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LLNL
Ground Water Project

2000 Annual Report

Technical Editors

G. Aarons*
M. Dresen*
L. Berg
F. Hoffman
G. Howard
R. Bainer
E. Folsom

Contributing Authors

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Environmental Protection Department
Environmental Restoration Program and Division

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Summary

Significant 2000 Livermore Site Ground Water Project (GWP) restoration activities included:

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. Thirteen documents or letter reports were submitted to the regulatory agencies in 2000. These documents consist of the Ground Water Project 1999 Annual Report, six Remedial Project Manager's meeting summaries, four quarterly self-monitoring reports, an Explanation of Significant Differences for changes to the ground water treatment system at Trailer 5475, and an Action Memorandum for a time-critical removal action, which documented the removal of soil containing residual polychlorinated biphenyls (PCBs) in the East Traffic Circle. Three of the U.S. Department of Energy (DOE)/LLNL Remedial Action Implementation Plan milestones were met ahead of schedule, and one was delayed three months with regulatory concurrence to accommodate an adjacent construction project unrelated to the GWP activities.
2. The Community Work Group met twice in 2000 to discuss the DOE budget, Long-Term Stewardship, technology deployments, and progress on the Livermore Site cleanup.
3. DOE/LLNL met two times with members of Tri-Valley Communities Against a Radioactive Environment and their scientific advisor to discuss the Livermore Site GWP activities.
4. The GWP submitted 1,546 ground water samples for analyses that were collected during 973 sampling events.
5. 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 HSU 1B and 2 model was re-calibrated in 2000. The previous model was calibrated to the Treatment Facility A (TFA) and Treatment Facility B (TFB) areas, and the revised model is calibrated for the entire site, including the Treatment Facility D (TFD) and Treatment Facility E (TFE) areas for the first time. 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.
6. DOE/LLNL began using electro-osmosis (EO) in a contaminant source area near the TFD Helipad to extract high concentrations of VOCs from fine-grained sediments in HSU 3. EO induces the migration of ground water containing VOCs to extraction wells for treatment. Model simulations aided in the design of control mechanisms that helped mitigate the adverse effects of electrochemical processes on system performance during EO.
7. The extraction wells operating in 2000, extraction rates, and estimated total VOC mass removed by the Livermore Site ground water and vapor treatment facilities in the TFA, TFB, Treatment Facility C (TFC), TFD, TFE, Treatment Facility G (TFG), Treatment Facility 406 (TF406), Treatment Facility 518 (TF518), and Treatment Facility 5475 (TF5475**)** areas are summarized in Table Summ-1. The 2000 estimated total VOC mass removal rate slightly exceeded that of 1999.

8. Remediation construction activities in 2000 included:
   - Operating a portable treatment unit in the TFD Helipad area.
   - Instrumenting EO cells and conducting field tests in the TF406 and TFD Helipad areas under the Accelerated Site Technology Deployment Initiative for source area cleanup as part of the Phased Source Remediation (PSR) strategy. Preliminary data show an increase in VOC concentrations at the cathode wells during EO operations.
   - Operating a solar treatment unit at TF518 North.
   - Operating a miniature treatment unit at TFD Southshore.
   - Operating a miniature treatment unit at TFE Southwest.
   - Operating an above-ground closed-loop catalytic reductive dehalogenation treatment unit (CRD-2) at Trailer 5475 (TF5475-3).
   - Conducting remediation testing at well W-1550 south of the helipad in the TFD area using a solar treatment unit.
9. Seventeen wells installed in 2000 are listed in Table Summ-2.
10. Five offsite monitor wells located on private property west of TFA were destroyed in November 2000.
11. Ten hydraulic tests conducted in 2000 are listed in Table Summ-3 and Appendix B.
12. Passive soil vapor surveys were conducted in June 2000 within the TF518 source area and around the perimeter of Buildings 419, 511, and 518 to characterize VOCs in near-surface sediments.
13. Savannah River Site characterization and remediation technologies were tested by:
    - Deploying Purge Water Management Systems in two wells at the Livermore Site as an alternative method to reduce sampling purge water.
    - Deploying a Ribbon Non-Aqueous Phase Liquid (NAPL) Sampler in the TF518 area to determine if NAPL was present in the vadose zone. No NAPL was detected.
14. LLNL performed a three-week recovery test on HSU 3B and 4 wells in the southeastern portion of the Livermore Site to evaluate the effects of de-watering from ground water extraction in these two hydrostratigraphic units.
15. DOE/LLNL operated all facilities in the TFA, TFB, TFC, TFD, TFE, TFG, TF406, TF518, and TF5475 areas in 2000. A total of 80 ground water extraction wells operated at 25 separate locations at an average flow rate of 962,000 gal per day. Vapor treatment facilities VTF518 and VTF5475 operated at an average flow of 29,700 standard cubic ft per day. Together, the ground water and vapor treatment facilities removed approximately 269 kg of VOC mass in 2000. Since initial operation, approximately 1,430 million gal of ground water and over 24 million cubic ft of vapor have been treated, removing more than 1,021 kg of VOCs.
16. The area inside the 5 parts per billion (ppb) HSU 1B offsite VOC plume contour is approximately one-third of its size in 1989 when our first ground water treatment facility began operating. The area of the HSU 2 offsite VOC concentrations greater than 5 ppb is 40 percent smaller since 1989, and currently covers an area of about 62 acres.
17. Ground water VOC plumes were aggressively extracted as part of the Engineered Plume Collapse strategy in 2000, resulting in subsequent changes in VOC

concentrations. VOC concentrations in the HSU 1B, 2 and 3A 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. Offsite HSU 1B wells are now below Maximum Contaminant Levels (MCLs) for all compounds of concern with the exception of two wells, W-571 and W-1425, which have maximum tetrachloroethene concentrations of 6.2 and 7.9 ppb, respectively.

Table Summ-1. Extraction wells operating in 2000, 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	245–345 gpm	13.8
TFB	W-357, W-610, W-620, W-621, W-655, W-704, W-1423	76–79 gpm	7.1
TFC	W-701, W-1015, W-1102, W-1103, W-1104, W-1116, W-1213	54–70 gpm	7.9
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-1523, W-1550, W-1551, W-1552, W-1601, W-1602, W-1651, W-1654	101–176 gpm	107
TFE	W-566, W-1109, W-1211, W-1409, W-1418, W-1422, W-1518, W-1520, W-1522	50–53 gpm	23.8
TF406	GSW-445, W-1309, W-1310	19–30 gpm	1.6
TFG	W-1111	9 gpm	0.8
TF5475	W-1302, W-1415, W-1606, W-1608	3 gpm	0.9
VTF5475	SVI-EST-504	20 scfm	102
TF518	W-112, W-1410	5–9 gpm	1.7
VTF518	SVI-518-201, SVI-518-303	0.6 scfm	2.8
2000 Totals		562–774 gpm 20.6 scfm	269.4

Notes:

kg = Kilograms.

gpm = Gallons per minute.

scfm = Standard cubic feet per minute.

Table Summ-2. Livermore Site wells installed in 2000.

Treatment facility area	Well(s)
TFA	W-1614
TFB	None
TFC	None
TFD	W-1650, W-1651, W-1652, W-1653, W-1654, W-1655, W-1656, W-1657
TFE	None
TF406	W-1613
TFG	None
TF518	W-1615
TF5475	W-1605, W-1606, W-1607, W-1608, W-1609, W-1610

Table Summ-3. Wells in which hydraulic tests were conducted in 2000.

Treatment facility area	Well(s)
TFA	W-1614
TFB	None
TFC	None
TFD	W-1601, W-1602, W-1654, W-1655
TFE	W-1518, W-1520, W-1522
TF406	W-1515
TFG	None
TF518	None
TF5475	W-1610

1. Introduction

This report summarizes the Lawrence Livermore National Laboratory (LLNL) Livermore Site Ground Water Project (GWP) activities for the year 2000 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 2000 GWP quarterly self-monitoring reports (Bainer and Joma, 2000a; Bainer and Abbott, 2000a, 2000b, 2001) were issued separately.

Figure 1 shows 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 drilled or sealed in 2000 are shown in larger type.

Appendices A through D present Well Construction and Closure Data, Hydraulic Test Results, the 2001 Ground Water Sampling Schedule, and the 2000 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 2000, 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 Ground Water Project 1999 Annual Report (Aarons et al., 2000) on schedule on March 31, 2000. DOE/LLNL also issued six final Remedial Project Managers' (RPMs') meeting summaries. Quarterly self-monitoring data were reported in letter reports (Bainer and Joma, 2000a; Bainer and Abbott, 2000a, 2000b, 2001).

An Explanation of Significant Differences was issued on February 28, 2000 that described a change to the ground water treatment system at Trailer 5475 (T5475) to allow ground water containing both VOCs and tritium above their Maximum Contaminant Levels (MCLs) to pass through an aboveground facility to treat VOCs (Berg, 2000). Treated water still containing tritium is subsequently recharged back into the same hydrostratigraphic unit (HSU) via two adjacent recharge wells.

DOE/LLNL also issued an Action Memorandum on March 6, 2000 for a time-critical removal action that documented the removal of soil containing residual polychlorinated biphenyls (PCBs) from the East Traffic Circle (Joma, 2000).

2.2. Milestones and Activities

Table 1 presents the 2000 Remedial Action Implementation Plan (RAIP) milestones (Table 5 in Dresen et al., 1993) for the Livermore Site. Three milestones were completed ahead of schedule, and one was delayed three months with regulatory concurrence to accommodate an adjacent construction project unrelated to GWP activities.

Environmental Restoration activities in 2000 also included:

- Continuing to implement Engineered Plume Collapse (EPC) to accelerate mass removal and cleanup at the Livermore Site. EPC incorporates hydrostratigraphic unit analysis, smart pump and treat, source isolation, and treatment of VOCs in fine-grained sediments.
- Deploying electro-osmosis (EO) as part of the Accelerated Site Technology Deployment Initiative (McNab and Ruiz, 1999). EO and Portable Treatment Unit 10 (PTU10) were deployed in the Treatment Facility D (TFD) Helipad area for source area cleanup as part of the Phased Source Remediation (PSR) strategy.
- Preparing data and graphics for DOE's Long-Term Stewardship document.
- Filling in a sinkhole around an abandoned well south of LLNL on Sandia National Laboratories' property.
- Receiving San Francisco Regional Water Quality Control Board (RWQCB) approval to reduce ground water monitoring of the residual fuel hydrocarbons at TFF (Bainer and Joma, 2000b).
- Working with consultants to review proposed modifications to the DRB to support a shallow, vegetated ecological system.
- Investigating and analyzing data associated with recently discovered high VOC concentrations in a perched water-bearing zone in the Building 518 area.
- Conducting Gore-Sorber™ studies in the Building 419, 511, and 518 areas to identify potential source areas.
- Arranging for the Savannah River Site to deploy their Purge Water Management System in two wells on the Livermore Site as another method to reduce purge water when sampling monitor wells.
- Arranging for the Savannah River Site to deploy their Ribbon Non-Aqueous Phase Liquid (NAPL) Sampler in the Treatment Facility 518 (TF518) area to determine if dense NAPL was present. No NAPL was detected.
- Preparing a Ground Water Initiative proposal for DOE requesting additional funds from Congress to accelerate treatment facility buildout and the start of Long-Term Stewardship. No decision has been made on this funding request.
- Proposing a change to postpone the Treatment Facility D Northwest Pipeline milestone with a higher priority location on the south side of the DRB (TFD Marina location). This change will be documented in an updated Consensus Statement in 2001.
- Receiving RWQCB approval to discharge water from well W-408 along the Treatment Facility A (TFA) West pipeline directly into Arroyo Seco to free up capacity on the pipeline (Chou, 2000a).
- Receiving RWQCB approval to discharge a portion of TFA treated water directly into Arroyo Seco to help manage the Recharge Basin (Chou, 2000b).
- Working with an LLNL wildlife biologist to manage the bullfrog population in the DRB.

- Participating at the Agency for Toxic Substances Disease Registry Site Team meetings.
- Conducing a design safety review for the second catalytic reductive dehalogenation (CRD) unit.
- Destroying five offsite wells on property north of East Avenue, south of Arroyo Seco, and west of Vasco Road to accommodate a new housing development.

2.3. Community Relations

The Community Work Group (CWG) met twice in 2000 to discuss the DOE budget, Long-Term Stewardship, technology deployments, and progress of the Livermore Site cleanup. Correspondence and communication continued with CWG members throughout the year. DOE/LLNL met twice 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 Technical Assistance Grant.

Other Livermore Site community relations activities in 2000 included communications and meetings with neighbors; local, regional, and national interest groups; other community organizations; public presentations including those to local Realtors; 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 questions were addressed via electronic mail, and documents, letters, and public notices were posted on a public website at www-envirinfo.llnl.gov.

3. Field Investigations

3.1. Ground Water Sampling

In 2000, the GWP collected 1,546 water samples during 973 sampling events. The samples were analyzed for VOCs, FHCs, PCBs, metals, radionuclides, or combinations of these analytes depending on the contaminants 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. After 18 months, algorithm logic and input from the Subproject Leaders are used to determine the sampling frequency.

Sampling methods for the 1,546 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 2000 were:

- Three volume pre-sample purge (three casing volumes removed by electric submersible pump prior to sampling): 272 events.
- Low-volume pre-sample purge (less than one casing volume removed by electric submersible pump prior to sampling): 125 events.
- Specific-Depth Grab Sampling (sample collected from a specific point within the screened interval with an EasyPump): 428 events.
- Other (grab samples with bailer, grab samples with electronic submersible, etc.): 148 events.

Wells identified as "Guard Wells" as specified in the Compliance Monitoring Plan (Nichols et al., 1996) are sampled quarterly using a three casing volume pre-sample purge method. All other sampling methods are determined by the Hydrogeology Group and Subproject Leaders. The sampling schedule for 2001 is presented in Appendix C.

LLNL utilized a cost-effective sampling device developed at LLNL (EasyPump) to replace existing higher cost sampling devices when they failed and wherever its use was deemed appropriate. This year at LLNL, the EasyPump was used to collect 428 samples (43% of the total number of sampling events). The use of this device saved several thousand dollars per well in pump replacement costs and produced no wastewater for treatment and disposal. If three volume pre-sample purge sampling was used at these 400 locations, approximately 40,000 gallons of purge water would have been produced. The Purge Water Management System is being used in two locations to also minimize waste water.

3.2. Source Investigations

Source investigations conducted in 2000 at Buildings 419/511 and TF518 are discussed below.

3.2.1. Buildings 419/511

A passive soil vapor survey using Gore-Sorber™ modules was conducted in June 2000 in the Building 419/511 (B419/511) area to screen for near-surface VOC sources around the perimeter of the buildings. Forty Gore-Sorber™ modules were deployed to depths of approximately 3 ft at various locations adjacent to both buildings. Results from this study indicate there may be three separate sources of VOCs in near-surface sediments in the vicinity of these two buildings: (1) a trichloroethene (TCE) source area immediately north of B419, (2) a TCE source area north of B511, and (3) a tetrachloroethene (PCE) source area along the east side of B511.

3.2.2. TF518

A passive Gore-Sorber™ soil vapor survey was also conducted in the TF518 source area in June 2000. Thirty Gore-Sorber™ modules were deployed to a depth of about 3 feet in a 40 ft × 110 ft grid area west of Vapor Treatment Facility 518 (VTF518) to screen for VOCs in near-surface sediments. Results from this study indicated that VOC concentrations were three orders of magnitude lower near the vapor extraction wells compared to those at the westernmost perimeter of the surveyed area, demonstrating the effectiveness of source area vapor extraction wells SVE-518-303 and SVE-518-101. The results of this study were used to locate additional vadose zone wells W-1615 and W-1616, west of the current vapor monitoring well positions.

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 2000, we further re-calibrated our three-dimensional (3-D) ground water models for the Livermore Site, and continued to evaluate the use of innovative technologies for source area remediation. Development of the hydrostratigraphic units (HSUs) 1B/2 and EO models in 2000 are described below.

4.1. HSU 1B/2 Model

In 2000, DOE/LLNL continued to use the 3-D ground water flow and contaminant transport model of HSUs 1B/2 for remediation system performance evaluation and optimization. The HSU 1B/2 model was used primarily to evaluate PCE and TCE transport for the TFA and Treatment Facility B (TFB) areas. The model proved useful during 2000 as a decision support tool, and was used by task leaders, hydrogeologists and engineers to:

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

In December 2000, the HSU 1B/2 model was re-calibrated. The previous model was calibrated to the TFA and TFB areas; however, the revised model is calibrated for the entire site. This revision included calibrating the model for the TFD and Treatment Facility (TFE) areas for the first time. Revisions to the model include:

- Increased vertical and horizontal resolution to improve model accuracy for resolving drawdown and contaminant transport.
- Modified areal recharge to conform with measured rainfall data rather than the average annual rainfall.
- Refined the hydraulic conductivity distribution to more accurately represent the site hydrogeology.
- Updated and added detail to model boundaries to more accurately represent variable hydrogeological conditions outside the model domain.
- Developed a more accurate initial contaminant plume distribution based on 1992 data.
- Updated well pumping histories for all onsite and known offsite wells.

These revisions improved simulations of LLNL remediation history. Figures 2 and 3 compare model results for PCE to the measured data for 2000. Overall, the match between the simulated and measured plumes shows good agreement. The primary difference is that the distal end of the offsite HSU 2 PCE plume did not detach as seen in the measured data. This level of variability between the model and measured data is most likely attributed to hydrogeological heterogeneity not included in the model, variability in measured data, and assumptions used in contouring measured data. The measured plumes show a slightly faster cleanup rate than the model results, indicating slightly conservative model assumptions. Further refinement of the model and analysis of the measured data can further minimize these differences. The good agreement between the modeled and measured PCE distributions indicates that the overall conceptual model is sound.

4.2. Electro-Osmosis Modeling

In 2000, DOE/LLNL continued to evaluate the effectiveness of EO to remediate areas with high VOC concentrations in fine-grained sediments. EO applies an electric field in the subsurface by placing electrodes within ground water wells. This electric field induces migration of ground water containing VOCs; however, the resulting electrolysis reactions also affect the pH in soil and ground water. To evaluate these effects, DOE/LLNL is 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. In 2000, model results were used to aid in the design of control mechanisms that will mitigate the adverse effects of these geochemical processes on system performance.

A series of detailed flow and transport models were developed in 2000 for the electro-osmotic remediation pilot test sites located at TFD Helipad and T5475. The models were developed using the FlexPDE code. The models were calibrated to a series of hydraulic tests that were conducted in the TFD Helipad and T5475 areas. The models were used to calculate reasonable extraction/injection rates from wells that were used in the design of the EO remediation systems and for the selection of the down-hole pumps.

In 2000, work began on developing a mathematical model that can simulate flow and transport that couples the processes of ground water flow and electro-osmotic flow. The model is intended to aid in the evaluation of field data from the electro-osmotic remediation pilot test sites to determine whether EO remediation can effectively reduce contamination in fine-grained sediments that are not significantly impacted by ground water extraction.

5. Annual Summary of Remedial Action Program

This section summarizes activities performed during 2000 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 2000, DOE/LLNL operated ground water treatment facilities in the TFA, TFB, Treatment Facility C (TFC), TFD, TFE, Treatment Facility (TFG), TF406, TF518, and Treatment Facility 5475 (TF5475) areas. A total of 80 ground water extraction wells supplied water to 25 separate treatment facilities at a combined average flow rate of about 670 gallons per minute (gpm). In 2000, these facilities treated about 308 million gal of ground water and removed about 270 kg of VOCs (Table 2). Since initial operation, approximately 1,430 million gal of ground water have been treated, and about 675 kg of VOCs have been removed from the subsurface (Fig. 4 and Table 3). In addition, DOE/LLNL operated two vapor treatment facilities, VTF518 and VTF5475. A total of 3 vapor extraction wells at two separate locations operated at a combined average flow rate of 20.6 standard cubic ft per minute (scfm). In 2000, these facilities treated over 7.6 million standard cubic ft (scf) of vapor and removed about 103 kg of VOCs (Table 2). Since initial operation, the two vapor treatment facilities combined have treated over 24 million scf of vapor and removed over 347 kg of VOCs (Fig. 4 and Table 3). The combined ground water and vapor treatment systems have removed over 1,021 kg of VOCs from the subsurface.

