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LLNL
Ground Water Project

1999 Annual Report

Technical Editors

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Environmental Protection Department
Environmental Restoration Program and Division

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Table of Contents

List of Figures

List of Tables

Appendices

Summary

Significant 1999 Livermore Site Ground Water Project (GWP) restoration activities included the following:

1. The Lawrence Livermore National Laboratory (LLNL) Livermore Site GWP submitted documents required by the Comprehensive Environmental Response, Compensation, and Liability Act and the Livermore Site Federal Facility Agreement. Fourteen documents or letter reports were submitted to the regulatory agencies in 1999, consisting of the 1998 Ground Water Project Annual Report, seven Remedial Project Manager's meeting Summaries, four quarterly self-monitoring reports, the updated Quality Assurance Project Plan, and a draft Explanation of Significant Differences describing changes to the ground water treatment system at Trailer 5475. All four 1999 U.S. Department of Energy (DOE)/LLNL Remedial Action Implementation Plan milestones were met on or achieved ahead of schedule.

2. The Community Work Group met once in 1999 to discuss the DOE budget, progress on the Livermore Site cleanup, and the Livermore Site Priority List/Consensus Statement.

3. DOE/LLNL met four times with members of Tri-Valley Communities Against a Radioactive Environment and their scientific advisor.

4. The GWP submitted 1,298 ground water samples for analyses that were collected during 905 sampling events.

5. LLNL provided oversight for surface geophysical studies and investigated magnetic anomalies in the East Traffic Circle Area as part of the settlement of the Natural Resources Defense Council's motion against the National Ignition Facility (NIF). Four shallow boreholes were drilled and one location was excavated to further investigate the possible presence of buried objects. Results of the subsurface investigation showed no indication of buried drums or a buried mass related to landfill activities.

6. LLNL supervised the excavation of seven test pits to explore for the possible presence of buried objects along the planned rerouting of the Drainage Retention Basin discharge pipeline near the northwest corner of the NIF site. No buried objects were discovered during the excavation.

7. Seven shallow confirmatory boreholes were drilled inside the East Traffic Circle following the discovery and removal of polychlorinated biphenyl (PCB)-contaminated soil excavated during a drainage improvement project. Soil samples collected from various depths within each borehole had PCB concentrations ranging from <1 to 133 parts per million in surface soil. Soil in the areas of highest concentration was excavated to depths of 0.5 to 1 ft and disposed at a regulated offsite facility.

8. Two slanted piezometers were installed at the vadose zone observatory in the southwest corner of the Treatment Facility A (TFA) area.

9. LLNL continued to use the three-dimensional ground water flow and contaminant transport model of hydrostratigraphic units 1B and 2 (HSU 1B and HSU 2) for remediation system performance evaluation and optimization. The model was used primarily to evaluate perchloroethylene and trichloroethylene transport in the TFA, Treatment Facility B (TFB), Treatment Facility C (TFC), and Treatment Facility G (TFG) areas. The HSU 1B and 2 ground water flow and transport model was converted from the Coupled Flow, Energy and Solute Transport (CFEST) computer code into the Finite Element subsurface FLOW system (FEFLOW) computer code. The 3-dimensional site-wide flow model was calibrated to measured ground water elevations, gradients, and volatile organic compound (VOC) plume distributions.
10. DOE/LLNL began evaluating electro-osmosis as a means to extract high concentrations of VOCs from fine-grained materials. Electro-osmosis will apply an electrical field in the subsurface by placing electrodes within wells. This electric field induces the migration of ground water containing VOCs. Electrochemical reactions affect the pH in the soil and ground water. These effects were evaluated using the reactive transport model code PHREEQC, Version 2. Model simulations will aid in the design of control mechanisms that will mitigate the potential adverse effects of electrochemical processes on system performance for the upcoming electro-osmosis deployment.
11. The 1999 extraction wells, extraction rates, and estimated VOC mass removed by the Livermore Site ground water treatment facilities and vapor treatment facilities in the TFA, TFB, TFC, TFD, TFE, TFG, TF406, TF518, and TF5475 areas are summarized in Table Summ-1. The estimated total VOC mass removal rate increased 31% from 1998.
12. Construction activities in 1999 included:
    - Construction of a vapor treatment facility at Trailer 5475 (VTF5475) was completed.
    - A solar treatment unit began operating at TFA-East.
    - A solar treatment unit began operating at Trailer 5475.
    - A portable treatment unit was installed at TFD South.
    - A portable treatment unit conducted remediation testing near the helipad in the TFD area.
    - Extraction well W-1423 was connected to TFB via a pipeline.
    - An electro-osmosis cell was instrumented and field tests were conducted at Treatment Facility F (TFF) under the Accelerated Site Technology Deployment Initiative for source area cleanup as part of Engineered Plume Collapse (EPC).
    - The Recharge Basin was reconditioned by ripping the basin floor to restore infiltration capacity, and constructing a concrete wall between the two cells of the basin to limit water infiltration from one cell to the other.
    - A barometric/wind pump for vadose zone wells was designed and tested.
13. Thirty-one wells installed in 1999 are listed in Table Summ-2.
14. Sixteen hydraulic tests conducted in 1999 are listed in Table Summ-3.

15. LLNL performed a recovery test on ground water elevations and VOC concentrations in wells completed in HSU 5 in the Building 518 area. Observed recovery rates suggest that very low rates of recharge are occurring in the southeastern corner of the site following a period of de-watering.

16. DOE/LLNL operated all facilities in the TFA, TFB, TFC, TFD, TFE, TFG, TF406, TF518, and TF5475 areas in 1999. A total of 69 ground water extraction wells operated at 20 separate locations at an average flow rate of 835,200 gal per day. Vapor treatment facilities VTF518 and VTF5475 operated at an average flow of 100,000 standard cubic ft per day. Together, these treatment facilities removed approximately 269 kg of VOC mass in 1999. Since initial operation, approximately 1,122 million gal of ground water and over 16 million cubic ft of vapor have been treated, removing more than 752 kg of VOCs.

17. The HSU 1B offsite VOC plume contours greater than the Maximum Contaminant Level (MCL) of 5 parts per billion (ppb) cover an area of approximately 20 acres. This is approximately one-third of its size in 1989 when our first ground water treatment facility began operating. The size of the HSU 2 offsite VOC plume over the MCL shows a reduction of 40 percent since 1989, and currently covers an area of about 62 acres.

    During the most recent sampling events, the highest VOC concentration in an HSU 1B offsite well was 15.4 ppb in November 1999 at well W-1425. The highest VOC concentration in an HSU 2 offsite well was 40.4 ppb in well W-903 in October 1999.

18. The Livermore Site VOC plumes were aggressively pumped as part of EPC in 1999. Changes in VOC concentrations were observed in response to ground water extraction. VOC concentrations in the HSU 1B, 2 and 3A plumes along the western margin of the Livermore Site continued to decline in response to ground water extraction. In HSU 1B in the TFA-offsite area, only well W-1425 contained VOC concentrations above MCLs. VOC concentrations near the TFA source area to the east continued to decline.

Table Summ-1. 1999 extraction wells, extraction rates, and estimated VOC mass removed.

Treatment facility area	Extraction wells	Extraction rate	Estimated total VOC mass removed (kg)
TFA	W-109, W-254, W-262, W-408, W-415, W-457, W-518, W-520, W-522, W-601, W-602, W-603, W-605, W-609, W-614, W-712, W-714, W-903, W-904, W-1001, W-1004, W-1009	220-312 gpm	14.0
TFB	W-357, W-610, W-620, W-621, W-655, W-704, W-1423	39-81 gpm	7.6
TFC	W-701, W-1015, W-1102, W-1103, W-1104, W-1116, W-1213	54-66 gpm	9.0
TFD	W-314, W-351, W-361, W-906, W-907, W-1206, W-1208, W-1215, W-1216, W-1301, W-1303, W-1306, W-1307, W-1308, W-1503, W-1504, W-1510, W-1551, W-1552	128-156 gpm	88.4
TFE	W-359, W-566, W-1109, W-1211, W-1409, W-1418, W-1422	59-65 gpm	38.1
TF406	GSW-445, W-1309, W-1310	9-19 gpm	1.0
TFG	W-1111	3.6-8 gpm	0.6
TF5475	W-1302, W-1415	1-2.6 gpm	1.7
VTF5475	SVI-EST-504	20 scfm	94.9
TF518	W-112	1-5 gpm	0.2
VTF518	SVI-518-201, SVI-518-303	18-50 scfm	13.1
1999 Total		514.6–714.6 gpm 38–70 scfm	268.6

Notes:

kg = Kilograms.

gpm = Gallons per minute.

scfm = Standard cubic feet per minute.

Table Summ-2. Livermore Site wells installed in 1999.

Treatment facility area	Well(s)
TFA	W-1509, SIP-INF-301, SIP-INF-302
TFB	None
TFC	None
TFD	W-1510, W-1511, W-1512, W-1523, W-1550, W-1551, W-1552, W-1553, W-1601, W-1602, W-1603, SIP-ETC-301, SIP-ETC-303
TFE	W-1505, W-1506, W-1507, W-1508, W-1516, W-1517, W-1518, W-1520, W-1522, SIP-ETS-601
TF406	W-1513, W-1514, W-1515, W-1519
TFG	None
TF518	None
TF5475	W-1604

Table Summ-3. Summary of 1999 hydraulic tests.

Treatment facility area	Well(s)
TFA	W-1107, W-1509
TFB	None
TFC	W-1427, W-1428
TFD	W-314, W-1502, W-1503, W-1504, W-1510, W-1550
TFE	W-274, W-1505, W-1506, W-1507
TF406	W-1514
TFG	None
TF518	W-1410
TF5475	None

1. Introduction

This report summarizes the 1999 Lawrence Livermore National Laboratory (LLNL) Livermore Site Ground Water Project (GWP) activities in five sections: Regulatory Compliance; Field Investigations; Ground Water Flow and Transport Modeling; Annual Summary of Remedial Action Program, including discussions of treatment facility activities; and Trends in Ground Water Analytical Results. The 1999 GWP quarterly self-monitoring reports (Bainer and Littlejohn, 1999d; 1999g: Bainer and Joma, 1999a; 2000) were issued separately.

Figures 1 and 2 show the locations of monitor wells, piezometers, extraction wells, and treatment facilities at the Livermore Site and vicinity, as well as other areas referenced in this report. Wells and boreholes drilled in 1999 are shown in larger type.

Appendices A through D present Well Construction and Closure Data, Hydraulic Test Results, the 2000 Ground Water Sampling Schedule, and the 1999 Drainage Retention Basin (DRB) Annual Monitoring Program Summary, respectively. Ground water volatile organic compound (VOC) analyses, water level elevations, and the Treatment Facility F/Treatment Facility 406 (TFF/TF406) area ground water fuel hydrocarbon (FHC) analyses are available on request.

2. Regulatory Compliance

In 1999, the U.S. Department of Energy (DOE)/LLNL submitted documents required by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Livermore Site Federal Facility Agreement (FFA). In addition, DOE/LLNL continued environmental restoration and community activities, as discussed below.

2.1. CERCLA Documents

As required by the FFA, DOE/LLNL issued the 1998 Ground Water Project Annual Report (Aarons et al., 1999) on March 23, 1999. DOE/LLNL also finalized and issued seven Remedial Project Managers' (RPMs') meeting summaries. Quarterly self-monitoring data were reported in letter reports (Bainer and Littlejohn, 1999d, 1999g; Bainer and Joma, 1999a, 2000). LLNL also issued an updated Quality Assurance Project Plan (Dibley, 1999).

A draft Explanation of Significant Differences was submitted on December 14, 1999 for regulatory review that described proposed changes to the ground water treatment system at Trailer 5475 to allow ground water containing both VOCs and tritium above their Maximum Contaminant Levels (MCLs) to go through an aboveground treatment unit (Berg, 1999).

DOE/LLNL started preparing a draft Action Memorandum (Berg and Bainer, 2000) for a time-critical removal action for soil containing residual polychlorinated biphenyls (PCBs) in the East Traffic Circle. The document will be finalized in 2000.

2.2. Milestones and Activities

Table 1 presents the 1999 Remedial Action Implementation Plan (RAIP) milestones (Table 5 in Dresen et al., 1993) for the Livermore Site. All four milestones were completed ahead of schedule.

Environmental Restoration activities in 1999 also included:

- Continuing to implement Engineered Plume Collapse (EPC) to accelerate mass removal and site cleanup at the Livermore Site. EPC incorporates hydrostratigraphic unit analysis, smart pump and treat, source isolation, and treatment of VOCs in fine-grained sediments.
- Conducting qualification phase experiments for electro-osmosis as part of the Accelerated Site Technology Deployment Initiative (McNab and Ruiz, 1999). Electro-osmosis will be deployed in 2000 for source area cleanup as part of EPC.
- Preparing sections of the National Ignition Facility (NIF) quarterly progress reports pursuant to a court Joint Stipulation and Order, in partial settlement of a Natural Resources Defense Council (NRDC) v. Richardson (DOE) lawsuit.
- Overseeing magnetometer surveys and investigating magnetic anomalies in the East Traffic Circle Area as part of the settlement of the NRDC motion for the NIF (Bainer and Littlejohn, 1999e,f).
- Reviewing magnetic survey results and excavating test pits along the route of the relocation of the Drainage Retention Basin (DRB) discharge pipeline near the northwest corner of the NIF (Bainer and Joma, 1999c).
- Disposing PCB-contaminated soil excavated from the East Traffic Circle (Bainer and Littlejohn, 1999a,c,e,f,h; DOE, 1999a,b,c,d).
- Preparing sections of, and attending Public Meetings for, the NIF Draft Supplemental Environmental Impact Statement (SEIS) (DOE, 1999d).
- Agreeing to a revised Livermore Site Consensus Statement/Priority List and the RAIP milestone schedule on April 16, 1999 (Bainer and Littlejohn, 1999b) with a second revision on December 3, 1999 (Bainer and Joma, 1999b).
- Renegotiating start-up sampling requirements, self-monitoring sampling requirements, and the location of the Treatment Facility A East and Treatment Facility G-1 receiving water station (Chou, 1999).
- Conducting a test to evaluate ground water elevation and VOC concentration changes after ceasing pumping in hydrostratigraphic unit 5 (HSU-5) in the Building 518 area.
- Designing and testing barometric/wind pumping for vadose zone wells.
- Investigating the cause of a decreased volume of soil vapor being extracted by Vapor Treatment Facility 518 (VTF518).
- Activating a portable treatment unit (PTU) in an area of high VOC concentrations in the Treatment Facility D (TFD) area.
- Coordinating with the developer of the property at the northwest corner of East Avenue and Vasco Road, south of Arroyo Seco, to identify wells that will need to be relocated due to a planned housing development.
- Starting construction of the Treatment Facility 518-North solar-powered treatment unit for an upcoming milestone in 2000.
- Monitoring and reporting ground water tritium concentrations in the Building 292 area (Bainer and Littlejohn, 1999f).
- Assuring that treatment facility operations are Y2K compliant.
- Participating in the Agency for Toxic Substances Disease Registry Site Team meetings regarding the 1998 soil sampling at Big Trees Park.

2.3. Community Relations

The Community Work Group (CWG) met once in 1999 to discuss the DOE budget, progress of the Livermore Site cleanup, and the Livermore Site Priority List/Consensus Statement. There was ongoing correspondence and communication with CWG members throughout the year. DOE/LLNL met four times with members of Tri-Valley Communities Against a Radioactive Environment (CAREs) and their scientific advisor as part of the activities funded by an Environmental Protection Agency (EPA) Technical Assistance Grant.

Other Livermore Site community relations activities in 1999 included communications and meetings with neighbors; local, regional and national interest groups; other community organizations; public presentations including those to local realtors, and to national and northern California peace leaders; producing and distributing the Environmental Community Letter; maintaining the Information Repositories and the Administrative Record; conducting tours of the site environmental activities; and responding to public and news media inquiries. In addition, community relations activities now allow for questions and responses via electronic mail, and include posting documents, letters and public notices on a public website at www-envirinfo.llnl.gov.

In 1999, DOE/LLNL submitted documents required by CERCLA and the Livermore Site FFA. In addition, DOE/LLNL continued environmental restoration activities as discussed below.

3. Field Investigations

3.1. Ground Water Sampling

In 1999, the GWP collected 1,298 water samples during 905 sampling events. The samples were analyzed for VOCs, FHCs, PCBs, metals, radionuclides, or combinations of these analytes depending on the compounds of concern.

Livermore Site ground water sampling frequency recommendations are updated quarterly using a cost-effective sampling algorithm that evaluates trends in contaminant levels in each well over an 18-month period. The sampling frequency is determined by the treatment facility Subproject Leaders based on algorithm results and other data. The main features of the algorithm that help to determine the sampling frequencies are based on the following criteria:

- Wells exhibiting little change [<10 parts per billion (ppb) per year] are sampled annually or biennially (every two years).
- Wells exhibiting moderate change (≥10 ppb but <30 ppb per year) are sampled semiannually (twice a year).
- Wells showing large annual change (≥30 ppb) are sampled quarterly.
- Wells with less than 18 months of analytical history are sampled quarterly for the first 18 months. Subsequently, algorithm logic and input from the Subproject Leaders for each treatment facility area determine the sampling frequency.

Sampling methods for the 1,298 samples collected from 400 wells and piezometers during the year vary depending on the yield of each well. Substantial cost reduction is achieved through the use of Low-Volume and Specific-Depth Grab Sampling methods and devices. Sampling methods used in 1999 were:

- Three volume pre-sample purge (three casing volumes removed by electric submersible pump prior to sampling): 549 locations.
- Low-volume pre-sample purge (less than one casing volume removed by electric submersible pump prior to sampling): 633 locations.
- Specific-Depth Grab Sampling (sample collected from a specific point within the screened interval with an EasyPump): 116 locations.

Wells located at the leading edge of VOC plumes are sampled quarterly using a three casing volume pre-sample purge method. The sampling schedule for 2000 is presented in Appendix C.

3.2. Source Investigations

Source investigations conducted in 1999 are discussed below by area.

3.2.1. East Traffic Circle Excavation and Related Boreholes

In October 1998, PCBs were discovered in soil excavated during a drainage improvement project (DOE, 1999a). The residual PCBs in the soil were believed to be from capacitors excavated during the East Traffic Circle (ETC) Landfill Closure in 1984. Following removal of the excavated soils, surface geophysical studies were conducted in and around the ETC in January and February 1999 to further investigate the possible presence of unidentified buried objects. Five magnetic anomalies were identified from a magnetometer survey which did not coincide with known buried utilities, requiring additional subsurface investigations.

Borehole SIB-NIF-201, located inside the ETC, was the first anomaly to be investigated (Fig. 2). Only debris typical of fill material was identified at depths of about 1.5 to 2.0 ft. No VOCs were detected in any of the samples. PCBs were detected in near surface samples at concentrations up to 17 ppm. To further asses the extent of residual PCBs in soil within the ETC, six additional boreholes (SIB-NIF-202 through SIB-NIF-207) were drilled to depths of 21 ft and sampled at various depths for VOCs, metals, radionuclides, and PCBs. Wood, concrete, ceramic, glass, and metal debris typical of fill material was identified in most of the boreholes at depths of approximately 1.5 to 2.0 ft. No VOCs were detected in any of the seven ETC boreholes. PCB concentrations in surface soil in the ETC ranged from <1 to 133 parts per million (ppm). Soil in the areas of highest concentration was excavated to depths of 0.5 to 1 ft and disposed at a regulated offsite facility (DOE 1999b,c).

Although not in the ETC, two boreholes were drilled in the Helipad area in March 1999 (DOE, 1999b). Boreholes SIB-NIF-208 and SIB-NIF-209 (Fig. 2) were drilled to depths of 21 ft and sampled at various depths for VOCs, metals, radionuclides, and PCBs to evaluate possible residual soil contamination where temporary waste-piles were created during the excavation and closure of the ETC Landfill in 1984. Sediment samples collected in 1984 contained PCB concentrations of 1.7 and 5.9 ppm in the vicinity of boreholes SIB-NIF-208 and SIB-NIF-209, respectively. No VOCs were detected in the sediment samples collected in 1999 from either borehole and PCB concentrations were <1 ppm (DOE, 1999b,c).

Borehole SIB-NIF-210 (Fig. 2) was drilled to a total depth of 21.5 ft in the center of and near the highest magnetic reading at a cluster of magnetic anomalies. No buried objects were encountered in the borehole and soil samples were collected for VOC, metals, PCB, and radiological analyses. No detectable concentrations of VOCs and no PCB concentrations above 1 ppm were detected in the sediment samples (DOE, 1999b). Metals were also within background values. Tritium, gross alpha, and gross beta were within background values (DOE, 1999c).

Boreholes SIB-ETC-301 and SIB-ETC-302 were drilled in April 1999 at locations that coincided with two additional magnetic anomalies (Fig. 2). Their locations were offset by about

20 ft from the centers of the anomalies due to logistical constraints. No metallic debris was observed in either borehole. Soil from SIB-ETC-301 contained no detectable VOCs. PCBs at 0.045 ppm were detected in the sample at 5 ft, which was below the EPA industrial Preliminary Remediation Goal (PRG) of 1.3 ppm for total PCBs. Unsaturated soil samples collected from SIB-ETC-302 contained no detectable VOCs, except for 0.002 ppm methylene chloride at 30 ft. No detectable PCBs were identified in sediment samples from SIB-ETC-302. Both boreholes were then advanced to depths of 100 ft and completed as piezometers as part of LLNL's continuing source investigation activities (DOE, 1999b).

On May 4, 1999, investigation began of the fifth magnetic anomaly in the center of Parking Lot E-5 where the geophysical surveys indicated a buried object about 40 ft long. A 5-ft square section of the asphalt parking lot was removed and the area was excavated (Fig. 2). A concrete slab was uncovered at a depth of 4 ft, which had cut-off I-beams imbedded at about 18-inch intervals. It is assumed that the concrete is a remnant of a foundation from a Navy-era or early LLNL building. Soil samples from boreholes for ground water monitoring wells surrounding the buried concrete slab showed no indication of soil contamination. The concrete slab was scanned using Geiger Muller, Air Proportion, and Fiddler detectors, which confirmed that there was no radioactive contamination (DOE, 1999b).

Results of the subsurface investigation showed no indication of buried drums or a buried mass related to landfill activities.

3.2.2. National Ignition Facility Related Boreholes/Test Excavations

On September 1, 1999, seven exploratory test pits were excavated to depths of 18 to 20 ft to investigate the possible presence of additional buried objects along a proposed route to relocate the DRB discharge pipeline near the northwest corner of the NIF (Bainer and Joma, 1999c). No buried objects were found in any of the test pits and the excavations were backfilled with the excavated soil.

3.2.3. Source Investigation in the Treatment Facility E Area

Piezometer SIP-ETS-601 was drilled and installed in the south-central portion of the Treatment Facility E (TFE) area to investigate an elevated TCE concentration in soil from a borehole drilled in the 1980s (Fig. 1). Elevated concentrations of VOCs, primarily TCE, were found in ground water bailed from the well, confirming the location of a suspected TFE source area.

3.2.4. Source Investigations at TFD

Three source investigation boreholes were drilled in the southeast portion of the TFD area in 1999. Boreholes SIB-ETC-301, SIB-ETC-302, and SIB-ETC-303 were drilled to better define the lateral and vertical extent of contamination within HSU-2 in the TFD-SE area. Borehole SIB-ETC-302 was originally completed as a piezometer, however the well casing failed during development and the well was destroyed by grouting it to the surface. The other two boreholes were completed as piezometers SIP-ETC-301 and SIP-ETC-303.

The Helipad source area is located northwest of the former ETC landfill in the eastern TFD area. Four wells (W-1550 through W-1553) were installed in this area during the summer of 1999 to further characterize the local hydrogeology and VOC concentrations in HSUs-3A and 3B. The wells were constructed for potential inclusion in a pilot test of electro-osmotic remediation of VOCs from the fine-grained sediments in a source area. In September 1999, wells W-1551 and W-1552 were connected to PTU-10 to remove and treat the elevated VOCs in ground water at the Helipad. The trichloroethylene (TCE) concentrations at the start of extraction in wells W-1551 and W-1552 were 6,188 ppb and 7,376 ppb, respectively.

4. Ground Water Flow and Transport Modeling

Ground water flow and contaminant transport models are used at the Livermore Site to optimize remediation system design and operation, to support ongoing subsurface characterization activities, and to improve our ability to forecast, monitor, and interpret the progress of the ground water remediation program. In 1999, we further developed our three-dimensional (3-D) ground water models for the Livermore Site, and began to evaluate the use of innovative technologies for source area remediation.

4.1. HSU 1B and 2 Model

In 1999, DOE/LLNL continued to use the 3-D ground water flow and contaminant transport model of HSUs 1B and 2 for remediation system performance evaluation and optimization. The HSU 1B and 2 model was used primarily to evaluate tetrachloroethylene (PCE) and TCE transport in the Treatment Facility A (TFA), Treatment Facility B (TFB), Treatment Facility C (TFC), and Treatment Facility G (TFG) areas. The model is used by LLNL Subproject Leaders, hydrogeologists, and engineers to:

- Optimize well extraction rates.
- Select pump sizes for wells.
- Analyze capture zones.
- Evaluate the interference patterns from increased pumping.
- Evaluate the impact of increased pumping on upgradient plumes.
- Forecast long-term cleanup scenarios.

In 1999, the HSU 1B and 2 ground water flow and transport model was converted from the CFEST (Coupled Flow, Energy and Solute Transport) computer code (Gupta et al., 1987) into the FEFLOW (Finite Element subsurface FLOW system) computer code (Diersch et al., 1998).

The HSU 1B and 2 model is a continuation of previous work by DOE/LLNL (Vogele et al., 1996; Demir et al., 1997). The 3-D flow model was calibrated to measured ground water elevation data collected from the Livermore Site monitor wells. These simulations are comprised of a series of remedial pumping time steps that reflect the extraction well pumping history and other significant hydrogeological conditions.

The model results and ground water concentrations observed in 1999 are compared on Figures 3 and 4. The model used the 1987 VOC plumes as the initial input and simulated transport to 1999. After twelve years of remediation, the observed plumes show a faster rate of cleanup than the model results, indicating that the assumptions used for the model were conservative. Despite the divergence in observed and simulated results, the model still proved useful during 1999 as a decision support tool as listed above. Future work on this model will include revising the model assumptions and calibration to better match the observed conditions.

4.2. Site-Wide Model for all HSUs

DOE/LLNL are developing a 3-D ground water flow and transport model for all Livermore Site HSUs using the FEFLOW computer code (Diersch et al., 1998) for remediation system performance evaluation and optimization. In 1999, work on the site-wide model primarily consisted of calibrating the model to observed ground water elevations, gradients, and VOC plume distributions. In addition, the model assumptions are being reviewed based, in part, on results from the HSU 1B and 2 model to better calibrate the model to the observed conditions.

Preliminary calibration results indicate good correlation during early time periods with moderate to no ground water extraction. However, in later time periods with high ground water extraction rates, the calibration is proving more difficult. During these higher extraction periods, the ground water elevations and VOC plume distributions are likely more influenced by the site heterogeneity than during the lower pumping rate periods. This is especially true in the deeper HSUs (HSUs 3A, 3B, 4, and 5) because of higher hydrogeological complexity such as strong permeability trends and variable vertical leakage between HSUs. In addition, there are less data available for the deeper HSUs. Future work on this model will include improving the hydrogeological input data sets to better calibrate the model to the observed conditions. The improvement of the hydrogeological data sets is primarily focused on more detailed boundary conditions, recharge history, and variable hydraulic conductivity regions.

4.3. Electro-Osmosis Modeling

In 1999, DOE/LLNL began evaluating electro-osmosis as a means for extracting high concentrations of VOCs from fine-grained materials. Electro-osmosis will apply an electric field in the subsurface by placing electrodes within ground water wells. This electric field induces the migration of ground water containing VOCs; however, the resulting electrolysis reactions also affect the spatial distribution of pH in soil and ground water. To evaluate these effects, DOE/LLNL are using the reactive transport model code PHREEQC Version 2 (Parkhurst and Appelo, 1999) to simulate these reactions. For example, the electrolysis reactions of water produce reduced pH values at the positively charged electrode (anode) and elevated pH values at the negatively charged electrode (cathode). These pH differences can significantly change the solubility of a variety of mineral phases in the soil and can also effect the adsorption of various trace metals. This may result in the precipitation of metal oxyhydroxide, calcium carbonate, or magnesium carbonate minerals near the cathode. Model simulations will be used to aid the design of control mechanisms that will mitigate the adverse effects of these geochemical processes on system performance for the upcoming electro-osmosis deployment.

5. Annual Summary of Remedial Action Program

This section summarizes activities performed during 1999 to support the Remedial Action Program at the Livermore Site. These activities include treatment system design, new construction, modifications to existing systems, treatment facility performance, treatability tests, well installation, well abandonment, and hydraulic tests.

In 1999, DOE/LLNL operated ground water treatment facilities in the TFA, TFB, TFC, TFD, TFE, TFG, TF406, TF518, and TF5475 areas. A total of 69 ground water extraction wells pumped water to 20 separate treatment facilities at a combined average flow rate of 580 gallons per minute (gpm). In 1999, the Livermore Site facilities treated over 290 million gal of ground water and removed about 160 kg of VOCs (Table 2). To date, approximately 1,122 million gal of ground water have been treated and about 510 kg of VOCs have been removed by all the Livermore Site treatment systems (Fig. 5 and Table 3). In addition, DOE/LLNL operated vapor treatment facilities in the TF518 and TF5475 areas. A total of 3 vapor extraction wells at 2 separate locations operated at a combined average flow rate of 70 standard cubic ft per minute (scfm). In 1999, these facilities treated 5.7 million standard cubic ft (scf) of vapor and removed about 108 kg of VOCs (Table 2). To date, these facilities have treated over 16 million scf of vapor and removed about 242 kg of VOCs at the site (Fig. 5 and Table 3). Cumulatively, the ground water and vapor treatment systems have removed over 752 kg of VOCs from the subsurface. The 1999 estimated total VOC mass removal rate increased 31% compared to 1998.

The performance of the treatment facilities is evaluated from several different data sets. Figures 6 through 11, respectively, show the hydraulic capture areas in HSUs 1B, 2, 3A, 3B, 4 and 5, based on December 1999 ground water elevation data. Figures 12 through 17 show fourth quarter total VOC isoconcentrations in the same six HSUs. Figures 18 through 33 show treatment facility extraction wells, pipelines, discharge locations, and self-monitoring program sampling stations. Several different types of treatment facilities were operated at LLNL in 1999. These include:

- Treatment Facilities located in buildings (TFs).
- Vapor Treatment Facilities (VTFs).
- Portable Treatment Units (PTUs).
- Miniature Treatment Units (MTUs).
- Granular activated carbon (GAC) Treatment Units (GTUs).
- Solar-powered Treatment Units (STUs).
- *In situ* Catalytic Reductive Dehalogenation treatment units (CRDs).

5.1. Treatment Facility A

Two treatment facilities, TFA and TFA East (TFA-E), operated in 1999 in the TFA area, located in the southwestern portion of the Livermore Site (Figs. 1, 18, and 19). TFA is located near the intersection of Vasco Road and East Avenue (Figs. 1 and 18). TFA-E is located along West Perimeter Drive in the southwestern corner of LLNL (Figs. 1 and 19).

In 1999, TFA treated ground water from 21 extraction wells, including seven HSU 1B wells (W-262, W-408, W-520, W-601, W-602, W-1001, W-1004), thirteen HSU 2 wells (W-109, W-415, W-457, W-518, W-520, W-603, W-605, W-609, W-614, W-714, W-903, W-904 and W-1009), and one HSU 3A well (W-712).

TFA treats ground water using a large-capacity air-stripping system that was installed in 1997. The effluent air from the stripper is passed through GAC filters to remove VOCs. The treated effluent air is then vented to the atmosphere. This new system is permitted by the California Regional Water Quality Control Board (RWQCB) to treat up to 500 gpm of ground water. From 1989 to 1997, TFA processed VOCs in ground water using an ultraviolet/hydrogen peroxide system.

The STU at TFA-E was activated on August 4, 1999, ahead of the August 6, 1999 RAIP milestone date. It uses a solar-powered pump to extract ground water from one HSU 2 well (W-254), which is then passed through a series of aqueous-phase GAC canisters for treatment.

Ground water treated at TFA is discharged to the Recharge Basin, located about 2,000 ft southeast of TFA on DOE property administered by Sandia National Laboratories (Figs. 1 and 18). Treated ground water from TFA-E is discharged to Arroyo Seco (Fig. 19).

From 1989 through September 1994, TFA treated ground water from well W-415. The TFA North and TFA Arroyo Pipelines connected nine additional extraction wells to TFA in September 1994. The TFA South Pipeline connected eight additional extraction wells to TFA in July 1995. The TFA North Pipeline connected one additional extraction well to TFA in June 1998, and two additional extraction wells in July 1998. Extraction wells and pipelines are shown in Figure 18.

5.1.1. Performance Summary

During 1999, the combined TFA facilities operated at an average flow rate of 253 gpm to treat over 137 million gal of ground water containing an estimated 14.0 kg of VOCs (Table 2).

Since system startup in 1989, TFA has treated over 652 million gal of ground water and removed about 123 kg of VOC mass from the subsurface (Table 3).

The TFA area extraction wells hydraulically control the VOC plumes in HSUs 1B, 2 and 3A based on the capture zone analysis shown on the ground water elevation contour maps (Figs. 6, 7, and 8) and the total VOC isoconcentration maps (Figs. 12, 13, and 14) for each HSU. Offsite HSU 1B extraction well W-408 was re-started in 1999 to ensure hydraulic control of the HSU 1B VOC plume at well W-1425 where the PCE concentration was 6.6 ppb in November 1999. Offsite HSU 2 extraction well W-109 operated from January through October to ensure hydraulic control of the HSU 2 VOC plume at well W-404 where the PCE concentration was 22 ppb in November 1999. Though wells W-408 and W-109 were not pumped during November and December 1999, both will resume pumping in January 2000.

5.1.2. Field Activities

In 1999, monitor well W-1509 was completed in HSU 1B in the TFA-E area. Well construction details are provided in Table A-1 of Appendix A.

In March of 1999, two inclined piezometers were installed in the TFA vadose zone site at TFA. Piezometers SIP-INF-301 and SIP-INF-302 (Fig. 1) were each constructed in a slanted borehole drilled 10 degrees from vertical due to the high density of previously installed wells in this area. These wells were screened in the first water-bearing zone, HSU 1B, to monitor the saturated zone directly beneath the vadose zone study area. Well construction details are provided in Table A-1 of Appendix A.

In 1999, a one-hour drawdown test was conducted in the TFA area on well W-1509. In addition, a 2-hour drawdown test was conducted on well W-1107 to evaluate hydraulic interconnection within the TFA HSU 1B source area. Results of the hydraulic tests are presented in Appendix B.

In 1999, the Recharge Basin was reconditioned by ripping the basin floor to restore infiltration capacity and constructing a concrete wall between the two cells of the basin to improve the operation and maintenance of individual cells. The reconditioning was necessary due to siltation, which caused reduction in infiltration rates, and to repair holes in the dividing berm wall created by burrowing animals.

5.1.3. Field-Scale Pilot Tests

The vadose zone infiltration experiments that began in the TFA area in 1998 area continued in 1999. The first experiment consisted of infiltrating 400 gal of water containing 1-micron diameter polystyrene spheres, which are non-reactive but fluorescent, and trace quantities of deuterated water, lithium bromide and potassium iodide. The infiltration events were monitored using absorbent pads, hybrid lysimeter/tensiometers, thermisters, and gypsum blocks deployed in boreholes using an instrumented membrane technology. The objective of these studies is to better understand the relationship between saturation changes near the water table and the arrival of chemical tracers. This work was funded, and is being conducted by the DOE Environmental Management Science Program through May 1999, and again beginning in October 1999.

Testing of DOE/LLNL-designed barometric/wind pump at a clean vadose zone site near TFA is ongoing. Barometric/wind pumping could simplify and reduce the costs of vadose zone treatment by relying on barometric pressure fluctuations and wind power instead of electrical power. The testing phase is estimated to be completed by the end of May 2000. Preliminary data show airflow from the test well up to 1 cfm with good correlation to barametric pressure and wind speed.

5.2. Treatment Facility B

One treatment facility operated in 1999 in the TFB area, located in the west-central portion of the Livermore Site (Figs. 1 and 20). TFB is located north of Mesquite Way near Vasco Road. In 1999, TFB treated ground water from seven extraction wells, consisting of three HSU 1B wells (W-610, W-620, and W-704), and four HSU 2 wells (W-357, W-621, W-655, and W-1423). Well W-1423 was connected to TFB on July 13, 1999, to enhance remediation of the leading edge of the HSU 2 VOC plume.

TFB treated ground water using a large-capacity air-stripping system installed in 1998. The effluent air from the stripper is passed through GAC filters to remove VOCs, and the treated air is vented to the atmosphere. Ground water is treated for hexavalent chromium using an ion-exchange unit. TFB requires treatment for hexavalent chromium only during the winter months based on the current metals discharge requirements (Berg et al., 1997). TFB is designed to treat up to 90 gpm of ground water. From 1990 to 1998, TFB processed VOCs in ground water using an ultraviolet/hydrogen peroxide system.

Treated ground water from TFB is discharged into the north-flowing drainage ditch parallel to Vasco Road that empties into Arroyo Las Positas to the north (Figs. 1 and 20). TFB complied with all permits throughout 1999.

From 1990 through September 1995, TFB treated ground water extracted from wells W-357 and W-704. The TFB North Pipeline and TFB West Pipeline connected four additional extraction wells to TFB in September 1995 (Fig. 19). Well W-1423 was connected to the TFB East Pipeline in July 1999.

5.2.1. Performance Summary

During 1999, TFB operated at an average flow rate of 62 gpm to treat over 30 million gal of ground water containing an estimated 7.6 kg of VOCs (Table 2). Since system startup in 1990, TFB has treated about 113 million gal of ground water and removed about 38 kg of VOC mass from the subsurface (Table 3).

The TFB area extraction wells hydraulically control the VOC plumes in HSUs 1B and 2 based on the capture zone analysis shown on the ground water elevation contour maps (Figs. 6 and 7) and the total VOC isoconcentration maps (Figs. 12 and 13) for each HSU. PCE concentrations associated with HSU 1B along the west side of TFB have been typically less than 2 ppb since August 1998.

5.2.2. Field Activities

No new monitor wells or extraction wells were installed and no hydraulic tests were conducted in the TFB area during 1999.

5.3. Treatment Facility C

Two treatment facilities, TFC and TFC Southeast (TFC-SE), operated in 1999 in the TFC area, located in the northwestern portion of the Livermore Site (Fig. 1). TFC is located north of Westgate Drive and west of Avenue A (Fig. 21). In 1999, TFC treated ground water from six HSU 1B extraction wells (W-701, W-1015, W-1102, W-1103, W-1104, and W-1116). PTU location TFC-SE is located near the intersection of Avenue A and Sixth Street (Figs. 1 and 22). TFC-SE treats ground water from one HSU 1B well (W-1213).

TFC and TFC-SE remove VOCs from ground water using air stripping. The effluent air from the stripper is treated with GAC prior to discharge to the atmosphere. Ground water is treated for hexavalent chromium using ion-exchange. Under the current metals discharge requirements, water from TFC and TFC-SE requires treatment for hexavalent chromium only during the winter months.

Treated ground water from TFC is discharged into Arroyo Las Positas (Figs. 1 and 21). Treated ground water from TFC-SE is discharged into a storm sewer that also empties into Arroyo Las Positas via a north-flowing drainage ditch (Figs. 1 and 22). The TFC effluent hexavalent chromium concentration was 32 ppb on February 10, 1999, above the wet season discharge limit of 22 ppb. The ion exchange unit was regenerated and subsequent samples were below the hexavalent chromium discharge limit through the end of December 1999. The TFC effluent total chromium concentration of 64 ppb on October 21, 1999, exceeded the discharge limit for unknown reasons. The historical range of total chromium concentrations in the influent is 28 to 24 ppb. TFC-SE complied with all permits throughout 1999.

From 1993 through September 1996, TFC treated ground water extracted from well W-701. The TFC North Pipeline connected five additional extraction wells to TFC in September 1996. TFC-SE began operation in January 1997.

5.3.1. Performance Summary

During 1999, the combined TFC area facilities operated at an average flow rate of 56 gpm to treat over 24 million gal of ground water containing an estimated 9.0 kg of VOCs (Table 2). Since system start up in 1993, the combined TFC area facilities have treated over 83 million gal of ground water and removed about 32 kg of VOC mass from the subsurface (Table 3).

In the TFC area, VOCs are confined to HSU 1B. The TFC area extraction wells hydraulically control the VOC plumes in HSU 1B based on the capture zone analysis shown on the ground water elevation contour map (Fig. 6) and the total VOC isoconcentration map for HSU 1B (Fig. 12).

5.3.2. Field Activities

No new wells were installed in the TFC area during 1999. Results for two one-hour drawdown tests conducted in the TFC area on wells W-1427 and W-1428 are presented in Appendix B.

