U.S. Department of Energy

Livermore Site Office, Livermore, California 94551

Lawrence Livermore National Laboratory

Lawrence Livermore National Security, LLC, Livermore, California 94551

LLNL-AR-404822

Five-Year Review Report for the Building 854 Operable Unit at Lawrence Livermore National Laboratory Site 300

Authors:

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G. Lorega

December 2008

*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.

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Jan 28, 2009

Victor Madrid Date
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Approval and Concurrence for the Five-Year Review for the Building 854 Operable Unit at Lawrence Livermore National Laboratory Site 300

Prepared by:

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

Approved:

1-27-09

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U.S. Department of Energy
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Concurrence:

1/17/09

Michael M. Montgomery Date
Assistant Director
Federal Facilities and Site Cleanup Branch
Superfund Division
U.S. Environmental Protection Agency, Region IX

Five-Year Review Summary Form

Site Identification		
Site name: Lawrence Livermore National Laboratory Site 300, Building 854 Operable Unit (OU)		
EPA ID: CA 2890090002		
Region: IX	State: California	City/County: San Joaquin/Alameda
Site Status		
NPL status: Final		
Remediation status: Operating		
Multiple OUs: Yes	Construction completion date: September 2007	
Has the site been put into reuse: No		
1.0REVIEW STATUS		
Reviewing agency: United States (U.S.) Department of Energy (DOE)		
Author name: Valerie R. Dibley		
Author title: Assistant Site 300 Environmental Restoration Project Leader	Author affiliation: Lawrence Livermore National Laboratory	
Review period: December 2003 to January 2008		
Date(s) of site inspection: February 5, 2008		
Type of review: Statutory		
Review number: 1		
Triggering action: Interim Remedial Design for the Building 854 OU		
Triggering action date: December 2003		
Due date: July 5, 2008		

Five-Year Review Summary Form (continued)

Deficiencies:

No deficiencies in the remedy were identified during this evaluation.

Recommendations and Follow-up Actions:

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

1. Increase pumping of 854-Source (SRC) ground water treatment system (GWTS) extraction well W-854-2218 to maximize yield and increase source area capture. This may include replacing the pump, and handling additional effluent discharge by constructing more misting towers or by reinjecting the effluent into a well upgradient of the source area. If the additional effluent were to be reinjected, a carbon source (e.g. lactate) would need to be added to the injected effluent to facilitate *in situ* bioremediation of nitrate.
2. Discontinue extraction from 854-SRC GWTS well W-854-17 due to extremely low yield.
3. Monitor total volatile organic compounds (VOC) concentrations in monitor well W-854-09. If concentrations remain above MCLs and show an increasing trend over time, convert well W-854-09 to a 854-SRC GWTS extraction well. However, W-854-09 would not be considered for conversion to an extraction well until after the flow rate and hydraulic capture of nearby extraction wells W-854-2218 (Recommendation 1) and W-854-03 (Recommendation 5) have been increased and sufficient time has been allowed for performance evaluation. This decision will most likely be made during preparation of the next five-year review for this OU. Any changes will be documented in the Recommendations and Follow-up Actions Section.
4. Continue operation of 854-SRC soil vapor treatment system (SVTS) extraction wellfield with periodic rebound tests conducted in the future as specified in the soil vapor extraction system shutoff criteria.
5. Increase the pumping rate of 854-Proximal (PRX) extraction well W-854-03 to maximize yield and increase hydraulic capture. This may include replacing the pump and handling additional discharge by increasing the size and efficiency of the biotreatment unit and/or adding misting towers to facilitate the increased discharge volume from this facility.
6. Monitor perchlorate concentrations in well W-854-45. DOE will evaluate data from this well to attempt to resolve some unusual temporal trends in ground water levels and perchlorate concentrations to confirm that they are representative of subsurface conditions. If this evaluation confirms that perchlorate concentrations detected in well W-854-45 are representative of subsurface conditions and that concentrations persist above the 6 microgram per liter (μg/L) Maximum Contaminant Level, DOE will discuss *in situ* remedial technologies for perchlorate in the immediate vicinity of this well with

the regulatory agencies. Any change to the remedy would be documented in an Explanation of Significant Differences (ESD).

7. Evaluate remedial options to remediate perchlorate in the vicinity of well W-854-1823. For example, DOE may evaluate *in situ* bioremediation by conducting a treatability study that would include hydraulic testing to determine the injection capacity of well W-854-1823, and the injection of a reagent (i.e., sodium lactate) to encourage microbial reduction of perchlorate to benign by-products. Any change to the remedy would be documented in an ESD.
8. If perchlorate concentrations continue to increase in wells W-854-45 and W-854-1823, additional investigation of the source and extent will be conducted. However, it is important to note that any investigation of extent of perchlorate ground water contamination would be limited due to steep topography and the presence of an ecological preserve in the area of these wells.
9. Continue to evaluate Monitored Natural Attenuation as a remedial approach for nitrate in the downgradient proximal and distal areas of the Building 854 OU. *In situ* bioremediation of nitrate is recommended for the source area, such as injecting both the nitrate-bearing effluent and a carbon source (e.g., sodium lactate) to facilitate *in situ* biodegradation. Any change to the remedy would be documented in an ESD.

No other follow-up actions were identified related to this Five-Year Review. As discussed below, these recommendations do not affect the protectiveness of the remedy.

DOE will: (1) estimate costs and the timeframe necessary to accomplish the new work scope, (2) prioritize new work scope and present these priorities to the regulatory agencies, (3) incorporate the new work scope into upcoming fiscal year budget requests, and (4) develop a schedule for implementing the work.

Protectiveness Statement:

The remedy at the Building 854 OU is expected to be protective of human health and the environment upon completion (i.e., when cleanup standards are achieved) for the site's industrial land use. In the interim, the remedy protects 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.

The cleanup standards for Building 854 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 upon completion.

The cleanup standards for VOCs in subsurface soil are to 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 California 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 (DOE) has conducted a Five-Year Review of the remedial actions implemented at the Building 854 operable unit (OU) at Lawrence Livermore National Laboratory (LLNL) Site 300. Environmental cleanup is conducted under the oversight of the U.S. Environmental Protection Agency (U.S. EPA), California Department of Toxic Substances Control (DTSC), and the California Regional Water Quality Control Board (RWQCB). DOE is the lead agency for environmental restoration at LLNL. The review documented in this report was conducted from December 2003 through January 2008. Parties providing analyses in support of the review include:

- U.S. DOE, Livermore Site Office.
- LLNL, Environmental Restoration Department.
- 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 (U.S. DOE, 2002) and the U.S. EPA (U.S. EPA, 2001a).

Section 121 of the Comprehensive 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, other Federal agencies are responsible for ensuring that five-year reviews are conducted at sites where five-year reviews are required or appropriate.

This is the first Five-Year Review for the Building 854 OU (OU 6). 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 CERCLA. The triggering action for the first Building 854 review was the December 15, 2003 submittal date of the Interim Remedial Design for the Building 854 Operable Unit at Lawrence Livermore National Laboratory Site 300 (Daily et al., 2003).

Five-year reviews are 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 the five-year reviews for OUs 3 and 8, respectively, in accordance with EPA guidance. 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 the first five-year review.

The background and description of the Building 854 OU are presented in Section 3. The following paragraphs include the descriptions and status of the other OUs and areas where environmental restoration activities are occurring at Site 300.

General Services Area OU (OU 1) – Solvents containing volatile organic compounds (VOCs) were commonly used as degreasing agents in craft shops in this OU. In the 1960s and 1970s, rinse water from these operations was disposed of in dry wells and volatile organic compound (VOC)-contaminated debris was buried in trenches. Ground water cleanup began in 1991 and soil vapor extraction started in 1994 as treatability studies. In 1995, a Final ROD for this OU was signed (U.S. DOE, 1997). The remedial design (Rueth et al., 1998) was completed in 1998 and build out of the remedial action was completed in September 2005. Ground water and soil vapor extraction have been very successful in decreasing the concentration and mass of subsurface contaminants and in reducing the offsite extent of contamination. Remediation has already reduced VOCs in ground water to meet cleanup standards in the Eastern General Services Area. DOE has performed two Five-Year Reviews for the General Services Area OU (Ferry et al., 2001a and Dibley et al., 2006a). The next Five-Year Review is scheduled for 2012.

Building 834 OU (OU 2) – The Building 834 facilities have been in use since the late 1950s for experiments involving thermal cycling of weapons components. From 1962 to 1978, intermittent spills and piping leaks resulted in contamination of the subsurface with trichloroethylene (TCE) and silicone oils. Nitrate contamination in ground water results from septic-system effluent but may also have natural sources. Ground water and soil vapor extraction and treatment began in 1986 as treatability studies. Cleanup continued under the Interim Site-Wide ROD for the OU and later under the Interim Site-Wide ROD for Site 300 (U.S. DOE, 2001) and continues under the Site-Wide ROD. The interim remedial design (Gregory et al., 2002) was completed in 2002. Construction completion was achieved in September 2005. DOE has performed two Five-Year Reviews for the Building 834 OU (Ferry et al., 2002a and Dibley et al., 2007a). The next Five-Year Review for this OU is scheduled for 2012.

Pit 6 Landfill OU (OU 3) – From 1964 to 1973, waste was buried in nine unlined trenches and animal pits at the Pit 6 Landfill. Contaminants in the subsurface include VOCs, tritium, nitrate, and perchlorate. In 1971, DOE excavated portions of the waste contaminated with depleted uranium. In 1997, a landfill cap was installed as a removal action to prevent infiltrating precipitation from further leaching contaminants from the waste. Because of decreasing TCE concentrations and tritium activities in ground water, the presence of TCE degradation products, and the short half-life of tritium (12.3 years), the selected remedy for TCE and tritium at the Pit 6 Landfill is monitored natural attenuation. Because ground water monitoring data for perchlorate and nitrate are limited, DOE will continue to monitor ground water to determine if and when an active remedy for these contaminants of concern (COCs) might be necessary. Construction completion was achieved in October 2002. A Five-Year Review for this OU is scheduled for 2012.

High Explosives Process Area OU (OU 4) – Surface spills from 1958 to 1986 resulted in the release of VOCs at the former Building 815 steam plant. High explosive (HE) compounds, nitrate, and perchlorate are present in the subsurface and are attributed to wastewater discharges to former unlined rinse water lagoons. The High Explosives Burn Pits were capped in 1998. Ground water extraction and treatment began in 1999 as treatability studies. Cleanup continued under the Interim Site-Wide ROD for Site 300 and continues under the Site-Wide ROD. The interim remedial design (Madrid et al., 2002) was completed in 2002. Construction completion was achieved in September 2007. DOE has performed a Five-Year Review for the High Explosives Process Area OU (Dibley et al., 2007b). The next Five-Year Review for this OU is scheduled for 2013.

Building 850 Firing Table (OU 5) – HE experiments have been conducted at the Building 850 Firing Table since 1958. Tritium was used in these experiments, primarily between 1963 and 1978. As a result of the dispersal of test assembly debris during explosions, surface soil was contaminated with metals, polychlorinated biphenyls (PCBs), dioxins, furans, HE compounds, and depleted uranium. Leaching from firing table debris resulted in tritium and depleted uranium contamination in subsurface soil and ground water. Nitrate has also been identified in ground water. PCB-contaminated shrapnel and debris was removed from the area around the firing table in 1998. The selected interim remedy for the Building 850 area included excavation of the contaminated surface soil and a nearby sand pile and monitored natural attenuation of tritium in ground water. A remedial design (Taffet et al., 2004) was completed in 2004. DOE and the regulatory agencies agreed to perform the Building 850 soil remediation 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. The selected remedy, excavation and solidification of PCB-, dioxin-, and furan-contaminated soil, is scheduled to be implemented in 2008. A Five-Year Review for this OU is scheduled for 2012.

Pit 7 Landfill Complex (OU 5) – The Pit 3, 4, 5, and 7 Landfills are collectively designated the Pit 7 Landfill Complex. Firing table debris containing tritium, depleted uranium, and metals was placed in the pits in the 1950s through the 1980s. The Pit 4 and 7 Landfills were capped in 1992. During years of above-normal rainfall (i.e., 1997-1998 El Niño), 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 in the Pit 7 Complex area. DOE and the regulatory agencies agreed that Pit 7 Complex required additional study so the Pit 7 Complex was not included in the Interim Site-Wide ROD and an area-specific Remedial Investigation/Feasibility Study (Taffet et al., 2005) was completed. An Amendment to the Interim Site-Wide ROD for the Pit 7 Complex was signed in January 2007 describing the selected remedies for the Pit 7 Complex (U.S. DOE, 2007). The interim remedial design (Taffet et al., 2008) and remedy implementation were completed in 2008. A Five-Year Review for this OU is scheduled for 2012.

Building 832 Canyon OU (OU 7) – TCE was released to soil and ground water through leaks and discharges of heat-exchange fluid at Buildings 830 and 832 between the late 1950s and 1985. Nitrate and perchlorate are also present in ground water. Ground water and soil vapor extraction and treatment began in 1999 as treatability studies. Cleanup continued under the Interim Site-Wide ROD for Site 300 and continues under the Site-Wide ROD. The interim remedial design (Madrid et al., 2006) was completed in 2002. Construction completion was achieved in September 2007. A Five-Year Review for this OU is scheduled for 2011.

Building 801 Dry Well and the Pit 8 Landfill (OU 8) – Waste fluid was discharged to a dry well located adjacent to Building 801D from the late 1950s to 1984, resulting in minor subsurface VOC contamination. The Pit 8 Landfill was used to dispose of debris from the Building 801 Firing Table until an earthen cover was installed in 1974. There is no evidence of a contaminant release from the landfill. No unacceptable risk or hazard was identified in either area. The selected interim remedy for this area is enhanced vadose zone and ground water monitoring to detect any future releases from the landfill. A Five-Year Review for this OU is scheduled for 2012.

Building 833 (OU 8) – TCE was used as a heat-exchange fluid in the Building 833 area from 1959 to 1982 and was released through spills and rinse water disposal, resulting in minor VOC contamination of the shallow soil/bedrock and perched ground water. The selected interim remedy for this area is continued monitoring. A Five-Year Review for this OU is scheduled for 2012.

Building 845 Firing Table and Pit 9 Landfill (OU 8) – High explosives experiments were conducted at the Building 845 Firing Table from 1958 to 1963. Leaching from firing table debris resulted in minor contamination of subsurface soil with depleted uranium and HE compounds. No ground water contamination has been detected. The Pit 9 Landfill was used to dispose of firing table debris generated at the Building 845 Firing Table. The debris buried in the pit may contain tritium, uranium, and/or HE compounds. However, there is no evidence of a contaminant release from the Pit 9 Landfill. No unacceptable risk or hazard was identified in either area. The selected interim remedy for this area is enhanced vadose zone and ground water monitoring to detect any future releases from the landfill. A Five-Year Review for this OU is scheduled for 2012.

Building 851 Firing Table (OU 8) – The Building 851 Firing Table has been used for high-explosives research since 1962. These experiments resulted in minor VOC, depleted uranium, metals, and HE contamination in soil and/or bedrock. Modeling indicated that these constituents in soil and bedrock do not pose a threat to ground water. While depleted uranium is present in ground water, activities are only a fraction of the cleanup standard. No unacceptable risk or hazard was identified in this area. The selected interim remedy for this area is continued monitoring. A Five-Year Review for this OU is scheduled for 2012.

Pit 2 Landfill (OU 8) – The Pit 2 Landfill was used from 1956 to 1960 to dispose of firing table debris from Buildings 801 and 802. No unacceptable risk or hazard to human health or ecological receptors has been associated with the Pit 2 Landfill. Ground water data indicate that a discharge of potable water to support a red-legged frog habitat located upgradient from the landfill may have leached depleted uranium from the buried waste. The frogs were relocated and the water discharge was discontinued, thereby removing the leaching mechanism. No contaminants were identified in surface or subsurface soil at the Pit 2 Landfill. A Five-Year Review is scheduled for OU 8 in 2012.

Building 812 (OU 9) – This facility has been in use since the 1960s. Gravel from the firing table was pushed into an adjacent ravine or to the side of the table. A Characterization Summary Report for this area was submitted 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 this area. A Remedial Investigation/Feasibility Study presenting the results of characterization activities and remedial alternatives for the Building 812 OU is scheduled for completion in 2008. 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.

Advanced Test Accelerator (Building 865) – 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. A Characterization Summary Report for this area was submitted in 2006 (Ferry and Holtzapple, 2006). Impact to ground water and ecological receptors was identified from metals in surface soil. Freon 113, Freon 11, and tetrachloroethene (PCE), were identified as COCs in ground water. Due to the low concentrations, limited or localized extent, and future decontamination and decommissioning of the building, DOE recommended inclusion of the Building 865 into OU 8 for monitoring-only.