The performance of the treatment facilities is evaluated from several different data sets. Figures 5 through 10, show the hydraulic capture areas in HSUs 1B, 2, 3A, 3B, 4 and 5, respectively, based on November 2000 ground water elevation data. Figures 11 through 16 show fourth quarter total VOC isoconcentrations in the same six HSUs. Figures 17 through 37 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 2000. 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).
- Catalytic Reductive Dehalogenation treatment units (CRDs).

The performance of each Livermore Site treatment facility is discussed in the following sections.

5.1. Treatment Facility A

Two treatment facilities, TFA and TFA East (TFA-E), located in the southwestern portion of the Livermore Site (Figs. 1, 17, and 18) operated in 2000 in the TFA area. TFA is located near the intersection of Vasco Road and East Avenue (Figs. 1 and 17). TFA-E is located along West Perimeter Drive in the southwestern corner of LLNL (Figs. 1 and 18).

In 2000, 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-522, 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 air is then vented to the atmosphere. This new system is permitted by the 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. 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 17). DOE/LLNL received permission from the RWQCB to discharge up to 100 gpm from TFA to Arroyo Seco to facilitate Recharge Basin maintenance. This option has not been exercised yet. TFA complied with all permits throughout 2000.

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.

TFA-E began operation in August 1999. TFA-E (STU7) uses a solar-powered pump to extract ground water from one HSU 2 well (W-254). The ground water is treated by a series of aqueous-phase GAC canisters. Treated ground water from TFA-E is discharged to Arroyo Seco (Fig. 18). TFA-E complied with all permits throughout 2000.

5.1.1. Performance Summary

During 2000, the combined TFA facilities operated at an average flow rate of 320 gpm and treated over 141 million gal of ground water containing an estimated 13.8 kg of VOCs (Table 2). Since system startup in 1989, TFA has treated over 793 million gal of ground water and has removed about 137 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. 5, 6, and 7) and the total VOC isoconcentration maps (Figs. 11, 12, and 13) for each HSU. Offsite HSU 1B extraction well W-408 continues to be pumped to ensure hydraulic control of the HSU 1B VOC plume at well W-1425 where the PCE concentration was 6 parts per billion (ppb) in August 2000. Offsite HSU 3B well W-506 is hydraulically influenced by ground water extraction from well W-712. Pumping from offsite HSU 2 extraction wells W-109 and W-904 was maintained at about 30 gallons per minute (gpm) each to ensure hydraulic control of the HSU 2 VOC plume at well W-404 where the PCE concentration was 17 ppb in July 2000.

5.1.2. Field Activities

In 2000, monitor well W-1614 was completed in HSU 1B in the TFA north pipeline area, and a one-hour drawdown test was conducted. Well construction details are provided in Table A-1 of Appendix A, and the results of the hydraulic test are presented in Appendix B.

Five offsite monitor wells (W-456, W-460, W-1005, W-1006, and W-1007) were destroyed in November 2000 because the property owner is preparing for a housing development. These wells were located on private property northwest of the intersection of East Avenue and Vasco Road. Well destruction details are provided in Table A-2 of Appendix A.

5.2. Treatment Facility B

One treatment facility operated in 2000 in the TFB area, located in the west-central portion of the Livermore Site (Figs. 1 and 19). TFB is located north of Mesquite Way near Vasco Road. In 2000, 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). Extraction from well W-655 was discontinued in January when its concentrations remained below MCLs for all contaminants of concern.

TFB treats 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 wet season (December 1–March 31) based on the current metals discharge requirements (Berg et al., 1997). 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 (Figs. 1 and 19). On August 2, 2000, a control and interlock system failed that allowed the discharge of about 39,000 gallons of ground water to the drainage ditch while the air stripper was offline. The RWQCB was notified on August 3, 2000 via telephone. After repairs, TFB was reactivated on October 10, 2000. Other than this incident, TFB was in compliance with all permits during 2000.

From 1990 through September 1995, TFB treated ground water extracted from wells W-357 and W-704. The TFB North Pipeline, TFB East 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 2000, TFB operated at an average flow rate of 71 gpm to treat over 27 million gal of ground water containing an estimated 7.1 kg of VOCs (Table 2). Since system startup in 1990, TFB has treated about 141 million gal of ground water and removed about 45 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. 5 and 6) and the total VOC isoconcentration maps (Figs. 11 and 12) for each HSU.

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 2000.

5.3. Treatment Facility C

Two treatment facilities, TFC and TFC Southeast (TFC-SE), operated in 2000 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. 20). In 2000, TFC treated ground water from six HSU 1B extraction wells (W-701, W-1015, W-1102, W-1103, W-1104, and W-1116). TFC-SE (PTU1) is located near the intersection of Avenue A and Sixth Street (Figs. 1 and 21). 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. Hexavalent chromium in the ground water is treated using ion-exchange. TFC and TFC-SE require treatment for hexavalent chromium only during the wet season (December 1–March 31) under the current metals discharge requirements (Berg et al., 1997).

Treated ground water from TFC is discharged into Arroyo Las Positas (Fig. 20). 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 (Fig. 21). TFC and TFC-SE complied with all permits throughout 2000.

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 2000, the combined TFC area facilities operated at an average flow rate of 56 gpm and treated almost 25 million gal of ground water containing an estimated 7.9 kg of VOCs (Table 2). Since system start up in 1993, the combined TFC area facilities have treated over 108 million gal of ground water and removed about 40 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. 5) and the total VOC isoconcentration map (Fig. 11).

5.3.2. Field Activities

No new boreholes or wells were drilled and no hydraulic tests were conducted in the TFC area during 2000.

5.4. Treatment Facility D

Eight treatment facilities operated in 2000 in the TFD area, located in the northeastern portion of the Livermore Site, near the Drainage Retention Basin (DRB) (Figs. 1 and 22–30). These facilities are TFD, TFD West (TFD-W), TFD East (TFD-E), TFD Southeast (TFD-SE), TFD South (TFD-S), TFD Southshore (TFD-SS), PTU10, and STU10. The latter two are discussed further in Section 5.4.3. 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. 22). TFD-W located south of North Inner Loop Road (Fig. 23), treats ground water from two HSU 2 extraction wells (W-1215 and W-1216). TFD-E is located east of the DRB (Fig. 24). 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-SE is located north of Avenue K and east of Inner Loop Road (Fig. 25). TFD-SE treats ground water from two extraction wells, HSU 2 well W-1308 and HSU 4 well W-314. TFD-S is located south of Inner Loop Road and the DRB (Fig. 26). 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.

One new treatment facility, TFD-SS, was activated June 30, 2000. With regulatory concurrence, this milestone was delayed three months due to an adjacent drainage and parking lot construction project. TFD-SS is located south of the DRB (Fig. 27). TFD-SS treats ground water from three extraction wells, including HSU 2 well W-1602, HSU 3B well W-1601, and HSU 4 well W-1523.

TFD, TFD-W, TFD-E, TFD-SE, TFD-S, and TFD-SS process ground water for VOC treatment using air stripping. The effluent air from the air strippers is treated with 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. 22 and 24). Treated ground water from TFD-W is discharged into a nearby underground storm sewer that also empties into Arroyo Las Positas (Fig. 23). Treated ground water from TFD-SE is discharged into a lined drainage ditch that flows west-northwest into the DRB or an unlined drainage ditch to the east that eventually intersects the lined ditch that flows into the DRB (Fig. 25). Treated ground water from TFD-S is discharged into a drainage ditch that flows north into the DRB (Fig. 26). Treated ground water from TFD-SS is discharged into an underground storm sewer that flows north into the DRB (Fig. 27). All TFD facilities were in compliance with all permits throughout 2000. The discharge pump at TFD failed on May 22, 2000. The discharge pump was repaired and the system resumed operation on June 1, 2000.

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. TFD-W (PTU6) was activated in April 1997, TFD-E (PTU8) began operating in September 1997, TFD-SE (PTU11) was activated in March 1998, TFD-S (PTU2) was activated in June 1999, and TFD-SS (MTU-2) was activated in June 2000.

5.4.1. Performance Summary

During 2000, the TFD area facilities operated at an average flow rate of 150 gpm to treat over 66 million gal of ground water containing an estimated 107 kg of VOCs (Table 2). Since system start up in 1994, the combined TFD facilities have treated over 250 million gal of ground water and removed about 342 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. 6, 7, 8, 9, and 10) and the total VOC isoconcentration maps (Figs. 12, 13, 14, 15, and 16) 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 2002 and 2003, respectively.

5.4.2. Field Activities

Eight wells were installed in the TFD area during 2000. Wells W-1650, W-1652, W-1653, W-1655, W-1656, and W-1657 were completed as anode/injection wells, and wells W-1651, and W-1654 were completed as cathode/extraction wells along with W-1552 for the TFD Helipad area EO pilot study (Section 5.4.3). Construction details for the new TFD area wells are provided in Table A-1 of Appendix A.

In 2000, one-hour drawdown tests were conducted on TFD area extraction wells W-1601, W-1602, and W-1655, and on injection well W-1654. Results of the hydraulic tests are presented in Appendix B.

TFD-W extraction well W-1216 (HSU 2) was redeveloped in December 2000. As a result, the drawdown in W-1216 decreased from 48 ft to 10 ft using an 8 gpm flow rate; therefore, the specific capacity of the well was increased by five-fold.

5.4.3. Field-Scale Pilot Test

During 2000, ERD began a pilot test to evaluate the potential of EO as a means of expediting removal of VOCs from source areas characterized by high VOC concentrations in low permeability sediments. An EO system was installed near the Helipad VOC source area during the spring and summer of 2000. The deployment site is characterized by relatively high VOC concentrations (5 to 10 parts per million [ppm], primarily TCE) in low-permeability, fine-grained sediments (average flow rates in wells in the area are less than 0.5 gal/min). The EO system consists of a grid of nine electrode-bearing ground water wells, with screened intervals for the wells ranging from 95 to 120 ft below ground surface. Ground water impacted by TCE and other VOCs is drawn by an induced direct current from the anode wells (positively charged) to the center array of wells holding negatively-charged electrodes (cathodes) by EO and hydraulic pumping (Fig. 29A). Water is circulated between the electrodes and buffering tanks at the surface to maintain pH neutrality during electrolysis reactions. A schematic diagram of an EO configuration is shown in Figure 29B. pH control is necessary to prevent the acidification of the sediments near the anodes (with consequent reduction in electro-osmotic conductivity) as well as formation of mineral deposits at the cathodes. Extracted ground water is treated in PTU10 that removes VOCs by air-stripping followed by GAC prior to venting to the atmosphere. Treated water is returned to the subsurface by injection at the anode wells to facilitate water management. Support equipment includes submersible pumps, water level sensors, and flow meters for each well, along with a manifold assembly that directs the flow of water between extraction wells, pH adjustment units for the cathode and anode arrays, the ground water treatment facility, and injection wells. Preliminary data shows an increase in VOC concentrations at the cathode wells during EO operation.

Following successful treatability tests conducted in 1997 and 1998, STU1 operated at well W-361 (HSU 3A) located on the south shore of the DRB (Fig. 1) in January 2000 only. Well W-1603 was installed in 1999 to replace well W-361 for future extraction.

When not connected to the EO pilot test, PTU10, located northeast of the DRB at the TFD Helipad area continued to operate at wells W-1551 (HSU 3A/3B) and W-1552 (HSU 3A/3B) in 2000 to expedite VOC mass removal and source area cleanup (Fig. 28). PTU10 operated at a flow rate of about 4.2 gpm, and treated about 1.7 million gallons of ground water containing an estimated 14.9 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 4.

STU10 operated at well W-1550 (HSU 3A/3B) for the remainder of 2000. STU10 is located in a parking lot east of the DRB and discharges treated ground water into the DRB via an underground storm sewer (Fig. 30). STU10 operated at a flow rate of about 2.9 gpm, and treated about 0.1 million gallons of ground water containing an estimated 1.2 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 4.

5.5. Treatment Facility E

Three treatment facilities, TFE East (TFE-E), TFE Northwest (TFE-NW), and TFE Southwest (TFE-SW) operated in the TFE area, located in the east-central portion of the Livermore Site (Figs. 1, 31, 32, and 33). TFE-E is located south of the DRB and Inner Loop Road (Fig. 31) and treats ground water from two extraction wells, W-1109 (HSU 2) and W-566 (HSU 5). TFE-NW is located south of the South Inner Loop Road, immediately west of Southgate Drive (Fig. 32). TFE-NW treats ground water from two extraction wells, W-1409 (HSU 2) and W-1211 (HSU 4).

One new treatment facility, TFE Southwest (TFE-SW), was activated June 27, 2000, ahead of the June 30, 2000 RAIP milestone date. TFE-SW is located south of the DRB and Inner Loop Road (Fig. 33) and uses an MTU to treat VOCs in ground water via an air stripper. The effluent air is treated with GAC to remove VOCs prior to venting to the atmosphere. TFE-SW treats ground water from three extraction wells (HSU-2 well W-1518, HSU-3B well W-1522, and HSU-4 well W-1520). Treated ground water from TFE-SW is discharged into a drainage ditch that flows north into the DRB (Fig. 33).

TFE-E and TFE-NW use PTUs to treat VOCs in ground water via an air stripper. The effluent air is treated with 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. 31). Treated ground water from TFE-NW is discharged into a storm drain that flows north into Arroyo Las Positas (Fig. 32). TFE-E, TFE-NW, and TFE-SW were in compliance with all permits throughout 2000.

TFE-E (PTU3) began operation in November 1996, and the location TFE-NW (PTU9) was activated in June 1998.

5.5.1. Performance Summary

During 2000, the TFE area facilities operated at an average flow rate of 63 gpm and treated over 28 million gal of ground water containing an estimated 23.8 kg of VOCs (Table 2). Since system startup in 1996, the combined TFE facilities have treated over 81 million gal of ground water and removed about 95 kg of VOC mass from the subsurface (Table 3).

The TFE-E, TFE-NW, and TFE-SW extraction wells hydraulically contain some portions of VOC plumes in HSUs 2, 3A, 3B, 4, and 5 based on the capture zone analysis shown on the ground water elevation contour maps (Figs. 6, 7, 8, 9, and 10) and the total VOC isoconcentration maps (Figs. 12, 13, 14, 15, and 16) for each HSU. The VOC plumes in HSUs 3, 4, and 5 in the western and southern portion of the TFE area should be hydraulically controlled once the TFE-Southeast, and TFE-West treatment facilities begin operating in 2001.

5.5.2. Field Activities

No new wells were installed in the TFE area during 2000. No hydraulic tests were conducted in the TFE area during 2000.

A three-week recovery test was conducted on HSU 3B and 4 wells in the southeastern portion of the Livermore Site to evaluate the effects of de-watering by extraction in these two HSUs. Between December 20, 2000 and January 3, 2001, the pumps in HSU 3B and 4 extraction wells at TFD-S, PTU4 (Section 5.5.3), and TFE-NW were shut off, and the rate of ground water level recovery was observed in surrounding HSU 3B and 4 extraction and monitor wells. This recovery test will help evaluate whether we can manage HSU 3B and 4 water levels in key extraction wells by reducing pumping elsewhere in the well field.

5.5.3. Field-Scale Pilot Tests

During 2000, PTU4 continued to treat water from 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. The facility was in compliance with all permits throughout 2000. Wells W-1418 and W-1422 pumped at a combined flow rate of about 25 gpm, and PTU4 treated about 5.9 million gal of ground water containing an estimated 8.7 kg of VOCs. These data are included in the TFE volume and mass data presented in Tables 2 and 3, and total mass removed data in Figure 4.

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 (Figs. 1 and 34). 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 with GAC to remove VOCs prior to venting to the atmosphere. In May 1999, the PTU at TFG-1 was replaced by GAC treatment unit 1 (GTU1). Three 450-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 influent concentrations have consistently been below the 22 ppb discharge limit since March 1997.

Treated ground water from TFG-1 is discharged to a storm drain located about 50 ft north of TFG-1 (Fig. 34) that empties into Arroyo Seco. TFG-1 was in compliance with all permits in 2000.

5.6.1. Performance Summary

During 2000, TFG-1 operated at an average flow rate of 8.5 gpm, treating over 3.9 million gal of ground water containing an estimated 0.8 kg of VOCs (Table 2). Since system startup in 1996, TFG-1 has treated almost 14 million gal of ground water and removed about 2.7 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. 6) and the total VOC isoconcentration map for HSU 2 (Fig. 12).

5.6.2. Field Activities

No new boreholes or wells were drilled and no hydraulic tests were conducted in the TFG area during 2000.

5.7. Treatment Facility 406

TF406 is located in the south-central portion of the Livermore Site, east of Southgate Drive near East Avenue (Fig. 35). In 2000, TF406 treated ground water from three extraction wells, GSW-445 (HSU 4), W-1309 (HSU 4) and W-1310 (HSU 5). Pumping was temporarily discontinued in September 2000 from HSU 4 extraction wells GSW-445 and W-1309 to increase water levels in HSU 4 extraction well W-1410 at TF518-North (See Section 5.9). Since TCE concentrations in HSU 4 well W-1309 rebounded from 5 ppb to 25 ppb during this time, we plan to resume pumping in 2001. Well GSW-445 TCE concentrations remained below the MCL of 5 ppb through December 2000.

TF406 uses PTU5 to process ground water for VOC treatment using an air stripper. GAC removes VOCs from effluent air prior to discharge to the atmosphere. All treated ground water is discharged to a storm drain that flows to Arroyo Las Positas (Fig. 35). TF406 was in compliance with all permits throughout 2000.

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 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 2000 to remediate FHCs in HSUs 3A and 3B. Active ground water extraction and treatment for residual dissolved FHCs at former Treatment Facility F was discontinued in 1996 with regulatory agency concurrence (RWQCB, 1996).

5.7.1. Performance Summary

During 2000, TF406 operated at an average flow rate of 25 gpm, treating over 12 million gal of ground water containing an estimated 1.6 kg of VOCs (Table 2). Since system startup in 1996, TF406 has treated over 34 million gal of ground water and removed about 5.8 kg of VOC mass from the subsurface (Table 3).

The TF406 and TF518-North (see Section 5.9) 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. 9 and 10) and the total VOC isoconcentration maps (Figs. 15 and 16) for each HSU. The VOC plumes in HSUs 3A, 4, and 5 should be hydraulically controlled once treatment facility TF406-Northwest is installed in 2002.

5.7.2. Field Activities

One well, W-1613 in HSU 3B, was installed in the TF406 area during 2000. Well construction details are provided in Table A-1 of Appendix A.

Two hydraulic tests were performed in the TF406 area in 2000 on well W-1515: a six-hour constant drawdown test and a step-drawdown test. Results of these tests are presented in Appendix B.

5.7.3. Field-Scale Pilot Tests

In February 2000, DOE/LLNL continued evaluating EO 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 fine-grained 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 were used to design and deploy the EO system that operated in the TFD Helipad area in 2000 (Section 5.4.3).

5.8. Vapor Treatment Facility 518

The VTF518 vapor treatment facility is located north of East Avenue and near Avenue H, adjacent to TF518 (Fig. 1). VTF518 was shut down in August 1999 due to lack of flow from the primary extraction well, SVI-518-201. Field investigations indicated that the reduction in vapor flow rates was due to development of a perched water layer, which severely restricted air flow in the vadose zone. Soil vapor extraction (SVE) flow rates were estimated at 0.6 scfm from well SVE-518-204. The vacuum produced by VTF518 caused an up-welling of the perched water, which contains high concentrations of VOCs. The ground water was extracted from two of the vapor extraction wells, SVI-518-204 and SVI-518-303, on a periodic basis during 2000 to expedite mass removal.

Soil vapor extracted from the vadose zone is passed through a series of GAC canisters to remove VOCs. Following treatment, the effluent air is discharged to the atmosphere. VTF518 was in compliance with its Bay Area Air Quality Management District permit throughout 2000.

VTF518 began operation in September 1995 by treating soil vapor from extraction well SVI-518-201 (Fig. 1). In 1997, 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 parts per million on a volume-to-volume basis ($ppm_{v/v}$) at the start of operation to 3 to 4 $ppm_{v/v}$ currently.

