Fourth Five-Year Review Report for the General Services Area Operable Unit at Lawrence Livermore National Laboratory Site 300

Authors:
R. Villarreal*
A. Verce*
D. Loll
L. Ferry
V. Madrid
T. Carlsen

Contributors:
D. Ardary*
G. Lorega
J. McKaskey*

September 2017

*Weiss Associates, Emeryville, California
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Environmental Restoration Department
Certification

I certify that the work presented in this report was performed under my supervision. To the best of my knowledge, the data contained herein are true and accurate, and the work was performed in accordance with professional standards.

Victor Madrid
California Registered Geologist
No. 5051
License expires: April 30, 2018
California Certified Hydrogeologist
No. 378
License expires: April 30, 2018
Approval for the
Fourth Five-Year Review Report for the
General Services Area Operable Unit at
Lawrence Livermore National Laboratory Site 300

Prepared by:

The United States Department of Energy
Livermore Field Office
Livermore, California

Approved:

[Signature]

Ariel Robertson
Site 300 Remedial Project Manager
U.S. Department of Energy
National Nuclear Security Administration
Livermore Field Office
Ariel Robertson  
Remedial Project Manager  
Livermore Environmental Programs Division  
Lawrence Livermore National Laboratory  
P.O. Box 808, L-574  
Livermore, California 94551

Re: U.S. EPA Concurrence with the Final Fourth Five-Year Review Report for Lawrence Livermore National Laboratory Site 300, General Services Area OU, September 2017

Dear Ms. Robertson:

The U.S. Environmental Protection Agency (EPA) has reviewed the Final Fourth Five-Year Review Report for the Lawrence Livermore National Laboratory (LLNL), Site 300 ("Site 300"), General Services Area ("GSA") OU dated September 2017 ("Report").

EPA has concluded that protectiveness cannot be fully determined until further information is obtained. Specifically, EPA must defer its long-term protectiveness determination until the DOE completes a vapor intrusion (VI) pathways analysis utilizing EPA’s 2015 Vapor Intrusion Screening Level (VISL) Guidance ("Guidance"), as recommended in the Final Fourth Five-Year Review, and all significant VI issues have been satisfactorily characterized and addressed pursuant to the Guidance.

On the basis of the information presented in the Final Fourth Five-Year Review, EPA has made the following short-term protectiveness determination:

The remedy at the LLNL Site GSA OU is considered protective of human health and the environment in the short term because Land Use Controls ("LUCs") are in place and there is no known current exposure to site contamination. To be protective in the long term, however, if the VI pathways analysis determines that there is VI risk related to the on-site buildings additional LUCs will have to be put in place to prevent exposure pathways until such time it is demonstrated that there no longer is a risk to human health from unrestricted use and unlimited exposure scenarios.
The Report also identifies seven additional recommendations which will be implemented as part of the routine administrative or programmatic processes that are already in place to optimize the operation of the remedy. Since these optimization activities do not implicate remedy protectiveness, EPA does not include them as Five-Year Review protectiveness issues.

EPA appreciates LLNL’s continued efforts to work closely with us to ensure that the remedies at the Site 300 are protective of human health and the environment now and in the future. We look forward to receiving the VISL evaluation work plan by December 30, 2017, addressing the matter with the agreed upon approach. Given the potential gravity of the health risk to on-site workers, EPA requests completion of the VISL evaluation by December 1, 2019. If you have any questions regarding this letter, please feel free to contact Andrew Bain at (415) 972-3167.

Sincerely,

[Signature]

Angeles Herrera
Assistant Director, Superfund Division
Federal Facilities and Site Cleanup Branch

Cc by Email:
Peter McKeregan, LLNL
Emily Mortazavi, DTSC
Nathan King, SFRWQCB
# Five-Year Review Summary Form

## SITE IDENTIFICATION

- **Site name:** Lawrence Livermore National Laboratory Site 300, General Services Area Operable Unit (OU) 1
- **EPA ID:** CA 2890090002
- **Region:** IX
- **State:** California
- **City/County:** San Joaquin/Alameda

## SITE STATUS

- **NPL status:** Final
- **Multiple OUs:** Yes
- **Has the site achieved construction completion?** Yes
- **Construction completion date:** June 2005

## REVIEW STATUS

- **Lead agency:** United States (U.S.) Department of Energy (DOE)/National Nuclear Security Administration (NNSA)
- **Author name:** R. Villarreal
- **Author title:** Site 300 Project Hydrogeologist
- **Author affiliation:** Weiss Associates Emeryville, California
- **Review period:** January 2011 to December 2015
- **Date(s) of site inspections:** March 22, 2016
- **Type of review:** Statutory
- **Review number:** 4
- **Triggering action date:** Final Record of Decision for the General Services Area OU
- **Due date:** December 14, 2016 (Final)
Five-Year Review Summary Form (continued)

### ISSUES/RECOMMENDATIONS

<table>
<thead>
<tr>
<th>OU(s) without Issues/Recommendations Identified in the Five-Year Review:</th>
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<tbody>
<tr>
<td>Not applicable.</td>
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<tr>
<th>Issues/Recommendations Identified in the Five-Year Review:</th>
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<tbody>
<tr>
<td><strong>OU(s):</strong> General Services Area OU (1)</td>
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<td><strong>Issue Category:</strong> No Issue</td>
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**Issue:** Although no deficiencies or issues were identified with groundwater and soil vapor extraction and treatment and monitoring portion of the General Services Area (GSA) OU remedy, the following recommendations/follow-up actions were developed by DOE/NNSA to further optimize Central GSA extraction and treatment system operations.

**Recommendation #1:** Complete optimization of the Central GSA groundwater and soil vapor extraction and treatment systems including conducting: (1) pneumatic and hydraulic communication testing, (2) additional vapor rebound testing, and (3) periodic reconfiguration of the pumping from soil vapor and dual-phase groundwater-soil vapor extraction wells. As discussed in Section 6.4.1.2, planned upgrades to the Central GSA treatment systems will provide additional data that can be used to refine the extent of hydraulic capture zones, further optimize extraction wellfield operation to maximize volatile organic compound (VOC) mass removal, and more rigorously estimate the remaining vapor phase source term.

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<tr>
<td><strong>Issue:</strong> Although no deficiencies or issues were identified with the groundwater and soil vapor extraction and treatment and monitoring portion of the General Services Area (GSA) OU remedy, the following recommendations/follow-up actions were developed by DOE/NNSA to better delineate the vertical distribution of VOCs in off-site Qal-Tns c1 hydrostratigraphic unit (HSU) groundwater. Although the installation of additional off-site monitoring wells is recommended, DOE/LLNL does not consider this a remedy deficiency or protectiveness issue. The performance measures for the remedy are the continued absence of detections of COCs in downgradient guard wells, indicating that there is no migration of COCs. This demonstrates that the remedy continues to be protective. The purpose of recommendations to improve performance monitoring is to further demonstrate that the remedy is effective.</td>
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| **Recommendation #2:** Installation of two off-site monitor wells upgradient of W-35A-01. These wells would be installed as a well pair with one well screened within the Qal stratigraphic unit and the second well installed in the underlying Tnbs 2 bedrock unit. The objective of installing these wells is to provide data to better delineate the vertical distribution of dissolved-phase VOCs in off-site groundwater in the Qal and Tnbs 2 downgradient of the Building 875 dry well pad. Because these wells would be located off site, implementation of this recommendation is contingent on receiving the property owner’s permission and other relevant permits, as necessary. |

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\(^a\) Because the new wells proposed in Recommendation #2 would be located off site, the schedule for implementation of this recommendation is contingent on the timely receipt of the property owner’s permission and other relevant permits, as necessary, and funding.
### Five-Year Review Summary Form (continued)

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<tr>
<td>Issue: NA</td>
<td>Recommendation #3: Remove 1,1,1-trichloroethane (1,1,1-TCA) as a groundwater contaminant of concern (COC) because: (1) concentrations of 1,1,1-TCA decreased to and have remained below its 200 µg/L Maximum Contaminant Level (MCL) cleanup standard in all Qt-Tnsc1 and Qal-Tnbs1 hydrostratigraphic unit (HSU) wells since 1994, and (2) 1,1,1-TCA has never been detected above the 0.5 µg/L reporting limit in any samples from Tnbs1 HSU wells. However, groundwater samples from GSA monitor wells would still be analyzed for volatile organic compounds (VOCs), including 1,1,1-TCA, by EPA Method 624. 1,1,1-TCA detections would still be reported/discussed in Compliance Monitoring Reports, but would no longer be discussed in the Contaminant Concentrations and Distribution section of these reports unless it is detected above the 200 µg/L MCL.</td>
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**Recommendation #4:** Remove bromodichloromethane as a groundwater COC because: (1) concentrations of total trihalomethanes (TTHMs), comprised of bromoform, chloroform, bromodichloromethane, and dibromochloromethane, have never been detected at or above the 80 µg/L MCL cleanup standard in any Qt-Tnsc1 or Qal-Tnbs1 HSU wells, and (2) concentrations of TTHMs decreased to and have remained below the 80 µg/L MCL cleanup standard in Tnbs1 wells since 2005. However, groundwater samples from GSA monitor wells would still be analyzed for VOCs, including bromodichloromethane, by EPA Method 624. Bromodichloromethane detections would still be reported/discussed in Compliance Monitoring Reports, but would no longer be discussed in the Contaminant Concentrations and Distribution section of these reports unless TTHMs are detected above the 80 µg/L MCL.

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**Recommendation #5:** Remove chloroform as a groundwater COC because:
1. Concentrations of TTHMs have never been detected at or above the 80 µg/L MCL cleanup standard in any Qt-Tnsc₁ or Qal-Tnbs₁ HSU wells, and
2. Concentrations of TTHMs decreased to and have remained below the 80 µg/L MCL cleanup standard in Tnbs₁ wells since 2005. However, groundwater samples from GSA monitor wells would still be analyzed for VOCs, including chloroform, by EPA Method 624. Chloroform detections would still be reported/discussed in Compliance Monitoring Reports, but would no longer be discussed in the Contaminant Concentrations and Distribution section of these reports unless TTHMs are detected above the 80 µg/L MCL.

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<tr>
<td><strong>Recommendation #6:</strong> Remove trichlorofluoromethane (Freon 11) as a groundwater COC because: (1) concentrations of Freon 11 decreased to and have remained below its 150 µg/L MCL cleanup standard in all Qt-Tnsco and Qal-Tnbs1 HSU wells since 1990, and (2) Freon 11 has never been detected above the 0.5 µg/L reporting limit in any samples from Tnbs1 HSU wells. However, groundwater samples from GSA monitor wells would still be analyzed for VOCs, including Freon 11, by EPA Method 624. Freon 11 detections would still be reported/discussed in Compliance Monitoring Reports, but would no longer be discussed in the Contaminant Concentrations and Distribution section of these reports unless it is detected above the 150 µg/L MCL.</td>
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**Recommendation #7:** Remove 1,1,2-trichloro-1,2,2-trifluoroethane (Freon 113) as a groundwater COC because: (1) Freon 113 has never been detected above its 1,200 µg/L MCL cleanup standard in any Qt-Tnsc₁, Qal-Tnbs₁, or Tnbs₁ HSU wells since 1987. However, groundwater samples from GSA monitor wells would still be analyzed for VOCs, including Freon 113, by EPA Method 624. Freon 113 detections would still be reported/discussed in Compliance Monitoring Reports, but would no longer be discussed in the Contaminant Concentrations and Distribution section of these reports unless it is detected above the 1,200 µg/L MCL.

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<th>Recommendation #8:</th>
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<tr>
<td>General Services Area OU (1)</td>
<td>This recommendation to re-evaluate potential VOC vapor inhalation risk in buildings in the vicinity of VOC soil and groundwater contamination is based on discussions with EPA regarding the release of EPA’s new vapor intrusion screening level calculation tool.</td>
<td>On October 18, 2016, a meeting was held between DOE/LLNL, the U.S. EPA, the California DTSC, and the RWQCB to discuss methods to perform VOC vapor intrusion pathway analysis in light of the recent release of EPA’s vapor intrusion screening level calculation tool, and DOE/LLNL’s vapor intrusion risk calculation methodologies used to date. However, there is an active soil vapor extraction system in close proximity to buildings where there are elevated concentrations of VOC contamination in the subsurface and the new methodology does not affect the protectiveness of the remedy.</td>
<td>As a result of this meeting/discussion, DOE agreed to conduct an analysis and develop a prioritized list for re-evaluation of potential VOC inhalation risk in buildings in the vicinity of VOC soil and groundwater contamination in the GSA OU (and at all other potential vapor intrusion sites at Site 300). A schedule for implementing a pilot program based on the prioritized list during the next five-year review period will also be developed.</td>
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* Milestone is contingent upon receiving adequate funding to conduct the vapor intrusion evaluation and obtaining DOE/regulatory concurrence on the evaluation methodology by 2019.
PROTECTIVENESS STATEMENT

**OU:** General Services Area OU (1)  
**Protectiveness Determination:** Deferred  
**Addendum Due Date:** NA

**Protectiveness Statement:** The remedy at the GSA OU currently protects human health and the environment in the short-term because there is no current exposure to site contamination and remedial treatment systems are effectively treating groundwater and soil vapor. Exposure pathways that could result in an unacceptable risk to on-site workers are being controlled by the implementation of land use and institutional controls, the Health and Safety Plan, and the Contingency Plan. The Eastern GSA VOC plume in the vicinity of off-site water-supply wells has been remediated to meet cleanup standards. However, in order for the remedy to be protective in the long-term, EPA requested that an additional institutional control be implemented to prevent potential future exposure to off-site groundwater contamination if a new water-supply well were to be installed in the off-site portion of the Central GSA VOC plume. The additional institutional control is discussed in Section 4.5.1.1 (Governmental Institutional Controls), and listed in #12 below.

The remedy protects human health because:

1. Groundwater remediation in the Eastern GSA has successfully reduced concentrations of trichloroethene (TCE) and other VOCs to below Maximum Contaminant Level (MCL) cleanup standards and is therefore protective of on-site and off-site groundwater and off-site private water-supply wells CDF1 and CON1, located downgradient of the Eastern GSA.

2. The risk associated with the migration of TCE vapors into Building 875 and subsequent inhalation by on-site workers has been mitigated by soil vapor extraction at the Building 875 dry well release site. While EPA issued new risk assessment guidance for indoor air vapor intrusion pathway in June 2015, there is an active soil vapor extraction system in close proximity to buildings where there are elevated concentrations of VOC contamination in the subsurface and the new methodology does not affect the protectiveness of the remedy.

3. Groundwater and soil vapor extraction and treatment in the Central GSA are effectively reducing VOC concentrations in groundwater and the vadose zone towards cleanup standards. Institutional/land use controls described in Sections 4.5.1.1, 4.1.1.2, and 4.5.1.4 are in-place to prevent exposure to VOCs in on-site subsurface soil and groundwater until cleanup standards are achieved.

4. Institutional controls (Section 4.1.1.2) control excavation activities to prevent on-site worker exposure to VOCs in (on-site) subsurface soil in the Central GSA until it can be verified that concentrations do not pose an exposure risk to on-site workers. VOCs are not an issue in off-site soil; therefore, no institutional/land use controls are needed for off-site soil.

5. Monitoring of VOCs in Central GSA groundwater will provide an early indication of changes in the concentrations/activities and/or lateral and vertical extent of these constituents that could impact human health or the environment. As indicated in the Site-Wide Contingency Plan (Dibley et al., 2009), if groundwater contaminant concentrations...
PROTECTIVENESS STATEMENT (Continued)

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(i.e., VOC concentrations in Central GSA groundwater) increases in a consistent and significant manner for reasons not attributable to remediation efforts (e.g., cyclic pumping), or natural aquifer or laboratory variables, DOE will notify the regulatory agencies and modifications to the remedial action (including land use controls) will be considered as necessary to protect human health.

6. Institutional controls (Section 4.5.1.1) prohibit the drilling of an on-site water-supply well in areas of contaminated groundwater with concentrations exceeding drinking water MCL groundwater cleanup standards. These institutional controls will remain in place until VOC concentrations are reduced to below cleanup standards in on-site groundwater.

7. VOC contamination emanating from the Central GSA is currently present at concentrations above groundwater cleanup standards in only two off-site monitor wells W-35A-01 and W-35A-10, located on Corral Hollow Ranch property. Ongoing remediation is reducing VOC concentrations in these wells and the off-site plume is stable.

8. Monitor wells W-35A-01 and W-35A-10 are located 1,000 ft upgradient from the nearest downgradient off-site water-supply wells CDF1 and CON1 and there are six monitor wells located downgradient of the Central GSA plume and upgradient of wells CDF1 and CON1 in which no VOCs are detected. These six wells are monitored regularly to provide an early indication of any migration of the Central GSA VOC plume toward the CDF1 and CON1 water-supply wells. As discussed in #4 above, per the Site-Wide Contingency Plan, if VOC concentrations or extent in off-site groundwater increase in a consistent and significant manner for reasons not attributable to remediation efforts, DOE will notify the regulatory agencies and modifications to the remedial action (including land use controls) will be considered as necessary to protect human health.

9. There is a mechanism for controlling exposure to VOCs in the downgradient water-supply wells CDF1 and CON1 should VOCs migrate from the Central GSA to these wells in the form of the 1991 Settlement Agreement between DOE and the water-supply well owner (Union Livestock) in which DOE agreed to:

• Install a replacement water-supply well in the event that water-supply wells CDF1 and CON1 become contaminated with VOCs from LLNL Site 300.

• Decommission wells CDF1 and CON1 after a replacement well is installed.

• Monitor CDF1 and CON1 for VOCs.

However, this proprietary institutional control is not currently necessary to prevent the consumption of contamination groundwater from the current or future water-supply wells on Union Livestock property because: (1) VOC concentrations in Eastern GSA on-site and off-site groundwater have been reduced to below groundwater cleanup standards, and (2) the Central GSA VOC plume is not currently present on or near the Union Livestock property or their water-supply wells CDF1 and CON1.
PROTECTIVENESS STATEMENT (Continued)

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10. Private off-site water-supply well GALLO1 is located on Corral Hollow Ranch property approximately 2,200 ft upgradient of the off-site portion of the VOC plume from the Central GSA, and therefore is not at risk of being contaminated by the Central GSA VOC plume.

11. As discussed in Governmental Institutional Controls Section 4.5.1.1, the San Joaquin County Ordinance Code, Section 9-1115 regulates the location, construction, repair and destruction of water-supply wells, and requires the drilling, alteration, or destruction of any wells in the county without a permit from the SJC EHD. Well construction/alteration and destruction permits require that all water wells are to be located an adequate horizontal distance from known or potential sources of pollution and contamination, including biological and chemical sources. The SJC EHD also requires that aquifer isolation is maintained during the drilling and well construction process to prevent cross contamination of aquifers. The threat of criminal sanctions for a failure to comply serves as a significant deterrent to the unlicensed drilling of wells. These measures will control the risk of exposure to contaminated groundwater by preventing the drilling of an off-site water-supply well within the footprint of the off-site VOC plume emanating from the Central GSA onto Corral Hollow Ranch until cleanup is complete.

12. Institutional/land use controls are in place and functioning as intended to prevent exposure. No current or planned changes in land use at the site suggest that they are not or would not be effective.

13. No new contaminant releases have been identified for the GSA OU, and continued detection monitoring will provide an indication of any future releases.

14. Exposure pathways that could result in unacceptable risk to on-site workers are being controlled by the implementation of land use/institutional controls, the Health and Safety Plan, and the Contingency Plan.

The cleanup standards for GSA OU groundwater are MCLs. Because MCL-based standards do not differentiate between industrial and residential use, the groundwater cleanup remedy will be protective under any land use scenario. The cleanup standards for VOCs in subsurface soil are to reduce concentrations to mitigate risk to on-site workers to less than a $1 \times 10^{-6}$ excess cancer risk and prevent further impacts to groundwater to the extent technically and economically feasible. Because some VOCs may remain in subsurface soil following the achievement of these cleanup standards, a land use control prohibits the transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use.

The Site 300 Federal Facility Agreement (FFA) is an enforceable agreement that prohibits DOE from transferring lands with unmitigated contamination that could cause potential harm unless it complies with the requirements of Section 120(h) of CERCLA, 42 U.S.C. 9620(h) and requirements for notification and protection of the integrity of the remedy set forth in Section 28.
## PROTECTIVENESS STATEMENT (Continued)

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of the FFA. In the event that the Site 300 property is transferred in the future, DOE will execute a land use covenant at the time of transfer in compliance with Title 22 California Code of Regulations Division 4.5, Chapter 39, Section 67391.1 as specified in the Site 300 Site-Wide ROD, and will implement deed restrictions per CERCLA 120(h). These land use controls will remain in place unless and until a risk assessment is performed in accordance with current U.S. EPA risk assessment guidance and the DOE/NNSA, U.S. EPA, the California Department of Toxic Substances Control, and the Regional Water Quality Control Board agree that it adequately shows that no unacceptable risk is present for residential or unrestricted land use.
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Appendix A

Appendix A1. General Services Area OU Five-Year Review Inspection Checklist
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Appendix A2. General Services Area OU Five-Year Review Site Inspection Checklist

Appendix B

Appendix B1. Responses to Regulatory Comments on the Draft Five-Year Review

Appendix B2. Responses to Regulatory Comments on the Draft Final Five-Year Review

Appendix C

Appendix C. Fourth Five-Year Review Addendum
1. Introduction

The United States (U.S.) Department of Energy/National Nuclear Security Administration (DOE/NNSA) has conducted a five-year review of the remedial actions implemented at the General Services Area (GSA) operable unit (OU) at Lawrence Livermore National Laboratory (LLNL) Site 300. Environmental cleanup is conducted under the oversight of the U.S. Environmental Protection Agency (U.S. EPA), the California Department of Toxic Substances Control (DTSC), and the California Regional Water Quality Control Board (RWQCB) – Central Valley Region. DOE is the lead agency for environmental restoration at LLNL. The review documented in this report was conducted from January 1, 2011 to December 31, 2015. Parties providing analyses in support of the review include:

- DOE/NNSA, Livermore Field Office.
- LLNL, Environmental Restoration Department (ERD).
- Weiss Associates.

The purpose of a five-year review is to evaluate the implementation and performance of a remedy to determine whether the remedy is currently protective and will continue to be protective of human health and the environment. The five-year review report presents the methods, findings, and conclusions of the review. In addition, the five-year review identifies issues or deficiencies in the selected remedy, if any, and presents recommendations to address them. The format and content of this document is consistent with guidance issued by DOE (U.S. DOE, 2002) and the U.S. EPA (U.S. EPA, 2001).

DOE is preparing this five-year review for the GSA OU (OU 1) pursuant to Section 121 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendment Reauthorization Act (SARA), which requires that remedial actions resulting in any hazardous substances, pollutants, or contaminants remaining at the site be subject to a five-year review. The National Contingency Plan 40 Code of Federal Regulations Section 300.430(f)(4)(ii) further provides that remedial actions which result in any hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure be reviewed every five years to ensure protection of human health and the environment. Consistent with Executive Order 12580, Federal agencies are responsible for ensuring that five-year reviews are conducted at sites owned or operated/controlled (as appropriate) by them where five-year reviews are required or appropriate.

LLNL Site 300 is a DOE/NNSA experimental test facility currently operated by the Lawrence Livermore National Security (LLNS), Limited Liability Corporation. The CERCLA site encompasses both the property occupied by LLNL (“Facility Property”) and properties to the south and east which are potentially affected by contamination from the Facility Property. The Facility Property is considered “on site” throughout this document and “off site” is considered outside of the boundaries of the Facility Property.

Site 300 is located in the Eastern Altamont Hills 17 miles east of Livermore, California (Figure 1). At Site 300, DOE/NNSA conducts research development, and testing associated with high explosive materials. Historic Site 300 operations involved the release of a number of contaminants to the environment. To effectively manage site cleanup, nine OUs have been designated at LLNL Site 300 based on the nature and extent of contamination (Figure 2):
GSA (OU 1) including the Central and Eastern GSA.

Building 834 (OU 2).

Pit 6 Landfill (OU 3).

High Explosives (HE) Process Area (OU 4) including Building 815, the HE Lagoons, and the HE Burn Pit.

Building 850/Pit 7 Complex (OU 5).

Building 854 (OU 6).

Building 832 Canyon (OU 7) including Buildings 830 and 832.

Site-Wide (OU 8) including Buildings 801, 833, 845, and 851 and the Pit 2, 8, and 9 Landfills.

Building 812 (OU 9).

Characterization is underway at the Building 865 area, and preparation of a Remedial Investigation/Feasibility Study (RI/FS) report will be prepared once the regulatory agencies concur that characterization is complete in the Building 865 area. A Proposed Plan will subsequently present the alternatives and a preferred remedy for public comment. A remedy will then be selected in an Amendment to the Site-Wide Record of Decision (ROD). Based on the selected remedy, the Building 865 area may either be incorporated into OU 8 or designated as a separate OU.

Five-year reviews are currently conducted individually for each OU at Site 300, except for OUs 3 and 8. The date of actual remedial action on-site construction, assumed to be the signature date of February 5, 1997 for the GSA OU Final Record of Decision (ROD) (U.S. DOE, 1997) was the trigger for the start of the first five-year review period. At the other OUs where construction began prior to the Site-Wide ROD as treatability studies and/or removal actions, DOE and the regulatory agencies agreed to use the completion of the OU-specific Remedial Design report as the trigger for start of the first five-year review period.

This is the fourth Five-Year Review for the GSA OU. This review is considered a statutory review because: (1) contamination will remain on site upon completion of the remedial action, (2) the Record of Decision was signed after October 17, 1986 (the effective date of the SARA), and (3) the remedial action was selected under CERCLA.

The First, Second, and Third Five-Year Reviews were completed in 2001 (Ferry et al., 2001), 2006 (Dibley et al., 2006), and 2011 (Valett et al., 2011), respectively.

Section 1.1 through 1.9 include the descriptions and status of the other OUs and areas where environmental restoration activities are occurring at Site 300. Section 2 presents the chronology of significant environmental restoration events at the GSA OU. Section 3 presents background and description for the GSA OU. Section 4 discusses remedial actions selected and implemented in the GSA OU, and progress towards meeting remedial action objectives and cleanup standards. Section 5 discusses remediation progress since the last (2011) Five-Year Review for the GSA OU. Sections 6 and 7 provide a discussion of the five-year review process and the technical assessment of the remedy function and protectiveness, respectively. Section 8 presents issues identified during the review process and Section 9 provides recommendations to address those issues. Section 10 summarizes the protectiveness of the remedy for the GSA OU.
Section 11 presents the schedule for the next review. References cited and acronyms and abbreviations used in the report are included in Sections 12 and 13, respectively.

1.1. **Building 834 (OU2)**

From 1962 to 1978, intermittent spills and piping leaks resulted in contamination of the subsurface soil and rock and groundwater with volatile organic compounds (VOCs) and silicone oils (tetrabutyl orthosilicate/tetrakis (2-ethylbutyl) silane [TBOS/TKEBs]). Nitrate in groundwater results from septic system effluent but may also have natural sources. There are no contaminants of concern (COCs) in surface soil.

Completed remedial activities include excavating VOC-contaminated soil (1983) and installing a surface water drainage system to prevent rainwater infiltration in the contaminant source area (1998). Groundwater and soil vapor extraction and treatment began in 1986 as treatability studies. An area-specific Interim ROD for the Building 834 OU (U.S. DOE, 1995) was superseded by the Interim Site-Wide ROD (U.S. DOE, 2001) and subsequent 2008 Site-Wide ROD (U.S. DOE, 2008). The Building 834 OU remedy includes monitoring, risk and hazard management including land use controls, and groundwater and soil vapor extraction and treatment. Significant in situ bioremediation is occurring in Building 834 groundwater and a treatability study was conducted that focused on understanding and enhancing this process. The remedial design was completed in 2002 and construction completion for the OU was achieved in September 2005.

Remediation has reduced VOC concentrations in groundwater from a historic maximum of 1,100,000 micrograms per liter (µg/L) (March 1988) to a 2015 maximum of 69,000 µg/L. TBOS/TKEBs in groundwater have also been reduced from a historic maximum concentration of 7,300,000 µg/L in 1995 to a 2015 maximum of 73 µg/L. While nitrate concentrations have decreased from a historic maximum of 749 milligrams per liter (mg/L) in 2000 to a 2015 maximum of 330 mg/L, the elevated nitrate concentrations continue to indicate an ongoing source of groundwater nitrate. Sources of nitrate at Building 834 include the septic system leach field located in the vicinity of well W-834-S1, and naturally occurring nitrate in soil. Nitrogenous compounds, like nitric acid or barium nitrate, might also have inadvertently been discharged into the septic system via a test cell floor drain. Facultative anaerobic bacteria in the Building 834 Core and T2 areas reduce nitrate locally by denitrification.

DOE has performed three Five-Year Reviews for the Building 834 OU (Ferry et al., 2002a, Dibley et al., 2007a, and Valett et al., 2012). The next (Fourth) Five-Year Review Report is scheduled for completion in 2017.

1.2. **Pit 6 Landfill (OU3)**

From 1964 to 1973, approximately 1,900 cubic yards (yd³) of waste from LLNL Livermore Site and Lawrence Berkeley Laboratory were buried in nine unlined trenches and animal pits at the Pit 6 Landfill. Infiltrating rainwater leached contaminants from pit waste resulting in tritium, VOC, and perchlorate contamination in groundwater. Nitrate contamination in groundwater results from septic system effluent. No COCs were identified in surface or subsurface soil.

In 1971, DOE excavated portions of the waste contaminated with depleted uranium. From 1973 to 1997, no waste was placed in the Pit 6 Landfill. In 1997, a landfill cap was installed as a
CERCLA removal action to prevent infiltrating precipitation from further leaching contaminants from the waste. Because of decreasing VOC concentrations in groundwater, the presence of trichloroethylene (TCE) degradation products, and the short half-life of tritium (12.3 years), the selected remedy for VOCs and tritium at the Pit 6 Landfill is monitored natural attenuation (MNA). Because groundwater monitoring data for perchlorate and nitrate were limited, DOE/NNSA continued to monitor groundwater to determine if and when an active remedy for these contaminants might be necessary. The remedy also includes risk and hazard management. Construction completion was achieved in October 2002. No remedial design document was required for this area.

The extent of contamination at the Pit 6 Landfill is limited and continues to decrease with concentrations/activities near and below cleanup standards. Natural attenuation has reduced total VOCs in groundwater from a historic maximum of 250 µg/L in 1988 to a 2015 maximum of 5.6 µg/L, consisting entirely of TCE. Tritium activities are well below the Maximum Contaminant Limit (MCL) cleanup standard and continue to decrease towards background levels. Perchlorate in groundwater has been reduced from a historic maximum concentration of 65 µg/L in 1998 to a 2015 maximum of 7.9 µg/L. The extent of nitrate at concentrations exceeding the MCL cleanup standard continues to be limited to one well located near a septic system. Installation of the landfill cap mitigated the on-site worker inhalation risk. There is no evidence of new contaminant releases from the Pit 6 Landfill indicated by the groundwater detection monitoring data.

DOE has performed one five-year review for this OU in 2013 (Buscheck et al., 2013). The next Five-Year Review Report is scheduled for completion in 2018.

1.3. High Explosives (HE) Process Area (OU4)

From 1958 to 1986, surface spills at the drum storage and dispensing area for the former Building 815 steam plant resulted in the release of VOCs to groundwater, subsurface soil, and bedrock. HE compounds, nitrate, and perchlorate detected in groundwater are attributed to wastewater discharges to former unlined rinse water lagoons that occurred from the 1950s to 1985. VOCs, nitrate, and perchlorate have also been identified as COCs in groundwater near the former HE Burn Pits. VOCs have been identified as COCs in surface water at Spring 5. HE compounds are the COCs in surface soil. HE compounds and VOCs are the COCs in subsurface soil. No further action was selected as the remedy for VOCs and High Melting Explosive (HMX) in surface and subsurface soil.

The HE Open Burn Facility was capped under the Resource Conservation and Recovery Act (RCRA) in 1998. In 1999, DOE implemented a CERCLA removal action to extract groundwater at the site boundary and prevent off-site TCE migration. The HE Process Area remedy selected in the Site-Wide ROD includes: (1) groundwater extraction and treatment for VOCs, HE compounds, and perchlorate, and (2) MNA for nitrate (except at Building 829 where nitrate is extracted and treated), (3) monitoring, and (4) risk and hazard management including land use controls. The remedial design was completed in 2002. Construction completion for the OU was achieved in September 2007. Five groundwater extraction and treatment systems currently operate in the OU. In 2013, use of the Building 829-Source groundwater treatment system was discontinued due to intermittent flow and very low production. Groundwater extracted from the
Building 829 source area is stored and transported to the Building 815-Source facility for treatment.

Groundwater remediation efforts have reduced total VOC concentrations from a historic maximum of 1,013 µg/L in 1993 to a 2015 maximum of 35 µg/L. Perchlorate concentrations have decreased from a historic maximum of 50 µg/L in 1998 to a 2015 maximum of 32 µg/L. Research Department Explosive (RDX) in groundwater has been reduced from a maximum historic concentration of 350 µg/L in 1988 to a 2015 maximum of 74 µg/L. Natural denitrification processes are reducing nitrate concentrations in groundwater to background levels. Remediation has also mitigated risk to on-site workers in the HE Process Area OU.

DOE has performed two Five-Year Reviews for the HE Process Area OU (Dibley et al., 2007b and Helmig et al., 2012). The next (Third) Five-Year Review Report is scheduled for completion in 2017.

1.4. **Building 850/Pit 7 Landfill Complex (OU5)**

This OU has been divided into two areas for cleanup purposes: (1) the Building 850 Firing Table area, and (2) the Pit 7 Landfill Complex.

A Remedial Action Completion Report for the Building 850/Pit 7 Landfill Complex OU was completed in 2011 (Dibley et al., 2011a). The First Five-Year Review Report for this OU is scheduled for completion in 2016.

1.4.1. **Building 850 Firing Table**

High explosives experiments were conducted at the Building 850 Firing Table from 1958 to 2008. Tritium was used in some of these experiments, primarily between 1963 and 1978. As a result of the destruction and dispersal of test assembly debris during detonations, surface soil was contaminated with metals, polychlorinated biphenyls (PCBs), dioxins, furans, HMX, and depleted uranium. Leaching from firing table debris has resulted in tritium and depleted uranium contamination in subsurface soil and groundwater. Nitrate and perchlorate are also COCs in groundwater. Tritium is the only COC in surface water (Well 8 Spring).

Gravel was removed from the firing table in 1988 and placed in the Pit 7 Landfill. PCB-contaminated shrapnel and debris were removed from the area around the firing table in 1998. The Building 850 remedy consists of MNA of tritium in groundwater, monitoring, and risk and hazard management including land use controls. A remedial design was completed in 2004. The remedial design included the excavation and off-site disposal of contaminated surface soil and sand pile. This remedy was not implemented due to a large increase in transportation and off-site disposal costs. DOE and the regulatory agencies agreed to clean up contaminated surface soil as a non-time critical removal action. An Engineering Evaluation/Cost Analysis (Dibley et al., 2008a) and Action Memorandum (Dibley et al., 2008b) were completed in 2008. A removal action was completed in 2010 for the excavation and solidification of PCB-, dioxin-, and furan-contaminated soil and sand pile. Since metals, HMX, and uranium in surface soil at Building 850 did not pose a risk to human health or threat to groundwater, a no further action remedy was selected. However, these co-located constituents in surface soil were removed during the PCB-, dioxin-, and furan-contaminated soil excavation/solidification removal action.

Natural attenuation has reduced tritium activities from a historic maximum of 566,000 picocuries per liter (pCi/L) in 1985 to a 2015 maximum of 18,700 pCi/L; below the
20,000 pCi/L MCL cleanup standard. Uranium activities are below the MCL cleanup standard and are within the range of natural background levels. The extent of nitrate with concentrations above the MCL cleanup standard is limited and does not pose a threat to human health or the environment. The maximum perchlorate concentration in 2015 was 41 µg/L, exceeding the 6 µg/L cleanup standard. A treatability study to evaluate *in situ* biodegradation of perchlorate is in progress.

In the November 20, 2014 Remedial Project Manager’s (RPM) Meeting, DOE/LLNL presented a summary and review of the Building 850 source area site conceptual model and site characterization data for perchlorate. One of the objectives of the presentation was to identify and discuss any outstanding perchlorate characterization issues or data gaps that the regulatory agencies might have before proceeding with the Focused Remedial Investigation/Feasibility Study (RI/FS) for perchlorate at Building 850. The regulatory agencies agreed that characterization was adequate to proceed with the Focused RI/FS for perchlorate in groundwater at Building 850 with the exception of the need for additional characterization of perchlorate in soil and groundwater directly beneath the firing table. The U.S. EPA, DTSC, and the RWQCB requested additional subsurface soil and groundwater sampling directly beneath the firing table to determine if a significant source of perchlorate was present in the vadose zone that would pose a continued threat to groundwater. Although HE compounds were not identified as COCs in the 2008 Site-Wide ROD, RDX and HMX were more recently detected in Building 850 groundwater and were evaluated as part of the recent (First) Five-Year Review process for the Building 850 area. DOE recommended sampling of subsurface soil and groundwater from boreholes drilled in the Building 850 Firing Table for HE compound analysis.

A Final Work Plan for the sampling of subsurface soil and groundwater for perchlorate and HE compound analysis at the Building 850 Firing Table for perchlorate analysis was submitted to the regulatory agencies in September 2015. This sampling effort was completed in the fall of 2015. The results of this subsurface soil sampling effort were presented to the regulators at the December 1, 2015 RPM meeting. The regulators agreed that the characterization of perchlorate (and HE compounds) at the Building 850 Firing Table was complete, and that DOE could proceed with preparing the Focused RI/FS for perchlorate. Preparation of the RI/FS is in progress.

1.4.2. Pit 7 Landfill Complex

The Pit 3, 4, 5, and 7 Landfills collectively comprise the Pit 7 Landfill Complex. Firing table debris containing tritium, depleted uranium, and metals was placed in the pits between 1958 and 1988. The Pit 4 and 7 Landfills were capped in 1992. The cap also covers about 30% of Pit 3. During years of above-normal rainfall (i.e., 1997-1998 El Niño event), groundwater rose into the bottom of the landfills and the underlying contaminated bedrock. This resulted in the release of tritium, uranium, VOCs, perchlorate, and nitrate to groundwater. There are no COCs in surface water or surface soil. Tritium and depleted uranium are COCs in subsurface soil.

DOE and the regulatory agencies agreed that the Pit 7 Landfill Complex required additional study. As a result, this area was not included in the 2001 Interim ROD and an area-specific RI/FS (Taffet et al., 2005) was completed. An Amendment to the Interim ROD for the Pit 7 Landfill Complex was signed in 2007 (U.S. DOE, 2007) that described the selected remedy for the Pit 7 Landfill Complex including monitoring; risk and hazard management including land use controls; MNA of tritium in groundwater; extraction and treatment of uranium, VOCs,
perchlorate, and nitrate in groundwater; and source control. The interim remedial design was completed in 2008. Construction of a drainage diversion system, designed to divert recharge away from the pits and minimize water table rises during intense rainfall events, was completed in 2008. Also, a groundwater extraction and treatment system was constructed in 2009-2010 to treat uranium, nitrate, perchlorate, and VOCs in groundwater.

Natural attenuation has reduced tritium activities in groundwater from a historic maximum of 2,660,000 pCi/L in 1998 to a 2015 maximum of 180,000 pCi/L, and has mitigated risk to on-site workers from inhalation of tritium vapors. Uranium activities have also decreased from a historic maximum of 781 pCi/L in 1998 to a 2015 maximum of 116 pCi/L. VOC concentrations are currently near or below their respective MCL cleanup standards. Nitrate concentrations in groundwater remain relatively stable, decreasing from a historic maximum of 90 mg/L in 2011 to a 2015 maximum of 64 mg/L. Perchlorate concentrations have decreased from a historic maximum of 40 µg/L in 2009 to a 2015 maximum of 14 µg/L.

1.5. Building 854 (OU6)

TCE was released to soil and groundwater through leaks and discharges of heat-exchange fluid, primarily between 1967 and 1984. Nitrate and perchlorate are also COCs in groundwater. HE compounds (HMX), PCBs, dioxins, furans, tritium, and metals were identified as COCs in surface soil. No further action was selected as the remedy for metals, HMX, and tritium in surface soil.

