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

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

Mr. Doug Feay
California Regional Water Quality Control Board
Lahontan Region - Victorville Branch Office
14440 Civic Drive, Suite 200
Victorville, CA 92392

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

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

The Department of Navy is pleased to provide the Final Second Five-Year Review Report, Operable Units 1-6, Marine Corps Logistics Base, Barstow, California.

If you have any questions, please contact me at (619) 532-1737.

Sincerely,

KRISTINA MADALI
Remedial Project Manager
By direction of the
Commanding Officer

Enclosures: 1. Final Second Five-Year Review Report, Operable Units 1-6, Marine Corps Logistics Base, Barstow, CA

Copy to: MCB Barstow

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

May 27, 2008

Ms Kristina Madali
Remedial Project Manager
Naval Facilities Engineering Command Southwest
937 North Harbor Drive
FISC Building 1, 3rd Floor
San Diego, CA 92132-5190

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

Dear Ms Madali:

The U.S. Environmental Protection Agency (U.S. EPA) Region 9 has received and reviewed "Final Second Five Year Review Report Operable Units 1 - 6 Marine Corps Logistics Base Barstow, California", dated December 18, 2007 (Barstow Final Five Year Review). The Barstow Final Five Year Review also provides Navy Responses to U.S. EPA's December 14, 2007, review comments on a November 7, 2007, Draft Five Year Review. The Barstow Final Five Year Review addresses completed and ongoing remedial actions taken pursuant to Superfund decision documents that have been prepared to date.

Based upon our review, U.S. EPA agrees with the findings, conclusions, and recommendations 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 Phillip Ramsey of my staff at (415) 972-3006.

Sincerely,

Michael Montgomery
Chief, Federal Facilities and
Site Cleanup Branch

cc: Ms Carmela Gonzalez, MCLB
Ms Soad Hakim, DTSC
Mr. Douglas Feay, RWQCB

RESPONSE TO COMMENTS ON
DRAFT SECOND FIVE-YEAR REVIEW REPORT,
November 7, 2007

OPERABLE UNITS 1–6
MARINE CORPS LOGISTICS BASE
BARSTOW, CALIFORNIA

DCN: ECSD-2201-0029-0005

December 18, 2007

Ms. Sue Hakim Remedial Project Manager Department of Toxic substances Control 5796 Corporate Avenue Cypress, California 90630 Comments: November 30, 2007	Responses by: Ms. Kristina A. Madali Remedial Project Manager NAVFAC Southwest 1220 Pacific Highway San Diego, CA 92132 Responses: December 18, 2007
General Comments OU 1	
Comment 1. GSU notes that the ROD and its attendant remedy, and the current Report are based on what amounts to a two-dimensional interpretation of the data. The groundwater model used in the RIIFS was the MOC version 3 two-dimensional fate and transport model. The current MODFLOW model is highly simplified, and comprises only 3 layers, with very little supporting aquifer parameter data on which to base calibrations. Calibration is based on a single snapshot of groundwater elevations in 2004, rather than a history of groundwater elevation and discharge data. GSU points out that the aquifer at Yermo extends to at least 600 feet below ground surface (bgs) and that monitoring and extraction wells that extend through less than 20% of the aquifer thickness may not provide representative data or adequate engineering control of the mass of groundwater	**Response 1.** The groundwater flow model (MODLFOW) used for capture zone modeling utilizes field data. Recalibration of the model as a result of regional changes in groundwater elevations is in progress. Additional documentation of field data used in modeling will be done. The model is a steady state model. Long term, large scale, and average conditions are assumed using the most current data to simulate future predictions. Transient processes are not simulated. Boundary conditions (constant head boundary) are modified to achieve the calibration criteria as a result of changes in regional groundwater elevations. In other words, hydraulic parameters such as hydraulic conductivity and vertical leakance values used in the model are valid for several calibrations. A multiport well with six ports (Y15-4-1 through Y15-4-6) was installed during December 2002 to further evaluate off-Base groundwater quality at multiple depths. The ports extend approximately from 210 feet below ground surface (bgs) to 510 feet bgs. Analyses of groundwater samples collected during the subsequent groundwater sampling events through the semiannual sampling event of 2007 (April/May 2007) did not indicate the presence of COCs at concentrations that are at or above the respective MCLs. This indicates that there is no "escaping" VOC contamination at depth that has bypassed the groundwater extraction wells (GEWs) at the Base boundary.

Comment 2. The groundwater plumes extend past the Yermo Annex Base boundary, and past the ability of the GETS to capture the escaping contaminants. At least one plume has affected two offsite private water supply wells, the Younts and Hodges wells. Plume expansion can be observed by comparing the groundwater plume maps in the ROD (Figures 3-2 and 3-3) with the groundwater plume map in the current Report. Comparison shows that the CAOC 16 and CAOC 26 plumes have expanded to the east and reached the last available groundwater monitoring points. The smaller TCE plume southeast of CAOC 26 has migrated about 4,000 feet to the east and is escaping the Annex area to the east. Additional groundwater wells are required to define the extent of these plumes and evaluate the need for additional remedial action.	**Response 2.** The historical extents of the TCE and PCE plumes at the Yermo Annex based on annual sampling conducted in 1996, 2000, 2004, and 2006 are shown on Figure 4-14 of the Second Five Year Review report. As can be noted from Figure 4-14, the TCE plume extent has decreased over the past 10 years (1996 to April / May 2007). These reductions may be attributed to ongoing operation of the CAOC 16 AS/SVE system in conjunction with groundwater extraction. The decrease in VOCs can also be attributed to the declining water table and other natural attenuation processes such as degradation, dilution, and dispersion. The extent of the PCE plume at Yermo North has also decreased between 1996 and 2007 (Figure 4-14). The decrease in PCE is much more pronounced when compared to TCE, with a distinct shrinkage in the vicinity of the CAOC 16 AS/SVE wells (Figure 4-14). Additional optimization activities proposed in the Second Five-Year Review are expected to address the remaining portion of the Yermo North (CAOC 16) plume. Based on the above discussion and the groundwater monitoring trends discussed in Section 4.4.4.2 for the Yermo North plume, the horizontal extent of the Yermo North plume appears to remain fairly stable. As discussed in the 2004 Annual Groundwater Monitoring Report (AGMR), the CAOC 26 plume, as mapped in the 2003 AGMR, was located in the central portion of Yermo. The majority of the plume has since diminished to concentrations below MCLs due to successful operation of a groundwater extraction and treatment system within the CAOC 26 plume boundaries. The areal extent of the TCE plume in the CAOC 26 area has shown a decrease over time (Figure 4-14). It is likely that the operation of CAOC 26 AS/SVE system and previous groundwater extraction through GEW-9, -10, -11, -12 have resulted in the observed decrease in the TCE plume.

	The PCE plume interpreted in 1996 can no longer be interpreted to exist (Figure 4-14). It is likely that the operation of CAOC 26 AS/SVE system in conjunction with previous groundwater extraction through GEW-9, -10, -11, -12 have resulted in this observed decrease in the areal extent of the PCE plume at CAOC 26. Groundwater samples from two monitoring wells (PMW-11 and -12) within the former CAOC 26 plume boundary have shown TCE concentrations above MCLs until recently. Semi-annual sampling performed in May 2007 showed TCE in PMW-11 at 4.0 µg/L and PMW-12 at 1.3 µg/L. The relatively low-level TCE concentrations in PMW-11 and -12 are believed to be residual concentrations that will be eventually treated through natural attenuation and/or the Yermo Annex GETS.
Comment 3. GSU is concerned that ongoing residential, industrial, and commercial development downgradient of the Yermo Annex is potentially threatened by the migration of the dissolved VOC plumes originating at the Base. The Navy should evaluate any groundwater uses within 5 miles downgradient of Yermo Annex, and evaluate the need for additional protective measures.	**Response 3.** Historical analytical results for the off-Base Younts and Hodges drinking water well treatment systems influent samples have shown COC concentrations well below the MCL levels. A review of historical groundwater monitoring data for the groundwater monitoring wells located farthest from the property boundary have shown concentrations that were well below the MCL values. Therefore, any COC concentrations in off-Base groundwater have been attenuating through natural processes and are not considered to be affecting the groundwater use. The Younts and Hodges groundwater system continues to treat the extracted groundwater.
Comment 4. The ROD was based on the assumption that dense non-aqueous phase liquids (DNAPLs) were not present, and that the VOC contamination was a result of either discharge of contaminated waste water or vapor transport of VOC, or both. GSU notes that the determination that DNAPLs are absent was based on a very limited dataset gathered during the Remedial Investigation/Feasibility Study (RI/FS) phase of work. These data support the finding that no pooling of DNAPL could be documented in the vadose zone near Building 573, a possible source of discharge. Early vertical profiling of groundwater contamination found that most of the detectable contamination appeared to be in the top 40 feet of the aquifer. GSU notes that the conclusion of	**Response 4.** As described in Section 6.6.1.1 of the Draft Final Remedial Investigation Report, Operable Units 1 and 2, Marine Corps Base Barstow, Barstow, California, deep vertical profile borings (VPBs) in the area of CAOC 16 (Yermo North plume area) indicated the following: • In the Building 573 area (CAOC 16), results from the VPB YVP-1 did not reveal the presence of TCE, PCE, and 1,1-DCE above the respective MCLs in groundwater below a depth of 163 feet bgs. • Another VPB, YAS-1 near Building 573 (CAOC 16) did not reveal the presence of TCE, PCE, and 1,1-DCE above the respective MCLs, in groundwater below a depth of 190 feet bgs.

the RIIFS may have been premature, and based on insufficient data. The 10 years of additional monitoring data seem to be inconsistent with the ROD assumption of discharge mechanism. The mapped data show that the CAOC 16 and CAOC 26 plumes continue to display relatively stable concentrations of VOCs at the suspected source area. Concurrently, the toes of the plumes continue to extend downgradient. This is not consistent with the assumed discharge of a slug of contaminated water to the aquifer, and strongly suggests one or more areas of free-phase VOC contamination, or a continuing discharge.	• VPB YS18-2 downgradient of Building 573 (CAOC 16) results indicated that TCE, PCE, and 1,1-DCE were not present above the respective MCLs in groundwater below a depth of 170 feet bgs. In addition, as discussed under Response 1, analyses of groundwater samples collected from the deep multiport well with six ports (Y15-4-1 through Y15-4-6) with the sampling ports extending approximately from 210 feet bgs to 510 feet bgs did not indicate the presence of COCs at concentrations that are at or above the respective MCLs. This indicates that there is no “escaping” VOC contamination at depth that has bypassed the GEWs at the Base boundary. The proposed optimization of remediation systems proposed in the Second Five-Year Review report is expected to address the remaining portion of the Yermo North (CAOC 16) plume.
Comment 5. GSU remains concerned that the source area under Building 573 has not been investigated and that site closure under CERCLA will not be appropriate until that task is complete.	**Response 5.** Additional optimization proposed in the Second Five-Year Review report is expected to address the Yermo North (CAOC 16) plume. Following the implementation and monitoring of the additional optimization activities, as necessary, DON will evaluate the monitoring data and take additional steps as needed to address the Yermo North (CAOC 16) plume.
Comment 6. Section 3.2.2 CAOC 16, OU5, page 3-4. GSU does not concur that the current ASISVE system is likely to remediate vadose zone soils under Building 573. The data are insufficient to make that assertion, and the Navy should remove that assertion from the Report.	**Response 6.** As discussed in Section 4.4.4.7, soil vapor VOC concentrations in the three combination wells near Building 573 (YCW16-1, YCW16-2, and YCW16-3) show a decrease or have remained at low levels relative to initial levels in 1999 in spite of their distance (up to 1,000 feet) from the SVE wells. Discussion presented in Section 3.2.2 reflects this observation. Additional optimization proposed in the Second Five-Year Review report is expected to address the Yermo North (CAOC 16) plume. Following the implementation and monitoring of the additional optimization activities, as necessary, DON will evaluate the monitoring data and take additional steps as needed to address the Yermo North (CAOC 16) plume.

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Comment 7. GSU notes that a large area of concrete was removed and replaced in the hardstand area near Building 573 during the reporting period. GSU requests the opportunity to review any geological, geotechnical, or engineering reports or other information on that work.	**Response 7.** Replacement of the Building 573 Hardstand concrete cap was undertaken following the guidance set forth in the Base Master Plan for continued monitoring and maintenance activities. The work included removal of the concrete cover and replacement with fresh concrete. No geological or geotechnical testing was performed. The MCLB Barstow Environmental Department reviewed the project. The replacement activities were completed so that the structural integrity of the concrete cap is maintained.
Comment 8. Section 7.7.4.3 Additional Optimization Recommendations OU1 Optimization Study, page 7-1 2. GSU requests clarification of item 3 "Evaluate whether the SVE wells may be shut off and the vapors allowed to escape into the atmosphere". The Navy should clarify the specific recommendation being made, and how the recommendation might be implemented	**Response 8.** The OU 1 Optimization Study made this recommendation to evaluate whether the air sparge vapors must continue to be collected by the SVE wells. An optimization work plan currently under preparation addresses the recommendations made in the previous OU 1 Optimization Study.
Comment 9. Same section. GSU concurs with the evaluation of pulsing of Air Sparging wells. GSU recommends filling in the gaps in the array even if pulsing existing wells does not increase mass removal rates.	**Response 9.** Comment noted.

Comment 10. GSU recommends that: • the data gaps at the Site be corrected by deeper exploration along the axis of the known plumes to define the vertical and lateral extent of the plumes in the aquifer as a whole, • Investigation of the source areas be completed, • the Conceptual Site Model be revised to take the thickness of the aquifer and the three-dimensional distribution of contaminants in to account, • the fate and transport model be revised using a three-dimensional analysis, • the GETS wells be deepened and the treatment system expanded as needed to intercept and treat the contaminated groundwater and meet the original intent of the ROD.	**Response 10.** DON proposes to evaluate additional optimization activities as recommended in the Second Five Year Review report to address the Yermo North plume. The selected optimization activities will be presented to the FFA and then implemented. Based on the performance monitoring of these additional optimization activities, the DON will evaluate if any additional steps will be required.
General Comments OU 2	
Comment 11. GSU notes that the ROD and its attendant remedy, and the current Report are based on what amounts to a two-dimensional interpretation of the data. GSU points out that the aquifer at Nebo is of extremely variable thickness, and is strongly affected by the leaky barrier of the Harper Lake-Camp Rock Fault system. GSU has commented in previous memoranda on these difficulties. GSU notes that in areas where groundwater negotiates a leaky vertical barrier, detailed groundwater gradient mapping is vital to understanding the groundwater regime. Areas where vertical groundwater movement is documented should be investigated for complex transport pathways. The current two-dimensional interpretation is likely to be inadequate for this purpose.	**Response 11.** As discussed in Section 7.6.1 of the Draft Final Remedial Investigation Report, Operable Units 1 and 2, Marine Corps Base Barstow, Barstow, California, two vertical profile borings (MW-C and MW-E) in the Nebo North plume area and vertical profile borings in the Nebo South plume area (NS6-A1 and NS6-A2) were used in addition to the other sampling locations in assessing the vertical and lateral extent of contamination. As discussed in Section 4.5.2.2 of the Second Five-Year Review, the historical extents of the Nebo North PCE plumes interpreted for 1996, 2000, 2004, and 2006 shown on Figure 4-19 indicate the following: • Historical Nebo North VOC monitoring data from 1996 and 2000 show that the PCE plume boundary line previously extended beyond fault line B to fault line C.

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GSU recommends that:

the data gaps at the Site be corrected by deeper exploration along the axis of the known plumes to define the vertical and lateral extent of the plumes in the aquifer as a whole,
the Conceptual Site Model be revised to take the variable tokhickness of the aquifer, the probable leaks through the local fault system, and the three-dimensional distribution of contaminants in to account,
the fate and transport model be revised using a three-dimensional analysis.

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VOC monitoring data from 2004 suggest that the PCE plume has shrunk as compared to 1996 and 2000 plume extents.
The annual 2006 and semiannual 2007 groundwater monitoring data show that the interpreted PCE plume extent is west of fault line B, indicating further shrinkage as compared to the 2004 PCE plume extent.

In general, it is apparent that the downgradient PCE plume extent has contracted, as concentrations in several Nebo North wells on either side of the fault lines have decreased.

It is evident that the Nebo North plume is not influenced significantly by the Harper Lake-Camp Rock Fault system based on the westward (upgradient) shrinkage of the Nebo North plume. As stated in the OUs 1 and 2 ROD, it appears that the natural attenuation continues to be the dominant mechanism in remediating the Nebo North plume.

The Nebo North AS/SVE system which became operational in October 2007 is expected to further treat the Nebo North source area as well as the Nebo North plume.

The Nebo South AS/SVE was finalized based on the success of the AS/SVE pilot testing. As discussed in Section 4.5.3.2 of the Second Five Year Review report, the historical extents of the Nebo South TCE plumes interpreted for 1996, 2000, 2004, and 2006 on Figure 4-23 indicate that the extent of the Nebo South TCE plume has decreased over time and that TCE concentration levels in a majority of the individual wells have also decreased over time. Additional optimization of the remediation activities are in progress as part of the continued operation of the Nebo South AS/SVE system.

Based on these observations, DON believes that the Nebo North and Nebo South plumes continue to be remediated and that additional investigation activities are not necessary.
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DCN: ECSD-2201-0029-0005

December 18, 2007

Mr. Phillip Ramsey Remedial Project Manager U. S. Environmental Protection, Region IX 75 Hawthorne Street San Francisco, CA 94105 Comments: December 14, 2007	Responses by: Ms. Kristina A. Madali Remedial Project Manager NAVFAC Southwest 1220 Pacific Highway San Diego, CA 92132 Responses: December 18, 2007
General Comments	
Comment 1. Major Components of a Five Year Review are included: The Navy has included all major components that are required by U.S. EPA in a Five Year Review.	**Response 1.** Noted.
Comment 2. Need for Modification to Protectiveness Statement: U.S. EPA in general agrees with the Navy on its determination that Operable Units (OUs) 1-6 are currently protective; however, as U.S. EPA does have concerns with the long term protectiveness at several of the OUs, we request some changes to the subject document with regards to this long-term protectiveness concern. With regards to the Navy protectiveness statement, U.S. EPA requests the following change: "The remedy for Barstow is considered protective in the short-term, because there is no evidence that there is current exposure. However, in order for remedies to remain protective in the long-term, Institutional Controls (ICs) restricting access to contaminated groundwater off-site must be put in place, the groundwater extraction system at OU-1 (Yermo Annex Groundwater) modified to improve capture, the Air Sparging/Soil Vapor Extraction system at OU-2 (Nebo South Groundwater) upgraded, the remedy at CAOC 20 (OU-3) re-evaluated, and the	**Response 2.** Section 3.6, Summary of Selected Remedy for the Yermo Annex Plume in the OUs 1 and 2 ROD includes the following language (please refer specifically to text in bold format) regarding the institution controls (ICs) (will be referred to as land use controls [LUCs]) for groundwater portion of Yermo Annex. "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."**

VOC detections at monitoring wells NSP-2 (down-gradient from CAOC 7/OU-6) and NPZ-14 (down-gradient from CAOCs 12 and 12) assessed."	Therefore, LUCs are in place for the off-Base Yermo Annex groundwater. The following overall protective statement has been added in the Executive Summary and Section 10.7: "The remedy for MCLB Barstow (Operable Units 1 to 6) is considered protective in the short-term because there is no evidence of current exposure. However, in order for remedies to remain protective in the long-term, the required actions include (i) modifications as necessary of the groundwater extraction system at OU 1 (Yermo Annex Groundwater) to improve capture; (ii) additional optimization of the CAOC 16 AS/SVE system at Yermo Annex; (iii) optimization of the Nebo South AS/SVE system (OU 2); (iv) an assessment of the concentration increases at CAOC 20 and if required, a re-evaluation of the CAOC 20 remedy, and (v) assessment of the VOC detections at monitoring wells NSP-2 (down-gradient from CAOC 7 [OU 6]) and NPZ-14 (down-gradient from CAOCs 11 and 12 [OU 2])."
Comment 3. Need for Additional Detail in Protectiveness Statements: The protectiveness statements for OUs 1, 2, 3, and 6 state that the remedies are currently protective, but do not include the details of why they are protective as recommended in EPA Guidance (EPA, 2001). For example, ICs are in place for all four of these OUs, but ICs are not mentioned in the respective protectiveness statements for each OU. Please discuss the elements of the remedies that protect human health and the environment in the short term.	**Response 3.** Protective statements (Section 10) have been revised as shown below (only protectiveness statement portions are included; recommendations for long term protectiveness can be found in the appropriate sections referenced below for each OU). The OU 1 protective statement (Section 10.1) has been revised as shown below: The RAs at CAOC 37 under OU 1 are currently protective of human health and the environment because of the on-going operation of the GETS and the CAOC 16 AS/SVE system that are in operation as well as the LUCs that are in place. The OU 2 protective statement (Section 10.2) has been revised as shown below: The RAs at CAOC 38 under OU 2 are currently protective of human health and the environment as a result of the natural attenuation remedy (Nebo North), CAOC 6 AS/SVE operation at Nebo South, and the LUCs that are in place.

	The OU 3 protective statement (Section 10.3) has been revised as shown below: The RAs at CAOC 20 under OU 3 are currently protective of human health and the environment because of the cap at CAOC 20, the LUCs that are in place, and implementation of the BMP for the respective CAOCs. The OU 6 protective statement (Section 10.6) has been revised as shown below: The RA at CAOC 7 under OU 6 currently protects human health and the environment because of the caps and the LUCs that are in place.
Comment 4. CAOCs with Residual Contamination: U.S. EPA recommends that a revised Five-Year Review contain more specific and concise information regarding several aspects of the OU-specific CERCLA Areas of Concern (CAOCs). In Section 3.0, Background, additional details are needed to describe the site histories and the specific nature of the ICs. Clarification is needed to reconcile Table 1-1, Summary of CAOCs, with Figure 1-6, Organization of OUs and CAOCs. For example Table 1-1 indicates that a number of sites, like CAOC 1, Landfill North of Golf Course, has site use restrictions being address through the Navy's Basewide Mater Plan process and notes that the Five Year Review needs to be conducted; however, on Figure 1-6, CAOC 1 is shown as being a No Further Action (NFA) site – without ICs. Also, as discussed with the Navy during a Navy-regulatory site tour in September 2007, each CAOC should have been provided with total CAOC area (acreage) along with areas (acreage) associate with formal ICs, such as areas with significant soil contamination or areas associated with a cap or barrier remedy.	**Response 4.** Figure 1-6 will be revised based on the contents of Table 1-1. Total CAOC areas and where applicable, formal LUC areas will be added to Table 1-1. The background information for the respective CAOCs in Section 3 was consistent with the First Five-Year Review. Where applicable, background information was updated based on the events that took place since the First Five Year Review. Considering that the respective RODs for the CAOCs have been adequately referenced in the Second Five-Year Review, additional details regarding the CAOCs could be accessed from the respective RODs. The DON requests the U.S. EPA to accept the RODs as the sources of additional information. If U.S. EPA prefers including additional details in the Five Year Review, DON proposes to further expand the background discussion in the Third Five-Year Review.

RESPONSE TO COMMENTS ON DRAFT SECOND FIVE-YEAR REVIEW REPORT November 7, 2007 OPERABLE UNITS 1–6 MARINE CORPS LOGISTICS BASE BARSTOW, CALIFORNIA DCN: ECSD-2201-0029-0005 December 18, 2007	
Comment 5. Need for Discussions on Newly Identified Areas of Potential Concern: The Navy is strongly encouraged to initiate discussions with the regulatory agencies regarding groundwater contamination at monitoring well NPZ-14 and Yermo Annex Site 20 (Second Hazardous Waste and Low-Level Radiological Area) as soon as possible. Regarding trichloroethylene (TCE) detections at CAOC 7 (Drum Storage and Landfill Area) down-gradient well NSP-2, if the next groundwater sampling round exceeds the TCE Maximum Contaminant Level (MCL), regulatory discussions and reevaluation of the remedy will need to occur.	**Response 5.** Comment noted.
Specific Comments	
Comment 1. Section 3.2.10 CAOC37 (OU 1 Groundwater), Page 3-6, and Figure 1-4, Yermo Annex Soil CAOCs and Groundwater Plumes: The extent of contamination is not shown in Figure 1-4 although the text of Section 3.2.10 states that this figure shows the extent of volatile organic compound (VOC) contamination and area of potential metals contamination. A review of Figure 1-4 reveals that CAOC 37 is not shown on the figure, and that the contour lines indicating the extent of contamination are not present. Please include the VOC contamination contour lines on Figure 1-4 and indicate that CAOC 37, while not depicted on the figure, includes the groundwater beneath Yermo Annex.	**Response 1.** VOC contamination distribution contour lines have been added to Figure 1-4. In addition, a note stating "CAOC 37 (not shown on this figure) includes groundwater beneath Yermo Annex" has been added to Figure 1-4. A similar note to indicate Nebo Main Base groundwater (CAOC 38) has been added to Figure 1-5 as well**.**

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Comment 2. Section 4.4.4.2 Reduction in VOC Concentrations, Yermo South Plume, Page 4-21: The last paragraph of the Yermo South Plume section states that the trichloroethene (TCE) concentration in well Y9-2 was below the maximum contaminant level (MCL) at 3.1 micrograms per liter (ug/L) during the 2007 semiannual monitoring event and that therefore, the plume is not inferred to be present off-Base. An examination of the concentration trends for well Y9-2 on Figure C-4 indicates that concentrations have fluctuated around the MCL for this well in the past. Therefore, additional monitoring data is required before the conclusion can be drawn that the plume is not present off-base.	**Response 2.** The following sentence in the last paragraph in Section 4.4.4.2 Reduction in VOC Concentrations, Yermo South Plume, has been deleted. Thus, the plume, as delineated by the 5 µg/L isoconcentration contour, is not inferred to be present off-Base.
Comment 3. Section 4.4.4.2 Reduction in VOC Concentrations, CAOC 26 Plume, Page 4-21-4-22: Similar to the previous comment, the last paragraph of the CAOC 26 Plume section states that the TCE concentrations in wells PMW-11 and PMW-12 were below the MCL during the 2007 semiannual monitoring event and that therefore, the plume is not inferred to be present. An examination of the concentration trends for wells PMW-11 and PMW-12 on Figure C-6 indicates that concentrations were previously above or fluctuating around the MCL. Therefore, additional monitoring data is required before the conclusion can be drawn that the plume is not present.	**Response 3.** The following sentence in the last paragraph in Section 4.4.4.2 Reduction in VOC Concentrations, CAOC 26 Plume, has been deleted Thus, the CAOC 26 plume, as delineated by the 5 µg/L isoconcentration contour, is not inferred to be present in the CAOC 26 area.

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Comment 4. Section 4.5.1.1, Groundwater Monitoring Data, Page 4-29: Regarding TCE detected in COAC 7 monitoring well NSP-2, the Navy provide text from the OUs 5-6 ROD which states, "…[a]fter a detection above an MCL, if the next three consecutive annual monitoring events indicate that contaminant concentration are above an MCL, then the remedy for the site will be reevaluated for compliance with the threshold criteria…". The VOC detections at well NSP-2, down-gradient of CAOC 7, Drum Storage and Landfill Areas, have exceeded the TCE MCL three years in a row; therefore, as described in the ROD, if the detected TCE concentration from the next groundwater monitoring event exceeds the MCL value, the remedy for the site *will* need to be reevaluated, not "may need to be reevaluated" as stated in text. Please make this correction.	**Response 4.** The suggested change has been made. The revised text portion in Section 4.5.1.1 Groundwater Monitoring Data is shown below. Accordingly, if the detected TCE concentration from the next groundwater monitoring event exceeds the MCL value, 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.

Comment 5. VOCs at (Monitoring Well) NPZ-14, Page 4-35: U.S. EPA appreciates the Navy bringing to U.S. EPA's attention detections of TCE in monitoring well NPZ-14 that have been documented since 2001. Given that the Navy has been detecting TCE at this groundwater sampling location which is down-gradient for CAOCs 11 and 12 (Fuel Burn Area and Radiator Cleaning Chemical Disposal Area, respectively), U.S. EPA requests some team discussion on this groundwater area, following completion of the next sampling event. Contrary to the Navy statement in the OU-2 Summary Form on page SF-4, U.S. EPA believes some additional assessments should have already been proposed by the Navy; however, U.S. EPA will accommodate one more round of groundwater sampling to confirm impacts to groundwater at this location as a trigger for team discussions.	**Response 5.** The second bullet under the Recommendations and Follow-up Actions portion of the OU-2 Summary Form (Page SF-4) has been revised as shown below: If TCE concentrations in NPZ-14 continue to remain above the MCL, appropriate action will be proposed after consultation with the FFA signatories. The following text has been added to Section 7.12.7: Dissolved TCE contamination has been detected in the southwest portion of Nebo Main Base (NPZ-14). If TCE concentrations continue to remain above the MCL based on the Annual 2007 groundwater monitoring data, appropriate action will be proposed after consultation with the FFA signatories. The fourth paragraph in Section 7.13.2 has been revised as shown below: Dissolved TCE contamination has been detected in the southwest portion of Nebo Main Base (NPZ-14) downgradient of CAOC 11 (Fuel Burn Area) and CAOC 12 (Radiator Cleaning Chemical Disposal Area). The following paragraph has been added to Section 7.13.2.2. Based on the Annual 2007 groundwater monitoring results, if TCE concentrations detected in NPZ-14 in the southwest portion of Nebo Main Base downgradient of CAOC 11 (Fuel Burn Area) and CAOC 12 (Radiator Cleaning Chemical Disposal Area) continue to remain above the MCL, appropriate action will be proposed after consultation with the FFA signatories.

RESPONSE TO COMMENTS ON
DRAFT SECOND FIVE-YEAR REVIEW REPORT
November 7, 2007

OPERABLE UNITS 1–6
MARINE CORPS LOGISTICS BASE
BARSTOW, CALIFORNIA

DCN: ECSD-2201-0029-0005

December 18, 2007

Comment 6. Section 7.9.5, Optimization, Pages 7-17 and 7-18: It does not appear that the Yermo North and South groundwater plumes are contained, as Yermo North and South groundwater plumes extend offbase. While the plumes appear to have decreased in size based on information presented on Figure 4-14, contaminant concentrations exceeding MCLs still exist east of the base property line for both plumes. The Navy proposes to deepen or replace well GEW-8 in order to improve capture of the Yermo North Plume. The Navy also proposes to shut down well GEW-3 because it does not contribute much to the capture of the Yermo South Plume. While it appears that concentrations of VOCs are gradually decreasing based on data presented in Appendix C, concentrations in some wells still oscillate around the MCL. Therefore it may be necessary to take additional measures to provide containment of the offsite portions of the plumes. Please address the uncertainty in the off-base extent of the OU 1 Yermo North and South plumes.	**Response 6.** Since submitting the First Five-Year Review, the Department of the Navy (DON) has installed a nested deep groundwater monitoring well with six multiple ports (Y15-4-1 through Y15-4-6) in the off-Base portion of the Yermo North plume to delineate the lateral and vertical extent of the off-Base Yermo North plume. Continued operation of the existing groundwater extraction wells GEW-7 and GEW-13 at increased pumping rates along with GEW-6 has likely resulted in off-Base Yermo North groundwater monitoring well concentrations below MCL values during the semi-annual 2007 groundwater monitoring event. In addition, the influent concentrations for the off-Base drinking water well treatment system continue to remain below MCL values. Additional optimization activities, such as the deepening of GEW-8, are currently being reviewed to further improve containment of the Yermo North plume as well as plume remediation. Off-Base groundwater quality for the Yermo North plume will be evaluated based on the monitoring data collected following these activities. The DON has also installed dual-completion groundwater monitoring wells Y9-4 & 5 and Y9-6 & 7 in Yermo South area to better delineate the Yermo South off-Base plume. COCs for the on-Base groundwater monitoring wells were not detected at or above MCL levels during the Annual 2006 groundwater monitoring event. COC concentrations were below the MCL values during the semi-annual 2007 groundwater monitoring event. Groundwater extraction from wells GEW-3 and GEW-14 is ongoing. Groundwater COC concentrations will continue to be monitored for the on-Base and off-Base groundwater monitoring wells. This monitoring data will be used to evaluate the off-Base groundwater quality for the Yermo South groundwater plume.