5.8.1. Performance Summary

From July to December 2000, VTF518 operated at an average flow rate of 0.6 scfm, treating about 138 thousand cubic ft (Kft^3) of vapor containing an estimated 2.8 kg of VOCs (Table 2). In addition, approximately 650 gallons of water containing about 0.09 kg of VOCs were hand-bailed from the two vapor extraction wells at VTF518 in 2000. Since system start up in 1995, VTF518 has treated nearly 15 Kft^3 of vapor and removed about 150 kg of VOC mass from the subsurface (Table 3).

5.8.2. Field Activities

Passive soil vapor surveys using Gore Sorbers™ were conducted around Buildings 419, 511, and 518 in the Building 518 area during the summer of 2000. The results indicated TCE concentrations in near surface soils east and north of B511, and north of B419 were 7.25 µg, 140 µg, and 35 µg, respectively. The Gore-Sorber™ data matched well with ground water VOC isoconcentration maps of the area. Results of the passive soil vapor survey near VTF518 show that the highest VOC concentrations are located northwest of the main vapor extraction area.

Two boreholes were drilled in the VTF518 area during 2000. Well W-1615 was installed as a vadose zone well, and well W-1616 was installed with an Instrumented Membrane System (IMS), formerly known as Seamist™ or FLUTE™ lined boreholes. Well construction details are provided in Table A-1 of Appendix A.

Two 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.

5.8.3. Field-Scale Pilot Tests

The VTF518 area was selected as a deployment site for a Savannah River Site source investigation tool, the NAPL Ribbon Sampler. The NAPL Ribbon, which is deployed along an open borehole wall using an IMS borehole liner, is used to identify the presence of dense non-aqueous phase liquids (DNAPLs) such as TCE. Based on the results of the passive soil vapor survey, boreholes B-1615 and B-1616 were drilled at locations with the highest surface VOC concentrations. No DNAPLs were detected in either of the boreholes.

5.9. Ground Water Treatment Facility 518

Two treatment facilities, TF518 and TF518 North (TF518-N) operated in the TF518 area in 2000 (Figs. 1, 36, and 37). TF518 is located north of East Avenue and east of Southgate Drive (Fig. 36), and treats ground water from HSU-5 extraction well W-112. A new treatment facility, TF518-N, was activated on January 26, 2000, ahead of the June 28, 2000 milestone date. TF518-N is located south of the South Outer Loop Road north of Building 411 (Figs. 1 and 37). TF518-N treats ground water from HSU-4 extraction well W-1410.

TF518 was originally equipped with a PTU and began operating in January 1998. In July 1998, miniature portable treatment unit 1 (MTU-1) replaced the PTU due to lower flow rates from the TF518 extraction wells. Pumping from well W-211 (HSU 6) was discontinued in May 1998 after six consecutive sampling events between September 1997 and April 1998 showed that VOC concentrations remained below the 5 ppb MCL. VOC concentrations in this well remained below MCLs in 2000. Continuous pumping was discontinued from well W-112 in December 1999 due to low water levels caused by dewatering HSU-5 in the southeastern portion of the Livermore Site. Cyclic pumping was discontinued in June 2000 after water levels failed to recover sufficiently. Future operation of TF518 is planned if HSU 5 water levels recover sufficiently to provide sustainable flow in well W-112.

The MTU at TF518 processes ground water for VOC treatment using an air stripper, and the effluent air is treated with GAC prior to venting to the atmosphere. When TF518 is operating, treated ground water is discharged to a storm drain located about 250 ft west that ultimately empties into Arroyo Las Positas (Fig. 36). TF518-N employs a series of aqueous-phase GAC canisters to treat ground water. Treated ground water from TF518-N is discharged into a storm drain that flows north and ultimately empties into Arroyo Las Positas (Fig. 37).

5.9.1. Performance Summary

During 2000, the combined TF518 area facilities operated at an average flow rate of 6.5 gpm, treating over 2.9 million gal of ground water containing an estimated 1.7 kg of VOCs (Table 2). Since system startup in January 1998, the combined TF518 facilities have processed over 6.6 million gal of ground water containing an estimated 3.0 kg of VOCs (Table 3).

The extraction wells in the TF518 and nearby areas provide hydraulic control of VOC plumes in HSU 4 and 5 based on the capture zone analysis shown on the ground water elevation contour maps (Figs. 9 and 10) and the total VOC isoconcentration maps (Figs. 15 and 16). The sustained de-watering in HSU 5 impacts hydraulic control by widening the capture areas.

5.9.2. Field Activities

No new boreholes or wells were drilled and no hydraulic tests were conducted in the TF518 area during 2000.

5.10. Treatment Facility 5475 (TF5475)

Three ground water treatment facilities operated in 2000 in the Trailer 5475 (T5475) area, located in the east-central portion of the Livermore Site (Figs. 1 and 38). TF5475-1, activated in September 1998, treats ground water from extraction well W-1302 (HSU 3A). TF5475-2, activated in March 1999, is located west of T5475 and treats ground water from HSU-2 well W-1415 (Fig. 38). TF5475-3 is located west of T5475 and treats ground water from two HSU 3A extraction wells, W-1606 and W-1608 (Fig. 1). TF5475-3 began operation on September 27, 2000, ahead of the September 29, 2000 RAIP milestone date.

TF5475-1 uses a CRD unit (CRD-1) to treat VOCs in ground water. CRD technology is based on the reaction of dissolved hydrogen on a palladium catalyst. When in contact with VOC-bearing ground water, the VOCs are reduced to ethane, methane, or ethene, and free chloride ions. Because of the quick reaction rates of CRD, treatment takes place during one pass through the unit. After treatment, the ground water is returned to the same HSU from which it was extracted. This technology treats VOCs in ground water while keeping the ground water containing tritium in the subsurface in the T5475 area. CRD-1 operates in extraction well W-1302, a dual-screened well in which it extracts ground water containing VOCs and tritium from the lower screened interval for VOC treatment, and then reinjects treated ground water containing tritium into the upper screened interval of the same HSU. CRD-1's destruction efficiency at TF5475-1 was over 90% in 2000. TF5475-1 was shut down February 24, 2000 due to biological fouling. The unit was flushed and resumed operation from July 12, 2000 to mid November when it was shut down again for maintenance. The facility did not run from mid November through the end of December.

TF5475-2 employs STU 5 that uses a direct current (DC)-powered pump to extract ground water through a series of aqueous-phase GAC canisters for treatment. Tritium is not a contaminant of concern at TF5475-2. Treated ground water from TF5475-2 is discharged into a storm sewer that flows north into Arroyo Las Positas (Fig. 38). TF5475-2 was in compliance throughout 2000, 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 in a storage tank until the samples were analyzed and results indicated no detectable VOCs in the effluent.

TF5475-3 uses CRD-2 to treat VOCs in ground water. CRD-2 also uses catalytic reductive dehalogenation and is similar in design to CRD-1, except that it is an above-ground treatment unit rather than deployed in a well. Due to elevated tritium concentrations in ground water within HSU 3A, TF5475-3 is a closed loop system. Ground water is extracted from wells W-1606 and W-1608, processed in CRD-2, and then returned to the subsurface using reinjection wells W-1605 and W-1607. The destruction efficiency for CRD-2 was greater than 90% in 2000.

5.10.1. Performance Summary

During 2000, the TF5475 area facilities operated at an average flow rate of 1.7 gpm to treat about 0.1 million gal of ground water containing an estimated 0.9 kg of VOCs (Table 2). Since system start up in 1998, the combined TF5475 facilities have treated over 0.3 million gal of ground water and removed about 3.2 kg of VOC mass from the subsurface (Table 3).

5.10.2. Field Activities

During 2000, two HSU 3A extraction wells, W-1606 and W-1608, and two HSU 3A re-injection wells, W-1605 and W-1607, were installed in the TF5475 area. Two HSU 5 extraction wells, W-1609 and W-1610 were also installed in the same area. Well construction details are provided in Table A-1 of Appendix A. An hydraulic injection test was conducted on well W-1610 in the T5475 area during 2000. Results of this test are presented in Appendix B.

5.11. Vapor Treatment Facility 5475 (VTF5475)

VTF5475 is located north of TF5475-3 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 in January 1999.

Soil vapor is extracted from the vadose zone using a vapor extraction system and is treated using GAC. Due to elevated tritium concentrations in the vadose zone, VTF5475 is a closed loop system. The vapor stream is heated to reduce the humidity of the tritiated vapor prior to entering the GAC. Following removal of VOCs from the process air-stream, tritiated vapor is re-injected into the subsurface at soil vapor inlet well SVI-ETS-505 (Fig. 1). Tritium absorbed by the GAC during treatment for VOCs is ultimately handled as mixed waste. 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.

5.11.1. Performance Summary

During 2000, VTF5475 operated at an average flow rate of 20 scfm and treated about 7.5 million scf of vapor containing an estimated 102 kg of VOCs (Table 2). Since system start up in 1999, VTF5475 operated at an average flow rate of 20 scfm and treated about 9.6 million scf of vapor containing an estimated 198 kg of VOCs (Table 3).

5.11.2. Field Activities

Two IMS sampling/monitoring wells, SEA-ETS-506 and SEA-ETS-507, continued 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. Ground Water Discharges During 2000

Tables 4 through 6 present the total volumes of water discharged to the following surface features:

- The Recharge Basin.
- Arroyo Las Positas.
- Arroyo Seco.

Approximately 143 Mgal of treated ground water from TFA was discharged to the Recharge Basin at an average flow rate of 267 gpm. About 164 Mgal of treated ground water was discharged to Arroyo Las Positas. An estimated 4.3 Mgal of treated ground water from TFA-E and TFG-1 was discharged into Arroyo Seco. Ground water from TFD-EO, TF5475-1, and TF5475-3 was piped back into wells for discharge into the same HSU from which it was extracted.

7. Trends in Ground Water Analytical Results

Overall, the decrease in size and concentration observed in the Livermore Site VOC plumes is consistent with the 270 kg of VOC removed by the ground water extraction wells during 2000. Therefore, most of the observed trends in VOC concentrations are attributed to the active ground water extraction system operating at the Livermore Site. Notable results of VOC analyses of ground water received from January 2000 through December 2000 are discussed below.

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. Offsite HSU 1B wells are now below MCLs for all contaminants of concern with the exception of two wells, W-571 and W-1425, that had maximum PCE concentrations of 6.2 ppb and 7.9 ppb in 2000 (PCE MCL = 5 ppb).

In the TFD area, VOC concentrations in parts of HSU 2 continue to decline in response to pumping the TFD extraction wells. Total VOC concentrations in HSU 2 extraction well W-906 have decreased from 789 ppb in 1995 to 100 ppb in October 2000. In nearby HSU 2 monitor well W-355, TCE concentrations have decreased from a maximum of 3,100 ppb in April 1992 to 36 ppb in October 2000.

The HSU 2 Freon 11 plume in the northeastern TFD area continues to decline in response to pumping at TFD-W extraction wells W-1215 and W-1216. Freon 11 concentrations in monitor well W-316, located near the source area, have decreased from 1,100 ppb in 1992 to 230 ppb in August 2000.

In the southern TFD and northern TFE areas, VOC concentrations in HSU 4 are showing significant decreases due to pumping at HSU 4 extraction wells W-1418 and W-1504. Total VOC concentrations in well W-1418 have declined from 945 ppb in 1998 to 153 ppb in November 2000. Total VOC concentrations in well W-1504 have declined from 338 ppb in 1999 to 231 ppb in October 2000.

In the TFE-E area, total VOC concentrations in HSU 2 extraction well W-1109 have decreased from 1,744 ppb in January 1998 to 586 ppb in October 2000. In nearby HSU 2 monitor well W-257, TCE concentrations have decreased from a maximum of 6,400 ppb in 1988 to 110 ppb in May 2000.

East of TFE in the T5475 area, significant decreases in VOC concentrations in HSU 3A were observed during 2000. Total VOC concentrations in monitor well SIP-ETS-204 have decreased from 8,130 ppb in 1998 to 600 ppb in May 2000. However, total VOC concentrations in HSU-3A monitor well W-1117 increased from 120 ppb in 1995 to 1,663 ppb in November 2000.

In the TF518 area, the offsite HSU 5 VOC plume continues to show significant decreases in VOC concentrations since the start of pumping at the TF406 and TF518 facilities in August 1996 and January 1998, respectively. Total VOC concentrations in offsite monitor well W-219 have declined from 114 ppb in October 1997 to 3 ppb in October 2000. Total VOC concentrations in another offsite monitor well, W-225, have declined from over 2,100 ppb in 1987 to 4 ppb in October 2000.

At VTF518, field investigations indicate a relatively recent development of perched water that is mobilizing VOCs from the vadose zone. Total VOC concentrations from samples of perched water in two vapor extraction wells ranged from 24,000 to 81,000 ppb in SVI-518-204, and 7,000 to 18,000 ppb in SVI-518-303.

In the TF518 North area, a significant increase in VOC concentrations was observed in HSU 3B monitor well GSW-011. Total VOC concentrations have increased from 31 ppb in February 1998 to 556 ppb in October 2000. This VOC plume appears to be migrating out of the B419 source area that is located 400 ft to the east.

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Figures

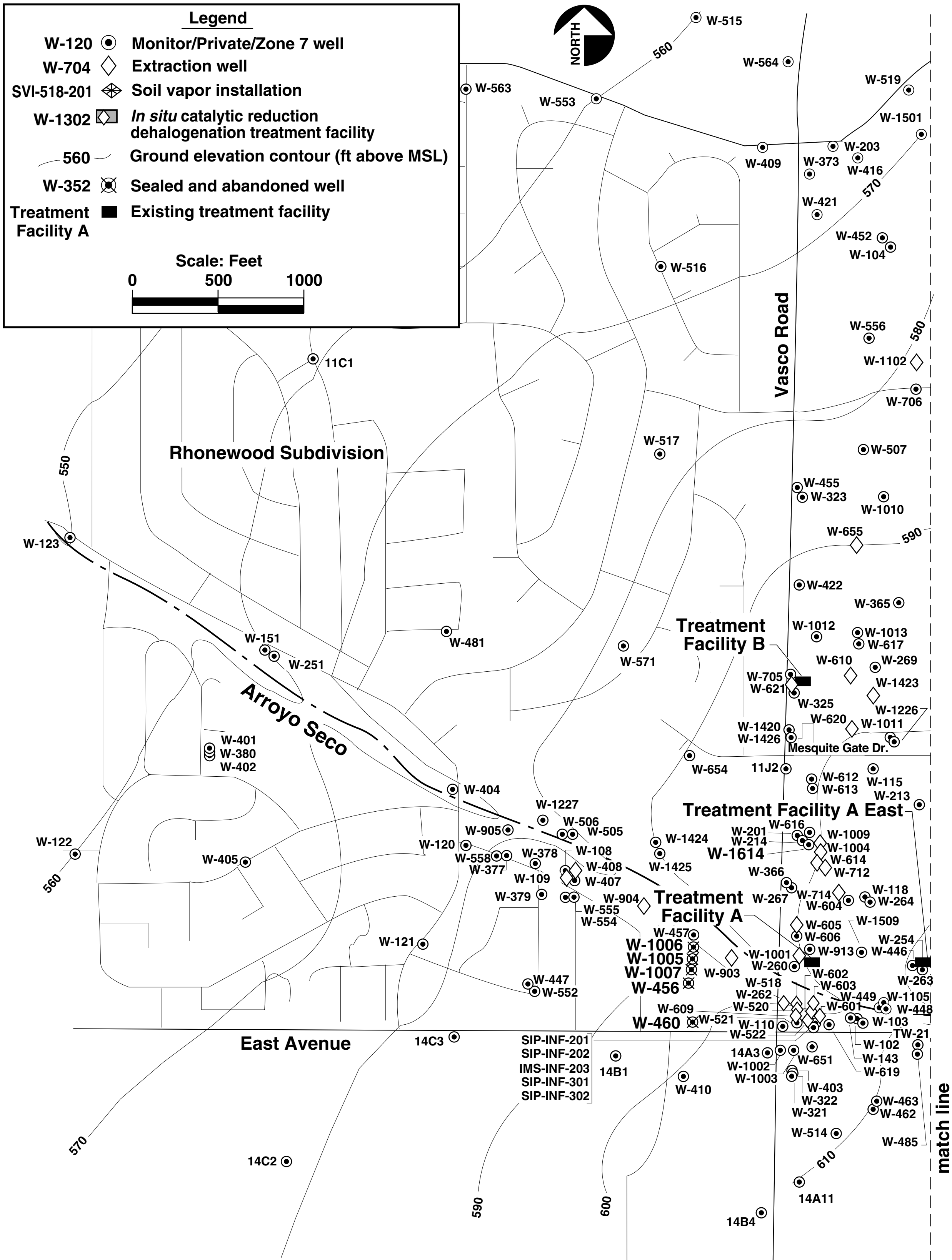

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Figure 1. Locations of Livermore Site monitor wells, extraction wells, and treatment facilities, December 2000.

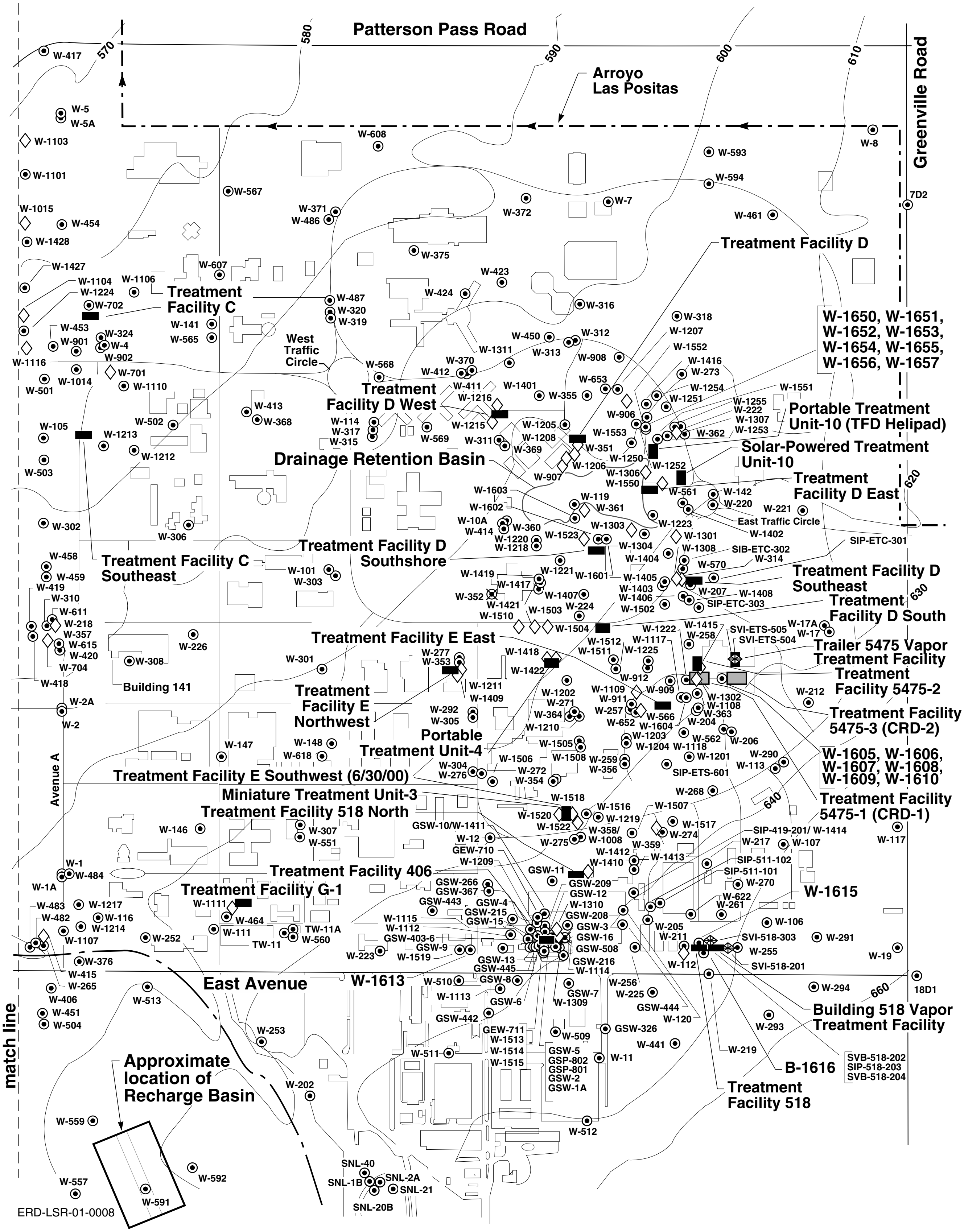

Figure 1 (continued).