2. Site Chronology

The chronology of important events at the Building 854 OU is summarized below.

<u>1959</u>

- Former water-supply Well 13 was drilled.

<u>1960-1973</u>

- Building 855 was used for the disassembly of test devices. A disposal lagoon was used for the disposal of liquids generated during Building 855 operations.

<u>1967-1986</u>

- Two TCE brine systems were installed and extensively used at the Building 854 Complex. TCE was released to subsurface soil through leaks and discharges of TCE-based heat exchange fluid from the TCE brine system.

<u>1983</u>

- Excavated TCE-contaminated soil near Buildings 854F and 854H in the Building 854 Complex.

<u>1989</u>

- Brine systems were removed from the Building 854 Complex.

<u>1990</u>

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

<u>1992</u>

- A Federal Facility Agreement for Site 300 was signed.

1994

- The Site-Wide Remedial Investigation report for Site 300 was issued in 1994 (Webster-Scholten et al., 1994).

1996

- Sealed and abandoned water-supply well 13 because TCE was detected in this well and it was a potential vertical conduit for contaminant migration.

1998

- Submitted the Building 854 Operable Unit Characterization Summary (Ziagos and Reber-Cox, 1998).

1999

- The Site-Wide Feasibility Study for Site 300 was issued (Ferry et al., 1999).
- Ground water extraction and treatment was initiated in the Building 854 source area.

2000

- Ground water extraction and treatment was initiated in the Building 854 proximal area.

2001

- An Interim Site-Wide ROD for Site 300 was signed that selected an interim remedy for the Building 854 OU. 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., 2001b).

2002

- Submitted the Compliance Monitoring Plan/Contingency Plan (CMP/CP) for Interim Remedies (Ferry et al., 2002b).
- Submitted the Building 854 Operable Unit Characterization Summary (Ferry and Kearns, 2002).

2003

- Submitted the Building 854 Interim Remedial Design Report (Daily et al., 2003).

2004

- Risk evaluation performed for the 2004 Annual Compliance Monitoring Plan (Dibley et al., 2005a) indicated there was no longer an onsite worker risk from the inhalation of VOCs volatilizing from the subsurface into outdoor air in the vicinity of Building 854F.

2005

- Excavated 100 cubic yards of contaminated soil from the former Building 855 disposal lagoon mitigating the onsite worker risk from the inhalation, ingestion, and dermal contact with PCB-, dioxin-, and furan-contaminated soil (Holtzapple, 2005).

- Initiated soil vapor extraction (SVE) treatability test in the Building 854 source area.
- Building 854F was demolished, therefore mitigating the onsite worker risk from the inhalation of VOCs volatilizing from the subsurface into indoor air inside Building 854F.

<u>2006</u>

- Expanded the extraction wellfield in the Building 854 source area.
- Ground water extraction and treatment was initiated in the Building 854 distal area.
- Risk evaluation performed for the 2006 Annual Compliance Monitoring Plan (Dibley et al., 2007c) indicated there was no longer an onsite worker risk from the inhalation of VOCs volatilizing from the subsurface into indoor air inside Building 854A.

<u>2007</u>

- Modified the treatment system in the Building 854 proximal area to increase extraction from the proximal wellfield.
- Construction of the interim remedy was completed.

<u>2008</u>

- EPA performed the construction completion inspection of the OU.
- The Site-Wide ROD was signed that selected remedies and cleanup standards for Site 300 including the Building 854 OU.

3. Background

3.1. Physical Characteristics

3.1.1. Site Description

LLNL Site 300 is a U.S. DOE experimental test facility operated by the Lawrence Livermore National Security, Limited Liability Corporation. It is located in the eastern Altamont Hills, 17 miles east of Livermore, California (Figure 1). At Site 300, DOE conducts research, development, and testing associated with high-explosive materials. During previous Site 300 operations, a number of contaminants were released 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). The climate at Site 300 is semi-arid; approximately 10 to 15 inches of precipitation falls each year, mostly in the winter.

The Building 854 OU covers an area of approximately 1.5 square miles in the western portion of LLNL Site 300. Fifteen buildings were built in the OU between 1959 and 1970 including the Building 854 Complex (Buildings 854A, B, C, D, E, F, G, H, J, and V), the Building 855 Complex (Buildings 855A, B, and C), Building 856, and Building 857 (Figure 2). The Building 854 Complex was used to test the stability of weapons and weapon components under various environmental conditions and mechanical and thermal stresses. In 1967, two TCE brine systems were installed at Building 854. The primary loop connected Buildings 854B and 854G and the secondary loop connected Buildings 854C, 854D, 854E, and 854F. TCE was released to the subsurface in the Building 854 OU through leaks and discharges of TCE-based heat exchange fluid from the secondary TCE brine system, primarily from outdoor valve stations and from piping between buildings. Both loops were extensively used until 1986, infrequently used after 1986, and removed in 1989. In 2005, Buildings 854B, C, D, E, F, G, and J were decontaminated and demolished. There are plans to decontaminate and demolish Building 854A in the future. Building 854V is still used as a HE magazine and Building 854H was converted to an HE magazine in 2006. In 2005, HE processing and machining operations started at Building 855, which had been unoccupied for a number of years.

3.1.2. Hydrogeologic Setting

This section describes the general hydrogeologic setting for the Building 854 OU including the unsaturated zone and the three hydrostratigraphic units (HSUs) underlying the area. An HSU is a water-bearing zone that exhibits similar hydraulic and geochemical properties. A conceptual hydrostratigraphic column for the northern portion of Site 300 including the Building 854 area is shown on Figure 3.

3.1.2.1. Vadose (Unsaturated) Zone

The vadose zone is approximately 100 feet (ft) thick and consists of up to 70 ft of poorly consolidated Quaternary landslide deposits (Qls) and the unsaturated portion of the lower Neroly $Tnbs_1$ sandstone. While trace amounts of moisture have been encountered in the vadose zone during drilling, the upper 100 ft of the subsurface is generally unsaturated.

3.1.2.2. Saturated Zone

The three HSUs underlying the Building 854 OU are described below.

Qls HSU – The Qls HSU is an unconfined, ephemeral water-bearing zone that occurs in sand, silt, and angular, weathered bedrock fragments within landslide deposits. It ranges up to 100 ft in total thickness, and the saturated thickness is spatially and temporally variable depending on seasonal rainfall. The Qls HSU is recharged by surface water runoff and direct rainfall infiltration. Discharge occurs at Springs 10 and 11, located at the toe of the landslide deposit in a canyon in the southern part of the OU. The landslide is underlain by up to 200 ft of sandstone, siltstone, and claystone of the lower Neroly Formation. When saturated, the depth to Qls HSU ground water ranges from 75 ft to 88 ft below ground surface (bgs). The unconfined ground water in this HSU generally flows in a south-southeast direction.

$Tnbs_1$/$Tnsc_0$ HSU – The $Tnbs_1$/$Tnsc_0$ HSU is comprised of the lower $Tnbs_1$ sandstone and underlying $Tnsc_0$ siltstone/claystone fractured bedrock, and is present throughout the Building 854 OU. The saturated thickness of the HSU varies from tens of feet near the upgradient recharge area to over 100 ft in downgradient areas. The depth to ground water ranges from 90 to 180 ft bgs. Ground water in this HSU is unconfined.

Hydrologic, chemical, and optical televiewer data indicate that fractures are important flow-controlling features in the $Tnbs_1$/$Tnsc_0$ HSU. The magnitude and speed of water level response observed during pumping tests suggests preferential flow along fractures. Fracture orientation also appears to influence the $Tnbs_1/Tnsc_0$ ground water flow direction. In the northern portion of the OU, ground water generally flows east-southeast. In the central and southern portions of the site, ground water generally flows south (Figure 4).

Tmss HSU – The Tmss HSU is comprised of sandstone, claystone, and pebble conglomerate bedrock of the Cierbo Formation, and is present throughout the Building 854 OU. The potentiometric surface for this HSU is separate and distinct from the overlying Neroly water-bearing zone, and the upper part of the Cierbo Formation is unsaturated beneath the Building 854 source area. The saturated thickness of the Tmss HSU in the Building 854 area is not known; this unit has never been fully penetrated during drilling in support of historic environmental investigations. The depth to ground water is approximately 300 ft bgs. Ground water in this HSU is confined.

3.1.2.3. Surface Water

Two springs, Springs 10 and 11, are located in the Building 854 OU, approximately 2,400 ft southeast of Building 855 (Figure 4). Springs 10 and 11 are perennial springs with flow rates of 0.5 and 0.1 gallons per minute (gpm), respectively. Water in these springs is thought to be derived from ground water discharging at the toe of the Qls deposits.

3.2. Land and Resource Use

Prior to the establishment of Site 300 as remote testing facility in 1955, the area was used for livestock grazing. Site 300 is currently an operating facility, and will remain under DOE control for the reasonably foreseeable future. Less than five percent of Site 300's 7000-acre property-area is developed. There have been no changes in land or ground water use in the Building 854 OU since the Interim Site-Wide ROD was signed in 2001 and none are anticipated. However, building use has changed since the Interim Site-Wide ROD. Many of the buildings in the OU have been decommissioned and/or demolished. In addition, Building 855 has been converted into a HE machining facility and Building 854H has been converted into an HE magazine. The Building 854 OU is accessible only to DOE/LLNL workers.

The Building 854 OU is entirely surrounded by Site 300 property and does not extend to the site boundary. Land use adjacent to the site boundary closest to the Building 854 OU consists of private rangeland and the Carnegie State Vehicular Recreation Area (SVRA). The nearest major population center (Tracy, California) is 8.5 miles to the northeast. There is no known planned modification or proposed development of the offsite rangeland closest to the OU. The SVRA continues to expand its infrastructure to accommodate increased public usage.

At Site 300, the regional aquifer ($Tnbs_1$ HSU) is a source of water for fire suppression and to process explosives. Bottled water is the primary source for onsite drinking water. There is no current onsite use of surface water by humans. Offsite, the regional aquifer supplies water for domestic and agricultural uses. There are no onsite or private offsite water-supply wells in use near the OU.

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). Special status species within the Building 854 OU include the endangered large-flowered fiddleneck (*Amsinckia grandiflora*) and the blue elderberry bush (*Sambucus mexicana*), host plant to the federally threatened valley elderberry long horn beetle (*Desmocerus californicus dimorphus*). The northern part of the OU resides within threatened California tiger salamander upland habitat. The southwestern quadrant of Site 300, encompassing the entire OU, was proposed as critical habitat of the Alameda whipsnake (*Masticophis lateralis euryxanthus*), listed as a threatened species. An *Amsinckia grandiflora* Reserve was designated per a memorandum of agreement between DOE and the U.S. Fish and Wildlife Service, and consists of 160 acres of Site 300. This reserve is located partially within the Building 854 OU. Site operations have successfully co-existed with nature all these years with no apparent ecological impacts. Access to these unique animal and plant populations is controlled and interactions with the wildlife are avoided.

3.3. History of Contamination

TCE was released to subsurface soil in the Building 854 OU through leaks and discharges of TCE-based heat exchange fluid from the TCE brine system. These leaks occurred primarily from outdoor valve stations and piping between buildings, or from waste fluid discharge practices that are no longer permitted at Site 300. Most spills are believed to have occurred between 1967 and 1984 (Stupfel, 1992). Nitrate and perchlorate are also detected in ground water. Although the distribution of these contaminants does not suggest a specific source, the presence of HE compounds in soil may indicate an anthropogenic contribution. Septic systems serving the Building 854 and 855 Complexes are also possible sources of anthropogenic nitrate.

Historical records indicated that wastewater containing PCB oils was discharged from Building 855A to a former lagoon, south of the building. The HE compound, High Melting Explosive (HMX), metals, and low tritium activities have been detected in soil in the Building 854 OU.

3.4. Initial Response

DOE began environmental investigations in the Building 854 area in 1983. Since then, 43 boreholes have been drilled in the OU, 32 of which were completed as ground water monitor wells (Figure 2). The geologic and chemical data from these wells and boreholes have been used to characterize the site hydrogeology and to monitor temporal and spatial changes in saturation and dissolved contaminants. Site characterization also included surface soil sampling, soil vapor flux chamber measurements, soil vapor surveys, hydraulic testing, and soil vapor extraction testing.

As summarized in Section 2, remediation activities at the Building 854 OU conducted prior to the Interim Site-Wide ROD included sealing and abandoning water-supply Well 13, and the excavation of TCE-contaminated soil near Buildings 854F and H. In addition, ground water extraction and treatment was initiated in 1999 with the installation of a ground water treatment system (GWTS) in the Building 854 source area. A GWTS was installed in the Building 854 proximal area in 2000.

3.5. Contaminants of Concern

COCs in surface soil in the Building 854 OU include lead, zinc, HMX, PCBs and tritium. No unacceptable risk or hazard to human health or ecological receptors has been identified for lead, zinc, HMX or tritium in the Building 854 area. A baseline human health risk of 7×10^{-5} was calculated for onsite worker inhalation, ingestion, and direct dermal contact with PCB-contaminated soil.

VOCs were identified as COCs in subsurface soil/rock in the Building 854 OU. Baseline cancer risks of 1.0×10^{-6} and 9.3×10^{-6} were calculated for onsite worker inhalation of VOCs volatilizing from the subsurface into indoor air at Buildings 854A and 854F, respectively. A baseline cancer risk of 1×10^{-5} was calculated for onsite worker inhalation of VOCs volatilizing from the subsurface into outdoor air at Building 854F.

At the Building 854 OU, VOCs are the primary COCs detected in ground water and perchlorate and nitrate are the secondary COCs. These constituents have been identified primarily in the $Tnbs_1/Tnsc_0$ HSU.

VOCs, primarily TCE, a suspected human carcinogen, are present in ground water and in water at Springs 10 and 11. There was no human health or ecological risk or hazard identified associated with TCE in ground or surface 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). There was no human health risk or hazard identified associated with perchlorate in ground water.

Elevated nitrate in ground water may be attributable to a combination of natural and anthropogenic sources in the Building 854 OU. Nitrate can cause non-carcinogenic health effects if ingested at elevated concentrations. There was no human health risk or hazard identified associated with nitrate in ground water.

3.6. Summary of Basis for Taking Action

Remedial actions were initiated in the Building 854 OU to address: (1) unacceptable human health risks associated with onsite worker inhalation exposure to VOCs volatilizing from subsurface soil into indoor air inside Building 854A and 854F and outdoor air in the vicinity of Building 854F, (2) an unacceptable human health risk was associated with onsite worker inhalation, ingestion, and direct dermal contact with PCB-, dioxin-, and furan-contaminated soil, and (3) VOCs, nitrate, and perchlorate present in ground water at concentrations exceeding drinking water Maximum Contaminant Level (MCL) cleanup standards.

4. Remedial Actions

4.1. Remedy Selection

The remedy selected for the Building 854 OU is intended to achieve the following Remedial Action Objectives (RAOs):

For Human Health Protection:

- Restore ground water containing VOC, nitrate, and perchlorate concentrations above cleanup standards.
- Prevent human ingestion of ground water containing VOC, nitrate, and perchlorate concentrations (single carcinogen) above cleanup standards.
- Prevent human incidental ingestion and direct dermal contact with PCBs, dioxins, and furans in surface soil that pose an excess cancer risk greater than 10^{-6} or hazard index greater than 1, a cumulative cancer risk (all carcinogens) in excess of 10^{-4}, or a cumulative hazard index (all noncarcinogens) greater than 1.
- Prevent human inhalation of VOCs volatilizing from subsurface soil to air that pose an excess cancer risk greater than 10^{-6} or hazard index greater than 1, a cumulative excess cancer risk (all carcinogens) in excess of 10^{-4}, or a cumulative hazard index (all noncarcinogens) greater than 1.
- Prevent human inhalation of PCBs, dioxins, and furans bound to resuspended surface soil particles that pose an excess cancer risk greater than 10^{-6} or hazard index greater than 1, a cumulative excess cancer risk (all carcinogens) in excess of 10^{-4}, or a cumulative hazard index (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 hazard index 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.

An RAO for human health protection/applicable or relevant and appropriate requirements (ARAR) compliance for ingestion of surface waters (i.e., water from Site 300 springs) was not developed because there is not a complete exposure pathway for ingestion of surface waters for humans at Site 300. Humans do not drink water from Site 300 springs. In addition, the springs in which contaminants are detected do not produce a sufficient quantity of water to be used as a water-supply (greater than 200 gallons per day). Total VOC concentrations in Springs 10 and 11 were below the 0.5 micrograms per liter (μg/L) detection limit in the second semester of 2007.