5.4. Treatment Facility D

Five treatment facilities operated in 1999 in the TFD area, located in the northeastern portion of the Livermore Site, near the Drainage Retention Basin (DRB) (Figs. 1, 23, 24, 25, 26, and 27). These facilities are TFD, TFD West, TFD East, TFD Southeast, and TFD South. TFD treated ground water from five extraction wells, including one HSU 2 well (W-906) one HSU 3A well (W-1208), two HSU 4 wells (W-351 and W-1206), and one HSU 5 well (W-907) (Fig. 23). TFD West (TFD-W), located south of North Inner Loop Road (Fig. 24), treats ground water from two HSU 2 extraction wells (W-1215 and W-1216). TFD East (TFD-E) is located east of the DRB (Fig. 25). TFD-E treats ground water from four extraction wells, including two HSU 2 wells (W-1303 and W-1306), one HSU 3A well (W-1301), and one HSU 4 well (W-1307). TFD Southeast (TFD-SE) is located south of the East Traffic Circle and east of Inner Loop Road (Fig. 26). TFD-SE treats ground water from two extraction wells, HSU 2 well W-1308 and HSU 4 well W-314.

One new treatment facility, TFD South (TFD-S), was activated June 23, 1999, ahead of the June 29, 1999 RAIP milestone date (Figs. 1 and 27). TFD-S is located south of Inner Loop Road and east of Southgate Drive. TFD-S treats ground water from three extraction wells, including HSU-2 well W-1510, HSU-3A/3B well W-1504, and HSU-4 well W-1503.

TFD, TFD-W, TFD-E, TFD-SE, and TFD-S process ground water for treatment of VOCs using air stripping. The effluent air from the air strippers is treated using GAC prior to venting to the atmosphere. Treated ground water from TFD and TFD-E is discharged into either the DRB or an underground pipeline downstream of the DRB weir, and flows northward to Arroyo Las Positas (Figs. 23 and 25). Treated ground water from TFD-W is discharged into a nearby storm sewer that also empties into Arroyo Las Positas (Fig. 24). Treated ground water from TFD-SE is discharged into a lined drainage ditch that flows northwest into the DRB (Fig. 26). Treated ground water from TFD-S is discharged into a drainage ditch that flows north into the DRB (Fig. 27). All TFD facilities were in compliance with all permits throughout 1999.

TFD began operation in September 1994, treating ground water from wells W-351, W-906, and W-907. Wells W-1206 and W-1208 were connected to TFD in April 1998. PTU location TFD-W was activated in April 1997, PTU location TFD-E began operating in September 1997, PTU location TFD-SE was activated in March 1998, and PTU location TFD South (TFD-S) was activated in June 1999.

5.4.1. Performance Summary

During 1999, the TFD area facilities operated at an average flow rate of 137 gpm to treat over 59 million gal of ground water containing an estimated 88.4 kg of VOCs (Table 2). Since system start up in 1994, the combined TFD facilities have treated over 183 million gal of ground water and removed about 235 kg of VOC mass from the subsurface (Table 3). These data include facilities used in field-scale pilot tests (Section 5.4.3).

The TFD area extraction wells hydraulically control VOCs in HSUs 2, 3A, 3B, 4, and 5 based on the capture zone analysis shown on the ground water elevation contour maps (Figs. 7, 8, 9, 10, and 11) and the total VOC isoconcentration maps (Figs. 13, 14, 15, 16, and 17) for each HSU. Distal VOC plumes in the western TFD area should be hydraulically controlled once planned TFC-East and TFC-Northeast treatment facilities are operating, scheduled for June 2002 and May 2003, respectively.

5.4.2. Field Activities

Thirteen wells were installed in the TFD area during 1999. Extraction well W-1510 (HSU 2) was installed and connected to TFD-S. Extraction wells W-1523 (HSU 4), W-1601 (HSU 3B), and W-1602 (HSU 2) were installed and are scheduled to be connected to a new facility, TFD South Shore (TFD-SS), in 2000. Extraction well W-1603 (HSU 3A) was installed as a replacement well for extraction well W-361, which was damaged during redevelopment. Four HSU 3A/3B monitor wells, W-1550, W-1551, W-1552, and W-1553 were completed in the TFD-E area, and monitor wells W-1511 (HSU 3B) and W-1512 (HSU 2) were completed in the TFD-S area. Piezometers SIP-ETC-301 (HSU 2) and SIP-ETC-303 (HSU 2) were also completed in the TFD-SE area. Piezometer SIP-ETC-302 was damaged during installation and was grouted to the surface (Table A-2 of Appendix A). Construction details for the new TFD area wells are provided in Table A-1 of Appendix A.

In 1999, five one-hour drawdown tests were conducted on TFD area wells W-1502, W-1503, W-1504, W-1510, and W-1550. In addition, a recovery test was conducted on extraction well W-314 at TFD-SE in January 1999. Results of the hydraulic tests are presented in Appendix B.

In December 1999, near-surface vadose zone VOCs were assessed using GORE-SORBERâ passive soil vapor sampling devices near the north end of the former East Traffic Circle Landfill. Thirty-two devices were installed about 50 ft apart into 1-inch diameter, 3-ft deep holes that were prepared using a slide hammer tool. After three weeks, the devices were removed. The sorbent material will be analyzed for VOCs in January 2000 and the results used to plan further characterization and remediation activities.

5.4.3. Field-Scale Pilot Tests

Following successful treatability tests conducted in 1997 and 1998, STU-1 was again operated at well W-361 (HSU 3A) from May through December 1999. STU-1 operated at a flow rate of about 2.4 gpm, and treated about 0.5 million gallons of ground water containing an estimated 2.4 kg of VOCs. These data are included in the TFD volume and VOC mass totals presented in Tables 2 and 3, and total mass removed in Figure 5.

PTU-10 operated at wells W-1551 (HSU 3A/3B) and W-1552 (HSU 3A/3B) from September through December 1999 to expedite VOC mass removal and site cleanup. PTU-10 operated at a flow rate of about 4.5 gpm, and treated about 0.5 million gallons of ground water containing an estimated 14.0 kg VOCs. These data are included in the TFD volume and VOC mass totals presented in Tables 2 and 3, and total mass removed in Figure 5.

5.5. Treatment Facility E

Two treatment facilities, TFE East (TFE-E) and TFE Northwest (TFE-NW), operated in the TFE area, located in the east-central portion of the Livermore Site (Figs. 1, 28, and 29). TFE-E is located near Avenue H and Third Street (Fig. 1) and treats ground water from two extraction wells, W-1109 (HSU 2) and W-566 (HSU 5). TFE-NW is located south of the Inner Loop Road, immediately west of Southgate Drive (Figs. 1 and 29). TFE-NW treats ground water from two extraction wells, W-1409 (HSU 2) and W-1211 (HSU 4).

TFE-E and TFE-NW use PTUs to treat VOCs in ground water using an air stripper, and the effluent air is treated using GAC to remove VOCs prior to venting to the atmosphere. Treated ground water from TFE-E is discharged into a drainage ditch that flows north into the DRB (Fig. 28). Treated ground water from TFE-NW is discharged into a storm drain that flows north into Arroyo Las Positas (Fig. 29). TFE-E and TFE-NW were in compliance with all permits throughout 1999.

The PTU at location TFE-E began operation in November 1996, and the PTU at location TFE-NW was activated in June 1998.

5.5.1. Performance Summary

During 1999, the TFE area facilities operated at an average flow rate of 60 gpm to treat over 28 million gal of ground water containing an estimated 38.1 kg of VOCs (Table 2). Since system startup in 1996, the combined TFE facilities have treated over 53 million gal of ground water and removed about 72 kg of VOC mass from the subsurface (Table 3).

The TFE-E extraction wells hydraulically contain some portions of VOC plumes in HSUs 2, 4, and 5 in the TFE area based on the capture zone analysis shown on the ground water elevation contour maps (Figs. 7, 10, and 11) and the total VOC isoconcentration maps (Figs. 13, 16, and 17) for each HSU. The VOC plumes in HSUs 3A, 4, and 5, located in the western and southern portion of the TFE area, should be hydraulically controlled once the TFE-Southwest, TFE-Southeast, and TFE-West treatment facilities are operating. The planned start-up dates for these treatment facilities are June 2000, January 2001, and April 2001, respectively.

5.5.2. Field Activities

Ten new wells were installed in the TFE area during 1999. Extraction wells W-1518 (HSU 2), W-1520 (HSU 4), and W-1522 (HSU 3B) are scheduled to be connected to TFE-SW in 2000. Extraction well W-1517 (HSU 2) is scheduled to be connected to TFE-SE in 2001. Monitor wells W-1505 (HSU 4), W-1506 (HSU 2), W-1508 (HSU 2) and W-1516 (HSU 5) were installed in the TFE-SW area. Monitor well W-1507 (HSU 5) and piezometer SIP-ETS-601

(HSU 2) were installed in the TFE-SE area. Construction details for the new wells are provided in Table A-1 of Appendix A.

In 1999, three one-hour drawdown tests were conducted in the TFE area on wells W-1505, W-1506, and W-1507. In addition, a bail-recovery test was conducted on well W-274. Results of these hydraulic tests are presented in Appendix B.

TFE-E extraction well W-1109 (HSU 2) was redeveloped in December 1998. As a result of the redevelopment, the flow rate in W-1109 increased from 2.5 gpm to 8.8 gpm in 1999. Consequently, the VOC mass removed from W-1109 increased from 5.6 kg in 1998 to 13.7 kg in 1999.

5.5.3. Field-Scale Pilot Tests

Two additional PTUs operated in the TFE area during 1999. PTU-4 continued to operate at wells W-1418 (HSU 4) and W-1422 (HSU 3B) in the northern part of the TFE area to expedite VOC mass removal and site cleanup. During 1999, wells W-1418 and W-1422 pumped at a combined flow rate of about 12.9 gpm, and PTU-4 treated about 6.4 million gal of ground water containing an estimated 12.9 kg of VOCs. These data are included in the TFE volume and mass numbers presented in Tables 2 and 3, and total mass removed in Figure 5.

PTU-10 operated at TFE-SE extraction well W-359 (HSU 5) from March to June 1999. During 1999, well W-359 pumped at an average flow rate of about 10 gpm and PTU-10 treated about 1.3 million gal of ground water containing an estimated 2.9 kg of VOCs. These data are included in the TFE volume and mass numbers presented in Tables 2 and 3, and total mass removed in Figure 5.

5.6. Treatment Facility G

TFG-1 is located in the south-central portion of the Livermore Site, near Avenue B, about 300 ft north of East Avenue (Fig. 1). TFG-1, activated in April 1996, treats ground water from HSU 2 extraction well W-1111.

Prior to May 1999, TFG-1 processed ground water for VOC treatment using an air stripper, and the effluent air was treated using GAC to remove VOCs prior to venting to the atmosphere. In May 1999, the PTU at TFG-1 was replaced by a GAC treatment unit (GTU). A year-long treatability study conducted in 1998 and 1999 demonstrated that the GAC treatment was effective in the efficient removal of VOCs from TFG area ground water. Three 400-lb GAC canisters in series are used to process the water from well W-1111. Ground water is no longer treated for hexavalent chromium since concentrations through November 1999 had consistently been below the discharge limit of 22 ppb since March 1997.

Treated ground water from TFG-1 is discharged to a storm drain located about 50 ft north of TFG-1 (Fig. 30) that empties into Arroyo Seco. TFG-1 was in compliance with all permits from January to October 1999. The TFG-1 effluent chloroform concentrations in November and December were 6.7 and 49 ppb, respectively, exceeding the discharge limit due to GAC breakthrough. The carbon in the unit was subsequently replaced.

5.6.1. Performance Summary

During 1999, TFG-1 operated at an average flow rate of 7 gpm, treating over 2.7 million gal of ground water containing an estimated 0.6 kg of VOCs (Table 2). Since system startup in 1996, TFG-1 has treated over 10 million gal of ground water and removed about 1.8 kg of VOC mass from the subsurface (Table 3).

TFG-1 extraction well W-1111 provides hydraulic control of HSU 2 in the TFG area based on the capture zone analysis shown on the ground water elevation contour map (Fig. 7) and the total VOC isoconcentration map for HSU 2 **(**Fig. 13).

5.6.2. Field Activities

No new boreholes or wells were drilled and no hydraulic tests were conducted in the TFG area during 1999.

5.7. Treatment Facility 406

TF406 is located in the south-central portion of the Livermore Site, east of Southgate Drive near East Avenue (Figs. 1 and 31). In 1999, TF406 treated ground water from three extraction wells, GSW-445 (HSU 4), W-1309 (HSU 4) and W-1310 (HSU 5).

TF406 uses a PTU to process ground water for VOC treatment using an air stripper, and the effluent air is treated using GAC to remove VOCs prior to discharge to the atmosphere. All treated ground water is discharged to a storm drain that flows to Arroyo Las Positas (Fig. 31). TF406 was in compliance with all permits throughout 1999.

When activated in August 1996, TF406 processed ground water from extraction wells GSW-445 and W-1114. In 1997, well W-1114 was destroyed and two new extraction wells, W-1309 and W-1310 were installed. TF406 began processing ground water from wells W-1309 and W-1310 in February 1998.

Passive bioremediation continued in the TF406 area during 1999 to remediate fuel hydrocarbons (FHCs) in HSUs 3A and 3B. Active ground water extraction and treatment for residual dissolved FHCs at Treatment Facility F was discontinued in 1996 with regulatory agency concurrence (RWQCB, 1996).

5.7.1. Performance Summary

During 1999, TF406 operated at an average flow rate of 16 gpm, treating over 7 million gal of ground water containing an estimated 1.0 kg of VOCs (Table 2). Since system startup in 1996, TF406 has treated over 22 million gal of ground water and removed about 4.2 kg of VOC mass from the subsurface (Table 3).

The TF406 extraction wells provide significant hydraulic control of VOC plumes in HSUs 4 and 5 in the TF406 area based on the capture zone analysis shown on the ground water elevation contour maps (Figs. 10 and 11) and the total VOC isoconcentration maps (Figs. 16 and 17) for each HSU. The VOC plumes in HSUs 3A, 4, and 5 should be hydraulically controlled once treatment facilities at TF518-North and TF406-Northwest are installed, in January 2000 and January 2002, respectively.

5.7.2. Field Activities

Four wells were installed in the TF406 area during 1999. Wells W-1513, W-1514, and W-1515 were installed in HSU 3A/3B as part of a field test to evaluate the use of electro-osmosis for cleaning up VOCs in saturated, fine-grained sediments. Monitor well W-1519 was installed in HSU-5 in the western TF406 area. Well construction details are provided in Table A-1 of Appendix A.

An 8-hour drawdown test was performed on well W-1514 in 1999. Results are presented in Appendix B.

5.7.3. Field-Scale Pilot Tests

During 1999, DOE/LLNL began evaluating electro-osmosis for remediating VOCs in fine-grained, low-permeability sediments. The TF406 area was chosen as a test location because prior characterization indicated the presence of good candidate lithologic sequences. Initial testing was conducted to determine design parameters (e.g., electrode spacing, voltage gradients), to evaluate operational issues (e.g., control of high pH and hydrogen gas at the cathode), and to measure electrochemical properties of the soil (e.g., electrical and electro-osmotic conductivity). The results of this work will be used for subsequent analysis and modeling necessary to evaluate electro-osmosis for potential deployment at LLNL. A report summarizing the results of the Qualifications Phase tests was issued in December 1999 (McNab, 1999).

5.8. Vapor Treatment Facility 518

The TF518 area is located in the southeastern portion of the Livermore Site (Fig. 1). The VTF518 treatment facility is located north of East Avenue and near Avenue H, adjacent to TF518 (Fig. 1). Soil vapor is extracted from the vadose zone using a vapor extraction system, and VOCs are removed from the vapor using GAC canisters. Following treatment, the effluent air is discharged to the atmosphere. VTF518 was in compliance with the Bay Area Air Quality Management District permit throughout 1999.

VTF518 began operation in September 1995 by treating soil vapor from extraction well SVI-518-201 (Fig. 1). In 1991, extraction well SVI-518-303 was added to the system. Since 1998, the flow rate from primary extraction well SVI-518-201 has dropped from about 29 scfm to less than 2 scfm. The majority of vapor flow during this time period was coming from the secondary extraction well SVI-518-303 (Fig. 1). VOC concentrations in SVI-518-303 have dropped from approximately 50 ppm at the start of operation to 3 to 4 ppm currently. VTF518 was shut down in August 1999 due to lack of flow from the primary extraction well, SVI-518-201. The causes for the reduction in flow are being investigated. Possible causes include the presence of a perched water layer adding moisture to the vadose zone and severely restricting air flow, or biofouling in the well screen.

5.8.1. Performance Summary

During 1999, VTF518 operated at an average flow rate of 49.8 scfm, treating about 3.6 million scf of vapor containing an estimated 13.1 kg of VOCs (Table 2). Since system start up in 1995, VTF518 has treated over 14 million scf of vapor and removed about 147 kg of VOC mass from the subsurface (Table 3).

5.8.2. Field Activities

Two Instrumented Membrane System (IMS) sampling/monitoring wells, SEA-518-301 and SEA-518-304, were installed in 1995 to monitor vadose zone remediation in the VTF518 area. The IMS system collects vapor pressure, soil temperature, soil moisture, and soil vapor concentration data from various discrete depths.

Extensive monitoring of the soil moisture levels and evaluation of vapor pressures between VTF518 area wells indicate that effective soil vapor extraction is not possible at this time due to increased moisture content in the vadose zone. While SVI-518-303 can still produce substantial flow, the current VOC concentrations suggest that there is little VOC mass remaining. Post-VTF518 shut-down monitoring of soil moisture and VOC concentrations will continue in order to evaluate future needs for soil vapor extraction in the VTF518 area.

5.9. Ground Water Treatment Facility 518

The TF518 area is located in the southeastern portion of the Livermore Site, north of East Avenue and near Avenue H, adjacent to VTF518 (Figs. 1 and 32). TF518 was constructed in 1997 and began operating in January 1998. In 1999, TF518 treated ground water from one extraction well, W-112 (HSU 5). Pumping from well W-211 (HSU 6) was discontinued in May 1998 after six consecutive sampling events between September 1997 and April 1998 showed TCE concentrations remained below the 5 ppb MCL. VOC concentrations remained below MCLs in 1999.

Sustainable flow rates from well W-112 have decreased steadily during 1998 from about 20 gpm to about 1 gpm in May 1999. TF518 periodically shut down during 1999 due to lack of sustainable flow and low water level conditions within W-112. Hydraulic data indicate that the cumulative pumping from HSU 5 wells at TF406, TFE, and TF518 has significantly lowered ground water levels in the southeastern portion of the Livermore Site and reduced yields observed in well W-112.

In July 1998, MTU-1 was activated in the TF518 area, replacing the PTU that had processed ground water there since January 1998. The MTU processes ground water for VOC treatment using an air stripper, and the effluent air is treated using GAC to remove VOCs prior to venting to the atmosphere. All treated ground water is discharged to a storm drain located about 250 ft north of TF518 that ultimately empties into Arroyo Las Positas (Fig. 32). TF518 was in compliance with all permits throughout 1999.

5.9.1. Performance Summary

During 1999, TF518 operated at an average flow rate of 2 gpm and treated over 0.9 million gal of ground water from well W-112 containing an estimated 0.2 kg of VOCs (Table 2). Since facility startup in January 1998, TF518 has processed over 3.7 million gal of ground water containing an estimated 1.2 kg of VOCs (Tables 2 and 3).

The TF518 extraction well provides hydraulic control of VOC plumes in HSU 5 in the TF518 source area based on the capture zone analysis shown on the ground water elevation contour map (Fig. 11) and the total VOC isoconcentration map (Fig. 17).

5.9.2. Field Activities

No boreholes or wells were drilled in the TF518 area during 1999. A step-drawdown test was conducted on proposed TF518 North extraction well W-1410. Results are presented in Appendix B.

A two-month recovery test was conducted on HSU 5 wells in the southwestern corner of the Livermore Site to evaluate the effects of de-watering by extraction and recharge in this hydrostratigraphic unit. Between July 15 and September 7, 1999, the pumps in all HSU 5 extraction wells at the Livermore Site were shut off, and the rate of ground water recovery was observed in both the extraction wells and in surrounding HSU 5 monitor wells. While the rate of recovery at extraction wells W-1310 (TF406) and W-566 (TFE-E) and adjacent observation wells performed as expected by recovering at a relatively fast rate when pumping ceased, recovery in well W-112 (TF518) and surrounding monitor wells was very slow apparently due to the lack of available ground water in the vicinity. The impact of the de-watering on the cleanup of the TF518 area is currently being evaluated.

5.9.3. Field-Scale Pilot Tests

PTU-10 was operated at proposed TF518 North extraction well W-1410 (HSU 3B) in September 1999. During this period, well W-1410 pumped at an average flow rate of about 11.8 gpm, and treated about 0.13 million gal of ground water containing an estimated 0.1 kg of VOCs. These data are included in the TF518 volume and mass totals presented in Tables 2 and 3, and Figure 5.

5.10. Treatment Facility 5475

Two ground water treatment facilities operated in 1999 in the TF5475 area, located in the east-central portion of the Livermore Site (Figs. 1 and 33). TF5475-1, activated in September 1998, treats ground water from extraction well W-1302 (HSU 3A). TF5475-2 is located west of Trailer 5475 (T5475), and treats ground water from HSU-2 well W-1415 (Figs. 1 and 33). TF5475-2 was activated on March 23, 1999, eight days before its milestone date.

TF5475-1 uses the CRD-1 unit to treat VOCs in ground water. This unit uses catalytic reductive dehalogenation, which is based upon the reaction of dissolved hydrogen on a palladium-alumina catalyst. When in contact with VOC bearing ground water, the VOCs are reduced to ethane, methane, and chloride. Because of the high reaction rates of the CRD, treatment takes place during one pass through the unit, allowing the treatment unit to be placed in the well casing. This technology treats VOCs in ground water while keeping the ground water containing tritium in the subsurface in the T5475 area. The CRD unit operates in extraction well W-1302, a dual-screened well in which the CRD unit extracts from the lower screened interval and injects treated ground water containing tritium into the upper screened interval of the same hydrostratigraphic unit. The required destruction efficiency is 90% or higher. The CRD unit's destruction efficiency at TF5475-1 was 80% in April 1999, due to low hydrogen supply. The hydrogen supply cell was replaced and the unit's destruction efficiency improved.

TF5475-2 employs an STU, which uses a direct current (DC)-powered pump to extract ground water and a series of aqueous-phase GAC canisters for treatment. Treated ground water from TF5475-2 is discharged into a storm sewer that flows north into Arroyo Las Positas (Fig. 33). TF5475-2 was in compliance throughout 1999 although anomalous data were reported in June and July that indicated breakthrough of VOCs from the carbon. Subsequent samples from the same carbon indicated no detectable VOCs. The effluent water was collected into a storage tank until the samples were analyzed and results indicated no detectable VOCs in the effluent.

5.10.1. Performance Summary

During 1999, the TF5475 area facilities operated at an average flow rate of 25 gpm to treat about 0.17 million gal of ground water containing an estimated 0.4 kg of VOCs (Table 2). Since system start up in 1998, the combined TF5475 facilities have treated over 0.2 million gal of ground water and removed about 2.3 kg of VOC mass from the subsurface (Table 3).

5.10.2. Field Activities

During 1999, one monitor well, W-1604, was installed in HSU 5 in the TF5475 area. Well construction details are provided in Table A-1 of Appendix A. No hydraulic tests were conducted in the T5475 area during 1999.

5.11. Vapor Treatment Facility 5475

VTF5475 is located on the eastern side of Trailer T5475 in the east-central portion of the Livermore Site, and treats soil vapor from vadose zone well SVI-ETS-504 (Fig. 1). VTF5475 began operation on January 21, 1999, ahead of the January 29, 1999 RAIP milestone date.

Soil vapor is extracted from the vadose zone using a vapor extraction system and is processed using GAC. Due to elevated tritium concentrations in the vadose zone, VTF5475 has been designed as a closed loop system. Following removal of VOCs from the process air-stream, the tritiated vapor is re-injected into the subsurface at soil vapor inlet well SVI-ETS-505 (Fig. 1). Because no effluent vapor from VTF5475 is released to the atmosphere, the Bay Area Air Quality Management District has granted the facility a letter of exemption for 24-hour operation.

5.11.1. Performance Summary

Since system start up in 1999, VTF5475 operated at an average flow rate of 20.0 scfm and treated about 2.1 million scf of vapor containing an estimated 94.9 kg of VOCs (Tables 2 and 3).

5.11.2 Field Activities

Two IMS sampling/monitoring wells, SEA-ETS-506 and SEA-ETS-507, are used to monitor vadose zone remediation in the VTF5475 area. The IMS system is used to collect vapor pressure, soil temperature, soil moisture, and soil vapor concentration data from various discrete depths.

6. Trends in Ground Water Analytical Results

Notable results of VOC analyses of ground water received from January 1999 through December 1999 are discussed below. Figures 12 through 17 are isoconcentration maps for total VOCs underlying the Livermore Site and vicinity within HSU 1B, HSU 2, HSU 3A, HSU 3B, HSU 4, and HSU 5, respectively.

The HSU 1B offsite VOC plume contours greater than the MCL of 5 ppb cover an area of approximately 20 acres. This is approximately one-third of its size in 1989 when our first ground water treatment facility began operating. The size of the HSU 2 offsite VOC plume over the MCL shows a reduction of 40 percent since 1989, and currently covers an area of about 62 acres.

During the most recent sampling events, the highest VOC concentration in an HSU 1B offsite well was 15.4 ppb in November 1999 at well W-1425. The highest VOC concentration in an HSU 2 offsite well was 40.4 ppb in well W-903 in October 1999.

Overall, the Livermore Site VOC plumes have remained relatively stable with respect to size in 1999, and changes in VOC concentrations are mostly observed in response to active ground water extraction.

Concentrations in the HSU 1B, 2 and 3A VOC plumes along the western margin of the Livermore Site in the TFA, TFB, and TFC areas continued to decline in response to ground water extraction.

VOC concentrations near the source area east of TFA continue to decline. Total VOC concentrations at extraction well W-254 declined from 195 ppb in January 1998 to 125 ppb in October 1999.

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Figures

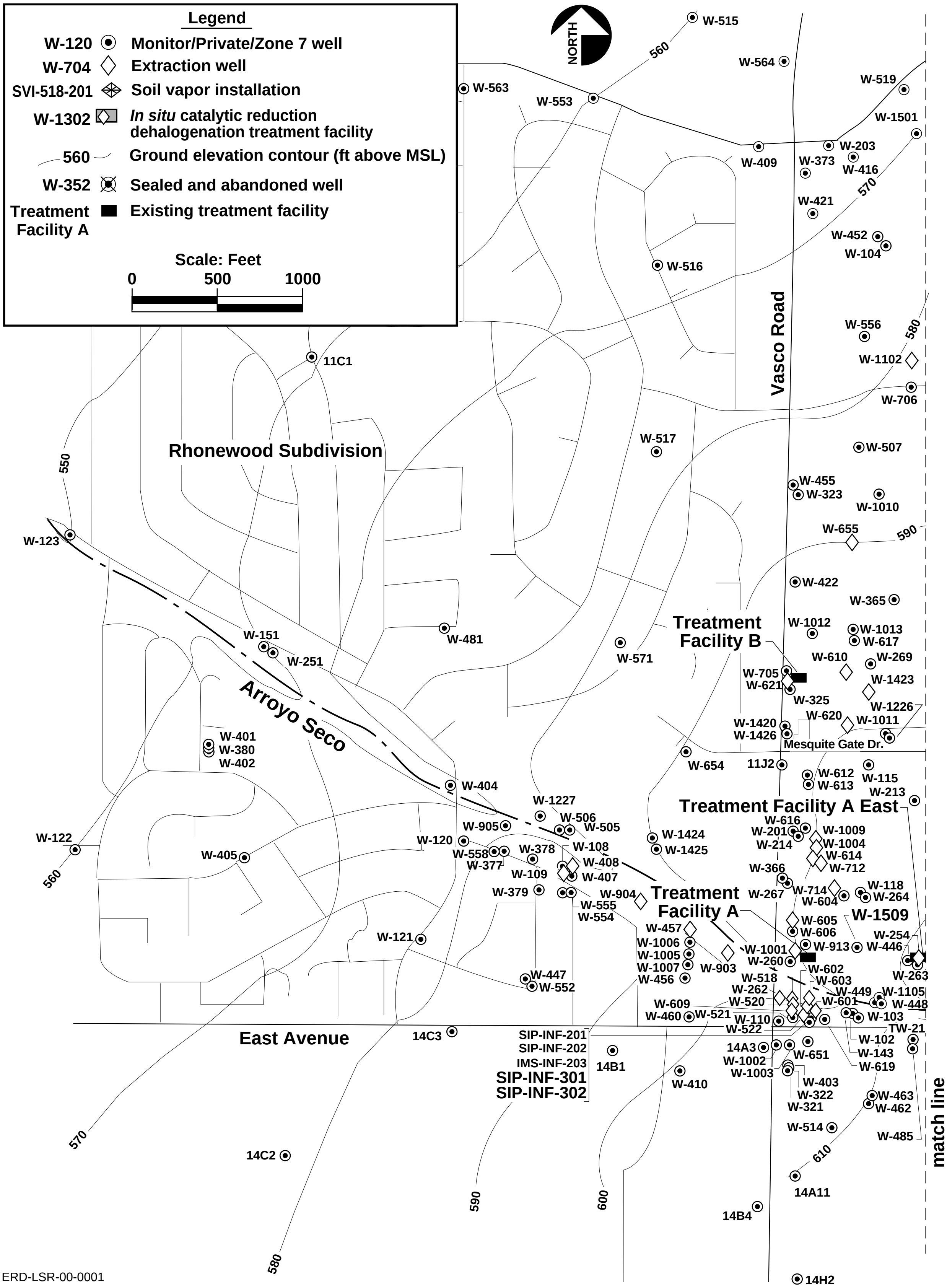

Figure 1. Locations of Livermore Site monitor wells, extraction wells, and treatment facilities, December 1999.

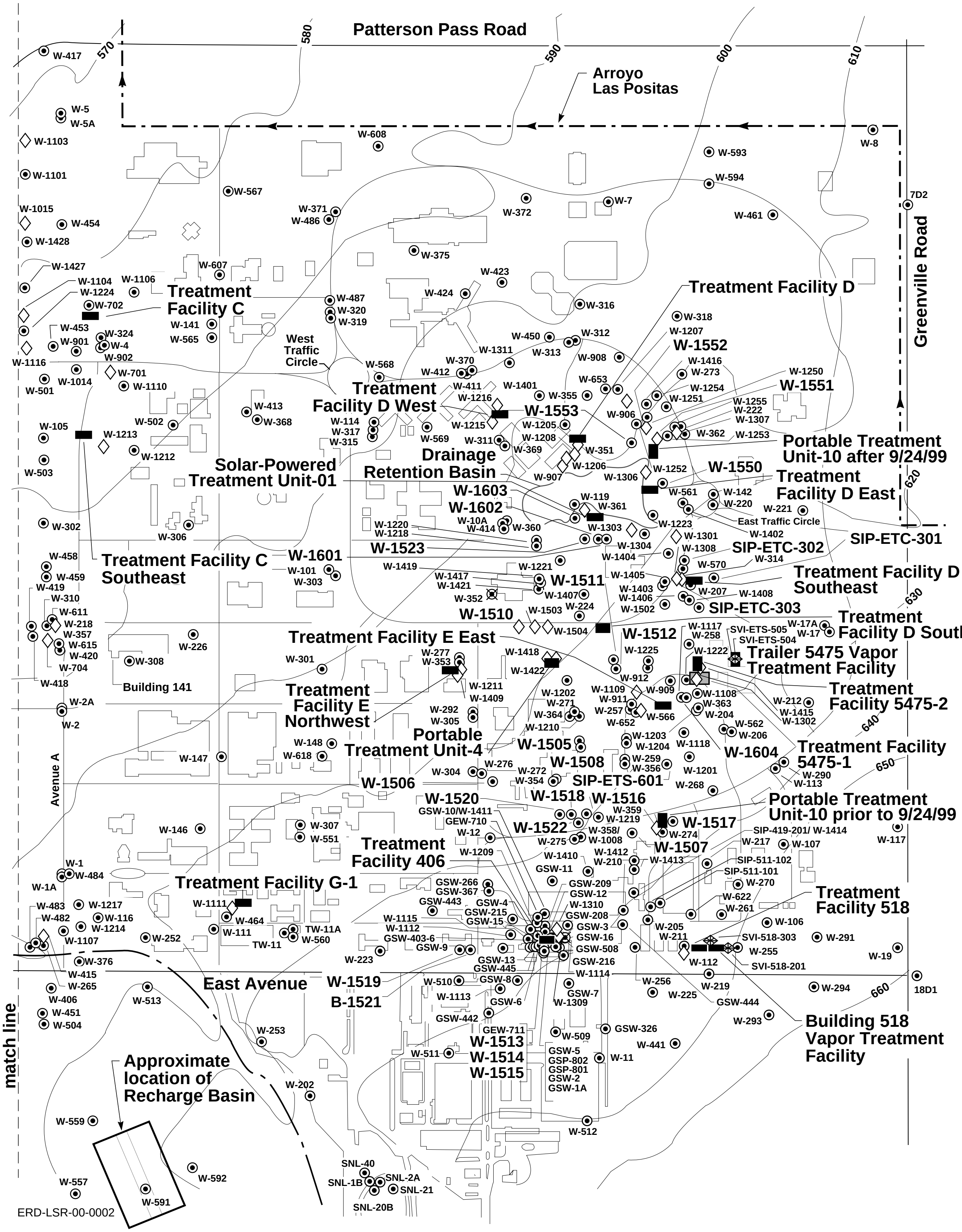

Figure 1 (continued).

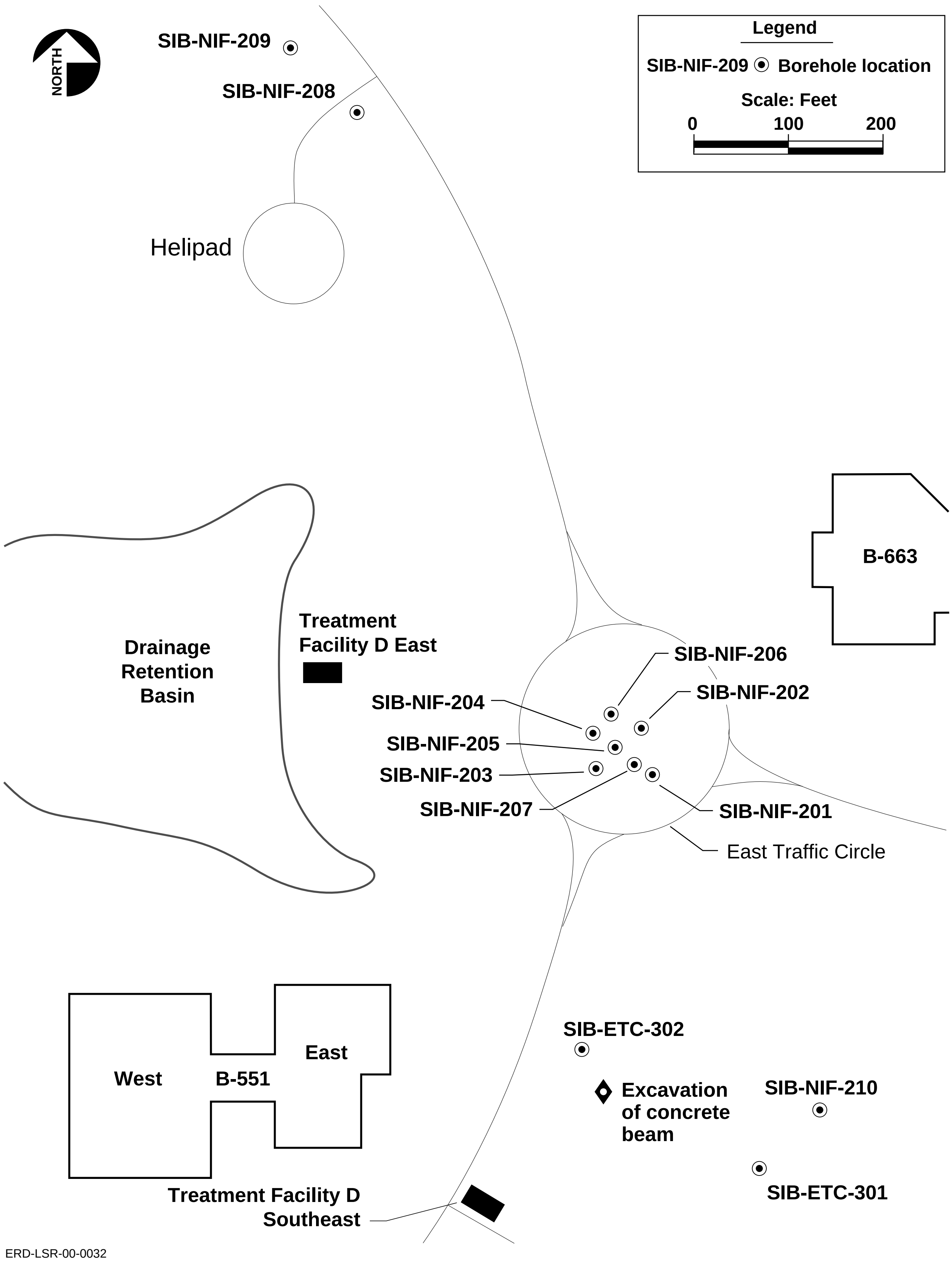

Figure 2. Location of NIF-related boreholes.

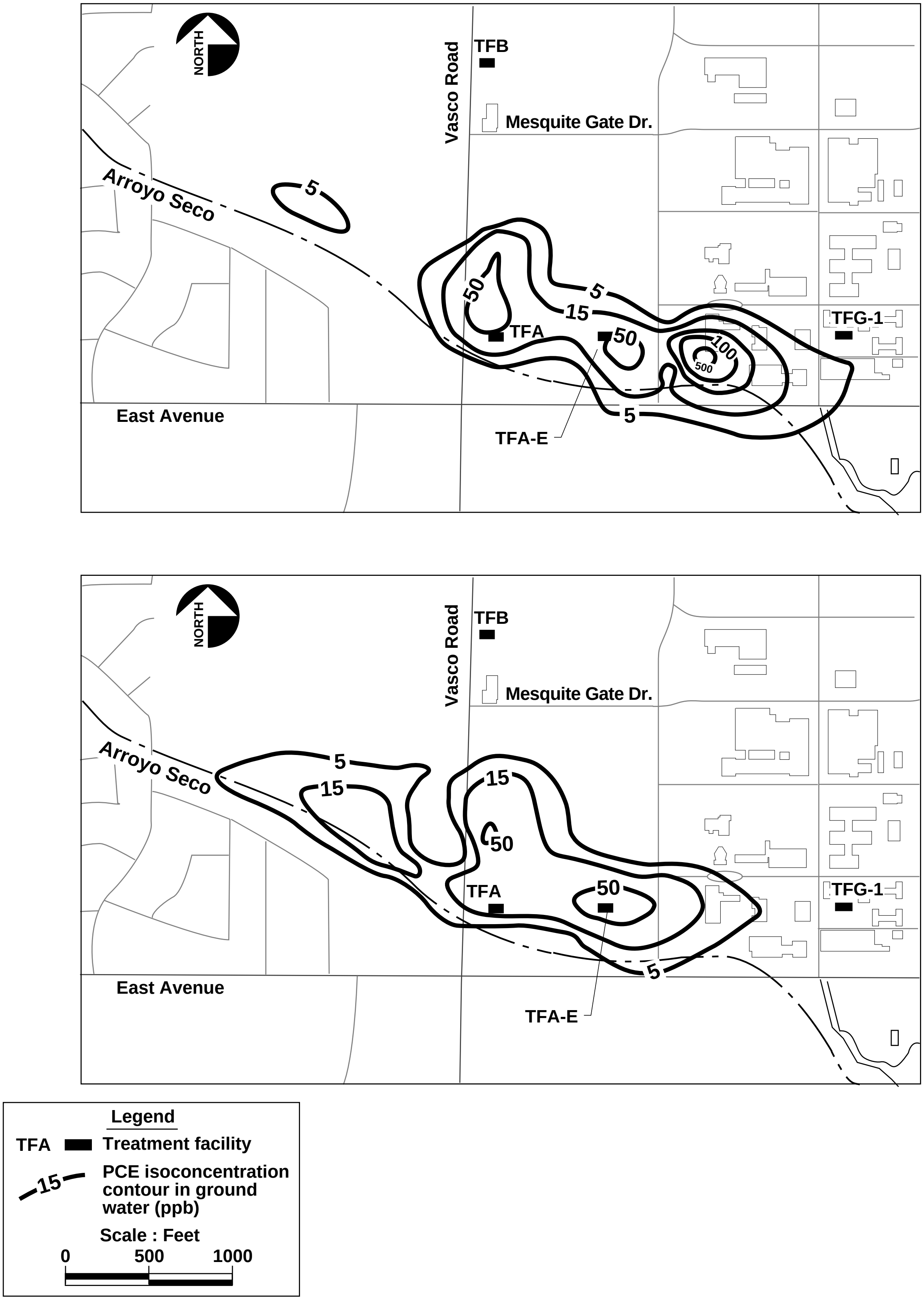

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Figure 3. Comparison of 1999 HSU 1B measured (top) and simulated (bottom) aqueous PCE concentrations in the TFA area.