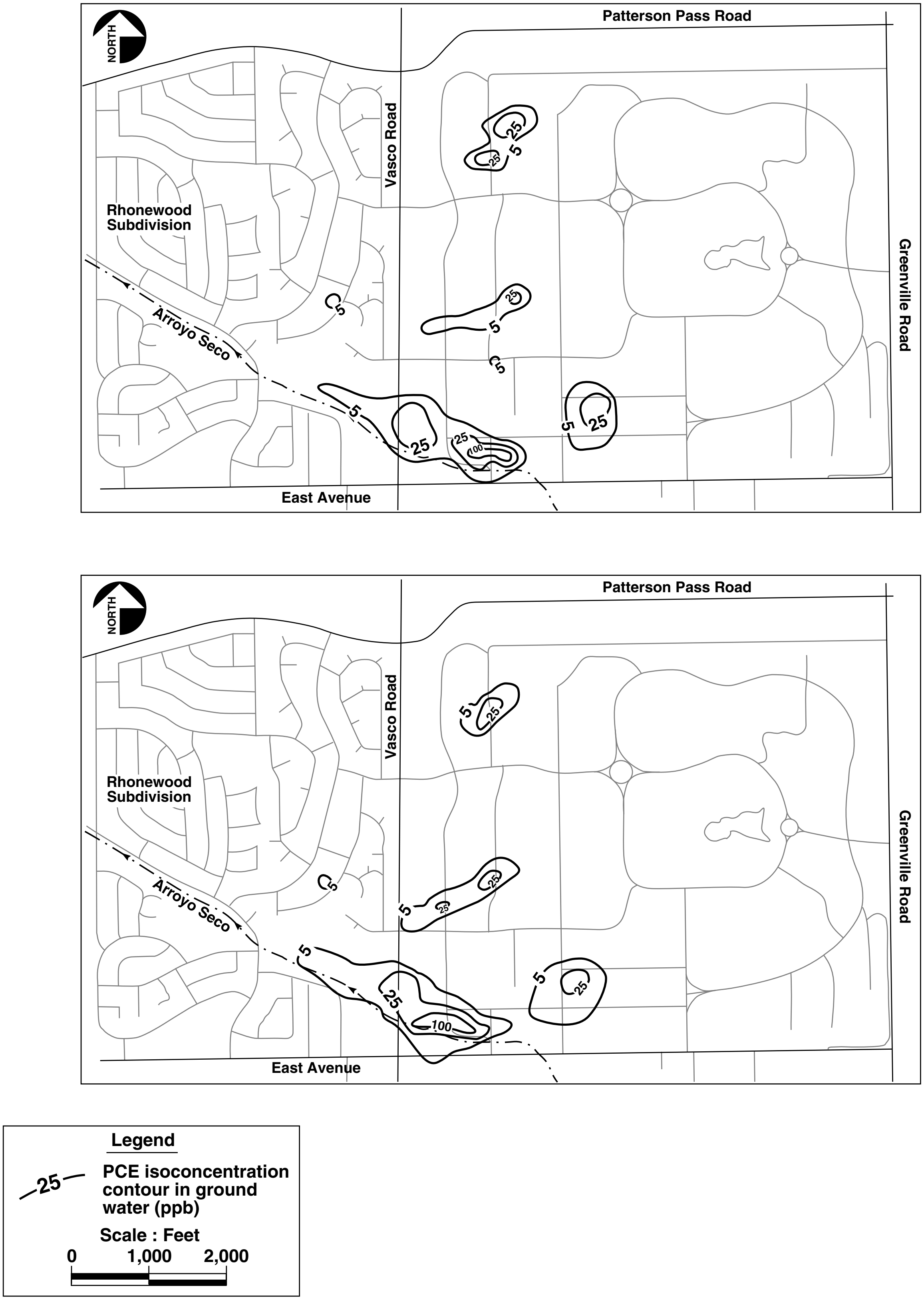

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Figure 2. Comparison of 2000 HSU 1B measured (top) and simulated (bottom) aqueous PCE concentrations at LLNL and vicinity.

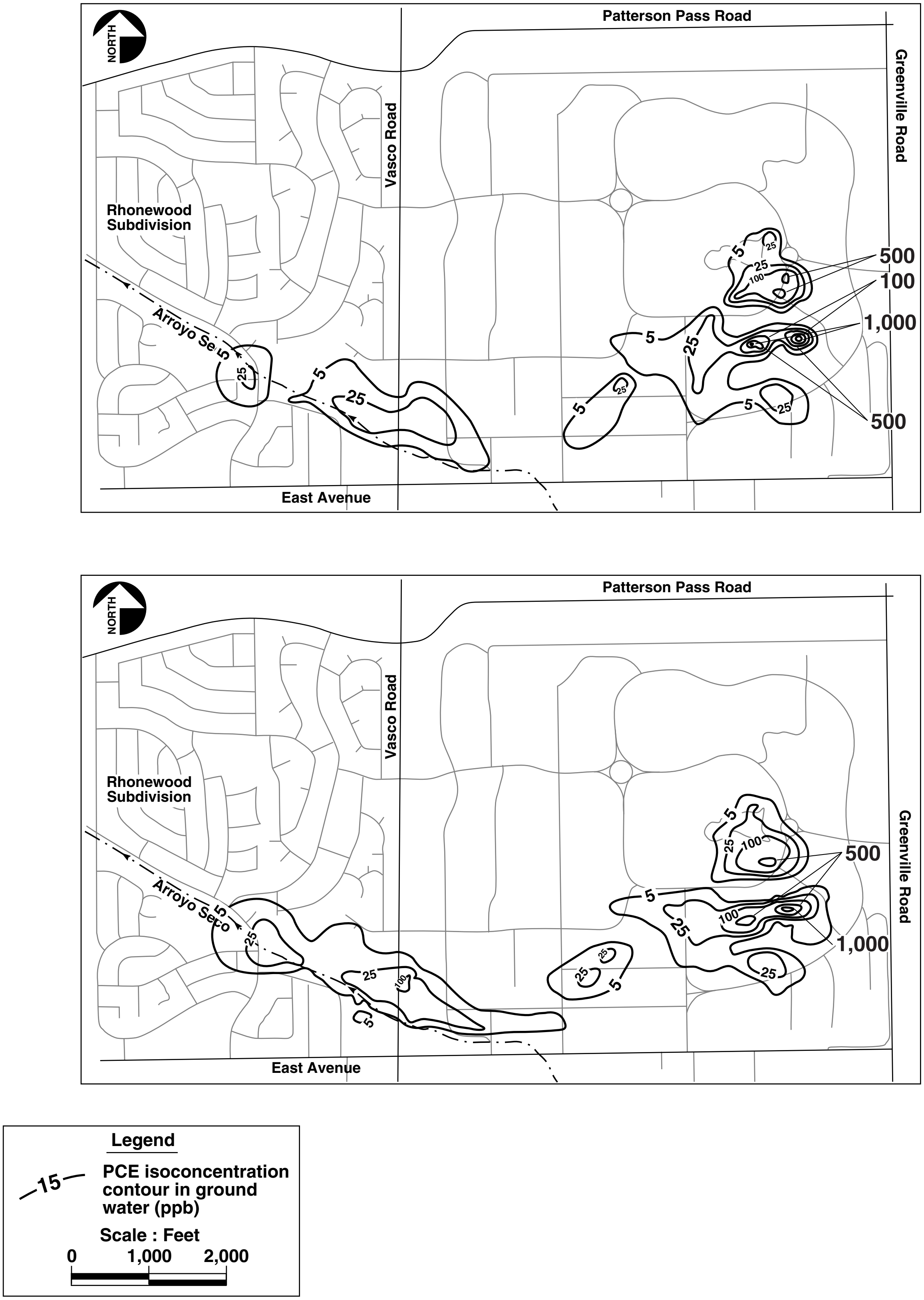

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Figure 3. Comparison of 2000 HSU 2 measured (top) and simulated (bottom) aqueous PCE concentrations at LLNL and vicinity.

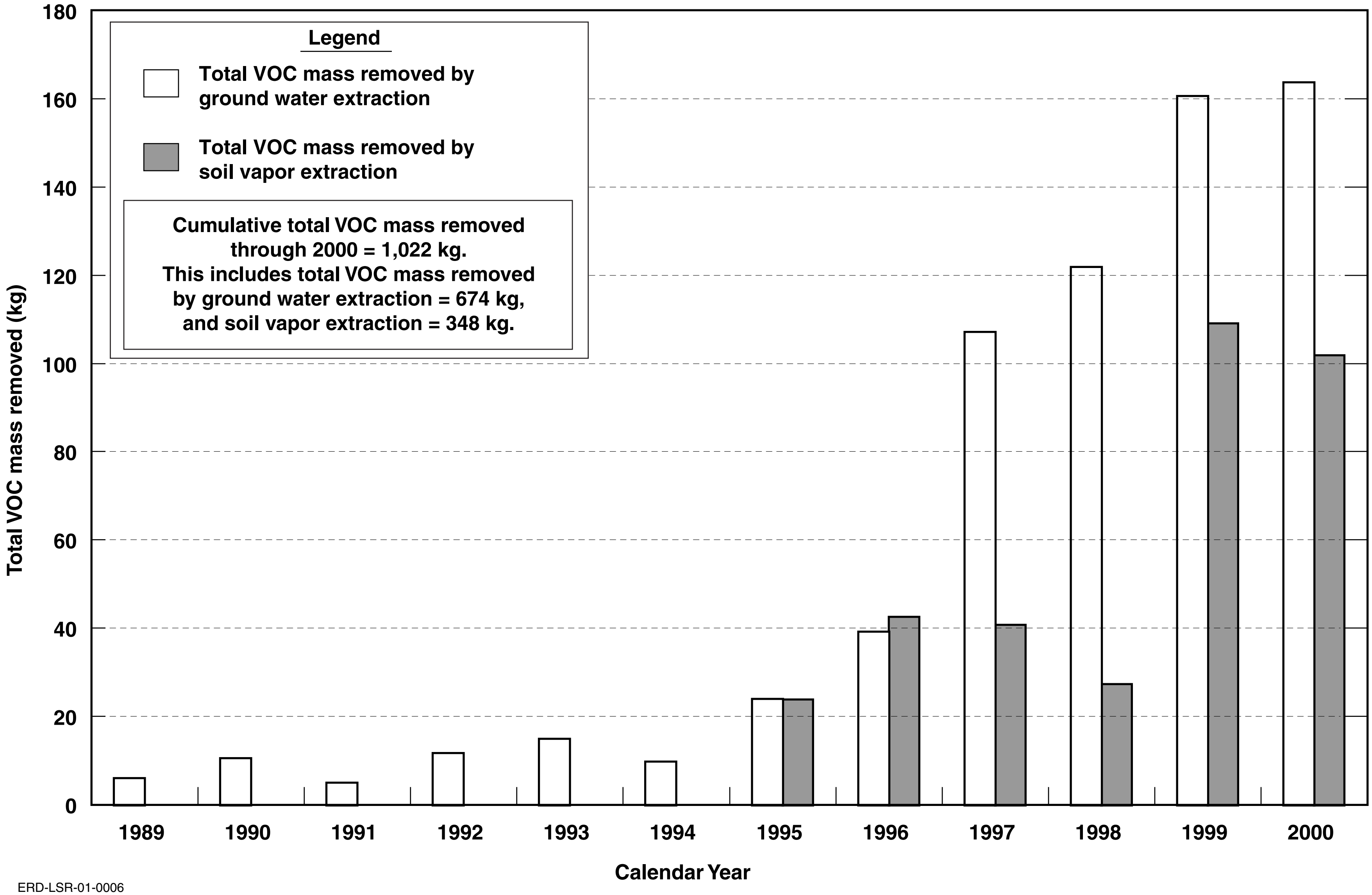

Figure 4. Total VOC mass removed from the Livermore Site subsurface over time.

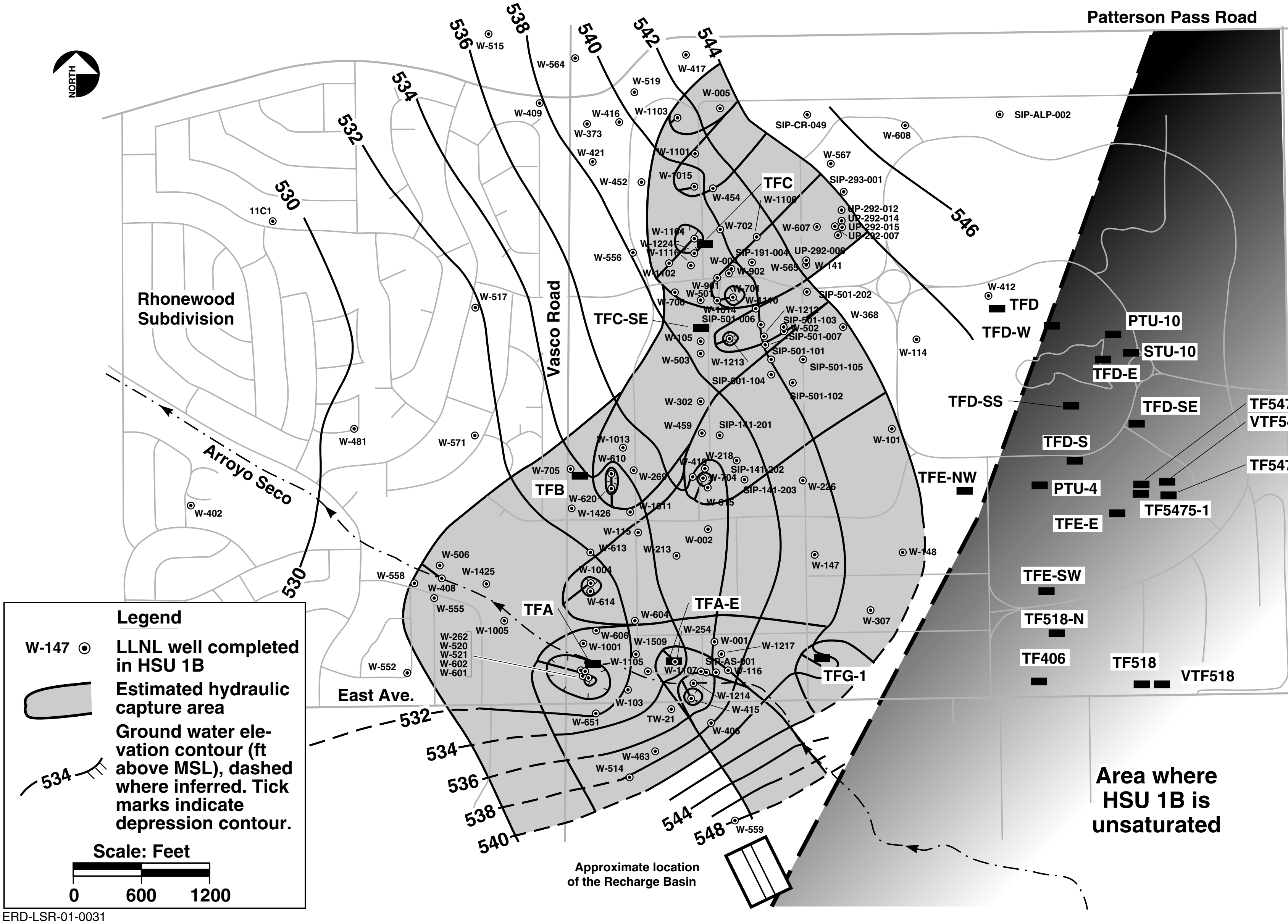

Figure 5. Ground water elevation contour map based on water levels collected from 134 wells completed within HSU 1B showing estimated hydraulic capture areas, LLNL and vicinity, November 2000.

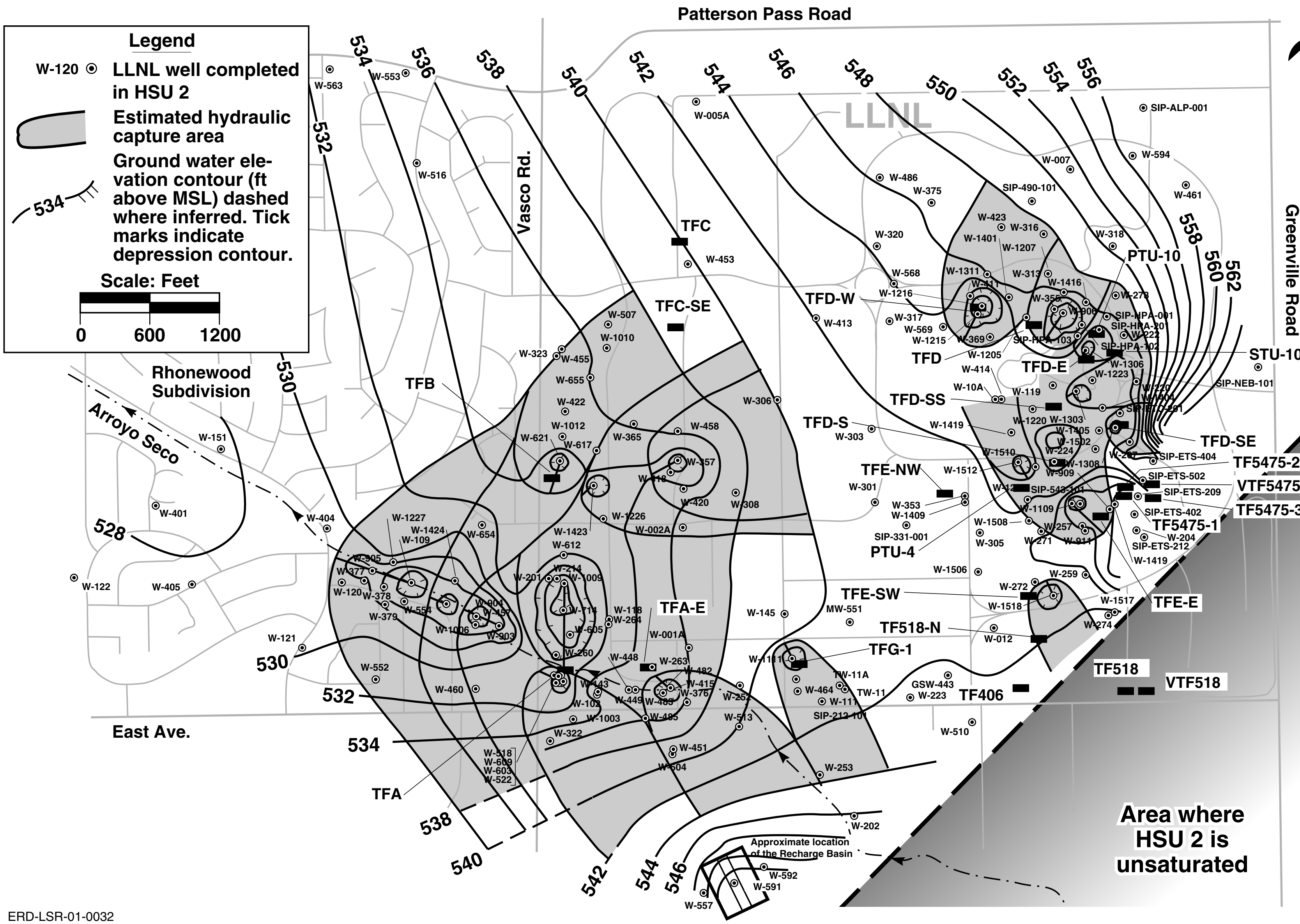

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Figure 6. Ground water elevation contour map based on water levels collected from 174 wells completed within HSU 2 showing estimated hydraulic capture areas, LLNL and vicinity, November 2000.