In the 2001 Interim Site-Wide ROD, an interim remedy for the Building 854 OU was selected based on its ability to contain contaminant sources, prevent further plume migration, remove contaminant mass from the subsurface, and protect human health and the environment. The selected interim remedy for the Building 854 OU consisted of:

1) No further action for metals, HE, and tritium in surface soil. No further action was accepted for these COCs in surface soil because: (1) source control measures have already been implemented to prevent further impact to ground water, and (2) there is no risk or hazard to human health or ecological receptors or threat to ground water posed by these contaminants.
2) Monitoring ground water and surface water for COCs.
3) Risk and hazard management to prevent human exposure to COCs and mitigate impacts to ecological receptors.
4) Source mass removal and mitigation of any inhalation risk at Buildings 854A and 854F through extraction and treatment of VOCs in ground water and soil vapor and nitrate in ground water.

Subsequent to the Interim Site-Wide ROD, additional characterization identified PCBs in surface soil in the former Building 855 lagoon at concentrations that posed an unacceptable risk to onsite workers. DOE/LLNL removed the PCB-contaminated soil from the lagoon to mitigate this risk as part of the interim remedy.

The 2008 Site-Wide ROD selected remedy for the Building 854 OU consisted of:

1) Monitoring ground water to evaluate the effectiveness of the remedy in achieving cleanup standards.
2) Risk and hazard management to prevent animal exposure to VOCs volatilizing from subsurface soil until risk and hazard are mitigated through active remediation. Annual risk re-evaluation indicates that the inhalation risk for VOCs volatilizing from subsurface soil at Buildings 854A and 854F has been mitigated through remediation. Risk and hazard associated with PCB, dioxin, and furan contaminated surface and subsurface soil was also mitigated through remediation. Therefore, risk and hazard management for these exposure pathways are no longer necessary. Institutional/land use controls have been implemented to prevent human exposure to contamination and to protect the integrity of the remedy.
3) Extracting and treating VOCs in soil vapor and ground water, and nitrate and perchlorate in ground water to mitigate unacceptable VOC inhalation risk for onsite workers, prevent further impacts to ground water, and reduce contaminant concentrations in ground water to cleanup standards.

4.2. Remedy Implementation

GWTS have been operating in the Building 854 OU since 1999, first as a treatability study and then under the Interim Site-Wide ROD, and continues under the Site-Wide ROD. Three GWTSs currently operate in the Building 854 OU: Building 854-Source (854-SRC), Building 854-Proximal (854-PRX), and Building 854-Distal (854-DIS). A soil vapor treatment system (SVTS) system also operates at 854-SRC.

The 854-SRC GWTS began operation in December 1999 treating ground water to remove VOCs and perchlorate. Ground water extraction was expanded in September 2006 from one well extracting at a flow rate of approximately 1 gpm, to four wells extracting at an approximate combined flow rate of 3 to 4 gpm. The current GWTS configuration includes a particulate filtration system, two ion-exchange columns containing SR-7 resin connected in series for perchlorate removal, and three aqueous-phase granular activated carbon (GAC) canisters connected in series for VOC removal. Nitrate-bearing treated effluent is then discharged via a misting tower over the landscape for uptake and utilization of the nitrate by indigenous grasses.

A SVTS system began operation at the 854-SRC in November 2005. Soil vapor is extracted from one well at an approximate flow rate of 53 standard cubic feet per minute (scfm). This system consists of vapor-phase GAC to remove VOCs from extracted soil vapor. Treated vapors are discharged to ambient air.

The 854-PRX GWTS began operation in November 2000 treating ground water to remove VOCs, nitrate, and perchlorate. Ground water is extracted from one well located southeast of the Building 854 complex at an approximate flow rate of 1 gpm. The GWTS configuration includes two ion-exchange columns containing SR-7 resin connected in series for perchlorate removal, three aqueous-phase GACs connected in series for VOC removal, and above-ground containerized wetland biotreatment for nitrate removal prior to being discharged into an infiltration trench. In 2007, the treatment system was modified to replace the solar power with site power to increase the volume of extracted ground water and contaminant mass removed by operating the GWTS 24 hours a day.

The 854-DIS GWTS began operation in July 2006 treating ground water to remove VOCs and perchlorate. Ground water is extracted from one well at an instantaneous flow rate of 1.2 gpm, when the solar-powered facility operates intermittently. However, the operational flow rate averaged over time is approximately 0.02 gpm. The current GWTS includes two SR-7 ion-exchange resin columns connected in series for perchlorate treatment followed by three aqueous-phase GAC canisters connected in series for VOC removal prior to being discharged into an infiltration trench.

In 2005, approximately 100 cubic yards of PCB-, dioxin-, and furan-contaminated surface and shallow subsurface soil from the former Building 855 lagoon was excavated and disposed at an offsite landfill (Holtzapple, 2005).

4.3. System Operations/Operation and Maintenance

In general, the Building 854 OU extraction and treatment systems are operating as designed and no significant operations, performance, maintenance, or cost issues were identified during this review. All required documentation is in place (or is scheduled to be produced), and treatment system operation and maintenance (O&M) activities are consistent with established procedures and protocols.

O&M procedures for the Building 854 treatment systems are contained in the following documents:

- Health and Safety Plan and Quality Assurance/Quality Control Plan for the O&M of the Building 854 Treatment Facilities, contained within the Interim Remedial Design report.
- Operations and Maintenance Manual for Miniature Treatment Units, Ground Water Treatment Units, and Solar Treatment Units, Volume 13 (Martins, 2007).
- Operations and Maintenance Manual, Volume 1: Treatment Facility Quality Assurance and Documentation (LLNL, 2004).
- Integration Work Sheet Safety Procedure #1341: Ground Water and Soil Vapor Treatment Facility Operations at Site 300.
- Building 832 Canyon and Building 854 OU Substantive Requirements and the Monitoring and Reporting Program issued by the California RWQCB.
- Site-Wide Compliance Monitoring Plan/Contingency Plan for Interim Remedies at LLNL Site 300.
- LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures (Goodrich and Wimborough, 2006).

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

The major O&M activities for the Building 854 treatment systems include:

- Maintaining the particulate filters.
- Maintaining the misting tower and infiltration trench used to discharge treated ground water.
- Maintaining the wetland biotreatment unit.
- Protecting the units from freezing in cold weather.
- Replacing spent GAC and resin.
- Replenishing vinegar used as carbon source for the wetland biotreatment unit.
- Routinely inspecting and maintaining extraction well pumps, pipelines, and flow meters.

The budgeted and actual environmental restoration costs for the Building 854 OU are tracked closely and are generally within the allocated budget, except when extra costs were incurred to address unanticipated problems or regulatory requests. Table 1 presents the actual costs for the last five fiscal years, 2003 through 2007.

4.4 Institutional Controls

Institutional/land use controls are non-engineered actions or measures used to prevent or limit the potential for human exposure to contamination at the Building 854 OU and to protect the integrity of the remedy. The general types of institutional/land use controls that are used to prevent human exposure to contamination at the Building 854 OU include:

- Access controls – Measures such as fences, signs, and security forces that are used to prevent exposure by controlling and/or restricting access to areas of contamination.
- Administrative controls – Measures such as pre-construction review and controls for limiting or restricting access to contaminated areas and prohibitions on water-supply well drilling.

Table 2 presents descriptions of: (1) the institutional/land use control objective and duration, (2) the risk necessitating land use controls, and (3) the specific institutional/land use controls and implementation mechanisms used to prevent exposure to contamination at the Building 854 OU. Figure 5 shows the specific areas of the Building 854 OU where the institutional/land use controls have been maintained or implemented.

Monitoring and inspection of the Building 854 OU will continue to be performed throughout the remediation period to determine whether the institutional/land use controls remain protective and consistent with all remedial action objectives. In addition, DOE will continue to review facility and land use to evaluate changes in exposure pathway conditions that could affect the risk assessment assumptions and calculations.

Institutional/land use controls are included in the Risk and Hazard Management Program contained in the Site-Wide Compliance Monitoring Plan. Any new or modified institutional/land use controls resulting from the Five-Year Review process will be incorporated in the Risk and Hazard Management Program contained in the revised Site-Wide Compliance Monitoring Plan. Risk and hazard monitoring results conducted during the year are submitted to the EPA and State regulatory agencies in the Annual Site 300 Site-Wide Compliance Monitoring Reports. In addition, DOE will work with LLNL Site 300 Management to incorporate these institutional/land use controls into the Site 300 Integrated Strategic Plan or other appropriate institutional planning documents.

The land use controls and requirements described herein are only applicable to the Building 854 OU and associated contaminated environmental media that are being addressed through the CERCLA process. DOE has implemented, and will continue to maintain, and enforce these institutional/land use controls at the Building 854 OU for as long as necessary to keep the selected remedy protective of human health and the environment.

If DOE later transfers these procedural responsibilities to another party by contract, property transfer agreement, or through another means, DOE will retain ultimate responsibility for the integrity of the remedy. In the event that the property is transferred in the future, DOE will execute a land use covenant at the time of transfer in compliance with California Code of Regulations Title 22, Division 4.5, Chapter 39, Section 67391.1. If the Site 300 property were to be transferred to an entity outside the U.S. DOE, the necessary institutional/land use controls would be determined prior to the property transfer based on: (1) the intended land use subsequent to the property transfer, and (2) contamination and associated risk, if any, remaining at the Building 854 OU.

The institutional controls were reviewed and are still effective for preventing exposure to contaminated media.

5. Five-Year Review Process

Claire Holtzapple, the Site 300 Remedial Project Manager for the DOE/National Nuclear Security Administration-Livermore Site Office, led the Five-Year Review of the Building 854 OU at LLNL Site 300. The following team members assisted in the review:

- Valerie Dibley, Deputy Project Leader, LLNL.
- John Valett, Hydrogeologist, Weiss Associates.
- Mark Buscheck, Hydrogeologist, Weiss Associates.
- Vic Madrid, Environmental Scientist, LLNL.
- Leslie Ferry, Project Leader, LLNL.

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

- Final Site-Wide Remedial Investigation for Lawrence Livermore National Laboratory Site 300.
- Final Site-Wide Feasibility Study for Lawrence Livermore National Laboratory Site 300.
- Interim Site-Wide Record of Decision for Lawrence Livermore National Laboratory Site 300.
- Site-Wide Record of Decision for Lawrence Livermore National Laboratory Site 300.
- Remedial Design Work Plan for Interim Remedies at Lawrence Livermore National Laboratory Site 300.
- Interim Remedial Design for the Building 854 Operable Unit at Lawrence Livermore National Laboratory Site 300.
- 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 854 OU (Dibley et al., 2004a; 2004b; 2005a; 2005b; 2006b; 2006c; 2007c, 2007b, and 2008c).

This Five-Year Review evaluates subsurface contaminant concentration and remediation system performance data collected through calendar year 2007.

The completed report will be placed in the Administrative Record file and the Information Repositories located in the LLNL Discovery Center in Livermore, California and in the Tracy Public Library in Tracy, California. Notice of its initiation and completion will be placed in two publications: *The Tracy Press* and *San Joaquin Herald*. The initial notice was published in *The Tracy Press* and *San Joaquin Herald* on July 9, 2008 and July 7, 2008, respectively.

6. Five-Year Review Findings

6.1. Interviews and Site Inspection

DOE/LLNL meets 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 Site 300 Environmental Restoration Project staff at Site 300 that routinely inspect the: (1) extraction wellfield and treatment facilities weekly, and (2) monitoring wellfield during ongoing, continuous sampling activities. The Site 300 Environmental Restoration Project conducts regular self-assessment inspections of all facilities and DOE conducts quarterly inspections of remediation activities at Site 300. The RWQCB RPM performs site inspections twice a year, and EPA and DTSC RPMs perform site inspections as requested. The EPA performed the construction completion inspection on February 5, 2008.

6.2. Changes in Cleanup Standards and To-Be-Considered Requirements

The following action-specific ARAR has been adopted since the Interim Site-Wide ROD was signed in 2001:

- The California Code and Regulations, Title 22, Section 67391.1 was adopted April 19, 2003. It contains requirements for imposing legal limitations on future site uses and activities through a land use covenant. There is no impact on the protectiveness of the remedy related to the new requirement for a land use covenant at the time of property transfer.
- The State of California established an MCL (6 μg/l) for perchlorate on October 18, 2007.

This action-specific ARAR and ARARs related to ground water cleanup were established in the 2008 Site-Wide ROD.

6.3. Changes in Land, Building, or Ground Water Use

There have been no changes in land or ground water use in the Building 854 OU since the Interim Site-Wide ROD however, building use has changed since the Interim Site-Wide ROD. Many of the buildings in the OU (Buildings 854B, C, D, E, F, G, and J) have been decommissioned and/or demolished. In addition, Building 855 has been converted into a HE machining facility and Building 854H was converted into an HE magazine. The Building 854 OU is accessible only to DOE/LLNL workers. Ground water in the area of the OU is not used for drinking water.

6.4. Changes in Exposure Pathways, Toxicity, and Other Contaminant Characteristics

There have been no changes in exposure pathways, toxicity, and other contaminant characteristics in the Building 854 OU since the Interim Site-Wide ROD was signed in 2001. However, in August 2001, U.S. EPA's Office of Research and Development released the draft "Trichloroethylene Health Risk Assessment: Synthesis and Characterization" that has since been undergoing external peer review (U.S. EPA, 2001b). This assessment indicates that, for those who have increased susceptibility and/or higher background exposures, TCE could pose a higher risk than previously considered. Since review of the toxicity value for TCE may continue for a number of years, this issue will be updated in future Five-Year Reviews.

6.5. Data Review and Evaluation

6.5.1. Surface Soil Remediation Progress

In 2005, approximately 100 cubic yards of PCB-, dioxin-, and furan-contaminated surface and shallow subsurface soil from the former Building 855 lagoon were excavated and disposed. The soil excavation was conducted to mitigate unacceptable exposure risk (greater than 10^{-6}) for onsite workers. Following soil excavation, sampling of the excavation was conducted to verify that the cleanup standards were met. The U.S. EPA Region 9 industrial soil PRGs for PCBs (0.74 milligrams per kilogram [mg/kg]) and 2,3,7,8-tetrachloro-di-benzodioxin (TCDD) (1.6×10^{-5} mg/kg) were selected as the cleanup standards. In January 2006, the regulatory agencies concurred that the PCB soil cleanup was complete.

6.5.2. Vadose Zone Remediation Progress

The 854-SRC SVTS extracts vapor from SVE well W-854-1834 and has been operating continuously since November 2005, except for intermittent periods due to weather-related delays or when rebound testing or electrical work was performed. SVE well W-854-1834 is located in the Building 854 TCE source area and screened exclusively in the vadose zone. The system's operational history (monthly vapor flow in standard cubic feet [scf]) and historical TCE vapor concentrations in parts per million on a volume-to-volume basis ($ppm_{v/v}$) are presented in Figure 6. The system currently operates a flow rate of approximately 50 scfm. At SVTS startup, the initial TCE concentrations were in the 3.7 to 4.4 $ppm_{v/v}$ range. VOC mass removed from vapor by the 854-SRC SVTS is presented in Figure 7. To date, the facility has removed 7.9 kilogram (kg) of total VOCs from vapor.

After about 14 months of continuous operation, the following series of rebound tests and sampling events were conducted:

- January 9, 2007: 1.2 $ppm_{v/v}$ of TCE was detected in a SVTS vapor sample.
- January 24 to April 4, 2007: operation of the SVTS was suspended for approximately three months for vapor rebound testing.
- April 4 to April 5, 2007: a rebound test was conducted during which vapor was extracted from extraction well W-854-1834 while influent VOC concentrations were monitored.

The initial vapor TCE concentration was 2.1 $ppm_{v/v}$. TCE concentrations stabilized in the 1.0 to 1.3 $ppm_{v/v}$ range, indicating that vapor TCE concentrations in the source area had not rebounded significantly during the three month shutdown period.

- April 6 to July 26, 2007: the SVTS remained off line.
- July 26, 2007: the SVTS was restarted while influent VOC concentrations were monitored in extraction well W-854-1834. The initial TCE vapor concentration was 0.44 $ppm_{v/v}$ and then stabilized in the 0.015 to 0.04 $ppm_{v/v}$ range, indicating that TCE vapor concentrations in the source area had decreased further while the SVTS system was offline.
- October 24, 2007: the influent VOC concentration had fallen below the reporting limit (<0.2 $ppm_{v/v}$) and the SVTS system was again suspended to allow VOC vapors to rebound.
- April 9, 2008: a third rebound test was conducted. The initial TCE vapor concentration five minutes after restarting the SVTS system was 0.38 $ppm_{v/v}$. Additional vapor samples were collected 4 hours and 8 days after restarting the SVTS system; TCE vapor concentrations were 0.68 and 0.32 $ppm_{v/v}$, respectively, indicating that TCE vapor concentrations had increased from the previous test but not rebounded significantly.