In 1983, TCE-contaminated soil was excavated at the northeast corner of Building 854F. Groundwater extraction and treatment has been conducted since 1999 to reduce VOC, nitrate, and perchlorate concentrations in groundwater. PCB-, dioxin-, and furan-contaminated soil in the Building 855 former rinse water lagoon was excavated in 2005 (Holtzapple, 2005). The remedy selected for this OU in the Site-Wide ROD includes monitoring, risk and hazard management including land use controls, and groundwater and soil vapor extraction and treatment. The remedial design was completed in 2003. Construction completion for the OU was achieved in September 2007. Three groundwater extraction and treatment systems and one soil vapor extraction and treatment system currently operate in the OU.

Groundwater remediation has reduced total VOC concentrations from a historic maximum of 2,900 µg/L in 1997 to a 2015 maximum of 93 µg/L. Nitrate concentrations have decreased from a historic maximum of 260 mg/L in 2003 to a 2015 maximum of 190 mg/L. Perchlorate concentrations in groundwater have also decreased from 27 µg/L in 2003 to 2015 maxima of 15 µg/L. Risks to on-site workers from inhalation of VOC vapors and from exposure to PCBs, dioxins, and furans in surface soil have been mitigated to below 10⁻⁶ excess cancer risk under an industrial exposure scenario.

DOE has performed two Five-Year Reviews for the Building 854 OU in 2009 and 2014 (Dibley et al., 2009a and Valett et al., 2014). The next (Third) Five-Year Review Report is scheduled for completion in 2018.
1.6. Building 832 Canyon (OU7)

TCE was used as a heat-exchange fluid as part of testing activities at Buildings 830 and 832. TCE and other VOCs were released to soil, bedrock, and groundwater as a result of piping leaks and surface spills during past activities at these buildings. VOCs, nitrate, and perchlorate are COCs in groundwater. VOCs, nitrate, and HMX are COCs in subsurface soil and bedrock, while HMX is also a COC in surface soil. VOCs and nitrate are COCs in surface water at Spring 3.

Groundwater and soil vapor extraction and treatment have been conducted since 1999 to reduce contamination in groundwater and subsurface soil. The Building 832 Canyon OU remedy includes monitoring, risk and hazard management, MNA for nitrate, and groundwater and soil vapor extraction and treatment. The interim remedial design was completed in 2006. Construction completion for the OU was achieved in September 2007. Three groundwater extraction and treatment systems and two soil vapor extraction and treatment systems currently operate in the OU to remediate VOC and perchlorate in groundwater.

Remediation has reduced VOC concentrations from a historic maximum of 30,000 µg/L in 1997 to 2015 maximum of 2,100 µg/L. Perchlorate concentrations have been reduced from a historic maximum of 51 µg/L in 1998 to a 2015 maximum of 18 µg/L. Nitrate concentrations in groundwater remain fairly stable, and are possibly the result of the ongoing contribution of nitrate from septic systems and natural bedrock sources. However, the MNA remedy for nitrate Building 832 Canyon OU groundwater continues to be effective and protective of human health and the environment, and to make progress toward meeting MCL cleanup standards. Natural denitrification processes continue to reduce nitrate concentrations, as nitrate has not been detected in groundwater above the MCL cleanup standard near the site boundary. Remediation has also mitigated risk to on-site workers in several locations in the Building 832 Canyon OU.

The First Five-Year Review of remediation in the Building 832 Canyon OU was completed in 2011 (Helmig et al., 2011). The Second Five-Year Review is scheduled for completion in 2016.

1.7. Site-Wide (OU8)

OU 8 includes the contaminant release sites that have a monitoring and risk and hazard management (including land use controls) remedy: the Building 801 Dry Well and Pit 8 Landfill, Building 833, Building 845 and Pit 9 Landfill, the Building 851 Firing Table, and the Pit 2 Landfill. OU 8 release sites have a monitoring and risk and hazard management remedy because either: (1) contaminants in surface and subsurface soil/bedrock do not pose a risk to humans or plant and animal populations or a threat to groundwater, (2) there is no groundwater contamination, (3) contaminant concentrations in groundwater do not exceed cleanup standards, and/or (4) the extent of contamination in groundwater is limited. These release sites are summarized below.

DOE has performed one Five-Year Review for this OU in 2013 (Buscheck et al., 2013). The Second Five-Year Review is scheduled for completion in 2018.

1.7.1. Building 801 Dry Well and the Pit 8 Landfill (OU8)

The Building 801 Firing Table was used for explosives testing and operations resulting in contamination of adjacent soil with metals and uranium. Use of this firing table was
discontinued in 1998, and the firing table gravel and some underlying soil were removed. Waste fluid was discharged to a dry well (sump) located adjacent to Building 801D from the late 1950s to 1984. The dry well was decommissioned and filled with concrete in 1984. VOCs, perchlorate and nitrate are COCs in groundwater due to the past releases from the Building 801 Dry Well. VOC concentrations in groundwater are currently near or below their respective MCL cleanup standards. TCE concentrations in Building 801/Pit 8 Landfill monitor wells are below the 5 µg/L MCL or the 0.5 µg/L reporting limit. 1,2-dichloroethane (DCA) concentrations are slightly above the State 0.5 µg/L MCL in two wells 1.5 µg/L in K8-01 and 1.1µg/L in K8-04, but below the 5 µg/L Federal MCL in all wells. Nitrate concentrations in groundwater currently exceed the MCL cleanup standard in two wells. Perchlorate is not currently detected in groundwater. VOCs are COCs in subsurface soil, but do not pose a risk to human health. The adjacent Pit 8 Landfill received debris from the Building 801 Firing Table until 1974, when it was covered with compacted soil. There is no evidence of contaminant releases from the landfill.

The remedy selected for this area in the Site-Wide ROD includes monitoring and risk and hazard management including land use controls. No further action was selected as the remedy for VOCs in subsurface soil at Building 801.

As specified in the Site-Wide ROD, no remedial design documents were required for this area (U.S. DOE, 2008).

1.7.2. Building 833 (OU8)

TCE was used as a heat-exchange fluid in the Building 833 area from 1959 to 1982 and was released through spills and rinse water disposal, resulting in TCE-contamination of subsurface soil and shallow perched groundwater. No contamination has been detected in the deeper regional aquifer. No COCs were identified in surface soil at Building 833.

The selected remedy for Building 833 includes monitoring and risk and hazard management including land use controls. As specified in the Site-Wide ROD, no remedial design document was required for this area (U.S. DOE, 2008). Groundwater monitoring at Building 833 has shown a decline in total VOC concentrations from a historic maximum of 2,100 µg/L in 1992 to a 2015 maximum of 130 µg/L, all of which consists of TCE. All but two of the monitor wells in the shallow, highly ephemeral, perched water bearing zone underlying Building 833 are dry. In two wells that contained sufficient water to sample, TCE was detected at a concentration of 110 µg/L in well W-833-33, and was below the 0.5 µg/L reporting limit in well W-833-30. No other VOCs were detected in these wells.

1.7.3. Building 845 Firing Table and the Pit 9 Landfill (OU8)

The Building 845 Firing Table was used from 1958 until 1963 to conduct explosives experiments. Leaching from firing table debris resulted in minor contamination of subsurface soil with depleted uranium and HMX but no unacceptable risk to human or ecological receptors or threat to groundwater was identified. No contaminants have been detected in surface soil or in groundwater at the Building 845 Firing Table. Debris generated at the Building 845 Firing Table was buried in the Pit 9 Landfill. There has been no evidence of contaminant releases from the Pit 9 Landfill.

The remedy selected for Building 845 and the Pit 9 Landfill in the Site-Wide ROD includes monitoring and risk and hazard management including land use controls. No further action was
selected as the remedy for uranium and HMX in subsurface soil at Building 845. As specified in the Site-Wide ROD, no remedial design document was required for this area (U.S. DOE, 2008).

1.7.4. Building 851 Firing Table (OU8)

The Building 851 Firing Table has been used for high explosives research since 1962. VOCs and uranium-238 were identified as COCs in subsurface soil, and RDX, uranium-238, and metals as surface soil COCs. However, no risk to humans or animal populations, or threat to groundwater associated with these contaminants in surface and subsurface soil was identified in the baseline risk assessment. Uranium-238 was identified as a COC in groundwater. However, it poses no risk to human or ecological receptors, and uranium activities remain well below cleanup standards and within the range of background levels.

In 1988, the firing table gravel was removed and disposed in Pit 7. Gravel has been replaced periodically since then. The remedy selected for Building 851 in the Site-Wide ROD includes monitoring and risk and hazard management including land use controls. No further action was selected as the remedy for VOCs and uranium in surface and subsurface soil, and for RDX and metal in surface soil at Building 851. As specified in the Site-Wide ROD, no remedial design document was required for this area (U.S. DOE, 2008).

In 2014, DOE/NNSA identified the need for additional investigation of uranium-238 in surface soil at the Building 851 Firing Table to determine if the results of the baseline risk assessment are still valid, given the ongoing use of the firing table after the remedial investigation was completed. In 2016, DOE/NNSA presented a plan to characterize the extent of uranium-238 in surface soil based on a combination of Field Instrument for the Detection of Low-Energy Radiation (FIDLER) surveys supplemented with surface soil samples. This characterization work plan was approved by the regulatory agencies, and the field work conducted in fall of 2016.

1.7.5. Pit 2 Landfill (OU8)

The Pit 2 Landfill was used from 1956 until 1960 to dispose of firing table debris from Buildings 801 and 802. Groundwater data indicate a discharge of potable water conducted from 1996 to 2005 to support a red-legged frog habitat located upgradient from the landfill may have leached depleted uranium from the buried waste. The frogs were relocated and the water discharge was discontinued, thereby removing the leaching mechanism. No contaminants were identified in surface or subsurface soil at the Pit 2 Landfill. No risk to human or ecological receptors has been identified at the Pit 2 Landfill.

The remedy selected for the Pit 2 Landfill in the Site-Wide ROD includes monitoring and risk and hazard management including land use controls. Monitoring data indicate that uranium activities remain below the MCL cleanup standard. There is no evidence of new contaminant releases from the Pit 2 Landfill indicated by the groundwater detection monitoring data. As specified in the Site-Wide ROD, no remedial design document was required for this area (U.S. DOE, 2008).

1.8. Building 812 (OU9)

The Building 812 Complex was built in the late 1950s-early 1960s and was used to conduct explosives tests and diagnostics until 2008. A Characterization Summary Report for this area
was completed in 2005 (Ferry and Holtzapple, 2005). The Building 812 Complex was designated as OU 9 in March 2007, based on characterization results that indicated the presence of uranium, VOCs, HE compounds, nitrate, and perchlorate in environmental media. In 2008, a draft RI/FS describing the results of characterization activities and remedial alternatives for the Building 812 OU (Taffet et al., 2008) was submitted to the regulatory agencies and a DOE task force. The DOE task force recommended additional characterization be performed at the OU and the regulatory agencies agreed. Additional characterization began in 2011 and is ongoing. A Final Work Plan for the sampling of surface soil in the Building 812 Firing Table area for PCB and HE compound analysis was submitted to the regulatory agencies on September 1, 2015. This sampling effort was completed in the fall of 2015. A revised RI/FS report will be prepared once the regulatory agencies concur that characterization is complete at the Building 812 OU. A Proposed Plan will subsequently present the alternatives and a preferred remedy for public comment. A remedy will then be selected in an Amendment to the Site-Wide ROD.

1.9. Building 865/Advanced Test Accelerator

Building 865 facilities were used to conduct high-energy laser tests and diagnostics in support of national defense programs from 1980 to 1995. The Building 865 Complex housed a 275-foot linear electron accelerator called the Advanced Test Accelerator (ATA). The ATA was designed to produce a repetitively pulsed electron beam for charged particle beam research. In 2006, a Characterization Summary Report for this area was submitted to the regulatory agencies (Ferry and Holtzapple, 2006). Tetrachloroethene (PCE), 1,1,2-trichloro-1,2,2-trifluoroethane (Freon 113), and trichlorofluoromethane (Freon 11) were identified as COCs in groundwater. However, concentrations of Freon 11 and Freon 113 are well below their MCLs; and PCE is only detected in one well at a concentration slightly above its 5 µg/L MCL (8.8 µg/L in well W-865-2004 in July 2015. In July of 2014, DOE/NNSA agreed to conduct additional characterization at Building 865 to add to the degree of certainty that residual contamination is not present in some areas where soil was previously characterized and/or excavated. A Final Work Plan for the sampling of subsurface soil at the Oil Conditioning System, Storm Drain Outfall, and former Surface Impoundment locations for VOCs and semi-volatile organic compounds (SVOCs) analysis was submitted to the regulatory agencies in August 2015. This sampling effort was completed in the fall of 2015. DOE/LLNL presented the results of the subsurface soil sampling results to the regulatory agencies at the January 2016 RPM meeting. The regulatory agencies concurred that characterization at Building 865 was complete. At the March 2016 RPM meeting, DOE/LLNL presented a schedule for submittal of the Building 865 RI/FS report. Following completion of the RI/FS, a Proposed Plan will present the alternatives and a preferred remedy for public comment. A remedy will then be selected in an Amendment to the Site-Wide ROD. If, following remedy selection, an active remedy is needed to address contamination in the Building 865 area, the Building 865 area will likely be designated as a separate OU (i.e., OU 10). If no significant risk or threat to groundwater is identified associated with Building 865 area contaminants, and a monitoring and institutional/land use control remedy is selected, the Building 865 area will likely be included as a release site in the Site-Wide OU (OU8).
2. Site Chronology

The following chronology of important environmental events in the GSA OU are summarized below:

1955
- LLNL Site 300 was established as a DOE high explosives test facility.

1960s/1970s
- Solvents from the craft shops were discharged to dry wells in the Central GSA.
- VOC-contaminated rinsewater was discharged to the ground surface at the Building 879 steam-cleaning/sink facility.
- VOC-contaminated shop debris was disposed in Eastern GSA trenches.

1970s/1980s
- Solvent spills from drum rack occurred.

1982
- Site investigations began in the GSA OU.

1984
- DOE began monitoring off-site water-supply well CON1 located downgradient of the Eastern GSA debris burial trench source area.

1987
- DOE began monitoring off-site water-supply well CDF1 located downgradient of the Eastern GSA debris burial trench source area.

1989-1990
- DOE installed and began monitoring a series of five guard wells located downgradient of the Eastern GSA debris burial trench source area and upgradient of off-site water-supply wells CDF1 and CON1 to provide an early indication of migration of the VOC plume towards the water-supply wells.

1990
- LLNL Site 300 was placed on the National Priorities List.

1991
- Groundwater extraction and treatment began in the Eastern GSA as a removal action.
- DOE signed a Settlement Agreement with the owner of the property and water-supply wells CDF1 and CON1 adjacent to the Eastern GSA in which DOE agreed to replace these wells in the event that they became contaminated by VOCs from Site 300.

1992
- A Federal Facility Agreement for Site 300 was signed. The parties to the Agreement included DOE, the U.S. EPA, DTSC, and the RWQCB.
1993
- Groundwater extraction and treatment began in the Central GSA as a removal action.

1994
- Soil vapor extraction and treatment began in the Central GSA as a removal action.
- The Site-Wide Remedial Investigation report (Webster-Scholten, 1994) was issued.

1995
- A Feasibility Study for the GSA OU was issued (Rueth et al., 1995).

1996
- The Proposed Plan for Environmental Cleanup of the GSA OU was issued (U.S. DOE, 1996).

1997
- A Record of Decision for the GSA OU was signed.
- Groundwater and soil vapor extraction and treatment began as a remedial action.

1998
- The Remedial Design document for the GSA OU was issued (Rueth et al., 1998). A Compliance Monitoring Plan and Contingency Plan for the GSA OU were included as appendices in the Remedial Design document.

1999
- The Phase I expansion of the Central GSA extraction wellfield was completed.

2001
- The First Five-Year Review for the GSA OU was issued.

2005
- The Phase II expansion of the Central GSA extraction wellfield was completed.
- Remedial action construction was completed June 2005.
- The U.S. EPA performed the OU construction completion inspection on July 13, 2005.
- Remediation efforts in the Eastern GSA successfully reduced concentrations of VOCs in groundwater to below their respective MCL cleanup standards set in the GSA ROD.

2006
- The Second Five-Year Review for the GSA OU was issued.

2007
- As VOC concentrations had remained below cleanup standards since 2005, the Eastern GSA groundwater extraction and treatment system was shut off on February 15, 2007 with the U.S. EPA, RWQCB, and DTSC approval. As required by the GSA ROD, groundwater monitoring was conducted for five years after shutdown to determine if VOC concentrations rise or “rebound” above MCL cleanup standards.
• The Central GSA groundwater treatment system began receiving partially treated water from the Building 830-Distal South (830-DISS) facility at the end of the first semester of 2007.

• In the Eastern GSA Compliance Feasibility Report submitted to regulatory agencies on July 15, 2007 (Holtzapple, 2007), DOE/LLNL evaluated on-site discharge options that could be implemented if VOC concentrations rebound above MCL cleanup standards requiring that the Eastern GSA extraction and treatment system be restarted.

• Soil vapor extraction from the entire Central GSA wellfield (W-7I, W-875-07, W-875-08, W-875-09, W-875-10, W-875-11, and W-875-15) was initiated in November 2007.

2008
• The Site-Wide ROD with selected remedies and cleanup standards for Site 300 was signed. The GSA OU was not included, as an OU-specific ROD for the GSA had already been signed. However, land use controls for the GSA OU were included in the Site-Wide ROD.

2009
• The revised Site-Wide Compliance Monitoring Plan and Contingency Plan for Interim Remedies was issued (Dibley et al., 2009b). Compliance monitoring and contingency plan requirements for the GSA OU were incorporated into the document.

2011
• The Third Five-Year Review for the GSA OU was issued.
• As recommended in the Third GSA Five-Year Review (Valett et al., 2011), one new extraction well, W-CGSA-2708, was installed to increase hydraulic capture of VOCs and contaminant mass removal in the northern VOC plume area.

2012
• As required by the GSA ROD, groundwater monitoring conducted for five years after shutdown determined that VOC cleanup standards had been achieved and no rebound had occurred in Eastern GSA groundwater. Therefore, DOE/NNSA, with the approval of the U.S. EPA, RWQCB, and DTSC obtained during a February 24, 2012 RPM meeting, initiated the closeout process of the Eastern GSA portion of the GSA OU. The regulatory agencies also accepted the schedule presented for decommissioning and demolition of the Eastern GSA treatment facility and extraction wellfield.

• The Draft Eastern GSA Final Close-out Report (Dibley et al., 2012a) was issued.
• As recommended in the Third GSA Five-Year Review (Valett et al., 2011), the Central GSA treatment facility effluent misting system upgrade and relocation was initiated.

2013
• The Draft Final Eastern GSA Final Close-out Report (Dibley et al., 2013a) was issued.
• In 2013, EPA and the RWQCB indicated that they felt that there were data gaps for SVOCs/polycyclic aromatic hydrocarbons (PAHs) and PCBs in subsurface soil and SVOCs and PCBs in groundwater in the vicinity of the Eastern GSA debris burial trenches that needed to be addressed. Therefore, DOE/NNSA agreed to collect additional subsurface soil samples from the Eastern GSA debris burial trenches for SVOC/PAH and PCB analysis to determine if these constituents were present, and if present, to determine...
whether or not the concentrations of these constituents could impact groundwater above Maximum Contaminant Levels (MCLs).

- Two new wells, W-CGSA-2907 and W-CGSA-2908, were installed upgradient of well W-CGSA-2708 in the vadose zone portion of the Qt-Tnsc1 HSU to inject treated effluent from the Central GSA-North (CGSA-North) treatment facility.

2014

- DOE/LLNL submitted and the regulators approved a work plan for the characterization of SVOCs/PAHs and PCBs in subsurface soil in the vicinity of the debris burial trenches in the Eastern GSA portion of the GSA OU. This characterization work was conducted in the late summer-early fall of 2014.
- The new injection wells, W-CGSA-2907 and W-CGSA-2908, were developed and tested during early 2014.
- Due to dense infrastructure that prevented constructing a pipeline from extraction well W-CGSA-2708 to the Central GSA groundwater extraction and treatment system, a new treatment facility (CGSA-North) was designed and constructed to treat groundwater extracted from W-CGSA-2708.
- As recommended in the Third GSA Five-Year Review (Valett et al., 2011), the Central GSA treatment facility effluent misting system upgrade and relocation was completed.

2015

- At the January 21, 2015 RPM meeting, DOE/LLNL presented the results of the characterization of SVOCs/PAHs and PCBs in subsurface soil and SVOCs/PAHs in groundwater in the vicinity of the Eastern GSA debris burial trenches. The regulatory agencies concurred that characterization was complete, and requested that DOE submit a Technical Memorandum summarizing the characterization results that upon approval, would be attached to the Eastern GSA Close-out report as an appendix.
- Construction and operational testing of the new CGSA-North groundwater treatment system was completed by the end of September. The system is designed to extract groundwater from extraction well W-CGSA-2708, treat it in three aqueous-phase GAC vessels (in series) to remove VOCs, with discharge of the treated effluent in re-injection well W-CGSA-2907. Due to the limited extraction capacity at W-CGSA-2708 and adequate injection capacity at W-CGSA-2907, well W-CGSA-2908 will be used as a monitor well rather than a second injection well for the CGSA-North treatment facility.

3. Background

3.1. Physical Characteristics

3.1.1. Site Description

The GSA OU is approximately 72 acres, located in the southeast corner of Site 300 (Figure 1). Within the GSA OU are a number of craft shops, storage buildings, and offices that support the research being conducted at Site 300. The GSA OU has been separated into the Central GSA and the Eastern GSA based on differences in hydrogeology and the distribution of environmental contaminants (Figure 3). The majority of structures are located in the Central
GSA, including a sewage treatment pond. The only structure present in the Eastern GSA is a sewage treatment overflow pond. The off-site area adjacent to the GSA OU is sparsely populated and used for agriculture. The nearest major population center (Tracy, California) is 8.5 miles to the northeast.

Evidence of a chemical release to groundwater in the GSA OU was first discovered in 1982 when 52 µg/L of TCE was detected in Well 7, a former on-site Site 300 water-supply well located in the GSA. Investigation of TCE in Well 7 led to the discovery and investigation of several other releases in the GSA OU, such as from former waste water/rinse water dry wells, a steam cleaning area, a decommissioned solvent drum rack, and a debris burial trench. These release sites and associated investigations and characterization are discussed in detail in Chapter 14 of the Final Site 300 Site-Wide Remedial Investigation (Webster-Scholten, 1994).

The GSA OU includes the release sites in the Central and Eastern GSA and any associated contamination released to environmental media. The OU boundary is defined by the current extent of VOCs in groundwater. As shown on Figure 1, the OU boundary is currently approximately 2,000 feet (ft) long by 1,000 ft wide. One groundwater and one soil vapor extraction and treatment systems are currently operating to remediate VOCs in Central GSA groundwater, with a second groundwater treatment system (CGSA-North) planned to begin continuous operation in 2016 to remediate VOCs in the Central GSA northern plume area. The Eastern GSA groundwater extraction and treatment system is still in place, but was shut down in February 2007 with regulatory approval when VOC concentrations were reduced below their respective MCL groundwater cleanup standards. Groundwater is monitored for VOCs in 71 wells to evaluate the progress of VOC remediation in the GSA OU. The locations of existing monitor, extraction, and water-supply wells, and treatment facilities for the Central and Eastern GSA are shown on Figures 4 and 5, respectively.

3.1.2. Central GSA

Chlorinated solvents, mainly TCE, were used as degreasing agents in craft shops in the Central GSA. Rinse water from these degreasing operations was disposed of in dry wells and as a result, subsurface soil and groundwater were contaminated with VOCs. There are no COCs in surface soil in the Central GSA. The Central GSA dry wells were used until 1982. In 1983 and 1984, these dry wells were decommissioned and excavated.

Groundwater cleanup began in the Central GSA in 1992 and soil vapor extraction started in 1994 as removal actions. In 1997, a Final ROD for the GSA OU (U.S. DOE, 1997) was signed and groundwater and soil vapor extraction and treatment continued as a remedial action. The selected remedy for the Central GSA includes monitoring, risk and hazard management including land use controls, and groundwater and soil vapor extraction and treatment. The remedial design was completed in 1998 and construction completion for the OU was achieved in September 2005.

Operation of the groundwater and soil vapor extraction and treatment systems to remove VOCs from the subsurface is ongoing. Remediation has reduced maximum VOC concentrations in groundwater and has mitigated the risk to on-site workers from inhalation of VOCs inside Building 875.
3.1.3. **Eastern GSA**

The sources of contamination in the Eastern GSA are debris burial trenches that received craft shop debris that contained solvent residue. Leaching of solvents from the debris resulted in the release of VOCs to groundwater.

Groundwater cleanup began in the Eastern GSA in 1991 as a removal action. In 1997, a Final ROD for the GSA OU was signed and groundwater extraction and treatment continued as a remedial action. The remedial design was completed in 1998 and construction completion for the OU was achieved in September 2005. A groundwater extraction and treatment system operated from 1991 to 2007 to remove VOCs from groundwater.

By 2005, VOC concentrations in both on-site and off-site groundwater in the Eastern GSA area had been reduced to below the MCL cleanup standards. In February 2007, the groundwater extraction and treatment system was shut down with regulatory concurrence. DOE/NNSA continued to monitor groundwater for five years, during which time VOC concentrations remained below the MCL cleanup standards, indicating that groundwater cleanup had been successfully completed in the Eastern GSA. Draft and Draft Final Close-out Reports for the Eastern GSA was submitted to the regulatory agencies in December 2012 and June 2013, respectively (Dibley and Ferry, 2012a; Dibley and Ferry, 2013a). Subsequently, the regulatory agencies requested additional characterization activities to determine if PCBs, SVOCs, and PAHs were present in subsurface soil in the Eastern GSA debris burial trench area. The characterization work was conducted in 2014, and the results presented to the regulators in the January 21, 2015 RPM meeting. The regulatory agencies concurred that characterization was complete, and requested that DOE submit a Technical Memorandum summarizing the characterization results that upon approval, would be attached to the Eastern GSA Close-out report as an appendix. The results of these characterization activities are briefly discussed in Section 6.4.2 and will be presented in more detail in a Technical Memorandum to be submitted per regulatory agreement in 2016. Data showing that VOC concentrations in Eastern GSA groundwater have been below cleanup standards since 2005 will be presented in the Close Out Report for the Eastern GSA subarea, scheduled to be finalized in 2017.

3.1.4. **Hydrogeologic Setting**

This section describes the general hydrogeologic setting for the GSA OU, including the unsaturated zone and the hydrostratigraphic units (HSUs) underlying the area. A southwest-northeast oriented hydrogeologic cross-section through the GSA OU is presented on Figure 6.

3.1.4.1. **Unsaturated (Vadose) Zone**

The vadose zone in the western portion of the Central GSA is comprised of the unsaturated portion of the Quaternary alluvial terrace (Qt) silty clay, sand, and gravel deposits, and the underlying Tertiary Neroly Upper Blue Sandstone (Tnbs). These deposits are unsaturated to a depth of approximately 10 to 30 feet below ground surface (ft bgs). Subsurface soil in the vadose zone is contaminated with VOCs in the vicinity of the Building 875 former dry wells.

In the eastern portion of the Central GSA (near the sewage treatment pond) and the Eastern GSA, the vadose zone is comprised of the unsaturated portion of the Quaternary alluvial (Qal) silty clay, sand, and gravel deposits and the underlying Tertiary Neroly Lower Blue Sandstone (Tnbs). In the Eastern GSA, these deposits are unsaturated to a depth of approximately 5 to
20 ft bgs. No COCs were identified in subsurface soil in the unsaturated Qal and Tnbs1 units in the Eastern GSA.

3.1.4.2. **Saturated Zone**

An HSU consists of one or more stratigraphic intervals that comprise a water-bearing zone exhibiting similar hydraulic and geochemical properties. There are three primary HSUs beneath the GSA OU: two shallow HSUs and one deeper HSU.

The shallow HSUs are:

- **Qt-Tertiary Neroly Middle Siltstone/Claystone (Tnsc1) HSU**, which is a water-bearing zone present in the western portion of the Central GSA that consists of Qt deposits and the portions of the underlying Neroly Tnbs2 and Tnsc1 bedrock units that are in direct hydraulic communication with the Qt.

- **The Qal-Tnbs1 HSU**, which is a water-bearing zone present within the eastern portion of the Central GSA and throughout the Eastern GSA, that consists of Qal deposits and the portion of the underlying Neroly Tnbs1 bedrock unit that is in direct hydraulic communication with the Qal.

The deeper HSU is:

- **Tnbs1 HSU** that consists of the regional Neroly Tnbs1 bedrock aquifer in the Central and Eastern GSA.

In the western portion of the Central GSA, the Qt-Tnsc1 HSU includes saturated Qt deposits, the Tnbs2 sandstone and the Tnsc1 siltstone/claystone bedrock units beneath the Qt. The Tnbs2 is a permeable sandstone that contains unconfined to confined groundwater. The Tnsc1 siltstone/claystone is generally low permeability and serves as an aquitard or confining layer that hydraulically separates the Qt-Tnsc1 HSU from the deeper Tnbs1 regional aquifer. The depth to groundwater in the Qt-Tnsc1 HSU is 10 to 30 ft bgs, and groundwater flows toward the south-southeast at a velocity of 0.05 to 0.10 feet per day (ft/day).

In the eastern portion of the Central GSA (near the sewage treatment pond) and throughout the Eastern GSA, the Qt deposits and the Tnbs2 and Tnsc1 bedrock units are not present. Qal deposits directly overlie the Tnbs1 bedrock. The Qal-Tnbs1 HSU consists of saturated Qal and the immediate underlying Tnbs1 bedrock and contains unconfined groundwater. In the Eastern GSA, the hydraulic conductivity of the Qal-Tnbs1 HSU is significantly greater than the Qt-Tnsc1 HSU in the western part of the Central GSA. The depth to groundwater in the Qal-Tnbs1 HSU is <5 to 20 ft bgs, depending on season and annual rainfall. Groundwater in the Qal flows towards the east and north along the Corral Hollow Creek drainage at a velocity of 0.5 to 3 ft/day. In this area, there is generally a natural upward hydraulic gradient from the Tnbs1 Neroly bedrock into the overlying Qal deposits.

The Tnbs1 HSU underlies and is hydraulically separated from the Qt-Tnsc1 HSU by the Tnsc1 siltstone/claystone confining layer in the western portion of the Central GSA. As shown on Figure 6, the Qt, Tnbs2, and Tnsc1 stratigraphic units are eroded and therefore not present in the eastern part of the Central GSA, and the Tnbs1 HSU directly underlies the Qal deposits in the eastern part of the Central GSA and the Eastern GSA. The Tnbs1 regional aquifer is separated into upper and lower units by a ten-foot thick claystone marker bed (CMB) that exists throughout the southeastern part of Site 300. Depth to groundwater in the Upper Tnbs1 HSU in the
southeastern part of Site 300 varies from 10 to 20 ft bgs and groundwater flows to the south-southeast. Groundwater velocity in the Tnbs$_1$ regional aquifer is approximately 0.3 ft/day.

Second semester 2014 and second semester 2015 potentiometric surface elevation contour maps for the Qt-Tnsc$_1$ and Qal-Tnbs$_1$ HSUs in the Central GSA are presented as Figure 7. Traditionally, only the most recent potentiometric surface elevation contour map (second semester 2015) would be included in a Five-Year Review Report. However, due to extended down time for the Central GSA groundwater extraction and treatment system in second semester 2015, the second semester 2014 potentiometric surface elevation contour maps are included to show typical extraction well capture zones. A potentiometric surface elevation contour map for the Qal-Tnbs$_1$ HSU in the Eastern GSA is presented as Figure 8. Wells screened in deeper Tnbs$_1$ bedrock HSU are not shown on Figures 7 or 8. VOCs have historically not been detected in the Tnbs$_1$ HSU, or have been sporadically detected at trace concentrations.

3.2. Land and Resource Use

Site 300 is currently an operating facility, and will remain under DOE control for the reasonably anticipated future. Less than five percent of Site 300’s 7,000-acre property is developed. Land use at Site 300, including the GSA OU, which occurs on the southeastern site boundary, is designated as restricted access, federal government industrial (experimental test) use. There have been no changes in land, building, or groundwater use in the GSA OU during the five-year review period, and other than the changes in on-site water supply uses documented below, none are anticipated. Craft shops, storage buildings, and offices in the Central GSA are used to support the research conducted at Site 300. Land in the Eastern GSA is undeveloped and is not used for LLNL programmatic activities.

Site 300 was originally selected as a DOE experimental test site because of the sparsely populated surrounding area. On the basis of residential population, the average density around the perimeter of Site 300 is less than one person per square mile. Land use adjacent to the site boundary closest to the GSA OU consists of private rangeland: Corral Hollow and Union Livestock Ranches located south of Site 300, Fireworks America, a private firm operating a fireworks storage facility adjacent to the eastern border of Site 300, and the Carnegie State Vehicular Recreation Area, located southwest of Site 300. The California Department of Fish and Wildlife (CDFW) operates an ecological preserve immediately east of Site 300 along Corral Hollow Road. There is no known planned modification or proposed development of the off-site rangeland closest to the OU. The nearest major population center (Tracy, California) is 8.5 miles to the northeast. There are plans to develop the land parcel east of Site 300 for residential housing, but thus far the development plans have been delayed by city restricted growth initiatives. As part of this development plan, a minimum buffer zone/open space of a mile to 1.5 miles is planned between residential development and the Site 300 boundary. The developer informed DOE/LLNL that groundwater would not be used as the water supply for this development.

Several off-site private water-supply wells located south of the GSA OU supply water for domestic and agricultural uses to neighboring ranches (Figure 3). There are no active on-site water-supply wells in the GSA OU. Two former on-site water-supply wells in the Central GSA, Wells 7 and 19, were decommissioned in 1988 and 1990, respectively, due to the detection of TCE in samples from these wells (Figure 4). Currently, on-site water-supply Well 20 and
backup water-supply Well 18, located west of the Central GSA in the HE Process Area OU (Figure 3), are the water-supply sources for Site 300, although bottled water is the primary source for on-site drinking water. Site 300 plans to transition to the Hetch Hetchy water supply in the near future. After Site 300 begins using the Hetch Hetchy reservoir as its primary water supply, Well 20 will become a backup water-supply well and Well 18 will no longer be used. Eventually, Well 18 will be decommissioned.

Site 300 has unique environmental qualities, largely because livestock have not grazed upon it for over 50 years and it contains several habitat types and numerous special-status species (e.g., threatened and endangered species, species of special concern, migratory birds, and rare plants). While the location of the Central GSA groundwater and soil vapor extraction systems is well developed and paved, the eastern part of the Central GSA is less developed, and contains a treatment pond that treats sewage from GSA administrative buildings (Figure 4). Adjacent to the Central GSA, the Eastern GSA occurs in the undeveloped southeastern corner of Site 300, and shares a boundary with the CDFW ecological preserve (Figure 5). The Eastern GSA also contains an overflow pond for the Central GSA sewage treatment pond. Introduced annual grasslands cover the majority of the undeveloped areas of the OU, with a few isolated areas of coastal sage scrub scattered throughout the OU (Dibley et al., 2014). A delineation of waters of the United States at Site 300 conducted in 2002 identified the overflow pond in the Eastern GSA as a wetland (Jones and Stokes, 2002). Additional mapping conducted in 2010 identified an additional 0.17 acres of jurisdictional waters in the OU (Paterson and Woollett, 2014). Corral Hollow Creek enters the CDFW ecological preserve near its boundary with the Eastern GSA and runs north for the length of the preserve. Riparian vegetation, including mulefat, cottonwood and willow, is associated with Corral Hollow Creek, and elderberry bushes are found near the boundary with the Eastern GSA. Two fresh water seeps, Springs 1 and 2 (identified as wetlands in Jones and Stokes, 2002), occur at the northern end of the CDFW preserve. Both springs are currently dry as a result of the ongoing drought in California. Wildlife within the OU is typical of California grasslands, and includes a variety of small mammals (such as deer mice, ground squirrels, rabbits and skunks), reptiles (such as western fence lizards and rattlesnakes), large mammals such as coyotes and mule deer, passerine birds (such as scrub jays, crows, wrens and towhees) and raptors (such as red-tailed hawks and golden eagles). Amphibians such as frogs and salamanders are found in areas that can sustain ponded water. A list of vertebrate and rare invertebrate species known to occur at Site 300 can be found in LLNL (2015).

No special-status plants occur within the GSA OU (Dibley et al., 2014). Five special-status species occur at Site 300 outside of the GSA OU. The federally endangered large-flowered fiddleneck (Amsinckia grandiflora) occurs to the west of the GSA OU within the Building 854 OU. The remaining four special-status plants all have a California Rare Plant Rank (CRPR) of 1B (California Native Plant Society, 2016). Plants with a CRPR of 1B are considered rare and endangered throughout their range. The big tarplant (Blepharizonia plumosa) occurs in OUs adjacent to the GSA OU (the Building 832 Canyon, Building 834 and High Explosive Process Area OUs). The diamond-petaled California poppy (Eschscholzia rhombipetala), the round-leaved filaree (California macrophylla) and the adobe navarretia (Navarretia nigelliformis ssp. radians), all occur in the far northern and western portions of Site 300 (Dibley et al., 2014).

The only special-status invertebrate species known to occur at Site 300 is the federally threatened valley elderberry longhorn beetle (Desmocerus californicus dimorphus). Although valley elderberry longhorn beetles have not been observed in the GSA OU, they have been
observed in the elderberry bushes located adjacent to the Eastern GSA in the CDFW ecological preserve (Dibley et al., 2014).

Three special-status amphibians are known to occur within the GSA OU boundaries, the California red-legged frog (*Rana aurora draytonii*), the California tiger salamander (*Ambystoma californiense*), and the Western spadefoot toad (*Spea hammondii*). A fourth species, the Coast Range Newt (*Taricha torosa torosa*), may occur in the OU. The California red-legged frog and the California tiger salamander are both federally threatened, and the California tiger salamander is also state-threatened. The entire OU resides within the upland dispersal and critical habitat for the California red-legged frog, and within the 1,100-meter buffer zone for California tiger salamander breeding pools (Dibley et al., 2014). The Western spadefoot toad and the Coast Range Newt are both California Species of Special Concern. The California red-legged frog, California tiger salamander and Western spadefoot toad have all bred successfully in the GSA OU. The California red-legged frog and California tiger salamander both successfully bred in the sewage overflow pond (located in the Central GSA), as well as in Pool M3 (located along the northern Central and Eastern GSA boundary, see Figure 4.2-3 in Dibley et al., 2014) between 1999 and 2008, although more recent breeding success is unknown. Pool M3 was enhanced for amphibian breeding as mitigation for loss of upland California tiger salamander and California red-legged frog habitat as a result of the Building 850 removal action. The Western spadefoot toad also successfully bred in Pool M3 between 1999 and 2008, as well as between 2009 and 2012 (Paterson and Woollett, 2014). Although the Coast Range newt has not been observed in the GSA OU, this species has been observed in the HE Process Area OU (Dibley et al, 2014). Coast Range newts at Site 300 show a tendency to inhabit areas within 1 km of Corral Hollow Creek and near oak woodland habitat, and are known to migrate over 2 km during the breeding season to aquatic habitats (Paterson and Woollett, 2014). Therefore, they may occasionally occur in the GSA OU.

Five special-status reptile species are known to occur at Site 300. These are the state and federally threatened Alameda whipsnake (*Masticophis laterialis euryxanthus*), and the California Species of Special Concern Coast horned lizard (*Phrynosoma blainvillii*), San Joaquin coachwhip (*Masticophis flagellum ruddockii*), silvery legless lizard (*Anniella pulchra pulchra*), and Pacific pond turtle (*Actinemys marmorata*). The Alameda whipsnake is most likely to occur within larger patches of coastal sage scrub with rock outcrops and grassland adjacent to these coastal sage scrub patches, which is the snake’s primary habitat (Dibley et al., 2014). This type of habitat primarily occurs in the southwestern portion of Site 300, which has been designated as critical habitat for this species. It is unlikely to occur in the small remnant portions of coastal sage scrub found in the GSA OU. Of the remaining special-status reptile species, while it is possible that the Coast horned lizard, silvery legless lizard and Pacific pond turtle may all occasionally occur in the GSA OU, only the San Joaquin coachwhip is known to occur in the OU, observed along the southern boundary of the OU (Dibley et al., 2014).

