U.S. Department of Energy
National Nuclear Security Administration
Livermore Site Office, Livermore, California 94550

Lawrence Livermore National Laboratory
Lawrence Livermore National Security, LLC, Livermore, California 94551

LLNL-AR-579495-DRAFT

Draft First Five-Year Review Report for Operable Units 3 and 8 at Lawrence Livermore National Laboratory Site 300

Authors:

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September 2012

*Weiss Associates, Emeryville, California

Environmental Restoration Department

This work performed under the auspices of the U. S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

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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.

Michael J. Taffet Date
California Professional Geologist
No. 5616
License expires: May 30, 2013
California Certified Hydrogeologist
No. 129
License expires: May 30, 2013

Approval for the First Five-Year Review for Operable Units 3 and 8 at Lawrence Livermore National Laboratory Site 300

Prepared by:

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

Approved:

____

Claire S. Holtzapple **Date**

Site 300 Remedial Project Manager
U.S. Department of Energy
National Nuclear Security Administration
Livermore Site Office

Five-Year Review Summary Form

SITE IDENTIFICATION		
Site name: Lawrence Livermore National Laboratory Site 300, Pit 6 Landfill Operable Unit (OU) 3 and OU 8		
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. OU 3: January 2008 OU 8: Not Applicable

REVIEW STATUS	
Lead agency: United States (U.S.) Department of Energy (DOE)/National Nuclear Security Administration (NNSA)	
Author name: M. Buscheck	
Author title: Project Hydrogeologist	Author affiliation: Weiss Associates- Emeryville, California
Review period: January 2007 to January 2012	
Date(s) of site inspection: OU 3: February 5, 2008 OU 8: Not Applicable	
Type of review: Statutory	
Review number: 1	
Triggering action date: OU 3: The Remedial Action Completion Report OU 8: 2008 Site-Wide Record of Decision (ROD)	
Due date: March 15, 2013	

Five-Year Review Summary Form (continued)

<table>
<tr><th colspan="5">ISSUES/RECOMMENDATIONS</th></tr>
<tr><td colspan="5"></td></tr>
<tr><th colspan="5">OU(s) without Issues/Recommendations Identified in the Five-Year Review:</th></tr>
<tr><td colspan="5">Not applicable.</td></tr>
<tr><th colspan="5">Issues/Recommendations Identified in the Five-Year Review:</th></tr>
<tr><td rowspan="3">OU(s): 3
Pit 6 Landfill</td><td colspan="4">Issue Category: No Issue</td></tr>
<tr><td colspan="4">Issue: No deficiencies in the overall remedy were identified during the Five-Year Review. The remedy is performing as intended. Some follow-up actions are recommended.</td></tr>
<tr><td colspan="4">Recommendation #1: Monitor trichloroethene (TCE) concentrations in ground water at well EP6-09; if concentrations increase or remain above 5 micrograms per liter (µg/L), remedial measures such as pump-and-treat or enhanced in situ bioremediation will be considered for this well.</td></tr>
<tr><th>Affect Current Protectiveness</th><th>Affect Future Protectiveness</th><th>Implementing Party</th><th>Oversight Party</th><th>Milestone Date</th></tr>
<tr><td>No</td><td>No</td><td>Federal Facility</td><td>EPA/State</td><td>March 2018</td></tr>
</table>

Five-Year Review Summary Form (continued)

ISSUES/RECOMMENDATIONS Continued				
OU(s): 3 Pit 6 Landfill	**Issue Category:** No Issue			
	Issue: NA			
	Recommendation #2: Remove 1,2-dichloroethane (1,2-DCA) as a ground water contaminant of concern (COC) because: (1) concentrations of 1,2-DCA decreased to and have remained below its 0.5 µg/L Maximum Contaminant Level (MCL) cleanup standard and reporting limit in all $Qt\text{-}Tnbs_1$ hydrostratigraphic unit (HSU) wells since 1998 (including in the two new Pit 6 wells W-PIT6-2816 and W-PIT6-2817 installed in 2012), and (2) 1,2-DCA has never been detected above the 0.5 µg/L reporting limit in any samples from $Tnbs_1$ Deep or Qal-Tts HSU wells. However, ground water samples from Pit 6 monitor wells would still be analyzed for volatile organic compounds (VOCs) by EPA Method 601 to monitor for TCE and chloroform in the remedial action monitor wells and for detections of any VOCs (including 1,2-DCA) in the detection monitor wells. 1,2-DCA results would still be reported/discussed in the Detection Monitoring section of the Compliance Monitoring Reports, but would no longer be discussed in the Contaminant Concentrations and Distribution section of these reports unless it is detected in the remedial action monitor wells.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	Federal Facility	EPA/State	March 2018

Five-Year Review Summary Form (continued)

<table>
<tr><th colspan="5">ISSUES/RECOMMENDATIONS Continued</th></tr>
<tr><td rowspan="3">OU(s): 3
Pit 6 Landfill</td><td colspan="4">Issue Category: No Issue</td></tr>
<tr><td colspan="4">Issue: NA</td></tr>
<tr><td colspan="4">Recommendation #3: Remove cis-1,2-dichloroethene (cis-1,2-DCE) as a ground water COC because: (1) cis-1,2-DCE has only been detected twice at concentrations above its 6 µg/L MCL cleanup standard in Qt-$Tnbs_1$ HSU Pit 6 wells, and not been detected in any Qt-$Tnbs_1$ HSU wells above this cleanup standard since 1993 (including in the two new Pit 6 wells W-PIT6-2816 and W-PIT6-2817 installed in 2012), (2) cis-1,2-DCE is currently detected above the 0.5 µg/L reporting limit in only one Pit 6 Qt-$Tnbs_1$ HSU ground water monitor well (K6-01S) at a concentration of 2.2 µg/L (fourth quarter 2011), and (3) cis-1,2-DCE has never been detected above the 0.5 µg/L reporting limit in any samples from $Tnbs_1$ Deep or Qal-Tts HSU wells. However, ground water samples from Pit 6 monitor wells would still be analyzed for VOCs by EPA Method 601 to monitor for TCE and chloroform in the remedial action monitor wells and for detections of any VOCs (including cis-1,2-DCE) in the detection monitor wells. Cis-1,2-DCE concentrations would still be reported/discussed as part of the evaluation of TCE monitored natural attenuation (MNA) and detection monitoring in the Compliance Monitoring Reports.</td></tr>
<tr><td>Affect Current Protectiveness</td><td>Affect Future Protectiveness</td><td>Implementing Party</td><td>Oversight Party</td><td>Milestone Date</td></tr>
<tr><td>No</td><td>No</td><td>Federal Facility</td><td>EPA/State</td><td>March 2018</td></tr>
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Five-Year Review Summary Form (continued)

<table>
<tr><th colspan="5">ISSUES/RECOMMENDATIONS Continued</th></tr>
<tr><td rowspan="3">OU(s): 3
Pit 6 Landfill</td><td colspan="4">Issue Category: No Issue</td></tr>
<tr><td colspan="4">Issue: NA</td></tr>
<tr><td colspan="4">Recommendation #4: Remove trans-1,2-DCE as a ground water COC because concentrations decreased to and have remained below the 0.5 µg/L reporting limit in all Pit 6 wells since 1993 (including in the two new Pit 6 wells W-PIT6-2816 and W-PIT6-2817 installed in 2012). However, ground water samples from Pit 6 monitor wells would still be analyzed for VOCs by EPA Method 601 to monitor for TCE and chloroform in the remedial action monitor wells and for detections of any VOCs (including trans-1,2-DCE) in the detection monitor wells. Trans-1,2-DCE results would still be reported/discussed in the Detection Monitoring section of the Compliance Monitoring Reports, but would no longer be discussed in the Contaminant Concentrations and Distribution section of these reports unless it is detected in the remedial action monitor wells.</td></tr>
<tr><td>Affect Current Protectiveness</td><td>Affect Future Protectiveness</td><td>Implementing Party</td><td>Oversight Party</td><td>Milestone Date</td></tr>
<tr><td>No</td><td>No</td><td>Federal Facility</td><td>EPA/State</td><td>March 2018</td></tr>
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Five-Year Review Summary Form (continued)

<table>
<tr><th colspan="5">ISSUES/RECOMMENDATIONS Continued</th></tr>
<tr><td rowspan="3">OU(s): 3
Pit 6 Landfill</td><td colspan="4">Issue Category: No Issue</td></tr>
<tr><td colspan="4">Issue: NA</td></tr>
<tr><td colspan="4">Recommendation #5: Remove tetrachloroethene (PCE) as a ground water COC because: (1) PCE has never been detected at concentrations exceeding its 5 μg/L MCL cleanup standard in any Pit 6 wells, (the maximum historical concentration of PCE detected was 3.2 μg/L in 1988), and (2) PCE has not been detected at concentrations above the 0.5 μg/L reporting limit in any Pit 6 wells since 2008 (including in the two new Pit 6 wells W-PIT6-2816 and W-PIT6-2817 installed in 2012). However, ground water samples from Pit 6 monitor wells would still be analyzed for VOCs by EPA Method 601 to monitor for TCE and chloroform in the remedial action monitor wells and for detections of any VOCs (including PCE) in the detection monitor wells. PCE results would still be reported/discussed in the Detection Monitoring section of the Compliance Monitoring Reports, but would no longer be discussed in the Contaminant Concentrations and Distribution section of these reports unless it is detected in the remedial action monitor wells.</td></tr>
<tr><td>Affect Current Protectiveness</td><td>Affect Future Protectiveness</td><td>Implementing Party</td><td>Oversight Party</td><td>Milestone Date</td></tr>
<tr><td>No</td><td>No</td><td>Federal Facility</td><td>EPA/State</td><td>March 2018</td></tr>
</table>

Five-Year Review Summary Form (continued)

ISSUES/RECOMMENDATIONS Continued				
OU(s): 3 Pit 6 Landfill	**Issue Category:** No Issue			
	Issue: NA			
	Recommendation #6: Remove 1,1,1-trichloroethane (1,1,1-TCA) as a ground water COC because: (1) 1,1,1-TCA has never been detected in any Pit 6 wells at concentrations above its 200 µg/L MCL cleanup standard (the maximum historical concentration of 1,1,1-TCA detected was 13 µg/L in 1990), and (2) 1,1,1-TCA has not been detected above the 0.5 µg/L reporting limit in any Pit 6 wells since 2000 (including in the two new Pit 6 wells W-PIT6-2816 and W-PIT6-2817 installed in 2012). However, ground water samples from Pit 6 monitor wells would still be analyzed for VOCs by EPA Method 601 to monitor for TCE and chloroform in the remedial action monitor wells and for detections of any VOCs (including 1,1,1-TCA) in the detection monitor wells. 1,1,1-TCA results would still be reported/discussed in the Detection Monitoring section of the Compliance Monitoring Reports, but would no longer be discussed in the Contaminant Concentrations and Distribution section of these reports unless it is detected in the remedial action monitor wells.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	Federal Facility	EPA/State	March 2018

Five-Year Review Summary Form (continued)

ISSUES/RECOMMENDATIONS Continued				
OU(s): 3 Pit 6 Landfill	**Issue Category:** No Issue			
	Issue: NA			
	Recommendation #7: Remove perchlorate as a ground water COC because perchlorate concentrations have decreased to and remained below the 4 µg/L reporting limit in all Pit 6 wells for over three years (including in the two new Pit 6 wells W-PIT6-2816 and W-PIT6-2817 installed in 2012). However, ground water samples from Pit 6 Landfill detection monitor wells would still be submitted for perchlorate analysis as part of the detection monitoring program to detect future releases from the Pit 6 Landfill. The perchlorate results would still be reported/discussed in the Detection Monitoring section of the Compliance Monitoring Reports, but would no longer be discussed in the Contaminant Concentrations and Distribution section of these reports unless it is detected in the remedial action monitor wells.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	Federal Facility	EPA/State	March 2018

Five-Year Review Summary Form (continued)

ISSUES/RECOMMENDATIONS Continued				
OU(s): 8 Building 801/ Pit 8 Landfill	**Issue Category:** No Issue			
	Issue: No deficiencies in the overall remedy were identified during the Five-Year Review. The remedy is performing as intended. Some follow-up actions are recommended.			
	Recommendation #1: Install additional monitor wells in the $Tnbs_1$/$Tnbs_0$ HSU in the vicinity of the Pit 8 Landfill to ensure full detection monitoring capability under the observed range of ground water flow directions. Up to two monitor wells located north of the landfill and potentially one monitor well located south of the landfill are being considered to accomplish this objective. The proposed locations of the additional monitor wells to be installed will be presented to the regulatory agencies for concurrence prior to installation. Because the funding for the installation of these wells is not currently included in DOE/NNSA's funding request profile, the schedule for well installation will be finalized when the funding request is approved.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	Federal Facility	EPA/State	To be determined (TBD)

Five-Year Review Summary Form (continued)

ISSUES/RECOMMENDATIONS Continued				
OU(s): 8 Building 845 Firing Table	**Issue Category:** No Issue			
	Issue: No deficiencies in the overall remedy were identified during the Five-Year Review. The remedy is performing as intended. Some follow-up actions are recommended.			
	Recommendation #1: Install additional monitor wells in the $Tnsc_0$ HSU in the vicinity of the Pit 9 Landfill to ensure full detection monitoring capability under the observed range of ground water flow directions. Up to two monitor wells east of the landfill and potentially one monitor well west of the landfill are being considered to accomplish this objective. The proposed locations of the additional monitor wells to be installed will be presented to the regulatory agencies for concurrence prior to installation. Because the funding for the installation of these wells is not currently included in DOE/NNSA's funding request profile, the schedule for well installation will be finalized when the funding request is approved.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	Federal Facility	EPA/State	TBD

Five-Year Review Summary Form (continued)

ISSUES/RECOMMENDATIONS Continued				
OU(s): 8 Building 833	**Issue Category:** No Issue			
	Issue: NA			
	Recommendation #1: No opportunities to improve remedy performance were identified. However, DOE/NNSA recommends removing cis-1,2-DCE as a ground water COC because: (1) cis-1,2-DCE has only been detected in one well (W-833-12) and cis-1,2-DCE concentrations in this well decreased to and have remained below the 0.5 µg/L reporting limit since April 1993, (2) cis-1,2-DCE has never been detected above the 0.5 µg/L reporting limit in the any other area wells, including well W-833-30, screened in the deeper $Tnbs_1$ HSU. However, ground water samples from Building 833 monitor wells would still be analyzed for VOCs by EPA Method 601 to monitor for TCE. Any cis-1,2-DCE detections would still be reported/discussed in the Compliance Monitoring Reports.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	Federal Facility	EPA/State	NA
OU(s): 8 Building 851 Firing Table	**Issue Category:** No Issue			
	Issue: No deficiencies in the overall remedy were identified during the Five-Year Review. The remedy is performing as intended. Some follow-up actions are recommended.			
	Recommendation #1: Install additional monitor wells in the Tmss HSU in the vicinity of Building 851 to ensure full monitoring capability under the nearly flat ground water gradient. Up to two monitor wells located southwest and northwest of Building 851 are being considered to accomplish this objective. The proposed locations of the additional monitor wells to be installed will be presented to the regulatory agencies for concurrence prior to installation. Because the funding for the installation of these wells is not currently included in DOE/NNSA's funding request profile, the schedule for well installation will be finalized when the funding request is approved.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	Federal Facility	EPA/State	TBD

Five-Year Review Summary Form (continued)

PROTECTIVENESS STATEMENT		
OU: OU 3 and OU 8	**Protectiveness Determination** Protective	**Addendum Due Date:** NA

Protectiveness Statement: The remedies at OU 3 (also called Pit 6 Landfill OU) and OU 8 are protective of human health and the environment for the site's industrial land use. The remedies protect human health because exposure pathways that could result in unacceptable risk to onsite workers are being controlled by the implementation of institutional controls, the Health and Safety Plan, and the Contingency Plan. DOE/NNSA's recommendations to install additional monitor wells in the vicinity of the Pit 8 and Pit 9 Landfills and Building 851 will add an additional layer of protection by increasing the detection monitoring capability under a range of ground water flow directions at the Pit 8 and Pit 9 Landfills and under the flat ground water gradient at Building 851.

The cleanup standards for ground water at Site 300 are drinking water standards. Because drinking water standards do not differentiate between industrial and residential use, the ground water cleanup remedy will be protective under any land use scenario.

Implementing the cleanup standards for VOCs in subsurface soil reduce concentrations to mitigate risk to onsite workers and prevent further impacts to ground water 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 is included in the Site-Wide Record of Decision. This prohibition will remain in place until and unless a risk assessment is performed in accordance with current U.S. Environmental Protection Agency (EPA) risk assessment guidance and is agreed by the DOE, the EPA, the California Department of Toxic Substances Control and the Regional Water Quality Control Board as adequately showing no unacceptable risk for residential or unrestricted land use.

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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 Operable Unit (OU) 3 (the Pit 6 Landfill OU) and OU 8 (the Site-Wide OU) at Lawrence Livermore National Laboratory (LLNL) Site 300. Environmental cleanup is conducted under the oversight of the U.S. Environmental Protection Agency (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 2007 to January 2012. Parties providing analyses in support of the review include:

- U.S. DOE/NNSA, Livermore Site 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 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 (DOE, 2002) and the U.S. EPA (EPA, 2001).

Section 121 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendment Reauthorization Act (SARA), requires that remedial actions that result in any hazardous substances, pollutants, or contaminants remaining at the site be subject to a Five-Year Review. The National Contingency Plan 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 where five-year reviews are required or appropriate.

LLNL Site 300 is a U.S. DOE/NNSA experimental test facility operated by the Lawrence Livermore National Security (LLNS), Limited Liability Corporation. It 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. These releases occurred primarily from spills, leaking pipes, leaching from unlined landfills and pits, high explosive test detonations, and disposal of waste fluids in lagoons and dry wells (sumps). Nine Operable Units (OUs) have been designated at LLNL Site 300 based on the nature and extent of contamination to effectively manage site cleanup (Figure 2):

- General Services Area (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, 9 Landfills.
- Building 812 (OU 9).

With the exception of this five-year review for OUs 3 and 8, five-year reviews are currently conducted individually for each OU at Site 300. The Remedial Action Completion Report (Holtzapple, 2008) and Site-Wide Record of Decision (ROD) (U.S DOE, 2008) are the triggers for start of the first five-year review period for OUs 3 and 8, respectively, in accordance with U.S. EPA guidance (U.S. DOE, 2002). 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 first Five-Year Review for OUs 3 and 8. This review is considered a statutory review because: (1) contamination will remain onsite 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 the CERCLA.

Section 2 presents the Five-Year Review for the OU 3 (Pit 6 Landfill OU). Section 3 presents the Five-Year Review for OU 8 (Site-Wide). The background and description of OUs 3 and 8 are presented in Sections 2 and 3, respectively. The following sections include the descriptions and status of the other OUs and areas where environmental restoration activities are occurring at Site 300.

1.1. General Services Area (GSA) OU (OU 1)

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. DOE has performed three Five-Year Reviews for the GSA OU (Ferry et al., 2001a; Dibley et al., 2006; and Valett et al., 2011). The fourth Five-Year Review is scheduled for 2016.

1.1.1. Central GSA

Chlorinated solvents, mainly trichloroethene (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 that were gravel-filled holes about 3 to 4 feet (ft) deep and two ft in diameter. As a result, subsurface soil and ground water was contaminated with volatile organic compounds (VOCs). There are no contaminants of concern (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.

Ground water 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 ground water and soil vapor extraction and treatment continued as a remedial action. The selected remedy for the Central GSA includes monitoring, risk and hazard management, and ground water 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 ground water and soil vapor extraction and treatment systems to remove VOCs from the subsurface is ongoing. Remediation has reduced maximum VOC concentrations in ground water from a historic maximum of 272,000 micrograms per liter (µg/L) to a 2011 maximum of 1,162 µg/L (March 2011) and has mitigated the risk to onsite workers from inhalation of VOCs inside Building 875.

1.1.2. Eastern GSA

The source of contamination in the Eastern GSA is an abandoned debris burial trench that received craft shop debris. Leaching of solvents from the debris resulted in the release of VOCs to ground water.

Ground water cleanup began in the Eastern GSA in 1991 as a removal action. In 1997, a Final ROD for the GSA OU was signed and ground water 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 ground water extraction and treatment system operated from 1991 to 2007 to remove VOCs from ground water.

As of July 2005, remediation had reduced VOC concentrations in on- and offsite ground water to meet cleanup standards. In February 2007, the treatment system was shut off and placed on standby with regulatory concurrence. Post-shutdown monitoring is being conducted to determine if VOC concentrations rebound above cleanup standards. If VOC concentrations remain below cleanup standards for five years, the treatment system and associated wellfield will be decommissioned. (Note: Although it falls outside this five-year review period, in February 2012, the five-year post-shutdown monitoring was completed. VOCs concentrations in Eastern GSA ground water remained below the cleanup standards during this five year monitoring period.)

1.2. Building 834 (OU 2)

From 1962 to 1978, intermittent spills and piping leaks resulted in contamination of the subsurface soil and rock and ground water with VOCs and silicone oils (tetrabutyl orthosilicate/tetrakis (2-ethylbutyl) silane [TBOS/TKEBs]). Nitrate in ground water may result from a combination of septic system discharge and naturally occurring nitrate in ground water. There are no 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). Ground water 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 ROD (U.S. DOE, 2001) and subsequent 2008 Site-Wide ROD. The Building 834 OU remedy includes monitoring, risk and hazard management, and ground water and soil vapor extraction and treatment. Significant *in situ* bioremediation is occurring in

Building 834 ground water 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 ground water from a historic maximum of 1,060,000 µg/L to a 2011 maximum of 210,000 µg/L (February 2011). TBOS/TKEBs in ground water have also been reduced from a historic maximum concentration of 7,300,000 µg/L in 1995 to a 2011 maximum of 4,800 µg/L (February 2011). While nitrate concentrations have decreased from a historic maximum of 749 milligrams per liter (mg/L) in 2000 to a 2011 maximum of 300 mg/L (February 2011), the elevated nitrate concentrations continue to indicate an ongoing source of ground water nitrate. It is likely that there are multiple sources of nitrate at Building 834. One possible anthropogenic source is the septic system leach field located in the vicinity of wells W-834-S1. A second probable source is natural soil nitrate. Additional sources could be nitrogenous compounds, like nitric acid or barium nitrate, that might have inadvertently been discharged into the septic system via a test cell floor drain or to the ground during accidental spills and/or pipeline leaks that released TCE to the environment. 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 Five-Year Review Report is scheduled for 2017.

1.3. High Explosive (HE) Process Area (OU 4)

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 ground water, subsurface soil, and bedrock. HE compounds, nitrate, and perchlorate detected in ground water 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 ground water 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 ground water at the site boundary and prevent offsite TCE migration. The HE Process Area remedy includes: (1) ground water extraction and treatment for VOCs, HE compounds, and perchlorate, and (2) monitored natural attenuation (MNA) for nitrate (except at Building 829 where nitrate is extracted and treated), (3) monitoring, and (4) risk and hazard management. The remedial design was completed in 2002. Construction completion for the OU was achieved in September 2007. Six ground water extraction and treatment systems currently operate in the OU.

Ground water remediation efforts have reduced total VOC concentrations from a historic maximum of 1,013 µg/L in 1993 to a 2011 maximum of 54 µg/L (July 2011). Perchlorate concentrations have decreased from a historic maximum of 50 µg/L in 1998 to a 2011 maximum of 29 µg/L (May 2011). Research Department Explosive (RDX) in ground water has been reduced from a maximum historic concentration of 350 µg/L in 1988 to a 2011 maximum concentration of 163 µg/L (August 2011). Natural denitrification processes are reducing nitrate concentrations in ground water to background levels. Remediation has also mitigated risk to onsite workers in the HE Process Area OU.

DOE has performed a Five-Year Review for the High Explosives Process Area OU (Dibley et al., 2007b). The second Five-Year Review Report is scheduled for 2013.

1.4. Building 850/Pit 7 Complex (OU 5)

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

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

1.4.1. Building 850 Firing Table (OU 5)

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 ground water. Nitrate and perchlorate are also COCs in ground water. 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 ground water, monitoring, and risk and hazard management. 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 offsite disposal costs. DOE and the regulatory agencies agreed to perform remediation of 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. Metals, HMX, and uranium in surface soil at Building 850 do not pose a risk to human health or threat to ground water, therefore a no further action remedy was selected. However, these constituents in surface soil were removed during the 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 2011 maximum of 53,300 pCi/L (May 2011). Uranium activities are below the cleanup standard and are within the range of natural background levels. The extent of nitrate with concentrations above cleanup standards is limited and does not pose a threat to human health or the environment. The maximum perchlorate concentration in 2011 was 74 µg/L (April 2011). A treatability study to evaluate *in situ* biodegradation of perchlorate is in progress.

1.4.2. Pit 7 Landfill Complex (OU 5)

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), ground water 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 ground water. 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 Complex required additional study. As a result, this area was not included in the 2001 Interim ROD and an area-specific Remedial Investigation/Feasibility Study (Taffet et al., 2005) was completed. An Amendment to the Interim ROD for the Pit 7 Complex was signed in 2007 (U.S. DOE, 2007) that described the selected remedy for the Pit 7 Complex including monitoring, risk and hazard management, MNA, ground water extraction and treatment, 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 ground water extraction and treatment system was constructed in 2009-2010 to treat uranium, nitrate, perchlorate, and VOCs in ground water.

Natural attenuation has reduced tritium activities in ground water from a historic maximum of 2,660,000 pCi/L in 1998 to a 2011 maximum of 575,000 pCi/L (April 2011) and has mitigated risk to onsite workers from inhalation of tritium vapors. Uranium activities have also decreased from a historic maximum of 781 pCi/L in 1998 to a 2011 maximum of 172 pCi/L (April 2011). VOC concentrations are currently near or below cleanup standards. Nitrate concentrations in ground water remain relatively stable, while perchlorate concentrations have decreased.

1.5. Building 854 (OU 6)

TCE was released to soil and ground water through leaks and discharges of heat-exchange fluid, primarily between 1967 and 1984. Nitrate and perchlorate are also COCs in ground water. 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. Ground water extraction and treatment has been conducted since 1999 to reduce VOC, nitrate, and perchlorate concentrations in ground water. PCB-, dioxin-, and furan-contaminated soil in the Building 855 former rinse water lagoon was excavated in 2005 (Holtzapple, 2005). The selected remedy for this OU includes monitoring, risk and hazard management, and ground water and soil vapor extraction and treatment. The interim remedial design was completed in 2003. Construction completion for the OU was achieved in September 2007. Three ground water extraction and treatment systems and one soil vapor extraction and treatment system currently operate in the OU.

Ground water remediation has reduced total VOC concentrations from a historic maximum of 2,900 μg/L in 1997 to a 2011 maximum of 120 μg/L (October 2011). Nitrate concentrations have decreased from a historic maximum of 260 mg/L in 2003 to a 2011 maximum of 180 mg/L

(June 2011). Perchlorate concentrations in ground water have also decreased from 27 µg/L in 2003 to a 2011 maximum of 16.4 µg/L (October 2011). Risks to onsite workers from inhalation of VOC vapors and from exposure to PCBs, dioxins, and furans in surface soil have been mitigated.

A Five-Year Review of remediation in the Building 854 OU was completed in January 2009 (Dibley et al., 2009a). The second Five-Year-Review Report is scheduled for 2014.

1.6. Building 832 Canyon (OU 7)

Contaminants were released from Buildings 830 and 832 through piping leaks and surface spills during past activities at these buildings. VOCs, nitrate, and perchlorate are the COCs in ground water. VOCs are the COCs in surface water at Spring 3. VOCs, nitrate, and HMX are the COCs in subsurface soil. HMX is also a COC in surface soil. No further action was selected as the remedy for HMX in surface soil and HMX and nitrate in subsurface soil.

Ground water and soil vapor extraction and treatment have been conducted since 1999 to reduce contamination in ground water and subsurface soil. The Building 832 Canyon OU remedy includes monitoring, risk and hazard management, MNA for nitrate, and ground water 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 ground water extraction and treatment systems and two soil vapor extraction and treatment systems currently operate in the OU.

Remediation has reduced total VOC concentrations from a historic maximum of 13,000 µg/L in 2003 to a 2011 maximum of 3,800 µg/L (October 2011). Perchlorate concentrations have been reduced from a historic maximum of 51 µg/L in 1998 to a 2011 maximum of 14 µg/L (March 2011). Nitrate concentrations in ground water remain fairly stable, and are possibly the result of the ongoing contribution of nitrate from septic systems and natural bedrock sources. Natural denitrification processes continue to reduce nitrate concentrations to background levels near the site boundary. Remediation has also mitigated the risk to onsite workers at several locations in the Building 832 Canyon OU.

A Five-Year Review of remediation in the Building 832 Canyon OU was completed in August 2011 (Helmig et al., 2011). The second Five-Year-Review Report is scheduled for 2016.

1.7. Building 812 (OU 9)

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 Remedial Investigation/Feasibility Study (RI/FS) describing the results of characterization activities and remedial alternatives for the Building 812 OU 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 will continue through 2012. A new RI/FS report is scheduled for 2014 following the completion of the characterization. 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.

1.8. 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). Freon 113, Freon 11, and tetrachloroethene (PCE) were identified as COCs in ground water. A Building 865 Technical Memorandum in Support of a Record of Decision Amendment (TMSRA) is scheduled for 2013.

2. Five-Year Review for the Pit 6 Landfill OU (OU 3)

2.1. Pit 6 Landfill OU Site Chronology

The following is a chronological listing of significant environmental restoration events at the Pit 6 Landfill OU:

<u>1964 to 1972</u>

- Waste was buried in the Pit 6 Landfill.

<u>1971</u>

- DOE/LLNL excavated waste containing depleted uranium from the landfill.

<u>1982</u>

- Site investigations began at the Pit 6 Landfill.

<u>1984</u>

- Monitoring of ground water began in downgradient active water-supply wells CARNRW1 and CARNRW2.

<u>1987</u>

- VOCs were first detected in ground water at the Pit 6 Landfill.

<u>1990</u>

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

<u>1992</u>

- A Federal Facilities Agreement (FFA) was signed for Site 300.
- Monitoring of ground water began in downgradient inactive water-supply well CARNRW3.

<u>1994</u>

- The Site-Wide Remedial Investigation report for Site 300 was issued that included the Pit 6 Landfill OU.
- A Feasibility Study for the Pit 6 Landfill OU was issued.

<u>1997</u>

- The Pit 6 Landfill was capped and closed under CERCLA.

<u>1998</u>

- Limited short-term ground water extraction and treatment of VOCs in ground water was conducted as a treatability study.
- A Post-Closure Plan for the Pit 6 Landfill OU was issued (Ferry et al., 1998).

<u>1999</u>

- The Site-Wide Feasibility Study for Site 300 was issued that included the Pit 6 Landfill OU (Ferry et al., 1999).

<u>2001</u>

- An Interim Site-Wide ROD for Site 300 was signed. The Interim Site-Wide ROD specified monitoring of ground water and surface water, risk and hazard management (e.g., administrative controls) to prevent human exposure to contaminants and impacts to ecological receptors, and monitored natural attenuation of VOCs and tritium in ground water for OU 3. The Interim Site-Wide ROD did not contain ground water cleanup standards.
- A Remedial Design Work Plan was issued that contained the strategic approach and schedule to implement the remedies in the Interim Site-Wide ROD (Ferry et al., 2001).

<u>2002</u>

- The Compliance Monitoring Plan/Contingency Plan (CMP/CP) for Interim Remedies was issued (Ferry et al., 2002).

<u>2008</u>

- The Site-Wide ROD with selected remedies and cleanup standards for Site 300 was signed. The remedy did not change in the 2008 Site-Wide ROD, with the exception that ground water cleanup standards were added in the 2008 Site-Wide ROD.

<u>2009</u>

- The revised CMP/CP was issued (Dibley et al., 2009b).

2.2. Pit 6 Landfill OU Background

2.2.1. Pit 6 Landfill OU Physical Characteristics

2.2.1.1. Pit 6 Landfill OU Site Description

The Pit 6 Landfill OU covers an area of 2.6 acres near the southwest corner of Site 300 (Figure 2). The LLNL buildings located in the OU are used to support firearms training operations by the LLNL Protective Forces Department. From 1964 to 1973, waste from the LLNL Livermore Site and Lawrence Berkeley Laboratory was buried in three unlined debris trenches and six animal pits located at the Pit 6 Landfill (Figure 3). The waste included laboratory equipment, craft shop debris, and biomedical waste. DOE/LLNL excavated the portion of waste containing depleted uranium in 1971. VOCs, tritium, nitrate, and perchlorate were identified as COCs in ground water and VOCs as COCs in surface water when present in

Spring 7. No COCs were identified in surface soil or subsurface soil/rock in the vadose zone. COCs are discussed in more detail in Section 2.2.5.

The Pit 6 Landfill was capped and closed in 1997 under CERCLA to prevent further leaching of contaminants that likely resulted from percolation of rainwater through the buried waste. The engineered, multi-layer cap is designed to prevent rainwater infiltration into the landfill, to mitigate potential damage by vegetation and burrowing animals, to prevent potential hazards from the collapse of void spaces in the buried waste, and to prevent the potential flux of VOC vapors from subsurface soil to air. Surface water flow onto the landfill is minimized by a diversion channel located on the north side and drainage channels located on the east, west, and south sides of the engineered cap.

Two active offsite water-supply wells (CARNRW1 and CARNRW2) are located about 1,500 ft east and downgradient of the Pit 6 Landfill (Figure 4). They provide water for the nearby Carnegie State Vehicle Recreational Area (SVRA) Park and are monitored monthly. Water pumped from well CARNRW1 is used for dust and fire suppression, and water from well CARNRW2 is piped across Corral Hollow Road to the Carnegie SVRA Park facilities. Offsite wells CARNRW3 and CARNRW4 are no longer actively pumped.

2.2.1.2. Pit 6 Landfill OU Hydrogeologic Setting

This section describes the general hydrogeologic setting for the Pit 6 Landfill OU, including the unsaturated zone, the hydrostratigraphic units (HSUs) underlying the landfill, and surface water located in the vicinity of the Pit 6 Landfill OU. A geologic cross-section is presented on Figure 5. The Pit 6 Landfill is located in the Corral Hollow-Carnegie fault zone, a series of subparallel, northwest-southeast trending strike-slip faults. Because this fault zone has a significant effect on the hydrogeology of the Pit 6 Landfill area, it is briefly described below.

The northern limit of the Corral Hollow-Carnegie fault zone (hereafter referred to as the fault zone) is located beneath the Pit 6 Landfill. It represents a structural discontinuity and hydraulic barrier that creates two ground water flow regimes in the bedrock. North of the fault zone, the Tertiary Neroly Lower Blue Sandstone ($Tnbs_1$) bedrock dips 10 to 20 degrees to the south-southwest. Within the fault zone, bedrock units are steep to vertically dipping. The $Tnbs_1$ bedrock within and north of the fault zone is unconformably overlain by Quaternary alluvial terrace (Qt) deposits. The fault does not extend into or offset these deposits. Hydrogeologic cross-sections showing the lateral and vertical distribution of total VOCs and tritium north of the fault zone, are shown on Figures 6 and 7, respectively. Hydrogeologic cross-sections showing the lateral and vertical distribution of total VOCs and tritium within the fault zone are shown on Figures 8 and 9, respectively.

Pit 6 Landfill OU Vadose (Unsaturated) Zone

Unconsolidated Qt deposits composed of silty and clayey sand and gravel beneath the Pit 6 Landfill are unsaturated to depths of approximately 25 to 45 ft below ground surface (bgs) north of the fault zone and variably saturated within the fault zone.

Pit 6 Landfill OU Saturated Zone

The three identified HSUs in the Pit 6 Landfill area are described below:

Qt-$Tnbs_1$ North HSU – Ground water in this HSU occurs in Qt deposits and fractured Neroly $Tnbs_1$ bedrock north of the Corral Hollow-Carnegie Fault Zone. Figure 10 presents a potentiometric surface map for the Qt-$Tnsbs_1$ HSU. Depth to ground water in this HSU ranges from 25 to over 80 feet bgs; approximately 30 to 35 ft below the base of the buried waste in Pit 6. As shown on Figure 10, ground water in this HSU flows to the east-southeast. Saturation in the Qt is laterally discontinuous and consists of, at most, a few feet of saturated silty gravel overlying the bedrock contact. Recharge for this unit occurs in the hills to the north. In recent years, water levels in some Qt-$Tnbs_1$ HSU wells north of the fault zone have gradually declined, in some cases dropping below the well screen and causing the well to go dry.

Qt-$Tnbs_1$ South HSU – Within the fault zone, the Qt-$Tnbs_1$ HSU consists of semi-consolidated Qt deposits that unconformably overlie vertically dipping, folded Neroly $Tnbs_1$ and Cierbo Formation (Tmss) bedrock. As shown on Figures 5 and 10, ground water elevations within this HSU are typically 15 to 20 ft higher than those north of the fault zone. The saturated thickness of the Qt-$Tnbs_1$ HSU within the fault zone is spatially and temporally variable, depending on geometry of fractures within the bedrock underlying the terrace deposits and the magnitude of seasonal rainfall. Ground water in this HSU within the fault zone generally flows to the east. This HSU received flow from the Qt-$Tnbs_1$ North HSU and direct infiltration. Discharge occurs locally at Springs 7, 8, and 15.

$Tnbs_1$ Deep HSU – A deeper water-bearing zone has been identified beneath a low-permeability confining layer at depth in the $Tnbs_1$ stratigraphic unit. Data indicate that this deeper $Tnbs_1$ water-bearing zone is not in hydraulic communication with the Qt and shallow $Tnbs_1$ fractured bedrock. Ground water levels in the deeper $Tnbs_1$ water-bearing zone do not respond to pumping of wells completed in the shallow Qt-$Tnbs_1$ HSU. Therefore, the deeper $Tnbs_1$ water-bearing zone is considered as a separate HSU. VOCs and tritium have sporadically been detected in this deeper $Tnbs_1$ HSU in the past, however, this HSU is currently not contaminated.

As part of this five-year review, the HSU in which each well is screened was re-evaluated based on recent hydraulic data. Based on responses to pumping of water-supply wells CARNRW1 and CARNRW2, as observed in water elevation hydrographs, wells EP6-07, K6-27, K6-34, and K6-35, which were previously assigned to the $Tnbs_1$ Deep HSU, were assigned to the Qt-$Tnbs_1$ North HSU.

There is also a water-bearing zone in Qal and Tts stratigraphic units that is restricted to the area south of Corral Hollow Road and consists of Quaternary alluvial deposits (Qal) associated with Corral Hollow Creek and the underlying Tesla Formations (Tts). Tts deposits are vertical and locally overturned in the area. Ground water elevations in the Qal-Tts HSU are typically 25 to 30 ft lower than in the Qt-$Tnbs_1$ HSU. Shallow ground water is ephemeral and present in the Qal only following significant precipitation. Ground water in the Qal flows eastward in the same general direction as stream flow in Corral Hollow Creek.

Pit 6 Landfill OU Surface Water

Three springs, Springs 7, 8 and 15, are located in the immediate vicinity of the Pit 6 Landfill and occur along traces of the fault zone (Figure 4). When present, water in these springs is derived from the Qt-$Tnbs_1$ South HSU within the fault zone. Spring 8 is a perennial spring located about 550 ft southwest and hydraulically upgradient of the Pit 6 Landfill. Ground water flows into Spring 8 at approximately 1 gallon per minute (gpm).

Springs 7 and 15 are intermittent springs located approximately 200 and 550 feet southeast and downgradient of the Pit 6 Landfill, respectively. Spring 7 has been dry since the summer of 2000. When flowing, ground water flows into this spring at a rate of approximately 2 gpm.

Spring 15 has been dry since late 1991. When flowing during the wet winter season, ground water flows into this spring at a rate of about 1 gpm.

A small man-made pond is located in the Carnegie SVRA, situated approximately 1,500 ft east-southeast of the Pit 6 Landfill. Ground water from offsite water-supply well CARNRW1 is used to fill the residence pond.

Influence of CARNRW1 pumping

As mentioned above, two active offsite water-supply wells (CARNRW1 and CARNRW2) are located about 1,500 ft east of the Pit 6 Landfill. (Figure 4). They provide water for the nearby Carnegie SVRA and are monitored monthly. CARNRW1 is generally pumped about once a week and CARNRW2 is used daily. LLNL has historically had only intermittent access to measuring water levels in CARNRW2, whereas water levels in CARNRW1 have been measured on a routine basis since late 1991 (monthly from late 1991 to 1993 and quarterly since 1993). During the third quarter of 2009, LLNL placed water-level transducers in guard wells K6-34 and W-PIT6-1819 to continuously monitor the influence of routine pumping of wells CARNRW1 and CARNRW2 on water levels in these guard wells. As shown on Figure 4, both guard wells are located north of the fault zone, with K6-34 and W-PIT6-1819 approximately 400 and 200 feet west, respectively, of the CARNRW wells. Guard wells K6-34 and W-PIT6-1819 are screened in the shallower Qt-$Tnbs_1$ North HSU. Although the K6-34 data set is not as complete due to periodic equipment/recording issues, transducer data for both wells generally indicate that water levels in these wells are influenced by pumping of the CARNRW wells.

Figure 11 shows the transducer data for W-PIT6-1819, as well as hydrographs (from hand water-level measurements) for CARNRW1 and other Qt-$Tnbs_1$ North HSU wells from 2009 through 2011. The influence of daily CARNRW2 pumping is observed in the small daily variation in the transducer data (usually 1 to 2 ft), whereas the influence of weekly CARNRW1 pumping on water levels in W-PIT6-1819 is observed in the larger weekly variation in the transducer data (usually 5 to 10 ft).

Due to insufficient water, ground water samples from EP6-08 and K6-24 have not been collected since April 2008 and January 2011, respectively. During the first semester of 2012, two new wells were drilled in the Qt-$Tnbs_1$ North HSU in the vicinity of these wells, but were screened at greater depths. As shown on Figure 4, well W-PIT6-2816 was drilled 30 feet east-southeast of EP6-08 and well W-PIT6-2817 was drilled 50 feet east-southeast of K6-24. Sample results (after well development) for these new wells are discussed in the remediation optimization evaluation section (Section 2.5.2) of this report**.**

2.2.2. Pit 6 Landfill OU Land and Resource Use

Site 300 is currently an operating facility, and will remain under DOE control for the reasonably anticipated future. Less than 5 percent of Site 300's 7,000-acre property-area is developed.

The LLNL buildings located within the OU boundary are used to support firearms training operations by the LLNL Protective Forces Department. Pistol and rifle ranges are operated in the OU. After demolition prior to capping, the rifle range was re-built on top of the Pit 6 Landfill cap.

The Pit 6 Landfill OU lies along the southern boundary of Site 300. The Carnegie SVRA, located across Corral Hollow Road from the Pit 6 Landfill OU, is an outdoor recreational facility operated by the California Department of Parks and Recreation for riding and racing private and commercial off-road motorcycles and four-wheel drive vehicles. The Carnegie SVRA continues to expand the park property towards the southwest of the OU. In addition, the Carnegie SVRA owns a parcel of land north of Corral Hollow Road at the eastern boundary of the OU that contains some residences and a pond used for firefighting and dust-suppression water.

There are no active onsite water-supply wells in the Pit 6 Landfill OU. However, as previously mentioned, two active offsite water-supply wells (CARNRW1 and CARNRW2) are located about 1,500 ft east of the Pit 6 landfill (Figure 4).

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, migratory birds, and rare plants). Annual grasslands cover the majority of the Pit 6 Landfill OU, with some blue oak woodlands occurring in the northeast corner of the OU. Wetlands are associated with Spring 8 (along the southwest boundary of the OU). Spring 7, located southwest of Spring 15, does not have significant wetland development as surface water has been absent from this location for the past 12 years. Small numbers of the big tarplant (*Blepharizonia plumosa*), an extremely rare late-season flowering plant included on the California Native Plant Society's List 1B, have been observed in the OU in the past, but the plant is not currently present. The critical habitat for the federally endangered large-flowered fiddleneck (*Amsinckia grandiflora*) occurs along the western boundary of the OU. The pond within the SVRA residence area provides breeding habitat for the federally threatened California red-legged frog (*Rana aurora draytonii*), while the wetland associated with Spring 8 provides additional aquatic habitat. The entire OU resides within the upland dispersal habitat for this species. The Pit 6 Landfill OU is also within the critical habitat for the federally threatened Alameda whipsnake (*Masticophis lateralis euryxanthus*).

A five-year ecological review reported in the 2008 Annual Compliance Monitoring Report (Dibley et al., 2009c), which updated the assessment of the ecological impacts from Site 300 contaminants, found no impact to ecological receptors from releases within the Pit 6 Landfill OU. An LLNL ecologist reviewed ecological data collected between 2008 and 2011 for the Pit 6 area to evaluate whether any changes in contaminant or ecological conditions that could impact ecological receptors. No changes were identified. Access to these unique animal and plant populations is controlled and interactions with the wildlife are avoided.

2.2.3. Pit 6 Landfill OU History of Contamination

From 1964 to 1973, approximately 2,000 cubic yards (yd^3) of solid waste were buried in nine separate trenches that comprised the Pit 6 Landfill (Figure 3). Consistent with historical disposal practices, the trenches were not lined. Three large trenches contain 1,700 yd^3 of solid waste that includes empty drums, glove boxes, lumber, ducting, and capacitors. Six smaller trenches contain 300 yd^3 of biomedical waste. Minor releases of VOCs, tritium, and perchlorate occurred from the Pit 6 Landfill prior to the installation of a CERCLA engineered cap in 1997. The septic system for the pistol range, located about 600 ft southeast of the Pit 6 Landfill is the likely source of nitrate contamination in ground water, although there may also be some contribution of nitrate from natural sources. The dissolved-phase masses of VOCs, tritium, and perchlorate released from the landfill are relatively small based on their low concentrations and limited extent in ground water.

2.2.4. Pit 6 Landfill OU Initial Response

DOE/LLNL began environmental investigations at the Pit 6 Landfill OU in 1982. Since then, 39 boreholes have been drilled; all of which were completed as ground water monitor wells (Figure 4). Three wells have since been abandoned to prevent downward migration of contaminants through long well screens and sand packs. The geologic and chemical data from these wells and boreholes are used to characterize the site hydrogeology and to monitor temporal and spatial changes in saturation and dissolved contaminant concentrations. Site characterization also included soil vapor and geophysical (electromagnetic and radiation) surveys, geological logging of a trench wall within the Corral Hollow Creek-Carnegie fault zone, and hydraulic testing of wells.

Remediation activities at the Pit 6 Landfill OU conducted prior to the Interim Site-Wide ROD included excavation of landfill waste containing depleted uranium in 1971. The Pit 6 Landfill was capped and closed in 1997 under CERCLA to prevent further leaching of contaminants resulting from percolation of rainwater through the buried waste. The engineered, multi-layer cap is intended to prevent rainwater infiltration into the landfill, mitigate potential damage by burrowing animals and vegetation, prevent potential hazards from the collapse of void spaces in the buried waste, and prevent the potential flux of VOC vapors from subsurface soil to air. Surface water flow onto the landfill is minimized by a diversion channel on the north side and drainage channels on the east, west and south sides of the engineered cap. EPA, DTSC, and the RWQCB approved the post-closure monitoring plan in May 1998.

In 1998, a short-term treatability test was conducted in which ground water was extracted from one well and treated using a potable treatment unit to remove VOCs.

2.2.5. Pit 6 Landfill OU Contaminants of Concern

COCs identified in ground water in the Pit 6 Landfill OU include: (1) VOCs (primarily TCE, but also chloroform, 1,2-dichloroethane [DCA], cis-1,2-dichloroethene [DCE], trans-1,2-DCE, PCE, and 1,1,1-trichloroethane [1,1,1-TCA]), (2) tritium, (3) perchlorate, and (4) nitrate. VOCs, tritium, and nitrate are present in ground water in the Qt-$Tnbs_1$ North and South HSUs. Perchlorate has historically been present at low concentrations in the Qt-$Tnbs_1$ North and South HSUs; but has not been detected in any Pit 6 ground water sample since early 2010. In the past, COCs have also been sporadically detected in the $Tnbs_1$ Deep HSU and Qal-Tts HSU, but are not currently present in these HSUs. The distribution and concentration of contaminants in ground water is described in detail in Section 2.5.1 below. VOCs (cis-1,2-DCE, trans-1,2-DCE, PCE, and TCE) have also been identified as COCs in surface water at Spring 7 when water is present. No COCs were identified in surface soil or subsurface soil/rock in the vadose zone.

VOCs, primarily TCE, a suspected human carcinogen, are present in the Pit 6 waste, ground water, and surface water (when present in Spring 7). The baseline human health risk assessment estimated the following cancer risks and hazard indices in OU 3:

1. Pit 6 Landfill – Cumulative risk of 5×10^{-6}, hazard index (HI) less than 1 to onsite workers, assuming continuous inhalation of VOC vapors volatilizing from the landfill and migrating into outdoor air over a 25-year period.
2. Spring 7 – Cumulative risk of 4×10^{-5}, HI of 1.5 to onsite workers, assuming continuous inhalation of VOC vapors volatilizing from the landfill and migrating into outdoor air over a 25-year period.

3. The Carnegie State Vehicular Recreation Area pond (offsite, east of the Pit 6 Landfill) – Cumulative risk of 3 x 10^{-6}, HI less than 1 to offsite residence from VOCs volatilizing from the State Vehicular Recreation Area pond. This risk scenario assumed no cleanup actions would be taken and that VOCs would migrate to the water-supply wells CARNRW-1 and CARNRW-2 used to fill the pond.

The baseline ecological risk assessment for the Pit 6 Landfill identified a HI greater than one for inhalation of VOCs in burrow air for ground squirrels and the San Joaquin kit fox. Risk mitigation progress is discussed in Section 2.5.4.

While tritium, a potential human carcinogen, occurs naturally at low activities in the environment, it is present in ground water in the Pit 6 Landfill OU above background (but below its cleanup standard/Maximum Contaminant Level [MCL]) as a result of releases from the landfill prior to capping of the pits. No unacceptable human health risk or hazard was identified for tritium in ground water.

Perchlorate, while not a carcinogen, interferes with iodide uptake into the thyroid gland. Because iodide is an essential component of thyroid hormones, perchlorate may disrupt thyroid functions by decreasing hormone production (EPA, 2005). Perchlorate has historically been detected in Pit 6 Landfill ground water at concentrations above the 6 μg/L drinking water MCL (historical maximum concentration of 65.2 μg/L in 1998), but concentrations have been below the 4 μg/L reporting limit since 2010.

Nitrate in ground water probably results from septic system effluent but may also have resulted from natural sources. Nitrate can cause non-carcinogenic health effects if ingested at elevated concentrations. Nitrate has been detected in Pit 6 Landfill ground water at concentrations above the 45 mg/L drinking water MCL (historical maximum concentration of 240 μg/L in 2000). Nitrate concentrations in ground water currently exceed the MCL cleanup standard in two wells.

2.2.6. Pit 6 Landfill OU Summary of Basis for Taking Action

Remedial actions were initiated in the Pit 6 Landfill OU to address unacceptable human health risks and ecological risk identified in Section 2.2.5.

2.3. Pit 6 Landfill OU Remedial Actions

2.3.1. Pit 6 Landfill OU Remedy Selection

The remedy selected for the Pit 6 Landfill OU is intended to achieve the following Remedial Action Objectives (RAOs):

<u>For Human Health Protection:</u>

- Restore ground water containing contaminant concentrations above cleanup standards.
- Prevent human ingestion of ground water containing contaminant concentrations (single carcinogen) above cleanup standards.
- Prevent human inhalation of VOCs volatilizing from waste in the Pit 6 Landfill to air that pose an excess cancer risk greater than 10^{-6} or HI greater than 1, a cumulative excess cancer risk (all carcinogens) in excess of 10^{-4}, or a cumulative HI (all noncarcinogens) greater than 1.

- Prevent human inhalation of VOCs volatilizing from surface water in Spring 7 to air that pose an excess cancer risk greater than 10^{-6} or HI greater than 1, a cumulative excess cancer risk (all carcinogens) in excess of 10^{-4}, or a cumulative HI (all noncarcinogens) greater than 1.
- Prevent human exposure to contaminants in media of concern that pose a cumulative excess cancer risk (all carcinogens) greater than 10^{-4} and/or a cumulative HI greater than one (all noncarcinogens).

For Environmental Protection:

- Restore water quality to ground water cleanup standards within a reasonable timeframe and to prevent plume migration to the extent technically and economically practicable. Maintain existing water quality that complies with ground water cleanup standards to the extent technically and economically practicable. This will apply to both individual and multiple constituents that have additive toxicology or carcinogenic effects.
- Ensure ecological receptors important at the individual level of ecological organization (listed threatened or endangered, State of California species of special concern) do not reside in areas where relevant hazard indices exceed 1.
- Ensure existing contaminant conditions do not change so as to threaten wildlife populations and vegetation communities.

In the 2001 Interim Site-Wide ROD, the remedy for the Pit 6 Landfill OU was selected based on its ability to contain contaminant sources, prevent further plume migration, and protect human health and the environment. The interim remedy was selected as the final remedy in the 2008 ROD.

The selected remedy for the Pit 6 Landfill OU consists of:

1. Monitoring ground water and surface water 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 onsite worker exposure to VOCs volatilizing from Spring 7. Institutional/land use controls will be implemented to prevent human exposure to contamination and to protect the integrity of the remedy.
3. MNA to reduce VOC and tritium concentrations in ground water to cleanup standards.
4. Inspecting the Pit 6 Landfill cover periodically for damage that could compromise its integrity and repairing any damage found.

2.3.2. Pit 6 Landfill OU Remedy Implementation

Monitoring of ground water and surface water at the Pit 6 Landfill includes:

- Detection monitoring of ground water to detect any new releases of contaminants from buried waste in the Pit 6 Landfill.
- Remedial action monitoring of COCs in ground water to evaluate the effectiveness of the remedy in reducing contaminant concentrations.
- Monitoring of surface water (springs) that could be affected by a release from the landfill.

As part of the detection monitoring program, ground water samples are collected from monitor wells located upgradient and directly downgradient of the landfill and analyzed for potential constituents of concern. Detection monitoring and results for the Pit 6 Landfill is discussed in Section 2.5.2. As part of the remedial action monitoring program, ground water samples are collected from wells and analyzed for ground water COCs. This program includes:

- Monthly monitoring of offsite water-supply wells owned and operated by the Carnegie State Park.
- Monitoring of guard wells located downgradient of the ground water plumes and upgradient of the Carnegie State Park wells to provide an early indication of movement of contaminants toward the water-supply wells.
- Monitoring of all wells to track changes in plume concentration and size to ensure there is no impact to downgradient receptors, evaluate the effectiveness of natural attenuation of VOCs and tritium to meet remedial action objectives, and verify the attainment of cleanup standards.

Surface water at Spring 7 is also monitored, when present, to determine if risk and hazard management measures, such as access restrictions, are necessary to prevent VOC inhalation exposure by onsite workers.

The results of ground water and surface water monitoring are discussed in Section 2.5.1.

The results of the detection and remedial action monitoring, as well as landfill inspections and maintenance, are reported quarterly and annually in the Compliance Monitoring Program Reports submitted by the LLNL Environmental Functional Area.

The results of remedial action ground water and surface water monitoring, remediation progress, risk re-evaluations, and the status of institutional control implementation are reported in the ERD semiannual Compliance Monitoring Reports.

Land Use Controls have been implemented to prevent damage to the landfill cap and inadvertent exposure to the waste (see Section 2.3.4).

2.3.3. Pit 6 Landfill OU Operation and Maintenance

The remedy for the Pit 6 Landfill OU is operating as designed and no significant operational, performance, or cost issues were identified during this five-year review. All required documentation is in place, and the landfill cap maintenance and monitoring procedures are consistent with established procedures and protocols.

Landfill maintenance and monitoring procedures are contained in the following documents:

- Post-Closure Plan for the Pit 6 Landfill Operable Unit at LLNL Site 300 (Ferry, et al., 1998).
- 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, 2009).

The major maintenance activities for the Pit 6 Landfill interim remedy include:

- Annual elevation survey of the pit cap to detect any differential settling or other earth movement.
- Annual inspection of the pit cap by a state-certified Professional Engineer to detect any excessive erosion, animal burrowing, or other penetrative damage.

- As necessary, repairs to the pit cap are made to correct problems identified during inspections.
- Annual inspections of the surface water runoff and drainage system for the landfill and after each major storm event to detect any erosion and accumulated debris.
- When necessary, the drainage channels are cleared of blockage and repaired to maintain the drainage system design capacity.

The landfill inspections and maintenance are reported in the quarterly and annual Pit 6 Post-Closure Monitoring Reports submitted by the LLNL Environmental Functional Area. The budgeted and actual environmental restoration costs for the Pit 6 Landfill OU are tracked closely and are consistently within or near the allocated budget. Table 1 presents the actual costs for the last five fiscal years, 2007 through 2011. (Note: Although it falls outside this five-year review period, in July 2012, DOE proposed and the regulatory agencies agreed to modify the detection monitoring and reporting program for the Pit 6 Landfill for consistency with the Detection Monitoring Program in the Compliance Monitoring Plan. DOE will submit an Addendum to the Compliance Monitoring Plan to incorporate the Pit 6 Detection Monitoring and Reporting Program which will supercede the 1998 Post-Closure Monitoring Plan.)

2.3.4. Pit 6 Landfill OU 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, and
- 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 onsite.

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.

The land use controls and requirements described herein are only applicable to the Pit 6 Landfill 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 landfill inspection results are currently reported in the quarterly Pit 6 Post-Closure Reports.

Land use controls for the Pit 6 Landfill OU are described in Table 2, that 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 Pit 6 Landfill OU. Figure 12 shows the specific areas of the Pit 6 Landfill OU where the land use controls have been 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 Pit 6 Landfill OU by objective, and the status of the land use controls are summarized below.

2.3.4.1. Pit 6 Landfill OU Land Use Control Objectives

Land use control objectives were established for the Pit 6 Landfill OU in the Site 300 ROD (DOE, 2008) to reduce risk and prevent exposure to contaminated environmental media. The risk drivers and associated land use control objectives identified for the Pit 6 Landfill include:

1. ***Risk Driver*** – VOCs and nitrate concentrations in ground water onsite exceed MCL cleanup standards.

   Land use control objectives:

   - Prevent onsite water-supply use/consumption of contaminated ground water until ground water cleanup standards are met.

2. ***Risk Driver*** – Potential exposure to contaminants in pit waste.

   Land use control objectives:

   - Maintain the integrity of landfill cover as long as the pit waste remains in place.
   - Control construction and other ground-breaking activities on the landfills to prevent cap/cover damage and/or inadvertent exposure to pit waste as long as the pit waste remains in place.
   - Prevent inadvertent exposure of onsite workers to the pit waste as long as the waste remains in place.
   - Prevent inadvertent exposure of unauthorized trespassers to the pit waste as long as the waste remains in place.

3. ***Risk Driver*** – The baseline risk assessment identified a risk of 4×10^{-5} for onsite workers from inhalation of VOCs volatilizing from Spring 7 into outdoor air.

   Land use control objective:

   - Prevent onsite site worker inhalation exposure to VOCs at Spring 7 until annual risk re-evaluation indicates that the risk is less than 10^{-6}.

4. ***Risk Driver*** – Potential exposure to contaminated environmental media.

   Land use control objective:

   - Prohibit transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use.

No COCs were identified in surface soil or subsurface soil/rock in the vadose zone in the Pit 6 Landfill OU.

2.3.4.2. Pit 6 Landfill Land Use Controls

This section discusses the land use controls including institutional controls, engineered controls, and physical barriers for the Pit 6 Landfill OU implemented to address the risk reduction objectives, and provides the current status of the controls.

Prevent Onsite Water-supply Use/consumption of Contaminated Ground Water: Governmental Institutional Controls

DOE/LLNL implements multiple layers of protection (land use controls) to prevent the water-supply use or consumption of onsite contaminated ground water in the Pit 6 Landfill OU until ground water cleanup standards are met. The land use controls include:

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

Governmental Institutional Controls Implementation Status

Dig Permit Process: A LLNL Dig Permit is required to drill and install any new onsite wells at Site 300. This permit process includes an evaluation of the proposed well location by the LLNL Environmental Analyst to determine if the proposed new water-supply well is located in an area of ground water contamination. If it is determined that the proposed water-supply well location is in a ground water contamination area, the Environmental Analyst works with the LLNL entity proposing the well installation and the LLNL Environmental Restoration Department to relocate the well to ensure ground water contaminants would not be drawn into the well.

Work Induction Board: Any proposed onsite well drilling activities are also submitted to the LLNL Work Induction Board, and are reviewed by the LLNL Environmental Restoration Department to ensure that new water-supply wells are not located in areas of ground water 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).

Contamination in the Pit 6 Landfill OU is limited to onsite ground water. TCE is present in only one well at a concentration slightly exceeding the drinking water standard; all other VOCs in ground water are below drinking water standards. Nitrate is detected at a concentration exceeding the drinking water standard in only one well. The elevated nitrate is likely due to septic system discharge rather than from the Pit 6 Landfill. Therefore, land use controls are not needed to prevent offsite water-supply use/consumption of contaminated ground water.

No plans for drilling onsite water-supply wells in the Pit 6 Landfill area were proposed during this five-year review period.

The LLNL processes for review of proposed new work are effective in preventing the drilling and installation of new onsite water-supply wells within areas of onsite ground water contamination, and are therefore protective of human health (onsite workers) in preventing the consumption of contaminated onsite ground water.

Maintain the Integrity of Landfill Cover: Governmental Institutional Controls

The land use controls that have been implemented to maintain the integrity of landfill cap as long as the pit waste remains in place include:

- Governmental Institutional Controls:
  - Inspection and Maintenance Program.

Additional controls were implemented to prevent excavation activities. Those controls are discussed in the *Control Construction and Other Ground-breaking Activities on the Landfills: Governmental Institutional Controls* below.

Governmental Institutional Controls Implementation Status

DOE inspects and maintains the landfill cap and ground water monitoring system. Landfill cap maintenance and inspection requirements are currently specified in the Pit 6 Landfill Post-Closure Plan and are reported in quarterly Post-Closure Monitoring Reports.

During this five-year review period, the landfill was inspected and maintained as required. The integrity of the landfill cover was maintained.

Control Construction and Other Ground-breaking Activities on the Landfills: Governmental Institutional Controls

The land use controls that have been implemented to control construction and other ground-breaking activities on the landfill to prevent cap/cover damage and/or inadvertent exposure to pit waste as long as the pit waste remains in place include:

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

Governmental Institutional Controls Implementation Status

Site 300 implements multiple layers of protection to prevent onsite worker exposure to contaminants in subsurface soil: Dig Permit and Work Induction Board processes.

Dig Permit Process: A LLNL Dig Permit is required to conduct any ground disturbing activities at Site 300, including activities that involve the excavation of soil and/or rock. This permit process includes an evaluation of the proposed location for the ground disturbing/excavation activity by the LLNL Environmental Analyst to determine if it is located in an area of soil/rock contamination. The Environmental Analyst works with the LLNL entity proposing the ground disturbing/excavation activity to determine if the activity can be moved. If the work plans cannot be modified to move excavation activities outside of areas of soil contamination, LLNL Environmental Health & Safety personnel evaluate the potential hazards and identify the necessary controls to be implemented prior to the start of work.

Work Induction Board: Any proposed excavation activities are submitted to the LLNL Work Induction Board, and are reviewed by LLNL Environmental Restoration Department to prevent excavation or damage of the Building 851 Firing Table. 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).

During this five-year review period, no excavation or construction activities were proposed in the Pit 6 Landfill OU. The LLNL processes for review of proposed new work (e.g., Work Induction Board and excavation permit processes) are effective in controlling excavation activities and is therefore protective of human health (onsite workers) in preventing exposure to waste contained in the landfill.