Comment 7. Section 7.13.1.2, CAOC 16, Page 7-30: The Air sparging and soil vapor extraction (AS/SVE) remedy at CAOC 16, may not be protective in the long-term. A number of optimization recommendations were made due to increasing groundwater concentrations downgradient of the zone of influence. In addition, U.S. EPA is concerned that ICs are needed for off-site portions of the plume greater that MCLs to protect against future residential groundwater use. Please revise the protectiveness statement for OU-1 to reflect that additional modifications to the remedy are required in order for the remedy to be considered protective in the long-term.	**Response 7.** Additional optimization of the CAOC 16 AS/SVE system has been recommended. These measures are expected to contribute to the long term protectiveness of the remedy. Section 3.6, Summary of Selected Remedy for the Yermo Annex Plume as stated in the OUs 1 and 2 ROD includes the following language regarding the LUCs for groundwater portion of Yermo Annex. The off-Base portion is included as well (highlighted in bold in the following paragraph). Therefore, LUCs are in place for the off-Base Yermo Annex groundwater, and the text does not require modification. 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.**
Comment 8. Section 7.13.1.7, Off-Base Extraction Wells, Page 7-32: The text states that the need for the installation of off-base groundwater extraction wells will be assessed during the Third Five-Year Review, but it appears these wells should be considered sooner. Based on the data presented in this Second Five-Year Review, it appears the OU 1 Yermo North and South groundwater plumes (Figure 4-14) containing contaminant concentrations above MCLs still exist east of the base property line. It is unclear why an additional five years of monitoring data are required in order to make the determination whether additional off-base groundwater extraction wells are needed, particularly for the	**Response 8.** As discussed under Response 6, continued operation of the existing groundwater extraction wells GEW-7 and GEW-13 at increased pumping rates along with GEW-6 has likely resulted in off-Base Yermo North groundwater monitoring well concentrations below MCL values during the semi-annual 2007 groundwater monitoring event. In addition, the influent concentrations for the off-Base drinking water well treatment system continue to remain below MCL values. As stated under Response 6, additional optimization activities, such as the deepening of GEW-8, are currently being reviewed to further improve containment of the Yermo North plume as well as plume remediation. These optimization activities are expected to further

Yermo North plume, which has had fairly consistent detections of VOCs off-Base at concentrations exceeding the MCL since approximately 2000, according to Figure 4-14. The need for off-base groundwater extraction wells should be reevaluated before the Third Five-Year Review.	improve containment of the Yermo North plume as well as plume remediation. Monitoring data collected following these activities will be used to evaluate off-Base groundwater remediation for the Yermo North plume. COC concentrations for the on-Base groundwater monitoring wells were not detected at or above MCL levels during the Annual 2006 groundwater monitoring event. COC concentrations were below the MCL values during the semi-annual 2007 groundwater monitoring event. Groundwater extraction from wells GEW-3 and GEW-14 is ongoing. Groundwater COC concentrations will continue to be monitored for the on-Base and off-Base groundwater monitoring wells. This monitoring data will be used to evaluate off-Base groundwater remediation for the Yermo South groundwater plume. The second sentence in Section 7.13.1.7 has been revised to remove references to the Third Five-Year Review as shown below: As discussed in Section 7.9.5, the need for the installation of off-base groundwater extraction wells will be evaluated based on future groundwater monitoring data following the implementation and monitoring of additional optimization activities for the Yermo North plume. For the Yermo South plume, future groundwater monitoring data will be evaluated to assess the need for off-base groundwater extraction wells. The last two sentences in the third paragraph of Section 7.9.5 have also been revised to remove references to the Third Five-Year Review as shown below: The need for the installation of off-base groundwater extraction wells will be evaluated based on future groundwater monitoring data following the implementation and monitoring of additional optimization activities for the Yermo North plume. For the Yermo South plume, future groundwater monitoring data will be evaluated to assess the need for off-base groundwater extraction wells.

RESPONSE TO COMMENTS ON DRAFT SECOND FIVE-YEAR REVIEW REPORT November 7, 2007 OPERABLE UNITS 1–6 MARINE CORPS LOGISTICS BASE BARSTOW, CALIFORNIA DCN: ECSD-2201-0029-0005 December 18, 2007	
Comment 9. Section 7.13.2.2, Nebo South, Page 7-33: This section does not appear to contain a protectiveness statement for the Nebo South groundwater plume. Please revise the text to include a protectiveness statement for Nebo South.	**Response 9.** The following text has been added to Section 7.13.2.2: The RAs at Nebo South under OU 2 currently protect human health and the environment as a result of the natural attenuation remedy (Nebo North), CAOC 6 AS/SVE operation at Nebo South, and the LUCs that are in place. However, in order for the remedy to be protective in the long term, continued optimization of the system and addressing the aging CAOC 6 AS/SVE system will be required.
Comment 10. Appendix B, Section 1.2, Capture Zone Evaluation Approach, Page B.1-3: This section states that capture zones were evaluated using particle tracking, but multiple lines of evidence should be used to evaluate capture. Please explain if other lines of evidence were used to evaluate capture.	**Response 10.** In addition to groundwater modeling used to evaluate capture zones, groundwater elevation contour maps are also used to evaluate capture. An additional sentence has been added to reflect this in Section 1.2, Capture Zone Evaluation Approach, Page B.1-3 in Appendix B.
REFERENCE EPA, 2001. Comprehensive Five-Year Review Guidance. EPA 540-R-01-007. June.	

MARINE CORPS LOGISTICS BASE,
BARSTOW

SECOND FIVE-YEAR REVIEW REPORT
OPERABLE UNITS 1–6
MARINE CORPS LOGISTICS BASE
BARSTOW, CALIFORNIA

December 2007

Prepared by:

NAVAL FACILITIES ENGINEERING COMMAND, SOUTHWEST

SECOND FIVE-YEAR REVIEW REPORT
OPERABLE UNITS 1–6
MARINE CORPS LOGISTICS BASE
BARSTOW, CALIFORNIA

December 19, 2007

DCN: ECSD-2201-0029-0006

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APPENDICES

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ABBREVIATIONS AND ACRONYMS

1,1-DCE	1,1-dichloroethene
µg/L	micrograms per liter
AGMR	Annual Groundwater Monitoring Report
AGRA	AGRA Earth and Environmental, Inc.
ARAR	applicable or relevant and appropriate requirement
AS/SVE	air sparging/soil vapor extraction
bgs	below ground surface
BMP	Base Master Plan
BEI	Bechtel Environmental, Inc.
BNI	Bechtel National, Inc.
CALNEV	CALNEV Pipeline Company, L.L.C.
CAOC	CERCLA Area of Concern
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFC	chlorofluorocarbon
CFR	Code of Federal Regulations
COC	constituent of concern
CUSUM	cumulative sum
DD	Decision Document
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethene
DDT	dichlorodiphenyltrichloroethane
DoD	Department of Defense
DON	Department of the Navy
DRMO	Defense Reutilization Materials Office
DTSC	Department of Toxic Substances Control
EPA	U.S. Environmental Protection Agency
ESD	Explanation of Significant Differences
FFA	Federal Facility Agreement
FS	Feasibility Study

ABBREVIATIONS AND ACRONYMS
(Continued)

ft/ft	feet per foot
FWENC	Foster Wheeler Environmental Corporation
GAC	granular activated carbon
GETS	Groundwater Extraction and Treatment System
GEW	ground extraction well
gpm	gallons per minute
GWQO	groundwater quality objective
HHRA	Human Health Risk Assessment
IC	institutional control
ILCR	Incremental Lifetime Cancer Risk
IRA	Interim Remedial Action
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
IWTP	Industrial Wastewater Treatment Plant
JEG	Jacobs Engineering Group
JVIM	Johnson and Ettinger Vapor Intrusion Model
LTGWMP	Long-term Groundwater Monitoring Plan
LUC	land use control
MCL	maximum contaminant level
MCLB	Marine Corps Logistics Base
MDAQMD	Mojave Desert Air Quality Management District
mg/kg	milligrams per kilogram
MTBE	methyl tert-butyl ether
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
OHM	OHM Remediation Services Corporation

ABBREVIATIONS AND ACRONYMS
(Continued)

OU	Operable Unit
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCE	perchloroethene
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
RI	Remedial Investigation
ROD	Record of Decision
ROI	radius of influence
RPM	Remedial Project Manager
SAP	Sampling and Analysis Plan
SCL	Shewhart control limit
SESOIL	SEasonal SOIL compartment model
SVOC	semivolatile organic compound
SWDIV	Southwest Division Naval Facilities Engineering Command
TBC	to be considered
TCE	trichloroethene
TCRA	time-critical removal action
TEF	Technical and Economic Feasibility
TN&A	TN & Associates
TPH	total petroleum hydrocarbons
TPH-d	total petroleum hydrocarbons as diesel
TRPH	total recoverable petroleum hydrocarbons
TtEC	Tetra Tech EC, Inc.

ABBREVIATIONS AND ACRONYMS
(Continued)

TtFW	Tetra Tech FW, Inc.
URS	URS Corporation
URSGI	URS Group, Inc.
USC	United States Code
VOC	volatile organic compound
VPB	vertical profile boring
Water Board	Regional Water Quality Control Board

DECLARATION OF ACCEPTANCE FOR OUS 1 – 6 SECOND FIVE-YEAR REVIEW REPORT – 2007 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.

KD Enzor

Kenneth D. Enzor
Colonel, U.S. Marine Corps
Commanding

19 DEC 2007

Date

EXECUTIVE SUMMARY

This Second Five-Year Review 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 Marine Corps Logistics Base (MCLB) Barstow, California (MCLB Barstow or Base). The IRP was developed by the Department of Defense (DoD) to clean up contamination at military facilities (such as MCLB Barstow) caused by past use, storage, handling, and disposal of hazardous and other potentially toxic substances.

In November 1989, the Base was placed on the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) National Priorities List (NPL) due to the presence of soil and groundwater contamination. Soil and groundwater at 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 MCLB Barstow. The DON's investigation and cleanup efforts are being conducted in conjunction with the U.S. Environmental Protection Agency (EPA), the Regional Water Quality Control Board (Water Board) – Lahontan Region, and the State of California Environmental Protection Agency's Department of Toxic Substances Control (DTSC).

MCLB Barstow is located in San Bernardino County, California, within the central Mojave Desert approximately 135 miles northeast of Los Angeles (Figure 1-1). MCLB 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).

The Base includes two separate facilities – Yermo Annex and Nebo Main Base. For the purposes of the IRP, the Base has been divided into a total of seven Operable Units (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). Records of Decision (RODs) were signed as pairs for the following OUs: in 1997 for OUs 3 and 4; in 1998 for OUs 1 and 2 and OUs 5 and 6. A seventh OU, OU 7, covers sites that were not covered under OUs 1 through 6. The ROD for OU 7 has not yet been signed, and it is therefore not subject to this five-year review. Remedial actions (RAs) have been implemented at CAOCs within OUs 1 through 6 (none at OU 7).

This five-year review evaluates the remedies implemented at each of the CAOCs at OUs 1 through 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 into question the protectiveness of the remedy?

OU 1 is the groundwater at Yermo Annex and includes three dissolved VOC plumes (CAOC 26, Yermo North, and Yermo South). Portions of the Yermo North and Yermo South 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). Treatment systems are in place at two on-Base drinking water wells and two off-Base drinking water wells. OU 1 includes groundwater monitoring for CAOCs from other OUs, specifically CAOCs 15, 16, 17, 20, 23, 26, and 35. CAOC 37 is listed under OU 1 on Table 1-1, which covers Yermo Annex groundwater.

The CAOC 26 AS/SVE system has met its ROD objective of reducing VOC contamination in soil and groundwater at CAOC 26 to acceptable levels and has been shut down. The CAOC 16 AS/SVE system and the Yermo Annex GETS are in operation and are meeting their objectives — VOC mass in groundwater and soil are being reduced, and overall VOC levels are decreasing for a majority of the wells. The RAs at OU 1 currently protect human health and the environment. However, in order for the remedy to be protective in the long term, actions that need to be taken include evaluating replacement or deepening of the groundwater extraction well GEW-8 to improve containment of the Yermo North plume and any additional remedial systems-related optimization in addressing the Yermo North plume remediation; continuing the current practice of procuring spare pumps for faster replacement in case of potential pump malfunctioning for the groundwater extraction wells in the Yermo North plume area; and addressing the aging GETS and CAOC 16 AS/SVE systems through timely replacement or repair of worn system components. It was noted that several groundwater monitoring and extraction wells may require cleaning and redevelopment to ensure full functionality and integrity of sample data.

The exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of the remedy selection are still valid. The aging GETS and CAOC 16 AS/SVE remedial system components could result in an increase in system down time and system-related Operations and Maintenance (O&M) costs. Various measures are being implemented to address these issues.

OU 2 is the groundwater at Nebo Main Base and includes two dissolved VOC plumes (Nebo North and Nebo South). It also includes groundwater monitoring associated with CAOC 7 (in the southern portion of Nebo Main Base) and for evaluation of pesticides (dieldrin) at Nebo North, specifically at CAOCs 1, 2, 3, and 14 (dieldrin was not detected). CAOC 38 addresses Nebo Main Base groundwater and is listed under OU 2 (Table 1-1). The selected remedy involves an AS/SVE system for groundwater and vadose zone VOC mass removal at Warehouse 2 and natural attenuation to reduce contamination in the groundwater plume to levels at or below maximum contaminant levels (MCLs). Nebo North GETS, a fail-safe system to the natural attenuation alternative selected for Nebo North, was not in operation during the second five-year review period. The Nebo North plume has decreased in extent with several wells showing overall decrease in VOC levels. Based on the results of the Extended Resource Conservation and Recovery Act (RCRA) Facility Assessment at Nebo North (which indicated elevated levels of VOCs in soil gas), an AS/SVE treatability study was completed during June 2003. This study indicated the feasibility of AS/SVE in reducing the concentrations at the the identified source area (former Building 50). It should be noted that the OUs 1 and 2 ROD (DON, 1998a) refers to Warehouse 2 as the Nebo North source area. Construction of the AS/SVE remediation system at Nebo North intended for source reduction was completed, and the system became operational during October 2007.

Based on the success of AS/SVE pilot testing, AS/SVE was selected as the final remedy for Nebo South. The exposure assumptions, toxicity data, cleanup levels, and RAOs used for this OU at the time of the remedy selection are still valid. The RAs at CAOC 38 under OU 2 currently protect human health and the environment. However, in order for the remedy to be protective in the long term, continued optimization of the system and addressing the aging CAOC 6 AS/SVE system are required. Several groundwater monitoring and extraction wells may require cleaning and redevelopment to ensure full functionality and integrity of sample data.

OU 3 is the shallow soils at Yermo Annex for which data existed prior to the Remedial Investigation (RI) and includes CAOCs 18, 20, 23, and 34. The institutional controls (ICs) (will be referred to as land use controls [LUCs]) implemented for CAOCs 18, 20, 23, and 34 and the caps constructed at CAOCs 20 and 23 continue to be protective of human health and the environment, with the exception that the gross alpha concentrations for the upgradient and cross-gradient wells at CAOC 20 exhibited statistically significant exceedances. Downgradient well gross alpha concentration was less than the respective MCL. Additional investigations have been recommended to evaluate these exceedances. If CAOC 20 is determined as the source of these exceedances, the RA at CAOC 20 will need to be reevaluated. 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 information that could call into question the effectiveness of the remedies at this OU.

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. CAOC 10 was originally eliminated (in 1994) as not requiring any action, but was subsequently found to require further investigation. No further action (NFA) was selected at the remaining

CAOCs, although Base Master Plan (BMP) modifications were required (and completed) for CAOCs 2, 5, and 11. The remedies continue to be protective of human health and the environment. 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 information that could call into question the effectiveness of the remedies at this OU.

OU 5 is the shallow soils at Yermo Annex (for which data did not exist prior to the RI) 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 as not requiring additional investigation/remediation. NFA was selected at CAOCs 19, 22, 24, 25, 27, 28, 29, 30, 31, and 32. NFA with BMP modifications was selected for CAOCs, 15, 17, 21, and 26. LUCs were selected and implemented for CAOC 16. A cap and LUCs were selected and installed for CAOC 35. The selected remedies at the CAOCs at OU 5 continue to be protective of human health and the environment, with the exception that VOC concentrations in groundwater downgradient of CAOC 16 show constituent of concern (COC) concentrations above the MCLs and/or increasing trends in a few wells. The GETS and CAOC 16 AS/SVE system that are in place are capable of treating these elevated VOC concentrations. Additional optimization of the remedial systems is required to address these elevated VOCs. 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 information that could call into question the effectiveness of the remedies at this OU.

OU 6 is the shallow soils at Nebo Main Base (for which data did not exist prior to the 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. NFA was selected at CAOCs 4, 6, 8, 12, 13, and 14. NFA with BMP modifications were required at CAOCs 1 and 3. A native soil cap and LUCs were selected and implemented at CAOC 7. Groundwater at CAOC 6 is covered under OU 2. The selected remedies at OU 6 continue to be protective of human health and the environment, with the exception that trichloroethene (TCE) concentrations at one of the CAOC 7 downgradient wells have exceeded the MCL over the past three sampling events. Detection of TCE above the MCL during the next groundwater sampling event would trigger a reevaluation of the remedy 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 information that could call into question the effectiveness of the remedies at this OU.

In summary, the remedy for MCLB Barstow (Operable Units 1 to 6) is considered protective in the short-term because there is no evidence of current exposure. However, in order for remedies to remain protective in the long-term, the required actions include (i) modifications as necessary of the groundwater extraction system at OU 1 (Yermo Annex Groundwater) to improve capture; (ii) additional optimization of the CAOC 16 AS/SVE system at Yermo Annex; (iii) optimization of the Nebo South AS/SVE system (OU 2); (iv) an assessment of the concentration increases at CAOC 20 and if required, a re-evaluation of the CAOC 20 remedy, and (v) assessment of the VOC detections at monitoring wells NSP-2 (down-gradient from CAOC 7 [OU 6]) and NPZ-14 (downgradient from CAOCs 11 and 12 [OU 2]). Issues were identified for some CAOCs. Recommendations and identified milestones to address these have been provided as part of this five-year review.

FIVE-YEAR REVIEW SUMMARY FORM – OU 1

SITE IDENTIFICATION

Site name *(from WasteLAN)* *Marine Corps Logistics Base*

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: ☐ EPA ☐ State ☐ Tribe ☒ Other Federal Agency Department of the Navy

Author name: Kristina Madali

Author Title: Remedial Project Manager	**Author affiliation:** Naval Facilities Engineering Command, Southwest

Review period: October 2002 to September 2007

Date(s) of inspection: July / 24 / 2007 to July / 25 / 2007

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) ROD signing date

Triggering action date*:* 12 / 30 / 2002

Due date (five years after triggering action date): 12 / 30 / 2007

FIVE-YEAR REVIEW SUMMARY FORM – OU 1
(Continued)

Issues:

- Effectiveness of AS/SVE in reducing dissolved VOC concentrations downgradient of CAOC 16.
- Effectiveness of GETS in containing the Yermo North Plume.
- Aging system components (CAOC 37 GETS and CAOC 6 and 16 AS / SVE Systems).
- Several groundwater monitoring and extraction wells may require cleaning and redevelopment to ensure full functionality and integrity of sample data.

Recommendations and Follow-up Actions:

- Additional optimization of the remedial system in addressing the Yermo North plume.
- Evaluate deepening or replacement of well GEW-8 to improve containment and continue to procure spare pumps for faster replacement in case of potential pump malfunctioning.
- Evaluate the possibility of replacing system components and the associated impact vs. continuing to service and repair the existing system components.

Protectiveness Statement(s):

The RAs at CAOC 37 under OU 1 are currently protective of human health and the environment because of the on-going operation of the GETS and the CAOC 16 AS/SVE system that are in operation as well as the LUCs that are in place. However, in order for the remedy to be protective in the long term, actions that need to be taken include evaluating replacement or deepening of the groundwater extraction well GEW-8 to improve containment of the Yermo North plume; Additional optimization of the remedial system in addressing the Yermo North plume remediation; continuing the current practice of procuring spare pumps for faster replacement in case of potential pump malfunctioning for the groundwater extraction wells in the Yermo North plume area; and addressing the aging GETS and CAOC 16 AS/SVE systems through evaluating the possibility of replacing system components and the associated impact vs. continuing to service and repair the existing system components.

Other Comments:

- None

Abbreviations and Acronyms:

AS/SVE – air sparging/soil vapor extraction
CAOC – Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Area of Concern
EPA – U.S. Environmental Protection Agency
GAC – granular activated carbon
GETS – Groundwater Extraction and Treatment System
MCL – maximum contaminant level
NPL – National Priorities List
OU – Operable Unit
SARA – Superfund Amendments and Reauthorization Act
RA – Remedial Action
ROD – Record of Decision
VOC – volatile organic compound

FIVE-YEAR REVIEW SUMMARY FORM – OU 2

SITE IDENTIFICATION		
Site name ***(from WasteLAN)*** *Marine Corps Logistics Base*		
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: ☐ EPA ☐ State ☐ Tribe ☒ Other Federal Agency Department of the Navy	
Author name: Kristina Madali	
Author Title: Remedial Project Manager	**Author affiliation:** Naval Facilities Engineering Command, Southwest
Review period: October / 2002 to September / 2007	
Date(s) of inspection: July / 24 / 2007 to July / 25 / 2007	
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) ROD signing date	
Triggering action date: 12 / 30 / 2002	
Due date (five years after triggering action date): 12 / 30 / 2007	

FIVE-YEAR REVIEW SUMMARY FORM – OU 2
(Continued)

Issues:

- Aging CAOC 6 AS/SVE system could affect system performance and may result in an increase in O&M costs.
- TCE detects at isolated well NPZ-14 in the southwest portion of Nebo Main Base downgradient of CAOC 11 (Fuel Burn Area) and CAOC 12 (Radiator Cleaning Chemical Disposal Area) I portion of Nebo Main Base.
- Several groundwater monitoring and extraction wells may require cleaning and redevelopment to ensure full functionality and integrity of sample data.

Recommendations and Follow-up Actions:

- Evaluate the possibility of replacing system components and the associated impact versus continuing to service and repair the existing system components.
- If TCE concentrations in NPZ-14 continue to remain above the MCL, appropriate action will be proposed after consultation with the FFA signatories.L.

Protectiveness Statement(s):

The RAs at CAOC 38 under OU 2 are currently protective of human health and the environment as a result of the natural attenuation remedy (Nebo North), CAOC 6 AS/SVE operation at Nebo South, and the LUCs that are in place.. However, in order for the remedy to be protective in the long term, continued optimization of the system and addressing the aging CAOC 6 AS/SVE system through evaluating the possibility of replacing system components and the associated impact vs. continuing to service and repair the existing system components.

Other Comments:

- None

Abbreviations and Acronyms:

AS/SVE – air sparging/soil vapor extraction
CAOC – Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Area of Concern
EPA – U.S. Environmental Protection Agency
MCL – maximum contaminant level
NPL – National Priorities List
O&M – Operation and Maintenance
OU – Operable Unit
RA – Remedial Action
ROD – Record of Decision
SARA – Superfund Amendments and Reauthorization Act
TCE – trichloroethene

FIVE-YEAR REVIEW SUMMARY FORM – OU 3

SITE IDENTIFICATION

Site name *(from WasteLAN)* *Marine Corps Logistics Base, Barstow*

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:** 01 / 29 / 1999

Has site been put into reuse? ☒ YES ☐ NO

REVIEW STATUS

Reviewing agency: ☐ EPA ☐ State ☐ Tribe ☒ Other Federal Agency Department of the Navy

Author name: Kristina Madali

Author Title: Remedial Project Manager | **Author affiliation:** Naval Facilities Engineering Command, Southwest

Review period: October / 2002 to September / 2007

Date(s) of inspection: July / 24 / 2007 to July / 25 / 2007

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 #3 ________
☐ Construction Completion ☒ Previous Five-Year Review Report
☐ Other (specify) ____________________

Triggering action date*:* 12 / 30 / 2002

Due date (five years after triggering action date): 12 / 30 / 2007

FIVE-YEAR REVIEW SUMMARY FORM – OU 3
(Continued)

Issues:

- Gross alpha concentrations in groundwater in the upgradient and cross-gradient wells exhibit exceedances (Note: Downgradient well gross alpha concentration during 2005 was less than the respective MCL.)

Recommendations and Follow-up Actions:

- Additional investigations to further evaluate these exceedances. If it is determined that the source of the exceedances is CAOC 20, a reevaluation of the remedy for COC 20 may be required. Appropriate action will be proposed after consultation with the FFA signatories.

Protectiveness Statement(s):

The RAs at CAOC 20 under OU 3 are currently protective of human health and the environment because of the cap at CAOC 20, the LUCs that are in place, and implementation of the BMP for the respective CAOCs. However, in order for the remedy to be protective in the long term, additional investigations are necessary to further evaluate the gross alpha exceedances in groundwater. If it is determined that the source of the exceedances is CAOC 20, a re-evaluation of the remedy for COC 20 may be required, followed by appropriate action with the concurrence of the FFA signatories.

For the remaining OU 3 CAOCs with RAs, the RAs protect human health and the environment.

Other Comments:

- None

Abbreviations and Acronyms:

CAOC – Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Area of Concern
COC – constituent of concern
EPA – U.S. Environmental Protection Agency
FFA – Federal Facility Agreement
MCL – maximum contaminant level
NPL – National Priorities List
OU – Operable Unit
RA – Remedial Action
ROD – Record of Decision
SARA – Superfund Amendments and Reauthorization Act

FIVE-YEAR REVIEW SUMMARY FORM – OU 4

SITE IDENTIFICATION		
Site name *(from WasteLAN)* *Marine Corps Logistics Base, Barstow*		
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:** 01 / 29 / 1999
Has site been put into reuse? ☒ YES ☐ NO	

REVIEW STATUS	
Reviewing agency: ☐ EPA ☐ State ☐ Tribe ☒ Other Federal Agency Department of the Navy	
Author name: Kristina Madali	
Author Title: Remedial Project Manager	**Author affiliation:** Naval Facilities Engineering Command, Southwest
Review period: October / 2002 to September / 2007	
Date(s) of inspection: July / 24 / 2007 to July / 25 / 2007	
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 #4 ________ ☐ Construction Completion ☒ Previous Five-Year Review Report ☐ Other (specify) ____________________	
Triggering action date: 12 / 30 / 2002	
Due date (five years after triggering action date): 12 / 30 / 2007	

FIVE-YEAR REVIEW SUMMARY FORM – OU 4
(Continued)

Issues:

- None

Recommendations and Follow-up Actions:

- None

Protectiveness Statement(s):

The remedies at OU 4 are protective of human health and the environment.

Other Comments:

- None

Abbreviations and Acronyms:

EPA – U.S. Environmental Protection Agency
NPL – National Priorities List
OU – Operable Unit
RA – Remedial Action
SARA – Superfund Amendments and Reauthorization Act

FIVE-YEAR REVIEW SUMMARY FORM – OU 5

SITE IDENTIFICATION

Site name *(from WasteLAN)* *Marine Corps Logistics Base, Barstow*

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:** 01 / 31 / 2001

Has site been put into reuse? ☒ YES ☐ NO

REVIEW STATUS

Reviewing agency: ☐ EPA ☐ State ☐ Tribe ☒ Other Federal Agency Department of the Navy

Author name: Kristina Madali

Author Title: Remedial Project Manager	**Author affiliation:** Naval Facilities Engineering Command, Southwest

Review period: October / 2002 to September / 2007

Date(s) of inspection: July / 24 / 2007 to July / 25 / 2007

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 / 30 / 2002

Due date (five years after triggering action date): 12 / 30 / 2007

FIVE-YEAR REVIEW SUMMARY FORM – OU 5
(Continued)

Issues:

- None

Recommendations and Follow-up Actions:

- None

Protectiveness Statement(s):

The remedies at OU 5 are protective of human health and the environment.

Other Comments:

- None

Abbreviations and Acronyms:

EPA – U.S. Environmental Protection Agency
NPL – National Priorities List
OU – Operable Unit
RA – Remedial Action
SARA – Superfund Amendments and Reauthorization Act

FIVE-YEAR REVIEW SUMMARY FORM – OU 6

SITE IDENTIFICATION

Site name *(from WasteLAN)* *Marine Corps Logistics Base, Barstow*

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 / 10 / 1999

Has site been put into reuse? ☒ YES ☐ NO

REVIEW STATUS

Reviewing agency: ☐ EPA ☐ State ☐ Tribe ☒ Other Federal Agency Department of the Navy

Author name: Kristina Madali

Author Title: Remedial Project Manager	**Author affiliation:** Naval Facilities Engineering Command, Southwest

Review period: October / 2002 to September / 2007

Date(s) of inspection: July / 24 / 2007 to July / 25 / 2007

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 / 30 / 2002

Due date (five years after triggering action date): 12 / 30 / 2007

FIVE-YEAR REVIEW SUMMARY FORM – OU 6
(Continued)

Issues:

- 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.

Recommendations and Follow-up Actions:

- 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.

Protectiveness Statement(s):

The RA at CAOC 7 under OU 6 currently protects human health and the environment because of the caps and the LUCs that are in place.. However, if the TCE concentration for the downgradient well NSP-2 exceeds the MCL during the next groundwater monitoring event, in order for the remedy to be protective in the long term, the RA for this CAOC will need to be re-evaluated for compliance with the threshold criteria, and if necessary, revise or enhance the selected remedy with the concurrence of the FFA signatories.

For the remaining OU 6 CAOCs with RAs, the RAs are protective of human health and the environment.

Other Comments:

- None

Abbreviations and Acronyms:

CAOC – Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Area of Concern
EPA – U.S. Environmental Protection Agency
FFA – Federal Facility Agreement
MCL – maximum contaminant level
NPL – National Priorities List
OU – Operable Unit
RA – Remedial Action
SARA – Superfund Amendments and Reauthorization Act
TCE – trichloroethene

1.0 INTRODUCTION

The Department of the Navy (DON) is conducting environmental restoration activities at the Marine Corps Logistics Base, Barstow, California (MCLB Barstow or 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 MCLB Barstow. The DON's investigation and cleanup efforts are being conducted in conjunction with the U.S. Environmental Protection Agency (EPA), Region IX, Regional Water Quality Control Board (Water Board) – Lahontan Region (referred to hereafter as the Water Board), 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).

MCLB Barstow is located in San Bernardino County, California, within the central Mojave Desert approximately 135 miles northeast of Los Angeles (Figure 1-1). MCLB 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 cleaned up under the IRP. This Five-Year Review will report on the status of the ongoing cleanup efforts at MCLB Barstow.

1.1 PURPOSE

The purpose of this Second Five-Year Review is to evaluate the implementation and performance of the selected remedies at MCLB Barstow and to verify whether the selected remedies continue to remain protective of human health and the environment. This Second Five-Year Review Report includes the methods, findings, and conclusions of the first five-year review. In addition, issues found during the review are identified, and recommendations to address them are presented in this report. The signature date for the first Five-Year Review was December 30, 2002 (DON, 2002). This Second Five-Year Review discusses how the issues identified during the first 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. According to the *Navy/Marine Corps Policy for Conducting Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Statutory Five-Year Reviews* (DON, 2004), a statutory five-year review is required when both of the following conditions are met:

- Upon 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 Record of Decision (ROD) or Decision Document (DD) for the site was signed on or after October 17, 1986.

The DON is preparing this Second 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.*

The DON is responsible for the five-year review of the remedies implemented at MCLB Barstow. This is the second five-year review for MCLB Barstow. The first five-year review report was signed on December 30, 2002. 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.

1.2 ORGANIZATION OF OPERABLE UNITS

To streamline the cleanup process, the Base has been divided into seven OUs, as follows:

1. OU 1 and OU 2 – address groundwater contamination at Yermo Annex and Nebo Main Base, respectively.
2. OU 3 and OU 4 – address soil contamination at Yermo Annex and Nebo Main Base, respectively, for which analytical data existed prior to the Remedial Investigation (RI).

3. 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.
4. OU 7 – addresses contamination not covered by OUs 1 through 6.

RODs have been signed for OUs 1 through 6, as follows:

1. *1 and 2: Operable Units 1 and 2, Final Record of Decision, Marine Corps Logistics Base, Barstow, California* (OUs 1 and 2 ROD [DON, 1998a]).
2. 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]).
3. *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]).
4. *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]).

Within each OU, there are several hazardous waste areas termed CERCLA Areas of Concern (CAOCs). Figures 1-4 and 1-5 show the CAOCs (1 through 38) and OUs 1 through 6 at the Yermo Annex and Nebo Main Base, respectively. Cleanup actions are ongoing or have been completed at OUs 1 through 6, while OU 7 is under investigation. Cleanup actions at the CAOCs can be broadly classified into the following three categories:

1. Requiring no further action (NFA)
2. Requiring institutional controls (ICs) (will be referred to as land use controls [LUCs]) to protect health and environment
3. Requiring cleanup, or RA

Those CAOCs identified as NFA in their respective RODs do not require five-year reviews. It should be noted that a number of CAOCs identified as NFA required modifications of the Base Master Plan (BMP) for MCLB Barstow. Modifications in general consisted of including site history and the requirement that the MCLB Barstow Environmental Department be contacted prior to construction activities at these CAOCs. CAOCs with these modifications were subjected to this five-year review. Figure 1-6 shows the organization of CAOCs and OUs at MCLB Barstow.

Some of the CAOCs are further divided into strata (discrete lateral areas of contamination) and zone (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 remediated or monitored under OU 1 or OU 2.

The CAOCs, OUs to which they belong, and five-year review requirements are summarized in Table 1-1. Five-year reviews are required for the following CAOCs: 1, 2, 3, 5, 6, 7, 11, 14, 15, 16, 17, 18, 20, 21, 23, 26, 34, 35, 37, and 38 (Table 1-1).

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

- On-Base drinking water wells (YDW-5, YDW-6A [also referred to as YDW-6], and YDW-7) at the Yermo Annex
- Off-Base (residential) drinking water wells adjacent to the Yermo Annex and Nebo Main Base
- Potential presence of metals in groundwater in the northern portion of Yermo Annex
- Potential presence of pesticides in groundwater in the northern portion of Nebo Main Base
- Potential limited volatile organic compound (VOC) contamination in groundwater in the southwestern portion of Nebo Main Base (well NPZ-14)

Groundwater monitoring at the Yermo Annex and Nebo Main Base is conducted in general accordance with the *Draft Final Operable Units 1-6 Long-term Groundwater Monitoring Plan* (LTGWMP*)* (DON, 1998c), and the *Draft Sampling and Analysis Plan, Marine Corps Logistics Base, Barstow, California, Revision 3* (SAP) (Tetra Tech FW, Inc. [TtFW], 2005a) in conjunction with the *Draft Final Addendum 01 to Sampling and Analysis Plan (Field Sampling/Project Quality Assurance Plan) Revision 3 (Addendum 01 to SAP)* (TN & Associates [TN&A], 2006). The 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].