Several special-status bird species may occur within the GSA OU. Special-status raptor species known to breed or regularly occur at Site 300 that may also occasionally occur within the GSA OU include the golden eagle (*Aquila chrysaetos*), white-tailed kite (*Elanus leucurus*) and the short-eared owl (*Asio flammeus*) (Dibley et al., 2014). These raptors may use the grasslands in the undeveloped areas of the OU for foraging. While several additional special-status bird species have been observed throughout Site 300, most have occurred within the northern portion of the site (Dibley et al., 2014). Nests of the loggerhead shrike (*Lanius ludovicianus*), a
California Species of Special Concern and a federal Bird of Conservation Concern, have been observed in the southern portion of the site. This species has been observed foraging within the GSA OU.

Three special-status mammal species occur within the GSA OU. The American badger (*Taxidea taxus*), a California Species of Special Concern, has denned in the GSA OU in the past (Rueth and Berry, 1995). Calls of the pallid bat (*Antrozous pallidus*) and western red bat (*Lasiurus blossevillii*), both California Species of Special Concern, have been detected in the GSA OU (Dibley et al., 2014). While Site 300, including the undeveloped areas of the GSA OU, represents potential habitat for the state and federally endangered San Joaquin kit fox (*Vulpes macrotis mutica*), none have ever been observed at Site 300, despite numerous surveys.

### 3.3. History of Contamination

The eight confirmed contaminant release sites in the GSA OU are shown on Figure 9 and listed below:

**Central GSA:**
1. The Building 879 Steam-Cleaning/Sink facility.
2. Former dry well 875-S1.
3. Former dry well 875-S2.
4. A decommissioned solvent drum rack and underground solvent retention tank.
5. Former dry well 872-S.
6. Former dry well 873-S.
7. A former debris burial trench west of the sewage treatment pond in the Central GSA.

**Eastern GSA:**
8. Several former debris burial trenches north of the sewage treatment overflow pond in the Eastern GSA.

Solvents containing VOCs were commonly used as degreasing agents in craft shops in the Central GSA. Rinse water from these operations was disposed in dry wells. Typically, the dry wells in the Central GSA were gravel-filled pits 3 to 4 ft deep and 2 ft wide. The dry wells were used until 1982 and all were excavated in 1983 and 1984. An automotive steam-cleaning area and a sink used to rinse equipment were formerly located near the northeast corner of Building 879; water from these operations was discharged to the ground surface. Solvents were released as spillage from a solvent storage/dispensing drum rack, formerly located north of Building 875. In 1970, a 55-gallon solvent retention tank, encased in concrete, was installed at the site of the former drum rack. Use of the solvent retention tank was discontinued in 1987, and the contents removed. A debris burial trench, located approximately 350 ft northeast of Building 875, was used in the 1960s to dispose of craft shop debris that was contaminated with small quantities of VOCs.

In the Eastern GSA, craft shop debris was disposed of in debris burial trenches during the 1960s and 1970s. Some of this debris was contaminated with small quantities of VOCs. Trenching of the debris burial area, interviews with former and present employees, and
examination of aerial photographs indicate that the trenches contained metal, ceramic, and glass debris from the craft shops.

3.4. Initial Response

DOE began environmental investigations in the GSA OU in 1982. Since then, over 100 monitor wells have been installed to characterize the vertical and horizontal extent of contamination throughout the GSA OU and to measure groundwater elevations. Other site characterization methods included soil sampling, soil vapor surveys, hydraulic testing, colloidal borescope investigations, and geophysical surveys. Test pits were also used to determine the extent of burial trenches and contamination in the Eastern GSA.

Pre-ROD remediation activities at the GSA OU included:
• Excavating and backfilling all dry wells.
• Sealing and decommissioning impacted or threatened water-supply wells.
• Removal actions to extract and treat contaminated groundwater and soil vapor in the Central GSA and groundwater in the Eastern GSA.

3.5. Contaminants of Concern

3.5.1. Human Health Considerations

The primary COC found in groundwater and subsurface soil at the GSA OU is TCE, comprising approximately 90% of the total VOCs. Other COCs in the GSA OU include PCE, cis-1,2-DCE, 1,1-dichloroethene (1,1-DCE), 1,1,1-trichloroethane (1,1,1-TCA), bromodichloromethane, chloroform, trichlorofluoromethane (Freon 11), and 1,1,2-trichloro-1,2,2-trifluoroethane (Freon 113).

The baseline human health risk assessment conducted in 1991 for the Central GSA estimated a maximum excess carcinogenic risk of $7 \times 10^{-2}$ if groundwater from a hypothetical water-supply well located at the site boundary near the Building 875 dry wells were to be ingested over a 70-yr period (risk values below $10^{-6}$ are considered protective). The corresponding non-carcinogenic hazard index was 560 (hazard indices below 1 are considered protective). The baseline risk assessment also estimated an excess cancer risk to on-site workers from TCE vapors migrating into Building 875 of $1 \times 10^{-5}$. As discussed in Section 6.4.1.2, soil vapor extraction has contributed to reducing the excess cancer risk due to inhalation of VOC vapors migrating into Building 875 from $1 \times 10^{5}$ prior to remediation to $9.5 \times 10^{-7}$ in 2000 (U.S. DOE, 2000). Inhalation risk within Building 875 is no longer of concern. The 1991 baseline human health risk assessment for the Eastern GSA estimated an excess carcinogenic risk of $5 \times 10^{-5}$ for ingesting groundwater from a hypothetical water-supply well located at the site boundary near the debris burial trench. The risk associated with potential use of contaminated groundwater at two off-site wells CDF1 and SR-1 was approximately $10^{-5}$. No unacceptable risk or hazard was associated with potential exposure to VOCs in surface or subsurface soil.

VOCs were identified as COCs in subsurface soil and groundwater in the Central GSA; no COCs were identified in surface soil. The highest pre-remediation concentration of TCE in subsurface soil was 360 milligrams per kilogram (mg/kg), detected below the Building 875 dry wells. In general, the highest concentrations of VOC contaminants in groundwater have also been detected in the Building 875 dry well pad area. The pre-remediation concentration of total
VOCs in groundwater was approximately 272,000 µg/L (in a bailed groundwater sample collected during drilling of the Building 875 dry well pad dual-phase extraction well W-875-07 in March 1992). The 2015 maximum total VOC concentration was 546.5 µg/L (W-875-07, August). VOCs remain below analytical laboratory reporting limits in the Central GSA guard wells. Total VOC concentrations in groundwater in the Qt-Tnsc1 and Qal-Tnbs1 HSUs are shown on Figure 10, based on data from second semester 2015.

VOCs were identified as COCs in groundwater in the Eastern GSA; no COCs were identified in surface or subsurface soil. Very low concentrations of VOCs (maximum of 0.017 mg/kg) were detected in the vadose zone beneath the Eastern GSA debris burial trenches. The highest pre-remediation concentration of total VOCs detected in shallow groundwater near the debris burial trench was approximately 77 µg/L. Prior to the start of remediation, the plume of TCE in groundwater exceeding the MCL of 5 µg/L extended approximately 4,200 ft off-site. Since then, as described in Section 4.3.2 and 6.4.2, the portion of the plume exceeding the 5 µg/L cleanup standard has been remediated in both on and off-site groundwater.

As described in Section 3.1.3, additional shallow subsurface soil characterization of the Eastern GSA debris burial trenches was conducted in 2014. A total of 38 soil samples were analyzed for SVOCs, PAHs and PCBs. Only PCBs (Aroclor 1254 and 1260) were detected above laboratory reporting limits in six of these soil samples. The detected PCBs however, were below the EPA human health industrial and residential soil regional screening levels for Aroclor 1254 and Aroclor 1260.

3.5.2. Ecological Considerations

No contaminants of ecological concern have been identified for the GSA OU. The baseline ecological risk assessment for the GSA OU was presented in the Site-Wide Remedial Investigation Report (Webster-Scholten, 1994), and updated in the GSA Feasibility Study (Rueth and Berry, 1995). The results of the GSA baseline ecological risk assessment are summarized below, and new information available since the completion of the GSA baseline ecological risk assessment is reviewed to ensure the conclusions of the GSA baseline ecological risk assessment remain valid.

The GSA baseline ecological risk assessment found that elevated cadmium concentrations in surface soil samples collected from a small area east of the sewage treatment pond in the Eastern GSA could pose a risk to individual burrowing herbivorous mammals (represented by the California ground squirrel), individual burrowing carnivorous mammals (represented by the San Joaquin kit fox), and individual non-burrowing herbivorous mammals (represented by the black-tailed deer). Elevated cadmium and VOC concentrations detected in surface and/or subsurface soil samples collected from the Building 875 dry well area in the Central GSA were found to pose a potential risk to burrowing herbivorous and carnivorous mammals, and cadmium in surface soil in this area could pose a potential risk to non-burrowing herbivorous mammals. Available survey data and site-wide observations at the time found robust California ground squirrel and black-tailed deer populations at Site 300. Thus, the GSA baseline ecological risk assessment concluded that the localized areas of elevated cadmium and VOCs concentrations in surface and/or subsurface soil in the GSA OU were not adversely impacting the Site 300 populations of these species (Rueth and Berry, 1995).

While burrowing and non-burrowing mammalian populations of non-special status species were found not to be at risk from cadmium or VOCs found in surface and/or subsurface soil in
the GSA OU, the GSA baseline ecological risk assessment found that individuals of special-status burrowing species could be at risk should they exclusively utilize burrows or dens near the Building 875 dry well in the Central GSA, or east of the sewage treatment pond in the Eastern GSA, and reside and forage exclusively in these areas. The only special-status species occurring in the Central GSA at the completion of the GSA baseline ecological risk assessment was the American badger, which was observed denning just south and east of the Building 883 corporation yard (Rueth and Berry, 1995). Cadmium was not detected in surface soil samples collected in the vicinity of this area. The only special-status species observed in the Eastern GSA at the completion of the GSA baseline ecological risk assessment was the California red-legged frog. Breeding populations were observed in the off-site reach of Corral Hollow Creek south and northeast of the Eastern GSA and into the CDFW ecological preserve. Cadmium was not detected in surface soil samples collected from these areas. The available data showed that elevated cadmium concentrations in surface soil in the GSA OU that could pose an ecological risk were limited to an isolated area just east of the sewage treatment pond, and elevated VOC concentrations in subsurface soil that could pose an ecological risk were limited to the Building 875 dry well area. Therefore, the GSA baseline ecological risk assessment concluded that individual special-status burrowing species were not at risk from cadmium or VOCs in surface and/or subsurface soil in the GSA OU due to their limited extent (Rueth and Berry, 1995).

In 2003 and 2004, burrow air from the Building 834 and Pit 6 areas was sampled quarterly for TCE and PCE (Dibley et al., 2004). The concentrations of VOCs in subsurface soil in these areas bound the concentration of VOCs found in the Central GSA Building 875 dry well area. TCE and PCE were detected in burrow air in both areas, but at concentrations significantly below that predicted in the baseline ecological risk assessment, and well below that necessary to result in an ecological risk (Dibley et al., 2004). The limited extent of VOC contamination, the developed nature of Building 875 dry well area, and evidence from the burrowing air sampling at the Building 834 and Pit 6 areas support the conclusion that special-status burrowing species are not likely to be at risk from subsurface VOC concentrations in the Central GSA Building 875 dry well area.

In 2005, the U.S. EPA issued Ecological Soil Screening Levels (EcoSSLs) for cadmium (U.S. EPA, 2005). The EcoSSLs were developed for terrestrial plants, soil invertebrates, and three guilds of birds and mammals representing herbivores, ground insectivores and carnivores. With the exception of those for avian and mammalian ground insectivores, all EcoSSLs for cadmium are significantly above the concentrations of cadmium found in the Eastern GSA. In developing these screening levels, the U.S. EPA rigorously screened the available literature to develop a reasonable, yet conservative, toxicity reference value (TRV). In the GSA baseline ecological risk assessment, a single paper (Wills et al. 1981) was used to derive the highly conservative TRV of 0.0055 mg/kg/d for mammals. This paper was only one of 145 studies used by the EPA to derive the TRV for the mammals of 0.777 mg/kg/day. Site 300 does not have any strictly ground insectivorous mammals (such as the shrew), and few strictly ground insectivorous birds (none of which are expected to occur in the undeveloped areas of the GSA OU). None of the special-status mammalian or bird species known or expected to occur in the GSA OU are ground insectivores, and thus are not expected to be at risk from cadmium in surface soil in the Eastern GSA.

Although no strictly ground insectivorous special-status mammalian or avian species are known or expected to occur in the GSA OU, several insectivorous reptilian and amphibian
special-status species are known to occur in the OU. These include the California tiger salamander (*Ambystoma californiense*), the California red-legged frog (*Rana draytonii*), the Western spadefoot toad (*Spea hammondii*), and the San Joaquin coachwhip (*Masticophis flagellum ruddockii*). These species may include ground-dwelling insects in their diet, although the arid nature of Site 300 limits the abundance and types of ground-dwelling insects. Although the EPA did not develop ecological soil screening levels for reptiles or amphibians due to the lack of data, it considers the mammalian and avian EcoSSLs to be protective of these guilds. While the cadmium concentrations in surface soil in the Eastern GSA exceed the mammalian and avian ground insectivore EcoSSLs, the extent of this contamination, as well as the availability of ground-dwelling insects, limits the risk to special-status reptiles and amphibians that may occur in the GSA OU.

In 2009, the Site 300 Compliance Monitoring Plan and Contingency Plan was revised, which included the GSA OU (Dibley et al., 2009b). The 2009 Compliance Monitoring Plan and Contingency Plan require an ecological review every five years, which updates the assessment of ecological impacts from Site 300 contaminants. One five-year ecological review has been completed under the 2009 Compliance Monitoring Plan and Contingency Plan. This five-year ecological review (referred to as the 2013 Five-Year Ecological Review), is reported on in the 2013 Annual Compliance Monitoring Report (Dibley et al., 2014), and evaluated chemical and biological data collected between January 1, 2008 and December 31, 2012. The 2013 Five-Year Ecological Review concluded contaminant and ecological conditions at Site 300, including those at the GSA OU, had not significantly changed.

As described in Section 3.5.1 above, characterization of SVOCs, PAHs and PCBs in shallow subsurface soil conducted the Eastern GSA debris burial trench area in 2014 indicated that of 39 soil samples analyzed for SVOCs, PAHs and PCBs, only PCBs (Aroclor 1254 and 1260) were detected above laboratory reporting limits in six of these soil samples. The U.S. EPA elected not to develop ecological screening levels for PCBs, but rather instructed risk assessors to consider all detections to be site-related, and evaluate the potential ecological impact on a case-by-case basis (U.S. EPA, 2005). Due to the types of terrestrial species found at the GSA OU, as well as the limited extent of PCB detected in the subsurface soil, it is unlikely the detection of PCBs in the shallow subsurface soil in the vicinity of the Eastern GSA debris burial trenches pose an ecological risk.

The evaluation presented in this section supports the conclusion that ecological receptors continue to not be at risk from contaminants in the GSA OU.

### 3.6. Summary of Basis for Taking Action

Remedial actions were initiated in the GSA OU to address unacceptable human health risks associated with subsurface contamination at the GSA OU including: (1) potential ingestion of groundwater containing VOCs at concentrations exceeding drinking water MCLs, and (2) on-site worker inhalation exposure to TCE volatilizing from the subsurface soil to indoor air within Building 875. The remedial actions were also initiated to restore the beneficial uses of groundwater in this area. The remedial action objectives for the GSA OU cleanup are discussed below in Section 4.1.
4. Remedial Actions

4.1. Remedial Action Objectives

The remedy selected for the GSA OU is intended to achieve the following Remedial Action Objectives (RAOs):

**Protection of Human Health:**
- Prevent human ingestion of the groundwater containing VOC concentrations (single carcinogen) above the State and Federal drinking water MCLs, a cumulative excess cancer risk (all carcinogens) greater than $10^{-6}$, and a cumulative hazard index (all non-carcinogens) greater than 1.
- Prevent human inhalation of VOCs in vapor volatilizing from subsurface soil into Building 875 at concentrations above those that pose an excess cancer risk of $10^{-6}$.

**Protection of the Environment:**
- Restore water quality, at a minimum, to water quality objectives that are protective of beneficial uses (i.e., MCLs).

The cleanup standard for groundwater in the GSA OU is to reduce VOC concentrations to MCLs in all impacted groundwater. VOCs in the vadose (unsaturated) zone will be remediated to the extent technically and economically feasible to minimize further degradation of the groundwater by contaminants in the vadose zone. The vadose zone cleanup will be completed when it is demonstrated that: (1) VOCs remaining in the vadose zone no longer cause concentrations in the leachate to exceed their respective groundwater MCL cleanup standards (established as a soil vapor concentration of 0.36 parts per million on a volume-to-volume basis [ppmv/v]) based on an interpretation of soil vapor data using an appropriate vadose zone model, and (2) VOCs have been removed to the extent technically and economically feasible to meet the groundwater cleanup levels sooner, more cost-effectively, and more reliably (U.S. DOE, 1997). Another cleanup standard is to mitigate the excess cancer risk from inhalation of indoor air within Building 875 caused by VOCs migrating into the building from the subsurface. This objective has been met as described in Section 3.5.

4.2. Remedy Selection

The remedy for the GSA OU was selected to contain contaminant sources, prevent further plume migration, remove contaminant mass from the subsurface, and protect human health and the environment both on site and off site. In the remedial design phase, DOE considered hydrogeologic factors, contaminant characteristics, available remedial technologies, and effective performance monitoring techniques.

The selected remedy for the GSA OU consists of:

1. Monitoring groundwater and soil vapor to evaluate the effectiveness of the remedy in achieving cleanup standards, and to ensure there is no impact to downgradient water-supply wells.
2. Risk and hazard management to prevent on-site worker exposure to VOCs volatilizing from subsurface soil into indoor air at Building 875 until risk and hazard is mitigated through active remediation. Annual risk re-evaluation indicates that the inhalation risk for VOCs volatilizing from subsurface soil into indoor air in Building 875 has been mitigated through remediation. Therefore, risk and hazard management for this exposure pathway is no longer necessary. The risk re-evaluation results are documented in the “Building 875 Inhalation Risk Mitigation Evaluation at the Central GSA at Lawrence Livermore National Laboratory Site 300” (U.S. DOE, 2000). Institutional/land use controls will be implemented to prevent human exposure to contamination and to protect the integrity of the remedy.

3. Extracting and treating VOCs in soil vapor and groundwater in the Central GSA to mitigate unacceptable VOC inhalation risk for on-site workers, prevent further impacts to groundwater and off-site plume migration, and reduce contaminant concentrations in soil and groundwater to MCL cleanup standards.

4. Extracting and treating VOCs in groundwater in the Eastern GSA to mitigate to reduce VOC concentrations in groundwater to MCL cleanup standards. VOC concentrations in Eastern GSA groundwater were reduced to below the MCL cleanup standards in 2005. With regulatory concurrence, the treatment facility was shut down in February 2007, and VOC concentrations remained below cleanup standards during the five-year post-facility shutdown rebound monitoring period (February 2007-February 2012).

4.3. Remedy Implementation

Remedial action monitoring requirements are contained in the Compliance Monitoring Plan and Contingency Plan for Environmental Restoration at LLNL Site 300 (Dibley et al., 2009b).

A risk and hazard management program, including institutional and land use controls, has been implemented at GSA OU. The land use/institutional controls for the GSA OU are described in Section 4.5 and Table 1.

The results of groundwater remedial action monitoring, remediation progress, and the status of institutional control implementation for the GSA OU are reported in the ERD semiannual and annual Compliance Monitoring Reports and in this Five-Year Review report. Sections 4.3.1 and 4.3.2 below present a summary of the actions DOE has taken to implement the selected remedy in the GSA OU, and also describe any significant modifications to the remedy since the Final ROD and Remedial Design documents for the GSA OU were issued. System operations and maintenance and institutional/land use controls, including the status of these controls in the GSA OU Controls are discussed in Sections 4.4 and 4.5, respectively. Information on the performance of the remedy, the current concentrations and distribution of contamination, and risk mitigation progress is included in Section 6.4.

4.3.1. Central GSA Remedy Implementation

The Central GSA remediation system consists of groundwater and soil vapor extraction and treatment as described below. A map of the Central GSA showing the locations of monitoring, extraction, injection, and former water-supply wells, and treatment facilities is presented in Figure 4.
4.3.1.1. Central GSA Groundwater Remedy Implementation

Groundwater cleanup began in the Building 875 dry well release area at Central GSA in 1993 using four extraction wells completed in the Qt-Tnsc1 HSU. The ROD and Remedial Design documents included plans to evaluate expansion of the groundwater extraction wellfield to include other contaminant sources and the downgradient extent of the VOC plume in the Qal-Tnbs1 HSU. VOCs have historically not been detected in the deeper Tnbs1 HSU, or have only been sporadically detected at trace concentrations, and no active remediation is occurring in this HSU. Since groundwater remediation began, three wellfield expansions have occurred:

- Phase I wellfield expansion occurred in 1999 and included the addition of three Qt-Tnsc1 HSU groundwater extraction wells to increase VOC mass removal and hydraulic capture of the plume. Extraction wells W-872-02 and W-873-07 were installed at the Building 872 and Building 873 dry well VOC release sites, respectively. Extraction well W-7O was installed hydraulically downgradient from the Building 875 dry well release area.

- Phase II wellfield expansion occurred in 2005 and included the addition of two Qal-Tnbs1 HSU groundwater extraction wells to increase hydraulic capture of the downgradient VOC plume. Extraction wells W-7R and W-7P were installed farther downgradient from the Building 875 dry well release area. W-7P is also located immediately downgradient of the Central GSA debris burial trench.

- Phase III wellfield expansion occurred between 2012 and 2015 and included installing one new groundwater extraction well, W-CGSA-2708, to increase hydraulic capture of VOCs and contaminant mass removal in the northern VOC plume area. In lieu of connecting this extraction well to the Central GSA groundwater extraction and treatment system, a new treatment facility (CGSA-North) was completed in 2015. Groundwater extracted from W-CGSA-2708 and treated at CGSA-North will be injected into a recently installed nearby injection well, W-CGSA-2907.

Between 2011 and 2015, contaminated groundwater was extracted from eight wells (W-7I, W-7O, W-7P, W-7R, W-872-02, W-873-07, W-875-07 and W-875-08) at a combined flow rate of approximately 0.2 to 11 gallons per minute (gpm). Due to declining water levels resulting from extraction and regional drought conditions, only four of these wells (W-7R, W-872-02, W-873-07, and W-875-08) contributed to the volumes extracted during 2014 and combined flow rates declined to a reporting period low of 0.2 gpm by the end of 2014. During 2015, the entire extraction wellfield contributed again to the volumes extracted; W-7O, W-7P, and W-7R were the main contributors with the largest gain coming from lowering the pump intake depth at W-7P. The combined flow rates increased and ranged between 8 and 11 gpm in 2015.

While declining water levels have resulted in diminished extraction rates throughout the reporting period, drought conditions have not affected the wellfield’s ability to exert hydraulic control on the VOC plume and groundwater extraction remains effective at preventing off-site plume migration. Extraction wells W-7I and W-875-07 are within the capture zone of deeper-screened extraction well W-875-08, and when operational, produce a minor fraction of the total groundwater volume extracted. Downgradient of extraction well W-7O, extraction well W-7R pumps groundwater continuously while the Central GSA treatment facility is operational, capturing VOCs migrating downgradient of extraction well W-7O independent of whether extraction well W-7O is operational. Extraction well W-7P is designed to extract groundwater
from Qal-Tnbs₁ HSU only, as the underlying Tnbs₁ HSU groundwater is not impacted by VOCs and discharges into the Qal-Tnbs₁ HSU. During drought periods, Qal sediments are essentially dry and extraction well W-7P is unable to operate. VOC concentrations in extraction well W-7P remained below 2 µg/L during the 2012-2014 drought period, prior to rebounding to 3.9 µg/L in early 2015 as Central GSA water levels rose due to seasonal precipitation, concurrently triggering groundwater extraction at extraction well W-7P.

The Central GSA groundwater treatment system also treats water from the Building 830-Distal South (830-DISS) facility, after removal of perchlorate at the 830-DISS facility. The current 830-DISS groundwater extraction wellfield consists of W-830-2216, W-830-51, W-830-52, and W-830-53. The current Central GSA groundwater treatment system configuration includes particulate filtration, air stripping to remove VOCs from extracted water, and granular activated carbon (GAC) to treat vapor effluent from the air stripper. Spent GAC treatment media are managed by the LLNL Radioactive and Hazardous Waste Management Department for recycling or disposal at the appropriate facility based on the characteristics of the spent treatment media. Treated groundwater is discharged to the surrounding natural vegetation using misting towers located on a hilltop about 750 ft north of the CGSA treatment system.

During 2015, construction of the new CGSA-North groundwater treatment system was completed to increase hydraulic capture of VOCs and contaminant mass removal in the northern VOC plume area. At the CGSA-North system, groundwater is extracted from one extraction well, W-CGSA-2708, treated and then discharged to the re-injection well W-CGSA-2907. The treatment system consists of a Cuno® filter followed by three aqueous-phase GAC vessels in series to remove VOCs. The treatment system is expected to operate cyclically and at very low flow rates (< 0.5 gpm).

During the last five years, the Central GSA groundwater treatment system operated in compliance with the RWQCB Substantive Requirements for Wastewater Discharge as documented in the semi-annual Site 300 Compliance Monitoring Reports. Treated vapors are discharged to the atmosphere under a permit from the San Joaquin Valley Unified Air Pollution Control District. Remediation efforts have reduced VOC concentrations in Central GSA groundwater from a historic maximum of 272,000 µg/L (1992) to a 2015 maximum of 547 µg/L.

4.3.1.2. Central GSA Vadose Zone Remedy Implementation

In July 1994, DOE began soil vapor extraction at the Building 875 dry well VOC source area as a removal action. The soil vapor extraction wellfield and treatment system described in the GSA ROD and Remedial Design documents has been fully implemented. Simultaneous groundwater extraction in the vicinity lowers the elevation of the groundwater surface and maximizes the volume of unsaturated soil influenced by vapor extraction. Soil vapor has historically been extracted from three to seven extraction wells, with others used as vapor inlet wells. In late 2007, Venturi™ flow meters were installed on each well. All seven extraction wells have been operating simultaneously since late 2007.

The current soil vapor treatment system consists of a water knockout chamber, a rotary vane blower, and four 140-pound (lb) vapor-phase GAC columns arranged in series. Spent vapor-phase GAC treatment media are managed by the LLNL Radioactive and Hazardous Waste Management Department for recycling or disposal at the appropriate facility based on the characteristics of the spent treatment media. Treated vapors are discharged to the atmosphere under a permit from the San Joaquin Valley Unified Air Pollution Control District.
Vadose zone remediation has reduced TCE concentrations in the Central GSA from a historic maximum of 529 ppm_{v/v} (1994) to a 2015 maximum of 1.4 ppm_{v/v}.

### 4.3.2. Eastern GSA Remedy Implementation

A groundwater treatment system operated in the Eastern GSA from 1991 to 2007 to remove VOCs from groundwater. A map of the Eastern GSA showing the locations of monitoring, extraction, water-supply wells, and the former treatment facility is presented on Figure 5. VOC-contaminated groundwater was extracted from three wells (W-26R-03, W-25N01, and W-25N-24), located downgradient from the Eastern GSA debris burial trenches, at a combined flow rate of 45 gpm. The extracted groundwater was treated in three 1,000-lb granular activated carbon units that removed VOCs through adsorption. The treated effluent water was discharged to nearby Corral Hollow Creek.

Remediation efforts in the Eastern GSA successfully reduced concentrations of TCE and other VOCs in groundwater and by 2005, VOC concentrations in both on-site and off-site groundwater in the Eastern GSA area had been reduced to below the drinking water cleanup standards set in the GSA ROD. Therefore, and as described in Sections 3.1.3 and 3.5.2 above, the groundwater treatment system was shut down with regulatory approval in 2007.

### 4.4. System Operations/Operation and Maintenance

The GSA OU extraction and treatment systems are operating as designed and no significant operations, performance, maintenance, or cost issues were identified during this Five-Year Review. All required documentation is in place, and treatment system operations and maintenance (O&M) activities are consistent with established procedures and protocols.

O&M procedures are contained in the following documents:

- Integration Work Sheet Safety Procedure #11341: Ground Water and Soil Vapor Treatment Facility Operations at Site 300.
- Integration Work Sheet Safety Procedure #11313: ERD Site 300 Off-Road Driving Training.
- Integration Work Sheet Safety Procedure #11343: ERD Routine Ground Water Sampling & Water Level Monitoring at Site 300.
- Integration Work Sheet Safety Procedure #14984: ERD Routine Electronic Operations at Site 300.
- Integration Work Sheet Safety Procedure #11339: ERD Site 300 Hydraulic Pump Operation.
- Integration Work Sheet Safety Procedure #11346: Spent Aqueous and Vapor-phase Granular Activated Carbon (GAC) Replacement at Site 300.
• GSA Compliance Monitoring Plan and Contingency Plan included in Appendices F and G of the GSA Remedial Design (Rueth et al., 1998), until incorporated into and superseded by the Site-Wide Compliance Monitoring Plan/Contingency Plan for Remedies at LLNL Site 300 (Dibley, et al., 2009).

• LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures (Goodrich and Lorega, 2016).


• Eastern GSA Treatment Facility Operations Checklist (LLNL, 1999).

• Central GSA: Substantive Requirements and the Monitoring and Reporting Program issued by the California RWQCB and the Permit to Operate issued by the San Joaquin Valley Unified Air Pollution Control District.

Monitoring and optimizing the performance and efficiency of the extraction and treatment systems comprises a large portion of the O&M activities. Extracted groundwater is sampled throughout the treatment process to ensure compliance with discharge requirements. Treatment system parameters such as pressure and flow are routinely recorded to anticipate potential mechanical problems and monitor system performance.

The major O&M activities for the Central GSA treatment systems include:

• Maintaining the particulate filters.
• Maintaining the misting towers used to discharge treated groundwater.
• Protecting the units from freezing in cold weather.
• Replacing spent GAC.
• Routinely inspecting and maintaining extraction well pumps, pipelines, and flow meters.
• Maintaining air stripper.
• Injecting anti-scaling compounds.
• Maintaining remote computer access and data collection capabilities.

The budgeted and actual costs associated with the management, investigation, testing, modeling, design, construction, and O&M of the environmental remediation activities within the GSA OU are tracked closely. The costs to operate, maintain, and monitor the GSA OU remedy are consistent with the estimated annual operating costs presented in the ROD for fiscal years 2011 and 2012. GSA OU costs in fiscal years 2013, 2014, and 2015 are higher than estimated in the ROD as a result of additional costs for: (1) facility upgrades to replace aging system components and increase operational efficiency, (2) to address critical habitat issues (i.e., relocating the Central GSA facility effluent misting towers), and (3) conduct additional regulatory requested characterization activities. Table 2 presents the actual costs for the last five fiscal years (2011 through 2015).

More specific maintenance details for the Central GSA OU treatment systems during this five-year review period are documented in the semiannual and annual Compliance Monitoring Reports. However, the main activities are summarized below (the CGSA-North groundwater treatment system did not become operational during this five-year review period; therefore, no details are provided below):
• The groundwater treatment system was shut down to prevent damage from freezing temperatures during the winter months of 2011, 2012, 2013, 2014, and 2015.

• The soil vapor treatment system was shut down to prevent damage from freezing temperatures during the winter months of 2010, 2011, and 2012.

• The groundwater treatment system was periodically shutting down from April 2010 until September 2010 for unknown reasons. The problem was finally diagnosed as an issue with the level switches in the misting transfer tank, and issues with the misting tank transfer pump.

• The groundwater treatment system was shut down for two weeks in August of 2010 to replace the entire pipeline made of black iron pipe with PVC pipe.

• The compressor that provides air to operate all extraction wells outfitted with auto pumps failed on December 20, 2010, and repairs were not completed until February 3, 2011. During this time, only extraction wells outfitted with electrical submersible pumps were in operation.

• Misting of the groundwater treatment system effluent was switched from the lower misting towers to the upper towers in October 2011.

• The groundwater treatment system was shut down from November 28, 2011 until January 19, 2012 due to transfer pump problems. Only extraction well W-7O operated from January 19 until February 6, when all wells were brought back online.

• Groundwater treatment system only operated Monday through Thursday from May 2013 until the new misting towers were brought on-line in April 2014. This was due to problems associated with the old misting towers.

• Groundwater extraction from well W-7I was shut off in September 2013 to correct totalizer issues. Soil vapor extraction was shut off in September 2013 for a rebound test. Extraction of both groundwater and soil vapor in well W-7I was restarted on September 16, 2013. On September 25, 2013, extraction well W-7I was shut down due to construction of the Central GSA misting tower road crossing and remained offline for the remainder of 2013.

• New misting towers were installed during the first quarter 2014 and testing and verification of the new misting towers was completed and the groundwater treatment system was restarted in April 2014.

• A new soil vapor treatment system compressor was installed in February 2014.

• In March 2015, the pump in well W-7P was removed, pump tubing was replaced, and the pump was mistakenly reinstalled deeper within the well, resulting in a lower intake depth from 20.0 to 32.2 ft below measuring point. This resulted in over pumping at W-7P during 2015; the pump intake depth will be changed to approximately 20 ft below measuring point during remedial system upgrades planned for 2016.

• The groundwater treatment system was restarted on March 16, 2015, following shutdown for freeze protection. Compliance samples were collected on March 17, 2015, that
indicated the presence of TCE in the effluent sample at a concentration of 0.57 µg/L; slightly above the 0.5 µg/L effluent limit. A second effluent verification sample was collected on March 19, 2015, and the treatment system was shut down pending receipt of the second sample results. No VOCs were detected in this sample. The treatment system was restarted on March 23, 2015 and an additional sample collected on March 24, 2015. No VOCs were detected in this March 24, 2015 sample. An influent flow rate of 14 gpm, which was more than twice the flow rates measured in 2014, coupled with reduced air flow in the stripper, reduced the efficiency of the stripper to remove all the VOCs. Maintenance was performed on the stripper.

- The groundwater treatment system was shut down on May 13, 2015 due to a detection of TCE (1.3 µg/L) in the effluent samples collected on May 12, 2015. Additional assessments were performed on the air stripper, and air flow rates were increased. The treatment system was restarted on May 20, 2015 for resampling and again shut down pending analytical results.

- Additional system inspections discovered partial clogging of the air inlet lines, which was believed to be the cause of the performance problems. The lines were cleared and the groundwater treatment system was restarted on May 26, 2015, and another effluent sample was collected. The treatment system was again shut down pending analytical results. No VOCs were detected in the May 20 or May 26, 2015 samples. The groundwater treatment system was restarted on June 1, 2015.

- The groundwater treatment system was offline from June 4 until August 17, 2015 due to an electrical problem with one of the misting head motors. The treatment system again shut down on September 8, 2015, due to additional electrical problem with the remaining misting head motors, and remained offline for the remainder of 2015. The system was restarted in April 2016.

### 4.5. Institutional and Land Use Controls

Land use controls are restrictions or controls that are implemented to protect human health and the environment, such as restricting access or limiting activities at a contaminated site.

Types of land use controls include:
- Institutional controls.
- Engineered controls.
- Physical barriers.

The U.S. EPA (2010) defines institutional controls as non-engineered instruments, such as administrative and legal controls, that help to minimize the potential for human exposure to contamination and/or protect the integrity of a response action. Institutional controls are typically designed to work by limiting land or resource use or by providing information that helps modify or guide human behavior at a site. Institutional controls are a subset of land use controls. Institutional controls are divided into four categories:

1. Proprietary controls.
2. Governmental controls.

3. Enforcement and permit tools.

4. Information devices.

Proprietary controls are generally created pursuant to state law to prohibit activities that may compromise the effectiveness of a remedial action or restrict activities or future resource use that may result in unacceptable risk to human health or the environment, such as easements and covenants. Governmental controls impose restrictions on land use or resource use, using the authority of a government entity. Federal landholding agencies, such as DOE, possess the authority to enforce institutional controls on their property. At active federal facilities, such as LLNL Site 300, land use restrictions may be addressed in master plans, facility construction review processes, and digging permit systems. Enforcement and permit tools are legal tools, such as Federal Facility Agreements (FFAs) that limit certain site activities or require the performance of specific activities. Information devices provide information or notifications to local communities that residual or contained contamination remains on site.

Land use controls also include engineering controls and physical barriers, such as fences and security guards, as means to protect human health by reducing or eliminating the hazard and/or the potential for exposure to contamination.

In this document, the term “land use controls” is used to encompass institutional controls, engineered controls, and physical barriers.

Land use controls are necessary to prevent human receptor exposure to contaminants in soil, and to groundwater currently above the MCLs. Land use controls are more effective if they are layered or implemented in series with each other. Layering can involve using different types of land use controls at the same time to enhance the protectiveness of the remedy. DOE/LLNL has implemented multiple layers of protection to prevent human receptor exposure to contaminants in soil, and in groundwater currently above the MCLs.

The land use controls and requirements described herein are only applicable to the GSA OU and associated contaminated environmental media that are being addressed through the CERCLA process. As required by the Site 300 Compliance Monitoring Plan, the land use controls are reviewed annually using the Institutional Controls Monitoring Checklist. The land use/institutional controls checklist was reviewed and approved by the regulatory agencies and was presented in the 2009 Compliance Monitoring Plan. The annual checklists are included in the annual Site 300 Compliance Monitoring Reports.

Land use controls for the GSA OU, as agreed to and presented in the Site-Wide ROD (DOE, 2008), are described in Table 1. Table 1 presents descriptions of: (1) the land use control objective and duration, (2) the risk necessitating these controls, and (3) the specific land use controls and implementation mechanisms used to prevent exposure to contamination at the GSA OU. Table 1 reflects the verbatim language from Table 2.9-13 from the 2008 Site-Wide Record of Decision, with risk reduction and/or mitigation discussion added where appropriate. Figure 3 shows the specific areas of the GSA OU where the land use controls are currently maintained or implemented.

The land use control objectives and the risk necessitating these controls, the specific land use controls and implementation mechanisms used to prevent exposure to contamination at the GSA OU by objective, and the status of the land use controls are summarized below. Section 4.5.1
also provides additional details on the land use control implementing mechanisms based on requests from and discussion with the regulatory agencies, and any changes to the land use controls as a result of risk reduction and/or mitigation that have occurred since the 2008 Site-Wide ROD. This includes any clarifying text per regulatory comments on this or previous Five-Year Reviews, and the status of the LUCs as of the current Five-Year Review date. As a result, the text in Section 4.5.1 below does not track directly with the text in Table 1.

4.5.1.  GSA Land Use Controls

Land use control objectives were established for the GSA OU in the Site-Wide ROD (U.S. DOE, 2008) to reduce risk and prevent exposure to contaminated environmental media (Table 1). The risk drivers, associated land use control objectives, and the land use controls to meet these objectives are described in Sections 4.5.1.1 through 4.5.1.4 below. These sections are organized by the land use control objectives identified for the GSA OU. While some of the types of implementing mechanisms of governmental institutional and land use controls (i.e., Dig Permit Process, Work Induction Board Process) that apply to the GSA OU are cited in more than one section below, they are cited separately as the implementing mechanisms vary according to the land use control objective.

DOE/LLNL has implemented multiple layers of protection (governmental institutional and land use controls) to prevent or control:

1. Water-supply use or consumption of contaminated groundwater in the GSA OU until groundwater cleanup standards are met.
2. Onsite worker exposure to VOCs in subsurface soil at the Central GSA Building 875 dry well pad area until it can be verified that subsurface soil does not pose an exposure risk to on-site workers.
3. Onsite worker inhalation exposure to VOCs inside Building 875 until annual risk re-evaluation indicates that the risk is less than 10^-6. (Note: The risk has been successfully reduced to less than 10^-6 through groundwater and soil vapor extraction and treatment in the Building 875 area as of 2000 [see Section 3.5], therefore, this institutional/land use control is no longer needed.)
4. Transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use.

4.5.1.1. Prevent Water-supply Use/Consumption of Contaminated Groundwater

**Risk Driver** – VOCs concentrations in groundwater exceeding cleanup standards.

**Land Use Control Objective**: Prevent water-supply use/consumption of contaminated groundwater until groundwater cleanup standards are met.

**Land Use Controls**: Because the controls to prevent water-supply use/consumption of contaminated groundwater differ for portions of the VOC plume that are present on site at LLNL Site 300 and off site, these controls and their status are discussed separately below.