Although the TCE vapor concentrations are typically low, including after rebound periods, significant VOC mass has been removed from the Building 854 source area during the two years of intermittent operation of the SVTS system. In fact, more total VOC mass has been removed via the SVTS system in two years than the total mass removed from all three ground water remediation systems over five years of operation. SVE well W-854-1834 is removing residual VOC mass that exists in the vadose zone in addition to total VOCs that are volatilizing from the underlying dissolved plume in the ground water. LLNL/DOE plan to continue operating the 854-SRC SVTS until vapor concentrations remain below reporting limits after extended shutdown periods and SVE shutoff criteria have been met.

6.5.3. Ground Water Remediation Progress

The construction of all treatment facilities and extraction wellfields specified in the Building 854 Remedial Design was completed in 2007. Remediation progress was evaluated by:

- Evaluating extraction wellfield capture zones (Figures 4 and 10).
- Reviewing ground water COC mass removal data (Figures 7 and 8).
- Reviewing COC concentration trends in ground water over time.
- Comparing pre-remediation and the 2007 ground water COC concentrations and spatial distribution (Figures 10 and 13).

The results of this evaluation for the COCs in Building 854 OU ground water, VOCs, perchlorate, and nitrate, are discussed below.

TCE has been detected in Building 854 OU ground water at concentrations exceeding the 5 μg/L MCL cleanup standard. A total VOC isoconcentration contour map (second semester 2007) for the $Tnbs_1/Tnsc_0$ HSU is presented in Figure 9. Overall, VOC concentrations in Building 854 ground water have decreased by two orders-of-magnitude from an historical, pre-remediation maximum of 2,900 μg/L in 1997 to a maximum concentration of 78 μg/L in the second semester of 2007. Figure 10 presents a comparison of the pre-remediation extent of the total VOC plume in 1999 to the extent of the total VOC plume in the second semester of 2007. The figure shows that since remediation started: (1) the portion of the northern VOC plume with concentrations greater than 100 μg/L has been remediated, and (2) the portion of the northern VOC plume with concentrations greater than 50 μg/L has been reduced or disappeared. In addition, remediation of VOCs in the Building 854 source area has successfully mitigated the risk to onsite workers at Buildings 854A and 854F. A hydrogeologic cross-section showing the vertical distribution of total VOCs in the Building 854 OU HSUs is shown in Figure 11. To date, approximately 5.2 kilograms (kg) of VOCs have been removed from ground water by the 854-SRC, 854-PRX, and 854-DIS extraction and treatment systems. Time-series plots of cumulative total VOC mass removed by these facilities are shown in Figure 7.

Perchlorate has been detected in Building 854 OU ground water at concentrations exceeding the 6 μg/L MCL cleanup standard. A perchlorate isoconcentration contour map (first semester 2007) for the $Tnbs_1/Tnsc_0$ HSU is presented in Figure 12. Perchlorate concentrations have decreased from a historical maximum of 27 μg/L in 2003 to 20 μg/L in the first semester of 2007. Figure 13 presents a comparison of the pre-remediation extent of the perchlorate plume in 1999 to the extent of the perchlorate plume in the first semester of 2007. While the extent of perchlorate in Building 854 ground water has not changed significantly over time, perchlorate is currently detected in three wells, W-854-03, -45, and -1823, in the Building 854 OU. Perchlorate has consistently been detected in wells W-854-03 and -1823; detections have been more sporadic in well W-854-45 with concentrations ranging from <0.4 μg/L to 9.9 μg/L. Perchlorate concentrations will continue to be closely monitored in these wells. To date, approximately 200 grams (g) of perchlorate have been removed from ground water by the 854-SRC, 854-PRX, and 854-DIS extraction and treatment systems. Time-series plots of cumulative perchlorate mass removed by these facilities are shown in Figure 8.

Nitrate has been detected in $Tnbs_1/Tnsc_0$, HSU ground water at concentrations exceeding the 45 milligram per liter (mg/L) MCL cleanup standard (Figure 14). The historical maximum and 2007 nitrate concentration of 260 mg/L was detected in ground water samples from shallow well W-854-14 in June 2006 and May 2007, respectively. Nitrate in this well is most likely due to a septic system at nearby Building 858. While the extent of nitrate in Building 854 OU ground water has not changed significantly during the period of remediation, this could be the result of the ongoing contribution of nitrate from septic systems and natural sources in the Neroly Formation bedrock. Geochemical and isotopic data (nitrogen and oxygen isotopes) collected in the Building 854 OU as part of the Site 300 nitrate monitored natural attenuation (MNA) study indicate that denitrification is taking place in Neroly Formation ground water. MNA is being considered as a remedial approach for nitrate in the downgradient proximal and distal areas of the Building 854 OU. *In situ* bioremediation of nitrate is also under consideration as part of source area optimization efforts. One scenario would be to use an existing well or install a new well to inject both the nitrate-bearing effluent and a carbon source (e.g., sodium lactate) to facilitate *in situ* bioremediation.

Figure 4 presents the hydraulic capture zones for the fully implemented ground water extraction and treatment remedy for the Building 854 OU. April 2007 data were used to prepare the ground water elevation contour map (Figure 4), since this is the most recent month in which ground water elevations were measured while all six extraction wells were operating. The capture zones depicted are based primarily on April 2007 ground water equipotential contours. For cases where control is sparse, a Thiem solution for steady-state radial flow in the vicinity of a pumping well was used to control the ground water elevation contours. The capture zones depicted on Figure 4 are also depicted on the second semester 2007 total VOC isoconcentration contour map in Figure 10. As can be seen on Figure 10, the highest total VOC concentrations in ground water above the 5 μg/L TCE MCL is captured by the extraction wellfield. Recommendations for further optimizing extraction, and thereby increasing hydraulic capture, are presented below for each treatment facility.

854-SRC GWTS – The 854-SRC GWTS began operation in December 1999 treating ground water to remove total VOCs and perchlorate. The GWTS has operated continuously, except for intermittent time periods due to weather related shut downs or when power outages occurred, electrical upgrades and GAC change-outs were performed, or pump and water level interlock problems were addressed. Ground water extraction was expanded in September 2006 from one well, W-854-02 extracting at a flow rate of approximately 1 gpm to include three additional wells, W-854-18A, W-854-17, and W-854-2218 extracting at an approximate combined flow rate of 2.5 to 3.0 gpm. The 854-SRC GWTS was constructed to initiate cleanup of the Building 854 source area, minimize further plume migration from the source area, and mitigate the VOC inhalation risk to onsite workers at Buildings 854A and F. Of the four current 854-SRC GWTS extraction wells, W-854-02 and W-854-2218 are relatively high yield, high mass removal wells. Wells W-854-17 and W-854-18A yield significantly less water and total VOC mass. Total VOC concentrations in extraction well W-854-02 have decreased from a pre-remediation maximum of 2,900 μg/L to 78 μg/L in the second semester of 2007. Total VOC and perchlorate mass removed from ground water by the 854-SRC GWTS are presented in Figures 7 and 8, respectively. To date, the facility has removed 4.7 kg of total VOCs and 120 g of perchlorate from ground water.

Extraction well W-854-02 is currently pumping at maximum capacity and should continue pumping at the current rate with no further modifications.

Extraction well W-854-2218 is capable of pumping at a higher yield. This well currently pumps at approximately 2 gpm and the pumping water level is typically at about 147 ft bgs. The screen bottom is at 165 ft bgs; therefore, there is still approximately 18 ft of available drawdown. Continued optimization efforts at 854-SRC will include increased pumping of extraction well W-854-2218 to maximize yield and further increase hydraulic capture. Increased pumping would require the installation of a higher capacity pump and would add to the total volume of 854-SRC GWTS effluent to be discharged. The effluent is currently discharged via misting towers, which are at or near capacity. Discharge of the additional effluent volume could be accommodated by either constructing more misting towers or by reinjecting into an upgradient well, which would have the added benefit of flushing the source area and recharging the $Tnbs_1/Tnsc_0$ HSU. If the additional effluent were to be reinjected, a carbon source (e.g. lactate) would need to be added to the injected effluent to facilitate *in situ* bioremediation of nitrate in the effluent.

Extraction well W-854-18A is currently pumping at maximum capacity and should continue pumping at the current rate, with no further modifications.

Extraction well W-854-17 (located 70 ft east of W-854-02) is currently pumping at maximum capacity. However, due to its low yield, this well is not significantly contributing to source area cleanup, and is under consideration to be taken offline as an extraction well.

Monitor well W-854-09 was installed in July 1996. This well was originally proposed to be converted to an extraction well as part of the 2006 854-SRC extraction wellfield expansion project. However, by May 2006, TCE concentrations in ground water samples from this well had been reduced from an historical maximum of 28 μg/L to below the 0.5 μg/L detection limit. Therefore, it was decided not to convert monitor well W-854-09 to an extraction well as part of the wellfield expansion. Since that time, TCE has been detected in ground water samples from this well at concentrations ranging from 7.4 μg/L to 9.1 μg/L. These concentrations indicate that the May 2006 ground water sample (<0.5 μg/L) may be anomalously low. Concentrations in this well will continue to be monitored. If the concentration trend increases, well W-854-09 may be converted to a 854-SRC GWTS extraction well. However, W-854-09 would not be considered for conversion to an extraction well until after the flow rate and hydraulic capture of 854-SRC and 854-PRX extraction wells have been upgraded as recommended in Section 9. Given the schedule for this extraction well field upgrade (Fiscal Year 2010) and the time required to evaluate its performance, the decision to convert W-854-09 to an extraction well will most likely be made during preparation of the next five-year review for this OU.

854-PRX GWTS – The 854-PRX GWTS began operation in November 2000 treating ground water to remove VOCs, perchlorate, and nitrate. The GWTS has operated continuously, except for intermittent periods when electrical upgrades and GAC change-outs were performed, pump replacement or repairs occurred, or freeze protection measures were taken. Ground water is extracted at an approximate flow rate of 1 gpm from well W-854-03 (the only extraction well connected to this facility). The facility was constructed to capture the proximal and distal portions of the ground water plume emanating from the Building 854 source area and prevent further migration of ground water contaminants in the $Tnbs_1/Tnsc_0$ regional HSU. Total VOC concentrations in W-854-03 have decreased from a pre-remediation maximum of 270 μg/L to 37 μg/L in the second semester of 2007. Total VOC and perchlorate mass removed from ground water by the 854-PRX GWTS is presented in Figures 7 and 8, respectively. To date, the facility has removed 0.49 kg of total VOCs and 81 g of perchlorate.

As part of ongoing optimization efforts in early 2007, pumping from extraction well W-854-03 was increased to 1.4 gpm after a new pump was installed and site power was added allowing this facility to operate on a 24-hour basis. At 1.4 gpm, the steady-state drawdown was only about 1 ft. With 19 ft of additional available drawdown, this well is capable of a much higher long-term yield. To test this well at a higher flow rate, a 6-hour test was performed on April 30, 2007 during which the well was pumped at 5 gpm, resulting in only 1 to 2 ft of drawdown. Given the low magnitude drawdown at 5 gpm during this test, this well appears to be capable of a much higher long-term flow rate than the current 1.4 gpm. However, increased pumping would require the installation of a higher capacity pump (at least 5 gpm) and would add to the total volume of effluent to be discharged to the aboveground containerized wetland biotreatment unit for nitrate removal prior to being discharged into an infiltration trench.

The performance of the 854-PRX GWTS is currently constrained by the limited capacity of the nitrate biotreatment unit and the infiltration trench. The additional flow through the 854-PRX GWTS as a result of increased pumping from extraction well W-854-03 could be addressed in the following ways:

- Increasing the efficiency of the biotreatment unit by adjusting the influent water temperature, cleaning and isolation of the flow through media to optimize biodegradation, additional nutrient injection, and/or optimization of the control and maintenance procedures,
- Increasing the size of the biotreatment unit,
- Supplementing the biotreatment unit with misting towers, and/or
- Replacing the biotreatment unit with misting towers.

Alternately, the biotreatment unit could be replaced by reinjection of nitrate-bearing effluent with *in situ* monitored natural attenuation of the nitrate. However, this would require modification of the selected remedy for nitrate in ground water through an Explanation of Significant Difference or ROD Amendment.

854-DIS GWTS – The 854-DIS GWTS began operation in July 2006 treating ground water to remove VOCs and perchlorate. The GWTS has operated continuously, except for intermittent time periods when electrical upgrades and GAC change-outs were performed, electrical repairs occurred, or freeze protection measures were taken. Ground water is extracted from one well (W-854-2139), at an instantaneous flow rate of 1.2 gpm when the solar-powered facility operates intermittently. However, the operational flow rate averaged over time is only about 0.02 gpm. The facility was constructed to capture the small contaminant plume in the vicinity of former Well 13, prevent further migration of ground water contaminants in the $Tnbs_1/Tnsc_0$ HSU, prevent further contaminant migration into the Ecological Preserve, and prevent contamination of Springs 10 and 11. Total VOC concentrations in extraction well W-854-2139 have decreased from a pre-remediation maximum of 59.6 μg/L to 42 μg/L in the second semester of 2007. VOCs have not been detected in Springs 10 and 11 since shortly after this GWTS became operational. To date, the GWTS has removed 0.0016 kg of total VOCs and 0.15 g of perchlorate. Extraction well W-854-2139 is currently pumping at maximum capacity. This facility should continue pumping at the current rate, with no further modifications.

Overall, analytical data and capture modeling indicate that the primary objectives of interim remedy in the Building 854 OU will be met including: (1) removal of contaminant mass from the Building 854 source area, (2) mitigation of the VOC inhalation risk to onsite workers at Buildings 854A and F, and (3) preventing further migration of ground water contaminants in the $Tnbs_1/Tnsc_0$ HSU. On going optimization efforts will improve the performance of the extraction wellfield, increase hydraulic capture, and continue removing contaminant mass.

6.5.4. Risk Mitigation Remediation Progress

The baseline risk assessment was presented in the Site-Wide Remedial Investigation (Webster-Scholten et al., 1994) and updated in the Site-Wide Feasibility Study (Ferry et al., 1999). A baseline cancer risk for onsite workers of 1×10^{-5} was calculated for the inhalation of VOCs into outdoor air at Building 854F. The remediation in the Building 854 OU mitigated this risk prior to the implementation of the CMP risk evaluations beginning in 2003. The risk evaluations performed for the 2003 and 2004 Annual Compliance Monitoring Reports indicated there was no longer an onsite worker risk from the inhalation of VOCs volatilizing from the subsurface into outdoor air in the vicinity of Building 854F.

A baseline cancer risk for onsite workers of 9.3×10^{-6} was calculated for the inhalation of VOCs that volatilize from the subsurface soil into the indoor air of Buildings 854F. Building 854F was demolished in 2005, removing the exposure pathway and risk.

An unacceptable cancer risk ($>10^{-6}$) for on-site workers was calculated for inhalation, ingestion, and dermal contact with PCB contaminated surface soil from the former Building 855 lagoon. The excavation of contaminated soil in 2005 mitigated this risk.

A baseline cancer risk for onsite workers of 1.0×10^{-6} was calculated for the inhalation of VOCs that volatilize from the subsurface soil into the indoor air of Buildings 854A. Remediation in the Building 854 OU mitigated this risk in 2005. The risk evaluations performed for the 2005 and 2006 Annual Compliance Monitoring Reports indicated there was no longer an onsite worker risk from the inhalation of VOCs volatilizing from the subsurface into indoor air inside Building 854A.

No unacceptable hazard to ecological receptors has been identified in the baseline ecological assessment. However, as described in 2003 Annual and First Semester 2004 Compliance Monitoring Reports, PCBs, dioxin, and furan compounds were detected in a lagoon adjacent to Building 855. In general, the very limited extent of the PCB, dioxin and furan contamination would preclude significant ecological impact due to the limited potential for exposure. However, the lagoon does act as a water catchment during the winter months when it may contain standing water. Both California tiger salamanders and California red-legged frogs are known to reside in springs and pools in the general vicinity of Building 854. The lagoon could provide limited habitat for either species during the winter months. As discussed above, the contaminated soil was removed in 2005 mitigating any ecological risk.

6.5.5. New Sources, Releases, or Contaminants

Ground water and soil vapor data indicate that there are no new sources, releases or contaminants in the Building 854 OU.

6.5.6. New Technology Assessment

No new technologies have been identified that are capable of accelerating or achieving cleanup in a more cost-effective manner in the Building 854 OU.

7. Technical Assessment

The protectiveness of the Building 854 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.