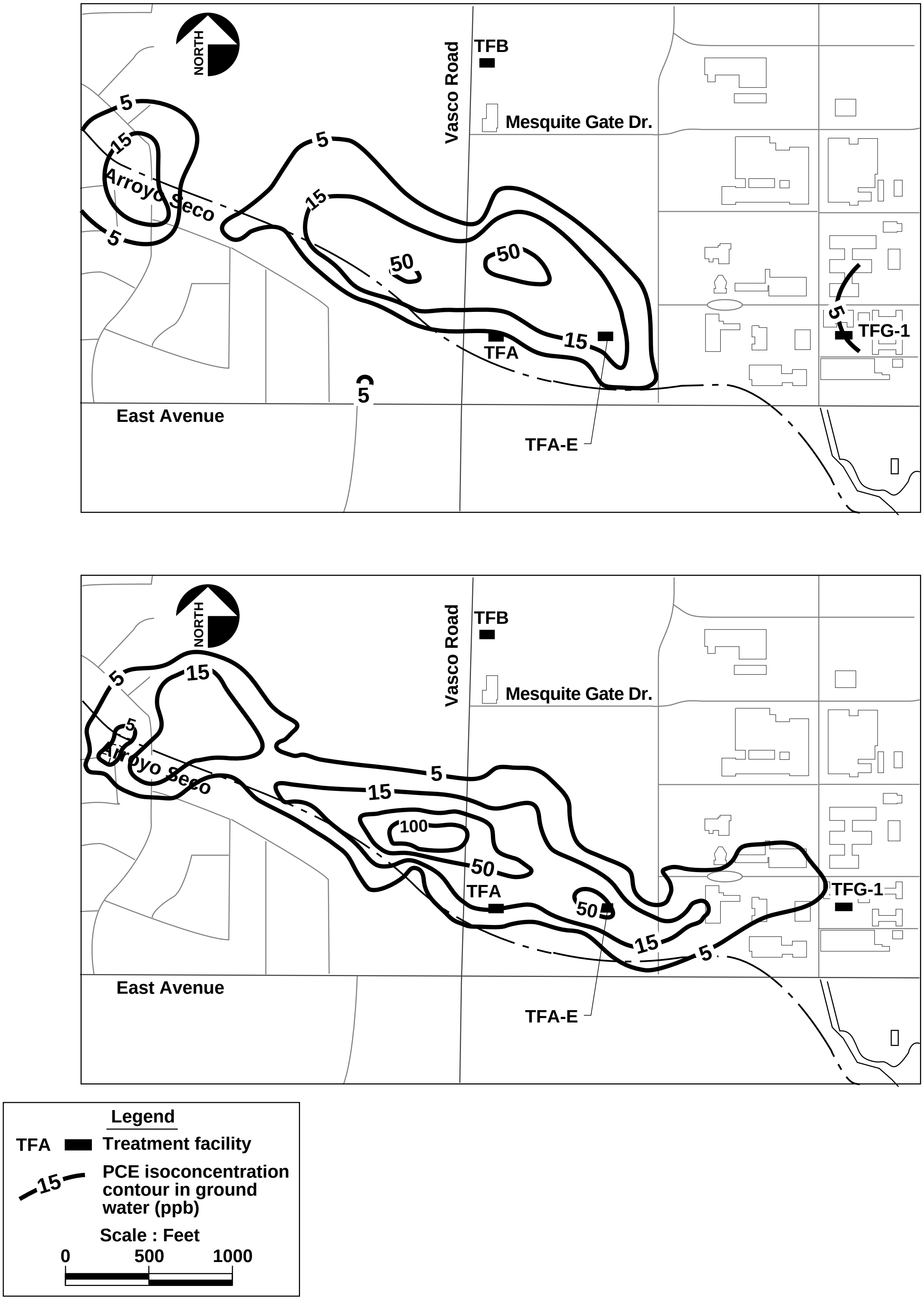

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Figure 4. Comparison of 1999 HSU 2 measured (top) and simulated (bottom) aqueous PCE concentrations in the TFA area.

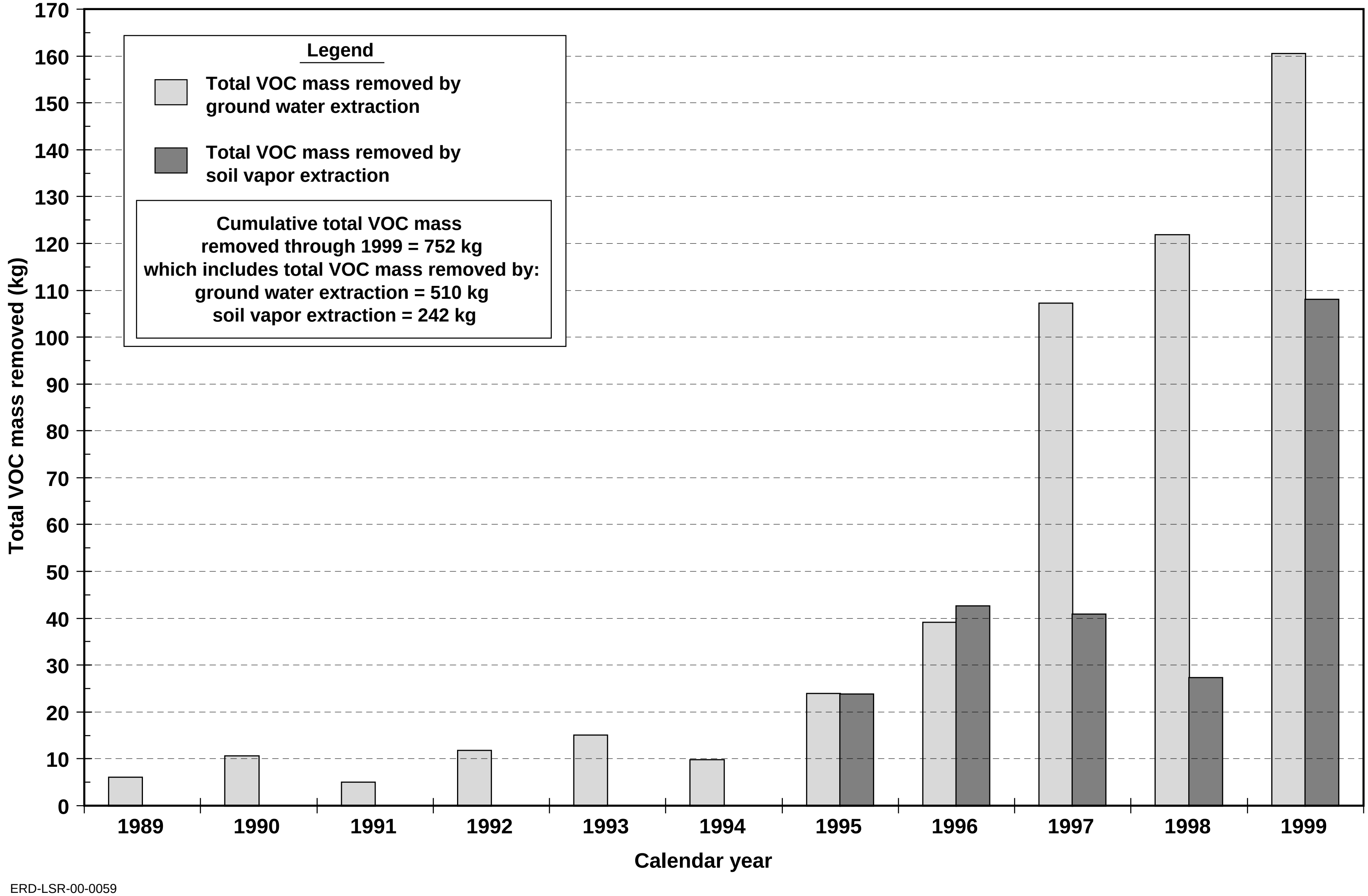

Figure 5. Total VOC mass removed from the Livermore Site subsurface over time.

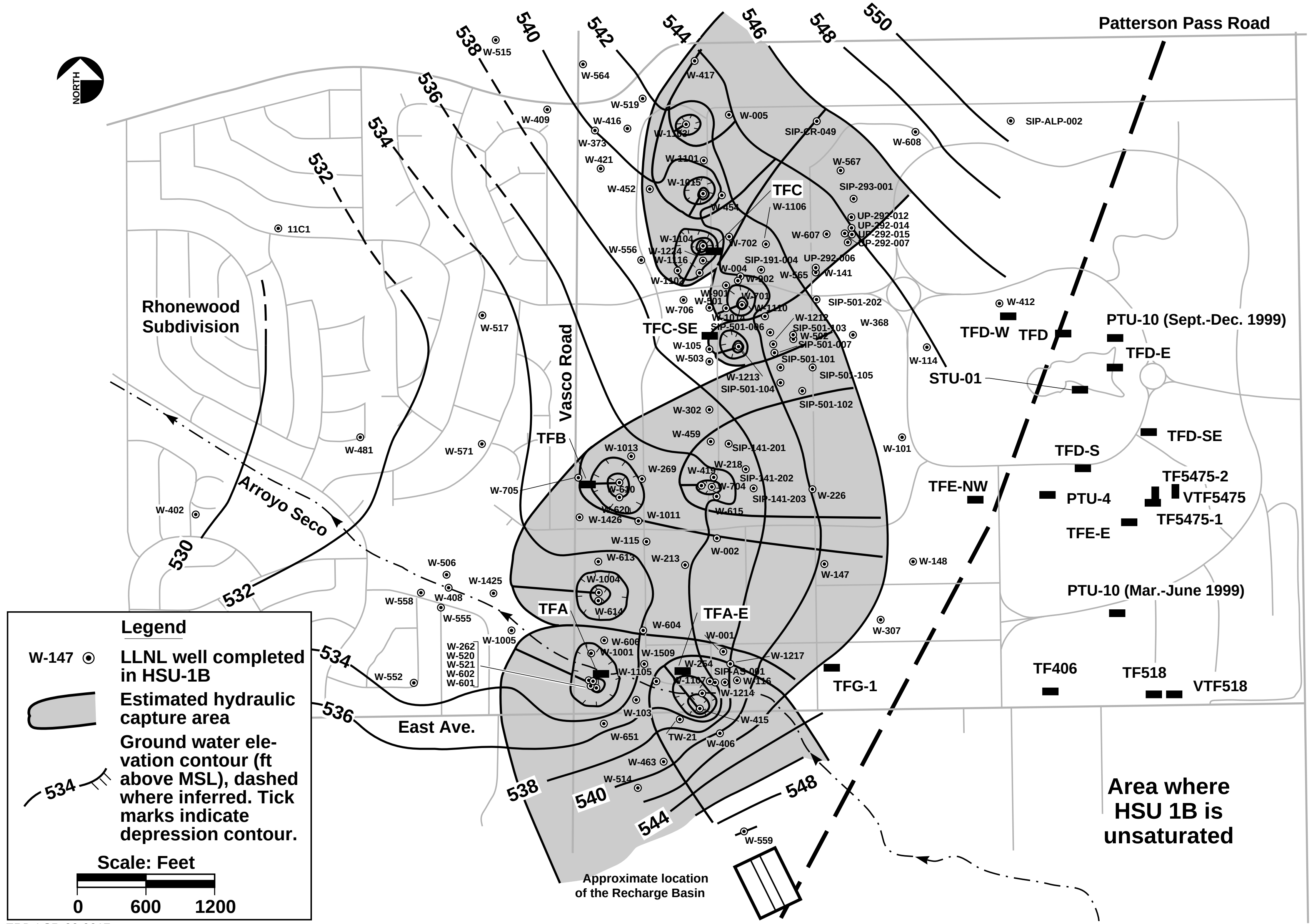

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Figure 6. Ground water elevation contour map based on water levels collected from 131 wells completed within HSU 1B showing estimated hydraulic capture areas, LLNL and vicinity, December 1999.

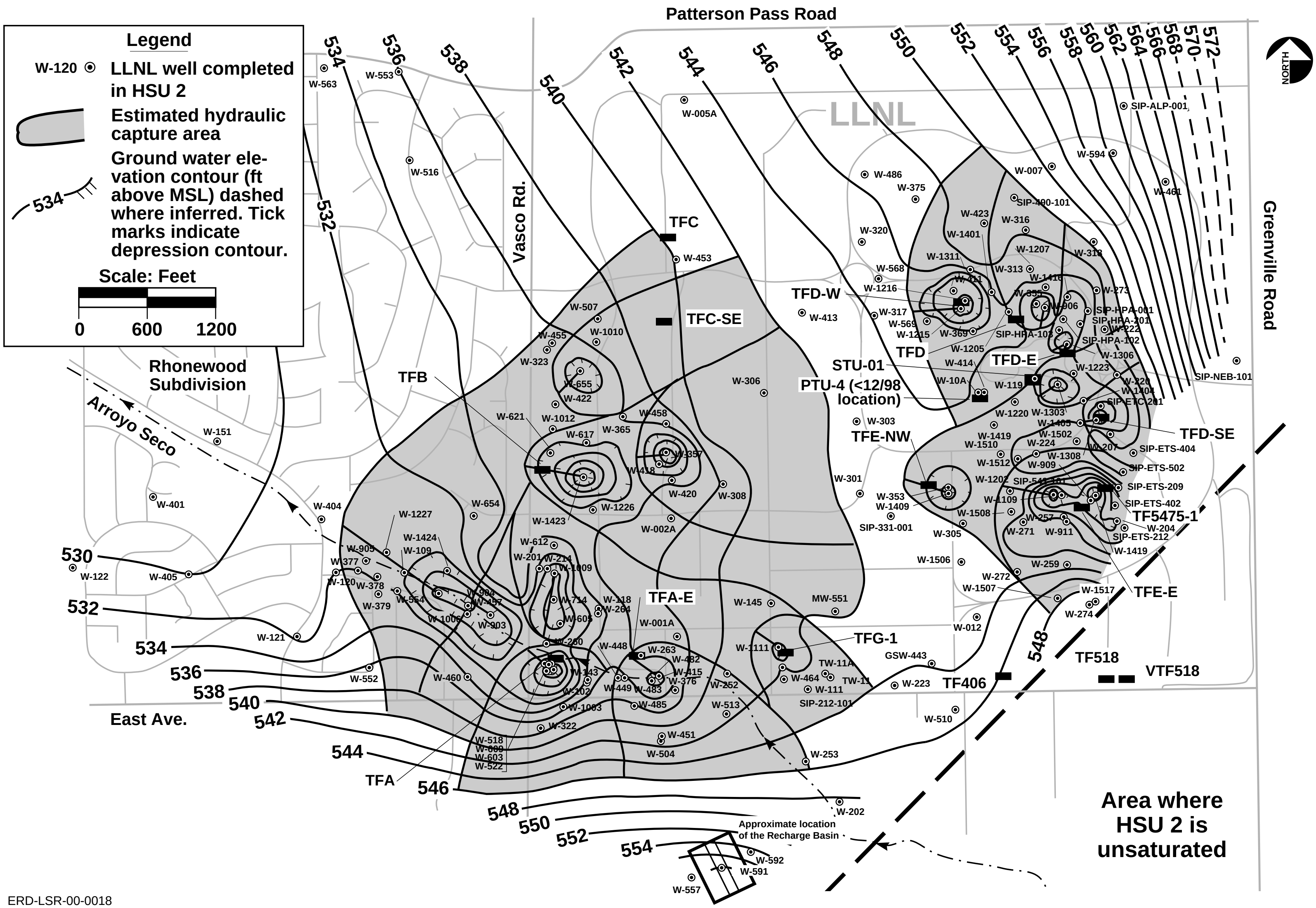

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Figure 7. Ground water elevation contour map based on water levels collected from 170 wells completed within HSU 2 showing estimated hydraulic capture areas, LLNL and vicinity, December 1999.

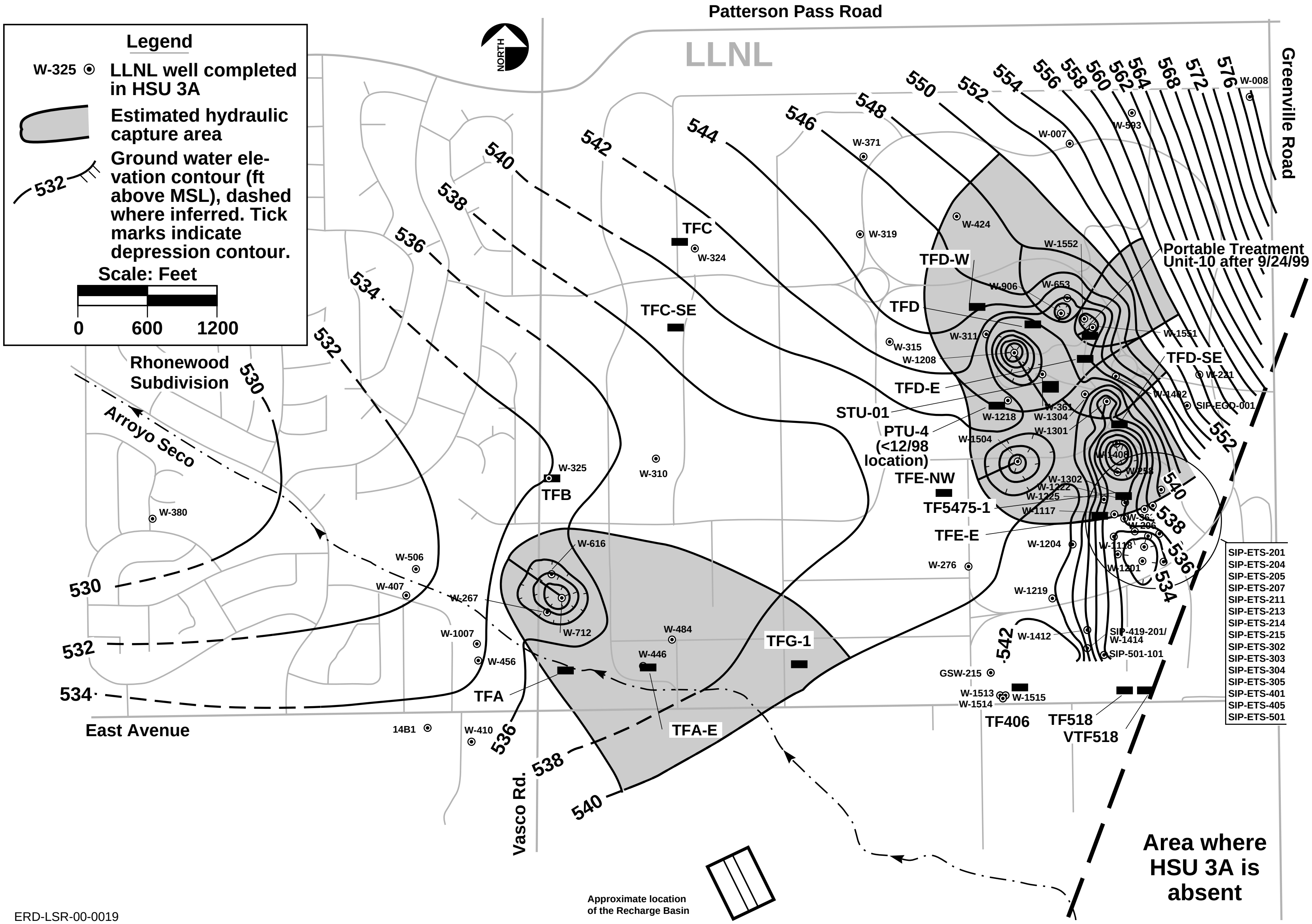

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Figure 8. Ground water elevation contour map based on water levels collected from 59 wells completed within HSU 3A showing estimated hydraulic capture areas, LLNL and vicinity, December 1999.

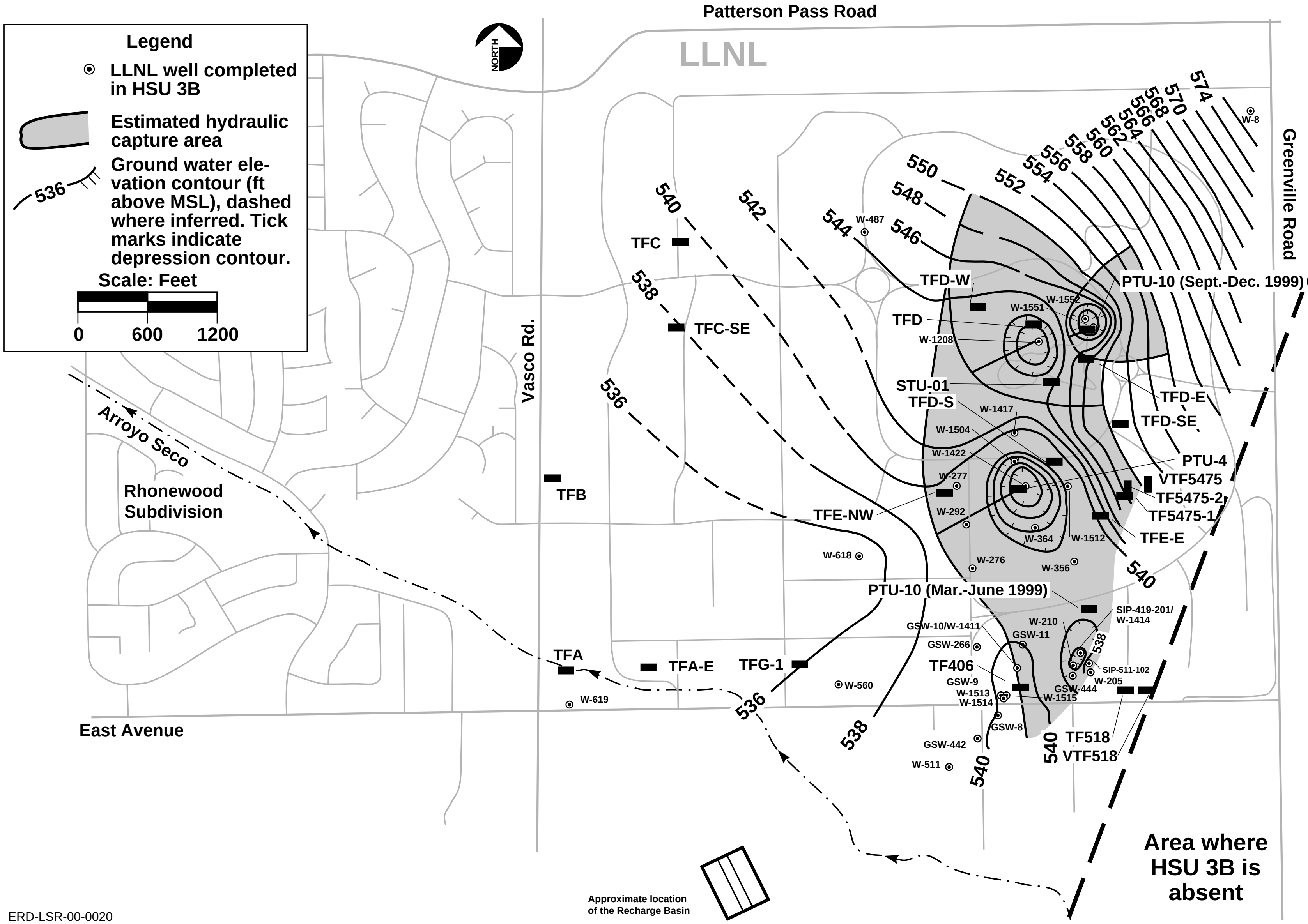

Figure 9. Ground water elevation contour map based on water levels collected from 26 wells completed within HSU 3B showing estimated hydraulic capture areas, LLNL and vicinity, December 1999.

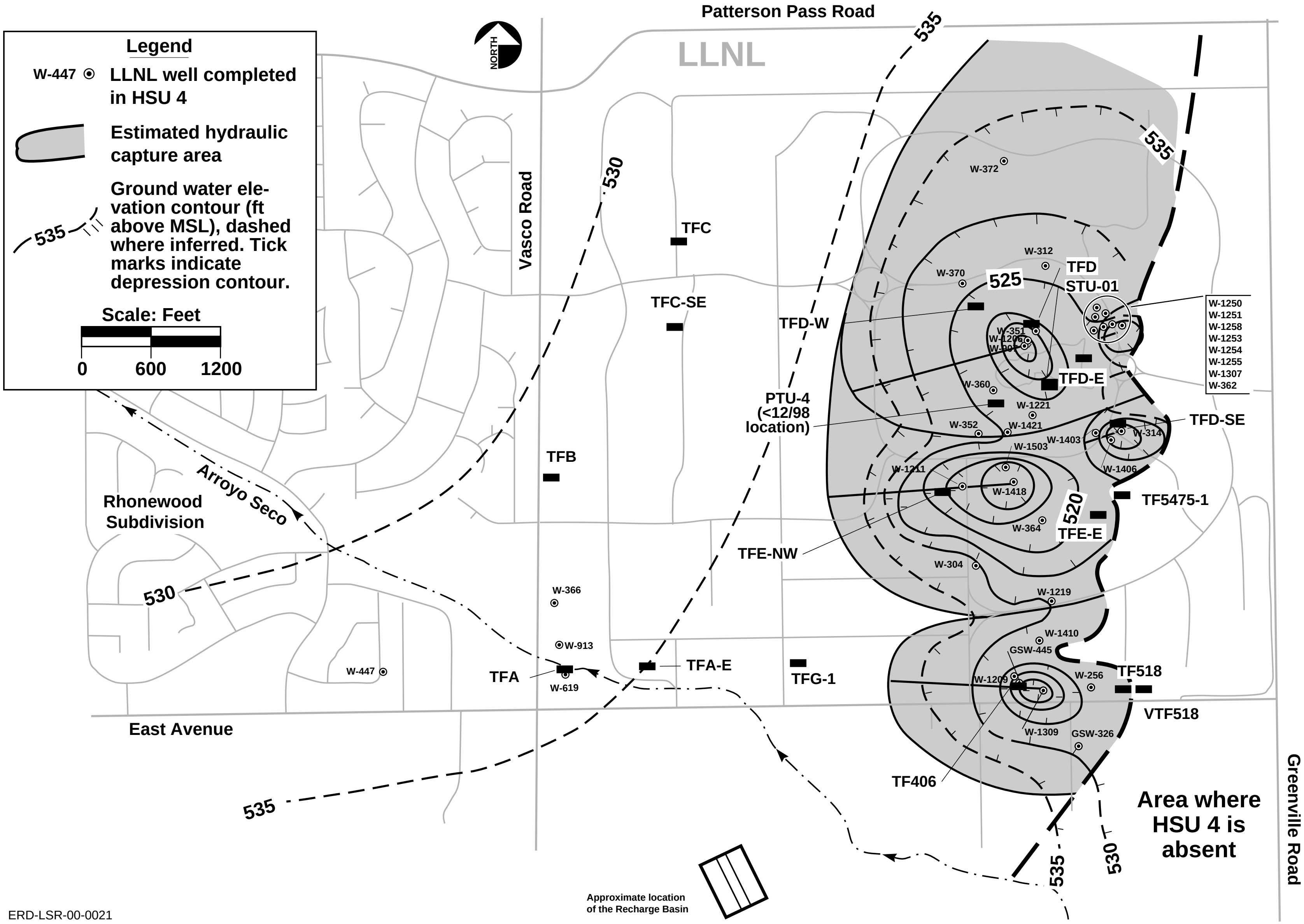

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Figure 10. Ground water elevation contour map based on water levels collected from 38 wells completed within HSU 4 showing estimated hydraulic capture areas, LLNL and vicinity, December 1999.

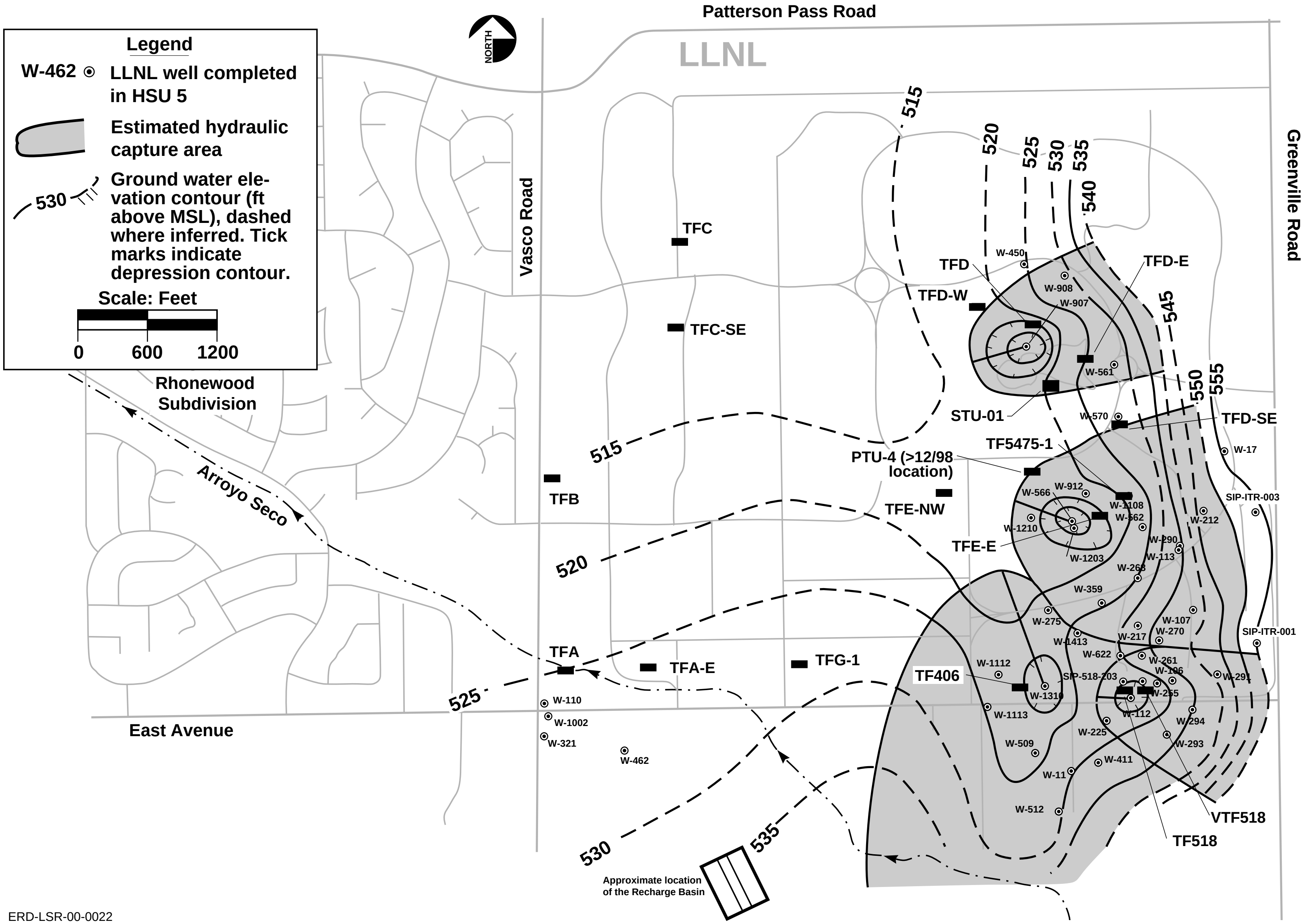

Figure 11. Ground water elevation contour map based on water levels collected from 45 wells completed within HSU 5 showing estimated hydraulic capture areas, LLNL and vicinity, December 1999.

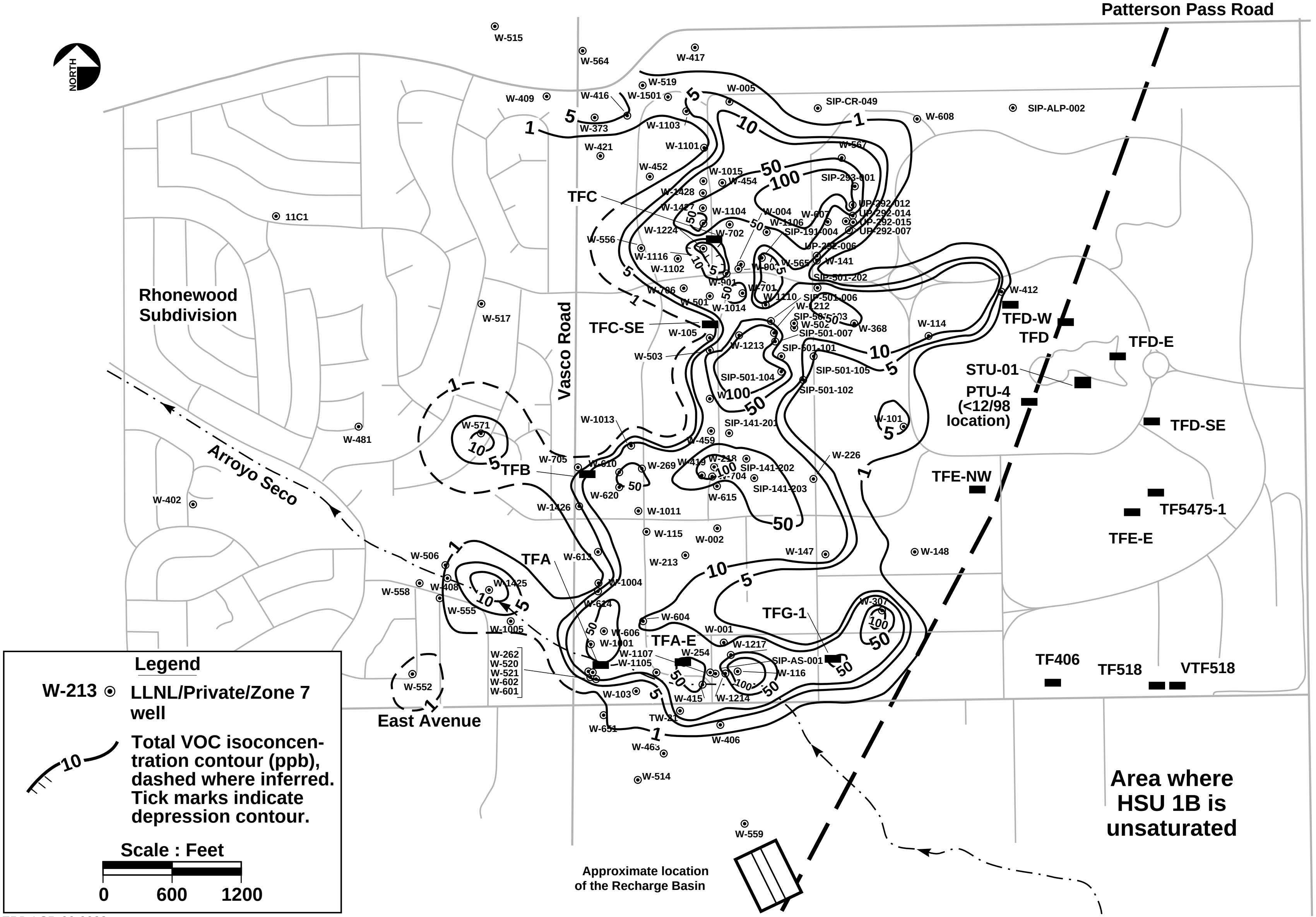

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Figure 12. Isoconcentration contour map of total VOCs for 125 wells completed within HSU 1B based on samples collected in the fourth quarter of 1999 (or the next most recent data), and supplemented with soil chemistry data from 44 borehole locations.

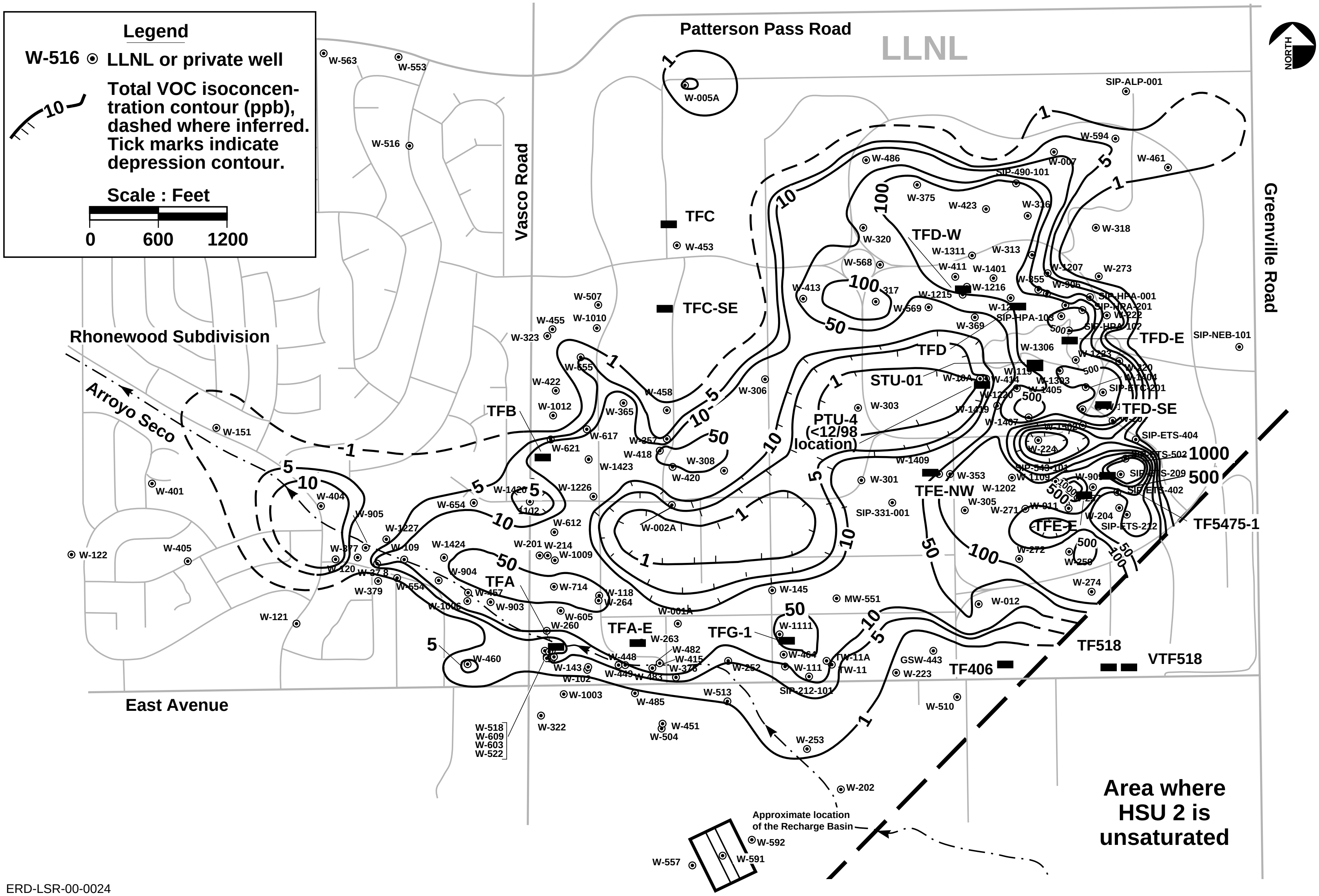

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Figure 13. Isoconcentration contour map of total VOCs for 188 wells completed within HSU 2 based on samples collected in the fourth quarter of 1999 (or the next most recent data), and supplemented with soil chemistry data from 98 borehole locations.

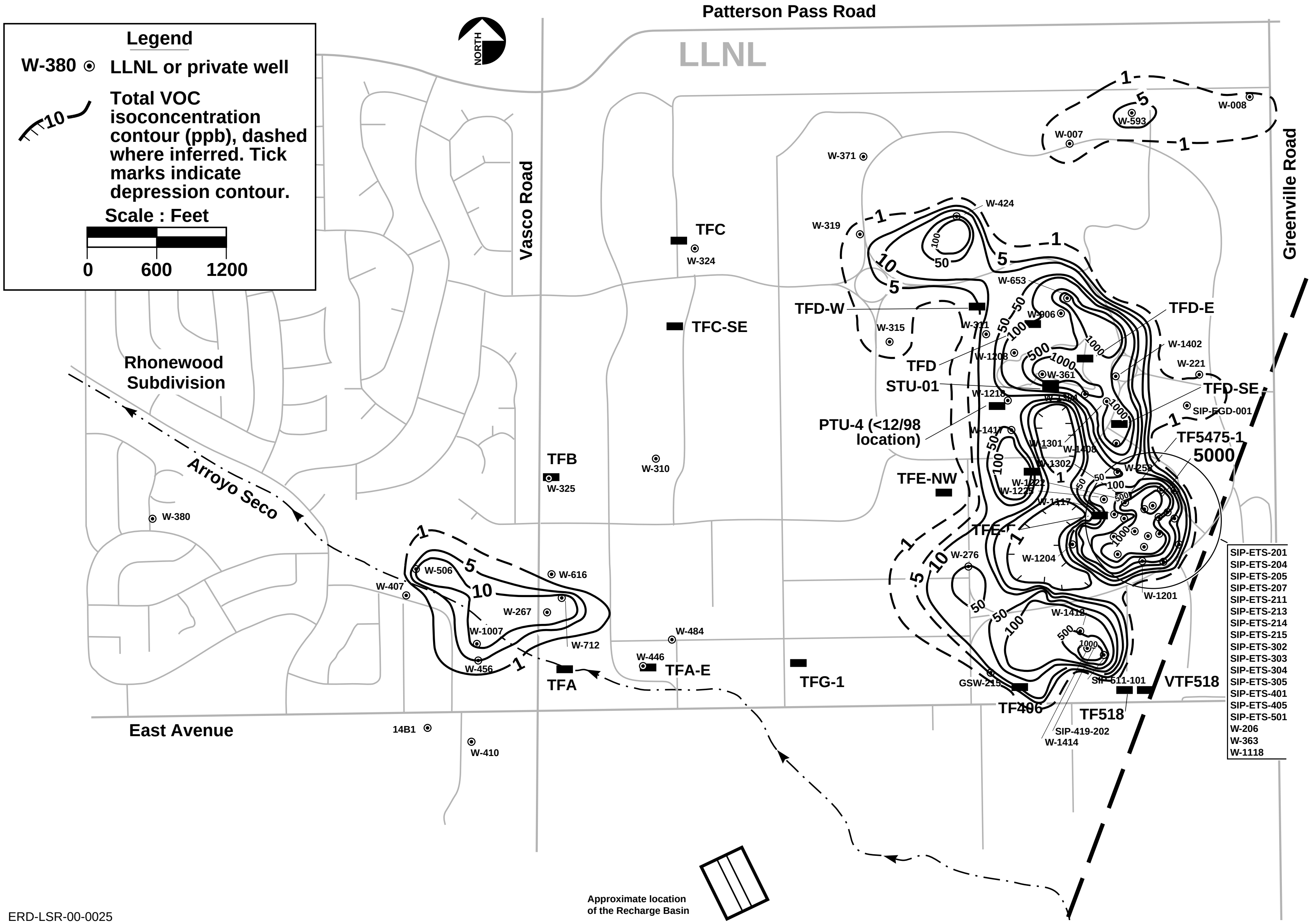

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Figure 14. Isoconcentration contour map of total VOCs for 87 wells completed within HSU 3A based on samples collected in the fourth quarter of 1999 (or the next most recent data), and supplemented with soil chemistry data from 146 borehole locations.