**Onsite Land Use Controls**: As discussed in Section 4.3.2, VOC concentrations in Eastern GSA on-site groundwater have been reduced to below groundwater cleanup standards (MCLs) through remediation. Therefore, the land use controls to prevent the water-supply use or consumption of on-site contaminated groundwater are no longer needed for the Eastern GSA subarea. Because
VOC concentrations on site in the Central GSA still exceed groundwater cleanup standards (MCLs), the land use controls described below are still in effect to prevent the water-supply use or consumption of on-site contaminated groundwater in the Central GSA subarea.

DOE/LLNL has implemented two layers of protection (land use controls) to prevent the water-supply use or consumption of on-site contaminated groundwater in the Central GSA area until groundwater cleanup standards are met. These land use controls are:

- **Governmental Controls:**
  - Dig Permit Process.
  - Work Induction Board Process.

**Governmental Controls:**

**Dig Permit Process:** The construction of water supply wells in the Central GSA subarea is prevented through implementation of the dig permit process. The dig permit process is applicable to well construction activities because well construction involves soil-disturbing activities, and no soil disturbance is allowed at Site 300 without a soil excavation permit approved by the LLNL Facilities and Infrastructure Documentation and Permits Group. A LLNL Dig Permit approved by the LLNL Facilities and Infrastructure Documentation and Permits Group is required to drill and install any new on-site wells at Site 300. Prior to a decision to grant any such permit, the LLNL Environment, Safety and Health (ES&H) Team Environmental Analyst (EA) must conduct an evaluation of the proposed well location to determine if the proposed new water-supply well is located in an area of groundwater contamination. As part of this evaluation, the EA reviews the LUC maps, such as Figure 11, provided by the LLNL ERD that show areas of contaminated groundwater with concentrations of contaminants of concern exceeding drinking water MCL groundwater cleanup standards. As water-supply well drilling is prohibited in these areas until cleanup standards are achieved, the EA works with the LLNL entity proposing the well installation and ERD to relocate the well to ensure groundwater contaminants would not be drawn into the well or that the proposed well would compromise the integrity of the remedy.

**Work Induction Board:** Any proposed on-site well drilling activities are also submitted to the LLNL Work Induction Board, and are reviewed by ERD to ensure that new water-supply wells are not located in areas of groundwater contamination. The Work Induction Board meets weekly to review new proposed work at Site 300 to ensure that work is conducted in conformance with the appropriate controls and includes the special concerns for work at Site 300 (i.e., environmental contamination). If installation of new water-supply wells is being proposed, ERD will ensure that the new water-supply wells are not located in areas of groundwater contamination or that they would compromise the integrity of the remedy.

**Five-Year Review Status:** As described above, land use controls are no longer needed for the Eastern GSA subarea to prevent the water-supply use or consumption of on-site contaminated groundwater as remediation has reduced VOC concentrations in Eastern GSA groundwater to below cleanup standards.

During this five-year review period, there were no dig permit applications or proposals brought to the Work Induction Board to drill and install new on-site water-supply wells within areas of on-site groundwater contamination in the Central GSA subarea.
Offsite Land Use Controls: The 2008 Site-Wide Record of Decision addresses the remediation of contaminated groundwater that extends to two privately owned property parcels located adjacent to and downgradient of the GSA OU; these parcels are referred to in this document as the Union Livestock property, and the Corral Hollow Ranch. The Union Livestock property is located adjacent to the Eastern GSA subarea of the GSA OU, and the Corral Hollow Ranch is located adjacent to the Central GSA subarea. The locations of these properties relative to the Eastern GSA and Central GSA subareas are shown on Figure 3. Both parcels, as well as Site 300, are located in San Joaquin County, California.

Union Livestock Property and Associated Water-Supply Wells

There are two active water-supply wells (CDF1 and CON1) located on the Union Livestock property. These wells are located downgradient from the debris burial trench source area in the Eastern GSA subarea (Figure 3). Prior to remediation, a VOC plume had migrated off site from the debris burial trench area off the Site 300 property to the vicinity of wells CDF1 and CON1. As discussed in Section 4.3.2, VOC concentrations in Eastern GSA groundwater, both on Site 300 and on Union Livestock property, have been reduced to below groundwater cleanup standards (MCLs) through remediation both on site and on Union Livestock property.

The VOC plume emanating from the Central GSA former dry wells is not currently present on or near the Union Livestock property or water-supply wells CDF1 and CON1. The closest off-site well with VOC contamination (W-35A-01) is located about 1,000 ft upgradient of the Union Livestock property boundary and water-supply wells CDF1 and CON1 (Figure 3). VOC concentrations in well W-35A-01 have decreased significantly as a result of remediation (90% reduction from the historical maximum concentration in 1991). In addition, between the Site 300 property boundary and water-supply wells CDF1 and CON1 there are six wells (W-35A-03, W-35A-04, W-35A-06, W-35A-11, W-35A-12, W-35A-13) in which no VOCs were detected above the laboratory reporting limits between W-35A-01. These wells are monitored regularly to provide an early indication in the extremely unlikely event of any migration of the VOC plume towards these water-supply wells. In addition, DOE monitors water-supply wells CDF1 and CON1 for VOCs monthly. Because there currently is no groundwater from Site 300 contaminated above MCLs on or near the Union Livestock property, land use controls to prevent the water-supply use or consumption of contaminated groundwater are no longer needed for the Union Livestock property. Continuing institutional control efforts are therefore focused on the Corral Hollow Ranch property.

Corral Hollow Ranch Property and Water-Supply Wells

VOCs associated with the groundwater plume from the Central GSA are currently detected at concentrations exceeding groundwater cleanup standards in two LLNL off-site monitor wells, W-35A-01 and W-35A-10, located approximately 50 and 100 ft beyond the Site 300 boundary, respectively. Both wells are located on the Corral Hollow Ranch property. The source of these VOCs is former dry wells located in the Central GSA. The portion of the Central GSA VOC plume that extends onto the Corral Hollow Ranch property is located approximately 2,200 ft downgradient of the GALLO1 water-supply well (Figure 3). Because the Central GSA VOC plume is located a significant distance downgradient from this water-supply, the well is not at risk of being contaminated by the Central GSA VOC plume. DOE nevertheless monitors water-supply well GALLO1 for VOCs monthly. DOE/LLNL currently relies on two layers of land use controls to prevent the water supply use or consumption of VOC-contaminated groundwater in
water-supply wells beyond the Site 300 property boundary until groundwater cleanup standards are met. These land use controls include Governmental Controls and Informational Devices. As neither of these land use controls is identified in the Site-Wide ROD and DOE/LLNL has yet to conclude an agreement with the landowner to provide point-of-use treatment as called for in the Site-Wide ROD, DoE/LLNL will either conclude an agreement with the landowner or modify the land use controls portion of the remedy during the next five-year review period to incorporate appropriate land use controls.

**Governmental Controls:**

The San Joaquin County well permitting process and well completion reporting process serves as a governmental institutional control to prevent water-supply use or consumption of contaminated groundwater from any new water-supply well by preventing the installation of new wells within the footprint of the Central GSA VOC plume that extends onto the Corral Hollow Ranch property.

The location, construction, repair and destruction of water supply, monitoring and geophysical wells and borings is regulated by the San Joaquin County Ordinance Code, Section 9-1115. The San Joaquin County ordinance prohibits the drilling, alteration, or destruction of any well in the county without a permit from the San Joaquin County Environmental Health Department (SJC EHD). The SJC EHD well construction/alteration and destruction permit requirements adhere to the Department of Water Resources (DWR) California Well Standards (Bulletins 74-81 and 74-90). Under the DWR’s California Well Standards, all water wells are required to be located an adequate horizontal distance from known or potential sources of pollution and contamination, including biological and chemical sources. The SJC EHD also requires that aquifer isolation is maintained during the drilling and well construction process to prevent cross contamination of aquifers. The DWR is responsible for maintaining a file of well completion reports, which must be submitted whenever a driller constructs, alters, or destroys a well.

In addition, all well construction, alteration, destruction, or abandonment must be performed by an individual with a C-57 Water Well Contractor’s License. All well drillers are required to file a completion report (Well Completion Report Form – DWR 188) with the DWR (California Water Code 13750.5-13751). The San Joaquin ordinance requires the completion report also be filed with SJC EHD. Individuals with a C-57 Water Well Contractor’s License must follow California DWR regulations and local standards. The completion report documents methods used for sealing off surface or contaminated waters and methods used for preventing contaminated waters of one aquifer from mixing with the waters of another aquifer. Failure to comply with any provision of the Health and Safety Code or Water Code, including but not limited to those listed above, is a misdemeanor. The threat of criminal sanctions serves as a significant deterrent to the unlicensed drilling of wells.

DOE/LLNL will use the San Joaquin well ordinance to help prevent exposure to the Central GSA VOC plume on the Corral Hollow property in two ways. First, DOE/LLNL will work to establish an agreement with the SJC EHD that sets forth procedures and protocols by which DOE/LLNL and SJC EHD cooperate and coordinate to prevent the approval of well drilling permits on the Coral Hollow property that could present a risk to human health or the environment or threaten the integrity of the remedy. One such protocol would be for the SJC EHD to annotate its records pertaining to the Corral Hollow property so that it will know to
contact DOE/LLNL if any permit is requested in relation to that property. Another such protocol would be for DOE/LLNL and SJC EHD to communicate not less than once each quarter regarding whether any Well Completion Reports have been filed for the Corral Hollow property. Under California Water Code 13752, the DWR must allow public access to Well Completion Reports. California law also now mandates these reports be made available online within the year.

As a further means of confirming that no well drilling is occurring on the Corral Hollow property, DOE/LLNL will on a weekly basis visually check those portions of the Corral Hollow property visible from public rights of way and Site 300 for any signs of well construction, alteration, or destruction.

In the event of indication that well construction activities described above are taking place, DOE/LLNL will contact the SJC EHD and the property owner and evaluate their potential impact, and take whatever steps are necessary to prevent a risk of exposure to contaminated groundwater or the compromise of the remedy’s integrity. LLNL will revise its institutional control checklist and other associated remedial-management related documents to reflect the steps outlined above and ensure their implementation. In addition, DOE/LLNL will report any changes noted through these mechanisms in the Institutional Control Monitoring Checklist in the Annual Compliance Monitoring Report.

These measures will help control the risk of exposure to contaminated groundwater until cleanup is complete, and help protect the integrity and effectiveness of the groundwater remedy.

**Informational Devices:** Throughout the remediation process, the owners of the Corral Hollow Ranch property have acted in a cooperative and responsible way. Under these circumstances, DOE/LLNL anticipates that informational devices will effectively contribute to controlling the risk of exposure to contaminated groundwater from the Central GSA through a water-supply well on the Corral Hollow property.

The Site 300 Compliance Monitoring Reports contain updates on the status of contaminant plumes and remediation progress in the GSA OU, and data collected from on-site and off-Site 300 property monitor and water-supply wells. DOE/LLNL has, and will continue, to send a copy of each report to the owners of the Corral Hollow property. In addition, LLNL on a quarterly basis will offer to meet with the owners and any tenants of the Corral Hollow property, at their convenience, to discuss the status of the contaminant plumes and remediation progress.

In addition, the correspondence described above will include information on accessing other information resources available to obtain information from websites and databases on the status of contamination and cleanup at Site 300 including the GSA OU, such as:

- RWQCB’s GeoTracker: [http://geotrackr.waterboards.ca.gov](http://geotrackr.waterboards.ca.gov)

**Five-Year Review Status:** During this five-year review period, no permits were requested and issued from the San Joaquin County to install a new water-supply well on any private property adjacent to Site 300 within areas of groundwater contamination sourced from Site 300. Monthly monitoring data indicates that VOCs from Site 300 were not detected above analytical
reporting limits in private water-supply wells CDF1 and CON1 located on the Union Livestock property. Private water-supply well GALLO1 is upgradient from VOC groundwater contamination emanating from the GSA OU and so is not at risk of contamination from it.

4.5.1.2. Control Excavation Activities to Prevent Onsite Worker Exposure to Contaminants in Subsurface Soil at the Building 875 Dry Well Pad Area

**Risk Driver** – Potential exposure to VOCs at depth in subsurface at the Building 875 dry well pad area.

**Land Use Control Objective:** Control excavation activities to prevent on-site worker exposure to VOCs in subsurface soil until it can be verified that concentrations do not pose an exposure risk to on-site workers.

**Land Use Controls:**
- Dig Permit Process.
- Work Induction Board Process

**Dig Permit Process:** A soil excavation permit approved by the LLNL Facilities and Infrastructure Documentation and Permits Group is required prior to any excavation or well installation work on site. As part of the soil excavation permit process, a preconstruction site evaluation is required and as soon as it is determined that soil or debris are to be disturbed at a project site, the Responsible Individual/project manager is required to notify the LLNL ES&H Team EA to initiate a preconstruction site evaluation. To document the request, a Site Evaluation Request Form is filled out and given to the LLNL ES&H Team EA with a description of the project attached, including project location, excavation footprint and depth, and a site map to scale showing the location of the proposed excavation activities. The LLNL ES&H Team EA evaluated the proposed project location to determine whether sampling of the project location is required.

The evaluation includes:
- Review of LLNL ERD historical source investigation.
- Review of Environmental Functional Area site evaluation documents.
- Review of current and past operations, and pre-existing soil analytical data.
- Visual inspection to evaluate the project site for possible contamination.

If this evaluation indicates there will be unacceptable environmental consequences such as use or exposure to contaminated groundwater or contaminated soil, the dig permit will not be issued unless and until the plan of work is amended to resolve such consequences. If no such consequences are apparent, the EA will determine whether soil sampling of the project location is required. If sampling of the project location is required, the LLNL ES&H Team EA and ES&H technician prepare and implement the sampling plan. The LLNL ES&H Team EA evaluates the results and, if a potential for contaminant exposure is identified, recommends methods to ensure that the original sampling adequately defined the hazards and that the necessary controls are identified and implemented prior to the start of work. These controls are identified through conditions to the soil excavation permit and are implemented by the Responsible Individual/project manager. The LLNL ES&H Team, including the ES&H Team EA, representatives from health and safety disciplines, and LLNL Waste Management will also work with the Responsible Individual/project manager proposing the project to determine if the
work plans can be modified to avoid areas of contamination or to relocate the well to ensure groundwater contaminants would not be drawn into the well.

During excavation or soil or debris disturbing activities such as well drilling, a Controlled Area (approximately 50 ft radius exclusion zone) is established with regulated access. If potentially contaminated soil or debris is unexpectedly discovered during excavation or soil or debris disturbing activities, the Responsible Individual/project manager is required under LLNL internal procedures to stop work and immediately notify the LNLL ES&H Team EA and the ERD so that the material can be evaluated. Samples are gathered to properly classify the soils and/or debris. After evaluating the results, the proper method of handling any contaminated material is implemented.

**Work Induction Board:** All proposed excavation or on-site well drilling activities are submitted to and must be cleared through the LLNL Work Induction Board. The Work Induction Board meets weekly to review new proposed work at Site 300 to ensure that work is conducted in conformance with the appropriate controls and includes the special concerns for work at Site 300 (i.e., environmental contamination).

If excavation activities or any significant changes in activities are proposed for the Central GSA Subarea, the Work Induction Board coordinates with the ERD and the LLNL ES&H Team EA to determine if the proposed excavation activity is located in an area where there is a potential for exposure to VOCs in subsurface soil. If a potential for contaminant exposure is identified, ES&H personnel ensures that hazards are adequately evaluated and necessary controls identified and implemented prior to the start of work.

**Five-Year Review Status:** During this five-year review period, there were three dig permit applications for excavation or construction activities within the GSA OU for which excavation/construction activities are controlled (Figure 11). These included dig permits for:
1. the installation of extraction well W-CGSA-2708 in 2012 in the northern VOC plume area,
2. the installation of two injection wells W-CGSA-2907 and W-CGSA-2908 in 2013 in the vadose zone portion of the Qt-Tns 1 HSU, and
3. the drilling and sampling of 13 boreholes in 2014 as part of the Eastern GSA Debris Burial Trench subsurface soil characterization.

During the drilling of these wells and boreholes, health and safety procedures were in place to prevent the drilling team from exposure to VOCs in subsurface soil. These procedures included regular monitoring of the well boreholes, drill cuttings, and the work area with an organic vapor analyzer during drilling. If VOCs are detected above background levels, the ES&H team is contacted to determine the need for additional personal protective equipment. However, this was not necessary during the drilling of W-CGSA-2708, W-CGSA-2907 and W-CGSA-2908 or the Eastern GSA debris burial trench boreholes, as VOCs were not detected above background during drilling monitoring.

**4.5.1.3. Prevent Onsite Site Worker Inhalation Exposure to VOCs inside Building 875:**

**Engineering Controls**

**Risk Driver:** A pre-remediation risk of $1 \times 10^{-5}$ was identified for on-site workers from inhalation of VOCs volatilizing from subsurface soil into ambient air inside Building 875 (Central GSA).
Land Use Control Objective: Maintain engineering controls to prevent on-site site worker inhalation exposure to VOCs inside Building 875 until annual risk re-evaluation indicates that the risk is less than $10^{-6}$.

Land Use Controls: DOE/LLNL implemented engineered controls to prevent on-site worker exposure to VOCs in subsurface soil at the Central GSA Building 875 dry well pad area that could migrate from the subsurface into the building until the annual risk re-evaluation indicates that the risk is less than 10-6. The engineered control consisted of:

- Evaluating and maintaining the heating, ventilating, and air-conditioning system for Building 875 to maintain a positive pressure to prevent VOC vapors from migrating into the building.

Five-Year Review Status: The risk was successfully reduced to less than $10^{-6}$ through groundwater and soil vapor extraction and treatment in the Building 875 area as of 2000 (see Section 3.5), therefore this institutional/land use control is no longer needed.

4.5.1.4. Prohibit Transfer of Lands with Unmitigated Contamination: Proprietary Controls

Risk Driver: Potential exposure to contaminated waste and/or environmental media.

Land Use Control Objective: Prohibit transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use.

Land Use Controls: Land use controls have been implemented to prohibit the transfer of Site 300 property or portions thereof with unmitigated contamination that could cause potential harm under residential or unrestricted land use, as required in the Site 300 Site-Wide ROD.

The Site 300 Site-Wide ROD requires the implementation of land use controls to prohibit the residential or unrestricted land use of Site 300 property or portions thereof with unmitigated contamination that could cause potential harm to human health.

To prevent the potential exposure to contaminated waste and/or environmental media in the event of the transfer of Site 300 property, the Site 300 FFA prohibits DOE from transferring lands with unmitigated contamination that could cause potential harm unless it complies with the requirements of Section 120(h) of CERCLA, 42 U.S.C. 9620 (h) and requirements for notification and protection of the integrity of the remedy set forth in Section 28 of the FFA. The Site 300 FFA has not been modified during this five-year review period, and its provisions remain as originally stated.

In the event that the Site 300 property is transferred in the future, DOE will execute a land use covenant at the time of transfer in compliance with Title 22 California Code of Regulations (CCR) Division 4.5, Chapter 39, Section 67391.1 as specified in the Site 300 Site-Wide ROD, and will implement deed restrictions per CERCLA 120(h). No change in ownership of Site 300 will take effect without provision for continued maintenance of any contaminant system, treatment system, monitoring system, or other response action(s) installed or implemented.

Development will be restricted to industrial land usage. These restrictions will remain in place unless and until a risk assessment is performed in accordance with then current U.S. EPA risk assessment guidance and the DOE, U.S. EPA, DTSC, and RWQCB agree that it adequately shows that no unacceptable risk for residential or unrestricted land use is present.

Five-Year Review Status: LLNL Site 300 remains an active DOE facility, and DOE has not proposed any plans to transfer any Site 300 land for residential, unrestricted, or non-- DOE
industrial land use during the five-year review period. Therefore, it has not been necessary to execute a land use covenant or deed restrictions. These institutional controls will be implemented if and when the property or a portion thereof is transferred in accordance with the requirements of the Site 300 Site-Wide ROD, Title 22 CCR Division 4.5, Chapter 39, Section 67391.1, and CERCLA 120(h).

4.5.2. Summary of the Status of the General Services Area OU Land Use Controls

The review of the land use controls for the GSA OU for this five-year review period determined that these controls are effective for preventing exposure to contaminated media. The San Joaquin County well permitting process and well completion reporting process as described in section 4.5.1.1 serve as a governmental institutional control to prevent water-supply use or consumption of contaminated groundwater from any off-site water-supply well that might be drilled within the footprint of the off-site VOC plume emanating from the Central GSA onto the Corral Hollow Ranch property.

DOE will implement, maintain, and enforce the land use controls for the GSA OU for as long as necessary to keep the selected remedy protective of human health and the environment. As documented in the Site-Wide ROD, if DOE later transfers these procedural responsibilities to another party by contract, property transfer agreement, or through another means, DOE will retain ultimate responsibility for the integrity of the remedy. In the event that the property is transferred in the future, DOE will execute a land use covenant at the time of transfer in compliance with California Code of Regulations Title 22, Division 4.5, Chapter 39, Section 67391.1. If the Site 300 property were to be transferred to an entity outside DOE, the necessary land use controls, including easements, would be determined prior to the property transfer based on: (1) the intended land use subsequent to the property transfer, and (2) contamination and associated risk, if any, remaining at the GSA OU.

5. Progress Since Last Review

This section describes the Protectiveness Statement and recommendations and follow-up actions from the third GSA OU Five-Year Review completed in 2011. It also describes the status of the actions recommended in this previous review.

5.1. Protectiveness Statement from Last Review

The 2011 Third GSA OU Five-Year Review determined that the remedy for the GSA OU was protective of human health and the environment for the site’s industrial land use. The remedy protects human health because exposure pathways that could result in unacceptable risk to on-site workers are being controlled by the implementation of institutional controls, the Health and Safety Plan, and the Contingency Plan. While not part of the selected remedy, the Health and Safety Plan and the Contingency Plan provide additional measures of protectiveness. For example, the Contingency Plan describes how DOE and the regulatory agencies plan to address potential problems that could arise during contaminant remediation (e.g., insufficient hydraulic control of plumes), as well as uncontrollable natural events (e.g., earthquakes) that could impact the effectiveness of the remedial actions.
The cleanup standards for GSA OU groundwater are drinking water standards. Because drinking water standards do not differentiate between industrial and residential use, the groundwater cleanup remedy will be protective under any land use scenario.

The cleanup standards for VOCs in subsurface soil are to reduce concentrations to mitigate risk to on-site workers and prevent further impacts to groundwater to the extent technically and economically feasible. Because some VOCs may remain in subsurface soil following the achievement of these cleanup standards, a land use control prohibits the transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use. This prohibition was entered into the administrative record for the GSA OU through a letter to the file. This prohibition will remain in place unless and until a risk assessment is performed in accordance with current U.S. EPA risk assessment guidance and is agreed by the DOE, the EPA, the DTSC, and RWQCB as adequately showing no unacceptable risk for residential or unrestricted land use.

No deficiencies in the remedy were identified during the 2011 Five-Year Review. However, EPA determined that, while the remedy is protective in the short term because there are no complete exposure pathways for human or ecological receptors, an additional institutional control was needed to prevent the owners of the property on which the VOC plume emanating from the Central GSA is located from installing a water-supply well within the footprint of this plume.

5.2. Recommendations and Follow-up Actions from the 2011 Five-Year Review

The following recommendations and follow-up actions were developed during the Five-Year Review process in 2011:

1. Drill and install one new extraction well (W-CGSA-2708) to increase hydraulic capture of VOCs and contaminant mass removal in the northern plume area. This new extraction well would be connected to the Central GSA groundwater extraction and treatment system.

2. Continue optimization of the Central GSA vapor treatment system during the next five years, including conducting pneumatic communication and additional rebound testing, and periodic reconfiguration of extraction and air inlet wells.

In addition, the EPA requested that DOE initiate a discussion with the owners of the property on which the off-site portion of the Central GSA VOC plume is located to discuss/negotiate a Memorandum of Understanding as an institutional control to prevent the installation of a water-supply well within the VOC plume until concentrations have been reduced to meet cleanup standards.

As discussed in Governmental Institutional Controls Section 4.5.1.1, the San Joaquin County Ordinance Code, Section 9-1115 regulates the location, construction, repair and destruction of water-supply wells, and requires the drilling, alteration, or destruction of any wells in the county without a permit from the SJC EHD. Well construction/alteration and destruction permits require that all water wells are to be located an adequate horizontal distance from known or potential sources of pollution and contamination, including biological and chemical sources. The SJC EHD also requires that aquifer isolation is maintained during the drilling and well
construction process to prevent cross contamination of aquifers. The threat of criminal sanctions for a failure to comply serves as a significant deterrent to the unlicensed drilling of wells. These measures will control the risk of exposure to contaminated groundwater by preventing the drilling of an off-site water-supply well within the footprint of the off-site VOC plume emanating from the Central GSA onto Corral Hollow Ranch until cleanup is complete.

No other follow-up actions were identified in the 2011 Five-Year Review.

5.3. Results of Implemented Actions

The status of actions taken in response to the 2011 Five-Year Review recommendations listed in Section 5.2 above are as follows:

1. The recommended groundwater extraction well, W-CGSA-2708, was drilled and installed in 2011 to hydraulically capture VOCs and remove contaminant mass in the northern GSA plume area. In lieu of connecting this extraction well to the Central GSA groundwater treatment system, W-CGSA-2708 was connected to a new groundwater treatment system, CGSA-North, completed in 2015. Two proposed injection wells, W-CGSA-2907 and W-CGSA-2908, were installed in 2013 to inject treated effluent from the CGSA-North treatment facility. Initial testing of CGSA-North suggests that W-CGSA-2708 has limited extraction capacity (<0.5 gpm) with TCE concentrations ranging between 2 and 15 µg/L. W-CGSA-2908 was connected to CGSA-North as an injection well. Due to its limited injection capacity, well W-CGSA-2907 will be used as a performance monitor well. The system is planned to start continuous operation in 2016. Additionally, the northern GSA plume is constrained down gradient by several wells, including W-875-04, W-876-01, W-875-02, W-875-06, W-875-06, and W-875-01, that contain TCE below the 5 µg/L cleanup goal. All of these groundwater monitoring wells exhibit long term declining TCE trends. DOE/LLNL will continue to monitor and report results from these wells in CMR reports. If any plume interior monitor wells or down gradient monitor wells exhibit a reversal in this trend, DOE/LLNL will consider modifications to the extraction well field and discuss additional measures with the regulatory agencies.

2. Pneumatic communication and rebound testing were not performed during the review period due to the lack of an adequate real-time data system at the Central GSA soil vapor treatment system. The Central GSA groundwater system is currently undergoing substantial upgrade activities, during which a real-time data acquisition system will be installed in the groundwater wellfield and treatment system. Planned upgrades to the soil vapor treatment system (i.e., new vapor flow meters and pneumatic pressure gauges) and subsequent pneumatic communication and rebound testing will allow for a more rigorous estimation of the remaining vapor phase source term. Based on testing results, the current soil vapor extraction wellfield configuration will be re-evaluated and reconfigured, if necessary, to optimize VOC mass removal. The results of the planned soil vapor treatment system testing and any resulting optimization efforts will be presented in the next Five-Year Review Report.

5.4. Status of Other Prior Issues

There are no other prior issues.
6. Five-Year Review Process

6.1. Notification of Review/Community Involvement

This Five-Year Review report will be placed in the Administrative Record file and the Information Repositories located in the LLNL Discovery Center in Livermore, California and in the Tracy Public Library in Tracy, California. Notice of its initiation and completion will be placed in two publications: The Tracy Press and San Joaquin Herald. The initial notice was published in The Tracy Press and San Joaquin Herald on July 1, 2016. Upon completion of the review, a copy of the final report will be placed in the information repositories, and a notice will appear in the newspapers announcing completion of the Five-Year Review Report. Completed documents can also be accessed electronically at LLNL’s Environmental Restoration Department electronic library web page at https://www-erd.llnl.gov/library/ or the Environmental Community Relations web page at https://www-envirinfo.llnl.gov/. Upon completion, the final Five-Year Review Report will be uploaded to the RWQCB’s GeoTracker database that can be accessed electronically at http://geotracker.waterboards.ca.gov/.

The draft, draft final and final Five-Year Review is also submitted for review to the community action group Tri-Valley Communities Against a Radioactive Environment.

6.2. Identification of Five-Year Review Team Members

The Five-Year Review of the GSA OU at LLNL Site 300 was led by Claire Holtzapple, Site 300 Remedial Project Manager for the DOE/NNSA-Livermore Field Office. The following team members assisted in the review:

- Leslie Ferry, Program Leader, Lawrence Livermore National Security (LLNS).
- Vic Madrid, Hydrogeology Team Leader, LLNS.
- Brian Hill, Treatment Facility Operator, LLNS.
- Larry Griffith, Treatment Facility Operator, LLNS.
- Ricky Villarreal, Hydrogeologist, Weiss Associates.

6.3. Document Review

This Five-Year Review included examination of the following relevant project documents and site data:

- Final Site-Wide Remedial Investigation for Lawrence Livermore National Laboratory Site 300 (Webster-Scholten, 1994).
- Final Feasibility Study for the General Services Area at Lawrence Livermore National Laboratory Site 300 (Rueth and Berry, 1995).
- Final Record of Decision for the General Services Area Operable Unit at Lawrence Livermore National Laboratory Site 300 (U.S. DOE, 1997).
\begin{itemize}
  \item Remedial Design Document for the General Services Area Treatment Facilities, Lawrence Livermore National Laboratory Site 300 (Rueth, et al., 1998).
  \item Building 875 Inhalation Risk Mitigation Evaluation at the Central GSA at Lawrence Livermore National Laboratory Site 300 (U.S. DOE, 2000).
  \item Operations and Maintenance Manual, Volume VI: Central General Services Area Vapor and Ground Water Treatment Facilities (LLNL, 2004).
  \item First Five-Year Report for the General Services Area Operable Unit at Lawrence Livermore National Laboratory Site 300 (Ferry et al., 2001).
  \item Second Five-Year Report for the General Services Area Operable Unit at Lawrence Livermore National Laboratory Site 300 (Dibley et al., 2006).
  \item Site-Wide Record of Decision for Lawrence Livermore National Laboratory Site 300 (U.S. DOE, 2008).
  \item Third Five-Year Report for the General Services Area Operable Unit at Lawrence Livermore National Laboratory Site 300 (Valett et al., 2011).
  \item Draft Close-out Report for the Eastern GSA General Services Area Operable Unit at Lawrence Livermore National Laboratory Site (Dibley and Ferry, 2012a).
  \item Characterization Work Plan for Subsurface Soil in the Eastern General Services Area Debris Burial Trenches Livermore National Laboratory Site 300 (Ferry et al., 2014c.).
  \item Semi-annual and Annual Site-Wide Compliance Monitoring Reports that include evaluations of remediation progress in the GSA OU (Dibley et al., 2011b, 2012b, 2012c, 2013b, and 2013c, 2014, and Ferry and Buscheck (ed.) 2014a, 2014b, and 2015).
\end{itemize}

This Five-Year Review evaluates subsurface contaminant concentration and remediation system performance data collected through calendar year 2015.

6.4. Data Review and Evaluation

6.4.1. Central GSA

VOCs have been identified as COCs in groundwater and subsurface soil, and have historically been identified within the Qt-Tnsc\textsubscript{1} and Qal-Tnbs\textsubscript{1} HSUs. VOCs are historically not detected, or have only been sporadically detected at trace concentrations within the deeper Tnbs\textsubscript{1} HSU. VOC concentrations and distribution in these HSUs in the Central GSA are discussed in Section 6.4.1.1. The progress of VOC remediation and mass removal in the Central GSA are discussed in Section 6.4.1.2.

6.4.1.1. VOC Concentrations and Distribution

VOCs detected in Central GSA groundwater consist primarily of TCE. During 2015, VOCs other than TCE present above their reporting limits were PCE, cis-1,2-DCE, trans-1,2-dichloroethylene (trans-1,2-DCE), 1,1-DCA, 1,1-DCE, 1,1,1-TCA, bromodichloromethane, chloroform, and Freon 11. Of these VOCs, only TCE, PCE, cis-1,2-DCE, and 1,1-DCE were detected at concentrations above their respective MCL cleanup standards. VOC concentrations and distribution are discussed by HSU below.
Qt-Tnsc₁ and Qal-Tnbs₁ HSUs

A VOC plume is present in Qt-Tnsc₁ and Qal-Tnbs₁ HSU groundwater in the Central GSA. The highest VOC and TCE concentrations have been detected in wells screened in the Qt-Tnsc₁ HSU within the Building 875 dry well pad area. Prior to remediation, the historic maximum total VOC concentration detected in Central GSA groundwater was 272,000 µg/L in a bail groundwater sample collected from the uncased borehole for dual-phase extraction well W-875-07 in the Building 875 dry well pad area in March 1992. Total VOC concentrations in the Building 875 dry well area have decreased to a 2015 maximum of 546.5 µg/L in dual-phase extraction well W-875-07 (August). While most of the VOCs detected in the Building 875 dry well area consist of TCE, other VOCs in this area detected during the reporting period included PCE, cis-1,2-DCE, 1,1-DCE, trans-1,2-DCE, and 1,1-DCA. Of these VOCs, only TCE, PCE, and cis-1,2-DCE were present at concentrations that significantly exceeded their MCL cleanup standards while 1,1-DCE was present at concentrations slightly above its MCL cleanup standard.

Overall, a decreasing trend of VOC concentrations in groundwater continued during the five-year reporting period in the dry well pad area. For example, TCE concentrations have decreased from a 1993 historic maximum of 240,000 µg/L in dual-phase extraction well W-875-07 to a 2015 maximum of 460 µg/L (August). PCE concentrations have decreased from a 1993 historic maximum of 25,000 µg/L in well W-875-07 to a 2015 maximum of 30 µg/L (August). In dual-phase extraction well W-7I, cis-1,2-DCE and 1,1-DCA concentrations have decreased from a 1993 historic maximum of 16,000 µg/L and 38 µg/L respectively, to a 2015 maximum of 71 µg/L (August) and 0.72 µg/L (April), respectively. While concentrations of cis-1,2-DCE in this well remain above its 6 µg/L MCL, 1,1,1-DCA concentrations have dropped below its 5 µg/L MCL cleanup standard.

During 2015, TCE soil vapor concentrations in individual vapor extraction wells in the Building 875 dry well pad area (wells W-7I, W-875-07, W-875-08, W-875-09, W-875-10, W-875-11, W-875-12 and W-875-15) ranged from below reporting limits in W-875-07, W-875-09, W-875-10, W-875-11, and W-875-15 to 1.4 parts per million on a volume per volume basis (ppm_v/v) in W-7I. These vapor concentrations have decreased significantly from the historic maximum TCE vapor concentration of 530 ppm_v/v detected in extraction well W-875-07 in 1994.

For monitor wells outside of the dry well pad area screened in the Qt-Tnsc₁ and the Qal-Tnbs₁ HSUs, the historic maximum total VOC concentration was detected in 1994 in extraction well W-7O (screened in the Qt-Tnsc₁ HSU) at 920 µg/L, declining to a 2015 maximum total VOC concentration of 96.45 µg/L (March). In addition to TCE, PCE, cis-1,2-DCE, 1,1-DCE, trans-1,2-DCE, and Freon 11 were also detected in wells outside of the dry well pad area. Of these VOCs, only TCE at 87 µg/L and PCE at 6.7 µg/L were present above their MCL cleanup standards.

South of the Site 300 boundary, seven monitor wells and two guard wells are screened in the Qt-Tnsc₁ and Qal-Tnbs₁ HSUs where VOCs are currently detected above their reporting limits in three of the nine off-site Qt-Tnsc₁ and Qal-Tnbs₁ HSU wells: W-35A-01, W-35A-09, and W-35A-10. VOC data for samples collected from these nine off-site monitor wells are summarized in Table 3. Of these three wells, VOCs are detected above cleanup standards in only two wells: W-35A-01 and W-35-10. VOC concentrations in off-site well W-35A-01 have decreased from a historic maximum of 545 µg/L in November 1991 to a concentration of...
61.13 µg/L in December 2015. The VOCs detected in well W-35A-01 are comprised of TCE and Freon 11 with only TCE concentrations (56 µg/L) exceeding its 5 µg/L MCL cleanup standard. VOC concentrations in off-site well W-35A-09 have decreased from a historic maximum of 13.9 µg/L in November 1999 to a current concentration of 0.65 µg/L in December 2015. The only VOC detected in well W-35A-09 is Freon 11, with a concentration (0.65 µg/L) well below its 150 µg/L MCL cleanup standard. VOC concentrations in off-site well W-35A-10 have decreased from a historic maximum of 86 µg/L in August 1994 to a concentration of 15 µg/L in December 2015; with only TCE concentrations (11 µg/L) exceeding its MCL cleanup standard. Figure 11 shows VOC concentration trends over time in wells W-35A-01, W-35A-09, and W-35A-10. While VOC concentrations in these wells fluctuate, the long-term, general concentration trends are decreasing over time in all three wells. Only TCE remains above its 5 µg/L MCL cleanup standard at 56 µg/L in W-35A-01 and at 11 µg/L in W-35A-10.

As shown on Figure 11, total VOC concentrations in off-site monitor well W-35A-01 vary significantly depending on purge volume and sampling method. The majority of samples collected at W-35A-01 were collected using a bailer or submersible pump after purging ≥90% of the well casing volume. However, during several sampling events that involved no or minimal purging, (e.g., a grab sample using a bailer, [LVBA] sample method or purging of the discharge line using a submersible pump, low volume electric submersible [LVES] sample method), the total VOC concentrations are generally below the analytical laboratory reporting limit or significantly lower than when the well is purged before sampling. Well W-35A-01 is screened across two stratigraphic units: Qal alluvium and Tnbs2 bedrock. The current conceptual understanding of dissolved-phase contaminants at W-35A-01 is that the shallower, Qal alluvial units are largely uncontaminated and the underlying, saturated Tnbs2 bedrock is impacted by VOCs. When a low-volume sample is collected from the well, the results are representative of Qal-derived water. However, when the well is purged prior to sampling, water is removed from the overlying Qal, and drawn into the well from the impacted Tnbs2, resulting in detectable VOCs. To ensure representative results for this important off-site monitor well, W-35A-01 is only sampled after purging three casing volumes.

During the reporting period, no VOCs were detected above their reporting limits in the remaining Qt-Tnsc1 and Qal-Tnbs1 HSU Central GSA wells located south of the Site 300 boundary, including guard wells W-35A-08 and W-35A-14, neither of which has had detectable VOCs since their construction in 1994. VOCs have only been detected once or twice in wells W-35A-03, W-35A-04, and W-35A-06 and VOCs have not been detected above their respective reporting limits in these wells since 1996. Total VOC concentrations in well W-35A-02 have decreased from historic maxima of 3.5 µg/L (February 1991) to below reporting limits in December 2015. VOC data for all off-site wells are summarized in Table 3; VOCs have never been detected in six of the 14 off-site wells, including two guard wells, W-35A-08 and W-35A-14.

**Upper Tnbs1 HSU**

Four GSA monitor wells are screened in the Upper Tnbs1 HSU on site (W-35A-05, W-35A-12, W-35A-13) and a single well off site (W-873-01). VOCs were last detected in this HSU in 2006 (0.59 µg/L TCE, W-35A-13).
**Lower Tnbs<sub>1</sub> HSU**

Ten monitor wells are screened in the deeper Lower Tnbs<sub>1</sub> HSU; five monitor wells are on site and the remaining five are south of the southern Site 300 boundary. The historic maximum total VOC concentration was detected in on-site monitor well W-7G at 47 µg/L (primarily TCE, 1989) declining to less than the reporting limit in all wells during 2015. VOCs have not been detected above their respective reporting limits in Lower Tnbs<sub>1</sub> Central GSA wells since 2001.

**COC Data Summary and Evaluation**

Of the nine COCs identified in the GSA groundwater, only four, TCE, PCE, 1,1-DCE, and cis-1,2-DCE, are routinely or have recently been detected above their respective MCLs. A data summary of the five remaining COCs is provided below.

Concentrations of 1,1,1-TCA decreased to and have remained below its 200 µg/L MCL cleanup standard in all Qt-Tnsc<sub>1</sub> and Qal-Tnbs<sub>1</sub> HSU wells since 1994, and have never been detected above the 0.5 µg/L reporting limit in any samples from Tnbs<sub>1</sub> HSU wells.

Total trihalomethanes (TTHMs), comprised of bromoform, chloroform, bromodichloromethane, and dibromochloromethane, have never been detected at or above the 80 µg/L MCL cleanup standard in any Qt-Tnsc<sub>1</sub> or Qal-Tnbs<sub>1</sub> HSU wells, and concentrations of TTHMs decreased to and have remained below the 80 µg/L MCL cleanup standard in Tnbs<sub>1</sub> wells since 2005.