The Nebo North Groundwater Extraction and Treatment System (GETS), a fail-safe system in case natural attenuation fails to stop plume migration, was not in operation during the second five-year review period. Construction of the air sparging/soil vapor extraction (AS/SVE) remediation system at Nebo North intended for source reduction was completed, and the system became operational during October 2007. 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-6A (also referred to as 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 35 (Yermo Annex) are operated and 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 operated in accordance with Appendix A of the *Remedial Action Report* (RAR), *CAOCs 20 and 23, OUs 3 and 4* (OUs 3 and 4 RAR), (Southwest Division Naval Facilities Engineering Command [SWDIV], 2000). The cap at CAOC 23 is operated 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).

1.3 FIVE-YEAR REVIEW AND DUE DATES

According to the NCP and 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 RAs at a site, hazardous substances, pollutants, or contaminants will remain above levels that allow for unlimited use and unrestricted exposure. The trigger date for this second five-year review is five years from the signature date for the first five-year review (DON, 2002). The first five-year review report for OUs 1 through 6 was signed on December 30, 2002. Accordingly, this second five-year review report is due on December 30, 2007.

1.4 DOCUMENT ORGANIZATION

This Five-Year Review Report is organized as follows:

- **Section 1.0** provides the purpose and authority for conducting the five-year review, lead agency for conducting the five-year review, review number, trigger due dates, identification of OUs at MCLB Barstow, and organization for the five-year review document.
- **Section 2.0** describes site chronology.
- **Section 3.0** describes the background of the sites (grouped by ROD) and provides general site description and history (grouped by location at Yermo Annex and Nebo Main Base).
- **Section 4.0** describes the remedial action objectives (RAOs) (grouped by ROD) and description of remedies conducted at the LUCs and RA sites (grouped by location at Yermo Annex and Nebo Main Base).
- **Section 5.0** describes the progress since the last five-year review.
- **Section 6.0** describes the five-year review process, including administrative components, community involvement, document and data review, site inspection, and interviews.
- **Section 7.0** presents the technical assessments of the sites, grouped by CAOCs, with summaries for each of the six OUs.

- **Section 8.0** presents any issues identified during the technical assessment, potential effects of issues, and discussion of any unresolved issues raised by other parties, grouped by CAOCs.
- **Section 9.0** includes recommendations and follow-up actions for the CAOCs.
- **Section 10.0** includes the protectiveness statement.
- **Section 11.0** proposes the date for the next review.
- **Section 12.0** provides the referenced documents used for this report.

2.0 OPERABLE UNIT CHRONOLOGIES

The chronology presented in Table 2-1 identifies significant events pertaining to OUs 1 through 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 available documents within the Administrative Record File.

3.0 BACKGROUND

The following sections discuss the site location RODs for MCLB Barstow and site description and history of the CAOCs at Yermo Annex and Nebo Main Base. Each ROD is discussed separately, while site description and history are discussed for each CAOC. The CAOCs at Yermo Annex are described first, followed by the CAOCs at Nebo Main Base. A description of geology and hydrogeology of Yermo Annex and Nebo Main Base is included as a part of the OUs 1 and 2 ROD discussion (Section 3.1.1). A majority of the information regarding the OUs and CAOCs discussed in Sections 3 and 4 of this report is based on information provided in the previous five-year review report (DON, 2002).

3.1 RECORDS OF DECISION FOR MCLB BARSTOW

3.1.1 OUs 1 and 2 ROD

The *OUs 1 and 2 ROD* (DON, 1998a) covers groundwater at Yermo Annex (OU 1) and Nebo Main Base (OU 2), respectively.

3.1.1.1 OU 1 Background, Geology, and Hydrogeology

At Yermo Annex (OU 1), there are three dissolved VOC plumes (see Figure 1-4): CAOC 26 plume, Yermo North plume, and Yermo South plume, all of which are undergoing RA. The dissolved VOCs primarily include trichloroethene (TCE) and perchloroethene (PCE). Groundwater monitoring for CAOCs 15, 16, 17, 20, 23, 26, and 35 (under OUs 3 and 5) is also included in OU 1, as is monitoring for potential metals contamination in groundwater beneath CAOC 16.

The Yermo Annex of MCLB Barstow lies within the west/northwest-trending Barstow Basin, which is approximately bounded by the Blackwater/Calico Faults to the northeast and by the Lenwood Fault to the southwest. The Barstow Basin dips sharply to the southeast and is filled with a sequence of late Tertiary to early Quaternary alluvial deposits. Surface sediments throughout the basin typically consist of windblown sand and recent alluvial deposits derived from the Mojave River or shed from adjacent highlands.

The sediments 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. Beneath these deposits lies a sequence of low permeability Tertiary volcanic and sedimentary rocks. These rocks likely constitute bedrock in this area. 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 *Remedial Investigation/Feasibility Study Remedial Investigation Report for Operable Units 1 and 2* (Jacobs Engineering Group [JEG], 1995a).

Two separate aquifers have been identified in the area surrounding the Yermo Annex, the regional aquifer, and the more localized Mojave River aquifer (Densmore, Cox, and Crawford, 1997). 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.

Based on June 1 and 4, 2007, groundwater level measurements at various Yermo Annex wells, depth to groundwater measurements range from 152 feet bgs to 177 feet bgs. Groundwater elevation contours provided in Figure 3-1 are based on these groundwater levels. Based on the interpreted groundwater elevation contours for the Yermo Annex area with the GETS in operation, the general direction of groundwater flow in the northern portion of the Yermo Annex is inferred to be generally west/southwest to east/northeast. Groundwater extraction from wells GEW-13, GEW-6 and GEW-7 results in northeasterly groundwater flow in general.

In the east-central portion of the Yermo Annex, the groundwater flow direction is inferred to be from the west/southwest to east/northeast (Figure 3-1). Groundwater flow trends west to east in the west-central portion of the Yermo Annex. East/northeasterly groundwater flow components can be noted in the southern portion of Yermo Annex as a result of groundwater extraction from wells GEW-3 and GEW-14. The inferred groundwater flow patterns are consistent with the groundwater flow patterns observed historically. The calculated hydraulic gradient ranges from 0.0007 feet per foot (ft/ft) in the west to 0.0093 ft/ft in the east (Figure 3-1).

Hydrographs for select wells at the Yermo Annex are presented in Figure 3-2. These hydrographs indicate that groundwater elevations show an overall decreasing trend since 1999. A slight increase in groundwater elevations can be noted during the first half of 2005 followed by a decreasing trend. The observed increase in groundwater elevations during the first half of 2005 is likely the result of the relatively heavy precipitation during 2004 and 2005.

3.1.1.2 OU 2 Background, Geology, and Hydrogeology

At Nebo Main Base (OU 2), there are two dissolved VOC plumes (see Figure 1-5): Nebo North plume and Nebo South plume, both of which are undergoing RA (CAOC 38). Groundwater monitoring for CAOC 7 (OU 6) is also included in OU 2, as is monitoring for potential pesticide contamination in groundwater at Nebo North (CAOC 14).

MCLB Nebo Main Base is underlain by sandy Quaternary-age deposits of the Mojave River alluvium in the north, and by gravelly alluvial fans in the south. These materials appear to be interlayered colluvium and stream alluvium progressing from Pleistocene-age material at depth to recent material at the surface.

The trace of the northwest-southeast trending Harper Lake-Camp Rock Fault cuts across the eastern quarter of the Main Base. The fault and the related structural features mark the eastern margin of the Barstow sub-basin with the Yermo sub-basin. Data from Nebo-South indicated that the material appears to be predominantly mid-alluvial fan colluvial materials, with some thin beds of possible alluvium. These alluvial materials, albeit possibly discontinuous, may form preferential pathways for contaminant and fluid migration (OHM, 1995). Groundwater flow is generally sub-parallel to the Mojave River, which is the main feature within this unit. The eastern margin of the Barstow sub-basin is marked by the Harper Lake-Camp Rock Fault.

Figure 3-3 shows groundwater elevation contours based on groundwater levels measured between May 24 and May 30, 2007. Significant influence from the Harper Lake-Camp Rock Fault on groundwater flow patterns can be noted from Figure 3-3. East of the fault, the groundwater flow was generally to the southeast with a relatively uniform hydraulic gradient of 0.003 ft/ft. Depth to groundwater ranges from approximately 16 feet bgs to 35 feet bgs based on May 2007 measurements. 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 and to the east in the southeast portion as well as in the northern portion (Figure 3-3). The calculated hydraulic gradient ranged from 0.0023 ft/ft to 0.0076 ft/ft. West of the Harper Lake-Camp Rock Fault, depth to groundwater measurements range from approximately 7 feet bgs to 209 feet bgs based on May 2007 measurements. Depth to groundwater measurements are higher in the southern portion of the site.

Hydrographs for select wells at the Nebo Main Base presented in Figure 3-4 indicate an overall decrease in groundwater elevations through 2004 followed by an increasing trend during the first half of 2005. This was followed by a slight decrease to no change in groundwater elevations. The observed increase in groundwater elevations during the first half of 2005 is likely as a result of the relatively heavy precipitation during the 2004–2005 rainy season.

3.1.2 OUs 3 and 4 ROD

The OUs 3 and 4 ROD (DON, 1997) covers shallow soil contamination at Yermo Annex (OU 3: CAOCs 18, 20, 23, 34) and at Nebo Main Base (OU 4: CAOCs 2, 5, 9, 11), for which analytical data existed prior to the RI (see Figures 1-4 and 1-5). Landfill caps were installed at CAOCs 20 and 23 (OU 3). Groundwater monitoring for these caps is covered under OU 1. Groundwater monitoring for CAOC 2 (OU 4) is covered under OU 2.

3.1.3 OUs 5 and 6 ROD

The OUs 5 and 6 ROD (DON, 1998b) addresses shallow soil contamination at the Yermo Annex (OU 5: CAOCs 15/17, 16, 19, 21, 22, 24 to 32, 35, 36) and at the Nebo Main Base (OU 6: CAOCs 1, 3, 4, 6, 7, 8, 10, 12, 13, 14, 33), for which analytical data did not exist prior to the RI (see Figures 1-4 and 1-5). It should be noted that the actions taken to assess the potential impact from soil on the underlying groundwater will be covered under OU 1 (Yermo Annex) or OU 2

(Nebo Main Base). A landfill cap was installed at CAOC 35, and associated groundwater monitoring is conducted under OU 1. Remediation of groundwater beneath CAOCs 15/17, 16, 26, and 35 is conducted under OU 1. A cap was installed at CAOC 7, and associated groundwater monitoring is conducted under OU 2. Groundwater monitoring to assess the potential impact from pesticides in soil under CAOCs 1, 3, and 14 is conducted under OU 2. Groundwater monitoring for CAOC 6 (Nebo South) is conducted under OU 2.

3.2 DESCRIPTION AND HISTORY – YERMO ANNEX CAOCS

A total of 22 CAOCs were identified at Yermo Annex (Figure 1-4) (Table 1-1). Following is a brief summary of site description, 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.

3.2.1 CAOC 15/17 (OU 5)

CAOC 15/17 is the Oil Storage/Spillage Area and Industrial Wastewater Treatment Plant (IWTP). 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 sludges. Mathematical modeling indicated that soil contamination would have very limited potential impacts to groundwater. An NFA remedy was chosen for the CAOC, as documented in the OUs 5 and 6 ROD (DON, 1998a). However, there was some uncertainty with respect to groundwater impact, as soil samples were limited to 12 feet bgs. To address this uncertainty, further vadose zone evaluation was conducted in conjunction with CAOC 16.

3.2.2 CAOC 16 (OU 5)

CAOC 16 is the Building 573 and perimeter area, 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. This greatly limits the potential for worker exposure to VOCs in soil gas (at shallow depths). It also minimizes the potential for impact to groundwater (from soil/soil gas VOCs) due to infiltration. A LUCs remedy was chosen for soils as documented in the OUs 5 and 6 ROD (DON, 1998b). Groundwater beneath the CAOC is impacted by VOCs and potentially metals, and is covered under the OU 1. Also, the vadose zone under CAOC 16 is being remediated under OU 1 via the CAOC 16 AS/SVE system.

3.2.3 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.

An NFA remedy with BMP modifications was chosen for this CAOC, as documented in the OUs 3 and 4 ROD (DON, 1997).

3.2.4 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 LUCs, NFA, and concrete cap, as documented in the OUs 3 and 4 ROD (DON, 1997).

3.2.5 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).

3.2.6 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.

3.2.7 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. An NFA remedy with BMP modifications was selected for this CAOC, as documented in the OUs 5 and 6 ROD (DON, 1998b). In addition to the soil samples, soil organic vapor surveys indicated that PCE concentrations in soil would impact groundwater. To address this residual vadose zone contamination, the OU 1 groundwater RA includes AS/SVE in combination with downgradient groundwater extraction wells.

3.2.8 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 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). The low levels of benzo[a]pyrene detected in the surface soils at Stratum 1 were to be noted in the BMP.

3.2.9 CAOC 35 (OU 5)

CAOC 35, the (currently 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 covered under OU 1.

3.2.10 CAOC 37 (OU 1 Groundwater)

CAOC 37 is the groundwater beneath the Yermo Annex. It is impacted by dissolved VOCs, and to some extent, dissolved metals. Figure 1-4 shows the extent of VOC contamination and area of potential metals contamination. The VOC contamination is being addressed via the Yermo Annex GETS and the CAOC 16 and CAOC 26 AS/SVE systems.

3.3 DESCRIPTION AND HISTORY – NEBO MAIN BASE CAOCS

A total of 16 CAOCs requiring RA were identified at Nebo Main Base, as shown on Figure 1-5 (Table 1-1). Following is a brief summary for each of the Nebo Main Base CAOCs with RAs, LUCs, groundwater monitoring, and NFA with BMP modifications.

3.3.1 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 were present in the samples, which were analyzed for VOCs, SVOCs, OCPs, PCBs, metals, cyanide, and TPH-d. 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 is monitored as a part of the OU 2 RA. An NFA remedy with BMP modifications was selected for CAOC 1, as documented by the OUs 5 and 6 ROD (DON, 1998b).

3.3.2 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 contamination 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. 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, groundwater is monitored under OU 2. An NFA remedy with BMP modifications was selected for CAOC 2, as documented in the OUs 3 and 4 ROD (DON, 1997).

3.3.3 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. Analytical results from sampling indicated non-detectable or low concentrations of VOCs, SVOCs, several pesticides, and extractable petroleum hydrocarbons. 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, the groundwater is monitored as a part of the OU 2 RA. An NFA remedy with BMP modifications was selected for CAOC 3, as documented by the OUs 5 and 6 ROD (DON, 1998b).

3.3.4 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. An NFA remedy with BMP modifications was selected for CAOC 5, as documented in the OUs 3 and 4 ROD (DON, 1997).

3.3.5 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. VOCs were non-detectable or believed to be analytical artifacts. Strata 2 and 3 indicated detections of numerous SVOCs, including PAHs, the majority of which were at low levels. In addition to the soil samples collected within CAOC 6, a number of vertical profile borings (VPBs) and other borings that indicate the presence of VOCs in soil gas at CAOC 6 have been advanced within CAOC 6 in support of the AS/SVE pilot study. Although VOCs were not detected in the soil samples from CAOC 6, there is known VOC contamination of downgradient groundwater. Groundwater contamination by VOCs has been confirmed to exist beneath this CAOC. For Nebo South, an interim remedy consisting of a GETS was proposed in the OUs 1 and 2 ROD (DON, 1998a). This system was not implemented as it may promote off-Base migration of on-Base VOC contamination. Following the success of pilot testing, AS/SVE was selected as the final remedy and the Nebo South ROD was finalized (DON, 2006). No further site characterization for VOCs in soils is recommended under the OUs 5 and 6 ROD (DON, 1998b).

3.3.6 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. 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 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, as required in the OUs 5 and 6 ROD (DON, 1998b), the BMP was amended to include a description of the history of CAOC 7, Strata 3 and 4, including the low levels of PCBs detected and language indicating that any actions planned in the area should be coordinated and reviewed by the MCLB Barstow Environmental Department.

Because of the uncertainties regarding Strata 1 and 2, a single layer native soil cap was the selected remedy along with above-mentioned restrictions in the BMP, as documented in the OUs 5 and 6 ROD (DON, 1998b).

3.3.7 CAOC 11 (OU 4)

CAOC 11, the Fuel Burn Area, is located in the southwest corner of the Nebo Main Base between the tank farm area to the north and the aboveground water storage tank 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 have no potential impacts to groundwater and that CAOC 11 is not likely a past, present, or future source of contamination to groundwater. An NFA remedy with BMP modifications was selected for CAOC 11, as documented in the OUs 3 and 4 ROD (DON, 1997).

3.3.8 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 sampling, each channel and outfall was inspected. 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 would impact these areas. All 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. Impacts to groundwater at CAOC 14 were evaluated using mathematical modeling. Results from modeling indicated that PAHs, PCBs, and pesticides could affect groundwater quality. All of these contaminants are nonvolatile, insoluble, and adsorb easily to soil particles. They are expected to be immobile in vadose zone spills. Results from additional mathematical modeling analysis 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. In order to address this uncertainty, groundwater is being monitored under OU 2. An NFA remedy with BMP modifications was selected for CAOC 14, as documented in the OUs 5 and 6 ROD (DON, 1998b).

3.3.9 CAOC 38 (OU 2 Groundwater)

CAOC 38 is the groundwater beneath the Nebo Main Base. It is impacted by dissolved VOCs. Figure 1-5 shows the extent of VOC contamination at the Nebo Main Base. The selected remedy involves an AS/SVE system for groundwater and vadose zone VOC mass removal and natural attenuation. The remedy also includes fail-safe pump-and-treat as a backup in case natural attenuation fails to stop plume migration. At Nebo South, an AS/SVE system that is in operation was deemed as the final remedy following the success of the pilot test.

4.0 REMEDIAL ACTIONS

The following sections discuss the remedy selected, implementation, and system O&M for various OUs.

4.1 REMEDIAL ACTION OBJECTIVES

RAOs for OUs 1 through 6 are summarized in the following sections.

4.1.1 OUs 1 and 2 ROD

For OUs 1 and 2, the Remedial Action Objective (RAO) is cleanup of groundwater to MCLs via containment of groundwater contamination at the MCL plume boundary (except directly beneath waste management areas/waste management units).

The RAO for vadose zone cleanup at OUs 1 and 2 is to remove contaminant mass in the subsurface soils to the degree necessary to:

1. Prevent further degradation of groundwater above groundwater cleanup standards.
2. Reduce the aquifer cleanup time.

4.1.2 OUs 3 and 4 ROD

The RAO for CAOCs 20 and 23 is to limit the potential exposure to the wastes remaining on site and minimize water infiltration and groundwater impacts.

NFA or LUC remedies were selected for the remaining CAOCs under OUs 3 and 4.

4.1.3 OUs 5 and 6 ROD

The RAO for the CAOC 35 Zone 1 (OU 5) remedy is to minimize water infiltration and potential future impact to groundwater and to limit potential human exposure to buried waste. The RAO for the selected remedy at CAOC 16 (OU 5) is to minimize via containment the potential for human exposure to contaminated soils. The RAO for CAOC 7 (Strata 1 and 2) under OU 6 is to minimize water infiltration and potential future impact to groundwater and limit via containment potential human exposure to buried wastes.

NFA or LUC remedies were selected for the remaining CAOCs under OUs 5 and 6.

4.2 DESCRIPTION OF REMEDIES – YERMO ANNEX

The following sections describe the RAs at the Yermo Annex. Only those CAOCs where LUCs, RAs, or BMP modifications are implemented are discussed. These include CAOCs 15/17, 16, 18, 20, 21, 23, 26, 34, 35 (Figure 4-1); and the OU 1 groundwater remediation systems, CAOC 37 (Figure 4-2).

4.2.1 CAOC 15/17 (OU 5)

At CAOC 15/17 (OU 5) (Figure 4-1), an NFA remedy was selected and determined to be protective of human health and the environment. Sections 12.1 through 12.6 of the BMP include a description of the history of this CAOC; the low levels of PCBs, hexavalent chromium, and PAHs; and language to the effect that any actions planned in these areas or changes in site use should be coordinated and reviewed by the MCLB Barstow Environmental Department.

4.2.2 CAOC 16 (OU 5)

The selected remedy for CAOC 16 is LUCs. The remedy involves maintaining 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 BMP has been amended (Sections 11.1 through 11.6) to reflect that the physical and structural integrity of the concrete hardstand shall be maintained; that any excavation, damage, or removal of the concrete hardstand will be reported to the MCLB Barstow Environmental Department; and that any actions taken that could compromise the long-term effectiveness of the concrete hardstand will be reported to the FFA signatories along with an evaluation of what measures are necessary to protect human health and the environment. 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, Feasibility Study (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.

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 EPA will be notified of such a change, and concurrence will be obtained before such a change is made.

It should be noted that an AS/SVE system was installed along the perimeter of CAOC 16 under OU 1. The OUs 1 and 2 ROD (DON, 1998a) require an evaluation of the vadose zone at CAOC 16 as a part of the five-year review. This evaluation is discussed in Section 6.7.

4.2.3 CAOC 18 (OU 3)

At CAOC 18 (Figure 4-1), an NFA remedy (that does not involve institutional or engineering controls) was selected and was determined to be protective of human health and the environment. However, because the Incremental Lifetime Cancer Risk (ILCR) exceeded 1×10^{-6}

in Strata 2 and 3, the OUs 3 and 4 ROD (DON, 1997) required that a brief description of these two strata be provided in the BMP, that low-level PCBs and pesticides detected in the soils be documented in the BMP, and that any planned activities in these areas or changes in site use should be coordinated through and reviewed by the MCLB Environmental Department. Sections 4.1 through 4.6 of the BMP address these items.

4.2.4 CAOC 20 (OU 3)

The objectives for the RA at Strata 1 and 2 at CAOC 20 (Figure 4-1) were to limit the potential for exposure to and disturbance of buried wastes and to minimize the potential for future releases to groundwater.

RAs at CAOC 20 (see Figure 4-3) consist of the following:

1. Replacing an existing concrete cap to minimize rainwater infiltration
2. Grading and berming to reduce rainwater infiltration over the concrete cap, thereby further minimizing rainwater infiltration
3. Groundwater monitoring and vadose zone infiltration monitoring

These were completed in 2000 and are discussed in detail in the OUs 3 and 4 RAR (SWDIV, 2000). As noted therein, the remedy was determined to be "operating properly and successfully" by the DON and all FFA Parties. 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 (SWDIV, 2002).

Data to be collected for CAOC 20 include soil moisture readings and groundwater monitoring results. Groundwater monitoring is conducted annually under OU 1.

4.2.5 CAOC 21 (OU 5)

The selected remedy for CAOC 21 (Figure 4-1) is an NFA remedy. However, because the ILCR at the CAOC exceeded 1×10^{-6}, the following items were incorporated into the BMP for informational and future planning purposes: a description of the history of the CAOC; an overview of the low levels of chlorinated pesticides, VOCs, SVOCs, PCBs, metals, and petroleum hydrocarbons; and language indicating that any actions planned within CAOC 21 or any changes in site use were required to be coordinated and reviewed by the MCLB Barstow Environmental Department. These items are addressed in Sections 13.1 through 13.6 of the BMP. A TCRA was conducted in 1997 to remove PCB-contaminated soils (greater than 1 mg/kg).

A deep vertical soil profile boring was advanced within CAOC 21 (per the OUs 5 and 6 ROD [DON, 1998b]) as part of the Extended RCRA Facility Assessment. VOCs were detected in soil gas at this boring. As documented in the *Final Remedial Investigation Report for Operable Unit 7, CAOCs 9.60, 10.27, 10.35, 10.37, 10.38/10.39, N-2 Area 1 and 10 at MCLB, Barstow, CA*

(Bechtel Environmental, Inc. (BEI), 2004), no further remedial action was recommended under OU 7 (CAOC 9.60). This recommendation was based on site conditions (including removal of the leaking underground storage tank and most of the associated impacted soil), fate and transport analysis, results of the baseline Human Health Risk Assessment (HHRA), and the conservative assumptions in the baseline HHRA that result in overestimates of exposure and risk.

4.2.6 CAOC 23 (OU 3)

An NFA remedy was selected for Strata 3, 5, and 5a (Figures 4-1 and 4-3). However, because of the carcinogenic risk, a brief description of the history of CAOC 23, Strata 5 and 5a, low levels of PCBs and pesticides detected in the soils, and the language to the effect of any actions planned in this area or changes in site use were required to be coordinated and reviewed by the MCLB Barstow Environmental Department. These items are included in Sections 3.1 through 3.6 of the BMP.

RAs at CAOC 23 consist of the following:

1. In-place abandonment of a water line
2. Deep dynamic compaction of soil
3. 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)
4. Groundwater monitoring and vadose zone infiltration monitoring

These were completed in 2000 and are discussed in detail in the OUs 3 and 4 RAR (SWDIV, 2000). As noted therein, the remedy was determined to be "operating properly and successfully" by the DON and all FFA Parties.

In addition to the above, four of the five geophysical anomalies at CAOC 23 (four at Stratum 1 and one at Stratum 4) (Figure 4-3) 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.

4.2.7 CAOC 26 (OU 5)

An NFA remedy was selected for CAOC 26 soils and does not involve institutional or engineering controls. Because of concerns over the potential for vapor-phase contaminants to escape from the subsurface and impact future on-site receptors, Sections 14.1 through 14.6 of the BMP provide a description of this CAOC and language to the effect of any actions planned in this area or changes in site use will be coordinated through and reviewed by the MCLB Barstow Environmental Department.

System performance monitoring and ambient air sampling were performed under OU 1 to conclusively verify that an on-site inhalation threat does not exist.

4.2.8 CAOC 34 (OU 3)

In July 1994, in a TCRA, the basins were demolished and removed, along with the soils within the basins. Contaminated surface soil near the basins was also excavated. A new wastewater treatment plant was constructed on this CAOC (Figure 4-1).

An NFA remedy selected for CAOC 34 does not involve institutional or engineering controls. Although the current wastewater treatment plant eliminates potential exposures at Stratum 1, Sections 5.1 through 5.6 of the BMP address contaminants in the soils and the low levels of benzo[a]pyrene detected in the surface soils at Stratum 1 and provide language indicating that any changes in site use must be coordinated through and reviewed by the MCLB Barstow Environmental Department.

4.2.9 CAOC 35 (OU 5)

The major components of the selected remedy at CAOC 35 (see Figures 4-1 and 4-4) 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)

These are discussed in detail in the OUs 5 and 6 RAR (SWDIV, 2002). As noted therein, the remedy was determined to be "operating properly and successfully" by the DON and all FFA Parties.

Also, four of the five geophysical anomalies from CAOC 23 (OU 3) were consolidated at CAOC 35 prior to installation of the cap.

4.2.10 OU 1 Groundwater Remediation Systems (CAOC 37)

The following is a description of the remedy as stated in the OUs 1 and 2 ROD (DON, 1998a). The selected remedy involves groundwater extraction, ex-situ treatment and 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 removing constituents to levels at secondary and primary MCLs as measured by groundwater monitoring wells. 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 and on interpretation of soil gas data using appropriate vadose zone fate and transport and groundwater mixing zone models.

Monitoring is conducted to verify adherence to groundwater cleanup standards. The major components of the selected remedy described in the ROD include the following:

- Remedy all the contaminant plumes that exceed the MCLs, except directly beneath waste management areas/waste management units, by extracting groundwater at three locations: 1) four on-Base wells at the CAOC 26 plume downgradient boundary[1]; 2) eight wells at the Base eastern boundary[2]; and 3) four off-Base wells at the MCL boundary.[3]
- Treat extracted groundwater aboveground by activated carbon units.
- Operate existing AS/SVE systems for groundwater/vadose zone source removal at CAOC 26 and for groundwater VOC mass removal downgradient of CAOCs 16, 15/17, and 35.
- Recharge treated groundwater back into the aquifer via two infiltration galleries located at the upgradient edge of the plume.
- Monitor the vadose zone at CAOCs 16 and 26, as well as downgradient of CAOCs 16 and 15/17 for the effectiveness of the AS/SVE systems.
- 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.
- 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.
- Implement LUCs including access restrictions 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.

Figures 4-2, 4-5, and 4-6 show the Yermo Annex GETS, CAOC 16 AS/SVE system, and CAOC 26 AS/SVE system, respectively. A description of the remediation systems is provided in the following subsections.

4.2.10.1 Yermo Annex GETS

The Yermo Annex GETS was designed primarily to provide hydraulic containment of the dissolved groundwater plumes at the Yermo Annex. The GETS has an operating capacity of 1,600 gallons per minute (gpm). During the first year of operations in 1996, the GETS extracted an average of 1,000 gpm. As of August 3, 2007, the system is operating at approximately 332

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[1]These wells were installed.

[2]These wells were installed, along with a ninth well downgradient of CAOC 16.

[3]The four off-Base wells have not been installed as of 2007, as the extent of the off-Base portions of the plumes has reduced since 1996.

gpm (current maximum flow rate). The reduced operational flow rate is a result of the shrinkage of the VOC plumes as well as reduced capacity of the extraction wells due to declining groundwater levels. As a consequence of declining groundwater levels several deeper groundwater extraction wells have been installed, and some of the existing groundwater extraction wells were deepened. During GETS operation, groundwater is withdrawn from four ground extraction wells (GEW) (GEW-3, -6, -7, and -14) located along the eastern boundary of the Yermo Annex and one extraction well located near Building 573 (GEW-13). The locations of these wells are shown on Figure 4-2. The extracted groundwater is conveyed to the treatment compound where the water is treated for VOCs with granular activated carbon (GAC), after which it is discharged into infiltration galleries near the main gate of the Yermo Annex.

An evaluation of the need for the four off-Base extraction wells was presented in the Draft Final Technical Memorandum (TtEC, 2005). This was followed by submission of a Draft Explanation of Significant Differences (ESD) (TtEC, 2006). Additional discussion regarding the ESD is included in Section 7.9.5 and 7.13.1.7.

4.2.10.2 CAOC 16 AS/SVE System

The CAOC 16 AS/SVE system was installed in 1996 to reduce contaminant mass in the vadose and saturated zones near and downgradient of Building 573 (see Figure 4-5), began operation in 1999, and is currently in operation. The CAOC 16 AS/SVE system injects air into the saturated zone through a network of AS wells that are screened below the water table. The injected air forms micro-channels in the saturated zone, volatilizing VOCs and transferring them to the unsaturated zone (vadose zone). The VOC-laden vapors are then extracted from the vadose zone by a system of SVE wells and discharged to the atmosphere (usage of the previously installed GAC system was discontinued as stated in Section 4.4.4.7).

4.2.10.3 CAOC 26 AS/SVE System

The CAOC 26 AS/SVE system is similar to the CAOC 16 AS/SVE system, was installed near Building 533 (see Figure 4-6) in 1996, and was in operation from 1996 through 1998.

4.2.10.4 On-Base Drinking Water System

The YDW-5 and YDW-6A (also referred to as YDW-6) GAC (old YDW-3) adsorption systems were installed circa 1989 to treat extracted groundwater for VOCs, primarily TCE, 1,1-dichloroethene (1,1 DCE) and PCE. The YDW-5 and YDW-6A GAC adsorption systems are identical, and each consists of two 20,000-pound GAC vessels in series. The YDW-6A adsorbers were previously designated for treating water from the YDW-3 drinking water well, which has been abandoned. YDW-6A (also referred to as YDW-6) was installed in 2000 to replace YDW-3. For the YDW-5 adsorption system, GAC in the lead vessel was replaced in August 2002 and August 2007. Both vessels for the YDW-6A adsorption system underwent retrofitting of the internal lining during September 2003 and were refilled with fresh GAC in March 2004.

4.2.10.5 Off-Base Drinking Water Systems

GAC systems were installed at drinking water wells at Younts and Hodges (off-Base) in 1995 as a TCRA, as documented in *Time-Critical Removal Action at Private Residences Domestic Water Supply Wells Located East of the Yermo Annex (Yermo Private Residences TCRA)* (OHM, 1996b). Each system contains two 200-pound GAC vessels in series. The GAC systems treat the extracted groundwater for VOCs. *The Operation and Maintenance Manual Off-Base Drinking Water Systems (Younts and Hodges)* (FWENC, 2003) recommends replacement of the GAC vessels for the Younts and Hodges treatment system when breakthrough of a lead or lag GAC adsorber is detected. The *Five-Year Review Report for Operable Units 1-6, Marine Corps Logistics Base, Barstow, California* (FWENC, 2002a) recommends replacing the GAC vessels in the Younts and Hodges GAC adsorption systems approximately once every 5 years. This time frame is based on the nature of the loadings (being intermittent, relatively low concentrations) and was confirmed after discussions with various GAC adsorption system vendors. The GAC was replaced in the Younts and Hodges system during July 2002 and, most recently, during August 2007.

4.3 DESCRIPTION OF REMEDIES – NEBO MAIN BASE

The following sections describe the remedies for various CAOCs at Nebo Main Base. Only those CAOCs where LUCs, RAs, or BMP modifications are implemented are discussed. These include CAOC 1, 2, 3, 5, 7, 11, and 14 (see Figures 1-5 and 4-7) and the OU 2 groundwater remediation systems, CAOC 38 (Figures 4-8 and 4-9).