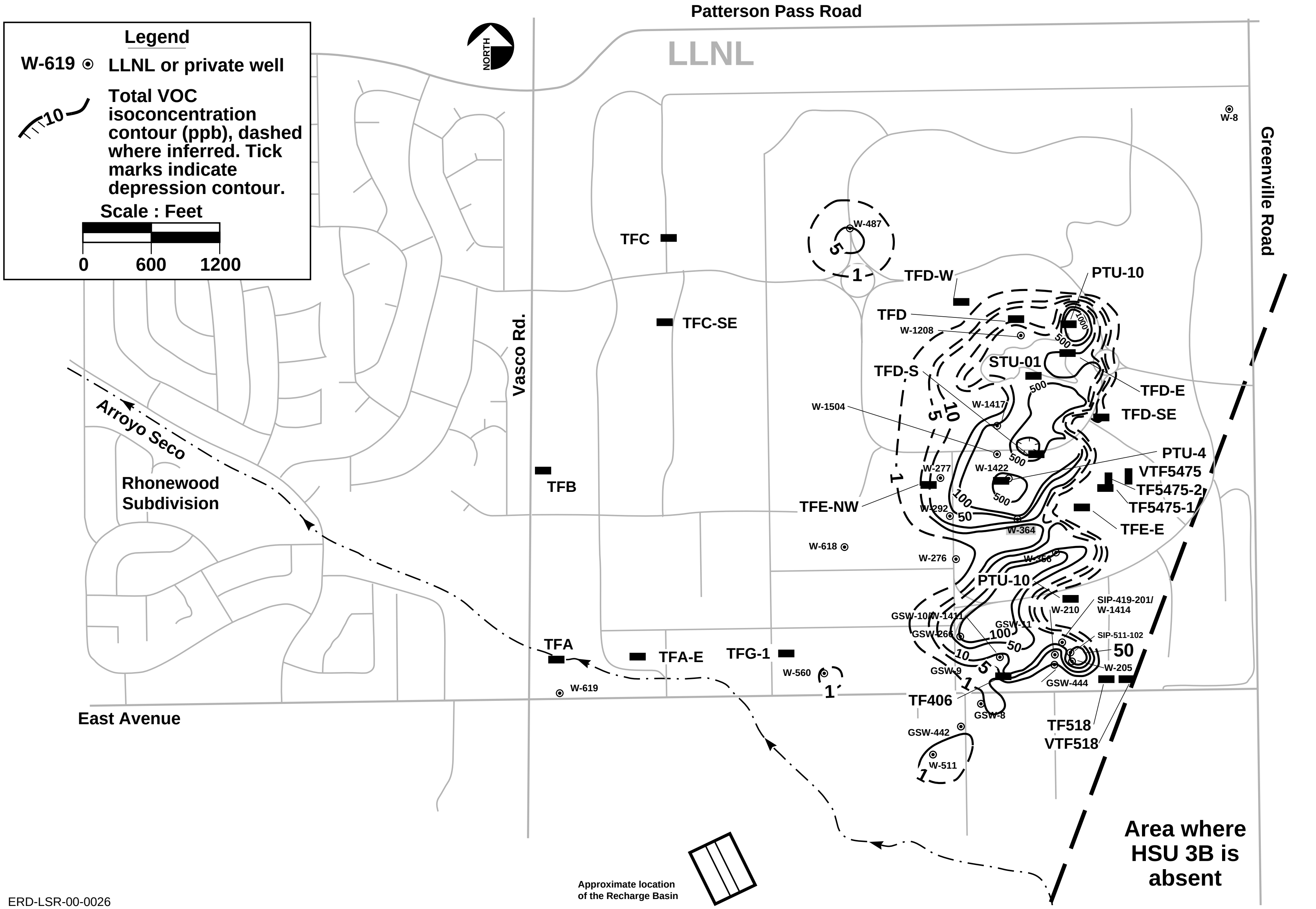

Figure 15. Isoconcentration contour map of total VOCs for 47 wells completed within HSU 3B based on samples collected in the fourth quarter of 1999 (or the next most recent data), and supplemented with soil chemistry data from 113 borehole locations.

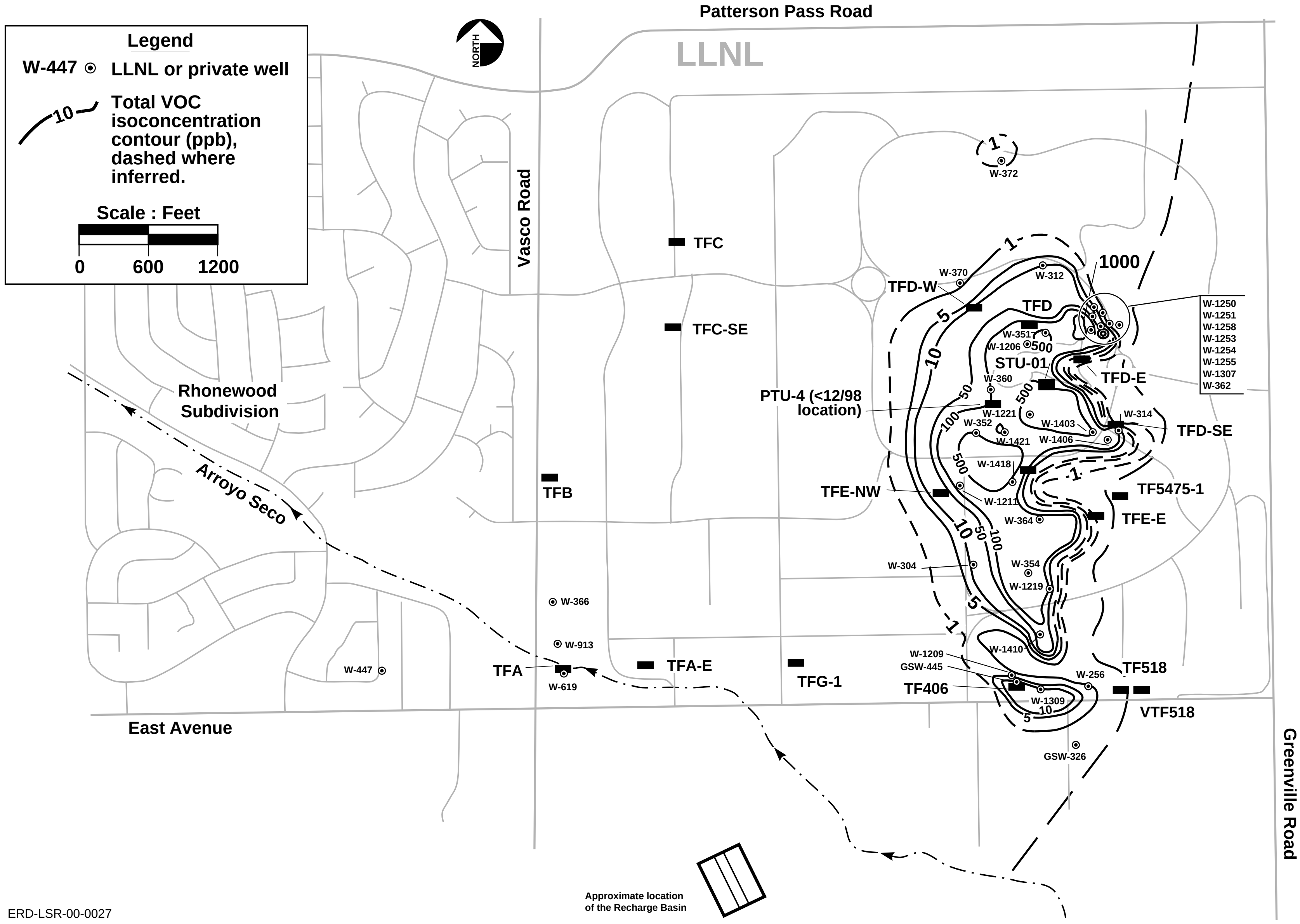

Figure 16. Isoconcentration contour map of total VOCs for 46 wells completed within HSU 4 based on samples collected in the fourth quarter of 1999 (or the next most recent data), and supplemented with soil chemistry data from 63 borehole locations.

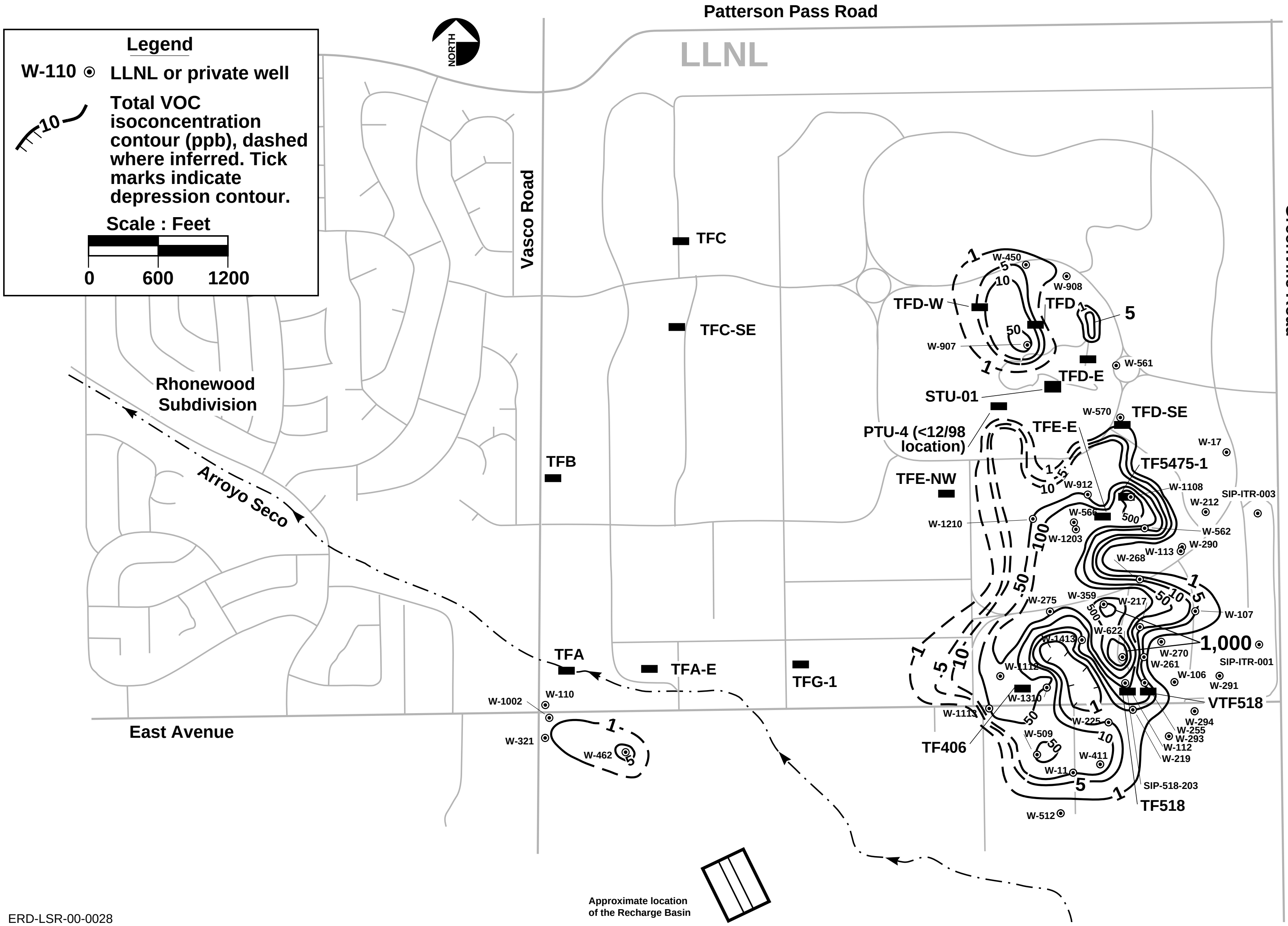

Figure 17. Isoconcentration contour map of total VOCs for 53 wells completed within HSU 5 based on samples collected in the fourth quarter of 1999 (or the next most recent data), and supplemented with soil chemistry data from 97 borehole locations.

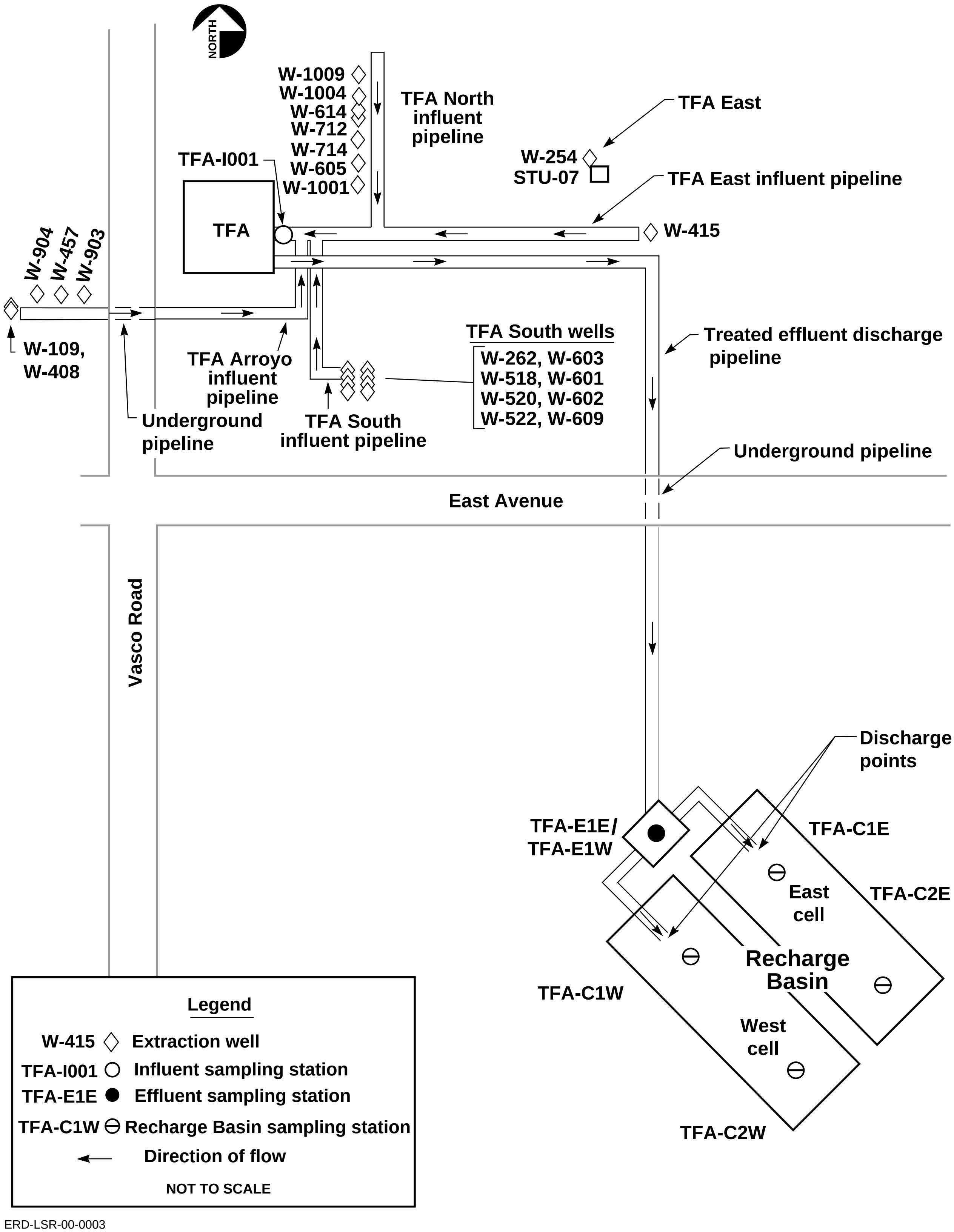

Figure 18. 1999 TFA extraction well, pipeline and discharge locations.

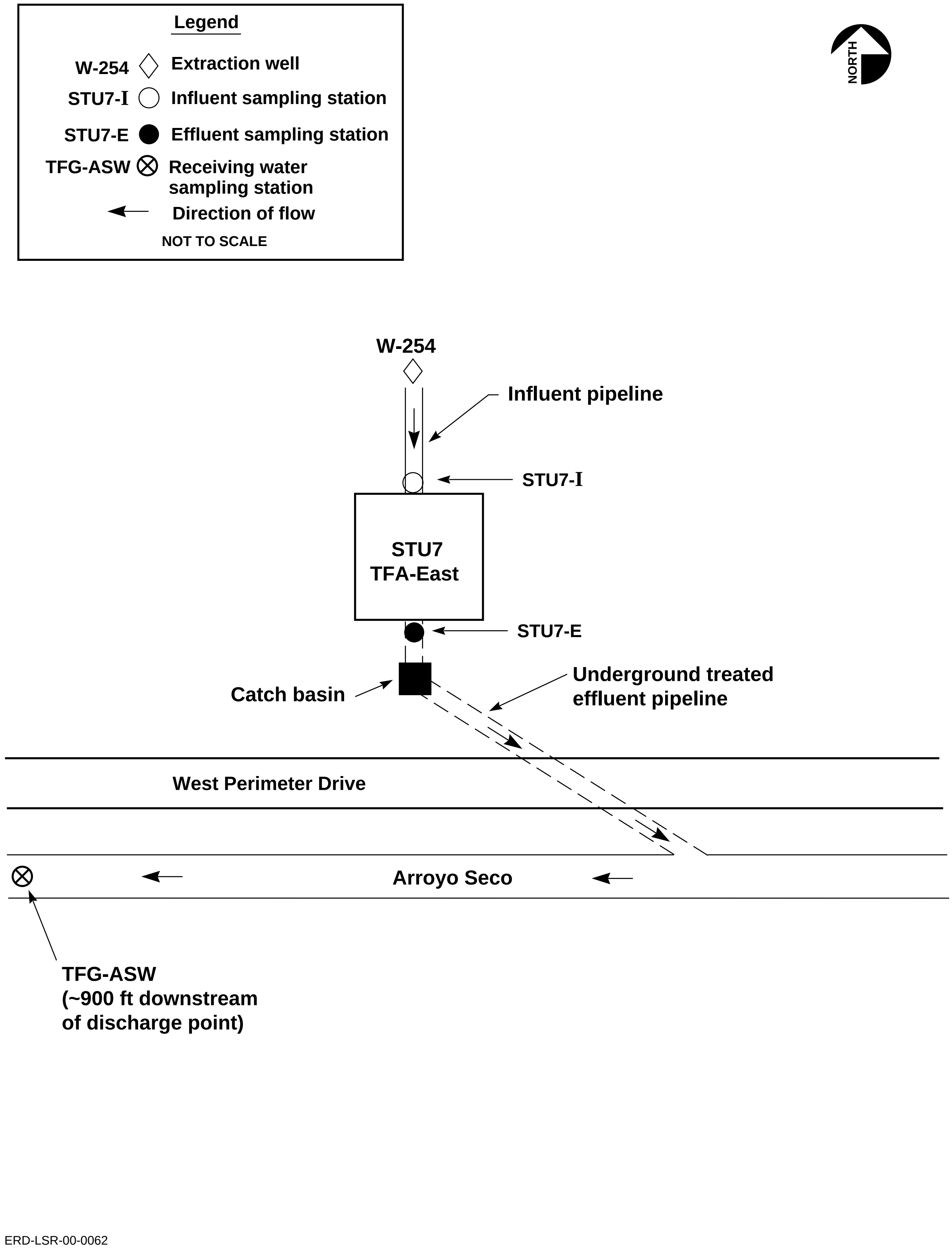

Figure 19. 1999 TFA East extraction well, pipeline and discharge locations.

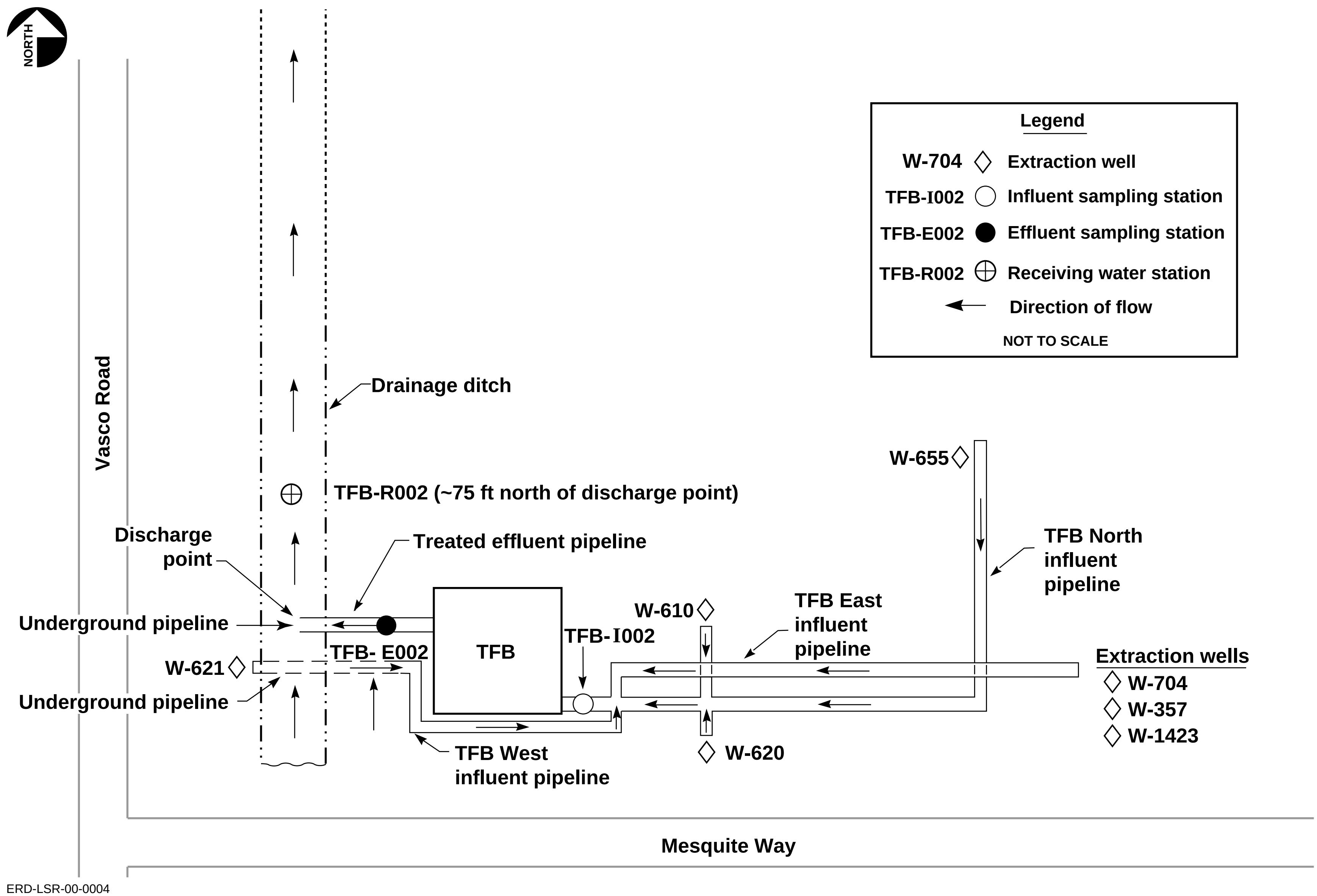

Figure 20. 1999 TFB extraction well, pipeline and discharge locations.

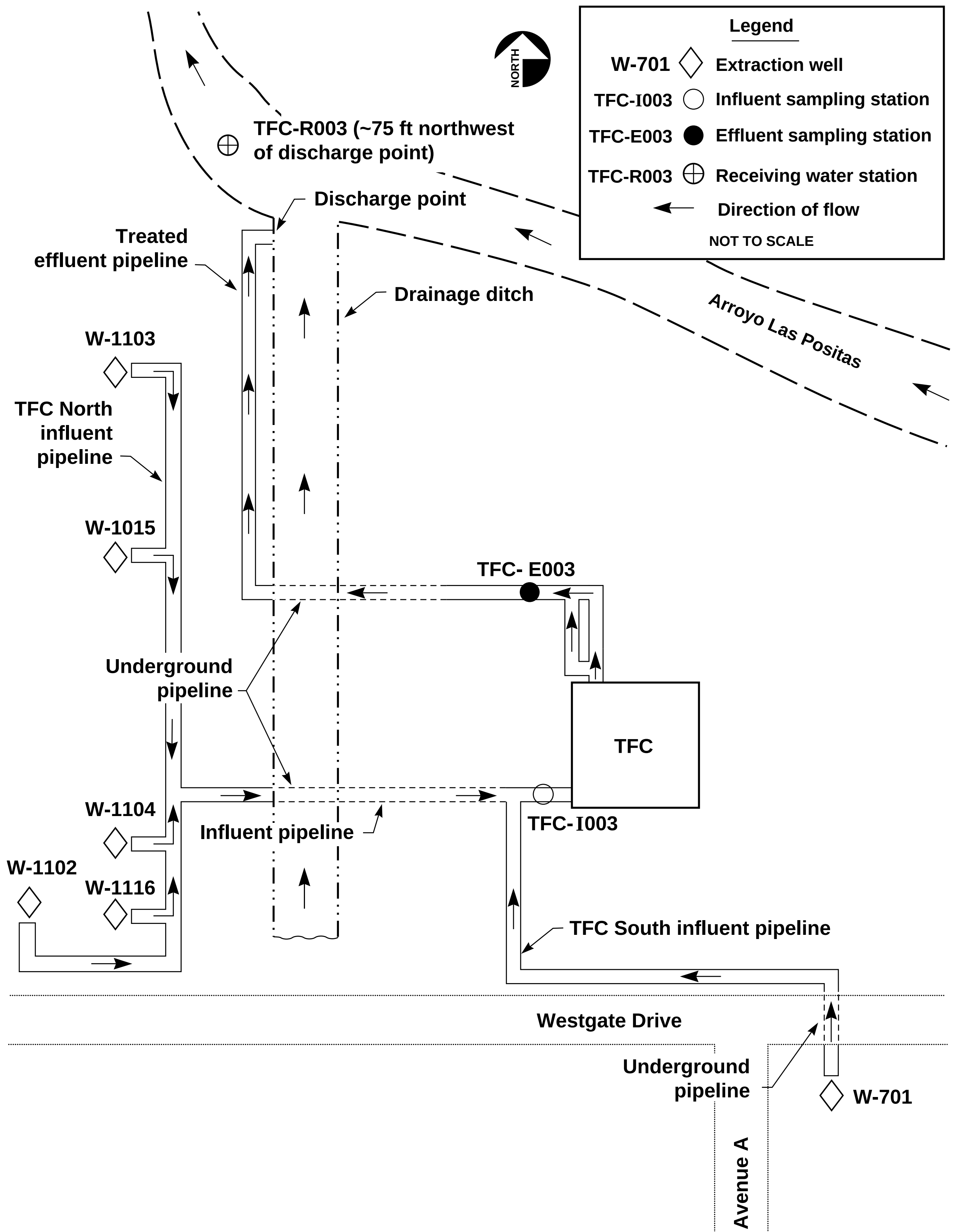

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Figure 21. 1999 TFC extraction well, pipeline and discharge locations.

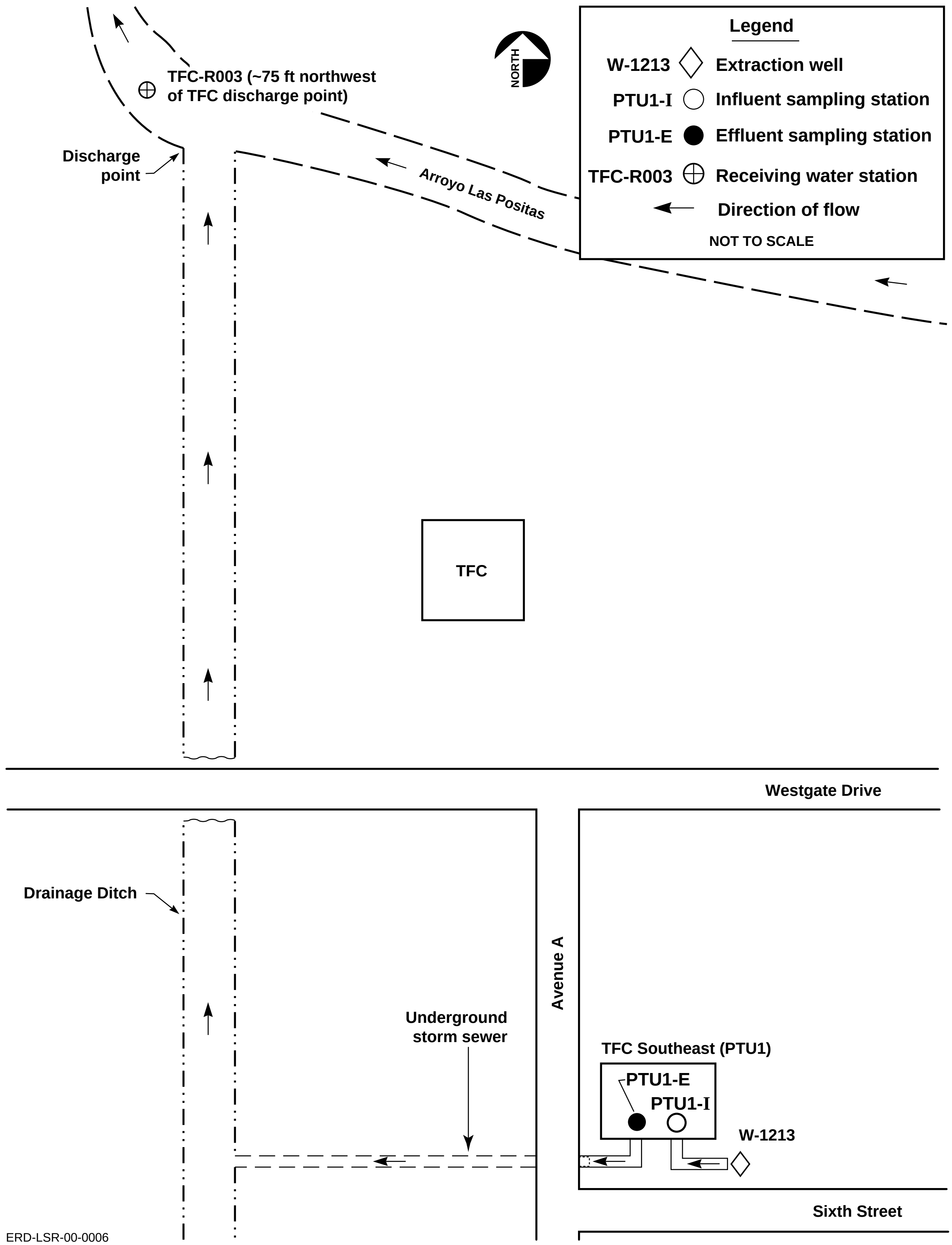

Figure 22. 1999 TFC Southeast extraction well, pipeline and discharge locations.

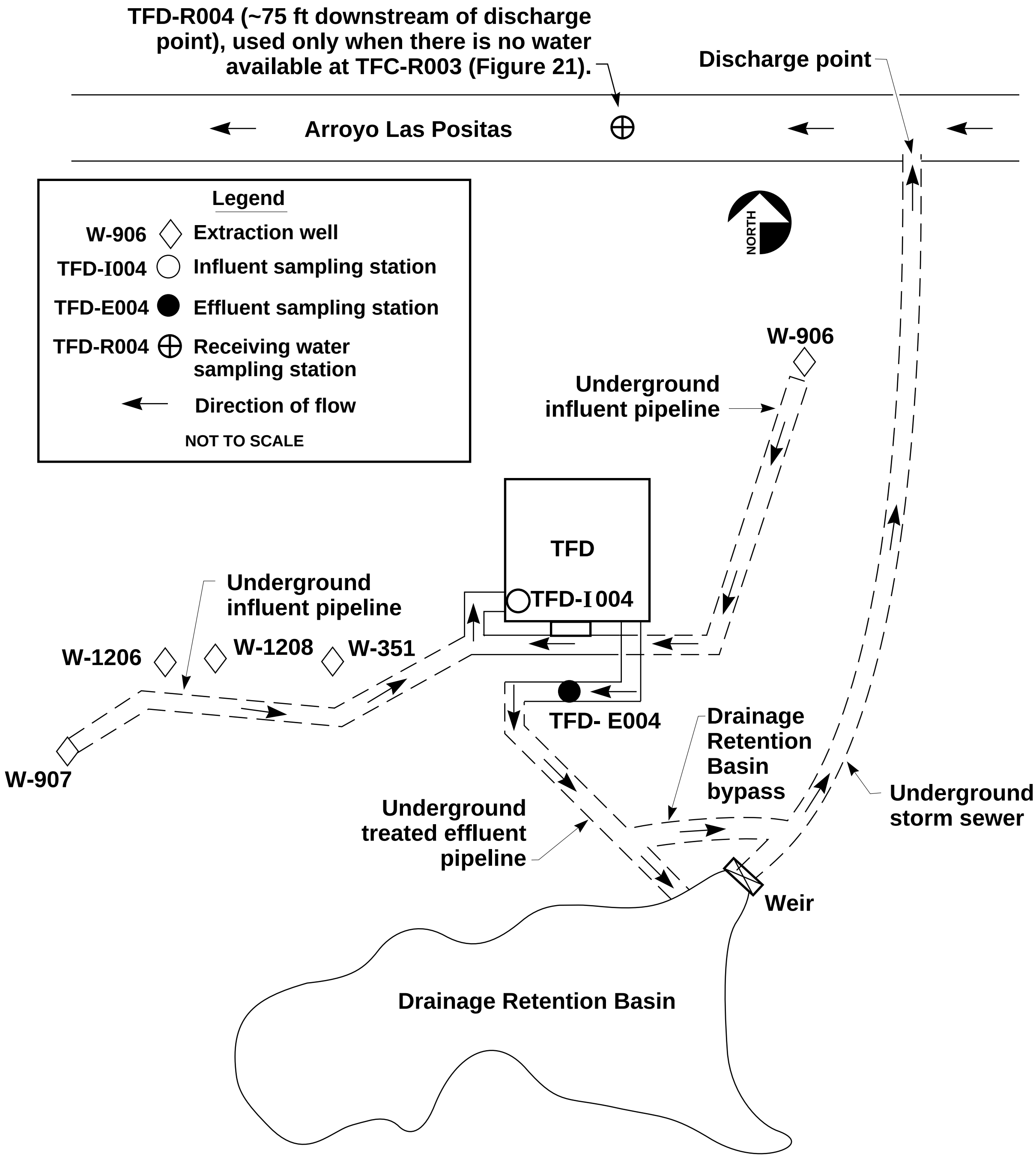

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Figure 23. 1999 TFD extraction well, pipeline and discharge locations.

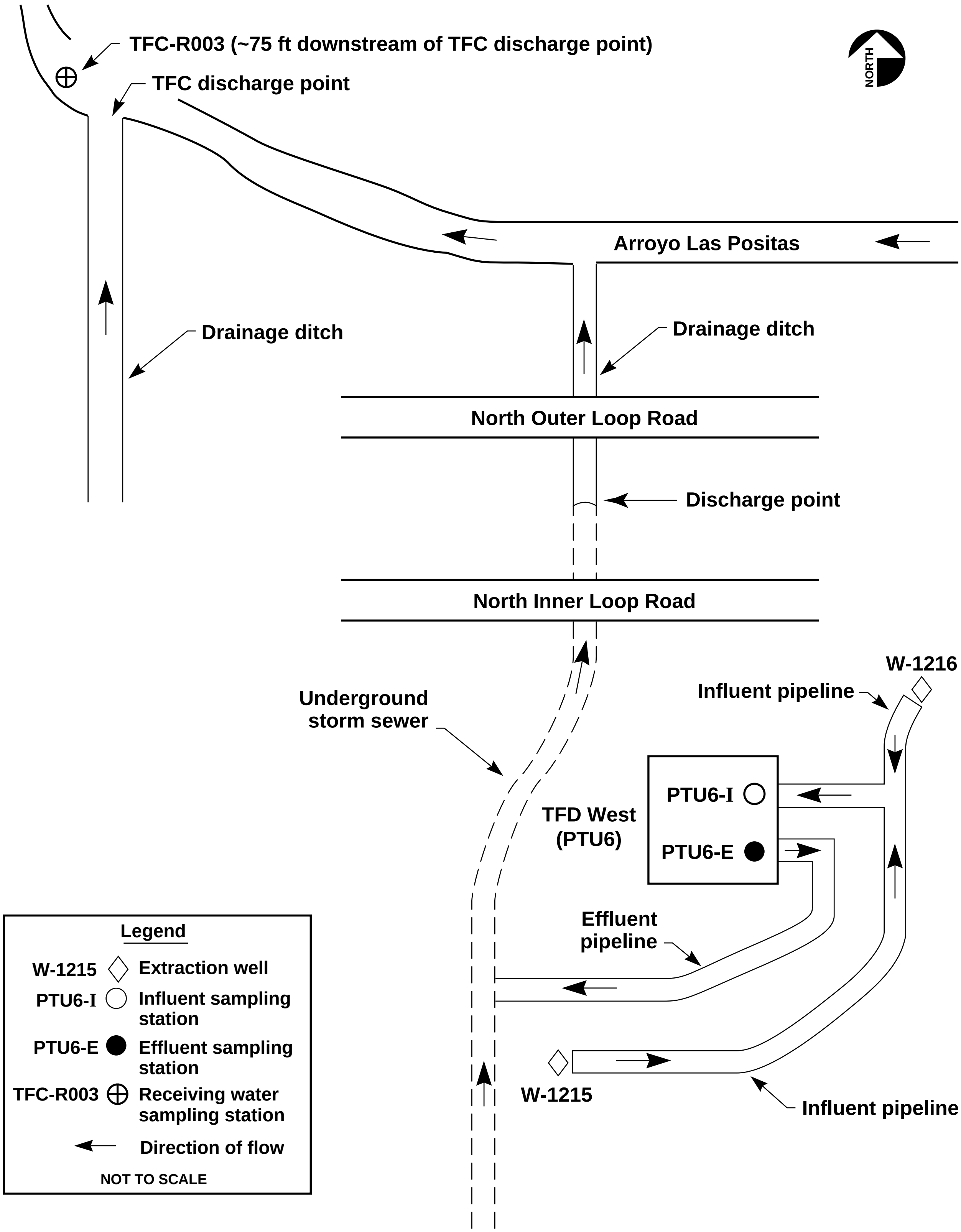

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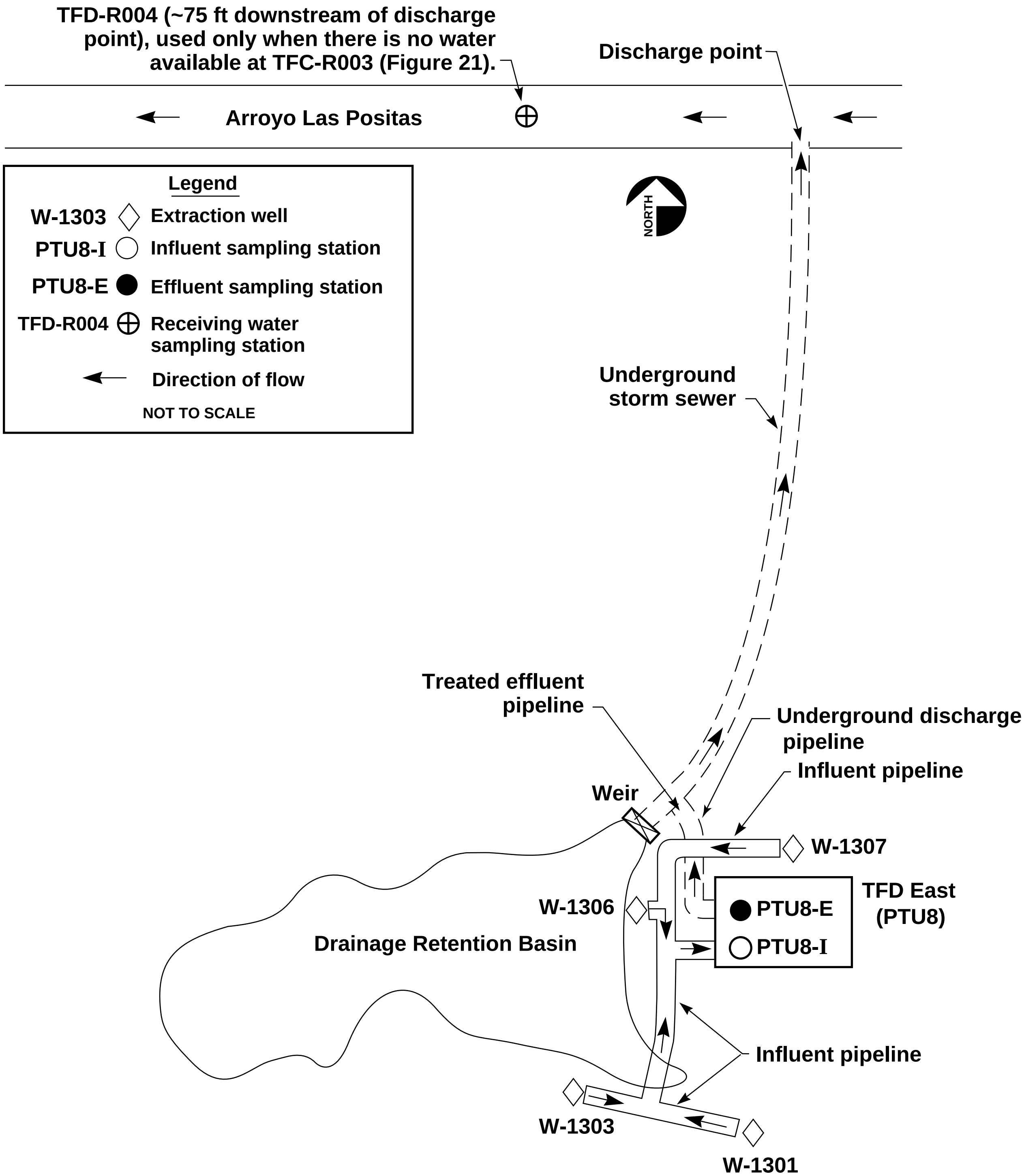
Figure 24. 1999 TFD West extraction well, pipeline and discharge locations.