Prevent Inadvertent Exposure of Onsite Workers to the Pit Waste: Governmental Institutional Controls

The land use controls that have been implemented to prevent inadvertent exposure of onsite workers to the pit waste as long as the waste remains in place include:

- Governmental Institutional Controls
  - Dig Permit Process.
  - Work Induction Board Process.

Governmental Institutional Controls Implementation Status

The governmental institutional controls implemented to prevent inadvertent exposure of onsite workers are the same as those discussed in the *Control Construction and Other Ground-breaking Activities on the Landfills: Governmental Institutional Controls* above.

During this five-year review period, no excavation or construction activities were proposed in the Pit 6 Landfill OU. The LLNL processes for review of proposed new work (e.g., Work Induction Board and excavation permit processes) are effective in controlling excavation activities and is therefore protective of human health (onsite workers) in preventing exposure to waste contained in the landfill.

Prevent Inadvertent Exposure of Onsite Workers to the Pit Waste: Physical Barriers

The land use controls that have been implemented to prevent inadvertent exposure of onsite workers to the pit waste as long as the waste remains in place include:

- Physical Barriers:
  - Signage.

Physical Barrier Implementation Status

Signage is maintained at the landfill access points prohibiting unauthorized access and requiring notification and authorization by LLNL Site 300 Management to enter, dig, excavate, or otherwise disturb soil or vegetation in this area.

The physical barriers to control and restrict access are effective in preventing prevent inadvertent exposure of onsite workers to the pit waste, and therefore are protective of human health.

Prevent Inadvertent Exposure of Unauthorized Trespassers to the Pit Waste: Physical Barriers

The land use controls that have been implemented to prevent inadvertent exposure of unauthorized trespassers to the pit waste as long as the waste remains in place include:

- Physical Barriers:
    - Fences.
    - Security Force.
    - Signage.

Physical Barrier Implementation Status

The fences surrounding Site 300, and signs and security forces control and restrict access to Site 300 to prevent inadvertent exposure by members of the public to contamination at Site 300. The LLNL Protective Services force conduct routine inspections of the fences surrounding Site 300. A member of the security force mans the entrance gate to Site 300 during hours when the front gate is open, and a DOE-issued security badge is required to gain entrance to the site. The site gates are closed and locked after 6 pm, and a security force member remains onsite overnight. Members of the public must apply for and obtain security badges and be escorted to access the site.

The physical barriers to control and restrict access are effective in preventing prevent inadvertent exposure by members of the public to contamination at Site 300, and therefore are protective of human health.

Prohibit Transfer of Lands with Unmitigated Contamination: Enforcement Tools

The land use controls that have been implemented to prohibit transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use include:

- Enforcement Tools:
    - Site 300 FFA.
    - ROD.

The land use control and implementation status is described in more detail below.

Enforcement Tools Implementation Status

To prevent the potential exposure to contaminated waste and/or environmental media, the Site 300 FFA 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 as specified in the Site 300 ROD. The Site 300 FFA and ROD have not been modified during this five-year review period, and these provisions remain as originally stated in these documents.

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.

During the five-year review period, DOE has not proposed any plans to transfer any Site 300 land for residential, unrestricted, or non-DOE industrial land use. Site 300 remains under the ownership, oversight, and operation of the U.S. DOE. The provisions in Site 300 FFA and ROD are effective in preventing the transfer of lands with unmitigated contamination that could cause potential harm under a residential or unrestricted land use, and therefore are protective of human health.

2.3.4.3. Summary of the Status of Pit 6 Landfill Land Use Controls

The review of the land use controls for the Pit 6 Landfill OU for this five-year review period determined that these controls are effective for preventing exposure to contaminated media. DOE will implement, maintain, and enforce the land use controls for the Pit 6 Landfill OU for as long as necessary to keep the selected remedy protective of human health and the environment.

2.4. Pit 6 Landfill OU Five-Year Review Process

2.4.1. Notification of Review/Community Involvement

The 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 September 28, 2012. Completed documents can also be accessed electronically at LLNL's Environmental Restoration Department electronic library web page at http://www-erd/library/ or the Environmental Community Relations web page at http://www-envirinfo.llnl.gov.

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

2.4.2. Identification of Five-Year Review Team Members

The Five-Year Review of the Pit 6 Landfill OU at LLNL Site 300 was led by Claire Holtzapple, Site 300 Remedial Project Manager for the DOE/NNSA-Livermore Site Office. The following team members assisted in the review:

- Leslie Ferry, Program Leader, LLNS.
- Valerie Dibley, Deputy Program Leader, LLNS.
- Vic Madrid, Hydrogeology Team Leader, LLNS.
- Michael Taffet, Hydrogeologist, LLNS.
- John Valett, Hydrogeologist, Weiss Associates.

2.4.3. Document Review

This Five-Year Review consisted of examining relevant project documents and site data:

- Final Site-Wide Remedial Investigation for Lawrence Livermore National Laboratory Site 300 (Webster-Scholten et al., 1994).
- Final Site-Wide Feasibility Study for Lawrence Livermore National Laboratory Site 300 (Ferry et al., 1999).

- Interim Site-Wide Record of Decision for Lawrence Livermore National Laboratory Site 300 (U.S. DOE, 2001).
- Site-Wide Record of Decision for Lawrence Livermore National Laboratory Site 300 (U.S. DOE, 2008).
- Remedial Design Work Plan for Interim Remedies at Lawrence Livermore National Laboratory Site 300 (Ferry et al., 2001).
- Site-Wide Remediation Evaluation Summary Report for Lawrence Livermore National Laboratory Site 300 (Ferry et al., 2006).
- Construction Completion Report for the Pit 6 Landfill Operable Unit at Lawrence Livermore National Laboratory Site 300 (Holtzapple, 2008).
- Post-Closure Plan for the Pit 6 Landfill Operable Unit Lawrence Livermore National Laboratory Site 300 (Ferry et al., 1998).
- Semi-annual ERD Compliance Monitoring Reports that include evaluations of remediation progress in the Pit 6 Landfill OU (Dibley et al., 2007c, 2008c, 2009c, 2009d, 2010a, 2010b, 2011a, 2011c, and 2012; LLNL 2008).

These documents are available on-line at www-erd.llnl.gov/library/index.html#reports.s300.

This Five-Year Review evaluates subsurface contaminant concentration and remediation system performance data collected through calendar year 2011.

2.5. Pit 6 Landfill OU Data Review and Evaluation

A review and evaluation were conducted of data collected during this review period to: (1) evaluate changes in contaminant distribution, concentrations, and remediation progress (Section 2.5.1), (2) landfill detection monitoring (Section 2.5.2), (3) identifying performance issues (Section 2.5.3), and (4) mitigating risk associated with COCs (Section 2.5.4).

2.5.1. Pit 6 Landfill OU Contaminant Distribution, Concentration, and Remediation Progress

VOCs, tritium, perchlorate, and nitrate are the COCs identified in ground water at the Pit 6 Landfill OU. Table 3 summarizes the historical and current concentrations/activities of TCE, tritium, perchlorate, and nitrate in the Pit 6 Landfill OU compared to ground water cleanup standards.

The distribution, concentrations, and remediation progress for VOCs, tritium, perchlorate, and nitrate in ground water in the Pit 6 Landfill OU, as well as a summary of the status of these COCs in offsite water-supply wells and springs, are described in Section 2.5.1.1 through 2.5.1.4.

2.5.1.1. VOC Distribution, Concentrations, and Remediation Progress

The VOC COCs in Pit 6 Landfill ground water include chloroform, 1,2-DCA, cis-1,2-DCE, trans-1,2-DCE, PCE, 1,1,1-TCA, and TCE. Of these VOCs, only TCE and cis-1,2-DCE have been detected consistently; the remaining VOCs have been detected sporadically.

Chloroform, 1,1,1-TCA and PCE have never been detected in ground water samples from wells in the Pit 6 area at concentrations above their MCL cleanup standards. For example, the maximum historical concentration of chloroform detected in Pit 6 ground water at concentrations was 14 µg/L (1994), significantly below the 80 µg/L MCL cleanup standard for total trihalomethanes (THMs). The maximum historical concentration of PCE detected was 3.2 µg/L (1988), below its 5 µg/L MCL cleanup standard. 1,1,1-TCA has been detected at concentrations of up to 13 µg/L (1990), well below its 200 µg/L MCL cleanup standard. Chloroform, 1,1,1-TCA, and PCE are not currently detected in Pit 6 ground water above the 0.5 µg/L reporting limit.

TCE, cis-1,2-DCE, trans-1,2-DCE, and 1,2-DCA have historically been detected in Pit 6 ground water at concentrations above their MCL cleanup standards. However, only TCE currently remains at a concentration above its 5 µg/L MCL cleanup standard in one well (EP6-09) as of the fourth quarter of 2011. Concentrations of TCE have decreased from a historical maximum of 250 µg/L in 1988 to a fourth quarter 2011 maximum of 5.9 µg/L (EP6-09). Concentrations of cis-1,2-DCE have decreased from a historical maximum of 12 µg/L in (1990) to a fourth quarter 2011 maximum of 2.2 µg/L; below its 6 µg/L MCL cleanup standard. Cis-1,2-DCE is currently detected above the 0.5 µg/L reporting limit in only one Pit 6 ground water monitor well (K6-01S). Trans-1,2-DCE concentrations have decreased from a historical maximum of 33 µg/L (1990) to below the 0.5 µg/L reporting limit in all wells by 1993. Concentrations of 1,2-DCA have decreased from a historical maximum of 3.5 µg/L to below its 0.5 µg/L MCL cleanup standard in all wells by 1998.

VOC concentrations and distribution in Pit 6 ground water and remediation progress for the individual HSUs, downgradient water-supply wells, and springs are discussed below.

2.5.1.1.1. VOC Concentrations and Distribution by HSU:

Qt-Tnbs$_1$ HSU

VOC contamination (primarily TCE, with minor concentrations of cis-1,2-DCE) in Pit 6 Landfill OU ground water is present primarily in the Qt-Tnbs$_1$ HSUs, with the greatest extent historically present in the Qt-Tnbs$_1$ South HSU. Concentrations and the distribution of total VOCs in the Qt-Tnbs$_1$ HSUs in the second semester of 2011 are presented on Figure 13. Unless otherwise indicated, the total VOC concentrations posted on Figure 13 are comprised wholly of TCE. Wells K6-36 and EP6-08 have been dry since 2006 and 2008, respectively, so the most recent available VOC concentrations from these wells (August 2006 and April 2008, respectively) were used for plume contouring. VOC concentrations and distribution in the Qt-Tnbs$_1$ North and South HSUs are discussed below.

Qt-Tnbs$_1$ North HSU - Within the Qt-Tnbs$_1$ North HSU, the VOC plume (concentration contour greater than 0.5 µg/L) extends from the pit to immediately east of well K6-36 (Figure 13). As shown on Figure 14, total VOC concentrations in the Qt-Tnbs$_1$ North HSU have decreased from a historic maximum of 7.7 µg/L (K6-24, May 1990, comprised of 6.9 µg/L of 1,1,1-TCA and 0.8 µg/L of TCE) to a most recent maximum of 1.8 µg/L (EP6-08, April 2008, comprised of 1.2 µg/L of PCE and 0.6 µg/L of TCE). VOCs have not been detected in well K6-24 since 1994, and well EP6-08 has been dry since 2008. Prior to going dry, well EP6-08 exhibited a generally stable VOC concentration trend. The third well shown on Figure 14, well K6-36, also shows a generally stable VOC concentration trend from 2000 (year drilled) to 2006 (year well went dry).

Because water levels in several Qt-Tnsb$_1$ North HSU wells have declined significantly or have gone dry in recent years, DOE installed two new monitor wells W-PIT6-2816 and W-PIT6-2817 adjacent to wells EP6-08 and K6-24, respectively, in order to collect ground water samples in areas where wells had previously gone dry. VOCs were not detected in ground water samples from these wells.

Qt-Tnbs$_1$ South HSU - Within the Qt-Tnbs$_1$ South HSU, the VOC plume extends from the pit to approximately halfway between well K6-16 and guard well K6-17 (Figure 13). VOCs have not been detected in guard well K6-17 since 2005. VOC concentrations in Qt-Tnbs$_1$ South HSU ground water have decreased from a historic maximum of 253 µg/L (K6-19, 1988) to a five-year review period maximum of 10 µg/L (EP6-09, October 2008) to a fourth quarter 2011 maximum of 5.9 µg/L (EP6-09).

As shown on Figure 13, the highest VOC concentrations (greater than 5 µg/L) at Pit 6 occur in the Qt-Tnbs$_1$ South HSU immediately south of the pit, in the vicinity of well EP6-09. This well (EP6-09) is the only Pit 6 well still containing TCE concentrations above the cleanup standard of 5 µg/L. Well K6-01S is the only well currently containing VOCs other than TCE, with cis-1,2-DCE detected at a concentration of 2.2 µg/L, below the 6 µg/L MCL cleanup standard. Cis-1,2-DCE has not been detected in Pit 6 wells above 6 µg/L since 1993. The presence of cis-1,2-DCE, a degradation product of TCE, in well K6-01S suggests that natural dechlorination may be occurring in the vicinity of this well.

As shown on Figure 15(a), total VOC concentrations in wells within the Qt-Tnbs$_1$ South HSU have decreased from a historic maximum of 253 µg/L (K6-19, November 1988, comprised of 250 µg/L of TCE and 3.2 µg/L of PCE) to a fourth quarter 2011 maximum of 5.9 µg/L, comprised entirely of TCE (EP6-09). Wells K6-19 and EP6-09 are located immediately adjacent to the southeast corner, and south-central portions of the pit, respectively. VOC concentrations in well K6-19 show a significant decrease from 1988 to 2001, and show a stable trend (below 5 µg/L) since 2006. Wells K6-16 and K6-18 show a trend similar to well K6-19. VOC (TCE) concentrations in well EP6-09 gradually increased from 1984 to 1992, gradually decreased from 1992 to 1994, and then gradually increased again from 1994 to late 1998. For two months in late 1998, ground water was extracted from well EP6-09 and treated to determine the effect on TCE trends. During this period, TCE concentrations decreased from 14 to 1.4 µg/L. Since 1998, TCE concentrations in well EP6-09 have rebounded to a maximum of 10 µg/L in October 2008, and remained relatively stable since then. The VOC (TCE) rebound in EP6-09 is shown in detail on Figure 15(b), which presents total VOC concentration trends for Qt-Tnbs$_1$ South HSU wells from 2000 through 2011. TCE concentrations in well EP6-09 have exceeded 5 µg/L since 2004. Concentrations of TCE in all other wells have been below 5 µg/L since 2001.

Acetone has sporadically been detected in Qt-Tnbs$_1$ South HSU well EP6-09 since July of 2008 with concentrations ranging from 12 to 220 µg/L. Analyses of ground water samples from well EP6-09 for acetone (EPA Method 8260) has occurred only since April of 2007. Acetone has also been detected in seven discrete one-time samples from seven other wells (primarily in the Qt-Tnbs$_1$ South HSU) near the Pit 6 Landfill between 1990 and 2003 with concentrations ranging from 5.4 to 78 µg/L. Of these seven samples, four were collected in late October 1990 and may reflect laboratory contamination. One of the remaining three sample results is 28 µg/L reported in a February 17, 2000 sample from well K6-01S. The duplicate sample collected from this well on this date contained no acetone above the 20 µg/L reporting limit. Of the other two samples, the most recent result was 78 µg/L of acetone in a sample collected from Qt-Tnbs$_1$ South HSU well EP6-08 in October 2003. Since the second quarter of 2011, duplicate ground water samples have been collected from well EP6-09 on a quarterly basis. From second quarter 2011 through first semester 2012, acetone has been detected in only one EP6-09 sample (12 µg/L in a duplicate sample from October, 2011). These results indicate that acetone in Pit 6 ground water occurs very sporadically and at low levels, and recently only in the vicinity of well EP6-09. Additionally, there is no State or Federal MCL for acetone, and the concentrations mentioned above are well below the taste and odor threshold of 300,000 µg/L.

A comparison of the 1988, 2007, and 2011 total VOC concentrations in the Qt-$Tnbs_1$ HSUs (Figure 16) shows the extent and magnitude of the VOC plume to decrease over time. Data from 1988 was used to represent the pre-remediation time period because this was the year of maximum VOC concentrations, as previously depicted on Figure 14(a). Also as shown on Figure 16, portions of the plume above 10 µg/L no longer exist. The portion of the plume above 5 µg/L has shifted slightly, from the southeast corner of the pit in 1988 to the south-central portion of the pit (vicinity of EP6-09) in 2007 and 2011.

$Tnbs_1$ Deep HSU:

Carbon tetrachloride and PCE were detected at 2.1 and 0.6 µg/L, respectively, in one sample collected from $Tnbs_1$ Deep HSU well K6-26 in April 1991. 1,1,1-TCA was detected from K6-26 at 0.9 µg/L in November 1991. One sample collected from Qal-Tts HSU well W-33C-01 in May 1990. Neither carbon tetrachloride, PCE, or 1,1,1-TCA nor any other VOCs have been detected above the 0.5 µg/L reporting limit in any other samples from $Tnbs_1$ Deep HSU wells.

Qal-Tts HSU

The VOC 1,1,1-TCA was detected at a concentration of 4.8 µg/L in one sample collected from Qal-Tts HSU well W-33C-01 in May 1990; well below the MCL cleanup standard of 200 µg/L. Neither 1,1,1-TCA nor any other VOCs have been detected above the 0.5 µg/L reporting limit in any other samples from Qal-Tts HSU wells.

2.5.1.1.2. Water-Supply Wells

As discussed in Section 2.2.2, CARNRW1, CARNRW2, CARNRW3, and CARNRW4 are offsite wells owned and operated by the Carnegie SVRA Park; only CARNRW1 and CARNRW2 are used as active water-supply wells. CARNRW1 is screened across the Qt-$Tnbs_1$ North and $Tnbs_1$ Deep HSUs. CARNRW2 and CARNRW3 are screened in the $Tnbs_1$ Deep HSU, and CARNRW4 is screened Qal-Tts HSU. DOE monitors these wells monthly for VOCs.

No VOCs have ever been detected in water-supply well CARNRW1 since monitoring began in 1984. VOCs are not detected in water-supply well CARNRW2, except for sporadic THM detections at concentrations below the total THM MCL of 80 µg/L (as a result of routine chlorination of this well). TCE was detected once in well CARNRW3 (2.8 µg/L, August 2005), however, the duplicate sample did not contain TCE (<0.5 µg/L). No other VOCs have ever been detected in CARNRW3. No VOCs have ever been detected in well CARNRW4.

Guard well W-PIT6-1819 was drilled upgradient of active water-supply wells CARNRW1 and CARNRW2 in 2002 to provide an early indication of migration of the VOC plume towards these wells. VOCs have not been detected in samples from well W-PIT6-1819 since monitoring began in 2002.

2.5.1.1.3. Springs

While TCE has historically been detected in shallow well BC6-13, which monitors Spring 7, at concentrations of up to 110 µg/L. This well (and spring) has been dry since 2000. TCE was detected in the last sample collected before the well and spring went dry at a concentration of

4 µg/L. However, DOE continues to monitor well BC6-11, which is used to monitor Spring 7, for water from which to collect a sample.

Spring 8, located upgradient of Pit 6, has not yielded detectable TCE concentrations when sampled. VOCs have been detected in Spring 15 once at a concentration of 1.2 µg/L (November 1991), however, this spring has been dry since 1991.

2.5.1.1.4. VOC Remediation Progress Summary

In general, VOCs in ground water near Pit 6 exhibit decreasing trends and the VOC plume extent is stable to decreasing. VOC concentrations in Pit 6 ground water have decreased from a historic maximum of 253 µg/L in 1988 to a fourth quarter 2011 maximum of 5.9 µg/L. The remediation progress summary for VOC COCs (chloroform, 1,2-DCA, cis-1,2-DCE, trans-1,2-DCE, PCE, 1,1,1-TCA, and TCE) in Pit 6 Landfill ground water include:

1,2-DCA concentrations of 1,2-DCA decreased to and have remained below its 0.5 µg/L MCL cleanup standard and reporting limit in all Qt-$Tnbs_1$ HSU wells since 1998 (including in the two new Pit 6 wells W-PIT6-2816 and W-PIT6-2817 installed in 2012). 1,2-DCA has never been detected above the 0.5 µg/L reporting limit in any samples from $Tnbs_1$ Deep or Qal-Tts HSU wells.

Cis-1,2-DCE has only been detected twice at concentrations above its 6 µg/L MCL cleanup standard in Qt-$Tnbs_1$ HSU Pit 6 wells, and not been detected in any Qt-$Tnbs_1$ HSU wells above this cleanup standard since 1993 (including in the two new Pit 6 wells W-PIT6-2816 and W-PIT6-2817 installed in 2012). Cis-1,2-DCE is currently detected above the 0.5 µg/L reporting limit, but below its 6 µg/L MCL cleanup standard in only one Pit 6 Qt-$Tnbs_1$ HSU ground water monitor well (K6-01S) at a concentration of 2.2 µg/L (fourth quarter 2011). Cis-1,2-DCE has never been detected above the 0.5 µg/L reporting limit in any samples from $Tnbs_1$ Deep or Qal-Tts HSU wells.

Trans-1,2-DCE concentrations decreased to and have remained below the 0.5 µg/L reporting limit in all Pit 6 wells since 1993 (including in the two new Pit 6 wells W-PIT6-2816 and W-PIT6-2817 installed in 2012).

PCE has never been detected at concentrations exceeding its 5 µg/L MCL cleanup standard in any Pit 6 wells, (the maximum historical concentration of PCE detected was 3.2 µg/L in 1988). PCE has not been detected at concentrations above the 0.5 µg/L reporting limit in any Pit 6 wells since 2008 (including in the two new Pit 6 wells W-PIT6-2816 and W-PIT6-2817 installed in 2012).

1,1,1-TCA has never been detected in any Pit 6 wells at concentrations above its 200 µg/L MCL cleanup standard (the maximum historical concentration of 1,1,1-TCA detected was 13 µg/L in 1990). 1,1,1-TCA has not been detected above the 0.5 µg/L reporting limit in any Pit 6 wells since 2000 (including in the two new Pit 6 wells W-PIT6-2816 and W-PIT6-2817 installed in 2012).

Concentrations of chloroform have decreased to below the 0.5 µg/L reporting limit in all Pit 6 wells.

TCE is currently present above its 5 µg/L MCL cleanup standard in only one well (5.9 µg/L in EP6-09), located immediately adjacent to the south-central portion of the pit. Because TCE concentrations rebounded in well EP6-09 following two months of extraction and treatment from this well in 1998 and have remained relative stable since 2008, DOE will monitor TCE in this well over the next five years. If TCE concentrations increase or remain above 5 µg/L cleanup standards, remedial measures such as pump-and-treat or enhanced *in situ* bioremediation will be considered for this well.

No VOCs are currently detected in any of the Carnegie SVRA water-supply wells, or in upgradient guard well W-PIT6-1819. VOCs exceed the MCL cleanup standard in only one well, located onsite approximately 1,300 ft upgradient of the these offsite water-supply wells. Both the guard well and water-supply wells will continue to be monitored for VOCs to provide an early indication of changes that could result in impacts to the water-supply wells. No VOCs have been detected in Spring 8, and Springs 7 and 15 have been dry since 2000 and 1991, respectively.

Therefore, the remedy for VOCs in ground water at the Pit 6 Landfill OU 3 is considered to be effective and protective. DOE is recommending the removal of 1,2-DCA, cis-1,2-DCE, trans-1,2-DCE, PCE, and 1,1,1-TCA as COCs in Section 2.9.

2.5.1.2. Tritium Concentrations, Distribution, and Remediation Progress

Tritium has never been detected at activities near or above the 20,000 pCi/L MCL cleanup standard in Pit 6 ground water. Tritium activities have decreased from a historic maximum of 3,420 pCi/L in 2000 to a fourth quarter 2011 maximum of 190 pCi/L. Tritium activities and distribution in Pit 6 ground water and remediation progress for the individual HSUs, downgradient water-supply wells, and springs are discussed below.

2.5.1.2.1. Tritium Activities and Distribution by HSU:

Qt-Tnbs$_1$ HSU

Tritium contamination in the Pit 6 Landfill OU ground water has historically been detected in both the Qt-Tnbs$_1$ North and South HSUs. Tritium activities in the Qt-Tnbs$_1$ HSU ground water have decreased from a historic maximum of 3,420 pCi/L (BC6-13, 2000) to a five-year review period maximum of 503 pCi/L (K6-19, 2007) to a current maximum of 190 pCi/L (K6-19). Well BC6-13 has been dry since 2000. The distribution of tritium activities in the Qt-Tnbs$_1$ HSUs in the second semester of 2011 is presented on Figure 17. Tritium activities and distribution in the Qt-Tnbs1 North and South HSUs are discussed below.

Qt-Tnbs$_1$ North HSU - Within the Qt-Tnbs$_1$ North HSU, the tritium plume (activity contour greater than 100 pCi/L) extends from the pit to immediately east of guard well W-PIT6-1819. Guard well W-PIT6-1819 was drilled in 2002, and tritium activities in this well have ranged from <100 to 295 pCi/L.

As shown on Figure 17, the highest tritium activities (greater than 1,000 pCi/L) occur in the Qt-Tnbs$_1$ North HSU immediately east of the pit and in the vicinity of well K6-36. Well (K6-36) has been dry since 2006, and the tritium activity in this well from August 2006 (1,200 pCi/L) was used for plume contouring.

As shown on Figure 18, tritium activities in Qt-Tnbs$_1$ North HSU wells have decreased from a historic maximum of 2,150 pCi/L (K6-36, August 2000) to a current maximum of 270 pCi/L (W-PIT6-1819, July 2011). Due to dry conditions, samples have not been collected from wells K6-36 and K6-24 since August 2006 and January 2011, respectively. Tritium activities in well K6-36 show a significant decreasing trend from 2000 to 2006. Tritium activities in well K6-24 show an increasing trend from 1998 to 1999 and then a decreasing trend from 1999 to January 2011. Tritium activities in well K6-33 show an increasing trend from 1997 to 2000 and then a decreasing trend from 2000 to 2011. Guard well W-PIT6-1819 has shown a generally stabilized trend since 2002.

DOE collected samples for tritium analysis from the two new monitor wells W-PIT6-2816 and W-PIT6-2817 installed in 2012 in areas where Qt-$Tnsb_1$ North HSU wells had gone dry. Tritium was detected at an activity of 122 pCi/L in a ground water sample collected from well W-PIT6-2817 and was not detected above the 100 pCi/L reporting limit in W-PIT6-2817.

Qt-$Tnbs_1$ South HSU - Within the Qt-$Tnbs_1$ South HSU, the tritium plume extends from the pit to immediately east of well K6-18. Tritium has not been detected in guard well K6-17. As shown on Figure 19, tritium activities in Qt-$Tnbs_1$ South HSU wells have decreased from a historic maximum of 2,520 pCi/L (K6-19, October 1999) to a current maximum of 190 pCi/L in the same well (October 2011). Well K6-19 is located immediately adjacent to the southeast corner of the pit. Qt-$Tnbs_1$ South HSU well BC6-13, which yielded the historic maximum tritium activity in the Pit 6 OU, is not shown on Figure 19 because it has been dry since 2000. Tritium activities in well K6-19 show a significant increase from 1997 to 1998, a stable trend greater than 1,000 pCi/L from 1998 to 2000, a significant decrease from 2000 to 2003, and a generally stable to slightly decreasing trend since 2003. Tritium activities in wells K6-16 and K6-18 show an increase from 1997 to 2003. Since 2003, well K6-16 shows a significant decreasing trend and well K6-18 shows a generally stable trend. Tritium was not sampled for in wells K6-16 and K6-18 from 1998 to 2002. Tritium activities in well K6-01S show an increase from 1998 to 2004, and a significant decrease since 2004.

A comparison of the 1998, 2007, and 2011 tritium activities in the Qt-$Tnbs_1$ HSU (Figure 20) shows the general extent and magnitude of the tritium plume has decreased over time. Although the landfill was capped in 1997, data from 1998 was used to represent the pre-remediation time period because this was the beginning of the time period (1998 to 2000) when the maximum tritium activities occurred (greater than 1,000 pCi/L in K6-19). Tritium activities from 1998 were contoured using an estimate of 1998 tritium activity in guard well W-PIT6-1819, which was drilled in 2002.

$Tnbs_1$ Deep HSU

Tritium has been detected in samples collected from $Tnbs_1$ Deep HSU well K6-26 four times: 400 pCi/L in February 1998, 1,680 pCi/L in May 1999, 126 pCi/L in January 2004, and 108 pCi/L in March 2009. Tritium has not been detected in any other samples from $Tnbs_1$ Deep HSU wells.

Qal-Tts HSU

Except for the detection of tritium in two samples collected from well CARNRW4 at activities slightly above the reporting limit (109 and 192 pCi/L in July and October 2005, respectively), tritium has never been detected in Qal-Tts HSU ground water.

2.5.1.2.2. Water-Supply Wells

Tritium has not been detected in water-supply wells CARNRW1, CARNRW2, or CARNRW3. Tritium activities have been below the reporting limit in well CARNRW4, except for two samples collected from well CARNRW4 (109 and 192 pCi/L in July and October 2005, respectively).

2.5.1.2.3. Springs

Tritium has been detected in shallow well BC6-13, which monitors Spring 7, at a historical maximum concentration of 3,420 pCi/L in May 2000. However, this well and spring have been dry since 2000, so DOE/LLNL have been unable to collect more recent samples since then. Tritium has not been detected in Springs 8 or 15.

2.5.1.2.4. Tritium Remediation Progress Summary

Tritium has never been detected near or above the 20,000 pCi/L MCL cleanup standard. Tritium activities in Pit 6 ground water have decreased from a historic maximum of 3,420 pCi/L in 2000 to a fourth quarter 2011 maximum of 190 pCi/L, indicating that natural attenuation is effective in reducing tritium activities towards background levels.

No tritium is currently detected in any of the Carnegie SVRA water-supply wells above the 100 pCi/L reporting limit. While tritium is currently detected in the upgradient guard well W-PIT6-1819, its activity (270 pCi/L) is several orders of magnitude below the MCL cleanup standard. Both the guard well and water-supply wells will continue to be monitored for tritium to provide an early indication of changes that could result in impacts to the water-supply wells. No VOCs have been detected in Spring 8, and Springs 7 and 15 have been dry since 2000 and 1991, respectively.

Tritium activities in ground water continue to decrease toward background levels and remain significantly below the 20,000 pCi/L cleanup standard, and the tritium plume extent is stable to decreasing. Therefore, the MNA remedy for tritium in ground water at the Pit 6 Landfill OU 3 is considered to be effective, and no optimization measures are needed.

2.5.1.3. Perchlorate Concentrations, Distribution, and Remediation Progress

Perchlorate concentrations in Pit 6 ground water have decreased from a historic maximum of 65.2 µg/L in 1998 to below the 4 µg/L reporting limit in all wells during 2011. Perchlorate concentrations (all less than 4 µg/L) in the Qt-Tnbs$_1$ HSUs in the first semester of 2011 are presented on Figure 21. Some wells north of the fault zone have been dry the last several years, and perchlorate samples have not been collected.

Perchlorate concentrations and distribution in Pit 6 ground water and remediation progress for the individual HSUs, downgradient water-supply wells, and springs are discussed below.

2.5.1.3.1. Perchlorate Concentrations and Distribution by HSU:

Qt-Tnbs$_1$ HSU

Perchlorate contamination in the Pit 6 Landfill OU ground water has historically been detected primarily in the Qt-Tnbs$_1$ HSUs. Perchlorate concentrations in the Qt-Tnbs$_1$ HSUs have decreased from a historic maximum of 65.2 µg/L (K6-19, Qt-Tnbs1 South HSU, 1998) to a five-year review period maximum of 6.9 µg/L (K6-18, 2009) to below the 4 µg/L reporting limit in all wells during 2011. Perchlorate concentrations in the Qt- Qt-Tnbs$_1$ North and South HSUs are discussed below.

Qt-Tnbs$_1$ North HSU - As shown on Figure 22, perchlorate concentrations in Qt-Tnbs$_1$ North HSU wells have decreased from a historic maximum of 9.8 µg/L (K6-24, May 2000) to below the 4 µg/L reporting limit by 2005. Well K6-36 shows a decreasing trend from 2000 to 2004 and concentrations less than 4 µg/L from 2005 to 2006, before going dry in 2006. Perchlorate has not been detected in Qt-Tnbs$_1$ North HSU guard well W-PIT6-1819.

DOE collected samples for perchlorate analysis from the two new monitor wells W-PIT6-2816 and W-PIT6-2817 installed in 2012 in areas where Qt-$Tnsb_1$ North HSU wells had gone dry. Perchlorate was not detected in ground water samples collected from wells W-PIT6-2816 and W-PIT6-2817.

Qt-$Tnbs_1$ South HSU - As shown on Figure 23, perchlorate concentrations in Qt-$Tnbs_1$ South HSU wells have decreased from a historic maximum of 65.2 µg/L (K6-19, 1998) to below the 4 µg/L reporting limit in 2010. Wells K6-16 and K6-19 both show a significant decreasing trend with concentrations consistently below 4 µg/L after 2001. Well K6-18 shows a significant decreasing trend from 1999 to 2000, a more moderate decreasing trend from 2000 to 2009, and concentrations consistently below 4 µg/L after 2009. Perchlorate was detected sporadically in well EP6-09 between 2002 and 2009. Perchlorate has not been detected in Qt-Tnbs1 South HSU guard well K6-17.

$Tnbs_1$ Deep HSU

Perchlorate has never been detected in $Tnbs_1$ Deep HSU ground water monitoring wells.

Qal-Tts HSU

Perchlorate has never been detected in Qal-Tts HSU ground water.

2.5.1.3.2. Water-Supply Wells

Perchlorate has not been detected in water-supply wells CARNRW1, CARNRW3, or CARNRW4. Perchlorate has been detected in one ground water sample from water-supply well CARNRW2 (4.3 µg/L, October 2001), however, the duplicate sample result was below the reporting limit of 4 µg/L.

2.5.1.3.3. Springs

Perchlorate results from samples collected from the Pit 6 springs, when sufficient water was available from which to sample, have been below the reporting limit of 4 µg/L.

2.5.1.3.4. Perchlorate Remediation Progress Summary

Perchlorate concentrations in Pit 6 ground water have decreased significantly from a historical maximum of 65.2 µg/L in 1998 to below the 4 µg/L reporting limit in all wells since 2009 (including in the two new Pit 6 wells W-PIT6-2816 and W-PIT6-2817 installed in 2012). No perchlorate is currently detected in any of the Carnegie SVRA water-supply wells or the upgradient guard well W-PIT6-1819 above the 4 µg/L reporting limit. Both the guard well and water-supply wells will continue to be monitored for perchlorate to provide an early indication of changes that could result in impacts to the water-supply wells. No perchlorate has been detected in the springs in the vicinity of Pit 6.

Therefore, the remedy for perchlorate in ground water at the Pit 6 Landfill OU 3 is considered to be effective and protective. DOE is recommending the removal of perchlorate as COC in Section 2.9.

2.5.1.4. Nitrate Concentrations, Distribution, and Remediation Progress

Nitrate concentrations in Pit 6 OU ground water have decreased from a historic maximum of 240 mg/L (K6-23, 2000) to a current maximum of 150 mg/L in the same well. Nitrate concentrations and distribution in Pit 6 ground water and remediation progress for the individual HSUs, downgradient water-supply wells, and springs are discussed below.

2.1.5.4.1. Nitrate Concentrations and Distribution by HSU:

Qt-Tnbs$_1$ HSU

At the Pit 6 Landfill OU, nitrate concentrations in ground water in excess of cleanup standards have historically been detected in the Qt-Tnbs$_1$ HSUs. Nitrate concentrations in the Qt-Tnbs$_1$ HSU ground water have decreased from a historic maximum of 240 mg/L (K6-23, 2000) to a five-year review period maximum of 220 mg/L (K6-23, 2007) to a current maximum of 150 mg/L in the same well. Nitrate concentrations in the Qt-Tnbs$_1$ HSUs for the first semester of 2011 are presented on Figure 24. As shown on Figure 24, nitrate concentrations in two wells currently exceed the 45 mg/L MCL cleanup standard: K6-23 (130 mg/L) within the Qt-Tnbs$_1$ South HSU and K6-24 (62 mg/L) in the Qt-Tnbs$_1$ North HSU. Nitrate concentrations in the Qt-Tnbs$_1$ North and South HSUs are discussed below.

Qt-Tnbs$_1$ North HSU - As shown on Figure 25, nitrate concentrations in Qt-Tnbs$_1$ North HSU ground water have been well below the 45 mg/L MCL cleanup standard with the exception of two samples from well K6-24 collected in 2011. Nitrate concentrations in well K6-24 shows a generally stable trend at low concentrations (less than 2 mg/L) until 2011 when the concentration increased significantly to 62 mg/L in January and 63 mg/L in April, before going dry in second semester 2011. Wells K6-04 and EP6-08 show generally stable trends until 2004 and decreasing trends since then. Some Qt-Tnbs$_1$ North HSU wells have been dry the last several years, and therefore samples have not been collected. However, DOE collected samples for nitrate analysis from the two new monitor wells W-PIT6-2816 and W-PIT6-2817 installed in 2012 in areas where Qt-Tnsb$_1$ North HSU wells had gone dry. Nitrate was detected at concentrations of 2.1 mg/L in a ground water sample collected from well W-PIT6-2816, and was not detected above the reporting limit in well W-PIT6-2817.

Qt-Tnbs$_1$ South HSU - As shown on Figure 26, nitrate concentrations in South HSU wells have decreased from a historic maximum of 240 mg/L (K6-23, May 2000) to a current maximum of 150 mg/L (July 2011) in the same well. This well (K6-23), as shown on Figure 25, has consistently yielded nitrate concentrations in excess of the 45 mg/L MCL cleanup standard (ranging in concentration between 130 and 240 mg/L). Well K6-23 is located in close proximity to the Building 899 septic system, a potential source of the nitrate. The nitrate time-series for well K6-18 (Figure 25) shows that nitrate exceeded the MCL cleanup standard in 1998 and 2009, but otherwise shows a general decreasing trend. Nitrate concentrations in wells K6-16 and EP6-09 show generally stable to slightly increasing trends, with concentrations well below the MCL cleanup standard.

Tnbs$_1$ Deep HSU

Nitrate has never been detected in Tnbs$_1$ Deep HSU ground water monitoring wells.

Qal-Tts HSU

Nitrate has historically been detected in Qal-Tts HSU ground water, however, concentrations have been significantly below the 45 mg/L MCL cleanup standard and within the range of background levels.

2.1.5.4.2. Water-Supply Wells

While nitrate is sporadically detected in downgradient active water-supply wells CARNRW1 and CARNRW2 above the reporting limit, nitrate concentrations detected in these well (less than 5.2 mg/L) are well below the 45 mg/L MCL cleanup standard, and within the range of background levels. Nitrate has also been detected in cross-gradient well CARNRW4, however concentrations have been significantly below the 45 mg/L MCL cleanup standard and within the range of background levels. Nitrate has not been detected in downgradient well CARNRW3.

2.1.5.4.3. Springs

Nitrate has not been detected from Pit 6 springs, when sampled.

2.1.5.4.4. Nitrate Remediation Progress Summary

Nitrate concentrations in Pit 6 ground water have decreased from a historic 240 mg/L in 2000 to a current maximum of 150 mg/L. Nitrate is currently present above the 45 mg/L MCL in only two wells; K6-23 and K6-24. Nitrate continues to be detected above the 45 mg/L cleanup standard in well K6-23, with concentrations ranging from 130 to 240 mg/L. The nitrate concentrations in this well may be attributable to the septic system at Building 899. Nitrate was also detected during the first semester 2011 for the first time above the 45 mg/L cleanup standard in well K6-24 (62 mg/L in January and 63 mg/L in April), before going dry in second semester 2011. While the remedy for nitrate in ground water at the Pit 6 Landfill OU 3 is considered to be effective, DOE will continue to investigate the cause/source of the high nitrate concentrations in wells K6-23 and K6-24.

No nitrate is currently detected in any of the Carnegie SVRA water-supply wells or the upgradient guard well W-PIT6-1819 above the 0.5 mg/L reporting limit. Nitrate concentrations in these well have always been well below the 45 mg/L MCL cleanup standard and within the range of background levels. Both the guard well and water-supply wells will continue to be monitored for nitrate to provide an early indication of changes that could result in impacts to the water-supply wells. No nitrate has been detected in the springs in the vicinity of Pit 6.

Therefore, the remedy for nitrate in ground water at the Pit 6 Landfill OU 3 is considered to be effective and protective.

2.5.2. Pit 6 Landfill Detection Monitoring and Results

Detection monitoring of the Pit 6 Landfill is conducted to identify any future releases to ground water in accordance with the requirements of the Pit 6 Post-Closure Plan. As part of the detection monitoring program, ground water samples are collected from wells located upgradient and wells directly downgradient of the landfill and analyzed for potential constituents of concern.

Potential constituents of concern, as defined by Title 23 of the California Code of Regulations, Chapter 15, are:

- Constituents identified in disposal records or that are potentially associated with the buried waste.
- Constituents detected above background concentrations in soil, ground water, and/or surface water in the immediate vicinity of the landfill, indicating a previous release.
- Constituents or breakdown products that can reasonably be expected to be associated with the type of waste disposed in the landfill.

Twenty-four constituents of concern, including VOCs, beryllium, mercury, perchlorate, tritium, uranium, and gross alpha/beta as surrogates for seven other radionuclides, are currently monitoring quarterly in the Pit 6 detection monitoring wells (EP6-06, EP6-08, EP6-09, K6-01S, K6-19, and K6-36). Field measurements of ground water physical parameters are collected at the time of sampling.

Statistical analyses and comparison of upgradient and downgradient concentrations of these constituents are used to determine if additional releases have occurred from the landfill. Statistical analysis of detection monitoring results started in 1998. Since then, three statistically significant evidence of releases have been reported based on comparisons to statistical limits as follows:

- In 1998, well EP6-09 exceeded its 1,2-DCA statistical limit of 0.5 µg/L with a concentration of 0.68 µg/L.
- In 2007, well EP6-08 exceeded its TCE statistical limit of 0.5 µg/L with a concentration of 0.8 µg/L.
- In 2008, well EP6-08 exceeded its uranium statistical limit of 1.62 pCi/L with an activity of 2.97 pCi/L.

These statistical limit exceedances were evaluated at the time, and the RWQCB concurred that they were not indicative of new releases because (1) both 1,2-DCA and TCE are known to have been released to ground water prior to the capping of Pit 6 as VOCs have historically been detected in both EP6-08 and EP6-09; (2) naturally occurring uranium is known to be present in Site 300 ground water, concentrations detected in well EP6-08 have always been within the background range for natural uranium, and the uranium-235/uranium-238 ($^{235}U/^{238}U$) atom ratio measured in Pit 6 detection monitor wells indicate that the uranium is natural (0.007); and (3) these concentration variances from the statistical limits, which are near reporting limits in these wells, are attributable to changes in hydrogeologic conditions.

A number of factors could cause a constituent's concentration in ground water to increase without being indicative of a new release from the landfill. Hydrogeologic conditions can change quickly even if they have been stable for a number of years. For example, if a high rainfall year occurs following several years of drought, especially immediately downgradient of a recharge area, it can cause water levels to rise and pick up residual VOCs or other constituents in the vadose zone that were released prior to capping. Similarly, increases in concentration of naturally occurring metals can result if water levels rise into soil or rock containing residual metal salts that were previously deposited when water levels dropped during drought periods. Additionally, DOE/LLNL briefly pumped and treated ground water from well EP6-09. After an initial decrease in VOC concentrations in this well, TCE concentrations increased when pumping ceased.

Based on evaluations of detection monitoring results since 1998, there have been no new releases of COCs since the landfill was capped.

2.5.3. Pit 6 Landfill OU Performance Issues

The remedy continues to be effective and protective of human health and the environment, and to make progress toward cleanup. Therefore, no performance issues were identified.

2.5.4. Pit 6 Landfill OU Risk Mitigation Remediation Progress

This section summarizes the results of the annual risk re-evaluations conducted for the Pit 6 Landfill OU to assess the progress of the remedy in mitigating risk associated with VOCs in the pit waste, at Spring 7, and in ground water that could migrate to the Carnegie SVRA Park wells and pond. The risks from COCs at the Pit 6 OU Landfill were summarized in Section 2.2.5 and are discussed in more detail in the 2008 Site-Wide ROD.

The cancer risks and hazard indices identified in the baseline human health risk assessment for OU 3 and the status/progress of the remedy in mitigating those risks and hazards are as follows:

- Pit 6 Landfill – A cumulative risk of 5×10^{-6} was estimated for onsite workers, assuming continuous inhalation of VOC vapors volatilizing from the landfill and migrating into outdoor air over a 25-year period. The landfill cap, installed as part of a CERCLA removal action in 1997, mitigated the inhalation risk associated with VOCs in the landfill waste.
- The Carnegie SVRA pond (offsite, east of the Pit 6 Landfill) – A cumulative hypothetical risk of 3×10^{-6} was estimated for offsite residence that could potentially inhale VOC vapors volatilizing from the Carnegie SVRA pond and migrating into outdoor air. Although water-supply well CARNRW1 is actually used to fill the Carnegie SVRA pond, the baseline risk assessment conservatively assumed that in the future, well CARNRW2, which has a much longer well screen than CARNRW1, could be used to provide water to the SVRA pond. The baseline risk assessment indicated that if the VOC source in the Pit 6 Landfill OU was not controlled, contaminated ground water could migrate to well CARNRW2 and result in an unacceptable risk from inhaling VOC vapors volatilizing from the pond. However, an engineered cap was placed over the Pit 6 Landfill preventing infiltration of precipitation and further releases of contaminants from the landfill. The VOC plume originating from the Pit 6 Landfill has not impacted CARNRW2. In addition, ground water VOC concentrations upgradient have substantially decreased, and are below the MCL cleanup standards, except for TCE in one well located onsite approximately 1,300 ft upgradient of CARNRW2. Therefore, no unacceptable risk or hazard exists at the Carnegie SVRA pond.
- Spring 7 – A cumulative risk of 4×10^{-5} and HI of 1.5 was estimated for onsite workers, assuming continuous inhalation of VOC vapors volatilizing from the Spring 7 and migrating into outdoor air over a 25-year period. The CMP/CP requires that the risk associated with volatile contaminants in surface water migrating upward into outdoor ambient air and being inhaled by workers be re-evaluated annually using current data and reported in the annual ERD Compliance Monitoring Reports. DOE, EPA, and the State regulatory agencies agreed that the risk would be considered successfully mitigated and risk management would be complete when the estimated risk is below 10^{-6} for two consecutive years. Risk re-evaluation and reporting for VOC inhalation in outdoor air near Spring 7 was initiated in 2003. No one regularly works in the vicinity of Spring 7 and this spring has been dry since 2000. Therefore, there is currently no potential for VOC inhalation from this spring. In addition, Spring 7 is fed by ground water and VOC concentrations in ground water in the Pit 6 Landfill area have decreased significantly. Therefore DOE/NNSA assumes that if surface water were present in this spring, the risk associated with the inhalation of VOCs has likely been reduced. The spring is and will continue to be monitored for the presence of surface water or green hydrophilic vegetation, and if either is observed, ambient air in the vicinity of the spring will be sampled to evaluate risk.

On September 28, 2011, the U.S. EPA released updated toxicity values and contaminant characteristics for TCE in the Integrated Risk Information System (IRIS) (EPA, 2011). Currently, the only significant impact of this change is presumed to be on the assessment of risk for the vapor inhalation pathway. As part of this report, on-site worker inhalation risks associated with vapor intrusion from the subsurface into indoor and outdoor air in the Pit 6 Landfill OU were evaluated using the new toxicity values where applicable. The Jury model (Jury et al., 1983) was used to assess the risk to onsite workers breathing in outdoor air containing TCE. The risk level in outdoor air was less than $1x10^{-6}$ and the hazard quotient was less than 1. For indoor air near building 899B, the Johnson-Ettinger model (1991) was used to assess the inhalation risk to onsite workers. Near Building 899B, only TCE has been detected above the reporting limit in ground water during the past five years. The risk assessment conducted for TCE using the Johnson-Ettinger model determined that the risk level was less than $1x10^{-6}$ and that the hazard quotient was less than 1 for this building.

The baseline ecological assessment indicated an inhalation risk for individual ground squirrels and kit fox from VOCs volatilizing from the Pit 6 Landfill (the combined inhalation Hazard Indices exceeded 1 for these species).

A burrow air-sampling program was conducted in 2004 to determine actual exposure concentrations. The results of the ecological survey program reported in the First Semester 2004 Compliance Monitoring Report (Dibley et al., 2004) indicated that burrow air did not contain VOCs at concentrations that would result in a HI or quotient greater than 1. Since there is no potential for ecological harm, VOCs in burrow air were deleted from the list of ecological COCs and are no longer evaluated and reported in the Compliance Monitoring Reports. In addition, surveys for sensitive species at the Pit 6 Landfill have been discontinued. (Note: kit foxes have never been observed in any ecological surveys at Site 300 or by Site 300 personnel working at the site. Risk for this sensitive species was evaluated due to the presence of potential habitat at Site 300.)

A Site-Wide Five-Year Ecological Review was performed in 2008 (Dibley et al., 2009c). No new ecological hazards were identified in the Pit 6 Landfill OU. No information was identified during this review to question the ecological protectiveness of the remedy.

2.6. Pit 6 Landfill OU Interviews and Site Inspection

DOE/NNSA and LLNL meet monthly with the EPA, RWQCB, and DTSC Remedial Project Managers (RPMs) and quarterly with a community action group at Technical Assistance Grant Meetings to discuss remediation activities, issues, and cleanup status and progress.

There is a continuous presence of ERD staff at Site 300 that routinely inspect the monitoring wellfield during sampling activities. The Pit 6 Landfill cap and associated drainage ways are annually inspected by an independent Registered Professional Civil Engineer. LLNL conducts self-assessment inspections and DOE/NNSA conducts quarterly 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 February 5, 2008. The Five-Year Review Inspection was performed by DOE/NNSA on August 16, 2011. The Five-Year Review Inspection Checklist is included as Attachment A.

Operational issues and resulting corrective actions identified during routine inspections associated with the landfill and monitoring wellfields are: (1) described in the Site 300 Compliance Monitoring Reports that are issued semi-annually by the LLNL ERD and quarterly and annually by the LLNL Environmental Functional Area 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 that are distributed following the meetings.

2.7. Pit 6 Landfill OU Technical Assessment

The protectiveness of the remedy was assessed by determining if:

1. The remedy is functioning as intended at the time of the decision documents.
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.

2.7.1. Remedy Function

The remedy was determined to be functioning as intended at the time of the decision documents because:

- No early indicators of potential remedy failure were identified.
- Costs have generally been within budget.
- The remedy is functioning as intended by reducing COC concentrations/activities.
- The Pit 6 Landfill cap is performing as designed, and new releases from the landfill have been detected since the cap was installed.
- 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.

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

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

- There have been no 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 or ecological receptors has been identified.
- There have been no changes in land, building, or water use.
- No new contaminants or sources have been identified.
- No remedy byproducts have been identified.
- Changes in location-, chemical-, or action-specific applicable or relevant and appropriate requirements (ARARs) or to-be-considered requirements:
  - The State of California established a 6 µg/L MCL for perchlorate on October 18, 2007. This action-specific ARAR and ARARs related to ground water cleanup were included in the 2008 Site-Wide ROD.

  - 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 Pit 6 OU remedy.
- Changes in toxicity and other contaminant characteristics:
  - On September 28, 2011, the U.S. EPA released updated toxicity values and contaminant characteristics for TCE in the IRIS. Currently, the only significant impact of this change is presumed to be on the assessment of risk for the vapor inhalation pathway. As discussed in Section 2.5.4, the inhalation risks associated with vapor intrusion from the subsurface into indoor and outdoor air for TCE for onsite workers were evaluated using the new toxicity values where applicable. No risk was identified for the vapor inhalation pathway.
- The review found that the remedy is making progress toward meeting the RAOs.

2.7.3. 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.
- No unanticipated events (i.e., natural disasters, new contaminants discovered, etc.) occurred that would call the protectiveness of the remedy into question.
- No additional information has been identified that would call the protectiveness of the interim remedy into question.
- No new technologies have been identified that are capable of accelerating or achieving cleanup in a more cost-effective manner in the Pit 6 Landfill OU.

2.8. Pit 6 Landfill OU Issues

No issues were identified during this evaluation.

2.9. Pit 6 Landfill OU Recommendations and Follow-Up Actions

The following recommendations to be carried out by the DOE/NNSA were developed during the review process:

1. Over the next five years, monitor TCE concentrations in ground water at well EP6-09; if concentrations increase or remain above 5 µg/L, remedial measures such as pump-and-treat or enhanced *in situ* bioremediation will be considered for this well.
2. Remove 1,2-DCA as a ground water COC because: (1) concentrations of 1,2-DCA decreased to and have remained below its 0.5 µg/L MCL cleanup standard and reporting limit in all Qt-$Tnbs_1$ HSU wells since 1998 (including in the two new Pit 6 wells W-PIT6-2816 and W-PIT6-2817 installed in 2012), and (2) 1,2-DCA has never been detected above the 0.5 µg/L reporting limit in any samples from $Tnbs_1$ Deep or Qal-Tts HSU wells. However, ground water samples from Pit 6 monitor wells would still be analyzed for VOCs by EPA Method 601 to monitor for TCE and chloroform in the remedial action monitor wells and for detections of any VOCs (including 1,2-DCA) in

the detection monitor wells. 1,2-DCA results would still be reported/discussed in the Detection Monitoring section of the Compliance Monitoring Reports, but would no longer be discussed in the Contaminant Concentrations and Distribution section of these reports unless it is detected in the remedial action monitor wells.

3. Remove cis-1,2-DCE as a ground water COC because: (1) cis-1,2-DCE has only been detected twice at concentrations above its 6 µg/L MCL cleanup standard in Qt-$Tnbs_1$ HSU Pit 6 wells, and not been detected in any Qt-$Tnbs_1$ HSU wells above this cleanup standard since 1993 (including in the two new Pit 6 wells W-PIT6-2816 and W-PIT6-2817 installed in 2012), (2) cis-1,2-DCE is currently detected above the 0.5 µg/L reporting limit in only one Pit 6 Qt-$Tnbs_1$ HSU ground water monitor well (K6-01S) at a concentration of 2.2 µg/L (fourth quarter 2011), and (3) cis-1,2-DCE has never been detected above the 0.5 µg/L reporting limit in any samples from $Tnbs_1$ Deep or Qal-Tts HSU wells. However, ground water samples from Pit 6 monitor wells would still be analyzed for VOCs by EPA Method 601 to monitor for TCE and chloroform in the remedial action monitor wells and for detections of any VOCs (including cis-1,2-DCE) in the detection monitor wells. Cis-1,2-DCE concentrations would still be reported/discussed as part of the evaluation of TCE MNA and detection monitoring in the Compliance Monitoring Reports.
4. Remove trans-1,2-DCE as a ground water COC because concentrations decreased to and have remained below the 0.5 µg/L reporting limit in all Pit 6 wells since 1993 (including in the two new Pit 6 wells W-PIT6-2816 and W-PIT6-2817 installed in 2012). However, ground water samples from Pit 6 monitor wells would still be analyzed for VOCs by EPA Method 601 to monitor for TCE and chloroform in the remedial action monitor wells and for detections of any VOCs (including trans-1,2-DCE) in the detection monitor wells. Trans-1,2-DCE results would still be reported/discussed in the Detection Monitoring section of the Compliance Monitoring Reports, but would no longer be discussed in the Contaminant Concentrations and Distribution section of these reports unless it is detected in the remedial action monitor wells.
5. Remove PCE as a ground water COC because: (1) PCE has never been detected at concentrations exceeding its 5 µg/L MCL cleanup standard in any Pit 6 wells, (the maximum historical concentration of PCE detected was 3.2 µg/L in 1988), and (2) PCE has not been detected at concentrations above the 0.5 µg/L reporting limit in any Pit 6 wells since 2008 (including in the two new Pit 6 wells W-PIT6-2816 and W-PIT6-2817 installed in 2012). However, ground water samples from Pit 6 monitor wells would still be analyzed for VOCs by EPA Method 601 to monitor for TCE and chloroform in the remedial action monitor wells and for detections of any VOCs (including PCE) in the detection monitor wells. PCE results would still be reported/discussed in the Detection Monitoring section of the Compliance Monitoring Reports, but would no longer be discussed in the Contaminant Concentrations and Distribution section of these reports unless it is detected in the remedial action monitor wells.
6. Remove 1,1,1-TCA as a ground water COC because: (1) 1,1,1-TCA has never been detected in any Pit 6 wells at concentrations above its 200 µg/L MCL cleanup standard (the maximum historical concentration of 1,1,1-TCA detected was 13 µg/L in 1990), and (2) 1,1,1-TCA has not been detected above the 0.5 µg/L reporting limit in any Pit 6 wells since 2000 (including in the two new Pit 6 wells W-PIT6-2816 and W-PIT6-2817

installed in 2012). However, ground water samples from Pit 6 monitor wells would still be analyzed for VOCs by EPA Method 601 to monitor for TCE and chloroform in the remedial action monitor wells and for detections of any VOCs (including 1,1,1-TCA) in the detection monitor wells. 1,1,1-TCA results would still be reported/discussed in the Detection Monitoring section of the Compliance Monitoring Reports, but would no longer be discussed in the Contaminant Concentrations and Distribution section of these reports unless it is detected in the remedial action monitor wells.

7. Remove perchlorate as a ground water COC because perchlorate concentrations have decreased to and remained below the 4 µg/L reporting limit in all Pit 6 wells for over three years (including in the two new Pit 6 wells W-PIT6-2816 and W-PIT6-2817 installed in 2012). However, ground water samples from Pit 6 Landfill detection monitor wells would still be submitted for perchlorate analysis as part of the detection monitoring program to detect future releases from the Pit 6 Landfill. The perchlorate results would still be reported/discussed in the Detection Monitoring section of the Compliance Monitoring Reports, but would no longer be discussed in the Contaminant Concentrations and Distribution section of these reports unless it is detected in the remedial action monitor wells.

No other follow-up actions were identified related to this Five-Year Review.

2.10. Pit 6 Landfill OU Protectiveness Statement

The remedy at the Pit 6 Landfill OU is protective of human health and the environment for the site's industrial land use. The remedy protects human health because: (1) tritium activities in ground water are below cleanup standards and are decreasing toward background levels, the extent of VOCs and nitrate with concentrations exceeding cleanup standards are limited to a few wells, and perchlorate is not detected in ground water, (2) the VOC inhalation risk to onsite workers has been mitigated by the installation of the landfill cap, (3) ground water monitoring will provide an early indication of migration of contaminants towards the site boundary and offsite water-supply wells, and (4) exposure pathways that could result in unacceptable risk to onsite workers are being controlled by the implementation of institutional controls, the Health and Safety Plan, and the Contingency Plan.

The cleanup standards for Pit 6 Landfill OU ground water are drinking water standards. Because drinking water standards do not differentiate between industrial and residential use, the ground water cleanup remedy will be protective under any land use scenario.

Because the waste in the Pit 6 Landfill will remain in place 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 is included in the Site-Wide ROD. This prohibition will remain in place until and unless a risk assessment is performed in accordance with current U.S. EPA risk assessment guidance and is agreed by the DOE, the U.S. EPA, the DTSC, and RWQCB as adequately showing no unacceptable risk for residential or unrestricted land use.

3. Five-Year Review for the Site-Wide OU (OU 8)

The Site 300 Site-Wide OU is comprised of release sites where there was no significant contamination found that can impact human health or the environment. For this reason, OU 8 contains the Site 300 areas with final remedies consisting of monitoring, risk and hazard management, and landfill inspection selected in the 2008 ROD. The Site-Wide OU (OU 8) consists of the following areas of Site 300:

- Building 801 and Pit 8 Landfill (Section 3.1)
- Building 845 Firing Table and Pit 9 Landfill (Section 3.2)
- Building 833 (Section 3.3)
- Building 851 Firing Table (Section 3.4)
- Pit 2 Landfill (Section 3.5)

The Pit 2 Landfill was moved from OU 5 to OU 8 after the Interim ROD.

3.1. Building 801 and Pit 8 Landfill

3.1.1. Building 801 and Pit 8 Landfill Site Chronology

The following is a chronological listing of significant environmental restoration events at the Building 801 and Pit 8 Landfill:

<u>1955–1999</u>

- Building 801 Firing Table was used for explosives testing from 1955 until 2001.
- Gravel was removed from the Building 801 Firing Table under oversight of the RWQCB in 1988.
- The Building 801D Dry Well was active from the late 1950s to about 1984 when it was decommissioned and filled with concrete.
- The Pit 8 Landfill was constructed in 1958.
- Debris from the Building 801 Firing Table was disposed of in Pit 8 until 1974 when an earthen native soil cover was installed.

<u>1990</u>

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

<u>1992</u>

- A FFA was signed for Site 300.

<u>1999</u>

- The Site-Wide Feasibility Study for Site 300 was issued that included Building 801 and the Pit 8 Landfill.

<u>2001</u>

- An Interim Site-Wide ROD for Site 300 was signed. The Interim Site-Wide ROD specified no further action for VOCs in subsurface soil at the Building 801 Dry Well and ground water monitoring as components of the remedy for Building 801 and the Pit 8 Landfill. The Interim Site-Wide ROD did not contain ground water cleanup standards.

- A Remedial Design Work Plan was issued that contained the strategic approach and schedule to implement the remedies in the Interim Site-Wide ROD.
- Outdoor firing experiments were discontinued when an indoor test chamber (the Contained Firing Facility) was built on the site of the former firing table.

2002

- The CMP/CP for Interim Remedies was issued.
- The Contained Firing Facility (CFF) began operating.

2008

- The Site-Wide ROD with selected remedies and cleanup standards for Site 300 was signed. The remedy did not change in the 2008 Site-Wide ROD, with the exception that ground water cleanup standards were established.

2009

- The revised CMP/CP was issued.

3.1.2. Building 801 and Pit 8 Landfill Background

3.1.2.1. Building 801 and Pit 8 Landfill Physical Characteristics

3.1.2.1.1. Building 801 and Pit 8 Landfill Site Description

Building 801 and the Pit 8 Landfill are part of the Building 801 Complex located in the northeastern portion of Site 300 (Figure 2). The Building 801 Complex covers approximately 90 acres and consists of the Building 801 Firing Table (replaced by the CFF in 2001), Buildings 801A, 801B, 801C, and 801D, the Flash X-ray facility, Pit 8 Landfill, an HE storage magazine, and a corporation yard. The Building 801 Complex is located at the base of a wide and shallow valley (Figure 27).

Explosives testing was initiated at the Building 801 Firing Table in 1955. Use of the firing table was suspended briefly in 1988, and the firing table gravel and some underlying soil were removed and disposed of in the Pit 1 Landfill in 1988 under oversight of the RWQCB (Lamarre and Taffet, 1989). Outdoor firing experiments resumed and continued until 2001, when an indoor test chamber, the CFF, was built on the site of the former firing table.

A dry well, located under Building 801D, was used to dispose of rinsewater from a sink in the machine shop at Building 801D from the late 1950s to about 1984. The dry well was decommissioned and filled with concrete in 1984 (Lamarre and Taffet, 1989).

The Pit 8 Landfill is an unlined landfill that was constructed in 1958 immediately northeast of the Building 801 Complex. Debris from the Building 801 Firing Table was disposed of in Pit 8 until 1974 when an earthen cover was installed. The total estimated volume of material disposed of in the Pit 8 Landfill is about 24,700 yd^3.