4.3.1 CAOC 1 (OU 6)

An NFA remedy was selected for CAOC 1. Because the ILCR at Strata 2 and 3 exceed 1 x 10^{-6}, for information and future planning purposes, a description and history of these two strata, a description of the activities that occurred for flood control purposes, a legal description (metes and bounds) of the boundary of CAOC 1, and the low levels of pesticides and PAHs detected in the surface soils at these two strata are addressed in Sections 15.1 through 15.6 in the BMP. Language in the BMP indicates that any changes in site use must be coordinated through and reviewed by the MCLB Barstow Environmental Department.

4.3.2 CAOC 2 (OU 4)

An NFA remedy was selected for CAOC 2, as documented by the ROD for OUs 3 and 4. Because the ILCR at Strata 1 and 3 exceeds 1 x 10^{-6}, for information and future planning purposes, the BMP was updated (Sections 6.1 through 6.6 of the BMP) to include the following: a description of the history of this stratum, the low levels of pesticides detected in the surface soils at these two strata, and language to the effect of any changes in site use must be coordinated through and reviewed by the MCLB Barstow Environmental Department. A TCRA was conducted from August to September 1994 during which 318 tons of impacted soils were removed.

4.3.3 CAOC 3 (OU 6)

The NFA remedy was selected for CAOC 3 soils under OUs 5 and 6. The selected NFA remedy does not involve institutional or engineering controls. Because the ILCR at Stratum 1 exceeds 1×10^{-6}, for information and future planning purposes, Sections 16.1 through 16.6 of the BMP have been modified to include the following: a description of the history of this stratum, the low levels of pesticides detected in the surface soils at this stratum, and language to the effect that any changes in site use must be coordinated through and reviewed by the MCLB Barstow Environmental Department.

4.3.4 CAOC 5 (OU 4)

An NFA remedy was selected for CAOC 5 soils. Because the ILCR at Strata 1 and 2 exceeds 1×10^{-6}, for information and future planning purposes, Section 7.0 of the BMP has been updated to include the following: a description of the history of these strata, the low levels of pesticide and PCB detections in Stratum 1 soils, the presence of dust suppression material in this stratum (dust suppression is discussed in the summary section of the BMP), and language to indicate that any changes in site use must be coordinated through and reviewed by the MCLB Barstow Environmental Department.

4.3.5 CAOC 7 (OU 6)

As stated in Section 3.3.7, an NFA remedy was selected for Strata 3 and 4. However, because there was the potential for minor surficial soil contamination to be present at Strata 3 and 4, Sections 10.1 through 10.6 of the BMP were amended to include a description of the history of CAOC 7 Strata 3 and 4, the low levels of PCBs detected, and language indicating that any actions planned in the area should be coordinated and reviewed by the MCLB Barstow Environmental Department.

Monolithic native soil caps were installed at Strata 1 and 2, as discussed in the OUs 5 and 6 RAR (SWDIV, 2002) and shown on Figure 4-10. The cap is maintained, and groundwater is monitored at three monitoring wells on an annual basis. Results of groundwater analysis are discussed in Section 4.5.1.1.

4.3.6 CAOC 11 (OU 4)

An NFA remedy was selected for CAOC 11. Because low levels of pesticides were detected in the soils that were within the risk range for carcinogenic site-related risks, Section 8.0 of the BMP was amended to include a description of site history for information and planning purposes, the levels of pesticides, and language effectively stating that any activities planned in this area or changes in site use should be coordinated through and reviewed by the MCLB Barstow Environmental Department.

4.3.7 CAOC 14 (OU 6)

An NFA remedy was selected for CAOC 14 under OU 6. Because low levels of pesticides, PCBs, and PAHs were detected in the soils that were within the risk range for carcinogenic site-related risks, Section 17.0 of the BMP includes the following: a description of the site history, the levels of pesticides detected, and language indicating that any activities planned in this area or changes in site use should be coordinated and reviewed by the MCLB Barstow Environmental Department.

4.3.8 OU 2 Groundwater Remediation Systems (CAOC 38)

The major components of the selected remedy at Nebo North include the following:

- Use AS/SVE system for groundwater/vadose zone source removal. The OUs 1 and 2 ROD (DON, 1998) refers to Warehouse 2 as the source area for the Nebo North plume. However, subsequent investigations identified the Former Building 50 as the Nebo North plume source area.
- Implement LUCs including access restrictions 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.
- Design and implement sampling protocol to monitor and evaluate the progress of natural processes in achieving remediation goals.
- Activate an existing groundwater extraction and treatment pilot study system on a contingency basis to provide containment backup if natural processes fail to contain the plume.
- Monitor vadose zone in the source area (identified as Former Building 50) for the effectiveness of the AS/SVE system.
- Monitor groundwater throughout the duration of the RA, which is estimated to take approximately 15 years, subject to evaluations of treatment and cost-effectiveness at 5-year intervals.

The major components of the selected remedy at Nebo South include the following:

- An AS/SVE system to remove VOCs from OU 2 Nebo South and the vadose zone at CAOC 6
- Land use controls (LUCs) including access restrictions to prevent the use of untreated groundwater for drinking water in the area of the plume above MCLs
- Vadose zone monitoring at CAOC 6 to measure the effectiveness of AS/SVE system operation. However, because of the relatively low VOC concentrations detected in the vadose zone, vapor sampling is being conducted by analyzing the system influent stream only on a monthly basis. Vadose zone monitoring (or confirmation sampling) would be performed to demonstrate compliance with remedial objectives and the related AS/SVE shut-down criteria.

- Groundwater monitoring during the AS/SVE system operational period
- Evaluations of treatment and cost-effectiveness at 5-year intervals until RAOs are met

No new drinking water wells have been installed within the plume areas at Nebo North and Nebo South.

A discussion of the status of the Nebo North GETS, Nebo North AS/SVE, and Nebo South AS/SVE system is provided in the following subsections.

4.3.8.1 Nebo North GETS

The Nebo North GETS was designed to provide hydraulic containment for the Nebo North Plume on a contingency basis if natural processes fail to contain the plume. Groundwater monitoring wells are monitored on a semiannual and/or annual basis. The GETS has not been in operation since 1996 as the plume has been shrinking (in terms of extent and concentrations). Figure 4-8 shows the Nebo North GETS.

4.3.8.2 Nebo North AS/SVE

As discussed in the AGMR 2007 (TN&A, 2007b), the Nebo North plume source area will be treated by an AS/SVE system per the OUs 1 and 2 ROD (DON, 1998a) and the *Draft Final Remedial Design Report and Remedial Action Work Plan* (TN&A, 2007a). The system was designed to treat VOCs from groundwater and the vadose zone at the former Building 50 area. The treatment system construction completion and startup took place during October 2007.

4.3.8.3 Nebo South AS/SVE

Following the success of the AS/SVE pilot test, AS/SVE was deemed as the final remedy for Nebo South groundwater (DON, 2006). Figure 4-9 shows the Nebo South AS/SVE system.

4.3.8.4 Off-Base Drinking Water Well

An off-Base residential well adjacent to the Nebo Main Base was taken out of service in June 1989 and the residence supplied with drinking water from the Base.

4.4 REMEDY PERFORMANCE – YERMO ANNEX

The following RAs have been implemented at the Yermo Annex:

- CAOC 20 – Landfill Cap
- CAOC 23 – Landfill Cap
- CAOC 35 – Landfill Cap
- CAOC 37 – Yermo Annex GETS

- CAOC 37 – AS/SVE system (downgradient/crossgradient of CAOCs 15/17, 16, and 35)
- CAOC 37 – AS/SVE system (CAOC 26)

The performance of the RAs at these CAOCs is discussed below. Historical groundwater and soil vapor analytical results as well as remediation system performance summaries for the CAOC 16 AS/SVE system, CAOC 26 AS/SVE system, and CAOC 37 GETS system can be found in various annual and semiannual groundwater monitoring reports for OUs 1 and 2 including the Annual Groundwater Monitoring Report (AGMR) for 2005 (TtEC, 2006), AGMR for 2006 (TN&A, 2007b), and the semiannual groundwater monitoring report for 2007 (TN&A, 2007c). Data trends for groundwater and soil vapor data are included in this report and are used in the following sections to support remedial performance evaluation.

4.4.1 CAOC 20 (OU 3)

The remedy at CAOC 20 consists of a concrete cap in combination with NFA. The concrete cap is maintained in accordance with the O&M Plan in Appendix A of the *OUs 3 and 4 RAR* (SWDIV, 2000) and is in good condition. Groundwater is monitored under OU 1. Figure A-1 in Appendix A shows groundwater monitoring wells in the vicinity of CAOCs 20, 23, and 35. Well YS20-1 is located upgradient of CAOC 20. Well YS20-2 was installed to serve as a downgradient well based on a west to east interpreted groundwater flow direction. However, the interpreted groundwater flow direction has since shifted. The newly interpreted flow direction is southwest to northeast (Figure 4-3) rendering YS20-2 to be a cross-gradient well as discussed in the *Final Technical Memorandum – Sampling Frequency Modification for OUs 1 and 2* (TtFW, 2005b) and the *Annual 2004 Groundwater Monitoring Summary Report Operable Units 1 and 2, Marine Corps Logistics Base*, *Barstow, CA* (TtFW, 2005c). The Industrial Wastewater Treatment and Recycling Facility groundwater monitoring well YIMW-5 (Figure A-1 in Appendix A) was noted to serve as a better candidate for downgradient monitoring at CAOC 20 (TtFW, 2005b and 2005c). Groundwater VOC analysis results, radiological analysis results, a cap maintenance summary, and an evaluation of CAOC 20 monitoring data are presented in the following sections.

4.4.1.1 Groundwater VOC Analysis Results

Historical concentration trends for TCE and PCE are presented in Figure A-2 in Appendix A 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 A-1 in Appendix A). Historical data for these wells indicate relatively stable TCE and PCE concentrations below MCLs for wells YS20-1 and YS20-2 (Figure A-2). TCE and PCE concentrations for the samples collected from well YIMW-5 were not detected at the respective detection limit since March 2003.

4.4.1.2 Radiological Analysis Results

Radiological analyses concentration trends are presented in Figure A-3 in Appendix A. Concentration trends are discussed below.

Gross alpha concentrations for the samples collected from the upgradient well YS20-1 have fluctuated since November 2003 above the respective MCL (15 picocuries per liter [pCi/L]). Concentrations of Radium 226 and Radium 228 remain below the combined radium-226/228 MCL of 5 pCi/L.

Cross-gradient well YS20-2 radiological data show gross alpha levels that have been slightly above MCL since 2004 and that have remained fairly steady since 2005. The observed gross alpha levels are less than the gross alpha levels observed in the upgradient well YS20-1. Gross beta, Radium 226, and Radium 228 concentrations were less than their respective MCLs.

As stated in Section 4.4.1, because of a slight shift in groundwater flow direction from east to northeast, it was noted that well YIMW-5 would serve better as a downgradient monitoring well at CAOC 20 (TtFW, 2005b and 2005c) (Figure A-1 in Appendix A). Well YIMW-5 was sampled for radiological analysis in November 2005 with detected gross alpha and gross beta concentrations less than the respective MCL values. This well was not sampled in 2006 due to a field sampling-related problem (TN&A, 2007).

CAOC 20 groundwater monitoring data are evaluated in the following section as required by the OUs 3 and 4 ROD (DON, 1997).

4.4.1.3 Evaluation of CAOC 20 Groundwater Monitoring Data

As a part of the five-year review process, the OUs 3 and 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, any appropriate action is to be proposed after consultation with the EPA, DTSC, and Water Board. The first Five-Year Review Report (DON, 2002) recommended that this evaluation be done in the second five-year review, as the fourth year of monitoring was 2003. This evaluation is discussed below.

As discussed in Section 4.4.1.1 above, TCE and PCE concentrations in the CAOC 20 groundwater monitoring wells YS20-1 and YS20-2 were below MCLs and indicate relatively stable concentration trends (Figure A-2 in Appendix A). TCE and PCE have remained at non-detect values in well YIMW-5 since March 2003.

Radiological analysis results indicate that gross alpha values were detected in upgradient well YS20-1 at fluctuating levels above the respective MCL since November 2003. Since 2004, relatively steady levels of gross alpha that are below the levels observed at the upgradient well YS20-1 but slightly above the MCLs were detected in the cross-gradient well YS20-2. Gross alpha was not detected in the downgradient well YIMW-5 at the respective detection limit. Statistical evaluation of gross alpha concentrations detected in wells YS20-1 and YS20-2 was performed. As discussed in Section B.2 in Appendix B of the Long-term Groundwater Monitoring Plan (LTGWMP) (DON, 1998c), control charts approach was used for statistical evaluation.

Control chart analysis for the gross alpha data from wells YS 20-1 and YS 20-2 is included in Attachment 1 of Appendix A. Also included in Attachment 1 of Appendix A is a background and description of the control chart analysis from *Statistical Analysis of Ground-water Monitoring Data at RCRA Facilities Addendum to Interim Final Guidance* (EPA, 1992). In the control chart analysis, mean and standard deviation values based on the baseline samples are computed. The calculated mean and standard deviation values for the baseline samples and the future sampling data are used to calculate standardized mean and cumulative sum (CUSUM) values (Attachment 1 of Appendix A) (EPA, 1992). Once the data have been standardized and plotted, a Control Chart is declared out of control if the sample concentrations become too large when compared to the baseline parameters. An out-of-control situation is indicated on the Control Chart when either the standardized means or CUSUMs cross one of two pre-determined threshold values (Attachment 1 of Appendix A) (EPA, 1992). The two pre-determined threshold values are the Shewhart control limit (SCL) and the “decision internal value” (h). In order for the use of control charts, the data should be normally distributed. While the LTGWMP (DON, 1998c) recommends use of control charts based on an arithmetic scale, the EPA guidance recommends use of data converted to logarithmic scale provided the data follows a log-normal distribution (EPA, 1992).

Groundwater monitoring data statistical analysis software ChemStat (Version 4.0.0.0) (Starpoint Software, Inc., 2001) was used to test the data set for normality of the baseline data and perform control chart analysis. The LTGWMP (DON, 1998c) recommends use of four to eight samples as the number of baseline samples for use in the control chart analysis. There are eight total samples each for wells YS20-1 and YS20-2, and analysis was performed using four baseline samples and six baseline samples. These baseline samples are not plotted on the control charts. The remaining samples in each case were treated as future monitoring data. Normality testing using ChemStat indicated that both the four-sample and six-sample baseline data sets for YS20-1 and YS20-2 were normally distributed both in arithmetic and logarithmic scales (Attachment 1 of Appendix A). Following the EPA guidance (Attachment 1 of Appendix A) (EPA, 1992), control chart analysis was performed using logarithmic data sets. Control charts for YS20-1 and YS20-2 are included in Attachment 1 of Appendix A. An out-of-control situation discussed in the above paragraph is indicated by a circle on the control charts representing a potential exceedance over the baseline. The following observations can be made based on the control chart analysis:

1. Based on the use of six baseline samples, there are no exceedances for wells YS20-1 and YS20-2 for gross alpha.

2. Based on the use of four baseline samples, for the well YS20-1, the standardized mean value does not cross the SCL value, indicating that concentration levels are not increasing rapidly (EPA, 1992). However, the CUSUM values exceed the "h" value for the annual 2005 and 2006 sampling events (Attachment 1 of Appendix A). A gradual increase or trend is particularly indicated if the CUSUM crosses its threshold, but the standardized mean does not (EPA, 1992).
3. For the well YS20-2, use of four baseline samples indicated an out-of-control situation as the standardized mean and the CUSUM values exceeded the SCL and "h" values, respectively (Attachment 1 of Appendix A).

Based on the results from the control chart analysis discussed above, gross alpha results for wells YS20-1 and YS20-2 indicate statistically significant exceedances. As discussed earlier, YS20-1 is an upgradient well. Upon consulting with the FFA signatories, additional investigations and/or evaluations are recommended to assess if the observed increase in gross alpha values is the result of releases at CAOC 20 or any upgradient sources. As stated earlier in Section 4.4.1, YS20-2 well was installed to function as a downgradient well. A shift in the interpreted groundwater flow direction to the northeast subsequent to the installation of the well has rendered it as a cross-gradient well. Additional investigations and/or evaluations will be necessary to further evaluate the gross alpha concentration increases at this well. As discussed in Sections 4.4.1 and 4.4.1.2, well YIMW-5 was noted to better serve as a downgradient well for monitoring radiological parameters (TtFW, 2005b and 2005c). Gross alpha concentration analyzed for the sample collected from YIMW-5 downgradient of CAOC 20 during the Annual 2005 groundwater sampling event was below the respective MCL value.

4.4.1.4 Cap Maintenance

Annual monitoring and maintenance reports (URS Corporation [URS], 2003; TerraVac, 2004, 2005, and 2007) for the CAOC 20 cap were reviewed. Based on the results presented in these reports, the cap and fence at CAOC 20 are in good working condition. Inspections were conducted to check for the presence of concrete cracks in the joint sealer. A minor crack was detected, reported, and monitored to detect any further growth (TerraVac, 2004), and no further growth of the crack was reported (TerraVac, 2005 and 2007). However, some additional minor crack repairs were performed (TerraVac, 2005). Debris and sediment were removed from the entrance of the 12-inch-diameter drainpipe and the discharge end of the drainpipe on an as-needed basis (TerraVac, 2004, 2005, and 2007). Weed control activities and inspection and maintenance of the chain-link fence were performed. Barbed wire was restrung on the south side of the fence in February 2004.

Soil moisture 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. The measured soil moisture content was relatively constant, and little to no variability over time was observed at each point (TerraVac, 2004, 2005, and 2007), indicating that the cap is functioning effectively. Soil moisture data collection failed in May 2004 due to mechanical problems. Data logger modifications and repairs were made in August 2005.

4.4.2 CAOC 23 (OU 3)

The remedy at CAOC 23 consists of a concrete cap in combination with LUCs. The cap is maintained in accordance with the *CAOC 23 O&M Manual* (AGRA, 1998) and is in good condition. Monitoring consists of groundwater (under OU 1) and vadose zone moisture (precipitation) monitoring. 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 for the option, as noted in Section 2.3.6.3 of the same ROD. VOC results and cap performance information are discussed in the following sections.

4.4.2.1 Groundwater VOC Analysis Results

Groundwater monitoring wells in the vicinity of CAOC 23 are shown in Figure A-1 in Appendix A. TCE and PCE concentration trends for several wells in the vicinity of CAOC 23 shown in Figure A-4 in Appendix A 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.

4.4.2.2 Cap Maintenance

A review of the annual operation and maintenance reports for the CAOC 23 cap (URS, 2003; and TerraVac, 2004, 2005, and 2007) indicated that the cap and fence are in good working condition.

Small cracks were observed in the joint sealer during inspections and sealed with a polyurethane sealant (TerraVac, 2004 and 2005). Weed control activities and inspection and maintenance of the chain-link fence were also performed (TerraVac, 2004, 2005, and 2007).

4.4.3 CAOC 35 (OU 5)

The remedy at CAOC 35 consists of a native soil cap with vadose zone moisture and groundwater monitoring. The soil cap is maintained in accordance with the CAOC 7 and 35 O&M Manual (BNI, 1999). CAOC 35 groundwater monitoring data trends (TCE and PCE) and cap maintenance are discussed in the following sections.

4.4.3.1 Groundwater VOC Analysis Results

Groundwater monitoring wells in the vicinity of CAOC 35 are shown in Figure A-1 in Appendix A. TCE and PCE concentration trends for several CAOC 35 monitoring wells presented in Figure A-5 in Appendix A indicate the following:

- TCE and PCE levels in well YS15-2 located upgradient of the cap fluctuate around the MCL.
- TCE and PCE concentrations cross-gradient of the cap (YS35-8) are relatively stable and below MCLs.
- TCE and PCE levels in wells located downgradient of the cap, including YEP-2 and YEP-3, are relatively stable and generally below MCLs

4.4.3.2 Cap Maintenance

A review of the annual operation and maintenance reports for the CAOC 35 cap (URS, 2003; TerraVac, 2004, 2005, and 2007) indicated that inspection and maintenance of chain-link fence and weed control activities were performed upon each site visit (TerraVac, 2004, 2005, and 2007). The cap and fence at CAOC 35 are in good working condition. However, soil undermining occurs along the north fence line during each rainfall. Backfilling was performed each time this occurred, and fence berm repair was also conducted (TerraVac, 2005). Heavy rainfalls also led to high vegetation growth at CAOC 35, but landscapers focused weed-clearing efforts on this area. During 2006, the fence along the southern perimeter was replaced.

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 is downloaded bimonthly. The measured soil moisture content was relatively constant, and little to no variability over time was observed at each point (TerraVac, 2004, 2005, and 2007), indicating that the cap is functioning effectively. The monument surveys revealed that some measurable differential settlement has occurred. During the December 14, 2006, survey, monument 1 (west monument) was found to be 0.07 feet lower than its original elevation in 1999 (0.04 feet from the August 2005 measurements), and monument 2 was found to have settled 0.18 feet (0.06 feet from the August 2005 survey). Further annual surveys were recommended.

4.4.4 CAOC 37 – Yermo Annex GETS (OU 1)

The Yermo Annex GETS is operated in accordance with the CAOC 37 O&M Manual (OHM, 1999) and SAP (TtFW, 2005a and TN&A, 2006). The following subsections describe the performance of the Yermo Annex GETS.

4.4.4.1 Containment at MCL Boundaries

The primary objective of the Yermo Annex GETS is hydraulic containment of contaminated groundwater at the MCLB Barstow boundary. This is monitored using groundwater level contour maps as well as groundwater modeling. As a part of the CAOC 37 GETS capture zone modeling included in Appendix B, groundwater modeling was performed to evaluate capture zones based on May 2007 pumping rates. A discussion of the groundwater extraction well status and performance is presented in Sections 4.4.4.5 and 4.4.4.6. As discussed in Section 4.4.4.5, as of May 2007, groundwater extraction wells GEW-3, -6, -7, -13, and -14 are in operation. The remaining wells are no longer in operation and are located within the areas where TCE, PCE, and 1,1-DCE concentrations are below MCLs.

The model-predicted capture zones based on May 2007 pumping rates are shown on Figure 4-11. Groundwater VOC plume boundaries based on 2006 annual groundwater monitoring data are also shown in Figure 4-11. Additional details on capture zone modeling are presented in Appendix B. The following observations can be made from the groundwater capture zones shown on Figure 4-11:

- Groundwater modeling results based on May 2007 pumping rates indicate capture of the Yermo North plume.
- Deepening of groundwater extraction wells GEW-6 and GEW-7 along the Base boundary, along with pumping from GEW-13, resulted in an improved capture of the Yermo North plume.
- GEW-13 provides capture of the southern portion of the Yermo North plume interior high-concentration zone. As of May 2007, the extraction rate at this well has been maximized to improve hydraulic capture in this area.
- The on-Base Yermo South plume, concentrations of which have declined below the MCLs, is captured primarily by extraction well GEW-14. GEW-14 pumping should continue until longer-term data confirm that the residual on-Base plume remains below MCLs.
- GEW-3 does not appear to be contributing to the capture of the Yermo South plume.

As discussed in AGMR 2006 (TN&A, 2007b), the maximized pumping rates during May 2007 showed an improved containment of the Yermo North plume when compared to the partial operation of the GETS in 2006 due to pump malfunction at GEW-7. The maximized May 2007 pumping rate showed a significant improvement in the capture of the Yermo North plume.

Groundwater extraction well GEW-8 is currently not in operation due to insufficient groundwater recovery rates caused by regional decline in groundwater levels and is located north of GEW-7 and GEW-15 (Figure 1-2). An additional modeling scenario included simulation of GEW-8 along with the wells that were in operation during May 2007, as discussed in Appendix B. Well GEW-8 was assumed to be reconstructed similar to GEW-7 via deepening or as a new well located near the existing well. Modeling results shown in Figure B.3-2 in Appendix B indicate that addition of reconstructed GEW-8 could serve as a backup well in the event of pump malfunction in well GEW-6 or GEW-7. In addition, modeling results indicate that addition of

GEW-8 to the currently operating wells GEW-6 and GEW-7 could improve containment of the Yermo North plume (Figure B.3-2 in Appendix B).

Recently, the DTSC recommended recalibration of the groundwater model to include change in groundwater elevations as well as to evaluate the possibility of including other groundwater extraction wells. Recalibration of the groundwater model is underway.

4.4.4.2 Reduction in VOC Concentrations

As discussed earlier, three separate groundwater VOC plumes have been identified at Yermo Annex. The Yermo North plume is located downgradient of CAOCs 16 and 35 (Figure 1-4), the Yermo South plume is located downgradient of CAOC 23 (historically downgradient of CAOC 20) (Figure 1-4), and the CAOC 26 plume is located downgradient of CAOC 26 in the central portion of the Base (Figure 1-4).

Figures 4-12 and 4-13 show TCE, PCE, and 1,1-DCE concentrations based on the Annual 2006 and Semi-Annual 2007 groundwater monitoring events for Yermo Annex along with plume interpretations. Maps showing well locations for each of these three plumes (Figures C-1, C-3, and C-5) precede respective trend charts in Appendix C. Historical TCE and PCE (and 1,1-DCE, where applicable) concentration trends for select wells for Yermo North (Figure C-2), Yermo South (Figure C-4), and CAOC 26 (Figure C-6) plumes are included in Appendix C. A brief summary of VOC trends for these plumes is presented below.

Yermo North Plume

The Yermo North plume is located hydraulically downgradient of CAOCs 16 and 35 (Figures 1-4 and C-1). The plume generally consists of TCE and PCE concentrations fluctuating slightly greater than or less than the MCL, with relatively higher VOC concentrations located downgradient of CAOC 35 (Figures 4-12 and 4-13). Long-term chemical concentration trends for the Yermo North plume presented in Figure C-2 indicate the following:

- Well YS15-2 is located cross-gradient of CAOC 35. TCE concentrations have fluctuated around the MCL and have recently increased above the MCL. PCE concentrations were historically low until an increase above the MCL in 2005, followed by a decrease during 2006 to below-MCLs.
- Historical TCE and PCE concentration data cross-gradient of CAOC 16 for the abandoned well YS35-2 between 1992 and 1995 indicate increasing TCE and PCE concentrations.
- TCE concentration data for YCW16-3 located downgradient of CAOC 16 indicate relatively stable concentrations slightly above the MCL. PCE concentration data for this well indicate decreasing trends below the MCL value. .
- Overall decreasing concentration trends for TCE and PCE downgradient of CAOC 16 since the CAOC 16 system began operation are evidenced from Well YCW16-2.

- Concentration trends for well YWA-1 indicate fluctuating concentrations of TCE, PCE, and 1,1-dichlorothene (1,1-DCE). Concentrations of TCE and PCE remain greater than the respective MCLs. Historical data for well YWA-2 indicate that 1,1-DCE and TCE concentrations have been fluctuating around the respective MCLs since February 2003, with the exception of November 2006. An overall increasing trend in PCE concentrations above the MCL can be noted.
- An overall increase in COC concentrations can be noted in general for the wells located downgradient of CAOC 16 (wells YS17-7, YS17-8, YS35-3, and YS35-4). In general, concentrations are above the respective MCLs.
- Wells GEW-8 and GEW-15 are non-pumping extraction wells located at the east end of the plume. PCE and TCE data for GEW-8 indicate that concentrations decreased to values below MCLs in 2003 but have since increased slightly above the MCL. PCE and TCE concentrations have fluctuated around MCLs in GEW-15 and both increased above MCLs in November 2006.
- Well PZ-C is located at the east end of the plume. Groundwater samples from this well indicate that TCE, PCE, and 1,1-DCE concentrations peaked in November 2005 and decreased during November 2006.
- Well YIMW-1 is located south of and cross-gradient to the plume. PCE and TCE concentrations in this well have remained below the respective MCLs.
- Well YW-2 is hydraulically located approximately 100 feet downgradient from well GEW-7 (active extraction well). PCE concentrations show an increase between 2004 and 2006 followed by a decrease during the semiannual 2007 event, with PCE levels above MCL since 2005. TCE and 1,1-DCE concentrations were less than the respective MCLs.
- TCE, PCE, and 1,1-DCE concentrations for the off-Base wells Y7-2 and Y7-3 were below the respective MCL values during the semiannual 2007 groundwater monitoring event. Historically, TCE, PCE, and 1,1-DCE concentrations were below MCLs in both wells, except for a December 2001 TCE concentration spike in both wells and a slight increase in 1,1-DCE in well Y7-2 in June 2005. The increases during the December 2001 and June 2005 events were likely as a result of groundwater recharge events.
- TCE, PCE, and 1,1-DCE concentrations in wells Y15-2 and Y15-3 were below their respective MCLs until late 2004-mid 2005 when concentrations slightly exceeded the respective MCLs. During the semiannual 2007 sampling event, concentrations of TCE, PCE, and 1,1-DCE were below MCL values.
- Well Y15-4 is a deep multi-port, off-Base well located approximately 400 feet upgradient of the Younts well (off Base drinking water supply well). Groundwater monitoring data from Y15-4 indicate no detectable TCE, PCE, and 1,1-DCE concentrations, with the exception of trace level (below-MCL) concentrations in the shallowest sampling port (Y15-4-1).
- VOCs have been sporadically detected in the Younts and Hodges influent at relatively low concentrations below MCLs (Figure C-2).

Yermo South Plume

The Yermo South plume, based on Annual 2006 groundwater monitoring data, is located downgradient of CAOC 23 (historically CAOC 20) (Figure 4-12). Hydraulic capture of this plume has been largely achieved by the GETS with wells GEW-3 and GEW-14 continuing to operate as extraction wells (Figure 4-11).

The primary COC in the Yermo South plume is TCE. Figure C-3 in Appendix C includes locations of various Yermo South monitoring wells. Historical TCE and PCE concentration trends shown in Figure C-4 in Appendix C indicate the following:

- TCE concentrations have fallen below the MCL in the majority of the on-Base Yermo South plume monitoring wells, including Y9-3, Y9-4, Y9-5, Y9-7, GEW-1, GEW-2, GEW-14, YS23-16, YS23-17, YS23-18, and YS23-19; therefore, the plume, as delineated by the 5 micrograms per liter (µg/L) isoconcentration contour, is inferred to no longer be present on the Base.
- The TCE concentrations in off-Base monitoring wells Y9-2, Y9-6, PMW-1, and PMW-2 have declined or remained stable, with the exception of that in well Y9-2, which measured 5.3 µg/L in November 2006.

The TCE concentration in Y9-2 was below the MCL at 3.1 µg/L during the semiannual 2007 groundwater monitoring event (Figure 4-13).

CAOC 26 Plume

The CAOC 26 plume, interpreted based on Annual 2006 groundwater monitoring data, is located downgradient of CAOC 26 and upgradient of CAOCs 16 and 35 (Figure 4-12) and is limited in extent to the vicinity of wells PMW-11 and PMW-12. Wells in the vicinity of and downgradient of CAOC 26 are shown on Figure C-5 in Appendix C. Concentrations trends for several of these wells shown on Figure C-6 in Appendix C indicate the following:

- Wells YS26-2 and YS26-3 are located in the vicinity of CAOC 26, and no increases in dissolved VOCs have been measured in these wells despite the CAOC 26 AS/SVE system remaining idle since 1998.
- Downgradient of CAOC 26, TCE and PCE concentrations are relatively stable to decreasing in wells PMW-7, PMW-8, PMW-9, and PMW-10, which have concentrations below MCLs.
- Wells PMW-11 and PMW-12 are located at the leading edge of the CAOC 26 plume, upgradient of CAOC 16, and historical data indicate that TCE concentrations in these wells have fluctuated near the MCL through 2006 followed by a decrease during the semiannual 2007 event to below the MCL values. PCE concentrations remained below the MCL values.

TCE concentrations were below the MCL during the semiannual 2007 monitoring event (Figure 4-13).

4.4.4.3 VOC Plume Behavior Over Time

As discussed earlier, three plumes have been identified at OU 1 – the Yermo North plume, the CAOC 26 plume, and the Yermo South plume. Although a comprehensive network of monitoring wells exists at OU 1, a number of these wells have become dry over time as regional water levels declined. New, dual-screened groundwater monitoring wells were installed by the DON to replace some of the dry wells. In some cases, wells were installed for non-IR Program purposes; however, the resulting data have served to enhance the understanding of the OU 1 plume delineation. Also, a number of HydroPunch samples were collected since 1993.

The historical extents of the TCE and PCE plumes at the Yermo Annex based on annual sampling conducted in 1996, 2000, 2004, and 2006 are shown on Figure 4-14. Also shown are inferred TCE and PCE extents based on semiannual 2007 groundwater monitoring data. Individual isoconcentration contour maps for TCE along with pertinent concentration data for years 1996, 2000, and 2004 are included as Figures D-1, D-2, and D-3, respectively, in Appendix D. The corresponding PCE isoconcentrations are presented as Figures D-4, D-5, and D-6, respectively, in Appendix D.

It should be noted that in all of the interpretations of plume extents, all available data were used for each graph. This includes historical trends for existing/dry wells and HydroPunch data. Because HydroPunch data represent a single temporal data point, it was assumed that the concentrations at that location would follow the same trend exhibited by monitoring wells in the vicinity of that HydroPunch. The annual 2006 and the semiannual 2007 groundwater monitoring data and associated isoconcentrations maps are shown in Figures 4-12 and 4-13. For the semiannual 2007 sampling event, the Annual 2006 event sampling data was used along with the April / May 2007 sampling event data, which was collected from a subset of the annual sampling wells. The sections below discuss the VOC plume behavior over time at OU 1.

Yermo North Plume Changes Over Time

As can be noted from Figure 4-14, the TCE plume extent has decreased over the past 10 years (1996 to April / May 2007). Historical TCE plume extent maps are presented in Figures D-1 to D3 (Appendix D), Figure 4-12 (Annual 2006), and Figure 4-13 (April / May 2007). These reductions may be attributable to ongoing operation of the CAOC 16 AS/SVE system in conjunction with groundwater extraction. The decrease in VOCs can also be attributed to the declining water table and other natural attenuating processes such as degradation, dilution, and dispersion.