ERD-LSR-00-0010

Figure 25. 1999 TFD East extraction well, pipeline and discharge locations.

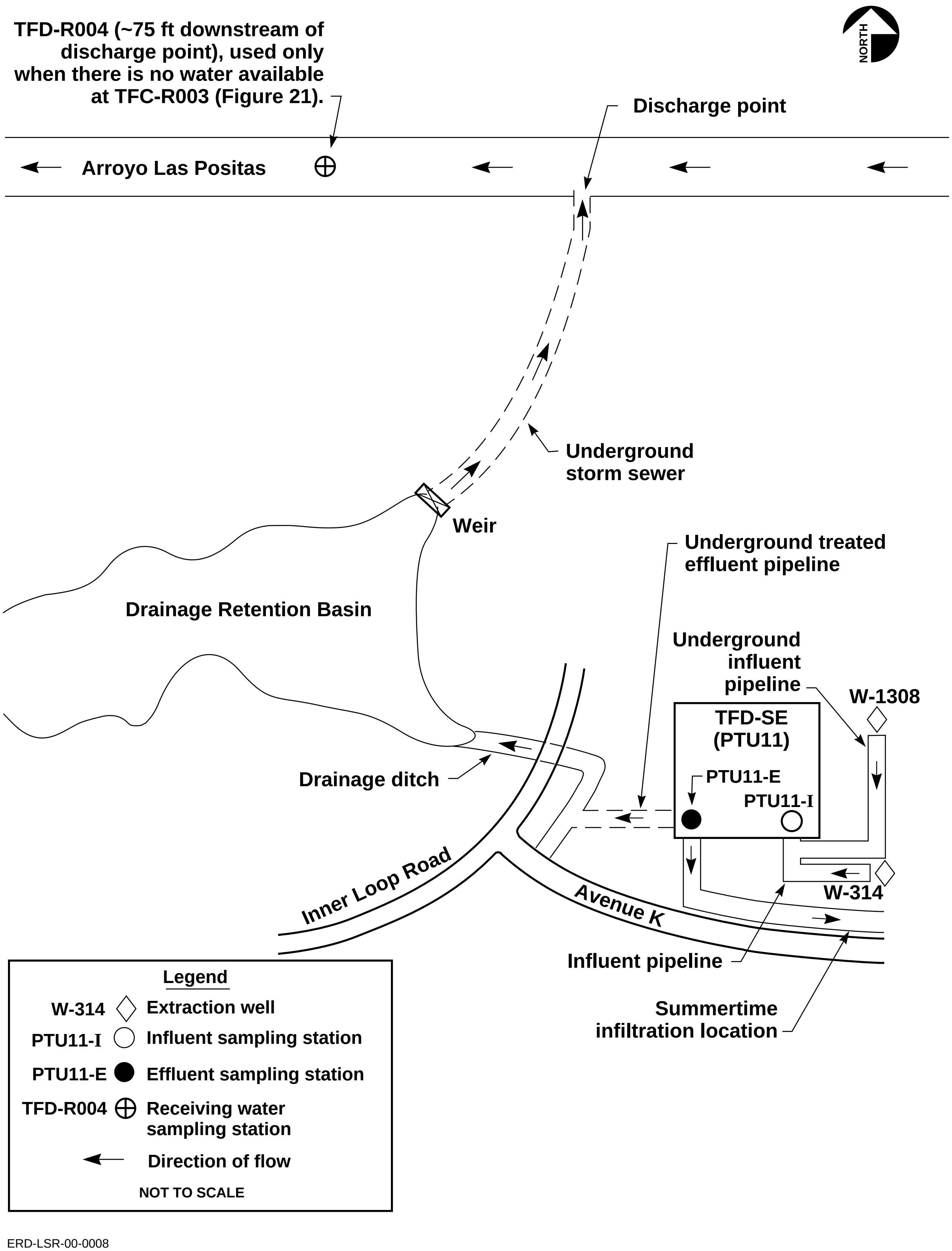


Figure 26. 1999 TFD Southeast extraction well, pipeline and discharge locations.

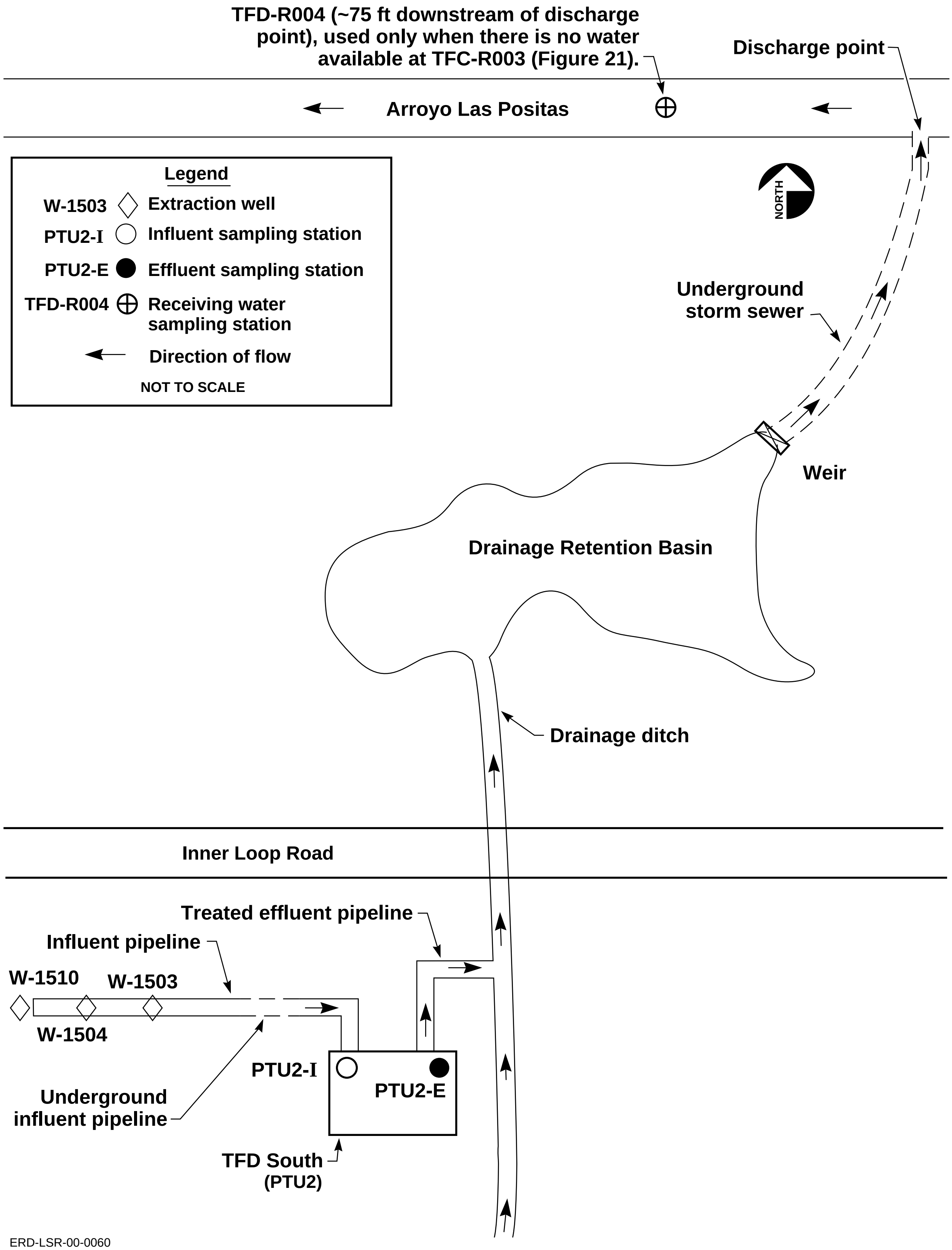


Figure 27. 1999 TFD South extraction well, pipeline and discharge locations.

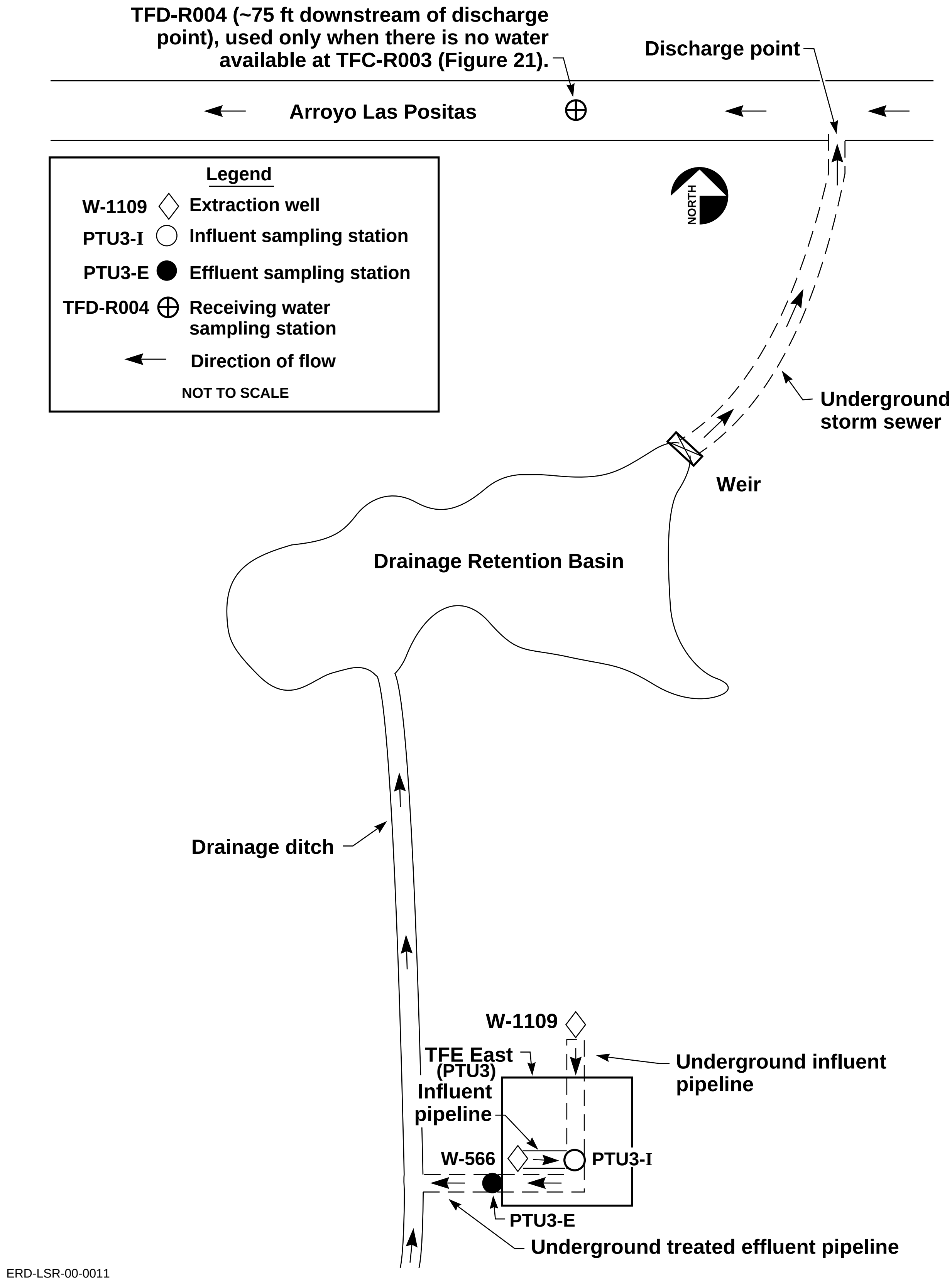
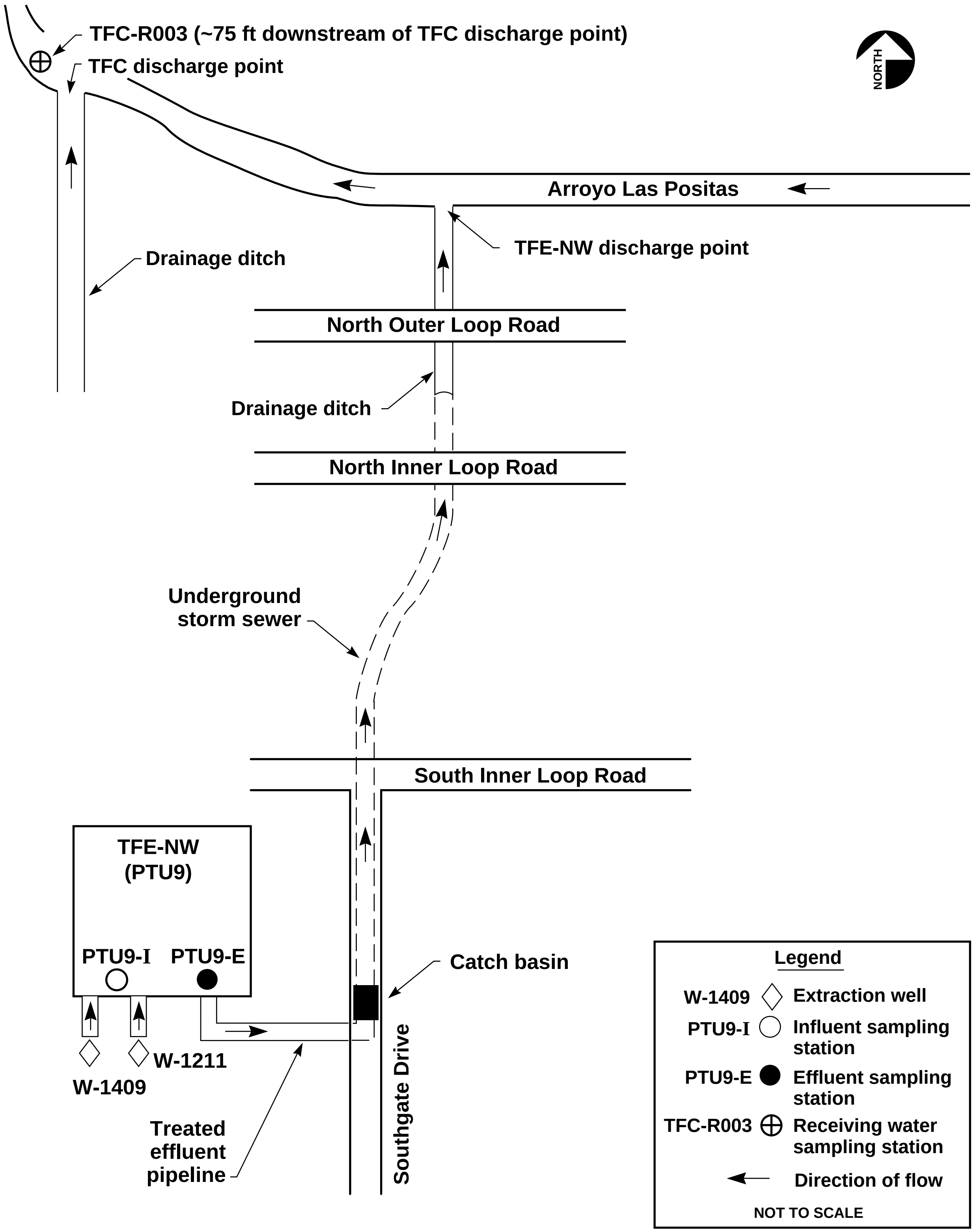
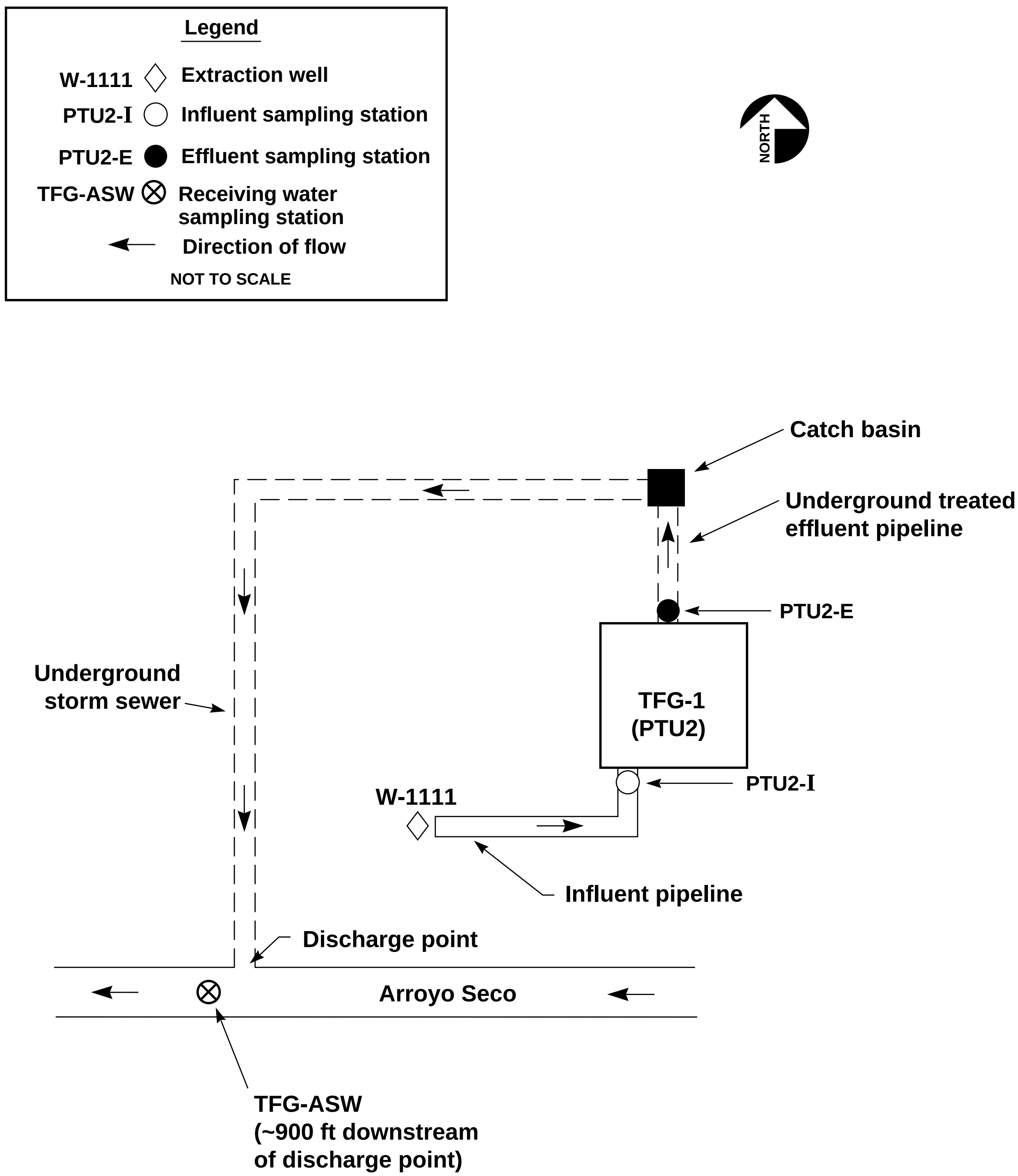


Figure 28. 1999 TFE East extraction well, pipeline and discharge locations.



ERD-LSR-00-0012

Figure 29. 1999 TFE Northwest extraction well, pipeline and discharge locations.



ERD-LSR-00-0013

Figure 30. 1999 TFG-1 extraction well, pipeline and discharge locations.

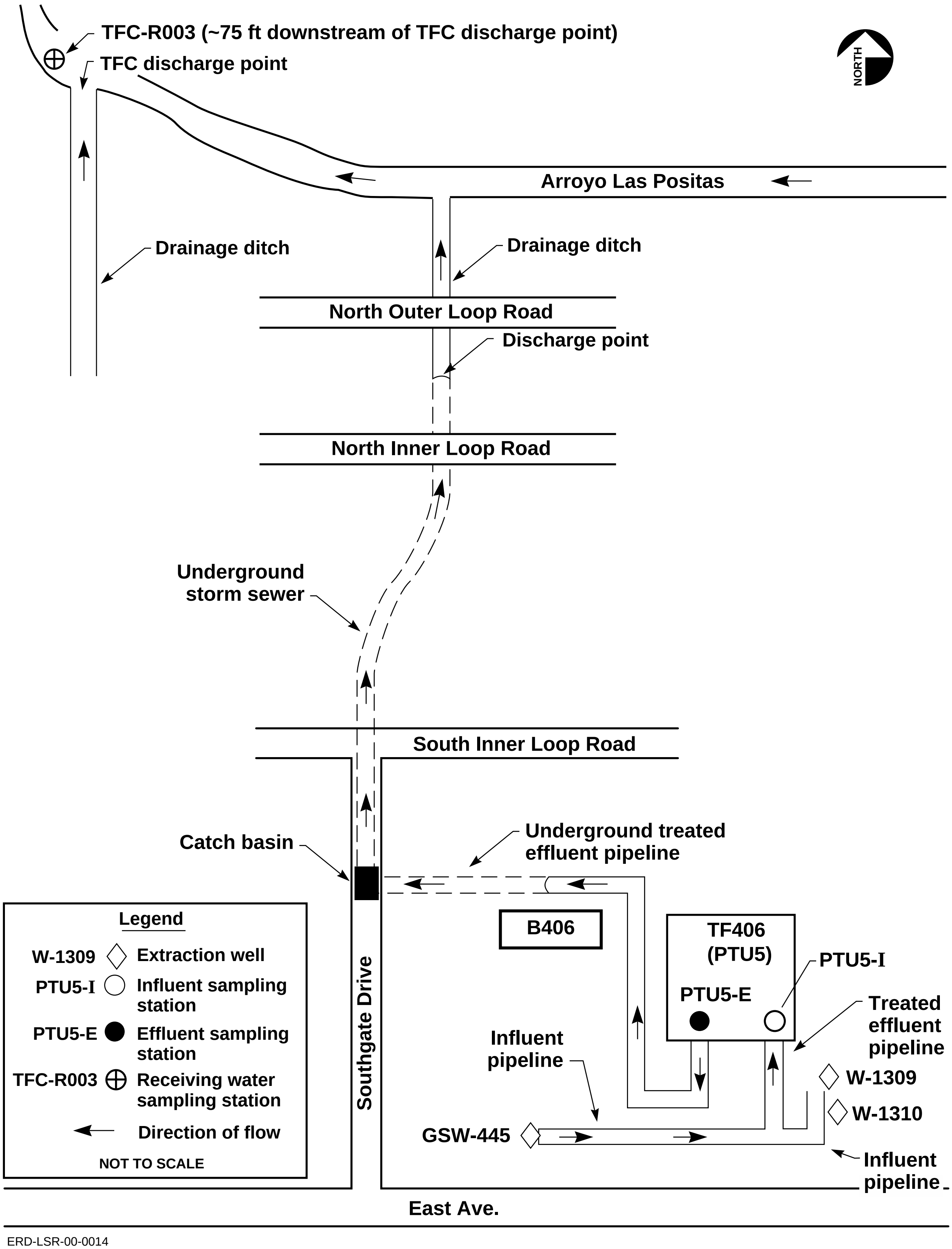


Figure 31. 1999 TF406 extraction well, pipeline and discharge locations.

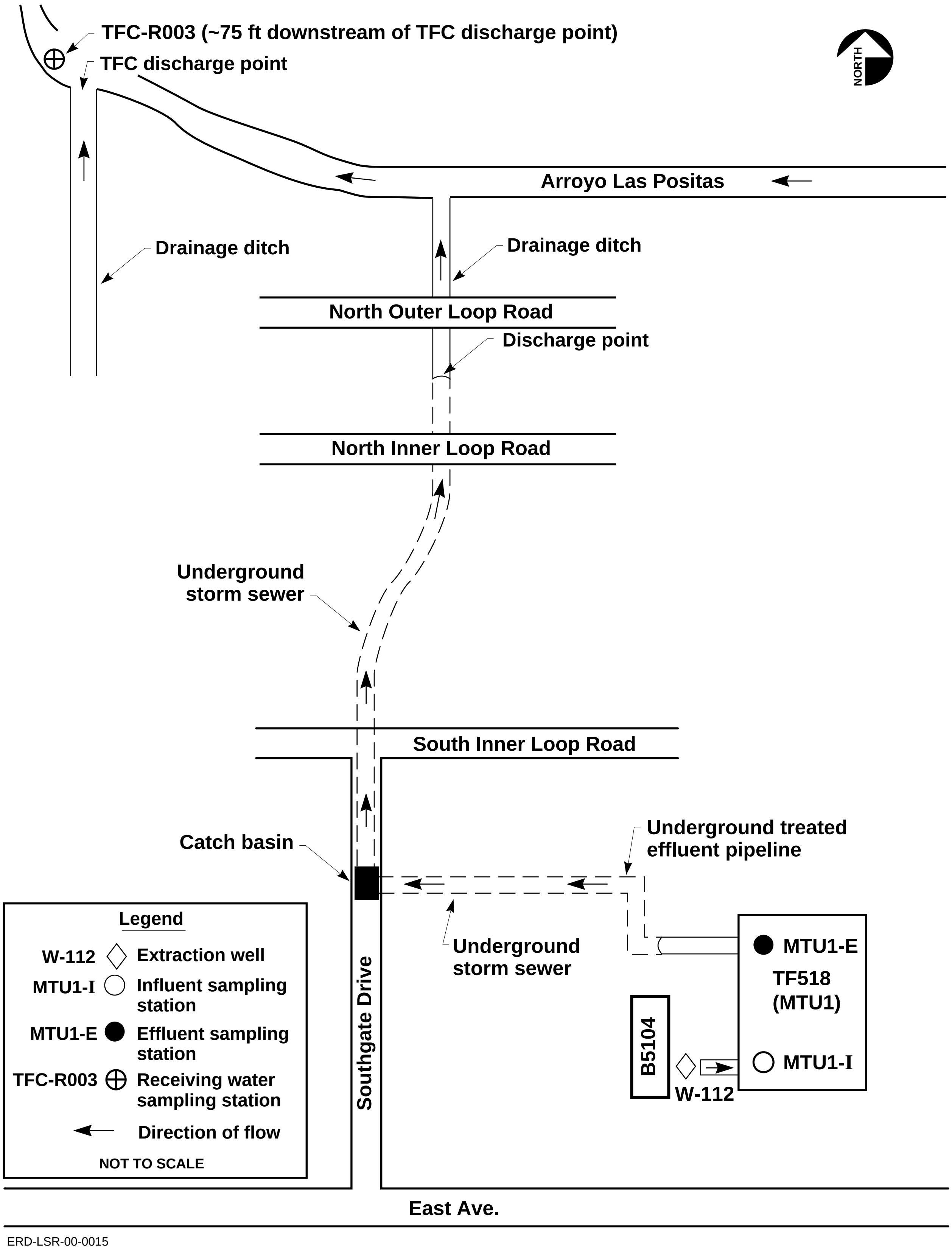


Figure 32. 1999 TF518 extraction well, pipeline and discharge locations.

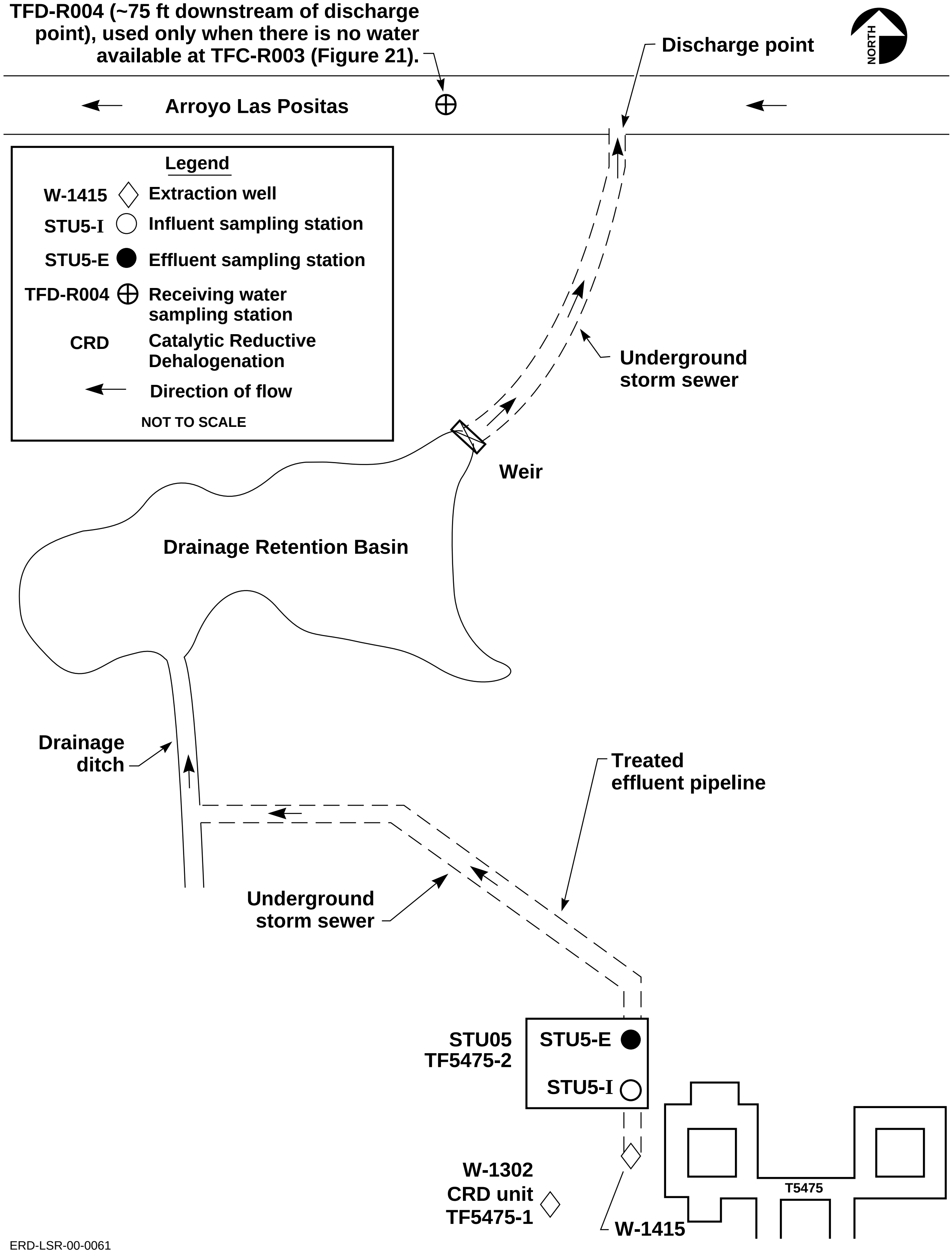


Figure 33. 1999 TF5475 extraction well, pipeline and discharge locations.

Tables

Table 1. 1999 Livermore Site Remedial Action Implementation Plan milestones.

Milestone	Milestone date	Completion date
Begin operation of VTF5475 (VES-1) Vapor Treatment Facility at Trailer 5475	1/29/99	1/21/99
Begin operation of TF5475-2 (STU-05)treatment unit at Trailer 5475	3/31/99	3/23/99
Begin operation of Treatment Facility D South portable treatment unit (PTU-2)	6/29/99	6/23/99
Begin operation of STU-07 treatment unit at Treatment Facility A	8/06/99	8/04/99

Table 2. Summary of 1999 VOC remediation.

Treatment facility area	Volume of ground water treated (Mgal)	Volume of soil vapor treated (Kft^3)	Estimated total VOC mass removed (kg)
TFA	137.0	–	14.0
TFB	30.1	–	7.6
TFC	24.5	–	9.0
TFD	59.6	–	88.4
TFE	28.5	–	38.1
TFG	2.7	–	0.6
TF406	7.4	–	1.0
TF5475	0.17	–	0.4
VTF5475	–	2,093	94.9
TF518	0.94	–	0.2
VTF518	–	3,596	13.1
Total	290.9	5,689	267.3

Notes:

kg = Kilograms.

Kft^3 = Thousands of cubic feet.

Mgal = Millions of gallons.

Table 3. Summary of cumulative VOC remediation.

Treatment facility area	Volume of ground water treated (Mgal)	Volume of soil vapor treated (Kft^3)	Estimated total VOC mass removed (kg)
TFA	652.1	–	123.0
TFB	113.7	–	38.3
TFC	83.5	–	32.3
TFD	183.9	–	235.0
TFE	53.1	–	71.9
TFG	10.1	–	1.8
TF406	22.0	–	4.2
TF5475	0.20	–	2.3
VTF5475	–	2,093	94.9
TF518	3.7	–	1.2
VTF518	–	14,769	147.3
Total	1,122	16,862	752.2

Notes:

kg = Kilograms.

Kft^3 = Thousands of cubic feet.

Mgal = Millions of gallons.

Appendix A

Well Construction and Closure Data

Table A-1. Well construction data, Lawrence Livermore National Laboratory and vicinity, Livermore, California.