This review determined that the remedy for the Building 854 OU was protective, based on the following:

- On April 19, 2003, the California Code of Regulations, Title 22, Section 67391.1 was adopted that contains requirements for imposing legal limitations on future site uses and activities through a land use covenant. However, there is no impact on the protectiveness of the remedy related to this new requirement for a land use covenant at the time of property transfer. In addition, the State of California enacted an MCL for perchlorate on October 18, 2007. There have been no other changes in location-, chemical-, or action-specific ARARs or to-be-considered requirements since the Interim Site-Wide ROD for Site 300 was signed, nor have there been changes in exposure pathways, toxicity, and other contaminant characteristics.
- There have been no changes in land, building, or water use in the Building 854 OU since the Interim Site-Wide ROD for Site 300 was signed that impact the protectiveness of the remedy.
- All required institutional controls are in place and no current or planned changes in land use at the site suggest that they are not or would not be effective.
- Ground water and soil vapor extraction and treatment are effectively reducing contaminant concentrations and mass in the subsurface. The maximum total VOC concentration in ground water has decreased by two orders of magnitude. To date, approximately 5.2 kg of total VOCs have been removed from ground water and 7.9 kg from vapor.
- Ground water and vapor treatment systems are performing as designed and will continue to be operated and optimized. Optimization may include installing higher capacity pumps to maximize yield and capture, upgrading treatment facilities to accommodate increased flow, and adding additional effluent discharge technologies, including injection wells and misting towers, where appropriate.
- System operation procedures are consistent with requirements.
- Costs have generally been within budget, except when extra costs were incurred to address unanticipated problems or regulatory requests.
- No early indicators of potential interim remedy failure were identified.
- The Health and Safety Plan and Site-Wide Contingency Plan are in place, sufficient to control risks, and properly implemented.
- There have been no changes in risk assessment methodologies that would call the protectiveness of the remedy into question.
- No additional information has been identified that would call the protectiveness of the remedy into question.

8. Deficiencies

No deficiencies in the remedy were identified during this evaluation.

9. Recommendations and Follow-Up Actions

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

1. Increase pumping 854-SRC GWTS extraction well W-854-2218 to maximize yield and increase source area capture. This may include replacing the pump, and handling additional effluent discharge by constructing more misting towers or by reinjecting the effluent into a well upgradient of the source area. If the additional effluent were to be reinjected, a carbon source (e.g. lactate) would need to be added to the injected effluent to facilitate *in situ* bioremediation of nitrate.
2. Discontinue extraction from 854-SRC GWTS well W-854-17 due to extremely low yield.
3. Monitor total VOC concentrations in monitor well W-854-09. If concentrations remain above MCLs and show an increasing trend over time, convert well W-854-09 to an 854-SRC GWTS extraction well. However, W-854-09 would not be considered for conversion to an extraction well until after the flow rate and hydraulic capture of nearby extraction wells W-854-2218 (Recommendation 1) and W-854-03 (Recommendation 5) have been increased and sufficient time has been allowed for performance evaluation. This decision will most likely be made during preparation of the next five-year review for this OU. Any changes will be documented in the Recommendations and Follow-up Actions Section.
4. Continue operation of 854-SRC SVTS extraction wellfield with periodic rebound tests conducted in the future as specified in the SVE system shutoff criteria.
5. Increase the pumping rate of 854-PRX extraction well W-854-03 to maximize yield and increase hydraulic capture. This may include replacing the pump and handling additional discharge by increasing the size and efficiency of the biotreatment unit and/or adding misting towers to facilitate the increased discharge volume from this facility.
6. Monitor perchlorate concentrations in well W-854-45. DOE will evaluate data from this well to attempt to resolve some unusual temporal trends in ground water levels and perchlorate concentrations to confirm that they are representative of subsurface conditions. If this evaluation confirms that perchlorate concentrations detected in well W-854-45 are representative of subsurface conditions and that perchlorate concentrations persist above the 6 μg/L MCL, DOE will discuss *in situ* remedial technologies for perchlorate in the immediate vicinity of this well with the regulatory agencies. Any change to the remedy would be documented in an Explanation of Significant Differences (ESD).
7. Evaluate remedial options to remediate perchlorate in the vicinity of well W-854-1823. For example, DOE may evaluate *in situ* bioremediation by conducting a treatability study that would include hydraulic testing to determine the injection capacity of well W-854-1823, and the injection of a reagent (i.e., sodium lactate) to encourage microbial reduction of perchlorate to benign by-products. Any change to the remedy would be documented in an ESD.

8. If perchlorate concentrations continue to increase in wells W-854-45 and W-854-1823, additional investigation of the source and extent will be conducted. However, it is important to note that any investigation of extent of perchlorate ground water contamination would be limited due to steep topography and the presence of an ecological preserve in the area of these wells, and by restrictions on drilling in surface water drainage ways.
9. Continue to evaluate MNA as a remedial approach for nitrate in the downgradient proximal and distal areas of the Building 854 OU. *In situ* bioremediation of nitrate is recommended for the source area, such as injecting both the nitrate-bearing effluent and a carbon source (e.g., sodium lactate) to facilitate *in situ* biodegradation. Any change to the remedy would be documented in an ESD.

No other follow-up actions were identified related to this Five-Year Review. As discussed below, these recommendations do not affect the protectiveness of the remedy.

DOE will: (1) estimate costs and the timeframe necessary to accomplish the new work scope, (2) prioritize new work scope and present these priorities to the regulatory agencies, (3) incorporate the new work scope into upcoming fiscal year budget requests, and (4) develop a schedule for implementing the work.

10. Protectiveness Statement

The remedy at the Building 854 OU is expected to be protective of human health and the environment upon completion (i.e., when cleanup standards are achieved) for the site's industrial land use. In the interim, the remedy protects 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.

The cleanup standards for Building 854 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 upon completion.

The cleanup standards for VOCs in subsurface soil are to 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 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 EPA, the DTSC, and RWQCB as adequately showing no unacceptable risk for residential or unrestricted land use.

11. Next Review

The next statutory review will be conducted within five years of the signature date of this report (2013).

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13. Acronyms and Abbreviations

ARARs	Applicable or relevant and appropriate requirements
ATA	Advanced Test Accelerator
bgs	Below ground surface
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CMP/CP	Compliance Monitoring Plan/Contingency Plan
DIS	Distal
DOE	Department of Energy
DTSC	Department of Toxic Substances Control
EPA	Environmental Protection Agency
ft	Feet
g	Gram
GAC	Granular activated carbon
gpm	Gallons per minute
GWTS	Ground water treatment system
HE	High explosives
HMX	High-Melting Explosive
HSU	Hydrostratigraphic unit
kg	Kilogram
LLNL	Lawrence Livermore National Laboratory
MCL	Maximum Contaminant Level
mg/kg	Milligram per kilogram
mg/L	Milligrams per liter
MNA	Monitored natural attenuation
O&M	Operation and maintenance
OU	Operable unit
PCBs	Polychlorinated biphenyls
PCE	Tetrachloroethylene
$ppm_{v/v}$	Parts per million on a volume-to-volume basis
PRX	Proximal
Qls	Quaternary landslide deposits
RAOs	Remedial Action Objectives
ROD	Record of Decision
RPMs	Remedial Project Managers
RWQCB	Regional Water Quality Control Board
SARA	Superfund Amendment Reauthorization Act
scfm	Standard cubic flow per minute
SRC	Source
SVE	Soil Vapor Extraction
SVRA	Carnegie State Vehicular Recreation Area

TCDD	Tetrachloro-di-benzodioxin
TCE	Trichloroethylene
$Tnbs_1$	Tertiary Neroly Lower Blue Sandstone
$Tnbs_2$	Tertiary Neroly Upper Blue Sandstone
$Tnsc_2$	Tertiary Neroly Upper Siltstone/Claystone
Tps	Tertiary Pliocene nonmarine sediments
Tpsg	Tertiary Pliocene sand and gravel
VOCs	Volatile organic compounds
U.S.	United States
µg/L	Micrograms per liter

Figures

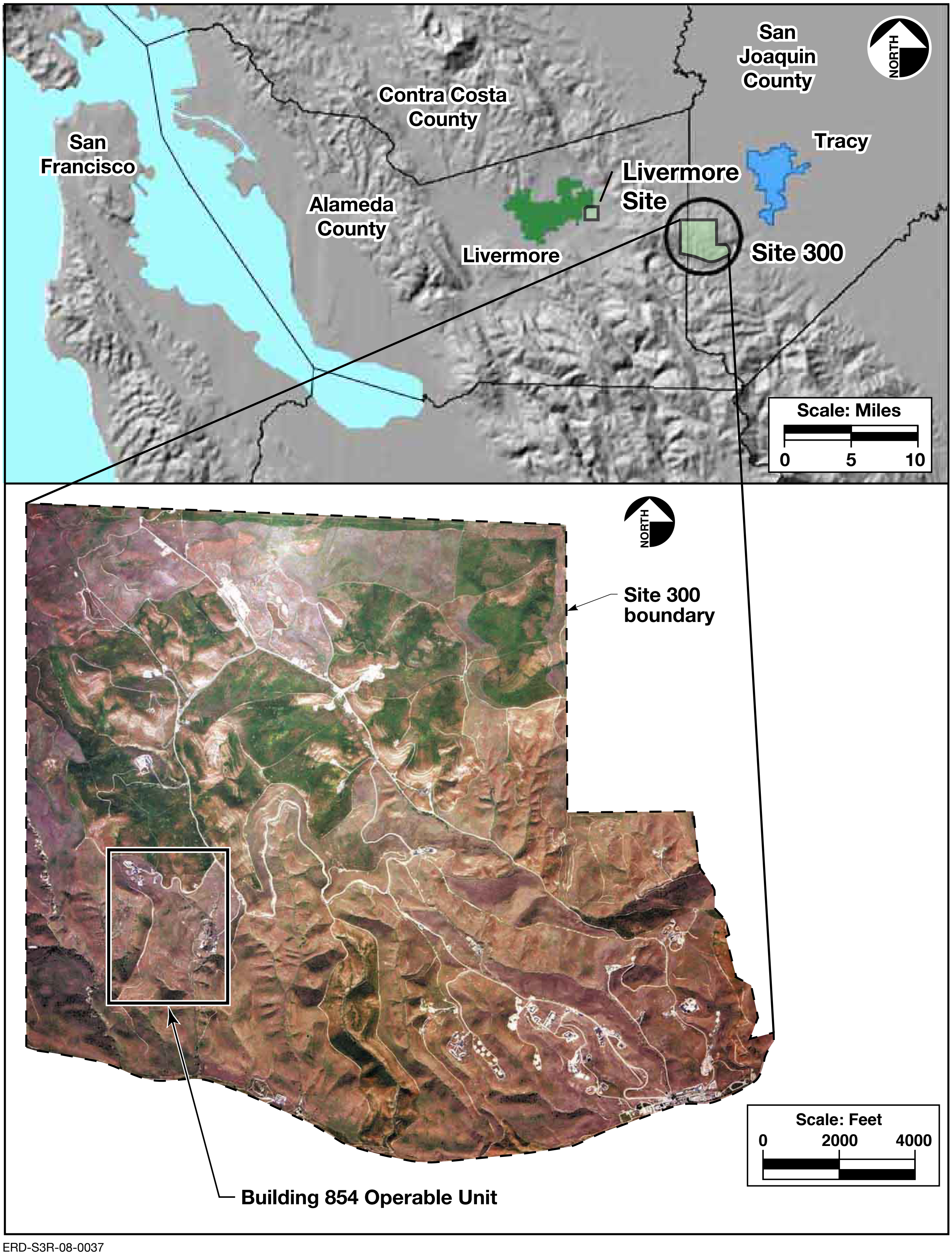

Figure 1. Location of LLNL Site 300 and the Building 854 Operable Unit.

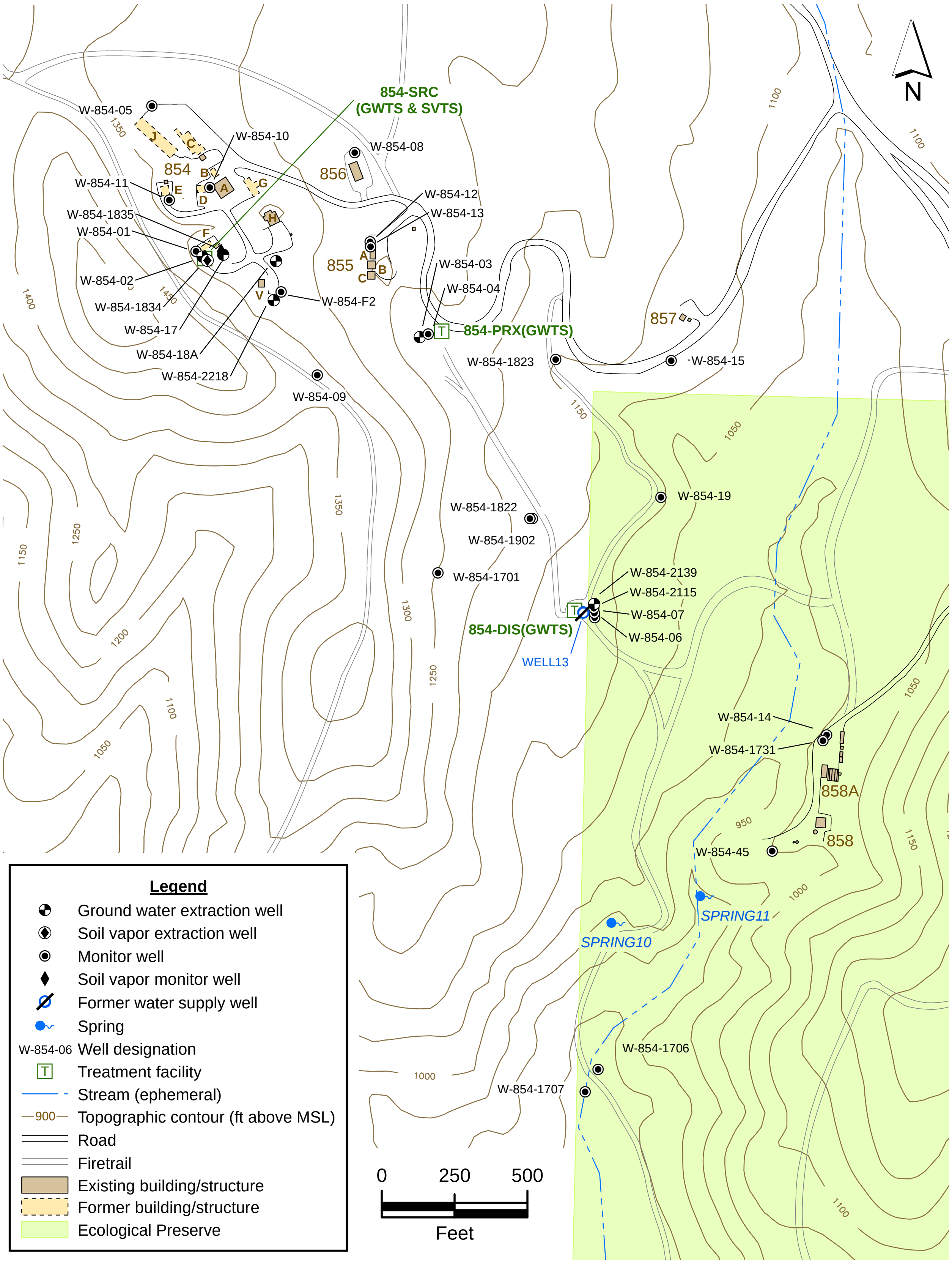

Figure 2. Building 854 Operable Unit site map showing monitor and extraction wells, former water-supply well 13, and treatment facilities.