The extent of the PCE plume at Yermo North has also decreased between 1996 and 2007 (Figure 4-14). The decrease in PCE is much more pronounced when compared to TCE, with a distinct shrinkage in the vicinity of the CAOC 16 AS/SVE wells (Figure 4-14) (also refer to Figure D-4 in comparison to Figures D-5 and D-6 in Appendix D). This difference may, in part, be attributable to the higher volatility of PCE compared to TCE (Henry's Law Constants: 0.75 for PCE and 0.42 for TCE)

Based on the above discussion and the groundwater monitoring trends discussed in Section 4.4.4.2 for the Yermo North plume, the horizontal extent of the Yermo North plume appears to remain fairly stable.

Yermo South Plume Changes Over Time

The interpreted extent of the TCE plume at Yermo South has decreased significantly between 1996 and April / May 2007 (Figure 4-14).

The TCE concentration in well Y9-2, the leading edge off-Base plume monitoring well, was slightly above the MCL (5.3 µg/L) during November 2006, but was less than the MCL in the other two off-site monitoring wells (Y9-6 and PMW-1). However, as discussed in Section 4.4.6.2, the TCE concentration in this well was below the MCL (3.1 µg/L) during the semiannual 2007 groundwater monitoring event (Figure 4-13). Thus, the Yermo South off-Base plume, as delineated by the 5 µg/L isoconcentration contour, is not inferred to be present.

The PCE plume at Yermo South shows a similar decrease in overall extent and can no longer be interpreted to exist after 2004 (Figure 4-14). These decreases can, in part, be attributed to previous groundwater extraction from GEW-1 and -2, ongoing extraction from GEW-3, and GEW 14 (since 2001).

Yermo CAOC 26 Plume Changes Over Time

Overall, since 1998, the CAOC 26 plume has been observed to significantly attenuate both in terms of plume extent and measured groundwater concentrations (Figure 4-14). The 2006 annual VOC groundwater data indicated monitoring wells PMW-11 and PMW-12, located at the leading edge of the plume, show TCE fluctuations around the MCLs since May 2001. However, during the semiannual 2007 groundwater monitoring event, TCE concentrations were below the MCL at 4 µg/L (well PMW-11) and 1.3 µg/L (well PMW-12) (Figure 4-13). Thus, the MCL isoconcentration is not inferred to be present in the CAOC 26 area based on this data.

The PCE plume observed in 1996 can no longer be interpreted to exist, based on groundwater concentrations being observed only at trace levels or less than method detection limits (Figure 4-14).

The decline of TCE and a steady state of PCE concentrations in the CAOC 26 plume can be attributed to the operation of the CAOC 26 AS/SVE system and groundwater extraction activities.

4.4.4.4 General Chemistry Analytical Data – Yermo Annex

The 2002 AGMR (FWENC, 2003) noted that the general chemistry of groundwater at the Yermo Annex remained relatively consistent over the last few years leading up to the report. Therefore, general water chemistry parameters analysis was discontinued in 2003. As discussed in the *Final*

Technical Memorandum – Sampling Frequency Modification for OUs 1 and 2 (TtFW, 2005b), there is no benefit in sampling for general chemistry unless a major hydrogeochemical event occurs.

4.4.4.5 Reduction of VOC Mass

As of June 2007, approximately 2.027 billion gallons of contaminated groundwater have been extracted and treated by the GETS, removing approximately 155.56 pounds of total VOCs since the initial startup in 1996.

Figure 4-15 shows a plot of the historical average annual flow rates and average annual VOC influent concentrations (TCE, PCE, and 1,1-DCE) vs. time. As can be seen in Figure 4-15, average annual flow rates have decreased since initial startup (December 1996), while influent VOC concentrations have fluctuated and are at or below start-up levels. Figure 4-15 shows the cumulative removals of TCE, PCE, and 1,1-DCE by the GETS. Removals appear to be gradually approaching asymptotic levels.

The levels of VOCs in the treated groundwater have remained below detection limits, indicating that the system is operating properly.

4.4.4.6 Extraction Well Status and Performance

Extraction well performance has generally declined since 1996 due to the ongoing overall drop in water levels at the Yermo Annex (and in the Yermo Annex area in general). Figure 4-15 indicates the flow performance of the GETS. Groundwater extraction wells GEW-14 and GEW-15 were added with longer screen intervals, and groundwater extraction wells GEW-6 and GEW-7 were deepened. As of May 2007, groundwater extraction wells GEW-3, GEW-6, GEW-7, GEW-13, and GEW-14 were in operation. As discussed in Section 4.4.4.1, capture zone modeling indicates that these wells with the associated pumping rates provide adequate capture of the plumes. Reconstruction or replacement of GEW-8 is expected to further improve containment of the Yermo North plume.

4.4.4.7 CAOC 37 – CAOC 16 AS/SVE System

The CAOC 16 AS/SVE system at the Yermo Annex was installed to reduce VOC contamination in the vadose and saturated zones near and downgradient of Building 573 (Figure 1-4). The CAOC 16 AS/SVE system consists of thirteen AS wells with shallow and deep casings (ASW-1 through ASW-13) and six SVE wells (VEW-1 through VEW-6). The CAOC 16 AS/SVE system has been in operation since June 1999 and is operated in accordance with the *CAOC 37 O&M Manual* (OHM, 1999).

The following sections discuss the performance of the CAOC 16 AS/SVE system.

VOC Removal Rates and Concentrations

System performance is shown on Figure 4-16 by plotting influent concentrations of total VOCs and several different chlorofluorocarbons (CFCs) over time and the cumulative mass removed by the CAOC 16 AS/SVE system. A total of over 8,353 pounds of VOCs and over 503 pounds of CFCs have been extracted from soil (and groundwater) by the CAOC 16 AS/SVE system as of June 2007. The following observations and trends can be observed from Figure 4-16:

1. Concentrations of VOCs in extracted soil vapor have decreased since 1999.
2. The concentrations of CFCs in extracted soil vapor have decreased to negligible levels, indicating that CFCs were localized and limited in the subsurface.
3. VOC removal rates have declined since 1999.

Pulsing of the AS system to enhance mass removal rates was initiated in September 2005. The pulse cycle consisted of 2 hours of AS operation followed by 1 hour of AS shutdown.

As documented in a letter sent to the regulatory agencies during September 2005, as well as the *Draft Explanation of Significant Differences Operable Unit 1* (DON, 2005), VOC emission rates remained well below the Mojave Desert Air Quality Management District (MDAQMD) allowable levels (39.6 pounds/day for VOCs and 600 pounds/day for freon). VOC extraction (and emission) rates for 2005, for 2006, and through June 2007 were well below the allowable level, and treatment of extracted vapors was therefore unnecessary. Discussions with MDAQMD staff indicate that elimination of granular activated carbon (GAC) is acceptable, and the EPA and the Water Board concurred with the elimination of the GAC. The DTSC recommended that effluent concentrations from the system be closely monitored. As such, monitoring of the effluent concentrations will continue.

Soil Vapor Monitoring – Effectiveness Wells

The CAOC 16 soil vapor monitoring and extraction wells were sampled quarterly through April 2003 and annually since the annual sampling event of 2003 (December 2003). The soil vapor samples were collected under static conditions (AS/SVE system not in operation). Wells YCW16-1, YCW16-2, and YCW16-3 have soil vapor probes at five different depths across the vadose zone. Locations of these wells, as well as the vapor extraction wells and groundwater monitoring wells, are shown in Figure E-1 in Appendix E. Historical vapor monitoring data trends for CAOC 16 soil vapor monitoring data are presented in Figure E-2 in Appendix E. The following observations are noted:

1. Soil vapor VOC concentrations in the extraction wells have generally decreased with time.
2. Soil vapor VOC concentrations in the monitoring wells within the vapor extraction well vicinity have generally decreased or have remained at low levels.

3. Soil vapor VOC concentrations in the three combination wells (YCW16-1, YCW16-2, and YCW16-3) show a decrease or have remained at low levels relative to initial levels in 1999 in spite of their distance (up to 1,000 feet) from the SVE wells.

Due to the AS/SVE system shutdown from April 2006 to February 2007, the total VOC concentrations of the soil vapors in monitoring wells YS17-8 and YM-11 increased from 7.89 µg/L and 0.17 µg/L in 2005 to 23.55 µg/L and 19.22 µg/L in 2006, respectively. These increases are not significant. The total VOC concentrations in these two wells are significantly less than historical concentrations (Figure E-2 in Appendix E).

Groundwater Monitoring – Effectiveness Wells

Samples collected from wells in the CAOC 16 area (YCW16-1, YCW16-2, YCW16-3, YS17-7, YS17-8, YS18-2, YWA-1, YWA-2, and YWB-1) are used to assess the effectiveness of the CAOC 16 AS/SVE system in reducing VOC concentrations in groundwater. Figure E-3 in Appendix E shows VOC concentrations in several wells in the CAOC 16 area. The following observations are noted:

- VOC concentrations in a majority of these wells show an overall decreasing trend with time.
- Groundwater PCE concentrations in wells YS17-7 and YS 17-8 are increasing over time.
- Groundwater concentrations of PCE, TCE, or 1,1-DCE are above their respective MCLs in YCW16-2, YCW16-3, YS17-7, YS17-8, YWA-1, and YWA-2.

Additional optimization of the remedial system is recommended to address the increases in the VOC concentrations in most wells immediately downgradient of the CAOC 16 AS zone of influence (for example, well YS17-7 [Figures E-1 and E-3 in Appendix E] and wells YS35-3 and YS35-4 [Figures C1 and C-2 in Appendix C]).

Overall Effectiveness – CAOC 16

As discussed above, there has been a reduction of VOCs in the vadose zone. There has also been a reduction in VOC levels in soil gas in the vicinity of the SVE wells. The GETS wells downgradient of CAOC 16 (GEW-6 and 13) continue to extract VOC-impacted groundwater and provide hydraulic capture at the MCL boundary (see Figure 4-11). VOC levels in groundwater generally show a decrease (except immediately downgradient of CAOC 35 and CAOC 16 AS/SVE radius of influence [ROI]) (for example, well YS17-7 [Figures E-1 and E-3 in Appendix E] and wells YS35-3 and YS35-4 [Figures C-1 and C-2 in Appendix C]). Based on the above discussion presented in Section 4.4.4.3 regarding the Yermo North plume extents and the groundwater monitoring trends discussed in Section 4.4.4.2, the horizontal extent of the Yermo North plume appears to remain fairly stable.

The decrease in VOC levels in soil gas and groundwater indicate that there is progress at CAOC 16 toward:

1. Meeting the groundwater cleanup goals.
2. Reducing mass of VOCs in the vadose zone.

4.4.4.8 CAOC 37 – CAOC 26 AS/SVE System

The CAOC 26 AS/SVE system was installed to reduce contaminant mass in the vadose and saturated zones at CAOC 26. The CAOC 26 AS/SVE system process is identical to the CAOC 16 AS/SVE system process. The AS/SVE system consists of five AS wells and seven SVE wells. The CAOC 26 AS/SVE system was started in December 1996 and operated through December 1998. It has not been in operation since then, as it has met its objectives, as discussed in the CAOC 26 Technical and Economic Feasibility (TEF) Report (CAOC 26 TEF Report) (FWENC, 2001). Approximately 1,449 pounds of VOCs were extracted from the subsurface during the AS/SVE system operation at CAOC 26. The monitoring network for CAOC 26 is shown in Figure E-4 in Appendix E.

VOC Reduction in Groundwater

VOCs in groundwater at CAOC 26 have remained below or approximately at MCLs since the CAOC 26 AS/SVE system shut down in 1998. This is shown on Figure E-5.

VOCs in Soil Gas at CAOC 26

Since the shutdown of the system in December 1998, the CAOC 26 soil vapor monitoring network has been sampled on an annual basis. Total VOC soil vapor concentration trends after the shutdown of the system are shown in Figure E-6 in Appendix E. The total VOC concentrations in the soil vapors obtained in October of 1996 (prior to the startup of the AS/SVE system) are excluded to clearly depict post-shutdown concentrations on a linear scale. In general, the total VOC concentrations of the soil vapors have decreased or remained relatively stable over the past five years. The increases observed between 2002 and 2004 in some of the samples have decreased and have remained relatively low since that time.

As can be seen from Figure E-6 (Appendix E), a slight overall increase in soil VOC concentrations can be noted in some cases when compared to the 1998 soil vapor VOC concentrations. A detailed evaluation was presented in the first Five-Year Review Report Operable Units 1-6 (DON, 2002) to evaluate the need for restarting the CAOC 26 AS/SVE system. Preliminary thresholds were established for such a restart. However, based on Figure E-6, the amount of VOC increase is minimal, and there is no need for restart at this time.

4.4.5 On-Base Drinking Water Wells

Due to the proximity of well YDW-5 to CAOC 16, and as a preventive measure for well YDW-6A (also referred to as YDW-6), these wells are equipped with a GAC treatment system (two 20,000-pound GAC vessels in series) to remove/filter any harmful VOCs from the water. A carbon changeout was conducted on the primary vessel at YDW-5 on August 22, 2007. Influent, intermediate, and effluent samples at YDW-5 and YDW-6A treatment systems and samples from well YDW-7 are collected on a monthly basis and analyzed for VOCs and nitrate/nitrite. Based on historical data, sporadic detections for VOCs at relatively low levels (below MCLs) have been observed. YDW-7 has been offline since approximately November 11, 2006, due to an electrical problem.

4.4.6 Off-Base Drinking Water Wells

The off-Base residential drinking water wells (Younts and Hodges) each have two 200-pound GAC vessels in service. Influent, intermediate, and effluent samples are collected from the Younts and Hodges wells on a semiannual basis. VOCs have been sporadically detected in the Younts and Hodges influent at relatively low concentrations below MCLs (Figure C-2). With the exception of the January 7, 2004, Younts intermediate sample, no VOC detections were reported in Younts and Hodges intermediate and effluent samples, indicating that VOCs are being effectively removed from the influent streams. A leak was observed in the Younts' well house bag filter on January 19, 2007, and the bag filter housing was replaced on February 19, 2007. The GAC changeout in the vessels was performed on August 7, 2007.

4.5 REMEDY PERFORMANCE – NEBO MAIN BASE

The following RAs have been implemented at the Nebo Main Base:

- CAOC 7 – Landfill Cap
- CAOC 38 – Nebo North GETS
- CAOC 38 – Nebo South AS/SVE

The performance of the RAs at these CAOCs is discussed below.

4.5.1 CAOC 7 (OU 6)

The cap at CAOC 7 is maintained in accordance with the *CAOC 7 and 35 O&M Manual* (BNI, 1999). The following sections discuss groundwater monitoring data and cap maintenance activities at CAOC 7.

4.5.1.1 Groundwater Monitoring Data

CAOC 7 monitoring well locations (Wells NS7-1, NSP-2, and NSP-3) are shown on Figure 4-10 and Figure F-1 in Appendix F. Historical VOC concentration trends for these wells shown in Figure F-2 in Appendix F indicate the following:

- None of the COCs were detected at or above MCLs in wells NS7-1 (downgradient well, Stratum 1) and NSP-3 (downgradient well, Stratum 2).
- In well NSP-2, the detected TCE concentrations remained at or below the MCL through June 2003. TCE concentrations were detected above the MCL values during the annual 2004, 2005, and 2006 groundwater monitoring events (6 μg/L, 7 μg/L, and 17 μg/L, respectively)

Section 4.6.3 of the OUs 5 and 6 ROD (DON, 1998b) states that:

> "*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*."

Accordingly, if the detected TCE concentration from the next groundwater monitoring event exceeds the MCL value, the remedy for the site will need to 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.

Samples from the CAOC 7 wells were also analyzed for 21 different OCPs during the annual monitoring events between 2002 and 2006 in accordance with the *LTGWMP* (DON, 1998c), SAP (TtFW, 2005a), and Addendum 01 to SAP (TN&A, 2006). None of the 21 OCPs were detected above their respective reporting limits in the samples collected.

Historical metals monitoring data for wells NS7-1, NSP-2, and NSP-3 indicate nickel and chromium concentrations measured well below the respective MCLs. The highest chromium concentration measured at well NSP-3 (14.5 μg/L, May 2001) and the highest nickel concentration measured at well NS7-1 (53.2 μg/L, June 2003) are well below the respective MCLs for chromium (50 μg/L) and nickel (100 μg/L).

4.5.1.2 Cap Maintenance Activities

A review of the annual operation and maintenance reports for the CAOC 7 caps (URS, 2003; TerraVac, 2004, 2005, and 2007) indicated that Strata 1 and 2 riprap and chain-link fences were inspected and maintained. The chain-link fence at Stratum 2 was undermined and damaged by severe rainfall, and a temporary repair to the desert tortoise fence was performed in August 2004

(TerraVac, 2004). Washout of riprap and native soil caused the tortoise fencing to bulge outward and distort the shape of both the chain-link and tortoise barriers, and initial fence reconstruction efforts were conducted in August 2005 (TerraVac, 2005). Reconstruction of the drainage swale along the northeast and west fence lines at Stratum 2 was performed, and Stratum 2 fence repairs were completed in October 2005 (TerraVac, 2005). Weed control activities were performed during each scheduled site visit (TerraVac, 2004, 2005, and 2007). Heavy rainfall also led to high vegetation growth at CAOC 7 Stratum 2, but landscapers focused efforts on this area and cleared the weeds.

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 is downloaded bimonthly. The measured soil moisture content was relatively constant, and little to no variability over time was observed at each point (URS, 2003; TerraVac, 2004, 2005, and 2007), indicating that the caps are functioning effectively. At Strata 1, a data recording problem resulted in limited data recovery for the period between October 2002 and June 2003, when the problem was discovered. The recording equipment's circuit board was replaced in August 2003, and a faulty sensor replaced in August 2004. Due to sensor failure, limited data is available for the period from January 2004 to July 2004. Data logger modifications and repairs were made to the systems in Strata 1 and 2 in August 2005.

The monument surveys revealed that no measurable differential settlement has occurred at Stratum 1 and that some measurable differential settlement has occurred at Stratum 2. During the December 14, 2006, monument survey in Stratum 1, both monuments were found to be 0.01 feet higher than their original elevations in 1999. This slight discrepancy was also observed in the August 2005 survey, and no settling had been reported during prior monument surveys. The December 14, 2006, survey at Stratum 2 revealed that monument 1 was 0.02 feet lower than its original elevation in 1999 and that the elevation of monument 2 was the same as its 1999 elevation.

4.5.2 CAOC 38 – Nebo North (OU 2)

As discussed in Section 4.3.8.1, the Nebo North GETS was designed to provide hydraulic containment for the Nebo North Plume in the event that natural processes fail to contain the plume. The GETS has not been in operation since 1996, as the plume has been shrinking (in terms of extent and concentrations). If required, the GETS at Nebo North would be operated in accordance with the Nebo North GETS O&M Manual (OHM, 1997).

As discussed in Section 4.3.8.2, the Nebo North source area AS/SVE treatment system construction completion and startup took place during October 2007.

The effectiveness of the Nebo North remedial action is discussed by examining the reduction in historical VOC concentrations, as well as plume reduction, as discussed in sections 4.5.2.1 and 4.5.2.2 below.

4.5.2.1 Reduction in VOC Concentrations

Shown on Figures 4-17 and 4-18 are TCE and PCE concentrations based on the annual and semiannual 2007 groundwater monitoring events, respectively. Figure F-3 in Appendix F shows a reference Nebo North site map with monitoring well locations. Historical TCE and PCE concentration trends for the Nebo North groundwater monitoring wells are included in Figure F-4 (Appendix F). A summary of these data trends is presented below.

- The Nebo North plume primarily consists of PCE with lesser concentrations and extent of TCE.
- For wells NWP-8 and NWP-9, located in the upgradient portion of the plume near the former Building 50 area (source area), the maximum PCE concentration during the Annual 2006 monitoring event was detected at NWP-9 (17 µg/L).
- Well NRF-1 is approximately 850 feet hydraulically downgradient of the source, between fault lines A and B. Historical data indicate a significant decrease in PCE concentrations from the highest concentration recorded in April 1993 (80 µg/L) to 9.6 µg/L in November 2006.
- Well T22A/B MW-1 is approximately 2,000 feet hydraulically downgradient of the source. There appears to be a gradual increasing trend in PCE concentrations. TCE concentrations are relatively stable. Concentration increases in this well may be related to the migration of an attenuating plume core.
- Wells MW-B, EW-E, EW-F, EW-H, NPZ-18, and NPZ-19 are located east and west of fault line B; and wells MW-D, NS2-1, and NNP-2 are located east and west of fault line C. Historical data for these downgradient wells indicate relatively stable TCE and PCE concentrations below the MCLs, with the exception of well MW-D and piezometer, NPZ-18.
  - Piezometer NPZ-18 is located east of fault line B and is a leading edge plume well. Historically, PCE concentrations for this well have remained below the MCL with the exception of a slight increase to 6 µg/L in November 2005 followed by a decrease to below the MCL during November 2006.
  - Monitoring well MW-D is located west of fault line C. For this well, the PCE concentration was above the MCL in February 2000 (6 µg/L) and remained slightly above the MCL until approximately May 2001. PCE concentrations have since declined, measuring 0.7 µg/L in November 2006.

4.5.2.2 VOC Plume Behavior Over Time – Nebo North

The historical extents of the Nebo North PCE plumes interpreted for 1996, 2000, 2004, and 2006 are shown on Figure 4-19. TCE plume extents are not shown for Nebo North, as detections of TCE have been sporadic and limited. Individual isoconcentration contour maps for PCE along with pertinent concentration data for years 1996, 2000, and 2004 are included as Figures F-5, F-6, and F-7, respectively, in Appendix F. It should be noted that all available data were used in the plume extent interpretation for each figure. This includes historical trends for existing/dry wells and HydroPunch data. Because HydroPunch data represent a single discrete point in time, it was assumed that the concentrations at that location would follow the same trend exhibited by monitoring wells in the vicinity of that HydroPunch. Figure 4-17 shows plume interpretation based on Annual 2006 monitoring data. The following observations can be made based on Figure 4-19 and the supporting figures:

- Historical Nebo North VOC monitoring data from 1996 and 2000 indicate that the PCE plume boundary line previously extended beyond fault line B to fault line C.
- VOC monitoring data from 2004 indicate that the PCE plume has shrunk as compared to 1996 and 2000 plume extents.
- The annual 2006 and semiannual 2007 groundwater monitoring data indicate that the interpreted PCE plume extent is west of fault line B, indicating further shrinkage as compared to the 2004 PCE plume extent.
- Historical analytical data indicate that PCE concentrations of 50 µg/L or greater were localized on the west and east ends of the plume in 1996, while in 2000 and 2004 the 50 µg/L plume line was only observed at the west end of the plume, near the source. A significant decline in PCE concentration is apparent in the west/northwestern area of the plume.

In general, it is apparent that the downgradient PCE plume extent has contracted, as concentrations in several Nebo North wells on either side of the fault lines have decreased.

4.5.3 CAOC 38 – Nebo South (OU 2)

The CAOC 6 AS/SVE system was installed to reduce the TCE contamination in the southeastern portion of Nebo Main Base (Figure 4-9). The AS/SVE system at Nebo South (CAOC 6) started operations as part of an Interim Remedial Action (IRA). Operation in IRA mode began in January 2004. The system operated in pilot and extended pilot testing modes beginning in October 2001. Following the success of the pilot test, AS/SVE was deemed the final remedy in the OU2 Nebo South ROD (DON, 2006). The well configuration of the CAOC 6 AS/SVE system is shown in Figure 4-9. The system is operated in accordance with the CAOC 6 O&M Manual (OHM, 1996a). The effectiveness of the Nebo South remedial action is assessed based on the reduction in VOC concentrations as well as plume reduction, as discussed in Sections 4.5.3.1 and 4.5.3.2 below. System performance is shown on Figure 4-20 and discussed in Section 4.5.3.3.

4.5.3.1 Reduction in VOC Concentrations

Shown on Figures 4-21 and 4-22 are TCE and PCE concentrations based on the annual and semiannual 2007 groundwater monitoring events, respectively. The primary COC in the groundwater plume underlying the Nebo South area is TCE. Figure G-1 in Appendix G shows a reference Nebo South site map with well locations. Historical TCE and PCE concentration trends for the Nebo South groundwater monitoring wells are included in Figure G-2. Groundwater concentration trends are discussed below.

- Significant decreases in concentrations are apparent following the start of the Phase 2 pilot test in December 2001.
- TCE concentrations at well NS6-3 show a decreasing trend through November 2004 to values below the MCL, followed by an increase to values near the MCL.
- Groundwater samples collected historically from wells NS6-5, NS6-6, NS6-7, and NS6-8 show TCE concentrations fluctuating around the MCL.
- TCE concentrations for well NS6-4 appear to show an increasing trend.
- Relatively stable TCE concentrations below MCLs can be noted for well NEP-4. TCE was not detected at or above the detection limit in well NEP-7
- TCE concentrations in NS6-AV6 showed a sporadic increase (Figure 4-21).

4.5.3.2 VOC Plume Behavior Over Time

The historical extents of the Nebo South TCE plumes interpreted for 1996, 2000, 2004, and 2006 are shown on Figure 4-23. PCE plume extents are not shown for Nebo South, as detections of PCE have been sporadic and limited. Individual isoconcentration contour maps for PCE along with pertinent concentration data for years 1996, 2000, and 2004 are included as Figures G-3, G-4, and G-5, respectively, in Appendix G. It should be noted that all available data were used in the plume extent interpretation for each figure. This includes historical trends for existing/dry wells and HydroPunch data. Since HydroPunch data represent a single discrete point in time, it was assumed that the concentrations at that location would follow the same trend exhibited by monitoring wells in the vicinity of that HydroPunch. Figure 4-21 shows plume interpretation based on Annual 2006 monitoring data. The following observations can be made based on Figure 4-23 and the supporting figures:

- The extent of the Nebo South TCE plume has decreased over time. TCE levels in individual wells have also decreased over time.
- Sporadic short-term TCE detections in the samples collected from AS/SVE and SVE wells can be noted.

4.5.3.3 CAOC 6 AS/SVE System Performance

The well configuration of the CAOC 6 AS/SVE system is shown in Figure 4-9.

Vapor samples were collected from the influent stream on a monthly basis during routine operations and from ambient air in June and August for analysis of VOCs by method TG-44. Figure 4-20 shows the influent concentrations of total VOCs and TCE over time and the cumulative mass removed by the CAOC 6 AS/SVE system. The AS and SVE wells are shown on Figure 4-9. Over 16 pounds of VOCs have been extracted from soil (and groundwater) by the CAOC 6 AS/SVE system as of June 2007. As discussed in Section 4.3.8, the OU 2 Nebo South ROD requires vadose zone monitoring at CAOC 6 for monitoring the effectiveness of the AS/SVE system. However, because of the relatively low VOC concentrations detected in the vadose zone, vapor sampling is being conducted by analyzing the system influent stream only on a monthly basis. Vadose zone monitoring (or confirmation sampling) would be performed to demonstrate compliance with remedial objectives and the related AS/SVE shut-down criteria.

Due to the low concentrations of VOCs in the influent stream and the VOC effluent emission rate falling well below the MDAQMD's allowable levels of 39.6 lbs/day, as documented in a letter sent to the regulatory agencies during September 2005, as well as the OU 2 Nebo South ROD (DON, 2006), carbon replacement for the CAOC 6 AS/SVE system was discontinued. The soil vapor VOC concentrations are still being monitored to determine the need for GAC.

The cumulative mass of total VOCs and TCE removed since system startup (Figure 4-20) indicates that VOCs continue to be removed from the system, but at a declining rate. Decreases in the removal rate and soil vapor VOC concentrations are attributed to the decrease in VOC mass in the soil and groundwater at CAOC 6.

4.5.3.4 CAOC 6 AS/SVE System Effectiveness

Since the startup of the CAOC 6 AS/SVE system, the Nebo South plume extent has decreased significantly. Figure G-2 in Appendix G shows the historical TCE and PCE concentrations for several wells at Nebo South. Historical data indicate that the TCE influent concentration to the system has declined since 2001. The following concentration results and trends can be noted from Figure G-2 (Appendix G):

- Groundwater TCE concentrations in a majority of the monitoring wells have declined since 2001 as a result of the CAOC 6 AS/SVE system operation.
- The TCE concentration in NS6-4 appears to be increasing with time. As a result, the air flow rates have been increased in nearby air sparge wells NS6-A1 and NS6-A3.
- Sporadic and inconsistent TCE detections have been reported in a few SVE and AS/SVE well groundwater samples.
- The other wells in Nebo South have shown decreases in VOC concentrations through 2006 with many decreases to values below the MCL for TCE.

In general, the AS/SVE system at Nebo South continues to reduce VOCs in soil and groundwater.

4.5.4 General Chemistry Results

As discussed in the 2002 AGMR (FWENC, 2003), the general chemistry of groundwater at the Nebo Main Base remained relatively consistent over the last few years preceding the report. Monitoring for general chemistry parameters was discontinued in 2003. As discussed in the *Final Technical Memorandum – Sampling Frequency Modification for OUs 1 and 2* (TtFW, 2005b), there is no benefit in continuing to sample for general chemistry unless a major hydrogeochemical event occurs.

4.5.5 Pesticides Monitoring at Nebo North

As discussed in the OUs 3 and 4 ROD (DON, 1997), annual monitoring is required for pesticides (dieldrin) at Nebo North (wells MW-D, NS1-6, and NS2-2). Dieldrin monitoring has been performed at wells MW-D and NS2-2 annually for 5 years. Historical monitoring data indicates that no detections have been reported above the respective reporting limits. Well NS1-6 could not be sampled for dieldrin since 2001 because of the presence of roots in the well. Historical data for the samples collected from NS1-6 do not indicate any detections of dieldrin. As per the LTGWMP (DON, 1998c), monitoring for pesticides can be discontinued after 5 years if the pesticides are not detected. Wells MW-F and NS2-1 were also sampled for dieldrin and other pesticides during the 2005 and 2006 annual sampling events. Concentrations of dieldrin were not detected above the respective reporting limits.

4.5.6 VOCS at NPZ-14

NPZ-14 is a piezometer located several thousand feet south of the Nebo North plume and west of Nebo South plumes (Figure 1-3). Groundwater samples collected from NPZ-14 indicate the presence of TCE at levels ranging from 10 μg/L (December 2001) to 35 μg/L (November 2006). Figure 4-24 shows a summary of VOC data for NPZ-14 that indicates a decreasing trend through late 2001, followed by an increasing trend in TCE levels. Groundwater monitoring data from the Nebo South wells indicate that there is no connection between NPZ-14 and CAOC 6 VOC contamination.

4.5.7 Off-Base Drinking Water Well

The off-Base residence (Johnston) continues to be supplied with drinking water by the Base.

4.6 METALS AT YERMO ANNEX

The OUs 1 and 2 ROD (DON, 1998a) requires an evaluation of metals in groundwater beneath CAOC 16 at the Yermo Annex (OU 1). The LTGWMP (DON, 1998c) requires monitoring of four background wells for metals in order to establish background metal levels for the Yermo Annex. However, these wells have been dry. Therefore, several selected wells at the Yermo Annex were sampled in 2002, 2003, 2004, 2005, 2006, and 2007 as background wells. Historical analytical results indicate that nickel and chromium concentrations exceed MCL values of 50 μg/L and 100 μg/L, respectively (TtEC, 2006). Yermo Annex-wide historical chromium and nickel concentrations are shown on Figure 4-25. Concentration trends are shown on Figure 4-25 as well as in Appendix H. As discussed in the AGMR 2007, due to a sample turbidity issue, several wells sampled during the annual 2006 groundwater sampling event were resampled during the semiannual groundwater sampling event (April / May 2007) (TN&A, 2007b). Accordingly, for the resampled wells, the resampling results were used in developing Figure 4-25. Turbidity was noted to have an impact on the sampling results in the OUs 1 and 2 ROD (DON, 1998c) as well. The following observations regarding chromium and nickel in groundwater beneath CAOC 16 are made based on Figure 4-25 and Appendix H:

- With the exception of YCW series wells in the vicinity of CAOC 16, a majority of the wells that are upgradient, cross-gradient, and downgradient of CAOC 16 indicate chromium and nickel concentrations that are in general below the respective MCL values. Wells with occasional exceedances (other then YCW wells) above the respective MCL values for chromium and nickel include:
  – Nickel concentrations for YS20-2 were slightly above the respective MCL value.
  – The nickel concentration was slightly above the MCL in YS34-2 during 2001 and has been below the MCL value since then. The chromium concentration in this well prior to the May 2007 sampling event remained below the respective MCL value.
  – Chromium concentrations remained below the respective MCL for well YS29-2 prior to the May 2007 groundwater sampling event. This well is a background well located at the west end of the Yermo Annex, approximately 800 feet west of recharge well YIG-2.
  – The minor MCL exceedance noted for the off-Base well PMW-2 during 2002 for chromium has since been well below the respective MCL value.
- Chromium and nickel concentrations in YCW wells indicate fluctuating trends above and below the respective MCL values.
- The May 2007 resampling results for chromium and nickel are generally greater than the historically observed values and/or the immediately previous event. As noted in the AGMR for 2006 (TN&A, 2007b), it was not always possible to meet the turbidity target for metals sampling. It is likely that turbidity may have had an impact on the May 2007 metals sampling results.