3.1.2.1.2. Building 801 and Pit 8 Landfill Hydrogeologic Setting

This section describes the hydrogeologic setting for the Building 801 and Pit 8 Landfill area, including the unsaturated zone, the underlying HSU, and surface water. A conceptual hydrostratigraphic column for the northern portion of Site 300 including the Building 801 and Pit 8 Landfill area is shown on Figure 28.

Building 801 and Pit 8 Landfill Vadose (Unsaturated) Zone

The vadose zone consists of unconsolidated Quaternary alluvial and colluvial deposits (Qal) composed of silty and clayey sand and loam on the slopes above Building 801 and in valley bottoms and underlying unsaturated $Tnbs_1$ bedrock. The upper $Tnbs_1$ bedrock is unsaturated to a depth of approximately 130 to 150 ft bgs.

Building 801 and Pit 8 Landfill Saturated Zone

The Building 801 and Pit 8 Landfill area is underlain by a single HSU, the $Tnbs_1/Tnbs_0$ HSU. This HSU consists of the $Tnbs_1$ and the basal blue sandstone ($Tnbs_0$). Ground water is present in the $Tnbs_1/Tnbs_0$ HSU under unconfined to confined conditions. Depth to water averages about 130 to 150 ft bgs. Recharge for this HSU occurs within alluvial channels. Since monitoring of the existing well network began in 1989, ground water flow direction in the $Tnbs_1/Tnbs_0$ HSU has ranged approximately 105 degrees northeast to southeast beneath Building 801 and the Pit 8 Landfill (Figure 27). The exact causes of the observed variability in ground water flow direction are unknown but may include changes in relative contributions of percolation from different recharge areas (both from construction [of impermeable surfaces] at the Building 801 CFF and natural factors), aquifer heterogeneity and variability in porous versus fracture flow, and long term changes in rock hydraulic properties due to seismicity and other processes. The HSU is saturated beneath the entire area and the saturated thickness varies from about 5 to 10 ft.

Building 801 and Pit 8 Landfill Surface Water

Natural surface water in the Building 801 and Pit 8 Landfill area is the result of runoff from precipitation. Natural surface runoff is rarely present, and only occurs briefly during more significant (greater than 0.3 inches/hour) or prolonged (greater than 2 hours) storms. There are no surface water bodies (i.e., springs) in the Building 801 and Pit 8 Landfill area.

3.1.2.2. Building 801 and Pit 8 Landfill 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 7000-acre property-area is developed.

The Building 801 and Pit 8 Landfill area is located in the central portion of Site 300, approximately 5,000 feet southwest of the Site 300 northeastern boundary. Outdoor firing experiments at the Building 801 Firing Table were discontinued in 2001 when the Contained Firing Facility indoor test chamber was built on the site of the former firing table. The Building 801 Contained Firing Facility continues to be regularly used for explosive testing. Use of the Pit 8 Landfill was discontinued and a cover installed in 1974. The Pit 8 Landfill area has not been used for site activities since that time.

There are no active onsite water-supply wells in the Building 801 and Pit 8 Landfill area.

A large area of native perennial grasslands occurs to the south and east of Building 801 and Pit 8 Landfill, whereas annual grasslands occur to the north and west of these facilities, and a small amount of coastal sage scrub occurs to the southeast of the facility. Large numbers of the big tarplant (*Blepharizonia plumosa*), an extremely rare late-season flowering plant included on the California Native Plant Society's List 1B, are routinely mapped around Building 801 and Pit 8 Landfill. The facilities occur within the upland dispersal habitat for the federally threatened California red-legged frog (*Rana aurora draytonii*). Loggerhead shrikes (*Lanius ludovicianus*), and burrowing owls (*Athene cunicularia*), both California Species of Special Concern, have been observed near the facilities. A five-year ecological review reported on in the 2008 Annual Compliance Monitoring Report (Dibley et al., 2009c), which updated the assessment of the ecological impacts from Site 300 contaminants, found no impact to ecological receptors from releases from Building 801 or Pit 8 Landfill. An LLNL ecologist reviewed ecological data collected between 2008 and 2011 for the area to evaluate whether any changes in contaminant or ecological conditions that could impact ecological receptors. No changes were identified. Access to these unique animal and plant populations is controlled and interactions with the wildlife are avoided.

3.1.2.3. Building 801 and Pit 8 Landfill History of Contamination

No environmental contamination has been identified associated with Building 801 Firing Table activities. Waste fluid discharges to the Building 801 Dry Well resulted in low concentrations of VOCs in the surrounding surface and subsurface soil and ground water. Contaminants have not been detected in the vicinity of or beneath the Pit 8 Landfill.

3.1.2.4. Building 801 and Pit 8 Landfill Initial Response

Investigations began in 1982 at the Building 801 and Pit 8 Landfill area to identify any potential contaminant release sites and contaminants in soil, bedrock, and ground water. Since then, 14 boreholes have been drilled; five of these boreholes have been completed as ground water monitor wells (Figure 27). The geologic, hydrologic, and chemical data from wells and boreholes were used to characterize the site hydrogeology and to monitor the temporal and spatial changes in saturation and dissolved contaminants. Firing table gravel and underlying soil and rock samples were also collected from five of the boreholes. Ground water monitoring has been conducted to evaluate VOCs released from the Building 801 Dry Well and to detect any potential future releases from the Pit 8 Landfill.

3.1.2.5. Building 801 and Pit 8 Landfill Contaminants of Concern

The following COCs have been identified in $Tnbs_1$/$Tnbs_0$ HSU ground water at Building 801: (1) VOCs including chloroform, TCE, and 1,2-DCA, and (2) nitrate. The distribution and concentration of contaminants in ground water is described in Section 3.1.5.1. TCE has also been identified as a COC in subsurface soil and rock in the vicinity of the former Building 801 dry well. No COCs have been identified in surface soil, subsurface soil/rock, or in ground water associated with the Pit 8 Landfill. No unacceptable risk or hazard to human receptors was identified associated with COCs at Building 801 or Pit 8 Landfill in the baseline risk assessment. Modeling conducted for this area in the Site-Wide Feasibility Study (Ferry et al., 1999) indicated that the TCE in the vadose zone does not represent a significant threat to ground water.

The baseline ecological assessment determined a risk from cadmium existed for ground squirrels and deer. Individual adult ground squirrels and individual adult and juvenile deer are at risk from ingestion of cadmium. The combined oral and inhalation pathway HQ exceed 1 for these species, which was driven by the oral pathway. Site-wide population surveys to identify the current risk to deer and ground squirrels found no adverse impacts. The ecological risk and hazard management measures required by the CMP/CP include: (1) periodically evaluating available biological survey data from Building 801 to determine potential population-level impacts to ground squirrel and deer exposed to cadmium in surface soil in these areas, as well as re-evaluating the ecological hazard associated with cadmium in surface soil. Cadmium surface soil sampling was conducted in November 2011; six samples were collected and all samples contained less than 0.5 milligrams per kilogram (mg/kg) of cadmium (reporting limit) (further detailed in Section 3.1.5.3, Figure 29, and Table 4).

3.1.2.6. Building 801 and Pit 8 Landfill Summary of Basis for Taking Action

The baseline risk assessment did not identify any human health risks or hazards, however, monitoring is required while contaminants remain above cleanup standards and the landfill remains in place.

The baseline ecological assessment determined a risk from cadmium existed for ground squirrels, and deer. However, site-wide population surveys to identify the current risk to deer and ground squirrels found no adverse impacts. Therefore, no active remediation was required.

3.1.3. Building 801 and Pit 8 Landfill Remedial Actions

3.1.3.1. Building 801 and Pit 8 Landfill Remedy Selection

The remedy selected for the Building 801 and Pit 8 Landfill is intended to achieve the following RAOs:

For Human Health Protection:

- Restore ground water containing contaminant concentrations above cleanup standards.
- Prevent human ingestion of ground water containing contaminant concentrations (single carcinogen) above cleanup standards.

For Environmental Protection:

- Restore water quality to ground water cleanup standards within a reasonable timeframe and to prevent plume migration to the extent technically and economically practicable. Maintain existing water quality that complies with ground water cleanup standards to the extent technically and economically practicable. This will apply to both individual and multiple constituents that have additive toxicology or carcinogenic effects.
- Ensure ecological receptors important at the individual level of ecological organization (listed threatened or endangered, State of California species of special concern) do not reside in areas where relevant hazard indices exceed 1.
- Ensure existing contaminant conditions do not change so as to threaten wildlife populations and vegetation communities.

A remedy was selected for the Building 801 and Pit 8 Landfill in the 2001 Interim Site-Wide ROD. The interim remedy was selected as the final remedy in the 2008 ROD.

The selected remedy for the Building 801 and Pit 8 Landfill consists of:

1. No further action for VOCs in subsurface soil.
2. Monitoring ground water to detect any future releases from the Pit 8 Landfill or changes in contaminant concentrations in ground water that could impact human health or the environment.
3. Risk and hazard management to prevent human exposure to contamination and to protect the integrity of the remedy.
4. Inspecting the Pit 8 Landfill cover periodically for damage that could compromise its integrity and repairing any damage found.

3.1.3.2. Building 801 and Pit 8 Landfill Remedy Implementation

Monitoring of ground water at the Building 801 and Pit 8 Landfill includes:

- Detection monitoring of ground water to detect any new releases of contaminants from buried waste in the Pit 8 Landfill.
- Remedial action monitoring of COCs in ground water to evaluate the effectiveness of the remedy in reducing contaminant concentrations.

As part of the detection monitoring program, ground water samples are collected from monitor wells located upgradient and directly downgradient of the landfill and analyzed for potential constituents of concern. The detection monitoring and results for the Pit 8 Landfill is discussed in Section 3.1.5.2.

As part of the remedial action monitoring program, ground water samples are collected from downgradient wells and analyzed for ground water COCs to track changes in plume concentration and size to ensure there is no impact to downgradient receptors, to meet remedial action objectives, and verify the attainment of cleanup standards. The remedial action monitoring results are discussed in Section 3.1.5.1.

Land Use Controls have been implemented to prevent damage to the landfill cap (see Section 3.1.3.4).

The results of the detection and remedial action monitoring, landfill inspections and maintenance, remediation progress, and the status of institutional control implementation are reported in the ERD semiannual Compliance Monitoring Reports.

3.1.3.3. Building 801 and Pit 8 Landfill Operation and Maintenance

The remedy for the Building 801 and Pit 8 Landfill is operating as designed and no significant operations, performance, or cost issues were identified during this evaluation. All required documentation is in place, and the landfill cover maintenance and monitoring procedures are consistent with established procedures and protocols.

Landfill maintenance and monitoring procedures are contained in the following documents:

- Site-Wide Compliance Monitoring Plan/Contingency Plan for Remedies at LLNL Site 300.
- LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures.

The major maintenance activities for the Pit 8 Landfill interim remedy include:

- Annual subsidence monitoring of the pit cover to detect differential settling or other earth movement.
- Annual inspection of the pit cover by the LLNL Maintenance and Utilities Services Department for excessive erosion, animal burrowing, or other penetrative damage.
- As needed, repairs to the pit cover are made to correct problems identified during inspections.
- Inspections of the surface water drainages for the landfill annually for erosion and accumulated debris.
- When necessary, the drainage channels are cleared of blockage and repaired to maintain the drainage system design capacity.

The landfill inspections and maintenance are reported in the annual ERD Compliance Monitoring Reports. The budgeted and actual environmental restoration costs for the Building 801 and Pit 8 Landfill are tracked and are consistently within or near the allocated budget. Table 1 presents the actual costs for the last five fiscal years, 2007 through 2011.

3.1.3.4. Building 801 and Pit 8 Landfill 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, and
- Physical barriers.

The U.S. EPA (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 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 onsite.

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. The land use controls and requirements described herein are only applicable to the Building 801/Pit 8 Landfill 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 inspection results are reported in the annual Site 300 Compliance Monitoring Reports.

Land use controls for the Building 801/Pit 8 Landfill are described in Table 5 which 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 Building 801/Pit 8 Landfill area. Figure 30 shows the specific areas of the Building 801/Pit 8 Landfill where the land use controls have been 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 Building 801/Pit 8 Landfill by objective, and the status of the land use controls are summarized below.

3.1.3.4.1. Building 801/Pit 8 Landfill Land Use Control Objectives

Land use control objectives were established for the Building 801/Pit 8 Landfill in the Site 300 ROD (DOE, 2008) to reduce risk and prevent exposure to contaminated environmental media. The risk drivers and associated land use control objectives identified for the Building 801/Pit 8 Landfill include:

1. ***Risk Driver*** - VOC concentrations in ground water onsite exceed cleanup standards.

   Land use control objectives:

   - Prevent onsite water-supply use/consumption of contaminated ground water until ground water cleanup standards are met.

2. ***Risk Driver*** - Potential exposure to VOCs at depth in subsurface soil near the former location of the Building 801 dry well. (Note: the VOCs at depth in subsurface soil do not pose a risk to onsite workers via the pathway where VOCs could volatilize and migrate through the vadose zone into outdoor air. However, risk for onsite worker exposure to VOCs at depth in subsurface soil during excavation activities was not calculated as this was not considered a long-term exposure scenario. As a result, land use controls based on the potential exposure to contaminants in subsurface soil during ground-breaking construction conservatively assume that these subsurface soil contaminants may pose a risk to human health.)

   Land use control objectives:

   - Control excavation activities to prevent onsite worker exposure to contaminants in subsurface soil until it can be verified that concentrations do not pose an exposure risk to onsite workers.

3. ***Risk Driver*** - Potential exposure to contaminants in pit waste.

   Land use control objectives:

   - Maintain the integrity of landfill cover as long as the pit waste remains in place.
   - Control construction and other ground-breaking activities on the landfills to prevent cap/cover damage and/or inadvertent exposure to pit waste as long as the pit waste remains in place.
   - Prevent inadvertent exposure of onsite workers to the pit waste as long as the waste remains in place.

- Prevent inadvertent exposure of unauthorized trespassers to the pit waste as long as the waste remains in place.

4. ***Risk Driver*** - Potential exposure to contaminated environmental media.

   Land use control objective:

   - Prohibit transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use

No COCs have been identified in surface soil, subsurface soil and rock, or ground water in the vicinity of or beneath the Pit 8 Landfill. No unacceptable risk or hazard to human or ecological receptors or threat to ground water was identified for COCs at the Building 801 Firing Table and Pit 8 Landfill in the baseline risk assessment.

3.1.3.4.2. Building 801/Pit 8 Landfill Land Use Controls

This section discusses the land use controls including institutional controls and physical barriers for the Building 801/Pit 8 Landfill that were established and are implemented to address the risk reduction objectives and their current status.

Prevent Onsite Water-supply Use/consumption of Contaminated Ground Water: Governmental Institutional Controls

DOE/LLNL implements multiple layers of protection (land use controls) to prevent the water-supply use or consumption of onsite contaminated ground water in the Building 801 area until ground water cleanup standards are met. The land use controls include:

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

Governmental Institutional Controls Implementation Status

Dig Permit Process: A LLNL Dig Permit is required to drill and install any new onsite wells at Site 300. This permit process includes an evaluation of the proposed well location by the LLNL Environmental Analyst to determine if the proposed new water-supply well is located in an area of ground water contamination. If it is determined that the proposed water-supply well location is in a ground water contamination area, the Environmental Analyst works with the LLNL entity proposing the well installation and the LLNL Environmental Restoration Department to relocate the well to ensure ground water contaminants would not be drawn into the well before a dig permit is issued.

Work Induction Board: Any proposed onsite well drilling activities are also submitted to the LLNL Work Induction Board, and are reviewed by the LLNL Environmental Restoration Department to ensure that new water-supply wells are not located in areas of ground water 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).

Currently, 1,2-DCA is the only VOC detected above its cleanup standard in the Building 801/Pit 8 Landfill area (see Section 3.1.5.1). VOCs in ground water are likely the result of releases from the former Building 801 dry well, which have migrated downgradient from Building 801 to the area beneath the landfill. The 2011 maximum 1,2-DCA concentration of

1.8 µg/L was detected in ground water collected from well K8-01 (immediately downgradient of Building 801 and upgradient of Pit 8 Landfill).

No plans for drilling onsite water-supply wells in the Building 801/Pit 8 Landfill area were proposed during this five-year review period.

The LLNL processes for review of proposed new work are effective in preventing the drilling and installation of new onsite water-supply wells within areas of onsite ground water contamination, and are therefore protective of human health (onsite workers) in preventing the consumption of contaminated onsite ground water.

Control Excavation Activities: Governmental Institutional Controls

The land use controls that have been implemented to control excavation activities to prevent onsite worker exposure to contaminants in subsurface soil until it can be verified that concentrations do not pose an exposure risk to onsite workers include:

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

Governmental Institutional Controls Implementation Status

Site 300 implements multiple layers of protection to prevent onsite worker exposure to contaminants in subsurface soil: Dig Permit and Work Induction Board processes.

Dig Permit Process: A LLNL Dig Permit is required to conduct any ground disturbing activities at Site 300, including activities that involve the excavation of soil and/or rock. This permit process includes an evaluation of the proposed location for the ground disturbing/excavation activity by the LLNL Environmental Analyst to determine if it is located in an area of soil/rock contamination. The Environmental Analyst works with the LLNL entity proposing the ground disturbing/excavation activity to determine if the activity can be moved. If the work plans cannot be modified to move excavation activities outside of areas of soil contamination, LLNL Environmental Health & Safety personnel evaluate the potential hazards and identify the necessary controls to be implemented prior to the start of work.

Work Induction Board: Any proposed excavation activities are submitted to the LLNL Work Induction Board, and are reviewed by LLNL Environmental Restoration Department to prevent excavation of subsurface soil. 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).

During this five-year review period, no excavation or construction activities were proposed in the Building 801/Pit 8 Landfill area. The LLNL processes for review of proposed new work (e.g., Work Induction Board and excavation permit processes) are effective in controlling excavation activities and are therefore protective of human health (onsite workers) in preventing exposure to contaminants in subsurface soil.

Maintain the Integrity of Landfill Cover: Governmental Institutional Controls

The land use controls that have been implemented to maintain the integrity of landfill covers as long as the pit waste remains in place include:

- Governmental Institutional Controls:

  - Inspection and Maintenance Program.

Additional controls were implemented to prevent excavation activities. Those controls are discussed in the *Control Excavation Activities: Governmental Institutional Controls* above.

Governmental Institutional Controls Implementation Status

DOE inspects and maintains the landfill cover and ground water monitoring system. Landfill cover maintenance and inspection requirements are specified in the Site 300 Compliance Monitoring Plan and the results are reported in the Annual Compliance Monitoring Reports.

During this five-year review period, the landfill was inspected and maintained as required. The integrity of the landfill cover was maintained.

Control Construction and Other Ground-breaking Activities on the Landfill: Governmental Institutional Controls

The land use controls that have been implemented to control construction and other ground-breaking activities on the landfill to prevent cap/cover damage and/or inadvertent exposure to pit waste as long as the pit waste remains in place include:

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

Governmental Institutional Controls Implementation Status

The governmental institutional controls implemented to prevent cap/cover damage and/or inadvertent exposure to pit waste as long as the pit waste remains in place are the same as those discussed in the *Control Excavation Activities: Governmental Institutional Controls* above.

During this five-year review period, no excavation or construction activities were proposed in the Pit 8 Landfill area. The LLNL processes for review of proposed new work (e.g., Work Induction Board and excavation permit processes) are effective in controlling excavation activities and is therefore protective of human health (onsite workers) in preventing exposure to waste contained in the landfill.

Prevent Inadvertent Exposure of Onsite Workers to the Pit Waste: Governmental Institutional Controls

The land use controls that have been implemented to prevent inadvertent exposure of onsite workers to the pit waste as long as the waste remains in place include:

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

Governmental Institutional Controls Implementation Status

The governmental institutional controls implemented to prevent inadvertent exposure of onsite workers are the same as those discussed in the *Control Excavation Activities: Governmental Institutional Controls* above.

During this five-year review period, no excavation or construction activities were proposed in the Pit 8 Landfill area. The LLNL processes for review of proposed new work (e.g., Work Induction Board and excavation permit processes) are effective in controlling excavation activities and is therefore protective of human health (onsite workers) in preventing exposure to waste contained in the landfill.

Prevent Inadvertent Exposure of Onsite Workers to the Pit Waste: Physical Barriers

The land use controls that have been implemented to prevent inadvertent exposure of onsite workers to the pit waste as long as the waste remains in place include:

- Physical Barriers:
    - Signage.

Physical Barrier Implementation Status

Signage is maintained at the landfill access points prohibiting unauthorized access and requiring notification and authorization by LLNL Site 300 Management to enter, dig, excavate, or otherwise disturb soil or vegetation in this area.

The physical barriers to control and restrict access are effective in preventing prevent inadvertent exposure of onsite workers to the pit waste, and therefore are protective of human health.

Prevent Inadvertent Exposure of Unauthorized Trespassers to the Pit Waste: Physical Barriers

The land use controls that have been implemented to prevent inadvertent exposure of unauthorized trespassers to the pit waste as long as the waste remains in place include:

- Physical Barriers:
    - Fences.
    - Security Force.
    - Signage.

Physical Barrier Implementation Status

The fences surrounding Site 300, and signs and security forces control and restrict access to Site 300 to prevent inadvertent exposure by members of the public to contamination at Site 300. The LLNL Protective Services force conduct routine inspections of the fences surrounding Site 300. A member of the security force mans the entrance gate to Site 300 during hours when the front gate is open, and a DOE-issued security badge is required to gain entrance to the site. The site gates are closed and locked after 6 pm, and a security force member remains onsite overnight. Members of the public must apply for and obtain security badges and be escorted to access the site.

The physical barriers to control and restrict access are effective in preventing prevent inadvertent exposure by members of the public to contamination at Site 300, and therefore are protective of human health.

Prohibit Transfer of Lands with Unmitigated Contamination: Enforcement Tools

The land use controls that have been implemented to prohibit transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use include:

- Enforcement Tools:
    - FFA.

- ROD.

The land use control and implementation status is described in more detail below.

Enforcement Tools Implementation Status

To prevent the potential exposure to contaminated waste and/or environmental media, the Site 300 FFA 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 as specified in the Site 300 Record of Decision (ROD). The Site 300 FFA and ROD have not been modified during this five-year review period, and these provisions remain as originally stated in these documents.

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.

During the five-year review period, DOE has not proposed any plans to transfer any Site 300 land for residential, unrestricted, or non-DOE industrial land use. Site 300 remains under the ownership, oversight, and operation of the U.S. DOE. The provisions in Site 300 FFA and ROD are effective in preventing the transfer of lands with unmitigated contamination that could cause potential harm under a residential or unrestricted land use, and therefore are protective of human health.

3.1.3.4.3. Summary of the Status of Building 801/Pit 8 Landfill Land Use Controls

The review of the land use controls for the Building 801/Pit 8 Landfill for this five-year review period determined that these controls are effective for preventing exposure to contaminated media. DOE will implement, maintain, and enforce the land use controls for the Building 801/Pit 8 Landfill for as long as necessary to keep the selected remedy protective of human health and the environment.

3.1.4. Building 801 and Pit 8 Landfill Five-Year Review Process

3.1.4.1. Notification of Review/Community Involvement

The 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 September 28, 2012. Completed documents can also be accessed electronically at LLNL's Environmental Restoration Department electronic library web page at http://www-erd/library/ or the Environmental Community Relations web page at http://www-envirinfo.llnl.gov.

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

3.1.4.2. Identification of Five-Year Review Team Members

The Five-Year Review of the Building 801 and Pit 8 Landfill at LLNL Site 300 was led by Claire Holtzapple, Site 300 Remedial Project Manager for the DOE/NNSA-Livermore Site Office. The following team members assisted in the review:

- Leslie Ferry, Program Leader, LLNS.
- Valerie Dibley, Deputy Program Leader, LLNS.
- Vic Madrid, Hydrogeology Team Leader, LLNS.
- Michael Taffet, Hydrogeologist, LLNS.
- Mark Buscheck, Hydrogeologist, Weiss Associates.

3.1.4.3. Document Review

This Five-Year Review consisted of examining relevant project documents and site data:

- Final Site-Wide Remedial Investigation for Lawrence Livermore National Laboratory Site 300 (Webster-Scholten et al., 1994).
- Final Site-Wide Feasibility Study for Lawrence Livermore National Laboratory Site 300 (Ferry et al., 1999).
- Interim Site-Wide Record of Decision for Lawrence Livermore National Laboratory Site 300 (U.S. DOE, 2001).
- Site-Wide Record of Decision for Lawrence Livermore National Laboratory Site 300 (U.S. DOE, 2008).
- Remedial Design Work Plan for Interim Remedies at Lawrence Livermore National Laboratory Site 300 (Ferry et al., 2001).
- Site-Wide Remediation Evaluation Summary Report for Lawrence Livermore National Laboratory Site 300 (Ferry et al., 2006).
- Semi-annual Site-Wide Compliance Monitoring Reports that include evaluations of remediation progress in the Building 801 and Pit 8 Landfill area of OU 8 (Dibley et al., 2007c, 2008c, 2009c, 2009d, 2010a, 2010b, 2011a, 2011c, and 2012; LLNL 2008).

These documents are available on-line at www-erd.llnl.gov/library/index.html#reports.s300.

This Five-Year Review evaluates subsurface contaminant concentration and remediation system performance data collected through calendar year 2011.

3.1.5. Building 801 and Pit 8 Landfill Data Review and Evaluation

This section is organized into four subsections: (1) analysis of contaminant distribution, concentration, and remediation progress (Section 3.1.5.1), (2) Pit 8 Landfill detection monitoring and results (Section 3.1.5.2), (3) performance issues (Section 3.1.5.3), and risk mitigation remediation progress (Section 3.1.5.3).

3.1.5.1. Building 801 and Pit 8 Landfill Contaminant Distribution, Concentrations, and Remediation Progress

The VOCs chloroform, 1,2-DCA, TCE, and perchlorate and nitrate are the COCs identified in ground water at Building 801. TCE is a COC in the vadose zone in the vicinity of the former Building 801 dry well. There are no COCs in ground water, vadose zone, or surface soil at the

Pit 8 Landfill. A list of COCs and their historic maximum and 2011 maximum concentrations for Building 801 and Pit 8 Landfill is detailed in Table 6. Figure 27 shows the 2011 concentrations of ground water COCs.

VOCs detected in $Tnbs_1/Tnbs_0$ HSU ground water in the Pit 8 Landfill area result from releases from the former Building 801 dry well, which have migrated downgradient from Building 801 to the area beneath the landfill.

During 2011, 1,2-DCA was the only VOC detected above its 0.5 µg/L MCL cleanup standard. However, the 2011 maximum 1,2-DCA concentration of 1.8 µg/L detected in well K8-01 (immediately downgradient of Building 801 and upgradient of Pit 8 Landfill) represents a decrease from: (1) the historic maximum 1,2-DCA concentration of 5 µg/L measured in the same well most recently in 1990, as well as (2) the five-year review period maximum 1,2-DCA concentration of 2.5 µg/L (K8-01, 2007). Time-series plots of 1,2-DCA trends since ground water monitoring for this compound began in 1987 are presented on Figure 31.

TCE concentrations have decreased from the historic maximum concentration of 6 µg/L (K8-01) to a fourth quarter 2011 maximum of 3.3 µg/L (K8-01). TCE has historically only been detected above the 5 µg/L MCL cleanup standard in one well (K8-01) and TCE concentrations in this well have decreased to and remained below the cleanup standard since April 1992. TCE has never been detected above the 5 µg/L MCL cleanup standard in the other wells since monitoring began in 1988. The presence of VOCs in ground water samples from well K8-04, located immediately downgradient of the Pit 8 Landfill, indicates a continuation of the VOC plume originating at the Building 801 dry well and is not due to a release from the Pit 8 Landfill. Time-series plots of TCE data since ground water monitoring for this compound began in 1987 are presented on Figure 32.

Chloroform has never been detected in Building 801/Pit 8 Landfill monitor wells at concentrations near or above the 80 µg/L MCL cleanup standard since monitoring for this constituent began in 1987 (maximum historical concentration of 2.4 µg/L in 1992). Chloroform concentrations have decreased to and remained below the 0.5 µg/L reporting limit in all wells since 2008.

Perchlorate has never been detected in Building 801/Pit 8 Landfill monitor wells at concentrations above the 6 µg/L MCL cleanup standard since monitoring for this constituent began in 1998. Perchlorate concentrations have decreased from the historic maximum concentration of 5 µg/L (K8-04, 2003) to below the 4 µg/L reporting limit in all wells since 2010.

Concentrations of nitrate in ground water in the vicinity of Building 801/Pit 8 Landfill have been relatively stable over time. The 2011 maximum nitrate concentration in the area was 57 mg/L (K8-04, May 2011). In 2011, a sample from well K8-04 and a duplicate sample from well K8-01 (both 47 mg/L, in May 2011) were the only detections in area wells that exceeded the 45 mg/L cleanup standard for nitrate. The historic maximum nitrate concentration is 64 mg/L (K8-01, 2002) and the five-year review period maximum nitrate concentration is 61 mg/L (K8-04, 2009). Overall, nitrate concentrations in ground water at the Building 801/Pit 8 Landfill generally are similar to previous years. Time-series plots of nitrate data since monitoring began in 1998 are presented on Figure 33.

In summary, VOCs, nitrate, and perchlorate have been identified as COCs in the $Tnbs_1/Tnbs_0$ HSU ground water due to the historic releases from the Building 801 dry well. Of these ground water COCs, only 1,2-DCA and nitrate currently exceed ground water cleanup standards. TCE concentrations are currently below its cleanup standards. Chloroform has never been detected at concentrations above its cleanup standard, and it has not been detected in ground water since 2008. Perchlorate has never been detected at concentrations above the cleanup standard, and it has not been detected in ground water since 2010.

3.1.5.2. Pit 8 Landfill Detection Monitoring and Results

Detection monitoring of the Pit 8 Landfill is conducted to identify any future releases to ground water in accordance with the requirements of the Site 300 CMP/CP. As part of the detection monitoring program for the Pit 8 Landfill, ground water samples are collected from two monitor wells located upgradient and three monitor wells located directly downgradient of the landfill and analyzed for potential constituents of concern.

Potential constituents of concern, as defined by Title 23 of the California Code of Regulations, Chapter 15, are:

- Constituents identified in disposal records or that are potentially associated with the buried waste.
- Constituents detected above background concentrations in soil, ground water, and/or surface water in the immediate vicinity of the landfill, indicating a previous release.
- Constituents or breakdown products that can reasonably be expected to be associated with the type of waste disposed of in the landfill.

The constituents of concern for the Pit 8 Landfill include VOCs, nitrate, perchlorate, tritium, HE compounds, uranium isotopes, Title 26 metals, lithium, and fluoride.

While TCE and 1,2-DCA are detected in wells downgradient of the landfill, concentrations of these VOC COCs are also detected in wells upgradient of the landfill at higher concentrations. This data indicate that these constituents have migrated downgradient for the Building 801D former dry well area, and do not represent a release of VOCs from the Pit 8 Landfill.

While nitrate was detected at concentrations above the 45 mg/L MCL cleanup standard in well K8-04 located downgradient of the landfill, nitrate was also detected at concentrations exceeding the cleanup standard in well K8-01, located upgradient of the landfill.

Perchlorate is not detected above the 4 µg/L reporting limit in wells located up- or downgradient of the Pit 8 Landfill.

Tritium activities in all samples collected during 2011 were below the reporting limit (<100 pCi/L), except for the regular and duplicate May 2011 samples from well K8-01 (144 ± 60.0 and 104 ± 75.3 pCi/L, respectively) and the regular November 2011 sample collected from the same well (155 ± 94.1 pCi/L). These activities are all within the range of background and well K8-01 is located upgradient of the landfill.

Since monitoring began, concentrations/activities of HE compounds, uranium isotopes, Title 26 metals, lithium, and fluoride in ground water samples collected from wells upgradient and downgradient of the Pit 8 Landfill have either been below reporting limits or within the range of background concentrations.

No contaminant releases have been identified from the Pit 8 Landfill. However, as discussed in Section 3.1.2.1.2 and shown on Figure 27, historic ground water elevation data indicate that the flow direction has ranged from northeast to southeast in the vicinity of the landfill. Therefore, DOE/NNSA recommends installing additional monitor wells in the vicinity of the landfill to ensure full detection monitoring capability under the observed range of ground water flow directions.

During the five-year review period, LLNS Maintenance and Utilities Services Department staff annually inspected the Pit 8 Landfill to identify any degradation or damage to the landfill surface or damage or blockage of the drainage ways that may have lead to: (1) increased infiltration of precipitation, (2) exposure to the landfill contents, and (3) flow of surface water on or adjacent to the landfill. During the five-year review period, maintenance personnel filled some animal burrows but otherwise, no significant issues (including subsidence) were reported during annual inspection of the landfill surface.

3.1.5.3. Building 801 and Pit 8 Landfill Performance Issues

The remedy continues to be effective and protective of human health and the environment, and to make progress towards meeting cleanup standards.

3.1.5.4. Building 801 and Pit 8 Landfill Risk Mitigation Remediation Progress

In the baseline risk assessment, no unacceptable human health risks or hazards associated with contaminants in surface soil, subsurface soil/bedrock, or ground water were identified for the Building 801 Dry Well or Pit 8 Landfill.

On September 28, 2011, the U.S. EPA released updated toxicity values and contaminant characteristics for TCE in the IRIS (EPA, 2011). Currently, the only significant impact of this change is presumed to be on the assessment of risk for the vapor inhalation pathway. However, since TCE was not detected above the cleanup standard in the Building 801 Dry Well/Pit 8 Landfill ground water during the past five years, this risk was not reassessed. In addition, there is no evidence of new releases or contamination that warrants re-evaluation of risk.

The baseline ecological risk assessment determined a risk from cadmium existed for ground squirrels, and deer. Individual adult ground squirrels and individual adult and juvenile deer are at risk from ingestion of cadmium. The combined oral and inhalation pathway HQ exceed 1 for these species, which was driven by the oral pathway. Site-wide population surveys to identify the current risk to deer and ground squirrels found no adverse impacts. The ecological risk and hazard management measures required by the CMP/CP include: (1) periodically evaluating available biological survey data from the Buildings 801 to determine potential population-level impacts to ground squirrel and deer exposed to cadmium in surface soil in these areas, as well as re-evaluating the ecological hazard associated with cadmium in surface soil.

Cadmium surface soil sampling was performed in November 2011 by an LLNL ecologist (Dibley, et al., 2012). A map of historical sampling locations including the November 2011 samples is depicted on Figure 29 and Table 4 provides a historical summary of cadmium analytical results including the November 2011 samples. All results (95% Upper Confidence Limit [UCL]) were below the Site 300 background for cadmium (1.9 mg/kg). There is clearly little ecological risk from cadmium in the Building 851 area, as areas with existing elevated cadmium concentrations are very small and isolated. Therefore, cadmium in surface soil will no longer be considered a contaminant of ecological concern in these areas. It would also appear that cadmium does not pose an ecological risk in the Building 801 area, however, additional sampling behind Building 801 is needed to definitively remove this risk. The additional sampling will be scheduled.

A Site-Wide Five-Year Ecological Review was performed in 2008 (Dibley et al., 2009c). No new ecological hazards were identified in the Building 801 and Pit 8 Landfill. No information was identified during this review to question the ecological protectiveness of the remedy.

3.1.6. Building 801 and Pit 8 Landfill Interviews and Site Inspection

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

There is a continuous presence of ERD staff at Site 300 that routinely inspect the monitoring wellfield during sampling activities. The Pit 8 Landfill cap and associated drainages are annually inspected by LLNL Maintenance and Utilities Services Department. The Site 300 ERD conducts self-assessment inspections and DOE/NNSA conducts quarterly inspections of remediation activities at Site 300. The RWQCB RPM performs site inspections twice a year, and the U.S. EPA and DTSC RPMs perform site inspections as requested. The EPA did not perform a construction completion inspection of OU 8 as the remedy required no construction. The Five-Year Review Inspection was performed by DOE/NNSA on August 16, 2011. The Five-Year Review Inspection Checklist is included as Attachment A.

Operational issues and resulting corrective actions identified during routine inspections associated with the landfill and monitoring wellfields are: (1) described in the 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 that are distributed following the meetings.

3.1.7. Building 801 and Pit 8 Landfill Technical Assessment

The protectiveness of the interim remedy was assessed by determining if:

1. The interim remedy is functioning as intended at the time of the decision documents.
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 interim remedy into question.

3.1.7.1. Remedy Function

The remedy was determined to be functioning as intended at the time of the decision documents because:

- No early indicators of potential remedy failure were identified.
- The remedy is functioning as intended by reducing COC concentrations/activities.
- 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.

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

- There have been no 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 or ecological receptors has been identified.
- There have been no changes in land, building, or water use.
- No new contaminants or sources have been identified.
- No remedy byproducts have been identified.
- Changes in location-, chemical-, or action-specific ARARs or to-be-considered requirements:
  - The State of California established a 6 µg/L MCL for perchlorate on October 18, 2007. This action-specific ARAR and ARARs related to ground water cleanup were included in the 2008 Site-Wide ROD.
  - The U.S. EPA NPDES Pesticide Rule changed in 2011, however, there are no discharges to the ground surface or NPDES permit required as part of the Building 801/Pit 8 Landfill remedy.
- Changes in toxicity and other contaminant characteristics:
  - On September 28, 2011, the U.S. EPA released updated toxicity values and contaminant characteristics for TCE in the IRIS. Currently, the only significant impact of this change is presumed to be on the assessment of risk for the vapor inhalation pathway. As discussed in Section 3.1.5.3, the Baseline Risk Assessment did not identify any human health risks in the Building 801 and Pit 8 Landfill.
- The review found progress toward meeting the RAOs.

3.1.7.3. 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.
- No unanticipated events (i.e., natural disasters, new contaminants discovered, etc.) occurred that would call the protectiveness of the remedy into question.
- No additional information has been identified that would call the protectiveness of the interim remedy into question.
- No new technologies have been identified that are capable of accelerating or achieving cleanup in a more cost-effective manner in the Building 801 and Pit 8 Landfill area.

3.1.8. Building 801 and Pit 8 Landfill Issues

No issues were identified during this evaluation. However, as discussed in Section 3.1.2.1.2 and shown on Figure 27, historic ground water elevation data indicate that the flow direction in the $Tnbs_1$/$Tnbs_0$ HSU has ranged from northeast to southeast in the vicinity of the landfill. Therefore, DOE/NNSA recommends installing additional monitor wells in the vicinity of the landfill to ensure full detection monitoring capability under the observed range of ground water flow directions.

3.1.9. Building 801 and Pit 8 Landfill Recommendations and Follow-Up Actions

The following recommendations to be carried out by the DOE/NNSA were developed during the review process:

1. Install additional monitor wells in the Tnbs1/$Tnbs_0$ HSU in the vicinity of the Pit 8 Landfill to ensure full detection monitoring capability under the observed range of ground water flow directions. Up to two monitor wells located north of the landfill and potentially one monitor well located south of the landfill are being considered to accomplish this objective. The proposed locations of the additional monitor wells to be installed will be presented to the regulatory agencies for concurrence prior to installation. Because the funding for the installation of these wells is not currently included in DOE/NNSA's funding request profile, the schedule for well installation will be finalized when the funding request is approved.

3.1.10. Building 801 and Pit 8 Landfill Protectiveness Statement

The remedy at the Building 801 and Pit 8 Landfill is protective of human health and the environment for the site's industrial land use. The remedy protects human health because: (1) VOC concentrations are decreasing towards the cleanup standard (TCE and chloroform are below the cleanup standard), and perchlorate concentrations are below reporting limits, (2) human health risks or hazards associated with contaminants in surface soil, subsurface soil/bedrock, or ground water were identified for the Building 801 Dry Well or Pit 8 Landfill, (3) no COCs have been identified in surface soil, subsurface soil/rock, or in ground water associated with the Pit 8 Landfill and there have been no releases from the landfill, and (4) exposure pathways that could result in unacceptable risk to onsite workers are being controlled by the implementation of institutional controls, the Health and Safety Plan, and the Contingency Plan. DOE/NNSA's recommendation to install additional monitor wells in the vicinity of the Pit 8 Landfill will add an additional layer of protection by increasing the detection monitoring capability under a range of ground water flow directions.

The cleanup standards for Building 801 and Pit 8 Landfill ground water are drinking water standards. Because drinking water standards do not differentiate between industrial and residential use, the ground water cleanup remedy will be protective under any land use scenario.

Because some VOCs may remain in subsurface soil and the waste in the Pit 8 Landfill will remain in place, 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 is included in the Site-Wide ROD. This prohibition will remain in place until and unless a risk assessment is performed in accordance with current U.S. EPA risk assessment guidance and is agreed by the DOE, the U.S. EPA, the DTSC, and RWQCB as adequately showing no unacceptable risk for residential or unrestricted land use.

3.2. Building 845 Firing Table and Pit 9 Landfill

3.2.1. Building 845 Firing Table and Pit 9 Landfill Site Chronology

The following is a chronological listing of significant environmental restoration events at the Building 845 Firing Table and Pit 9 Landfill:

1958–1968

- Explosives experiments were conducted at the Building 845 Firing Table from 1958 until 1963.
- Approximately 4,400 yd^3 of debris from the Building 845 Firing Table were deposited in the Pit 9 Landfill prior to 1968.

1988

- A total of 1,942 yd^3 of gravel from the Building 845 Firing Table, and 390 yd^3 of soil from the Building 845 Firing Table berm were removed and disposed of at the Nevada Test Site (Lamarre and Taffet, 1989).

1990

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

1992

- A FFA was signed for Site 300.

1999

- The Site-Wide Feasibility Study for Site 300 was issued that included the Building 845 firing table and Pit 9 Landfill.

2001

- An Interim Site-Wide ROD for Site 300 was signed. The Interim Site-Wide ROD specified no further action for HMX and uranium in subsurface soil and bedrock and monitoring as components of the remedy for Building 845 and the Pit 9 Landfill. The Interim Site-Wide ROD did not contain ground water cleanup standards.
- A Remedial Design Work Plan was issued that contained the strategic approach and schedule to implement the remedies in the Interim Site-Wide ROD.

2002

- The CMP/CP for Interim Remedies was issued.

2008

- The Site-Wide ROD with selected remedies and cleanup standards for Site 300 was signed. The remedy did not change in the 2008 Site-Wide ROD, with the exception that ground water cleanup standards were established in the 2008 Site-Wide ROD.

2009

- The revised CMP/CP was issued.

3.2.2. Building 845 Firing Table and Pit 9 Landfill Background

3.2.2.1. Building 845 Firing Table and Pit 9 Landfill Physical Characteristics

3.2.2.1.1. Building 845 Firing Table and Pit 9 Landfill Site Description

The Building 845 Firing Table and Pit 9 Landfill are located toward the center of Site 300 (Figure 2). The Building 845 Firing Table and Pit 9 Landfill cover approximately 6 acres. The Pit 9 Landfill is located within the upper portions of a U-shaped valley that opens to the north. Building 845 is located about 200 ft northeast of the landfill (Figure 34).

High explosives experiments were conducted at the Building 845 Firing Table from 1958 to 1963. The Pit 9 Landfill was used until 1968 to dispose of approximately 4.400 yd^3 of debris generated at the Building 845 Firing Table (Lamarre and Taffet, 1989). In 1988, firing table gravel and soil from a berm at the firing table were removed and disposed of at the Nevada Test Site.

Currently, Building 845 houses the Explosives Waste Treatment Facility that consists of the open detonation table, open burn pan, and open burn cage.

3.2.2.1.2. Building 845 Firing Table and Pit 9 Landfill Hydrogeologic Setting

This section describes the hydrogeologic setting for the Building 845 and Pit 9 Landfill area, including the unsaturated zone and the HSU underlying the area, and surface water. A conceptual hydrostratigraphic column for the northern portion of Site 300, including the Building 845 Firing Table and Pit 9 Landfill area, is shown on Figure 28.

Building 845 Firing Table and Pit 9 Landfill Vadose (Unsaturated) Zone

The vadose zone consists of up to 110 ft of unconsolidated Quaternary alluvial and colluvial deposits (Qal) and underlying unsaturated lower $Tnbs_1$ bedrock.

Building 845 Firing Table and Pit 9 Landfill Saturated Zone

The Building 845 Firing Table and Pit 9 Landfill area is underlain by a single water-bearing zone: the $Tnsc_0$ HSU. This HSU consists of the Tertiary Neroly Formation $Tnsc_0$ basal claystone unit. Ground water is generally confined, and depth to water averages about 110 ft beneath Building 845. Recharge for this HSU occurs on hilltops and within alluvial channels. Since monitoring of the existing well network began in 1988, ground water flow direction in the $Tnsc_0$ HSU has ranged approximately 75 degrees northwest to northeast beneath Building 845 and the Pit 9 Landfill (Figure 34). The exact causes of the observed variability in ground water flow direction are unknown but may include changes in relative contributions of percolation from different recharge areas (both from construction [of impermeable surfaces] at the nearby Explosives Waste Treatment Facility and natural factors, aquifer heterogeneity and variability in porous versus fracture flow, and long term changes in rock hydraulic properties due to seismicity and other processes. The HSU is saturated beneath the entire area and the saturated thickness varies from about 5 to 10 ft.

Building 845 Firing Table and Pit 9 Landfill Surface Water

Natural surface water in the Building 845 and Pit 9 Landfill area is the result of surface runoff from precipitation. Natural surface runoff is rarely observed, and only occurs briefly during significant or prolonged storms. There are no surface water bodies (i.e., springs) in the Building 845 and Pit 9 Landfill area.

3.2.2.2. Building 845 Firing Table and Pit 9 Landfill Land and Resource Use

Site 300 is currently an operating facility, and will remain under DOE control for the reasonably anticipated future. Less than 5 percent of Site 300's 7000-acre property-area is developed.

The Building 845 Firing Table and Pit 9 Landfill are near the center of Site 300, approximately 4,500 feet west of the closest (eastern) site boundary. As stated previously, the Building 845 area houses the Explosives Waste Treatment Facility that consists of the open detonation table, open burn pan, and open burn cage. The open detonation table is used for six to eight detonations a year at no more than 8 pounds each. Any explosives waste put on the open burn pan is completely gone after treatment. There is a small amount of ash that remains from the open burn cage that is collected in a drum for up to nine months near the open burn units. Details of these operations have not changed in the last five years.

There are no active onsite water-supply wells in the Building 845 Firing Table and Pit 9 Landfill area.

Large areas of native perennial grasslands occur to the southeast and northwest of Building 845 Firing Table and Pit 9 Landfill, with annual grasslands covering the remainder of the area. The big tarplant (*Blepharizonia plumosa*), an extremely rare late-season flowering plant included on the California Native Plant Society's List 1B, has also been mapped in the area around Building 845 Firing Table and Pit 9 Landfill. The facilities occur within the upland dispersal habitat for the federally threatened California red-legged frog (*Rana aurora draytonii*). Loggerhead shrikes (*Lanius ludovicianus*), and burrowing owls (*Athene cunicularia*), both California Species of Special Concern, have been observed near the facilities. A five-year ecological review reported on in the 2008 Annual Compliance Monitoring Report (Dibley et al., 2009c), which updated the assessment of the ecological impacts from Site 300 contaminants, found no impact to ecological receptors from releases from Building 845 Firing Table or Pit 9 Landfill. An LLNL ecologist reviewed ecological data collected between 2008 and 2011 for the area to evaluate whether any changes in contaminant or ecological conditions that could impact ecological receptors. No changes were identified. Access to these unique animal and plant populations is controlled and interactions with the wildlife are avoided.

3.2.2.3. Building 845 Firing Table and Pit 9 Landfill History of Contamination

Leaching of uranium-238 and HE compounds from Building 845 Firing Table debris resulted in contamination of shallow subsurface soil and bedrock underlying the firing table. No contaminants have been detected in ground water under the Building 845 Firing Table. Soil, rock, and ground water monitoring data indicate that contaminants have not been released from the Pit 9 Landfill.

3.2.2.4. Building 845 Firing Table and Pit 9 Landfill Initial Response

Investigations began at the Building 845 Firing Table and the Pit 9 Landfill in 1982 to identify potential contaminant release sites and contaminants in soil, bedrock, and ground water. Since then, nine boreholes have been drilled; four of these boreholes have been completed as ground water monitor wells (Figure 34). The geologic and chemical data from wells and boreholes were used to characterize the site hydrogeology and to monitor the temporal and spatial changes in saturation and to detect any dissolved contaminants. Firing table gravel and soil and rock samples were also collected from several boreholes located in this area. As stated previously, firing table gravel and the soil berm at the Pit 9 Landfill were removed and disposed of at the Nevada Test Site in 1988. Ground water monitoring has been conducted to evaluate to detect any potential future releases from the Pit 9 Landfill.

3.2.2.5. Building 845 Firing Table and Pit 9 Landfill Contaminants of Concern

There are no COCs in $Tnsc_0$ HSU ground water, surface water, or surface soil in the Building 845 area. Uranium-238 and the HE compound HMX have been identified as COCs in the vadose zone underlying the Building 845 Firing Table. No COCs have been identified in surface soil, subsurface soil and rock, or ground water in the vicinity of or beneath the Pit 9 Landfill. No unacceptable risk or hazard to human or ecological receptors or threat to ground water was identified for COCs at the Building 845 Firing Table and Pit 9 Landfill in the baseline risk assessment. Modeling documented in the Site-Wide Feasibility Study (Ferry et al., 1999) indicated that the uranium and HMX in the vadose zone do not represent a significant threat to ground water.

3.2.2.6. Building 845 Firing Table and Pit 9 Landfill Summary of Basis for Taking Action

The baseline risk assessment did not identify any human or ecological health risks or hazards, however, monitoring is required while the landfill remains in place.

3.2.3. Building 845 Firing Table and Pit 9 Landfill Remedial Actions

3.2.3.1. Building 845 Firing Table and Pit 9 Landfill Remedy Selection

The Site 300 Human Health and Environmental Protection RAOs are not applicable to the remedy selected for the Building 845 Firing Table and Pit 9 Landfill because there is no ground water contamination or human health or ecological risks or hazards identified.

A remedy for the Building 845 Firing Table and Pit 9 Landfill was selected in the 2001 Interim Site-Wide ROD. The interim remedy was selected as the final remedy in the 2008 ROD.

The selected remedy for the Building 845 Firing Table and Pit 9 Landfill consists of:

1. No further action for HMX and uranium in subsurface soil/rock.
2. Continued monitoring ground water to detect any future releases from the Pit 9 landfill that could impact human health or the environment.
3. Risk and hazard management to prevent human exposure to contamination and to protect the integrity of the remedy.
4. Inspecting Pit 9 Landfill cover periodically for damage that could compromise its integrity and repairing any damage found.

3.2.3.2. Building 845 and Pit 9 Landfill Remedy Implementation

Monitoring of ground water at the Building 845 Firing Table and Pit 9 Landfill includes:

- Detection monitoring of ground water to detect any new releases of contaminants from buried waste in the Pit 9 Landfill.
- Monitoring of ground water for subsurface soil/rock COCs (uranium and HMX) to determine if these contaminants impact ground water.

As part of the detection monitoring program, ground water samples are collected from monitor wells located upgradient and directly downgradient of the landfill and analyzed for potential constituents of concern. Detection monitoring and results for the Pit 9 Landfill are discussed in Section 3.2.5.2.

Land Use Controls have been implemented to prevent damage to the landfill cover and inadvertent exposure to the waste (see Section 3.2.3.4).

The results of the detection monitoring and ground water monitoring, landfill inspections and maintenance, remediation progress, and the status of institutional control implementation are reported in the ERD semiannual Compliance Monitoring Reports.

3.2.3.3. Building 845 Firing Table and Pit 9 Landfill Operation and Maintenance

The remedy for the Building 845 Firing Table and Pit 9 Landfill is operating as designed and no significant operations, performance, or cost issues were identified during this evaluation. All required documentation is in place, and the landfill cover maintenance and monitoring procedures are consistent with established procedures and protocols.

Landfill maintenance and monitoring procedures are contained in the following documents:

- Site-Wide Compliance Monitoring Plan/Contingency Plan for Remedies at LLNL Site 300.
- LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures.

The major maintenance activities for the Pit 9 Landfill interim remedy include:

- Annual subsidence monitoring of the pit cap to detect differential settling or other earth movement.
- Annual inspection of the pit cap by the LLNL Maintenance and Utilities Services Department for excessive erosion, animal burrowing, or other penetrative damage.
- As needed, repairs to the pit cap are made to correct problems identified during inspections.
- Inspections of the surface water drainages for the landfill annually for erosion and accumulated debris.
- When necessary, the drainage channels are cleared of blockage and repaired to maintain the drainage system design capacity.

The landfill inspections and maintenance are reported in the annual ERD Compliance Monitoring Reports. The budgeted and actual environmental restoration costs for the Building 845 Firing Table and Pit 9 Landfill are tracked and are consistently within or near the allocated budget. Table 1 presents the actual costs for the last five fiscal years, 2007 through 2011.

3.2.3.4. Building 845 Firing Table and Pit 9 Landfill 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, and
- Physical barriers.

The U.S. EPA (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 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 onsite.

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. The land use controls and requirements described herein are only applicable to the Building 845/Pit 9 Landfill 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 inspection results are reported in the annual Site 300 Compliance Monitoring Reports.

Land use controls for the Building 845/Pit 9 Landfill are described in Table 5, which 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 Building 845/Pit 9 Landfill area. Figure 35 shows the specific areas of the Building 845/Pit 9 Landfill where the land use controls have been 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 Building 845/Pit 9 Landfill by objective, and the status of the land use controls are summarized below.

3.2.3.4.1. Building 845/Pit 9 Landfill Land Use Control Objectives

Land use control objectives were established for the Building 845/Pit 9 Landfill in the Site 300 ROD (DOE, 2008) to reduce risk and prevent exposure to contaminated environmental media. The risk drivers and associated land use control objectives identified for the Building 845/Pit 9 Landfill include:

1. ***Risk Driver*** - Potential exposure to depleted uranium and HMX at depth in subsurface soil. (Note: Risk for onsite worker exposure to uranium and HMX at depth in subsurface soil during excavation activities was not calculated as this was not considered a long-term exposure scenario. As a result, land use controls based on the potential exposure to contaminants in subsurface soil during ground-breaking construction conservatively assume that these subsurface soil contaminants may pose a risk to human health.)

Land use control objectives:

- Control excavation activities to prevent onsite worker exposure to contaminants in subsurface soil until it can be verified that concentrations do not pose an exposure risk to onsite workers.

2. ***Risk Driver*** - Potential exposure to contaminants in pit waste.

Land use control objectives:

- Maintain the integrity of landfill cover as long as the pit waste remains in place.
- Control construction and other ground-breaking activities on the landfill to prevent cap/cover damage and/or inadvertent exposure to pit waste as long as the pit waste remains in place.
- Prevent inadvertent exposure of onsite workers to the pit waste as long as the waste remains in place.
- Prevent inadvertent exposure of unauthorized trespassers to the pit waste as long as the waste remains in place.

3. ***Risk Driver*** - Potential exposure to contaminated environmental media.

Land use control objective:

- Prohibit transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use

No COCs have been identified in surface soil, subsurface soil and rock, or ground water in the vicinity of or beneath the Pit 9 Landfill. There are no COCs in ground water, surface water, or surface soil in the Building 845 area. No unacceptable risk or hazard to human or ecological receptors or threat to ground water was identified for COCs at the Building 845 Firing Table and Pit 9 Landfill in the baseline risk assessment.

3.2.3.4.2. Building 845/Pit 9 Landfill Land Use Controls

This section discusses the land use controls including institutional controls and physical barriers for the Building 845/Pit 9 Landfill that were established and are implemented to address the risk reduction objectives and their current status.

Control Excavation Activities: Governmental Institutional Controls

The land use controls that have been implemented to control excavation activities to prevent onsite worker exposure to contaminants in subsurface soil until it can be verified that concentrations do not pose an exposure risk to onsite workers include:

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

Governmental Institutional Controls Implementation Status

Site 300 implements multiple layers of protection to prevent onsite worker exposure to contaminants in subsurface soil: Dig Permit and Work Induction Board processes.

Dig Permit Process: A LLNL Dig Permit is required to conduct any ground disturbing activities at Site 300, including activities that involve the excavation of soil and/or rock. This permit process includes an evaluation of the proposed location for the ground disturbing/excavation activity by the LLNL Environmental Analyst to determine if it is located in an area of soil/rock contamination. The Environmental Analyst works with the LLNL entity proposing the ground disturbing/excavation activity to determine if the activity can be moved. If the work plans cannot be modified to move excavation activities outside of areas of soil contamination, LLNL Environmental Health & Safety personnel evaluate the potential hazards and identify the necessary controls to be implemented prior to the start of work.

Work Induction Board: Any proposed excavation activities are submitted to the LLNL Work Induction Board, and are reviewed by LLNL Environmental Restoration Department to prevent excavation in the Building 845 Firing Table area. 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).

During this five-year review period, no excavation or construction activities were proposed in the Building 845/Pit 9 Landfill area. The LLNL processes for review of proposed new work (e.g., Work Induction Board and excavation permit processes) are effective in controlling excavation activities and are therefore protective of human health (onsite workers) in preventing exposure to contaminants in subsurface soil.

Maintain the Integrity of Landfill Cover: Governmental Institutional Controls

The land use controls that have been implemented to maintain the integrity of landfill covers as long as the pit waste remains in place include:

- Governmental Institutional Controls:
    - Inspection and Maintenance Program.

Additional controls were implemented to prevent excavation activities. Those controls are discussed in the *Control Construction and Other Ground-breaking Activities on the Landfills* below.

Governmental Institutional Controls Implementation Status

DOE inspects and maintains the landfill cover and ground water monitoring system. Landfill cover maintenance and inspection requirements are specified in the Site 300 Compliance Monitoring Plan and the results are reported in the Annual Compliance Monitoring Reports.

During this five-year review period, the landfill was inspected and maintained as required. The integrity of the landfill cover was maintained.

Control Construction and Other Ground-breaking Activities on the Landfills: Governmental Institutional Controls

The land use controls that have been implemented to control construction and other ground-breaking activities on the landfill to prevent cap/cover damage and/or inadvertent exposure to pit waste as long as the pit waste remains in place include:

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

Governmental Institutional Controls Implementation Status

Site 300 implements multiple layers of protection to maintain the integrity of the Pit 9 Landfill cover: Dig Permit and Work Induction Board processes.

Dig Permit Process: The Dig Permit process reviews all onsite excavation. Any proposed excavation would be approved by the LLNL Environmental Restoration Department to prevent excavation or damage of the Pit 9 Landfill cover.

Work Induction Board: Any proposed excavation activities are submitted to the LLNL Work Induction Board, and are reviewed by LLNL Environmental Restoration Department to prevent excavation or damage of the Pit 9 Landfill cover. 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).

During this five-year review period, no excavation or construction activities were proposed in the Pit 9 Landfill area. The LLNL processes for review of proposed new work (e.g., Work Induction Board and excavation permit processes) are effective in controlling excavation activities and is therefore protective of human health (onsite workers) in preventing exposure to waste contained in the landfill.

Prevent Inadvertent Exposure of Onsite Workers to the Pit Waste: Governmental Institutional Controls

The land use controls that have been implemented to prevent inadvertent exposure of onsite workers to the pit waste as long as the waste remains in place include:

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

Governmental Institutional Controls Implementation Status

The governmental institutional controls implemented to prevent inadvertent exposure of onsite workers are the same as those discussed in the *Control Construction and Other Ground-breaking Activities on the Landfills* above.

During this five-year review period, no excavation or construction activities were proposed in the Pit 9 Landfill area. The LLNL processes for review of proposed new work (e.g., Work Induction Board and excavation permit processes) are effective in controlling excavation activities and is therefore protective of human health (onsite workers) in preventing exposure to waste contained in the landfill.

Prevent Inadvertent Exposure of Onsite Workers to the Pit Waste: Physical Barriers

The land use controls that have been implemented to prevent inadvertent exposure of onsite workers to the pit waste as long as the waste remains in place include:

- Physical Barriers:
    - Signage.

Physical Barrier Implementation Status

Signage is maintained at the landfill access points prohibiting unauthorized access and requiring notification and authorization by LLNL Site 300 Management to enter, dig, excavate, or otherwise disturb soil or vegetation in this area.

The physical barriers to control and restrict access are effective in preventing prevent inadvertent exposure of onsite workers to the pit waste, and therefore are protective of human health.

Prevent Inadvertent Exposure of Unauthorized Trespassers to the Pit Waste: Physical Barriers

The land use controls that have been implemented to prevent inadvertent exposure of unauthorized trespassers to the pit waste as long as the waste remains in place include:

- Physical Barriers:
    - Fences.
    - Security Force.
    - Signage.

Physical Barrier Implementation Status

The fences surrounding Site 300, and signs and security forces control and restrict access to Site 300 to prevent inadvertent exposure by members of the public to contamination at Site 300. The LLNL Protective Services force conduct routine inspections of the fences surrounding Site 300. A member of the security force mans the entrance gate to Site 300 during hours when the front gate is open, and a DOE-issued security badge is required to gain entrance to the site. The site gates are closed and locked after 6 pm, and a security force member remains onsite overnight. Members of the public must apply for and obtain security badges and be escorted to access the site.

The physical barriers to control and restrict access are effective in preventing prevent inadvertent exposure by members of the public to contamination at Site 300, and therefore are protective of human health.

Prohibit Transfer of Lands with Unmitigated Contamination: Enforcement Tools

The land use controls that have been implemented to prohibit transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use include:

- Enforcement Tools:
    - FFA.
    - ROD.

The land use control and implementation status is described in more detail below.

Enforcement Tools Implementation Status

To prevent the potential exposure to contaminated waste and/or environmental media, the Site 300 FFA 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 as specified in the Site 300 ROD. The Site 300 FFA and ROD have not been modified during this five-year review period, and these provisions remain as originally stated in these documents.

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.

During the five-year review period, DOE has not proposed any plans to transfer any Site 300 land for residential, unrestricted, or non-DOE industrial land use. Site 300 remains under the ownership, oversight, and operation of the U.S. DOE. The provisions in Site 300 FFA and ROD are effective in preventing the transfer of lands with unmitigated contamination that could cause potential harm under a residential or unrestricted land use, and therefore are protective of human health.

3.2.3.4.3. Summary of the Status of Building 845/Pit 9 Landfill Land Use Controls

The review of the land use controls for the Building 845/Pit 9 Landfill for this five-year review period determined that these controls are effective for preventing exposure to contaminated media. DOE will implement, maintain, and enforce the land use controls for the Building 845/Pit 9 Landfill for as long as necessary to keep the selected remedy protective of human health and the environment.

3.2.4. Building 845 Firing Table and Pit 9 Landfill Five-Year Review Process

3.2.4.1. Notification of Review/Community Involvement

The 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 September 28, 2012. Completed documents can also be accessed electronically at LLNL's Environmental Restoration Department electronic library web page at http://www-erd/library/ or the Environmental Community Relations web page at http://www-envirinfo.llnl.gov.

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

3.2.4.2. Identification of Five-Year Review Team Members

The Five-Year Review of the Building 845 and Pit 9 Landfill at LLNL Site 300 was led by Claire Holtzapple, Site 300 Remedial Project Manager for the DOE/NNSA-Livermore Site Office. The following team members assisted in the review:

- Leslie Ferry, Program Leader, LLNS.
- Valerie Dibley, Deputy Program Leader, LLNS.
- Vic Madrid, Hydrogeology Team Leader, LLNS.
- Michael Taffet, Hydrogeologist, LLNS.
- Mark Buscheck, Hydrogeologist, Weiss Associates.