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
Monitor Wells						
W-1	21-Oct-80	122.5	116.0	95-100	1B/2	NA
W-1A	12-Apr-84	180.0	156.0	145-156	2	NA
W-2	29-Aug-80	102.5	101.0	86-101	1B	NA
W-2A	02-Apr-84	185.0	164.0	150-164	2	NA
W-4	28-Jul-80	92.0	90.0	75-90	1B	NA
W-5	24-Oct-80	93.5	90.0	56-71 81-86	1B	NA
W-5A	09-Apr-84	115.0	105.0	95-105	2	NA
W-7	03-Oct-80	110.5	100.5	76-81 88-98	2/3A	NA
W-8	14-May-81	110.0	105.0	72-77 92-102	3A/3B	NA
W-10A	08-Sep-80	110.7	110.0	85-95 100-105	2	NA
W-11	03-Jun-81	252.0	191.0	136-141 177-187	5	NA
W-12	14-Aug-80	115.75	115.0	99-114	2	NA
W-17	08-Oct-80	114.0	114.0	94-109	5	NA
W-17A	20-May-81	181.4	160.0	127-132 147-157	7	NA
W-19	19-Sep-80	164.75	161.0	147-157	7	NA
W-101	25-Jan-85	77.0	72.0	62-72	1B	1
W-102	12-Feb-85	396.5	171.5	151.5-171.5	2	40
W-103	14-Feb-85	96.0	89.5	79.5-89.5	1B	5
W-104	21-Feb-85	61.5	56.5	38.75-56.5	1B	2.5
W-105	26-Feb-85	69.0	62.0	42-62	1B	0.7
W-106	06-Mar-85	144.0	134.5	127.5-134.5	5	0.1-0.2
W-107	13-Mar-85	128.0	122.0	115-122	5	1-3
W-108	21-Mar-85	113.5	69.0	57-69	1A	10
W-110	26-Apr-85	371.0	365.0	340-365	5	6
W-111	02-May-85	122.0	117.0	97-117	2	1.5
W-113	16-May-85	124.0	115.0	100-115	5	0.9
W-114	23-May-85	70.5	63.0	51-63	1B	0.5

Table A-1. (Continued)

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
W-115	03-Jun-85	106.0	95.0	88-95	1B	1.1
W-116	14-Jun-85	181.0	91.0	86-91	1B	0.3
W-117	27-Jun-85	202.0	148.0	138-148	7	0.2
W-118	19-Jul-85	206.5	110.0	99-110	2	8
W-119	02-Aug-85	139.0	102.5	87.5-102.5	2	3.3
W-120	19-Aug-85	195.0	153.0	147-153	2	1
W-121	23-Aug-85	194.0	171.0	159-171	2	3.75
W-122	17-Aug-85	189.0	132.0	125-132	2	15
W-123	01-Oct-85	174.0	47.7	37.3-47.7	1A	5
W-141	23-Mar-85	61.5	60.0	45-60	1B	0.8
W-142	29-Mar-85	74.2	72.0	62-72	2	0.8
W-143	12-Apr-85	130.0	126.0	121-126	2	0.8
W-146	16-Jul-85	225.0	125.0	115-125	2	5
W-147	26-Jul-85	137.0	87.0	77-87	1B	0.5
W-148	08-Aug-85	152.0	98.0	83-98	1B	0.5
W-151	30-Sep-85	237.0	157.5	148.5-157.5	2	1.5
W-201	17-Oct-85	211.0	161.0	151-161	2	14
W-202	07-Nov-85	191.0	109.0	99-109	2	0.5
W-203	15-Nov-85	87.0	41.0	31-41	1A	3
W-204	22-Nov-85	110.0	110.0	100-110	2	5+
W-205	09-Dec-85	180.0	117.0	107-117	3B	<0.1
W-206	19-Dec-85	188.0	118.0	106-118	3A	<0.5
W-207	24-Jan-86	150.0	85.0	69-85	2	<0.5
W-210	11-Mar-86	176.0	113.0	108-113	3B	<0.5
W-211	19-Mar-86	215.5	193.0	183-193	7	1
W-212	28-Mar-86	183.0	136.0	124-136	5	1
W-213	04-Apr-86	174.0	100.0	94-100	1B	2
W-214	11-Apr-86	146.0	141.5	134-141.5	2	20+
W-217	20-May-86	200.0	112.5	98.5-112.5	5	<0.5
W-218	30-May-86	201.0	71.0	64.5-71	1B	6
W-219	13-Jun-86	214.0	148.0	141-148	5	2
W-220	25-Jun-86	196.0	92.5	82.5-92.5	2	<0.5
W-221	07-Jul-86	178.0	95.0	82-95	3A	2
W-222	17-Jul-86	197.0	83.0	63-83	2	5
W-223	15-Aug-86	202.0	153.0	146-153	2	5.2

Table A-1. (Continued)

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
W-224	26-Aug-86	199.0	88.0	78-88	2	3
W-225	09-Sep-86	238.0	166.0	152-166	5	2.5
W-226	25-Sep-86	173.0	86.0	71-86	1B	<0.25
W-251	03-Oct-85	50.0	47.5	35.5-47.5	1A	2
W-252	18-Oct-85	197.0	126.0	108-126	2	3
W-253	30-Oct-85	180.0	128.0	112.5-128	2	1
W-255	05-Dec-85	187.0	124.0	115-124	5	1
W-256	19-Dec-85	187.0	137.0	132-137	4	<0.5
W-257	15-Jan-86	197.0	96.5	82.5-96.5	2	<0.5
W-258	31-Jan-86	157.0	121.5	116.5-121.5	3A	0.5
W-259	07-Feb-86	200.0	99.0	93.5-99	2	<0.5
W-260	27-Feb-86	215.0	151.0	141-151	2	3.5
W-261	12-Mar-86	225.0	118.5	109-118.5	5	<0.5
W-263	07-Apr-86	146.0	130.0	123-130	2	2
W-264	14-Apr-86	170.0	151.0	141-151	2	20+
W-265	25-Apr-86	216.0	211.0	205-211	3A	3
W-267	27-May-86	196.0	179.0	172.5-179	3A	1
W-268	04-Jun-86	213.0	150.5	138-150.5	5	1
W-269	16-Jun-86	185.0	92.0	79-92	1B	2
W-270	26-Jun-86	185.0	127.0	113-127	5	<0.5
W-271	07-Jul-86	201.0	112.0	105-112	2	2.1
W-272	18-Jul-86	226.0	110.0	95-110	2	1
W-273	11-Aug-86	203.0	84.0	64-84	2	3
W-274	21-Aug-86	217.0	95.0	90-95	2	<0.5
W-275	05-Sep-86	262.0	184.0	179-184	5	4
W-276	17-Sep-86	267.0	170.0	153.5-169.5	3A/3B	12
W-277	03-Oct-86	254.0	169.0	163-169	3B	1.1
W-290	08-Jul-86	181.0	126.0	119.5-126	5	<0.5
W-291	24-Jul-86	194.0	137.0	127-137	5	<0.5
W-292	14-Aug-86	250.0	184.5	176-184.5	3B	9
W-293	27-Aug-86	229.0	155.0	145-155	5	<1
W-294	15-Sep-86	251.0	139.0	122-139	5	1
W-301	07-Oct-86	203.0	141.0	136-141	2	5.5
W-302	22-Oct-86	191.0	83.5	78-83.5	1B	2
W-303	28-Oct-86	197.0	128.0	124-128	2	15

Table A-1. (Continued)

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
W-304	12-Nov-86	207.0	200.0	195-200	4	1
W-305	18-Nov-86	146.0	138.0	128-138	2	20
W-306	04-Dec-86	207.0	110.0	98-110	2	8.5
W-307	15-Dec-86	214.0	102.0	93-102	1B	1
W-308	13-Jan-87	194.0	113.0	107-113	2	2
W-309	20-Jan-87	73.0	NA	NA	NA	NA
W-310	04-Feb-87	202.0	184.5	176.5-184.5	3A	10
W-311	20-Feb-87	226.5	147.5	134.5-147.5	3A	5
W-312	05-Mar-87	224.5	168.0	160-168	4	25
W-313	12-Mar-87	99.0	85.0	80-85	2	5.5
W-315	03-Apr-87	215.0	156.0	141-156	3A	15
W-316	15-Apr-87	196.0	71.0	66-72	2	3
W-317	20-Apr-87	100.0	95.0	88-95	2	7
W-318	28-Apr-87	200.0	81.0	74-81	2	0.5
W-319	05-May-87	198.0	125.0	119-125	3A	25
W-320	11-May-87	106.0	99.0	94-99	2	3
W-321	29-May-87	356.0	321.5	305-321.5	5	60
W-322	01-Jul-87	565.5	152.0	142-152	2	4
W-323	04-Aug-87	200.0	127.0	122-127	2	7
W-324	17-Aug-87	219.0	189.0	184-189	3A	15
W-325	28-Aug-87	312.0	170.0	158-170	3A	4
W-353	12-Nov-86	205.0	101.0	95.5-101	2	1
W-354	24-Nov-86	185.0	179.0	163-179	4/5	8
W-355	05-Dec-86	202.0	107.0	102-107	2	2
W-356	18-Dec-86	237.0	137.0	133-137	3B	6
W-360	24-Feb-87	260.0	204.5	181.5-204.5	4	30
W-362	13-Mar-87	151.0	145.0	131-145	4	12
W-363	24-Mar-87	195.0	129.0	117-129	3A	<0.5
W-364	31-Mar-87	195.0	165.0	155-165	3B/4	5
W-365	09-Apr-87	187.0	125.0	120-125	2	8.5
W-366	20-Apr-87	273.0	251.0	240-251	4	13
W-368	06-May-87	206.0	78.0	70-78	1B	3
W-369	14-May-87	204.0	113.0	107-113	2	2
W-370	29-May-87	286.0	208.0	196.5-208	4	5
W-371	12-Jun-87	233.0	162.0	155-162	3A	1.5
W-372	25-Jun-87	218.0	152.5	147.5-152.5	4	1

Table A-1. (Continued)

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
W-373	06-Jul-87	178.0	99.0	89-99	1B	7
W-375	29-Jul-87	223.0	71.0	65-71	2	0.75
W-376	27-Aug-87	249.0	172.0	162-172	2	2
W-377	04-Sep-87	159.0	144.0	141.5-144	2	2.5
W-378	09-Sep-87	155.0	150.0	146-150	2	5
W-379	14-Sep-87	155.0	150.0	146-150	2	5
W-380	01-Oct-87	195.0	182.0	170-182	3A	10
W-401	05-Nov-87	159.0	153.0	109-153	2	25
W-402	13-Oct-87	104.0	102.0	92-102	1B	40
W-403	16-Nov-87	585.0	495.0	485-495	7	3
W-404	04-Dec-87	245.0	158.0	150-158	2	33
W-405	04-Jan-88	244.0	162.0	132-162	2	50
W-406	20-Jan-88	213.0	94.0	79-84	1B	2
W-407	04-Feb-88	215.0	205.0	192-205	3A	4
W-409	07-Mar-88	272.0	78.0	71-78	1B	30
W-410	30-Mar-88	369.0	205.0	193-205	3A	35
W-411	12-Apr-88	192.0	138.0	131-138	2	8
W-412	18-Apr-88	104.0	74.0	67-74	1B	2.5
W-413	28-Apr-88	163.0	115.0	100-115	2	25
W-414	20-May-88	179.0	74.0	69.5-74	2	0.5
W-416	10-Jun-88	152.0	80.5	72-80.5	1B	30
W-417	20-Jun-88	152.0	60.0	51-60	1B	5
W-418	24-Jun-88	124.0	118.0	108-118	2	2.5
W-419	29-Jun-88	82.0	75.5	62.5-75.5	1B	3
W-420	26-Jul-88	127.0	111.0	105-111	2	5
W-421	23-Aug-88	181.0	90.0	75-90	1B	4.5
W-422	02-Sep-88	203.0	139.5	133-139.5	2	5
W-423	09-Sep-88	308.0	118.0	106-118	2	14
W-424	04-Oct-88	208.0	144.0	137-144	3A	3
W-441	14-Oct-87	250.0	144.0	135-144	5	2.5
W-446	18-Dec-87	202.0	196.0	186-196	3A	3
W-447	05-Feb-88	353.0	274.0	256-274	4	5
W-448	17-Feb-88	235.0	127.5	120.5-127.5	2	15
W-449	07-Mar-88	172.0	165.0	152-165	2	3
W-450	21-Mar-88	300.0	200.0	193-200	5	2

Table A-1. (Continued)

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
W-451	06-Apr-88	202.0	112.0	106-112	2	1.5
W-452	15-Apr-88	210.0	79.5	64-79.5	1B	5
W-453	27-Apr-88	185.0	130.3	121-130	2	4
W-454	09-May-88	196.0	83.5	73-83.5	1B	3
W-455	19-May-88	184.0	162.5	148-162.5	2	5
W-456	09-Jun-88	343.0	180.5	172-180.5	3A	2
W-458	30-Jun-88	212.5	116.0	108-116	2	2
W-459	20-Jul-88	76.0	73.0	59.5-73	1B	1.5
W-460	22-Jul-88	361.0	140.5	135-140.5	2	30
W-461	16-Aug-88	133.0	51.5	41.5-51.5	2	<0.5
W-462	12-Sep-88	385.0	336.5	331-336.5	5	5
W-463	16-Sep-88	93.0	92.5	87-92.5	1B	5
W-464	30-Sep-88	253.0	104.5	96-104.5	2	3.5
W-481	04-Nov-88	224.5	105.0	100-105	1B	2
W-482	15-Jan-88	218.0	170.0	165-170	2	<0.5
W-483	26-Jan-88	140.0	130.0	115-130	2	2.5
W-484	11-Feb-88	255.0	188.0	185-188	3A	0.5
W-485	25-Feb-88	249.0	157.0	151-157	2	2
W-486	11-Mar-88	167.0	108.0	100-108	2	2
W-487	17-Mar-88	180.0	151.0	148-151	3B	1
W-501	13-Oct-88	174.0	92.0	84-92	1B	6.5
W-502	25-Oct-88	158.0	59.0	55-59	1B	<0.5
W-503	02-Nov-88	187.0	80.0	74-80	1B	1
W-504	21-Nov-88	358.0	167.0	157-167	2	3
W-505	15-Dec-88	278.0	180.0	167-180	3A	60
W-506	22-Dec-88	120.0	115.0	101-115	1B	30
W-507	18-Jan-89	158.0	139.0	129-139	2	50
W-508	17-Feb-89	316.0	305.0	287-305	7	60
W-509	03-Mar-89	305.0	184.0	179-184	5	1
W-510	15-Mar-89	300.0	119.0	111-119	2	<0.5
W-511	31-Mar-89	316.0	176.0	167-176	3B	1
W-512	13-Apr-89	261.0	176.0	166-176	5	2.5
W-513	26-Apr-89	259.0	115.0	102-115	2	1
W-514	17-May-89	386.0	115.5	92-115.5	1B	2
W-515	30-May-89	211.0	78.0	68-78	1B	3.5

Table A-1. (Continued)

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
W-516	09-Jun-89	203.0	119.0	114-119	2	15
W-517	20-Jun-89	215.0	88.0	80-88	1B	6.7
W-519	14-Aug-89	186.5	80.5	60-80.5	1B	25
W-521	13-Sep-89	166.0	95.0	86-95	1B	1
W-551	18-Oct-88	308.0	155.5	151-155.5	2	20
W-552	25-Oct-88	70.5	64.0	48.5-64	1B	3
W-553	03-Nov-88	186.0	106.5	99-106.5	2	1
W-554	22-Nov-88	239.0	141.5	126.5-141.4	2	60
W-555	05-Dec-88	122.0	116.5	102.5-116.5	1B	20
W-556	15-Dec-88	192.0	81.5	76-81.5	1B	6
W-557	22-Dec-88	122.5	118.0	102-118	2	2
W-558	17-Jan-89	117.0	110.5	101-110.5	1B	20
W-559	24-Jan-89	105.0	100.0	93-100	1B	0.75
W-560	07-Feb-89	263.0	206.5	201-206.5	3B	10
W-561	23-Feb-89	180.0	152.0	143-152	5	4
W-562	08-Mar-89	263.0	158.0	145-158	5	2
W-563	17-Mar-89	192.0	105.0	95-105	2	2
W-564	30-Mar-89	184.0	85.0	79.5-85	1B	3
W-565	06-Apr-89	177.0	82.5	75-82.5	1B	15
W-567	27-Apr-89	194.0	61.5	51-61	1B	10
W-568	05-Jun-89	156.0	101.0	97-101	2	30
W-569	16-May-89	215.0	109.5	101-109.5	2	4
W-570	09-Jun-89	180.0	175.0	161-175	5	1
W-571	15-Jun-89	223.5	207.5	102-107	1B	22
W-591	29-Nov-88	112.0	107.5	97-107.5	2	<0.5
W-592	12-Dec-88	136.5	113.0	101-113	2	1.5
W-593	06-Feb-89	159.0	92.5	82-92.5	3A	1.5
W-594	27-Feb-89	156.0	61.0	55-61	2	0.5
W-604	27-Nov-89	111.0	83.0	76-82	1B	0.5
W-606	21-Dec-89	145.0	89.0	73-89	1B	2
W-607	24-Jan-90	186.0	55.0	49-55	1B	3
W-608	07-Feb-90	162.0	66.0	55-66	1B	3
W-611	04-Apr-90	161.0	98.0	87.5-98	1B	2
W-612	19-Apr-90	222.0	136.0	126-136	2	10
W-613	02-May-90	93.0	88.0	81.5-88	1B	7

Table A-1. (Continued)

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
W-615	01-Jun-90	121.0	99.0	91-99	1B	3
W-616	14-Jun-90	255.0	188.0	178-188	3A	8
W-617	26-Jun-90	200.0	110.0	103-110	2	6
W-618	17-Jul-90	357.0	205.0	201-205	3B	10
W-619	07-Aug-90	330.0	252.0	232-252	3B/4	30
W-622	28-Sep-90	206.0	112.0	104-112	5	<0.5
W-651	22-Feb-90	155.0	89.0	82-89	1B	0.5
W-652	15-Mar-90	318.0	256.0	245-256	7	2
W-653	29-Mar-90	225.0	128.0	122-128	3A	0.5
W-654	11-Apr-90	240.0	158.0	140-158	2	20
W-702	24-Oct-90	180.5	95.0	77-95	1B	10
W-703	03-Dec-90	586.0	325.0	298-325	5	10
W-705	26-Dec-90	126.0	90.0	77-90	1B	2
W-706	16-Jan-91	178.0	84.0	71-84	1B	2
W-901	24-Feb-93	97.8	88.0	79-83	1B	1
W-902	22-Jan-93	95.5	88.0	80-83	1B	1
W-905	07-Apr-93	221.0	144.5	134-144	2	4
W-908	18-Aug-93	239.0	197.0	180-197	5/6	<0.5
W-909	04-Nov-93	252.0	113.5	80.5-108.5	2	2
W-911	20-Dec-93	180.0	113.5	73.5-108.5	2	3
W-912	07-Oct-93	239.0	174.0	168-174	5	3
W-913	08-Dec-93	454.0	255.0	235-255	4	25
W-1002	31-Jan-94	292.5	260.0	246-260	5	16
W-1003	08-Feb-94	184.0	147.0	140-147	2	1.5
W-1005	14-Mar-94	192.0	110.0	98-110	1B	20
W-1006	10-Mar-94	154.0	149.0	141-149	2	15
W-1007	31-Mar-94	199.5	182.0	172-182	3A	2
W-1008	13-Apr-94	246.0	238.0	229.5-238	7	10
W-1010	24-May-94	463.0	142.0	128-142	2	20
W-1011	06-Jun-94	106.0	89.0	75-89	1B	3
W-1012	20-Jun-94	161.0	117.0	96-112	2	5
W-1013	29-Jun-94	147.0	73.0	65-73	1B	1.4
W-1014	12-Jul-94	99.0	89.0	65-89	1B	30

Table A-1. (Continued)

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
W-1101	10-Nov-94	200.0	79.0	76.0-79.0	1B	0.5
W-1105	17-Jan-95	110.0	93.0	78-93	1B	3.5-4
W-1106	08-Feb-95	245.0	86.0	76-85	1B	15
W-1107	06-Mar-95	199.5	93.0	74-88	1B	<0.5
W-1108	27-Mar-95	250.0	156.0	142-156	5	12
W-1110	04-May-95	252.0	92.2	68-92	1B	7
W-1112	28-Jun-95	263.0	210.0	201-210	5	3
W-1113	18-Jul-95	260.0	214.0	204-214	5	2.5
W-1115	12-Oct-95	126.5	118.2	108-118	3A	1
W-1117	11-Sep-95	154.0	132.3	122-132	3A	1
W-1118	27-Sep-95	225.0	125.0	115-125	3A	3.5
W-1201	18-Oct-95	225.0	133.0	125-133	3A	1
W-1202	26-Oct-95	99.3	99.0	83-99	2	5[+]
W-1203	07-Nov-95	224.0	206.2	196-206	5	18[+]
W-1204	20 Nov-95	225.0	126.2	118-126	3A	2.5
W-1205	27-Nov-95	91.0	82.0	72-82	2	<0.5
W-1206	06-Dec-95	220.0	191.0	174-186	4	40[+]
W-1207	13-Dec-95	92.0	90.0	70-90	2	<0.5
W-1208	09-Jan-96	166.0	163.0	135-163	3A/3B	40
W-1209	26-Jan-96	210.0	164.0	148-164	4	3
W-1210	12-Feb-96	250.0	223.0	213-223	5	3
W-1211	05-Mar-96	273.0	205.0	185-200	4	25[+]
W-1212	19-Mar-96	150.0	75.0	52-75	1B	3
W-1214	22-Apr--96	180.0	100.0	80-100	1B	2
W-1217	15-May-96	182.0	98.5	78-98	1B	<0.5
W-1218	29-May-96	240.0	145.5	127-145	3A	6.7
W-1219	04-Jun-96	201.0	142.0	138-142	4	<0.5
W-1220	12-Jun-96	120.0	117.0	90-112	2	18
W-1221	01-Jul-96	220.0	172.0	162-172	4	4
W-1222	26-Jun-96	175.0	125.5	115-125	3A	6
W-1223	23-Jul-96	175.0	102.0	87-97	2	4
W-1224	05-Sep-96	125.0	104.5	99-104	1B	4.3
W-1225	14-Aug-96	150.0	121.2	113-121	3A	2
W-1226	06-Aug-96	155.0	126.5	116-126	2	1

Table A-1. (Continued)

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
W-1227	09-Oct-96	200.0	134.0	126-134	2	11
W-1250	07-Jun-96	210.0	200.0	130-135	4	0.85
W-1251	03-Jul-96	210.0	200.0	134-139	4	1.3
W-1252	25-Jul-96	208.0	202.3	135-140	4	<0.5
W-1253	15-Aug-96	206.0	200.1	127-132	4	<0.5
W-1254	15-Aug-96	125.0	200.0	131-141	4	26
W-1255	27-Aug-96	208.0	200.7	124-129	4	<0.5
W-1304	20-Feb-97	149.5	125.0	120-125	3A	0.75
W-1311	25-Sep-97	153.0	120.5	100-120	2	14
W-1401	15-Oct-97	250.0	120.0	105-120	2	7
W-1402	04-Nov-97	135.0	112.0	102-112	3A	4
W-1403	12-Nov-97	175.0	142.5	132-142	4	3.5
W-1404	20-Nov-97	162.0	97.7	87-97	2	3.1
W-1405	24-Nov-97	100.0	97.8	87-97	2	4.5
W-1406	15-Dec-97	201.0	150.0	139.2-149.2	4	9.2
W-1407	12-Dec-97	224.0	118.7	105-118	2	1.5
W-1408	12-Jan-98	134.0	128.0	118-128	3A	3.8
W-1410	20-Feb-98	205.0	133.0	126-131	3B/4	8
W-1411	04-Feb-98	133.0	128.0	114-128	3B	10
W-1412	11-Feb-98	201.0	107.0	92-107	2	0.75
W-1413	26-Mar-98	163.5	157.7	147-157	5	1
W-1414	31-Mar-98	128.0	107.5	97-107	3A	0.1
W-1416	02-Jun-98	194.5	105.0	85-100	2	10
W-1417	23-Apr-98	225.0	155.0	130-150	3A/3B	20
W-1419	11-May-98	175.0	115.5	90-110	2	4.5
W-1420	17-June-98	177.5	112.0	102-112	2	10
W-1421	28-May-98	230.0	172.0	156-167	4	3
W-1424	20-Aug-98	225.0	146.0	126-146	2	6.2
W-1425	31-Aug-98	115.0	100.5	88.5-100.5	1B	1
W-1426	09-Sep-98	89.0	85.0	70-85	1B	8
W-1427	22-Sep-98	104.0	80.2	70-80	1B	17
W-1428	29-Sep-98	104.0	78.4	63-78	1B	25
W-1501	13-Oct-98	126.0	86.0	72-86	1B	7.5

Table A-1. (Continued)

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
W-1502	28-Oct-98	204.0	98.7	88-98	2	1.7
W-1503	18-Nov-98	234.0	181.5	171-181	4	25
W-1504	14-Dec-98	168.0	162.5	140-160.4	3A/3B	21.7
W-1505	21-Jan-99	276.0	184.5	174-184	4	15
W-1506	8-Feb-99	160.0	120.0	110-120	2	3
W-1507	19-Feb-99	201.5	169.5	159-169	5	0.5
W-1508	3-Mar-99	135	128.5	118-128	3A	0.75
W-1509	22-Mar-99	175	88.5	73-88	1B	8
W-1510	7-Apr-99	114.5	113.5	93-113	2	5
W-1511	22-Apr-99	229	146	138-146	3B	15
W-1512	29-Apr-99	100	98.5	88-98	2	0.5
W-1513	10-May-99	122	120	108-120	3A/3B	0.1
W-1514	19-May-99	127.5	126	103-121	3A/3B	6.5
W-1515	3-Jun-99	130	121.5	102-120	3A/3B	3
W-1516	22-Jun-99	204.5	200	188-200	5	10
W-1517	29-Jun-99	154	122.4	87-97	2	0.1
W-1518	6-Jul-99	184	112	84-107	2	3
W-1519	28-Jul-99	245	238	222-237	5	30
W-1520	23-Jul-99	178.3	173	160-168	4	3.5
W-1522	9-Aug-99	169	161	141-156	3B	9
W-1523	1-Aug-99	216	172.3	164-172	4	15
W-1550	22-Jun-99	200	130	98-125	3A/3B	10
W-1553	12-Aug-99	153	130	98-125	3A/3B	0.5
W-1601	18-Oct-99	169	160	150-155	3B	3.5
W-1602	27-Oct-99	115.5	110.7	80-90 100-110	2	8
W-1603	10-Nov-99	144	140	130-135	3A	17.2
W-1604	30-Nov-99	194	148.7	138-148	4	8
TW-11	09-Jun-81	112.5	107.0	97-107	2	NA
TW-11A	16-Mar-84	163.0	160.0	133-160	2	NA
TW-21	12-Jun-81	111.5	95.0	85-95	1B	NA
GEW-710	02-Aug-91	159.0	158.0	94-137	3A/3B	25

Table A-1. (Continued)

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
GSW-1A	12-Jun-86	208.0	133.0	115-133	3B	12
GSW-2	14-Feb-85	113.0	107.0	87-107	3A	NA
GSW-3	07-Feb-85	115.0	105.0	85-105	3A	NA
GSW-4	22-Feb-85	112.0	106.0	86-106	3A	NA
GSW-5	19-Mar-85	110.0	104.0	94-104	3A	NA
GSW-6	28-Feb-86	212.0	137.0	121-137	3B	6
GSW-7	14-Mar-86	176.5	123.4	110.8-123.4	3B	2
GSW-8	01-Apr-86	176.0	133.0	127.5-133	3B	2
GSW-9	14-Apr-86	197.5	152.5	147-152.5	3B	1
GSW-11	07-May-86	182.5	126.0	116-126	3B	2
GSW-12	27-May-86	205.0	191.0	186.5-191	5	1
GSW-13	27-Jun-86	198.0	134.5	125-134.5	3B	1
GSW-15	14-Aug-87	148.0	145.0	20.5-28	1B	3.5
				38-44	1B	
				50-56	2	
				60-64	2	
				68-73	2	
				77-83	2	
				95-105	3A	
				120-130	3B	
GSW-16	19-Oct-87	146.0	145.0	23-28	1B	20.5-30
				38-43	1B	
				50-55	2	
				61-66	2	
				78-83	2	
				95-105	3A	
				120-130	3B	
GSW-208	06-Feb-86	211.0	123.0	108-118	3B	<2
GSW-209	27-Feb-86	204.0	135.2	112.8-132.8	3B	2
GSW-215	22-Apr-86	213.5	133.5	127-133.5	3A	2
GSW-216	09-May-86	193.0	120.5	110.5-120.5	3B	3
GSW-266	08-May-86	220.0	166.0	159-166	3B	1
GSW-326	02-Oct-87	230.0	134.0	129-134	4	0.5
GSW-367	29-Apr-87	159.0	124.0	114-124	2	2

Table A-1. (Continued)

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
GSW-403-6	11-May-84	138.0	113.6	90-110	3A	NA
GSW-442	27-Oct-87	270.0	145.0	138-145	3B	0.5
GSW-443	09-Nov-87	291.0	141.0	123-141	2	5
GSW-444	20-Nov-87	278.0	120.0	110-120	3B	0.3
GSW-445	09-Dec-87	319.0	161.0	155-161	4	3
Dynamic Stripping Project Wells[c]						
GSP-SNL-001	07-Jan-92	147.0	104.0	99-104	3A	NA
			131.0	118-131	3B	NA
GEW-808	05-Jun-92	164.0	150.0	50-140	2/3A/3B	25
GIW-813	25-Jun-92	140.7	87.0	67-87	2	NA
			104.0	89-99	3A	
			127.0	107-127	3A/3B	NA
GIW-814	19-Jun-92	149.6	106.5	86.5-106.5	2/3A	NA
			117.0	110-120	3A	
			132.0	121-141	3B	NA
GIW-815	15-Jun-92	143.0	97.0	77-97	2/3A	NA
			117.0	102-112	3A	
			132.0	112.8-132	3B	NA
GEW-816	03-Jun-92	161.7	150.0	50-140	3A/3B	40
GIW-817	29-Jun-92	150.1	102.0	82-102	2/3A	NA
			122.0	107-117	3A	
			141.0	121-141	3B	NA
GIW-818	06-Jul-92	150.0	102	82-102	2/3A	NA
			125	110-120	3A	
			140	120-140	3B	NA
GIW-819	10-Jul-92	150.0	98.6	78.6-98.6	2/3A	NA
			123	108-118	3A/3B	
			141	121-141		NA
GIW-820	16-Jul-92	143.3	105	85-105	2/3A	NA
			132	112-132	3A3B	NA
HW-GP-001	17-Apr-92	120.0	77.0	67-77	2	NA
			113.0	103-113	3A	NA
HW-GP-002	13-May-92	120.0	78.0	68-78	2	NA
			117.0	107-117	3A	NA

Table A-1. (Continued)

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
HW-GP-003	20-May-92	119.0	76.5 119.0	66.5-76.5 109-119	2 3A	NA NA
HW-GP-102	13-Aug-93	140.0	137.5	72.5-133.5	2/3A/3B	NA
HW-GP-103	23-Aug-93	138.0	137.5	71.5-132.5	2/3A/3B	NA
HW-GP-104	02-Sep-93	138.0	137.2	72.2-132.2	2/3A/3B	NA
HW-GP-105	28-Sep-93	138.0	137.5	72.5-132.5	2/3A/3B	NA
TEP-GP-106	21-Sep-93	137.5	135.5	NA	NA	NA
Extraction Wells						
W-109	02-Apr-85	289.0	147.0	137-147	2	12
W-112	10-May-85	129.0	123.5	111-123.5	5	4
W-254	21-Nov-85	277.0	91.5	84.5-91.5	1B	5
W-262	20-Mar-86	256.0	100.0	91-100	1B	7
W-314	20-Mar-87	228.0	142.0	129-142	4	9.5
W-351	17-Oct-86	191.0	151.0	146-152	4	2.9
W-357	12-Jan-87	197.0	123.0	107-123	2	8
W-359	10-Feb-87	195.0	150.5	138-150.5	5	10
W-361	05-Mar-87	257.0	135.0	125-135	3A	4
W-408	16-Feb-88	131.0	122.5	101-122.5	1B	35
W-415	12-Aug-88	205.0	183.7	79-179	1B/2	>50
W-457	22-Jun-88	289.0	149.5	130-149.5	2	20
W-518	08-Aug-89	251.0	139.0	131-139	2	2.5
W-520	30-Aug-89	160.0	101.5	94-101.5	1B	12
W-522	05-Oct-89	145.5	141.5	134-141.5	2	25
W-566	19-Apr-89	317.0	207.0	197-207	5	12
W-601	13-Oct-89	146.0	96.0	88-96	1B	15
W-602	06-Nov-89	168.0	100.0	90-100	1B	10
W-603	15-Nov-89	150.0	147.0	141-147	2	5
W-605	08-Dec-89	246.0	136.0	130-136	2	10
W-609	21-Feb-90	120.0	112.0	104-112	2	4
W-610	16-Mar-90	453.0	84.5	69-84.5	1B	4

Table A-1. (Continued)

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
W-614	18-May-90	262.0	123.0	100-123	2	12
W-620	30-Aug-90	206.0	88.5	75-88.5	1B	5
W-621	09-Sep-90	149.0	120.0	113-120	2	4
W-655	25-Apr-90	193.0	130.0	121-129.5	2	2
W-701	10-Oct-90	159.0	86.0	74-86	1B	10
W-704	01-Feb-91	135.0	107.0	67-76 88-97	1B	20
W-712	29-Aug-91	200.0	185.5	170-185.5	3A	8
W-714	02-Jul-91	135.0	128.0	107-128	2	7.5
W-903	28-Apr-93	223.0	145	132-140	2	20
W-904	06-May-93	212.0	154.0	121-133 140-149	2	20
W-906	27-Jul-93	200.0	132.0	58-132	2/3A	10
W-907	02-Sep-93	239.0	220.0	172.7-188.8 204.5-215.0	4 5	25 NA
W-1001	20-Dec-93	105.0	92.0	85-92	1B	1.4
W-1004	23-Feb-94	99.0	97.0	71-91	1B	7
W-1009	02-May-94	191	140	134-140	2	20
W-1015	10-Aug-94	437	94	84-94	1B	20
W-1102	29-Nov-94	163.0	95.5	76.0-94.0	1B	8
W-1103	15-Dec-94	200.0	82.0	70.0-82.0	1B	3.5
W-1104	18-Jan-95	165.0	99.0	77-87 92-98	1B	35^+
W-1109	11-Apr-95	121	113	94-108	2	3
W-1111	01-Jun-95	152	129	88-108 120-124	1B/2 2	10.5 NA
W-1116	17-Aug-95	214	101	72-98	1B	9
W-1213	02-Apr-96	129.0	76.0	64-76	1B	5^+
W-1215	17-Apr-96	175.0	120.0	103-120.5	2	8.5
W-1216	07-May-96	200.0	124.0	94-124	2	14

Table A-1. (Continued)

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
W-1301	04-Dec-96	180.0	120.3	112-120	3A	15
W-1302	21-Jan-97	145.0	138.9	116.5-122.2	3A	7.5
				125.8-133.8		
W-1303	06-Feb-97	199.5	107	78-102	2	10
W-1306	06-May-97	200	106	81-101	2	3.3
W-1307	07-Feb-97	150	142	126-136	4	20
W-1308	22-Jul-97	150.0	116.0	81-111	2	7
W-1309	11-Aug-97	220.0	157.0	142-152	4	6.0
W-1310	08-Sep-97	220.0	198.0	173-193	5	28
W-1409	23-Jan-98	143	140	76-140	2	20
W-1415	15-Apr-98	182.0	104.8	74.5-104.5	2	2
W-1418	05-May-98	252.5	190.0	176-190	4	9
W-1422	14-May-98	173.5	169.0	162-169	3A/3B	10
W-1423	08-Jul-98	175.0	134.5	99.5-109.5 119.5-129.5	2	22.4
W-1503	18-Nov-98	234.0	181.5	171-181	4	25
W-1504	14-Dec-98	168.0	162.5	140-160.4	3A/3B	21.7
W-1510	7-Apr-99	114.5	113.5	93-113	2	5
W-1513	10-May-99	122	120	108-120	3A/3B	0.1
W-1514	19-May-99	127.5	126	103-121	3A/3B	6.5
W-1515	3-Jun-99	130	121.5	102-120	3A/3B	3
W-1551	8-Jul-99	153	129	93-124	3A/3B	10.5
W-1552	27-Jul-99	153.5	130	97-125	3A/3B	2
Other Wells						
7D2	07-Jun-76	74	72.3	63.2-67.3	3A	NA
11C1	08-Jun-76	68	66.2	56.2-61.2	1B	NA
11H5	08-Nov-85	NA	255	NA	NA	NA
11J2	26-Apr-79	112	110	90-92	1B	NA
				102-108	2	
11Q4	NA	NA	NA	NA	NA	NA
11Q5	NA	NA	NA	NA	NA	NA
14A3	07-Dec-77	NA	110	100-105	1B	NA
14A11[d]	NA	NA	NA	NA	NA	NA

Table A-1. (Continued)

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
14B1	13-Aug-59	300	234	146-149	2	NA
				192-195	3A	
				198	3A	
				200	3A	
				203	3A	
				205	3A	
				207	3A	
				209-213	3A	
				226	3A	
				230	3B	
				234	3B	
14B4	Aug-60	NA	260	143-148	2	NA
				155-159	2	
				186-189	3A	
				205-215	3A	
				245-250	4	
14B7	NA	NA	NA	NA	NA	NA
14H1	NA	NA	288	NA	NA	NA
14H2[d]	NA	NA	NA	NA	NA	
18D1[d]	NA	NA	NA	NA	7	NA
Source Investigation Piezometers						
SIP-141-201	02-Feb-96	77	74.2	57-74	1B	NA
SIP-141-202	12-Feb-96	80	74	64-74	1B	NA
SIP-141-203	20-Feb-96	87	83	72-83	1B	NA
SIP-191-001	15-Apr-94	50	45	40-45	1A	NA
SIP-191-002	21-Apr-94	50	61	45-61	1B	NA
SIP-191-003	26-Apr-94	50.5	45	35-45	1B	NA
SIP-191-004	29-Apr-94	57.5	53.5	47.5-53.5	1B	NA
SIP-191-005	04-May-94	54	48	42-48	1A	NA
SIP-191-101	18-Nov-94	68.5	64	58-64	1B	NA
SIP-212-101	14-Mar-96	94	90.5	87-90.5	2	NA
SIP-293-001	05-Dec-90	56.5	50	45-50	1B	NA
SIP-331-001	21-Sep-91	122	116.5	106.5-116.5	2	NA
SIP-419-101	08-Sep-98	127	123	112-123	3B	NA
SIP-419-202	06-Mar-96	110	106.5	97-106.5	3A	NA

Table A-1. (Continued)

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
SIP-490-102	08-Nov-95	75	73.5	53.5-73.5	2	NA
SIP-501-004	20-0ct-94	60	56.9	48-56.9	1B	NA
SIP-501-006	11-Nov-92	59.5	56	50-56	1B	NA
SIP-501-007	16-Nov-92	64	59	53-59	1B	NA
SIP-501-101	10-May-94	77.5	73	69-73	1B	NA
SIP-501-102	16-May-94	77	73	67-73	1B	NA
SIP-501-103	20-Mar-94	63	57.5	51-57.5	1B	NA
SIP-501-104	15-Jul-94	67	62	50-62	1B	NA
SIP-501-105	01-Sep-94	73	68	63-68	1B	NA
SIP-501-201	29-Nov-94	65	58.5	54-58.5	1B	NA
SIP-501-202	01-Jul-95	70	64.5	58-64.5	1B	NA
SIP-511-101	25-Jan-96	110	106.7	100-106.7	3A	NA
SIP-511-102	02-Apr-96	114	110.3	108-110	3B	NA
SIP-514-107	03-Jan-90	21.5	17	9-17	1B	NA
SIP-514-109	05-Jan-90	21.5	20	7-22	1B	NA
SIP-514-112	08-Jan-90	21.5	18	7-18	1B	NA
SIP-514-114	09-Jan-90	21.5	17	4-17	1B	NA
SIP-514-116	10-Jan-90	21.5	17	7-17	1B	NA
SIP-514-117	11-Jan-90	21.5	17.5	7-17.5	1B	NA
SIP-514-119	12-Jan-90	21.5	16	6-16	1B	NA
SIP-514-123	17-Jan-90	26.5	23	11.5-23	1B	NA
SIP-514-124	18-Jan-90	21.5	17	6-17	1B	NA
SIP-514-125	19-Jan-90	21.5	15	6-15	1B	NA
SIP-514-126	18-Jan-90	26.5	21.5	4-21.5	1B	NA
SIP-518-203	19-Sep-95	127	127	121-127	5	NA
SIP-543-101	31-Jan-95	111	104	43-103	2	NA
SIP-ALP-001	03-May-90	66	60	45-60	2	NA
SIP-ALP-002	07-May-90	62	57.5	47.5-57.5	1B/2	NA
SIP-AS-001	30-Apr-90	100	100.5	81-90.5	1B	NA
SIP-CR-049	26-Feb-90	42	40	36-40	1B	NA
SIP-EGD-001	16-Oct-90	101.5	85	75-85	3A	NA
SIP-ETC-201	26-Mar-96	106	101	81-101	2	NA
SIP-ETC-301	12-Apr-99	102	83	76-82	2	NA
SIP-ETC-303	24-May-99	111	88.1	82-88	2	NA
SIP-ETS-201	05-Feb-91	95	90	85-90	3A	NA

Table A-1. (Continued)

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
SIP-ETS-204	07-May-91	93	97	87-97	3A	NA
SIP-ETS-205	20-Jun-91	103	95	89.5-95	3A	NA
SIP-ETS-207	11-Jul-91	103.5	98.5	89.75-98.5	3A	5
SIP-ETS-209	25-Jul-91	96.6	90	79.75-90	2	NA
SIP-ETS-211	06-Aug-91	103	98.5	95-98.5	3A	NA
SIP-ETS-212	14-Aug-91	106.5	1023	97.5-1023	2	NA
SIP-ETS-213	15-Nov-91	118.5	116.5	108.5-116.5	3A	NA
SIP-ETS-214	22-Nov-91	101	101	86-101	3A	NA
SIP-ETS-215	03-Dec-91	94.5	94.5	84.5-94.5	3A	NA
SIP-ETS-302	30-Mar-92	117.4	113	97-113	3A	NA
SIP-ETS-303	02-Apr-92	110.7	102	95-102	3A	NA
SIP-ETS-304	27-Aug-92	100	97	90-97	3A	NA
SIP-ETS-306	11-Sep-92	101	93	80-5-93	3A	NA
SIP-ETS-401	02-Aug-95	122	121	116-121	3A	NA
SIP-ETS-402	08-Aug-95	110	107	97-107	2	NA
SIP-ETS-404	22-Aug-95	99	95.5	83.5-95.5	2	NA
SIP-ETS-405	29-Aug-95	126	123	114.5-123	3A	NA
SIP-ETS-501	16-Nov-95	110	106.5	100-1006.5	3A	NA
SIP-ETS-502	05-Dec-95	95	88	80-88	2	NA
SIP-ETS-601	07-Jun-99	115.5	104.9	98.3-104.8	2	NA
SIP-HPA-001	20-Apr-90	92.75	75	65-75	2	NA
SIP- HPA-003	19-Apr-90	91.5	66	61-66	2	NA
SIP- HPA-102	08-Dec-94	76	72	67-72	2	NA
SIP-HPA-103	01-Mar-95	77	72.5	67-72.7	2	NA
SIP- HPA-201	14-May-96	97.5	76	71-76	2	NA
SIP-IES-001	16-Sep-92	50.2	46.5	44-46.5	1B	NA
SIP-IES-002	05-Oct-92	41.5	39.2	33-39.2	1A	NA
SIP-INF-201	30-Jun-98	85.9	85.0	64.9-84.6	1B	NA
SIP-INF-202	02-Jul-98	86.3	85.2	64.9-84.8	1B	NA
SIP-INF-301	24-Mar-99	97	95.4	60-95	1B	NA
SIP-INF-302	29-Mar-99	97	88.4	53-88	1B	NA
SIP-ITR-001	19-Apr-91	121.6	115	105-115	5	NA
SIP-ITR-002	02-Apr-91	100	84	79-84	2	NA
SIP-ITR-003	25-Apr-91	121.5	106	98.5-106	5	NA

Table A-1. (Continued)

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
SIP-NEB-101	23-Sep-92	68.7	66	57-66	2	NA
UP-292-006	07-Nov-90	74	57.5	47.5-57.5	1B	NA
UP-292-007	26-Nov-90	71	56	46-56	1B	NA
UP-292-012	31-Oct-91	67.7	60	45-60	1B	NA
UP-292-014	07-Nov-91	66	66	50-66	1B	NA
UP-292-015	11-Nov-91	61.5	60.5	49.5-60.5	1B	NA
UP-292-020	30-Oct-92	68.5	64	56.5-64	1B	NA
SIP-PA-002	29-Jan-90	16.5	16.5	4-16.5	1B	NA
SIP-PA-003	26-Jan-90	18	14	4-14	1B	NA
SIP-PA-005	04-Jan-90	11.5	8	3-8	1B	NA
SIP-PA-006	04-Jan-90	13.5	12	5-12	1B	NA
SIP-PA-007	04-Jan-90	11.5	5	1-5	1B	NA
SIP-PA-010	25-Jan-90	11.5	9	3-9	1B	NA
SIP-PA-012	29-Jan-90	11.5	9	2-9	1B	NA
SIP-PA-013	24-Jan-90	16.5	13	8-13	1B	NA
SIP-PA-015	25 -Jan-90	21.5	17.5	2-17.5	1B	NA
SIP-PA-016	24 -Jan-90	11.5	11.5	7-11.5	1B	NA
SIP-PA-017	24 -Jan-90	16.5	14	7-14	1B	NA
SIP-PA-018	25 -Jan-90	11.5	8	6-8	1B	NA
SIP-PA-019	26 -Jan-90	16.5	12	2-12	1B	NA
SIP-PA-021	23 -Jan-90	11.5	10	2-10	1B	NA
SIP-PA-024	23 -Jan-90	16.5	15	5-15	1B	NA
SIP-PA-025	23 -Jan-90	11.5	7	4-7	1B	NA
SIP-PA-026	29 -Jan-90	11.5	10	2-10	1B	NA
SIP-PA-027	29 -Jan-90	8.5	7	2-7	1B	NA
SIP-PA-028	23 -Jan-90	11	8	5-8	1B	NA
SIP-PA-030	24 -Jan-90	11.5	8	4-8	1B	NA
SIP-PA-034	04-Jan-90	6.5	5	3-5	1B	NA
SIP-PA-035	04 -Jan-90	11.5	11.5	6.5-11.5	1B	NA
Soil Vapor Installations						
IMS-INF-203	08-Jul-98	63	63	NA[e]	1A	NA
SVI-518-101	21-Sep-90	125	61	55-61	2	NA
SVI-518-202	03-Nov-93	120.6	73.8	19-73.8	1B/2	NA
SVI-518-204	05-Nov-93	121.5	46	24-46	1B/2	NA
SEA-518-301	11-Sep-95	102.6	100	NA[e]	1B/2/5	NA
SVI-518-302	22-Jun-95	104.5	39.3	11-39	1B	NA

Table A-1. (Continued)

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
SEA-518-304	11-Sep-95	100	50	NA[e]	1B/2/5	NA
SEA-ETS-305	03-9-92	85	85	NA[e]	1B/2	NA
SVI-ETS-505	18-Jul-96	80.5	77.5	45-75	2	NA
SEA-ETS-506	24-Jul-96	75	66	NA[e]	1B/2	NA
SEA-ETS-507	30-Jul-96	75	66	NAe	1B/2	NA
Soil Vapor Extraction						
SVI-ETS-504	09-Jul-96	76.5	67	42-67	2	NA
SVI-518-201	03-Mar-93	59.8	50	34-50	1B/2	NA
SVI-518-303	29-Jun-95	104.5	42	6-40	1B	NA

Notes: Boreholes B-707, B-708, B-709, B-713, B-715, and B-750 were drilled for the Dynamic Underground Stripping Demonstration Project "Clean Site."

