstow, California

AIS-TN&A Joint Venture

Date: May 4, 2012

File: Barstow_5yrRev.dwg



Legend

- Paved Road
- Dirt Road
- Fence Line
- Base Boundary
- NSP-3 Groundwater Monitoring Well
- NS7-V1 Vapor Extraction Well
- 5 Approximate TCE Isoconcentration Contour (ug/L)

Monitoring Well Sample

Well Screen Interval — Analyte

Well ID	Screen	TCE	PCE	DCE
NSP-2	183' - 203'	10	0.39 U	0.43 U

Red Result indicates an MCL excedence

Concentration (ug/L)

Notes

1) Analytical results shown in ug/L (micrograms per liter) for the wells sampled during the 2011 Annual Groundwater and Soil Vapor Monitoring Event.

2) VOC = Volatile Organic Compound
CAOC = CERCLA Area of Concern
PCE = Tetrachloroethene
TCE = Trichloroethene
DCE = 1,1-Dichloroethene
U = Not Detected (value indicates reporting limit)
CAOC - CERCLA Area of Concern
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act

Approximate Scale in Feet

0 — 400

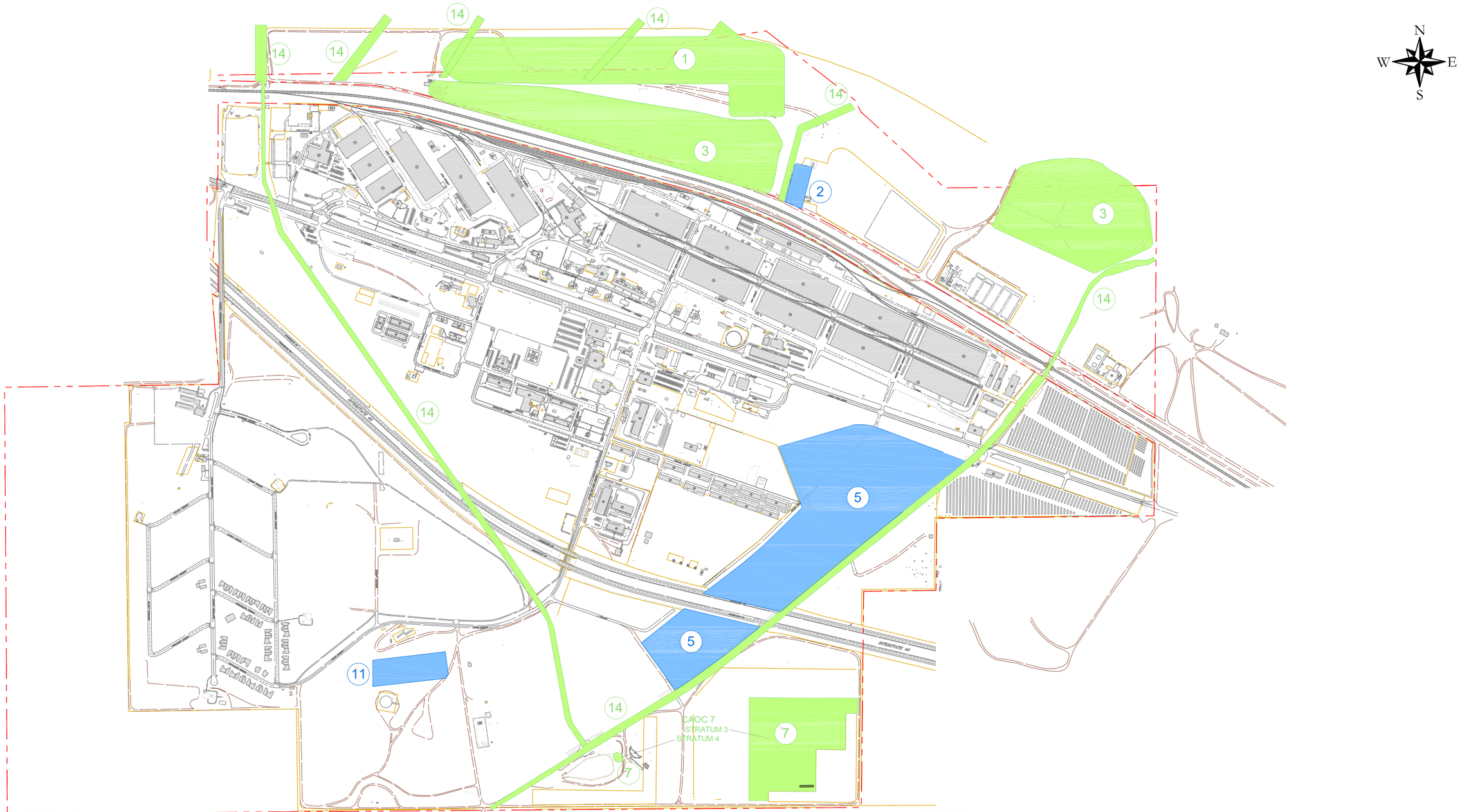
Figure 8-5
CAOC-7, Selected VOC Concentrations in Groundwater and Soil Gas (2011 Annual)

Nebo Main Base
Marine Corps Logistics Base
Barstow, California

AIS-TN&A Joint Venture

Date: May 4, 2012

File: Barstow_5yrRev.dwg



Legend

- Paved Road
- Dirt Road
- Railroad Tracks
- Fence Line
- Base Boundary
- Operable Unit 4 (CAOC ##)
- Operable Unit 6 (CAOC ##)

Notes

1) CAOC - CERCLA Area of Concern
   CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
2) CAOC 7 Strata 3 and 4 only