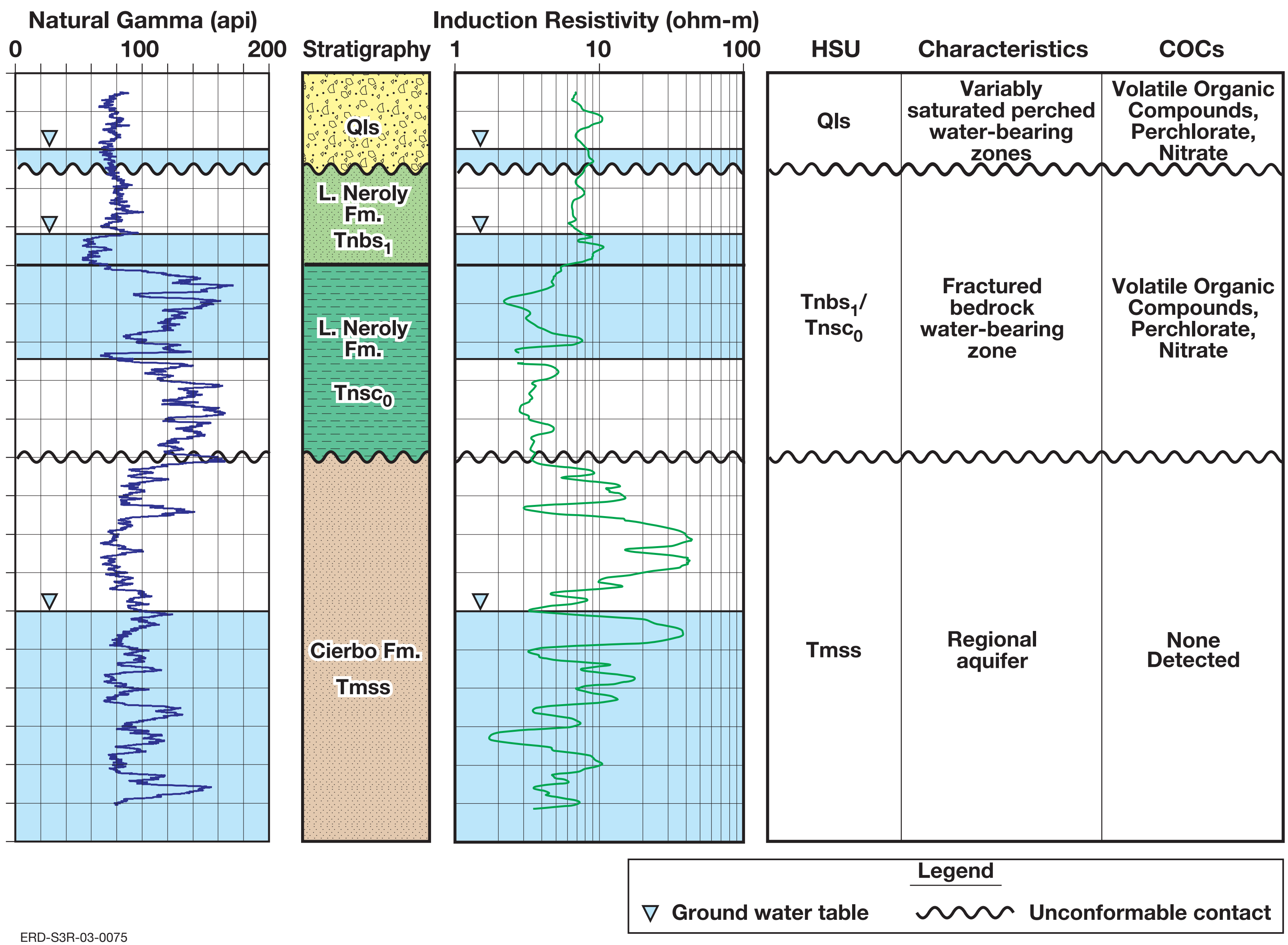

Figure 3. Summary of stratigraphy and hydrostratigraphy for the Building 854 Operable Unit.

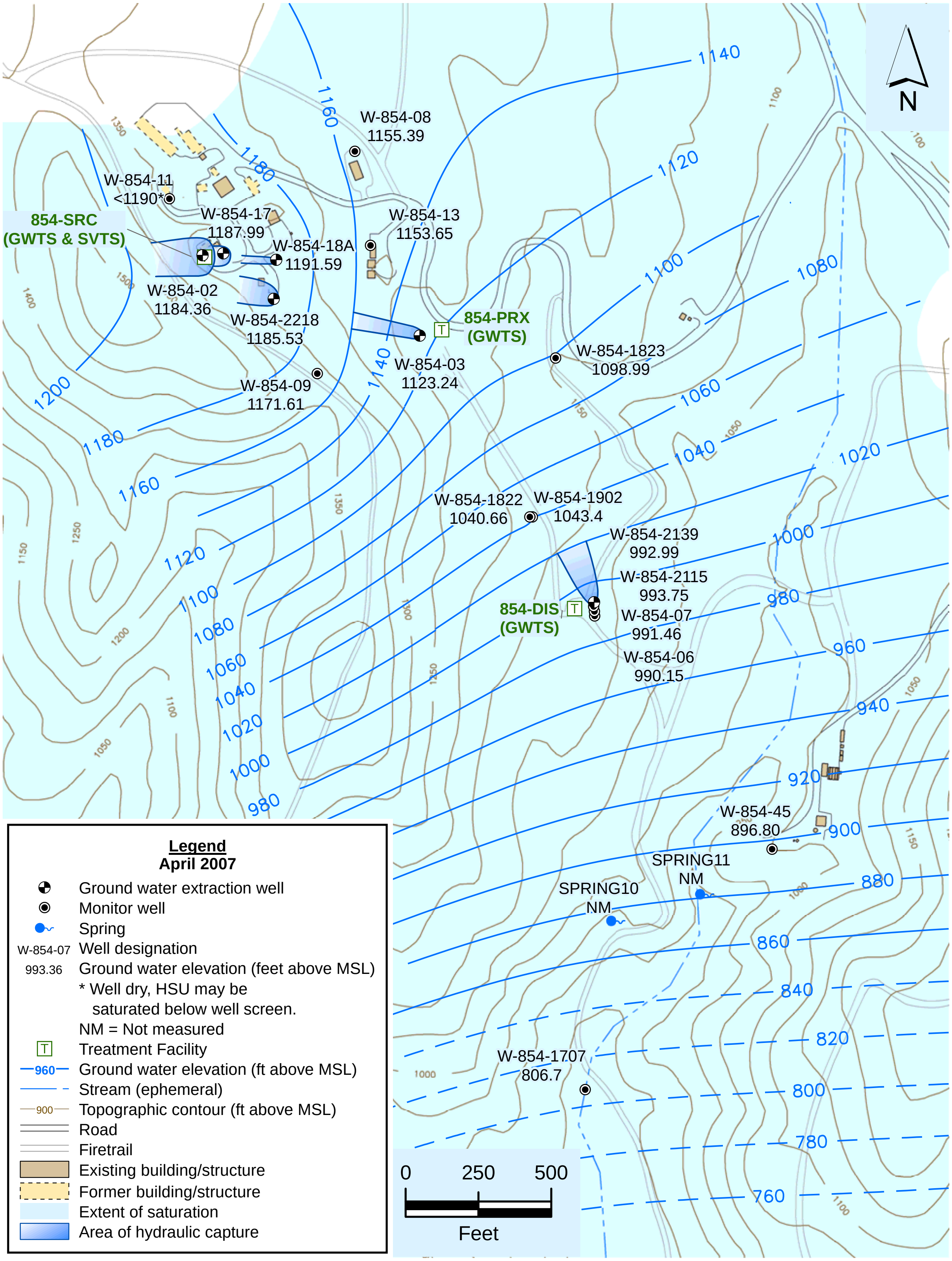

Figure 4. Ground water elevation contour map of the $Tnbs_1/Tnsc_0$ hydrostratigraphic unit in the Building 854 Operable Unit.

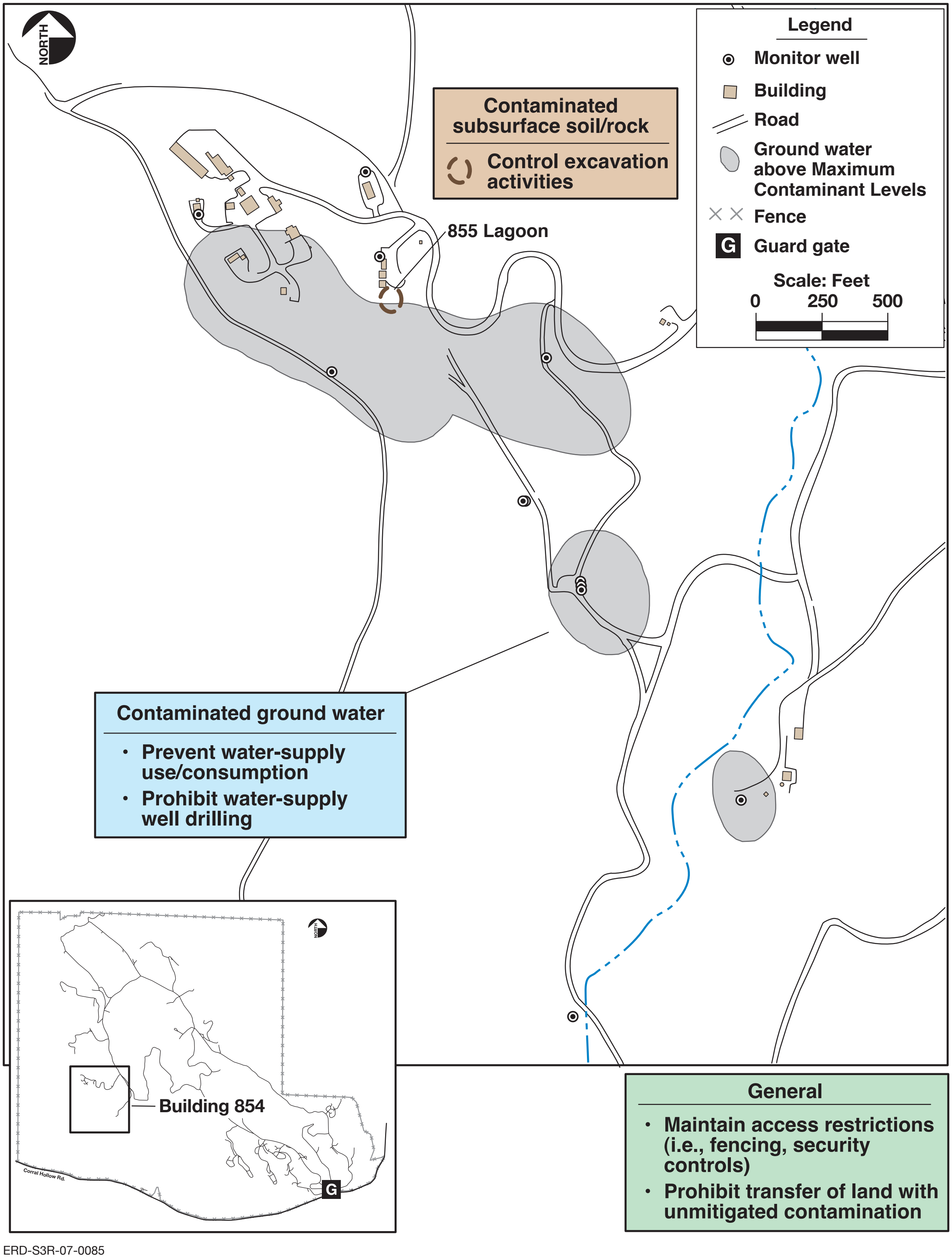

Figure 5. Building 854 Operable Unit institutional/land use controls.

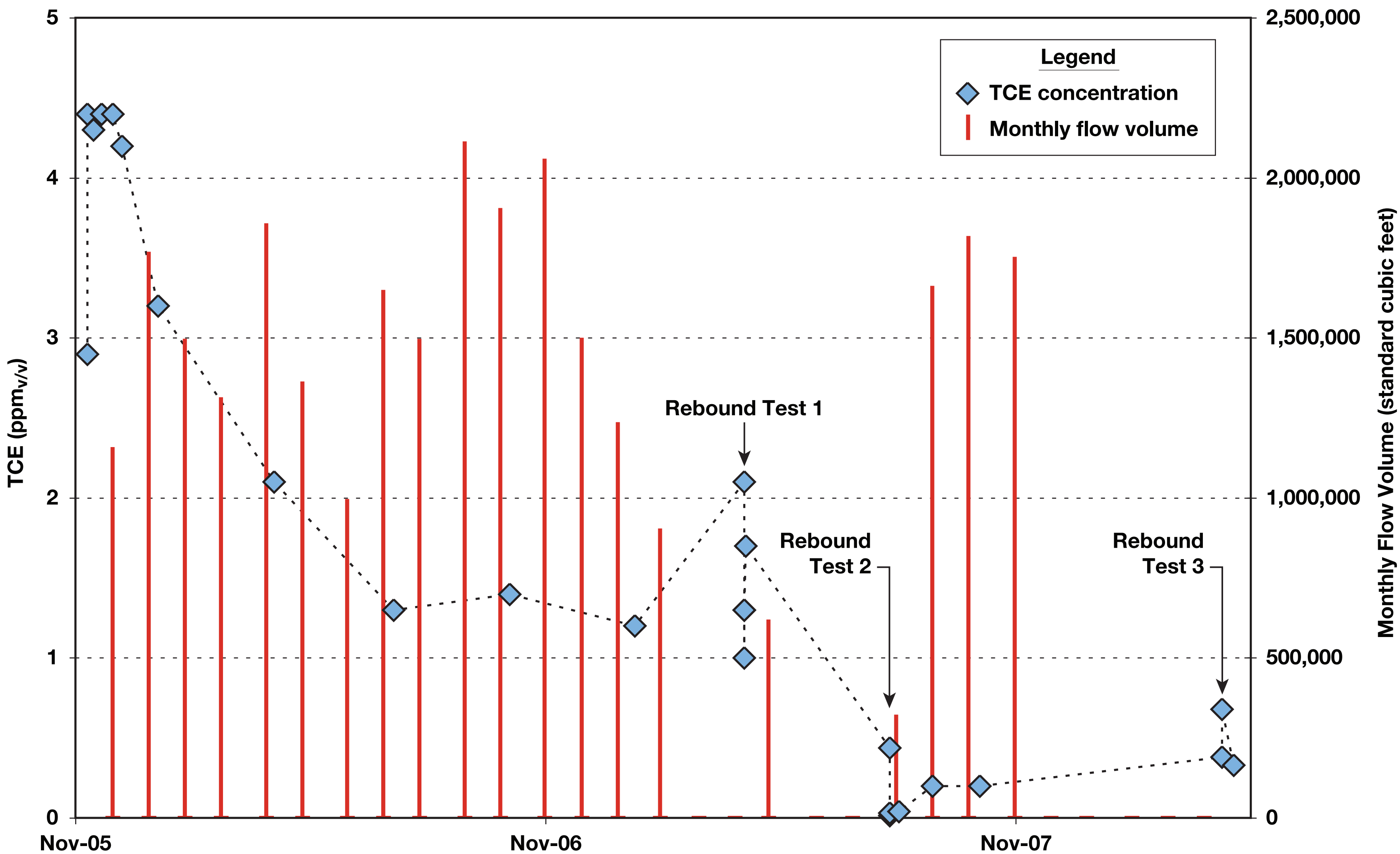

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Figure 6. Building 854-source soil vapor extraction and treatment system: operational history and historical trichloroethene (TCE) vapor concentrations in parts per million on a volume-to-volume basis (ppm$_{v/v}$).

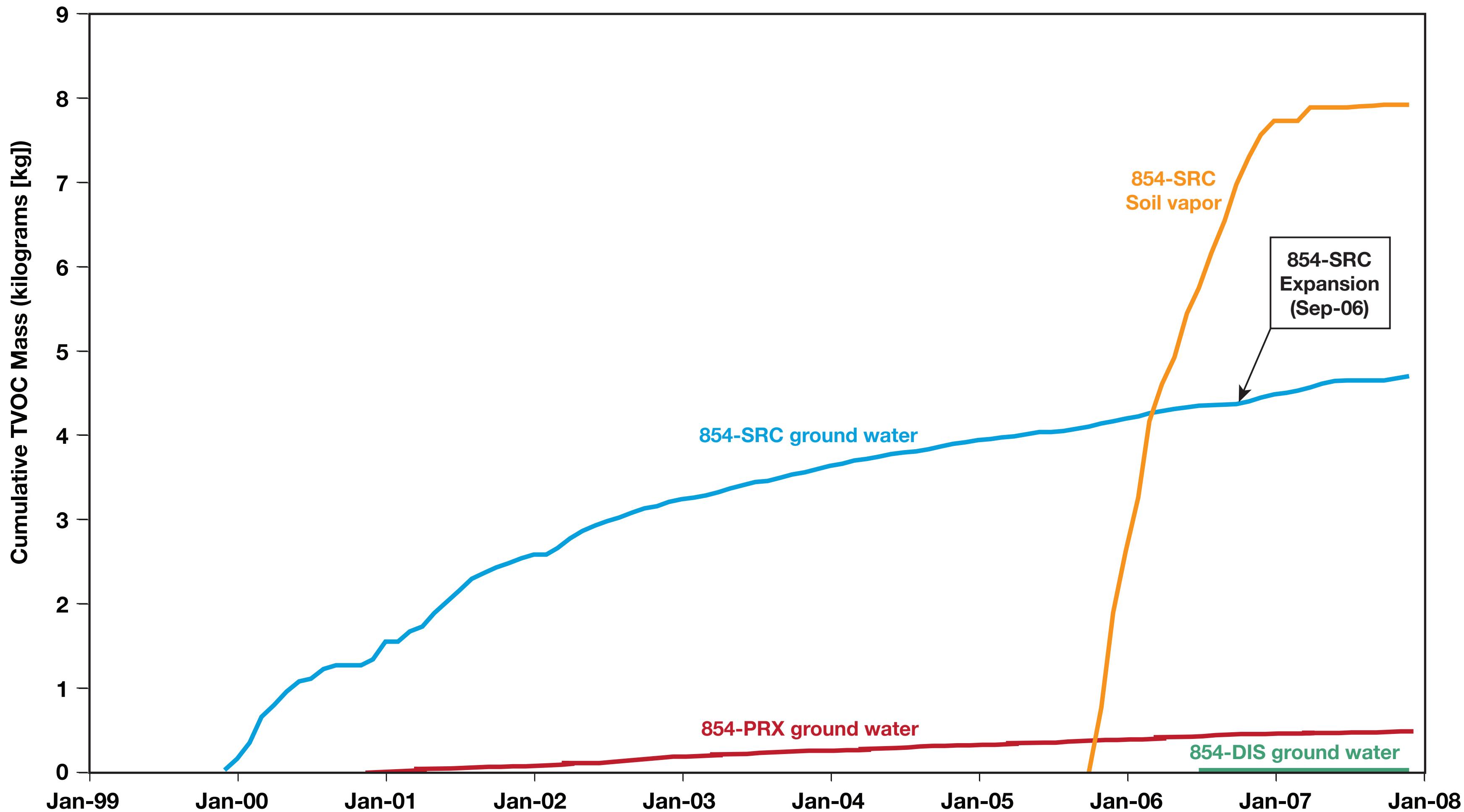

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Figure 7. Time-series plot of total volatile organic compounds (TVOCs) mass removed by treatment facilities in the Building 854 Operable Unit.