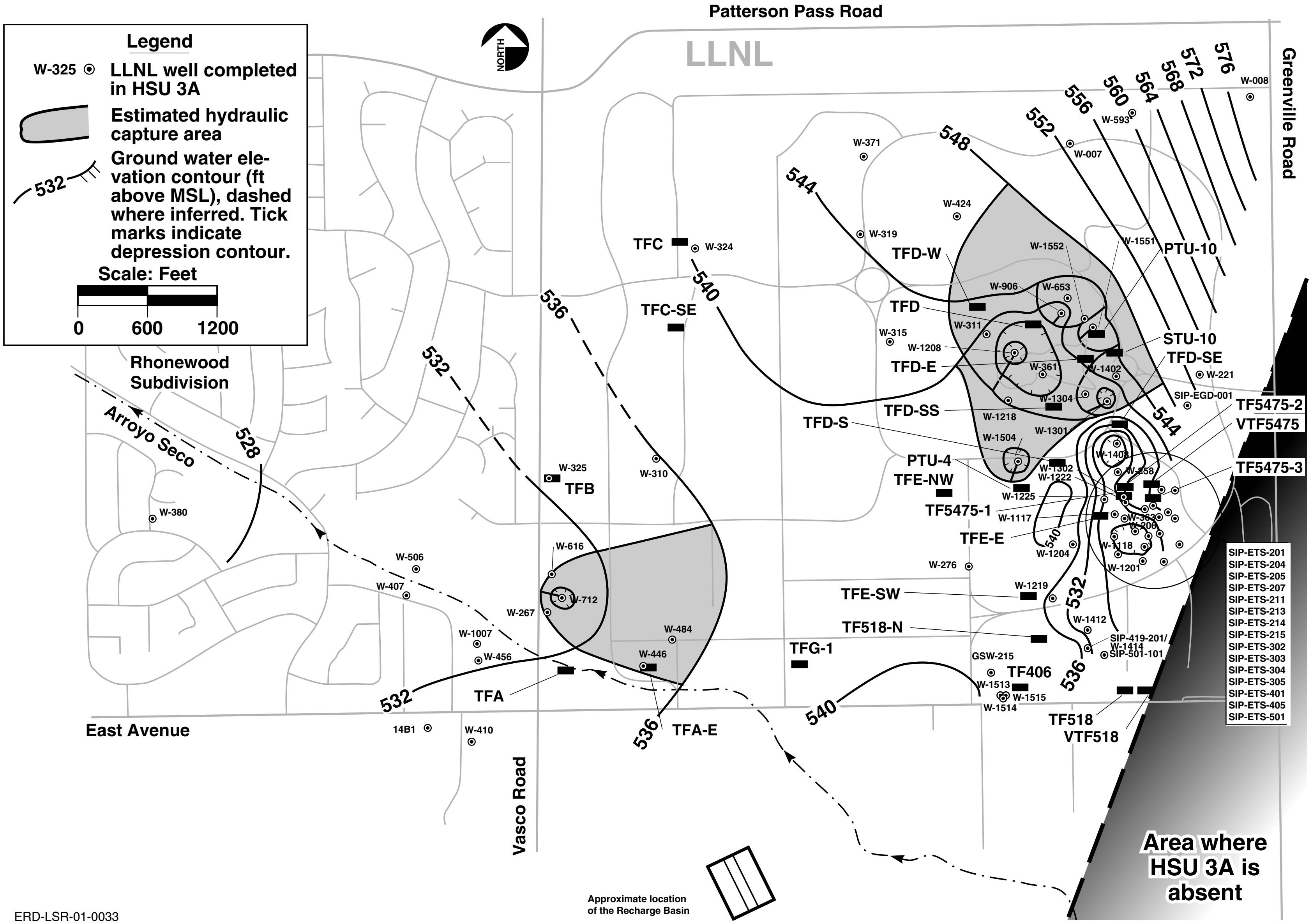

Figure 7. Ground water elevation contour map based on water levels collected from 76 wells completed within HSU 3A showing estimated hydraulic capture areas, LLNL and vicinity, November 2000.

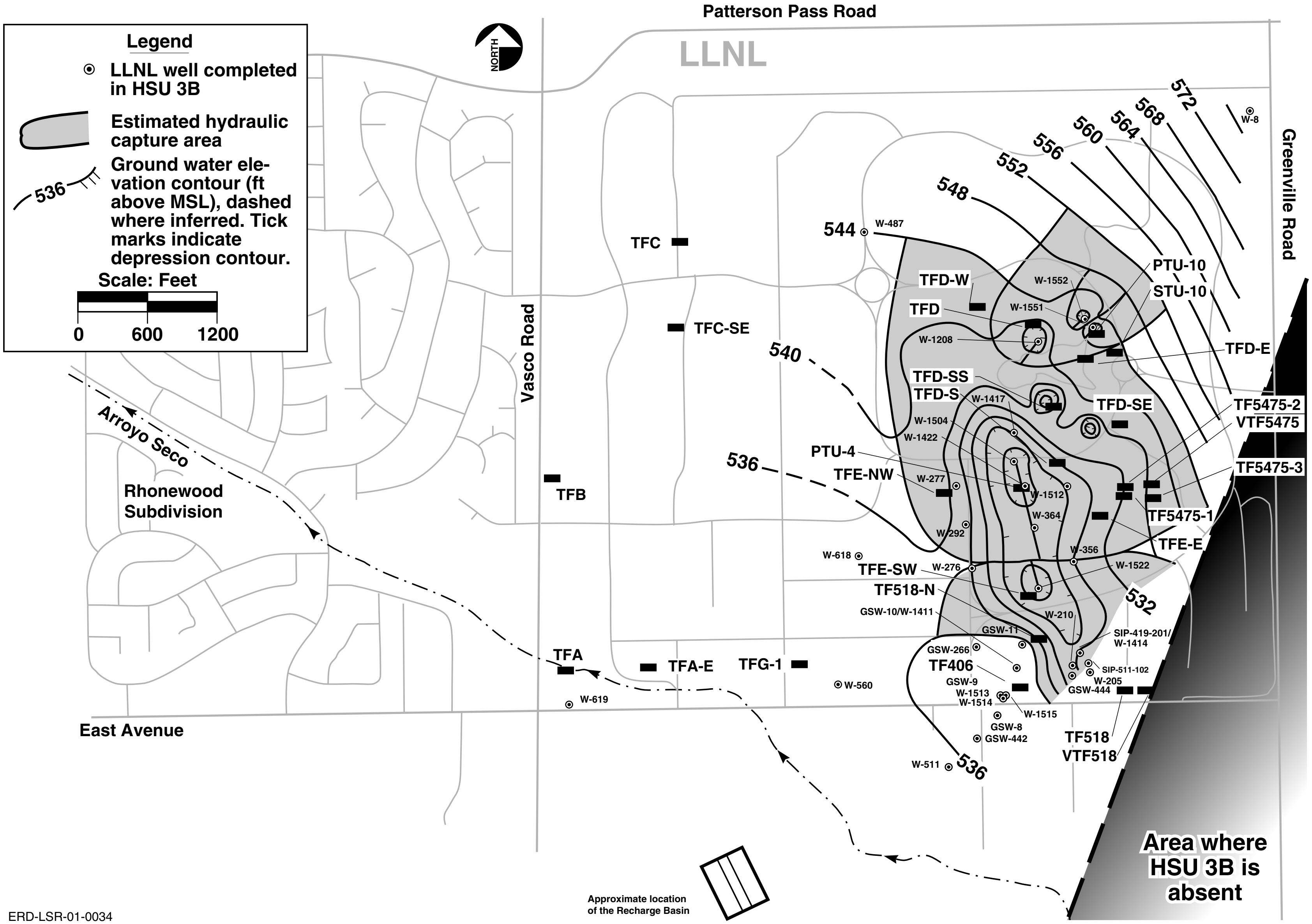

Figure 8. Ground water elevation contour map based on water levels collected from 42 wells completed within HSU 3B showing estimated hydraulic capture areas, LLNL and vicinity, November 2000.

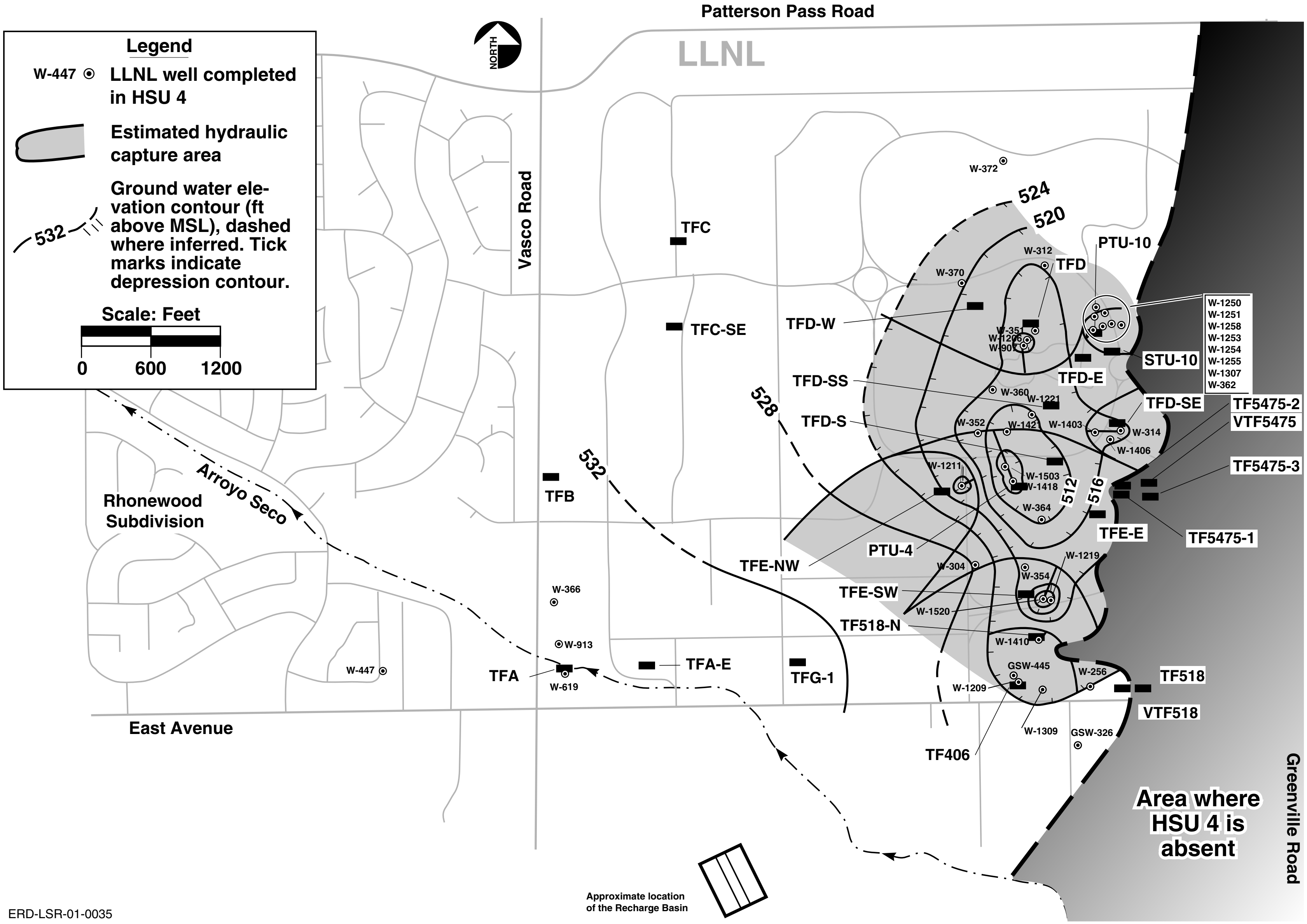

Figure 9. Ground water elevation contour map based on water levels collected from 35 wells completed within HSU 4 showing estimated hydraulic capture areas, LLNL and vicinity, November 2000.

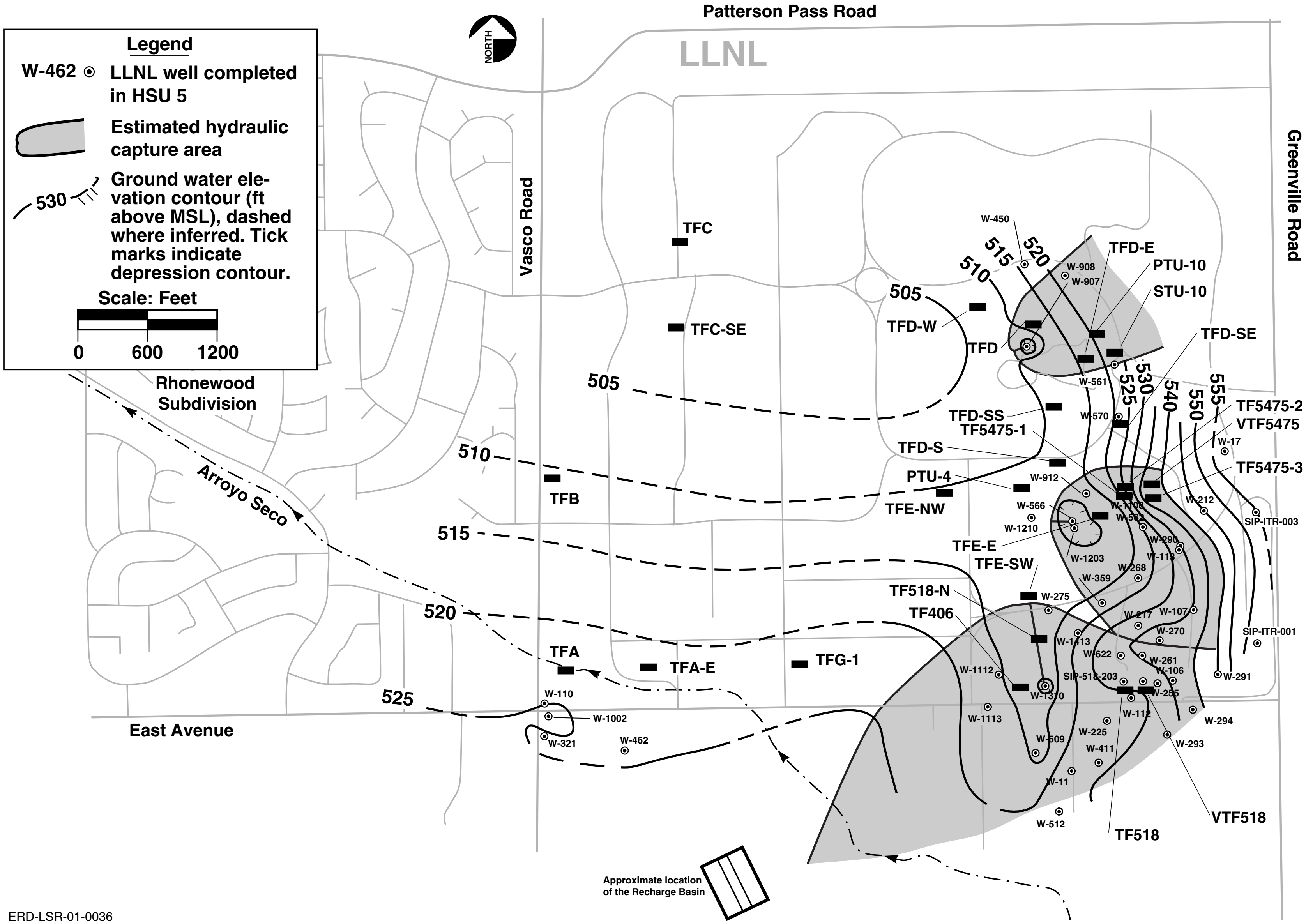

Figure 10. Ground water elevation contour map based on water levels collected from 51 wells completed within HSU 5 showing estimated hydraulic capture areas, LLNL and vicinity, November 2000.

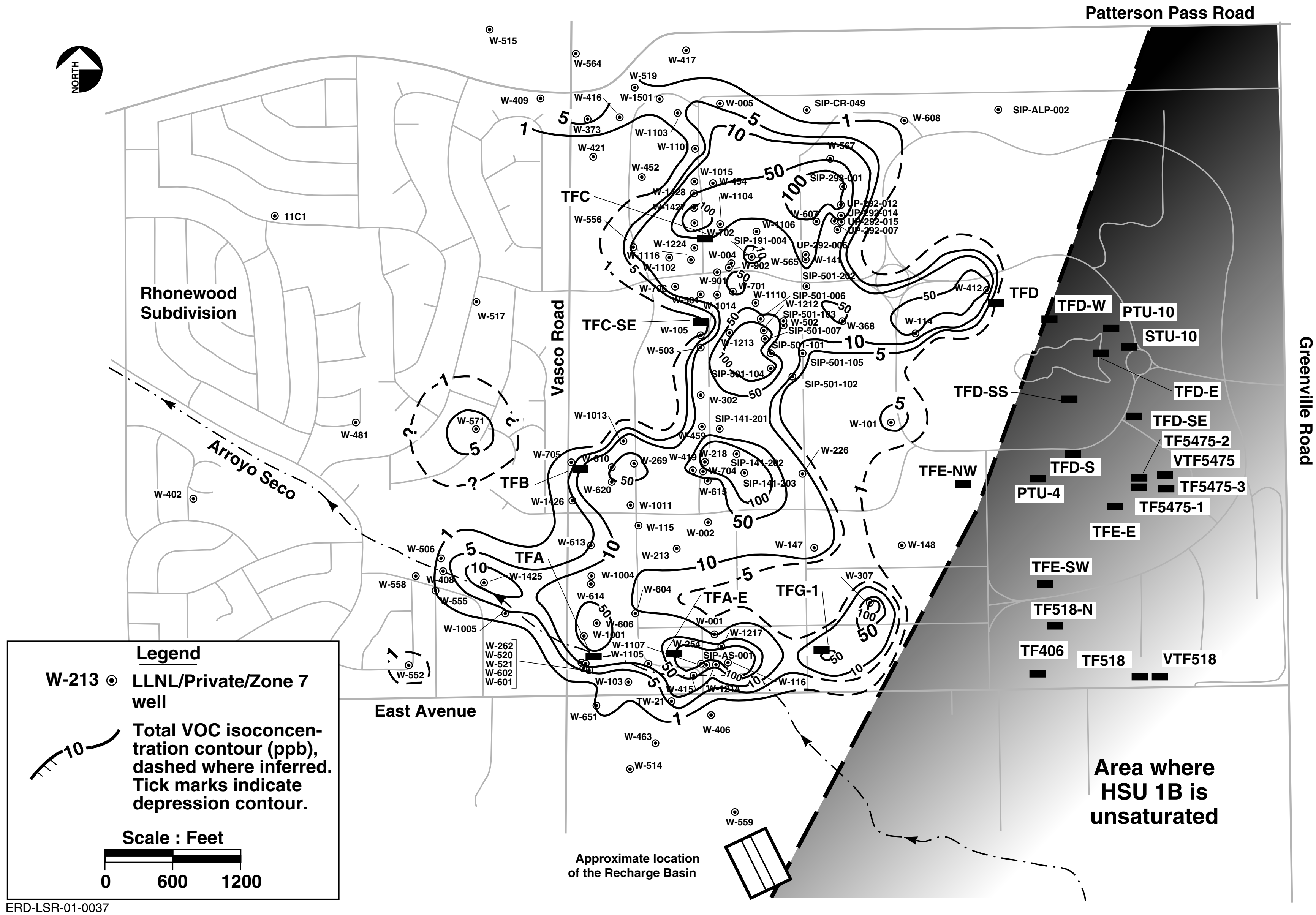

Figure 11. Isoconcentration contour map of total VOCs for 136 wells completed within HSU 1B based on samples collected in the fourth quarter of 2000 (or the next most recent data), and supplemented with soil chemistry data from 46 borehole locations.