Approximate Scale in Feet

0 900 1800

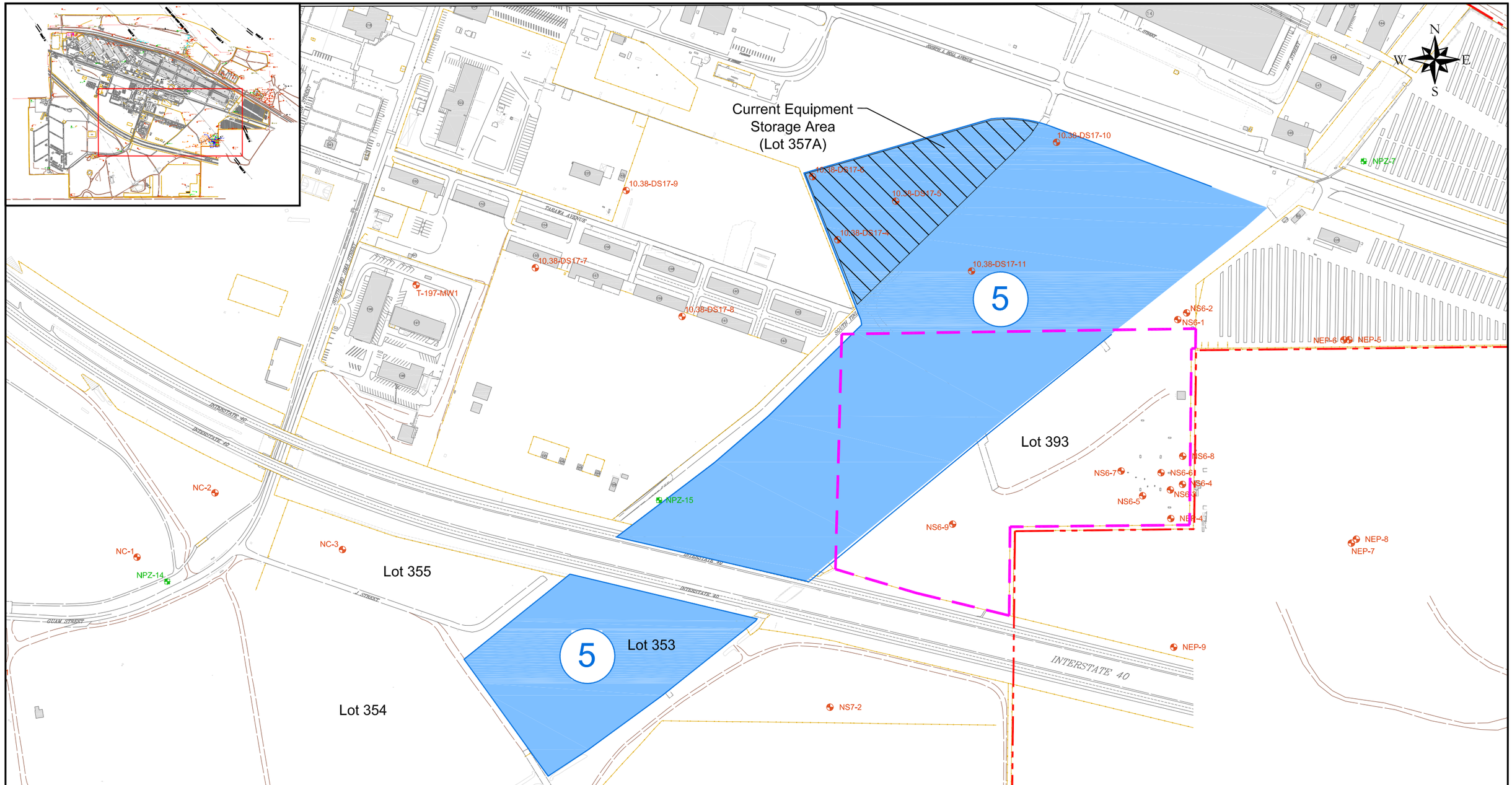
Figure 8-6
CAOCs 1, 2, 3, 5, 7(Strata 3,4), 11, and 14:
No Further Action with
Base Master Plan Modifications

Nebo Main Base
Marine Corps Logistics Base
Barstow, California

AIS-TN&A Joint Venture

Date: September 4, 2012

File: Barstow_5yrRev.dwg



Legend

- Paved Road
- Dirt Road
- Railroad Tracks
- Fence Line
- Base Boundary
- CAOC 6 Land Use Control (LUC) Boundary
- Operable Unit 4 (CAOC ##)
- NS6-9 Groundwater Monitoring Well
- NPZ-14 Piezometer

Notes

1) CAOC - CERCLA Area of Concern
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act

Approximate Scale in Feet

0 350 700

Figure 8-7
CAOC 6 LUC Boundary and CAOC 5 Chemicals Storage Area

Nebo Main Base
Marine Corps Logistics Base
Barstow, California

AIS-TN&A Joint Venture

Date: May 4, 2012

File: Barstow_5yrRev.dwg

Appendices A - H

Appendix A	Five-Year Review Public Notice
Appendix B	Documentation of Interviews and Site Inspections
Appendix C	Technical Assessment Report – Review of Exposure Assumptions, Toxicity Data, Cleanup Levels, and RAOs for OU 1 - OU 6
Appendix D	Yermo Annex OU 1 (CAOC 37) – Supporting Information for Five-Year Review of Remedial Systems
Appendix E	OUs 3 and 5 (Yermo Annex) Supporting Information for Five-Year Review
Appendix F	Nebo Main Base OU 2 – Technical Assessment of Remedial Systems
Appendix G	OUs 4 and 6 (Nebo Main Base) Supporting Information for Five-Year Review
Appendix H	FFA Regulatory Comments and DON Responses to Comments

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