The OUs 1 and 2 ROD (DON, 1998c) stated that spatial variation and large temporal variations in the concentrations of the metals including chromium and nickel throughout 4 years of sampling (prior to the signing of the ROD) suggest that turbidity or sampling techniques may have resulted in the higher reported concentrations. Turbidity during sampling was noted to be an ongoing issue due to the nature of the interbedded sands, silts, and clays in the alluvial aquifers at MCLB Barstow. Changes in iron concentrations from each sampling event (an indicator of sample turbidity) correlated closely to nickel and chromium concentrations in the suspected wells as stated in the OUs 1 and 2 ROD (DON, 1998c). As discussed above, the turbidity target for metals sampling could not be reached for some samples during the May 2007 sampling.

As a result of the fluctuating concentration trends above and below the MCLs for chromium and nickel observed in the YCW series wells and the possible impact of turbidity on metals monitoring results, it is recommended that the YCW series wells continue to be monitored for these metals. In order to address the turbidity issue, it is recommended that groundwater sampling methods for metals be evaluated and appropriate steps be taken minimize the effect of turbidity on metals monitoring results. A statistical evaluation is recommended once the analyzed chromium and nickel concentrations show relatively stable concentrations over a period of at least four events. Metals monitoring at the remaining wells, with the exception of wells YS20-2 and PMW-2, may be discontinued.

4.7 OPERATION AND MAINTENANCE

A summary of O&M activities and costs for each system is presented in this section.

4.7.1 O&M Activities

The following sections summarize O&M activities for each of the remediation systems.

4.7.1.1 GETS at Yermo

Major O&M events and dates of occurrence for this system are as follows:

- 2 new carbon vessels were brought online to treat methyl tert-butyl ether (MTBE) (9/12/02).
- Carbon changeout was done in two lead vessels (4/30/03).
- Groundwater extraction well GEW-6 was deepened and became fully operational during November 2004.
- Carbon changeout was done in all six vessels (10/7/05).
- Extraction well GEW-15 was taken offline because of a collapsed screen (10/12/05).
- Extraction well GEW-7 was deepened and became operational during April 2006.

4.7.1.2 CAOC 16 AS/SVE at Yermo

Major O&M events and dates of occurrence for this system are as follows:

- Carbon vessel changeout (8/16/02)
- Blower motor replaced (6/1/04)
- Carbon vessels taken offline (7/7/05)
- SVE Blower replaced after downtime from April 2006 to February 2007

4.7.1.3 Drinking Water Treatment Systems at Yermo and Off-Base Younts and Hodges System

Major O&M events and dates of occurrence for YDW Treatment Systems are as follows:

- YDW-5 adsorption system carbon changeout (August 2007)
- YDW-6A [also referred to as YDW-6) adsorption system underwent retrofitting of the internal lining during 2003 and was refilled with fresh GAC in 2004

Major O&M events and dates of occurrence for Younts and Hodges System are as follows:

- Backfilter housing replaced (March 2007) for the Younts System
- Carbon changeout took place on August 22, 2007, for both Younts and Hodges System.

4.7.1.4 CAOC 6 AS/SVE at Nebo

The major O&M event and date of occurrence for this system is as follows:

- SVE vacuum blower replaced on February 21, 2006

4.7.2 Costs

The O&M costs associated with RAs are an indicator of remedy performance in that a wide variation in actual costs from projected costs may indicate poor performance. The projected costs (based on the respective RODs) and actual estimated costs of O&M associated with the OUs are summarized in Table 4-1.

Based on Table 4-1, actual costs are in the same range as projected costs (where available) and are typically lower. The aging GETS and CAOC 6 and 16 AS/SVE systems resulted in an increase in system-related O&M costs for OUs 1 and 2 during the 2006 – 2007 operational period, as well as system downtime.

5.0 PROGRESS SINCE THE LAST FIVE-YEAR REVIEW

This section describes issues that have been identified at the end of the initial five-year review period and response actions that have been made during this five-year review period to ensure that the remedies continue to be long-term effective and protective of the environment.

The protectiveness statement from the previous five-year review report (DON, 2002) stated the following:

> *The RAs at OUs 1 through 6 are protective of human health and the environment. This determination is made utilizing the information considered in the performance of this five-year review.*

The following recommendations were made for the systems at Yermo Annex at the end of the first five-year review period (DON, 2002):

- Submit ESD for deviation from OU 1 ROD.
- Due to increases in soil gas concentrations at CAOC 26, continue annual monitoring of soil gas concentrations, and restart SVE, if necessary.
- Optimize AS/SVE operations at CAOC 16.
- Due to declining groundwater levels, evaluate capture zone annually.
- Due to increase in dissolved VOC concentrations in off-Base residential wells, evaluate vertical extent of VOC contamination downgradient of the Base boundary.
- Prepare O&M manual and changeout GAC at least every 5 years for Younts and Hodges system.
- Prepare O&M manual for YDW Treatment Systems.

The following recommendations were made for the systems at Nebo Main Base at the end of the initial five-year review period (DON, 2002):

- Make fencing repairs at CAOC 7, OU 6.
- Implement an AS/SVE pilot test, followed by a full-scale operation, if feasible, at CAOC 38, OU 2.
- If AS/SVE is not feasible at CAOC 38, OU 2, submit ESD to provide rationale for not installing off-Base groundwater extraction wells as specified by ROD.
- Due to VOC detections at monitoring well NPZ-14, monitor well annually.

Tables 5-1 and 5-2 outline the actions taken since the last five-year review, with respect to recommendations in the last five-year review.

6.0 FIVE-YEAR REVIEW PROCESS

The EPA's *Comprehensive Five-Year Review Guidance* (EPA, 2001) and DON Policy for Conducting CERCLA Statutory Five-Year Reviews (DON, 2004) 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 between September 6, 2007, and September 22, 2007, to inform the public about the ongoing second five-year review process. The FFA signatories were notified prior to placing the public notices. Proofs of publication are included in Appendix I.

Upon completion of the five-year review process, fact sheets will be mailed to parties on the Base's IRP community mailing list.

6.1.2 Identification of Five-Year Review Team

The five-year review team consisted of the following:

1. Ms. Carmela Gonzalez (MCLB Barstow Environmental Department)
2. Ms. Kristina Madali, (NAVFAC SW)

Ms. Madali was supported by NAVFAC SW technical, legal, and managerial staff as well as their contractors.

The FFA signatories were provided with a draft of the Second Five-Year Review Report for review.

6.1.3 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
- Five-year Review Report development and review

These tasks were accomplished during the May–December 2007 time period.

6.2 COMMUNITY INVOLVEMENT

As mentioned in Section 6.1.1, public notifications were placed in the local newspapers to inform the public about the ongoing second five-year review. Copies of the second five-year review will be placed into the information repository as well as the local site information repository.

6.3 DOCUMENT REVIEW

This five-year review consists of a review of relevant documents including annual O&M reports. A list of references cited in the subject five-year review is included in Section 12.0. The previous sections of this report, specifically, Sections 3.0, 4.0, and 5.0, include results from the review of the annual O&M reports and relevant documents.

6.4 DATA REVIEW AND EVALUATION

Data reviewed for the five-year review consisted of the following:

1. Groundwater monitoring data for OUs 1 and 2
2. Soil vapor monitoring data for OUs 1 and 2
3. O&M data for active remediation systems
4. O&M data for the landfill cap systems
5. BMP amendments

6.5 FINDINGS FROM SITE INTERVIEWS, INSPECTIONS, AND INFORMATION REQUESTS

Site inspection of CAOCs was conducted on July 24 and 25, 2007. Information was gathered from the MCLB Environmental Department and the O&M contractors regarding the sites and systems.

Shown on Table 6-1 are findings from site inspection for those sites with site development. Appendix I includes the corresponding photographs. Also shown in Appendix I are photographs for CAOC 7, 20, 23, and 35 landfill cap systems. As can be seen from Table 6-1, site development activities for these activities were coordinated through the MCLB Environmental Department as required by the BMP.

Based on the information obtained from the MCLB Environmental Department, it was noted that approximately 194,000 square feet of the hardstand was replaced at a cost of approximately $3.5 million as a part of the ongoing maintenance of the hardstand at CAOC 16. The hardstand replacement project took place during February–September 2007. The MCLB Barstow Environmental Department reviewed the project.

A majority of the information gathered from the MCLB Environmental Department and the O&M contractors has been incorporated into Sections 4 and 7. Findings gathered from site interviews and information collection from the OUs 1 and 2 O&M contractor that could impact the system performance as well as O&M costs are summarized below:

- It was noted that the aging GETS and CAOC 6 and 16 AS/SVE systems resulted in an increase in system-related O&M costs for OUs 1 and 2 during the 2006–2007 operational period, as well as system downtime.
- For some of the aging system components, finding replacement parts could be difficult. It was noted that some of the manufacturers are no longer supporting older designs (for example, the 3-inch magnetic flow meters found in the GETS at Yermo Annex will not be supported by the manufacturer after this year). System upgrade costs are expected to be large. In addition, after upgrading required parts, compatibility with older parts and the related adjustments could also pose challenges. Addressing the aging system component issues has already resulted in an increase in man-hours during the 2006–2007 O&M period.
- It was also noted that several groundwater monitoring and extraction wells may require cleaning and redevelopment to ensure full functionality and integrity of sample data.

7.0 TECHNICAL ASSESSMENT

This 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 ROD(s)?

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?

7.1 TECHNICAL APPROACH

The technical assessment requires evaluation of the above-mentioned three questions. These questions can include a number of considerations, as discussed below.

7.1.1 Technical Assessment Questions

7.1.1.1 *Question A:* Is the Remedy Functioning as Intended by the ROD(s)?

The EPA's guidance document for five-year reviews 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?

7.1.1.2 *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.

7.1.1.3 *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.

7.1.2 Organizational Approach

The considerations noted above for each of the three questions are discussed for CAOCs with LUCs, RAs, and NFAs with BMP modifications in the following sections. All CAOCs with BMP modifications are discussed as a group for both the Yermo Annex and the Nebo Main Base. Since Question B is appropriate for evaluation on a ROD-wise basis, Appendix J includes its evaluation for each of the three RODs. The other questions are addressed below.

7.2 TECHNICAL ASSESSMENT FOR CAOCS WITH BMP MODIFICATIONS AND INSTITUTIONAL CONTROLS

The NFA remedy with BMP modifications was selected for a number of CAOCs under OUs 3, 4, 5, and 6 at the Yermo Annex (CAOCs 15/17, 16, 18, 21, 26, and 34) and Nebo Main Base (CAOCs 1, 2, 3, 5, 6, 11, 14). Groundwater monitoring at CAOCs 16 and 26 (VOCs) is covered under OU 1, while groundwater monitoring at CAOCs 1, 2, 3 (dieldrin), 6 (VOCs), and 14 (dieldrin) is covered under OU 2. The LUCs remedy was selected at CAOCs 16, 20, 23, and 35 at the Yermo Annex, and at CAOC 7 at the Nebo Main Base.

All of the CAOCs with BMP modifications and LUCs had a requirement that the CAOC history and contaminants be included in the BMP, and that planned activities within the CAOC be reviewed by the MCLB Barstow Environmental Department. As discussed in Sections 4.2 and 4.3, the BMP has been updated as required for all of these CAOCs. With the exception of CAOCs 1, 11, 14, and 16, there have been no activities within these CAOCs. Activities at CAOCs 1, 11, 14, and 16 were coordinated with the MCLB Barstow Environmental Department. There are no indicators of potential problems associated with the remedy selected and implemented for these CAOCs.

A review of the OUs 3 and 4 ROD (DON, 1997) and OUs 5 and 6 ROD (DON, 1998b) indicates that there have been several changes to toxicity (reference dose, reference concentration, and carcinogenicity) for contaminants within the CAOCs according to EPA's Integrated Risk Information System (IRIS) (EPA, 2007). Several Preliminary Remediation Goals (PRGs) have also been amended (EPA, 2004). The RAOs remain unchanged. Appendix J provides additional details on the review of changes in applicable or relevant and appropriate requirements (ARARs) and toxicity data.

No new information has come to light that might call into question the protectiveness of the selected remedy at these CAOCs.

A review of the ILCR values for those CAOCs involving an NFA remedy with BMP modification indicated that the ILCR values for a majority of these sites fall within the risk management range of $1x10^{-6}$ to 1×10^{-4} Excess Cancer Risk. Accordingly, it may not be necessary to continue to include these sites whose ILCRs are within the risk management range as a part of the respective RODs and in future Five-Year reviews. It is recommended that these CAOCs be re-evaluated by considering the ILCR values, other risk-related information, and any restrictions applicable for these sites to determine whether or not these sites should continue to be part of the respective RODs. Following this re-evaluation, Explanation of Significant Differences (ESDs) will be prepared to document the CAOCs recommended for elimination from the respective RODs and future Five-Year Reviews.

7.2.1 Implementation of BMP Modification and LUCs Remedies

As discussed in Sections 4.2 and 4.3, BMP modifications have been made for those CAOCs requiring BMP modifications. LUCs (fences, signs, and/or restrictions on activities) are in place at CAOCs 7, 16, 20, 23, and 35. Based on discussions with Base personnel, the MCLB Barstow Environmental Department is notified of construction activities on Base. This allows the MCLB Barstow Environmental Department to determine if these activities fall within a CAOC, and if additional actions are required. The BMP and the RODs contain specific requirements for notification of and approval by FFA signatories if construction activities impact the restrictions on activities at these CAOCs.

7.3 TECHNICAL ASSESSMENT FOR CAOC 16 (OU 5)

As discussed in Section 4.2.2, the LUC remedy was selected for CAOC 16 (OU 5) (per the OUs 5 and 6 ROD, DON, 1998b), with a requirement that CAOC 16 history be included in the BMP, and that planned activities within the CAOC be reviewed by the MCLB Barstow Environmental Department. The OUs 1 and 2 ROD (DON, 1998a) required evaluation of the CAOC 16 AS/SVE system and GETS in reducing groundwater and vadose zone contamination at CAOC 16.

7.3.1 Remedial Action Performance

The performance of the CAOC 16 AS/SVE and CAOC 37 GETS under Operable Unit 1 are discussed in Section 7.7 and 7.9, respectively.

7.3.2 System O&M

The AS/SVE system at CAOC 16 under Operable Unit 1 (CAOC 37) is discussed in Section 7.7.

7.3.3 Institutional Controls

The LUCs for CAOC 16 are functioning properly. Construction activity at CAOC 16, associated with the Paint and Undercoat Facility, reported as ongoing in the previous Five-Year Review, (DON, 2002), was completed and the facility became operational during October 2003. This project was coordinated through and reviewed by the MCLB Barstow Environmental Department. Since the last five-year review, a welding shop (March 2004 to September 2004) and a new blast facility (August 2005 to January 2006) were constructed at CAOC 16. These projects were coordinated through and reviewed by the MCLB Barstow Environmental Department.

As a part of the ongoing maintenance of the hardstand at CAOC 16, approximately 194,000 square feet of the hardstand was replaced at a cost of approximately $3.5 million. The hardstand replacement project took place between February and September 2007. This project was also coordinated through and reviewed by the MCLB Barstow Environmental Department.

7.3.4 Monitoring Activities

Monitoring activities at CAOC 16 are associated with the AS/SVE system under Operable Unit 1 (CAOC 37) and are discussed in Section 7.7.

7.3.5 Optimization

Optimization of the remedy at CAOC 16 is associated with the AS/SVE system under Operable Unit 1 (CAOC 37) and is discussed in Section 7.7.

7.3.6 Early Indicators of Potential Problems

There are no indicators of potential problems associated with the remedy selected and implemented for CAOC 16.

7.3.7 Validity of Exposure Assumptions, Toxicity Data, Cleanup Levels, RAOs

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 with predicted impacts to groundwater. Soil analytical data are not available due to the nature of the site. Maintenance operations are ongoing. Groundwater impacts are being evaluated under OU 1. The RAOs remain unchanged. Appendix J provides additional details on the review of changes in ARARs, toxicity data, and ARARs for this CAOC.

7.3.8 Other Information

No new information has come to light that might call into question the protectiveness of the selected remedy at this CAOC.

7.4 TECHNICAL ASSESSMENT FOR CAOC 20 (OU 3)

The remedy selected at CAOC 20 (landfill cap) under the OUs 3 and 4 ROD (DON, 1997) has been implemented successfully, as discussed in Section 4.2.4.

RAOs focused on preventing exposure to contaminants in excess of an ILCR of 1 x 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. LUCs were enacted to prevent disturbance of the soils and to prevent future land use. Maintenance of the concrete cap and soil cap were used to establish the protectiveness of the remedy.

In addition, groundwater monitoring has been conducted for detection monitoring. As part of the five-year review process, the OUs 3 and 4 ROD (DON, 1997) requires that the RA 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, any appropriate action is to be proposed after consultation with the EPA, DTSC, and Water Board. The first Five-Year Review Report (DON, 2002) stated that this evaluation would be done in the subject second five-year review, as the fourth year of monitoring was 2003. This evaluation is presented in Section 4.4.1.

7.4.1 Remedial Action Performance

As discussed in Section 4.4.1.1, TCE and PCE concentrations in the CAOC 20 groundwater monitoring wells are below MCLs and indicate stable concentration trends. However, radiological analysis concentration trend charts indicated increasing trends for the gross alpha concentrations measured in wells YS20-1 and YS20-2 as discussed in Section 4.4.1.2. A statistical evaluation of the gross alpha monitoring data in these wells indicated statistically significant exceedances of gross alpha concentrations for wells YS20-1 and YS20-2. As discussed under Section 4.4.1, YS20-1 is an upgradient well. Additional investigations and/or evaluations upon consultation with the FFA signatories are recommended to assess if the observed increase in gross alpha values are the result of releases at CAOC 20 or any upgradient sources.

Well YS20-2 was installed to function as a downgradient well. The observed shift in the interpreted groundwater flow direction to the northeast subsequent to the installation of YS20-2 has rendered this well a cross-gradient well. Additional investigations and/or evaluations will be necessary upon consultation with the FFA signatories to further evaluate the gross alpha concentration increases at this well. As discussed in Section 4.4.1.2, well YIMW-5 was noted to better serve as a downgradient well for monitoring radiological parameters (TtFW, 2005a and

2005b). Gross alpha concentration analyzed for the sample collected from YIMW-5 downgradient of CAOC 20 during the annual 2005 groundwater sampling event was below the respective MCL.

Therefore, the remedy is currently protective of human health and the environment. Additional investigations are necessary to evaluate the statistically significant exceedances for gross alpha in groundwater observed in the upgradient well YS20-1 and the cross-gradient well YS20-2.

7.4.2 System O&M

There are no operating systems associated with CAOC 20. The 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.

7.4.3 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.

7.4.4 Monitoring Activities

Monitoring activities at CAOC 20 consist of cap inspection, moisture monitoring, and annual groundwater monitoring (to determine if there is any impact to groundwater from CAOC 20). The number of moisture monitoring points, wells, and sampling frequency are adequate to monitor remedy effectiveness (Section 4.4.1). As a result of the observed gross alpha exceedances in groundwater, wells YS20-1 and YS20-2, additional monitoring may be required as a part of the additional investigations to assess the source of gross alpha exceedances.

7.4.5 Optimization

Given the nature of the remedy implemented at CAOC 20, there is no scope for optimization. The frequency of monitoring is annual, which is considered adequate.

7.4.6 Early Indicators of Potential Problems

As discussed in Section 7.4.1, statistically significant exceedances for gross alpha results for the upgradient well YS20-1 and the cross-gradient well YS20-2 were noted. However, gross alpha concentration from the downgradient well YIMW-5 during 2005 was below the respective MCL. Additional investigations and activities may be required upon consultation with the FFA signatories to verify the observed increases in the upgradient well YS20-1 as well as the cross-gradient well YS20-2. The remedy for CAOC 20 may require a re-evaluation if these additional investigations indicate that the observed gross alpha exceedances are as a result of CAOC 20.

7.4.7 Validity of Exposure Assumptions, Toxicity Data, Cleanup Levels, RAOs

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 low levels of VOCs, SVOCs, metals, and pesticides, with relatively limited (predicted) impacts to groundwater. A review of the OUs 3 and 4 ROD (DON, 1997) indicates that the only change to toxicity data or cleanup levels is the lowered PRG for arsenic. This change has no impact on the protectiveness of the remedy because arsenic was determined to be at background levels (Bechtel Environmental, Inc. [BEI], 2003). In addition, the PRG decrease did not cause any soils which were not already above the PRGs to be above the PRGs. These changes do not affect the RAOs. Appendix J provides additional details on the review of changes in ARARs, toxicity data, and ARARs for this CAOC.

7.4.8 Other Information

No new information has come to light that might call into question the protectiveness of the selected remedy at this CAOC. There have been no activities at this CAOC requiring MCLB Barstow Environmental Department review, and none appear to be planned at this time.

7.5 TECHNICAL ASSESSMENT FOR CAOC 23 (OU 3)

As discussed in Section 4.2.6, a combination of NFA remedy and concrete cap was selected for CAOC 23, with a requirement that CAOC 23 history be included in the BMP and that planned activities within the CAOC be reviewed by the MCLB Barstow Environmental Department. As discussed in Section 4.2.6, the BMP has been updated as required.

7.5.1 Remedial Action Performance

The following RAOs were developed: minimize the potential for disturbance of wastes, minimize potential future releases to groundwater, attain landfill closure ARARs, and provide a final remedy that minimizes impacts to existing Defense Reutilization Materials Office (DRMO) facilities. 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 salvage yard. Levels of COCs in groundwater are below MCLs, as discussed in Section 4.4.2. The remedy is therefore performing effectively.

7.5.2 Institutional Controls

The LUCs for CAOC 23 are functioning properly. There have been activities within the area consistent with the use of the cap as a laydown area for DRMO. No activities were observed that would have violated the LUCs.

7.5.3 Monitoring Activities

Monitoring activities at CAOC 23 consist of cap inspection, weed control, and annual groundwater monitoring (to determine if there is any impact to groundwater from CAOC 23). The cap is surveyed annually for settling. The number of wells and sampling frequency are adequate to monitor remedy effectiveness. Small cracks were observed in the joint sealer during inspections and were sealed with a polyurethane sealant (TerraVac, 2004 and 2005).

7.5.4 Optimization

Given the nature of the remedy implemented at CAOC 23, there is no scope for optimization. The frequency of monitoring is annual, which is considered adequate.

7.5.5 Early Indicators of Potential Problems

There are no indicators of potential problems associated with the remedy selected and implemented for CAOC 23.

7.5.6 Validity of Exposure Assumptions, Toxicity Data, Cleanup Levels, RAOs

There have been no changes that impact the validity of technical assumptions, toxicity data, cleanup levels, and RAOs at this CAOC (see Appendix J). Soils at this CAOC were impacted by low levels of VOCs, with impacts to groundwater predicted to be relatively low. A review of the OUs 3 and 4 ROD (DON, 1997) indicates that the only change to toxicity data or cleanup levels is the 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 soil that was not already above the PRGs to be above the PRGs. The RAOs are not affected by these changes. Appendix J provides additional details on the review of changes in ARARs, toxicity data, and ARARs for this CAOC.

7.5.7 Other Information

No new information has come to light that might call into question the protectiveness of the selected remedy at this CAOC. There have been no activities at this CAOC requiring MCLB Barstow Environmental Department review, and none appear to be planned at this time.

7.6 TECHNICAL ASSESSMENT FOR CAOC 35 (OU 5)

As discussed in Section 4.2.9, the remedy selected at CAOC 35 is a monolithic native soil cap. It has been implemented successfully, as discussed in Section 4.4.3.

7.6.1 Remedial Action Performance

The RAOs developed for CAOC 35 include: minimize the potential for the disturbance of the wastes, minimize the potential of future releases to groundwater, and attain landfill closure ARARs. Through the installation of a cap, the remedy has met each of the RAOs. Groundwater monitoring for the CAOC has been conducted under OUs 1 and 2 and indicates that TCE and PCE levels in downgradient wells YEP-2 and YEP-3 are below MCLs.

This remedy is protective of human health and the environment.

7.6.2 System O&M

There are no operating systems associated with CAOC 35. The cap is surveyed annually for settlement. The O&M costs are minimal, primarily associated with moisture monitoring. The remedy is cost effective and utilizes a permanent solution. The fence around the site is intact and in good repair.

7.6.3 Institutional Controls

The LUC that is in place at the site is restricted use of the site. No activities were observed that would have violated the LUC. No new site uses of groundwater are planned, or were reported and/or observed.

7.6.4 Monitoring Activities

Monitoring activities at CAOC 35 consist of:

1. Cap inspection
2. Moisture content monitoring beneath the soil
3. Groundwater monitoring in the vicinity of the cap

These are considered adequate to verify the effectiveness of the remedy. Surveying data for the monuments should be closely monitored to verify differential settlement (TerraVac, 2007).

7.6.5 Optimization

Given the nature of the remedy implemented at CAOC 35, there is no scope for optimization. The frequency of groundwater monitoring is annual, which is considered adequate.

7.6.6 Early Indicators of Potential Problems

There are no indicators of potential problems associated with the remedy selected and implemented for CAOC 35.

7.6.7 Validity of Exposure Assumptions, Toxicity Data, Cleanup Levels, RAOs

There have been no changes that impact the validity of technical assumptions, toxicity data, cleanup levels, and RAOs at this CAOC (see Appendix J). 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 the 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 J provides additional details on the review of changes in ARARs, toxicity data, and ARARs for this CAOC.

7.6.8 Other Information

No new information has come to light that might call into question the protectiveness of the selected remedy at this CAOC. There have been no activities at this CAOC requiring MCLB Barstow Environmental Department review, and none appear to be planned at this time.

7.7 TECHNICAL ASSESSMENT FOR OU 1 (CAOC 37): CAOC 16 AS/SVE SYSTEM

The CAOC 16 AS/SVE system at the Yermo Annex was installed to reduce VOC contamination in the vadose and saturated zones near and downgradient of Building 573 (Figure 4-5) as discussed in Section 4.4.4.7. The CAOC 16 AS/SVE system has been in operation since June 1999.

It should be noted that the OUs 1 and 2 ROD (DON, 1998a) provides some specific requirements for CAOC 16 groundwater with respect to the five-year review, as follows:

1. It specifically excludes vadose zone cleanup at CAOC 16, due to the logistics of installing wells on the Building 573 hardstand. However, it requires an evaluation of overall technical and economic feasibility of vadose zone cleanup at this CAOC.
2. It also requires demonstration (by evaluation of soil vapor and groundwater monitoring data) that adequate progress is being made toward cleanup of groundwater at CAOC 16 (due to both groundwater extraction and AS/SVE).

Hence, the following discussions address remediation progress at CAOC 16 of groundwater and the vadose zone due to the CAOC 16 AS/SVE system, as well as due to those groundwater extraction wells that are directly impacting the Yermo North plume.

7.7.1 Remedial Action Performance

The RAO for the CAOC 16 AS/SVE system is the reduction of VOCs in groundwater at the CAOC 16 area. As discussed in Section 4.4.4.7, VOC concentrations in a majority of the CAOC 16 wells show an overall decreasing trend with time (Figures E-1 and E-3 in Appendix E). It is noted, however, that some increases have been observed. For example, groundwater PCE concentrations in YS17-7 and YS 17-8 are increasing over time (Figures E-1 and E-3 in Appendix E). Groundwater concentrations of PCE, TCE or 1,1-DCE are above their respective MCLs in YCW16-2, YCW16-3, YS17-7, YS17-8 and YWA-1. Additional optimization of the remedial systems is recommended to address these increases.

In addition, as also discussed in Section 4.4.4.7, soil vapor VOC concentrations have also decreased since 1999 in the extracted vapor as well as in the monitoring wells / probes.

Overall Effectiveness – CAOC 16

As discussed above, there has been a reduction of VOCs in the vadose zone. There has also been a reduction in VOC levels in soil gas in the vicinity of the SVE wells. The GETS wells downgradient of CAOC 16 (GEW-6, GEW-7, and 13) continue to extract VOC-impacted groundwater and provide hydraulic capture at the MCL boundary (see Figure 4-11). VOC levels in groundwater generally show a decrease (except immediately downgradient of CAOC 35 and CAOC 16 AS/SVE ROI). In general, VOC levels in the groundwater at CAOC 16 have remained stable or decreased slightly with the exception of some of the wells downgradient of the CAOC 16 AS zone of influence.

As discussed in Section 4.4.4.7, there has been a reduction of VOCs in the vadose zone. Overall, VOC levels in soil gas in the vicinity of the SVE wells have generally declined (Figures E-1 and E-2 in Appendix E). The relatively small increase in VOC levels between 2005 and 2006 as a result of system downtime is not significant when compared to the overall decrease in VOC concentrations. The total VOC concentrations measured during 2006 are significantly less than the historical values.

VOCs in the soil vapor probes of the combination wells, which are as far as 1,000 feet away from the SVE wells, appear to have decreased or have remained at low levels relative to initial levels in 1999. This decrease in VOCs at the combination wells may be due to the ongoing SVE. While the distance of the combination wells from the extraction wells is higher than the normal range of ROI expected at CAOC 16 (approximately 300 feet), the hardstand may be acting as an impermeable barrier, thereby extending the ROI.

The decrease in VOC levels in soil gas beneath the hardstand, and the general decrease in VOC levels in groundwater in several wells indicates that there is progress at CAOC 16 toward: 1) meeting groundwater cleanup goals and 2) reducing VOCs in the vadose zone.

7.7.2 System O&M

The continued operation of the system (with optimization) will verify the effectiveness of this remedy.

7.7.3 Monitoring Activities

Monitoring activities for the CAOC 16 AS/SVE system consist of the following:

1. VOC levels in soil gas from extraction wells – while the system is in operation
2. VOC levels in soil gas from monitoring wells and extraction wells – after a 1-week shutdown – representing static conditions

3. VOC levels in groundwater from groundwater monitoring wells in the vicinity of AS wells

These activities are adequate for monitoring the performance of the system.

7.7.4 Optimization

In general, the levels of VOCs in groundwater monitoring wells in the vicinity of the AS wells have either decreased or remained stable over the last 5 years. Possible optimizations include the modification of system operating parameters and additional optimization as discussed below.

7.7.4.1 Modification of System Operating Parameters

The following modifications to the system operating parameters can be implemented to increase performance:

- Increase the AS and SVE flow rates in wells with greater VOC concentrations and decrease the flow rates in wells with lower VOC concentrations.
- Consider the shutdown of AS well ASW-5, which is in an area where VOC concentrations are low based on 2006 groundwater monitoring data. The 2007 annual groundwater monitoring data should be used to further verify the relatively low VOC concentrations prior to the shutdown of ASW-5.

7.7.4.2 Additional Optimization

The results of the pilot study at CAOC 16 presented in the *Draft Final Engineering Evaluation/Cost Analysis, Operable Unit 1* (JEG, 1995b) indicate that a radius of sparging influence of approximately 75 feet would be appropriate for the sparging system. However, at CAOC 16, the sparging system spacing ranges from 300 to 400 feet.

Additional optimization of the remedial system is recommended.

7.7.4.3 Additional Optimization Recommendations – OU 1 Optimization Study

As a part of the OU 1 optimization study (URS Group, Inc., [URSGI], 2005a), the following recommendations were made:

1. Discontinue the use of wells ASW-1, -2, -3, -4, and -13 which are currently outside the Yermo North plume.
2. Discontinue using the vapor-phase GAC adsorbers, eliminate vapor influent and intermediate sampling, and reduce vapor effluent sampling to a quarterly schedule.
3. Evaluate whether the SVE wells may be shut off and the vapors allowed to escape into the atmosphere.
4. Pulse the existing AS wells on an optimum on/off schedule determined through pilot testing.

5. If pulsing is effective in significantly increasing the mass removal rate, consider installing additional AS wells within the plume to eliminate existing gaps in the systems zone of influence.
6. Consider installing AS wells in “hotspots” within the plume to enhance VOC removal.

As discussed earlier, pulsing of the existing AS wells has already been implemented. The DON has received FFA signatories’ comments on the OU 1 optimization study. An optimization work plan is being prepared.

7.7.5 Early Indicators of Potential Problems

There are no early indicators of potential problems for the CAOC 16 AS/SVE system.

7.7.6 Validity of Exposure Assumptions, Toxicity Data, Cleanup Levels, RAOs

There have been no changes that impact the validity of technical assumptions, toxicity data, cleanup levels, and RAOs at this CAOC (see Appendix J). Soils at this CAOC were impacted by VOCs, with (predicted) impacts to groundwater. A review of the OUs 1 and 2 ROD (DON, 1998a) indicates that there have been changes to toxicity data or cleanup levels for contaminants in groundwater. In January 2006, EPA lowered the MCL for arsenic. Because this CAOC is concerned with VOCs and because arsenic in soil was determined to be consistent with background (BEI, 2003), the MCL change does not affect the protectiveness of the remedy. Changes in toxicity of several VOCs have occurred (EPA, 2007). However, these changes are not expected to affect the protectiveness of the remedy because MCLs are being used as treatment standards. The RAOs remain unchanged. Appendix J provides additional details on the review of changes in ARARs, toxicity data, and ARARs for this CAOC.

7.7.7 Other Information

No new information has come to light that might call into question the protectiveness of the selected remedy at this CAOC.

7.8 TECHNICAL ASSESSMENT FOR OU 1: CAOC 26 AS/SVE SYSTEM

The CAOC 26 AS/SVE system was installed to reduce contaminant mass in the vadose and saturated zones at CAOC 26. The CAOC 26 AS/SVE system was started in December 1996 and operated through December 1998. It has not been in operation since then, as it has met its objectives, as discussed in the CAOC 26 TEF Report (FWENC, 2001).