NA = Not applicable or not available.

[a] Hydrostratigraphic Units (HSUs) are numbered consecutively downward from ground surface. An HSU is defined as sediments that are grouped together based on the hydrogeologic and contaminant transport properties. The permeable layers within an HSU are considered to be in good hydraulic communication, whereas permeable layers in different HSUs are considered to be in poor hydraulic communication. HSU contacts are interpreted and are subject to change.

[b] Flow rate after 4 hours of air-lift pumping/surging.

[c] Wells installed for the Dynamic Underground Stripping Demonstration Project include extraction wells (GEW series), injection wells (GIW series), temperature monitoring wells (TEP series), and heating wells (HW series). TEP wells consist of two nested 1-in. inside diameter (ID) piezometers surrounding a blank fiberglass 2-in. ID casing instrumented with geophysical sensors. Therefore, the screened intervals listed refer to the two individual piezometers.

[d] Well number was changed in December 1988 to be consistent with Alameda County Flood Control and Water Conservation District, Zone 7 well identification. Well number changes made on this table are:

4A6 ------> 14H2

18D81 ------> 18D1

14A84 ------> 14A11

[e] Instrumented membrane systems (IMS)(formerlyFLUTe/SEAMIST membranes) with vapor ports set at varying depths.

Table A-2. Well closure data, Lawrence Livermore National Laboratory and vicinity, Livermore, California.

Well number	Date installed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU monitored	Closure date
Monitor Wells						
W-14A	26-Aug-80	111.0	109.0	80,95,105	2	11-Dec-87
W-15	17-Nov-80	285.0	267.0	239-265	7	13-May-88
W-18	22-Aug-80	161.0	152.5	80-90	2	11-Nov-85
				100-105	2	
				112-117	3A	
				128-133	5	
				143-153	5	
W-149	23-Aug-85	201.0	169.0	161-169	2	29-Aug-96
W-150	13-Sep-85	212.0	162.0	157-162	2	11-Apr-90
W-352	29-Oct-86	235.0	201.0	181-201	4	18-Dec-97
W-358	04-Feb-87	248.0	239.0	230-239	7	15-Apr-94
W-1114	07-Aug-95	223	205	177-200	5	22-Apr-97
GSW-1	05-Feb-85	112.0	109.0	85-106	3A	06-Jun-86
GSW-10	29-Apr-86	205.5	127.5	114-127.5	3B	27-Jan-98
GSW-20	18-May-84	134.0	101.3	95-101.3	3A	03-Sep-87
Extraction Wells						
GEW-711	24-May-91	167.5	157.0	94-137	3A,3B	16-Jun-92
Other Wells						
1N1	15-Jan-48	600	600	427-442	7	21-Oct-88
				450-453	1B	
				465-469	NA	
				500-515	NA	
				575-588	NA	
11A1	08-Jun-76	66	64.7	54.7-59.7	NA	18-Aug-88
2R9 (11A5)[a]	NA	NA	NA	NA	NA	19-Jul-88
11BA[b]	NA	NA	NA	NA	NA	10-Jun-87
11H1	04-Nov-41	NA	519	157-161	NA	31-Oct-88
				169-177	NA	
				224-228	NA	
				243-245	NA	

Table A-2. (Continued)

Well number	Date installed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU monitored	Closure date
				254-256	NA	
				306-314	NA	
				319-327	NA	
				339-342	NA	
				414-419	NA	
				424-431	NA	
				477-479	NA	
11H4	05-Apr-60	272	272	166-170	NA	07-Oct-88
				174-176	NA	
				183-185	NA	
				200-202	NA	
				211-214	NA	
				224-230	NA	
				250-252	NA	
				260-265	NA	
11J1	1941	160	NA	NA	NA	03-Aug-88
11J4[c]	1965	NA	NA	NA	NA	11-Oct-88
11K1	06-Jan-42	NA	621	247-255	NA	26-Sep-88
				272-276	NA	
				297-304	NA	
				322-339	NA	
				554-557	NA	
				580-602	NA	
11K2	NA	NA	232	NA	NA	03-Oct-88
11Q2	NA	NA	264	NA	NA	16-Aug-88
11Q3	NA	NA	120	NA	NA	10-Aug-88
11Q6[c]	NA	NA	280	NA	NA	11-Jan-89
11R3	08-May-61	140	117	NA	NA	03-Sep-85
11R4	NA	NA	NA	NA	NA	03-Sep-85
11R5[c]	NA	NA	NA	NA	NA	26-Jul-85
12M1	09-Dec-42	702	702	375-378	NA	15-Apr-84
				420-426	NA	
				452-473	NA	
				560-564	NA	
				609-621	NA	

Table A-2. (Continued)

Well number	Date installed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU monitored	Closure date
				626-657	NA	
12N1	14-Apr-42	702	681	392-399	NA	24-Jan-89
				514-518	NA	
				527-536	NA	
				666-670	NA	
				678-681	NA	
13D1[c]	29-Oct-56	NA	400	200-400	NA	23-Aug-88
14A1[c]	12-Jul-43	246	227	102-107	NA	13-Sep-88
				113-119	NA	
				144-148	NA	
				176-179	NA	
				188-190	NA	
				192-194	NA	
				219-222	NA	
				223-227	NA	
14A2[c]	15-Nov-56	NA	229	122-130	NA	12-Sep-88
				140-150	NA	
				160-180	NA	
14A4[c]	15-Jun-59	NA	252	167-170	NA	29-Aug-88
				175-179	NA	
				192-202	NA	
				235-246	NA	
14A8	NA	NA	86	NA	NA	22-Jul-88
14B2	22-Aug-56	NA	312	185-312	NA	11-Nov-88
14B8	NA	NA	385	NA	NA	23-Oct-89
TEP-GP-001	21-Jan-92	165.0	97.0 117.0 160.5	87-97 107-117	3A 3B	09-Feb-93
TEP-GP-003	28-Jan-92	161.0	129.5 161.0	124.5-129.5	3B	13-Feb-93
TEP-GP-004	05-Feb-92	161.0	106.0 134.0 161.0	96-106 124-134	3A 3B	13-Feb-93
TEP-GP-005	18-Feb-92	161.0	124.5 161.0	114.5-124.5	3B	13-Feb-93

Table A-2. (Continued)

Well number	Date installed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU monitored	Closure date
TEP-GP-006	26-Feb-92	161.0	127.0 161.0	107-127	3B	13-Feb-93
TEP-GP-007	13-Mar-92	161.0	161.0			NA
TEP-GP-008	03-Mar-92	161.0	110.0 161.0	100-110	3A	13-Feb-93
TEP-GP-009	06-May-92	161.7	107.0 130.5 161.0	98-107 120.5-130.5	3A 3B	13-Feb-93
TEP-GP-010	24-Mar-92	161.0	124.5	114.5-124.5	3B	12-Feb-93
TEP-GP-011	07-Apr-92	161.0	108.0 161.0	98-108	3A	13-Feb-93
TEP-GP-002	24-Jun-92	161.4	133.0 161.0	102-112.5 122-133	3A 3B	NA
Source Investigation Piezometers						
SIP-ETC-302	22-Apr-99	104	89.4	79-89	2	26-Apr-99
SIP-ETS-105	11-Feb-90	110	103	87-103	3A	18-Nov-93
SIP-ETS-207						
SIP-PA-029	22 -Jan-90	11.5	7	5-7	1B	18-Nov-93
SIP-419-201	29-Feb-96	126	107	97-107	3A/3B	25-Mar-98
SIP-490-101	01-Nov-95	59	56	53-56	2	21-Dec-95
SIP-514-101	28-Dec-89	26	22	7-22	1B	03-Sep-96
UP-292-001	03-Dec-90	54.6	49.5	44.5-49.5	1B	25-Sep-95

Note:

NA = Not applicable or not available.

[a] **Well 11A5 was renamed 2R9 by the Alameda County Flood Control and Water Conservation District, Zone 7 in November 1997. Well 11A5 now corresponds to monitor well W-409.**

[b] **Well not recognized by Alameda County Flood Control and Water Conservation District, Zone 7.**

[c] **Well number was changed in December 1988 to be consistent with Alameda County Flood Control and Water Conservation District, Zone 7 well identification. Well identification changes made on this table are:**

11J81 ------> 1J4

11R81 ------> 11R5

11Q81 ------> 11Q6

13D81 ------> 13D1

Table A-2. (Continued)

Well number	Date installed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU monitored	Closure date

14A81 ------> 14A1

14A82 ------> 14A2

14A83 ------> 14A4

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Appendix B

Hydraulic Test Results

Table B-1. Results of hydraulic tests[a].

Well	Date	Type of test[b]	Flow rate (Q) (gpm)	Transmis-sivity (T) (gpd/ft)	Hydraulic conductivity (K)[c] (gpd/sq ft)	Data quality[d]
W-001	1-Dec-83	Drawdown	5.7	2,000	110	Fair
W-001	23-Jan-85	Drawdown	7.1	3,100	170	Good
W-001A	22-Jan-85	Drawdown	1.4	190	19	Good
W-002	1-Dec-83	Slug	0.0	110	34	Poor
W-002A	24-Jan-85	Drawdown	10.3	2,700	200	Good
W-004	1-Dec-83	Drawdown	3.3	63	13	Good
W-005	1-Dec-83	Drawdown	4.3	110	20	Good
W-005	24-Jan-85	Drawdown	7.9	1,100	210	Fair
W-005A	23-Jan-85	Drawdown	13.0	1,300	130	Poor
W-007	1-Dec-83	Slug	0.0	43	14	Fair
W-008	1-Dec-83	Drawdown	2.9	29	4.9	Fair
W-011	1-Dec-83	Drawdown	4.1	130	15	Good
W-017	1-Dec-83	Slug	0.0	38	2.5	Good
W-017	21-Feb-86	Slug	0.0	85	5.7	Good
W-018	1-Dec-83	Drawdown	2.6	20	2.7	Poor
W-102	25-Mar-86	Drawdown	6.4	1,100	76	Good
W-102	5-Sep-86	Drawdown	24.0	770	53	Good
W-102	15-Sep-86	Longterm	27.5	4,200	290	Good
W-103	25-Apr-86	Drawdown	6.7	15,000	1,500	Good
W-104	3-Mar-88	Drawdown	5.4	1,200	170	Fair
W-104	25-Mar-88	Drawdown	3.3	450	45	Fair
W-105	6-Apr-87	Drawdown	0.8	73	7.3	Fair
W-106	19-Feb-86	Slug	0.0	7.4	1.3	Excel
W-107	17-Jun-85	Drawdown	1.0	94	9.4	Poor
W-108	29-Oct-85	Drawdown	7.9	750	63	Poor
W-109	5-Mar-86	Drawdown	8.1	3,200	530	Good
W-109	4-Sep-87	Drawdown	20.0	1,600	270	Good
W-109	29-Sep-87	Longterm	11.6	130	22	Fair
W-109	16-Oct-87	Drawdown	8.0	2,300	380	Fair
W-110	18-Jun-85	Drawdown	5.0	1,300	130	Good
W-111	13-Jun-85	Drawdown	1.0	370	37	Good
W-111	21-Nov-85	Drawdown	1.0	370	37	Good
W-112	18-Nov-86	Drawdown	13.4	2,100	170	Fair
W-112	15-Dec-86	Longterm	13.2	3,100	260	Fair
W-112	5-Nov-96	Longterm	13.7	3,300	260	Fair

Table B-1. (Continued)

Well	Date	Type of test[b]	Flow rate (Q) (gpm)	Transmis-sivity (T) (gpd/ft)	Hydraulic conductivity (K)[c] (gpd/sq ft)	Data quality[d]
W-113	17-Apr-86	Slug	0.0	7.4	1.2	Excel
W-115	5-Mar-86	Drawdown	1.1	180	30	Good
W-116	24-Dec-85	Slug	0.0	37	7.5	Good
W-117	20-Feb-86	Slug	0.0	2	0.4	Good
W-118	5-Mar-86	Drawdown	10.0	2,100	230	Good
W-119	8-Aug-85	Drawdown	2.0	1,600	110	Good
W-120	22-Apr-86	Drawdown	1.1	23	5.6	Poor
W-121	10-Sep-85	Drawdown	2.0	120	7.5	Good
W-121	23-Sep-85	Drawdown	4.0	23	1.5	Excel
W-121	14-Oct-85	Drawdown	3.0	34	2.2	Excel
W-121	15-Oct-85	Drawdown	4.5	45	3.0	Excel
W-122	28-Oct-85	Drawdown	10.8	490	49	Good
W-123	28-Oct-85	Drawdown	5.8	40	4.4	Poor
W-142	3-Mar-88	Slug	0.0	2,600	330	Excel
W-143	3-Mar-88	Slug	0.0	1,200	240	Excel
W-149	9-Sep-85	Drawdown	4.0	120	19	Good
W-149	11-Sep-85	Drawdown	8.0	95	16	Excel
W-149	11-Oct-85	Drawdown	4.8	58	9.7	Excel
W-149	11-Oct-85	Drawdown	7.0	70	12	Good
W-150	2-Oct-85	Drawdown	3.1	640	210	Fair
W-150	3-Oct-85	Drawdown	6.0	720	240	Fair
W-150	10-Oct-85	Drawdown	8.8	630	210	Fair
W-150	10-Oct-85	Drawdown	12.0	620	210	Fair
W-151	28-Oct-85	Drawdown	5.8	550	61	Poor
W-201	5-Mar-86	Drawdown	10.0	740	86	Excel
W-203	2-Mar-88	Drawdown	6.6	1,100	110	Good
W-204	23-Jan-86	Drawdown	1.9	100	15	Fair
W-205	14-Feb-86	Slug	0.0	5.9	1.9	Good
W-205	18-Feb-86	Slug	0.0	5.9	1.9	Good
W-206	14-Apr-86	Slug	0.0	120	11	Good
W-207	2-Mar-88	Slug	0.0	380	32	Excel
W-210	9-Jun-86	Slug	0.0	0.6	0.1	Good
W-211	22-Oct-86	Drawdown	2.9	37	12	Fair
W-211	8-Dec-86	Longterm	1.0	44	15	Fair
W-211	16-Sep-97	Longterm	1.1	14	1.4	Good
W-212	12-May-86	Drawdown	0.8	18	3.1	Poor

Table B-1. (Continued)

Well	Date	Type of test[b]	Flow rate (Q) (gpm)	Transmis-sivity (T) (gpd/ft)	Hydraulic conductivity (K)[c] (gpd/sq ft)	Data quality[d]
W-213	22-Apr-86	Drawdown	3.8	190	38	Good
W-214	7-Oct-86	Longterm	27.6	2,300	350	Good
W-217	15-Jul-86	Slug	0.0	750	120	Good
W-218	17-Jun-86	Drawdown	11.7	6,400	1,100	Good
W-218	12-Nov-86	Longterm	7.7	4,000	670	Good
W-219	15-Jul-86	Drawdown	4.3	620	76	Good
W-219	23-Feb-87	Longterm	5.2	66	8.0	Fair
W-220	21-Aug-86	Slug	0.0	28	5.5	Excel
W-221	5-Aug-86	Drawdown	2.1	120	16	Fair
W-222	12-Aug-86	Drawdown	16.0	1,700	160	Excel
W-222	8-Mar-85	Longterm	7.7	1,100	180	Good
W-223	27-Aug-86	Drawdown	4.0	510	110	Good
W-224	28-Oct-86	Drawdown	7.6	3,600	400	Excel
W-225	23-Oct-86	Drawdown	4.0	85	11	Good
W-225	12-Jan-87	Longterm	2.0	62	8.5	Fair
W-226	31-Mar-87	Slug	0.0	1,700	160	Fair
W-252	4-Nov-85	Drawdown	4.0	920	50	Fair
W-252	19-Nov-85	Drawdown	5.6	800	43	Fair
W-254	27-Jan-86	Drawdown	4.2	340	38	Fair
W-254	27-Feb-86	Drawdown	3.2	370	41	Good
W-255	21-Jan-86	Drawdown	5.0	2,800	250	Fair
W-255	21-Jan-86	Drawdown	6.0	2,000	180	Fair
W-255	6-Jan-87	Longterm	2.0	400	36	Fair
W-256	11-Apr-86	Slug	0.0	11	5.5	Good
W-257	15-Apr-86	Slug	0.0	120	24	Good
W-258	5-Jun-86	Slug	0.0	35	9.0	Excel
W-258	29-Oct-86	Slug	0.0	32	8.0	Good
W-259	26-Mar-88	Slug	0.0	15	5.0	Good
W-260	25-Mar-86	Drawdown	3.0	140	22	Good
W-260	1-Oct-86	Longterm	1.4	120	18	Good
W-261	27-May-86	Slug	0.0	7	2.3	Excel
W-262	11-Apr-86	Drawdown	12.5	2,000	250	Excel
W-262	23-Sep-86	Longterm	22.0	2,750	340	Good
W-262	27-Apr-87	Longterm	23.1	6,800	810	Good
W-263	22-Apr-86	Drawdown	1.2	37	7.4	Poor
W-263	4-Nov-86	Longterm	1.8	76	15	Excel

Table B-1. (Continued)

Well	Date	Type of test[b]	Flow rate (Q) (gpm)	Transmis-sivity (T) (gpd/ft)	Hydraulic conductivity (K)[c] (gpd/sq ft)	Data quality[d]
W-264	7-May-86	Drawdown	8.1	930	100	Good
W-264	29-Oct-86	Longterm	23.0	480	50	Good
W-265	19-May-86	Drawdown	0.7	180	34	Fair
W-267	2-Jun-86	Drawdown	0.5	420	85	Poor
W-268	14-Nov-86	Drawdown	5.0	230	18	Good
W-269	14-Jul-86	Drawdown	5.0	570	95	Good
W-270	30-Dec-86	Slug	0.0	14	2.0	Good
W-271	4-Aug-86	Drawdown	5.5	340	76	Fair
W-272	19-Aug-86	Drawdown	0.8	150	30	Fair
W-273	27-Aug-86	Drawdown	3.2	600	90	Good
W-274	25-Mar-85	Slug	0.0	38	7.6	Fair
W-274	2-Feb-99	Slug	0.0	10	2	Fair
W-275	30-Oct-86	Drawdown	7.0	730	150	Fair
W-275	2-Mar-87	Longterm	5.5	830	170	Fair
W-276	21-Nov-86	Drawdown	13.0	960	110	Good
W-276	4-May-87	Longterm	24.0	2,700	300	Fair
W-277	3-Nov-86	Drawdown	0.9	74	25	Fair
W-290	5-Jan-87	Slug	0.0	14	4.0	Excel
W-291	27-Jan-87	Slug	0.0	25	7.1	Fair
W-292	28-Aug-86	Drawdown	6.0	400	56	Excel
W-294	29-Dec-86	Drawdown	5.3	5,300	29	Fair
W-294	29-Dec-86	Drawdown	5.9	5,400	300	Good
W-301	30-Oct-86	Drawdown	6.0	460	100	Good
W-302	18-Nov-86	Drawdown	1.0	100	27	Good
W-302	18-Nov-86	Drawdown	2.0	76	21	Fair
W-303	12-Nov-86	Drawdown	11.1	210	70	Good
W-304	13-Mar-87	Drawdown	0.9	74	25	Fair
W-305	26-Nov-86	Drawdown	19.0	720	72	Excel
W-305	18-May-87	Longterm	20.1	640	64	Excel
W-306	31-Mar-87	Drawdown	9.5	270	68	Good
W-307	26-Mar-87	Drawdown	0.9	66	33	Fair
W-308	4-Dec-87	Drawdown	2.6	27	5.4	Good
W-310	17-Feb-87	Drawdown	6.7	58	850	Good
W-311	19-Mar-87	Drawdown	9.8	130	12	Good
W-311	17-Nov-87	Longterm	9.9	370	26	Good
W-312	27-Mar-87	Drawdown	20.5	1,800	300	Poor

Table B-1. (Continued)

Well	Date	Type of test[b]	Flow rate (Q) (gpm)	Transmis-sivity (T) (gpd/ft)	Hydraulic conductivity (K)[c] (gpd/sq ft)	Data quality[d]
W-312	3-Nov-87	Longterm	18.8	1,700	280	Good
W-313	25-Mar-87	Drawdown	7.9	3,000	600	Good
W-313	5-Oct-87	Longterm	9.6	3,400	680	Good
W-314	10-Apr-87	Drawdown	26.4	2,900	390	Good
W-314	13-Jul-87	Longterm	13.6	2,500	330	Fair
W-314	14-Oct-97	Longterm	12	1,400	100	Fair
W-315	9-Apr-87	Drawdown	15.4	150	11	Good
W-315	5-Jan-85	Longterm	24.5	571	41	Excel
W-316	4-May-87	Drawdown	7.8	1,400	280	Good
W-317	12-May-87	Drawdown	12.1	300	43	Fair
W-317	15-Dec-87	Longterm	8.2	120	17.1	Good
W-318	7-Aug-87	Slug	0.0	120	16	Good
W-319	29-Jul-87	Drawdown	48.0	7,200	1,500	Good
W-320	15-May-87	Drawdown	1.8	58	17	Fair
W-320	15-May-87	Drawdown	3.0	22	3.7	Fair
W-320	26-Jun-87	Drawdown	2.1	49	14	Fair
W-321	28-Jul-87	Drawdown	40.0	6,600	450	Good
W-322	3-Aug-87	Drawdown	3.1	85	15	Good
W-323	11-Aug-87	Drawdown	3.4	205	59	Good
W-324	10-Sep-87	Drawdown	6.6	200	50	Good
W-325	10-Sep-87	Drawdown	6.0	160	13	Excel
W-351	12-Nov-86	Drawdown	5.7	27	14	Poor
W-352	30-Dec-86	Drawdown	20.0	280	14	Good
W-352	7-Jul-87	Longterm	19.5	120	6.0	Excel
W-353	20-Nov-86	Drawdown	2.1	60	17	Good
W-354	30-Dec-86	Drawdown	17.6	2,000	220	Fair
W-354	30-Dec-86	Drawdown	18.0	2,400	260	Good
W-354	20-Apr-87	Longterm	17.8	310	34	Good
W-355	29-Dec-86	Drawdown	2.1	19	5.0	Fair
W-356	17-Mar-87	Drawdown	5.7	180	59	Good
W-356	16-Jul-96	Longterm	4.9	230	57	Poor
W-357	18-Feb-87	Drawdown	15.0	1,300	110	Good
W-357	21-Jul-87	Longterm	9.2	210	18	Good
W-358	18-Mar-87	Drawdown	9.2	210	32	Excel
W-359	9-Mar-87	Longterm	19.0	2,800	290	Fair
W-359	20-Mar-87	Drawdown	18.6	1,100	110	Good

Table B-1. (Continued)

Well	Date	Type of test[b]	Flow rate (Q) (gpm)	Transmis-sivity (T) (gpd/ft)	Hydraulic conductivity (K)[c] (gpd/sq ft)	Data quality[d]
W-360	22-May-87	Drawdown	30.0	4,800	210	Excel
W-361	16-Mar-87	Drawdown	4.3	67	11	Good
W-361	12-Jan-85	Longterm	5.3	178	30	Good
W-362	23-Mar-87	Drawdown	16.4	470	49	Good
W-362	21-Sep-87	Longterm	13.6	370	39	Good
W-363	24-Jul-87	Slug	0.0	20	3.0	Excel
W-364	8-Apr-87	Drawdown	8.6	51	10	Fair
W-364	1-Jun-87	Longterm	4.8	110	22	Good
W-365	14-May-87	Drawdown	10.0	36	15	Fair
W-366	11-May-87	Drawdown	19.0	780	92	Fair
W-368	11-May-87	Drawdown	2.9	81	8.5	Fair
W-369	25-Jun-87	Drawdown	7.0	580	96	Good
W-369	10-Nov-87	Longterm	5.5	89	18	Good
W-370	23-Jun-87	Drawdown	4.4	84	10	Fair
W-371	24-Jun-87	Drawdown	3.3	15	3.0	Good
W-372	23-Nov-87	Slug	0.0	310	62	Excel
W-373	28-Jul-87	Drawdown	4.0	660	77	Fair
W-373	28-Jul-87	Drawdown	6.5	50	6.0	Poor
W-376	26-Jan-88	Drawdown	2.9	65	8.5	Fair
W-380	23-Oct-87	Drawdown	4.0	33	4.7	Excel
W-401	23-Oct-87	Drawdown	42.0	950	24	Excel
W-402	22-Oct-87	Drawdown	41.0	13,500	1,400	Good
W-403	3-Dec-87	Drawdown	9.7	370	26	Good
W-404	4-Feb-85	Drawdown	45.0	3,200	530	Good
W-405	16-Feb-85	Drawdown	47.2	546	14	Good
W-406	28-Jan-85	Drawdown	7.4	7,500	940	Fair
W-407	23-Feb-85	Drawdown	14.4	75	7.5	Fair
W-408	5-Apr-85	Drawdown	45.0	43,000	3,100	Good
W-409	22-Mar-85	Drawdown	20.0	230	38	Good
W-410	28-Apr-85	Drawdown	35.0	6,800	570	Fair
W-411	5-May-85	Drawdown	14.0	50	83	Good
W-412	6-May-88	Drawdown	4.1	700	64	Fair
W-414	27-Jul-85	Slug	0.0	150	38	Good
W-415	31-Aug-85	Drawdown	10.0	3,100	78	Fair
W-416	11-Jul-85	Drawdown	50.0	2,600	330	Good
W-417	27-Jun-88	Drawdown	5.3	340	57	Fair

Table B-1. (Continued)

Well	Date	Type of test[b]	Flow rate (Q) (gpm)	Transmis-sivity (T) (gpd/ft)	Hydraulic conductivity (K)[c] (gpd/sq ft)	Data quality[d]
W-420	16-Aug-85	Drawdown	3.5	710	100	Excel
W-421	12-Sep-85	Drawdown	4.8	320	27	Excel
W-422	19-Sep-85	Drawdown	8.6	230	42	Good
W-423	12-Oct-85	Drawdown	22.0	1,500	130	Good
W-424	17-Oct-85	Drawdown	4.5	130	19	Good
W-441	30-Oct-87	Drawdown	6.0	500	56	Good
W-441	13-Apr-88	Drawdown	13.0	2,200	240	Poor
W-441	19-Apr-88	Longterm	14.0	470	52	Good
W-447	26-Feb-88	Drawdown	7.1	124	850	Poor
W-448	24-Mar-85	Drawdown	24.5	4,200	600	Good
W-449	21-Mar-85	Drawdown	6.2	170	11	Good
W-450	14-Apr-88	Drawdown	3.3	38	650	Fair
W-451	27-Apr-88	Drawdown	2.1	80	16	Good
W-452	2-May-88	Drawdown	5.2	310	21	Excel
W-453	3-May-88	Drawdown	5.8	67	7.4	Fair
W-455	22-Jun-88	Drawdown	5.8	160	13	Good
W-456	14-Jul-85	Drawdown	4.5	260	33	Fair
W-457	29-Jul-85	Drawdown	20.5	450	24	Excel
W-458	2-Aug-85	Drawdown	0.8	24	150	Fair
W-460	1-Sep-85	Drawdown	17.0	1,900	380	Fair
W-461	7-Sep-85	Slug	0.0	690	140	Good
W-462	27-Sep-85	Drawdown	19.0	360	60	Good
W-463	11-Oct-85	Drawdown	24.0	1,600	200	Good
W-464	8-Nov-88	Drawdown	9.0	370	53	Good
W-481	2-Dec-87	Drawdown	1.1	8	1.7	Good
W-486	23-Mar-85	Drawdown	6.0	230	30	Good
W-487	14-Apr-88	Drawdown	2.2	45	15	Good
W-501	21-Oct-85	Drawdown	9.7	170	21	Good
W-502	14-Nov-85	Slug	0.0	12	30	Good
W-503	11-Nov-88	Drawdown	1.3	15	3.0	Fair
W-504	8-Dec-85	Drawdown	10.0	590	84	Good
W-505	21-Mar-89	Drawdown	34.2	653	76	Good
W-506	10-Feb-89	Drawdown	31.0	7,423	460	Good
W-507	6-Feb-89	Drawdown	39.0	2,900	290	Good
W-508	29-Mar-89	Drawdown	30.0	47,000	2,600	Good
W-509	11-May-89	Drawdown	0.9	10	2.0	Fair

Table B-1. (Continued)

Well	Date	Type of test[b]	Flow rate (Q) (gpm)	Transmis-sivity (T) (gpd/ft)	Hydraulic conductivity (K)[c] (gpd/sq ft)	Data quality[d]
W-510	11-May-89	Slug	0.0	220	110	Good
W-511	11-May-89	Drawdown	1.7	63	11	Fair
W-512	27-Apr-89	Drawdown	2.9	85	9.4	Good
W-513	9-May-89	Drawdown	0.6	33	3.0	Fair
W-514	26-May-89	Drawdown	1.4	84	530	Fair
W-515	6-Jun-89	Drawdown	2.8	37	4.2	Fair
W-516	19-Jun-89	Drawdown	19.5	1,428	286	Good
W-517	27-Jun-89	Drawdown	7.3	370	53	Good
W-518	10-Aug-89	Drawdown	6.2	1,421	178	Good
W-519	31-Aug-89	Drawdown	31.5	5,700	475	Excel
W-520	24-Jan-90	Drawdown	22.8	3,300	560	Excel
W-521	1-Feb-90	Drawdown	0.6	44	4.9	Fair
W-522	5-Feb-90	Drawdown	20.0	3,700	620	Fair
W-551	8-Nov-85	Drawdown	37.0	350	88	Good
W-552	12-Dec-88	Drawdown	38.0	4,700	390	Good
W-553	17-Nov-85	Drawdown	2.2	55	7.9	Fair
W-554	10-Jan-89	Drawdown	21.5	1,800	150	Good
W-555	28-Dec-88	Drawdown	14.0	460	23	Fair
W-556	25-Jan-89	Drawdown	17.0	850	170	Fair
W-557	23-Jan-89	Drawdown	1.2	570	36	Poor
W-558	23-Mar-89	Drawdown	24.7	5,200	650	Good
W-560	8-Mar-89	Drawdown	1.7	30	7.6	Fair
W-561	13-Mar-89	Drawdown	1.1	12	2.1	Fair
W-562	28-Mar-89	Drawdown	1.0	16	2.3	Fair
W-563	31-Mar-89	Drawdown	1.1	14	2.3	Fair
W-564	26-Apr-89	Drawdown	1.6	44	5.0	Poor
W-565	18-Apr-89	Drawdown	15.6	1,600	260	Good
W-566	2-May-89	Drawdown	17.0	780	86	Good
W-566	31-Aug-93	Longterm	22.5	2,580	520	Fair
W-567	4-May-89	Drawdown	10.4	2,600	320	Excel
W-568	20-Jun-89	Drawdown	18.3	620	160	Fair
W-569	24-May-89	Drawdown	2.8	100	15	Fair
W-570	8-Jun-89	Drawdown	1.1	7	1.1	Fair
W-571	17-Jul-89	Drawdown	17.7	1,000	200	Excel
W-592	23-Jan-89	Drawdown	2.2	2,200	280	Poor
W-593	22-Feb-89	Drawdown	2.2	57	11.4	Good

Table B-1. (Continued)

Well	Date	Type of test[b]	Flow rate (Q) (gpm)	Transmis-sivity (T) (gpd/ft)	Hydraulic conductivity (K)[c] (gpd/sq ft)	Data quality[d]
W-594	16-Mar-89	Slug	0.0	380	54	Excel
W-601	8-Feb-90	Drawdown	22.5	6,900	770	Excel
W-602	29-Jan-90	Drawdown	24.0	5,300	620	Good
W-603	7-Feb-90	Drawdown	6.1	100	20	Fair
W-604	20-Feb-90	Slug	0.0	380	63	Good
W-605	28-Feb-90	Drawdown	4.8	50	12	Good
W-606	21-Feb-90	Slug	0.0	120	20	Fair
W-607	22-Feb-90	Drawdown	1.4	800	100	Good
W-608	28-Feb-90	Drawdown	1.2	230	30	Fair
W-609	9-Mar-90	Drawdown	6.7	470	70	Good
W-610	28-Mar-90	Drawdown	5.8	5,500	380	Good
W-611	16-Apr-90	Drawdown	3.5	1,000	110	Fair
W-612	24-May-90	Drawdown	13.5	550	55	Good
W-612	05-Apr-94	Longterm	14	230	40	Good
W-613	23-May-90	Drawdown	4.8	2,550	360	Good
W-614	7-Jun-90	Drawdown	6.7	1,650	130	Good
W-615	21-Jun-90	Drawdown	1.3	130	19	Fair
W-616	27-Jun-90	Drawdown	2.0	390	40	Fair
W-617	12-Jul-90	Drawdown	2.8	53	6.8	Good
W-618	1-Aug-90	Drawdown	1.9	24	4.8	Fair
W-619	30-Aug-90	Drawdown	11.8	190	11	Good
W-620	1-Oct-90	Drawdown	5.8	6,500	650	Good
W-621	4-Oct-90	Drawdown	3.8	310	39	Good
W-622	12-Oct-90	Slug	0.0	130	16	Fair
W-651	16-Mar-90	Slug	0.0	530	180	Fair
W-652	22-Mar-90	Drawdown	1.0	11	3.8	Good
W-653	11-Apr-90	Drawdown	0.3	2	1.9	Fair
W-654	25-Apr-90	Drawdown	21.7	390	25	Fair
W-655	12-May-90	Drawdown	12.2	1,000	220	Good
W-701	23-Oct-90	Drawdown	14.5	6,800	650	Good
W-701	3-Oct-92	Step	16.5	5,200	430	Good
W-701	1-Apr-93	Drawdown	24	3,700	370	Good
W-702	29-Nov-90	Drawdown	2.5	150	30	Good
W-702	25-Feb-93	Step	4.6	36	7	Poor
W-703	19-Dec-90	Drawdown	7.0	230	9.1	Good
W-704	4-Mar-91	Drawdown	19.0	1,800	140	Fair

Table B-1. (Continued)

Well	Date	Type of test[b]	Flow rate (Q) (gpm)	Transmis-sivity (T) (gpd/ft)	Hydraulic conductivity (K)[c] (gpd/sq ft)	Data quality[d]
W-705	20-Feb-91	Drawdown	0.8	40	6.1	Fair
W-706	29-Jan-91	Drawdown	0.2	8	1	Fair
W-712	25-Feb-92	Drawdown	7.8	750	48	Good
W-712	18-Mar-93	Longterm	15.1	1,440	93	Good
W-714	6-Dec-91	Drawdown	2.9	140	6.7	Good
W-902	25-Mar-93	Drawdown	0.6	6	2	Fair
W-909	18-Oct-95	Drawdown	2.7	150	5.1	Good
W-911	2-Feb-96	Drawdown	1.4	53	2.1	Good
W-912	10-Nov-95	Drawdown	4.1	65	11	Poor
W-913	16-Aug-95	Drawdown	23.5	730	36	Good
W-1001	13-Aug-95	Drawdown	1.3	170	25	Fair
W-1002	19-Jun-97	Drawdown	16.8	680	49	Good
W-1003	26-Jun-97	Drawdown	1.2	5.1	0.7	Poor
W-1006	17-Jun-97	Drawdown	17.4	180	23	Fair
W-1007	23-Sep-95	Drawdown	1.6	13	1.3	Fair
W-1008	17-Jan-97	Drawdown	7.3	110	13	Good
W-1010	10-Jul-95	Drawdown	20.3	1,650	140	Fair
W-1011	11-Jul-95	Drawdown	3.8	240	17	Good
W-1012	13-Jul-95	Drawdown	3.3	35	2.2	Fair
W-1013	13-Jul-95	Drawdown	2.7	2,000	250	Poor
W-1014	28-Aug-96	Drawdown	31.1	7,700	320	Good
W-1101	22-Nov-95	Drawdown	0.8	9.9	3.3	Good
W-1102	29-Jan-96	Drawdown	14.7	81	4.5	Fair
W-1103	29-Nov-95	Drawdown	3	19	1.6	Fair
W-1105	17-Jul-95	Drawdown	2.4	320	26	Fair
W-1106	24-Jul-96	Drawdown	7.1	5,200	580	Good
W-1107	9-Apr-97	Drawdown	6.7	3,500	250	Poor
W-1107	04-May-99	Drawdown	6.6	4,300	310	Fair
W-1108	3-Nov-95	Drawdown	12.3	950	68	Good
W-1108	25-Jun-96	Longterm	11.6	1,000	70	Poor
W-1109	26-Jun-95	Drawdown	8.7	460	33	Fair
W-1109	4-Jun-96	Longterm	6.8	760	40	Poor
W-1110	22-Jan-96	Drawdown	6.3	690	29	Fair
W-1111	20-Oct-95	Drawdown	15.8	2,100	95	Good
W-1111	9-Dec-96	Longterm	11.2	160	7.9	Poor
W-1112	24-May-96	Drawdown	6.4	94	10	Fair

Table B-1. (Continued)

Well	Date	Type of test[b]	Flow rate (Q) (gpm)	Transmis-sivity (T) (gpd/ft)	Hydraulic conductivity (K)[c] (gpd/sq ft)	Data quality[d]
W-1113	26-Aug-96	Drawdown	1	5.5	0.6	Good
W-1114	27-Oct-95	Longterm	15.1	270	12	Fair
W-1116	23-Feb-96	Drawdown	6.6	290	11	Fair
W-1117	23-Aug-96	Drawdown	0.7	3.4	0.34	Fair
W-1118	18-Jan-96	Drawdown	5.6	350	35	Good
W-1201	1-Nov-96	Drawdown	1	8.3	0.92	Poor
W-1203	2-May-96	Drawdown	18.8	900	90	Good
W-1204	22-Feb-96	Drawdown	1.3	17	2.2	Poor
W-1205	27-Nov-96	Slug	0	330	33	Fair
W-1207	27-Nov-96	Slug	0	900	45	Poor
W-1209	17-May-96	Drawdown	0.98	11	0.69	Good
W-1210	30-May-96	Drawdown	3.8	7.3	0.73	Fair
W-1211	26-Jul-96	Drawdown	28.6	5,000	330	Good
W-1212	14-May-96	Drawdown	1.9	35	2.5	Good
W-1212	10-Sep-96	Longterm	1.3	85	3.6	Poor
W-1213	22-Jul-96	Drawdown	11.6	500	42	Fair
W-1213	30-Jul-96	Longterm	9.6	440	37	Poor
W-1214	28-Apr-97	Drawdown	2.2	110	5.4	Fair
W-1215	15-Aug-96	Drawdown	11.6	610	61	Fair
W-1215	8-Oct-96	Longterm	9.8	3,000	300	Poor
W-1216	14-Aug-96	Drawdown	11.4	210	6.9	Good
W-1216	15-Oct-96	Longterm	11.1	160	5.4	Poor
W-1218	11-Nov-96	Drawdown	5.8	83	4.6	Fair
W-1218	8-Jul-97	Longterm	4.8	210	12	Fair
W-1219	27-May-97	Drawdown	0.4	2.5	0.63	Poor
W-1220	13-Nov-96	Drawdown	20.3	2,600	120	Good
W-1220	15-Jul-97	Longterm	20	4,700	210	Fair
W-1221	27-Dec-96	Drawdown	3.1	29	2.9	Fair
W-1222	31-Oct-96	Drawdown	6.1	430	43	Good
W-1224	22-May-97	Drawdown	5	55	11	Good
W-1225	31-Mar-97	Drawdown	4.1	83	10	Good
W-1226	27-Feb-97	Drawdown	2.2	14	1.4	Excel
W-1227	11-Apr-97	Drawdown	15.1	380	48	Fair
W-1254	19-Nov-96	Longterm	18.9	1,130	110	Fair
W-1301	10-Mar-97	Longterm	4.7	120	15	Fair
W-1303	18-Mar-97	Longterm	7.8	490	21	Fair