3.2.4.3. Document Review

This Five-Year Review consisted of examining relevant project documents and site data:

- Final Site-Wide Remedial Investigation for Lawrence Livermore National Laboratory Site 300 (Webster-Scholten et al., 1994).
- Final Site-Wide Feasibility Study for Lawrence Livermore National Laboratory Site 300 (Ferry et al., 1999).
- Interim Site-Wide Record of Decision for Lawrence Livermore National Laboratory Site 300 (U.S. DOE, 2001).
- Site-Wide Record of Decision for Lawrence Livermore National Laboratory Site 300 (U.S. DOE, 2008).
- Remedial Design Work Plan for Interim Remedies at Lawrence Livermore National Laboratory Site 300 (Ferry et al., 2001).
- Site-Wide Remediation Evaluation Summary Report for Lawrence Livermore National Laboratory Site 300 (Ferry et al., 2006).
- Semi-annual Site-Wide Compliance Monitoring Reports that include evaluations of remediation progress in the Building 845 Firing Table and Pit 9 Landfill area of OU 8 (Dibley et al., 2007c, 2008c, 2009c, 2009d, 2010a, 2010b, 2011a, 2011c, and 2012; LLNL 2008).

These documents are available on-line at www-erd.llnl.gov/library/index.html#reports.s300.

This Five-Year Review evaluates subsurface contaminant concentration and remediation system performance data collected through calendar year 2011.

3.2.5. Building 845 Firing Table and Pit 9 Landfill Data Review and Evaluation

This section is organized into four subsections: (1) analysis of contaminant distribution, concentrations, and remediation progress (Section 3.2.5.1), (2) detection monitoring and results for the Pit 9 Landfill (Section 3.2.5.2), (3) performance issues (Section 3.2.5.3), and (4) risk mitigation remediation progress (Section 3.2.5.4).

3.2.5.1. Building 845 Firing Table and Pit 9 Landfill Contaminant Distribution, Concentrations, and Remediation Progress

No COCs have been identified in surface soil, vadose zone, or ground water for the Pit 9 Landfill. Detection monitoring results for the landfill are discussed in Section 3.2.5.2.

There are no ground water COCs at the Building 845 Firing Table. Uranium-238 and HMX are COCs in the vadose zone underlying the Building 845 Firing Table (Table 7). In the past, leaching of Building 845 Firing Table debris and gravel resulted in minor depleted uranium and HMX contamination of shallow subsurface soil and bedrock underlying the firing table. Accordingly, ground water in this area is monitored for these constituents. Modeling documented in the Site-Wide Feasibility Study (Ferry et al., 1999) concluded that HMX and uranium in the vadose zone do not pose a threat to ground water.

The historic maximum HMX concentration measured in soil is 0.54 mg/kg (1988), well below the U.S. EPA Regional Screening Level (RSL) (Table 7). HMX concentrations in ground water samples remain below the 1 µg/L reporting limit. The historic maximum uranium-238 activity measured in soil is 1.2 picocuries per gram (pCi/g) (1988), below the Industrial

Preliminary Remediation Goal (PRG) for uranium-238 of 1.8 pCi/g and the Site 300 background activity of 3.1 pCi/g. Uranium activities in ground water samples from area wells remain very low (<1 pCi/L) and the $^{235}U/^{238}U$ atom ratios indicate that only natural uranium is present. Figure 34 shows second semester 2011 ground water concentrations for HMX, total uranium activities, and uranium-235/uranium-238 ($^{235}U/^{238}U$) atom ratios.

3.2.5.2. Pit 9 Landfill Detection Monitoring and Results

Detection monitoring of the Pit 9 Landfill is conducted to identify any future releases to ground water in accordance with the requirements of the Site 300 CMP/CP. As part of the detection monitoring program, ground water samples are collected from monitor wells located upgradient and directly downgradient of the Pit 9 Landfill and analyzed for potential constituents of concern.

Potential constituents of concern, as defined by Title 23 of the California Code of Regulations, Chapter 15, are:

- Constituents identified in disposal records or that are potentially associated with the buried waste.
- Constituents detected above background concentrations in soil, ground water, and/or surface water in the immediate vicinity of the landfill, indicating a previous release.
- Constituents or breakdown products that can reasonably be expected to be associated with the type of waste disposed of in the landfill.

The constituents of concern for the Pit 9 Landfill include VOCs, nitrate, tritium, perchlorate, HE compounds, uranium isotopes, Title 26 metals, lithium, and fluoride.

Concentrations and activities of VOCs, nitrate, tritium, perchlorate, HE compounds, uranium isotopes, Title 26 metals, lithium, and fluoride concentrations/activities in samples collected from the four $Tnsc_0$ HSU wells since monitoring began in 1987 have been either below reporting limits or within the range of background.

No contaminant releases have been identified from the Pit 9 Landfill. However, as discussed in Section 3.2.2.1.2 and shown on Figure 34, historic ground water elevation data indicate that the flow direction has ranged from northwest to northeast in the vicinity of the landfill. Therefore, DOE/NNSA recommends installing additional monitor wells in the vicinity of the landfill to ensure full detection monitoring capability under the observed range of ground water flow directions.

During the five-year review period, LLNS Maintenance and Utilities Services Department staff annually inspected the Pit 9 Landfill to identify any degradation or damage to the landfill surface or damage or blockage of the drainage ways that may have lead to: (1) increased infiltration of precipitation, (2) exposure to the landfill contents, and (3) flow of surface water on or adjacent to the landfill. During the five-year review period, maintenance personnel filled some animal burrows and cracks but otherwise, no significant issues (including subsidence) were reported during annual inspection of the landfill surface.

3.2.5.3. Building 845 Firing Table and Pit 9 Landfill Performance Issues

The remedy continues to be effective and protective of human health and the environment, and to make progress toward cleanup.

3.2.5.4. Building 845 Firing Table and Pit 9 Landfill Risk Mitigation Remediation Progress

No unacceptable risks or hazards associated with contaminants in surface soil, subsurface soil/bedrock, or ground water were identified for the Building 845 Firing Table or the Pit 9 Landfill in the baseline human health and ecological risk assessments.

On September 28, 2011, the U.S. EPA released updated toxicity values and contaminant characteristics for TCE in the IRIS (EPA, 2011). Currently, the only significant impact of this change is presumed to be on the assessment of risk for the vapor inhalation pathway. However, since TCE was not detected above the reporting limit in the Building 845 Firing Table/Pit 9 Landfill ground water during the past five years, this risk was not reassessed. In addition, there is no evidence of new releases or contamination that warrants re-evaluation of risk.

A Site-Wide Five-Year Ecological Review was performed in 2008 (Dibley et al., 2009c). No new ecological hazards were identified in the Building 845 and Pit 9 Landfill. No information was identified during this review to question the ecological protectiveness of the remedy.

3.2.6. Building 845 Firing Table and Pit 9 Landfill Interviews and Site Inspection

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

There is a continuous presence of ERD staff at Site 300 that routinely inspect the monitoring wellfield during sampling activities. The Pit 9 Landfill cover and associated drainage ways are annually inspected by the LLNL Maintenance and Utilities Services Department. The Site 300 ERD conducts self-assessment inspections and DOE/NNSA conducts quarterly inspections of remediation activities at Site 300. The RWQCB RPM performs site inspections twice a year, and the U.S. EPA and DTSC RPMs perform site inspections as requested. The U.S. EPA did not perform a construction completion inspection of OU 8 as the remedy required no construction. The Five-Year Review Inspection was performed by DOE/NNSA on August 16, 2011. The Five-Year Review Inspection Checklist is included as Attachment A.

Operational issues and resulting corrective actions identified during routine inspections associated with the landfill and monitoring wellfields are: (1) described in the 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 that are distributed following the meetings.

3.2.7. Building 845 Firing Table and Pit 9 Landfill Technical Assessment

The protectiveness of the interim remedy was assessed by determining if:

1. The interim remedy is functioning as intended at the time of the decision documents.
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 interim remedy into question.

3.2.7.1. Remedy Function

The remedy was determined to be functioning as intended at the time of the decision documents because:

- No early indicators of potential interim remedy failure were identified.
- The remedy is functioning as intended. Monitoring indicates that constituents monitored in ground water remain below analytical reporting limits or within the range of background.
- 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.

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

- There have been no 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 or ecological receptors has been identified.
- There have been no changes in land, building, or water use.
- No new contaminants or sources have been identified.
- No remedy byproducts have been identified.
- Changes in location-, chemical-, or action-specific ARARs or to-be-considered requirements:
  - The State of California established a 6 µg/L MCL for perchlorate on October 18, 2007. This action-specific ARAR and ARARs related to ground water cleanup were included in the 2008 Site-Wide ROD.
  - The U.S. EPA NPDES Pesticide Rule changed in 2011, however, there are no discharges to the ground surface or NPDES permit required as part of the Building 845/Pit 9 Landfill remedy.
- Changes in toxicity and other contaminant characteristics:
  - On September 28, 2011, the U.S. EPA released updated toxicity values and contaminant characteristics for TCE in the IRIS. Currently, the only significant impact of this change is presumed to be on the assessment of risk for the vapor inhalation pathway. However, as discussed in Section 3.2.5.4, the Baseline Risk Assessment did not identify any human health risks in the Building 845 and Pit 9 Landfill.

The Site 300 Human Health Protection RAOs are not applicable to the remedy selected for the Building 845 Firing Table and Pit 9 Landfill because there is no ground water contamination and no unacceptable risks or hazards associated with contaminants in surface soil or subsurface soil/bedrock were identified for the Building 845 Firing Table or the Pit 9 Landfill in the baseline human health and ecological risk assessments. In the vicinity of the Building 845 Firing Table, HMX concentrations and uranium activities in soil samples were below applicable PRGs and RSLs and Site 300 background levels. Ground water monitoring has revealed no impacts from these vadose zone COCs. In the vicinity of the Pit 9 Landfill, no contaminants have been detected in ground water since wells were installed in 1987 or in environmental media in the nearly 50 years since this landfill has been in existence.

3.2.7.3. 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.
- No unanticipated events (i.e., natural disasters, new contaminants discovered, etc.) occurred that would call the protectiveness of the remedy into question.
- No additional information has been identified that would call the protectiveness of the interim remedy into question.
- No new technologies are necessary to accelerate or achieve cleanup in a more cost-effective manner in the Building 845 and Pit 9 Landfill area, because: (1) no constituents are detected in ground water above reporting limits or background, (2) uranium activities and HMX concentrations in subsurface soil are below U.S. EPA's PRGs and RSLs for these constituents, and (3) there are no impacts to ground water from HMX and uranium in subsurface soil.

3.2.8. Building 845 Firing Table and Pit 9 Landfill Issues

No issues were identified during this evaluation. However, as discussed in Section 3.2.2.1.2 and shown on Figure 34, historic ground water elevation data indicate that the flow direction in the $Tnsc_0$ HSU has ranged from northwest to northeast in the vicinity of the landfill. Therefore, DOE/NNSA recommends installing additional monitor wells in the vicinity of the landfill to ensure full detection monitoring capability under the observed range of ground water flow directions.

3.2.9. Building 845 Firing Table and Pit 9 Landfill Recommendations and Follow-Up Actions

The following recommendations to be carried out by the DOE/NNSA were developed during the review process:

1. Install additional monitor wells in the $Tnsc_0$ HSU in the vicinity of the Pit 9 Landfill to ensure full detection monitoring capability under the observed range of ground water flow directions. Up to two monitor wells east of the landfill and potentially one monitor well west of the landfill are being considered to accomplish this objective. The proposed locations of the additional monitor wells to be installed will be presented to the regulatory agencies for concurrence prior to installation. Because the funding for the installation of these wells is not currently included in DOE/NNSA's funding request profile, the schedule for well installation will be finalized when the funding request is approved.

No other follow-up actions were identified related to this Five-Year Review.

3.2.10. Building 845 and Pit 9 Landfill Protectiveness Statement

The remedy for the Building 845 and Pit 9 Landfill is protective of human health and the environment for the site's industrial land use. The remedy protects human health because: (1) no constituents are detected in ground water above cleanup standards, analytical reporting limits, or background in the Building 845 and Pit 9 Landfill area, (2) no unacceptable risk or hazard to humans or threat to ground water were identified for COCs in subsurface soil (HMX and uranium) at the Building 845 Firing Table, (3) no COCs have been identified in surface soil or ground water in the vicinity of or beneath the Pit 9 Landfill and there is no evidence of releases from the Pit 9 Landfill, and (4) exposure pathways that could result in unacceptable risk to onsite workers are being controlled by the implementation of institutional controls, the Health and Safety Plan, and the Contingency Plan. DOE/NNSA's recommendation to install additional monitor wells in the vicinity of the Pit 9 Landfill will add an additional layer of protection by increasing the detection monitoring capability under a range of ground water flow directions.

The cleanup standards for Site 300 ground water are drinking water standards. Because drinking water standards do not differentiate between industrial and residential use and no constituents are detected in ground water above cleanup standards, analytical reporting limits, or background, the ground water cleanup remedy will be protective under any land use scenario.

Because the waste in the Pit 9 Landfill will remain in place, 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 is included in the Site-Wide ROD. This prohibition will remain in place until and unless a risk assessment is performed in accordance with current U.S. EPA risk assessment guidance and is agreed by the DOE, the U.S. EPA, the DTSC, and RWQCB as adequately showing no unacceptable risk for residential or unrestricted land use.

3.3. Building 833

3.3.1. Building 833 Site Chronology

The following is a chronological listing of significant environmental restoration events at the Building 833:

<u>1959–1982</u>

- Building 833 was used to conduct thermal and mechanical tests on various mixtures of HE compounds.
- Environmental studies began in 1981 when LLNL initiated a survey of potential TCE spills to the ground at Site 300.

<u>1985–1990</u>

- DOE/LLNL performed active and passive soil vapor surveys, drilled boreholes and monitor wells, and collected and analyzed soil and ground water samples.
- LLNL Site 300 was placed on the National Priorities List in 1990.

<u>1992</u>

- A FFA was signed for Site 300.

<u>1993</u>

- Site 300 ERD sampling staff began occupancy of Building 833 for office use, equipment storage, and maintenance.

<u>1999</u>

- The Site-Wide Feasibility Study for Site 300 was issued that included the Building 833 release site.

2001

- An Interim Site-Wide ROD for Site 300 was signed. The Interim Site-Wide ROD specified exposure control through risk and hazard management; and ground water monitoring as components of the remedy for the Building 833. The Interim Site-Wide ROD did not contain ground water cleanup standards.
- A Remedial Design Work Plan was issued that contained the strategic approach and schedule to implement the remedies in the Interim Site-Wide ROD.

2002

- The CMP/CP for Interim Remedies was submitted.

2008

- The Site-Wide ROD with selected remedies and cleanup standards for Site 300 was signed. The remedy did not change in the 2008 Site-Wide ROD, with the exception that ground water cleanup standards were established in the 2008 Site-Wide ROD.

2009

- The revised CMP/CP was issued.

3.3.2. Building 833 Background

3.3.2.1. Building 833 Physical Characteristics

3.3.2.1.1. Building 833 Site Description

Building 833 and the subject area covers approximately 4 acres of a hilltop located in the southeastern part of Site 300 (Figure 2). Building 833 was used from 1959 to 1982 to conduct thermal and mechanical tests on various mixtures of HE compounds. TCE served exclusively as the heat-transfer fluid for these tests. Surface discharge of waste fluids occurred through spills, building wash down, and release of rinsewater from the test cell and settling basin to an adjacent lagoon.

Beginning in 1993, Building 833 was repurposed for storage and offices for ERD sampling personnel.

3.3.2.1.2. Building 833 Hydrogeologic Setting

This section describes the hydrogeologic setting for the Building 833 area, including the unsaturated zone, the two HSUs underlying the area and surface water present in the area. A conceptual hydrostratigraphic column for the southeast portion of Site 300, including the Building 833 area, is shown on Figure 28.

Building 833 Vadose (Unsaturated) Zone

The vadose zone consists of unconsolidated Quaternary alluvial and colluvial deposits (Qal) and unsaturated Tertiary Pliocene sand and gravel sediments (Tpsg). When ground water is present in the ephemeral Tpsg HSU, the vadose zone is approximately 20 to 25 ft thick, but may be thicker when no ground water is present in the Tpsg HSU.

Building 833 Saturated Zone

Two HSUs units have been identified in the Building 833 area: the Tpsg HSU and $Tnbs_1$ HSU.

The Tpsg HSU is a shallow, highly ephemeral perched water-bearing zone contained within unconsolidated sand and gravel. During heavy rainfall events, this HSU may become saturated. However, ground water monitoring from 1993 to 2005 has shown little evidence of saturation. Since 2003, all wells screened in the Tpsg HSU at Building 833 were dry or only contained water within a sump below the screen. When present, depth to water is about 20 to 25 ft bgs, and the saturated thickness varies from 0 to 5 ft. Due to the lack of saturation in wells screened in the HSU, a ground water gradient and flow direction cannot be accurately determined. Recharge for this HSU occurs on hilltops via rainwater percolation.

The Tertiary Pliocene nonmarine sediments (Tps) claystone aquitard prevents downward movement of perched Tpsg ground water into the underlying Neroly bedrock. Approximately 300 ft of unsaturated Neroly Formation upper blue sandstone ($Tnbs_2$) and lower siltstone/claystone ($Tnsc_1$) are present beneath the Tps aquitard.

The $Tnbs_1$ HSU is comprised of Neroly Formation Lower blue sandstone stratigraphic unit ($Tnbs_1$). Depth to ground water in this HSU is over 325 ft below Building 833. Ground water within this HSU generally flows southeast with a moderate gradient.

Building 833 Surface Water

Natural surface water in the Building 833 area is the result of surface runoff from precipitation. Natural surface runoff is rarely present, and only occurs briefly during significant or prolonged storms. There are no surface water bodies (i.e., springs) in the Building 833 area.

3.3.2.2. Building 833 Land and Resource Use

Site 300 is currently an operating facility, and will remain under DOE control for the reasonably anticipated future. Less than 5 percent of Site 300’s 7000-acre property-area is developed.

Building 833 is located in the southeastern part of Site 300 (Figures 1 and 2) and is approximately 1,800 feet west of the closest (eastern) site boundary. The Building 833 is currently used as storage and offices for the ERD sampling personnel.

There are no active onsite water-supply wells in the Building 833 area.

Annual grasslands surround Building 833. The big tarplant (*Blepharizonia plumosa*), an extremely rare late-season flowering plant included on the California Native Plant Society's List 1B, has been periodically mapped in the area around the facility. Building 833 also occurs within the upland dispersal habitat for the federally threatened California red-legged frog (*Rana aurora draytonii*) and the threatened California tiger salamander (*Ambystoma californiense*). Loggerhead shrikes (*Lanius ludovicianus*), a California Species of Special Concern, have been observed nearby. A five-year ecological review reported on in the 2008 Annual Compliance Monitoring Report (Dibley et al., 2009c), which updated the assessment of the ecological impacts from Site 300 contaminants, found no impact to ecological receptors from releases from Building 833. An LLNL ecologist reviewed ecological data collected between 2008 and 2011 for the area to evaluate whether any changes in contaminant or ecological conditions that could impact ecological receptors. No changes were identified. Access to these unique animal and plant populations is controlled and interactions with the wildlife are avoided.

3.3.2.3. Building 833 History of Contamination

Spills, earthen disposal pits, and rinse water disposal at Building 833 resulted in minor VOC contamination of perched ground water in the Tpsg HSU. TCE was discharged to the ground surface at Building 833 and to a rinse water lagoon adjacent to Building 833, resulting in contamination of the vadose zone and ground water in the area. TCE has been identified in Tpsg sediments at a maximum concentration of 1.5 mg/kg in the immediate area of Building 833. The historic maximum TCE concentration in Tpsg ground water at Building 833 was 2,100 µg/L in 1992. Ground water is only occasionally present in small quantities in the Tpsg HSU beneath Building 833. There is no contamination in the $Tnbs_1$ HSU beneath Building 833.

No TCE or other VOCs were detected in surface soil samples collected in the vicinity of the former lagoon. TCE concentrations in shallow subsurface soil (less than 10 ft) ranged from 0.0031 mg/kg to 0.0085 mg/kg. The results of both active and passive soil vapor surveys in the vicinity of the lagoon also indicated that a significant VOC source was not present in surface or shallow subsurface soil. Because soil in the vicinity of the lagoon did not pose a risk to human or ecological receptors, or further threat to ground water, no cleanup was required.

3.3.2.4. Building 833 Initial Response

Environmental studies began in 1981 when LLNL initiated a survey of potential TCE spills to the ground at Site 300 to identify contaminant source areas and the distribution of contaminants in soil, bedrock, and ground water. Since then 63 boreholes have been drilled at Building 833; nine of these boreholes have been completed as ground water monitor wells (Figure 36). The geologic and chemical data from wells and boreholes were used to characterize the site hydrogeology and to monitor the temporal and spatial changes in saturation and dissolved contaminants. Site characterization activities also included active and passive soil vapor surveys.

3.3.2.5. Building 833 Contaminants of Concern

At Building 833, VOCs TCE and cis-1,2-DCE are the COCs in ground water. TCE is also a vadose zone COC. There are no COCs identified in surface water or surface soil at Building 833. TCE is present only in perched ground water in the Tpsg HSU (Figure 36). The distribution and concentration of contaminants in ground water is described in Section 3.3.5.1. Because this HSU is limited to the Building 833 area, there is no migration pathway for TCE from the Building 833 area to onsite or offsite water-supply wells. In addition, exposure, use, or ingestion of the contaminated ground water is highly unlikely because the perched water-bearing zone is naturally unsuitable for drinking water due to high dissolved solid concentrations and low sustainable yields.

The baseline risk assessment for the Building 833 area estimated a cancer risk of 1×10^{-6} (one in one million) with an HI less than 1 for onsite workers inhaling VOC vapors volatilizing from the subsurface and migrating into indoor air at Building 833. Engineering controls consisting of enhanced ventilation/positive pressure were in place to prevent infiltration and buildup of VOC vapors inside Building 833 that could result in an unacceptable exposure risk to workers in this building. No unacceptable hazard to ecological receptors was identified in the baseline risk assessment for Building 833.

Risk mitigation remediation progress is discussed in Section 3.3.5.3.

3.3.2.6. Building 833 Summary of Basis for Taking Action

Remedial actions were initiated at Building 833 to address unacceptable human health risks associated with onsite worker inhalation exposure to VOCs volatilizing from the subsurface soil to indoor air.

3.3.3. Building 833 Remedial Actions

3.3.3.1. Building 833 Remedy Selection

The remedy selected for the Building 833 is intended to achieve the following RAOs:

For Human Health Protection:

- Restore ground water containing contaminant concentrations above cleanup standards.
- Prevent human ingestion of ground water containing contaminant concentrations (single carcinogen) above cleanup standards.
- Prevent human inhalation of VOCs volatilizing from subsurface soil to air that pose an excess cancer risk greater than 10^{-6} or HI greater than 1, a cumulative excess cancer risk (all carcinogens) in excess of 10^{-4}, or a cumulative HI (all noncarcinogens) greater than 1.
- Prevent human exposure to contaminants in media of concern that pose a cumulative excess cancer risk (all carcinogens) greater than 10^{-4} and/or a cumulative HI greater than one (all noncarcinogens).

For Environmental Protection:

- Restore water quality to ground water cleanup standards within a reasonable timeframe and to prevent plume migration to the extent technically and economically practicable. Maintain existing water quality that complies with ground water cleanup standards to the extent technically and economically practicable. This will apply to both individual and multiple constituents that have additive toxicology or carcinogenic effects.

There are no RAOs for the protection of ecological receptors as the baseline ecological risk assessment indicated that there was no risk or hazard to ecological receptors at Building 833.

The remedy for the Building 833 was selected in the 2001 Interim Site-Wide ROD. The interim remedy was selected as the final remedy in the 2008 ROD.

The selected remedy for the Building 833 consisted of:

1. Monitoring ground water to detect changes in VOC concentrations that could impact human health or the environment.
2. Risk and hazard management to prevent onsite worker exposure to VOCs volatilizing from subsurface soil into indoor air at Building 833 until risk is mitigated. Institutional/land use controls will continue to be implemented to prevent human exposure to contamination and to protect the integrity of the remedy.

3.3.3.2. Building 833 Remedy Implementation

Land Use Controls have been implemented to prevent inhalation risk of VOCs volatilizing (see Section 3.2.3.4). The VOC inhalation risk at Building 833 is re-evaluated annually.

Ground water monitoring has been implemented and the results are reported in the semi-annual ERD Compliance Monitoring Report. Samples of ground water are collected for VOC analysis.

3.3.3.3. Building 833 Operation and Maintenance

The remedy for the Building 833 is operating as designed and no significant operations, performance, or cost issues were identified during this evaluation. All required documentation is in place and monitoring procedures are consistent with established procedures and protocols.

Monitoring procedures are contained in the following documents:

- Site-Wide Compliance Monitoring Plan/Contingency Plan for Remedies at LLNL Site 300.
- LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures.

The budgeted and actual environmental restoration costs for the Building 833 are tracked and are consistently within or near the allocated budget. Table 1 presents the actual costs for the last five fiscal years, 2007 through 2011.

3.3.3.4. Building 833 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, and
- Physical barriers.

The U.S. EPA (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 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 onsite.

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.

The land use controls and requirements described herein are only applicable to the Building 833 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 inspection results are reported in the annual Site 300 Compliance Monitoring Reports.

Land use controls for the Building 833 are described in Table 5 which 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 Building 833. Figure 37 shows the specific areas of the Building 833 where the land use controls have been 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 Building 833 by objective, and the status of the land use controls are summarized below.

3.3.3.4.1. Building 833 Land Use Control Objectives

Land use control objectives were established for the Building 833 in the Site 300 ROD (DOE, 2008) to reduce risk and prevent exposure to contaminated environmental media. The risk drivers and associated land use controls identified for the Building 833 include:

1. ***Risk Driver*** - VOC concentrations in ground water onsite exceed cleanup standards.

   Land use control objectives:

   - Prevent onsite water-supply use/consumption of contaminated ground water until ground water cleanup standards are met.

2. ***Risk Driver*** - Potential exposure to VOCs at depth in subsurface soil.

   Land use control objective:

   - Control excavation activities to prevent onsite worker exposure to contaminants in subsurface soil until it can be verified that concentrations do not pose an exposure risk to onsite workers.

3. ***Risk Driver*** - The baseline risk assessment identified a risk of 1×10^{-6} for onsite workers from inhalation of VOCs volatilizing from subsurface soil into ambient air inside Building 833.

   Land use control objective:

   - Prevent onsite site worker inhalation exposure to VOCs inside Building 833 until annual risk re-evaluation indicates that the risk is less than 10^{-6}.

4. ***Risk Driver*** - Potential exposure to contaminated environmental media.

Land use control objective:

- Prohibit transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use.

3.3.3.4.2. Building 833 Land Use Controls

This section discusses the land use controls including institutional controls, engineered controls, and physical barriers for the Building 833 that were established and are implemented to address the risk reduction objectives and their current status.

Prevent Onsite Water-supply Use/consumption of Contaminated Ground Water: Governmental Institutional Controls

DOE/LLNL has implemented multiple layers of protection (land use controls) to prevent the water-supply use or consumption of onsite contaminated ground water in the Building 833 area until ground water cleanup standards are met. The land use controls include:

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

Governmental Institutional Controls Implementation Status

Dig Permit Process: A LLNL Dig Permit is required to drill and install any new onsite wells at Site 300. This permit process includes an evaluation of the proposed well location by the LLNL Environmental Analyst to determine if the proposed new water-supply well is located in an area of ground water contamination. If it is determined that the proposed water-supply well location is in a ground water contamination area, the Environmental Analyst works with the LLNL entity proposing the well installation and the LLNL Environmental Restoration Department to relocate the well to ensure ground water contaminants would not be drawn into the well before a dig permit is issued.

Work Induction Board: Any proposed onsite well drilling activities are also submitted to the LLNL Work Induction Board, and are reviewed by the LLNL Environmental Restoration Department to ensure that new water-supply wells are not located in areas of ground water 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).

During this five-year review period, the LLNL processes for review of proposed new work were effective in preventing the drilling and installation of new onsite water-supply wells within areas of onsite ground water contamination, and are therefore protective of human health (onsite workers) in preventing the consumption of contaminated onsite ground water.

Control Onsite Excavation Activities: Governmental Institutional Controls

The land use controls that have been implemented to control excavation activities to prevent onsite worker exposure to contaminants in subsurface soil until it can be verified that concentrations do not pose an exposure risk to onsite workers include:

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

Governmental Institutional Controls Implementation Status

Site 300 implements multiple layers of protection to prevent onsite worker exposure to contaminants in subsurface soil: Dig Permit and Work Induction Board processes.

Dig Permit Process: A LLNL Dig Permit is required to conduct any ground disturbing activities at Site 300, including activities that involve the excavation of soil and/or rock. This permit process includes an evaluation of the proposed location for the ground disturbing/excavation activity by the LLNL Environmental Analyst to determine if it is located in an area of soil/rock contamination. The Environmental Analyst works with the LLNL entity proposing the ground disturbing/excavation activity to determine if the activity can be moved. If the work plans cannot be modified to move excavation activities outside of areas of soil contamination, LLNL Environmental Health & Safety personnel evaluate the potential hazards and identify the necessary controls to be implemented prior to the start of work.

Work Induction Board: Any proposed excavation activities are submitted to the LLNL Work Induction Board, and are reviewed by LLNL Environmental Restoration Department. 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).

During this five-year review period, no excavation or construction activities were proposed in the Building 833 area. The LLNL processes for review of proposed new work (e.g., Work Induction Board and dig permit processes) are effective in controlling excavation activities and are therefore protective of human health (onsite workers) in preventing exposure to contaminants in subsurface soil.

Prevent Onsite Site Worker Inhalation Exposure to VOCs inside Building 833: Engineered Controls

DOE/LLNL has implemented engineered controls to prevent onsite site worker inhalation exposure to VOCs inside Building 833 until 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 833 to maintain a positive pressure to prevent VOC vapors from migrating into the building.

Engineering Controls Implementation Status

A pre-remediation risk of 1×10^{-6} was identified for onsite workers from inhalation of VOCs volatilizing from subsurface soil into ambient air inside Building 833. To prevent onsite site worker inhalation exposure to VOCs inside Building 833, engineering controls (heating, ventilating, and air-conditioning system for Building 833) 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} as of 2011 (see Section 3.3.5.3), therefore, this institutional/land use control is no longer needed.

Prohibit Transfer of Lands with Unmitigated Contamination: Enforcement Tools

The land use controls that have been implemented to prohibit transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use include:

- Enforcement Tools:
    - FFA.
    - ROD.

The land use control and implementation status is described in more detail below.

Enforcement Tools Implementation Status

To prevent the potential exposure to contaminated waste and/or environmental media, the Site 300 FFA 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 as specified in the Site 300 ROD. The Site 300 FFA and ROD have not been modified during this five-year review period, and these provisions remain as originally stated in these documents.

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.

During the five-year review period, DOE has not proposed any plans to transfer any Site 300 land for residential, unrestricted, or non-DOE industrial land use. Site 300 remains under the ownership, oversight, and operation of the U.S. DOE. The provisions in Site 300 FFA and ROD are effective in preventing the transfer of lands with unmitigated contamination that could cause potential harm under a residential or unrestricted land use, and therefore are protective of human health.

Other Controls: Physical Barriers

The fences surrounding Site 300, signs, and security forces control and restrict access to Site 300; thereby preventing the inadvertent exposure by members of the public to contamination at Site 300. The LLNL Protective Services Force conducts routine inspections of the fences surrounding Site 300 to ensure they are intact. A member of the security force mans the entrance gate to Site 300 during hours when the front gate is open, and a DOE-issued security badge is required to gain entrance to the site. The site gates are closed and locked after 6 pm, and a security force member remains onsite overnight. Members of the public must apply for and obtain security badges and be escorted to access the site.

The physical barriers to control and restrict access are effective in preventing inadvertent exposure by members of the public to contamination at Site 300, and therefore are protective of human health.

3.3.3.4.3. Summary of the Status of Building 833 Land Use Controls

The review of the land use controls for the Building 833 for this five-year review period determined that these controls are effective for preventing exposure to contaminated media.

DOE will implement, maintain, and enforce the land use controls for the Building 833 for as long as necessary to keep the selected remedy protective of human health and the environment.

3.3.4. Building 833 Five-Year Review Process

3.3.4.1. Notification of Review/Community Involvement

The 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 September 28, 2012. Completed documents can also be accessed electronically at LLNL's Environmental Restoration Department electronic library web page at http://www-erd/library/ or the Environmental Community Relations web page at http://www-envirinfo.llnl.gov.

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

3.3.4.2. Identification of Five-Year Review Team Members

The Five-Year Review of the Building 833 at LLNL Site 300 was led by Claire Holtzapple, Site 300 Remedial Project Manager for the DOE/NNSA-Livermore Site Office. The following team members assisted in the review:

- Leslie Ferry, Program Leader, LLNS.
- Valerie Dibley, Deputy Program Leader, LLNS.
- Vic Madrid, Hydrogeology Team Leader, LLNS.
- Michael Taffet, Hydrogeologist, LLNS.
- Mark Buscheck, Hydrogeologist, Weiss Associates.

3.3.4.3. Document Review

This Five-Year Review consisted of examining relevant project documents and site data:

- Final Site-Wide Remedial Investigation for Lawrence Livermore National Laboratory Site 300 (Webster-Scholten et al., 1994).
- Final Site-Wide Feasibility Study for Lawrence Livermore National Laboratory Site 300 (Ferry et al., 1999).
- Interim Site-Wide Record of Decision for Lawrence Livermore National Laboratory Site 300 (U.S. DOE, 2001).
- Site-Wide Record of Decision for Lawrence Livermore National Laboratory Site 300 (U.S. DOE, 2008).
- Remedial Design Work Plan for Interim Remedies at Lawrence Livermore National Laboratory Site 300 (Ferry et al., 2001).
- Site-Wide Remediation Evaluation Summary Report for Lawrence Livermore National Laboratory Site 300 (Ferry et al., 2006).
- Semi-annual Site-Wide Compliance Monitoring Reports that include evaluations of remediation progress in the Building 833 area of OU 8 (Dibley et al., 2007c, 2008c, 2009c, 2009d, 2010a, 2010b, 2011a, 2011c, and 2012; LLNL 2008).

These documents are available on-line at www-erd.llnl.gov/library/index.html#reports.s300.

This Five-Year Review evaluates subsurface contaminant concentration and remediation system performance data collected through calendar year 2011.

3.3.5. Building 833 Data Review and Evaluation

This section is organized into three subsections: (1) analysis of contaminant distribution, concentration, and remediation progress (Section 3.3.5.1), (2) performance issues (Section 3.3.5.2), and (3) risk mitigation remediation progress (Section 3.3.5.3).

3.3.5.1. Building 833 Contaminant Distribution, Concentration, and Remediation Progress

At Building 833, the VOCs TCE and cis-1,2-DCE are the COCs present in perched ground water. TCE is also a COC in subsurface soil in the vadose zone in the Building 833 area. A list of primary COCs and their historic maximum and 2011 maximum concentrations is detailed in Table 6. Figure 36 shows 2011 VOC concentrations in ground water.

The Tpsg HSU is a shallow, highly ephemeral perched water-bearing zone. During heavy rainfall events, this HSU may become saturated, but quarterly monitoring of the wells from 1993 to present has shown little evidence of saturation. When saturated, monitoring conducted from 1993 to present has shown a general decline in total VOC concentrations. VOCs detected in Tpsg HSU ground water are comprised entirely of TCE. TCE concentrations have decreased from a historic maximum concentration of 2,100 µg/L (W-833-03, 1992) to a five-year review period maximum TCE concentration of 180 µg/L (Tpsg HSU well W-833-28, in 2008). The most recent 2011 maximum TCE concentration was 150 µg/L (Tpsg HSU well W-833-33, February 2011). TCE has never been detected in deeper $Tnbs_1$ HSU well W-833-30.

Cis-1,2-DCE has been detected at a historic maximum concentration of 58 µg/L (Tpsg HSU well W-833-12, 1993). Cis-1,2-DCE has not been detected in well W-833-12 since 1993 and has never been detected in any other area wells including well W-833-30, screened in the deeper $Tnbs_1$ HSU.

During 2011, VOCs were not detected in ground water samples collected from the deep $Tnbs_1$ HSU monitor well W-833-30, indicating that VOC contamination continues to be limited to the shallow Tpsg perched water-bearing zone. Since its construction in 1991, VOCs have only been detected twice, both in 1992, in the deeper $Tnbs_1$ HSU monitor well W-833-30, in very small concentrations (0.8 and 1.6 µg/L of chloroform and PCE, respectively).

In summary, spills, earthen disposal pits and rinsewater disposal at Building 833 resulted in minor VOC contamination of perched ground water in the Tpsg HSU. The Tpsg HSU is a shallow, highly ephemeral perched water-bearing zone. After heavy rainfall events, this HSU may become saturated, but historic quarterly monitoring of the wells since 1993 has shown little evidence of saturation. VOCs have shown a general decreasing trend in the Tpsg HSU since monitoring began in 1988. No VOCs are present underlying $Tnbs_1$ regional aquifer.

3.3.5.2. Building 833 Performance Issues

The remedy continues to be effective and protective of human health and the environment, and to make progress toward cleanup.

3.3.5.3. Building 833 Risk Mitigation Remediation Progress

The baseline risk assessment for the Building 833 area estimated a cancer risk of 1×10^{-6} (one in one million) with an HI less than 1 for onsite workers inhaling VOC vapors volatilizing from the subsurface and migrating into indoor air at Building 833. These risks have been re-evaluated and reported annually since 2003 as part of the Risk and Hazard Management Program.

The 2006 re-evaluation indicated that Building 833 indoor air levels are no longer of concern (less than 10^{-6}) (Dibley et al., 2007d). The risk was re-evaluated each year until 2011 and remained below 1×10^{-6}. Therefore the risk is considered mitigated and risk re-evaluations will be discontinued.

On September 28, 2011, the U.S. EPA released updated toxicity values and contaminant characteristics for TCE in the IRIS (EPA, 2011). Currently, the only significant impact of this change is presumed to be on the assessment of risk for the vapor inhalation pathway. As part of the 2011 Annual CMR, the inhalation risk for on-site workers breathing indoor air at Building 833 was re-evaluated using the new toxicity values. The hazard quotient was less than 1 and the individual and cumulative excess cancer risk remained below 1×10^{-6} (Dibley et al., 2012).

No unacceptable hazard to ecological receptors was identified in the baseline ecological risk assessment. A Site-Wide Five-Year Ecological Review was performed in 2008 (Dibley et al., 2009c). No new ecological hazards were identified in the Building 833. No information was identified during this review to question the ecological protectiveness of the remedy.

3.3.6. Building 833 Interviews and Site Inspection

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

There is a continuous presence of ERD staff at Site 300 that routinely inspect the monitoring wellfield during sampling activities. The Site 300 ERD conducts self-assessment inspections and DOE/NNSA conducts quarterly inspections of remediation activities at Site 300. The RWQCB RPM performs site inspections twice a year, and the U.S. EPA and DTSC RPMs perform site inspections as requested. The U.S. EPA did not perform a construction completion inspection of OU 8 as the remedy required no construction. The Five-Year Review Inspection was performed by DOE/NNSA on August 16, 2011. The Five-Year Review Inspection Checklist is included as Attachment A.

3.3.7. Building 833 Technical Assessment

The protectiveness of the interim remedy was assessed by determining if:

1. The interim remedy is functioning as intended at the time of the decision documents.
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 interim remedy into question.

3.3.7.1. Remedy Function

The remedy was determined to be functioning as intended at the time of the decision documents because:

- No early indicators of potential interim remedy failure were identified.
- The remedy is functioning as intended by reducing COC concentrations/activities.

- 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.

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

- There have been no 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 or ecological receptors has been identified.
- There have been no changes in land, building, or water use.
- No new contaminants or sources have been identified.
- No remedy byproducts have been identified.
- Changes in location-, chemical-, or action-specific ARARs or to-be-considered requirements:
  - The State of California established a 6 µg/L MCL for perchlorate on October 18, 2007. This action-specific ARAR and ARARs related to ground water cleanup were included in the 2008 Site-Wide ROD.
  - The U.S. EPA NPDES Pesticide Rule changed in 2011, however, there are no discharges to the ground surface or NPDES permit required as part of the Building 833 remedy.
- Changes in toxicity and other contaminant characteristics:
  - On September 28, 2011, the U.S. EPA released updated toxicity values and contaminant characteristics for TCE in the IRIS. Currently, the only significant impact of this change is presumed to be on the assessment of risk for the vapor inhalation pathway. As discussed in Section 3.3.5.3, the Baseline Risk Assessment estimated a cancer risk of 1×10^{-6} for onsite workers inhaling VOC vapors volatilizing from the subsurface and migrating into indoor air at Building 833. As part of the 2011 annual CMR, the inhalation risk for Building 833 was re-evaluated using the new toxicity value. The hazard quotient was less than 1 and the individual and cumulative excess cancer risk remained below 1×10^{-6}(Dibley et al., 2012).
- The review found progress toward meeting the RAOs.

3.3.7.3. 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.
- No unanticipated events (i.e., natural disasters, new contaminants discovered, etc.) occurred that would call the protectiveness of the remedy into question.
- No additional information has been identified that would call the protectiveness of the interim remedy into question.

- No new technologies have been identified that are capable of accelerating or achieving cleanup in a more cost-effective manner in the Building 833 Landfill area.

3.3.8. Building 833 Landfill Issues

No issues were identified during this evaluation.

3.3.9. Building 833 Recommendations and Follow-Up Actions

The following recommendations to be carried out by the DOE/NNSA were developed during the review process:

1. Remove cis-1,2-DCE as a ground water COC because: (1) cis-1,2-DCE has only been detected in one well (W-833-12) and cis-1,2-DCE concentrations in this well decreased to and have remained below the 0.5 µg/L reporting limit since April 1993, (2) cis-1,2-DCE has never been detected above the 0.5 µg/L reporting limit in the any other area wells including well W-833-30, screened in the deeper $Tnbs_1$ HSU.

However, ground water samples from Building 833 monitor wells would still be analyzed for VOCs by EPA Method 601 to monitor for TCE. Any cis-1,2-DCE detections would still be reported/discussed in the Compliance Monitoring Reports.

3.3.10. Building 833 Protectiveness Statement

The remedy at the Building 833 is protective of human health and the environment for the site's industrial land use. The remedy protects human health because: (1) VOCs in ground water are decreasing towards cleanup standards, (2) engineering controls prevented exposure of onsite workers that could inhale VOC vapors volatilizing from the subsurface and migrating into indoor air at Building 833 until the risk was mitigated in 2011, and (3) exposure pathways that could result in unacceptable risk to onsite workers are being controlled by the implementation of institutional controls, the Health and Safety Plan, and the Contingency Plan.

The cleanup standards for Building 833 ground water are drinking water standards. Because drinking water standards do not differentiate between industrial and residential use, the ground water cleanup remedy will be protective under any land use scenario.

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 is included in the Site-Wide ROD. This prohibition will remain in place until and unless a risk assessment is performed in accordance with current U.S. EPA risk assessment guidance and is agreed by the DOE, the U.S. EPA, the DTSC, and RWQCB as adequately showing no unacceptable risk for residential or unrestricted land use.

3.4. Building 851 Firing Table

3.4.1. Building 851 Site Chronology

The following is a chronological listing of significant environmental restoration events at the Building 851:

<u>1962–Present</u>

- Building 851 Firing Table began operating in 1962.

1988

- Building 851 Firing Table gravels were removed in 1988.

1990

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

1992

- A FFA was signed for Site 300.

1999

- The Site-Wide Feasibility Study for Site 300 was issued that included the Building 851.

2001

- An Interim Site-Wide ROD for Site 300 was signed. The Interim Site-Wide ROD specified no further action for VOCs and uranium in soil and bedrock and for RDX and metals in surface soil as well as monitoring as components of the remedy for the Building 851 area. The Interim Site-Wide ROD did not contain ground water cleanup standards.
- A Remedial Design Work Plan was issued that contained the strategic approach and schedule to implement the remedies in the Interim Site-Wide ROD.

2002

- The CMP/CP for Interim Remedies was issued.

2008

- The Site-Wide ROD with selected remedies and cleanup standards for Site 300 was signed. The remedy did not change in the 2008 Site-Wide ROD, with the exception that ground water cleanup standards were established in the 2008 Site-Wide ROD.

2009

- The revised CMP/CP was issued.

3.4.2. Building 851 Firing Table Background

3.4.2.1. Building 851 Firing Table Physical Characteristics

3.4.2.1.1. Building 851 Firing Table Site Description

Building 851 complex area covers 5 acres and is located in the northwestern part of Site 300 (Figure 2). The Building 851 complex consists of Buildings 851A (bunker), Building 851B (machine shop), and the Building 851 Firing Table. The firing table has been used since 1962 to conduct experimental high explosives research. Firing table gravels were removed in 1988 and are still replaced periodically to prevent: (1) compaction of gravel that could reduce shock dampening and, (2) the accumulation of contaminants in firing table gravels that could be released to the environment. Gravels from Building 851 Firing Table were formerly disposed of in the Pit 3 Landfill (open 1958 to 1967), Pit 4 Landfill (open 1968 to 1974), Pit 5 Landfill (open 1968 to 1978), and the Pit 7 Landfill (open 1978 to 1988). Since the Pit 7 Landfill was closed in 1988, gravel removed from the Building 851 Firing Table has been transported to the Nevada Test Site for disposal.

3.4.2.1.2. Building 851 Firing Table Hydrogeologic Setting

This section describes the hydrogeologic setting for the Building 851 area, including the unsaturated zone, one HSU underlying the area, and surface water in the area. A conceptual hydrostratigraphic column for the northern portion of Site 300 including the Building 851 area is shown on Figure 28.

Building 851 Firing Table Vadose (Unsaturated) Zone

The vadose zone consists of approximately 100 to 150 ft of unconsolidated Quaternary alluvial and colluvial deposits (Qal), Quaternary landslide deposits (Qls), and underlying unsaturated Neroly Formation $Tnbs_1$lower blue sandstone and $Tnsc_0$ siltstone/claystone bedrock.

Building 851 Firing Table Saturated Zone

The Tmss HSU consists of one stratigraphic unit: the Cierbo Formation (Tmss) that is comprised of sandstone, claystone, pebble conglomerate, and shale. Tmss strata beneath the Building 851 area are saturated; ground water is under confined conditions. Depth to water varies from 100 to 150 ft below ground surface, and the saturated thickness varies from 5 to 10 ft. Since monitoring of the existing well network began in 1988, the ground water gradient in the Tmss HSU in the vicinity of Building 851 has remained nearly flat (Figure 38).

Building 851 Firing Table Surface Water

Natural surface water in the Building 851 area is the result of surface runoff from precipitation. Natural surface runoff is rarely observed, and only occurs briefly during more significant or prolonged storms. There are no surface water bodies (i.e., springs) in the Building 851 area.

3.4.2.2. Building 851 Firing Table Land and Resource Use

Site 300 is currently an operating facility, and will remain under DOE control for the reasonably anticipated future. Less than 5 percent of Site 300's 7000-acre property-area is developed.

The Building 851 Firing Table is located in the northwestern part of Site 300 (Figure 2) and is approximately 3,300 feet east of the closest (western) site boundary. The Building 851 complex continues to be used for high explosive testing.

There are no active onsite water-supply wells in the Building 851 area.

Annual grasslands surround the Building 851 complex, with a small amount of native perennial grasslands and coastal sage scrub located to the north of the facility. The big tarplant (*Blepharizonia plumosa*), an extremely rare late-season flowering plant included on the California Native Plant Society's (CNPS) List 1B, is routinely mapped around the perimeter of the facility. The diamond-petal poppy (*Eschscholzia rhombipetela*), also a CNPS List 1B plant, occurs on a hillside to the west of the facility. In addition, the round-leaved filaree (*California macrophylla*, formerly known as *Erodium macrophyllum*), another CNPS List 1B plant, occurs along the fire trials directly behind (west) of the facility. The Building 851 complex is located within the critical habitat for the federally threatened Alameda whipsnake (*Masticophis lateralis euryxanthus*). The Building 851 complex also occurs within the upland dispersal habitat for the federally threatened California red-legged frog (*Rana aurora draytonii*). Loggerhead shrikes (*Lanius ludovicianus*), and burrowing owls (*Athene cunicularia*), both California Species of Special Concern, have been observed nearby. A five-year ecological review reported on in the

2008 Annual Compliance Monitoring Report (Dibley et al., 2009c), which updated the assessment of the ecological impacts from Site 300 contaminants, found no impact to ecological receptors from releases from the Building 851 complex. An LLNL ecologist reviewed ecological data collected between 2008 and 2011 for the area to evaluate whether any changes in contaminant or ecological conditions that could impact ecological receptors. No changes were identified. Access to these unique animal and plant populations is controlled and interactions with the wildlife are avoided.

3.4.2.3. Building 851 Firing Table History of Contamination

High explosives testing have been conducted at the Building 851 Firing Table since 1962. Firing table gravels were removed in 1988 and are still replaced periodically to prevent accumulation of contaminants in gravels that could be released to the environment. Former explosives experiments resulted in the release of uranium-238, the HE compound HMX, and metals to the surrounding surface soil; VOCs and uranium-238 to subsurface soil; and uranium-238 to ground water.

3.4.2.4. Building 851 Firing Table Initial Response

Investigations at the Building 851 complex began in 1988 to identify contaminant source areas and the distribution of contaminants in soil, bedrock, and ground water. Since then, 12 boreholes have been drilled at Building 851; four of these boreholes have been completed as ground water monitor wells (Figure 38). The geologic and chemical data from wells and boreholes were used to characterize the site hydrogeology and to monitor the temporal and spatial changes in saturation and dissolved contaminants. Five of the boreholes were drilled within the firing table to characterize the extent of any contamination in firing table gravels and underlying vadose zone. Firing table gravels and some contaminated soil were removed in 1988 and disposed in Pit 7. Ground water monitoring has been conducted to evaluate uranium activities in ground water.

3.4.2.5. Building 851 Firing Table Contaminants of Concern

Uranium-238 has been identified as a COC in Tmss HSU ground water in the Building 851 area. However, the maximum total uranium activities in ground water continue to be a fraction of the 20 pCi/L MCL cleanup standard and are at similar levels to those at which uranium naturally occurs in ground water in this area. VOCs (cis-1,2-DCE and TCE) and uranium-238 are COCs in subsurface soil and rock. The HE compound, RDX, uranium-238, and the metals cadmium, copper, and zinc were identified as COCs in surface soil. The distribution and concentration of contaminants in soil and ground water is described in detail in Section 3.4.5.1.

As agreed with the regulatory agencies and consistent with site use, risk associated with contaminants at Site 300 was calculated using an industrial exposure scenario. No risk or hazard associated with surface soil, subsurface soil/bedrock, or ground water were identified for the Building 851 Firing Table in the baseline risk assessment (Ferry et al., 1999).

Modeling conducted in the Site-Wide Feasibility Study indicated that COCs in surface soil and subsurface soil/rock do not pose a significant threat to ground water. The water-bearing zone (Tmss HSU) affected by contamination is not used for drinking water.

The baseline ecological assessment determined a risk from cadmium existed for ground squirrels, and deer. Individual adult ground squirrels and individual adult and juvenile deer are at risk from ingestion of cadmium. The combined oral and inhalation pathway HQ exceed 1 for these species, which was driven by the oral pathway. Site-wide population surveys to identify the current risk to deer and ground squirrels found no adverse impacts. The ecological risk and hazard management measures required by the CMP/CP include: (1) periodically evaluating available biological survey data from the Buildings 851 to determine potential population-level impacts to ground squirrel and deer exposed to cadmium in surface soil in these areas, as well as re-evaluating the ecological hazard associated with cadmium in surface soil. Cadmium surface soil sampling was conducted in November 2011; three samples were collected and all samples contained less than 0.5 mg/kg of cadmium (reporting limit) (Figure 40, Table 8, and Section 3.1.5.3).

3.4.2.6. Building 851 Summary of Basis for Taking Action

The baseline risk assessment did not identify any human health risks or hazards, however, monitoring is required while contaminants remain above cleanup standards.

The baseline ecological assessment determined a risk from cadmium existed for ground squirrels, and deer. However, site-wide population surveys to identify the current risk to deer and ground squirrels found no adverse impacts. Therefore, no active remediation was required.

3.4.3. Building 851 Firing Table Remedial Actions

3.4.3.1. Building 851 Firing Table Remedy Selection

The remedy selected for the Building 851 Firing Table is intended to achieve the following RAOs:

For Human Health Protection:

- Restore ground water containing contaminant concentrations above cleanup standards.
- Prevent human ingestion of ground water containing contaminant concentrations (single carcinogen) above cleanup standards.

For Environmental Protection:

- Restore water quality to ground water cleanup standards within a reasonable timeframe and to prevent plume migration to the extent technically and economically practicable. Maintain existing water quality that complies with ground water cleanup standards to the extent technically and economically practicable. This will apply to both individual and multiple constituents that have additive toxicology or carcinogenic effects.
- Ensure ecological receptors important at the individual level of ecological organization (listed threatened or endangered, State of California species of special concern) do not reside in areas where relevant hazard indices exceed 1.
- Ensure existing contaminant conditions do not change so as to threaten wildlife populations and vegetation communities.

The remedy for the Building 851 Firing Table was selected in the 2001 Interim Site-Wide ROD. The interim remedy was selected as the final remedy in the 2008 ROD.

The selected remedy for the Building 851 Firing Table consisted of:

1. No further action for VOCs and uranium in subsurface soil/bedrock and for RDX and metals in surface soil.
2. Monitor ground water to detect changes in contaminant concentrations that could impact human health or the environment.

3. Land Use Controls will continue to be implemented to prevent human exposure to contamination and to protect the integrity of the remedy.

3.4.3.2. Building 851 Firing Table Remedy Implementation

Ground water monitoring has been implemented and the results are reported in the semi-annual Compliance Monitoring Reports. The four monitor wells at the Building 851 complex are sampled and analyzed for uranium isotopes and VOCs. Water elevations are also measured quarterly.

3.4.3.3. Building 851 Operation and Maintenance

The remedy for the Building 851 Firing Table is operating as designed and no significant operations, performance, or cost issues were identified during this evaluation. All required documentation is in place and monitoring procedures are consistent with established procedures and protocols.

Monitoring procedures are contained in the following documents:

- Site-Wide Compliance Monitoring Plan/Contingency Plan for Remedies at LLNL Site 300.
- LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures.

The budgeted and actual environmental restoration costs for the Building 851 Firing Table are tracked and are consistently within or near the allocated budget. Table 1 presents the actual costs for the last five fiscal years, 2007 through 2011.

3.4.3.4. Building 851 Firing Table 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, and
- Physical barriers.

The U.S. EPA (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 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 onsite.

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. The land use controls and requirements described herein are only applicable to the Building 851 Firing Table 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 inspection results are reported in the annual Site 300 Compliance Monitoring Reports.

Land use controls for the Building 851 Firing Table are described in Table 5 which 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 Building 851 Firing Table. Figure 39 shows the specific areas of the Building 851 Firing Table where the land use controls have been 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 Building 851 Firing Table by objective, and the status of the land use controls are summarized below.

3.4.3.4.1. Building 851 Firing Table Land Use Control Objectives

Land use control objectives were established for the Building 851 Firing Table in the Site 300 ROD (DOE, 2008) to reduce risk and prevent exposure to contaminated environmental media. The risk drivers and associated land use control objectives identified for the Building 851 Firing Table include:

1. ***Risk Driver*** - Potential exposure to depleted uranium and VOCs at depth in subsurface soil.

   Land use control objectives:

   - Control excavation activities to prevent onsite worker exposure to contaminants in subsurface soil until it can be verified that concentrations do not pose an exposure risk to onsite workers. (Note: Risk for onsite worker exposure to uranium and VOCs at depth in subsurface soil during excavation activities was not calculated as this was not considered a long-term exposure scenario. As a result, land use controls based on the potential exposure to contaminants in subsurface soil during ground-breaking construction conservatively assume that these subsurface soil contaminants may pose a risk to human health.)

2. ***Risk Driver*** - Potential exposure to contaminated environmental media.

   Land use control objective:

   - Prohibit transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use.

The only COC in ground water (uranium) is below the cleanup standard (see Section 3.4.5.1), there is no contamination offsite associated with the Building 851 Firing Table, and no unacceptable risk or hazard to human or ecological receptors was identified for the Building 851 Firing Table in the baseline risk assessment.

3.4.3.4.2. Building 851 Firing Table Land Use Controls

This section discusses the land use controls including institutional controls and physical barriers for the Building 851 Firing Table that were established and are implemented to address the risk reduction objectives and their current status.

Control Excavation Activities: Governmental Institutional Controls

The land use controls that have been implemented to control excavation activities to prevent onsite worker exposure to contaminants in subsurface soil until it can be verified that concentrations do not pose an exposure risk to onsite workers include:

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

Governmental Institutional Controls Implementation Status

Site 300 implements multiple layers of protection to prevent onsite worker exposure to contaminants in subsurface soil: Dig Permit and Work Induction Board processes.

Dig Permit Process: A LLNL Dig Permit is required to conduct any ground disturbing activities at Site 300, including activities that involve the excavation of soil and/or rock. This permit process includes an evaluation of the proposed location for the ground disturbing/excavation activity by the LLNL Environmental Analyst to determine if it is located in an area of soil/rock contamination. The Environmental Analyst works with the LLNL entity proposing the ground disturbing/excavation activity to determine if the activity can be moved. If the work plans cannot be modified to move excavation activities outside of areas of soil contamination, LLNL Environmental Health & Safety personnel evaluate the potential hazards and identify the necessary controls to be implemented prior to the start of work.

Work Induction Board: Any proposed excavation activities are submitted to the LLNL Work Induction Board, and are reviewed by LLNL Environmental Restoration Department to prevent excavation or damage of the Building 851 Firing Table. 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).

During this five-year review period, no excavation or construction activities were proposed in the Building 851 Firing Table area. The LLNL processes for review of proposed new work (e.g., Work Induction Board and excavation permit processes) are effective in controlling excavation activities and are therefore protective of human health (onsite workers) in preventing exposure to contaminants in subsurface soil.

Prohibit Transfer of Lands with Unmitigated Contamination: Enforcement Tools

The land use controls that have been implemented to prohibit transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use include:

- Enforcement Tools:
  - FFA.
  - ROD.

The land use control and implementation status is described in more detail below.

Enforcement Tools Implementation Status

To prevent the potential exposure to contaminated environmental media, the Site 300 FFA 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 as specified in the Site 300 ROD. The Site 300 FFA and ROD have not been modified during this five-year review period, and these provisions remain as originally stated in these documents.

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.

During the five-year review period, DOE has not proposed any plans to transfer any Site 300 land for residential, unrestricted, or non-DOE industrial land use. Site 300 remains under the ownership, oversight, and operation of the U.S. DOE. The provisions in Site 300 FFA and ROD are effective in preventing the transfer of lands with unmitigated contamination that could cause potential harm under a residential or unrestricted land use, and therefore are protective of human health.

Other Controls: Physical Barriers

The fences surrounding Site 300, signs, and security forces control and restrict access to Site 300; thereby preventing the inadvertent exposure by members of the public to contamination at Site 300. The LLNL Protective Services Force conducts routine inspections of the fences surrounding Site 300 to ensure they are intact. A member of the security force mans the entrance gate to Site 300 during hours when the front gate is open, and a DOE-issued security badge is required to gain entrance to the site. The site gates are closed and locked after 6 pm, and a security force member remains onsite overnight. Members of the public must apply for and obtain security badges and be escorted to access the site.

The physical barriers to control and restrict access are effective in preventing inadvertent exposure by members of the public to contamination at Site 300, and therefore are protective of human health.

3.4.3.4.3. Summary of the Status of Building 851 Firing Table Land Use Controls

The review of the land use controls for the Building 851 Firing Table for this five-year review period determined that these controls are effective for preventing exposure to contaminated media. DOE will implement, maintain, and enforce the land use controls for the Building 851 Firing Table for as long as necessary to keep the selected remedy protective of human health and the environment.

3.4.4. Building 851 Firing Table Five-Year Review Process

3.4.4.1. Notification of Review/Community Involvement

The 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 September 28, 2012. Completed documents can also be accessed electronically at LLNL's Environmental Restoration Department electronic library web page at http://www-erd/library/ or the Environmental Community Relations web page at http://www-envirinfo.llnl.gov.

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

3.4.4.2. Identification of Five-Year Review Team Members

The Five-Year Review of the Building 851 Firing Table at LLNL Site 300 was led by Claire Holtzapple, Site 300 Remedial Project Manager for the DOE/NNSA-Livermore Site Office. The following team members assisted in the review:

- Leslie Ferry, Program Leader, LLNS.
- Valerie Dibley, Deputy Program Leader, LLNS.
- Vic Madrid, Hydrogeology Team Leader, LLNS.
- Michael Taffet, Hydrogeologist, LLNS.
- Mark Buscheck, Hydrogeologist, Weiss Associates.

3.4.4.3. Document Review

This Five-Year Review consisted of examining relevant project documents and site data:

- Final Site-Wide Remedial Investigation for Lawrence Livermore National Laboratory Site 300 (Webster-Scholten et al., 1994).
- Final Site-Wide Feasibility Study for Lawrence Livermore National Laboratory Site 300 (Ferry et al., 1999).
- Interim Site-Wide Record of Decision for Lawrence Livermore National Laboratory Site 300 (U.S. DOE, 2001).
- Site-Wide Record of Decision for Lawrence Livermore National Laboratory Site 300 (U.S. DOE, 2008).

- Remedial Design Work Plan for Interim Remedies at Lawrence Livermore National Laboratory Site 300 (Ferry et al., 2001).
- Site-Wide Remediation Evaluation Summary Report for Lawrence Livermore National Laboratory Site 300 (Ferry et al., 2006).
- Semi-annual Site-Wide Compliance Monitoring Reports that include evaluations of remediation progress in the Building 851 Firing Table area of OU 8 (Dibley et al., 2007c, 2008c, 2009c, 2009d, 2010a, 2010b, 2011a, 2011c, and 2012; LLNL 2008).

These documents are available on-line at www-erd.llnl.gov/library/index.html#reports.s300.

This Five-Year Review evaluates subsurface contaminant concentration and remediation system performance data collected through calendar year 2011.

3.4.5. Building 851 Firing Table Data Review and Evaluation

This section is organized into three subsections: (1) analysis of contaminant distribution, concentrations, and remediation progress (Section 3.4.5.1), (2) performance issues (Section 3.4.5.2), and (3) risk mitigation remediation progress (Section 3.4.5.3).

3.4.5.1. Building 851 Firing Table Contaminant Distribution, Concentrations, and Remediation Progress

Uranium-238 is the only ground water COC at the Building 851 Complex. The historic maximum, the 2011 maximum concentration, and cleanup standard for this ground water COC for the Building 851 Firing Table are detailed in Table 6. Figure 38 shows second semester 2011 ground water activities for total uranium and the 2011 $^{235}U/^{238}U$ atom ratios.

TCE, cis-1,2-DCE, and uranium-238 are vadose zone (subsurface soil) COCs. These vadose zone COCs, their historic maximum concentration detected in subsurface soil at Building 851, and applicable PRGs and RSLs are presented in Table 7.

The HE compound, RDX, uranium-238, and the metals cadmium, copper, and zinc are surface soil COCs. These surface soil COCs, their historic maximum concentration detected in surface soil at Building 851, and applicable PRGs and RSLs are presented in Table 7.