Concentrations of Freon 11 decreased to and have remained below its 150 µg/L MCL cleanup standard in all Qt-Tnsc<sub>1</sub> and Qal-Tnbs<sub>1</sub> HSU wells since 1990, and has never been detected above the 0.5 µg/L reporting limit in any samples from Tnbs<sub>1</sub> HSU wells.

Freon 113 has never been detected above its 1,200 µg/L MCL cleanup standard in any Qt-Tnsc<sub>1</sub>, Qal-Tnbs<sub>1</sub>, or Tnbs<sub>1</sub> HSU wells since 1987.

DOE/NNSA is recommending the removal of 1,1,1-TCA, bromodichloromethane, chloroform, Freon 11, and Freon 113 as groundwater COCs in Section 9.

**6.4.1.2. VOC Remediation and Mass Removal**

Significant progress has been made towards remediating VOCs in the vadose zone and groundwater in the GSA OU. Groundwater and soil vapor remediation was initiated in 1992 and 1994, respectively, and since that time has removed a total of 105 kilograms (kg) of VOCs from the subsurface. Vadose zone and groundwater remediation progress are discussed in Sections 6.4.1.2.1 and 6.4.1.2.2, respectively.

**6.4.1.2.1. Vadose Zone Remediation Progress**

Ongoing performance of the Central GSA soil vapor extraction system is evaluated by reviewing temporal trends in soil vapor extraction well concentrations during both active extraction and non-active rebound periods.

As shown on Figure 12, the vapor extraction and treatment system has removed 78.22 kg of the 105 kg of total VOCs removed from the subsurface as of the end of 2015. Modeling performed in the Remedial Design (Rueth, et al, 1998) estimated that approximately 35 kg of TCE would be removed by soil vapor extraction by 2015. The actual mass removed by 2015 is approximately twice the estimated mass removed. This difference in VOC vapor mass estimates may be due to uncertainties in the source term, as discussed in the Remedial Design. In addition,
the input parameters and assumptions for the Non-isothermal Unsaturated/saturated Flow and Transport (NUFT) modeling conducted in 1997 were based on only three years of data from extraction wellfield operations. After 22 years of extraction wellfield operation, significantly more data is currently available on wellfield conditions and performance (i.e., well vapor flows, mass removal) with which to evaluate vapor-phase source term, long-term performance, and mass removal.

Vadose zone remediation has been ongoing at the Building 875 dry well contaminant source area since July 1994. Simultaneous groundwater extraction in the vicinity lowers the elevation of the groundwater surface and maximizes the volume of unsaturated soil influenced by vapor extraction. Soil vapor has historically been extracted from three to seven extraction wells, with others used as vapor inlet wells. All seven vapor extraction wells have been operational since late 2007. Soil vapor extraction system monthly flow volumes are shown on Figure 13 alongside individual vapor extraction well TCE vapor concentrations. As seen on Figure 13, TCE vapor concentrations in individual extraction wells have decreased from a start-up maximum of 529 ppmv/v (W-875-07) to a current second semester 2015 maximum of 1.4 ppmv/v (W-7I). During periods of facility shutdown, TCE vapor concentrations in the extraction wells have generally rebounded from low concentrations just prior to shutdown, however, the magnitude of this rebound has generally decreased over time. Most recently, rebounding was observed after the system was shut down for excess condensate freeze protection between November 2010 and March 2011. TCE vapor concentrations in individual extraction wells ranged from 0.26 to 15 ppmv/v prior to shutdown, and from 0.15 to 72 ppmv/v at the end of the rebound period. Rebound of TCE concentrations was not measured after the most recent shutdown period from November 2011 to February 2012 when the system was down due to transfer pump problems. The continued decline in vapor concentrations, from a maximum of 529 ppmv/v in W-875-07 collected in November 1999 to the most recent maximum of 72 ppmv/v (Figure 13) during rebound monitoring, and the absence of VOC concentration rebound after the most recent shutdown period indicate significant source area remediation progress.

TCE soil vapor concentrations in the facility influent have decreased over time from a maximum of 417 ppmv/v in January 1995 (six months after start-up) to 1.1 ppmv/v in 2007. Influent sampling stopped in late 2007 after the individual well Venturi™ flow meters were installed, allowing for the sampling of individual vapor extraction wells. Collecting vapor samples at the individual wellheads allows for a more accurate calculation of VOC mass removed by vapor extraction.

Future optimization of the Central GSA vapor treatment system, planned to begin after system upgrades are completed, will include pneumatic communication, additional rebound and flow/vacuum testing, and periodic reconfiguration of extraction and possible use of air inlet wells.

6.4.1.2.2. Groundwater Remediation Progress

Ongoing performance of the Central GSA groundwater remediation system is evaluated using multiple data sets including:

- Comparing historic maximum groundwater VOC concentrations and plume extent to current concentrations and extent,
- Reviewing temporal VOC trends in individual wells,
• Evaluating extraction wellfield hydraulic capture zones, and
• Evaluating dissolved-phase VOC mass removal.

These performance indicators are summarized and documented in the annual CMR reports and are discussed below. In addition, this section discusses the reassessment of COC dissolved phase source terms, revisitation of the GSA conceptual model, and calculation of an updated cleanup time estimate that were conducted as part of this five-year review.

Comparison of Historic and Current VOC Concentrations and Extent

To evaluate remediation progress, the spatial distribution of VOCs in Central GSA groundwater in 2005, 2010, and 2015 was compared to evaluate changes resulting from ongoing remediation (Figure 14). Although the overall extent of VOCs in groundwater with concentrations above 5 µg/L has not changed significantly, the footprint of total VOC concentrations greater than 50 µg/L has been significantly reduced and the footprint greater than 100 µg/L is constrained to the vicinity of the Building 875 dry well pad. The second semester 2010 total VOC isoconcentration contour map on Figure 16 has been modified since it was submitted in the previous (3rd) GSA Five-Year Review to depict the total VOC plume based on the recent evaluation of well HSU completions.

Temporal VOC trends

Long-term VOC concentrations trends in Central GSA groundwater were also evaluated to assess groundwater remediation progress. Overall, remediation has significantly reduced VOC concentrations in Central GSA groundwater. Total VOC concentrations have decreased from an historic maximum of 272,000 µg/L (dry well pad extraction well W-875-07, 1992) to a 2015 maximum (August) of 546.5 µg/L in the same well.

VOC concentration trends and monthly flow volumes in the Building 875 dry well pad groundwater extraction wells W-875-07 and -08 are presented on Figure 15a. The concentration trends in Figure 15a (and 15b) are shown on a logarithmic scale to better differentiate trends between wells. Total VOC concentrations in dry well pad extraction well W-875-07 have decreased from a pre-remediation historic maximum of 272,000 µg/L in 1992 to a 2015 maximum of 546.5 µg/L in the same well. Total VOC concentrations in well W-875-08 have also significantly decreased a pre-remediation maximum concentration of 72,339 µg/L in 1992 to a 2015 maximum of 365 µg/L.

Figure 15b shows VOC concentrations trends and monthly flow volumes measured in extraction wells outside of the Building 875 dry well pad area, including wells W-872-02 and W-873-07, located near the former Building 872 and 873 dry wells, and wells W-7O, -7P, and -7R, located northeast of the Building 875 dry well pad.

VOC concentrations in wells W-872-02 and W-873-07 have decreased from a pre-remediation historical maximum of 27 µg/L in 1992 to 15 µg/L in the 2nd semester 2015 in well W-872-02, and from a pre-remediation historical maximum of 91 µg/L in 2003 to 3.8 µg/L in the 2nd semester 2015 in well W-873-07. VOC concentrations in extraction wells W-7O, -7R, and -7P, located northwest of the dry well pad area, have also decreased from:

- W-7P: A historical maximum of 58 µg/L in 1994 to 4.9 µg/L in the 2nd semester 2015.
- W-7R: A historical maximum of 15 µg/L in 2002 to 5.7 µg/L in the 2nd semester 2015.
- W-7O: A historical maximum of 870 µg/L in 1994 to 32 µg/L in the 2nd semester 2015.
VOC concentration trends in extraction wells have continued to generally decrease during this five-year review period.

Figure 16 shows VOC trends for monitor wells in the northern plume area of the Central GSA. These wells, including W-889-01, have generally shown stable to decreasing concentration trends over the past five years. Extraction well W-CGSA-2708, shown on Figures 4 and 7, has been installed in the immediate vicinity of W-889-01 to capture VOCs and remove contaminant mass removal in the northern plume that resulted from releases from the former solvent drum rack. Groundwater extraction will begin in 2016 at Central GSA-North facility. The VOC concentration trends in extraction well W-CGSA-2708 and W-889-01 will be used to assess performance and cleanup progress of the northern plume area.

Hydraulic Capture

The hydraulic capture zones presented on Figure 7a were prepared using data from the second semester 2014, as the Central GSA groundwater treatment system was shut down due to misting tower problems for the majority of the second semester 2015. These capture zones show that extraction wells generally capture the area of highest concentrations in the VOC plume, including the highest concentrations in the dry well pad area. Figure 7b show groundwater potentiometric surface under non-pumping conditions in the second semester of 2015. Upgrades to the Central GSA groundwater extraction treatment system are planned in 2016, including installation of an automated data acquisition system, including water level monitoring in all groundwater extraction wells and nearby performance monitoring wells. The automated data acquisition system will provide real-time water level data that can be used to more accurately measure hydraulic response, evaluate hydraulic capture zones, and optimize extraction wellfield performance, and to maximize VOC mass removal.

As discussed previously, an extraction well (W-CGSA-2708) and treatment facility was installed to capture the northern VOC plume in the former steam cleaning/sink area. The facility is scheduled to begin operations in 2016 and hydraulic capture will be evaluated after operations are underway.

Dissolved-Phase Mass Removal

The total cumulative dissolved-phase mass of VOCs in groundwater extracted and treated by the Central GSA system is shown on Figure 12. Approximately 26 kg of VOCs has been removed from Central GSA groundwater by the end of 2015. As shown in Figure 12, VOC mass removal from groundwater has slowed over the past fifteen years. Soil vapor extraction continues to remove the majority of VOC mass in the Central GSA. However, continued groundwater extraction is effective in dewatering the Tnbs2, exposing a greater volume of soil/rock for vapor extraction, which is a more effective mass removal technology. Modeling performed for the GSA Remedial Design (Rueth, et al, 1998) using the NUFT model estimated that approximately 8 kg of TCE would be removed by groundwater extraction by 2015. The actual mass removed by 2015 is approximately three times the NUFT model simulated mass removed. However, the input parameters and assumptions for the NUFT modeling conducted in 1997 were based on only three years of performance data from extraction wellfield operations. The difference in the NUFT model estimate of mass removed compared to the actual mass removed is likely due to the uncertainty in the original mass of VOCs present in soil and groundwater in the Building 875 dry well source area and the more limited wellfield performance data available when the NUFT modeling was conducted. After 22 years of
extraction wellfield operation and VOC monitoring in the Central GSA area, significantly more data are now available regarding wellfield operations and performance (i.e., well flows, hydraulic capture, mass removal). The additional performance data collected during the last 20 years and data that will be collected after the data acquisition system is installed in 2016 will be used to more accurately evaluate cleanup progress during the next five-year reporting period.

Reassessment of Source Terms, Conceptual Model, Cleanup Time Estimate

As stated in Section 7.5.1.1 (Groundwater Remediation Progress) of the 2011 Five-Year Review Report, DOE/LLNL has reassessed COC dissolved phase source terms, revisited the GSA conceptual model, and updated the cleanup time estimate using a mixed-tank model based on total VOC concentration and mass removal data from the reporting period. A reassessment of the vapor-phase source term has not yet been completed. Planned upgrades to the soil vapor treatment system (i.e., new vapor flow meters and pneumatic pressure gauges) and subsequent pneumatic communication and rebound testing will allow for a more rigorous estimation of the remaining vapor phase source term. The results of the planned soil vapor treatment system testing will be presented in the next Five-Year Review Report.

The dissolved-phase source term reassessment was performed using current total VOC concentrations in groundwater and a geometric approximation of the saturated Qt-Tnsc1 and Qal-Tnbs1 HSUs. Using the total VOC plume map shown on Figure 10, the approximate volume of groundwater with total VOC concentrations greater than 5 µg/L was calculated based on four shell volumes corresponding to the total VOC concentration contour intervals from 5-10 µg/L, 10-50 µg/L, 50-100 µg/L, and >100 µg/L, respectively. Applying a laboratory-derived porosity of 0.36 (Rueth, et al, 1998), the total volume of groundwater with total VOC concentration greater than 5 µg/L is approximately seven million gallons. Multiplying each shell volume by the geometric mean of the lower and upper total VOC concentration limit for that shell and then summing the mass from each shell, the total dissolved phase VOC mass remaining is approximately 1 kg.

In light of current data, revisions to the GSA conceptual model are not currently necessary. The bulk of total VOC contamination within the GSA is found in the subsurface near the location of two former dry wells, 875-S1 and 875-S2 (Figure 3), into which VOC-contaminated rinsewater was disposed. The total VOC plume within the Qt-Tnsc1 and Qal-Tnbs1 HSUs is well characterized and significant progress has been made in reducing initial concentrations in both soil vapor and groundwater by multiple orders of magnitude through soil vapor and groundwater remediation. Any new information or data that results in a revision to the conceptual model will be reported in the next Five-Year Review Report.

The mixed-tank model estimates the length of time necessary to reduce the average concentration of individual contaminants in groundwater to the cleanup standards by performing a mass balance calculation on the total VOC plume, idealized as a well-mixed “tank.” In the well-mixed tank approximation, as groundwater is removed from the subsurface via extraction, clean groundwater (total VOC concentration of 0 µg/L) is pulled into the plume from the surrounding groundwater margins and a new average concentration is established between the plume and saturated soil. As described in Section 6.4.1.1, TCE makes up the majority of detected VOCs within the GSA, and with isolated exceptions, is the most concentrated VOC at all Central GSA wells. Given current VOC concentrations and distribution within the Central GSA, remediating TCE in groundwater to regulatory thresholds would concurrently reduce all
other detected VOCs below their respective regulatory thresholds. As such, TCE concentrations are used within the mixed-tank model to provide a conservative estimate of the time to cleanup. The average total VOC plume concentration used in the mixed tank model \((C_0 = 31 \, \mu g/L)\) was approximated using the flow weighted average influent concentration from the individual extraction wells in the Central GSA extraction wellfield during the reporting period. The long-term extraction wellfield flow rate was estimated at 1.5 million gallons per year using operational data. Laboratory derived, site-specific soil parameters used in the 1998 NUFT model (Rueth, et al, 1998) were used to conservatively account for TCE partitioning between the sorbed and dissolved phases. Using these input parameters, the mixed-tank model estimates approximately 24 years to reduce the average influent TCE concentration to below 5 \(\mu g/L\) as shown by the mixed-tank model TCE decline curves presented in Figure 17.

Uncertainty due mainly to long-term climatic conditions and recharge rates and subsurface heterogeneity are accounted for in the mixed-tank model results by applying a +/-10\% variance to the extraction flow rate, TCE decay rate, and retardation factor. Additionally, a +/-20\% variance was applied to conservatively account for uncertainty in TCE plume distribution and corresponding average influent TCE concentration. Incorporating the relative contributions from individual extraction wells including the uncertainty into the mixed-tank model, the minimum estimate of time for TCE in all extraction wells to decrease below 5 \(\mu g/L\) is 42 years (2058) and the maximum estimate is 100 years (2116). This cleanup time is primarily driven by the high TCE concentrations in the Building 875 dry well pad source area; TCE concentrations in wells outside the dry well pad area achieved cleanup standards within approximately 30 years. Note that these estimates assume that the extraction wellfield would continue to operate based on past operational parameters without any groundwater or soil vapor extraction wellfield optimization or improvements in operational efficiency. These estimates should therefore be considered as an upper limit to the time estimated to achieve cleanup at Central GSA. Realistically, the Central GSA groundwater treatment system will be operated dynamically with continued optimization and necessary wellfield changes to increase remedial efficiency, making the mixed-tank model estimates of cleanup time conservative.

### 6.4.2. Eastern GSA Remediation Progress

DOE began groundwater remediation at the Eastern GSA in 1991 as a removal action and continued as a remedial action after the 1997 GSA ROD. As of the second semester 2005, and shown on Figure 18, remediation efforts in the Eastern GSA reduced concentrations of TCE in groundwater from a historic maximum of 77 \(\mu g/L\) to below analytical reporting limits (0.5 \(\mu g/L\)) in the majority of wells and to below the 5 \(\mu g/L\) MCL cleanup standard in all wells with a single anomalous exception described below. Figure 18a shows the monthly volume of treated groundwater at the Eastern GSA facility.

The Eastern GSA groundwater extraction and treatment system was shut off on February 15, 2007 with regulatory approval. As required by the GSA ROD, groundwater monitoring was conducted for five years after shutdown (to February 15, 2012) to determine if VOC concentrations rose or “rebounded” above MCL cleanup standards. Additionally, in the Eastern GSA Compliance Feasibility Report submitted to regulatory agencies on July 15, 2007, DOE/LLNL evaluated on-site discharge options that could be implemented if VOC concentrations rebounded above MCL cleanup standards requiring that the Eastern GSA extraction and treatment system be restarted (Holtzapple, 2007). Since February 2007, TCE
concentrations in groundwater remained below the 5 µg/L cleanup standard in all wells, with the exception of one detection above 5 µg/L during the first semester of 2009 (6.9 µg/L in well W-26R-01, May) (Figure 17b). Well W-26R-01 and nearby well W-26R-04 were re-sampled for VOCs in June 2009. During the re-sample event, four groundwater samples were collected from each well; two collected after low flow purging and two after purging three casing volumes. For each purge method, the two samples were submitted to different analytical laboratories. TCE concentrations did not exceed 5 µg/L in any of the eight groundwater samples collected during the June 2009 re-sampling event. The regulatory agencies agreed that monitoring of Eastern GSA wells could continue as described in the post-shutdown monitoring plan. The regulatory agencies agreed during a February 24, 2012 Remedial Project Manager’s (RPM) Meeting, that cleanup of the Eastern GSA was complete, monitoring and reporting could cease, and that close out documentation should be submitted. A Draft Close Out Report for the Eastern GSA subarea was submitted to the regulatory agencies in December 2012 (Dibley and Ferry, 2012a).

At the regulatory agencies request, additional characterization activities were conducted in 2014 to determine if SVOCs, PAHs, and/or PCBs were present in subsurface soil in the Eastern GSA debris burial trench area.

Thirty-five subsurface soil samples and three quality control (QC) duplicate soil samples were collected from 13 shallow boreholes drilled to a maximum depth of 15 ft bgs within the Eastern GSA. Samples were analyzed for SVOCs, PAHs, and PCBs. No SVOCs or PAHs were detected in any sample above analytical reporting limits, which are below U.S. EPA human health industrial and residential regional screening levels. PCBs were detected above laboratory reporting limits in four routine soil samples and two QC samples from five boreholes at depths ranging from 2 ft to 5 ft bgs. PCB concentrations ranged from 0.01 mg/kg to 0.037 mg/kg. The PCBs detected were Aroclor 1254 (maximum detection 0.037 mg/kg) and Aroclor 1260 (maximum detection 0.025 mg/kg). Samples containing detectable PCBs were horizontally and vertically bounded by boreholes/samples where PCBs were not detected. The detected PCBs were below the U.S. EPA human health industrial and residential regional screening levels of 0.97 mg/kg for Aroclor 1254 and 0.99 mg/kg for Aroclor 1260. The U.S. EPA elected not to develop ecological screening levels for PCBs, but rather instructed risk assessors to consider all detections to be site-related, and evaluate the potential ecological impact on a case-by-case basis (U.S. EPA, 2005). Due to the types of terrestrial species found at the GSA OU, as well as the limited extent of PCB detected in the subsurface soil, it is unlikely the detection of PCBs in the shallow subsurface soil in the vicinity of the Eastern GSA debris burial trenches pose an ecological risk. Detailed results of the investigation were provided in the Close Out Report for the Eastern GSA Subarea at LLNL Site 300, which was finalized on June 5, 2017.

As shown on Figure 12, the Eastern GSA groundwater extraction and treatment system had removed 7.56 kg of VOCs as of February 2007.

### 6.4.3. Risk Mitigation Progress

The baseline human health risk assessment conducted in 1991 estimated a maximum excess carcinogenic risk of $7 \times 10^{-2}$ if groundwater from a hypothetical water-supply well located at the site boundary near the Building 875 dry wells were to be ingested over a 70-yr period. The corresponding non-carcinogenic hazard index was 560. Although this risk has been reduced through remediation, TCE concentrations remain above MCL cleanup standard in Central GSA groundwater. As described above, the VOC concentrations in the Central GSA groundwater have
been reduced from a pre-remediation concentration of total VOCs in groundwater of 272,000 µg/L in 1992 to a 2015 maximum of 547 µg/L (W-875-07, August).

The baseline risk assessment also estimated an excess cancer risk to on-site workers from TCE vapors migrating into Building 875 of $1 \times 10^{-5}$. As described in Section 4.3.2, soil vapor extraction has contributed to reducing the excess cancer risk due to inhalation of VOC vapors migrating into Building 875 from $1 \times 10^{-5}$ prior to remediation to $9.5 \times 10^{-7}$ in 2000. Therefore, inhalation risk within Building 875 is no longer of concern.

The 1991 baseline human health risk assessment estimated an excess carcinogenic risk of $5 \times 10^{-5}$ for ingesting groundwater from a hypothetical water-supply well located at the site boundary near the Eastern GSA debris burial trench. The risk associated with potential use of contaminated groundwater at two off-site wells CDF1 and SR-1 was approximately $10^{-5}$. As described in Section 4.3.2, the VOC concentrations in Eastern GSA groundwater have been reduced to below MCL cleanup standards. There were no VOCs detected above MCL cleanup standards in on-site or off-site groundwater.

No unacceptable risk or hazard was associated with potential exposure to VOCs in surface or subsurface soil.

The baseline ecological assessment, conducted to evaluate the potential for adverse impact to plants and animals from long-term exposure to contaminants in the GSA OU, determined that VOCs do not pose ecological risk in this area. This determination was based on estimates of potential hazard from exposure to contaminants that were calculated for mammal and aquatic species that could potentially inhabit this area, as well as biological surveys conducted to determine which species actually inhabit or migrate through the GSA OU. As described in Section 3.5.2, no newly or previously unidentified unacceptable ecological risk or hazard has been identified in the baseline risk assessment or in subsequent ecological reviews.

6.5. Interviews and Site Inspection

DOE/NNSA and LLNL meet approximately monthly with U.S. EPA, RWQCB, and DTSC RPMs and quarterly to semi-annually with a community action group at Technical Assistance Grant Meetings to discuss remediation activities, issues, and cleanup status and progress.

On April 11, 2016, DOE/NNSA submitted interview forms to the U.S. EPA, RWQCB, and DTSC requesting regulatory input on the GSA OU by May 27, 2016. No input was received from the U.S. EPA, the RWQCB, or DTSC.

There is a continuous presence of ERD staff at Site 300 that routinely inspect the monitoring wellfield during sampling activities. The treatment facility operator regularly inspects the GSA OU extraction wellfield and groundwater and soil vapor treatment systems to identify system components needing repair or replacement to ensure the effective and compliant operation of the systems. Additional details of routine inspections of remedy components are discussed in Section 4.4.

LLNL conducts self-assessment inspections and DOE/NNSA conducts inspections of remediation activities at Site 300. The RWQCB RPM performs site inspections twice a year, and the U.S. EPA and DTSC RPMs request periodic site inspections. The U.S. EPA performed the construction completion inspection on July 13, 2005. LLNL ERD conducted their Five-Year Inspection on March 22, 2016. The regulatory agencies were invited to participate in a Five-
Year Review Inspection on May 24, 2016. The RWQCB RPM elected to perform their inspection on May 12, 2016 during their annual site inspection. However, EPA and DTSC were unable to participate on May 24 due to scheduling restrictions. The Five-Year Review Inspection Checklist Photographs and completed Inspection Checklist for GSA OU are included in Appendix A as Appendix A1 and Appendix A2, respectively.

Operational issues and resulting corrective actions identified during routine inspections associated with the GSA OU groundwater and soil vapor treatment systems, and the OU monitoring wellfields are: (1) described in the semiannual Site 300 Compliance Monitoring Reports that are issued semi-annually by the LLNL ERD and (2) discussed and presented in the RPM Project Updates that are issued prior to and discussed with the regulators at the monthly RPM meetings. The contents of the Project Updates are incorporated into the RPM meeting minutes distributed following the meetings.

7. Technical Assessment

The protectiveness of the remedy was assessed by determining if:
1. The remedy is functioning as intended in the decision document (GSA ROD).
2. The assumptions used in the decision-making process are still valid.
3. Any additional information has been identified that would call the protectiveness of the remedy into question.

7.1. Remedy Function

The remedy, as selected in the ROD, is functioning as intended because:

- No early indicators of potential remedy failure were identified.
- System operation procedures are consistent with requirements.
- Costs have generally been within budget, except when extra costs were incurred to address unanticipated problems, work scope, or regulatory requests.
- Groundwater and dual-phase extraction and treatment are effectively reducing contaminant concentrations and mass in the subsurface. In the Central GSA, the current maximum VOC concentrations in both groundwater and soil vapor have been reduced by over two orders-of-magnitude since system startup. Soil vapor extraction at the Building 875 release site has contributed to reducing the human health risk due to inhalation of TCE vapors within nearby Building 875 to a level that is not of concern. VOCs remain below reporting limits in the Central GSA guard wells.
- Groundwater remediation in the Eastern GSA has successfully reduced concentrations of TCE and other VOCs to below MCL cleanup standards. U.S. DOE/LLNS shut down the groundwater extraction and treatment system in February 2007 and monitored groundwater through 2012 to determine if VOC concentrations rose or “rebound” above MCL cleanup standards post-shutdown. In 2012, the regulatory agencies agreed that the post-shutdown monitoring did not indicate rebound of VOCs above cleanup standards, and that groundwater remediation was completed in the Eastern GSA subarea.
Groundwater and vapor treatment systems are performing as designed and will continue to be operated and optimized. The groundwater treatment system is scheduled to receive real-time data collection instrumentation and undergo pneumatic and communication testing in 2016.

Institutional controls are in place. No current or planned changes in land use at the site suggest that they are not or would not be effective.

Overall, this five-year review indicates that the Remedial Action Objectives (RAOs) for the GSA OU remedy will be met including: (1) the inhalation risk from VOCs in soil at Building 875 has been mitigated, (2) VOCs in Eastern GSA groundwater have been remediated to meet groundwater cleanup standards and over five years of rebound monitoring has verified that VOC concentrations remained below cleanup standards following treatment system shutdown, (3) ongoing extraction and treatment of VOCs in Central GSA groundwater and the vadose zone continue to reduce VOC concentrations towards cleanup standards, and (4) institutional/land use controls will prevent exposure to VOCs until cleanup standards are met.

7.2. Changes to Exposure Assumptions, Toxicity Data, Cleanup Levels, and Remedial Action Objectives

The assumptions used in the decision-making process were determined to still be valid because:

- The risk assessment methodology for indoor air vapor intrusion pathway has been modified in the last five years. In June 2015, EPA issued new risk assessment guidance (U.S. EPA, 2015). However, there is an active soil vapor extraction system in close proximity to buildings where there are elevated concentrations of VOC contamination in the subsurface and the new methodology does not affect the protectiveness of the remedy. There have been no other significant changes in risk assessment methodologies or calculations that could call the protectiveness of the remedy into question.
- There have been no changes in exposure pathways that could call the protectiveness of the remedy into question.
- No new or previously unidentified unacceptable risk or hazard to human health have been identified.
- There have been no changes in land, building, or water use in the GSA OU or off site since the previous Five-Year Review.
- No new contaminants, source areas, or remedy by-products have been identified in the GSA OU since the previous Five-Year Review.
- Changes in location-, chemical-, or action-specific applicable or relevant and appropriate requirements (ARARs) or to-be-considered requirements:
  - The U.S. EPA National Pollution Discharge Elimination System (NPDES) Pesticide Rule changed in 2011. However, there are no discharges to the ground surface or NPDES permit required as part of the GSA OU remedy.
- The review found that the remedy is making progress toward meeting the RAOs.
7.3. Other Information

No additional information was identified that would call the protectiveness of the remedy into question:

- The Health and Safety Plan and Site-Wide Contingency Plan are in place, sufficient to control risks, and properly implemented.
- There have been no changes in risk assessment methodologies that could call the protectiveness of the remedy into question.
- No new or previously unidentified unacceptable risk or hazard to human health or ecological receptors has been identified in annual risk re-evaluations or in ecological reviews.
- No unanticipated events (i.e., natural disasters) occurred that would call the protectiveness of the remedy into question.
- No additional information has been identified that would call the protectiveness of the remedy into question.

8. Issues

No deficiencies or issues were identified with the monitoring and soil vapor and groundwater extraction and treatment portion of the GSA OU remedy selected to address VOCs in groundwater and soil vapor. However, recommendations are presented in Section 9 to optimize the operation of the Central GSA wellfield, and to better delineate the vertical distribution of dissolved-phase VOCs in off-site Qal-Tnsc1 HSU groundwater downgradient of the Building 875 dry well pad. Although the installation of additional monitoring wells is recommended, DOE/LLNL does not consider this a remedy deficiency or protectiveness issue. The performance measures for the remedy are the continued absence of detections of COCs in downgradient guard wells, indicating that there is no migration of COCs. This demonstrates that the remedy continues to be protective. The purpose of recommendations to improve performance monitoring is to further demonstrate that the remedy is effective.

The review of the institutional/land use controls for the GSA OU for this five-year review period determined that these controls are effective for preventing short-term and long-term exposure to contaminated media.

9. Recommendations and Follow-up Actions

Although no deficiencies or issues were identified with the monitoring and soil vapor/groundwater extraction and treatment portion of the GSA OU remedy, the following recommendations/follow-up actions were developed by DOE/NNSA to further optimize Central GSA extraction and treatment system operations, and better delineate the vertical distribution of VOCs in off-site Qal-Tnsc1 HSU groundwater:

1. Complete optimization of the Central GSA groundwater and soil vapor extraction and treatment systems including conducting: (1) pneumatic and hydraulic communication testing, (2) additional vapor rebound testing, and (3) periodic reconfiguration of the pumping from soil vapor and dual-phase groundwater and -soil vapor extraction wells.
As discussed in Section 6.4.1.2, planned upgrades to the Central GSA treatment systems will provide additional data that can be used to refine the extent of hydraulic capture zones, further optimize extraction wellfield operation to maximize VOC mass removal, and more rigorously estimate the remaining vapor-phase source term.

2. Installation of two off-site monitor wells upgradient of W-35A-01. These wells would be installed as a well pair with one well screened within the Qal stratigraphic unit and the second well installed in the underlying Tnbs2 bedrock unit. The objective of installing these wells is to provide data to better delineate the vertical distribution of dissolved-phase VOCs in off-site groundwater in the Qal and Tnbs2 downgradient of the Building 875 dry well pad. Because these wells would be located off-site, implementation of this recommendation is contingent on receiving the property owner’s permission and other relevant permits, as necessary.

3. Remove 1,1,1-trichloroethane (1,1,1-TCA) as a groundwater contaminant of concern (COC) because: (1) concentrations of 1,1,1-TCA decreased to and have remained below its 200 µg/L Maximum Contaminant Level (MCL) cleanup standard in all Qt-Tnsc1 and Qal-Tnbs1 hydrostratigraphic unit (HSU) wells since 1994, and (2) 1,1,1-TCA has never been detected above the 0.5 µg/L reporting limit in any samples from Tnbs1 HSU wells. However, groundwater samples from GSA monitor wells would still be analyzed for volatile organic compounds (VOCs), including 1,1,1-TCA, by EPA Method 624. 1,1,1-TCA detections would still be reported/discussed in Compliance Monitoring Reports, but would no longer be discussed in the Contaminant Concentrations and Distribution section of these reports unless it is detected above the 200 µg/L MCL.

4. Remove bromodichloromethane as a groundwater COC because: (1) concentrations of total trihalomethanes (TTHMs), comprised of bromoform, chloroform, bromodichloromethane, and dibromochloromethane, have never been detected at or above the 80 µg/L MCL cleanup standard in any Qt-Tnsc1 or Qal-Tnbs1 HSU wells, and (2) concentrations of TTHMs decreased to and have remained below the 80 µg/L MCL cleanup standard in Tnbs1 wells since 2005. However, groundwater samples from GSA monitor wells would still be analyzed for VOCs, including bromodichloromethane, by EPA Method 624. Bromodichloromethane detections would still be reported/discussed in Compliance Monitoring Reports, but would no longer be discussed in the Contaminant Concentrations and Distribution section of these reports unless TTHMs are detected above the 80 µg/L MCL.

5. Remove chloroform as a groundwater COC because: (1) concentrations of TTHMs have never been detected at or above the 80 µg/L MCL cleanup standard in any Qt-Tnsc1 or Qal-Tnbs1 HSU wells, and (2) concentrations of TTHMs decreased to and have remained below the 80 µg/L MCL cleanup standard in Tnbs1 wells since 2005. However, groundwater samples from GSA monitor wells would still be analyzed for VOCs, including chloroform, by EPA Method 624. Chloroform detections would still be reported/discussed in Compliance Monitoring Reports, but would no longer be discussed in the Contaminant Concentrations and Distribution section of these reports unless TTHMs are detected above the 80 µg/L MCL.

6. Remove trichlorofluoromethane (Freon 11) as a groundwater COC because: (1) concentrations of Freon 11 decreased to and have remained below its 150 µg/L MCL cleanup standard in all Qt-Tnsc1 and Qal-Tnbs1 HSU wells since 1990, and (2) Freon 11
has never been detected above the 0.5 µg/L reporting limit in any samples from Tnbs₁ HSU wells. However, groundwater samples from GSA monitor wells would still be analyzed for VOCs, including Freon 11, by EPA Method 624. Freon 11 detections would still be reported/discussed in Compliance Monitoring Reports, but would no longer be discussed in the Contaminant Concentrations and Distribution section of these reports unless it is detected above the 150 µg/L MCL.

7. Remove 1,1,2-trichloro-1,2,2-trifluoroethane (Freon 113) as a groundwater COC because: (1) Freon 113 has never been detected above its 1,200 µg/L MCL cleanup standard in any Qt-Tnsc₁, Qal-Tnbs₁, or Tnbs₁ HSU wells since 1987. However, groundwater samples from GSA monitor wells would still be analyzed for VOCs, including Freon 113, by EPA Method 624. Freon 113 detections would still be reported/discussed in Compliance Monitoring Reports, but would no longer be discussed in the Contaminant Concentrations and Distribution section of these reports unless it is detected above the 1,200 µg/L MCL.

In addition, the recommendations include a re-evaluation of potential VOC inhalation risk in buildings in the vicinity of VOC soil and groundwater contamination per discussion with EPA and the release of EPA’s new vapor intrusion screening level calculation tool:

8. On October 18, 2016, a meeting was held between DOE/LLNL, the U.S. EPA, the California DTSC, and RWQCB to discuss methods to perform VOC vapor intrusion pathway analysis in light of the recent release of EPA’s vapor intrusion screening level calculation tool, and DOE/LLNL’s vapor intrusion risk calculation methodologies used to date. As a result of this meeting/discussion, DOE agreed to conduct an analysis and develop a prioritized list for re-evaluation of potential VOC inhalation risk in buildings in the vicinity of VOC soil and groundwater contamination at Site 300, including the GSA OU. A schedule for implementing a pilot program based on the prioritized list during the next five-year review period will also be developed.

DOE is the lead agency and party responsible for implementation of these actions. The U.S. EPA and California DTSC and RWQCB are the oversight parties for implementation. These actions will be completed by December 30, 2021, assuming adequate funding is received in time to meet this milestone date. No other follow-up actions were identified related to this Five-Year Review Report.

10. Protectiveness Statement

The remedy at the GSA OU currently protects human health and the environment in the short-term because there is no current exposure to site contamination and remedial treatment systems are effectively treating groundwater and soil vapor. Exposure pathways that could result in an unacceptable risk to on-site workers are being controlled by the implementation of land use and institutional controls, the Health and Safety Plan, and the Contingency Plan. The Eastern GSA VOC plume in the vicinity of off-site water-supply wells has been remediated to meet cleanup standards. However, in order for the remedy to be protective in the long-term, EPA requested that an additional institutional control be implemented to prevent potential future exposure to off-site groundwater contamination if a new water-supply well were to be installed.
in the off-site portion of the Central GSA VOC plume. The additional institutional control is discussed in Section 4.5.1.1 (Governmental Institutional Controls), and listed in #12 below.

The remedy protects human health because:

1. Groundwater remediation in the Eastern GSA has successfully reduced concentrations of TCE and other VOCs to below MCL cleanup standards and is therefore protective of on-site and off-site groundwater and off-site private water-supply wells CDF1 and CON1, located downgradient of the Eastern GSA. The term “off site” is defined as outside the Site 300 boundary.

2. The risk associated with the migration of TCE vapors into Building 875 and subsequent inhalation by on-site workers has been mitigated by soil vapor extraction at the Building 875 dry well release site. While EPA issued new risk assessment guidance for indoor air vapor intrusion pathway in June 2015, there is an active soil vapor extraction system in close proximity to buildings where there are elevated concentrations of VOC contamination in the subsurface and the new methodology does not affect the protectiveness of the remedy.

3. Groundwater and soil vapor extraction and treatment in the Central GSA are effectively reducing VOC concentrations in groundwater and the vadose zone towards cleanup standards. Institutional/land use controls described in Sections 4.5.1.1, 4.1.1.2, and 4.5.1.4 are in-place to prevent exposure to VOCs in on-site subsurface soil and groundwater until cleanup standards are achieved.

4. Institutional controls (Section 4.1.1.2) control excavation activities to prevent on-site worker exposure to VOCs in (on-site) subsurface soil in the Central GSA until it can be verified that concentrations do not pose an exposure risk to on-site workers. VOCs are not an issue in off-site soil. Therefore no institutional/land use controls are needed for off-site soil.

5. Monitoring of VOCs in Central GSA groundwater will provide an early indication of changes in the concentrations/activities and/or extent of these constituents that could impact human health or the environment. As indicated in the Site-Wide Contingency Plan (Dibley et al., 2009), if groundwater contaminant concentrations (i.e., VOC concentrations in Central GSA groundwater) increase in a consistent and significant manner for reasons not attributable to remediation efforts (e.g., cyclic pumping), or natural aquifer or laboratory variables, DOE will notify the regulatory agencies and modifications to the remedial action (including land use controls) will be considered as necessary to protect human health.

6. Institutional controls (Section 4.5.1.1) prohibit the drilling of an on-site water-supply well in areas of contaminated groundwater with concentrations exceeding drinking water MCL groundwater cleanup standards. These institutional controls will remain in place until VOC concentrations are reduced to below cleanup standards in on-site groundwater.

7. VOC contamination emanating from the Central GSA is currently present at concentrations above groundwater cleanup standards in only two off-site monitor wells W-35A-01 and W-35A-10, located on the Corral Hollow Ranch property. Ongoing remediation is reducing VOC concentrations in these wells and the off-site plume is stable.
8. Monitor wells W-35A-01 and W-35A-10 are located 1,000 ft upgradient from the nearest downgradient off-site water-supply wells CDF1 and CON1 and there are six monitor wells located downgradient of the Central GSA plume and upgradient of wells CDF1 and CON1 in which no VOCs are detected. These six wells are monitored regularly to provide an early indication of any migration of the Central GSA VOC plume toward the CDF1 and CON1 water-supply wells. As discussed in #4 above, per the Site-Wide Contingency Plan, if VOC concentrations or extent in off-site groundwater increase in a consistent and significant manner for reasons not attributable to remediation efforts, DOE will notify the regulatory agencies and modifications to the remedial action (including land use controls) will be considered as necessary to protect human health.

9. There is a mechanism for controlling exposure to VOCs in the downgradient water-supply wells CDF1 and CON1 should VOCs migrate from the Central GSA to these wells in the form of the 1991 Settlement Agreement between DOE and the water-supply well owner (Union Livestock) in which DOE agreed to:
   • Install a replacement water-supply well in the event that water-supply wells CDF1 and CON1 become contaminated with VOCs from LLNL Site 300.
   • Decommission wells CDF1 and CON1 after a replacement well is installed.
   • Monitor CDF1 and CON1 for VOCs.