7.8.1 Remedial Action Performance

The RAO for the CAOC 26 AS/SVE system is the reduction of VOCs in groundwater and vadose zone in the CAOC 26 area. As discussed in Section 4.4.4.8, there has been a reduction of VOCs in the vadose zone, as evidenced by the removal of approximately 1,140 pounds of VOCs by the system. The levels of VOCs in groundwater near the CAOC 26 AS/SVE system have also generally remained below MCLs since 1998. Based on this, the CAOC 26 Technical and Economic Feasibility Report (FWENC, 2001) was submitted and approved. The CAOC 26 AS/SVE system remains inactive.

The VOC levels in the groundwater monitoring well in the vicinity of CAOC 26 remain below MCLs. In addition to VOCs in groundwater, VOCs in soil gas in the soil gas probes were also monitored annually. In general, the total VOC concentrations of the soil vapors have remained relatively stable over the past five years. The increases observed between 2002 and 2004 in some of the sampling locations have decreased and have remained relatively stable.

7.8.2 System O&M

The system is not in operation.

7.8.3 Monitoring Activities

Monitoring activities for the CAOC 26 AS/SVE system consist of the following:

1. Annual monitoring of VOCs in groundwater at Wells YS26-2 and 3
2. Annual monitoring of VOCs in soil gas probes

Considering the relatively stable and low levels of VOCs in soil gas, if the VOC levels in soil gas based on the next monitoring event continue to be low and relatively stable, it is recommended that soil gas monitoring at CAOC 26 be conducted once every two years upon obtaining concurrence from the FFA signatories. If after two years, VOC levels continue to remain relatively low and stable, VOC monitoring frequency may be changed to once every five years.

7.8.4 Optimization

As the system is not in operation, optimization is not required.

7.8.5 Early Indicators of Potential Problems

As noted in the OUs 1 and 2 ROD (DON, 1998a), soil gas VOCs in the shallow subsurface have been identified as a potential risk, due to migration to the surface. Soil gas VOCs at depth may impact groundwater.

The OUs 1 and 2 ROD (DON, 1998a) required an evaluation of the effectiveness of the CAOC 26 SVE wells in extracting soil gas from the shallow subsurface. To address this concern and the potential impact of increase in soil gas VOCs, a detailed evaluation was previously performed as a part of the previous Five-Year Review (DON, 2002), which included the following:

1. Impact of soil gas VOCs in the shallow subsurface on aboveground receptors, based on modeling using the Johnson and Ettinger Vapor Intrusion Model (JVIM)

2. Ability of existing AS/SVE system to extract soil gas from shallow subsurface
3. Impact of soil gas VOCs at depth on groundwater, based on SEasonal SOIL compartment model (SESOIL)

According to JVIM calculations, the concentrations would have to increase by a factor of 10 in order to have an impact on aboveground receptors. It was recommended that if soil gas VOCs increase by a factor of 5, then shallow soil-gas surveys should be considered, followed by re-evaluation of potential impacts using the JVIM. However, soil gas concentrations at CAOC 26 remained low and relatively unchanged and did not increase by a factor of 5. Therefore, JVIM calculations do not require adjustment at this time.

Moreover, if there were to be an increase in VOCs in soil gas at shallow depths that warranted restart of the SVE system, the existing SVE wells would be capable of removing VOCs from these depths, notwithstanding the depth of the extraction wells (150 to 160 feet bgs), as discussed in the first Five-Year Review (DON, 2002).

Additionally, SESOIL results (DON, 2002) indicated that an increase in VOCs would have limited impact to groundwater. Assuming a worst-case scenario in which VOC soil gas concentrations increase by a factor of 20 and stay at that level, SESOIL results indicated that PCE concentrations in groundwater would still not exceed the MCL over a period of 100 years as discussed in the first Five-Year Review (DON, 2002). Soil gas concentrations monitored between 2002 and 2006 did not increase by a factor of 20. Therefore, the soil gas VOC levels observed in the CAOC 26 area are not expected to have an impact on groundwater quality. COC levels in groundwater continue to remain below MCLs in the CAOC 26 area further indicating that the VOC levels in soil gas do not impact groundwater quality in the CAOC 26 area.

7.8.6 Validity of Exposure Assumptions, Toxicity Data, Cleanup Levels, RAOs

There have been no changes that impact the validity of technical assumptions, toxicity data, cleanup levels, and RAOs at this CAOC (see Appendix J). Soils at this CAOC were impacted by low levels of VOCs, with VOC impacts to groundwater. A review of the OUs 1 and 2 ROD (DON, 1998a) indicates that there have been changes to toxicity data or cleanup levels for these contaminants in groundwater. In January 2006, EPA lowered the MCL for arsenic. Because this CAOC is concerned with VOCs and because arsenic in soil was determined to be consistent with background (BEI, 2003), the MCL change does not affect the protectiveness of the remedy. Changes in toxicity of several VOCs have occurred (EPA, 2007). However, these changes are not expected to affect the protectiveness of the remedy because MCLs are being used as treatment standards. The RAOs remain unchanged. Appendix J provides additional details on the review of changes in ARARs, toxicity data, and ARARs for this CAOC.

7.8.7 Other Information

No new information has come to light that might call into question the protectiveness of the selected remedy at this CAOC. There have been no activities at this CAOC requiring MCLB Barstow Environmental Department review, and none appear to be planned at this time.

7.9 TECHNICAL ASSESSMENT FOR OU 1 GETS

The Yermo Annex GETS was designed primarily to provide hydraulic containment of the dissolved groundwater plumes at the Yermo Annex.

7.9.1 Remedial Action Performance

As discussed in Section 4.4.4, the GETS is performing adequately, as evidenced by the following observations:

1. Containment at the MCL plume boundary
2. VOC mass reduction
3. Reduction in VOC concentrations

Due to an overall decrease in groundwater levels, in order to maintain containment, new and deeper groundwater extraction wells were installed (GEW-14 and GEW-15). Well GEW-15 is no longer in operation due to a bent well screen. Groundwater extraction wells GEW-6 and GEW-7 have been deepened to increase the pumping rates as well as their longevity. The model-predicted capture zones based on May 2007 pumping rates are shown on Figure 4-11, which indicates containment of the on-Base groundwater plumes. A groundwater modeling discussion is presented in Appendix B. As discussed in Section 4.4.4.1, based on modeling results, the maximized pumping rates during May 2007 indicate an improved containment when compared to the partial operation of the GETS in 2006 due to pump malfunction at GEW-7. Deepening or replacement of groundwater extraction well GEW-8 is recommended to further improve the containment of the Yermo North plume. It is recommended that the current practice of procuring additional groundwater extraction well pumps be continued to minimize downtime of the groundwater extraction wells in the event of a potential pump failure. As discussed in Section 4.4.4.1, recalibration of the groundwater model is underway following DTSC's recommendation.

Thus, the remedy selected in the OUs 1 and 2 ROD (DON, 1998a) has been implemented successfully. The remedy is protective of human health and the environment in the short term, in meeting the objective of attaining hydraulic containment at the MCL boundaries. For long-term protection, recommendations discussed in the above paragraph should be considered.

7.9.2 System O&M

Based on the discussion presented in Section 4.4.4., the operation of the system will allow meeting the RAOs. As of May 2007, the operating groundwater extraction wells included

GEW-3, GEW-6, GEW-7, GEW-13, and GEW-14. As discussed in Section 4.4 and in Appendix B, based on groundwater modeling results, well GEW-3 may not be contributing to the containment of Yermo South plume and is in an area where TCE, PCE, and 1,1-DCE are below MCLs. Thus, well GEW-3 may be switched off. Annual 2006 groundwater monitoring results for Yermo South indicated one well slightly above the MCL for TCE. Semiannual 2007 groundwater monitoring results for this well indicated TCE concentration below the MCL. While the Yermo South plume can no longer be interpreted, it is recommended that well GEW-14 continue to be operated until it is verified that TCE and PCE concentrations in Yermo South area continue to remain below MCLs.

As discussed in Section 4.4.4.1 and in Appendix B, when compared to the partial operation of the GETS in 2006 due to pump malfunction, the maximized May 2007 pumping rates showed a significant improvement in the capture of the Yermo North plume (Figure 4-11). Along the eastern Base boundary, wells GEW-6 and GEW-7 are in operation in the Yermo North area. In order to safeguard against potential pump and/or well malfunctioning of GEW-6 and/or GEW-7, it is recommended that well GEW-8 be deepened or replaced. Pumping from well GEW-8 along with GEW-7 and GEW-6 could further improve containment along the eastern Base boundary in the Yermo North area as discussed in Appendix B (Figure B-4 in Appendix B).

For the CAOC 26 plume, as discussed in Section 4.4.4.2, the annual 2006 groundwater monitoring results indicate that with the exception of wells PMW-11 and PMW-12, concentrations in the remaining wells were below MCLs. TCE levels were slightly above the MCL for wells PMW-11 and PMW-12 during the Annual 2006 groundwater sampling event. The semiannual 2007 groundwater monitoring results indicated that TCE levels for wells PMW-11 and PMW-12 were below the MCLs. For the CAOC 26 plume, any remaining mass of VOCs are expected to be captured by well GEW-13 (Figure 4-11).

7.9.3 Institutional Controls

No new groundwater supply wells have been installed in the plumes areas, on or off Base. Installation of such wells would require notification of the MCLB Barstow Environmental Department.

7.9.4 Monitoring Activities

Monitoring wells in the vicinity of the extraction wells are sampled to assess system effectiveness in accordance with the LTGWMP (DON, 1998c) and SAP (TtFW, 2005a) in conjunction with Addendum 01 to SAP (TN&A, 2006).

7.9.5 Optimization

As discussed in Section 7.9.2, switching off Well GEW-3 is recommended due to the relatively low pumping rate. Given the location of well GEW-3 with respect to the recent configuration of the Yermo South plume, GEW-3 does not contribute much to the capture of the Yermo South plume.

For the Yermo North plume, deepening or replacement of well GEW-8 is recommended. Modeling results presented in Appendix B indicate that this well can contribute to the containment of the Yermo North plume in case of malfunctioning extraction pumps in GEW-6 and/or GEW-7. In addition, pumping from deepened GEW-8 is expected to improve capture of the Yermo North plume as discussed in Section 4.4.4 and in Appendix B.

One of the requirements of the OUs 1 and 2 ROD (DON, 1998a) was to install four additional groundwater extraction wells off Base to provide containment of the off-Base portions of the Yermo North plume and Yermo South plume. However, based on the monitoring of the off-Base plumes since 1996, it appears that concentrations of VOCs off Base are generally decreasing (Figures C-1, C-2, C-3, and C-4 in Appendix C), as is the lateral extent of contamination (Figure 4-14). A draft final Technical Memorandum (TtEC, 2005) followed by a draft ESD (DON, 2005) were submitted to the FFA parties. As a result of the increase in VOC levels following the relatively heavy precipitation during 2004 and 2005, it was decided that the need for the off-Base groundwater extraction wells be evaluated during the subject Second Five-Year Review. As noted earlier, the semiannual 2007 groundwater monitoring results indicated off-Base TCE, PCE, and 1,1-DCE concentrations below the respective MCLs for the Yermo North and Yermo South plumes. The need for the installation of off-base groundwater extraction wells will be evaluated based on future groundwater monitoring data following the implementation and monitoring of additional optimization activities for the Yermo North plume. For the Yermo South plume, future groundwater monitoring data will be evaluated to assess the need for off-base groundwater extraction wells.

The following optimization recommendations were made for the OU 1 GETS, as a part of the OU 1 Optimization Study (URSGI, 2005a):

- Evaluate water-level data for evidence of hydraulic containment during each quarter.
- Update the sampling and analysis plan to eliminate current inconsistencies.
- Track operating costs in greater detail to permit more comprehensive evaluation.
- Adjust well yield to the lowest pumping rates necessary to maintain hydraulic containment.
- Modify the groundwater sampling program by reducing sampling frequency at selected wells and eliminating unnecessary wells.
- Implement a strategy to evaluate site closure at the Yermo South plume that is consistent with the approach described in the LTGWMP.
- Evaluate the feasibility and cost efficiency of utilizing AS wells as an alternative to the GETS.

The DON has received FFA signatories' comments on the OU 1 optimization study. Preparation of an optimization work plan is under progress.

7.9.6 Early Indicators of Potential Problems

Early indicators of potential problems for the GETS are discussed in the following sections.

7.9.6.1 Yermo North Plume Containment

Modeling results indicate that operation of Wells GEW-6, -7, -13, -14, and -15 provides hydraulic capture at the MCL plume boundary. As stated earlier, malfunction of GEW-6 and GEW-7 may have an impact on the plume capture along the eastern Base boundary in the Yermo North area. Accordingly, based on modeling results presented in Appendix B, it is recommended that well GEW-8 be deepened or replaced to provide containment for the Yermo North plume should GEW-6 and/or GEW-7 go offline due to potential malfunctioning.

Modeling results also indicate that well GEW-8 can potentially improve overall capture of the plume in the Yermo North area when operated along with GEW-6 and GEW-7. In addition, in order to minimize the downtime of the operating groundwater extraction wells, it is recommended that the current practice of procuring the spare pumps be continued. The capture zone should be evaluated on an annual basis based on groundwater modeling. Recalibration of the groundwater model is underway following DTSC's recommendation. Quarterly evaluation of plume capture is to be completed using groundwater elevation maps. Installation of additional wells should be considered if capture of the on-Base contaminant plume above MCLs is reduced.

7.9.6.2 Aging System Components

As discussed in Section 6.5, information gathered from the OUs 1 and 2 O&M contractor included the following regarding the potential impact of the aging remedial systems:

- Increases in O&M costs and system downtime during 2006–2007 occurred as a result of the aging GETS and CAOC 6 and 16 AS/SVE systems.
- System upgrades may be necessary as replacement parts for the aging system may become difficult to procure. In addition, after upgrading of required parts, compatibility with older parts and the required adjustments could also pose challenges. These issues have already resulted in an increase in man-hours to address some of the system component issues during 2006–2007 O&M period.
- It was also noted that several groundwater monitoring and extraction wells may require cleaning and redevelopment to ensure full functionality and integrity of sample data.

7.9.7 Validity of Exposure Assumptions, Toxicity Data, Cleanup Levels, RAOs

There have been no changes that impact the validity of technical assumptions, toxicity data, cleanup levels, and RAOs at this CAOC (see Appendix J). Groundwater is impacted by VOCs. A review of the OUs 1 and 2 ROD (DON, 1998a) indicates that there have been changes to toxicity data or cleanup levels for these contaminants in groundwater. In January 2006, EPA lowered the MCL for arsenic. Because this CAOC is concerned with VOCs and because arsenic in soil was determined to be consistent with background (BEI, 2003), the MCL change does not affect the protectiveness of the remedy. Changes in toxicity of several VOCs have occurred (EPA, 2007). However, these changes are not expected to affect the protectiveness of the remedy because MCLs are being used as treatment standards. The RAOs remain unchanged. Appendix J provides additional details on the review of changes in ARARs, toxicity data, and ARARs for this CAOC.

7.9.8 Other Information

There have been no activities at this CAOC requiring MCLB Barstow Environmental Department review, and none appear to be planned at this time. There have been a few developments pertaining to groundwater that might have some influence on the effectiveness of this remedy. These are discussed below.

7.9.8.1 Temporary Increase in Dissolved VOCs in Off-Base Wells During Semiannual 2005 Groundwater Monitoring Event

As discussed in the 2005 AGMR (TtEC, 2006), due to the relatively heavy rainfall during late 2004 and early 2005, dissolved VOC concentrations in the Yermo Annex off-Base wells showed a slight increase. VOC concentrations have in general decreased in several wells and have remained relatively stable since this time. During the most recent semiannual 2007 groundwater sampling event, TCE, PCE, and 1,1-DCE concentrations in these off-Base wells were below the respective MCLs.

7.9.8.2 Temporary Increase in Dissolved VOCs in December 2001

As discussed in first Five-Year Review (DON, 2002), a distinctive spike in VOC concentrations was observed in December 2001 following an intense storm event in September 2001. Since that time, VOC concentrations have in general decreased. Elevated levels of dissolved VOCs measured in the off-Base Yermo Annex wells during the semiannual 2005 event as discussed in the above section were significantly less than the VOC concentrations observed in December 2001.

7.9.8.3 Vertical Extent of VOC Contamination

As discussed earlier, a multiport well (Y15-4) with six multiple ports, referred to as Y15-4-1 through Y15-4-6, was installed during December 2002 to further evaluate off-Base groundwater quality at multiple depths. The ports extend approximately from 210 feet bgs to 510 feet bgs. Analyses of groundwater samples collected during the subsequent groundwater sampling events through the semiannual sampling event of 2007 did not indicate the presence of COCs at concentrations that are at or above the respective MCLs (Figure 4-13). This indicates that there is no vertical VOC migration detected downgradient of the groundwater extraction wells located at the Base boundary.

The potential migration of contaminants through deeper layers was investigated and the results were described in Section 6.6.1.1 of the *Draft Final Remedial Investigation Report, Operable Units 1 and 2, Marine Corps Base Barstow, Barstow, California* (JEG, 1995b). Deep VPB YVP-1 in the area of CAOC 16 (Yermo North plume area) did not reveal the presence of TCE, PCE, and 1,1-DCE above the respective MCLs in groundwater below a depth of 163 feet bgs. Another VPB, YAS-1 near Building 573 (CAOC 16), did not reveal the presence of TCE, PCE, or 1,1-DCE above the respective MCLs, in groundwater below a depth of 190 feet bgs. Results from VPB of YS18-2, downgradient of Building 573 (CAOC 16), indicated that TCE, PCE, and 1,1 DCE were not present above the respective MCLs in groundwater below a depth of 170 feet bgs.

7.9.8.4 Soil Gas Sampling of Existing Groundwater Monitoring Wells

In order to verify whether a zone of VOC-contaminated soil may potentially exist above the water table, soil gas sampling of select groundwater monitoring wells was conducted between January and February 2004. Details pertaining to sampling activities, as well as results, can be found in the *Draft Data Summary Report – Soil Gas Sampling of Groundwater Monitoring Wells at Yermo Annex and Nebo Main Base* (TtFW, 2004). The data obtained indicated the following:

1. VOC concentrations in the soil gas in the vadose zone directly above the groundwater at the Yermo Annex were generally low at the off-Base and on-Base locations sampled.
2. There was a substantial correlation of soil gas VOC data with groundwater VOC data at the off-Base and on-Base locations sampled. At Y9-4&5, low levels of TCE were detected in the deepest soil gas probe. Low levels of TCE were also detected in the groundwater sample collected from Y9-4. However, the deepest soil gas probe indicated PCE below detection limits, whereas PCE was detected in groundwater at these locations. Both TCE and PCE were below detection limits in both soil gas and groundwater at Y13-1. Thus, other than PCE in Y9-4, there is a correlation between the observed VOC concentrations in groundwater and those predicted based on soil gas concentrations. This in turn implies that soil gas VOCs are present in the same general area as that occupied by the groundwater VOC plume. At the Yermo Annex, VOCs were detected in the soil gas at most of the locations where VOCs were detected in groundwater.
3. At those locations where VOCs were detected, the ratio of predicted concentrations of individual VOCs in groundwater (TCE to PCE) were in agreement with the ratio of actual concentrations of these VOCs.

Based on these observations, it was concluded that VOCs are present in soil gas in the vadose zone above the groundwater VOC plumes. This provided one possible explanation for the observed spike in concentrations of VOCs in groundwater observed during the December 2001 sampling event. There was a discernible rise in water levels in December 2001, following a short but intense rainfall event in September 2001. The rising water table likely came into contact with the VOCs in the soil gas, causing a measurable rise in dissolved VOC levels in the groundwater. This phenomenon could also potentially be the cause for the observed increase in the dissolved VOC levels in the off-Base wells during 2005 as described in Section 7.9.8.1.

As discussed in Section 7.9.8.2, sampling subsequent to that of December 2001 indicated that the spike was temporary in nature and that all dissolved VOC concentrations have returned to historical levels. Thus, while VOCs are likely present in soil gas, they do not pose a long-term or significant threat to groundwater. Similarly, the slight increase observed in the off-Base wells during the semiannual 2005 groundwater monitoring event has also decreased since then as described in Section 7.9.8.1.

7.9.8.5 Detection of MTBE

As discussed in the first Five-Year Review report (DON, 2002), MTBE was detected at a number of monitoring wells in the southeast portion of the Yermo Annex. The CALNEV Pipeline Company, L.L.C. (CALNEV) Barstow Terminal (referred to as the CALNEV Site) fuel-handling facility located immediately adjacent to the southern perimeter of Yermo Annex (see Figure 3-1) is hydraulically upgradient of the Base. The Calnev site is owned by Kinder Morgan Energy Partners, LLC.

Based on the *Groundwater Investigation Report, CALNEV Pipeline Company, L.L.C. – Barstow Terminal Site, Daggett, California* (CALNEV Groundwater Investigation Report) (CH2M Hill, 2002) as well as the recent groundwater elevation data presented in the *Semi-Annual Groundwater Monitoring and Interim Corrective Action Measures Report Second Quarter – 2007* (CH2M Hill, 2007), groundwater flow beneath the CALNEV Site has been to the northeast. The CALNEV Site had three documented hydrocarbon releases. Numerous site investigations and RAs have occurred at the CALNEV Site since 1992. The first release was discovered during 1992, while the remaining two releases were discovered during 1995, as noted in the CALNEV Groundwater Investigation Report (CH2M Hill, 2002). Several hydrocarbon constituents, including benzene, toluene, ethylbenzene, xylenes, MTBE, and total hydrocarbons (total petroleum hydrocarbons as gasoline and TPH-d), have been detected beneath the CALNEV Site above the groundwater quality objectives (GWQOs) for the Mojave River Aquifer. MTBE and benzene have been detected at the highest concentrations at monitoring wells downgradient from the CALNEV Site. During the June 1995 sampling event, the maximum detected MTBE concentration in a downgradient well was 25,000 μg/L. Sustained high concentrations of MTBE were observed in two downgradient wells.

Overall, MTBE concentrations exhibited a decreasing trend at the CALNEV Site between June 1995 and the earlier part of 2005 (CH2M Hill, 2007). During the second quarter 2005, several CALNEV wells showed spikes in dissolved phase concentrations, apparently as a result of a rise in water levels (CH2M Hill, 2007). Based on reviews of historic data and model predictions utilizing particle-tracking, it was concluded that groundwater plumes may have migrated off site in the mid-1990s and may be present at concentrations exceeding the GWQOs beyond the extent of the CALNEV Site's downgradient monitoring well network. It was further concluded that based on current water quality data for the CALNEV Site, hydrocarbons present in the soil do not appear to pose a threat to groundwater at current or declining groundwater levels. However, because significant water level increases have occurred in the past and soil contamination has been observed within this range of water level fluctuations, significant water level increases may pose a threat to groundwater, as described in the first Five-Year Review (DON, 2002). This is likely the cause for the observed increase in hydrocarbon concentrations during second quarter 2005 at the CALNEV Site. Data summary tables presented in the *Semi-Annual Groundwater Monitoring and Interim Corrective Action Measures Report Second Quarter – 2007* (CH2M Hill, 2007) indicate maximum detected MTBE concentrations of 75,000 μg/L during August 2005, 20,000 μg/L during December 2005, and 100,000 μg/L during January 2006. Concentrations have since then decreased. In April 2007, MTBE was detected at a concentration of 11 μg/L in one monitoring well at the CALNEV Site, and no MTBE detections were reported in May and June 2007 (CH2M Hill, 2007).

Figures 7-1 and 7-2 show MTBE concentrations detected in Yermo Annex groundwater monitoring wells during the Annual 2006 and Semiannual 2007 groundwater sampling events. Historical MTBE concentration trends for select Yermo annex wells included in Appendix K indicate that MTBE concentrations detected at relatively high levels in some of the groundwater monitoring wells during 2002 and 2003 have since decreased. The annual 2006 groundwater sampling results indicate that MTBE was detected above the laboratory reporting limit of 1.0 μg/L in one well from the annual groundwater sampling event at the Yermo Annex. MTBE was detected in groundwater extraction well GEW-06, located near the eastern-central base boundary, at a concentration of 1.3 μg/L. MTBE was also detected in two groundwater samples from wells Y9-2 and YWA-2 below the laboratory reporting limit at estimated values of 0.22 μg/L and 0.29 μg/L, respectively (Figure 7-2).

As stated in the first Five-Year Review report (DON, 2002), the DON has installed two additional GAC vessels at the GETS treatment pad to account for possible MTBE occurrence in extracted groundwater.

7.10 TECHNICAL ASSESSMENT FOR CAOC 7 (OU 6)

Monolithic native soil caps were installed at Strata 1 and 2, as discussed in the OUs 5 and 6 RAR (SWDIV, 2002) and shown on Figure 4-10. The cap is maintained, and groundwater is monitored at three monitoring wells on an annual basis.

7.10.1 Remedial Action Performance

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. As discussed in Section 4.5.1, historical VOC concentration trends for the CAOC 7 groundwater monitoring wells indicate that none of the COCs were detected at or above MCLs in wells NS7-1 (downgradient well, Stratum 1, see Figure 4-10) and NSP-3 (downgradient well, Stratum 2). In well NSP-2 (downgradient well, Stratum 1), the detected TCE concentrations remained at or below the MCL through June 2003. TCE concentrations were detected above the MCLs during the annual 2004, 2005, and 2006 groundwater monitoring events. Section 4.6.3 of the OUs 5 and 6 ROD (DON, 1998b) states that following 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 re-evaluated for compliance with the threshold criteria, and if necessary, the selected remedy will be revised or enhanced with the concurrence of the FFA signatories.

Accordingly, if the detected TCE concentration from the next groundwater monitoring event exceeds the MCL, the remedy for the site may need to be re-evaluated for compliance with the threshold criteria, and if necessary, the selected remedy revised or enhanced with the concurrence of the FFA signatories. Pending this verification, the selected remedy is protective of human health and the environment.

The RAO for this CAOC was preventing exposure to contaminants and reducing precipitation infiltration. As discussed in Section 4.5.1.2, maintenance activities have taken place at the CAOC 7 cap to maintain cap integrity. Moisture monitoring data does not indicate significant variation with depth indicating that the cap is performing effectively.

There have been no activities within this CAOC.

7.10.2 System O&M

There are no operating systems associated with CAOC 7. The O&M costs are minimal, primarily associated with occasionally repairing well monuments that have become damaged. The cap is surveyed annually for settling. The remedy is cost effective and utilizes a permanent solution. The fence around the site is intact.

7.10.3 Institutional Controls

The LUC in place at CAOC 7 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.

7.10.4 Monitoring Activities

Monitoring activities at CAOC 7 consist of:

1. Moisture content monitoring
2. Groundwater monitoring

These are considered adequate to verify the effectiveness of the remedy.

7.10.5 Optimization

Given the nature of the remedy implemented at CAOC 7, there is no scope for optimization. The frequency of monitoring is annual, which is considered adequate for well NSP-2. Historically, TCE and PCE concentrations in wells NS7-1 and NSP-3 have been not detected over the past five years. The OUs 5 and 6 ROD (DON, 1998b) allows reduction of sampling frequency to once every 5 years if all results are below MCLs (after concurrence with EPA, DTSC, and Water Board). Therefore, it is recommended that the monitoring frequency for wells NS7-1 and NSP-3 be reduced to once every five years upon obtaining concurrence from EPA, DTSC, and the Water Board.

7.10.6 Early Indicators of Potential Problems

TCE concentrations were detected above the MCL values during the annual 2004, 2005, and 2006 groundwater monitoring events in well NSP-2. The OUs 5 and 6 ROD (DON, 1998b) states that following 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 re-evaluated for compliance with the threshold criteria, and if necessary, the selected remedy will be revised or enhanced with the concurrence of the FFA signatories. If the detected TCE concentration from the annual groundwater monitoring event 2007 exceeds the MCL value, the remedy for the site may need to be re-evaluated for compliance with the threshold criteria, and if necessary, the selected remedy revised or enhanced with the concurrence of the FFA signatories.

7.10.7 Validity of Exposure Assumptions, Toxicity Data, Cleanup Levels, RAOs

There have been no changes that impact the validity of technical assumptions, toxicity data, cleanup levels, and RAOs at this CAOC (see Appendix J). Soils at this CAOC were impacted by low levels of 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 the 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. The RAOs remain unchanged. Appendix J provides additional details on the review of changes in ARARs, toxicity data, and ARARs for this CAOC.

7.10.8 Other Information

No new information has come to light that might call into question the protectiveness of the selected remedy at this CAOC. There have been no activities at this CAOC requiring MCLB Barstow Environmental Department review, and none appear to be planned at this time.

7.11 TECHNICAL ASSESSMENT FOR OU 2 GROUNDWATER REMEDIATION SYSTEMS (CAOC 38) – NEBO NORTH

The Nebo North GETS was designed to provide hydraulic containment for the Nebo North Plume on a contingency basis if natural processes fail to contain the plume.

7.11.1 Remedial Action Performance

The GETS has not been in operation since 1996 as the plume has been shrinking (in terms of extent and concentrations) as discussed in Sections 4.5.2.1 and 4.5.2.2.

Construction completion and startup of an AS/SVE system to treat the Nebo North plume source area at the former Building 50 area took place during October 2007.

7.11.2 Monitoring Activities

Monitoring activities for Nebo North consist of groundwater sampling on an annual and/or semiannual basis in accordance with the LTGWMP (DON, 1998c) and the SAP (TtFW, 2005a) in conjunction with Addendum 01 to SAP (TN&A, 2006).

7.11.3 Optimization

As discussed in Section 4.5.5, historical dieldrin groundwater monitoring data during the past eight annual events since 1998 for the select wells in the Nebo North area did not reveal detections at or above the respective reporting limits. Per the LTGWMP (DON, 1998c), monitoring for pesticides can be discontinued after 5 years if the pesticides are not detected. Accordingly, it is recommended that dieldrin monitoring under OU 2 be discontinued upon obtaining concurrence from the FFA signatories.

The OU 2 optimization study (URSGI, 2005b) provided the following recommendations for the Nebo North plume:

- Maintain the GETS on inactive status, because groundwater monitoring results indicate that the Nebo North plume continues to recede.
- Track operating costs in greater detail to permit more comprehensive evaluation of expenditures.
- Modify the groundwater sampling program by reducing sampling frequency at selected wells and eliminating unnecessary wells.
- Develop a strategy for documenting site closure at the Nebo North plume that is generally consistent with the approach described in Appendix B of the LTGWMP.
- Given the plume's attenuation without active remediation, re-evaluate the need to install and operate an AS/SVE System to reach remedial action objectives for groundwater.

As discussed earlier, an AS/SVE system is currently being installed (expected to be in operation in October 2007) to address the source area (former Building 50) for the Yermo North plume. The DON has received FFA signatories' comments on the OU 2 optimization study. An optimization work plan is being prepared.

7.11.4 Early Indicators of Potential Problems

There are no early indicators of potential problems.

7.11.5 Validity of Exposure Assumptions, Toxicity Data, Cleanup Levels, RAOs

There have been no changes that impact the validity of technical assumptions, toxicity data, cleanup levels, and RAOs at this CAOC. Groundwater at this CAOC is impacted by dissolved VOCs. A review of the OUs 1 and 2 ROD (DON, 1998a) indicates that there have been no changes to toxicity data or cleanup levels for these contaminants in soil. The RAOs also remain unchanged.

7.11.6 Other Information

No new information has come to light that might call into question the protectiveness of the selected remedy at this CAOC. Construction completion and startup of the Nebo North AS/SVE system to treat the Nebo North source area (former Building 50) took place during October 2007. There have been no other activities at this CAOC requiring MCLB Barstow Environmental Department review, and none appear to be planned at this time.

7.12 TECHNICAL ASSESSMENT FOR OU 2 GROUNDWATER REMEDIATION SYSTEMS – NEBO SOUTH

The AS/SVE system at Nebo South (CAOC 6) started operations as part of an IRA. Operation in IRA mode began in January 2004. The system has operated in pilot and extended pilot testing modes since October 2001. Following the success of the pilot AS/SVE treatment system, the Nebo South ROD was finalized with AS/SVE as the final remedy for Nebo South (DON, 2006).

7.12.1 Remedial Action Performance

As discussed in Sections 4.5.3.1 through 4.5.3.4, operation of the Nebo South AS/SVE system has resulted in:

- The extent of the Nebo South TCE plume has decreased over time.
- TCE levels in a majority of the wells have decreased well below MCLs.
- VOCs continue to be removed from the subsurface, but at a declining rate. Decreases in the removal rate and soil vapor VOC concentrations are attributed to the decrease in VOC mass in the soil and groundwater at CAOC 6.

The remedy is considered to be protective of human health and the environment in the short term, in meeting the remedial objectives. However, as described earlier, the aging CAOC 6 AS/SVE system components may have an impact on long-term protectiveness. Various measures are being implemented to minimize system down time.

7.12.2 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. Installation of such wells would require notification of the MCLB Barstow Environmental Department.

7.12.3 Monitoring Activities

Monitoring activities for groundwater are conducted semiannually and/or annually and are considered adequate for monitoring plume migration.

7.12.4 Optimization

As discussed in Section 4.5.3.3, due to the low concentrations of VOCs in the influent stream and the VOC effluent emission rate falling well below the MDAQMD's allowable levels of 39.6 lbs/day, as documented in a letter sent to the regulatory agencies in September 2005, as well as the OU 2 Nebo South ROD (DON, 2006), carbon replacement for the CAOC 6 AS/SVE system was discontinued. The soil vapor VOC concentrations are still being monitored to determine the need for GAC.