The 2011 maximum total uranium activity detected in ground water samples from wells in the Building 851 complex area was 0.962 pCi/L (W-851-08, November), far below the 20 pCi/L MCL cleanup standard and well within natural background levels. The historic maximum uranium activity was 3.2 pCi/L (W-851-07, October 1991) and the five-year review period maximum activity was 1.4 pCi/L (W-851-08, November 2009). From 1994 to 2011, the $^{235}U/^{238}U$ atom ratio in samples from wells W-851-06 and W-851-08 have indicated the addition of some depleted uranium to the total uranium in the ground water with a slight trend over time toward a higher percentage of natural uranium ($^{235}U/^{238}U$ atom ratio trending upward and closer to 0.0072). Over the same time period, samples from wells W-851-05 and W-851-07 exhibited some added depleted uranium with a more pronounced trend toward natural uranium in more recent samples. During 2011, the samples from these wells contained only natural uranium. Overall, 2011 uranium activities in ground water have been similar to previous years and remain far below the 20 pCi/L cleanup standard and within the range of natural background levels.

In summary, a small amount of depleted uranium was added to pre-existing natural uranium in ground water in the Tmss HSU at Building 851. The total uranium in ground water has trended toward natural uranium over time. Total uranium activities have always been well below the MCL cleanup standard of 20 pCi/L.

COCs in the vadose zone are TCE, cis-1,2-DCE, and uranium-238. These vadose zone COCs, their historic maximum concentration in subsurface soil, and applicable RSLs and PRG are detailed in Table 7. The historic maximum TCE concentration measured in soil was 0.0003 mg/kg (1990), well below its Industrial RSL (6.4 mg/kg). The historic maximum cis-1,2-DCE concentration measured in soil was 0.012 mg/kg (1990) well below its Industrial RSL (2,000 mg/kg).

Since monitoring of Building 851 wells began in 1990, TCE has never been detected in ground water above its cleanup standard of 5 µg/L and cis-1,2-DCE has never been detected above its reporting limit (typically <0.5 µg/L). VOCs were only reported in three historic ground water samples collected at Building 851 with a maximum of 2.7 µg/L of total VOCs; the last detection was from a sample collected in 1992. Ground water has not been impacted by vadose zone VOCs.

While the historic maximum uranium-238 activity measured in subsurface soil in the Building 851 area (11 pCi/g in 1990) exceeds the Industrial PRG, no risk or hazard was identified associated with this COC in subsurface soil. Overall, uranium activities in ground water have been well below the 20 pCi/L cleanup standard and within the range of background levels, indicating that ground water has not been significantly affected by vadose zone uranium-238.

COCs in surface soil are RDX, cadmium, copper, zinc, and uranium-238. These surface soil COCs, their historic maximum concentrations in surface soil, and applicable PRGs and RSLs are presented in Table 7. The historic maximum RDX concentration measured in surface soil is 0.031 mg/kg (1990), well below its Industrial RSL (24 mg/kg). The historic maximum cadmium concentration measured in surface soil is 9 mg/kg (1990), well below its Industrial RSL (800 mg/kg). The historic maximum copper concentration measured in surface soil is 79 mg/kg (1990), well below its Industrial RSL (41,000 mg/kg). The historic maximum zinc concentration measured in surface soil is 360 mg/kg (1990), well below its Industrial RSL (310,000 mg/kg). While the historic maximum uranium-238 activity measured in surface soil (14.1 pCi/g in 1990), no risk or hazard associated with uranium-238 in surface soil was identified in the baseline risk assessment.

Surface soil and vadose zone COCs have not been detected in ground water above cleanup standards. Although some depleted uranium has been detected in ground water, its activities have been well below cleanup standards and $^{235}U/^{238}U$ atom ratios in wells where depleted uranium was detected have been trending to natural uranium during the five-year review period. The other vadose zone COCs have not been detected in ground water in excess of background concentrations.

Modeling documented in the Site-Wide Feasibility Study (Ferry et al., 1999) concluded that contaminants in subsurface soil and the vadose zone do not pose a threat to ground water. Results of ground water monitoring support this conclusion.

3.4.5.2. Building 851 Performance Issues

The remedy continues to be effective and protective of human health and the environment, and to make progress toward cleanup.

3.4.5.3. Building 851 Risk Mitigation Remediation Progress

No unacceptable human health risk or hazard associated with contaminants in surface soil, subsurface soil/bedrock, or ground water were identified for the Building 851 area in the baseline risk assessment (Ferry et al., 1999).

On September 28, 2011, the U.S. EPA released updated toxicity values and contaminant characteristics for TCE in the IRIS (EPA, 2011). Currently, the only significant impact of this change is presumed to be on the assessment of risk for the vapor inhalation pathway. However, since TCE was not detected above the reporting limit in the Building 851 area ground water during the past five years, this risk was not reassessed. In addition, there is no evidence of new releases or contamination that warrants re-evaluation of risk.

Total uranium activities in ground water have always been well below the 20 pCi/L MCL and at similar levels to those at which uranium naturally occurs in ground water in this area. Ground water data do not indicate any new sources, releases, or contaminants in the Building 851 area.

The baseline ecological assessment determined a risk from cadmium existed for ground squirrels, and deer. Individual adult ground squirrels and individual adult and juvenile deer are at risk from ingestion of cadmium. The combined oral and inhalation pathway HQ exceed 1 for these species, which was driven by the oral pathway. Site-wide population surveys to identify the current risk to deer and ground squirrels found no adverse impacts. The ecological risk and hazard management measures required by the CMP/CP include: (1) periodically evaluating available biological survey data from the Buildings 851 to determine potential population-level impacts to ground squirrel and deer exposed to cadmium in surface soil in these areas, as well as re-evaluating the ecological hazard associated with cadmium in surface soil.

Cadmium surface soil sampling was performed in November 2011 by an LLNL ecologist (Dibley, et al., 2012). A map of historical sampling locations including the November 2011 is depicted on Figure 40 and Table 8 provides a historical summary of cadmium analytical results including the November 2011 samples. All results (95% UCLs) were below the Site 300 background for cadmium (1.9 mg/kg). There is clearly little ecological risk from cadmium in the Building 851 area, as areas with existing elevated cadmium concentrations are very small and isolated. Therefore, cadmium in surface soil will no longer be considered a contaminant of ecological concern in these areas. It would also appear that cadmium does not pose an ecological risk in the Building 851 area, however, additional sampling behind Building 851 is needed to definitively remove this risk. The additional sampling will be scheduled.

A Site-Wide Five-Year Ecological Review was performed in 2008 (Dibley et al., 2009c). No new ecological hazards were identified in the Building 851. No information was identified during this review to question the ecological protectiveness of the remedy.

3.4.6. Building 851 Firing Table Interviews and Site Inspection

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

There is a continuous presence of ERD staff at Site 300 that routinely inspect the monitoring wellfield during sampling activities. The Site 300 ERD conducts self-assessment inspections and DOE/NNSA conducts quarterly inspections of remediation activities at Site 300. The

RWQCB RPM performs site inspections twice a year, and the U.S. EPA and DTSC RPMs perform site inspections as requested. The U.S. EPA did not perform a construction completion inspection of OU 8 as the remedy required no construction. The Five-Year Review Inspection was performed by DOE/NNSA on August 16, 2011. The Five-Year Review Inspection Checklist is included as Attachment A.

3.4.7. Building 851 Firing Table Technical Assessment

The protectiveness of the interim remedy was assessed by determining if:

1. The interim remedy is functioning as intended at the time of the decision documents.
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 interim remedy into question.

3.4.7.1. Remedy Function

The remedy was determined to be functioning as intended at the time of the decision documents because:

- No early indicators of potential interim remedy failure were identified.
- The remedy is functioning as intended by reducing COC concentrations/activities.
- 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.

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

- There have been no 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 or ecological receptors has been identified.
- There have been no changes in land, building, or water use.
- No new contaminants or sources have been identified.
- No remedy byproducts have been identified.
- Changes in location-, chemical-, or action-specific ARARs or to-be-considered requirements:
  - The State of California established a 6 µg/L MCL for perchlorate on October 18, 2007. This action-specific ARAR and ARARs related to ground water cleanup were included in the 2008 Site-Wide ROD.
  - The U.S. EPA NPDES Pesticide Rule changed in 2011, however, there are no discharges to the ground surface or NPDES permit required as part of the Building 851 remedy.
- Changes in toxicity and other contaminant characteristics:

  - On September 28, 2011, the U.S. EPA released updated toxicity values and contaminant characteristics for TCE in the IRIS. Currently, the only significant impact of this change is presumed to be on the assessment of risk for the vapor inhalation pathway. However, as discussed in Section 3.4.5.3, the Baseline Risk Assessment did not identify any human health risks at Building 851.
- The review found progress toward meeting the RAOs.
- A small amount of depleted uranium contamination trending over time toward natural exists in ground water in the Tmss HSU at activities well below the cleanup standard of 20 pCi/L. Metal and RDX concentrations in surface soil and VOC concentrations in subsurface soil are below applicable RSLs. Ground water has not been impacted by uranium, metals, or RDX in surface soil or VOCs and uranium in subsurface soil.

3.4.7.3. 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.
- No unanticipated events (i.e., natural disasters, new contaminants discovered, etc.) occurred that would call the protectiveness of the remedy into question.
- No additional information has been identified that would call the protectiveness of the interim remedy into question.
- No new technologies have been identified that are capable of accelerating or achieving cleanup in a more cost-effective manner in the Building 851 area.

3.4.8. Building 851 Firing Table Issues

No issues were identified during this evaluation. However, as discussed in Section 3.4.2.1.2 and shown on Figure 38, historic ground water elevation data indicate that the ground water gradient in the Tmss HSU has remained nearly flat in the vicinity of Building 851. Therefore, DOE/NNSA recommends installing additional Tmss HSU monitor wells in the vicinity of Building 851 to ensure full monitoring capability under the observed nearly flat ground water gradient.

3.4.9. Building 851 Firing Table Recommendations and Follow-Up Actions

The following recommendations to be carried out by the DOE/NNSA were developed during the review process:

1. Install additional monitor wells in the Tmss HSU in the vicinity of Building 851 to ensure full monitoring capability under the nearly flat ground water gradient. Up to two monitor wells located southwest and northwest of Building 851 are being considered to accomplish this objective. The proposed locations of the additional monitor wells to be installed will be presented to the regulatory agencies for concurrence prior to installation. Because the funding for the installation of these wells is not currently included in DOE/NNSA's funding request profile, the schedule for well installation will be finalized when the funding request is approved.

3.4.10. Building 851 Firing Table Protectiveness Statement

The remedy at the Building 851 Firing Table is protective of human health and the environment for the site's industrial land use. The remedy protects human health because: (1) concentrations of ground water COCs below MCL cleanup standards and are within the range of background levels, (2) no unacceptable human health risk or hazard associated with contaminants in surface soil, subsurface soil/bedrock, or ground water were identified in the baseline risk assessment, (3) metal and RDX concentrations in surface soil and VOCs in subsurface soil are below applicable RSLs, and (4) ground water has not been impacted by uranium, metals or RDX in surface soil or VOCs and uranium in subsurface soil. Exposure pathways that could result in unacceptable risk to onsite workers (i.e., excavation of subsurface soil) are being controlled by the implementation of institutional controls, the Health and Safety Plan, and the Contingency Plan. DOE/NNSA's recommendation to install additional monitor wells in the vicinity of Building 851 will add an additional layer of protection by increasing the monitoring capability under a nearly flat ground water gradient.

The cleanup standards for Building 851 ground water are drinking water standards. Because drinking water standards do not differentiate between industrial and residential use, the ground water cleanup remedy will be protective under any land use scenario.

Because some VOCs may remain in subsurface soil, 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 is included in the Site-Wide ROD. This prohibition will remain in place until and unless a risk assessment is performed in accordance with current U.S. EPA risk assessment guidance and is agreed by the DOE, the U.S. EPA, the DTSC, and RWQCB as adequately showing no unacceptable risk for residential or unrestricted land use.

3.5. Pit 2 Landfill

3.5.1. Pit 2 Landfill Site Chronology

The following is a chronological listing of significant environmental restoration events at the Pit 2 Landfill:

1956–1960

- Debris from the Buildings 801 and 802 firing tables was deposited in the Pit 2 Landfill.
- In 1960, an earthen cover was installed on the landfill.

1990

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

1992

- A FFA was signed for Site 300.

1996

- Potable water was continuously discharged to maintain a wetland habitat for red-legged frogs (a federally listed endangered species) within a drainage channel that extends along the northern and eastern margin of the Pit 2 Landfill.

1999

- The Site-Wide Feasibility Study for Site 300 was issued that included the Pit 2 Landfill.

2001

- An Interim Site-Wide ROD for Site 300 was signed. The Interim Site-Wide ROD specified ground water monitoring to detect any potential future contaminant releases as the remedy for the Pit 2 Landfill. The Interim Site-Wide ROD did not contain ground water cleanup standards.
- A Remedial Design Work Plan was issued that contained the strategic approach and schedule to implement the remedies in the Interim Site-Wide ROD.

2002

- The CMP/CP for Interim Remedies was submitted.

2005

- The potable water discharge to maintain a wetland habitat for red-legged frogs within a drainage channel that extends along the northern and eastern margin of the Pit 2 Landfill was discontinued.

2008

- The Site-Wide ROD with selected remedies and cleanup standards for Site 300 was signed. The remedy did not change in the 2008 Site-Wide ROD, with the exception that ground water cleanup standards were established in the 2008 Site-Wide ROD.

2009

- The revised CMP/CP was issued.

3.5.2. Pit 2 Landfill Background

3.5.2.1. Pit 2 Landfill Physical Characteristics

3.5.2.1.1. Pit 2 Landfill Site Description

The Pit 2 Landfill is an unlined landfill that was constructed in 1956. The Pit 2 Landfill covers approximately 1.5 acres and is located in the northeastern part of Site 300 south of Building 865 (Figure 2). The Pit 2 Landfill was used until 1960 to dispose of firing table debris from the firing tables at Buildings 801 and 802.

3.5.2.1.2. Pit 2 Landfill Hydrogeologic Setting

This section describes the hydrogeologic setting for the Pit 2 Landfill area, including the unsaturated zone, three HSUs, and surface water present in the area. A conceptual hydrostratigraphic column for the northern portion of Site 300 including the Pit 2 Landfill area is shown on Figure 28.

Pit 2 Landfill Vadose (Unsaturated) Zone

The vadose zone in the Pit 2 Landfill area consists of unconsolidated Quaternary alluvial and colluvial deposits (Qal) composed of silty and clayey sand and loam that are unsaturated to a depth of approximately 5 to 50 ft bgs.

Pit 2 Landfill Saturated Zones

Three HSUs are present in the Pit 2 Landfill area: the Qal/WBR HSU, the $Tnbs_1/Tnbs_0$ HSU, and the Tmss HSUs. The Qal/WBR HSU in the Pit 2 Landfill area consists of unconsolidated Quaternary alluvial and colluvial deposits (Qal) and underlying weathered bedrock in the Elk Ravine drainage channels. This HSU is generally unconfined and unsaturated in Elk Ravine except for short periods following winter storms. Until 2005, potable water from Building 865 was discharged to Elk Ravine to maintain a wetland habitat for red-legged frogs, a federally listed endangered species (U.S. DOE, 2011). While this discharge occurred, the Qal/WBR was likely perennially saturated in Elk Ravine in the area south of Building 865 and around the northern and eastern boundaries of the Pit 2 Landfill. In 2005, the frogs were relocated to a constructed wetland habitat, and the discharge of water from Building 865 was discontinued. Depth to water in the Qal/WBR HSU varies from 0 to 25 ft bgs. Ground water flow follows the topography/ground elevation contours and is parallel to stream channel axes (Figure 41).

The $Tnbs_1/Tnbs_0$ HSU in the Pit 2 Landfill area is comprised of the Neroly Formation Lower Blue Sandstone ($Tnbs_1$) and the Basal Blue Sandstone ($Tnbs_0$). Ground water in this HSU is unconfined to confined. The HSU is saturated beneath Elk Ravine, where depth to water is approximately 50 to 65 ft bgs. The saturated thickness of the HSU may be from 25 to 100 ft. As suggested by the potentiometric surface contours shown on Figure 42, the southwestern branch of the Elk Ravine Fault may locally either be a conduit or a barrier to ground water flow in this HSU.

The Tmss HSU is comprised of sandstone of the Cierbo Formation (Tmss). The saturated thickness of this HSU may be over 40 ft beneath Elk Ravine.

Pit 2 Landfill Surface Water

Surface water in the vicinity of the Pit 2 Landfill is the result of either surface runoff from precipitation or from spring discharge upstream of the landfill area. Natural surface runoff is rarely observed, and only occurs briefly during more significant or prolonged storms. During severe storms, surface water may flow within Doall Ravine or Elk Ravine for short distances before infiltrating into the ground. As discussed previously, perennial surface water was present south of Building 865 around the northern and eastern boundaries of the Pit 2 Landfill until the discharge from Building 865 was discontinued in 2005.

3.5.2.2. Pit 2 Landfill Land and Resource Use

The Pit 2 Landfill is located in the central portion of Site 300, approximately 6,300 feet south of the closest site (northern) boundary. Use of the Pit 2 Landfill was discontinued and a cover installed in 1960. The Pit 2 Landfill area has not been used for site activities since that time.

There are no active onsite water-supply wells in the Pit 2 Landfill area.

Site 300 has unique environmental qualities, largely because it has not been grazed for over 50 years and contains several habitat types and numerous special status species (e.g., threatened and endangered species, migratory birds, and rare plants). Pit 2 Landfill is covered by annual grassland, although a large area of native perennial grassland occurs to the south of the pit. The big tarplant (*Blepharizonia plumosa*), an extremely rare late-season flowering plant included on the CNPS List 1B, is periodically mapped within the vicinity of the pit. Pit 2 Landfill occurs within the upland dispersal habitat for the federally threatened California red-legged frog (*Rana aurora draytonii*) and the threatened California tiger salamander (*Ambystoma californiense*). The Sharp Pool, to the northwest of Pit 2, also provides non-breeding aquatic habitat for the red-legged frog. Loggerhead shrikes (*Lanius ludovicianus*), burrowing owls (*Athene cunicularia*), and a San Joaquin coachwhip (*Masticophis flagellum ruddocki*), all California Species of Special Concern, have all been observed nearby. A five-year ecological review reported on in the 2008 Annual Compliance Monitoring Report (Dibley et al., 2009c), which updated the assessment of the ecological impacts from Site 300 contaminants, found no impact to ecological receptors from releases from the Pit 2 Landfill. An LLNL ecologist reviewed ecological data collected between 2008 and 2011 for the area to evaluate whether any changes in contaminant or ecological conditions that could impact ecological receptors. No changes were identified. Access to these unique animal and plant populations is controlled and interactions with the wildlife are avoided.

3.5.2.3. Pit 2 Landfill History of Contamination

Debris from the Buildings 801 and 802 firing tables were disposed in the Pit 2 Landfill.

No COCs were identified in surface soil, subsurface soil, or surface water in the Pit 2 Landfill area. While uranium was not originally identified as a contaminant in ground water, the increases in uranium activities in the Pit 2 monitor wells between 1996 and 2005 may have been the result of the discharge of potable water that was used to maintain a wetland habitat for red-legged frogs within a drainage channel that extends along the northern and eastern margin of the Pit 2 Landfill. This discharge occurred between 1996 and 2005. Since the discharge was discontinued in 2005, total uranium activities detected in Pit 2 Landfill detection monitor wells, especially in well W-PIT2-1934, have decreased and are within background levels for total uranium. There have been no other releases from the Pit 2 Landfill.

3.5.2.4. Pit 2 Landfill Initial Response

Investigations began at the Pit 2 Landfill in 1982 to identify contaminant sources and the distribution of contaminants in soil, bedrock, and ground water. Since then, ten boreholes have been drilled; all of these boreholes have been completed as ground water monitor wells (Figures 41 and 42). The geologic and chemical data from wells and boreholes were used to characterize the site hydrogeology and to monitor the temporal and spatial changes in saturation and to detect any dissolved contaminants. Ground water monitoring has been conducted to evaluate to detect any potential future releases from the Pit 2 Landfill.

3.5.2.5. Pit 2 Landfill Contaminants of Concern

No COCs were identified in surface soil, subsurface soil and rock, or surface water at the Pit 2 Landfill. Nitrate was identified as a COC for ground water. The distribution and concentration of contaminants in ground water is described in detail in Section 3.5.5.1 of this review. No unacceptable risk or hazard to human or ecological receptors was identified for the Pit 2 Landfill in the baseline risk assessment.

3.5.2.6. Pit 2 Landfill Summary of Basis for Taking Action

The baseline risk assessment did not identify any human or ecological health risks or hazards, however, monitoring is required while contaminants remain above cleanup standards and the landfill remains in place.

3.5.3. Pit 2 Landfill Remedial Actions

3.5.3.1. Pit 2 Landfill Remedy Selection

The remedy selected for the Pit 2 Landfill is intended to achieve the following RAOs:

<u>For Human Health Protection:</u>

- Restore ground water containing contaminant concentrations above cleanup standards.
- Prevent human ingestion of ground water containing contaminant concentrations (single carcinogen) above cleanup standards.

For Environmental Protection:

- Restore water quality to ground water cleanup standards within a reasonable timeframe and to prevent plume migration to the extent technically and economically practicable. Maintain existing water quality that complies with ground water cleanup standards to the extent technically and economically practicable. This will apply to both individual and multiple constituents that have additive toxicology or carcinogenic effects.

The remedy for the Pit 2 Landfill was selected in the 2001 Interim Site-Wide ROD. The interim remedy was selected as the final remedy in the 2008 ROD.

The selected remedy for the Pit 2 Landfill consists of:

1. Monitoring ground water to detect any future releases from the Pit 2 Landfill or changes in contaminant concentrations that could impact human health or the environment.
2. Risk and hazard management to prevent human exposure to contamination and to protect the integrity of the remedy.
3. Inspecting the Pit 2 Landfill cover periodically for damage that could compromise its integrity and repairing any damage found.

3.5.3.2. Pit 2 Landfill Remedy Implementation

Monitoring of ground water at the Pit 2 Landfill includes:

- Detection monitoring of ground water to detect any new releases of contaminants from buried waste in the Pit 2 Landfill.
- Remedial action monitoring of COCs in ground water to evaluate the effectiveness of the remedy in reducing contaminant concentrations.

As part of the detection monitoring program, ground water samples are collected from monitor wells located upgradient and directly downgradient of the landfill and analyzed for potential constituents of concern. The detection monitoring and results for the Pit 8 Landfill is discussed in Section 3.5.5.2.

As part of the remedial action monitoring program, ground water samples are collected from downgradient wells and analyzed for ground water COCs to track changes in plume concentration and size to ensure there is no impact to downgradient receptors, to meet remedial action objectives, and verify the attainment of cleanup standards. The remedial action monitoring results are discussed in Section 3.5.5.1.

Land Use Controls have been implemented to prevent damage to the landfill cap (see Section 3.5.3.4).

The results of the detection and remedial action monitoring, landfill inspections and maintenance, remediation progress, and the status of institutional control implementation are reported in the ERD semiannual Compliance Monitoring Reports.

3.5.3.3. Pit 2 Landfill System Operations/Operation and Maintenance

The remedy for the Pit 2 Landfill is operating as designed and no significant operations, performance, or cost issues were identified during this evaluation. All required documentation is in place, and the landfill cap maintenance and monitoring procedures are consistent with established procedures and protocols.

Landfill maintenance and monitoring procedures are contained in the following documents:

- Site-Wide Compliance Monitoring Plan/Contingency Plan for Remedies at LLNL Site 300.
- LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures.

The major maintenance activities for the Pit 2 Landfill interim remedy include:

- Annual subsidence monitoring of the pit cover to detect differential settling or other earth movement.
- Annual inspection of the pit cover by the LLNL Maintenance and Utilities Services Department for excessive erosion, animal burrowing, or other penetrative damage.
- As needed, repairs to the pit cover are made to correct problems identified during inspections.
- Inspections of the surface water drainages for the landfill annually for erosion and accumulated debris.
- When necessary, the drainage channels are cleared of blockage and repaired to maintain the drainage system design capacity.

The landfill inspections and maintenance are reported in the annual ERD Compliance Monitoring Reports. The budgeted and actual environmental restoration costs for the Pit 2 Landfill are tracked and are consistently within or near the allocated budget. Table 1 presents the actual costs for the last five fiscal years, 2007 through 2011.

3.5.3.4. Pit 2 Landfill 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, and
- Physical barriers.

The U.S. EPA (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 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 onsite.

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. The land use controls and requirements described herein are only applicable to the Pit 2 Landfill 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 inspection results are reported in the annual Site 300 Compliance Monitoring Reports.

Land use controls for the Pit 2 Landfill are described in Table 5 which 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 Pit 2 Landfill. Figure 43 shows the specific areas of the Pit 2 Landfill where the land use controls have been 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 Pit 2 Landfill by objective, and the status of the land use controls are summarized below.

3.5.3.4.1. Pit 2 Landfill Land Use Control Objectives

Land use control objectives were established for the Pit 2 Landfill in the Site 300 ROD (DOE, 2008) to reduce risk and prevent exposure to contaminated environmental media. The risk drivers and associated land use control objectives identified for the Pit 2 Landfill include:

1. ***Risk Driver*** - Potential exposure to contaminants in pit waste.

   Land use control objectives:

   - Maintain the integrity of landfill cover as long as the pit waste remains in place.
   - Control construction and other ground-breaking activities on the landfills to prevent cap/cover damage and/or inadvertent exposure to pit waste as long as the pit waste remains in place.
   - Prevent inadvertent exposure of onsite workers to the pit waste as long as the waste remains in place.
   - Prevent inadvertent exposure of unauthorized trespassers to the pit waste as long as the waste remains in place.

2. ***Risk Driver*** - Potential exposure to contaminated environmental media.

Land use control objective:

- Prohibit transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use

No COCs were identified in surface soil, subsurface soil and rock, or surface water, the only COC in ground water (nitrate) is below the cleanup standard (see Section 3.5.5.1), there is no contamination offsite associated with the Pit 2 Landfill, and no unacceptable risk or hazard to human or ecological receptors was identified for the Pit 2 Landfill in the baseline risk assessment.

3.5.3.4.2. Pit 2 Landfill Land Use Controls

This section discusses the land use controls including institutional controls, engineered controls, and physical barriers for the Pit 2 Landfill that were established and are implemented to address the risk reduction objectives and their current status.

Maintain the Integrity of Landfill Cover: Governmental Institutional Controls

The land use controls that have been implemented to maintain the integrity of landfill covers as long as the pit waste remains in place include:

- Governmental Institutional Controls:
  - Inspection and Maintenance Program.

Additional controls were implemented to prevent excavation activities. Those controls are discussed in the *Control Construction and Other Ground-breaking Activities on the Landfills* below.

Governmental Institutional Controls Implementation Status

DOE inspects and maintains the landfill covers and ground water monitoring systems. Landfill cap maintenance and inspection requirements are specified in the Site 300 Compliance Monitoring Plan and the results are reported in the Annual Compliance Monitoring Reports.

During this five-year review period, the landfill was inspected and maintained as required. The integrity of the landfill cover was maintained.

Control Construction and Other Ground-breaking Activities on the Landfills: Governmental Institutional Controls

The land use controls that have been implemented to control construction and other ground-breaking activities on the landfill to prevent cap/cover damage and/or inadvertent exposure to pit waste as long as the pit waste remains in place include:

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

Governmental Institutional Controls Implementation Status

Site 300 implements multiple layers of protection to maintain the integrity of the Pit 2 Landfill cover: Dig Permit and Work Induction Board processes.

Dig Permit Process: The Dig Permit process reviews all onsite excavation. Any proposed excavation would be approved by the LLNL Environmental Restoration Department to prevent excavation or damage of the Pit 2 Landfill cover.

Work Induction Board: Any proposed excavation activities are submitted to the LLNL Work Induction Board, and are reviewed by LLNL Environmental Restoration Department to prevent excavation or damage of the Pit 2 Landfill cover. 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).

During this five-year review period, no excavation or construction activities were proposed in the Pit 2 Landfill area. The LLNL processes for review of proposed new work (e.g., Work Induction Board and excavation permit processes) are effective in controlling excavation activities and is therefore protective of human health (onsite workers) in preventing exposure to waste contained in the landfill.

Prevent Inadvertent Exposure of Onsite Workers to the Pit Waste: Governmental Institutional Controls

The land use controls that have been implemented to prevent inadvertent exposure of onsite workers to the pit waste as long as the waste remains in place include:

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

Governmental Institutional Controls Implementation Status

The governmental institutional controls implemented to prevent inadvertent exposure of onsite workers are the same as those discussed in the *Control Construction and Other Ground-breaking Activities on the Landfills* above.

During this five-year review period, no excavation or construction activities were proposed in the Pit 2 Landfill area. The LLNL processes for review of proposed new work (e.g., Work Induction Board and excavation permit processes) are effective in controlling excavation activities and is therefore protective of human health (onsite workers) in preventing exposure to waste contained in the landfill.

Prevent Inadvertent Exposure of Onsite Workers to the Pit Waste: Physical Barriers

The land use controls that have been implemented to prevent inadvertent exposure of onsite workers to the pit waste as long as the waste remains in place include:

- Physical Barriers:
    - Signage.

Physical Barrier Implementation Status

Signage is maintained at the landfill access points prohibiting unauthorized access and requiring notification and authorization by LLNL Site 300 Management to enter, dig, excavate, or otherwise disturb soil or vegetation in this area.

The physical barriers to control and restrict access are effective in preventing prevent inadvertent exposure of onsite workers to the pit waste, and therefore are protective of human health.

Prevent Inadvertent Exposure of Unauthorized Trespassers to the Pit Waste: Physical Barriers

The land use controls that have been implemented to prevent inadvertent exposure of unauthorized trespassers to the pit waste as long as the waste remains in place include:

- Physical Barriers:
  - Fences.
  - Security Force.
  - Signage.

Physical Barrier Implementation Status

The fences surrounding Site 300, and signs and security forces control and restrict access to Site 300 to prevent inadvertent exposure by members of the public to contamination at Site 300. The LLNL Protective Services force conduct routine inspections of the fences surrounding Site 300. A member of the security force mans the entrance gate to Site 300 during hours when the front gate is open, and a DOE-issued security badge is required to gain entrance to the site. The site gates are closed and locked after 6 pm, and a security force member remains onsite overnight. Members of the public must apply for and obtain security badges and be escorted to access the site.

The physical barriers to control and restrict access are effective in preventing prevent inadvertent exposure by members of the public to contamination at Site 300, and therefore are protective of human health.

Prohibit Transfer of Lands with Unmitigated Contamination: Enforcement Tools

The land use controls that have been implemented to prohibit transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use include:

- Enforcement Tools:
  - FFA.
  - ROD.

The land use control and implementation status is described in more detail below.

Enforcement Tools Implementation Status

To prevent the potential exposure to contaminated waste and/or environmental media, the Site 300 FFA 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 as specified in the Site 300 ROD. The Site 300 FFA and ROD have not been modified during this five-year review period, and these provisions remain as originally stated in these documents.

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.

During the five-year review period, DOE has not proposed any plans to transfer any Site 300 land for residential, unrestricted, or non-DOE industrial land use. Site 300 remains under the ownership, oversight, and operation of the U.S. DOE. The provisions in Site 300 FFA and ROD are effective in preventing the transfer of lands with unmitigated contamination that could cause potential harm under a residential or unrestricted land use, and therefore are protective of human health.

3.5.3.4.3. Summary of the Status of Pit 2 Landfill Land Use Controls

The review of the land use controls for the Pit 2 Landfill for this five-year review period determined that these controls are effective for preventing exposure to contaminated media. DOE will implement, maintain, and enforce the land use controls for the Pit 2 Landfill for as long as necessary to keep the selected remedy protective of human health and the environment.

3.5.4. Pit 2 Landfill Five-Year Review Process

3.5.4.1. Notification of Review/Community Involvement

The 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 September 28, 2012. Completed documents can also be accessed electronically at LLNL's Environmental Restoration Department electronic library web page at http://www-erd/library/ or the Environmental Community Relations web page at http://www-envirinfo.llnl.gov.

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

3.5.4.2. Identification of Five-Year Review Team Members

The Five-Year Review of the Pit 2 Landfill at LLNL Site 300 was led by Claire Holtzapple, Site 300 Remedial Project Manager for the DOE/NNSA-Livermore Site Office. The following team members assisted in the review:

- Leslie Ferry, Program Leader, LLNS.
- Valerie Dibley, Deputy Program Leader, LLNS.
- Vic Madrid, Hydrogeology Team Leader, LLNS.
- Michael Taffet, Hydrogeologist, LLNS.
- Mark Buscheck, Hydrogeologist, Weiss Associates.

3.5.4.3. Document Review

This Five-Year Review consisted of examining relevant project documents and site data:

- Final Site-Wide Remedial Investigation for Lawrence Livermore National Laboratory Site 300 (Webster-Scholten et al., 1994).
- Final Site-Wide Feasibility Study for Lawrence Livermore National Laboratory Site 300 (Ferry et al., 1999).
- Interim Site-Wide Record of Decision for Lawrence Livermore National Laboratory Site 300 (U.S. DOE, 2001).

- Site-Wide Record of Decision for Lawrence Livermore National Laboratory Site 300 (U.S. DOE, 2008).
- Remedial Design Work Plan for Interim Remedies at Lawrence Livermore National Laboratory Site 300 (Ferry et al., 2001).
- Site-Wide Remediation Evaluation Summary Report for Lawrence Livermore National Laboratory Site 300 (Ferry et al., 2006).
- Semi-annual Site-Wide Compliance Monitoring Reports that include evaluations of remediation progress in the Pit 2 Landfill area of OU 8 (Dibley et al., 2007c, 2008c, 2009c, 2009d, 2010a, 2010b, 2011a, 2011c, and 2012; LLNL 2008).
- Pit 1 Evaluation Summary Report for Lawrence Livermore National Laboratory Site 300 (U.S. DOE 2011).

These documents are available on-line at www-erd.llnl.gov/library/index.html#reports.s300.

This Five-Year Review evaluates subsurface contaminant concentration and remediation system performance data collected through calendar year 2011.

3.5.5. Pit 2 Landfill Data Review and Evaluation

This section is organized into four subsections: (1) analysis of contaminant distribution, concentrations, and remediation progress (Section 3.5.5.1), (2) Pit 2 Landfill detection monitoring and results (Section 3.5.5.2), (3) performance issues (Section 3.5.5.3), and (4) risk mitigation remediation progress (Section 3.5.5.4).

3.5.5.1. Pit 2 Landfill Contaminant Distribution, Concentrations, and Remediation Progress

Nitrate is the only COC identified in ground water in the Pit 2 Landfill area. Historic maximum and 2011 maximum concentrations for this COC at the Pit 2 Landfill are included in Table 6. No COCs have been identified in surface water, surface soil, or the vadose zone at the Pit 2 Landfill. Detection monitoring results for the landfill are discussed in Section 3.5.5.2.

While nitrate has been detected in both the Qal/WBR and $Tnbs_1/Tnbs_0$ HSUs, nitrate has only been detected at concentrations above the 45 mg/L MCL cleanup standard in the $Tnbs_1/Tnbs_0$ HSU. Nitrate has not been detected in the Tmss HSU ground water at concentrations above background levels. Therefore, nitrate in this HSU is not discussed further.

Second semester 2011 ground water concentrations for nitrate and activities for tritium, total uranium and $^{235}U/^{238}U$ atom ratios, are on shown on (1) Figure 41 for the Qal/WBR HSU and (2) Figure 42 for the $Tnbs_1/Tnbs_0$ HSU.

Nitrate concentrations in ground water in the vicinity of the Pit 2 Landfill have been relatively stable over time.

The Qal/WBR HSU is generally unsaturated except for short periods following winter storms. When present, the depth to ground water in the Qal/WBR HSU is 15 to 20 ft bgs. For wells screened within the Qal/WBR HSU, the 2011 maximum nitrate concentration of 29 mg/L (NC2-14S, May 2011) was below its 45 mg/L cleanup standard. The historic maximum nitrate concentration of 42 mg/L (NC2-14S, 2003) and the five-year review period maximum nitrate concentration of 37 mg/L (W-PIT2-2304, 2008) are both below the 45 mg/L cleanup standard. The 2008 Final Site-Wide ROD cited a historic maximum nitrate concentration of 186 mg/L (in

1993, from well K2-04S screened in the Qal/WBR HSU) (U.S. DOE, 2008). This well was not included as part of this Five-Year Review because it: (1) is located approximately 800 feet upgradient of the Pit 2 Landfill (farther east of NC2-14S) and (2) is likely impacted by historic nitrate releases from Building 850 and not from Pit 2.

Depth to ground water within the $Tnbs_1/Tnbs_0$ HSU is currently over 50 ft to over 70 ft beneath the Pit 2 Landfill. For wells screened within the $Tnbs_1/Tnbs_0$ HSU, the 2011 maximum nitrate concentration in the Pit 2 Landfill area of 38 mg/L (W-PIT2-1935, May 2011) was below the 45 mg/L cleanup standard. The historic maximum nitrate concentration was 106 mg/L (K2-01C, 1993). Other than a 1998 nitrate detection of 48 mg/L in the same well, nitrate levels above the cleanup level have not been detected in this or any other well screened in the $Tnbs_1/Tnbs_0$ HSU since monitoring began in 1993. The five-year review period maximum nitrate concentration is 42 mg/L (W-PIT2-1934, May 2007). Figure 44 presents time-series plots of nitrate detections in the $Tnbs_1/Tnbs_0$ HSU since monitoring began in 1993.

3.5.5.2. Pit 2 Landfill Detection Monitoring and Results

Detection monitoring of the Pit 2 Landfill is conducted annually to identify any future releases to ground water in accordance with the requirements of the Site 300 CMP/CP. As part of the detection monitoring program, ground water samples are collected from monitor wells located upgradient and directly downgradient of the Pit 2 Landfill and analyzed for potential constituents of concern.

Potential constituents of concern, as defined by Title 23 of the California Code of Regulations, Chapter 15, are:

- Constituents identified in disposal records or that are potentially associated with the buried waste.
- Constituents detected above background concentrations in soil, ground water, and/or surface water in the immediate vicinity of the landfill, indicating a previous release.
- Constituents or breakdown products that can reasonably be expected to be associated with the type of waste disposed in the landfill.

The constituents of concern for the Pit 2 Landfill include VOCs, nitrate, tritium, perchlorate, HE compounds, uranium isotopes, Title 26 metals, lithium, and fluoride.

Concentrations and activities of VOCs, nitrate, HE compounds, Title 26 metals, lithium, and fluoride concentrations/activities in samples collected since monitoring began in 1982 have been either below reporting limits or within the range of background.

Concentrations/activities of tritium, perchlorate, and uranium in Qal/WBR and $Tnbs_1/Tnbs_0$ HSU ground water in the vicinity of the Pit 2 Landfill are discussed below.

Tritium

Tritium was not detected Qal/WBR HSU well W-PIT2-2301, located downgradient of the Pit 2 Landfill, at activities above the 100 pCi/L reporting limit during the five-year review period. The maximum tritium activity in the Qal/WBR HSU ground water during the five-year review period was detected at an activity of 4,620 pCi/L (June 2007) in well NC2-14S, located upgradient of the landfill. Tritium detected in this well has migrated in Qal/WBR ground water from the Building 850 area.

During the five-year review period, the maximum tritium activities in wells located downgradient from Pit 2 were detected in well K2-01C. Tritium activities in this well decreased from 6,120 pCi/L in October 2007 to 4,070 pCi/L in November 2011. During the five-year review period, tritium activities in $Tnbs_1/Tnbs_0$ HSU well NC2-08, located cross-/downgradient of the landfill, decreased from 7,820 pCi/L in March 2007 to 4,460 ± 885 pCi/L in November 2011. A ground water sample collected on February 15, 2006 from well NC2-08 yielded a reported tritium activity of 26,500 pCi/L (analyzed by General Engineering Laboratory, Charleston SC); another laboratory (formerly Thermo Nutech, now Eberline Laboratory, Richmond CA) detected 9,460 pCi/L for tritium in a duplicate sample. The higher activity measured is likely spurious as it is conspicuously inconsistent with the other tritium data from this well (shown on the time-series plots on Figure 45). These data indicate that tritium activities in $Tnbs_1/Tnbs_0$ HSU ground water are decreasing (especially in wells immediately downgradient of the landfill) and are currently a fraction of the historic maximum. Figure 45 shows tritium time-series plots for Pit 2 wells screened in the $Tnbs_1/Tnbs_0$ HSU and illustrates the historical upward then downward trend in tritium apparently affected by the discharge of potable water from 1996 to 2005. The overall distribution of tritium activities in $Tnbs_1/Tnbs_0$ HSU ground water in the Pit 2 Landfill area appears to include a large component resulting from migration of the Building 850 tritium plume into the Pit 2 Landfill area. While some tritium may have been released to ground water from the Pit 2 Landfill, the data indicate that tritium activities in ground water immediately downgradient of the landfill are decreasing and are currently a fraction of the historic maxima and cleanup standard.

Perchlorate

Within the Qal/WBR HSU, perchlorate has only been detected once at or above its 6 µg/L MCL cleanup standard in well NC2-14S (2004). Well NC 2-14S is located upgradient of the landfill. Within the deeper $Tnbs_1/Tnbs_0$ HSU, perchlorate has only been detected three times at or above its cleanup standard in well K2-03 (11.3 µg/L, November 2010) and in well NC2-08 (6 µg/L, May 2003 and May 2004). Both K2-03 and NC2-08 are located upgradient of the landfill. During 2011, perchlorate was not detected above its cleanup standard in any Pit 2 area ground water samples representative of both HSUs.

Uranium

Uranium activities detected in Qal/WBR HSU wells W-PIT2-2301 and W-PIT2-2302, located downgradient of the Pit 2 Landfill, were all within the range of background levels during the five-year review period (0.1 to 1.3 pCi/L). The maximum tritium activity in the Qal/WBR HSU ground water during the five-year review period was detected at an activity of 4,620 pCi/L (June 2007) in well NC2-14S, located upgradient of the landfill. $^{235}U/^{238}U$ atom ratio data from Qal/WBR HSU ground water reveal a slightly depleted uranium signature.

Uranium isotope data from ground water sampled in Pit 2 wells screened in the $Tnbs_1/Tnbs_0$ HSU have also been very low. The historic and five-year review period maximum uranium activities were 27.4 pCi/L and 10.7 pCi/L, respectively, both measured in downgradient well K2-01C (June 1994 and April 2008, respectively). The 2011 maximum activity was 8.4 pCi/L detected in well K2-03 (May 2011), located upgradient from the landfill. In 2011, wells located downgradient of Pit 2 Landfill had even lower uranium activities. Figure 46 presents time-series plots of uranium activities in $Tnbs_1/Tnbs_0$ HSU ground water. The plots show downward trends in uranium activity since the discharge of potable water stopped in 2005 and that uranium activities have remained below the 20 pCi/L cleanup standard since 1994. $^{235}U/^{238}U$ atom ratio data from $Tnbs_1/Tnbs_0$ HSU ground water have also revealed a depleted uranium signature. Time-series plots of these data are depicted on Figure 47 and show a slight trend toward natural uranium since the discharge of potable water was discontinued in 2005.

The detection of depleted uranium in ground water indicates that low activities of depleted uranium have been added to the naturally occurring uranium in the ground water by the Pit 2 Landfill. The release likely resulted from the continuous discharge of potable water from 1996 to 2005 to maintain a wetland habitat for red-legged frogs (a federally listed endangered species) within a drainage channel that extends along the northern and eastern margin of the Pit 2 Landfill. Since this discharge stopped, Qal/WBR HSU wells located immediately downgradient of Pit 2 have generally been dry. Ground water sampled from downgradient $Tnbs_1/Tnbs_0$ HSU wells W-PIT2-1934 and W-PIT2-1935, both located along the northern and eastern margin of the Pit 2 Landfill, have exhibited a decrease in total uranium activities as demonstrated by the uranium atom ratio activity time-series plots depicted on Figure 46. The 2011 samples collected from downgradient wells W-PIT2-1934 and W-PIT2-1935 and analyzed by mass spectrometry contained only natural uranium at 4.5 and 1.8 pCi/L, respectively (May 2011). Samples collected from these wells and analyzed by alpha spectrometry contained 4.6 and 1.7 pCi/L of uranium, respectively.

No contaminant releases have been identified from the Pit 2 Landfill since the discharge to Elk Ravine was discontinued in 2005.

LLNS Maintenance and Utilities Services Department staff annually inspect the Pit 2 Landfill to identify any degradation or damage to the landfill surface or damage or blockage of the drainage ways that could lead to: (1) increased infiltration of precipitation, (2) exposure to the landfill contents, and (3) flow of surface water on or adjacent to the landfill. During the five-year review period, maintenance personnel filled animal burrows but no significant issues (including subsidence) were reported during annual inspection.

3.5.5.3. Pit 2 Landfill Performance Issues

The remedy continues to be effective and protective of human health and the environment, and to make progress toward cleanup.

3.5.5.4. Pit 2 Landfill Risk Mitigation Remediation Progress

No unacceptable risks or hazards associated with contaminants in surface soil, subsurface soil/bedrock, or ground water were identified for the Pit 2 Landfill in the baseline risk assessment.

On September 28, 2011, the U.S. EPA released updated toxicity values and contaminant characteristics for TCE in the IRIS (EPA, 2011). Currently, the only significant impact of this change is presumed to be on the assessment of risk for the vapor inhalation pathway. However, TCE is not a COC in the Pit 2 Landfill ground water.

Although there is evidence of a possible new release of depleted uranium from the landfill, re-evaluation of risk does not appear to be warranted at this time because total uranium activities are below its cleanup standard, and there is not threat of impacts to water-supply wells.

A Site-Wide Five-Year Ecological Review was performed in 2008 (Dibley et al., 2009c). No new ecological hazards were identified in the Pit 2 Landfill area. No information was identified during this review to question the ecological protectiveness of the remedy.

3.5.6. Pit 2 Landfill Interviews and Site Inspection

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

There is a continuous presence of ERD staff at Site 300 that routinely inspect the monitoring wellfield during sampling activities. The Pit 2 Landfill cap and associated drainage ways are annually inspected by the LLNL Maintenance and Utilities Services Department. The Site 300 ERD conducts self-assessment inspections and DOE/NNSA conducts quarterly inspections of remediation activities at Site 300. The RWQCB RPM performs site inspections twice a year, and the U.S. EPA and DTSC RPMs perform site inspections as requested. The U.S. EPA did not perform a construction completion inspection of OU 8 as the remedy required no construction. The Five-Year Review Inspection was performed by DOE/NNSA on August 16, 2011. The Five-Year Review Inspection Checklist is included as Attachment A.

Operational issues and resulting corrective actions identified during routine inspections associated with the landfill and monitoring wellfields are: (1) described in the 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 that are distributed following the meetings.

3.5.7. Pit 2 Landfill Technical Assessment

The protectiveness of the interim remedy was assessed by determining if:

1. The interim remedy is functioning as intended at the time of the decision documents.
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 interim remedy into question.

3.5.7.1. Remedy Function

The remedy was determined to be functioning as intended at the time of the decision documents because:

- No early indicators of potential interim remedy failure were identified.
- The remedy is functioning as intended by reducing COC concentrations/activities.
- 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.

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

- There have been no 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 or ecological receptors has been identified.

- There have been no changes in land, building, or water use.
- No new contaminants or sources have been identified.
- No remedy byproducts have been identified.
- Changes in location-, chemical-, or action-specific ARARs or to-be-considered requirements:
  - The State of California established a 6 µg/L MCL for perchlorate on October 18, 2007. This action-specific ARAR and ARARs related to ground water cleanup were included in the 2008 Site-Wide ROD.
  - The U.S. EPA NPDES Pesticide Rule changed in 2011, however, no there are no discharges to ground surface or NPDES permit required as part of the Pit 2 Landfill remedy.
- Changes in toxicity and other contaminant characteristics:
  - On September 28, 2011, the U.S. EPA released updated toxicity values and contaminant characteristics for TCE in the IRIS. Currently, the only significant impact of this change is presumed to be on the assessment of risk for the vapor inhalation pathway. However, as discussed in Section 3.5.5.4, the Baseline Risk Assessment did not identify any human health risks in the Pit 2 Landfill area and VOCs have not been detected in the Pit 2 Landfill area.
- The review found progress toward meeting the RAOs.

3.5.7.3. 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.
- No unanticipated events (i.e., natural disasters, new contaminants discovered, etc.) occurred that would call the protectiveness of the remedy into question.
- No additional information has been identified that would call the protectiveness of the interim remedy into question.
- No new technologies have been identified that are capable of accelerating or achieving cleanup in a more cost-effective manner in the Pit 2 Landfill area.

3.5.8. Pit 2 Landfill Issues

No issues were identified during this evaluation.

3.5.9. Pit 2 Landfill Recommendations and Follow-Up Actions

No recommendations or follow-up actions were identified related to this Five-Year Review.

3.5.10. Pit 2 Landfill Protectiveness Statement

The remedy at the Pit 2 Landfill is protective of human health and the environment for the site's industrial land use. The remedy protects human health because: (1) nitrate concentrations in ground water have decreased to below the MCL cleanup standard, (2) no unacceptable risks or hazards associated with contaminants in surface soil, subsurface soil/bedrock, or ground water were identified for the Pit 2 Landfill in the baseline risk assessment, (3) no contaminant releases have been identified from the Pit 2 Landfill since the discharge to Elk Ravine was discontinued in 2005, and (4) exposure pathways that could result in unacceptable risk to onsite workers are being controlled by the implementation of institutional controls, the Health and Safety Plan, and the Contingency Plan.

The cleanup standards for Pit 2 Landfill ground water are drinking water standards. Because drinking water standards do not differentiate between industrial and residential use, the ground water cleanup remedy will be protective under any land use scenario.

Because the waste in the Pit 2 Landfill will remain in place, 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 is included in the Site-Wide ROD. This prohibition will remain in place until and unless a risk assessment is performed in accordance with current U.S. EPA risk assessment guidance and is agreed by the DOE, the U.S. EPA, the DTSC, and RWQCB as adequately showing no unacceptable risk for residential or unrestricted land use.

4. Next Review

The next statutory review will be conducted within five years of the signature date of this report (2017).

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6. Acronyms and Abbreviations

1,1,1-TCA	1,1,1-Trichloroethane
ARARs	Applicable or relevant and appropriate requirements
ATA	Advanced Test Accelerator
bgs	Below ground surface
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFF	Contained Firing Facility
CMP/CP	Compliance Monitoring Plan/Contingency Plan
CNPS	California Native Plant Society
COC	Contaminant of concern
DCA	Dichloroethane
DCE	Dichloroethene or Dichloroethylene
DOE	Department of Energy
DTSC	Department of Toxic Substances Control
EPA	Environmental Protection Agency
ERD	Environmental Restoration Department
FFA	Federal Facilities Agreement
ft	Feet
gpm	Gallons per minute
GSA	General Services Area
HE	High explosives
HI	Hazard Index
HMX	High-Melting Explosive
HSU	Hydrostratigraphic unit
ICs	Institutional Controls
IRIS	Integrated Risk Information System
LLNL	Lawrence Livermore National Laboratory
LLNS	Lawrence Livermore National Security
LUCs	Land Use Controls
MCL	Maximum contaminant level
mg/kg	Milligrams per kilogram
mg/L	Milligrams per liter
MNA	Monitored natural attenuation
NNSA	National Nuclear Security Administration
NPDES	National Pollution Discharge Elimination System
OU	Operable unit
PCBs	Polychlorinated biphenyls
PCE	Tetrachloroethene or Tetrachloroethylene
pCi/g	picoCuries per gram

pCi/L	picoCuries per liter
PHG	Public Health Goal
PRG	Preliminary Remediation Goal
Qal	Quaternary alluvium
Qls	Quaternary landslide deposits
Qt	Quaternary alluvial terrace
RAOs	Remedial Action Objectives
RCRA	Resource Conservation and Recovery Act
RDX	Research Department explosive
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
RPMs	Remedial Project Managers
RSL	Regional Screening Level
RWQCB	Regional Water Quality Control Board
SARA	Superfund Amendment Reauthorization Act
SVRA	Carnegie State Vehicular Recreation Area
TBOS/TKEBS	Tetrabutyl orthosilicate/ Tetrakis (2-ethylbutyl) silane
TCA	Trichloroethane
TCE	Trichloroethylene
THMs	Total trihalomethanes
TMSRA	Technical Memorandum in Support of a Record of Decision Amendment
Tmss	Miocene Cierbo Formation—lower siltstone/claystone member
$Tnbs_0$	Neroly silty Sandstone
$Tnbs_1$	Tertiary Neroly Lower Blue Sandstone
$Tnbs_2$	Tertiary Neroly Upper Blue Sandstone
$Tnsc_0$	Tertiary Neroly Formation—lower siltstone/claystone member
$Tnsc_1$	Tertiary Neroly Lower Siltstone/Claystone
Tps	Tertiary Pliocene nonmarine sediments
Tpsg	Tertiary Pliocene sand and gravel
Tts	Tesla Formations
$^{235}U/^{238}U$	Uranium-235/uranium-238 (atom ratio)
UCL	Upper Confidence Limit
U.S.	United States
VOCs	Volatile organic compounds
yd^3	Cubic yards
µg/L	Micrograms per liter

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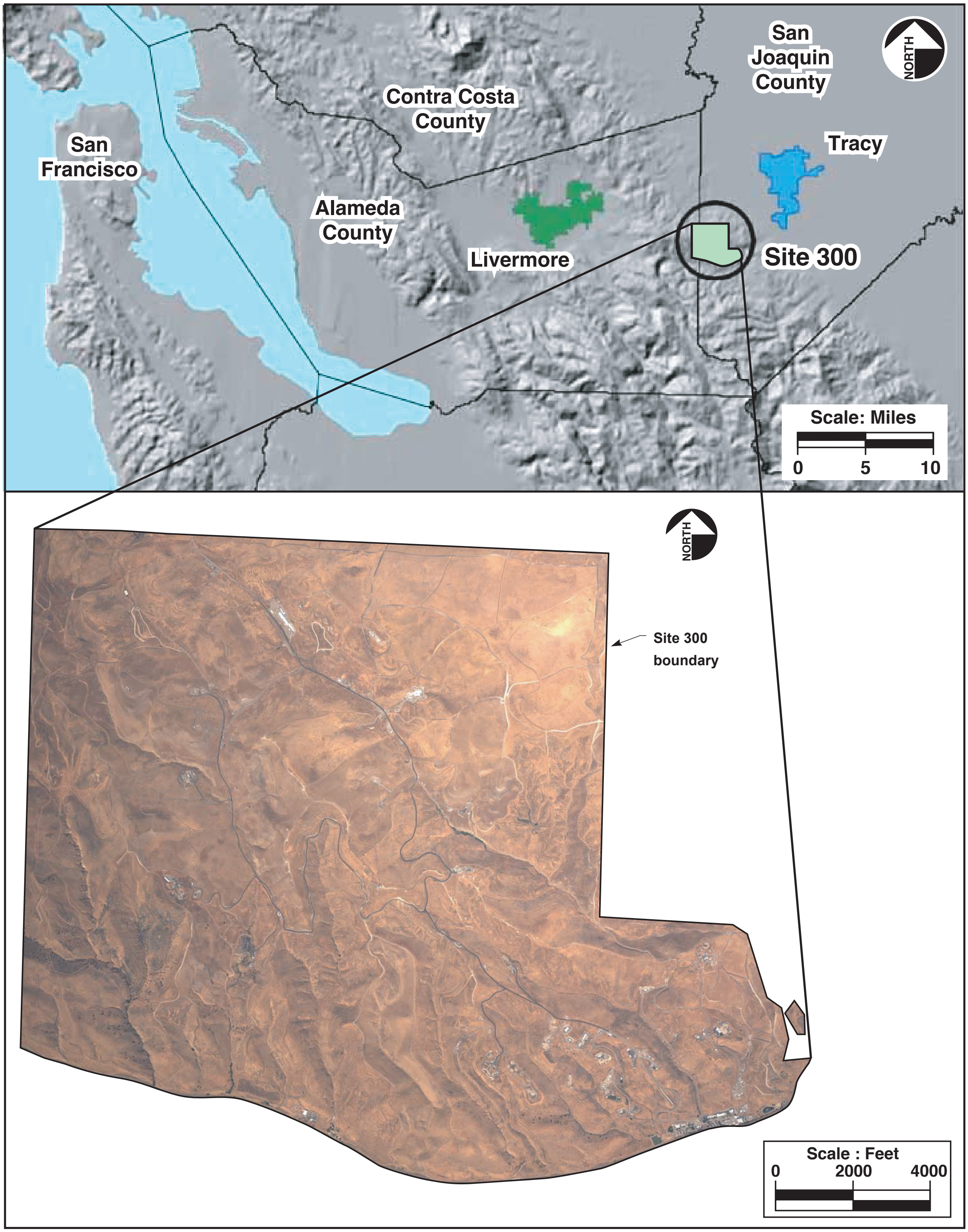

ERD-S3R-12-0039

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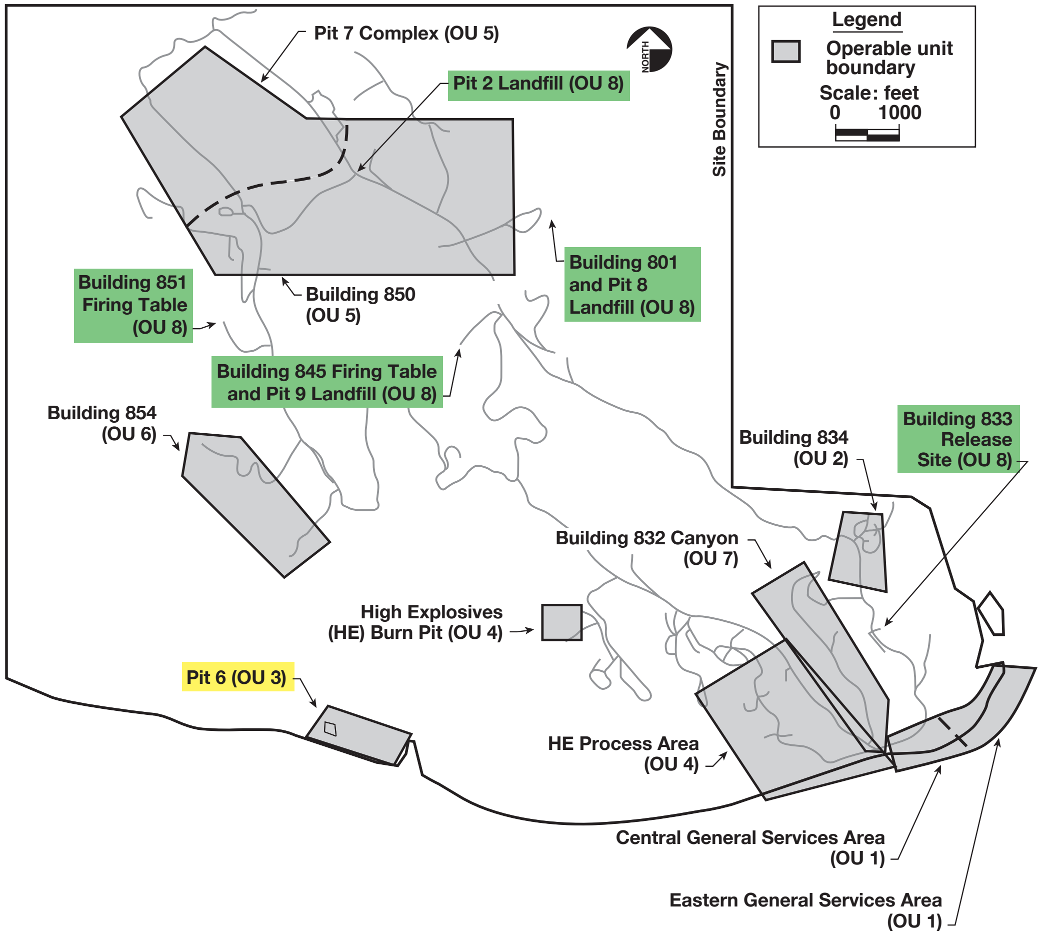

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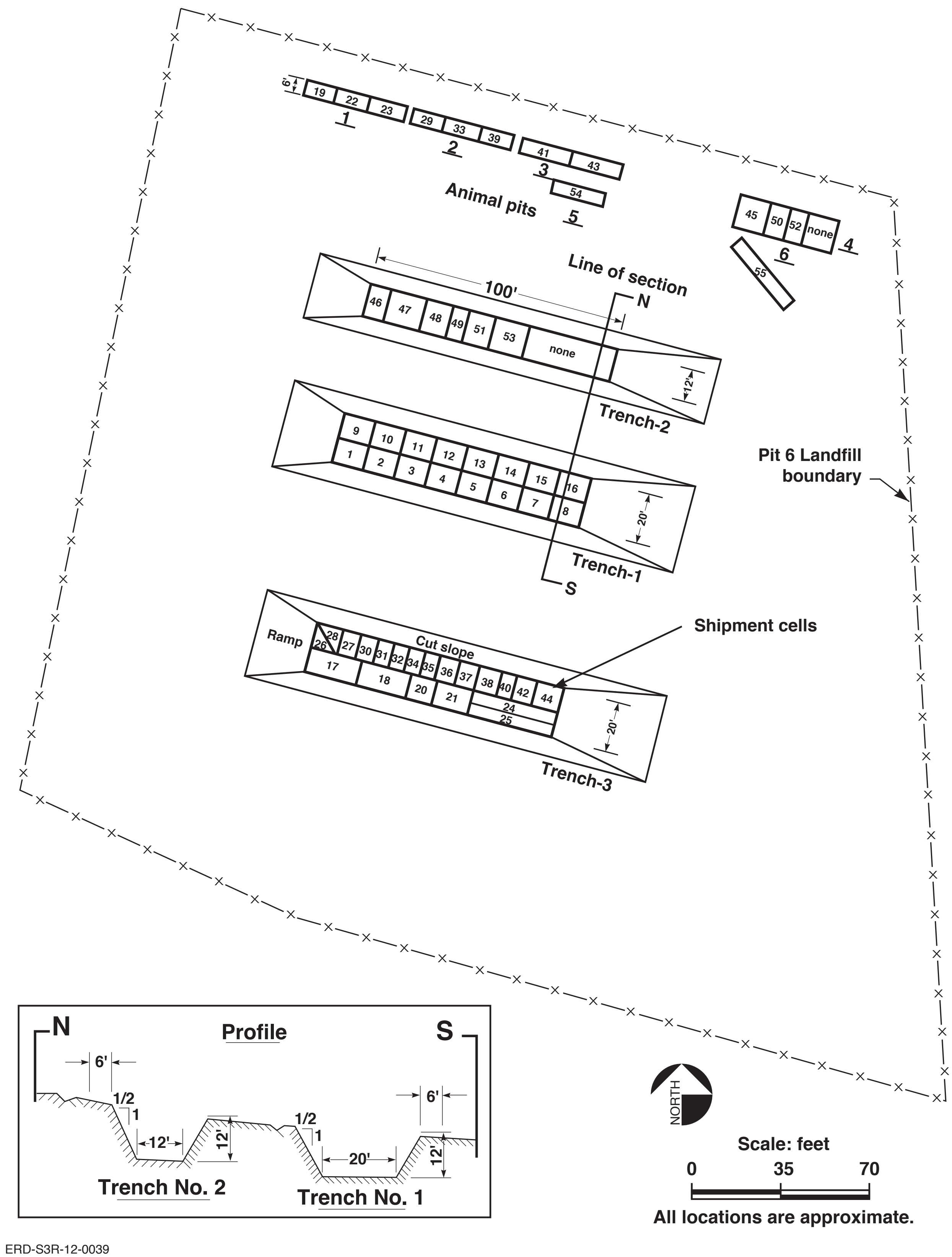