Table B-1. (Continued)

Well	Date	Type of test[b]	Flow rate (Q) (gpm)	Transmis-sivity (T) (gpd/ft)	Hydraulic conductivity (K)[c] (gpd/sq ft)	Data quality[d]
W-1304	2-Jul-97	Drawdown	0.7	2.6	0.52	Poor
W-1306	30-Apr-97	Drawdown	2.8	24	1.2	Good
W-1306	18-Jun-97	Longterm	1.6	54	2.7	Poor
W-1307	31-Jul-97	Drawdown	11.6	1,100	110	Good
W-1308	14-Aug-97	Drawdown	6.5	150	5.1	Good
W-1308	7-Oct-977	Longterm	4	530	18	Fair
W-1309	15-Oct-97	Drawdown	9.1	90	8.9	Fair
W-1310	10-Mar-97	Drawdown	27.9	1,060	53	Good
W-1311	29-Oct-97	Drawdown	12.2	290	15	Good
W-1401	11-Nov-97	Drawdown	7	100	6.8	Excel
W-1402	12-Dec-97	Drawdown	2.6	100	10.2	Fair
W-1403	21-Jul-98	Drawdown	5.4	95	13	Good
W-1404	21-Apr-98	Drawdown	6.5	210	84	Good
W-1405	23-Apr-98	Drawdown	6.4	1,300	360	Fair
W-1406	17-Apr-98	Drawdown	11.1	3,600	360	Good
W-1407	3-Apr-98	Drawdown	1.1	8.7	1.0	Excellent
W-1408	15-Apr-98	Drawdown	2.7	85	28	Fair
W-1410	29-Jun-98	Drawdown	11.5	3,000	500	Poor
W-1410	8-Sep-99	Step	6.5	3,800	650	Poor
W-1411	15-May-98	Drawdown	12.3	14,700	1,300	Poor
W-1412	29-May-98	Slug	0.0	2	0.67	Fair
W-1413	8-Jun-98	Drawdown	0.63	8.7	3.5	Fair
W-1415	11-Jun-98	Drawdown	0.87	18	1.2	Fair
W-1416	28-Jul-98	Drawdown	12.3	1,300	180	Good
W-1417	1-Jul-98	Drawdown	15.1	130	11	Good
W-1417	16-Jul-98	Step	5.9	150	13	Fair
W-1418	25-Sep-98	Drawdown	10.7	78	6.5	Excellent
W-1418	16-Dec-98	Step	10.5	490	41	Fair
W-1419	15-Jul-98	Step	6.1	47	3	Poor
W-1420	12-Aug-98	Drawdown	13.1	3,000	220	Poor
W-1421	14-Jul-98	Step	1.82	14	1.8	Poor
W-1421	17-Jul-98	Step	3.8	22	2.8	Poor
W-1422	18-Sep-98	Drawdown	12.0	170	33	Excellent
W-1422	18-Dec-98	Step	11.7	160	32	Good
W-1423	12-Nov-98	Drawdown	24.6	540	39	Fair
W-1424	1-Oct-98	Drawdown	6	48	6.9	Excellent

Table B-1. (Continued)

Well	Date	Type of test[b]	Flow rate (Q) (gpm)	Transmis-sivity (T) (gpd/ft)	Hydraulic conductivity (K)[c] (gpd/sq ft)	Data quality[d]
W-1425	1-Oct-98	Drawdown	1.4	15	2.4	Fair
W-1426	13-Nov-98	Drawdown	6.5	840	56	Good
W-1427	11-Jan-99	Drawdown	7.9	2,100	300	Good
W-1428	13-Jan-99	Drawdown	8.1	8,200	550	Good
W-1501	20-Nov-98	Drawdown	7.2	68	11	Good
W-1502	17-May-99	Drawdown	1.5	360	60	Good
W-1503	12-Feb-99	Drawdown	17.6	1,700	180	Good
W-1504	18-Feb-99	Drawdown	15.4	600	60	Fair
W-1505	29-Apr-99	Drawdown	11.2	280	35	Fair
W-1506	19-Apr-99	Drawdown	3.1	50	5.4	Good
W-1507	27-Apr-99	Drawdown	0.65	15.0	1.9	Fair
W-1509	09-Apr-99	Drawdown	7.2	7,000	700	Good
W-1510	14-Apr-99	Drawdown	6.6	280	20	Fair
W-1514	23-Jun-99	Longterm	5.8	440	90	Good
W-1550	28-Dec-99	Drawdown	10.0	330	35	Fair
TW-11	24-Jan-85	Drawdown	0.3	200	20	Good
TW-11A	24-Jan-85	Drawdown	10.0	3,100	110	Fair
GSW-01	11-Dec-85	Slug	0.0	72	0.2	Fair
GSW-01A	14-Jul-86	Drawdown	13.4	12,000	790	Good
GSW-02	17-Dec-85	Slug	0.0	240	10	Good
GSW-03	23-Dec-85	Slug	0.0	510	41	Good
GSW-04	19-Dec-85	Slug	0.0	17	0.9	Good
GSW-05	12-Feb-86	Slug	0.0	99	9	Excel
GSW-06	23-Iun-86	Drawdown	25.0	4,800	310	Good
GSW-06	16-Jun-87	Longterm	20.0	5,500	350	Good
GSW-07	3-Apr-86	Drawdown	4.3	230	23	Excel
GSW-08	19-Nov-86	Drawdown	2.0	230	38	Good
GSW-09	28-May-86	Drawdown	1.9	500	63	Poor
GSW-10	22-May-86	Drawdown	14.3	21,000	2,000	Good
GSW-11	2-Jun-86	Drawdown	4.7	390	45	Excel
GSW-12	7-Jun-86	Drawdown	0.8	51	11	Fair
GSW-13	4-Aug-86	Slug	0.0	110	13	Excel
GSW-13	8-Aug-86	Slug	0.0	62	7	Good
GSW-15	23-Feb-88	Drawdown	25.8	1,500	190	Good
GSW-208	8-May-86	Drawdown	1.9	440	80	Good
GSW-209	8-May-86	Drawdown	6.1	1,200	120	Good

Table B-1. (Continued)

Well	Date	Type of test[b]	Flow rate (Q) (gpm)	Transmis-sivity (T) (gpd/ft)	Hydraulic conductivity (K)[c] (gpd/sq ft)	Data quality[d]
GSW-215	4-Jun-86	Drawdown	1.9	220	40	Poor
GSW-216	16-Jan-92	Drawdown	10.5	3,500	440	Fair
GSW-266	20-Jun-86	Drawdown	2.1	470	72	Good
GSW-266	18-Nov-86	Drawdown	3.0	450	64	Good
GSW-266	18-Nov-86	Drawdown	4.7	410	59	Good
GSW-367	11-May-87	Drawdown	6.9	200	29	Fair
GSW-403-6	8-Dec-85	Slug	0.0	4	0.2	Good
GSW-442	23-Nov-87	Drawdown	1.2	32	4.6	Good
GSW-443	30-Nov-87	Drawdown	10.3	260	8.7	Good
GSW-444	28-Jan-88	Slug	0.0	9	0.86	Good
GSW-445	26-Jan-85	Drawdown	4.7	43	4.30	Fair
GEW-710	23-Sept-91	Step	36.0	4,800	220	Excel
GEW-816	15-Aug-92	Drawdown	39.0	12,000	1,100	Good
11H4	15-Jan-85	Drawdown	24.6	2,000	77	Good
11H4	19-Jan-85	Longterm	29.5	1,780	18	Good
11J4	10-Jun-88	Drawdown	17.0	1,000	15	Excel
11J4	14-Jun-85	Longterm	16.0	1,100	16	Good
13D1	9-Feb-85	Longterm	50.0	4,800	48	Excel

[a] The pumping test results were obtained by using the analytic techniques of Theis (1935), Cooper and Jacob (1946), Papadopulos and Cooper (1967), Hantush and Jacob (1955), Hantush (1960), or Boulton (1963). The particular method used is dependent on the character of the data obtained. The slug test results were obtained using the method of Cooper *et al.* (1967). (See references below.)

[b] "DRAWDOWN" denotes 1-h pumping tests; "LONGTERM" denotes 24- to 48-h pumping tests; "STEP" denotes a step-drawdown test, flow rate given is the maximum or final step.

[c] K is calculated by dividing T by the thickness of permeable sediments intercepted by the sand pack of the well. This thickness is the sum of all sediments with moderate to high estimated conductivities determined from the geologic and geophysical logs of the well.

[d] Hydraulic test quality criteria:

Excel: High confidence that type curve match is unique. Data are smooth and flow rate well controlled.

Good: Some confidence that curve match is unique. Data are not too "noisy." Well bore storage effects, if present, do not significantly interfere with the curve match. Boundary effects can be separated from properties of the pumped zone.

Fair: Low confidence that curve match is unique. Data are "noisy." Multiple leakiness and other boundary effects tend to obscure the curve match.

Poor: Unique curve match cannot be obtained due to multiple boundaries, well bore storage, uneven flow rate, or equipment problems. Usually, the test is repeated.

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Appendix C

2000 Ground Water Sampling Schedule

Table C-1. 2000 LLNL Livermore Site ground water sampling schedule.

Well number	2000 VOC sampling frequency	Next quarter sample date	Metals, RAD, etc. (1-00)	VOCs
W-001	O	2-01		E601
W-001A	O	4-01		E601
W-002	O	4-01		E601
W-002A	A	1-00		E601
W-004	O	2-01		E601
W-005	A	1-00		E601
W-005A	O	4-01		E601
W-007	E	4-00		E601
W-008	O	1-01	WGMG	E601
W-010A	O	2-01		E601
W-011	A	1-00		E601
W-012	S	1-00		E601
W-017	E	4-00	WGMG	E601
W-017A	E	3-00		E601
W-019	E	4-00		E601
W-101	A	1-00		E601
W-102	O	2-01		E601
W-103	O	4-01		E601
W-104	Q	1-00		E601
W-105	S	1-00		E601
W-106	E	3-00		E601
W-107	O	1-01		E601
W-108	O	3-01		E601
W-110	Q	1-00		E601
W-111	O	2-01		E601
W-113	O	4-01		E601
W-114	S	1-00		E601
W-115	O	3-01		E601
W-116	Q	1-00		E601
W-117	E	4-00		E601
W-118	S	1-00		E601
W-119	Q	1-00	WGMG	E601
W-120	Q	1-00		E601
W-121	Q	1-00	WGMG	E601
W-122	E	1-00		E601
W-123	E	1-00		E601

Table C-1. (Continued)

Well number	2000 VOC sampling frequency	Next quarter sample date	Metals, RAD, etc. (1-00)	VOCs
W-141	O	2-01		E601
W-142	Q	1-00		E601
W-143	O	4-01		E601
W-146	O	4-01		E601
W-147	O	4-01		E601
W-148	O	4-01	WGMG	E601
W-151	Q	1-00	WGMG	E601
W-201	O	4-01		E601
W-202	E	4-00		E601
W-203	E	2-00		E601
W-204	S	1-00	WGMG	E601
W-205	Q	1-00		E601
W-206	Q	1-00		E601
W-207	Q	1-00		E601
W-210	A	3-01	E906	E601
W-212	E	4-00		E601
W-213	B	4-01		E601
W-214	B	2-01		E601
W-217	S	2-00		E601
W-218	Q	1-00		E601
W-219	S	2-00		E601
W-220	A	1-00		E601
W-221	Q	1-00	WGMG	E601
W-222	S	1-00		E601
W-223	A	1-00		E601
W-224	A	1-00		E601
W-225	A	4-00		E601
W-226	E	1-00	WGMG/NPDES	E601
W-251	Q	1-00		E601
W-252	O	2-01		E601
W-253	E	4-00		E601
W-255	A	2-00		E601
W-256	A	1-00		E601
W-257	Q	1-00		E601
W-258	Q	1-00		E601
W-259	Q	1-00		E601

Table C-1. (Continued)

Well number	2000 VOC sampling frequency	Next quarter sample date	Metals, RAD, etc. (1-00)	VOCs
W-260	A	4-00		E601
W-261	E	3-00		E601
W-263	Q	1-00		E601
W-264	O	4-01		E601
W-265	O	3-01		E601
W-267	S	1-00		E601
W-268	Q	1-00		E601
W-269	O	2-01		E601
W-270	A	4-00		E601
W-271	Q	1-00		E601
W-272	S	1-00		E601
W-273	A	4-00		E601
W-274	Q	1-00		E601
W-275	A	4-00		E601
W-276	S	1-00		E601
W-277	A	1-00		E601
W-290	E	4-00		E601
W-291	E	4-00		E601
W-292	O	2-01		E601
W-293	E	2-00		E601
W-294	O	2-01		E601
W-301	O	4-01		E601
W-302	S	1-00		E601
W-303	O	2-01		E601
W-304	O	3-01		E601
W-305	A	4-00	WGMG	E601
W-306	A	1-00	WGMG/NPDES	E601
W-307	S	1-00	WGMG/NPDES	E601
W-308	O	4-01		E601
W-310	E	3-00		E601
W-311	Q	1-00		E601
W-312	O	2-01		E601
W-313	Q	1-00		E601
W-315	Q	1-00		E601
W-316	Q	1-00		E601
W-317	A	4-00		E601

Table C-1. (Continued)

Well number	2000 VOC sampling frequency	Next quarter sample date	Metals, RAD, etc. (1-00)	VOCs
W-318	Q	1-00		E601
W-319	O	4-01		E601
W-320	Y	1-00		E601
W-321	A	4-00		E601
W-322	Q	1-00		E601
W-323	Q	1-00		E601
W-324	E	2-00		E601
W-325	E	4-00		E601
W-353	Q	1-00		E601
W-354	Q	1-00		E601
W-355	Q	1-00		E601
W-356	Q	1-00		E601
W-359	Q	1-00	WGMG	E601
W-360	Q	1-00		E601
W-362	O	3-01		E601
W-363	Q	1-00	WGMG	E601
W-364	Q	1-00		E601
W-365	O	3-01		E601
W-366	O	2-01		E601
W-368	A	1-00		E601
W-369	S	2-00		E601
W-370	A	4-00		E601
W-371	O	3-01		E601
W-372	O	3-01		E601
W-373	O	2-01	WGMG	E601
W-375	Q	1-00		E601
W-376	O	2-01		E601
W-377	O	2-01		E601
W-378	O	4-01		E601
W-379	O	4-01		E601
W-380	E	4-00		E601
W-401	E	2-00		E601
W-402	E	4-00		E601
W-403	E	3-00		E601
W-404	Q	1-00		E601
W-405	Q	1-00		E601

Table C-1. (Continued)

Well number	2000 VOC sampling frequency	Next quarter sample date	Metals, RAD, etc. (1-00)	VOCs
W-406	A	1-00		E601
W-407	Q	1-00		E601
W-409	Q	1-00		E601
W-410	Q	1-00		E601
W-411	Q	1-00		E601
W-412	S	1-00		E601
W-413	A	1-00		E601
W-414	O	3-01		E601
W-416	O	2-01		E601
W-417	O	3-01		E601
W-418	O	2-01		E601
W-419	Q	1-00		E601
W-420	S	2-00		E601
W-421	Q	1-00		E601
W-422	O	3-01		E601
W-423	Q	1-00		E601
W-424	Q	1-00		E601
W-446	O	4-01		E601
W-447	O	4-01		E601
W-448	O	2-01		E601
W-449	O	4-01		E601
W-450	A	1-00		E601
W-451	E	1-00		E601
W-452	E	4-00		E601
W-453	E	3-00		E601
W-454	O	4-01		E601
W-455	E	1-00		E601
W-456	O	3-01		E601
W-458	E	4-00		E601
W-459	O	2-01		E601
W-460	A	1-00		E601
W-461	Q	1-00		E601
W-462	O	3-01		E601
W-463	A	1-00		E601
W-464	Q	1-00		E601
W-481	Q	1-00		E601

Table C-1. (Continued)

Well number	2000 VOC sampling frequency	Next quarter sample date	Metals, RAD, etc. (1-00)	VOCs
W-482	O	2-01		E601
W-483	A	2-00		E601
W-484	E	3-00		E601
W-485	O	2-01		E601
W-486	A	1-00	E906	E601
W-487	A	1-00		E601
W-501	S	2-00		E601
W-502	O	2-01		E601
W-503	O	3-01		E601
W-504	O	4-01		E601
W-505	O	2-01		E601
W-506	S	1-00		E601
W-507	O	2-01		E601
W-509	S	2-00		E601
W-510	E	3-00		E601
W-511	E	1-00		E601
W-512	O	4-01		E601
W-513	E	3-00		E601
W-514	A	3-00		E601
W-515	Q	1-00		E601
W-516	E	4-00		E601
W-517	Q	1-00		E601
W-519	O	4-01		E601
W-521	O	4-01		E601
W-551	S	3-00		E601
W-552	O	2-01		E601
W-553	E	4-00		E601
W-554	O	2-01		E601
W-555	O	2-01		E601
W-556	A	3-00	WGMG	E601
W-557	E	3-00		E601
W-558	Q	1-00		E601
W-559	E	3-00		E601
W-560	O	4-01		E601
W-561	E	2-00		E601
W-562	A	2-00		E601

Table C-1. (Continued)

Well number	2000 VOC sampling frequency	Next quarter sample date	Metals, RAD, etc. (1-00)	VOCs
W-563	E	2-00		E601
W-564	Q	1-00		E601
W-565	E	4-00		E601
W-567	A	4-00		E601
W-568	Q	1-00		E601
W-569	S	1-00		E601
W-570	O	3-01		E601
W-571	O	3-01	WGMG	E601
W-591	E	3-00		E601
W-592	O	3-01		E601
W-593	O	1-01	WGMG	E601
W-594	O	1-01		E601
W-604	A	3-00		E601
W-606	A	4-00		E601
W-607	A	4-00		E601
W-608	E	3-00		E601
W-611	Q	1-00		E601
W-612	O	2-01		E601
W-613	A	1-00		E601
W-615	A	2-00		E601
W-616	A	1-00		E601
W-617	O	3-01		E601
W-618	Q	1-00		E601
W-619	O	3-01		E601
W-622	Q	1-00		E601
W-651	Q	1-00		E601
W-652	O	2-01		E601
W-653	Q	1-00		E601
W-654	O	4-01		E601
W-702	S	3-01		E601
W-705	A	4-01		E601
W-706	O	3-01		E601
W-750	Q	1-00		E601
W-901	A	2-01		E601
W-902	A	3-01		E601
W-905	O	3-01		E601

Table C-1. (Continued)

Well number	2000 VOC sampling frequency	Next quarter sample date	Metals, RAD, etc. (1-00)	VOCs
W-908	A	4-00		E601
W-909	Q	1-00		E601
W-911	Q	1-00		E601
W-912	Q	1-00		E601
W-913	Q	1-00		E601
W-1002	O	3-01		E601
W-1003	O	4-01		E601
W-1005	A	1-00		E601
W-1006	S	4-01		E601
W-1007	A	1-00		E601
W-1008	E	4-00		E601
W-1010	O	4-01		E601
W-1011	O	2-01		E601
W-1012	O	3-01	WGMG	E601
W-1013	O	3-01		E601
W-1014	S	1-00		E601
W-1101	O	2-01		E601
W-1105	O	2-01		E601
W-1106	A	4-00		E601
W-1107	Q	1-00		E601
W-1108	Q	1-00		E601
W-1110	A	1-00		E601
W-1112	Q	1-00		E601
W-1113	A	4-00		E601
W-1117	Q	1-00		E601
W-1118	Q	1-00		E601
W-1201	Q	1-00		E601
W-1202	Q	1-00		E601
W-1203	Q	1-00		E601
W-1204	A	4-00		E601
W-1205	Q	1-00		E601
W-1207	Q	1-00		E601
W-1209	S	2-00		E601
W-1210	O	2-01		E601
W-1212	Q	1-00		E624
W-1214	S	1-00		E601

Table C-1. (Continued)

Well number	2000 VOC sampling frequency	Next quarter sample date	Metals, RAD, etc. (1-00)	VOCs
W-1217	Q	1-00		E601
W-1218	Q	1-00		E601
W-1219	Q	1-00		E601
W-1220	Q	1-00		E601
W-1221	Q	1-00		E601
W-1222	Q	1-00		E601
W-1223	Q	1-00		E601
W-1224	A	3-00		E601
W-1225	Q	1-00		E601
W-1226	A	4-00		E601
W-1227	A	2-00		E601
W-1250	Q	1-00		E601
W-1251	O	4-01		E601
W-1252	Q	1-00		E601
W-1253	Q	1-00		E601
W-1254	O	4-01		E601
W-1255	Q	1-00		E601
W-1304	Q	1-00		E601
W-1311	Q	1-00		E601
W-1401	Q	1-00		E601
W-1402	Q	1-00		E601
W-1403	Q	1-00		E601
W-1404	Q	1-00		E601
W-1405	Q	1-00		E601
W-1406	Q	1-00		E601
W-1407	Q	1-00		E601
W-1408	Q	1-00		E601
W-1410	Q	1-00		E601
W-1411	Q	1-00		E601
W-1412	Q	1-00	E906	E601
W-1413	Q	1-00		E601
W-1414	Q	1-00	E906	E601
W-1415	Q	1-00		E601
W-1416	Q	1-00		E601
W-1417	Q	1-00		E601
W-1419	Q	1-00		E601

Table C-1. (Continued)

Well number	2000 VOC sampling frequency	Next quarter sample date	Metals, RAD, etc. (1-00)	VOCs
W-1420	Q	1-00		E601
W-1421	Q	1-00		E601
W-1423	Q	1-00		E601
W-1424	Q	1-00		E601
W-1425	Q	1-00		E601
W-1426	Q	1-00		E601
W-1427	Q	1-00		E601
W-1428	Q	1-00		E601
W-1501	Q	1-00		E601
W-1502	Q	1-00		E601
W-1505	Q	1-00		E601
W-1506	Q	1-00		E601
W-1507	Q	1-00		E601
W-1508	Q	1-00		E601
W-1509	Q	1-00		E601
W-1511	Q	1-00	E906	E601
W-1512	Q	1-00		E601
W-1516	Q	1-00		E601
W-1517	Q	1-00		E601
W-1518	Q	1-00		E601
W-1519	Q	1-00		E601
W-1520	Q	1-00		E601
W-1522	Q	1-00		E601
W-1523	Q	1-00		E601
W-1550	Q	1-00		E601
W-1553	Q	1-00		E601
W-1601	Q	1-00		E601
W-1602	Q	1-00		E601
W-1603	Q	1-00		E601
W-1604	Q	1-00		E601
TW-11	A	4-00		E601
TW-11A	O	3-01		E601
TW-21	O	2-01		E601
11C1	E	1-00		E601
14A11	E	4-00		E601
14A3	A	4-00		E601

Table C-1. (Continued)

Well number	2000 VOC sampling frequency	Next quarter sample date	Metals, RAD, etc. (1-00)	VOCs
14B1	O	1-01	WGMG	E601
14B4	O	2-01		E601
14C1	E	1-00		E601
14C2	O	4-01		E601
14C3	A	3-00		E601
14H1	E	2-00		E601
18D1	O	2-01		E601
GEW-710	A	4-00		E601
GSW-006	A	2-00	E602	E601
GSW-007	O	4-01		E601
GSW-008	O	2-01		E601
GSW-009	O	3-01		E601
GSW-011	O	4-01	WGMG	E601
GSW-013	O	2-01		E624
GSW-215	Q	1-00		E601
GSW-266	S	1-00		E601
GSW-326	O	1-01		E601
GSW-367	O	4-01		E601
GSW-442	E	4-00		E601
GSW-443	O	4-01		E601
GSW-444	S	1-00		E601

Notes:

O = Odd years.

A = Annual.

S = Semiannual.

Q = Quarterly.

E = Even years.

E601 = EPA Method 601 for purgeable halocarbons.

E602 = EPA Method 602 for aromatic volatile compounds.

E624 = EPA Method 624 for volatile organic compounds (VOCs).

E906 = EPA Method 906 for tritium.

WGMG = Water Guidance and Monitoring Group. This work is related to the environmental surveillance monitoring programs carried out at DOE sites to complement restoration activities.

Appendix D

1999 Drainage Retention Basin Annual Monitoring Program Summary

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1999 Drainage Retention Basin Annual Monitoring Program Summary

This Appendix summarizes the 1999 LLNL Operations and Regulatory Affairs Division routine maintenance activities, maintenance monitoring, and discharge data for the DRB. The DRB is an artificial water body with about 43 acre-ft (approximately 1.4×10^7 gal) capacity that is located in the central portion of the Livermore Site (Fig. D-1). It receives storm water runoff and treated ground water from Livermore Site treatment facilities.

Discharge samples are collected at the first release of the rainy season and in conjunction with at least one additional storm water monitoring event, as requested by the RWQCB. In addition, samples are collected during each dry season release event. Release water samples are collected at sample location CDBX and are compared with the LLNL Arroyo Las Positas outfall samples collected at sample location WPDC (Fig. D-1). Release samples are used to determine compliance with discharge limits established in the CERCLA *Record of Decision for the Lawrence Livermore National Laboratory, Livermore Site* (DOE, 1992) and the *Explanation of Significant Differences for Metals Discharge Limits at the Lawrence Livermore National Laboratory, Livermore Site* (Berg et al., 1997).

Weekly maintenance field monitoring measurements are conducted at sample locations CDBA, CDBC, CDBD, CDBE, CDBF, CDBJ, CDBK, and CDBL (Fig. D-2). Monthly, quarterly, semi-annual and annual maintenance samples are collected at sampling location CDBE (Fig. D-2). These maintenance samples are used for management decisions regarding the DRB. Management action levels (MALs) are specified in the *Drainage Retention Basin Management Plan, Lawrence Livermore National Laboratory* (Limnion Corp., 1991). The MAL is the concentration at which corrective management responses are implemented. In most cases, short-term variations outside the normal range are not significant, and management response is required only if the MAL is substantially exceeded.

Complete analytical results of samples collected within the basin and from releases are reported in the 1999 LLNL Livermore Site Quarterly Self-Monitoring Reports.

D.1. Drainage Retention Basin Maintenance Monitoring

Samples collected during 1999 within the DRB at sample location CDBE occasionally did not meet the MALs for ammonia nitrogen, chemical oxygen demand, dissolved oxygen, lead, nitrate (as nitrogen), dissolved oxygen, pH, specific conductance, temperature, total dissolved solids, total phosphorus (as phosphorus) and turbidity (Table D-1).

Table D-1. Constituents monitored at CDBE exceeding MALs.

Analysis	MAL	Maximum value	Minimum value	Samples not meeting MALs/ samples collected
Ammonia Nitrogen (mg/L)	>0.1	0.22	<0.02	2/12
Chemical Oxygen Demand (mg/L)	>20	46	<20	2/4
Dissolved Oxygen (% saturation)	<80	119	34	34/51
Dissolved Oxygen (mg/L)	<5	13.2	3.2	10/51
Nitrate (as N) (mg/L)	>0.2	2.0	<0.1	11/12
pH (units)	<6.0 and >9.0	9.24	8.24	5/12
Lead (μg/L)	6.4	9.3	<5	1/12
Specific Conductance	900	1210	648	8/12
Temperature (degrees F)	<15 and > 26	25.5	7.6	26/51
Total Dissolved Solids (mg/L)	>360	745	372	12/12
Total Phosphorous (as P) (mg/L)	>0.02	0.21	0.08	12/12
Turbidity (meters)	<0.914	1.19	0.203	48/50

Ammonia exceeded its MAL only twice in 1999. The presence of ammonia in the water indicates that reducing conditions are occurring within the DRB. The dissolved oxygen readings are believed to be low due to the inability of the circulation pumps to supply the oxygen demand occurring in the DRB. The oxygen demand is most likely a result of increasing organic debris as the DRB goes through annual cycles of alga/blooms and receives decaying organic debris during winter storms when nutrients enter the DRB during winter runoffs. Chemical oxygen demand first exceeded the MALs in 1997 and continued to be high throughout 1998 and during the spring and summer quarters of 1999.

Total phosphorous also continued to exceed the MAL throughout 1999. Phosphorous reached a maximum of 0.21 mg/L in May 1999. Though this concentration is still well above MAL of 0.02 mg/L, it is substantially below the maximum 1.9 mg/L concentration in 1998. The reduced concentration of total phosphorus is a result of the LLNL Environmental Restoration Division changing from *JP-7* (a polyphosphate based antiscalant) to *Belsperse 161* for inhibiting scaling in the ground water treatment systems. *Belsperse 161* adds negligible phosphate to the DRB. Nitrate as nitrogen concentrations also continued to exceed the MAL during 1999. Nitrate is introduced into the DRB with winter storm flows and in treated ground water.

Although nutrient levels have been high since 1994, chlorophyll “a”, which indicates the level of alga/growth, remains well below the 10 mg/L MAL, ranging from 2.35 μg/L to 84.6 μg/L. An aquatic system is considered to be eutrophic (well nourished) when chlorophyll “a” levels exceed 10 μg/L. The chlorophyll “a” concentration (and therefore the alga/mass) continues to increase over previous years. The alga/bloom cycle, available nutrients, low dissolved oxygen concentration, high temperature, and high chemical oxygen demand all indicate that the DRB is an aquatic system experiencing stress. However, annual toxicity tests conducted in October 1999 indicated no toxicity for the three species tested (C*eriodaphnia dubia, Pimephales promelas,* and *Selanastrum capricornutum).*

Semiannual and annual maintenance sampling was conducted during April and October 1998. Quarterly sampling was conducted in January, April, July, and October. Results for oil and grease, volatile organic compounds, total organic carbon, gross alpha, gross beta, and tritium all met their MALs. The only organic compounds that were found in samples collected from the DRB in measurable concentrations were benzo(a)pyrene (0.14 µg/L and 0.12 µg/L), bromocil (1.8 µg/L), and diuron (1.8 µg/L and 0.3 µg/L).

In 1997, LLNL began quarterly microbiological monitoring to evaluate the nature and health of the DRB aquatic community as an expression of water quality. LLNL also began semi-annual biological monitoring to evaluate the impact of the operation of the DRB has on surrounding and downstream ecosystems. During 1999, LLNL discontinued the microbiological monitoring due to a lack of resources to collect and analyze samples. Semi-annual biological monitoring continued. Data for the biological monitoring is reported in the LLNL *Site Annual Environmental Report.*

D-2. Drainage Retention Basin Discharge Monitoring

Releases from the DRB occurred continuously from January through the end of June 1999. At the end of June the weir gate was closed and treated water from the ground water treatment facilities accumulated. Two dry season samples were collected. The first sample was collected on June 28 just prior to closing the weir gate. The second sample was collected on August 19 during a brief dry season release. The first wet season release started on October 4. Wet season samples were collected on October 4 and November 8. The November 8 sampling was concurrent with the first storm water sampling of the 1999/2000 wet season.

Flow measurements were not taken during 1999 because of a change in the way water is released from the DRB. The water is now released by raising the weir gate and letting water flow out of a small opening at the bottom instead of lowering the gate and letting the water flow freely over the top. This change was made to enable greater storage capacity by letting the water levels get lower than the gate in the DRB and contain flows from a 25-year storm event. The flow meter at the DRB is designed to monitor open channel flow. When operations changed to releasing the water from the bottom of the weir, closed channel flow resulted. The DRB flow meter is not designed to measure closed channel flow. LLNL is evaluating whether to continue discharge flow monitoring.

Storm water runoff that previously entered the LLNL eastern perimeter drainage channel was re-routed into the DRB. This re-routing from the eastern watershed allowed LLNL to maintain aquatic vegetation, such as red-legged frog habitat, within the eastern perimeter drainage channel and Arroyo Las Positas.

Discharge samples from the DRB exceeded the pH limit of 8.5 units in June (8.82 units) and November (8.52 units) possibly resulting from alga/blooms. Measurements taken at sampling location WPDC were above pH 8.5 in June (8.9) and August (8.72). All other discharge samples complied with discharge limits identified in DOE (1992) and (Berg et al., 1997). Dry season (April 1–November 30) limits were used to evaluate compliance of the June, August, October, and November samples.

Though not regulated, glyphosate (the active ingredient of the herbicides *Round up* and *Rodeo*) was detected for the first time in a sample collected from within the DRB or from a DRB release. The November 8 sample collected from sample location CDBX had a glyphosate concentration of 100 µg/L. The corresponding sample collected from WPDC had a glyphosate concentration of 99 µg/L. Influent samples taken during a storm event show that the glyphosate was washing onto the LLNL site from an upstream source. The concentration of glyphosate in samples collected from the three eastern locations influent to the LLNL site ranged from 95 to 100 µg/L. The glyphosate concentration is well below the 700 µg/L California Maximum Contaminant Level (MCL) for drinking water.

D-3. Future Activities

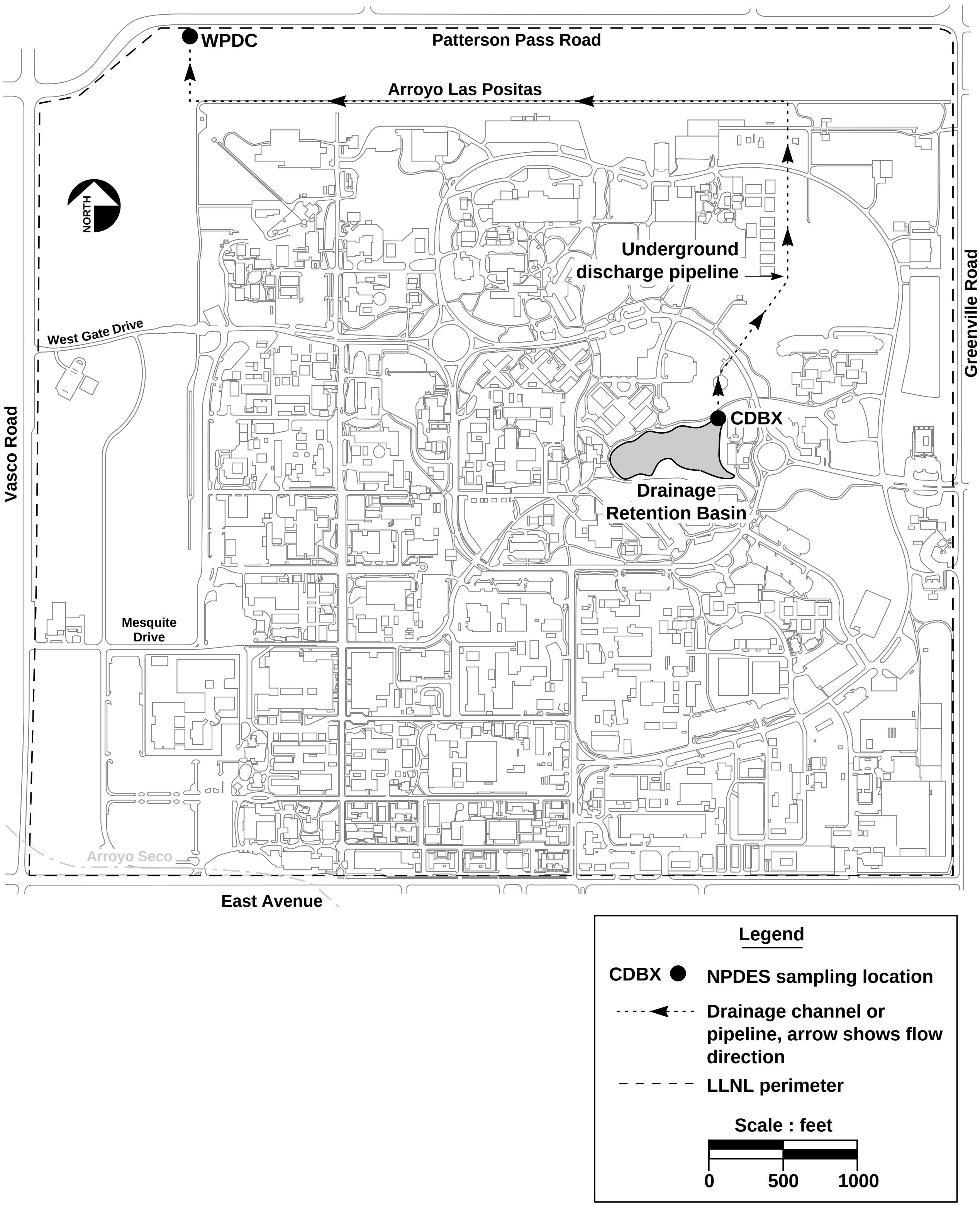
LLNL is in the process of revising the *Drainage Retention Basin Management Plan.* The management plan revision will identify a management strategy to replace the patented Limnion Corporation Nutri-pod nutrient removal system, which LLNL abandoned in 1995. LLNL convened internal stakeholders to identify and prioritize the DRB management action goals and to identify the preferred strategy to meet these goals. An interim revision is scheduled to be completed by September 2000. The interim management plan will be implemented until LLNL can obtain funding to design and implement the retrofits required for the final management strategy.

D-4. References

Berg, L., E. Folsom, M. Dresen, R. Bainer, A. Lamarre (Eds.) (1997), *Explanation of Significant Differences for Metals Discharge Limits at the Lawrence Livermore National Laboratory Livermore Site*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-125927).

The Limnion Corporation (1991), *Drainage Retention Basin Management Plan: Lawrence Livermore National Laboratory,* Concord, Calif.

U.S. Department of Energy (DOE) (1992), *Record of Decision for the Lawrence Livermore National Laboratory, Livermore Site*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-109105).



ERD-LSR-00-0031

Figure D-1. Location of the Drainage Retention Basin showing discharge sampling locations.

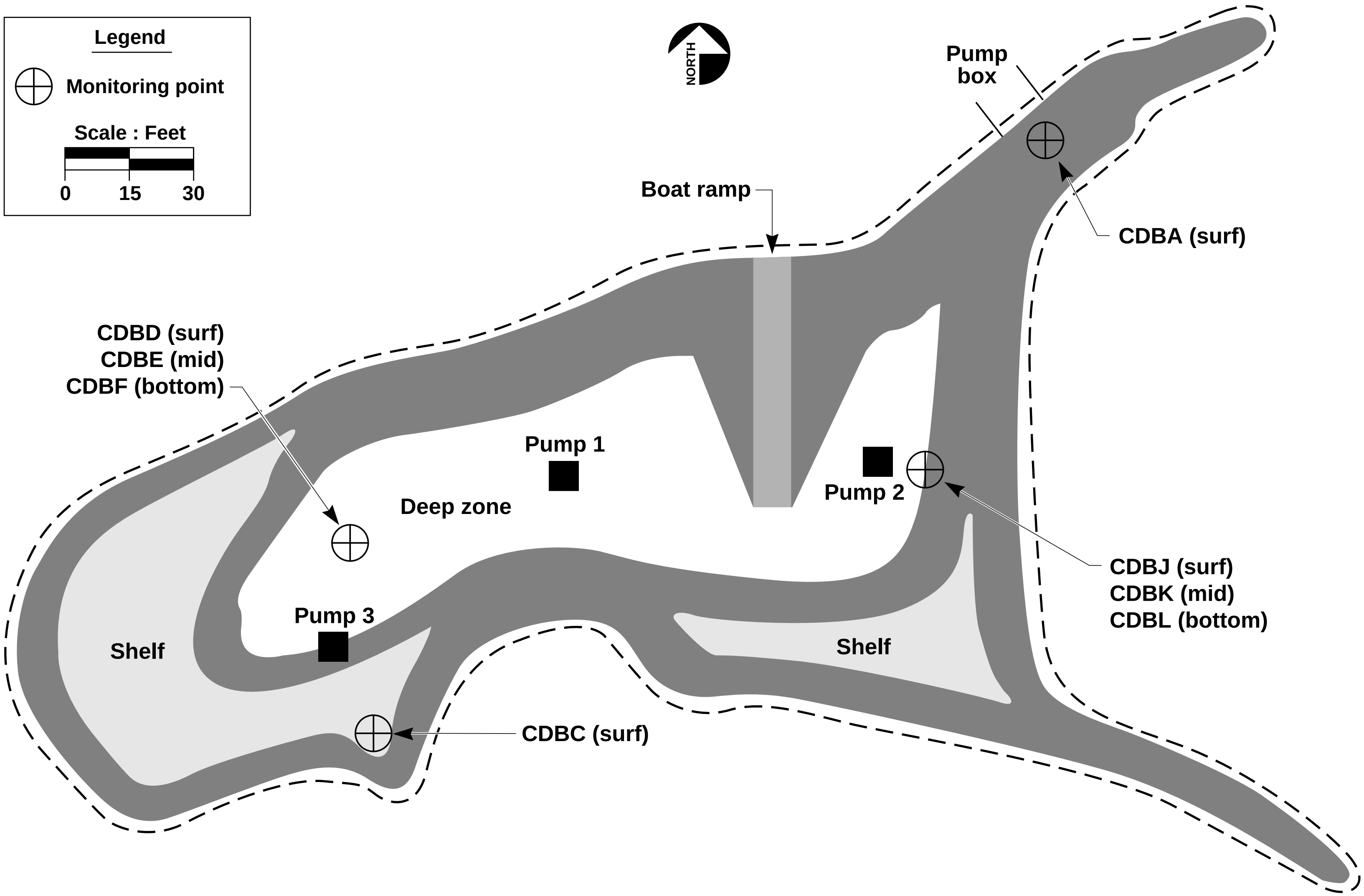


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Figure D-2. Monitoring locations in the Drainage Retention Basin.