As a result of the observed increase in TCE concentration in well NS6-4, air flow rates have been increased in nearby air sparge wells NS6-A1 and NS6-A3. Pulsing of the AS/SVE system is also being implemented.

The OU 2 optimization study (URSGI, 2005b) provided the following recommendations for the Nebo North plume:

- Track operating costs in greater detail to permit more comprehensive evaluation.
- Modify the groundwater sampling program by eliminating an unnecessary well.
- Discontinue the use of AS/SVE wells NS6-AV5, -AV9, -AV11, and -AV12, which are currently outside the Nebo South plume.
- Discontinue using the vapor-phase GAC adsorbers and eliminate vapor influent and intermediate sampling, as untreated vapor emissions do not exceed discharge limits.
- Pulse the existing AS wells on an optimum on/off schedule determined through pilot testing.

The DON has received FFA signatories' comments on the OU 2 optimization study. Preparation of an optimization work plan is under progress.

7.12.5 Early Indicators of Potential Problems

There are no early indicators of potential problems at this time.

7.12.6 Validity of Exposure Assumptions, Toxicity Data, Cleanup Levels, RAOs

There have been no changes that impact the validity of technical assumptions, toxicity data, cleanup levels, and RAOs at this CAOC (see Appendix J). Soils at this CAOC were impacted by low levels of VOCs, with limited (predicted) impacts to groundwater. A review of OUs 1 and 2 ROD (DON, 1998a) indicates that there have been changes to toxicity data or cleanup levels for these contaminants in groundwater. In January 2006, EPA lowered the MCL for arsenic. Because this CAOC is concerned with VOCs and because arsenic in soil was determined to be consistent with background (BEI, 2003), the MCL change does not affect the protectiveness of the remedy. Changes in toxicity of several VOCs have occurred (EPA, 2007). However, these changes are not expected to affect the protectiveness of the remedy because MCLs are being used as treatment standards. The RAOs remain unchanged. Appendix J provides additional details on the review of changes in ARARs, toxicity data, and ARARs for this CAOC.

7.12.7 Other Information

As stated earlier, the aging AS/SVE system components may have an impact on the protectiveness of the selected remedy at this CAOC. There have been no activities at this CAOC requiring MCLB Barstow Environmental Department review, and none appear to be planned at this time.

Dissolved TCE contamination has been detected in the southwest portion of Nebo Main Base (NPZ-14). If TCE concentrations continue to remain above the MCL, appropriate action will be proposed after consultation with the FFA signatories.

7.13 TECHNICAL ASSESSMENT SUMMARIES

Following is a summary of technical assessment for OUs 1 through 6.

7.13.1 OU 1 Technical Assessment Summary

OU 1 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 system to reduce vadose and groundwater contamination (VOCs) at CAOC 26.
- CAOC 16 AS/SVE system to reduce groundwater contamination (VOCs) at CAOC 16.

- Yermo Annex GETS to remediate VOC-contaminated groundwater below Yermo Annex MCLs.
- Treatment systems at two on-Base and two off-Base drinking water wells.

OU 1 also has the following requirements for 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).

Following is a summary of the technical assessment for OU 1.

7.13.1.1 CAOC 26

The CAOC 26 AS/SVE system is protective of human health and environment. VOCs in soil gas are monitored annually, and in general, have remained relatively low and stable relative to initial levels from 1999. The increases observed between 2002 and 2004 in some of the samples have decreased and have remained relatively stable. Soil vapor concentrations would have to increase by a factor of 10 in the shallow subsurface to impact aboveground receptors as discussed in the first Five-Year Review (DON, 2002). In terms of impact to groundwater, assuming a worst-case scenario in which concentrations increase by a factor of 20 and remain at that level, SESOIL results indicate that MCLs would not be exceeded even at 100 years (DON, 2002). As discussed in Section 7.8.5, soil gas concentrations monitored between 2002 and 2006 did not increase by a factor of 20. Therefore, the soil gas VOC levels observed in the CAOC 26 area are not expected to have an impact on groundwater quality. VOCs in groundwater in the zone of influence of the CAOC 26 AS/SVE system continue to remain below MCLs and are expected to remain at these levels. Should there be a need to restart the SVE portion (due to increase in soil gas VOCs), the existing SVE wells can extract soil gas from the shallow subsurface.

As discussed in Section 4.4.4.2, the annual 2006 groundwater monitoring results indicate that with the exception of wells PMW-11 and PMW-12, concentrations in the remaining wells were below MCLs. The semiannual 2007 groundwater monitoring results indicated that TCE levels for wells PMW-11 and PMW-12 were below the MCLs. For the CAOC 26 plume, any remaining mass of VOCs are expected to be captured by well GEW-13 (Figure 4-11).

7.13.1.2 CAOC 16

The CAOC 16 AS/SVE system along with LUCs are protective of human health and environment. While reduction of vadose zone contamination was not an RAO, the SVE portion of the system appears to be effective in doing so. The AS portion appears to be effective in reducing VOCs in groundwater in the zone of influence of the CAOC 16 AS wells based on the observed decrease in groundwater concentrations in a majority of the wells. However, downgradient of the zone of influence of CAOC 16, increase in groundwater concentrations were noted as discussed in Section 4.4.4.7. Pulsing of AS/SVE is under progress. Additional optimization may be warranted for contaminated groundwater outside of the zone of AS influence, east of the existing AS wells. Groundwater modeling results included in Appendix B indicate that the portion of the GETS associated with CAOC 16 provides hydraulic capture at the MCL boundary (wells GEW-13, GEW-6, and GEW-7). Deepening or replacement of the groundwater extraction well GEW-8 is recommended to further improve hydraulic capture.

7.13.1.3 GETS

As discussed above in Section 7.9.1, GETS is considered generally adequate in containing the Yermo North, Yermo South, and the CAOC 26 plumes. As discussed in Section 7.9.5, reconstruction of GEW-8 via deepening or replacement of the well is recommended to further improve capture of Yermo North plume and to provide containment in case of malfunctioning of wells GEW-6 or GEW-7. The treatment system for extracted groundwater has been functioning effectively.

7.13.1.4 On-Base Drinking Water Wells

The GAC treatment systems for wells YDW-5 and YDW-6A (also referred to as YDW-6) are protective of human health and the environment.

7.13.1.5 Off-Base Drinking Water Wells

The GAC treatment systems for the Younts and Hodges wells are protective of human health and the environment.

7.13.1.6 Metals at Yermo Annex

An evaluation of metals in groundwater beneath CAOC 16 at the Yermo Annex (OU 1) is required under OUs 1 and 2 ROD (DON, 1998a). The LTGWMP (DON, 1998c) requires monitoring of four background wells for metals, in order to establish background metal levels for the Yermo Annex. However, these wells have been dry. Therefore, several selected wells at the Yermo Annex were sampled as background wells. Background analytical results for the wells that are upgradient, cross-gradient, and downgradient of CAOC 16 indicate chromium and nickel concentrations that are in general below the respective MCLs.

Chromium and nickel concentrations in YCW series wells indicate fluctuating trends above and below the respective MCL values. The OUs 1 and 2 ROD (DON, 1998c) stated that spatial variation and large temporal variations in the concentrations of the metals including chromium and nickel throughout 4 years of sampling (prior to the signing of the ROD) suggest that turbidity or sampling techniques may have resulted in the higher reported concentrations.

As a result of the fluctuating concentration trends above and below the MCLs for chromium and nickel observed in the YCW series wells and the possible impact of turbidity on metals monitoring results, it is recommended that the YCW series wells continue to be monitored for these metals. In order to address the turbidity issue, the condition of the well screens will need to be assessed and appropriate action will need to be taken. A statistical evaluation is recommended once the analyzed chromium and nickel concentrations show relatively stable concentrations over a period of at least four events. Metals monitoring at the remaining wells with the exception of wells YS20-2 and PMW-2 may be discontinued.

7.13.1.7 Off-Base Extraction Wells

The OUs 1 and 2 ROD (DON, 1998a) requires installation of four off-Base extraction wells at Yermo Annex. These wells have not been installed to date because of the overall decrease in levels and extent of dissolved VOCs at off-Base monitoring wells. As discussed in Section 7.9.5, the need for the installation of off-base groundwater extraction wells will be evaluated based on future groundwater monitoring data following the implementation and monitoring of additional optimization activities for the Yermo North plume. For the Yermo South plume, future groundwater monitoring data will be evaluated to assess the need for off-base groundwater extraction wells.

7.13.2 OU 2 Technical Assessment Summary

OU 2 is the groundwater at Nebo Main Base, and includes two dissolved VOC plumes (Nebo North and Nebo South). It also includes groundwater monitoring associated with CAOC 7 and includes an evaluation of pesticides at Nebo North.

As per the OUs 1 and 2 ROD (DON, 1998a), the Nebo North GETS is in place to provide hydraulic containment for the Nebo North plume on a contingency basis if natural processes fail to contain the plume. The Nebo North AS/SVE system became operational during October 2007.

For Nebo South, an interim remedy consisting of a GETS was proposed in the OUs 1 and 2 ROD (DON, 1998a). This system was not implemented as it may promote off-Base migration of on-Base VOC contamination. Following the success of pilot testing, AS/SVE was selected as the final remedy and the Nebo South ROD was finalized (DON, 2006).

Dissolved TCE contamination has been detected in the southwest portion of Nebo Main Base (NPZ-14) downgradient of CAOC 11 (Fuel Burn Area) and CAOC 12 (Radiator Cleaning Chemical Disposal Area).

Following is a summary of the technical assessment for OU 2.

7.13.2.1 Nebo North

VOCs

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 (in terms of extent and concentrations; see Sections 4.5.2.1 and 4.5.2.2). The remedy at Nebo North is protective of human health and the environment.

Pesticides

Dieldrin has not been detected at or above reporting levels in select groundwater monitoring wells at Nebo North, based on eight annual events since 1998. Per the LTGWMP (DON, 1998c) monitoring for dieldrin can be discontinued after 5 years if this trend continues. As recommended in Section 7.11.3, monitoring for dieldrin may be discontinued upon obtaining concurrence from the FFA signatories.

7.13.2.2 Nebo South

Groundwater TCE concentrations in a majority of the monitoring wells have declined since 2001 as a result of the CAOC 6 AS/SVE system operation.

However, the TCE concentration in NS6-4 appears to be increasing with time. As a result, the air flow rates have been increased in nearby air sparge wells NS6-A1 and NS6-A3. Further, trace levels of PCE were detected in NS6-8 for the first time since December 2004 at a level of 1.6 μg/L.

The RAs at Nebo South under OU 2 currently protect human health and the environment as a result of the natural attenuation remedy (Nebo North), CAOC 6 AS/SVE operation at Nebo South, and the LUCs that are in place. However, in order for the remedy to be protective in the long term, continued optimization of the system and addressing the aging CAOC 6 AS/SVE system will be required.

As discussed in Section 4.8, NPZ-14 (located several thousand feet away from the Nebo South plume) indicates TCE at levels ranging from 10 to 31 μg/L. This well should be monitored annually. Additional investigations may be necessary if TCE concentrations continue to remain above MCL. The general groundwater flow direction in the vicinity of NPZ-14 is to the east (Figure 3-3). The approximate distance to the eastern property boundary is 3,150 ft. TCE and PCE were not detected in wells NS7-2 and NPZ-15 located in the general downgradient direction although well NS7-2 was last sampled in February 2003 and NPZ-15 in December 2000. A round of groundwater samples is recommended from these wells to verify the concentrations.

Based on the Annual 2007 groundwater monitoring results, if TCE concentrations detected in NPZ-14 in the southwest portion of Nebo Main Base downgradient of CAOC 11 (Fuel Burn Area) and CAOC 12 (Radiator Cleaning Chemical Disposal Area) continue to remain above the MCL, appropriate action will be proposed after consultation with the FFA signatories.

7.13.3 OU 3 Technical Assessment Summary

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.

The OUs 3 and 4 ROD (DON, 1997) requires that the RA for CAOC 20 be re-evaluated based on the monitoring data. Groundwater monitoring data for gross alpha exhibited statistically significant exceedances for the upgradient well YS20-1 and the cross-gradient well YS20-2. However, gross alpha concentration in the downgradient well YIMW-5 during 2005 was below the corresponding MCL. Accordingly, the remedial measures at CAOC 20 are protective in the short term as additional investigations are necessary upon consultation with the FFA signatories to evaluate the groundwater gross alpha concentration exceedances.

Remedial measures at CAOC 23 are considered protective of human health and the environment. Groundwater monitoring and NFAs (with BMP modification) implemented at CAOCs 18 and 34 are protective of human health and the environment.

7.13.4 OU 4 Technical Assessment Summary

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). This remedy continues to be protective of human health and the environment.

7.13.5 OU 5 Technical Assessment Summary

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, 25, 27, 28, 29, 30, 31, and 32 (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. Increases in groundwater concentrations in wells downgradient of CAOC 35 were noted. While the groundwater extraction wells downgradient of the CAOC 35 wells could capture these exceedances, additional sparge wells have been recommended to address these exceedances. In addition, an additional groundwater extraction well has been recommended to be deepened to improve capture of the Yermo North plume. 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. The selected remedies at the remaining CAOCs at OU 5 are considered protective of human health and the environment.

7.13.6 OU 6 Technical Assessment Summary

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/remediation. NFA was required at CAOCs 4, 6, 8, 12, 13, and 14. LUCs were required at CAOCs 1 and 3. A native soil cap and LUCs were implemented at CAOC 7. Groundwater at CAOC 6 is covered under OU 2.

Groundwater monitoring data for TCE in well NSP-2 (downgradient well, Stratum 1, Figure 4-10) were detected above the MCL during the past three annual events. If the TCE monitoring data from the next groundwater sampling event exceeds the MCL, as required by the OUs 5 and 6 ROD (DON, 1998b), the remedy for the site will need to be re-evaluated, and if necessary, the selected remedy revised or enhanced with the concurrence of the FFA signatories. Therefore, the selected remedy at CAOC 7 is currently protective of human health and the environment. The selected remedies at the remaining CAOCs of OU 6 are considered protective of human health and the environment.

8.0 ISSUES

Issues for the CAOCs discussed in Section 4.0, if any, are summarized in Tables 8-1 and 8-2 for Yermo Annex and Nebo Main Base, respectively.

9.0 RECOMMENDATIONS AND FOLLOW-UP ACTIONS AT OUs 1 THROUGH 6

Summaries of recommendations and follow-up actions at the 11 Yermo Annex CAOCs and eight Nebo Main Base CAOCs (that require LUCs or RAs) are provided in Tables 9-1 and 9-2, respectively.

10.0 PROTECTIVENESS STATEMENT

This section includes protectiveness statements for the operable units based on the information presented in Sections 4 and 7.

10.1 OPERABLE UNIT 1

The RAs at CAOC 37 under OU 1 are currently protective of human health and the environment because of the GETS and the CAOC 16 AS/SVE system that are in operation as well as the LUCs that are in place. However, in order for the remedy to be protective in the long term, the following actions need to be taken:

1. Evaluate deepening or replacement of the groundwater extraction well GEW-8 to improve containment of the Yermo North plume.
2. Evaluate the need for additional AS wells for the CAOC 16 system to augment the GETS in addressing the Yermo North plume remediation.
3. Continue the current practice of procuring spare pumps for faster replacement in case of potential pump malfunctioning for the groundwater extraction wells in the Yermo North plume area.
4. In order to address the aging GETS and CAOC 16 AS/SVE system components, evaluate the possibility of replacing system components and the associated impact vs. continuing to service and repair the existing system components.

10.2 OPERABLE UNIT 2

The RAs at CAOC 38 under OU 2 are currently protective of human health and the environment because of the natural attenuation remedy (Nebo North), CAOC 6 AS/SVE at Nebo South, and LUCs that are in place. However, in order for the remedy to be protective in the long term, the following actions need to be taken:

1. Continue optimization of the system.
2. In order to address the aging CAOC 6 AS/SVE system components, evaluate the possibility of replacing system components and the associated impact vs. continuing to service and repair the existing system components.

10.3 OPERABLE UNIT 3

The RAs at CAOC 20 under OU 3 are currently protective of human health and the environment because of the caps at CAOCs 20 and 23 as well as the LUCs that are in place.

However, in order for the remedy at CAOC 20 to be protective in the long term, additional investigations upon consultation with the FFA signatories are necessary to further evaluate the gross alpha exceedances 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.

10.4 OPERABLE UNIT 4

For the CAOCs with RAs at OU 4, the RAs are protective of human health and the environment.

10.5 OPERABLE UNIT 5

For the CAOCs with RAs at OU 5, the RAs are protective of human health and the environment.

10.6 OPERABLE UNIT 6

The RA at CAOC 7 under OU 6 currently protects human health and the environment because of the caps and the LUCs that are in place.

However, if the TCE concentration for the downgradient well NSP-2 exceeds the MCL during the next groundwater monitoring event, in order for the remedy to be protective in the long term, the RA for this CAOC will need to be re-evaluated for compliance with the threshold criteria, and if necessary, the selected remedy will be revised or enhanced with the concurrence of the FFA signatories.

For the remaining OU 6 CAOCs with RAs, the RAs are protective of human health and the environment.

10.7 OVERALL PROTECTIVENESS STATEMENT

The remedy for MCLB Barstow (Operable Units 1 to 6) is considered protective in the short-term because there is no evidence of current exposure. However, in order for remedies to remain protective in the long-term, the required actions include (i) modifications as necessary of the groundwater extraction system at OU 1 (Yermo Annex Groundwater) to improve capture; (ii) additional optimization of the CAOC 16 AS/SVE system at Yermo Annex; (iii) optimization of the Nebo South AS/SVE system (OU 2); (iv) an assessment of the concentration increases at CAOC 20 and if required, a re-evaluation of the CAOC 20 remedy, and (v) assessment of the VOC detections at monitoring wells NSP-2 (down-gradient from CAOC 7 [OU 6]) and NPZ-14 (down-gradient from CAOCs 11 and 12 [OU 2]).

11.0 NEXT REVIEW

The next five-year review for OUs 1 through 6 is required by December 19, 2012, which is five years from the date of this review.

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TABLES

TABLE 1-1

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

TABLE 1-1

SUMMARY OF CAOCs

CAOC	OU	Selected Remedy	Total Area (acres)	Areas Requiring BMP Modifications (acres)	Area of Formal LUCs (acres)	5-Yr Review Required?
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 proposed for elimination from the RI/FS. This was accepted by the FFA Parties, and is therefore, not subject to the five-year review process
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 maps (Figures 1-4 and 1-5) as well as the BMP modifications and the formal LUCs areas 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 2-1

OPERABLE UNIT HISTORY AND CHRONOLOGIES

DATE	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 Environmental Protection Agency, Department of Toxic Substances Control, and the 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
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.

TABLE 2-1

OPERABLE UNIT HISTORY AND CHRONOLOGIES

DATE	EVENT
2002	First Five-Year Review conducted for OUs 1 through 6.
December 2005	Draft ESD Submitted for the Yermo Annex Off-Base Groundwater Extraction Wells (OU 1).
August 2006	Nebo South Operable Unit 2 Proposed Plan completed.
September 2006	Nebo South Operable Unit 2 Final ROD signed.
June 2007	Nebo South Operable Unit 2 Draft Land Use Control Remedial Design document submitted.
2007	Second 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
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

TABLE 4-1

OPERATION AND MAINTENANCE COSTS

CAOC	OU	O&M Item	Projected Costs	Actual Costs	Comments
20	3	Cap maintenance and monitoring	$20,200 per year (for four years)	Maintenance: $10,000 per year (for four years)	Monitoring costs covered under OU 1 groundwater monitoring.
23	3	Cap maintenance and monitoring	Not estimated	Maintenance: $14,000 per year	Monitoring costs covered under OU 1 groundwater monitoring.
35	5	Cap maintenance and monitoring	Not available (were part of total cost estimate of $1,432,215 for capital and O&M)	Maintenance: $14,000 per year	Monitoring costs covered under OU 1 groundwater monitoring.
7	6	Cap maintenance and monitoring	Not available (were part of total cost estimate of $1,273,080 for capital and O&M)	Maintenance: $11,000 per year	Monitoring costs covered under OU 2 groundwater monitoring.
37	1	Operation of two AS/SVE systems and one GETS, groundwater monitoring	$1.2 Million per year	$696,000	One AS/SVE system (CAOC 26) is not in operation. The aging GETS and CAOC 16 AS/SVE systems have resulted in an increase in system related O&M costs during 2006 – 2007. Future system related O&M costs are likely to increase as a result of these aging systems.
38	2	Operation of two GETS, groundwater monitoring	$371,000 per year	$274,000	The Nebo North GETS is on standby status. At Nebo South AS/SVE is the final remedy and thus GETS does not apply. If the Nebo north GETS were in operation, costs would increase by approximately $150,000 per year. Costs would also increase as a result of the Nebo North AS/SVE which became operational during October 2007. The aging CAOC 6 AS/SVE system has resulted in an increase in system related O&M costs during 2006 – 2007. Future system related O&M costs are likely to increase as a result of the age of this system.

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

TABLE 5-1

ISSUES IDENTIFIED DURING THE FIRST FIVE-YEAR REVIEW AND FOLLOW-UP ACTIONS AT YERMO ANNEX

CAOC	OU	Issue	Recommendations/ Follow-up Actions	Milestone Date	Action Taken and Outcome	Date of Action
37	1	Off-Base extraction wells have not been installed	Submit ESD for deviation from ROD	June 2003	Following the approval of a technical memorandum, a draft ESD was submitted during December 2005 (DON, 2005). A further evluation has been presented in the subject Second Five-Year Review based on the Draft ESD review comments.	December 2005
37	1	Increase in VOC levels in soil gas at CAOC 26	Continue annual monitoring, restart SVE if necessary	N/A	Continued annual monitoring of VOC levels in soil gas was conducted. A declining or steady trend has been observed. Modeling results indicated no impact to groundwater. Groundwater concentrations have been non-detect in a majority of the wells. Restarting of SVE was not necessary.	N/A
37	1	Effectiveness of AS/SVE in reducing dissolved VOC concentrations at CAOC 16	1. Switch to pulsed mode 2. Evaluate the need for additional AS wells	June 2003	Optimization has been ongoing since 2002. The AS/SVE system was switched to a pulsing mode during September 2005. The system appears to be performing effectively. Additional AS wells appear to be necessary downgradient of existing AS well network.	Optimization ongoing since 2002. Switch to pulsed mode during September 2005
37	1	Declining water levels	Evaluate capture on an annual basis	December 2003	Capture zone analysis has been performed on an annual basis. Capture zone analysis in combination with the groundwater elevation contours indicated capture of the plume with the GETS being on.	Capture zone anaylisis has been performed on an annual basis since 2003.
37	1	Increase in VOCs at off-Base residential wells	Evaluate vertical extent of dissolved VOC contamination downgradient of Base boundary	March 2003	A 511-ft bgs deep multi-port groundwater monitoring well (Y15-4) with six discrete depth sampling ports was installed between December 2002 and January 2003, using the Westbay® sampling system. COC concentrations analyzed since 2003 have been below MCLs at 212 ft bgs and non-detect at 272 ft bgs, 362 ft bgs, 404 ft bgs, 454 ft bgs, and 511 ft bgs.	Between December 2002 and January 2003
37	1	Adequate background information is not available for metals (CAOC 16)	Evaluate background metals in groundwater at Yermo Annex	December 2003	Background metals analysis has been conducted between 2003 and 2007. Adequate data sets are available.	Between 2003 and 2007
37	1	(Temporary) increase in dissolved VOCs in groundwater in December 2001	None	N/A	Subsequent monitoring data indicated a general decrease in dissolved VOCs from the levels measured during the annual event in 2001.	N/A
--	1	Younts and Hodges wells GAC change out has occurred once in past seven years, no formal O&M manual	Prepare formal O&M manual, changeout GAC at least every 5 years	February 2003	A formal O&M Manual was prepared and finalized on September 15, 2003 (FWENC, 2003a). This manual includes the O&M details for the system. Following the GAC changeout during July 2002, most recently, GAC was changed during August 2007.	September 15, 2003 (O&M Manual finalization) August, 2007 (GAC Chageout)
--	1	YDW-5 – no formal O&M manual in place	Prepare formal O&M manual	February 2003	A formal O&M Manual was prepared and finalized on September 15, 2003 (FWENC, 2003b). This manual includes the O&M details for the system.	September 15, 2003

Abbreviations and Acronyms:

AS – air sparging
bgs – below ground surface
CAOC – CERCLA Area of Concern
CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act
COC – constituent of concern
ESD – Explanation of Significant Differences
ft – foot
FWENC – Foster Wheeler Environmental Corporation
GAC – granular activated carbon
GETS – Groundwater Treatment and Extraction System
MCL – maximum contaminant level
N/A – not applicable
O&M – Operation and Maintenance
OU – Operable Unit
ROD – Record of Decision
SVE – soil vapor extraction
VOC – volatile organic compound

TABLE 5-2

ISSUES IDENTIFIED DURING THE FIRST FIVE-YEAR REVIEW AND FOLLOW-UP ACTIONS AT NEBO MAIN BASE

CAOC	OU	Issue	Recommendations/ Follow-up Actions	Milestone Date	Action Taken and Outcome	Date of Action
7	6	Fencing required minor repairs	Make repairs	January 2003	Fence repairs were conducted during August 2004, August 2005, and October 2005. The fence was observed in good condition based on the 2006 Annual Report as well as the site inspections.	August 2004, August 2005, and October 2005
38	2	Nebo North - AS/SVE not yet installed	Implement AS/SVE pilot test, followed by full-scale, if feasible	N/A	A pilot test was completed during June 2003 (BNI, 2004). Full-scale implementation is underway as of September 2007. The system is expected to be in operation during October 2007.	June 2003 (Pilot Test) June 2007 to Present (Full-Scale Implementation) October 2007 (Anticipated startup of the Full-Scale system)
38	2	Nebo South - deviation from ROD - installation of off-Base GEWs has not been done	If AS/SVE is deemed feasible, submit ESD to explain the rationale for not installing off-Base GEWs	June 2003	Following the success of the Phase 2 AS/SVE testing, AS/SVE was finalized as the remedy in the Final OU 2 Nebo South ROD (DON, 2006) during September 2006.	September 2006
38	2	NPZ-14 VOC detects	Monitor annually	N/A	Monitoring of VOCs at NPZ-14 is ongoing on an annual basis. Well NPZ-14 is located several thousand feet south of the Nebo North plume and west of the Nebo South plume (Figure 1-3). Fluctuating TCE concentrations in well NPZ-14 ranged from 10 µg/L (December 2001) to 35 µg/L (November 2006) (Figure 4-24). No trend is apparent at this time. A number of new wells were installed in the Nebo South area as a part of the Phase 2 AS/SVE for the Nebo South plume. Monitoring data from these wells does not seem to indicate a connection between NPZ-14 and CAOC 6 VOC contamination. Data from NPZ-14 is interpreted at this time to indicate a relatively small isolated occurrence of TCE in groundwater in the vicinity of NPZ-14.	Annual monitoring

Abbreviations and Acronyms:

µg/L – micrograms per liter
AS – air sparging
BNI – Bechtel National, Inc.
CAOC – CERCLA Area of Concern
CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act
DON – Department of the Navy
ESD – Explanation of Significant Differences
GEW – ground extraction well
N/A – not applicable
O&M – Operation and Maintenance
OU – Operable Unit
ROD – Record of Decision
SVE – soil vapor extraction
TCE – trichloroethene
VOC – volatile organic compound

TABLE 6-1

SITE INSPECTIONS FINDINGS SUMMARY FOR THE CAOCs WITH SITE DEVELOPMENT

CAOC	OU	Description of Structure / Activity	Start Date	Completion Date	Activities in this area or changes in site use coordinated through and reviewed by the MCLB Barstow Environmental Department?
YERMO ANNEX					
17	1	90 day storage facility expanded	9/4/2007	11/4/2007	Yes
NEBO MAIN BASE					
11	2	New 2-story concrete/cinder block building (Building 373) used for Fire Department training	9/29/2004	5/5/2007	Yes
14	2	Drainage channel improvements (concrete lining)	3/6/2007	6/6/2007	Yes

Abbreviations and Acronyms:
CAOC – CERCLA Area of Concern
CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act
MCLB – Marine Corps Logistics Base
OU – Operable Unit

TABLE 8-1

ISSUES AT YERMO ANNEX

CAOC	OU	Issue	Currently Affects Protectiveness (Y/N)	Affects Future Protectiveness (Y/N)
15/17	5	None	N/A	N/A
16	5	None (see under CAOC 37 for CAOC 16 AS/SVE)	N/A	N/A
18	3	None	N/A	N/A
20	3	Gross alpha concentrations in groundwater in the upgradient and cross-gradient wells exhibit exceedances (Note: Downgradient well gross alpha concentration during 2005 was less than the respective MCL.)	N	Y
21	3	None	N/A	N/A
23	3	None	N/A	N/A
26	5	None (see under CAOC 37 for CAOC 26 AS/SVE)	N/A	N/A
34	3	None	N/A	N/A
35	5	None	N/A	N/A
37	1	CAOC 16 – no reduction in dissolved VOCs within the zone of AS influence at CAOC 16 and downgradient of CAOC 35, likely due to inadequate number of AS wells.	N	N
37	1	GETS – malfunctioning of groundwater extraction well pumps likely affecting the Yermo North plume capture.	N	Y
37	1	Aging CAOC 16 AS/SVE system and GETS affecting the system's performance as well as resulting in an increase in O&M costs.	N	Y

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
N/A – not applicable
O&M – Operations and Maintenance
OU – Operable Unit
VOC – volatile organic compound
Y/N – yes/no

TABLE 8-2

ISSUES AT NEBO MAIN BASE

CAOC	OU	Issue	Currently Affects Protectiveness (Y/N)	Affects Future Protectiveness (Y/N)
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	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.	N	Y
11	4	None	N/A	N/A
14	6	None	N/A	N/A
38	2	TCE concentrations in NPZ-14, which is a few thousand feet away from the identified Nebo South dissolved VOC plume, continue to show levels of TCE above MCLs.	N	N
38	2	Aging CAOC 6 AS/SVE system could affect system performance and may result in an increase in O&M costs.	N	Y

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
O&M – Operations and Maintenance
OU – Operable Unit
TCE – trichloroethene
VOC – volatile organic compound
Y/N – yes/no

TABLE 9-1

RECOMMENDATIONS AND FOLLOW-UP ACTIONS AT YERMO ANNEX

CAOC	OU	Issue	Recommendations/Follow-up Actions	Milestone Date	Affects Protectiveness? (Y/N)	
					Current	Future
15/17	5	None	None	N/A	N/A	N/A
16	5	None (see under CAOC 37 for CAOC 16 AS/SVE)	None	N/A	N/A	N/A
18	3	None	None	N/A	N/A	N/A
20	3	Gross alpha concentrations in groundwater in the upgradient and cross-gradient wells exhibit exceedances (Note: Downgradient well gross alpha concentration during 2005 was less than the respective MCL.)	Additional investigations to further evaluate these exceedances. 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 be proposed after consultation with the FFA signatories.	December 2008	N	Y
21	3	None	None	N/A	N/A	N/A
23	3	None	None	N/A	N/A	N/A
26	5	None	None	N/A	N/A	N/A
34	3	None	None	N/A	N/A	N/A
35	5	None	None	N/A	N/A	N/A
37	1	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	N	Y
37	1	Effectiveness of GETS in containing the Yermo North Plume	1. Evaluate deepening of well GEW-8 to improve containment. 2. Evaluate the need for additional AS wells for the CAOC 16 system to augment the GETS. 3. Procure spare pumps for faster replacement in case of potential pump malfunctioning.	December 2008	N	Y
37	1	Aging system components (CAOC 37 GETS and CAOC 6 and 16 AS / SVE Systems)	Evaluate the possibility of replacing system components and the associated impact vs. continuing to service and repair the existing system components.	December 2008	N	Y

TABLE 9-1

RECOMMENDATIONS AND FOLLOW-UP ACTIONS AT YERMO ANNEX

Abbreviations and Acronyms:

AS/ SVE – air sparging/ – soil vapor extraction
CAOC – CERCLA Area of Concern
CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act
GAC – granular activated carbon
N/A – not applicable
OU – Operable Unit
O&M – Operation and Maintenance
VOC – volatile organic compound
Y/N – yes/no

TABLE 9-2

RECOMMENDATIONS AND FOLLOW-UP ACTIONS AT NEBO MAIN BASE

CAOC	OU	Issue	Recommendations/ Follow-up Actions	Milestone Date	Affects Protectiveness? (Y/N)	
					Current	Future
1	6	None	None	N/A	N/A	N/A
2	4	None	None	N/A	N/A	N/A
3	6	None	None	N/A	N/A	N/A
5	4	None	None	N/A	N/A	N/A
7	6	TCE concentrations in one downgradient well (NSP-2) have exceeded the MCL over the past three events.	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	N	Y*
11	4	None	None	N/A	N/A	N/A
14	6	None	None	N/A	N/A	N/A
38	2	Aging CAOC 6 AS/SVE system could affect system performance and may result in an increase in O&M costs.	Evaluate the possibility of replacing system components and the associated impact vs. continuing to service and repair the existing system components.	December 2008	N	Y
38	2	NPZ-14 TCE detects	Monitor annually. Additional investigations may be necessary if TCE concentrations continue to remain above MCL.	December 2009	N	N

Note:

* after fence is repaired

Abbreviations and Acronyms:

AS/SVE – air sparging/soil vapor extraction
CAOC – CERCLA Area of Concern
CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act
FFA – Federal Facility Agreement
MCL – maximum contaminant level
N/A – not applicable
OU – Operable Unit
TCE – trichloroethene
Y/N – yes/no