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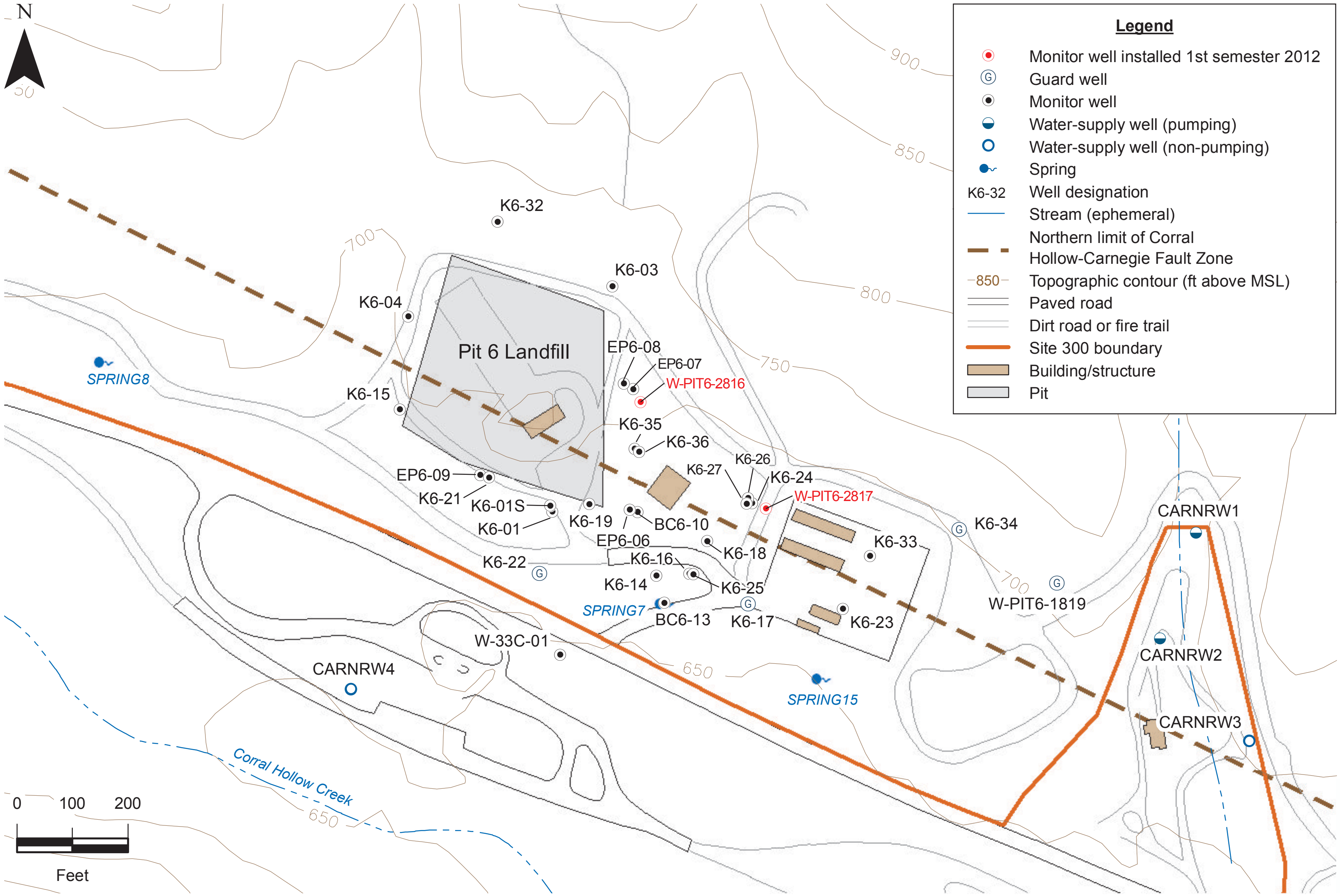

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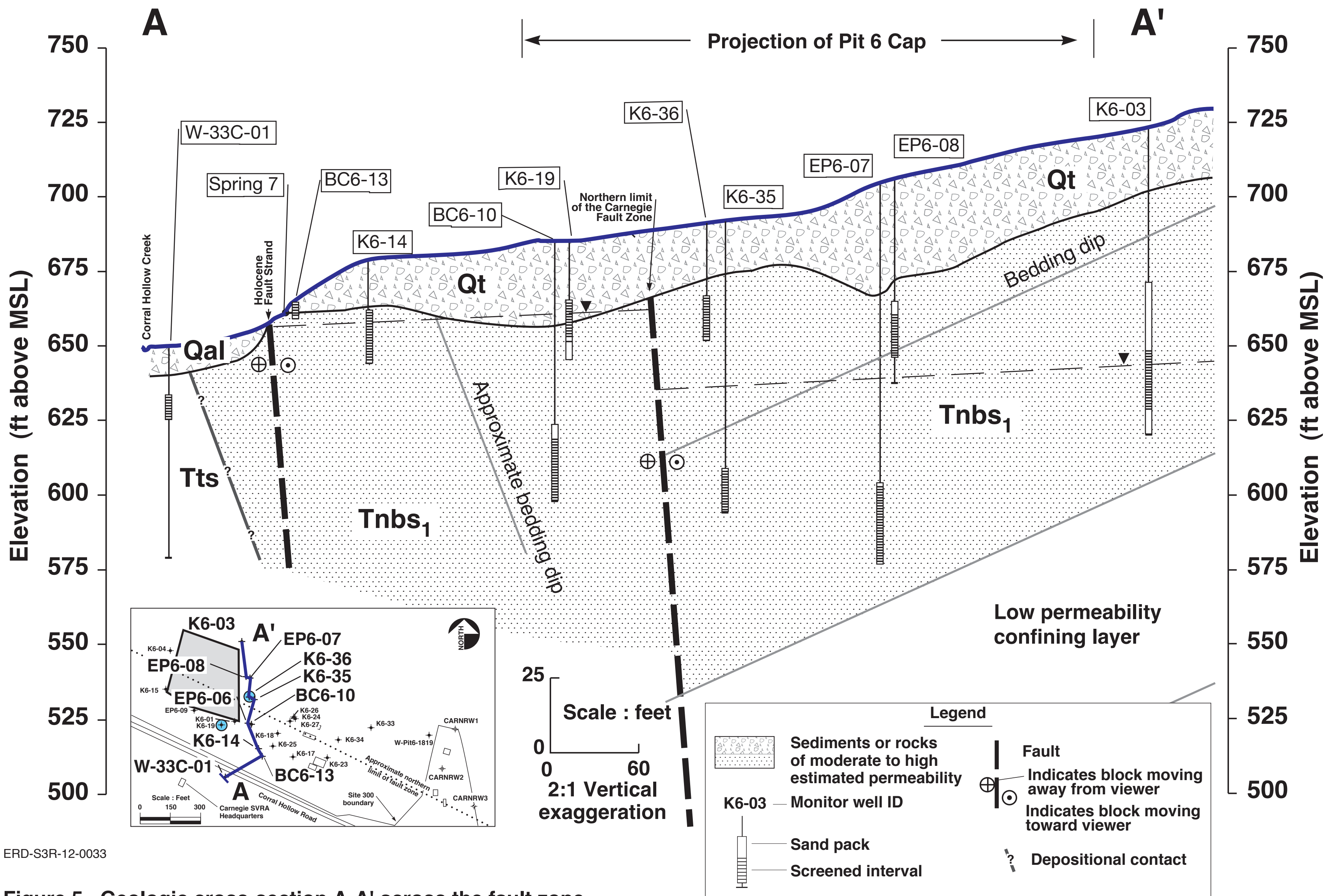

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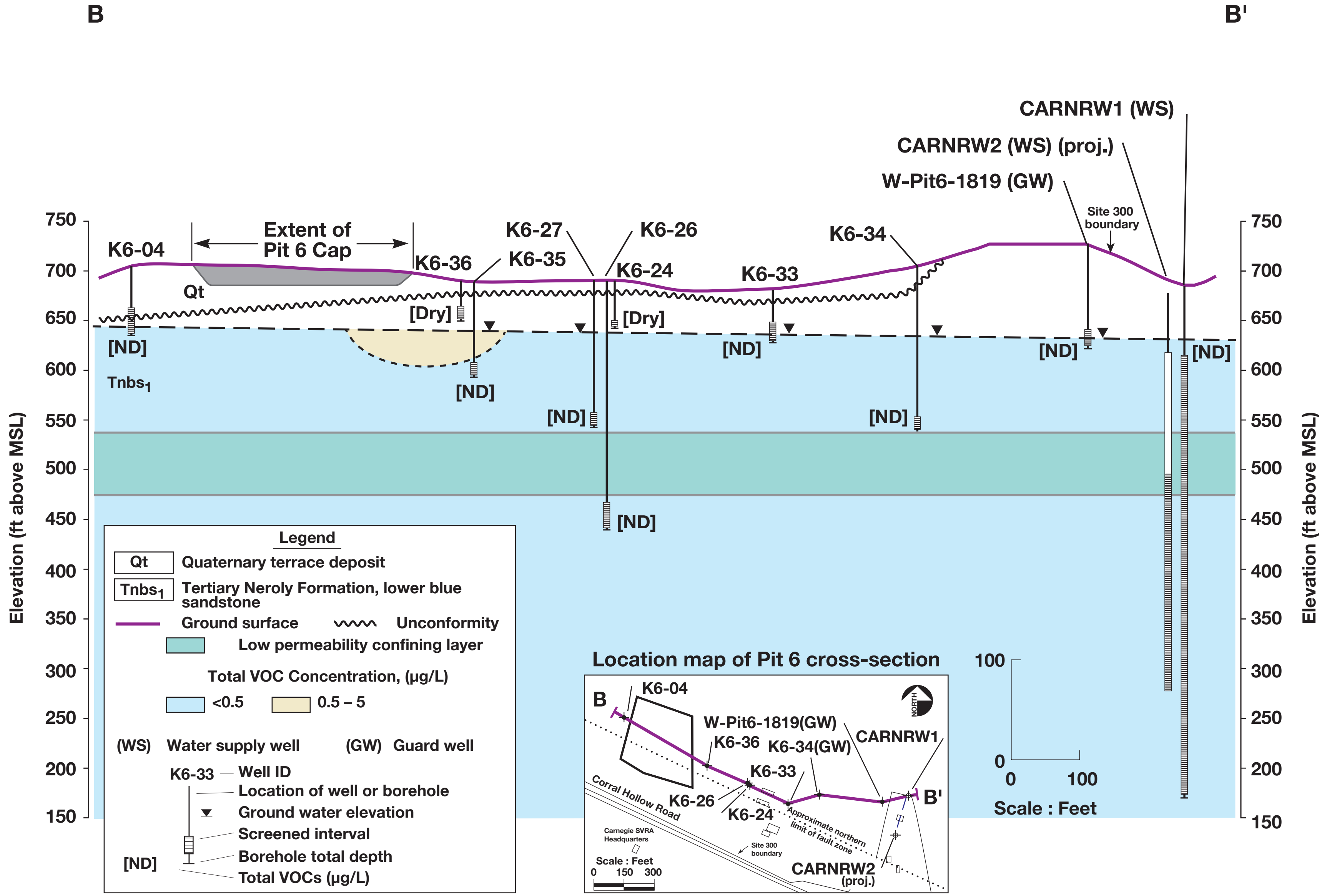

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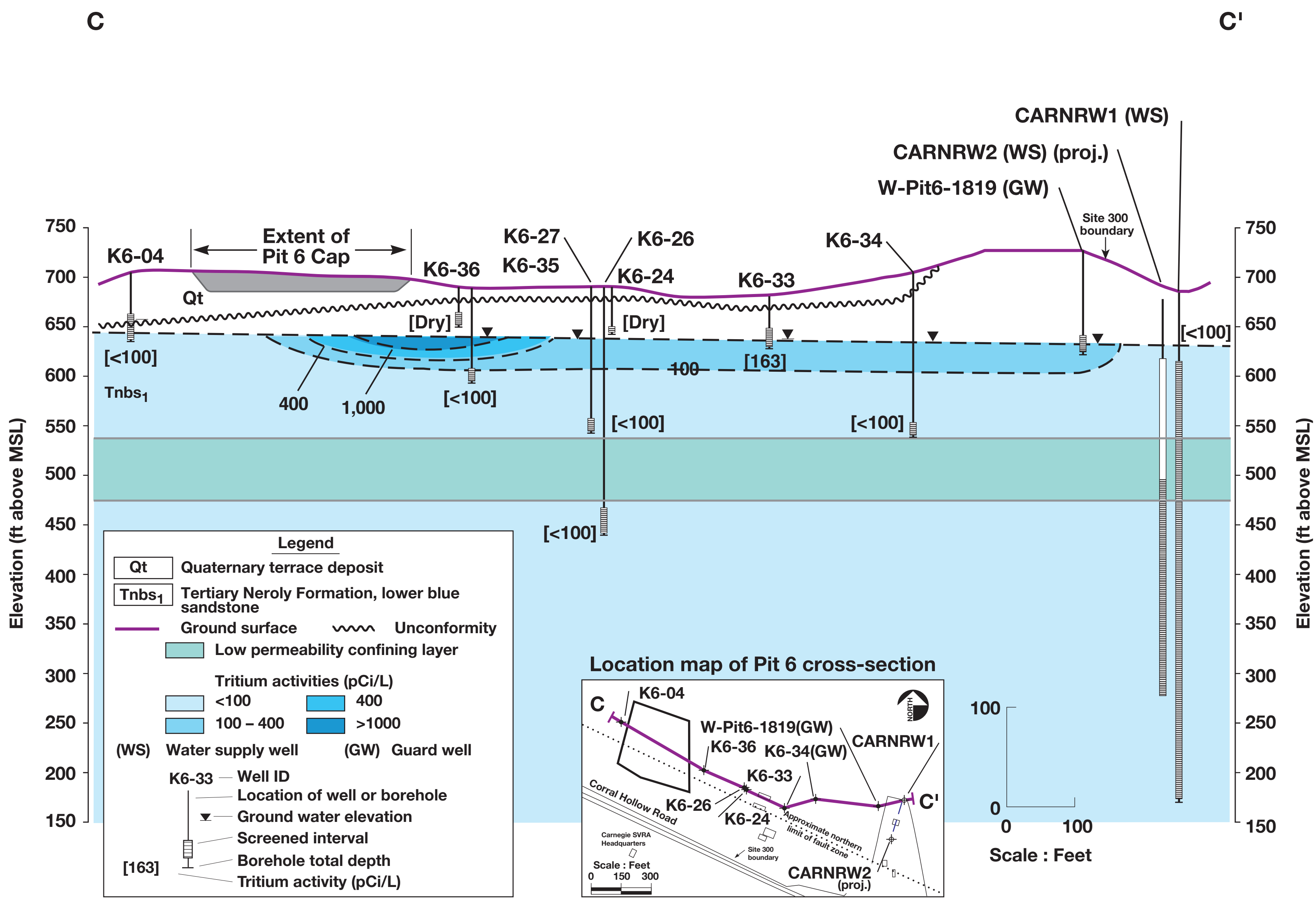

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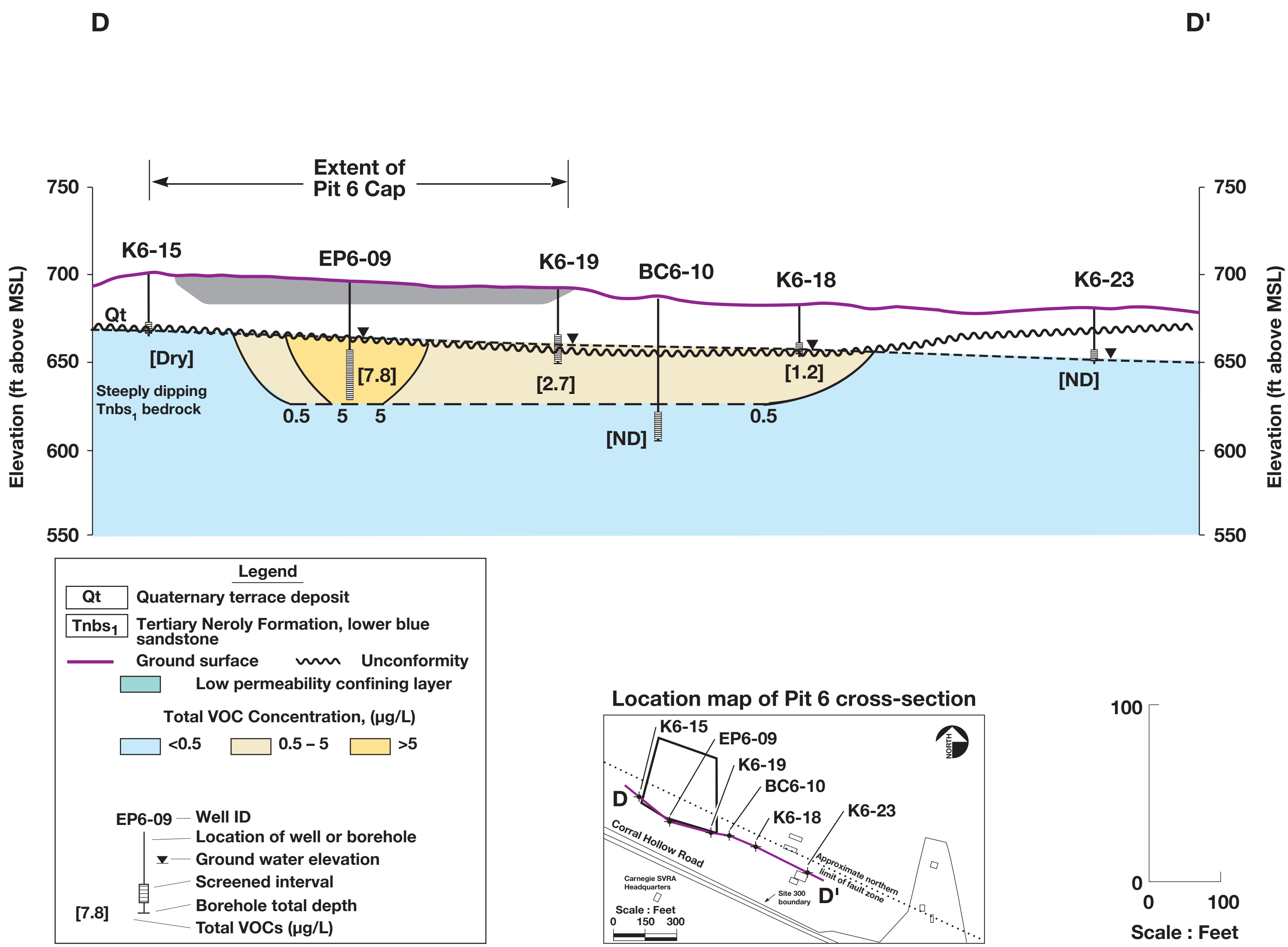

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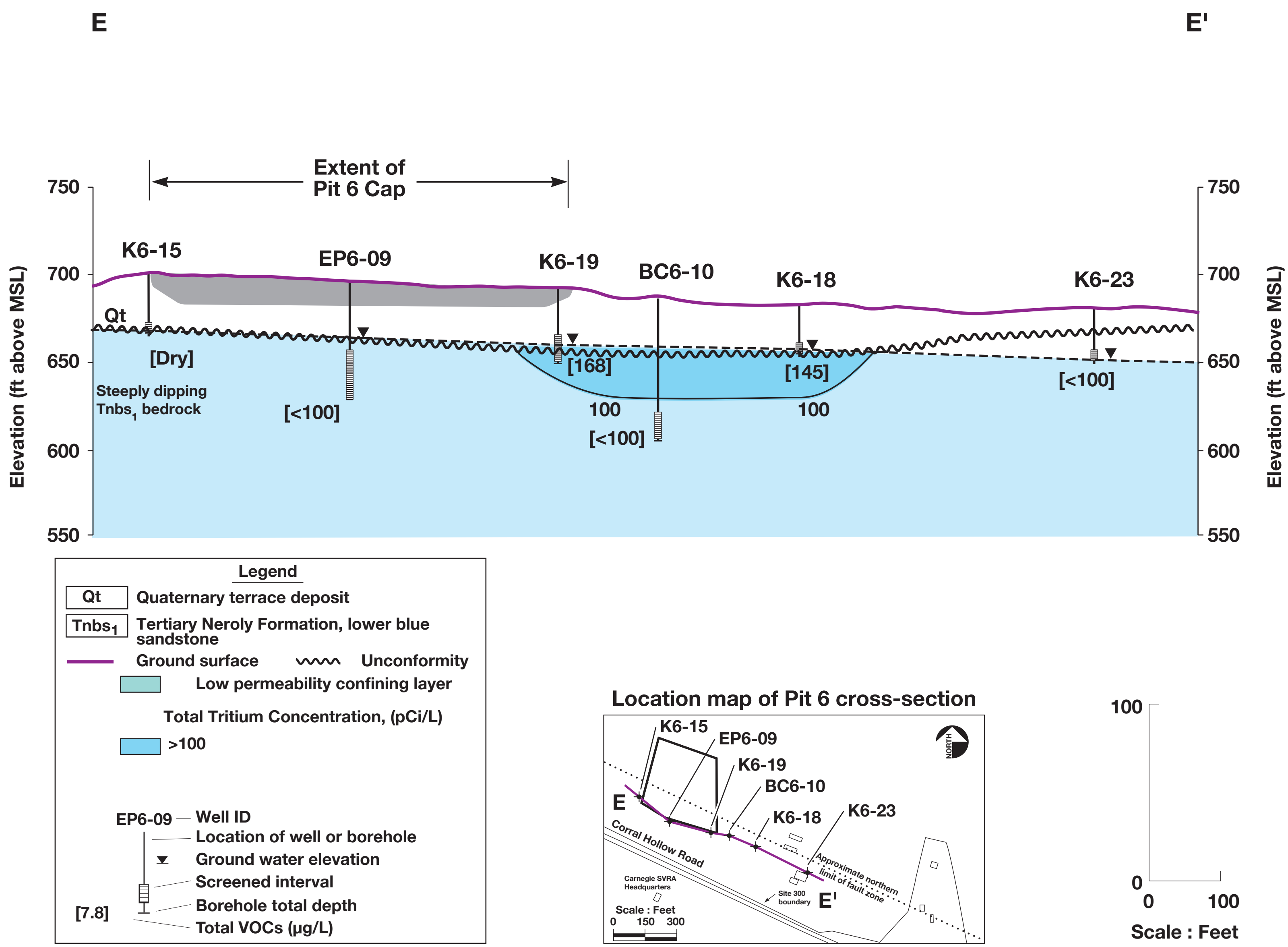

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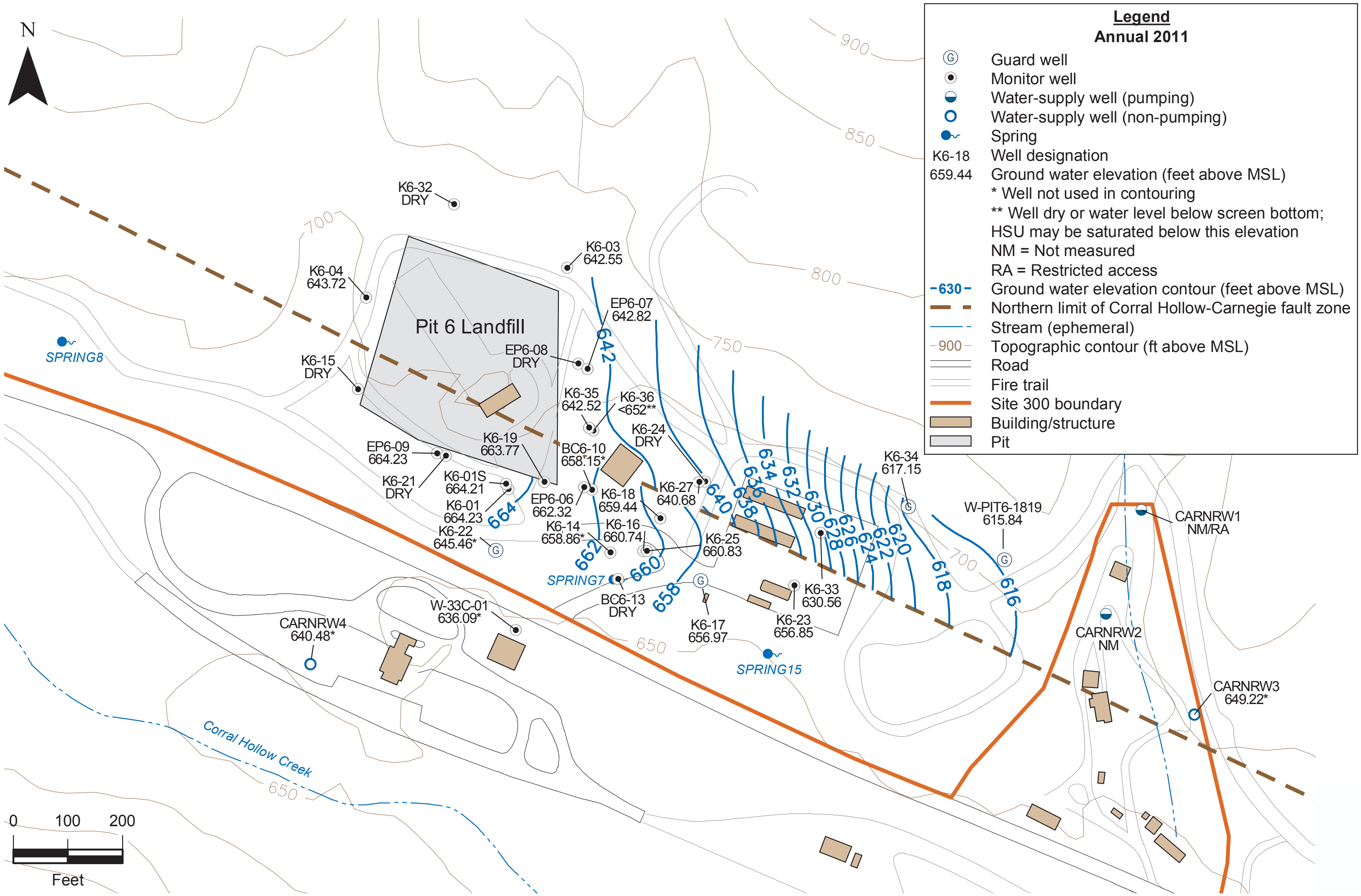

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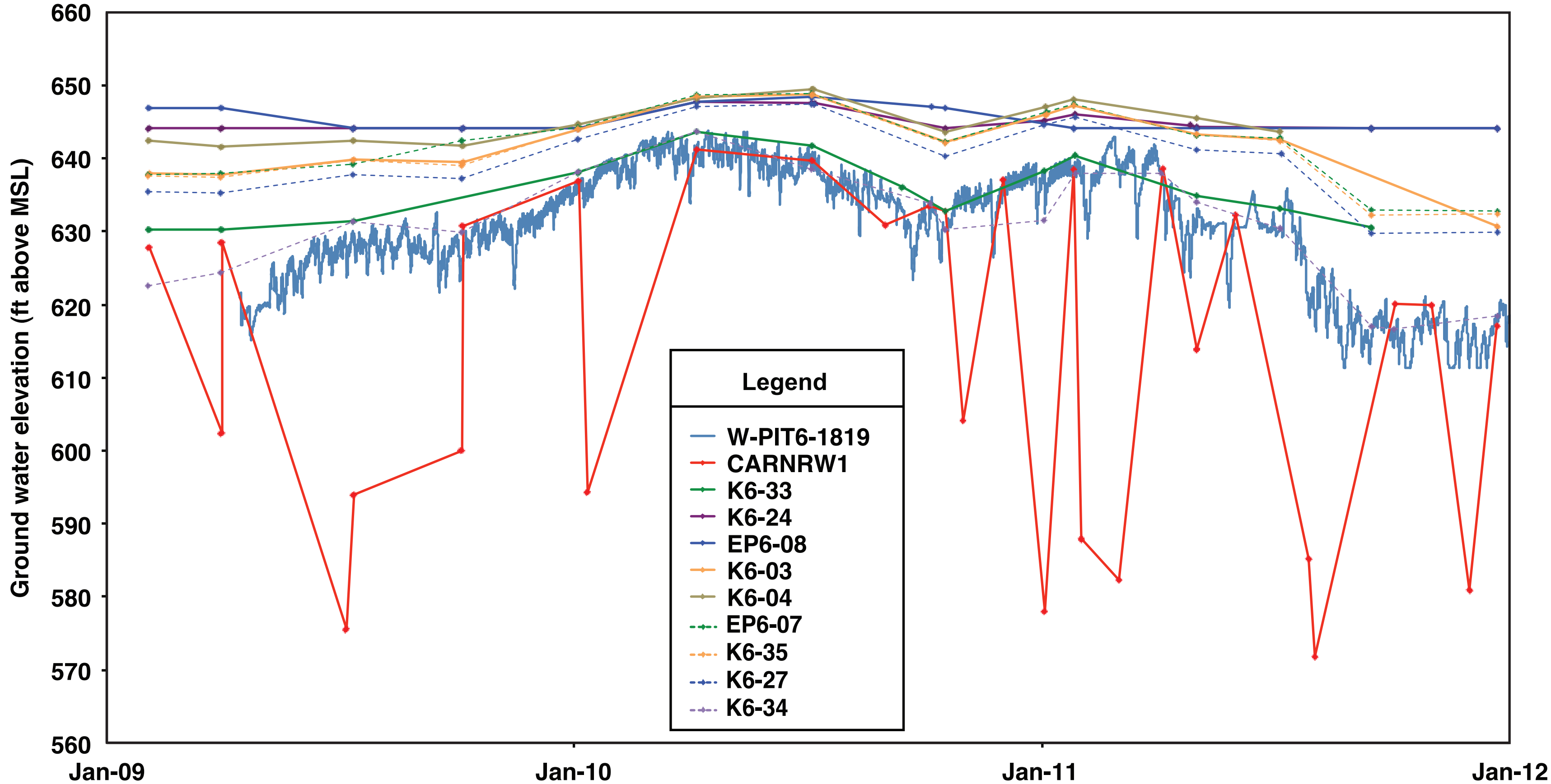

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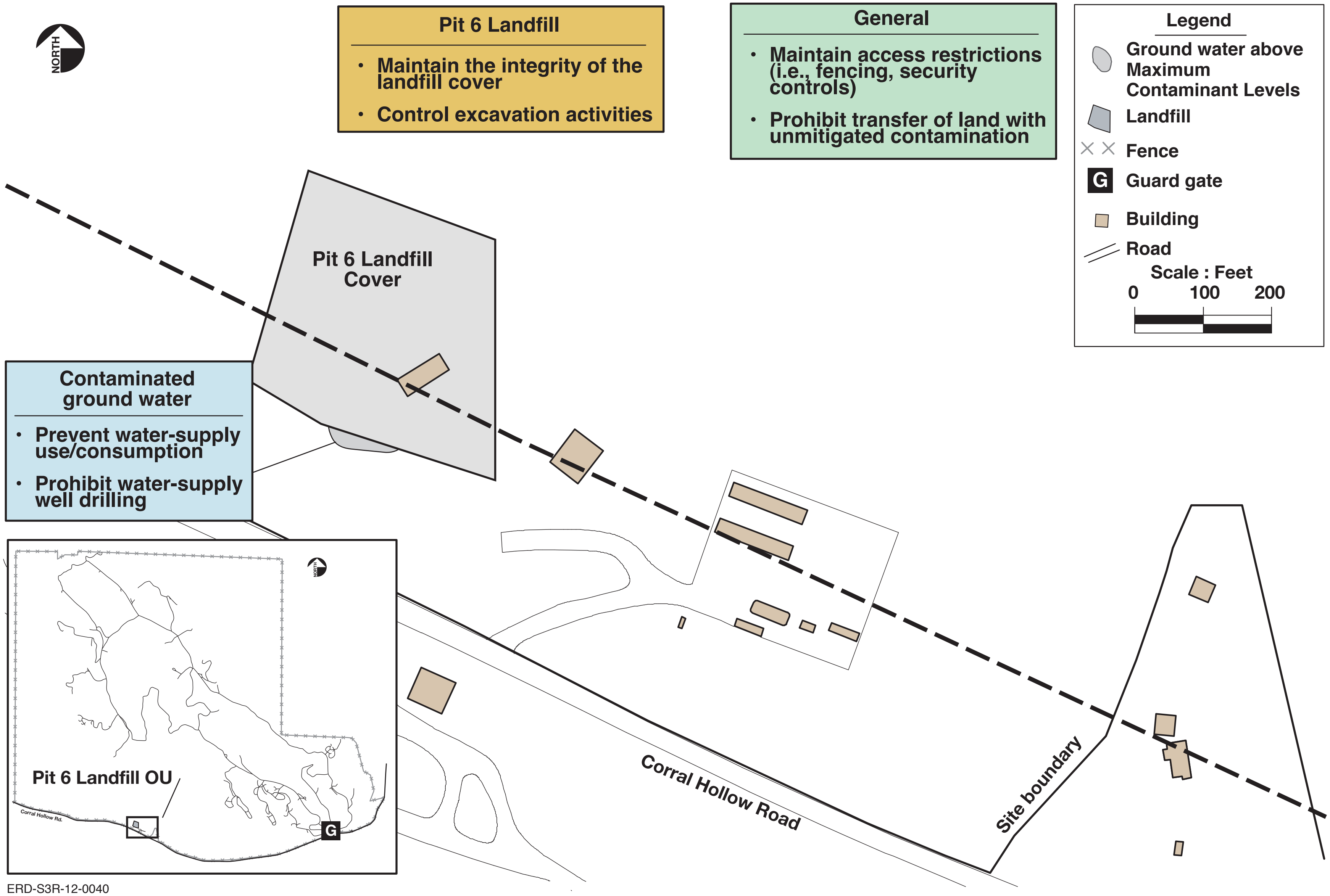

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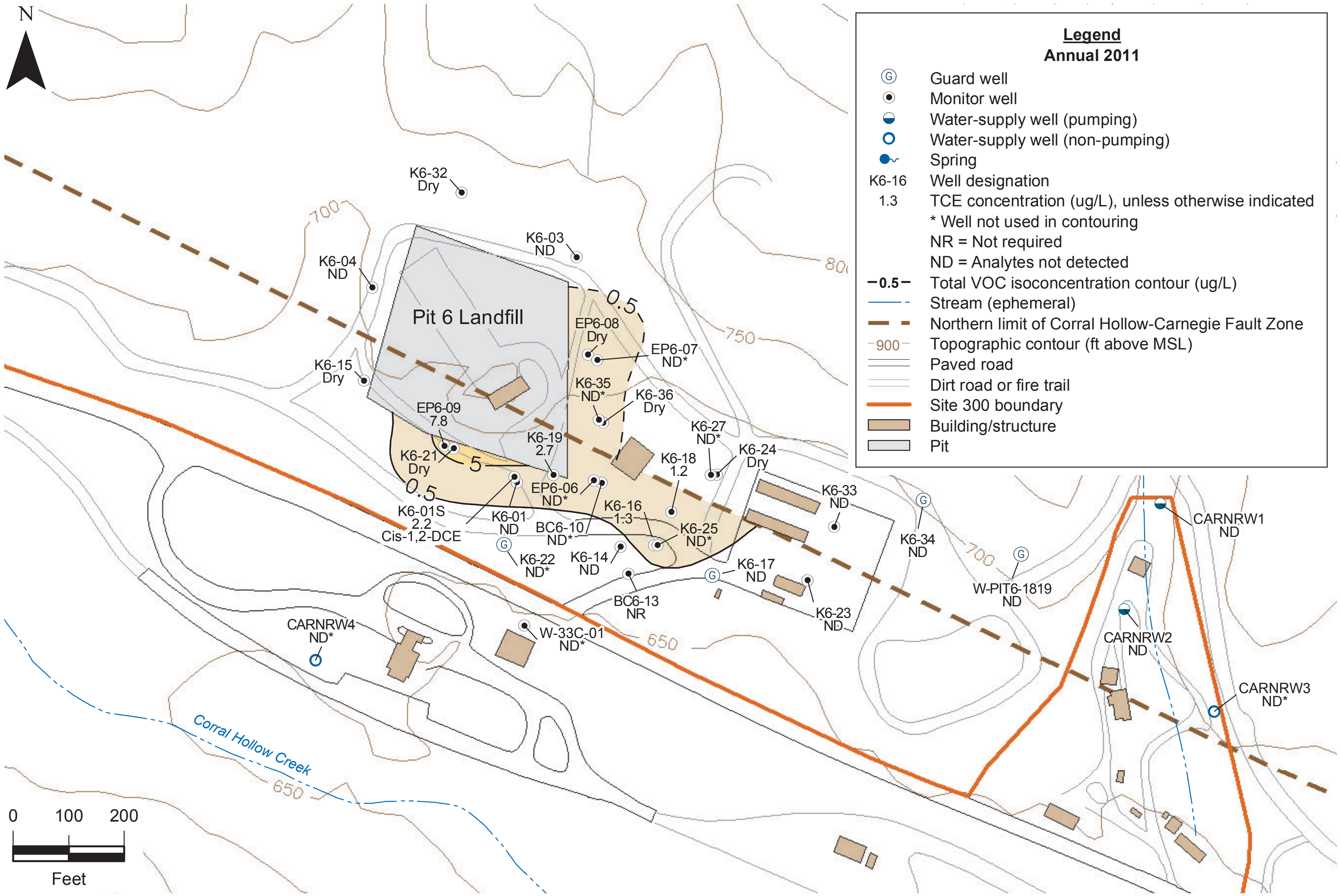

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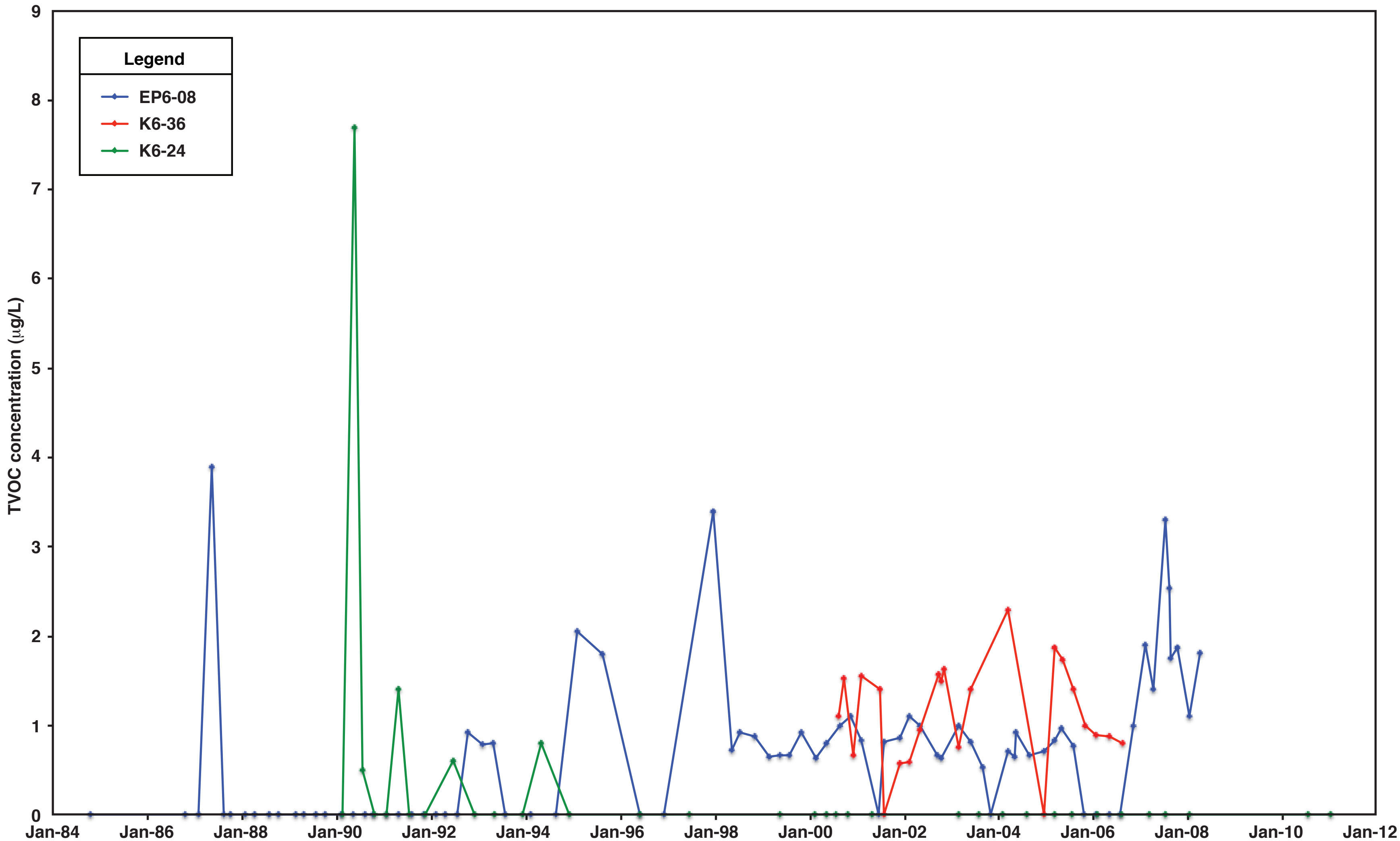

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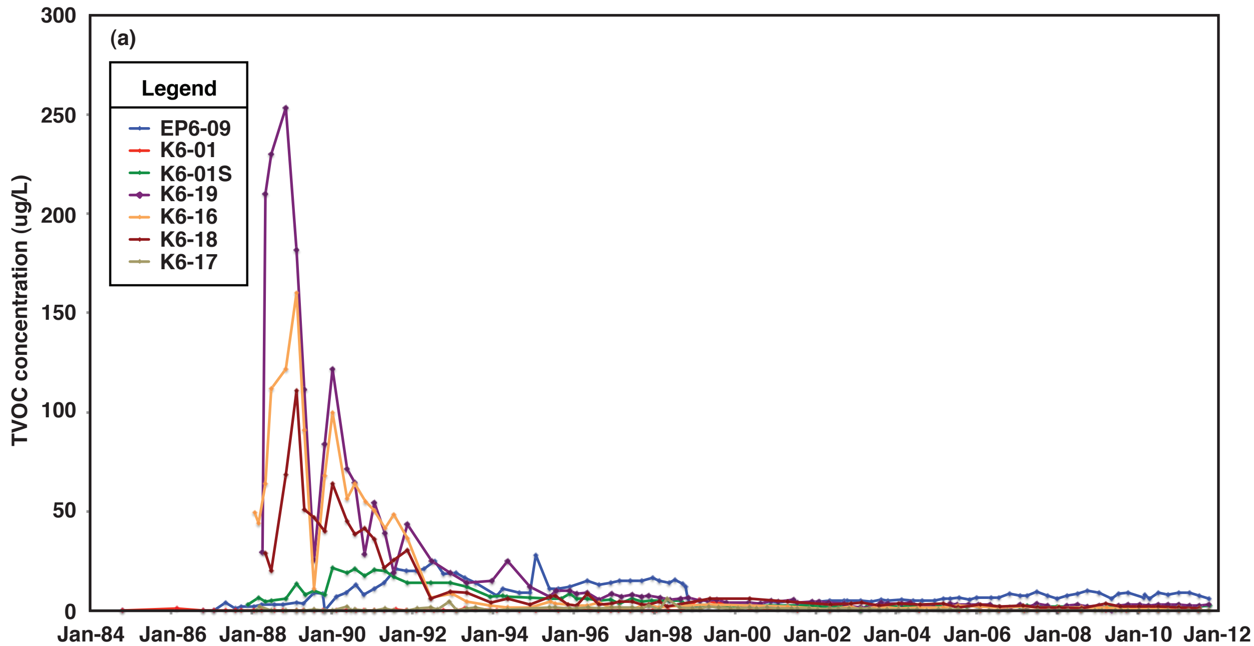

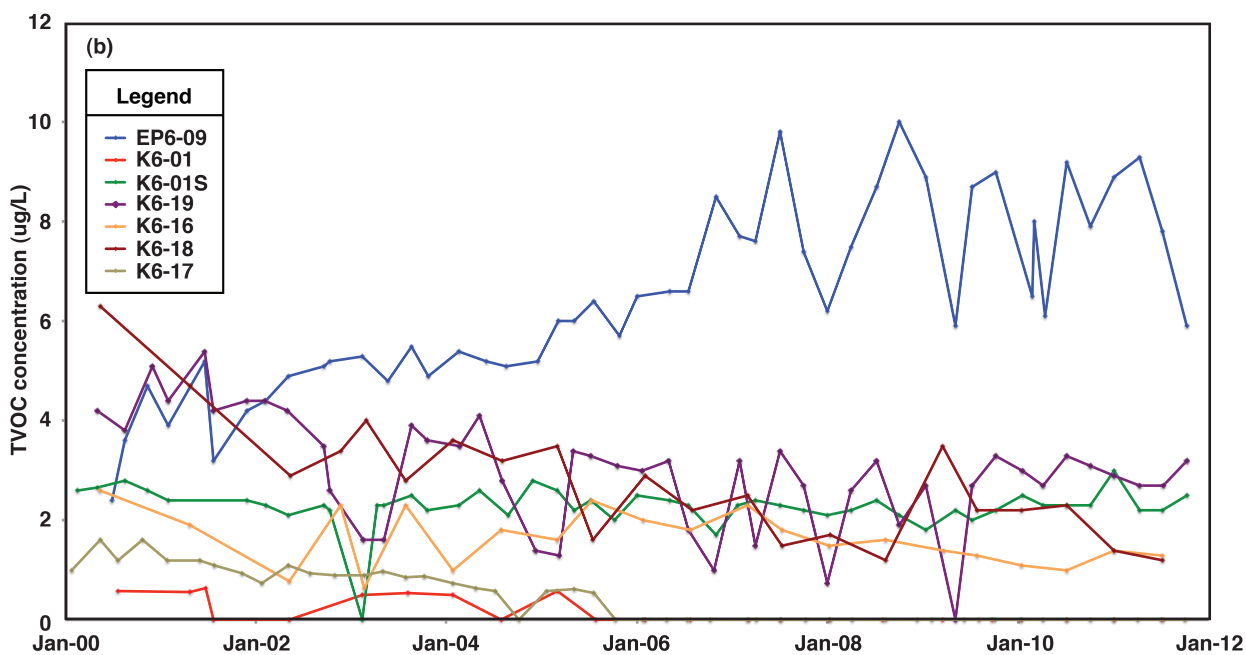

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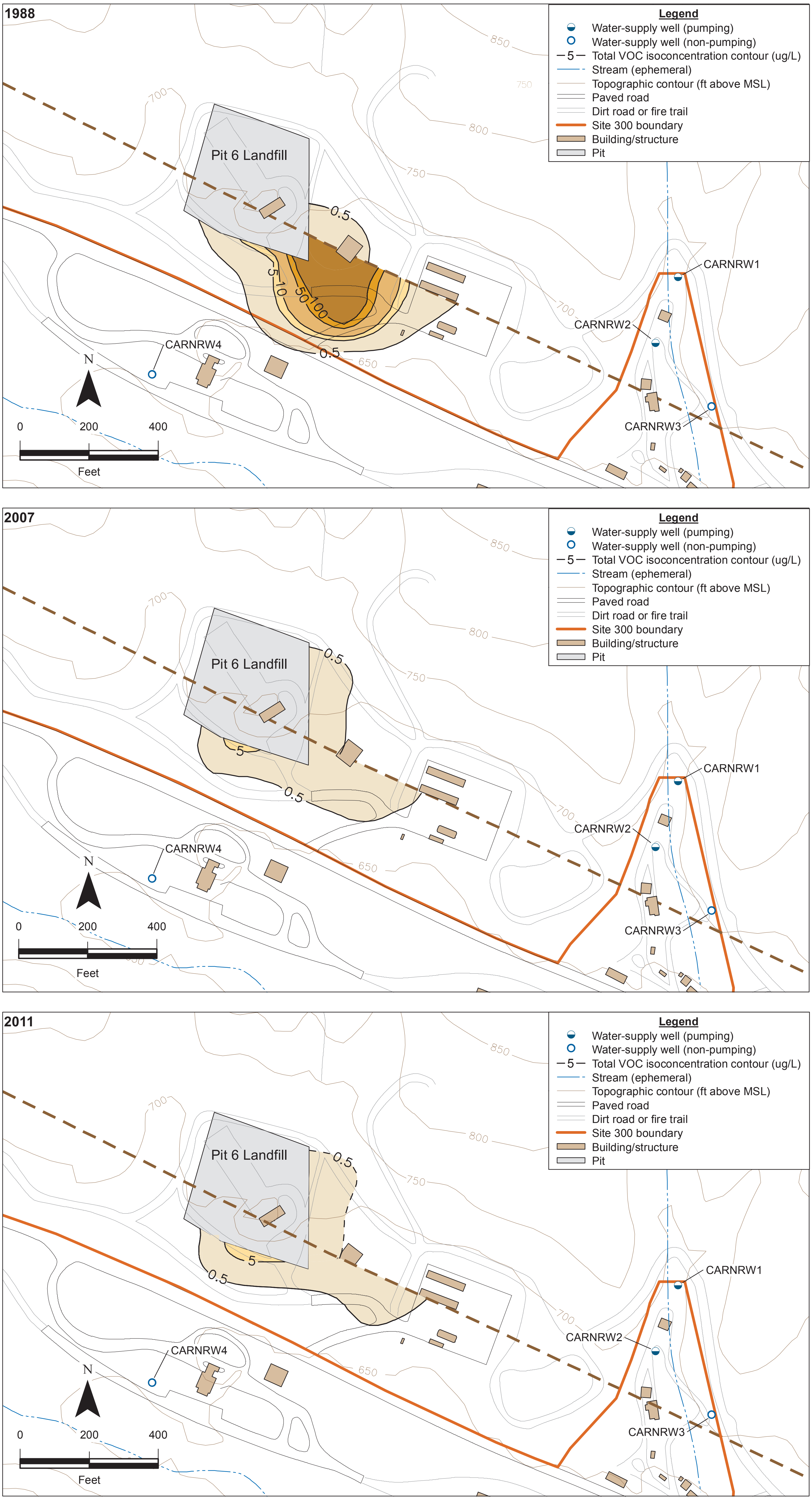

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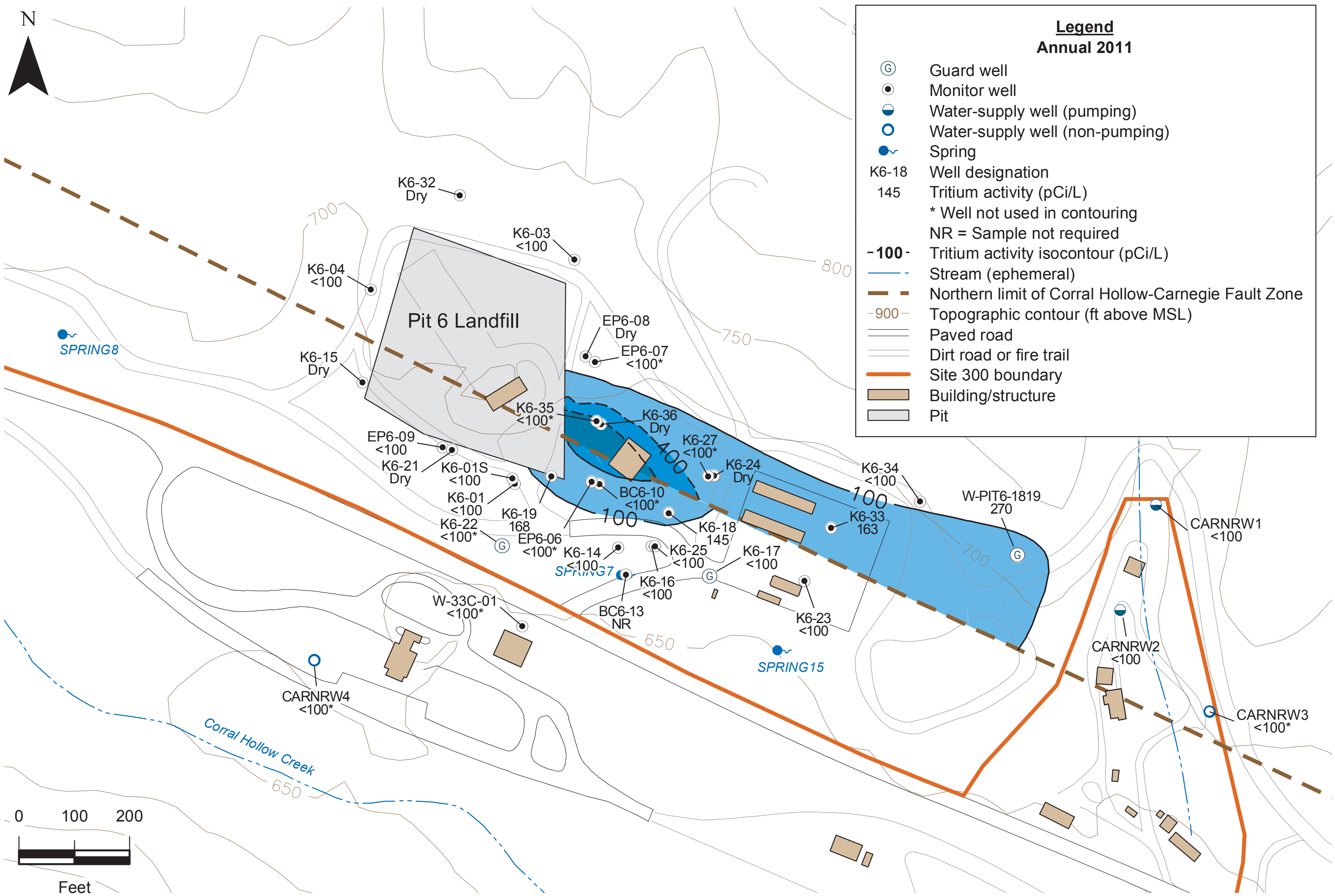

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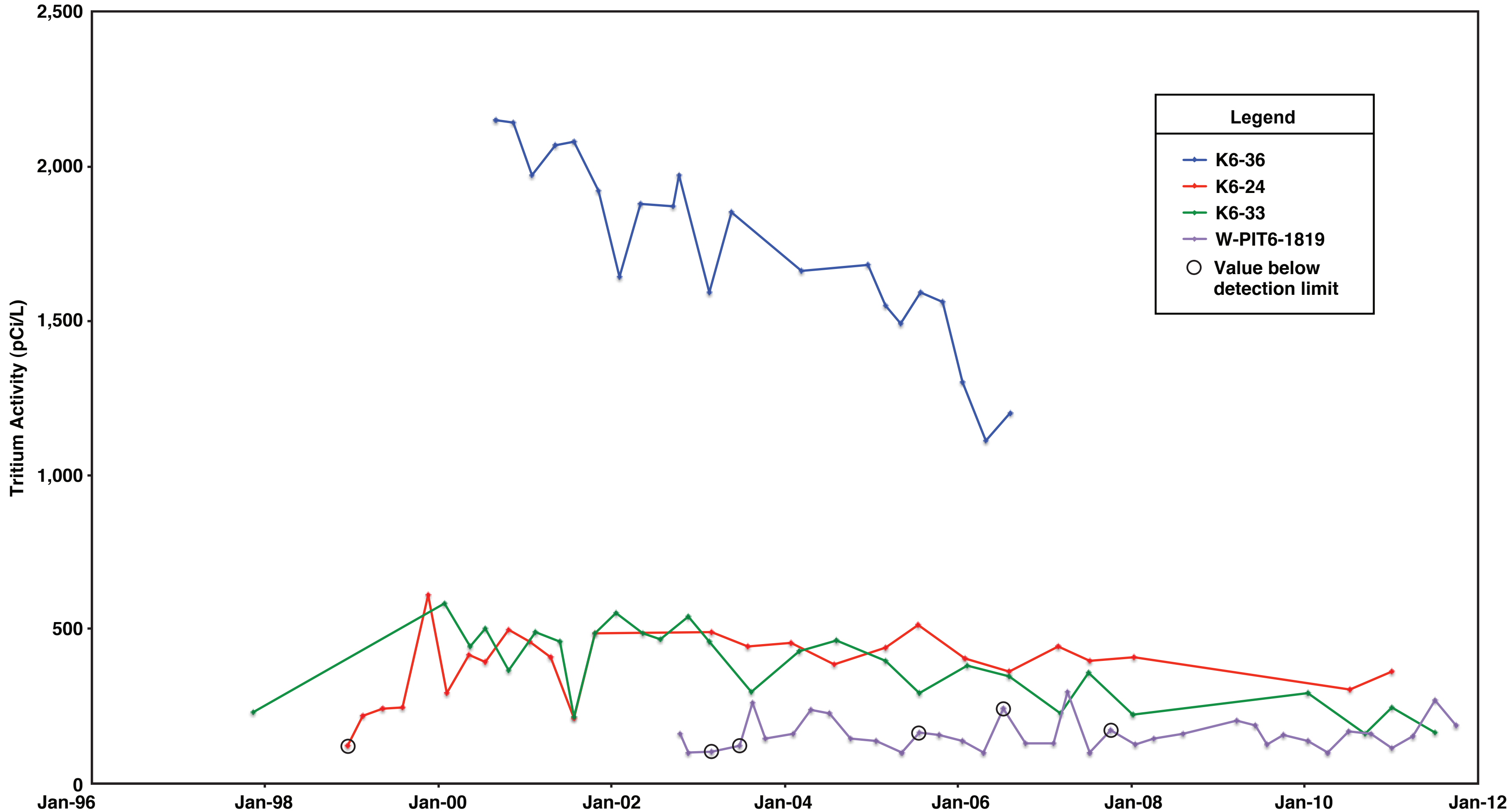

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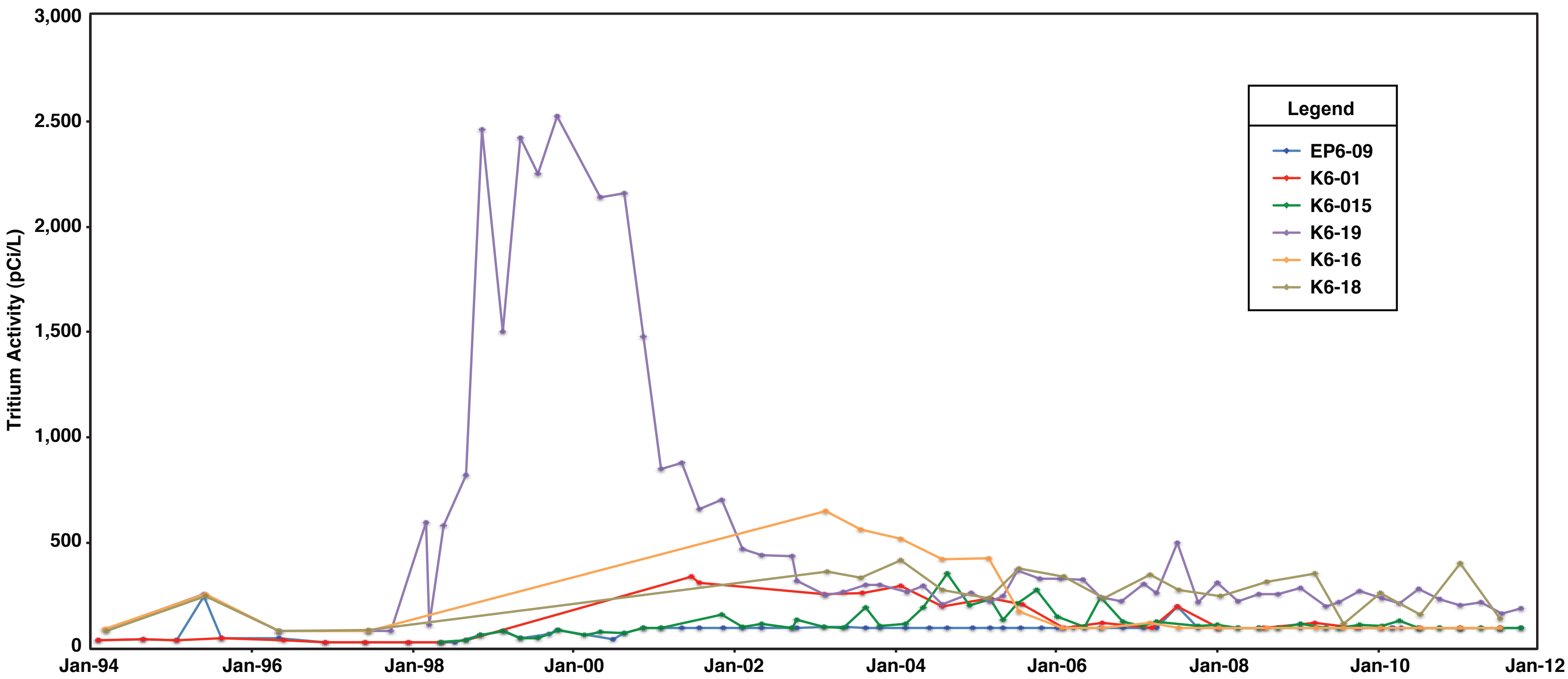

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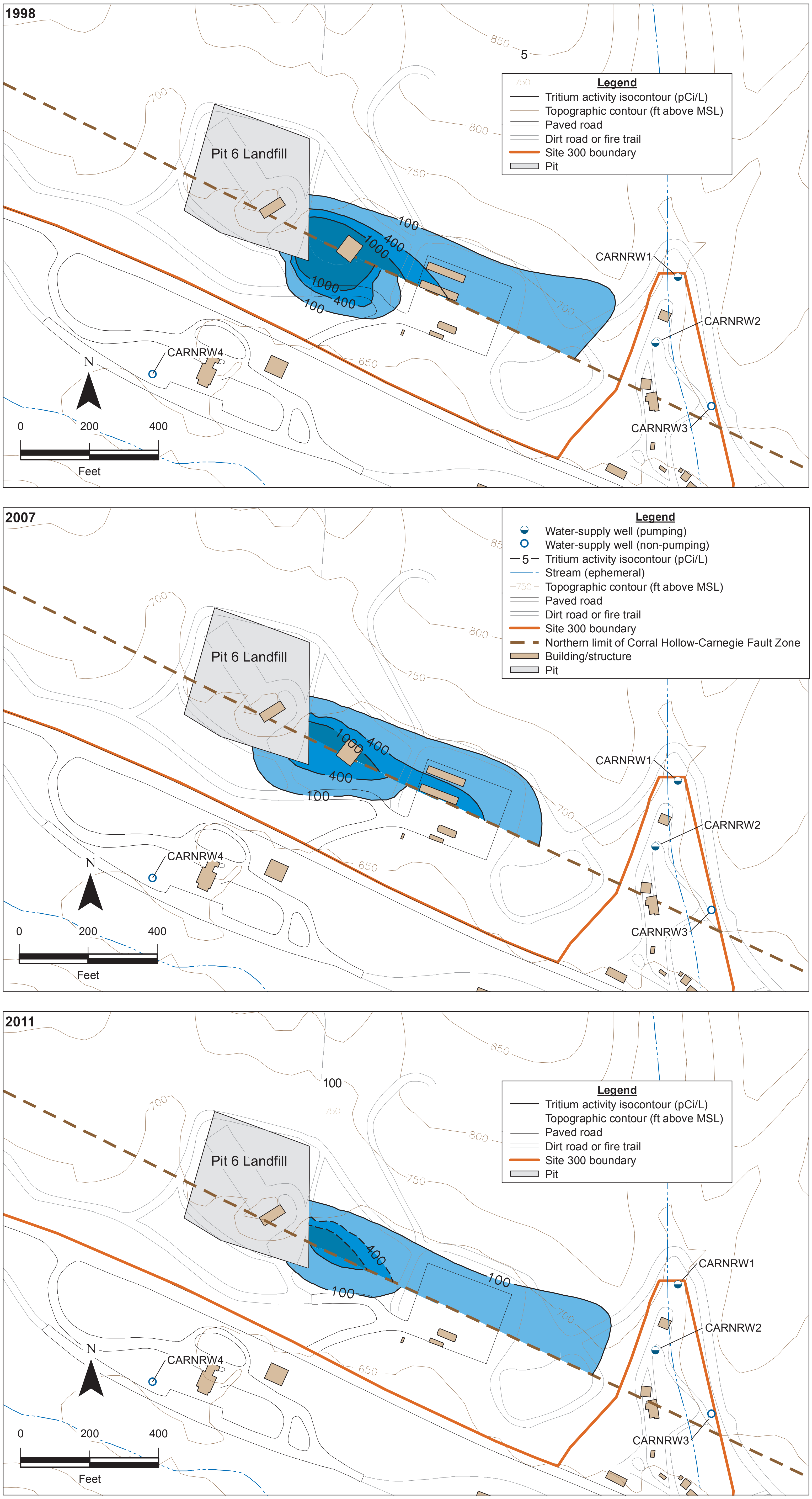