   However, this proprietary institutional control is not currently necessary to prevent the consumption of contamination groundwater from the current or future water-supply wells on Union Livestock property because: (1) VOC concentrations in Eastern GSA on-site and off-site groundwater have been reduced to below groundwater cleanup standards, and (2) the Central GSA VOC plume is not currently present on or near the Union Livestock property or their water-supply wells CDF1 and CON1.

10. Private off-site water-supply well GALLO1 is located on Corral Hollow Ranch property approximately 2,200 ft upgradient of the off-site portion of the VOC plume from the Central GSA, and therefore is not at risk of being contaminated by the Central GSA VOC plume.

11. As discussed in Governmental Institutional Controls Section 4.5.1.1, the San Joaquin County Ordinance Code, Section 9-1115 regulates the location, construction, repair and destruction of water-supply wells, and requires the drilling, alteration, or destruction of any wells in the county without a permit from the SJC EHD. Well construction/alteration and destruction permits require that all water wells are be located an adequate horizontal distance from known or potential sources of pollution and contamination, including biological and chemical sources. The SJC EHD also requires that aquifer isolation is maintained during the drilling and well construction process to prevent cross contamination of aquifers. The threat of criminal sanctions for a failure to comply serves as a significant deterrent to the unlicensed drilling of wells. These measures will control the risk of exposure to contaminated groundwater by preventing the drilling of an off-site water-supply well within the footprint of the off-site VOC plume emanating from the Central GSA onto Corral Hollow Ranch until cleanup is complete.
12. Institutional/land use controls are in place and functioning as intended to prevent exposure. No current or planned changes in land use at the site suggest that they are not or would not be effective.

13. No new contaminant releases have been identified for the GSA OU, and continued detection monitoring will provide an indication of any future releases.

14. Exposure pathways that could result in unacceptable risk to on-site workers are being controlled by the implementation of land use/institutional controls, the Health and Safety Plan, and the Contingency Plan.

While DOE considers the remedy for the GSA OU to be protective, EPA may elect to defer their remedy protectiveness determination for the GSA OU remedy until the vapor intrusion re-evaluation is completed.

The cleanup standards for GSA OU groundwater are MCLs. Because MCL-based standards do not differentiate between industrial and residential use, the groundwater cleanup remedy will be protective under any land use scenario. The cleanup standards for VOCs in subsurface soil are to reduce concentrations to mitigate risk to on-site workers and prevent further impacts to groundwater to the extent technically and economically feasible. Because some VOCs may remain in subsurface soil following the achievement of these cleanup standards, a land use control prohibits the transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use.

The Site 300 FFA is an enforceable agreement that prohibits DOE from transferring lands with unmitigated contamination that could cause potential harm unless it complies with the requirements of Section 120(h) of CERCLA, 42 U.S.C. 9620(h) and requirements for notification and protection of the integrity of the remedy set forth in Section 28 of the FFA. In the event that the Site 300 property is transferred in the future, DOE will execute a land use covenant at the time of transfer in compliance with Title 22 CCR Division 4.5, Chapter 39, Section 67391.1 as specified in the Site 300 Site-Wide ROD, and will implement deed restrictions per CERCLA 120(h). These land use controls will remain in place unless and until a risk assessment is performed in accordance with current U.S. EPA risk assessment guidance and the DOE/NNSA, U.S. EPA, DTSC, and RWQCB agree that it adequately shows that no unacceptable risk is present for residential or unrestricted land use.

11. Next Review

The next statutory review will be conducted within five years of the signature date of this report (2021).
12. References


U.S. DOE (2007), *Amendment to the Interim Site-Wide Record of Decision for the Pit 7 Complex at Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-222569).

U.S. DOE (2008), *Site-Wide Record of Decision for Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-236665).


13. Acronyms and Abbreviations

aMSL  Above mean sea level
ARARs  Applicable or relevant and appropriate requirements
ATA  Advanced Test Accelerator
bgs  below ground surface
CCR  California Code of Regulations
CDFW  California Department of Fish and Wildlife
CGSA  Central General Services Area
CERCLA  Comprehensive Environmental Response, Compensation and Liability Act
CMB  Claystone marker bed
COC  Contaminant of concern
CRPR  California Rare Plant Rant
DCA  Dichloroethane
DCE  Dichloroethene or Dichloroethylene
DOE  Department of Energy
DTSC  Department of Toxic Substances Control
DWR  (California) Department of Water Resources
EA  Environmental Analyst
EcoSSLs  Ecological Soil Screening Levels
EPA  Environmental Protection Agency
EHD  Environmental Health Department
ERD  Environmental Restoration Department
ES&H  Environmental Safety & Health
FFA  Federal Facilities Agreement
Freon 11  Trichlorofluoromethane
ft  Feet
ft³  Cubic feet
ft/day  Feet per day
FY  Fiscal year
g  Gram
GAC  Granular activated carbon
gpd  Gallons per day
gpm  Gallons per minute
GSA  General Services Area
HE  High explosives
HI  Hazard Index
HMX  High-Melting Explosive
HSU  Hydrostratigraphic unit
IW  Insufficient water
kg  Kilogram
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>lb</td>
<td>Pound</td>
</tr>
<tr>
<td>LLNL</td>
<td>Lawrence Livermore National Laboratory</td>
</tr>
<tr>
<td>LLNS</td>
<td>Lawrence Livermore National Security, LLC</td>
</tr>
<tr>
<td>LVBA</td>
<td>Low volume sampling methodology by which a grab sample is retrieved</td>
</tr>
<tr>
<td>LVES</td>
<td>Low volume electric submersible</td>
</tr>
<tr>
<td>MCL</td>
<td>Maximum contaminant level</td>
</tr>
<tr>
<td>mg/kg</td>
<td>Milligram per kilogram</td>
</tr>
<tr>
<td>mg/L</td>
<td>Milligrams per liter</td>
</tr>
<tr>
<td>MNA</td>
<td>Monitored natural attenuation</td>
</tr>
<tr>
<td>MOU</td>
<td>Memorandum of Understanding</td>
</tr>
<tr>
<td>MSL</td>
<td>Mean sea level</td>
</tr>
<tr>
<td>MTM</td>
<td>Mixed tank model</td>
</tr>
<tr>
<td>ND</td>
<td>Not detected (analytes)</td>
</tr>
<tr>
<td>NM</td>
<td>Not measured</td>
</tr>
<tr>
<td>NNSA</td>
<td>National Nuclear Security Administration</td>
</tr>
<tr>
<td>NPDES</td>
<td>National Pollution Discharge Elimination System</td>
</tr>
<tr>
<td>NS</td>
<td>Not sampled (typically a well)</td>
</tr>
<tr>
<td>NUFT</td>
<td>Non-isothermal unsaturated/saturated flow and transport</td>
</tr>
<tr>
<td>O&amp;M</td>
<td>Operations and maintenance</td>
</tr>
<tr>
<td>OU</td>
<td>Operable unit</td>
</tr>
<tr>
<td>PAHs</td>
<td>Polycyclic aromatic hydrocarbons</td>
</tr>
<tr>
<td>PCBs</td>
<td>Polychlorinated biphenyls</td>
</tr>
<tr>
<td>PCE</td>
<td>Tetrachloroethene or Tetrachloroethylene</td>
</tr>
<tr>
<td>pCi/L</td>
<td>PicoCuries per liter</td>
</tr>
<tr>
<td>ppm&lt;sub&gt;v/v&lt;/sub&gt;</td>
<td>Parts per million volume for volume</td>
</tr>
<tr>
<td>Qal</td>
<td>Quaternary alluvium</td>
</tr>
<tr>
<td>QC</td>
<td>Quality control</td>
</tr>
<tr>
<td>Qt</td>
<td>Quaternary terrace deposits</td>
</tr>
<tr>
<td>RA</td>
<td>Restricted access</td>
</tr>
<tr>
<td>RACR</td>
<td>Remedial Action Completion Report</td>
</tr>
<tr>
<td>RAOs</td>
<td>Remedial Action Objectives</td>
</tr>
<tr>
<td>RCRA</td>
<td>Resource Conservation and Recovery Act</td>
</tr>
<tr>
<td>RDX</td>
<td>Research department explosive</td>
</tr>
<tr>
<td>RI/FS</td>
<td>Remedial Investigation/Feasibility Study</td>
</tr>
<tr>
<td>ROD</td>
<td>Record of Decision</td>
</tr>
<tr>
<td>RPMs</td>
<td>Remedial Project Managers</td>
</tr>
<tr>
<td>RWQCB</td>
<td>Regional Water Quality Control Board</td>
</tr>
<tr>
<td>SARA</td>
<td>Superfund Amendment Reauthorization Act</td>
</tr>
<tr>
<td>scfm</td>
<td>Standard cubic feet per minute</td>
</tr>
<tr>
<td>SJC</td>
<td>San Joaquin County</td>
</tr>
<tr>
<td>SRC</td>
<td>Source</td>
</tr>
</tbody>
</table>
SWRI  Site-Wide Remedial Investigation
SVOCs  Semivolatile organic compounds
TBOS/TKEBS  Tetrabutyl orthosilicate/ Tetrakis (2-ethylbutyl) silane
TCA  Trichloroethane
TCE  Trichloroethylene
TFRT  Treatment Facility Real Time
Tnbs$_2$  Tertiary Neroly Upper Blue Sandstone
Tnbs$_1$  Tertiary Neroly Lower Blue Sandstone
Tnsc$_1$  Tertiary Neroly siltstone/claystone
TRV  Toxicity reference value
TTHM  Total trihalomethane
UC  Unsafe conditions
U.S.  United States
VOCs  Volatile organic compounds
yd$^3$  Cubic yards
µg/L  Micrograms per liter
Figures
Figure 1. Location of LLNL Site 300 and the General Services Area Operable Unit.
Figure 2. Site 300 map showing Operable Unit locations.
Contaminated groundwater land use controls (prevent water-supply use/consumption)
- Onsite Institutional Control Governmental
  (Dig Permit and Work Induction Board Process)
- Onsite Institutional Control Governmental
  (San Joaquin Co. well drilling permit requirements)
- Proprietary (DOE agreements with offshore property owners)
- Informational

Figure 3. Map showing Central and Eastern General Services Area (GSA) Subarea boundaries, water-supply wells, and GSA institutional/land use controls.
Figure 4. Central General Services Area Subarea site map showing monitor, extraction, and water-supply wells, and treatment facilities.
Figure 5. Eastern General Services Subarea site map showing monitor, extraction, and water-supply wells, and treatment facility.
Legend

Hydrostratigraphic units (HSU), where unsaturated or impermeable

<table>
<thead>
<tr>
<th>HSU</th>
<th>Legend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quaternary alluvial deposit</td>
<td>&lt; 0.5</td>
</tr>
<tr>
<td>Quaternary terrace deposits</td>
<td>&gt; 0.5</td>
</tr>
<tr>
<td>Tertiary Neroly Formation, upper blue sandstone</td>
<td>&gt; 5 – 10</td>
</tr>
<tr>
<td>Tertiary Neroly Formation, middle siltstone/claystone</td>
<td>&gt; 10 – 50</td>
</tr>
<tr>
<td>Tertiary Neroly Formation, lower blue sandstone (upper)</td>
<td>&gt; 100 – 1,000</td>
</tr>
<tr>
<td>Tertiary Neroly Formation, lower blue sandstone (lower)</td>
<td>&gt; 50 – 100</td>
</tr>
<tr>
<td>Tertiary Neroly Formation, lower siltstone/claystone</td>
<td>&gt; 10 – 50</td>
</tr>
<tr>
<td>Claystone marker bed</td>
<td>≤ 0.5</td>
</tr>
</tbody>
</table>

Total VOC concentrations (µg/L), where HSU is saturated

<table>
<thead>
<tr>
<th>VOC Concentration (µg/L)</th>
<th>Legend</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 100 – 1,000</td>
<td></td>
</tr>
<tr>
<td>&gt; 50 – 100</td>
<td></td>
</tr>
<tr>
<td>&gt; 10 – 50</td>
<td></td>
</tr>
<tr>
<td>&gt; 5 – 10</td>
<td></td>
</tr>
<tr>
<td>&gt; 10 – 5</td>
<td></td>
</tr>
<tr>
<td>&gt; 5 – 1</td>
<td></td>
</tr>
<tr>
<td>≥ 0.5 – 5</td>
<td></td>
</tr>
<tr>
<td>&lt; 0.5</td>
<td></td>
</tr>
</tbody>
</table>

Other symbols

- Widespread confining layer
- Potentiometric surface, dashed where inferred
- Unconformity
- Extraction well
- Dual extraction well
- Monitor well
- Pezometer
- Guard well
- Injection well
- Water - supply well (decommissioned)
- Water - supply well (non - pumping)
- Water - supply well (pumping)
- Treatment facility
- Normal Fault, dashed where inferred; arrows show relative movement
- Below ground surface

Well symbols

- Well ID
- Well casing
- Sand pack
- Screened interval
- Sand pack
- Total depth of boring during drilling

Vertically and horizontally scaled, in feet

Elevation, in feet above mean sea level

0 100 200 300 400 500 600

Distance, in feet

0 200 400 600 800 1,000 1,200 1,400 1,600 1,800 2,000 2,200 2,400 2,600

Figure 6. Hydrogeologic cross-section of the General Services Area.
Figure 7. Central General Services Area Subarea groundwater potentiometric surface maps [a] second semester 2014 and [b] second semester 2015 for the Qt-Tnsc1 and Qal-Tnbs1 hydrostratigraphic units including hydraulic capture zones.
Figure 8. Eastern General Services Area Operable Unit groundwater potentiometric surface map for the Qal-Tnbs, hydrostratigraphic unit.
Figure 9. Contaminant release sites in the General Services Area.
Figure 10. Central General Services Area Subarea total volatile organic compound (VOC) isoconcentration contour map (second semester 2015) for the Qt-Tnsc₁ and Qal-Tnbs₁ hydrostratigraphic units.
Figure 11. Time-series plots of total volatile organic compound (VOC) concentration in groundwater offsite wells a) W-35A-01, b) W-35A-09, and c) W-35A-10.

*LVBA: Low volume sampling methodology by which a grab sample is retrieved by gently lowering a bailer into well.
LVES: The length of discharge line is purged using single speed electric submersible prior to sampling.
Figure 12. Cumulative total volatile organic compound (VOC) mass removed from groundwater and soil vapor in the General Services Area.
Figure 13. Central General Services Area soil vapor extraction and treatment system: extraction well trichloroethene (TCE) vapor concentrations and monthly facility flow.
Figure 14. Comparison of the distribution of total volatile organic compounds (TVOCs) in the Qi-TrnsC and Qai-TnbsA hydrostratigraphic units at Central GSA in second semester 2005, second semester 2010, and second semester 2015.
Figure 15. Central General Services Area groundwater extraction and treatment system: Time-series plots of a) dry well pad area extraction well total volatile organic compound (VOC) concentrations and monthly facility flow, and (b) other extraction well total VOC concentrations.
Figure 16. Time-series plots of total volatile organic compound (VOC) concentrations in groundwater for the northern Central General Services Area wells.
Figure 17. Mixed-tank model (MTM) trichloroethene (TCE) concentration decay curves for Central GSA groundwater.

The equation used to model the concentration of TCE is:

$$C_W(t) = C_W(0) \exp \left[ - \left( \frac{Qp}{VwR} + \lambda \right) t \right]$$

- **t**: Time (years)
- **$C_W(t)$**: Average TCE concentration of plume at time $t$ (μg/L)
- **$C_W(0)$**: Initial average TCE plume concentration at $t = 0$ (2016)
- **Qp**: 31 μg/L Extraction pumping rate; 5,792,725 L/year
- **Vw**: Estimated total volume of contaminated groundwater with TCE concentration greater than 5 μg/L; 25,942,770 L
- **R**: Retardation factor; 3.5
- **λ**: First-order decay rate constant; 0.0139/year

$C_W(0) = 31 \mu g/L$
Figure 18. Eastern General Services Area groundwater extraction and treatment system: Time-series plots of a) former extraction well TCE concentrations and monthly facility flow, b) debris burial trench area monitoring well TCE concentrations, and c) downgradient monitoring well TCE concentrations.
Tables
Table 1. Description of institutional/land use controls for the General Services Area Operable Unit.

<table>
<thead>
<tr>
<th>Institutional/land use control performance objective and duration</th>
<th>Risk necessitating institutional/land use control</th>
<th>Institutional/land use controls and implementation mechanism</th>
</tr>
</thead>
</table>
| Prevent water-supply use/consumption of contaminated groundwater until groundwater cleanup standards are met. | VOC concentrations in groundwater exceeding cleanup standards. | **Central GSA:** There are no existing or planned water-supply wells in the Central GSA Operable Unit. Any proposed well drilling activities would be submitted to the LLNL Work Induction Board, and are reviewed by LLNL Environmental Restoration Department to ensure that new water-supply wells are not located in areas of groundwater contamination. Existing offsite downgradient water-supply wells are monitored monthly for contaminants of concern in groundwater that could potentially impact the wells. There is a Memorandum of Understanding with the owners of the offsite downgradient water-supply wells that includes point-of-use treatment if VOCs above MCLs are detected in the well.  

**Eastern GSA:** In 2006, VOC concentrations in Eastern GSA groundwater have been reduced to below groundwater cleanup standards (MCLs) through remediation, therefore this institutional/land use control is no longer needed. |

| Control excavation activities to prevent onsite worker exposure to VOCs in subsurface soil until it can be verified that concentrations do not pose an exposure risk to onsite workers. | Potential exposure to VOCs at depth in subsurface soil at the Building 875 dry well pad. | **Central GSA:** All proposed excavation activities must be cleared through the LLNL Work Induction Board and require an excavation permit. The Work Induction Board coordinates with LLNL Environmental Restoration Department to identify if there is a potential for exposure to contaminants in the proposed construction areas. If a potential for contaminant exposure is identified, LLNL Hazards Control ensures that hazards are adequately evaluated and the necessary controls are identified and implemented prior to the start of work. The Work Induction Board including the LLNL Environmental Analyst will also work with the Program proposing the construction project to determine if the work plans can be modified to move construction activities outside of areas of contamination. Controls for excavation activities will be incorporated into the LLNL Site 300 Integrated Strategic Plan or other appropriate institutional planning documents.  

**Eastern GSA:** Institutional/land use controls are not necessary to prevent worker exposure to VOCs in surface and subsurface soil because concentrations are below the U.S. EPA’s industrial and residential Preliminary Remediation Goals. |
Table 1. Description of institutional/land use controls for the General Services Area Operable Unit. (Continued)

<table>
<thead>
<tr>
<th>Institutional/land use control performance objective and duration</th>
<th>Risk necessitating institutional/land use control</th>
<th>Institutional/land use controls and implementation mechanism</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintain engineering controls to prevent onsite site worker inhalation exposure to VOCs inside Building 875 until annual risk re-evaluation indicates that the risk is less than 10^-6.</td>
<td>A pre-remediation risk of 1 x 10^-5 was identified for onsite workers from inhalation of VOCs volatilizing from subsurface soil into ambient air inside Building 875 (Central GSA).</td>
<td><strong>Central GSA:</strong> Engineering controls (heating, ventilating, and air-conditioning system for Building 875) were implemented to prevent onsite worker exposure to VOCs that could migrate from the subsurface into the building until the inhalation risk was mitigated through remediation. The risk has been successfully reduced to less than 10^-6 through groundwater and soil vapor extraction and treatment in the Building 875 area as of 2000 (see Section 3.5), therefore this institutional/land use control is no longer needed.</td>
</tr>
<tr>
<td>Prohibit transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use.</td>
<td>Potential exposure to contaminated waste and/or environmental media.</td>
<td><strong>Eastern GSA:</strong> There is no risk or hazard associated with soil in the Eastern GSA. The Site 300 Federal Facilities Agreement contains provisions that assure DOE will not transfer lands with unmitigated contamination that could cause potential harm. In the event that the Site 300 property is transferred in the future, DOE will execute a land use covenant at the time of transfer in compliance with Title 22 California Code of Regulations, Division 4.5, Chapter 39, Section 67391.1. Development will be restricted to industrial land usage. These restrictions will remain in place until and unless a risk assessment is performed in accordance with then current U.S. EPA risk assessment guidance and is agreed by the DOE, U.S. EPA, DTSC, and RWQCB as adequately showing no unacceptable risk for residential or unrestricted land use. These restrictions will be incorporated into the LLNL Site 300 Integrated Strategic Plan or other appropriate institutional planning document.</td>
</tr>
</tbody>
</table>

Notes:
- DOE = United States Department of Energy.
- DTSC = California Department of Toxic Substances Control.
- GSA = General Services Area.
- LLNL = Lawrence Livermore National Laboratory.
- MCLs = Maximum Contaminant Levels.
- RWQCB = California Regional Water Quality Control Board.
- U.S. EPA = United States Environmental Protection Agency.
- VOCs = Volatile organic compounds.

a Table 1 reflects the verbatim language from Table 2.9-13 from the 2008 Site-Wide Record of Decision, with risk reduction and/or mitigation discussion added where appropriate.

b Risk for onsite worker exposure to VOCs at depth in subsurface soil could not be re-calculated as there are no new subsurface soil data. Land use controls based on the potential exposure to VOCs in subsurface soil during ground-breaking construction activities conservatively assume that the VOCs in subsurface soil may pose a risk to human health.
Table 2. Actual annual costs for the General Services Area Operable Unit for fiscal years (FY) 2011 through 2015.

<table>
<thead>
<tr>
<th>Fiscal Year</th>
<th>Annual Budget</th>
<th>Actual Annual Cost</th>
<th>Cost Variance</th>
<th>Cost Variance Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>$489,460.62</td>
<td>$565,089.49</td>
<td>-$75,628.87</td>
<td>The FY 2011 costs were slightly over budget due to several activities costing more than planned including drilling, sampling and analysis, and facility maintenance. In addition, the GSA Five-Year Review was accelerated at EPA’s request requiring additional resources.</td>
</tr>
<tr>
<td>2012</td>
<td>$466,566.30</td>
<td>$687,054.30</td>
<td>-$220,488.00</td>
<td>The FY 2012 costs were over budget due to acceleration of the Central GSA facility effluent discharge system upgrades from FY 2013 into FY 2012.</td>
</tr>
<tr>
<td>2013</td>
<td>$1,311,696.79</td>
<td>$1,230,475.01</td>
<td>$81,211.78</td>
<td>The FY 2013 costs were slightly under budget due to completion of the Central GSA facility effluent discharge system upgrades that were conducted on FY 2012 carryover.</td>
</tr>
<tr>
<td>2014</td>
<td>$1,678,170.46</td>
<td>$1,173,353.55</td>
<td>$504,816.91</td>
<td>The FY 2014 costs were under budget due to delays in initiating FY 2014 as a result of an extended Continuing Resolution, and delays in implementing the Central GSA wellfield expansion to the northern plume due to critical habitat issues associated with the pipeline construction.</td>
</tr>
<tr>
<td>2015</td>
<td>$1,390,528.20</td>
<td>$1,131,177.02</td>
<td>$259,351.18</td>
<td>The FY 2015 costs were under budget due to delays in initiating FY 2015 as a result of an extended Continuing Resolution, delaying planned upgrades to the Central GSA treatment facility.</td>
</tr>
</tbody>
</table>

Notes:

FY = Fiscal year.
O&M = Operations and maintenance.
Table 3. Volatile organic compound data summary for off-site Central General Services Area monitor wells.

<table>
<thead>
<tr>
<th>Well ID</th>
<th>Well Type</th>
<th>Geologic unit of well completion</th>
<th>HSU</th>
<th>Date first sampled</th>
<th># Samples collected</th>
<th># Detection above analytical method reporting limit</th>
<th>Maximum historical total VOC concentration (µg/L)</th>
<th>Date of maximum historical concentration detection</th>
<th>Current (Dec. 1, 2015) total VOC concentration (µg/L)</th>
<th>Current (Dec. 1, 2015) individual VOCs detected (µg/L)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>W-35A-01</td>
<td>Monitor well</td>
<td>Qal</td>
<td>Qal-QalTnbs1</td>
<td>May 1, 1989</td>
<td>97</td>
<td>89</td>
<td>545</td>
<td>Nov-91</td>
<td>61.13</td>
<td>TCE: 56 Freon 11: 1.3</td>
<td>TCE MCL cleanup standard: ≤ 5 µg/L Freon 11 MCL cleanup standard: ≥ 150 µg/L</td>
</tr>
<tr>
<td>W-35A-02</td>
<td>Monitor well</td>
<td>Qal</td>
<td>Qal-QalTnbs1</td>
<td>May 1, 1989</td>
<td>76</td>
<td>13</td>
<td>3.5</td>
<td>Feb-91</td>
<td>NA</td>
<td>NA</td>
<td>VOC concentration of 31 µg/L detected in May 2005. Detection considered as an outlier as VOC concentrations near or below 0.5 µg/L in 40 samples before and &lt;0.5 µg/L in subsequent 21 samples.</td>
</tr>
<tr>
<td>W-35A-03</td>
<td>Monitor well</td>
<td>Qal</td>
<td>Qal-QalTnbs1</td>
<td>May 1, 1989</td>
<td>64</td>
<td>1</td>
<td>17</td>
<td>May-91</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>W-35A-04</td>
<td>Monitor well</td>
<td>Qal</td>
<td>Qal-QalTnbs1</td>
<td>December 1, 1989</td>
<td>102</td>
<td>2</td>
<td>0.99</td>
<td>Sep-96</td>
<td>NA</td>
<td>NA</td>
<td>Last VOC detection &gt;0.5 µg/L reporting limit in September 1999.</td>
</tr>
<tr>
<td>W-35A-06</td>
<td>Monitor well</td>
<td>Qal</td>
<td>Qal-QalTnbs1</td>
<td>March 1, 1990</td>
<td>62</td>
<td>1</td>
<td>6</td>
<td>Nov-90</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>W-35A-08</td>
<td>Guard well</td>
<td>Tnbs2</td>
<td>Qal-QalTnbs1</td>
<td>May 1, 1994</td>
<td>66</td>
<td>0</td>
<td>&lt;0.5</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>W-35A-09</td>
<td>Monitor well</td>
<td>Tnbs2</td>
<td>Qal-QalTnbs1</td>
<td>May 1, 1994</td>
<td>60</td>
<td>55</td>
<td>13.9</td>
<td>Nov-99</td>
<td>0.65</td>
<td>Freon 11: 0.65</td>
<td>Freon 11 MCL cleanup standard: ≥ 150 µg/L</td>
</tr>
<tr>
<td>W-35A-10</td>
<td>Monitor well</td>
<td>Tnbs2</td>
<td>Qal-QalTnbs1</td>
<td>May 1, 1994</td>
<td>66</td>
<td>66</td>
<td>86</td>
<td>Aug-94</td>
<td>15</td>
<td>TCE: 11 Freon 11: 4</td>
<td>TCE MCL cleanup standard: ≤ 5 µg/L Freon 11 MCL cleanup standard: ≥ 150 µg/L</td>
</tr>
<tr>
<td>W-35A-14</td>
<td>Guard well</td>
<td>Tnbs2</td>
<td>Tnbs2</td>
<td>August 1, 1994</td>
<td>65</td>
<td>0</td>
<td>&lt;0.5</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>W-35A-05</td>
<td>Monitor well</td>
<td>Tnsc1</td>
<td>Qal-QalTnbs1</td>
<td>December 1, 1989</td>
<td>62</td>
<td>0</td>
<td>&lt;0.5</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>W-35A-07</td>
<td>Monitor well</td>
<td>Tnbs1</td>
<td>Qal-QalTnbs1</td>
<td>May 1, 1994</td>
<td>44</td>
<td>0</td>
<td>&lt;0.5</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>W-35A-11</td>
<td>Monitor well</td>
<td>Tnbs1</td>
<td>Qal-QalTnbs1</td>
<td>June 1, 1994</td>
<td>44</td>
<td>0</td>
<td>&lt;0.5</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>W-35A-12</td>
<td>Monitor well</td>
<td>Tnbs1</td>
<td>Qal-QalTnbs1</td>
<td>July 1, 1994</td>
<td>49</td>
<td>0</td>
<td>&lt;0.5</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>W-35A-13</td>
<td>Monitor well</td>
<td>Tnbs1</td>
<td>Qal-QalTnbs1</td>
<td>August 1, 1994</td>
<td>56</td>
<td>24</td>
<td>2.4</td>
<td>May-95</td>
<td>NA</td>
<td>NA</td>
<td>Last VOC detection &gt;0.5 µg/L reporting limit in October 2003.</td>
</tr>
</tbody>
</table>

Notes:
- Sample date: December 1, 2015
- GSA = General Services Area
- HSU = Hydrostratigraphic unit
- MCL = Maximum contaminant level (drinking water)
- NA = Not applicable; constituent(s) not detected above analytical reporting limit
- TCE = Trichloroethene
- VOC = Volatile organic compound
- µg/L = Micrograms per liter
Table 4. Contaminant of concern (COC) data summary for all Central General Services Area wells.

<table>
<thead>
<tr>
<th>COC</th>
<th>MCL (µg/L)</th>
<th>Maximum historical concentration (µg/L)</th>
<th>Date of maximum historical concentration</th>
<th>Location of maximum historical concentration</th>
<th>Most recent concentration above MCL (µg/L)</th>
<th>Date of most recent concentration above MCL</th>
<th>Location of most recent concentration above MCL</th>
<th>Most recent detection (µg/L)</th>
<th>Date of most recent detection</th>
<th>Location of most recent detection</th>
<th>Time since most recent detection above MCL</th>
<th>Retain as COC?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,1,1-Trichloroethane (1,1,1-TCA)</td>
<td>200</td>
<td>1,000</td>
<td>May 17, 1993</td>
<td>W-875-10</td>
<td>300</td>
<td>August 3, 1994</td>
<td>W-71</td>
<td>0.53</td>
<td>April 16, 1998</td>
<td>W-873-03</td>
<td>&gt; 22 years</td>
<td>No</td>
</tr>
<tr>
<td>1,1-Dichloroethene (1,1-DCE)</td>
<td>6</td>
<td>860</td>
<td>March 26, 1993</td>
<td>W-71</td>
<td>7.8</td>
<td>August 19, 2015</td>
<td>W-875-07</td>
<td>4.3</td>
<td>April 5, 2016</td>
<td>W-71</td>
<td>~ 1 year</td>
<td>Yes</td>
</tr>
<tr>
<td>1,1-Dichloroethane (1,1-DCA)</td>
<td>5</td>
<td>239</td>
<td>April 9, 1992</td>
<td>W-875-08</td>
<td>6.4</td>
<td>April 21, 2015</td>
<td>W-875-08</td>
<td>3.8</td>
<td>August 19, 2015</td>
<td>W-875-08</td>
<td>&gt; 1 year</td>
<td>Yes</td>
</tr>
<tr>
<td>Bromodichloromethane</td>
<td>80*</td>
<td>27 (110*)</td>
<td>May 6, 2005</td>
<td>W-7E</td>
<td>27 (110*)</td>
<td>May 6, 2005</td>
<td>W-7E</td>
<td>1.8</td>
<td>November 19, 2007</td>
<td>W-7E</td>
<td>&gt; 11 years</td>
<td>No</td>
</tr>
<tr>
<td>Chloroform</td>
<td>80*</td>
<td>46 (110*)</td>
<td>May 6, 2005</td>
<td>W-7E</td>
<td>46 (110*)</td>
<td>May 6, 2005</td>
<td>W-7E</td>
<td>1</td>
<td>May 8, 2012</td>
<td>W-7E</td>
<td>&gt; 11 years</td>
<td>No</td>
</tr>
<tr>
<td>cis,1,2-Dichloroethene (cis-1,2-DCE)</td>
<td>6</td>
<td>1,600</td>
<td>March 23, 1993</td>
<td>W-7I</td>
<td>49</td>
<td>April 5, 2016</td>
<td>W-875-08</td>
<td>49</td>
<td>April 5, 2016</td>
<td>W-875-08</td>
<td>---</td>
<td>Yes</td>
</tr>
<tr>
<td>Tetrachloroethene (PCE)</td>
<td>5</td>
<td>13,000</td>
<td>July 16, 1993</td>
<td>W-875-07</td>
<td>52</td>
<td>April 5, 2016</td>
<td>W-875-07</td>
<td>52</td>
<td>April 5, 2016</td>
<td>W-875-07</td>
<td>---</td>
<td>Yes</td>
</tr>
<tr>
<td>Trichloroethene (TCE)</td>
<td>5</td>
<td>120,000</td>
<td>July 16, 1993</td>
<td>W-875-07</td>
<td>410</td>
<td>April 5, 2016</td>
<td>W-875-07</td>
<td>410</td>
<td>April 5, 2016</td>
<td>W-875-07</td>
<td>---</td>
<td>Yes</td>
</tr>
<tr>
<td>1,1,2-Trichloro-1,2,2-Trifluoroethane (Freon 113)</td>
<td>1,200</td>
<td>7.9</td>
<td>June 12, 1990</td>
<td>W-876-01</td>
<td>Never over MCL</td>
<td>Never over MCL</td>
<td>Never over MCL</td>
<td>2.1</td>
<td>January 19, 2001</td>
<td>W-7Q</td>
<td>Never over MCL</td>
<td>No</td>
</tr>
</tbody>
</table>

Notes:
- **COC** = Contaminant of concern.
- **MCL** = Maximum Contaminant Level.
- **µg/L** = Micrograms per liter.
- **80** = Total trihalomethane MCL (total trihalomethane concentration is the sum of bromoform, chloroform, bromodichloromethane, and dibromochloromethane concentrations).
- **110** = Total trihalomethane concentration corresponding to May 6, 2005 bromodichloromethane and chloroform detections.
Appendix A
Appendix A1

General Services Area OU
Five-Year Review Inspection Checklist Photographs
General Services Area OU
Five-Year Review Inspection Checklist Photographs

1. Central GSA groundwater and soil vapor extraction and treatment systems, misting towers, and other system components

2. Central GSA-North groundwater extraction and treatment system, injection well, and other system components
Photographs of the Central GSA groundwater and soil vapor extraction and treatment systems, misting tower, and other system components
Central GSA Groundwater and Soil Vapor Extraction and Treatment System extraction wells, dry well pad area, and dual-extraction well.
Central GSA Groundwater and Soil Vapor Extraction and Treatment Systems

(a) Example of current wellhead configuration for vapor extraction well (W-875-09 shown).

(b) Example of current piezometer configuration for dry well pad area piezometers (W-875-12 shown).

(c) Central GSA soil vapor treatment system.

(d) Central GSA soil vapor treatment system operating permits and procedures.

Central GSA groundwater and soil vapor treatment system vapor extraction well, dry well pad piezometers, and vapor system overview.
Central GSA Groundwater and Soil Vapor Extraction and Treatment Systems

(a) Central GSA soil vapor treatment system influent piping and flow meters.

(b) Central GSA soil vapor treatment system knockout drum.

(c) Central GSA soil vapor treatment system GAC vessels.

(d) Central GSA soil vapor treatment system effluent discharge stack.

Central GSA soil vapor treatment system influent pipelines, knockout drum, GAC vessels, and effluent stack.
Central GSA Groundwater and Soil Vapor Extraction and Treatment Systems

(a) Pipeline and conduit running from dry well pad area to W-7O alongside Site boundary fencing.

(b) Example of current wellhead configuration for monitor well (W-7Q shown).

(c) Example of current wellhead configuration for well with air-actuated pump east of dry well pad area (W-7O shown).

(d) Central GSA groundwater treatment system enclosure.

Central GSA groundwater treatment system monitor and extraction wells, treatment system enclosure, and influent and effluent pipelines and connections.
Central GSA groundwater and Soil Vapor Extraction and Treatment Systems

(a) Central GSA groundwater treatment system influent and effluent pipeline and connections.

(b) Central GSA groundwater treatment system electrical controls.

(c) Central GSA influent manifold, valves, and flow meters.

(d) Central GSA groundwater treatment system influent filtration.

Central GSA groundwater treatment system electrical controls, influent manifold, filtration, air stripper and GAC vessels.
Central GSA Groundwater and Soil Vapor Extraction and Treatment Systems

(a) Central GSA groundwater treatment system air stripper and GAC vessels.

(b) Central GSA groundwater treatment system pipeline between treatment system and batch tank.

(c) Central GSA groundwater treatment system batch tank.

(d) Central GSA groundwater treatment system batch tank pump, controls, flow meter, and pipelines.

Central GSA groundwater treatment system air stripper, effluent pipeline to batch tank, and batch tank controls.
Central GSA Groundwater and Soil Vapor Extraction and Treatment Systems

(a) Central GSA groundwater treatment system effluent pipeline road crossing to misting towers.

(b) Central GSA groundwater treatment system pipelines from batch tank to misting towers.

(c) Central GSA groundwater treatment system misting towers.

(d) Central GSA groundwater treatment system individual misting tower in the down position.

Central GSA groundwater treatment system effluent pipeline and misting towers.
Central GSA Groundwater and Soil Vapor Extraction and Treatment Systems

(a) Central GSA groundwater treatment system individual misting tower controls.

(b) Central GSA groundwater treatment system misting tower winch.

(c) Central GSA groundwater treatment system misting tower head.

(d) Central GSA groundwater treatment system misting tower manifold and electrical controls.

Central GSA groundwater treatment system misting tower electrical controls and manifold, winch, and misting tower head.
Photographs of the Central GSA-North groundwater extraction and treatment system, injection well, and other system components
Central GSA-North Groundwater Extraction and Treatment System

(a) Example of current wellhead configuration for well with air-actuated pump (W-CGSA-2708 shown).

(b) Example of current wellhead configuration for well with air-actuated pump (W-CGSA-2708 shown).

(c) Central GSA-North treatment system.

(d) Central GSA-North treatment system controls, manifold, flow meter, and check valve.

Central GSA-North groundwater treatment system extraction well, system overview, system controls, system manifold, system flow meter and check valve.
Central GSA-North Groundwater Extraction and Treatment System

(a) Central GSA-North treatment system GAC vessels.

(b) Central GSA-North treatment system injection well W-CGSA-2907.

(c) Example of current wellhead configuration for Central GSA-North injection well (W-CGSA-2907 shown).

(d) Example of current wellhead configuration for Central GSA-North monitor well (W-CGSA-2908 shown).

Central GSA-North groundwater treatment system GAC vessels, and injection and monitor well.
Appendix A2

General Services Area OU
Five-Year Review Site Inspection Checklist
Appendix A2

General Services Area Operable Unit
Five-Year Review Site Inspection Checklist
Lawrence Livermore National Laboratory (LLNL) Site 300

I. SITE INFORMATION

Site Name: General Services Area (GSA) Operable Unit (OU), LLNL Site 300
Date of inspection: March 22, 2016
Location and Region: Corral Hollow Road, San Joaquin/Alameda County, California
EPA Region: 9
EPA ID: CA 2890090002
Weather/Temperature: The climate of Site 300 is semiarid and windy with wide temperature variations.

Remedy Includes:
- Monitoring groundwater and soil vapor to evaluate the effectiveness of the remedy in achieving cleanup standards, and to ensure there is no impact to downgradient water-supply wells.
- Risk and hazard management (including institutional and administrative controls):
  - Maintain institutional/land use controls for the GSA OU specified in Table 1 and Section 4.5.1 of the Five-Year Review.
  - Prevent onsite workers exposure to volatile organic compounds (VOCs) volatilizing from subsurface soil and impacts to onsite workers until risk and hazard is mitigated through active remediation. Annual risk re-evaluation indicates that the inhalation risk for VOCs volatilizing from subsurface soil into indoor air in Building 875 has been mitigated through remediation. Therefore, risk and hazard management for this exposure pathway is no longer necessary. The risk re-evaluation results are documented in the “Building 875 Inhalation Risk Mitigation Evaluation at the Central GSA at Lawrence Livermore National Laboratory Site 300” (U.S. DOE, 2000).
- Extracting and treating VOCs in soil vapor and groundwater in the Central GSA to mitigate unacceptable VOC inhalation risk for onsite workers, prevent further
impacts to groundwater and offsite plume migration, and reduce contaminant concentrations in soil and groundwater to cleanup standards.

- Extracting and treating VOCs in groundwater in the Eastern GSA to reduce VOC concentrations in groundwater to cleanup standards. VOC concentrations in Eastern GSA groundwater have been below cleanup standards since February 2007.

**Site Map:** See Figures 2, 3, and 4 in the GSA OU Fourth Five-Year Review Report.

II. INTERVIEWS

1. O&M Site Manager

**Lawrence Livermore National Security (LLNS), LLC (M&O Contractor to DOE):** Leslie Ferry, Site 300 Environmental Restoration (ER) Program Leader.