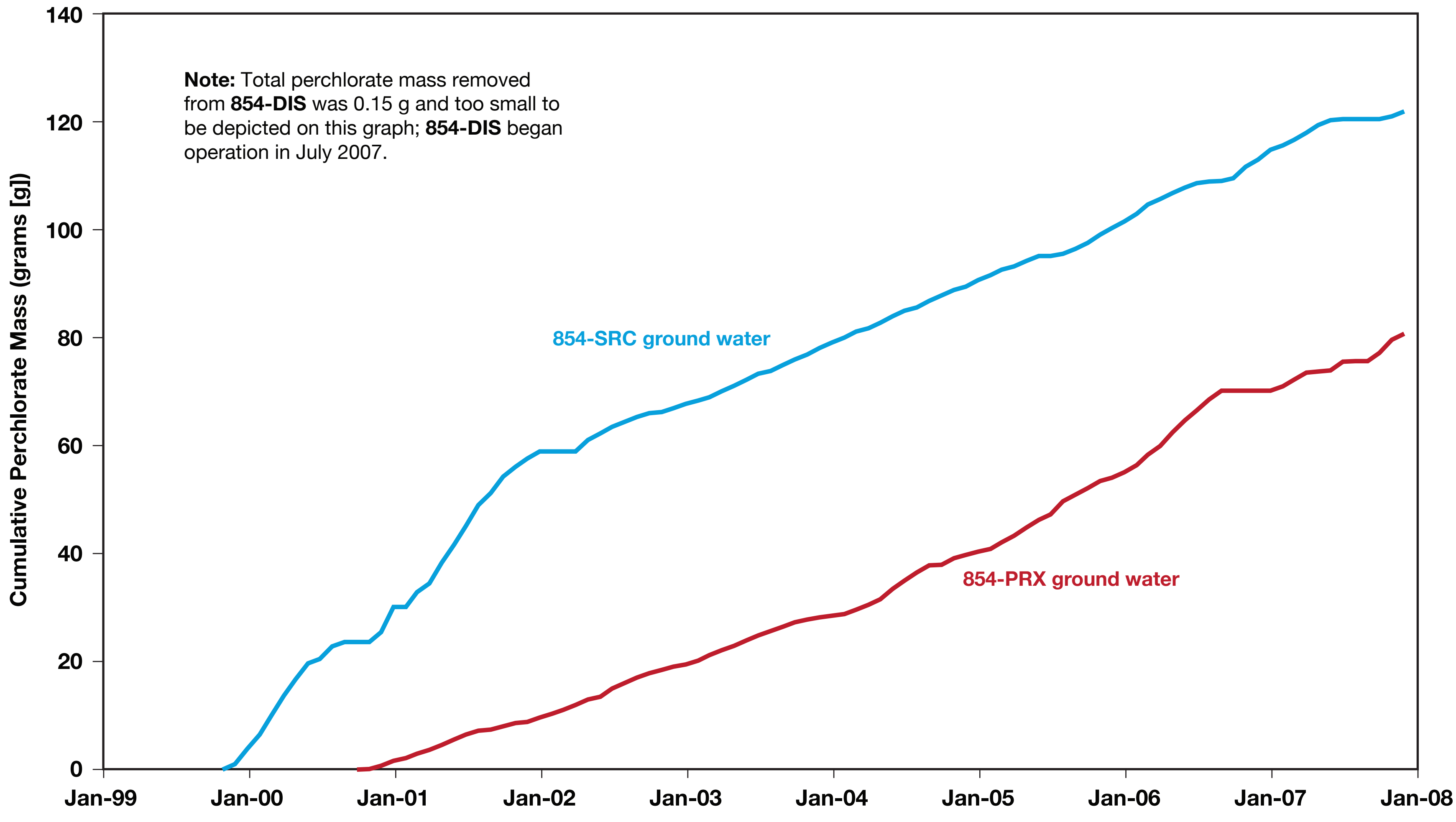

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Figure 8. Time-series plot of perchlorate mass removed by treatment facilities in the Building 854 Operable Unit.

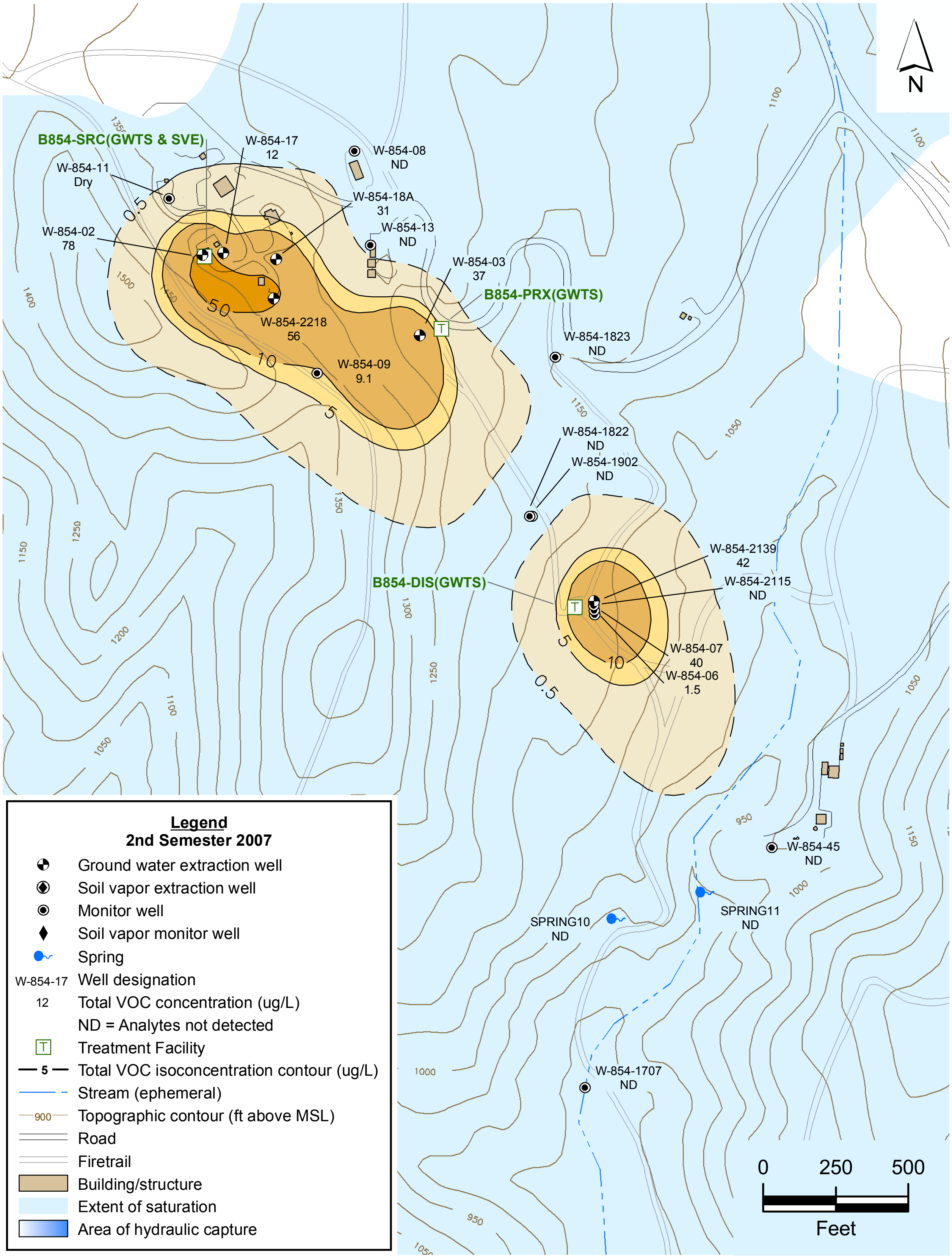

Figure 9. Building 854 Operable Unit total VOC isoconcentration contour map for the $Tnbs_1/Tnsc_0$ hydrostratigraphic unit (2nd semester 2007).

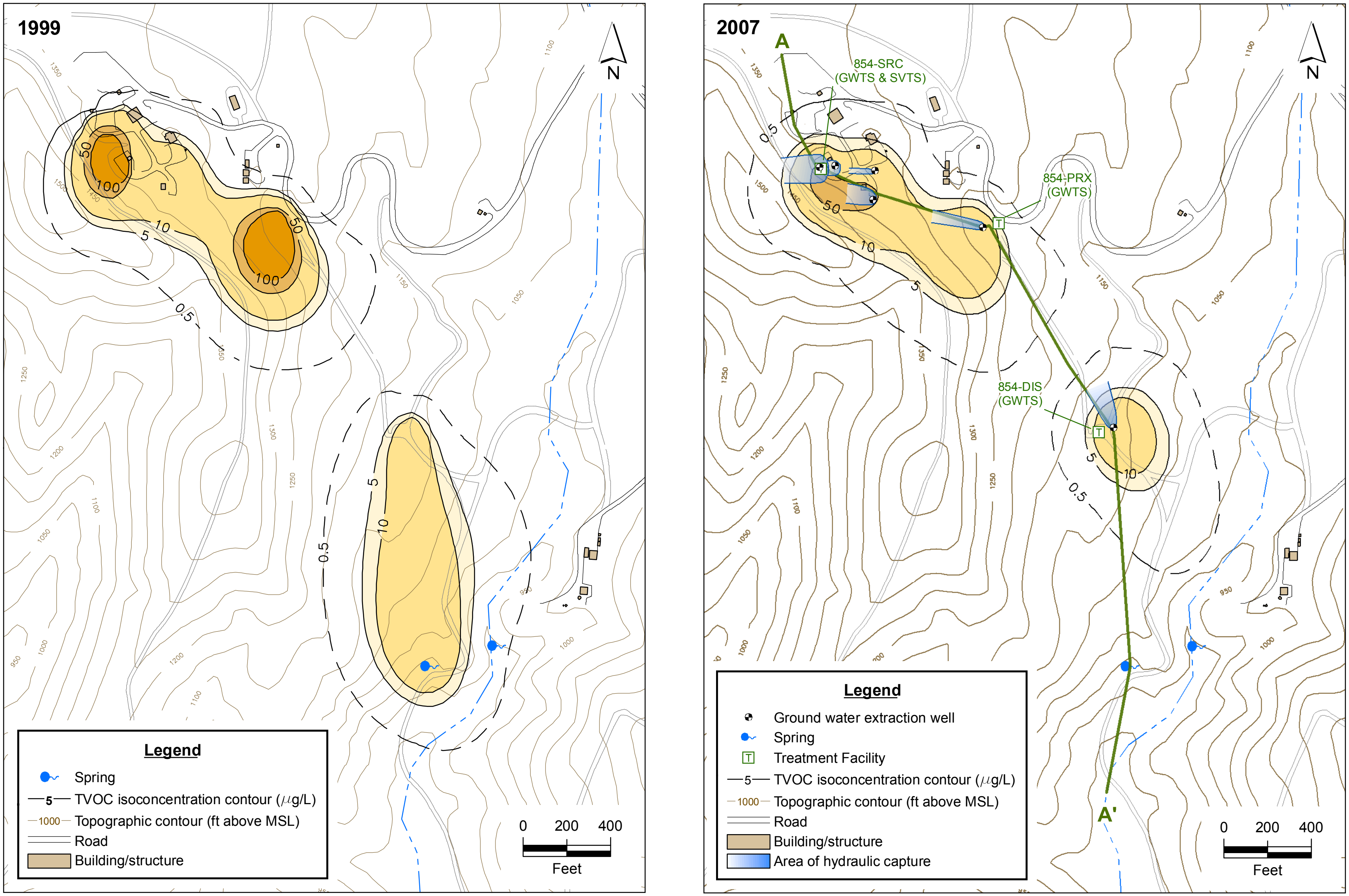

Figure 10. Comparison of the distribution of total volatile organic compounds (TVOCs) in ground water in the $Tnbs_1/Tnsc_0$ hydrostratigraphic unit in the Building 854 Operable Unit in 1999 and 2nd semester 2007.

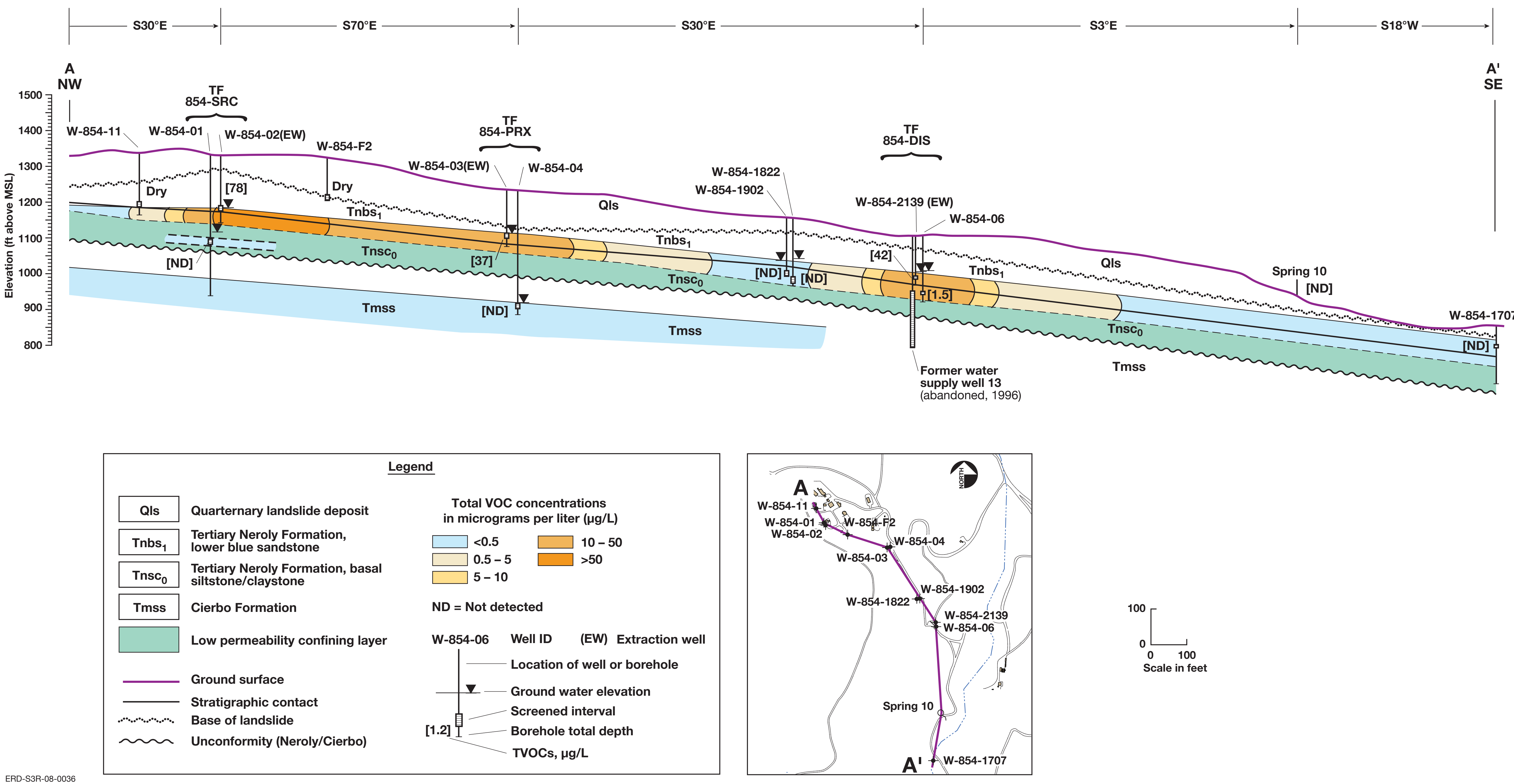

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Figure 11. Hydrogeologic cross-section of the Building 854 Operable Unit.