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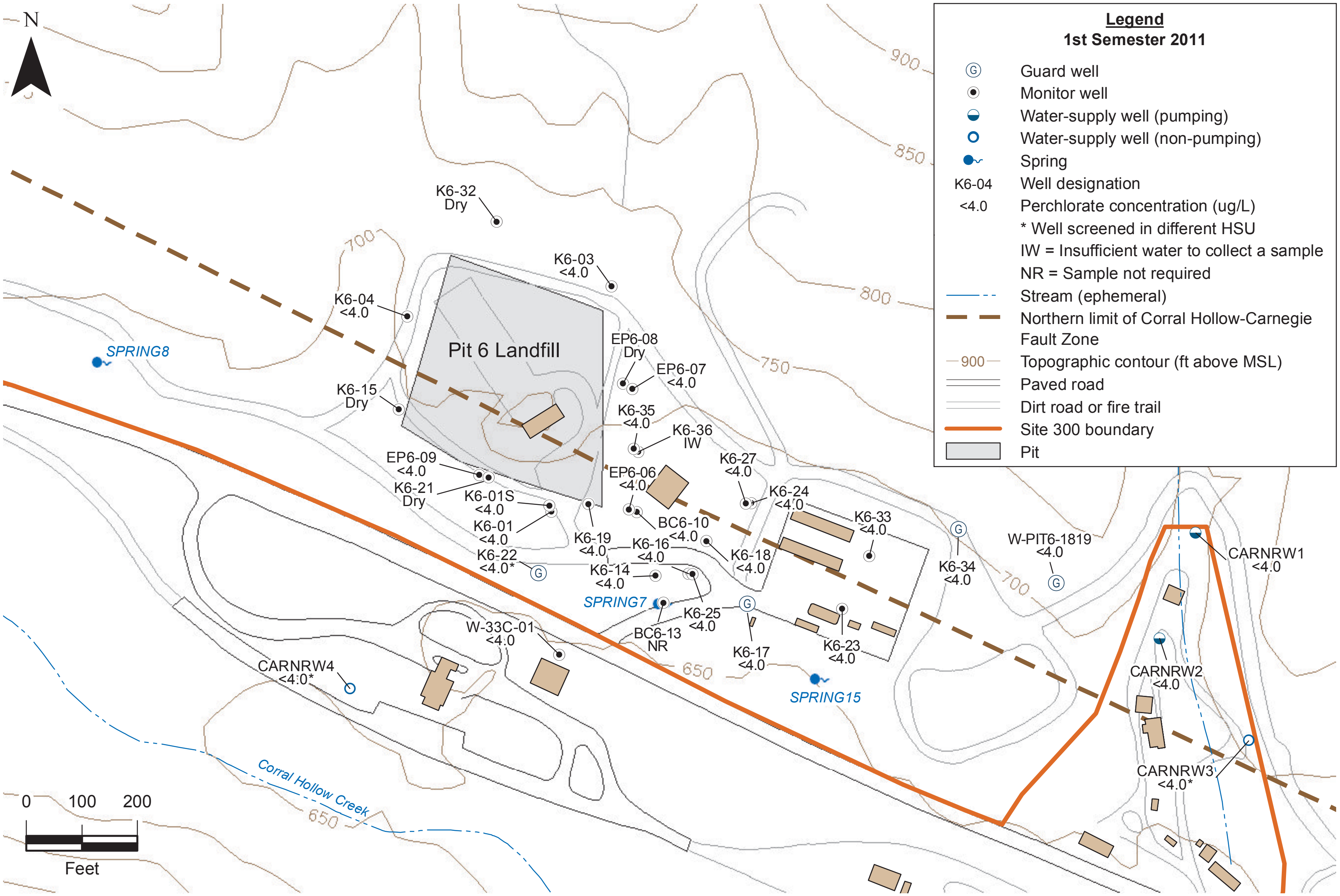

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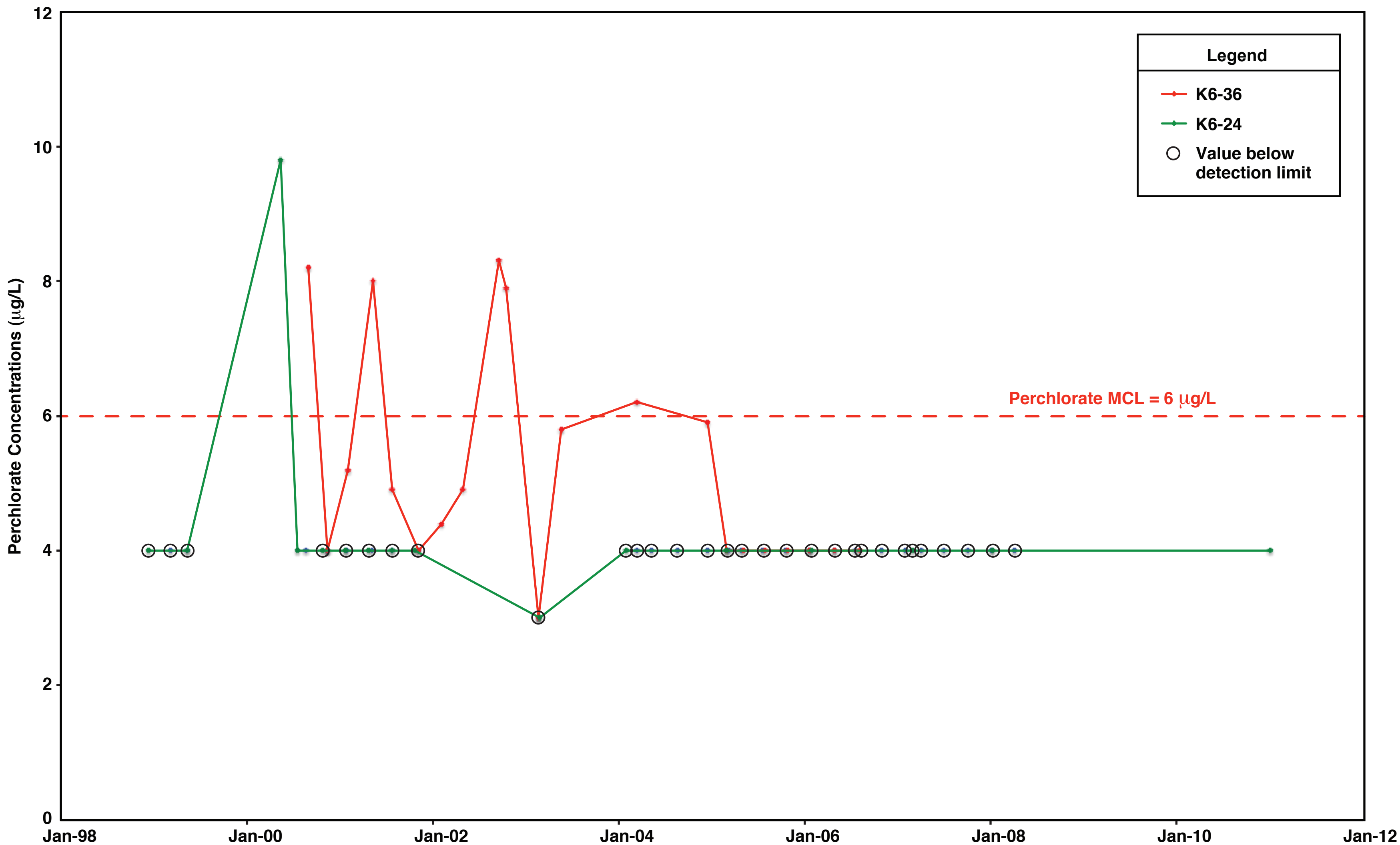

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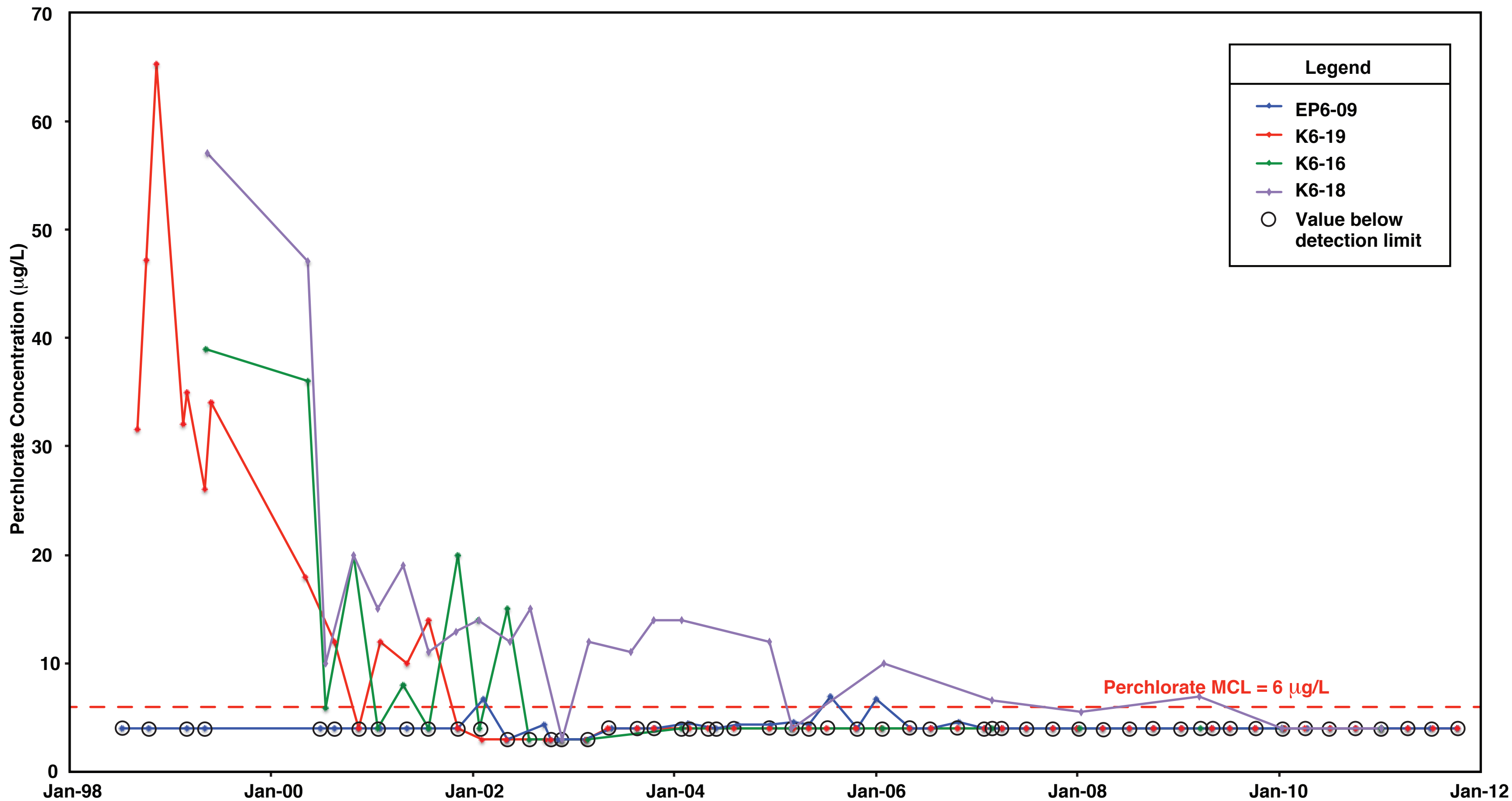

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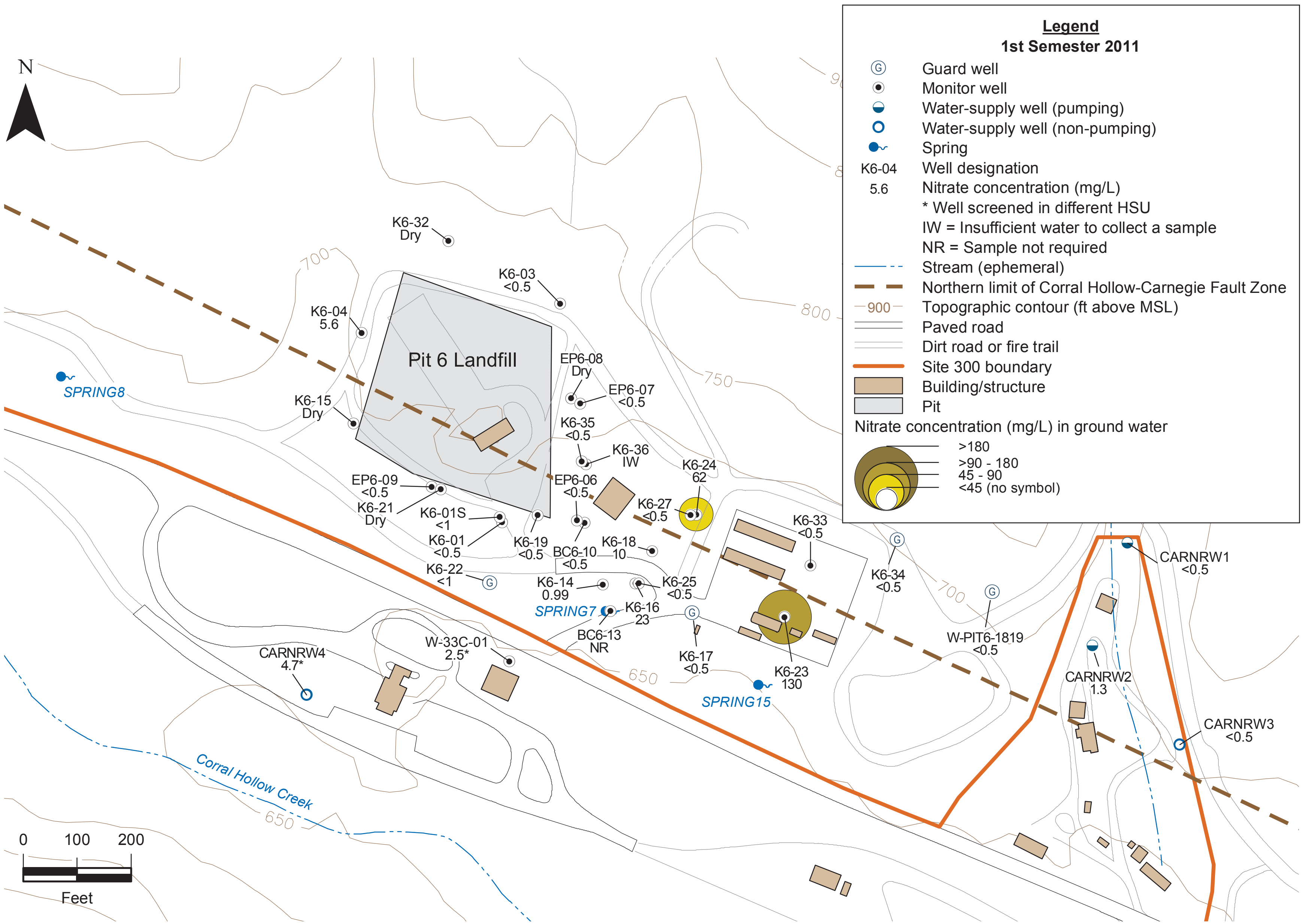

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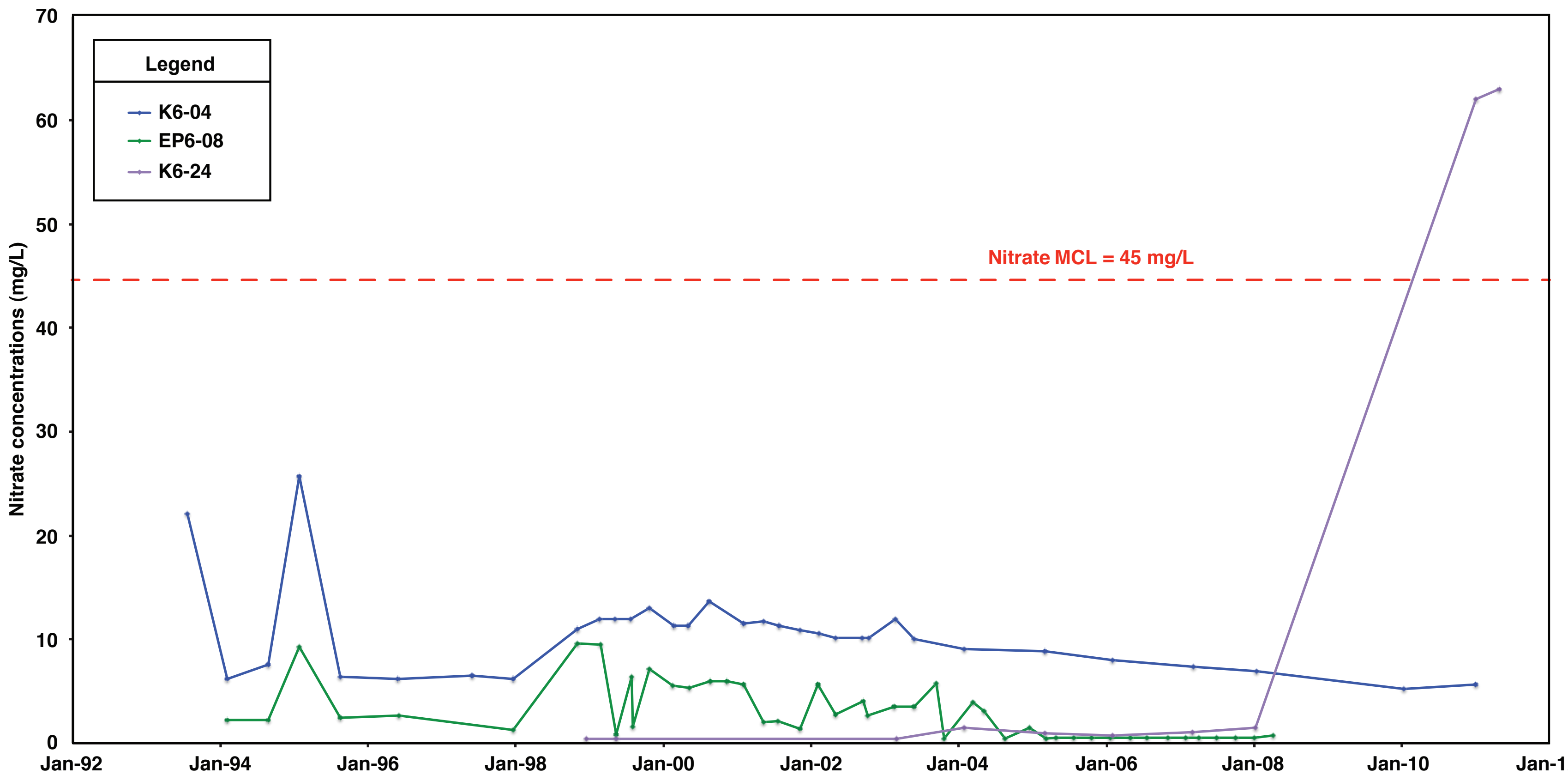

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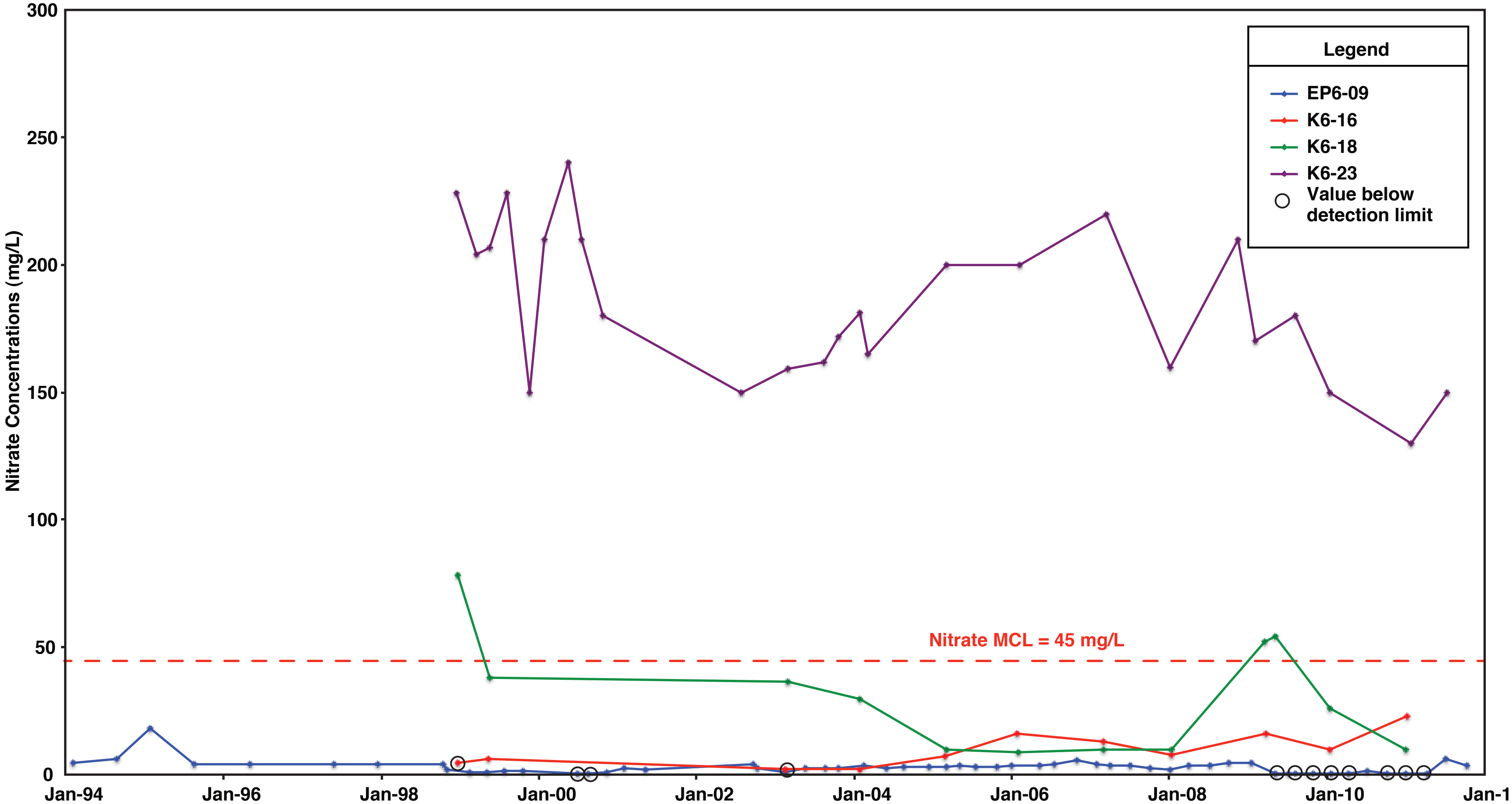

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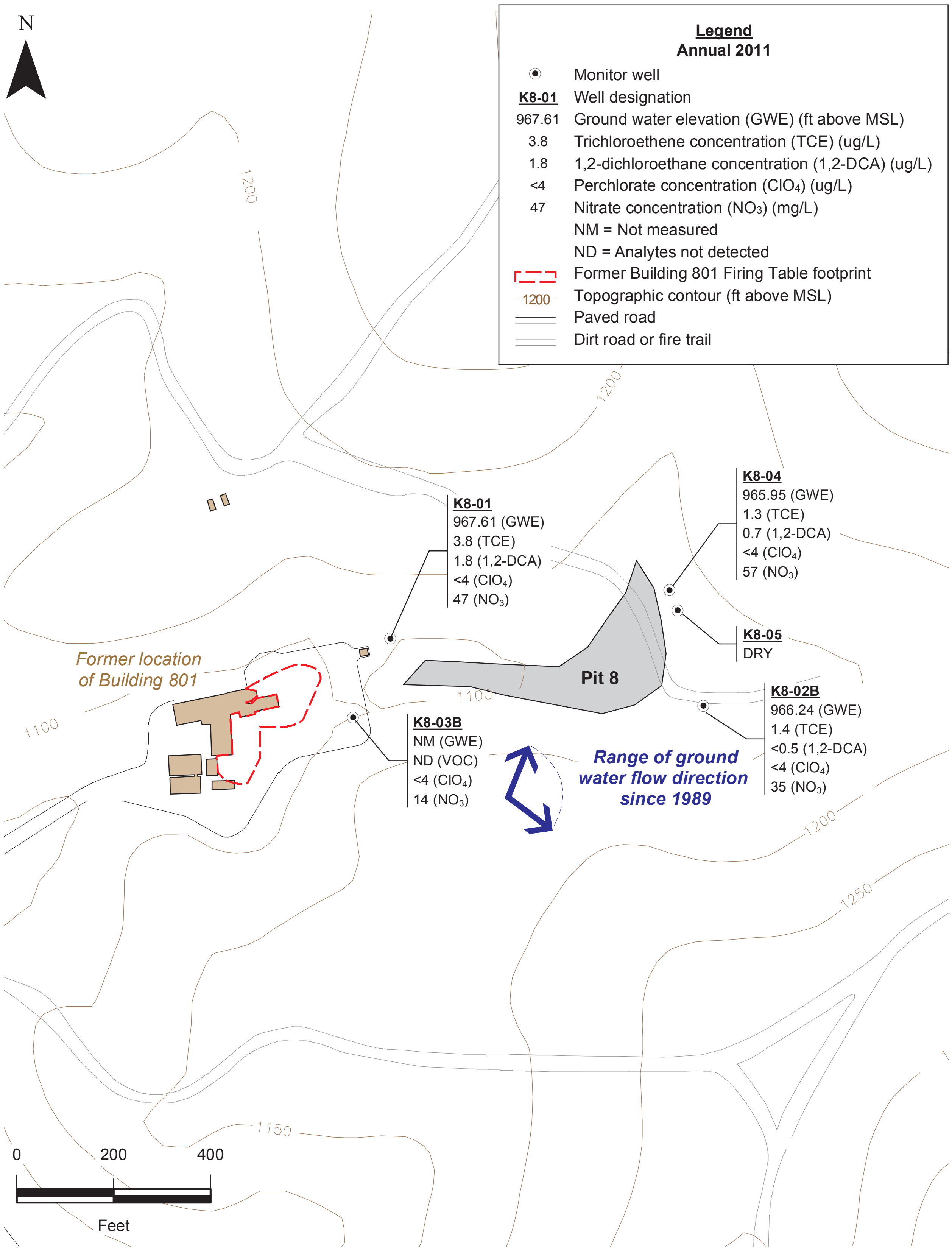

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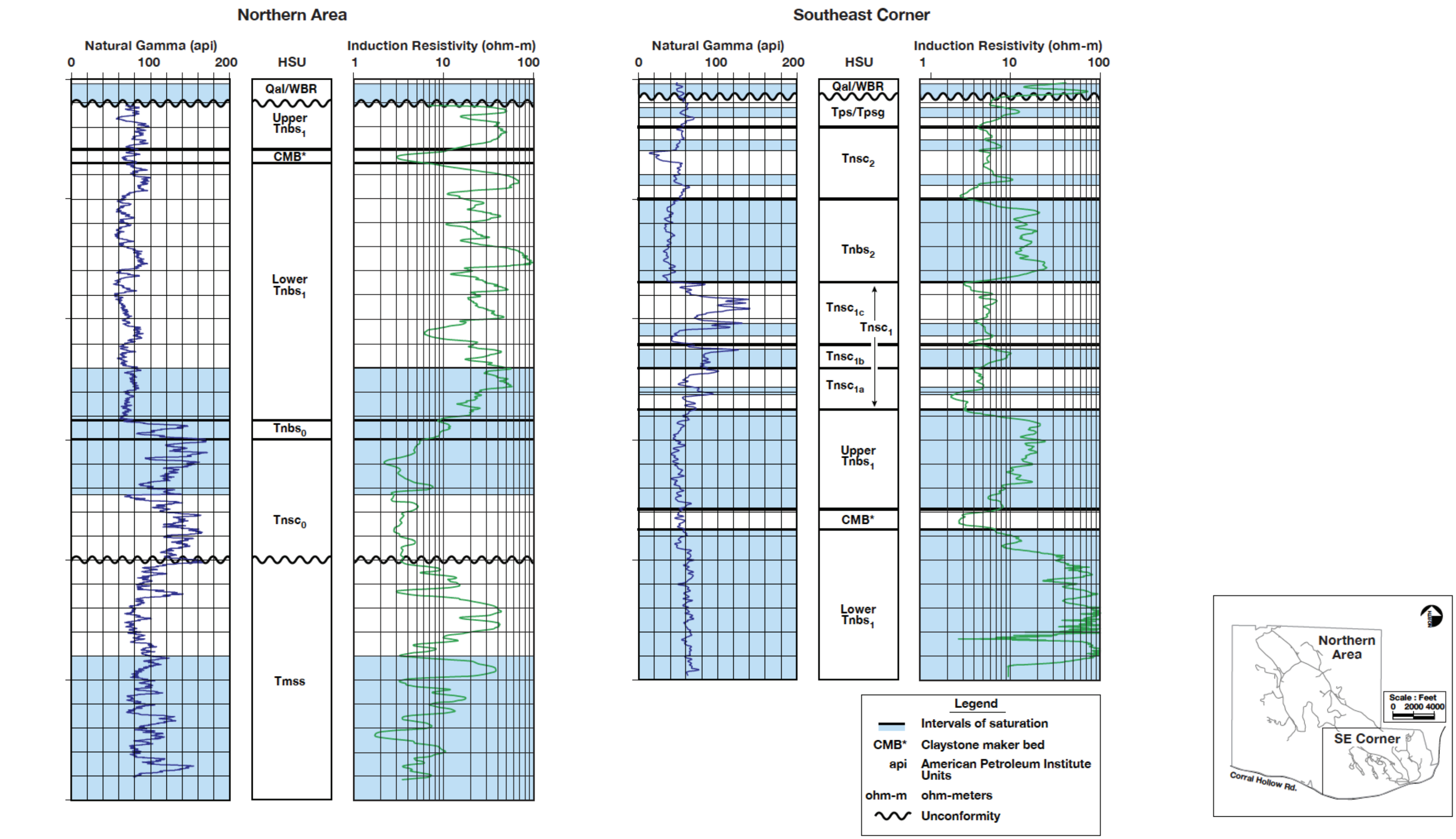

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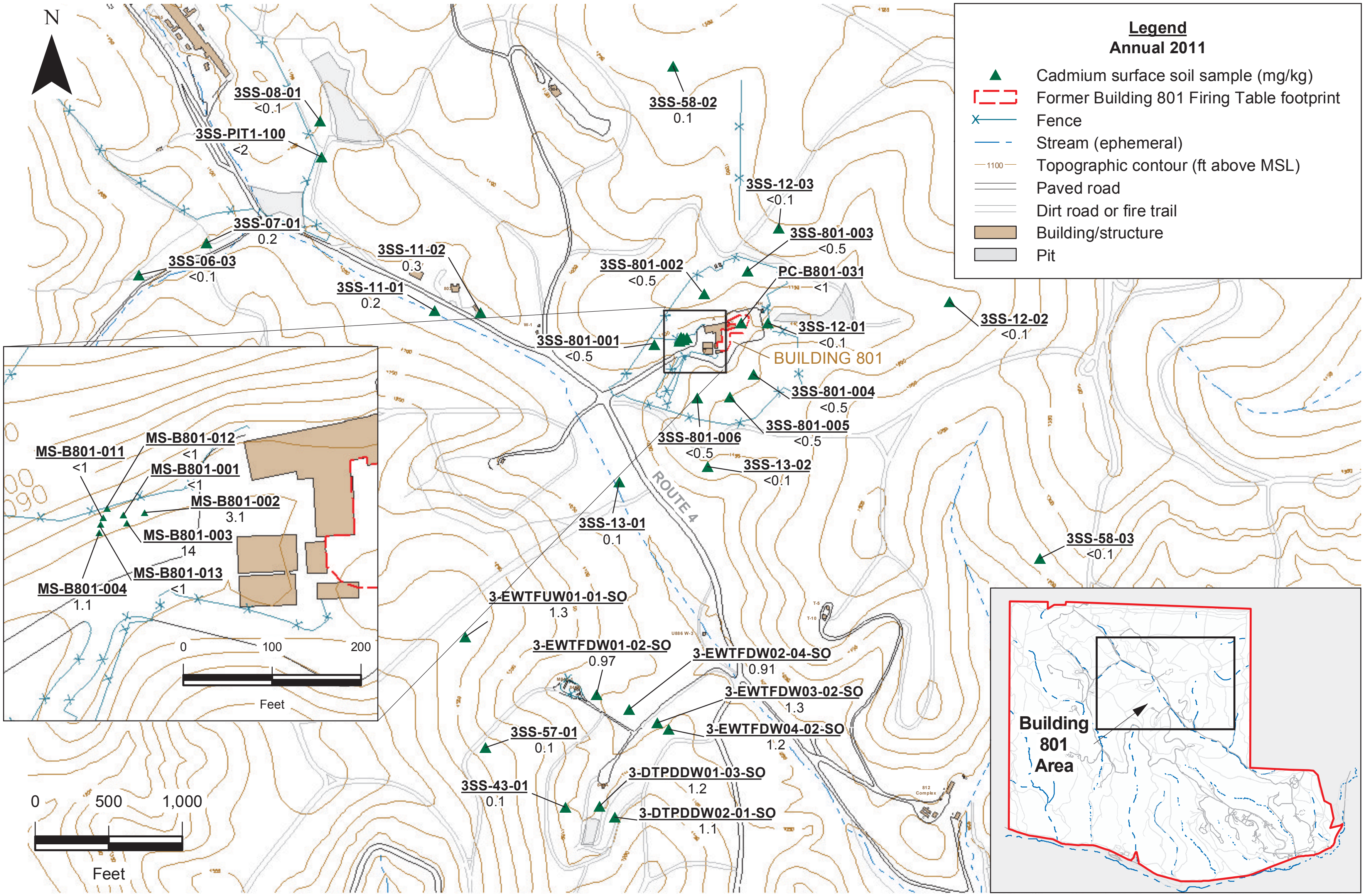

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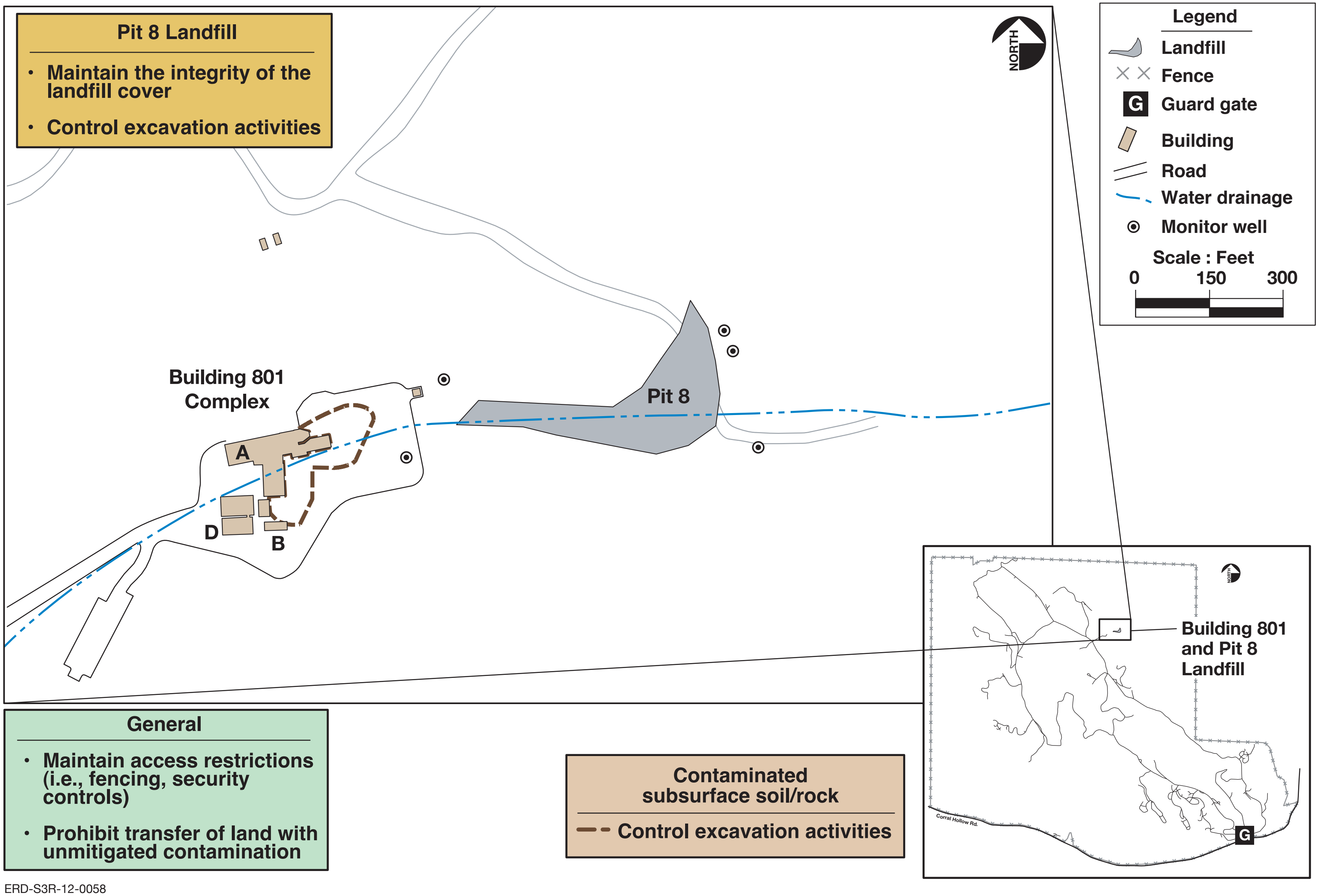

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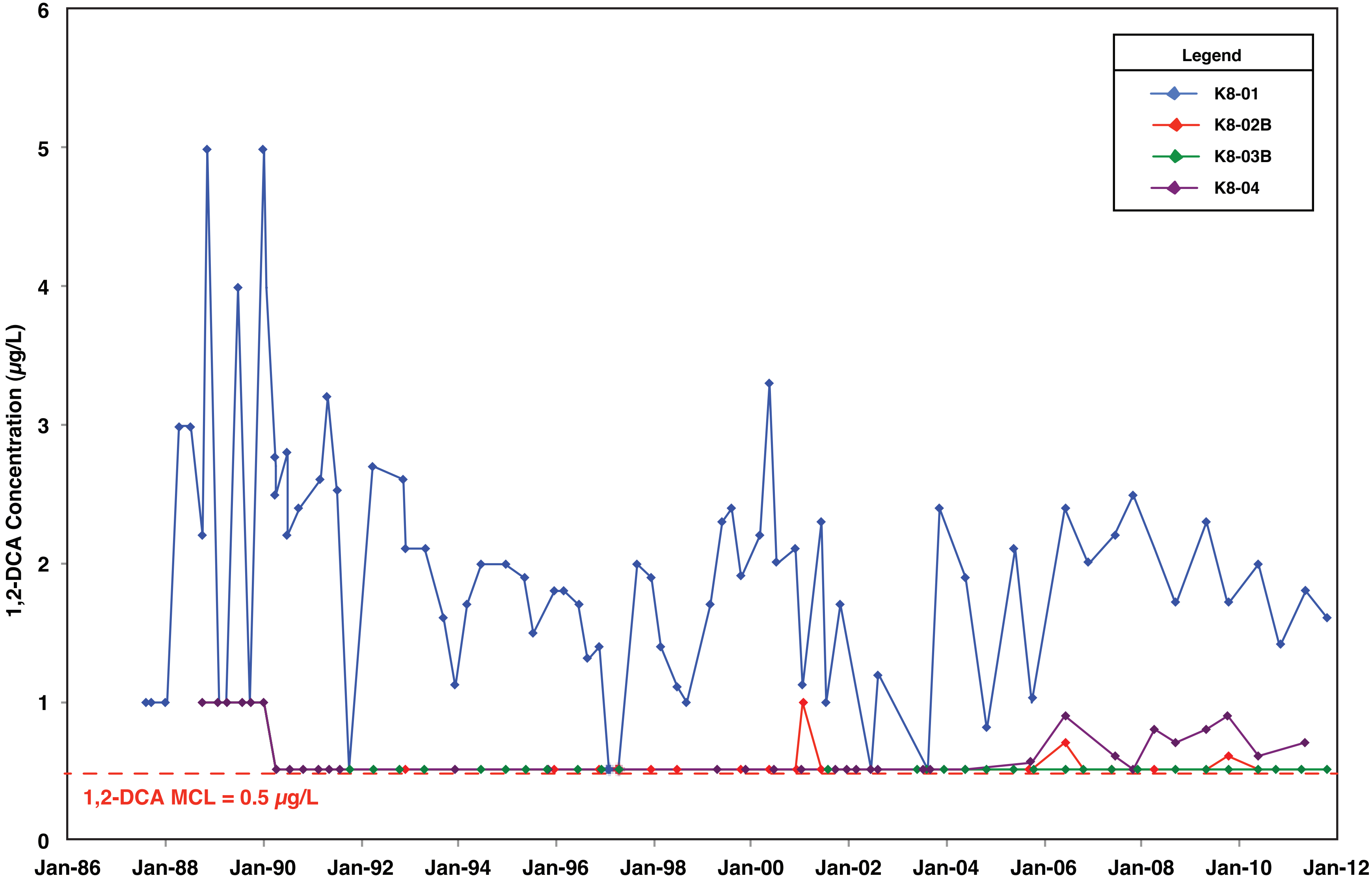

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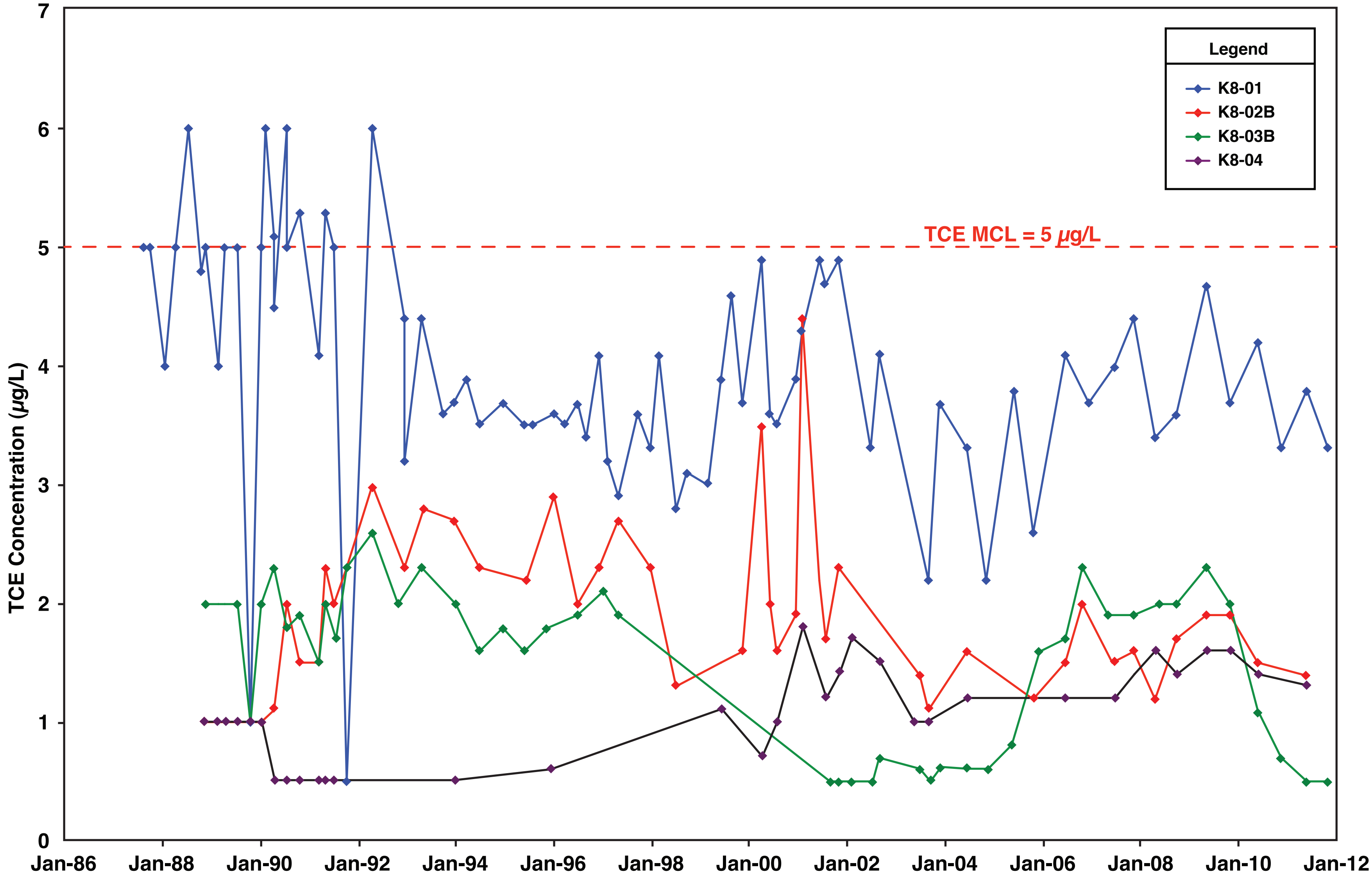

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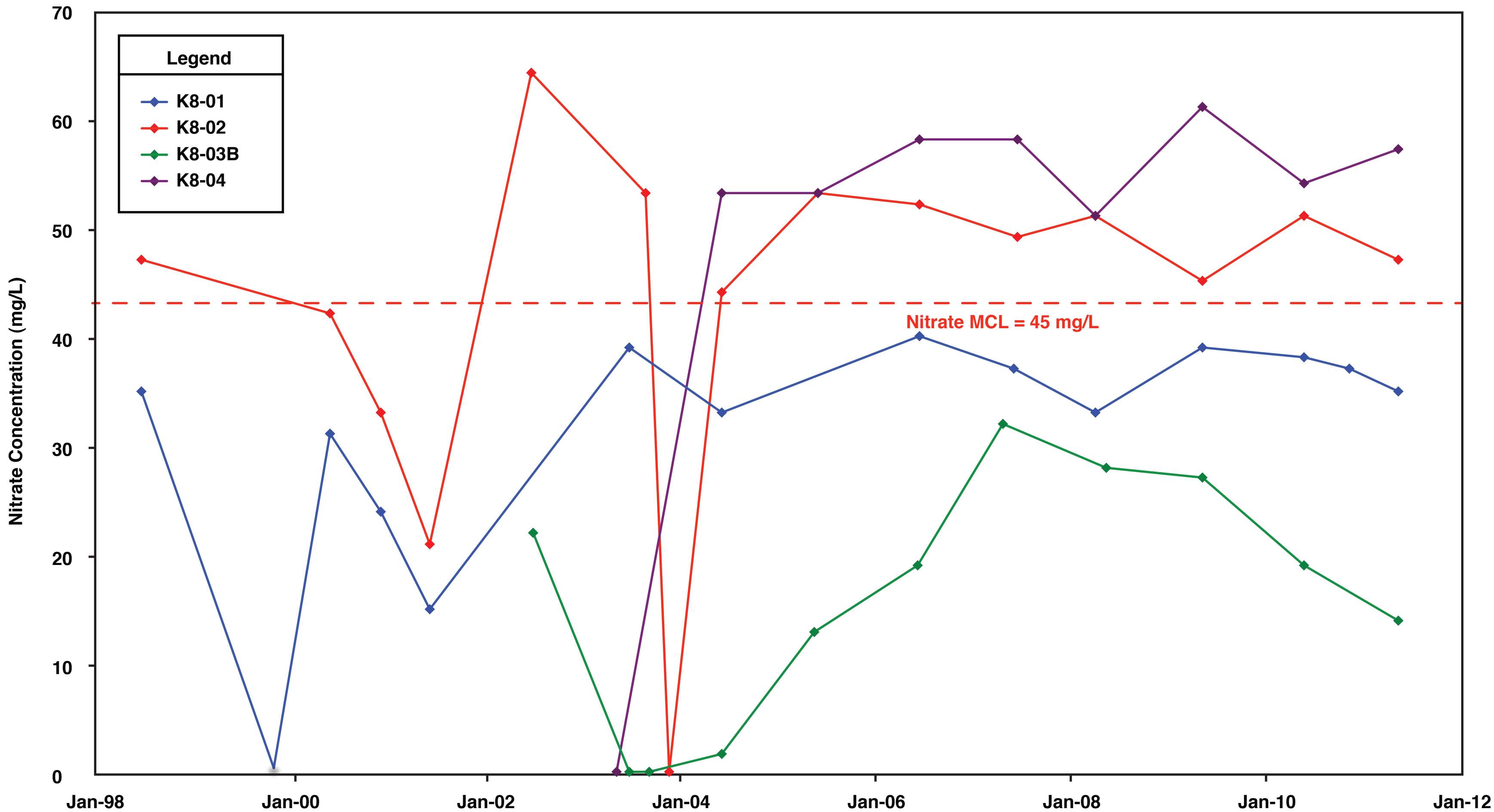

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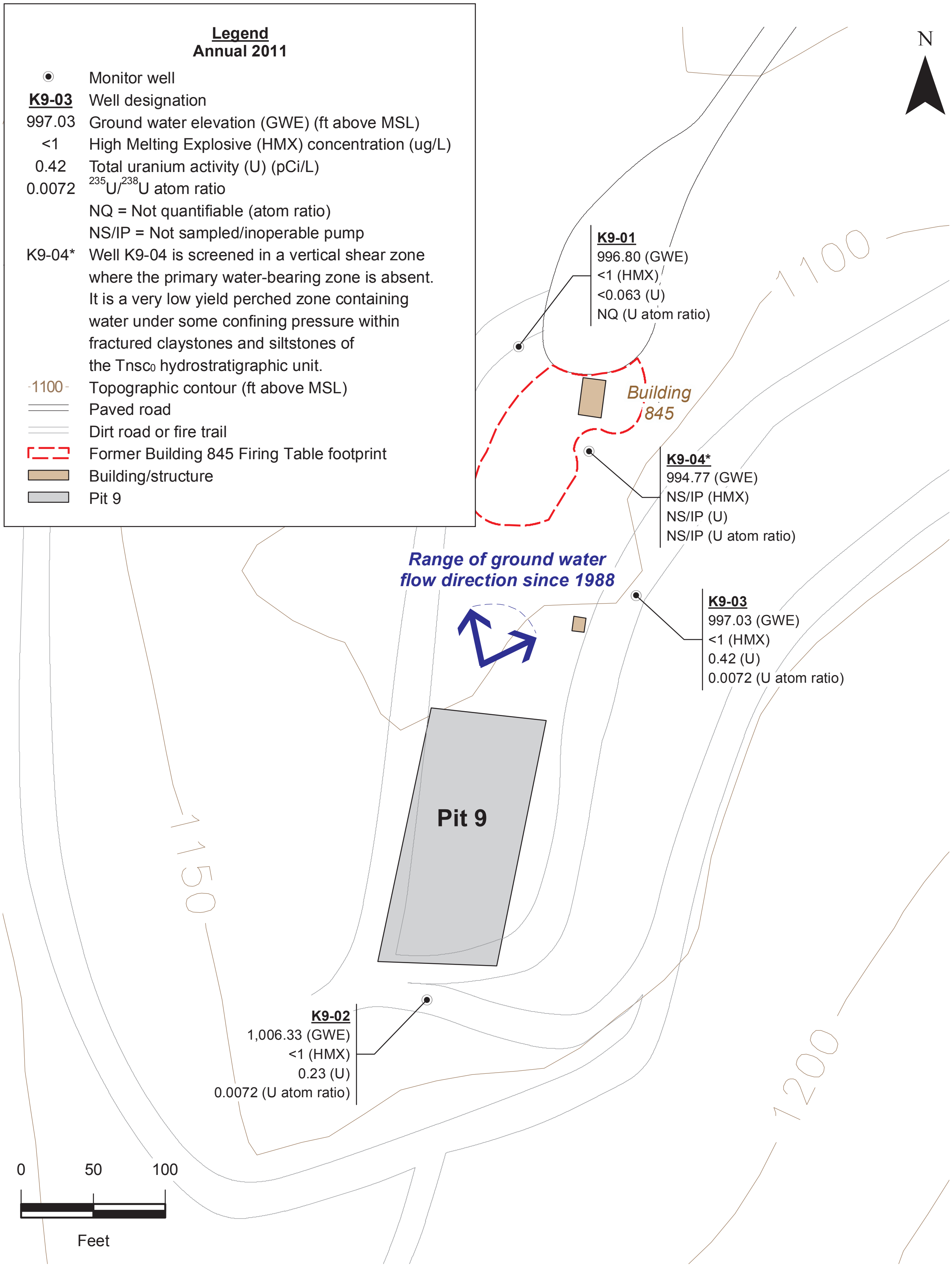

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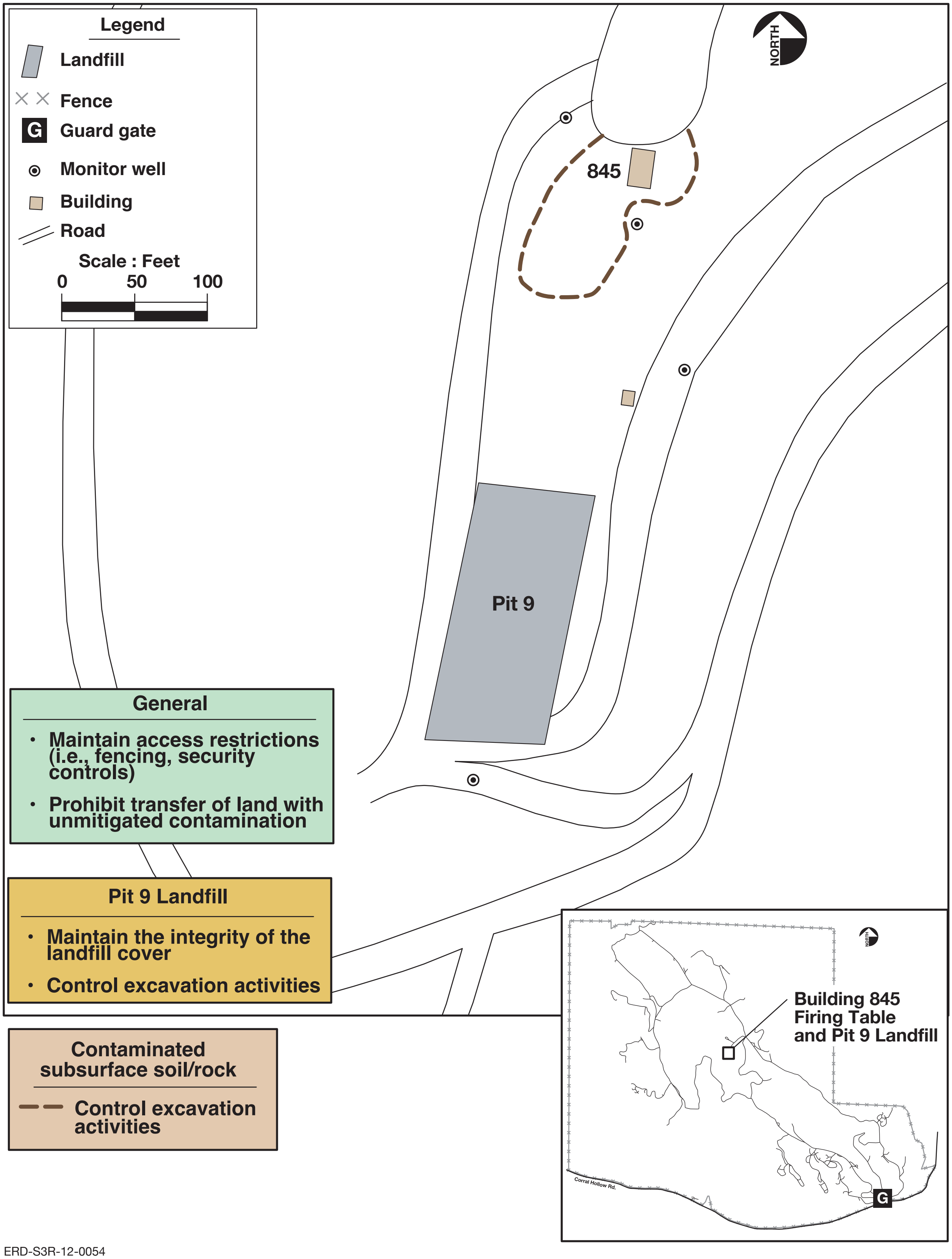

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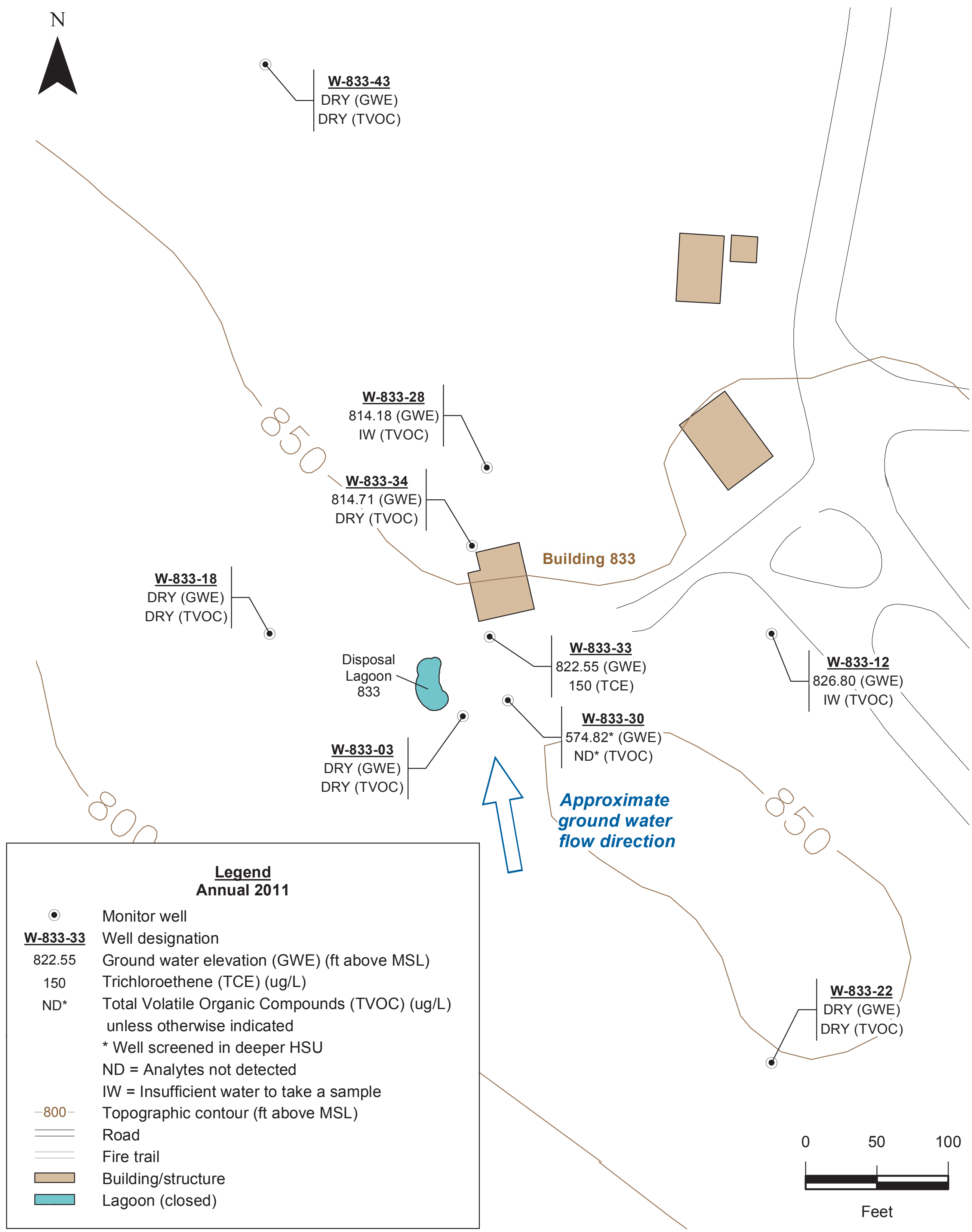

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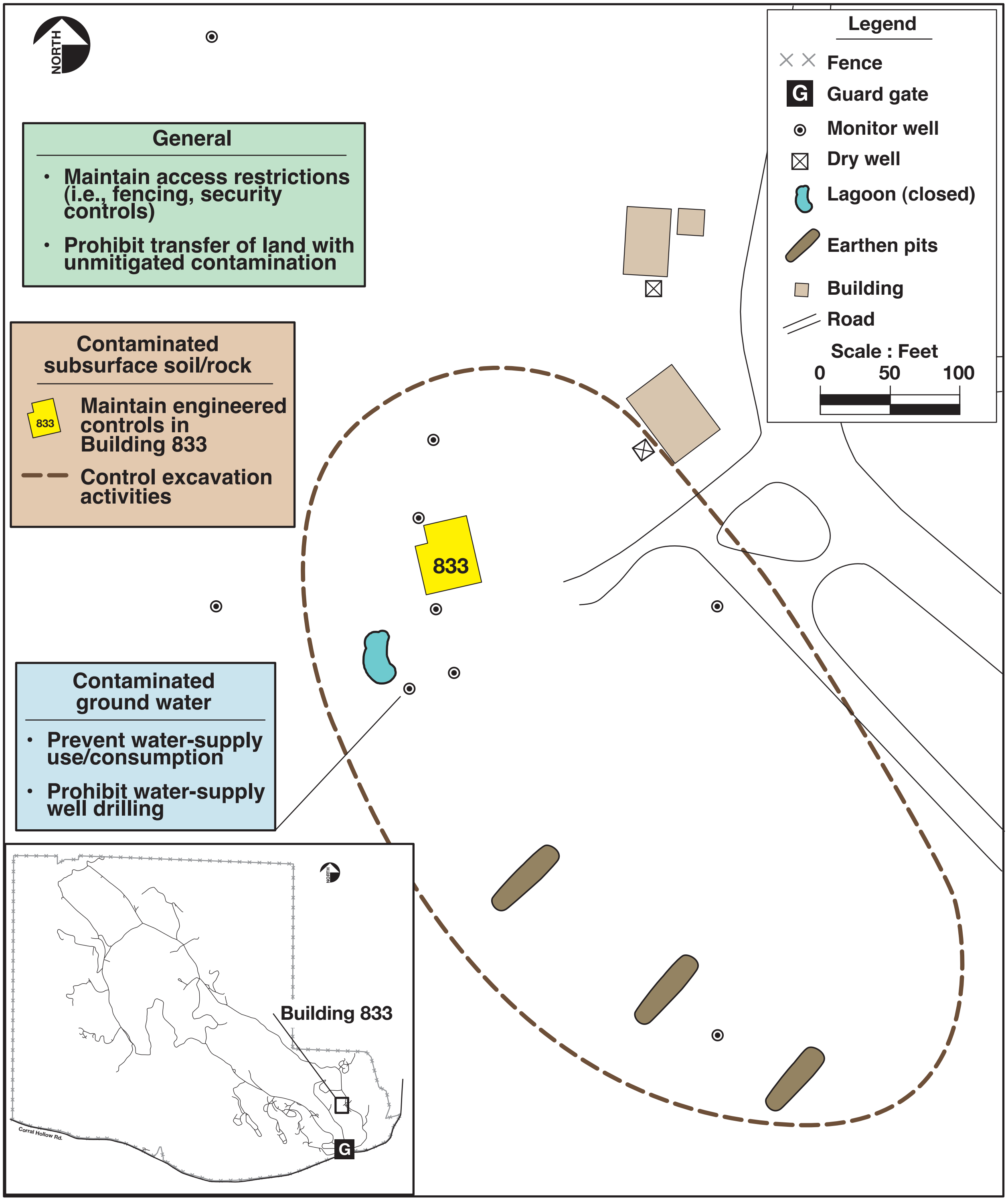