**Remarks:**
As there is a full-time presence of the DOE-LFO Remedial Project Manager (RPM) and the LLNS Site 300 ER Program Leader, Site 300 ER Field Operations Manager, and the GSA OU treatment facility operators at the site, the oversight, inspections, evaluations, and discussions of the GSA OU remedy are ongoing. Remedy performance, facility operations, and any related issues are managed in real-time in collaboration with the Field Operations Manager, the facility operator, and full-time staff from the Site 300 ER Field Operations, Hydrogeology, Engineering, Water Quality Sampling, and Analysis Teams. As such, there was no single “interview” of DOE or LLNS O&M Managers or interview results that can be referenced. The information contained within this inspection checklist is a compilation of this and other DOE-LFO RPM routine inspections, evaluations, and discussions with the LLNS Site 300 ER Program Leader and staff regarding the GSA OU remedy and treatment facilities. In addition, DOE/LLNS presents and discusses any treatment facility operations and maintenance (O&M) or other remedy related issues with the regulatory agencies on an ongoing basis via monthly regulatory RPM project updates and meetings, and in the semi-annual and annual compliance monitoring reports.

2. O&M Staff

**Lawrence Livermore National Security (LLNS), LLC (M&O Contractor to DOE):**

<table>
<thead>
<tr>
<th>Name</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steve Orloff</td>
<td>Site 300 ER Field Operations Manager (LLNS)</td>
</tr>
<tr>
<td>Larry Griffith</td>
<td>Operator – Central GSA groundwater and soil vapor extraction and treatment systems (LLNS)</td>
</tr>
</tbody>
</table>
Remarks:
As there is a full-time presence of the DOE-LFO RPM, LLNS Site 300 ER Program Leader, Site 300 ER Field Operations Manager, and GSA OU treatment facility operator at the site, the oversight, inspections, evaluations, and discussions of the GSA OU remedy are ongoing. Facility operations and any related issues are managed in real-time by the entities listed above in collaboration with full-time staff from the Site 300 ER Field Operations, Hydrogeology, Engineering, Water Quality Sampling and Analysis Teams. As such, there was no single “interview” of O&M staff or interview results that can be referenced. The information contained within this inspection checklist is a compilation of this and other DOE-LFO RPM routine inspections, evaluations, and discussions regarding the GSA OU remedy and treatment facilities.

3. Local Regulatory Authorities and Response Agencies (i.e., State and Tribal offices, emergency response office, police department, office of public health or environmental health, zoning office, recorder of deeds, or other city and county offices, etc.) Fill in all that apply.

Not applicable.

4. Federal and State Regulatory Authorities and Response Agencies (i.e., U.S. Environmental Protection Agency, California Department of Toxic Substances Control [DTSC], Regional Water Quality Control Board-Central Valley Region). Fill in all that apply.

Remarks: DOE sent a request for input from the U.S. EPA, DTSC, and RWQCB on April 11, 2016. No responses were received from any of these regulatory agencies.

III. ON-SITE DOCUMENTS & RECORDS VERIFIED

1. O&M Documents

O&M manual: Readily available and up-to-date
As-built drawings: Readily available and up-to-date
Maintenance logs: Readily available and up-to-date

As-built drawings for the GSA OU treatment facilities are maintained in the LLNL Environmental Restoration Department files. The GSA OU treatment facilities consist of the Central GSA groundwater and soil vapor extraction and treatment systems, and the Central GSA-North groundwater extraction and treatment system. The GSA OU treatment facilities maintenance activities are recorded in a facility-specific logbook maintained by the facility operator. Inspections, operation, and maintenance of the GSA OU groundwater extraction and treatment systems are performed under the lead of the treatment facility operator, with as-needed maintenance assistance from mechanical and electrical/electronics technicians and engineers. Treatment facility inspection, operation, and routine maintenance procedures are documented in the LLNL Site 300 Operations and Maintenance Manual. The groundwater monitor well network for the GSA OU is routinely inspected during semi-annual sampling activities. Maintenance activities for the monitoring network included pump replacements, repairing damaged wiring, and general wellhead maintenance on an as-needed basis. LLNL maintains a database (known as “Well Track”) that tracks both the history and current status of well maintenance, including wells currently in need of maintenance. Operation and maintenance activities associated with the GSA OU groundwater monitor wells are recorded and maintained in the well logbooks maintained by the Sampling Technicians.

2. Site-Specific Health & Safety Plan

Site-Specific Health & Safety Plan: Readily available and up-to-date
Contingency Plan/Emergency Response Plan: Readily available and up-to-date

Site-specific health and safety information for Environmental Restoration activities is contained in the “Site Safety Plan for LLNL CERCLA Investigations at Site 300.” Activity-specific hazards and controls are contained in the LLNL Environmental Restoration Integration Work Sheets. Activities conducted at LLNL Site 300 are also conducted in accordance with the LLNL Environment, Safety, and Health Plan.

The contingency plan, including contingency actions in the event of natural disasters or other emergencies, for the GSA OU remedial action is included in the “Compliance Monitoring Plan and Contingency Plan for the Environmental Restoration at LLNL Site 300.”

Emergency responses are also contained in 1) Volume II, Part 22 of the LLNL Environment, Safety, and Health Plan, and 2) the Self-Help Plans.
3. O&M and OSHA Training Records

O&M and OSHA Training Records

Operation and maintenance activities associated with the GSA OU groundwater and soil vapor extraction and treatment systems are recorded and maintained in the facility-specific logbooks maintained by the facility operators. In addition, O&M activities are discussed in monthly Project Updates submitted to the regulatory RPMs, at regular RPM meetings, and in the semi-annual and annual Site-Wide Compliance Monitoring Reports.

OSHA HAZWOPER training for LLNS ER Department staff is up-to-date. Training Records for LLNS ER Department staff are maintained electronically in the LLNL Laboratory Training Records and Information (LTRAIN) System.

4. Permits and Service Agreements

Air discharge permit: Readily available and up-to-date
Effluent discharge permit: Not applicable*
Waste Disposal: Readily available and up-to-date
Other service agreements: Readily available and up-to-date

Remarks:

Air discharge permit: The air permits to operate Central GSA soil vapor treatment systems issued by the San Joaquin Valley Air Pollution Control District (SJVAPCD) are maintained at the treatment facility, and in files at Building 543. The Central GSA-North facility does not treat soil vapor, therefore there is no air permit associated with this facility.

*Effluent discharge: Effluent discharge limits are contained in the Substantive Requirements for Waste Discharge issued by the Regional Water Quality Control Board (RWQCB)-Central Valley Region and in the Site-Wide Record of Decision (ROD) for LLNL Site 300. The RWQCB Substantive Requirements and Site-Wide ROD are maintained in the administrative record at LLNL; the Site-Wide ROD is also available on-line at www.erd.llnl.gov/library/index.html.

Waste Disposal: Spent treatment media is stored at a permitted onsite storage facility (EPA ID No CA2890090002) by the LLNL Radioactive and Hazardous Waste Department prior to shipment offsite to a permitted disposal facility.

Other Service Agreements: The LLNL Maintenance and Utility Department (MUSD) performs annual compressor maintenance and semi-annual blower maintenance for the Central GSA treatment facility.
Other permits: None.

5. Gas Generation Records

Gas Generation Records: Not applicable

6. Settlement Monument Records

Settlement Monument Records: Not applicable

7. Groundwater Monitoring Records

Groundwater Monitoring Records: Readily available and up-to-date

Remarks: Groundwater monitoring records for the GSA OU are maintained in the LLNL ER Department’s Taurus Environmental Information Management System (TEIMS) database. The groundwater compliance monitoring results are presented in the semi-annual and annual Site-Wide Compliance Monitoring Reports that are sent to the U.S. EPA, the RWQCB, and the DTSC, and are available on-line at www-erd.llnl.gov/library/index.html.

8. Leachate Extraction Records:

Leachate Extraction Records: Not applicable

9. Discharge Compliance Records

Air: Readily available and up-to-date
Water: Readily available and up-to-date

Remarks:

Air: Air discharge monitoring results for the Central GSA soil vapor treatment system are recorded weekly in the treatment facility logbooks. The SJVAPCD conducts annual inspections to ensure compliance with the air permit discharge requirements. The air permit compliance status is also reported in the RPM Project Updates.
**Water (effluent):** The GSA OU groundwater extraction and treatment systems effluent discharge compliance records are maintained in the LLNL ER Department’s TEIMS data base, and are presented in the semi-annual and annual Site-Wide Compliance Monitoring Reports that are sent to the U.S. EPA, the RWQCB, and DTSC, and are available on-line at www-erd.llnl.gov/library/index.html.

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Daily Access/Security Logs: Readily available and up-to-date

**Remarks:** The entire perimeter of Site 300 is enclosed by a 4-ft-high, barbed-wire fence. Warning signs are placed around the perimeter of Site 300 on the barbed wire fence indicating that the site is U.S. government property, an explosives test facility, and that trespassing is forbidden by law. Site 300 is a restricted access facility with a single point of entry secured by a guarded gate manned 24-hours; only personnel with appropriate clearance and identification are granted entry. The OU is accessible only to DOE/LLNL workers. Full-time LLNL workers are housed at Buildings 870 through 877 inclusive, 879, 880, 883, 890, and 892. Occasional workers in this area include environmental restoration staff conducting monitoring, characterization, and remediation activities.

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**IV. O&M COSTS**

**1. O&M Organization**

Contractor for Federal Facility: The Environmental Restoration Department of Lawrence Livermore National Security, LLC; the M&O contractor for the U.S. DOE at LLNL.

**2. O&M Cost Records**

O&M Cost Records: Readily available and up-to-date

**Remarks:** The actual annual costs for the GSA OU during the review period (2011-2015) are presented in Table 2 of the Five-Year Review. LLNS Environmental Restoration Department provides monthly reports to the DOE-LFO RPM on GSA OU restoration planned and actual costs with explanations/justifications of any cost variances.
3. Unanticipated or Unusually High O&M Costs During the Review Period

The costs to operate and maintain the Central GSA extraction and treatment system are consistent with the estimated annual operating costs presented in the ROD for fiscal years 2011 and 2012. GSA OU costs in fiscal years 2013, 2014, and 2015 are higher than estimated in the ROD as a result of additional costs for: (1) facility upgrades to replace aging system components and increase operational efficiency, and (2) to address critical habitat issues (i.e., relocating the Central GSA facility effluent misting towers).

V. ACCESS AND INSTITUTIONAL CONTROLS

A. Fencing

1. Fencing Damaged

Fencing damaged location: Fencing in good condition
Gate secured: Yes

Remarks: LLNL Site 300 is a restricted access facility that is surrounded by fencing to prevent unauthorized access. See Daily Access/Security Logs above.

B. Other Access Restrictions

2. Signs and Other Security Measures

Signs and Other Security Measures In Place Yes

Remarks: LLNL Site 300 is a restricted access facility that is surrounded by fencing and has a full-time security force to prevent unauthorized access to the site. See Daily Access/Security Logs above.

C. Institutional Controls (ICs)

1. Implementation and Enforcement
Site conditions imply ICs not properly implemented: No
Site conditions imply ICs not being fully enforced: No

Type of monitoring (e.g., self-reporting, drive by): Physical inspection
Frequency: Physical ICs are inspected annually.
ICs are reviewed annually for adequacy and protectiveness.

Responsible party/agency: U.S DOE
Contact Name: Claire Holtzapple
Title: DOE-LFO Site 300 Environmental Restoration RPM
Phone No.: 925/422-0670
IC Inspection Date: 03/14/2016

Reporting is up-to-date: Yes
Reports are verified by the lead agency: Yes
Specific requirements in deed or decision document have been met: See remarks
Violations have been reported: No
Other problems or suggestions: See remarks

Remarks: EPA requested that an additional institutional control be implemented to prevent potential future exposure to offsite groundwater contamination if a new water-supply well were to be installed in the offsite portion of the Central GSA VOC plume (See Section 4.5.1.1). Refer to Section 4.5 (Institutional and Land Use Controls) of the GSA OU Five-Year Review for further details on institutional controls in the GSA OU.

2. Adequacy

ICs are adequate: See remarks

Remarks: The onsite institutional controls are adequate. While offsite institutional controls are adequate to protect human health in the short-term because there is no current exposure to site contamination. However, EPA requested that an additional institutional control be implemented to prevent potential future exposure to offsite groundwater contamination if a new water-supply well were to be installed in the offsite portion of the Central GSA VOC plume (See Section 4.5.1.1). Refer to Section 4.5 (Institutional and Land Use Controls) of the GSA OU Five-Year Review for further details on institutional controls in the GSA OU.
D. General

1. Vandalism/trespassing

Vandalism/trespassing: No vandalism evident

Remarks: LLNL Site 300 is a restricted access facility that is surrounded by fencing and has a full-time security force to prevent unauthorized access to the site.

2. Land Use Changes Onsite

Land Use Changes Onsite: No

Remarks: There have been no changes in land, building, or groundwater use in the GSA OU during the five year review period, and other than the changes in onsite water-supply source discussed below, none are anticipated. Craft shops, storage buildings, and offices in the Central GSA are used to support the research conducted at Site 300. Land in the Eastern GSA is undeveloped and is not used for LLNL programmatic activities.

At Site 300, groundwater is used for a variety of needs including cooling towers, High Explosives (HE) processing, and fire suppression. There are no active onsite water-supply wells in the GSA OU. Bottled water is the primary source of onsite drinking water, however potable groundwater from onsite water-supply Well 20, located in the HE Process Area OU, is available as necessary for potable supply. Well 18, also located in the southeast part of the HE Process Area OU is used as a backup water-supply well. Site 300 is currently scheduled to transition to Hetch Hetchy water as its primary onsite water supply. See the Section 3.2 (Land and Resource Use) of this Five-Year Review for additional details.

3. Land Use Changes Offsite

Land Use Changes Offsite: No

Remarks: Land use adjacent to the site boundary closest to the GSA OU consists of private rangeland located south of Site 300, Fireworks America, a private firm operating a fireworks storage facility adjacent to the eastern border of Site 300, and the Carnegie State Vehicular Recreation Area, located southwest of Site 300. The California Department of Fish and Wildlife (CDFW) operates an ecological preserve immediately east of Site 300 along Corral Hollow Road. There is no known planned modification or proposed development of the offsite rangeland closest to the OU.
The nearest major population center (Tracy, California) is 8.5 miles to the northeast. There are plans to develop the land parcel east of Site 300 for residential housing, but thus far the development plans have been delayed by city restricted growth initiatives. As part of this development plan, a minimum buffer zone/open space of a mile to 1.5 miles is planned between residential development and the Site 300 boundary. The developer informed DOE/LLNL that groundwater would not be used as the water-supply for this development.

Several offsite private water-supply wells located south of the GSA OU supply water for domestic and agricultural uses to neighboring ranches.

See Section 3.2 (Land and Resource Use) of this Five-Year Review for additional details.

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**VI. GENERAL SITE CONDITIONS**

**A. Roads**

1. Roads Damaged

   Roads damaged location: Roads adequate

   **Remarks:** The GSA OU treatment facilities and wells are accessed by roads in adequate condition maintained by the LLNL Site 300 management.

**B. Other Site Conditions**

   **Remarks:** Buildings and other facilities in the GSA OU are maintained in good condition by the LLNL Site 300 management.

**VII. LANDFILL COVERS**

   Not applicable

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**VIII. VERTICAL BARRIER WALLS**

   Not applicable

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**IX. GROUNDWATER/SURFACE WATER REMEDIES**

   Applicable

   **A. Groundwater Extraction Wells, Pumps, and Pipelines**

   Applicable
1. Pumps, Wellhead Plumbing, and Electrical

Central GSA:
Good condition: Yes
All required wells properly operating: Yes

Remarks: The extraction wells are inspected weekly, are in good condition, and when the system is operational, operate properly. In addition, the Central GSA extraction wellfield will be upgraded in 2016 to replace aging system components and increase the operational efficiency and data collection capabilities. Currently facility upgrades include improved instrumentation at individual extraction well wellheads, including real-time flow and elevation data measurement and collection instruments. The upgraded system will be started for continuous operation once upgrades are completed.

Central GSA-North:
Good condition: Yes
All required wells properly operating: Yes

Remarks: The extraction and injection wells are inspected weekly, are in good condition, and are operating properly. Central GSA-North is currently in the testing and verification period prior to continuous startup, and is anticipated to start operating as-designed in 2016. At Central GSA-North, groundwater is extracted via low-flow, cyclic pumping at W-CGSA-2708, and treated effluent is injected into W-CGSA-2907.

2. Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances

Central GSA:
Good condition: Yes

Remarks: All extraction system pipelines and valves are inspected weekly and are in good condition. The Central GSA extraction and treatment facility, including extraction system pipelines and valves, are scheduled to be upgraded as needed in 2016.

Central GSA-North:
Good condition: Yes

Remarks: All extraction system pipelines and valves are inspected weekly and are in good condition. The Central GSA-North extraction and treatment facility was completed in 2015 and all facility components remain in good condition.
3. Spare Parts and Equipment

Readily available: Yes
Good condition: Yes

Remarks: Spare parts for routine equipment maintenance are readily available and in good condition.

B. Surface Water Collection Structures, Pumps, and Pipelines

Not applicable

C. Treatment System

Applicable

1. Treatment Train (check components that apply)

<table>
<thead>
<tr>
<th>Component</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metals removal</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Air Stripping</td>
<td>Yes</td>
</tr>
<tr>
<td>Oil/Water separation</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Bioremediation</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Carbon adsorbers</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Ion exchange resin</td>
<td>Yes</td>
</tr>
<tr>
<td>Filters: Cuno particulate</td>
<td>Yes</td>
</tr>
<tr>
<td>Additive (e.g., chelation agent, flocculent):</td>
<td>No</td>
</tr>
<tr>
<td>Good condition</td>
<td>Yes</td>
</tr>
<tr>
<td>Sampling ports properly marked and functional:</td>
<td>Yes</td>
</tr>
<tr>
<td>Sampling/maintenance log displayed and up-to-date:</td>
<td>Yes</td>
</tr>
<tr>
<td>Equipment properly identified</td>
<td>Yes</td>
</tr>
<tr>
<td>Quantity of surface water treated annually*:</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Quantity of groundwater treated annually*:</td>
<td>1,418,583 gallons</td>
</tr>
<tr>
<td>Central GSA</td>
<td></td>
</tr>
<tr>
<td>Central GSA-North</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Quantity of soil vapor treated annually*:</td>
<td>16,979,443 cubic feet</td>
</tr>
<tr>
<td>Central GSA</td>
<td></td>
</tr>
<tr>
<td>Central GSA-North</td>
<td>Not applicable</td>
</tr>
</tbody>
</table>

*: Quantities based on an average of the annual totals from January 2011 to December 2015.

Remarks: Refer to Section 4.4 (System Operations/Operation and Maintenance) of the GSA OU Five-Year Review for further details about the GSA OU groundwater and soil vapor treatment systems operations and maintenance. Photographs of the GSA groundwater and soil extraction and treatment systems, and the CGSA-North groundwater extraction and treatment system are included in Appendix A1.
2. **Electrical Enclosures and Panels (properly rated and functional)**

Good condition: Yes

**Remarks:** The electrical control panel and enclosure are in good condition, properly rated, and functional.

3. **Tanks, Vaults, Storage Vessels**

Good condition: Yes
Proper secondary containment: Yes

**Remarks:** A 1,000-gallon tank is located near to the Central GSA treatment system and is used to store treated groundwater prior to misting of the facility effluent. Secondary containment is not necessary for the effluent storage tank as they are used to store treated groundwater.

4. **Discharge Structure and Appurtenances**

**Groundwater Treatment System Effluent Discharge Structures:**

Good condition (Central GSA Misting Towers): Yes
Good condition (Central GSA-North Injection Well): Yes

**Remarks:**

<table>
<thead>
<tr>
<th>Treatment System</th>
<th>Discharge Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central GSA</td>
<td>Misting towers (4)</td>
</tr>
<tr>
<td>Central GSA-North</td>
<td>Injection well (1)</td>
</tr>
</tbody>
</table>

Photographs of Central GSA groundwater treatment facility effluent misting tower structures and the Central GSA-North groundwater treatment facility effluent injection well are included in Appendix A1. New effluent misting towers were installed during the first quarter 2014 and use of the new towers to mist treated effluent started in April 2014. Electrical problems with the misting head motors encountered in fourth quarter of 2015 have been corrected, and the misting towers are operating effectively.
Soil Vapor Treatment System Effluent Discharge Structures:

Good condition: Yes

**Remarks:** The treated air effluent from the Central GSA soil vapor treatment system is currently discharged via a 20-foot high, 12-inch diameter vapor stack. A photograph of Central GSA soil vapor treatment facility effluent discharge stack is included in Appendix A1. Soil vapor is not extracted or treated by the Central GSA-North facility.

5. Treatment Buildings

Not applicable

6. Monitoring Wells:

- Properly secured/locked: Yes
- Functioning: Yes
- Routinely sampled: Yes
- Good condition: Yes
- All required wells located: Yes
- Needs maintenance: No

**Remarks:** The current GSA OU wellfield consists of: six groundwater extraction wells, three dual-extraction wells (soil vapor and groundwater), four soil vapor extraction wells, and 62 groundwater monitor wells. During second semester 2015, groundwater monitoring was conducted in accordance with the Compliance Monitoring Plan monitoring requirements with the following exceptions:

- A total of 10 required analyses in six different wells (W-7PS, W-872-01, W-875-03, W-CGSA-1732, W-CGSA-1733, and W-CGSA-1735) were not performed due to the absence of or insufficient water for sample collection.
- A single required analysis in W-7C was not performed due to an inoperable sampling pump. The pump has since been replaced.

D. Monitoring Data

1. Monitoring Data

- Is routinely submitted on time: Yes
- Is of acceptable quality: Yes
2. Monitoring data suggests:

Groundwater plume is effectively contained: Yes
Contaminant concentrations are declining: Yes

Remarks: Refer to Section 6.4 (Data Review and Evaluation) of the GSA OU Five-Year Review for further details on the progress of the remedial action at the GSA OU.

E. Monitored Natural Attenuation (MNA)

Not applicable

X. OTHER REMEDIES

If there are remedies applied at the site which are not covered above, attach an inspection sheet describing the physical nature and condition of any facility associated with the remedy:

Soil vapor is extracted from three dual-extraction wells and four dedicated vapor extraction wells at Central GSA. The extracted soil vapor is treated using granular activated carbon. The inspections of the soil vapor system at the Central GSA is included in the checklist for the groundwater extraction and treatment system in Section IX above.

XI. OVERALL OBSERVATIONS

A. Implementation of the Remedy

Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emission, etc.). Describe issues and observations relating to whether the remedy is effective and functioning as designed.

The remedy selected for the GSA OU is intended to reduce the mass of contaminant sources, prevent further plume migration, remove contaminant mass from the subsurface, and reduce contaminant concentrations in groundwater to cleanup standards. Refer to Section 4.1 (Remedial Action Objectives) of the Five-Year Review for further details on the remedial action objectives.

The groundwater and soil vapor extraction and treatment remedy at the GSA OU is effective, functioning as designed, and is protective of human health and the environment for the site’s industrial land use. Refer to Section 7 (Technical Assessment) and Section 10 (Protectiveness Statement) of the GSA OU Five-Year Review for further details regarding the remedy effectiveness, functionality, and protectiveness.
No deficiencies or issues with the remedy for the GSA OU were identified during this evaluation. Refer to Section 8 (Issues) and Section 9 (Recommendations and Follow-up Actions) of the GSA OU Five-Year Review for further details regarding deficiency conclusions and recommendations for follow-up actions developed as part of the review process.

B. Adequacy of O&M

Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy.

There were no issues or observations related to the implementation and scope of operation and maintenance procedures for the GSA OU groundwater and soil vapor extraction and treatment facilities.

Major upgrades to the Central GSA groundwater and soil vapor extraction and treatment systems are currently being designed and will be implemented in 2016. These upgrades include replacement of aging system components, and improved instrumentation, piping, monitoring and extraction well surface completions, and data collection capabilities (i.e., real-time flow and groundwater elevation data collection instrumentation for extraction wells).

C. Early Indicators of Potential Remedy Problems

Describe issues and observations, such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs, that suggest that the protectiveness of the remedy may be compromised in the future.

There were no issues or observations that suggest that the protectiveness of the groundwater and soil vapor extraction and treatment remedy at the GSA OU may be compromised in the future. DOE’s long-term plans include periodic assessments and upgrades to the GSA OU groundwater and soil vapor extraction and treatment systems to ensure effectiveness and protectiveness of the remedy.

D. Opportunities for Optimization

Describe possible opportunities for optimization in monitoring tasks or the operation of the remedy.

Opportunities for optimization for Central GSA groundwater and soil vapor extraction and treatment facilities were previously identified as part of ERD’s remediation evaluation process. These opportunities are currently being addressed as part of the Central GSA extraction and treatment system upgrade planned in 2016, including replacement of aging system components, improved instrumentation, piping, monitoring and extraction well surface completions, and data collection
capabilities. Optimization of the upgraded Central GSA groundwater and soil vapor extraction and treatment facilities will be re-evaluated upon the completion of comprehensive hydraulic testing conducted on the upgraded treatment facility.

The Central GSA-North facility operator recommended installing a check-valve in the treatment line upstream of the facility flow meter to prevent the gravity-driven back flow of water across the meter upon facility shutdown.

Refer to Section 9 (Recommendations and Follow-up Actions) of the Five-Year Review for further details regarding recommendations for optimization of the GSA OU extraction and treatment systems developed as part of the review process.
Appendix B

Responses to Regulatory Comments
Appendix B1

Responses to Regulatory Comments on the Draft Five-Year Review
Appendix B1

Comment Responses for the Draft Fourth Five-Year Review Report for the General Services Area (GSA) Operable Unit at Lawrence Livermore National Laboratory (LLNL) Site 300

Regional Water Quality Control Board (RWQCB) comments and responses:

GENERAL COMMENTS

1. Central Valley Water Board Staff concur with DOE’s Recommendation to remove 1,1,1-trichlorethane, bromodichloromethane, chloroform, Freon 11, and Freon 113 as groundwater COCs (contaminants of concern) at the Central GSA because these constituents have not been detected above cleanup standards for over 10 years. DOE (U.S. Department of Energy) will continue to monitor for these constituents; however, these constituents will not be discussed in depth in monitoring reports unless they are detected above MCLs (Maximum Contaminant Levels).

Response: DOE/LLNL appreciates the RWQCB’s concurrence with DOE’s Recommendations #3 through #7 to remove 1,1,1-trichlorethane, bromodichloromethane, chloroform, Freon 11, and Freon 113 as groundwater COCs at the Central GSA. As noted above and in the Five-Year Review report, DOE will continue to monitor for these constituents. However, these constituents will not be discussed in depth in monitoring reports unless they are detected above MCLs.

2. Central Valley Water Board staff also concur with the recommendation to install two additional offsite wells within the Quaternary terrace deposits (Qt) and Tertiary Neroly Siltstone/Claystone (Tnsc1) hydrostratigraphic units (HSUs) to obtain data to better define the vertical distribution of dissolved-phase VOCs (volatile organic compounds) in these HSUs offsite. Figure 6 of the FYR (Five-Year Review) provides a cross section that runs in a west to east general direction; Central Valley Water Board staff request that a north to south cross section through the offsite monitoring wells also be included in the next FYR to provide a visual of the hydrogeologic profile and extent of contamination offsite.

Response: DOE/LLNL appreciates the RWQCB’s concurrence with DOE’s Recommendation #2 to install two additional offsite wells in the Quaternary alluvium (Qal) and Tertiary Neroly Upper Blue Sandstone (Tnbs2) stratigraphic units to obtain data to better define the vertical distribution of dissolved-phase VOCs in this HSU offsite. As requested, DOE/LLNL will
include a north to south cross-section through the offsite monitoring wells in the next Five-Year Review to provide a visual representation of the hydrogeologic profile and extent of contamination offsite.

Please note that, as discussed in the Recommendation #2 text in the Five-Year Review Summary Form and in Section 9 (Recommendations and Follow-up Actions), DOE/LLNL’s ability to install these two offsite wells is contingent on receiving the property owner’s permission and other relevant permits, as necessary.

3. Based on Figure 14 of the FYR, there are no notable changes in the size of the VOC plumes for the time period between 2010 and 2015. Therefore, Central Valley staff concur with DOE’s recommendation to optimize, expand, and upgrade the Central GSA groundwater and soil vapor extraction and treatment systems to maximize VOC mass removal and expedite groundwater cleanup at the Central GSA.

Response: DOE/LLNL appreciates the RWQCB’s concurrence with the DOE’s Recommendation #1 to refine the extent of hydraulic capture zones, further optimize extraction wellfield operation to maximize VOC mass removal, and more rigorously estimate the remaining vapor phase source term.

4. Recommendation #8 states that DOE is negotiating a memorandum of understanding (MOU) with the owner of the property on which the offsite portion of the Central GSA VOC plume is located, to prevent installation of a watersupply well within the VOC plume. This will satisfy the long-term land use controls required to prevent exposure to VOCs in the offsite groundwater. However, VOCs were also identified as COCs in soil at the Central GSA, including some offsite locations. Therefore, Central Valley Water Board staff recommend that the MOU agreement also include language to prevent excavating/digging of soil in the contaminated offsite area to prevent exposure to subsurface VOCs in the soil.

Response: Any VOC contamination in offsite soil/rock would have been transported via groundwater and would only be sorbed to the sedimentary particle surfaces, and is likely of very low concentrations within the saturated portion of soil/rock, currently more than 15 feet below ground surface. The maximum trichloroethylene (TCE) concentrations detected in subsurface soil/rock samples collected from the boreholes for well W-35A-01 (0.029 milligrams per kilogram [mg/kg]) and in well W-35A-10 (0.15 mg/kg) when they were installed in 1989 and 1994, respectively, are below both the residential and industrial soil Regional Screening Levels (RSLs) (May 2016). The U.S Environmental Protection Agency’s (EPA’s) residential soil RSLs (May 2016) for TCE are 0.94 mg/kg (excess cancer risk) and 4.1 mg/kg
(noncancer effects); the industrial soil RSLs (May 2016) for TCE are 6.0 mg/kg (excess cancer risk) and 19 mg/kg (noncancer effects). EPA’s industrial soil RSLs are calculated based on an exposure scenario of 8 hours per day, 250 days per year for 25 years, and the residential soil RSLs are calculated based on an exposure scenario of 24 hours per day, 350 days per year, for 30 years. Therefore, there is no risk associated with excavating/digging into soil in the offsite area of ground water contamination to prevent exposure to subsurface VOCs in soil/rock, and institutional/land use control are not needed to prevent exposure.

5. Section 6.1 of the FYR provides information about how and where the FYR can be accessed by the public. Central Valley Water Board staff request that the FYR also be uploaded to the GeoTracker database and the URL link for accessing GeoTracker (http://geotracker.waterboards.ca.gov/) be included in Section 6.1 of the FYR.

Response: The Final Five-Year Review will be uploaded to GeoTracker upon completion. The URL link for accessing GeoTracker (http://geotracker.waterboards.ca.gov/) was added to Section 6.1 of the Final Five-Year Review.
California Department of Toxic Substances Control (DTSC) comments and responses:

GENERAL COMMENTS

1. **Section 3.1.3, Eastern GSA, Third Paragraph** - Please provide data showing that VOC concentrations in Eastern GSA groundwater have been below cleanup standards since 2005.

   **Response:** Text has been added to Section 3.1.3 “Eastern GSA” that indicates that the data showing that VOC concentrations in Eastern GSA groundwater have been below cleanup standards since 2005 will be presented in the Final Close Out Report for the Eastern GSA subarea, scheduled to be finalized in 2017. Since this document and data/information contained therein is still in regulatory review and has not been finalized, it is not included in this Five-Year Review.

2. **Section 4.1, Remedial Action Objectives.** The second paragraph states that VOCs in the vadose zone will be remediated to the extent technically and economically feasible to minimize further degradation of the groundwater by contaminants in the vadose zone. Please note that any area that is not cleaned up to allow for unrestricted land use will require a land use covenant or similar mechanism to be recorded with County to ensure industrial use of the site upon transfer to a non-federal entity.

   **Response:** DOE acknowledges that any area that is not cleaned up to allow for unrestricted land use will require a land use covenant or similar mechanism to ensure industrial use of the site upon transfer to a non-federal entity. This provision is included in Section 4.5.1.4 “Prohibit Transfer of Lands with Unmitigated Contamination” of this Five-Year Review.

3. **Section 4.2, Remedy Selection, Item 2.** The second sentence states that annual risk re-evaluation indicates that the inhalation risk for VOCs volatilizing from subsurface soil into indoor air in Building 875 has been mitigated through remediation. Please provide historical data, as an appendix, showing that indoor air within Building 875 is no longer a problem.

   **Response:** The information referenced in DTSC’s comment was provided to EPA, DTSC, and the RWQCB in the “Building 875 Inhalation Risk Mitigation Evaluation at the Central GSA at Lawrence Livermore National Laboratory Site 300” (U.S. DOE, 2000) referenced in Section 4.2. It was also discussed in previous Five-Year Reviews (i.e., 2006 Second Final Five-Year Review
A Five-Year Review report is intended to provide an update on the status of remediation during the five-year review period, which in this case is January 2011 through December 2015. As such, it is not necessary to provide data to document all evaluations conducted by DOE and decisions made by DOE and the regulatory agencies prior to the current five-year review period. In light of the regulatory agencies request to both streamline and move toward consolidated five-year reviews for multiple OUs, attempting to include all historical information for all OUs in every five-year review report would be impracticable.

4. Section 4.3, Remedy Selection, Second Paragraph. The Five-Year Review Report is a stand alone document and should include/summarize the results of remedial action ground water monitoring, remediation progress, and the status of institutional control implementation for the GSA OU reported in the ERD (Environmental Restoration Department) semiannual and annual Compliance Monitoring Reports. Please include/summarize those results in this report.

Response: In addition to the semiannual and annual Compliance Monitoring Reports, the results of remedial action ground water monitoring, remediation progress, and the status of institutional control implementation are also presented in this Five-Year Review Report as follows:

- Remedy Implementation for Central GSA and Eastern GSA (Sections 4.3.1 and 4.3.2, respectively).
- System Operations/Operation and Maintenance (Section 4.4).
- Institutional/Land Use Controls, including the status of these controls (Section 4.5).
- Data Review and Evaluation, including a discussion of the ground water monitoring data, extent of VOC contamination in ground water, and risk mitigation progress (Section 6.4).

The text in the third paragraph Section 4.3 was modified to state that “the results of remedial action ground water monitoring, remediation progress, and the status of institutional control implementation for the GSA OU are reported in the ERD semiannual and annual Compliance Monitoring Reports and in this Five-Year Review report.” The text in the fourth paragraph of Section 4.3 was modified to reference the sections of the Five-Year Review report that contain the discussions of system operations and maintenance and the status of institutional/land use controls.

5. Section 4.3.1.1, Central GSA Groundwater Remedy Implementation. Discuss whether remediation efforts are reducing concentrations of TCE (trichloroethene) and other VOCs in groundwater as intended.
Response: The reduction in VOC concentrations and distribution as a result of ground water and vadose zone remediation is discussed in detail in Section 6.4 “Data Review and Evaluation.” For example, Section 6.4.1.1 “VOC Concentrations and Distribution” states that: “Prior to remediation, the historic maximum total VOC concentration detected in Central GSA ground water was 272,000 µg/L in a bailed ground water sample collected from the uncased borehole for dual-phase extraction well W-875-07 in the Building 875 dry well pad area in March 1992. Total VOC concentrations in the Building 875 dry well area have decreased to a 2015 maximum of 546.5 µg/L in dual-phase extraction well W-875-07 (August).” Section 6.4.1.2.1 “Vadose Zone Remediation Progress” states that: “Vadose zone remediation has been ongoing at the Building 875 dry well contaminant source area since July 1994. TCE vapor concentrations in individual extraction wells have decreased from a start-up maximum of 529 ppm_v (well W-875-07) to a current second semester 2015 maximum of 1.4 ppm_v (well W-71).”

However, text has been added to Section 4.3.1.1 and 4.3.1.2 summarizing the VOC concentration reductions in the Central GSA ground water and vadose zone as a result of remediation efforts as requested.

6. Section 6.1, Notification of Review/Community Involvement. Also attached to the Five-Year Review Report a copy of the initial and final notices published in the Tracy Press. Also consider translating those notices to Spanish since the Spanish speaking population in Tracy and surrounding areas has grown significantly over the few years.

Response: Part of the purpose of the Public Notices is to notify the community stakeholders that DOE is conducting a Five-Year Review, and the location and availability of the Five-Year Review document for public review. It was not feasible to attach a copy of the initial public notice to the Final Five-Year Review Report as the initial notice was not published until after the Draft Five-Year Review Report was published and placed in the public repositories and website. DOE will send a copy of the initial notice with the submittal of the Draft Final Five-Year Review Report. Similarly, it is not feasible to attach a copy of the final notice to the Draft Final or Final Five-Year Review Report as the final notice is not published until after the Five-Year Review Report is finalized. However, DOE/LLNL will send the regulators a copy of the final notice after it is published to insert into the Five-Year Review.

DOE will consider DTSC’s suggestion regarding the translation of Public Notices to Spanish.

7. Section 6.4.2, Eastern GSA Remediation Progress, Fourth Paragraph. Please provide analytical results of the additional characterization activities conducted in
Response: While the additional characterization field work was conducted in 2014, the Technical Memorandum that presented and evaluated this data was not approved by the regulators and finalized until 2016, which is outside the five-year review period covered by this report (January 2011-December 2015.) Per agreement with the regulators, the Technical Memorandum will be included in the Close Out Report for the Eastern GSA Subarea, scheduled to be finalized in early 2017. Therefore, the characterization results were not included in this Five-Year Review.
U.S. Environmental Protection Agency (EPA) comments:

The Draft Five-Year Review for the GSA OU was submitted to the regulatory agencies for review on June 22, 2016. Per the Federal Facility Agreement and chronological schedule, regulatory comments were due to DOE on August 21, 2016. On August 16, 2016, EPA notified DOE that their comments would not be submitted until at least September 15, 2016. On August 24, 2016, EPA requested an electronic copy of the document text to expedite their review; DOE e-mailed the text to EPA the same day.

On November 30 2016, DOE requested that EPA submit comments on the Draft Five-Year Review by December 15, 2016 to continue to make progress in finalizing the Five-Year Review, and help relieve the backlog of Five-Year Reviews that was accumulating due to late or no submittal of comments by EPA.

Because, as of March 3, 2017, DOE had still not received any EPA comments on the draft document, the Draft Final Five-Year Review is being issued without EPA comments. At the January 19, 2017 RPM meeting, the DOE RPM notified the EPA RPM of the intent to issue the draft final document without having received or addressed EPA comments on the draft document.

However, DOE has made some changes to the Draft Final GSA Five-Year Review in response discussions with EPA on this or other Five-Year Review reports including:

- Text has been included in Section 9 of the Draft Final GSA Five-Year Review to address the vapor intrusion VOC inhalation risk re-evaluation methodologies identified by EPA on the Draft Final Building 832 Canyon OU Five-Year Review.
- Text in Section 4.5.1.1 has been revised regarding institutional/land use controls to prevent water-supply use/consumption of offsite contaminated ground water until ground water cleanup standards are met based on DOE’s discussions with EPA.
- Miscellaneous text edits were made throughout the Draft Final Five-Year Review for the GSA OU based on EPA comments on the Draft and Draft Final for the Building 832 Canyon OU.
Appendix B2

Responses to Regulatory Comments on the Draft Final Five-Year Review
Appendix B2

Comment Responses for the Draft Final Fourth Five-Year Review Report for the General Services Area Operable Unit at Lawrence Livermore National Laboratory (LLNL) Site 300

U.S. Environmental Protection Agency (EPA) comments on the Draft and Draft Final:

LETTER OPENING COMMENT:
The U.S. EPA has reviewed the Draft Fourth Five-Year Review Report (“DFFYR” or “Report”) for Operable Unit 1 (GSA) at the LLNL Site 300 dated June 2016. Given that the statutory deadline for this FYR is not until September 28, 2017, EPA had formally requested additional time to review and comment on the draft document. We were disappointed to hear that DOE opted to move forward with producing the Final FYR without considering our comments.