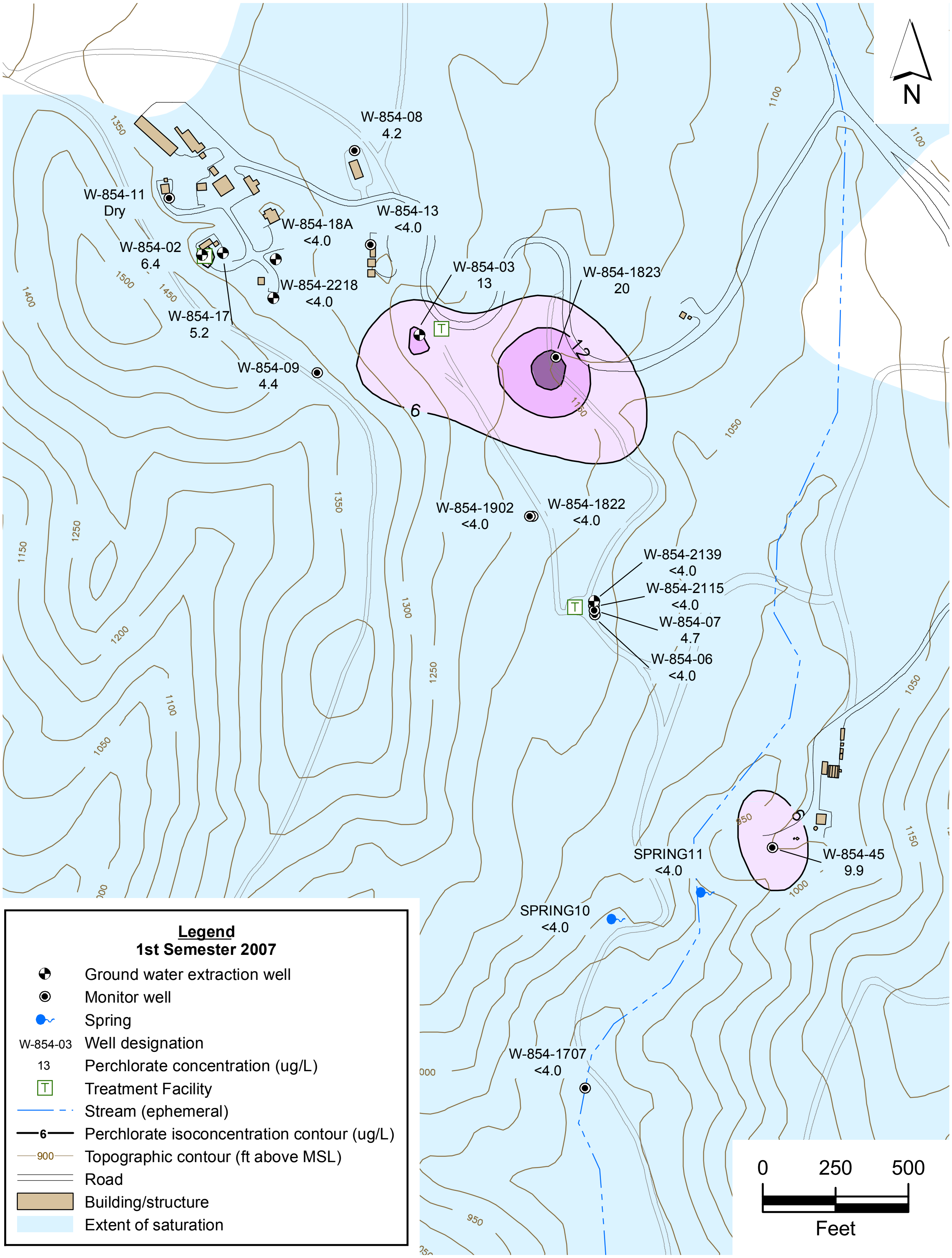

Figure 12. Building 854 Operable Unit perchlorate isoconcentration contour map for the $Tnbs_1/Tnsc_0$ hydrostratigraphic unit (1st semester 2007).

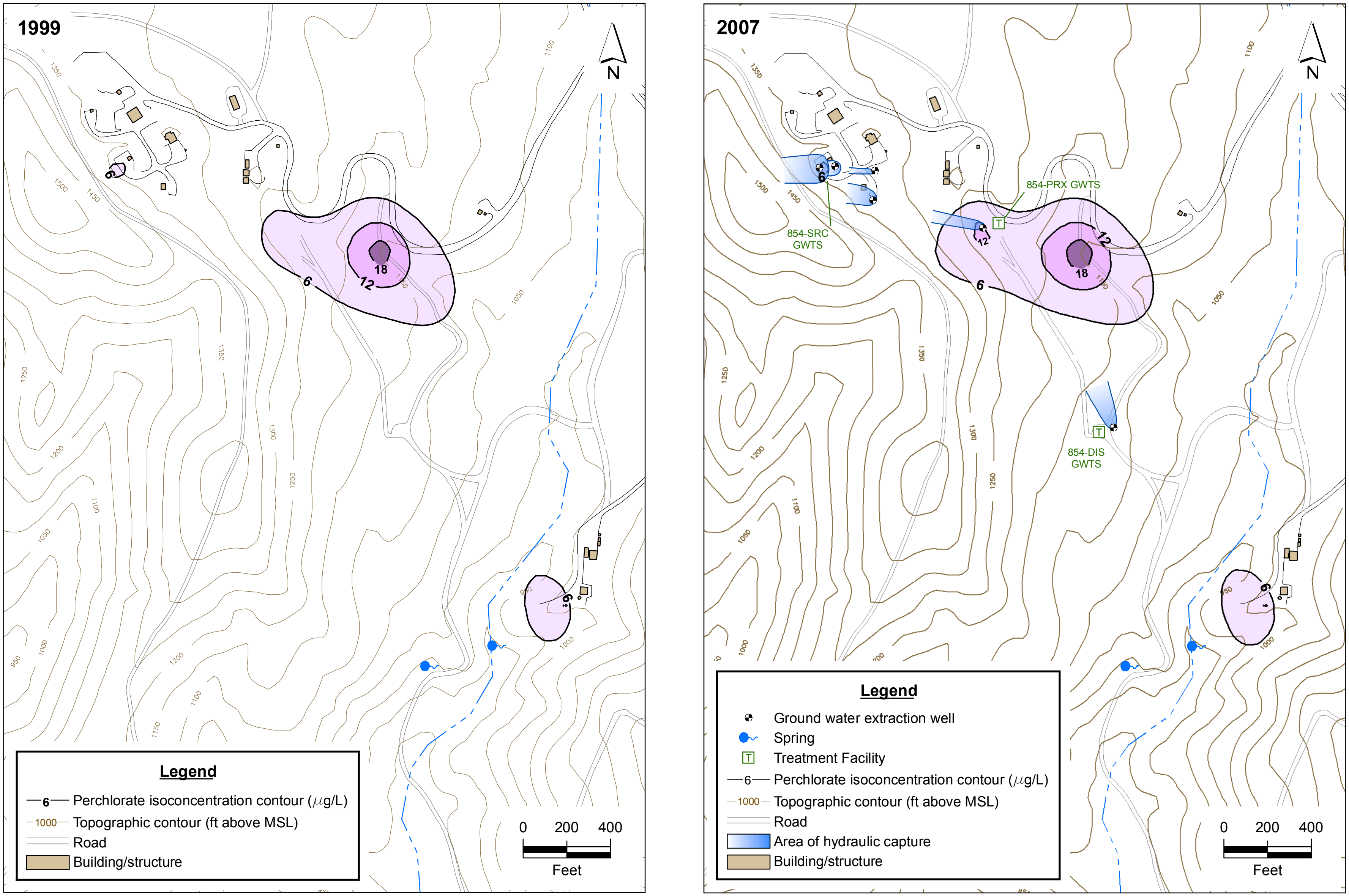

Figure 13. Time-series isoconcentration maps of perchlorate in ground water (1999 and 2007) in the Building 854 Operable Unit.

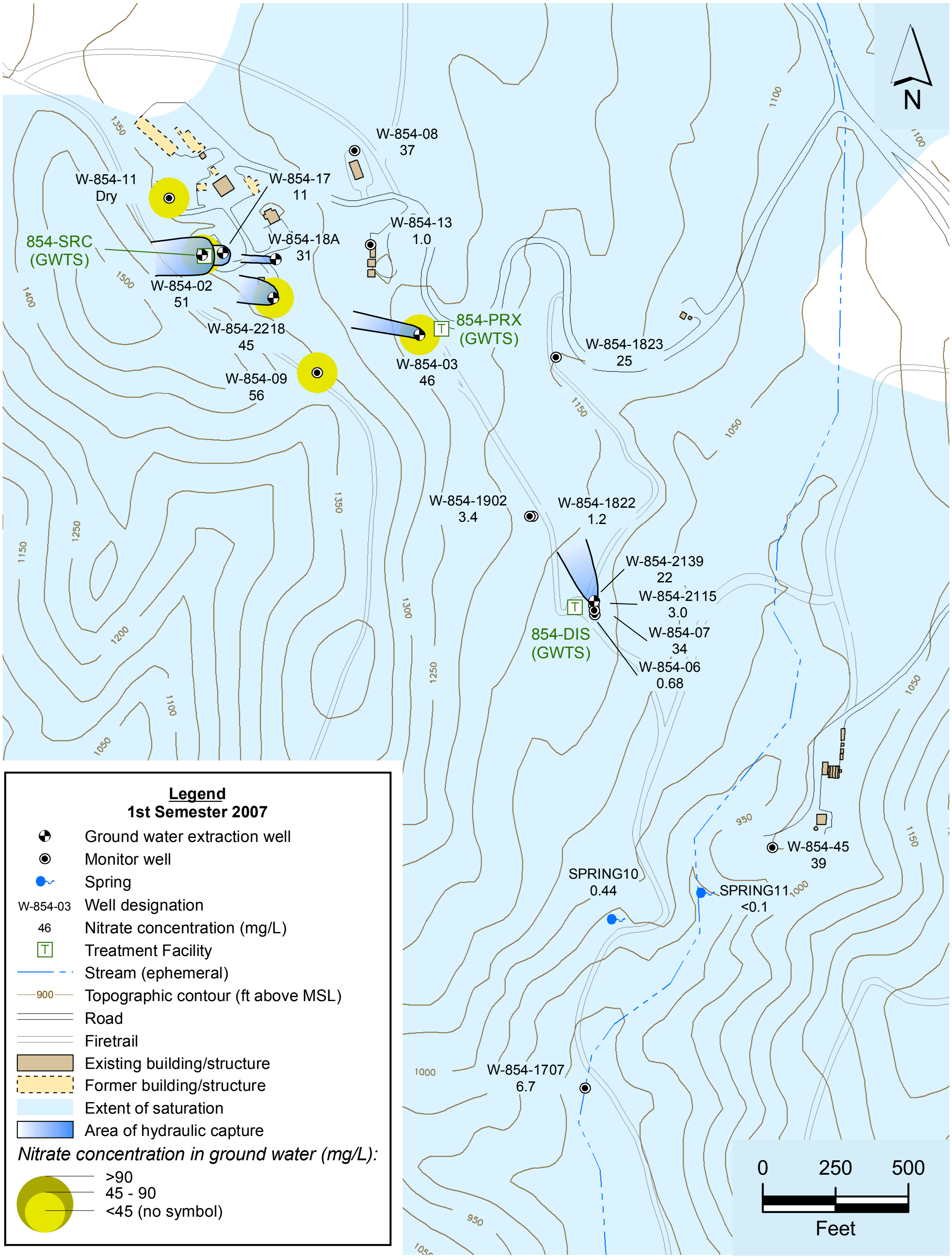

Figure 14. Nitrate concentration map in the $Tnbs_1/Tnsc_0$ hydrostratigraphic unit in the Building 854 Operable Unit (1st semester 2007).

Tables

Table 1. Actual annual costs for the Building 854 Operable Unit for fiscal years 2003 through 2007.

Fiscal Year	Annual Budget	Actual Annual Cost
2003	$613,830	$669,581
2004	$387,893	$168,624
2005	$621,889	$390,750
2006	$538,751	$615,361
2007	$495,033	$445,625

Table 2. Description of institutional/land use controls for the Building 854 Operable Unit.

Institutional/land use control performance objective and duration	Risk necessitating institutional/land use control	Institutional/land use controls and implementation mechanism
Prevent water-supply use/consumption of contaminated ground water until ground water cleanup standards are met.	VOCs, nitrate, and perchlorate concentrations in ground water exceeding cleanup standards.	There are no existing or planned water-supply wells in the Building 854 Operable Unit. Any proposed well drilling activities would be submitted to the LLNL Work Induction Board, and are reviewed by LLNL Environmental Restoration 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 and modeling indicates the plumes will not 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 VOCs in subsurface soil until it can be verified that concentrations do not pose an exposure risk to onsite workers.	Potential exposure to VOCs at depth in subsurface soil at the Building 854 Complex[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 LLNL Environmental Restoration to identify if there is a potential for exposure to contaminants in the proposed construction areas. If a potential for contaminant exposure is identified, LLNL Hazards Control ensures that hazards are adequately evaluated and the necessary controls are identified and implemented prior to the start of work. The Work Induction Board including the LLNL Environmental Analyst will also work with the Program proposing the construction project to determine if the work plans can be modified to move construction activities outside of areas of contamination. Controls for excavation activities will be incorporated into the LLNL Site 300 Integrated Strategic Plan or other appropriate institutional planning documents.

Table 2. Description of institutional/land use controls for the Building 854 Operable Unit. (Continued)

Institutional/land use control performance objective and duration	Risk necessitating institutional/land use control	Institutional/land use controls and implementation mechanism
Maintain building occupancy restriction to prevent onsite site worker inhalation exposure to VOCs inside Buildings 854A and 854F and outside Building 854F until annual risk re-evaluation indicates that the risk is less than 10^{-6}.	Pre-remediation risks of 1×10^{-6} and 9×10^{-6} for onsite workers from inhalation of VOCs volatilizing from subsurface soil into ambient air inside Buildings 854A and 854F, respectively and 1×10^{-5} for onsite workers from inhalation of VOC volatilizing into outdoor air in the vicinity of Building 854F.	Building 854F was demolished in 2005 removing the indoor air exposure pathway, therefore this institutional/land use control is no longer needed to prevent onsite worker exposure to VOCs in indoor air. The inhalation risks associated with outdoor air in the vicinity of Building 854F and Building 854A indoor air have been successfully reduced to less than 10^{-6} since 2004 and 2006, respectively, through ground water extraction and treatment, therefore this institutional/land use control is no longer needed to prevent onsite worker exposure to VOCs in Building 854F outdoor air and Building 854A indoor air.
Maintain land use restrictions at the former Building 855 lagoon until remediation of PCB-, dioxin-, and furan-contaminated soil reduces the risk to onsite workers to less than 10^{-6}.	A pre-remediation risk of 1×10^{-6} was identified for onsite workers inhalation or ingestion of resuspended particulates and dermal contact with PCBs, and dioxin and furan compounds in surface soil at the former Building 855 lagoon.	In 2005, PCB-, dioxin-, and furan-contaminated soil in the former Building 855 lagoon was excavated for offsite disposal as a remedial action. As a result, the risk to onsite workers was reduced to less than 10^{-6}. Therefore, this institutional/land use control is no longer needed to prevent onsite worker exposure to PCBs, and dioxin and furan compounds in soil at the former Building 855 lagoon. However, a very limited volume of subsurface soil remains at a depth of approximately 8 feet below ground surface with PCBs, and dioxin and furan compound concentrations above residential preliminary remediation goals. The land transfer prohibition control described below prevents exposure under a residential land use.
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 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.

Table 2. Description of institutional/land use controls for the Building 854 Operable Unit. (Continued)

Institutional/land use control performance objective and duration	Risk necessitating institutional/land use control	Institutional/land use controls and implementation mechanism
Prohibit transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use. *(continued)*		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 current U.S. EPA risk assessment guidance and is agreed by the DOE, U.S. EPA, DTSC, and RWQCB as adequately showing no unacceptable risk for residential or unrestricted land use. These restrictions will be incorporated into the LLNL Site 300 Integrated Strategic Plan or other appropriate institutional planning document.

Notes:

DOE = United States Department of Energy.

DTSC = California Department of Toxic Substances Control.

LLNL = Lawrence Livermore National Laboratory.

PCB = Polychlorinated biphenyl.

RWQCB = California Regional Water Quality Control Board.

U.S. EPA = United States Environmental Protection Agency.

VOCs = Volatile organic compounds.

[a] **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 VOCs in subsurface soil during excavation activities conservatively assume that the VOCs in subsurface soil may pose a risk to human health.**