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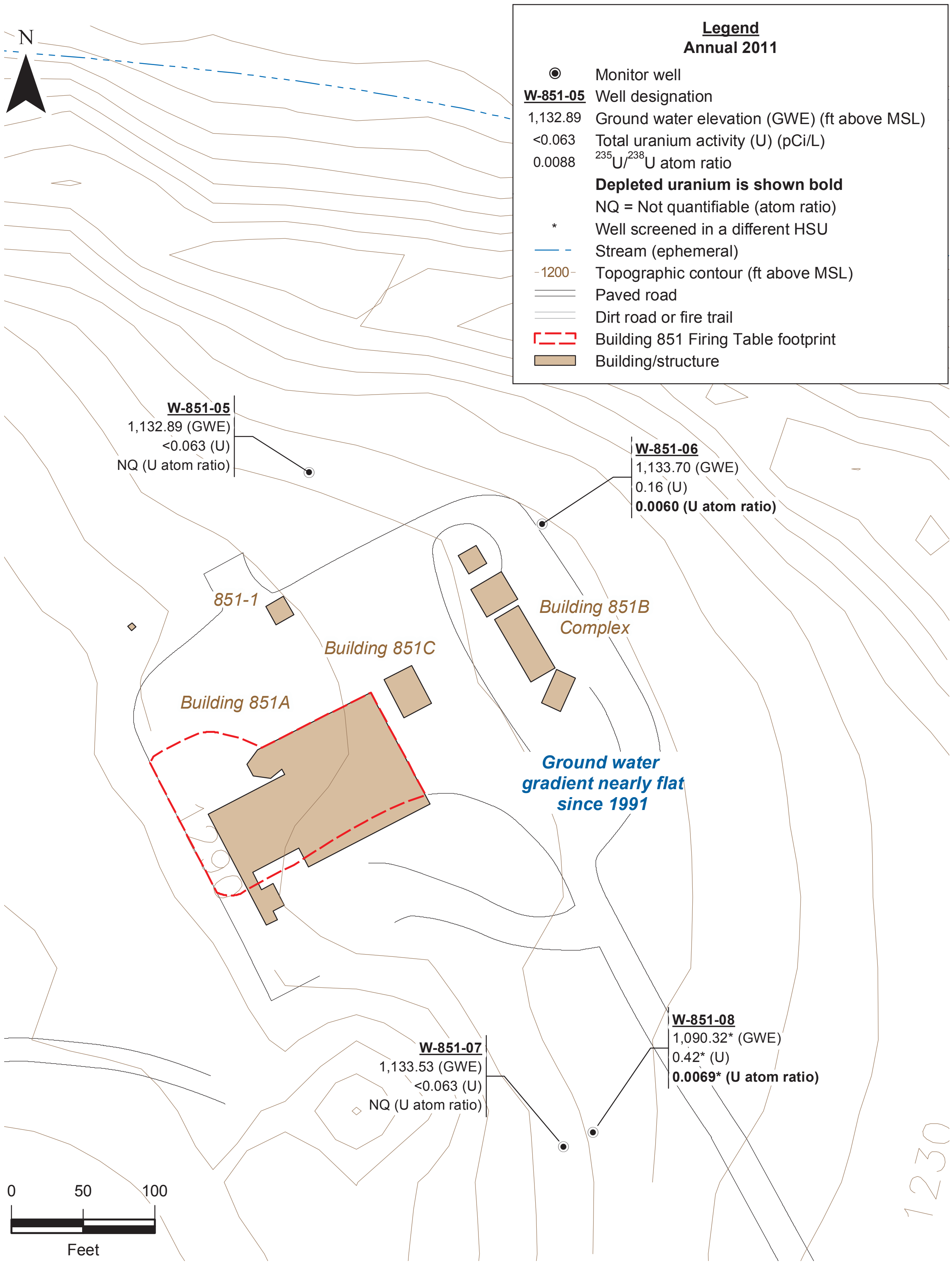

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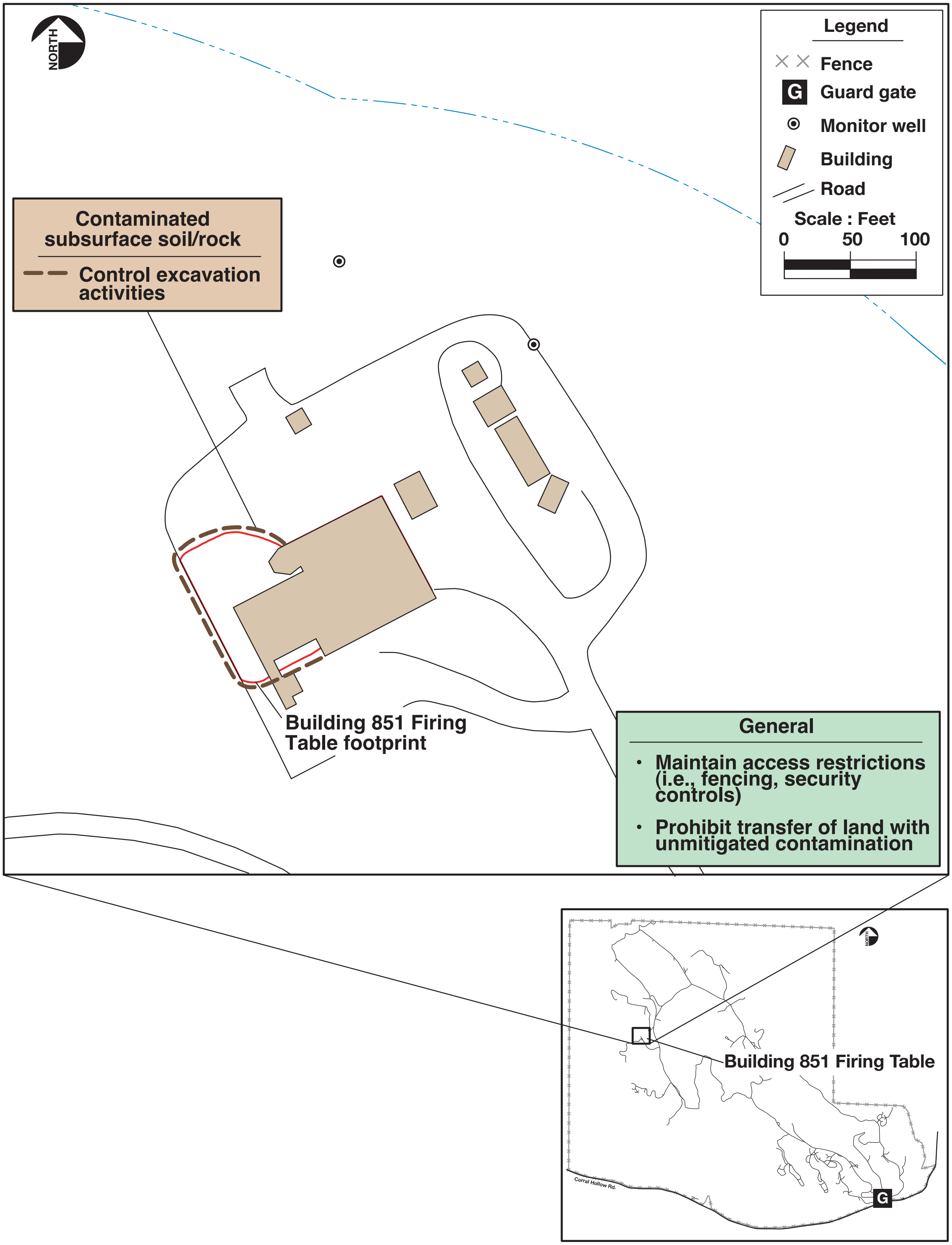

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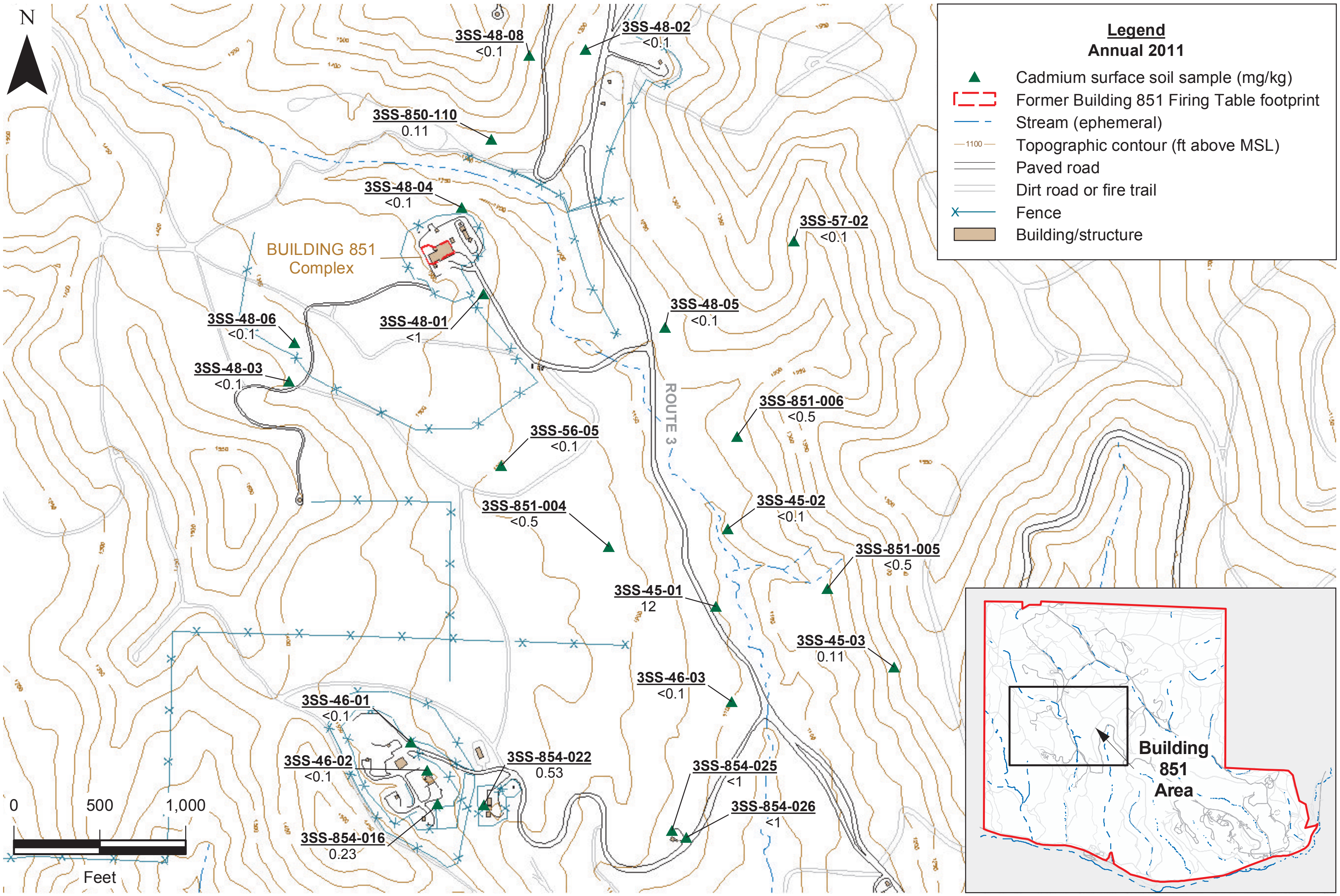

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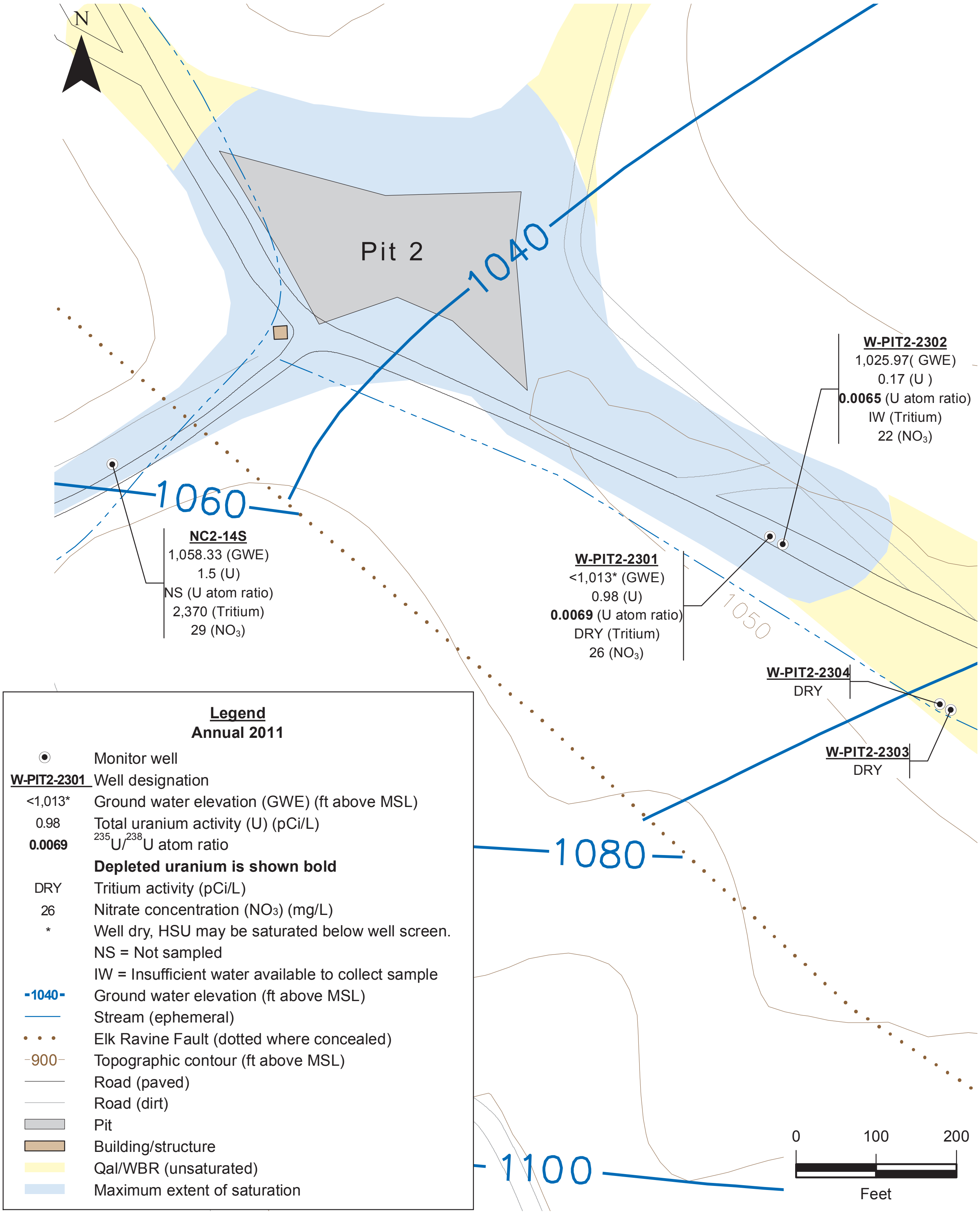

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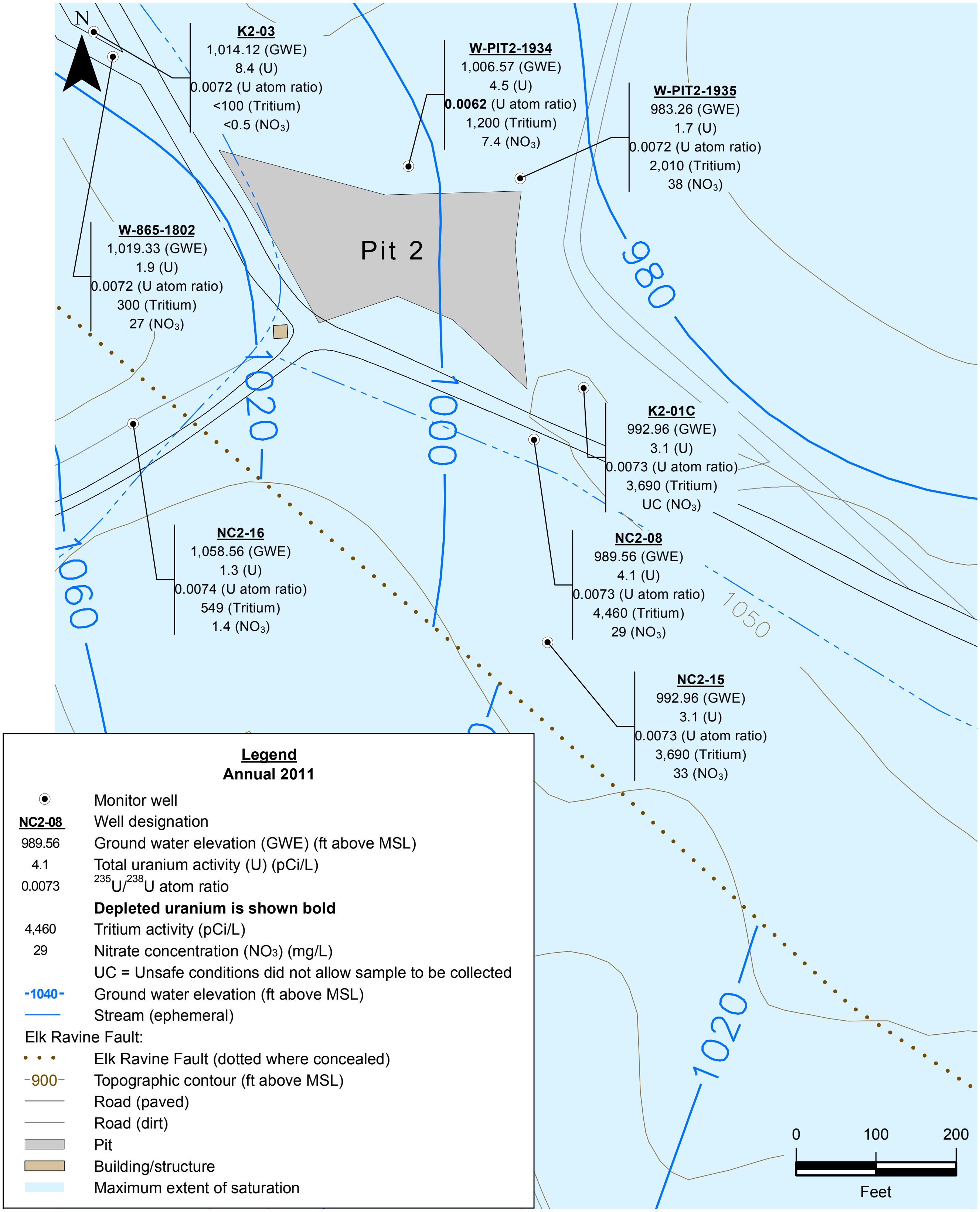

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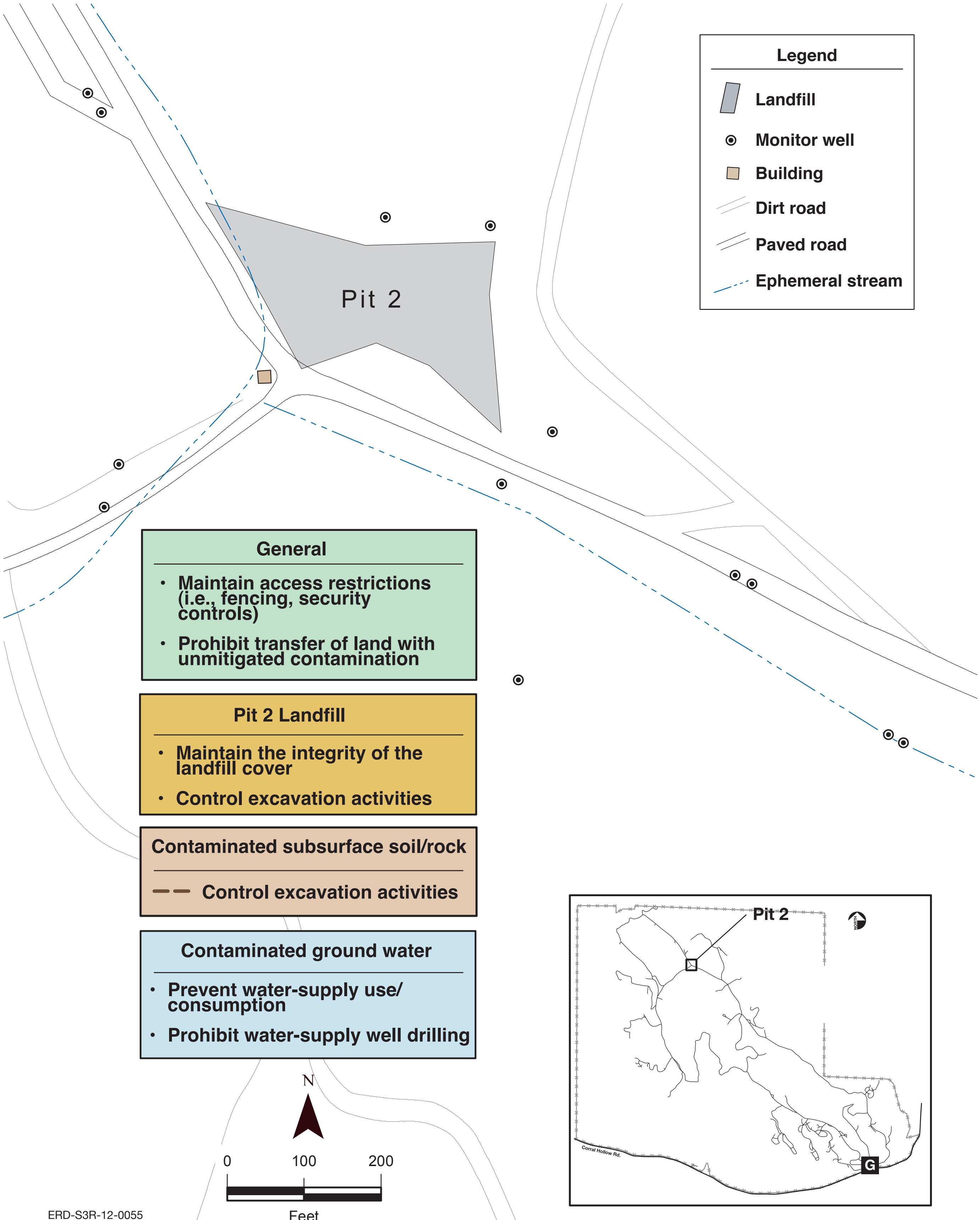

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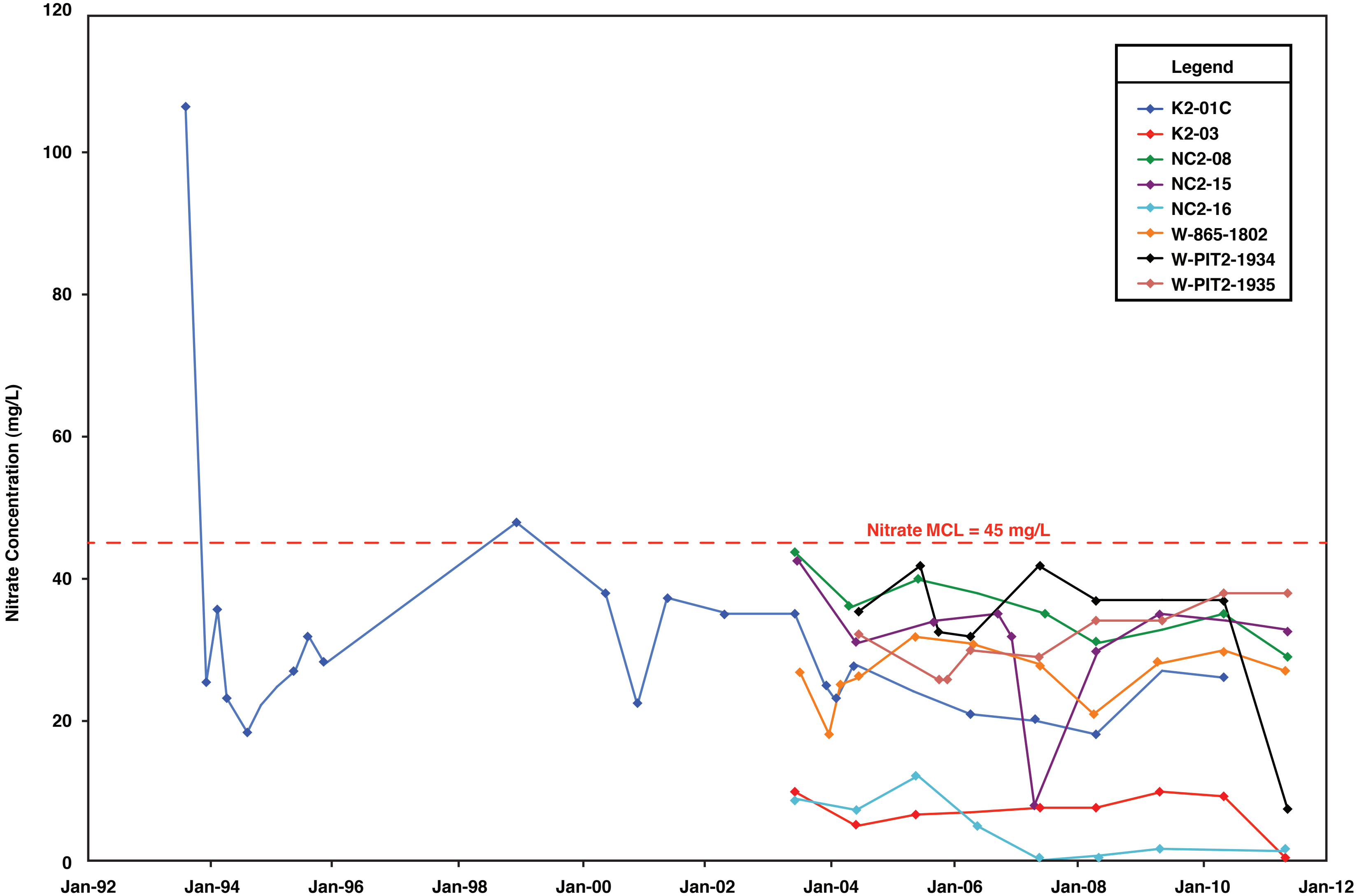

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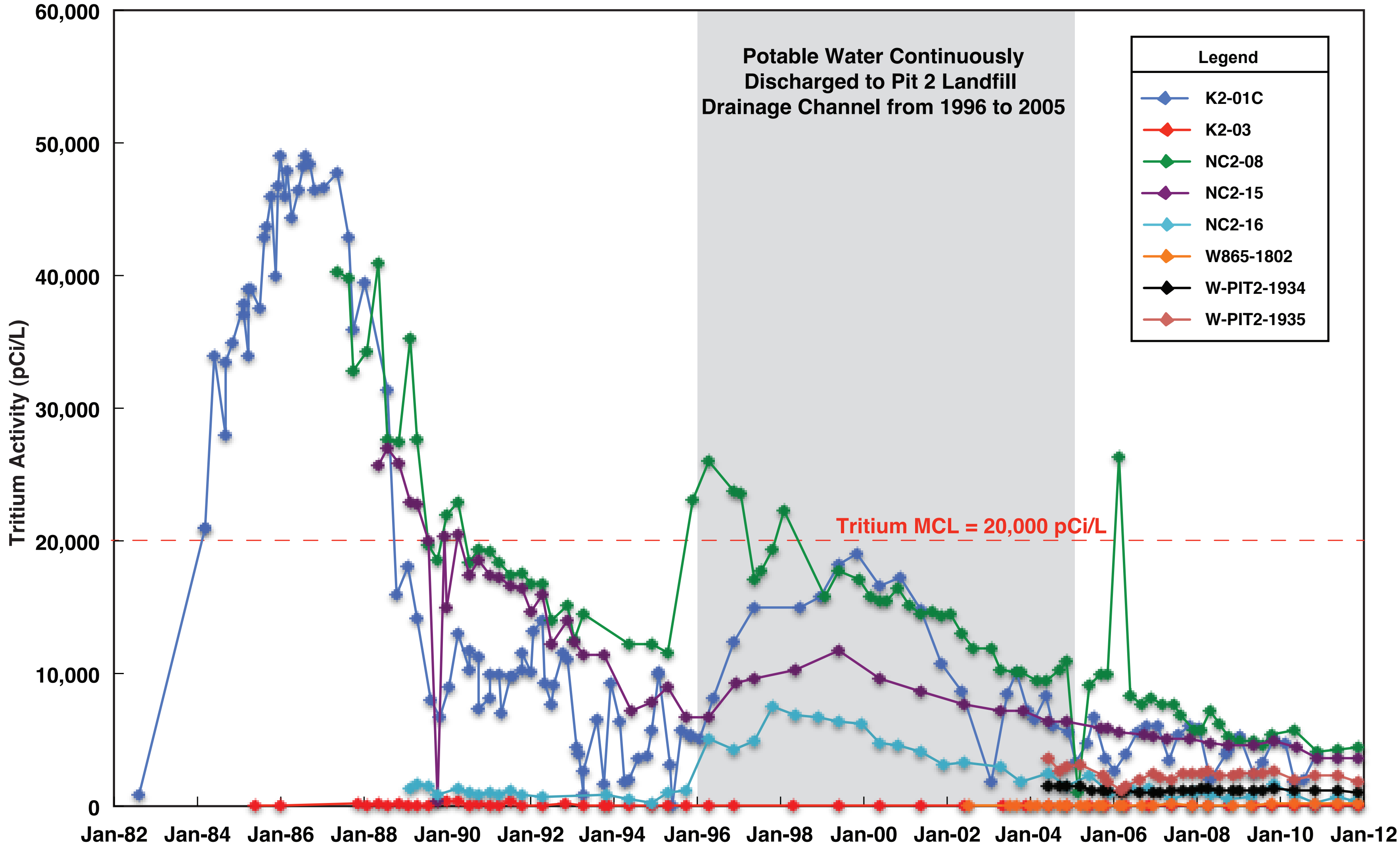

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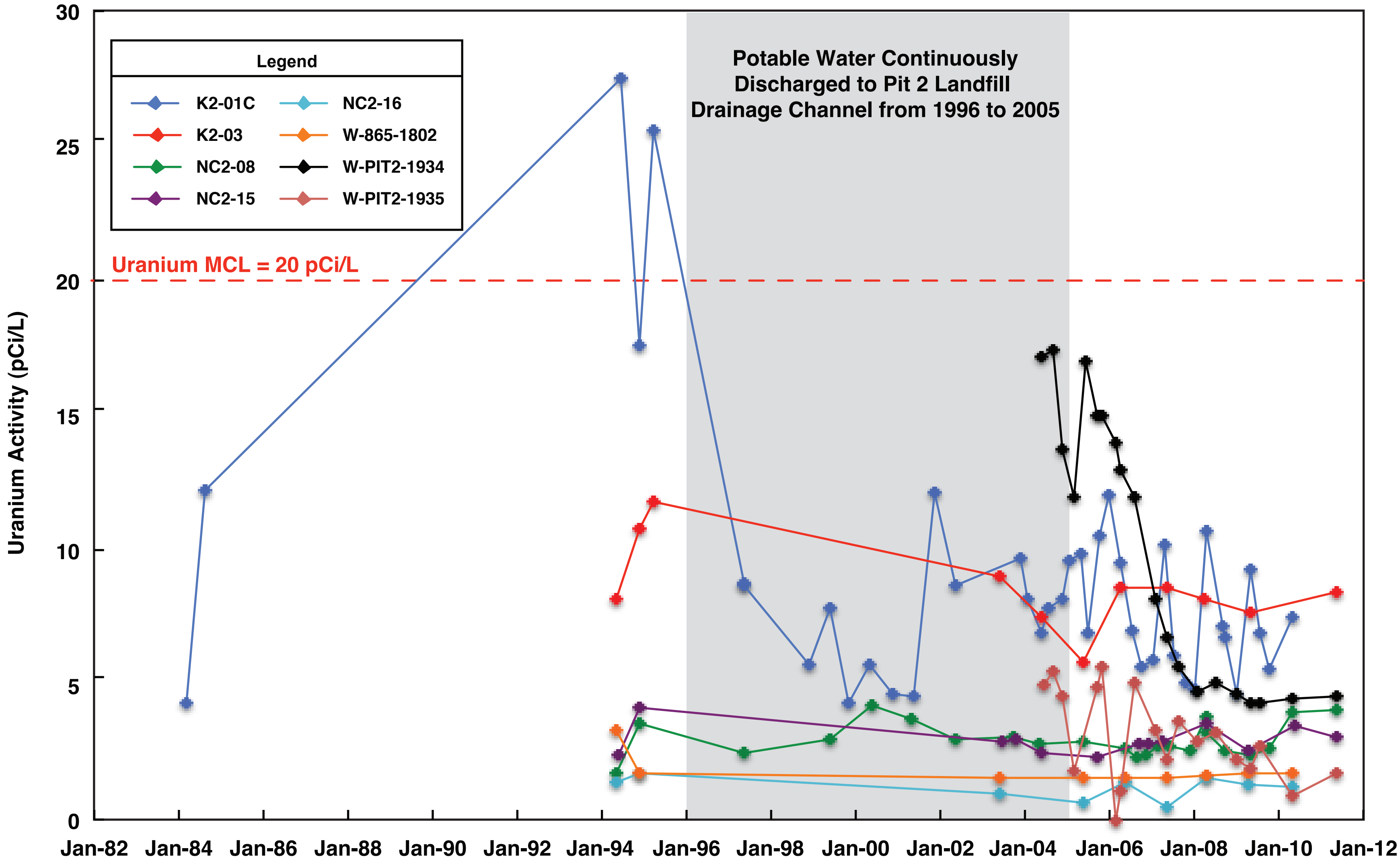

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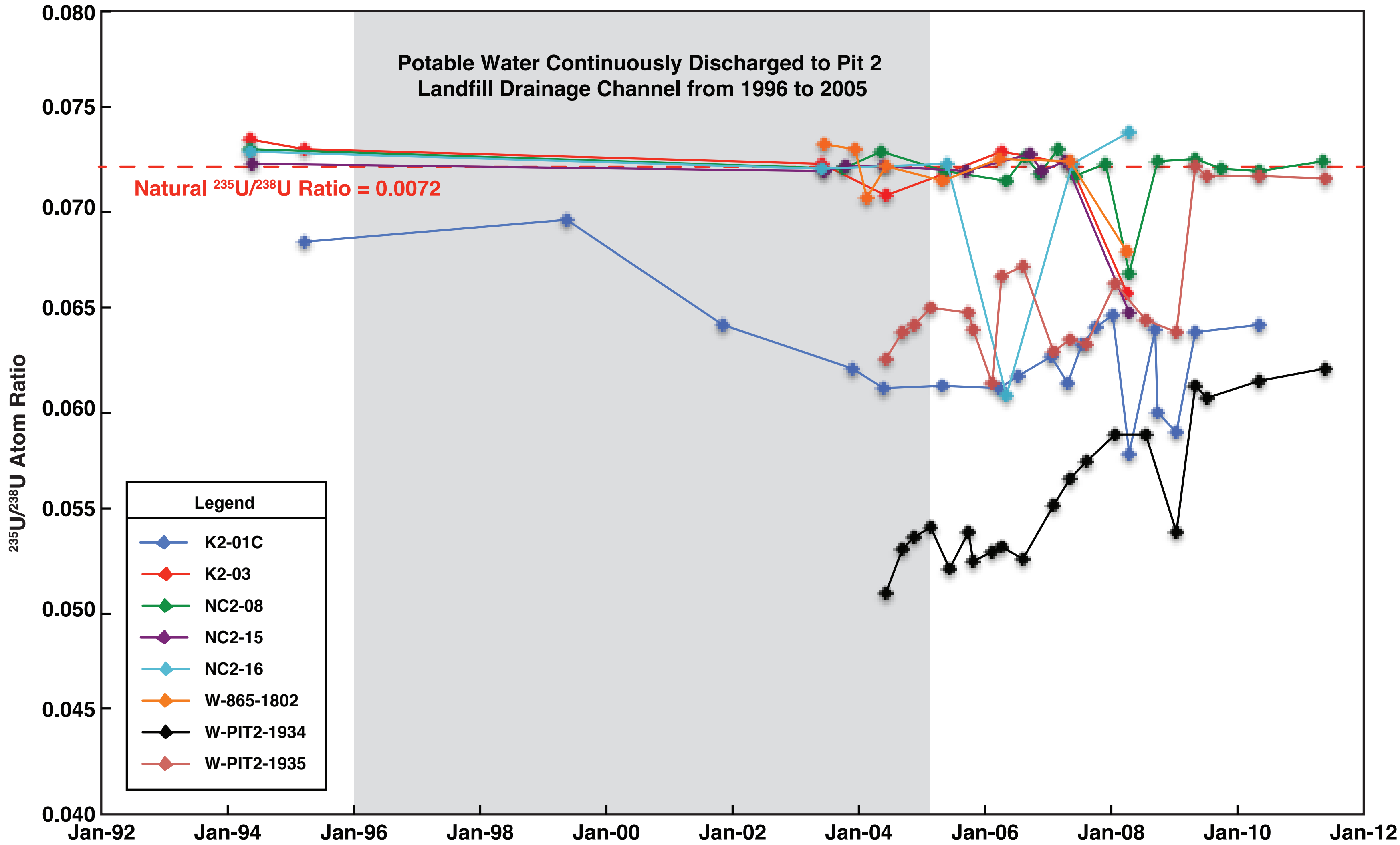

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Fiscal Year	Annual Budget	Actual Annual Cost	Cost Variance[a]
2007	$825,984.64	$839,655.08	-$13,670.44
2008	$905,026.58	$803,016.10	$102,010.48
2009	$460,037.44	$612,009.99	-$151,972.55
2010	$527,613.88	$617,291.15	-$89,677.27
2011	$616,931.38	$737,487.65	-$120,556.27

Notes:

[a] **Cost variances were caused by increases in sample analysis costs, discretionary sampling, data management and performance evaluation effort.**

Costs for the Pit 6 Landfill and Operable Unit 8 and captured in the same cost account therefore cannot be presented separately.

Table 2. Description of land use (institutional and engineered) controls for the Pit 6 Landfill Operable Unit.

Land use control performance objective and duration	Risk necessitating Land use control	Land use controls and implementation mechanism
Prevent water-supply use/consumption of contaminated groundwater until ground water cleanup standards are met.	VOCs, and nitrate concentrations in ground water exceeding drinking water standards.	There are no existing or planned water-supply wells in the Pit 6 Landfill Operable Unit. Any proposed well drilling activities would be submitted to the LLNL Work Induction Board, and are reviewed by the LLNL Environmental Restoration Department to ensure that new water-supply wells are not located in areas of ground water contamination. Prohibitions on drilling water-supply wells in areas of ground water contamination will be incorporated into the LLNL Site 300 Integrated Strategic Plan or other appropriate institutional planning documents. Contamination is limited to onsite ground water. TCE is present in only one well at a concentration slightly exceeding the drinking water standard; all other VOCs in ground water are below drinking water standards. Nitrate is detected at a concentration exceeding the drinking water standard in only one well. The elevated nitrate is likely due to septic system discharge rather than from the Pit 6 Landfill. Therefore, land use controls are not needed to prevent offsite water-supply use/consumption of contaminated ground water.
Maintain the integrity of landfill cap as long as the pit waste remains in place.	Potential exposure to contaminants in pit waste[a].	DOE will inspect and maintain the landfill cap, and ground water monitoring system. Landfill cap maintenance and inspection requirements are specified in post-closure plan for the Pit 6 Landfill.
Control construction and other ground-breaking activities on the Pit 6 Landfill to prevent cap/cover damage and/or inadvertent exposure to pit waste as long as the pit waste remains in place.	Potential exposure to contaminants in pit waste[a].	All proposed ground-breaking construction activities must be cleared through LLNL Work Induction Board and require an excavation permit. The Work Induction Board coordinates with the 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, the LLNL Hazards Control ensures that hazards are adequately evaluated and necessary controls 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 construction and other ground-breaking activities will be incorporated into the LLNL Site 300 Integrated Strategic Plan or other appropriate institutional planning documents.

Table 2. Description of land use (institutional and engineered) controls for the Pit 6 Landfill Operable Unit. (Continued)

Land use control performance objective and duration	Risk necessitating Land use control	Land use controls and implementation mechanism
Maintain access restrictions to prevent inadvertent exposure of onsite workers to the pit waste as long as the waste in the Pit 6 Complex Landfill remains in place.	Potential exposure to contaminants in pit waste[a].	Signage is in place and will be maintained at the Pit 6 Landfill access points prohibiting unauthorized access and requiring notification and authorization by LLNL Site 300 Management to enter, dig, excavate, or otherwise disturb soil or vegetation in this area (see administrative controls for ground-breaking construction activities above). These access restrictions will be incorporated into the LLNL Site 300 Integrated Strategic Plan or other appropriate institutional planning documents.
Maintain access restrictions to prevent inadvertent exposure of unauthorized trespassers to the pit waste as long as the waste in the Pit 6 Complex Landfill remains in place.	Potential exposure to contaminants in pit waste[a].	Site access by unauthorized trespassers is prevented by fences and warning signs at the site boundary and control entry systems at Site 300. These measures are maintained by the LLNL Security Department. There is no offsite contamination associated with the Pit 6 Landfill to which the public could be exposed. These access restrictions will be incorporated into the LLNL Site 300 Integrated Strategic Plan or other appropriate institutional planning documents.
Maintain land use restriction in the vicinity of Spring 7 until annual risk re-evaluation indicates that the risk is less than 10^{-6}.	A 4 x 10^{-5} risk was identified for onsite workers continuously inhaling VOC vapors volatilizing from Spring 7 into outdoor air.	Spring 7 has been dry since 2003. Current activities in the vicinity of the Well 8 Spring are restricted to semi-annual spring sampling. The time spent sampling is well below the exposure scenario for which the unacceptable exposure risk was calculated, which assumed a worker would spend 8 hours a day, five days a week for 25 years working at Spring 7. DOE will conduct annual risk re-evaluations when water is present in Spring 7 to determine when the inhalation risk has been mitigated. The risk re-evaluation results will be reported in the Annual Site-Wide Compliance Monitoring Reports. Any significant changes in activities conducted in the Spring 7 area must be cleared through the LLNL Work Induction Board. The Work Induction Board coordinates with the LLNL Environmental Restoration Department to identify if there is a potential for exposure to contaminants as a result of the proposed area usage. If a potential for contaminant exposure is identified as a result of these changes in activities or area use, LLNL Hazards Control is notified and determines any necessary personal protective equipment to prevent exposure.

Table 2. Description of land use (institutional and engineered) controls for the Pit 6 Landfill Operable Unit. (Continued)

Land use control performance objective and duration	Risk necessitating Land use control	Land use controls and implementation mechanism
Prohibit transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use.	Potential exposure to contaminated waste and/or environmental media.	The Site 300 Federal Facility Agreement contains provisions that assure that 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 the 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.

Notes:

DOE = U.S. Department of Energy.

DTSC = California Department of Toxic Substances Control.

U.S. EPA = United States Environmental Protection Agency.

LLNL = Lawrence Livermore National Laboratory.

RWQCB = California Regional Water Quality Control Board.

TCE = Trichloroethylene.

VOCs = Volatile organic compounds.

[a] **A risk for exposure to contaminants in the pit waste could not be calculated due to safety restrictions on penetrating landfill waste. Land use controls based on the potential exposure to contaminants in pit waste conservatively assume that the waste contaminants may pose a risk to human health.**

Table 3. Historical and current maximum concentrations of trichloroethene, chloroform, 1,2-DCA, cis-1,2-DCE, trans-1,2-DCE, tetrachloroethene, 1,1,1-TCA, tritium, perchlorate, and nitrate in the Pit 6 Operable Unit compared to ground water cleanup standards.

Constituent	Historical Maximum			2011 Maximum			Cleanup Standard
	Concentration/Activity	Well	Sample Date	Concentration/Activity	Well	Sample Date	
Trichloroethene	250 µg/L	K6-19	Nov-88	9.3 µg/L	EP6-09	Apr-11	5 µg/L
Chloroform	14 µg/L	K6-19	May-94	<0.5 µg/L	All wells	N/A	80 µg/L[a]
1,2-DCA	3.5 µg/L	BC6-13	Nov-87	<0.5 µg/L	All wells	N/A	0.5 µg/L
Cis-1,2-DCE	12 µg/L	BC6-13	Jan-90	3 µg/L	K6-01S	Oct-11	6 µg/L
Trans-1,2-DCE	33 µg/L	BC6-13	Jul-91	<0.5 µg/L	All wells	N/A	10 µg/L
Tetrachloroethene	3.2 µg/L	K6-19	Nov-88	<0.5 µg/L	All wells	N/A	5 µg/L
1,1,1-TCA	13	K6-18	May-90	<0.5 µg/L	All wells	N/A	200 µg/L
Tritium	3,420 pCi/L	BC6-13	May-00	403 pCi/L	K6-18	Jan-11	20,000 pCi/L
Perchlorate	65.2 µg/L	K6-19	Nov-98	<4 µg/L	All wells	N/A	6 µg/L
Nitrate	240 mg/L	K6-23	May-00	150 mg/L	K6-23	Jul-11	45 mg/L

Notes:

Apr = April.
Jan = January.
Jul = July.
Oct = October.
mg/L = Milligrams per liter.
Nov = November.
pCi/L = PicoCuries per liter.
µg/L = Micrograms per liter.
DCA = Dichloroethane.
DCE = Dichloroethene.
TCA = Trichloroethane.

[a] State and Federal Maximum Contaminant Level (MCL) for total trihalomethanes.

Table 4. Cadmium concentrations in the vicinity of Building 801 used to calculate the 95% Upper Confidence Limit of the mean.

Location ID	Cadmium mg/kg	Date Sampled	Description
3SS-06-03	<0.1	8/31/94	Collected as part of Site Wide Remedial Investigation and Site Wide Feasibility Study background determination.
3SS-07-01	0.2	9/20/91	
3SS-08-01	<0.1	9/20/91	
3SS-11-01	0.2	9/20/91	
3SS-11-02	0.3	9/20/91	
3SS-12-01	<0.1	9/18/91	
3SS-12-02	<0.1	9/18/91	
3SS-12-03	<0.1	8/30/94	
3SS-13-01	0.1	9/18/91	
3SS-13-02	<0.1	8/31/94	
3SS-43-01	0.1	9/18/91	
3SS-57-01	0.1	8/31/94	
3SS-58-01	<0.1	8/30/94	
3SS-58-02	0.1	8/30/94	
3SS-58-03	<0.1	8/31/94	
3SS-801-001	<0.5	11/1/11	Collected as part of the current evaluation of cadmium impacts on ecological receptors.
3SS-801-002	<0.5	11/1/11	
3SS-801-003	<0.5	11/1/11	
3SS-801-004	<0.5	11/1/11	
3SS-801-005	<0.5	11/1/11	
3SS-801-006	<0.5	11/1/11	
MS-B801-001	<1	10/4/94	Collected as part of an investigation into the environmental impact of Building 801 cooling tower discharge. Estimated coordinates are available. Cooling tower discharge subsequently re-routed.
MS-B801-002	3.1	10/4/94	
MS-B801-003	14	10/4/94	
MS-B801-004	1.1	10/4/94	
MS-B801-011	<1	2/3/95	Collected as part of an investigation into the environmental impact of Building 801 cooling tower discharge. Estimated coordinates are not available but available documentation indicates the locations to be a bit further downgradient from above locations.
MS-B801-012	<1	2/3/95	
MS-B801-013	<1	2/3/95	
PC-B801-031	<1	6/27/97	Pre-construction soil sampling location for the construction of the Contained Firing Facility. The only preconstruction soil sample that was not subsequently paved over. Estimated coordinates available.

Table 4. Cadmium concentrations in the vicinity of Building 801 used to calculate the 95% Upper Confidence Limit of the mean. (Continued)

Location ID	Cadmium mg/kg	Date Sampled	Description
3SS-PIT1-100	<2	6/29/06	One of four samples collected as part of the Pit 1 investigation. Represents the approximate median of the samples.
3-DTPDDW01-03-SO	1.2	5/19/09	Collected adjacent to the Explosive Waste Treatment Detonation Pad near Building 845 as part of an ongoing permit application. Each data point represents the approximate median of four samples collected from each location. Locations are approximate.
3-DTPDDW02-01-SO	1.1	5/20/09	
3-EWTFDW01-02-SO	0.97	5/18/09	Collected downwind of the Explosive Waste Treatment Facility at Building 845 as part of an ongoing permit application. Each data point represents the approximate median of four samples collected from each location. Locations are approximate.
3-EWTFDW02-04-SO	0.91	5/18/09	
3-EWTFDW03-02-SO	1.3	5/19/09	
3-EWTFDW04-02-SO	1.2	5/19/09	
3-EWTFUW01-01-SO	1.3	5/21/09	Collected upwind of the Explosive Waste Treatment Facility at Building 845 as part of an ongoing permit application. The data point represents the approximate median of four samples collected from the location. Location is approximate.
N	37		
Average[a]	-0.8323		
Std[b]	1.2524		
H statistic[c]	2.6930		
95% UCL[d]	1.67 mg/kg		

Notes:

N = Number of soil samples used in calculation.
mg/kg = Milligrams per kilogram.
Std = Standard Deviation.
95% UCL = 95 Percent Upper Confidence Limit of the Mean.
ID = Identification.

[a] Average of the lognormally-transposed data.

[b] Standard Deviation of the lognormally-transposed data.

[c] H statistic interpolated from Table A12 (pg. 265) in Gilbert, 1987.

[d] 95% Upper Confidence Limit of the mean in standard un-transposed units.

Table 5. Description of land use (institutional and engineered) controls for the Operable Unit 8.

Land use control performance objective and duration	Risk necessitating Land use control	Land use controls and implementation mechanism
Prevent water-supply use/consumption of contaminated groundwater until ground water cleanup standards are met.	*Buildings 801 and 833* VOC concentrations in ground water exceeding drinking water standards.	There are no existing or planned water-supply wells in the vicinity of Buildings 801 or 833. 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 ground water contamination. Prohibitions on drilling water-supply wells in areas of ground water contamination will be incorporated into the LLNL Site 300 Integrated Strategic Plan or other appropriate institutional planning documents. 1.2-DCA in Building 801 ground water is limited to only 2 wells at concentrations only slightly exceeding the state drinking water standard and are decreasing. All other VOCs in Building 801 ground water are below drinking water standards. VOCs in Building 833 ground water are limited to a shallow, perched, ephemerally saturated aquifer. There is no pathway for the VOC in ground water to migrate offsite. Therefore, land use controls are not needed to prevent offsite water-supply use/consumption of contaminated ground water.
Control excavation activities to prevent onsite worker exposure to contaminants in subsurface soil until it can be verified that concentrations do not pose an exposure risk to onsite workers.	*Building 801 Dry Well* Potential exposure to VOCs at depth in subsurface soil[a]. *Building 845 Firing Table* Potential exposure to depleted uranium and HMX at depth in subsurface soil[a]. *Building 851 Firing Table* Potential exposure to depleted uranium and VOCs at depth in subsurface soil[a]. *Building 833* Potential exposure to VOCs at depth in subsurface soil[a].	All proposed excavation activities must be cleared through the LLNL Work Induction Board and require an excavation permit. The Work Induction Board coordinates with the 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 necessary controls 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.

Table 5. Description of land use (institutional and engineered) controls for the Operable Unit 8. (Continued)

Land use control performance objective and duration	Risk necessitating Land use control	Land use controls and implementation mechanism
Maintain engineering controls to prevent onsite site worker inhalation exposure to VOCs inside Building 833 until annual risk re-evaluation indicates that the risk is less than 10^{-6}.	A risk of 1×10^{-6} was identified for onsite workers from potential inhalation of VOCs volatilizing from subsurface soil into ambient air inside Building 833.	Engineering controls (heating, ventilating, and air-conditioning system for Building 833) 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.
Maintain the integrity of landfill covers as long as the pit waste remains in place.	*Pit 2, 8 and 9 Landfills* Potential exposure to contaminants in pit waste[b].	DOE will inspect and maintain the landfill covers and ground water monitoring systems. Landfill cap maintenance and inspection requirements are specified in the Site 300 Compliance Monitoring Plan.
Control construction and other ground-breaking activities on the landfills to prevent cap/cover damage and/or inadvertent exposure to pit waste as long as the pit waste remains in place.	*Pit 2, 8 and 9 Landfills* Potential exposure to contaminants in pit waste[b].	All proposed ground-breaking construction activities must be cleared through the LLNL Work Induction Board and require an excavation permit. The Work Induction Board coordinates with the 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 necessary controls 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 construction and other ground-breaking activities will be incorporated into the LLNL Site 300 Integrated Strategic Plan or other appropriate institutional planning documents.

Table 5. Description of land use (institutional and engineered) controls for the Operable Unit 8. (Continued)

Land use control performance objective and duration	Risk necessitating Land use control	Land use controls and implementation mechanism
Maintain access restrictions to prevent inadvertent exposure of onsite workers to the pit waste as long as the waste remains in place.	*Pit 2, 8 and 9 Landfills* Potential exposure to contaminants in pit waste[b].	Signage will be maintained at the landfill access points prohibiting unauthorized access and requiring notification and authorization by LLNL Site 300 Management to enter, dig, excavate, or otherwise disturb soil or vegetation in this area (see administrative controls for ground-breaking construction activities above). These access restrictions will be incorporated into the LLNL Site 300 Integrated Strategic Plan or other appropriate institutional planning documents.
Maintain access restrictions to prevent inadvertent exposure of unauthorized trespassers to the pit waste as long as the waste remains in place.	*Pit 2, 8 and 9 Landfills* Potential exposure to contaminants in pit waste[b].	Site access by unauthorized trespassers is prevented by fences and warning signs at the site boundary and control entry systems at Site 300. These measures are maintained by the LLNL Security Department. There is no offsite contamination associated with the Pit 2, 8, or 9 landfills to which the public could be exposed. These access restrictions will be incorporated into the LLNL Site 300 Integrated Strategic Plan or other appropriate institutional planning documents.
Prohibit transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use.	Potential exposure to contaminated waste and/or environmental media.	The Site 300 Federal Facility Agreement contains provisions that assure that 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 the 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.

Notes appear on the following page.

Table 5. Description of land use (institutional and engineered) controls for the Operable Unit 8. (Continued)

Notes:

DCA = Dichloroethane.

DOE = United States Department of Energy.

DTSC = California Department of Toxic Substances Control.

U.S. EPA = United States Environmental Protection Agency.

HMX = High melting explosive.

LLNL = Lawrence Livermore National Laboratory.

RWQCB = California Regional Water Quality Control Board.

VOCs = Volatile organic compounds.

[a] Risk for onsite worker exposure to contaminants at depth in subsurface soil during excavation activities was not calculated as this was not considered a long-term exposure scenario. As a result, land use controls based on the potential exposure to contaminants in subsurface soil during ground-breaking construction activities conservatively assume that these subsurface soil contaminants may pose a risk to human health.

[b] A risk for exposure to contaminants in the pit waste could not be calculated due to safety restrictions on penetrating landfill waste. Land use controls based on the potential exposure to contaminants in pit waste conservatively assume that the waste contaminants may pose a risk to human health.

Table 6. Historical and current maximum concentrations of ground water contaminants of concern in the Operable Unit 8 compared to ground water cleanup standards.

Constituent	Hydrostratigraphic Unit Impacted	Historical Maximum Concentration/ Activity	Historical Maximum Well	Historical Maximum Sample Date	2011 Maximum Concentration/ Activity	2011 Maximum Well	2011 Maximum Sample Date	Cleanup Standard
Building 801 and Pit 8 Landfill area								
1,2-DCA	$Tnbs_1/Tnbs_0$	5 µg/L	K8-01	Jan-90	1.8 µg/L	K8-01	May-11	0.5 µg/L
TCE	$Tnbs_1/Tnbs_0$	6 µg/L	K8-01	Apr-92	3.8 µg/L	K8-01	May-11	5 µg/L
Chloroform	$Tnbs_1/Tnbs_0$	2.4 µg/L	K8-02B	Apr-92	<0.5 µg/L	All wells	NA	80 µg/L
Perchlorate	$Tnbs_1/Tnbs_0$	5 µg/L	K8-04	May-03	<4 µg/L	All wells	NA	6 µg/L
Nitrate	$Tnbs_1/Tnbs_0$	64 mg/L	K8-01	Jun-02	57 mg/L	K8-04	May-11	45 mg/L
Building 833 area								
TCE	Tpsg	2,100 µg/L	W-833-03	Aug-92	150 µg/L	W-833-33	Feb-11	5 µg/L
cis-1,2-DCE	Tpsg	58 µg/L	W-833-12	Feb-93	<0.5 µg/L	All wells	NA	6 µg/L
Building 851 Firing Table area								
Uranium	Tmss	3.2 pCi/L	W-851-07	Oct-91	0.962 pCi/L	W-851-08	Nov-11	20 pCi/L
Pit 2 Landfill area								
Nitrate	Qal/WBR	42 mg/L	NC2-14S	Jun-03	29 mg/L	NC2-14S	May-11	45 mg/L
Nitrate	$Tnbs_1/Tnbs_0$	106 mg/L	K2-01C	Aug-93	38 mg/L	W-PIT2-1935	May-11	45 mg/L

Notes:

1,2-DCA = 1,2-Dichloroethane.
cis-1,2-DCE = cis-1,2-Dichloroethene.
Apr = April.
Aug = August.
Feb = February.
Jan = January.
Jul = July.
Jun = June.
mg/L = Milligrams per liter.
NA = Not applicable.
Nov = November.
Oct = October.
pCi/L = PicoCuries per liter.
TCE = Trichloroethene.
Tmss = Miocene Cierbo Formation—lower siltstone/claystone member.
$Tnbs_0$ = Neroly silty Sandstone.
$Tnbs_1$ = Tertiary Neroly Lower Blue Sandstone.
Tpsg = Tertiary Pliocene sand and gravel.
Qal/WBR = Quaternary alluvium/Weathered bedrock.
µg/L = Micrograms per liter.

Building 845 and Pit 9 Landfill have no identified COCs in ground water.

Table 7. Historical maximum concentrations/activities of surface soil and vadose zone contaminants of concern in the Building 845 and Building 851 Firing Tables compared to regulatory screening criteria.

Constituent	Area	Concentration/ Activity	Sample Date	Industrial PRG[a]	Industrial RSL[b]
Historic Maximum of Vadose Zone COCs					
HMX	Building 845 Firing Table	0.54 mg/kg	1988	NA	49,000 mg/kg
Uranium-238	Building 845 Firing Table	1.2 pCi/g	1988	1.8 pCi/g	NA
TCE	Building 851 Firing Table	0.0003 mg/kg	1990	NA	6.4 mg/kg
cis-1,2-DCE	Building 851 Firing Table	0.012 mg/kg	1988	NA	2,000 mg/kg
Uranium-238	Building 851 Firing Table	11 pCi/g	1990	1.8 pCi/g	NA
Historic Maximum of Surface Soil COCs					
RDX	Building 851 Firing Table	0.031 mg/kg	1990	NA	24 mg/kg
Cadmium	Building 851 Firing Table	9 mg/kg	1990	NA	800 mg/kg
Copper	Building 851 Firing Table	79 mg/kg	1990	NA	41,000 mg/kg
Zinc	Building 851 Firing Table	360 mg/kg	1990	NA	310,000 mg/kg
Uranium-238	Building 851 Firing Table	14.1 pCi/g	1990	1.8 pCi/g	NA

Notes:

cis-1,2-DCE = cis-1,2-Dichloroethene.
COCs = Contaminants of concern.
HMX = High Melting Explosive.
mg/kg = Milligrams per kilogram.
NA = Not applicable.
pCi/g = PicoCuries per gram.
PRG = Preliminary Remediation Goals.
RDX = Research Department explosive.
RSL = Regional Screening Levels.
TCE = Trichloroethene.
µg/L = Micrograms per liter.

[a] Preliminary Remediation Goals promulgated by the EPA Pacific Southwest, Region 9, October 2004 (http://www.epa.gov/region9/superfund/prg/).

[b] Regional Screening Levels (formerly PRGs) promulgated by the EPA Pacific Southwest, Region 9, April 2012 (http://www.epa.gov/region9/superfund/prg/).

Table 8. Cadmium concentrations in the vicinity of Building 851 used to calculate the 95% Upper Confidence Limit of the mean.

Location ID	Cadmium mg/kg	Date Sampled	Description
3SS-45-01 D[a]	0.1	9/24/91	Collected as part of Site Wide Remedial Investigation and Site Wide Feasibility Study background determination.
3SS-45-01	12	9/24/91	
3SS-45-02	<0.1	9/2/94	
3SS-45-03	0.11	9/13/94	
3SS-46-01	<0.1	9/17/91	
3SS-46-01	<0.1	9/17/91	
3SS-46-02	<0.1	9/17/91	
3SS-46-03	<0.1	9/2/94	
3SS-48-01	<1	9/24/91	
3SS-48-02	<0.1	9/23/91	
3SS-48-03	<0.1	9/24/91	
3SS-48-04	<0.1	9/24/91	
3SS-48-05	<0.1	8/31/94	
3SS-48-06	<0.1	8/31/94	
3SS-48-08	<0.1	8/31/94	
3SS-56-05	<0.1	9/2/94	
3SS-57-02	<0.1	9/14/94	
3SS-850-110	0.11	7/26/94	Collected as part of the Building 850 investigation.
3SS-851-004	<0.5	11/1/11	Collected as part of the current evaluation of cadmium impacts on ecological receptors.
3SS-851-005	<0.5	11/1/11	
3SS-851-006	<0.5	11/1/11	
3SS-854-016	0.23	11/22/95	Representative locations from the Building 854 investigation. All locations are on native soil and have available coordinates.
3SS-854-022	0.53	11/22/95	
3SS-854-025	<1	11/22/95	
3SS-854-026	<1	11/22/95	
N	24		
Average[b]	-1.5019		
Std[c]	1.2283		
H statistic[d]	2.826		
95% UCL[e]	0.98 mg/kg		

Notes appear on the following page.

Table 8. Cadmium concentrations in the vicinity of Building 851 used to calculate the 95% Upper Confidence Limit of the mean. (Continued)

Notes:

N = **Number of soil samples used in calculation.**

mg/kg = **Milligrams per kilogram.**

Std = **Standard Deviation.**

95% UCL = **95 Percent Upper Confidence Limit of the Mean.**

ID = **Identification.**

[a] **Not used in the calculation of the 95% UCL.**

[b] **Average of the lognormally-transposed data.**

[c] **Standard Deviation of the lognormally-transposed data.**

[d] **H statistic interpolated from Table A12 (pg. 265) in Gilbert, 1987.**

[e] **95% Upper Confidence Limit of the mean in standard un-transposed units.**

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