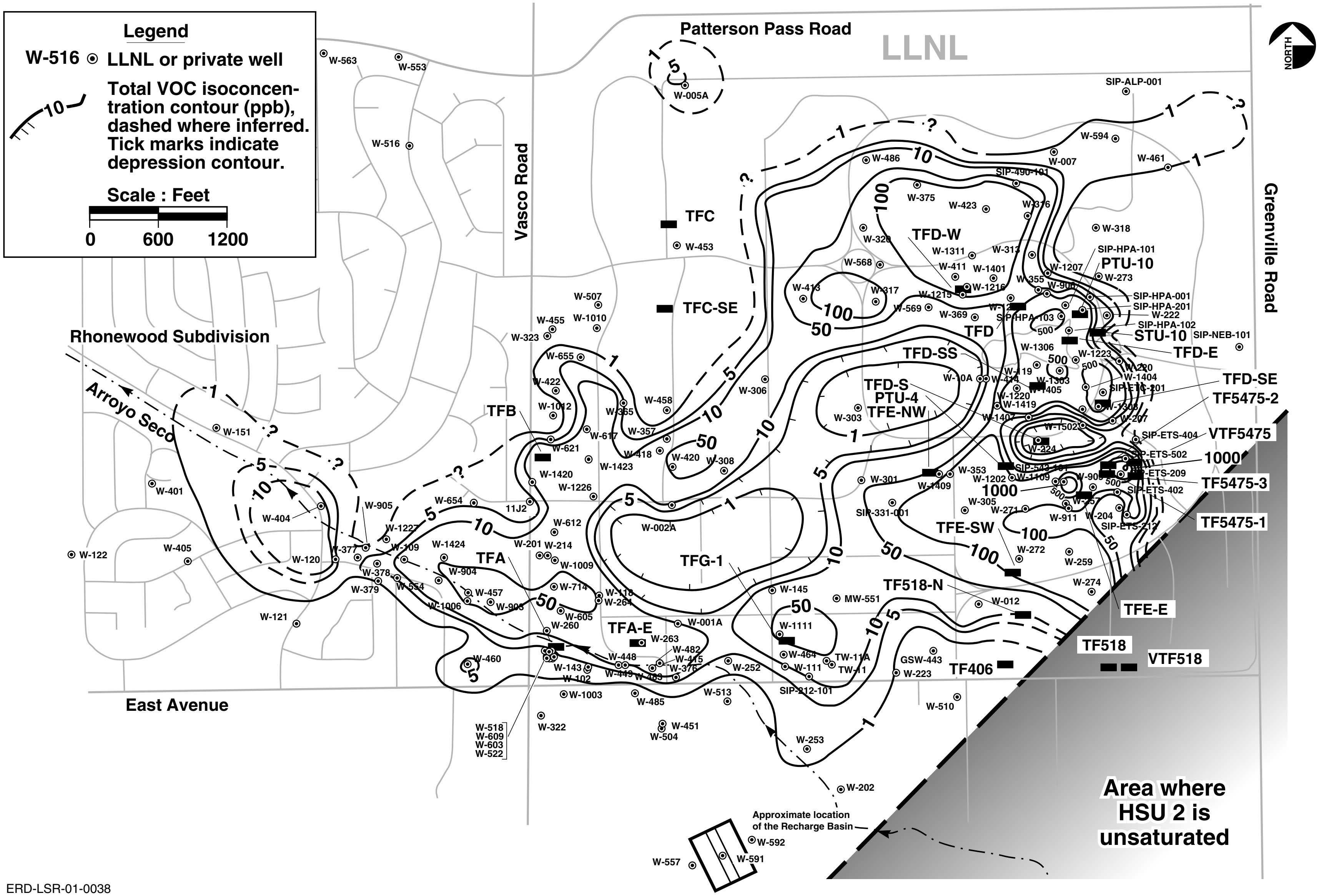

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Figure 12. Isoconcentration contour map of total VOCs for 187 wells completed within HSU 2 based on samples collected in the fourth quarter of 2000 (or the next most recent data), and supplemented with soil chemistry data from 104 borehole locations.

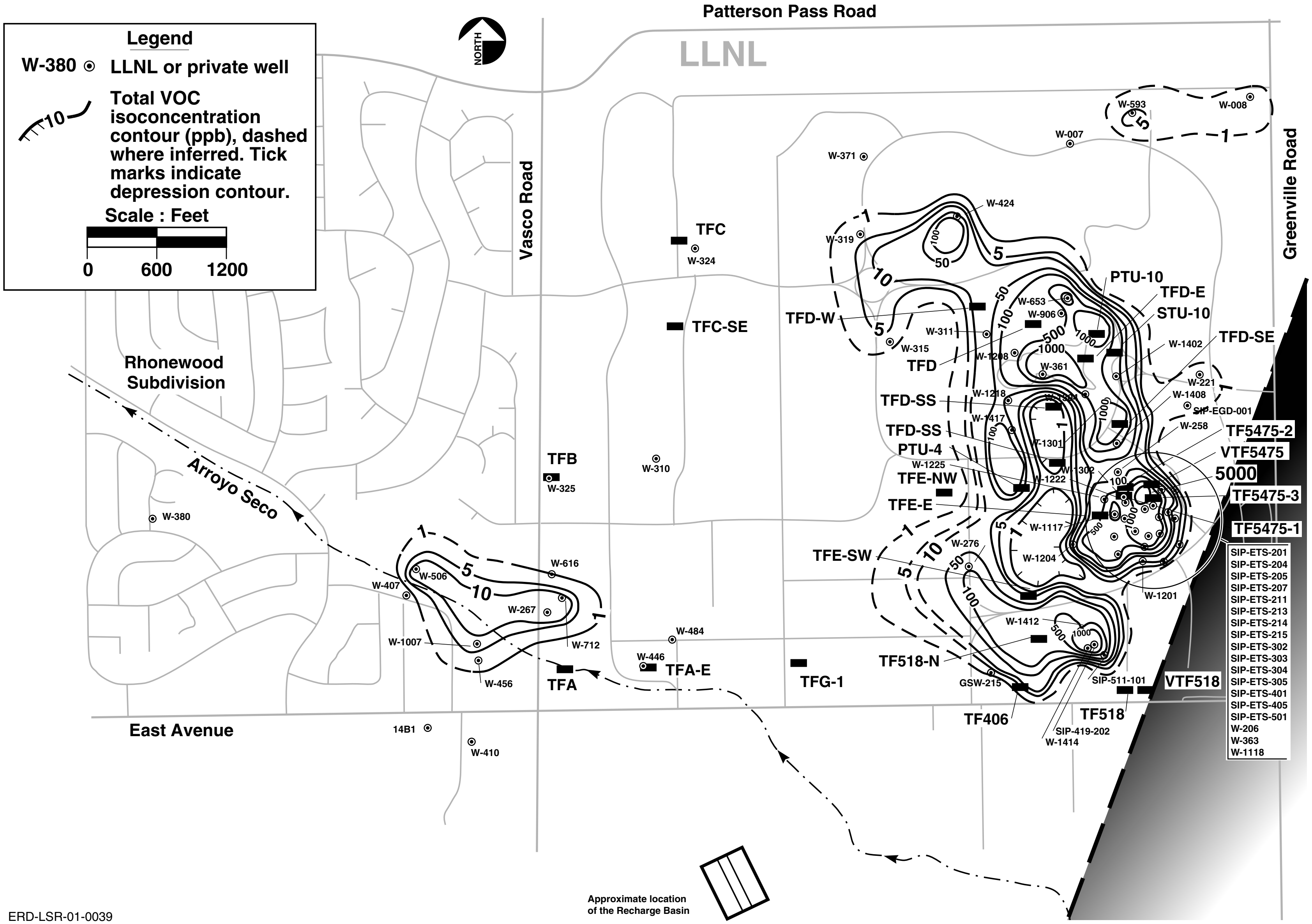

Figure 13. Isoconcentration contour map of total VOCs for 96 wells completed within HSU 3A based on samples collected in the fourth quarter of 2000 (or the next most recent data), and supplemented with soil chemistry data from 148 borehole locations.

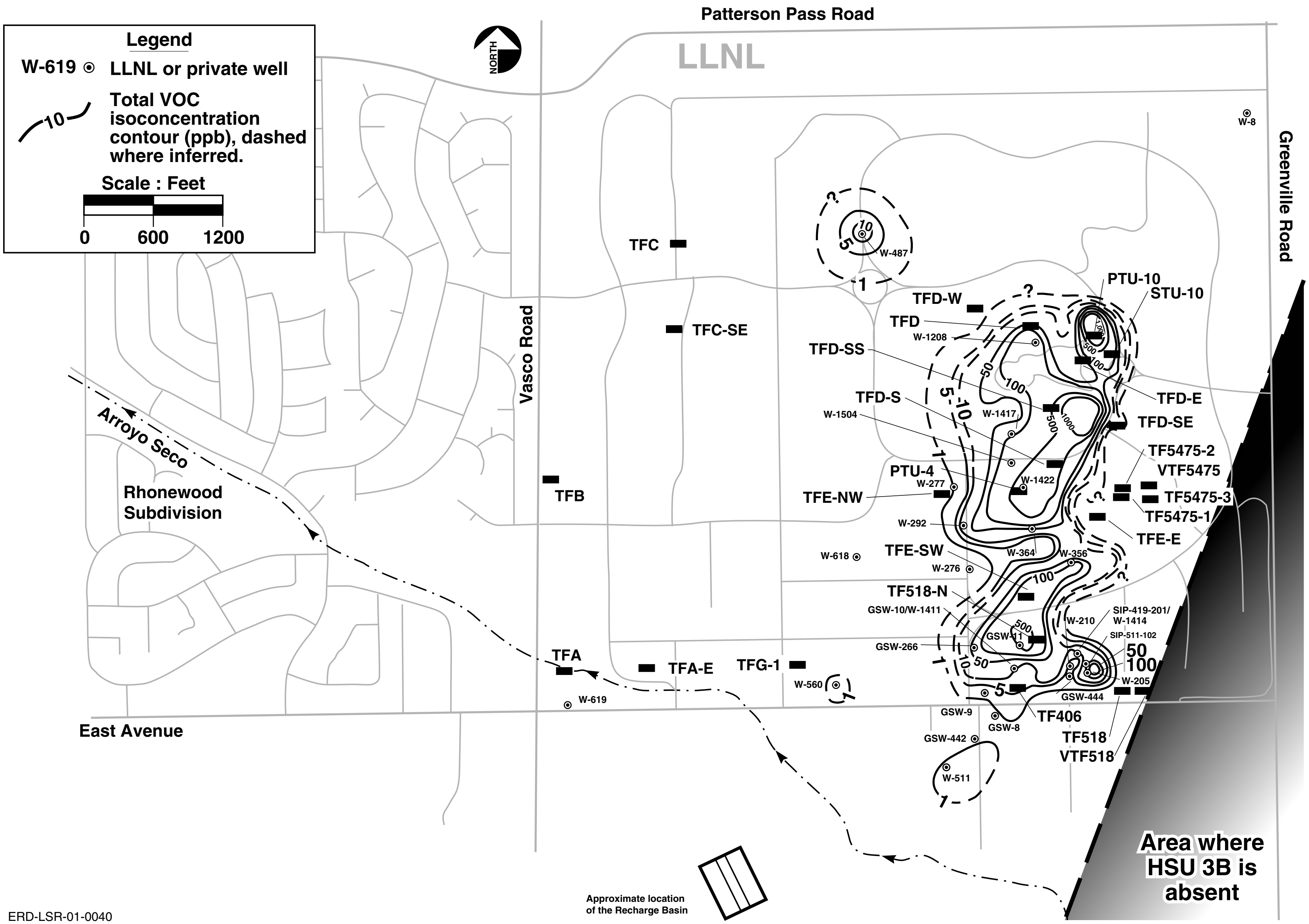

Figure 14. Isoconcentration contour map of total VOCs for 55 wells completed within HSU 3B based on samples collected in the fourth quarter of 2000 (or the next most recent data), and supplemented with soil chemistry data from 108 borehole locations.

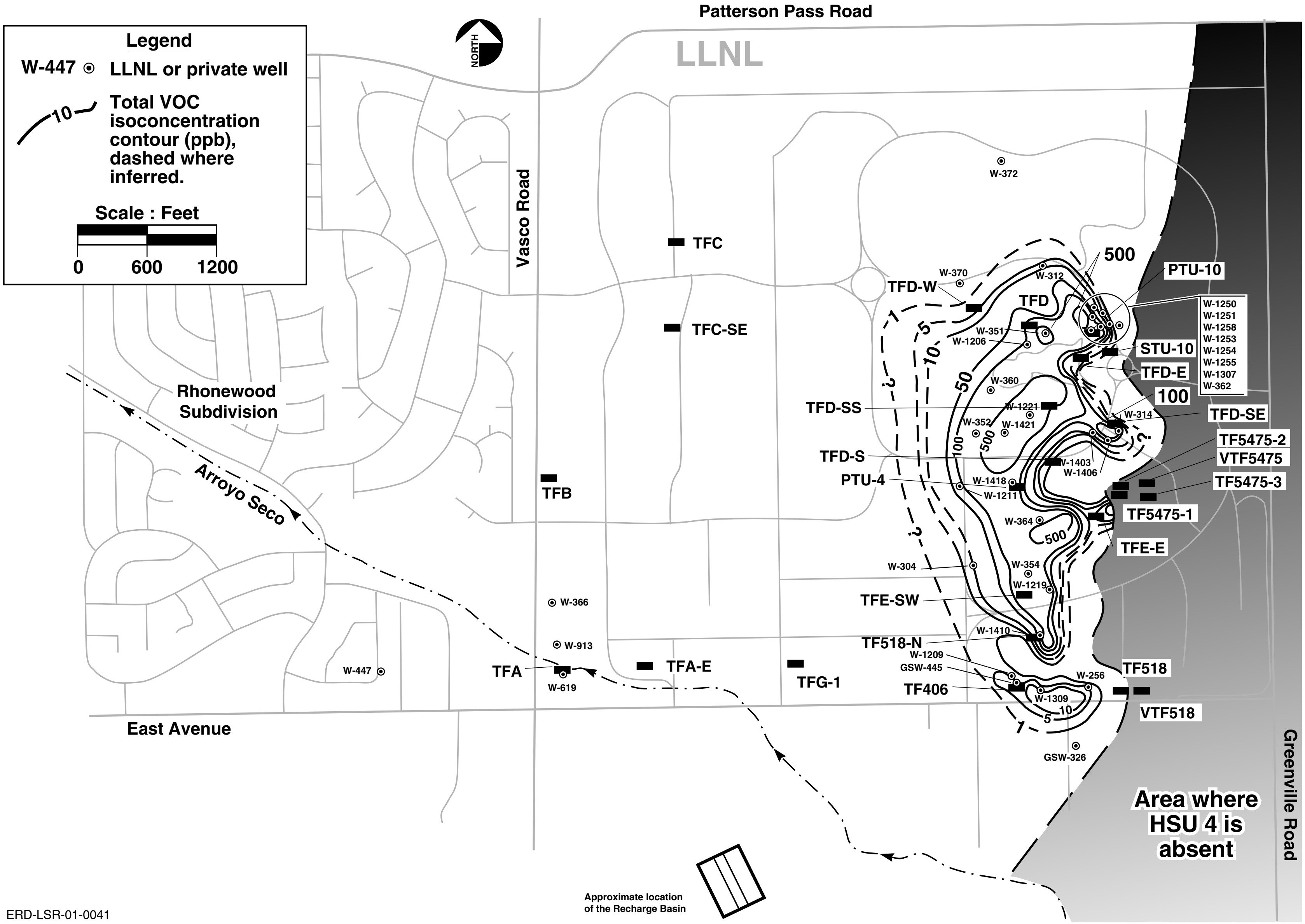

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Figure 15. Isoconcentration contour map of total VOCs for 43 wells completed within HSU 4 based on samples collected in the fourth quarter of 2000 (or the next most recent data), and supplemented with soil chemistry data from 64 borehole locations.

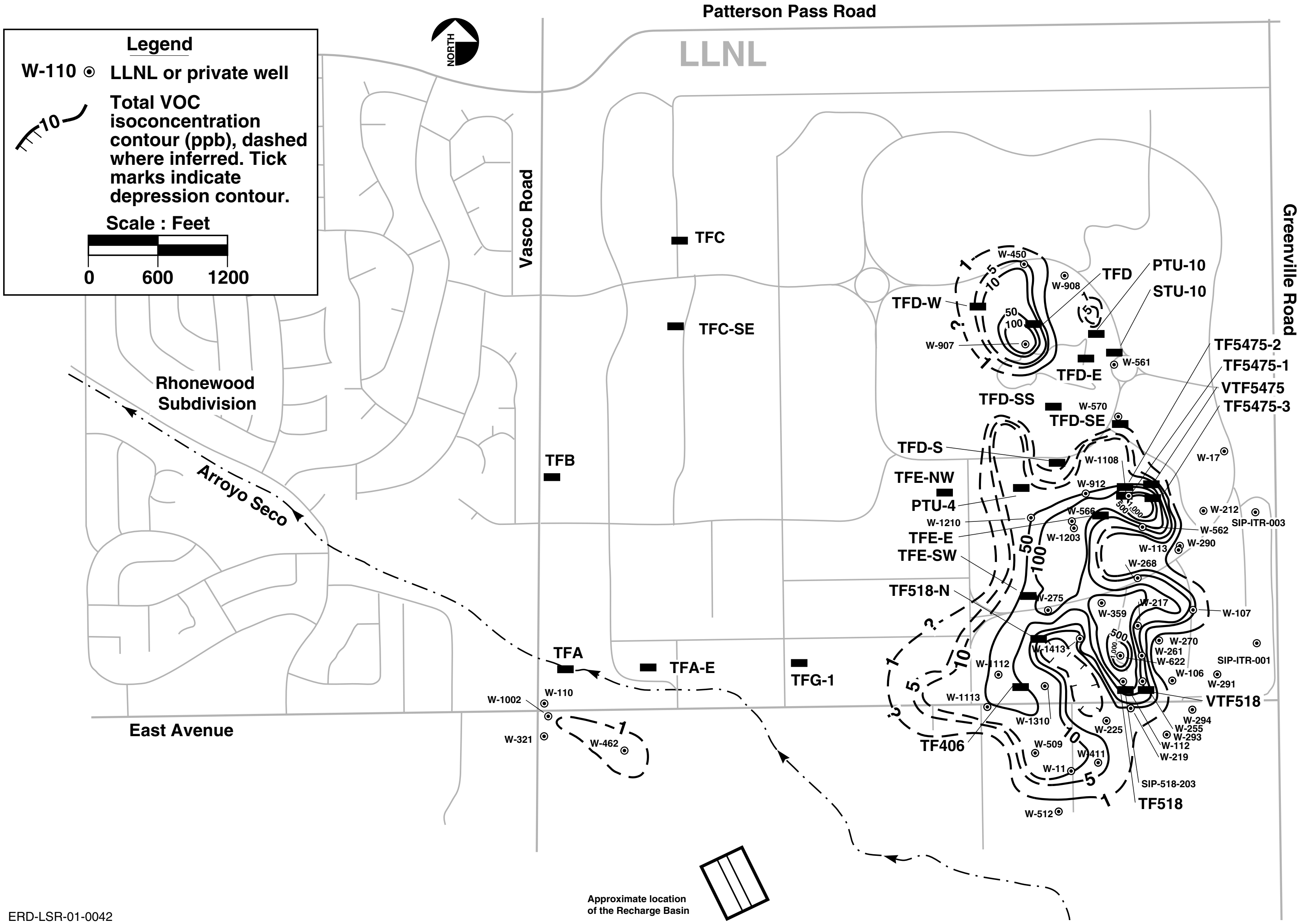

Figure 16. Isoconcentration contour map of total VOCs for 55 wells completed within HSU 5 based on samples collected in the fourth quarter of 2000 (or the next most recent data), and supplemented with soil chemistry data from 94 borehole locations.