Response: EPA has proposed, and discussions between EPA and DOE are underway, to revise Five-Year Review (FYR) deliverable dates, including consolidation of Operable Unit (OU)-specific FYRs. It is currently planned that, when agreement between EPA, DOE, and the state regulators is reached on the path forward and a new schedule has been established for the Site 300 FYRs, the Federal Facility Agreement (FFA)/Chronological schedule for document deliverables will be revised. Until that time, DOE is still bound to the most recent signed FFA/Chronological schedule of deliverable dates. In accordance with the current signed FFA/Chronological deliverables schedule, DOE submitted the Draft GSA FYR to the regulators on June 21, 2016. Per the FFA, regulatory comments were due to DOE on August 21, 2016. DTSC and RWQCB submitted comments to DOE on the Draft GSA FYR on August 30, 2016, and September 8, 2016, respectively. At the January 19, 2017 Remedial Project Manager’s (RPM) meeting, EPA indicated to DOE that they would submit comments on the Draft GSA FYR by January 20, 2017. DOE notified EPA of the intent to proceed with issuance of the Draft Final GSA FYR at the January 19, 2017 RPM meeting, and indicated to EPA that their comments would be addressed in the Final GSA FYR. Because EPA comments had not yet been received, DOE issued the Draft Final GSA FYR on March 27, 2017.

GENERAL COMMENTS

Laboratory [LLNL] Site 300, California, June 2016 (the FYR) Summary Form indicates that, “Recently discovered technical issues have called the potential to execute this MOU [Memorandum of Understanding] into serious questions;” however, the FYR does not identify the “recently discovered technical issues.” The statement regarding the technical issues is made in several sections of the FYR, such as Section 4.5.1.1 and Section 9.0, but no additional information is provided. Please revise the FYR to identify the “recently discovered technical issues” and discuss how these issues impact the potential to execute the MOU.

**Response:** As discussed between DOE and EPA, the MOU between DOE/NNSA and the Corral Hollow Ranch property owner is no longer a viable option and Recommendation #8 has been removed from the FYR. Therefore, the requested information is no longer relevant and was not added.

2. The figures included in the FYR do not provide sufficient information about the extent of institutional control (IC) boundaries. Section 3.5 of the memorandum Recommended Evaluation of Institutional Controls: Supplement to the Comprehensive Five-Year Review Guidance (the Supplemental IC Evaluation), dated September 2011, recommends including “Maps that illustrate the areas of remaining contamination (e.g., contaminated ground water plume), parcel boundaries, and an overlay of any ICs that may be in place.” In addition it is important to show the extent of IC boundaries relative to the extent of contamination so that the adequacy of the IC boundaries can be evaluated. Please revise the FYR to ensure site figures depict the extent of IC boundaries.

**Response:** Figure 3 shows the contaminated groundwater plume, property parcels in the vicinity of the GSA OU, and ICs for the GSA OU. The contaminated groundwater land use controls are in effect for the groundwater plume areas with concentrations above cleanup standards (shown in grey). The area of subsurface soil VOC contamination (in the vicinity of the Building 875 dry well pad) to which the excavation controls apply has been added to this figure.

3. The FYR does not discuss the source(s) of the exposure factors used in the original human health risk assessment (HHRA). As such it is unclear whether any of the risk and hazard estimates warrant revision. It is noted that since September 29, 2011, EPA has published several resources with more current exposure factors, including the Exposure Factors Handbook: 2011 Edition, dated September 2011; and OSWER Directive 9200.1-120 (Update of Standard Default Exposure Parameters), dated February 6, 2014. EPA has also promulgated a document to supplement aspects of the 2014 Update of Standard Default Exposure Factors. This supplementary document, OSWER Directive 9285.6-03, originally dated February 6, 2014, was updated September 14, 2015 and is titled Frequently Asked Questions (FAQs) About Update of Standard Default Exposure Factors (EPA, 2015). The FYR should clarify if any of the exposure factors used in the original HHRA have changed since that time, and if so, if the changes are deemed substantive and necessitate re-calculation.
of risk and hazard. Please revise the FYR to include an in-depth evaluation of changes in exposure factors and exposure assumptions, including exposure pathways and receptors, and clarify if any of these changes affect the protectiveness of the remedy.

Response: In the 1997 GSA Record of Decision (ROD) and 2008 Site-Wide ROD, DOE agreed to remediate VOCs in GSA groundwater to meet Federal or State Maximum Contaminant Levels (MCLs), whichever is more stringent. The MCLs for most of the GSA OU groundwater contaminants of concern (COCs), including trichloroethene (TCE) (Federal and State: 5 µg/L), cis-1,2-dichloroethene (DCE) (State: 6 µg/L), tetrachloroethene (PCE) (Federal and State: 5 µg/L), 1,1,1-trichloroethane (TCA) (Federal and State: 200 µg/L), 1,1-DCE (State: 6 µg/L), have not changed since they were selected as the cleanup standards in the GSA and Site-Wide ROD. The MCL for chloroform and bromodichloromethane have decreased from the 1997 GSA (ROD) from 100 to 80 µg/L for total trihalomethanes, but are the same as established in the 2008 Site-Wide ROD. Bromodichloromethane and chloroform have not been detected in any GSA wells since 2007 and 2012, respectively. Since the MCLs have not changed within the FYR period, they are not discussed (as changes). As groundwater cleanup is based on the MCLs, rather than on a risk estimate, a re-evaluation of risk based on changes to exposure factors is not necessary to demonstrate the protectiveness of the remedy.

VOCs are the only COCs present in subsurface soil at the GSA OU. EPA has requested that the inhalation risk associated with VOCs be re-evaluated using Vapor Intrusion Screening Levels (VISLs). Therefore, evaluating risk associated with VOCs in subsurface soil based on any changes to exposure factors used in the original baseline human health risk assessment seems unnecessary, and contradictory to EPA’s request to use VISLs for this evaluation. However, a discussion of the changes in EPA methodologies to evaluate vapor inhalation risk was added to Sections 6.4.3 and 7.2 of the Final GSA FYR. A new recommendation (#8) was also added to the FYR Summary Form and in Section 9 of the Draft Final GSA FYR in which DOE agreed to conduct an analysis and develop a prioritized list for re-evaluation of potential VOC inhalation risk in buildings in the vicinity of VOC soil and groundwater contamination in the GSA OU (and at all other potential vapor intrusion sites at Site 300).

There are no surface soil COCs in the GSA OU, and there is no surface water present in this OU.

4. The FYR does not include sufficient comparisons of the toxicity criteria employed in the original HHRA to current toxicity criteria for each contaminant of concern (COC). As such, it is unclear whether any of the risk and hazard estimates warrant revision. For example, the toxicity criteria for trichloroethene (TCE) were updated
in November 2011 and it was reclassified as a mutagen. Similarly, toxicity criteria for tetrachloroethene (PCE) were updated in May 2012. Note that this list of examples may not be exhaustive. Please revise the FYR to provide a comparison of the toxicity criteria used in the original HHRA to current toxicity criteria for each COC. Please also clarify if any re-calculation of risk and hazard are necessary to demonstrate continued protectiveness of the remedy and/or if cleanup goals should be revised on the basis that improved approaches are available for calculating new/current cleanup standards.

Response: See response to Comment 3.

5. The milestone dates listed in the Summary Form are more than five years in the future (i.e., after the time that the Fifth FYR has to be signed), but it is unclear why the recommendations will not be implemented sooner. For example, Recommendation #2 includes installation of two off-site wells, but it should not take five years to install and sample these wells, particularly since the data from the new well locations should be obtained before the next FYR. Also it should be possible to implement the recommendations for removal of specific COCs (i.e., Recommendations #3 through #7) in less than five years. Please revise the milestone dates provided in the Summary Form to ensure recommendations can be implemented before the next FYR, where possible.

Response: The dates for implementation of recommendations involving field work (i.e., Recommendation #2) are set at the end of the next FYR period due to the Federal process to request and receive funding for these activities, uncertainties about receiving the funding when requested, as well as uncertainties as to when the Recommendations and FYR will be finalized/approved. The Federal funding process requires that funding for a given Fiscal Year be requested two years in advance, and are submitted in the February –March timeframe of each year. For example, the funding request cycle for Fiscal Year 2020 will begin in February–March of 2018. In addition, LLNL is required to submit Biological Assessments, and then receive a Biological Opinion from the U.S. Fish and Wildlife Service for ground-disturbing work. Field work is generally limited to mid-May through mid-October, as most of Site 300 is a critical habitat for special-status species. Assuming funding and the appropriate approvals are received, the activities in any given fiscal year must be balanced to what can realistically be accomplished logistically, given these constraints. If funding is not approved or budget cuts prevent the work from being accomplished in the planned fiscal year, it must be rescheduled to a subsequent year. As a result, DOE/LLNL have set a conservative milestone as the end of the FYR period to ensure the milestone can be met. However, if funding and approvals allow, DOE/LLNL would implement these recommendations prior to the end of the five-year period.
The recommendations to remove specific COCs (i.e., Recommendations #3 through #7) will be considered as accomplished/implemented once the Final FYR is approved by the regulatory agencies. However, because the review and approval cycles for draft, draft final, and final FYRs have become considerably longer due to delays in regulatory reviews, DOE/LLNL again have set conservative milestones as the end of the FYR period, as it is not clear when the Final FYR will be approved. For example, DOE submitted the Draft Third GSA FYR to the regulators on June 21, 2011 and was due to be finalized on December 11, 2011. However, EPA did not sign the Final FYR until October 2012. The current GSA FYR is already seven months behind schedule due to delays in regulatory reviews.

SPECIFIC COMMENTS

1. Summary Form, Page iii and Section 9.0, Recommendations and Follow-Up Actions, Page 60: Recommendation #2 of the Summary Form indicates that the proposed installation of two off-site monitoring wells is not related to an issue; however, the purpose of these wells is to better delineate the vertical delineation of the volatile organic compound (VOC) plume off-site. The data gap regarding the vertical delineation off-site is not an issue that impacts protectiveness, but is still an issue nonetheless. Please revise the FYR to identify the need to delineate the vertical delineation of the VOC plume off-site as an issue that does not impact protectiveness.

Response: Text was added to Recommendation #2 in the Five-Year Summary Form of the Draft Final FYR as follows: “Although the installation of additional off-site monitoring wells is recommended, DOE/LLNL does not consider this a remedy deficiency or protectiveness issue. The performance measures for the remedy are the continued absence of detections of COCs in downgradient guard wells, indicating that there is no migration of COCs. This demonstrates that the remedy continues to be protective. The purpose of recommendations to improve performance monitoring is to further demonstrate that the remedy is effective.”

2. Summary Form, Page ix and Section 9.0, Recommendations and Follow-Up Actions, Page 61: Recommendation #8 of the Summary Form indicates that the proposed MOU recommended by the previous FYR is not related to an issue; however the purpose of MOU is to increase the long-term effectiveness of ICs, and the potential for agricultural wells represents a concern that could impact future protectiveness. The potential for installation of agricultural wells does not impact current protectiveness, but may impact future protectiveness and as such should be identified as an issue. Please revise the FYR to identify the potential for installation of agricultural wells that may impact future protectiveness.
As discussed between DOE and EPA, the MOU between DOE/DOE/NNSA and the Corral Hollow Ranch property owner is no longer a viable option and Recommendation #8 has been removed from the FYR. Therefore, the requested information is no longer relevant and was not added to Recommendation #8.

The text in Section 4.5.1.1 was revised as follows: “DOE/LLNL will use the San Joaquin well ordinance to help prevent exposure to the Central GSA VOC plume on the Corral Hollow property in two ways. First, DOE/LLNL will work to establish an agreement with the SJC EHD that sets forth procedures and protocols by which DOE/LLNL and SJC EHD cooperate and coordinate to prevent the approval of well drilling permits on the Coral Hollow property that could present a risk to human health or the environment or threaten the integrity of the remedy. One such protocol would be for the SJC EHD to annotate its records pertaining to the Corral Hollow property so that it will know to contact DOE/LLNL if any permit is requested in relation to that property. Another such protocol would be for DOE/LLNL and SJC EHD to communicate not less than once each quarter regarding whether any Well Completion Reports have been filed for the Coral Hollow property. Under California Water Code 13752, the DWR must allow public access to Well Completion Reports. California law also now mandates these reports be made available online within the year.

As a further means of confirming that no well drilling is occurring on the Corral Hollow property, DOE/LLNL will on a weekly basis visually check those portions of the Corral Hollow property visible from public rights of way and Site 300 for any signs of well construction, alteration, or destruction.”

As these prohibitions and requirements are applicable to any well drilled, regardless of its intended use, this institutional/land use control would apply to the drilling of wells for agricultural use and would be protective in the long-term.

3. Section 1.0, Introduction, Pages 1 and 2 and Section 1.9, Building 865/Advanced Test Accelerator, Page 10: Section 1.0 provides a bulleted list of sites and OUs at LLNL Site 300, but Building 865 is not included in this list. In addition, Section 1.9 does not discuss how Building 865 relates to the rest of the sites/OUs. Please revise Section 1.0 to include Building 865 and revise Section 1.9 to discuss how Building 865 relates to the rest of the sites/OUs associated with LLNL Site 300.

Response: Text has been added to Section 1 that includes a description of the status of the Building 865 area.

Text has also been added to Section 1.9 that states: “If, following remedy selection, an active remedy is needed to address contamination in the
Building 865 area, the Building 865 area will likely be designated as a separate OU (i.e., OU 10). If no significant risk or threat to groundwater is identified associated with Building 865 area contaminants, and a monitoring and institutional/land use control remedy is selected, the Building 865 area will likely be included as a release site in the Site-Wide OU (OU8).”

4. **Section 1.5, Building 854 (OU6), Page 7:** The last sentence of Section 1.5 states that, “The next (Third) Five-Year Review Report is schedule for completion in 2018,” but the Second FYR was completed in 2014, so the Third FYR should be scheduled for completion in 2019. The trigger date for the Third FYR should be the date the Second FYR was finalized (i.e., the date EPA concurrence letter was signed). Please revise Section 1.5 to resolve this discrepancy.

**Response:** The date for the next (Third) FYR Report for the Building 854 OU is based on the most recent Federal Facility Agreement (FFA)/Chronological schedule of deliverable dates. According to this schedule, the Second FYR report was scheduled to be completed in 2013 (but was not completed until 2014 due to regulatory delays), and the Fourth FYR report is scheduled to be completed in 2018.

EPA has proposed, and discussions between EPA and DOE are underway, to revise FYR deliverable dates, including consolidation of OU-specific FYRs. It is currently planned that, when agreement between EPA and DOE is reached on the path forward and new schedule for the Site 300 FYRs, the FFA/Chronological schedule for document deliverables will be prepared. At that time, the FYR deliverable dates will be revised in the FYR documents.

However, DOE will continue to present the FYR schedules based on the signed FFA/Chronological schedule, until a new schedule is agreed upon.

5. **Section 4.3.1.1, Central GSA Groundwater Remedy Implementation, Page 28:** Section 4.3.1.1 should discuss how drought conditions impacted plume migration and hydraulic control. The last paragraph on page 28 states that, “Due to declining water levels resulting from extraction and regional drought conditions, only four of these wells (W-7R, W-872-02, W-873-07, and W-875-08) contributed to the volumes extracted during 2014 and combined flow rates declined to a reporting period low of 0.2 gpm [gallons per minute],” but does not provide additional discussion of the impacts of declining water levels on plume migration and hydraulic control. Please revise Section 4.3.1.1 to discuss how drought conditions impacted plume migration and hydraulic control.

**Response:** The following text has been added to Section 4.3.1.1: “While declining water levels have resulted in diminished extraction rates throughout the reporting period, drought conditions have not affected the wellfield’s ability to exert hydraulic control on the VOC plume and groundwater extraction.
remains effective at preventing off-site plume migration. Extraction wells W-7I and W-875-07 are within the capture zone of deeper-screened extraction well W-875-08, and when operational, produce a minor fraction of the total groundwater volume extracted. Downgradient of extraction well W-7O, extraction well W-7R pumps groundwater continuously while the Central GSA treatment facility is operational, capturing VOCs migrating downgradient of extraction well W-7O independent of whether extraction well W-7O is operational. Extraction well W-7P is designed to extract groundwater from Qal-Tnbs1 HSU only, as the underlying Tnbs1 HSU groundwater is not impacted by VOCs and discharges into the Qal-Tnbs1 HSU. During drought periods, Qal sediments are essentially dry and extraction well W-7P is unable to operate. VOC concentrations in extraction well W-7P remained below 2 µg/L during the 2012-2014 drought period, prior to rebounding to 3.9 µg/L in early 2015 as Central GSA water levels rose due to seasonal precipitation, concurrently triggering groundwater extraction at extraction well W-7P.”

6. Section 4.4, System Operations/Operation and Maintenance, Page 31 and Table 2, Actual Annual Costs for the General Services Area Operable Unit for Fiscal Years (FY) 2011 through 2015: According to Section 4.4, operations and maintenance (O&M) costs “are consistent with the estimated annual operating costs presented in the ROD for fiscal years 2011 and 2012,” while the “costs in fiscal Years 2013, 2014, and 2015 are higher than estimated;” however, this is not consistent with the information presented in Table 2. According to Table 2, the actual costs for 2011 and 2012 were greater than the budgeted costs, while the actual costs for 2013, 2014, and 2015 were less than the budgeted costs. Please revise the FYR to resolve these discrepancies.

Response: The text in Section 4.4, discusses that costs during the FYR period relative to that which was estimated in the ROD (rather than by comparing budgeted versus actual costs as referenced in the comment above). In Fiscal Years 2013 through 2015, both the budget and actual costs were higher than those estimated in the ROD as a result of additional costs for: (1) facility upgrades to replace aging system components and increase operational efficiency, (2) addressing critical habitat issues (i.e., relocating the Central GSA facility effluent misting towers), and (3) conducting additional regulatory-requested characterization activities. Table 4 explains the reason for the cost variance between the budgeted and actual costs for each fiscal year. Therefore, the text in Section 4.4 was not modified.

7. Section 4.4, System Operations/Operation and Maintenance, Page 31: It is unclear why the groundwater treatment system was shut down to prevent damage from freezing temperatures during the winter months of 2011 through 2015, while the soil vapor treatment system was only shut down to prevent damage from freezing temperatures during the winter months of 2010 through 2012. Please revise
Section 4.4 to explain why the soil vapor treatment system was able to operate during the winter months of 2013, 2014, and 2015.

Response: In general, LLNL is more conservative in the shutdown of the groundwater extraction and treatment system during freezing weather than for the shutdown of the soil vapor extraction and treatment system. The groundwater extraction and treatment system is operated cyclically, the treated groundwater is collected in a storage transfer tank, and then periodically pumped to the misting towers when the high level switch indicates sufficient water in the tank. Therefore, there tends to be periods of time during which water is standing in the water extraction, treatment, and discharge system pipelines, with a relatively high potential for freezing and pipe breakage. The only freeze damage potential for the soil vapor system is the condensate collection system. Relative to the groundwater system, the condensate in the soil vapor system is a much smaller volume of water, and is collected in a water knockout drum that not likely to be damaged in freezing temperature. In 2013, it was determined that the soil vapor treatment system could run without upconing of groundwater in the extraction well, or damage to the soil vapor system. Therefore, LLNL continued to run the soil vapor extraction and treatment system during the winter months to remove VOC mass from the subsurface.

8. Section 4.5.1.1, Prevent Water-Supply Use/Consumption of Contaminated Groundwater, Page 38: It is unclear whether there is an unacceptable risk associated with the consumption of crops and/or livestock watered with contaminated groundwater. According to Section 4.5.1.1, “the risk associated with this pathway has not been calculated based on current VOC concentrations in offsite groundwater” so “it is uncertain if an unacceptable risk exists.” The FYR should clarify whether this risk requires calculation. Please revise Section 4.5.1.1 to indicate whether the risk associated with the consumption of crops and/or livestock watered with contaminated groundwater needs to be calculated.

Response: The original baseline risk assessment for the Central GSA estimated a risk if a well were to be drilled at the site boundary and used for drinking water, as well as for agricultural purposes (i.e., the risk estimate included the consumption of fruits and vegetables, beef cattle, and milk from dairy cattle that were “watered” from this well). The VOC concentrations used to calculate the baseline risk were several orders of magnitude higher that those detected in off-site monitor wells in 2015. For example, TCE, PCE, and 1,1-DCE concentrations of 35,100 µg/L, 8,110 µg/L, and 800 µg/L, respectively, were used to calculate the baseline risk. Concentrations of TCE, PCE, and 1,1-DCE in off-site groundwater in December 2015 were 56 µg/L, 3.6 µg/L, and 0.99 µg/L, respectively. In addition, the baseline risk assessment assumed the presence of other VOCs (i.e., 1,220 µg/L of 1,1,1-TCA) that are not currently detected in off-site groundwater above the reporting limit. Because the cleanup
Standards for TCE, PCE, and 1,1-DCE are their MCLs, these concentrations should be protective for agricultural use once achieved. In the interim, as discussed in the response to EPA’s Specific Comment #2, the institutional control/land use control (San Joaquin County ordinance and the San Joaquin EHD should be protective in the short-term by prohibiting the drilling of any well within areas of known groundwater contamination. Therefore, the risk associated with the consumption of crops or livestock water with contaminated groundwater does not need to be estimated.

9. Section 5.3, Results of Implemented Actions, Page 44: Item 1 of Section 5.3 indicates that, “Initial testing of CGSA-North suggests that W-CGSA-2708 has limited extraction capacity (<0.5 gpm);” however, this new extraction well was installed to hydraulically capture VOCs in the northern GSA plume area, so it is unclear whether the well will achieve this goal if the extraction capacity is limited. Additional options should be proposed as a contingency in the event that extraction well W-CGSA-2708 cannot hydraulically capture VOCs in the northern GSA plume area.

Response: The northern GSA plume is limited in extent with relatively low VOC concentrations, and has not migrated in the 29 years during which groundwater in this area has been monitored. However, the installation and groundwater extraction from well W-CGSA-2708 was proposed to expedite cleanup because the VOC concentrations in well W-889-01 had remained relatively stable over the previous FYR time period (January 2006-December 2010). However, during the current FYR period (January 2010-December 2015), VOC concentrations in W-889-01 decreased from 30.2 µg/L to 9.4 µg/L, with TCE concentrations in December 2015 (7.7 µg/L) only slightly above the 5 µg/L MCL and significantly less than the historical maximum of 75 µg/L in 1998. TCE concentrations in nearby well W-875-01 have similarly decreased from a historical maximum of 190 µg/L in 1992 to below the 5 µg/L cleanup standard by December 2015 (2.0 µg/L). TCE concentrations in well W-CGSA-2708 have decreased from 15 µg/L in 2013 to 6.5 µg/L in 2016. The northern VOC plume is currently limited to three wells (W-889-01, W-875-01, and W-CGSA-2708), all located in close proximity to each other. Therefore, it does not appear that contingency options are necessary to control this northern GSA plume at this time. If conditions change, DOE/LLNL will discuss if additional measures are needed to control this plume with the regulators.

10. Section 6.4.1.1, VOC Concentrations and Distribution, Page 47 and Table 4, Contaminants of Concern (COC) Data Summary for all Central General Services Area Wells: Section 6.4.1.1 states that cis-1,2-dichloroethene (cis-1,2-DCE) and 1,1-dichloroethane (1,1-DCA) concentrations in 2015 were “71 µg/L [micrograms per liter] (August) and 0.72 µg/L (April), respectively, below the 5 µg/L MCL [Maximum Contaminant Level] cleanup standard;” however, Table 4
does not identify 1,1-DCA as a COC and the MCL for cis-1,2-DCE is 6 µg/L, not 5 µg/L. Please revise Section 6.4.1.1 to clarify the statement regarding cis-1,2-DCE and 1,1-DCA concentrations in 2015.

Response: The text in Section 6.4.1.1 was revised to state: “In dual-phase extraction well W-7I, cis-1,2-DCE and 1,1-DCA concentrations have decreased from a 1993 historic maximum of 16,000 µg/L and 38 µg/L respectively, to a 2015 maximum of 71 µg/L (August) and 0.72 µg/L (April), respectively. While concentrations of cis-1,2-DCE in this well remain above its 6 µg/L MCL, 1,1,1-DCA concentrations have dropped below its 5 µg/L MCL cleanup standard.” In addition, data for 1,2-DCA have been added to Table 4.

11. Section 6.4.1.2.1, Vadose Zone Remediation Progress, Page 50: Section 6.4.1.2.1 discusses rebound during the 2010/2011 winter shutdown of the soil vapor extraction system (November 2010 through March 2011), but rebound during the more recent winter shutdown (i.e., the winter months of 2012) is not discussed. Please revise Section 6.4.1.2.1 to also include discussion of rebound during the 2011/2012 winter shutdown of the soil vapor extraction system.

Response: Text in Section 6.4.1.2.1 was modified to state: “Rebound of TCE concentrations was not measured after the most recent shutdown period from November 2011 to February 2012 when the system was down due to transfer pump problems. The continued decline in vapor concentrations, from a maximum of 529 ppmv/v in W-875-07 collected in November 1999 to the most recent maximum of 72 ppmv/v (Figure 13) during rebound monitoring, and the absence of VOC concentration rebound after the most recent shutdown period indicate significant source area remediation progress.”

12. Section 6.4.2, Eastern GSA Remediation Progress, Page 55: The FYR does not indicated when the Close Out Report for the Eastern GSA will be finalized. Section 6.4.2 states that the draft version of this document was submitted in December 2012. While it is understood that the document was put on hold while the additional characterization activities were conducted at the Eastern GSA debris burial trench area, this work has been complete, so the Close Out Report should be able to move forward. Please revise the FYR to estimate when the Close Out Report for the Eastern GSA will be finalized.

Response: Section 6.4.2 was revised to indicate that the report was finalized on June 5, 2017.

13. Section 6.5, Interviews and Site Inspection, Pages 56 and 57: Section 6.5 should summarize the interviews (e.g., who was interviewed, any highlights of the interviews, etc.) and the findings of the site inspection (e.g., whether any components require maintenance or repair, any components not in place or
functioning, etc.). Please revise Section 6.5 to summarize the interviews and site inspection.

Response: Based on recent discussions with the regulatory agencies of the need to streamline the FYR reports, especially in light of the pending FYR consolidation effort, DOE has elected to avoid repeating information in the FYRs. Instead, the checklist that contains the results of the inspection is referenced in Section 6.5.

14. Figure 2, Site 300 Map Showing Operable Unit (OU) Locations: Figure 2 does not display the locations of all of the sites/OUs discussed in the subsections of Section 1.0. Missing sites/OUs include Building 815 (OU4), Building 830 (OU7), the Pit 9 landfill (OU8) and Building 812 (OU9). Figure 2 also does not show the location of Building 865. Please revise Figure 2 to depict the locations of the Building 815 (OU4), Building 830 (OU7), Pit 9 landfill (OU8), and Building 812 (OU9), as well as Building 865.

Response: As indicated, Figure 2 is a map showing the location of OUs at Site 300. Building 815 and Building 830 are individual buildings within the High Explosives Process Area OU (4) and the Building 832 Canyon OU (7), respectively, and therefore are not shown on the map. The location of the Pit 9 Landfill is already included on Figure 2 as Building 845 Firing Table/Pit 9 (OU 8). However, the locations of Building 812 (OU9) and the Building 865 were added to Figure 2.

15. Appendix A2, General Services Area OU Five-Year Review Site Inspection Checklist, Page 15: Item 6, Monitoring Wells, on page 15 of the Site Inspection Checklist answers “yes” to wells needing maintenance, but no specific wells area listed and no maintenance concerns are discussed in the text of the FYR. Please revise the FYR to resolve this discrepancy.

Response: The response to Item 6, Monitoring Wells in the Site Inspection Checklist in Appendix A2 was incorrectly answered “yes” and has been changed to “no.”

ADDITIONAL SPECIFIC EPA COMMENTS ON GSA INSTITUTIONAL/LAND USE CONTROLS

1. In combining the discussion of institutional controls (ICs) in relation to both Union Livestock and Corral Hollow Ranch properties, the narrative creates confusion (see, e.g., the brief paragraph just before the section labeled “Proprietary Institutional Controls”).

Page 12
Response: Section 4.5 was updated to address EPA comments regarding institutional and land use controls per the redline-strikeout text that the EPA provided to DOE on July 14, 2017.

2. Concerning the San Joaquin County well ordinance and contractors’ licensing requirements:
   a. By its terms, the ordinance doesn’t apply to (or control the use of) the existing well as that well already is in place and the ordinance “prohibits the drilling, alteration, or destruction of any well….without a permit;”
   b. The existence of the ordinance in itself is insufficient to qualify as protective in relation to future wells; LLNL, at a minimum, must put in place an agreement with the San Joaquin County Environmental Health Department (EHD), whereby LLNL would keep EHD informed about the plume and EHD would keep LLNL informed about any well permit applications so that LLNL is able to have input with regard to the approval of any well applications that may pose a threat to human health or the environment, or compromise the integrity of the remedy. EHD and LLNL also need to put in place procedures and protocols to ensure that EHD staff know to notify LLNL with regard to wells within a certain geographic area, etc.;
   c. The contractor licensing requirement doesn’t apply to the existing well either, and though a person who drills without a license or fails to comply with well-related requirements may be charged with a misdemeanor, this disincentive to legitimate well drillers would not deter so-called fly-by-night drillers, particularly in relatively remote locations. So it is overstated to say that “these measures will control the risk of exposure…” Additionally, it isn’t clear why LLNL deleted the paragraph about agricultural wells which states that the well ordinance doesn’t offer protection from an agricultural well and that the risk from such a well is unknown because there has been no risk calculation based on the current VOC concentrations; if true/still current information, then the Five-Year Review should note this and provide for action to address the situation. (The reference to :proprietary controls” at the end of the agricultural well paragraph is misplaced if it is referring to the stricken-through text at the bottom of the page, as that text describes an enforcement tool, not a proprietary control.)

Response: See response to Comment 1.

3. The discussion of the agreement with Union Livestock errors in its reference to the “Settlement Agreement” as a proprietary control, common examples of which, as noted in EPA’s ICs’ guidance, “include easements that restrict use (also know as negative easements) and restrictive covenants.” By contrast, the Union Livestock “Settlement Agreement,” is more like a “administrative orders, permits, Federal Facility Agreements (FFAs), and Consent Decrees (CDs), that limit certain site activities or require the performance of specific activities (e.g., monitor and report
on IC effectiveness)” which EPA categorizes as “enforcement tools.” Although not at the level of a CD, an MOU is a negotiated agreement.

**Response:** See response to Comment 1.

**Administrative Order:** Enforceable order issued by a public authority (under the powers conferred to it by one or more statutes) to an individual or an organization to take certain corrective actions, or to refrain from an activity.

**Federal Facility Agreement:**

**Consent Decree:** A legal document submitted by the Department of Justice on behalf of EPA for approval by a federal judge to settle a case. A consent decree can be used to formalize an agreement between EPA and potentially responsible parties for cleanup at a Superfund site.

4. LLNL’s discussion of “information Institutional Control Devices” is inadequate. Where, as here, there is a single landowner impacted by the plume, LLNL at a minimum should provide annual notices to the affected property owner, rather than placing the onus on the property owner to check Site 300 monitoring reports. In addition, LLNL shouldn’t just periodically meet with “property owner” (presumably of Union Livestock and Corral Hollow Ranch), but should incorporate into an IC plan regular meetings.

**Response:** See response to Comment 1. Analytical data collected from the GALLO1 well is provided to the Gallos (Corral Hollow Ranch) in an annual report.

5. There is only a single reference to protecting the integrity of the remedy, but this is an important consideration in evaluating the adequacy of ICs (ICs may be inadequate in terms of protecting human health and the environment, as well as in terms of remedy integrity).

**Response:** See response to Comment 1.

**MINOR COMMENTS**

1. The FYR uses the phrase “Memorandum of Agreement” and the phrase “Memorandum of Understanding” or “MOU” interchangeably; however, the FYR should use consistent terminology for this document. Please revise the FYR to use the phrase “Memorandum of Understanding” or “MOU” in place of “Memorandum of Agreement.”

**Response:** As discussed between DOE and EPA, the MOU between DOE DOE/NNSA and the Corral Hollow Ranch property owner is no longer a viable option and Recommendation #8 and references to the MOU have been removed from the FYR. Therefore, the requested changes are no longer relevant and were not added.
2. Summary Form, Page iv: The last sentence of Recommendation #3 of the Summary Form discusses 1,2-TCA detections, but it appears this statement should refer to 1,1,1-TCA detections instead. Please revise Recommendation #3 of the Summary Form to replace “1,2-TCA” with “1,1,1-TCA.”

Response: The text in Recommendation #3 in the Summary Form has been revised to reference 1,1,1-TCA, as requested.

3. Section 6.4.1.2.2, Groundwater Remediation Progress, Page 51: The second paragraph under the Temporal VOC Trends discussion references Figure 17a and Figure 17b, but there are no figures with these numbers included in the FYR. Please revise the FYR to include the missing figures or to correct the figure references.

Response: The text in the second paragraph of Section 6.4.1.2.2 has been corrected to reference Figure 15 (a and b).
California Department of Toxic Substances Control (DTSC) comments:

The Department of Toxic Substances Control has reviewed the Draft Final 4th Five-Year Review Report for the General Services Area Operable Unit at Lawrence Livermore National Laboratory Site 300. DTSC’s comments have been adequately addressed. DTSC remains concern about vapor intrusion pathways at Site 300 and supports the addition of the Five-Year Review recommendation regarding analysis of these pathways.

Response: The U.S. Department of Energy (DOE) appreciates DTSC’s comment and approval of the Five-Year Review Report for the General Services Area Operable Unit.

Regional Water Quality Control Board (RWQCB) comments:

The California Regional Water Quality Control Board, Central Valley Region (Central Valley Water Board) staff have reviewed the March 2017 Draft Final Fourth Five-Year Review Report for General Services Area Operable Unit at Lawrence Livermore National Laboratory Site 300 (FYR).

Central Valley Water Board staff previously submitted comments on the draft version of the FYR on 8 September 2017. Our comments were adequately addressed and we have no further comments on the FYR. However, we note that re-evaluation of potential risks associated with inhalation of volatile organic compounds based on the recently released U.S. Environmental Protection Agency’s (EPA’s) Vapor Intrusion Screening Level (VISL Calculator) is an outstanding issue that needs to be addressed to determine whether or not the current remedy at the GSA remains protective, and implement vapor intrusion mitigation measures if warranted.

Response: The U.S. Department of Energy (DOE) appreciates RWQCB’s review of the Five-Year Review Report for General Services Area Operable Unit and that they have no further comments.
Appendix C

Fourth Five-Year Review Addendum
A five-year review addendum is generally completed where the protectiveness determination is deferred in order to collect further information. The following is a letter from EPA dated October 30, 2017, which contains comments that will be addressed in the five-year review addendum.
October 30, 2017

Ariel Robertson
Remedial Project Manager
Livermore Environmental Programs Division
Lawrence Livermore National Laboratory
P.O. Box 808, L-574
Livermore, California 94551

Re: U.S. EPA Comments with the Final Fourth Five-Year Review Report for Lawrence Livermore National Laboratory Site 300, General Services Area OU, September 2017

Dear Ariel:

The U.S. Environmental Protection Agency (EPA) has reviewed the Final Fourth Five-Year Review Report for the Lawrence Livermore National Laboratory (LLNL), Site 300 (“Site 300”), General Services Area (“GSA”) OU dated September 2017 (“Report”).

Enclosed, please find our comments on the final report. Please advise us how the Lab intends to address EPA’s comments.

SPECIFIC COMMENTS

1. Page x, Summary Form, deleted Issue and Recommendation 8: The discussion in the Summary nowhere mentions the lack of a remedy decision document for the LUCs LLNL relies on in relation to the GSA OU. This item would be a good place to insert such a discussion as it dealt with LUCs before the text was deleted. The discussion, in summary form, should describe what the ROD requires, explain what transpired between the ROD and 4th FYR; and discuss the current LUCs situation (i.e., governmental control(s) and informational device(s)).

2. Page xii, Summary Form, new Issue and Recommendation 8: The text states that the VI analysis does not impact protectiveness but, as commented on the Main Site and Building 834 FYRs, this text is contrary to EPA comments that a protectiveness determination isn’t possible at present due to the lack of
VI data. The need to redo the analysis certainly implicates the issue of protectiveness, so the claim about protectiveness should be deleted.

3. Page xiv, “Protectiveness Statement,” introductory ¶: a) References to the H&SP and Contingency Plan should be deleted because, as noted in relation to other FYRs, these plans are not relevant to the remedy’s protectiveness. b) The description of the status of ICs in the last two sentences is not accurate; please revise the text to provide an accurate description of the ICs issue, namely that it was discovered that the IC required in the ROD was never put into place by LLNL, LLNL subsequently investigated various IC options, including the IC identified in the ROD, as of this FYR LLNL has settled on a governmental control and informational devices as described in Sections 4.5.1 – 4.5.2.

4. Page xiv, “Protectiveness Statement,” List ¶ 2: The text states that the VI analysis does not impact protectiveness but, as commented on the Main Site and Building 834 FYRs, this text is contrary to EPA comments that a protectiveness determination isn’t possible at present due to the lack of VI data. The need to redo the analysis certainly implicates the issue of protectiveness, so the claim about protectiveness should be deleted.

5. Page xiv - xv, “Protectiveness Statement,” ¶ after List ¶ 4: Discussion of the Contingency Plan should be deleted because it is not relevant to the question of the remedy’s protectiveness.

6. Page xv, “Protectiveness Statement,” List ¶ 8: Revise the first sentence to be the same as the revised text in the narrative text: “In addition, between the Site 300 property boundary and water-supply wells CDF1 and CON1 there are six wells (W-35A-03, W-35A-04, W-35A-06, W-35A-11, W-35A-12, W-35A-13) in which no VOCs were detected above the laboratory reporting limits”. As noted in comment 4, the discussion about the Site-Wide Contingency Plan should be deleted.

7. Page xvi, “Protectiveness Statement,” Text Box: Replace the word “contamination” with the word “contaminated.”

8. Page xvii, “Protectiveness Statement,” List ¶ 11: Replace the work “requires” in the 3rd line with the appropriate term, e.g., prohibits. In the 10th line, replace the phrase “will control,” with the phrase “will help ensure control.”

9. Page xviii, “Protectiveness Statement,” List ¶ 12: Add to the first sentence a reference to the need to modify the remedy to include the LUCs being relied on in relation to the off-property plume.

10. Page 1, “Introduction,” 4th ¶: The definition of “site” is anywhere that contamination has come to be located, so the term “potentially” should be deleted. Also, for consistency with changes made to other documents in response to comments about the scope of “site,” it would be preferable to use the phrase “off-property” rather than “off-site” when referring to areas outside the boundaries of the Site 300 facility property.

11. Page 29, Section 4.3, 4th ¶, 2nd sentence: Revise the phrase “institutional/land use controls” to “land use controls” to avoid confusion about the terms given that the later phrase encompasses “institutional controls.”
12. **Page 37, Section 4.5.1, list item 3:** Given the need to evaluate VI risk using EPA’s 2015 VI risk assessment guidance, the conclusion that LUCs no longer are necessary in relation to VI in Building 875 is inappropriate. Please revise this section to reflect the uncertainty about VI risk pending completion of the new VI evaluation. Also, per comment 11, replace the compound reference to “institutional/land use controls” with a reference to “land use controls” (unless the reference is limited to just ICs, in which case the compound phrase should be replaced with a reference to ICs alone).

13. **Page 39, Section titled “Union Livestock Property . . .,” 2nd ¶, 9th line:** The text “between W-35A-01” after the word “limits” was the subject of a “comment” in EPA’s original comments as apparently out of place but, although the comment was deleted, the text, though clearly extraneous, was not. Delete the text “between W-35A-01.”

14. **Pages 47 – 48, Section 4.5.2:** A sentence should be added to this section concerning informational devices used as a LUC too, as they are discussed in the text.

15. **Page 48, Section 5.1, 1st ¶:** The discussion of the HS&P and Contingency Plan was identified as an issue in EPA’s original comments with the request that the text be deleted unless it was describing a determination or conclusion of the Third Five Year Review. As the text remains in the document, we assume that it is descriptive of the Third FYR; if not, delete the text; if so, identify it as a determination or conclusion of the Third FYR.

16. **Page 49, Section 5.2, 3rd ¶:** Delete the term “Institutional” in the phrase “Governmental Institutional Controls” in the first line. In the last sentence, insert the phrase “help ensure” before the term “control.”

If you have any questions regarding these comments, please feel free to contact me at (415) 972-3167.

Sincerely,

/s/
Andrew Bain
Remedial Project Manager
Nevada and Federal Facilities Section

Cc by Email:
Dolores Loll, LLNL
Emily Mortazavi, DTSC
Aimee Phiri, CVRWQCB