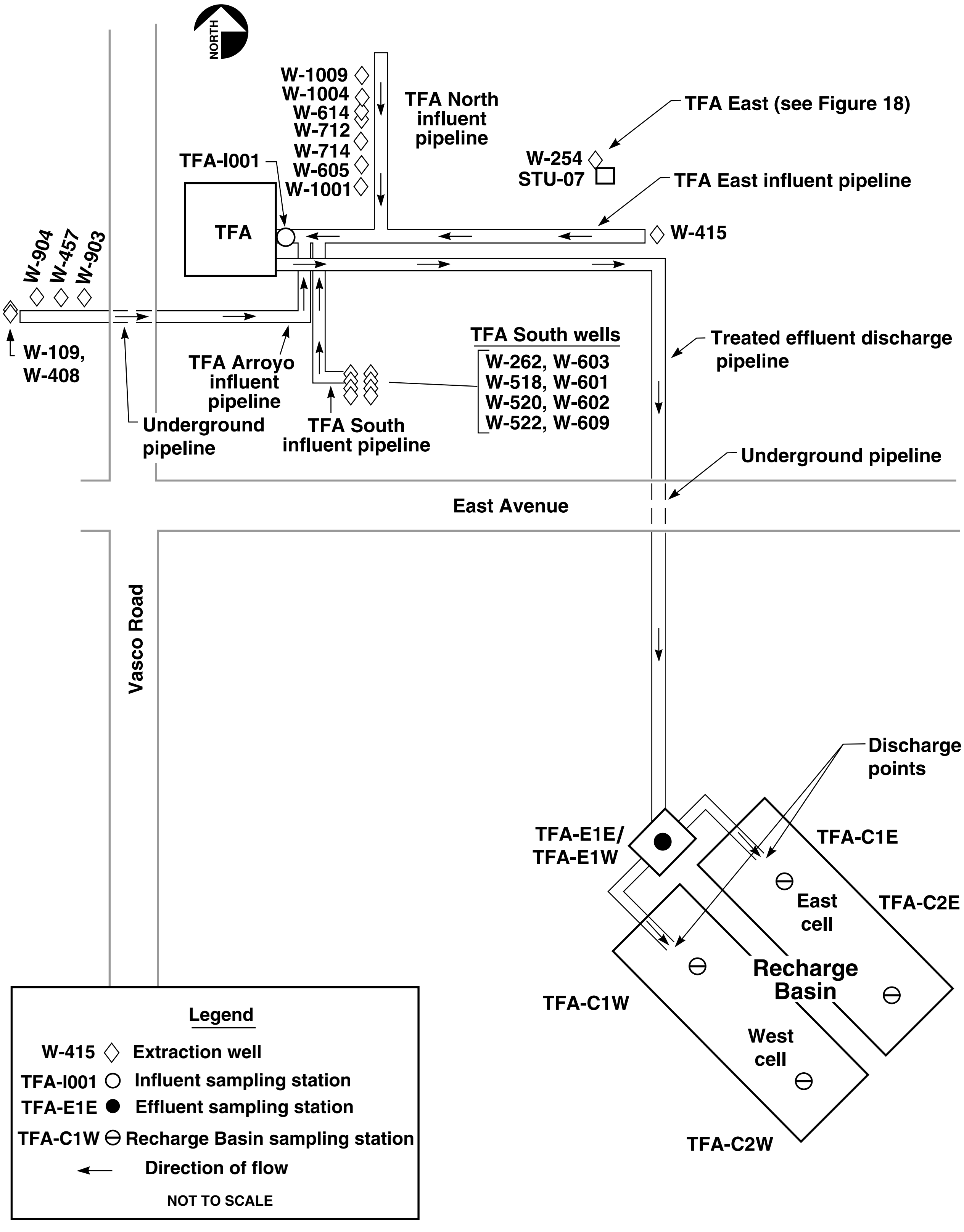

Figure 17. TFA extraction wells, pipelines and discharge locations.

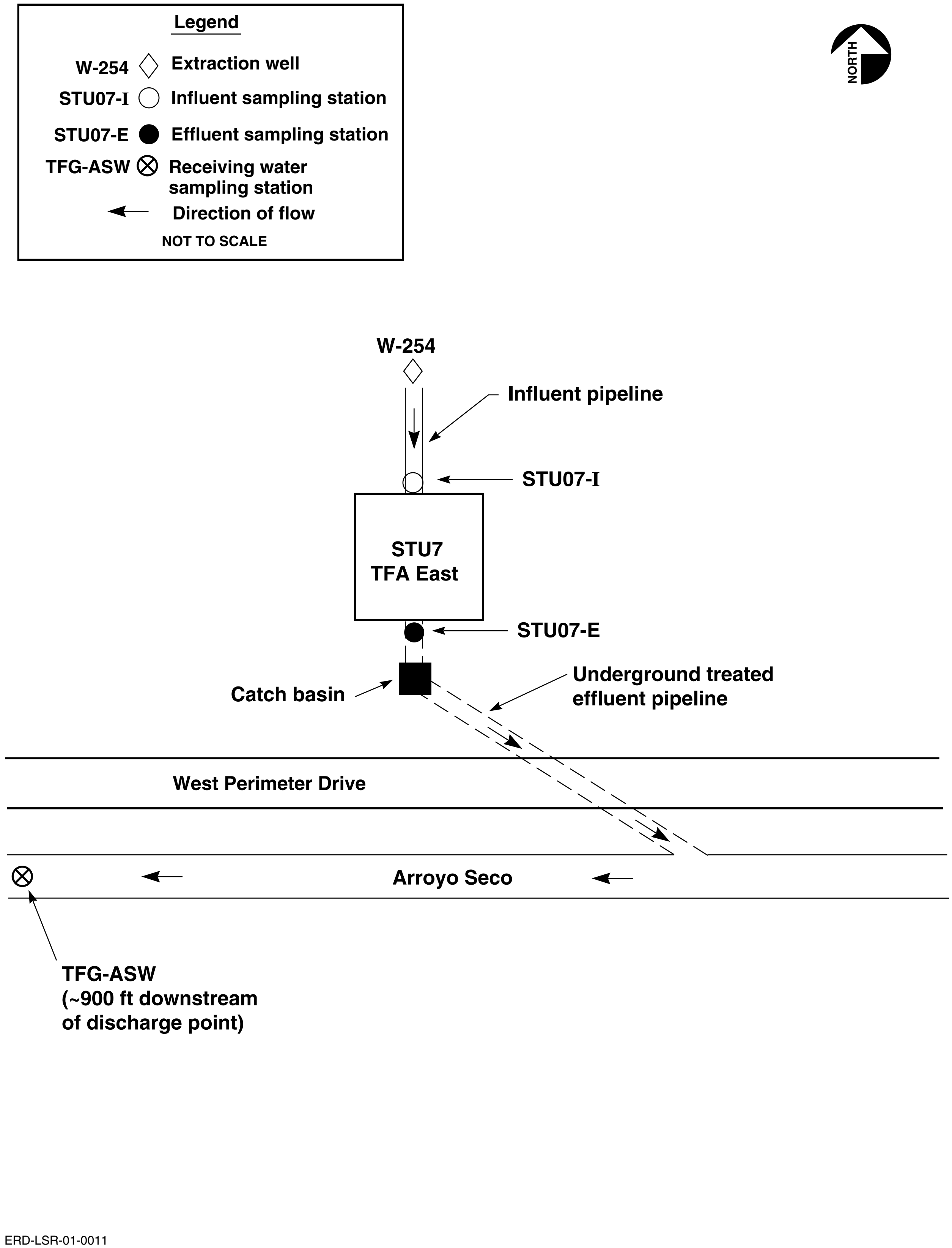

Figure 18. TFA East extraction well, pipelines and discharge location.

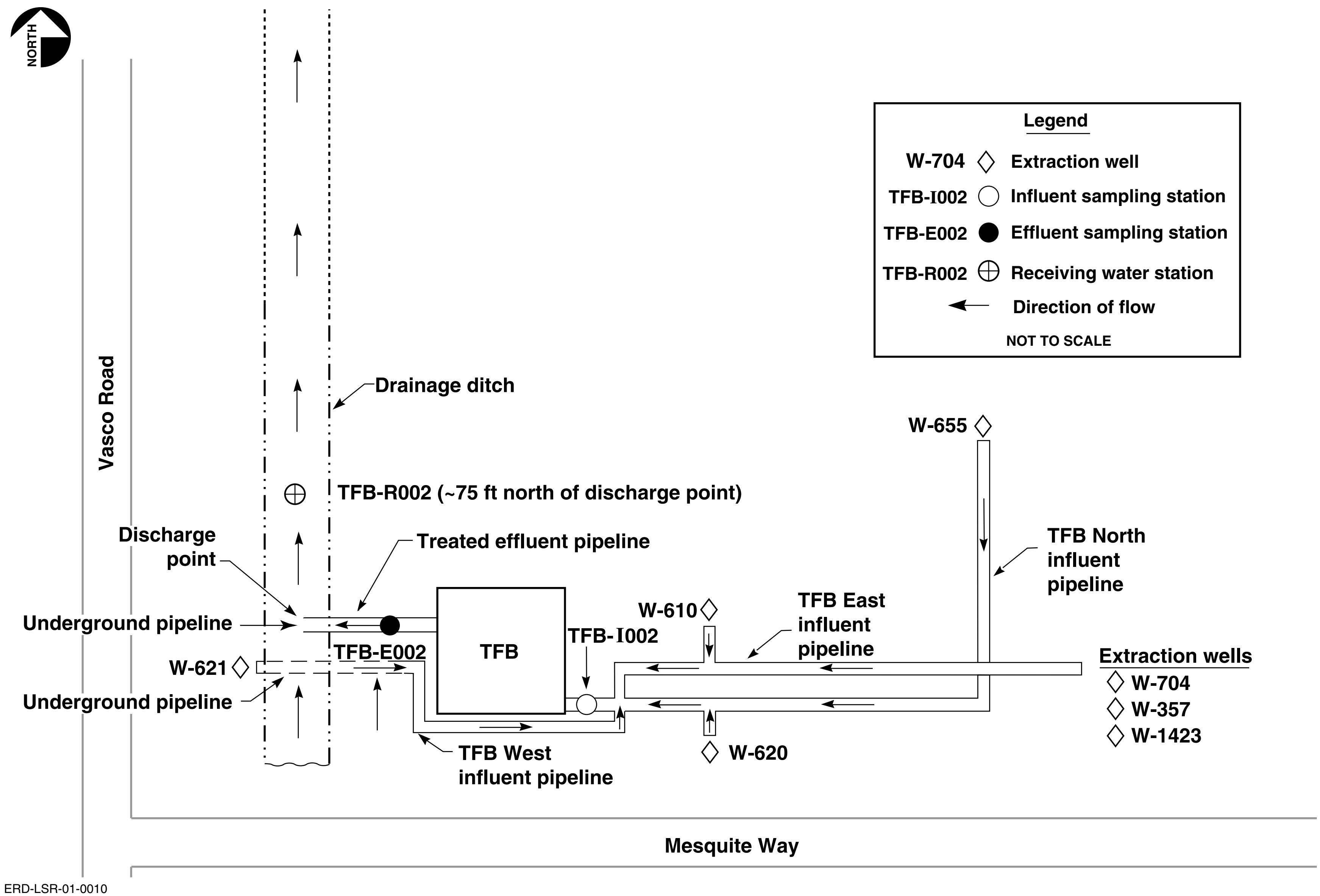

Figure 19. TFB extraction wells, pipelines and discharge location.

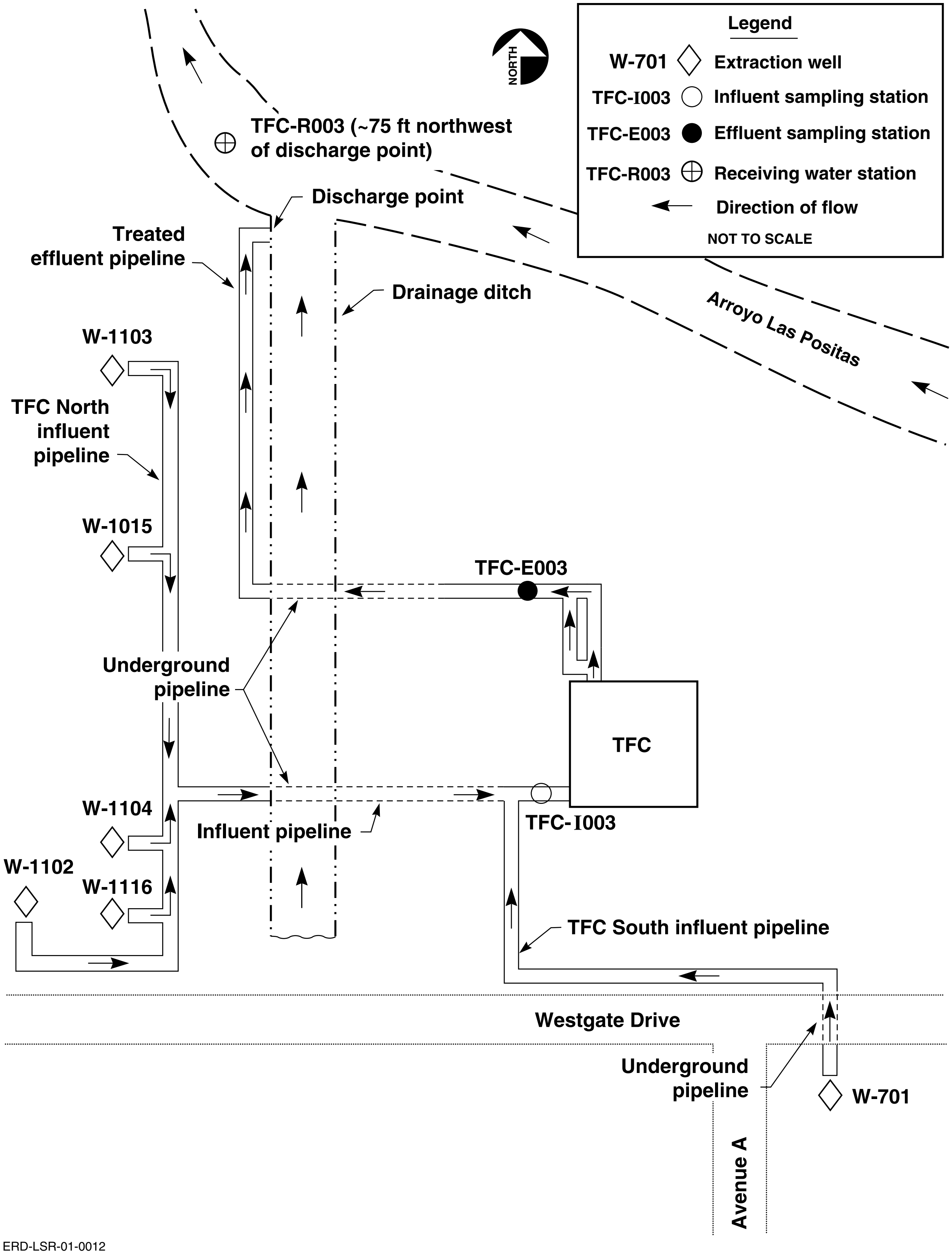

Figure 20. TFC extraction wells, pipelines and discharge location.

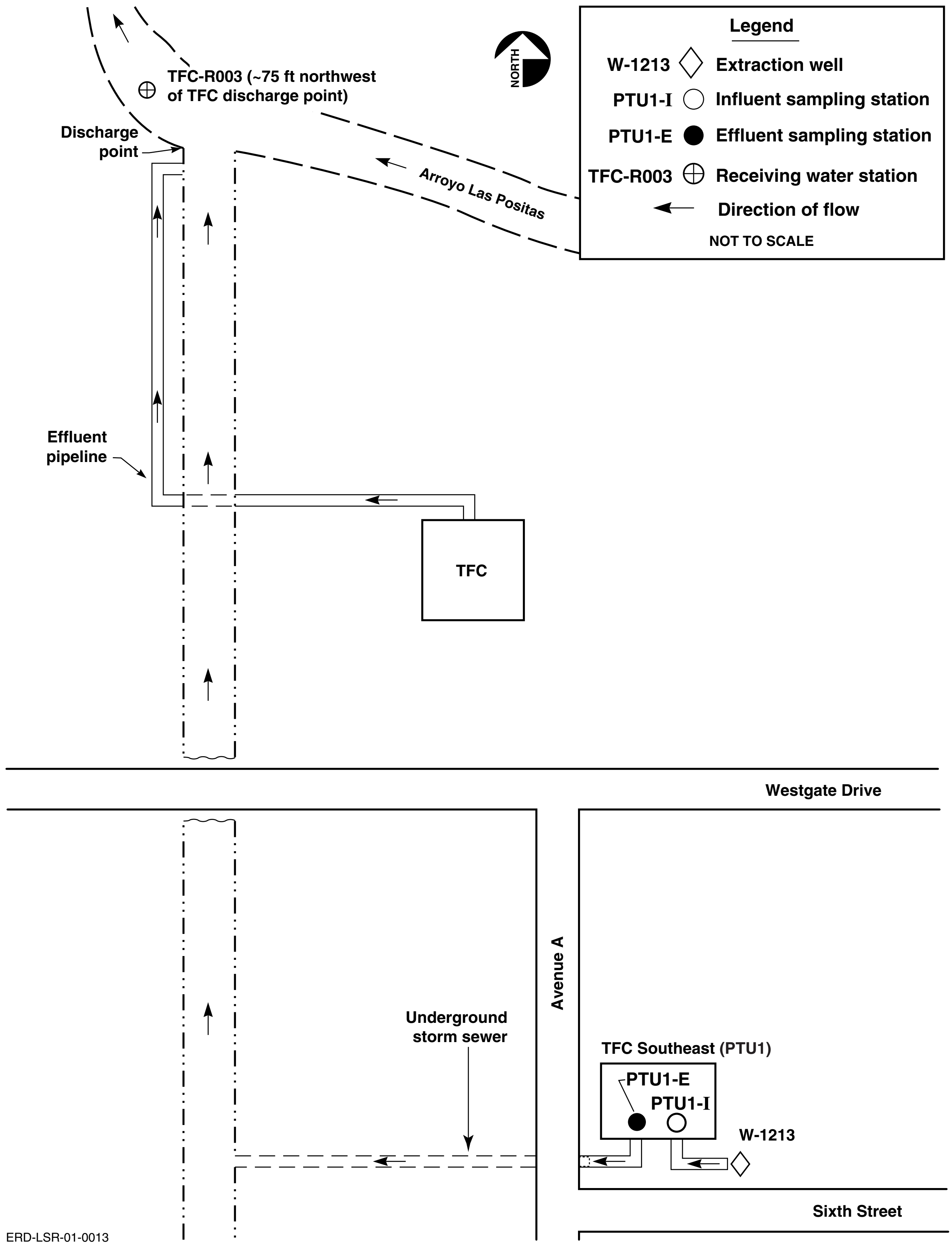

Figure 21. TFC Southeast extraction well, pipelines and discharge location.

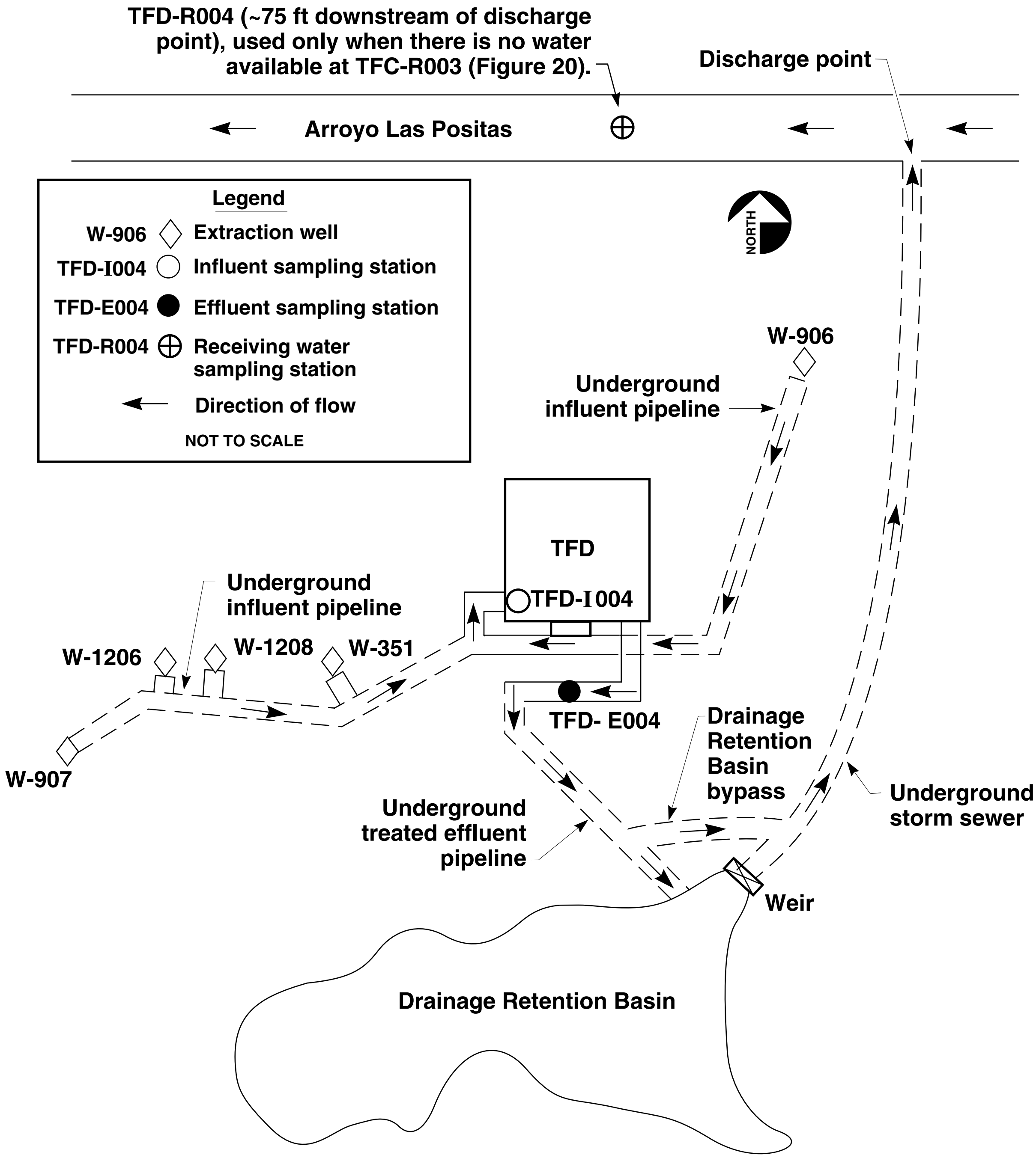

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Figure 22. TFD extraction wells, pipelines and discharge locations.

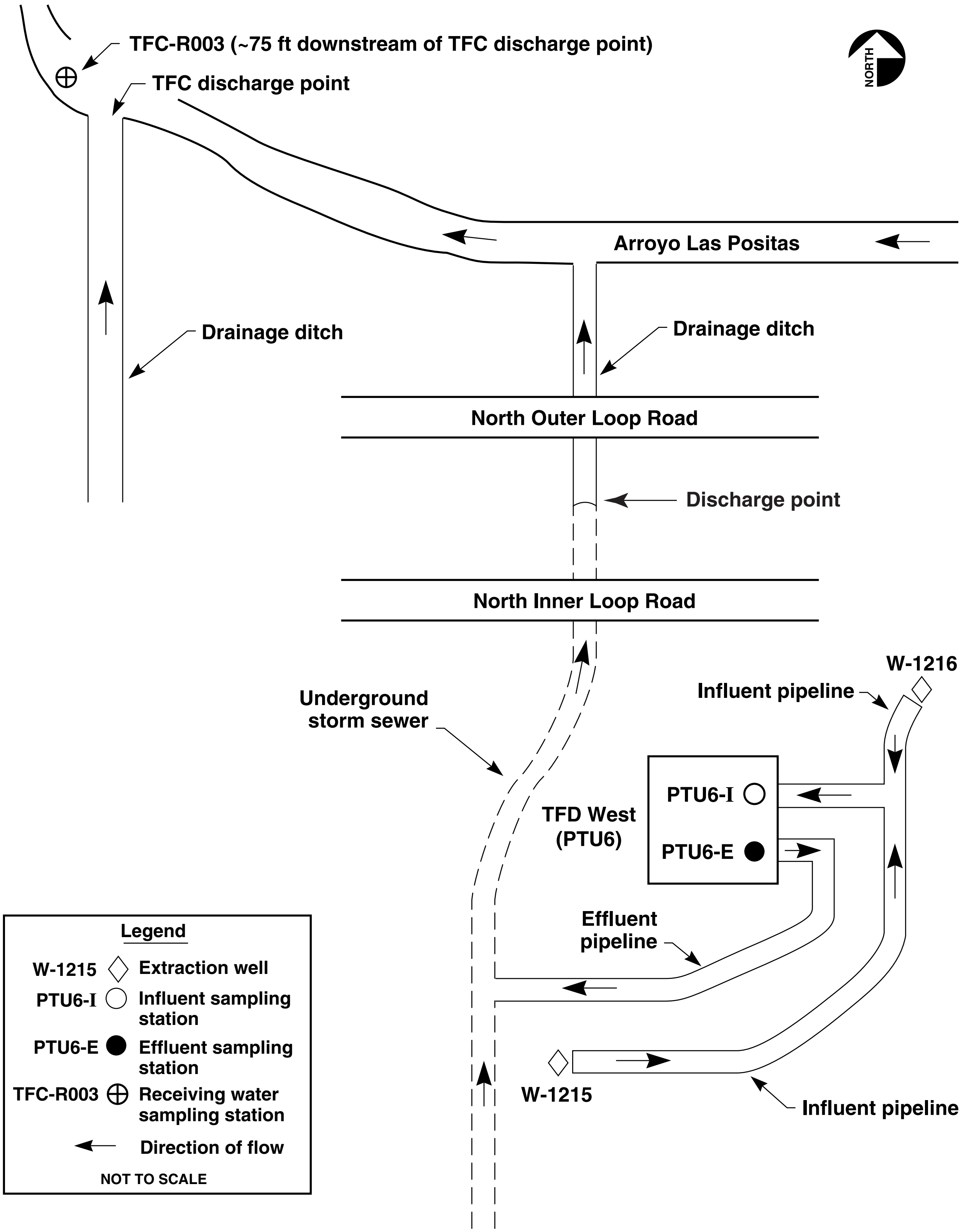

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Figure 23. TFD West extraction wells, pipelines and discharge location.

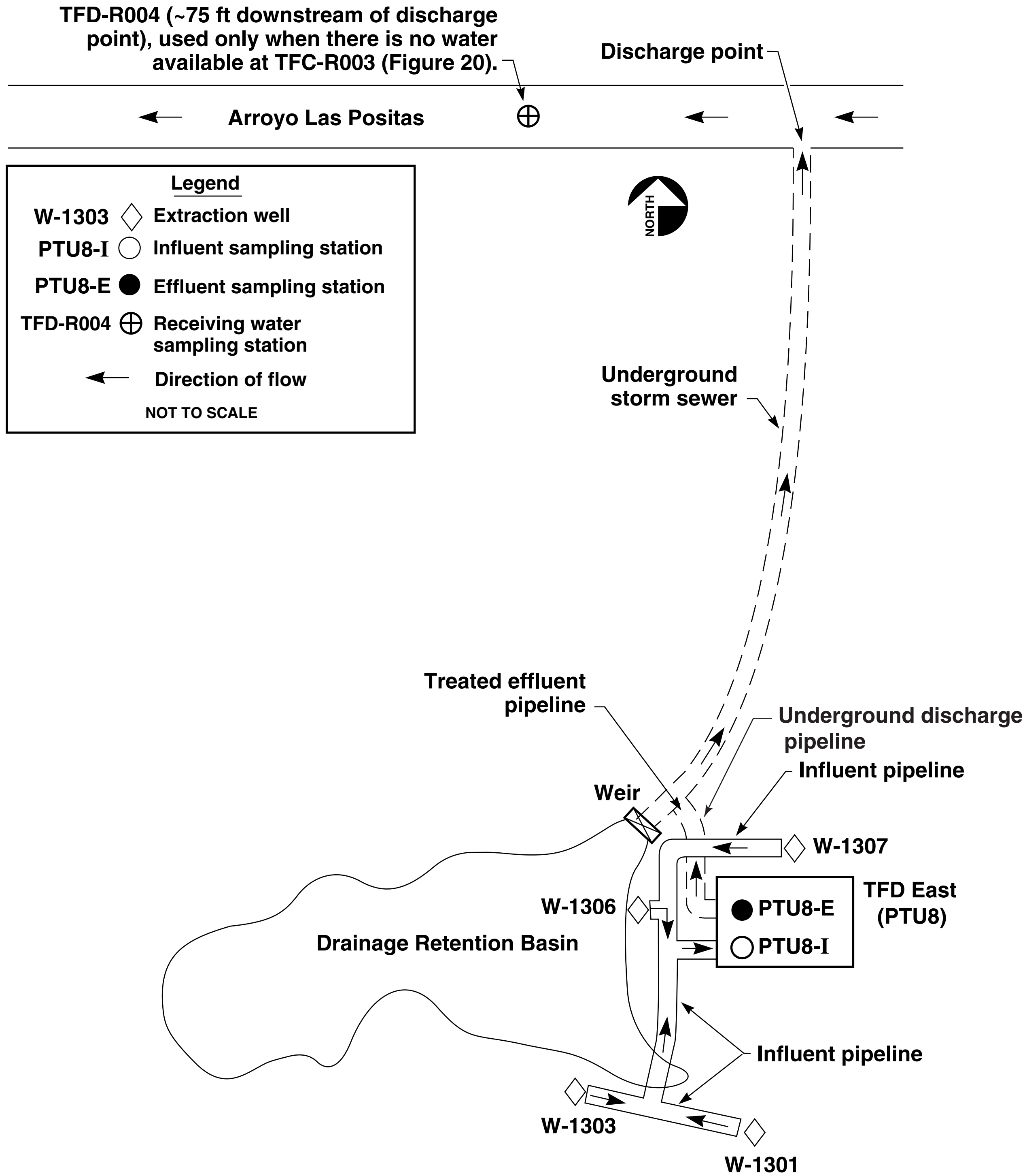

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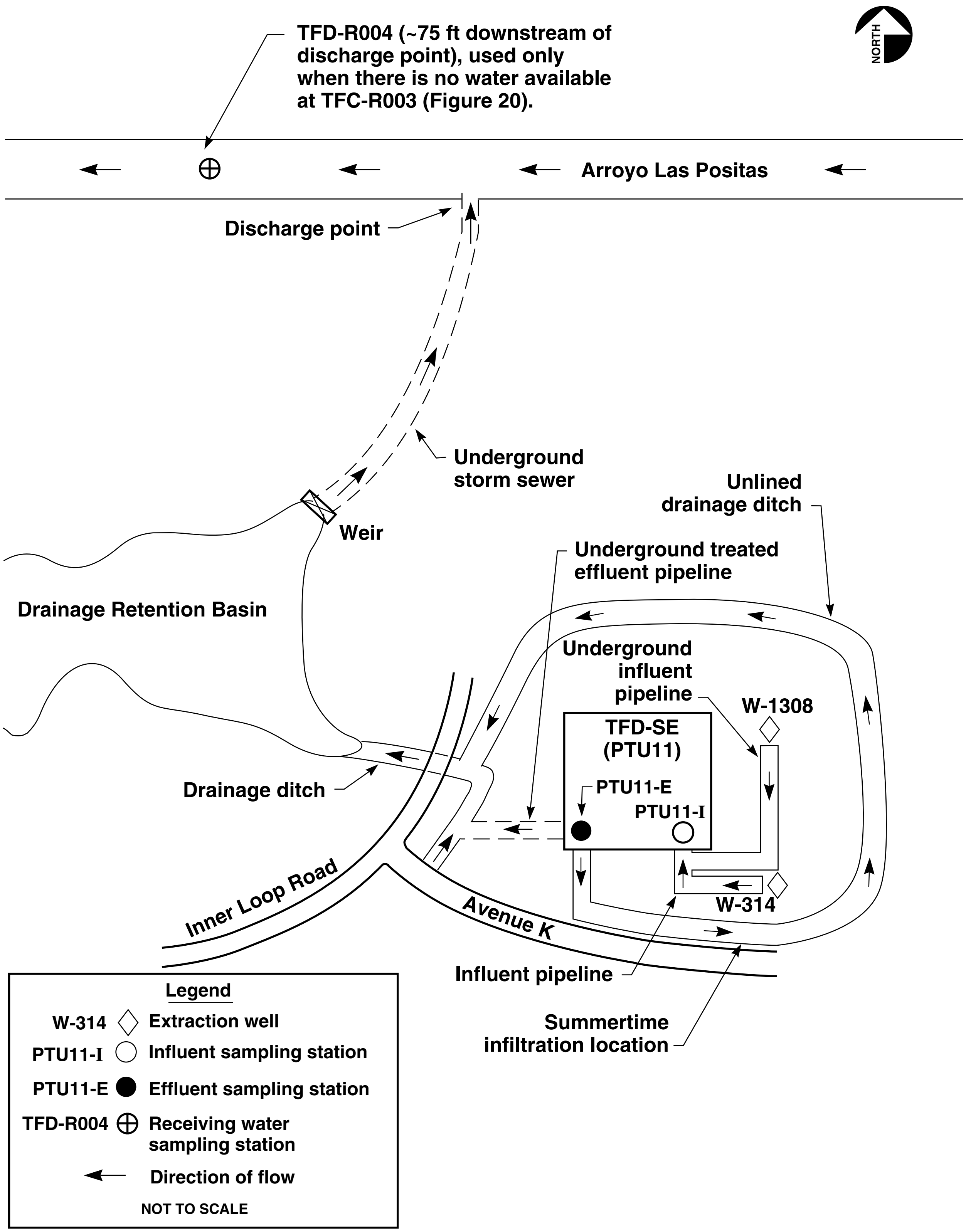
Figure 24. TFD East extraction wells, pipelines and discharge location.



ERD-LSR-01-0018

Figure 25. TFD Southeast extraction wells, pipelines and discharge locations.

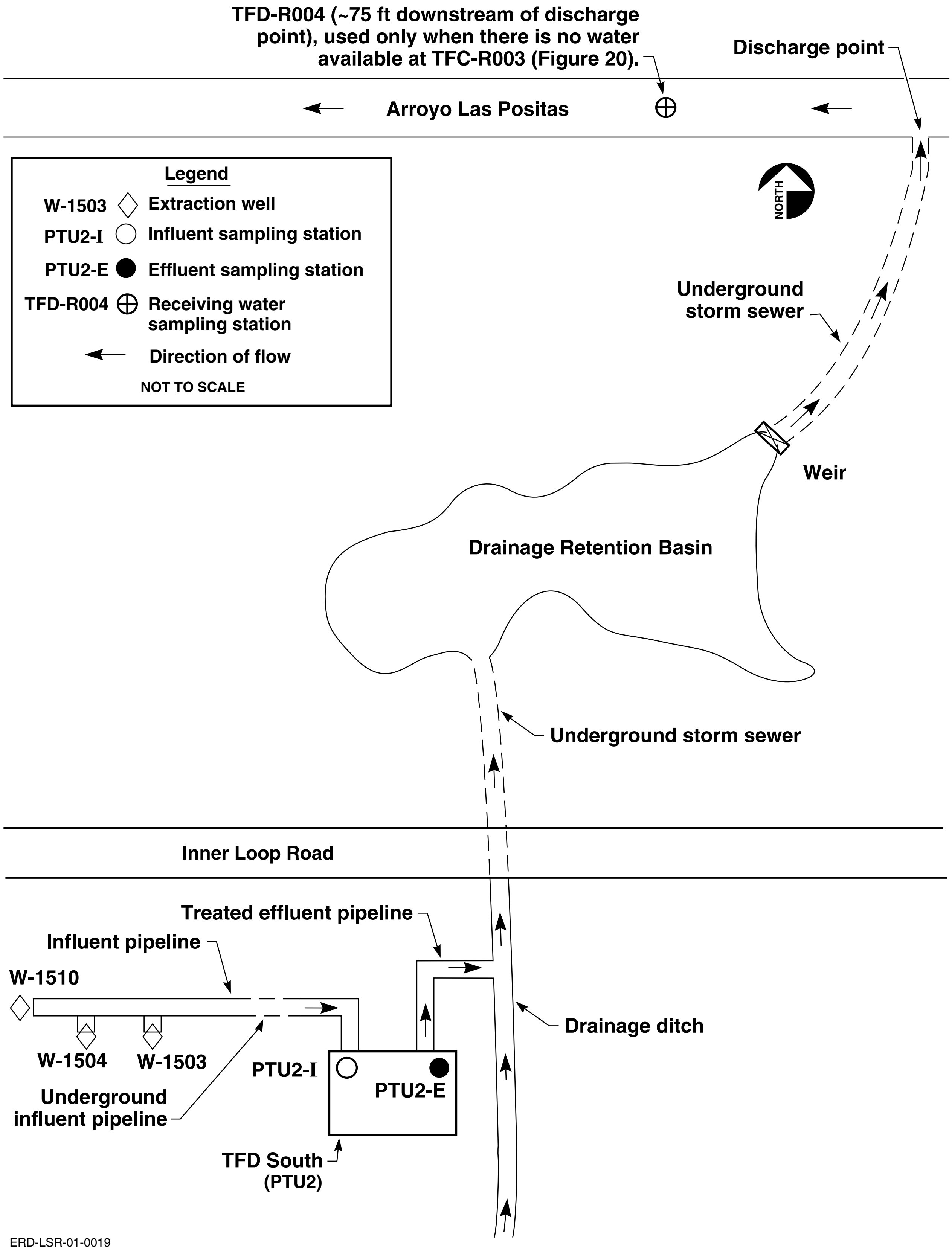


Figure 26. TFD South extraction wells, pipelines and discharge location.

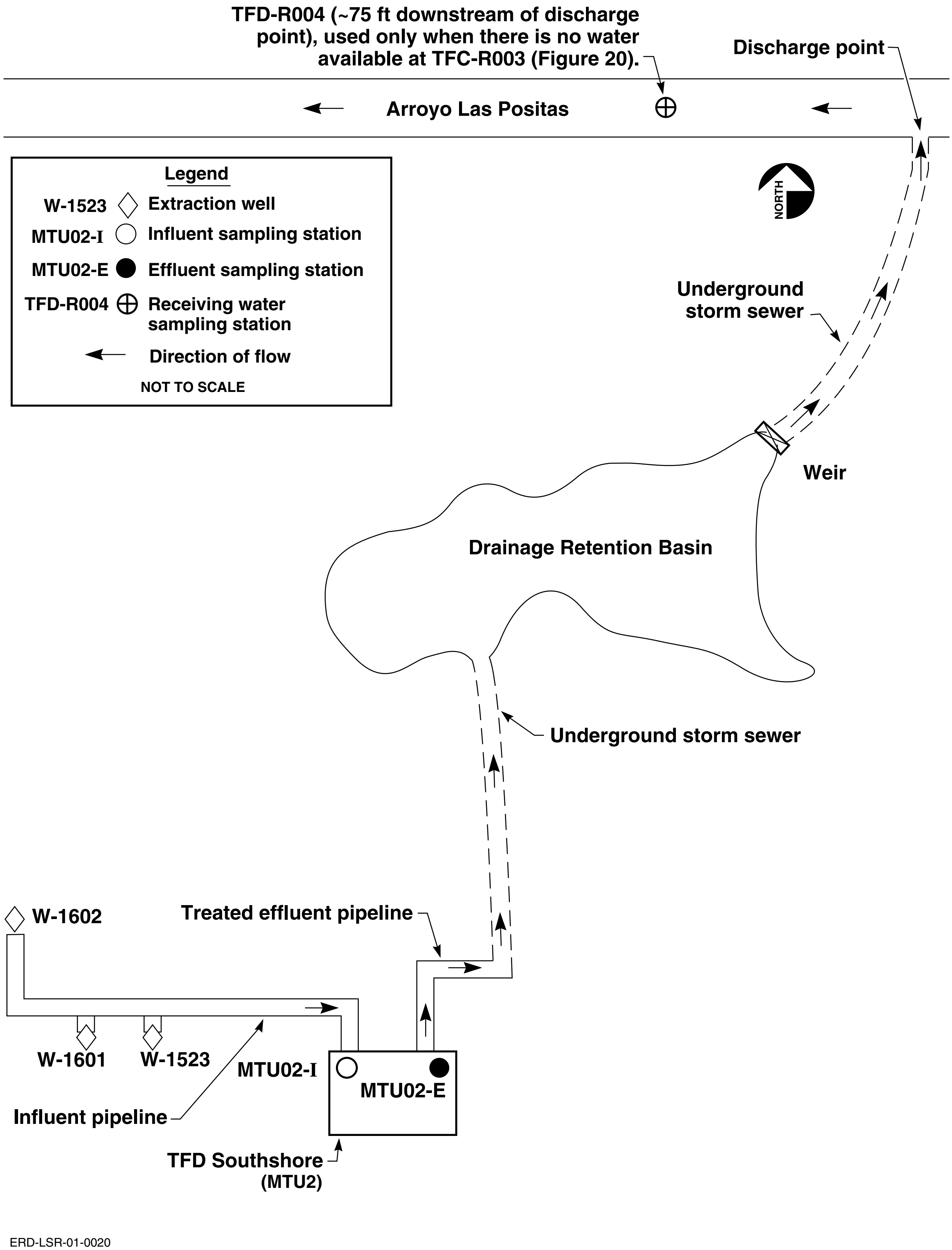
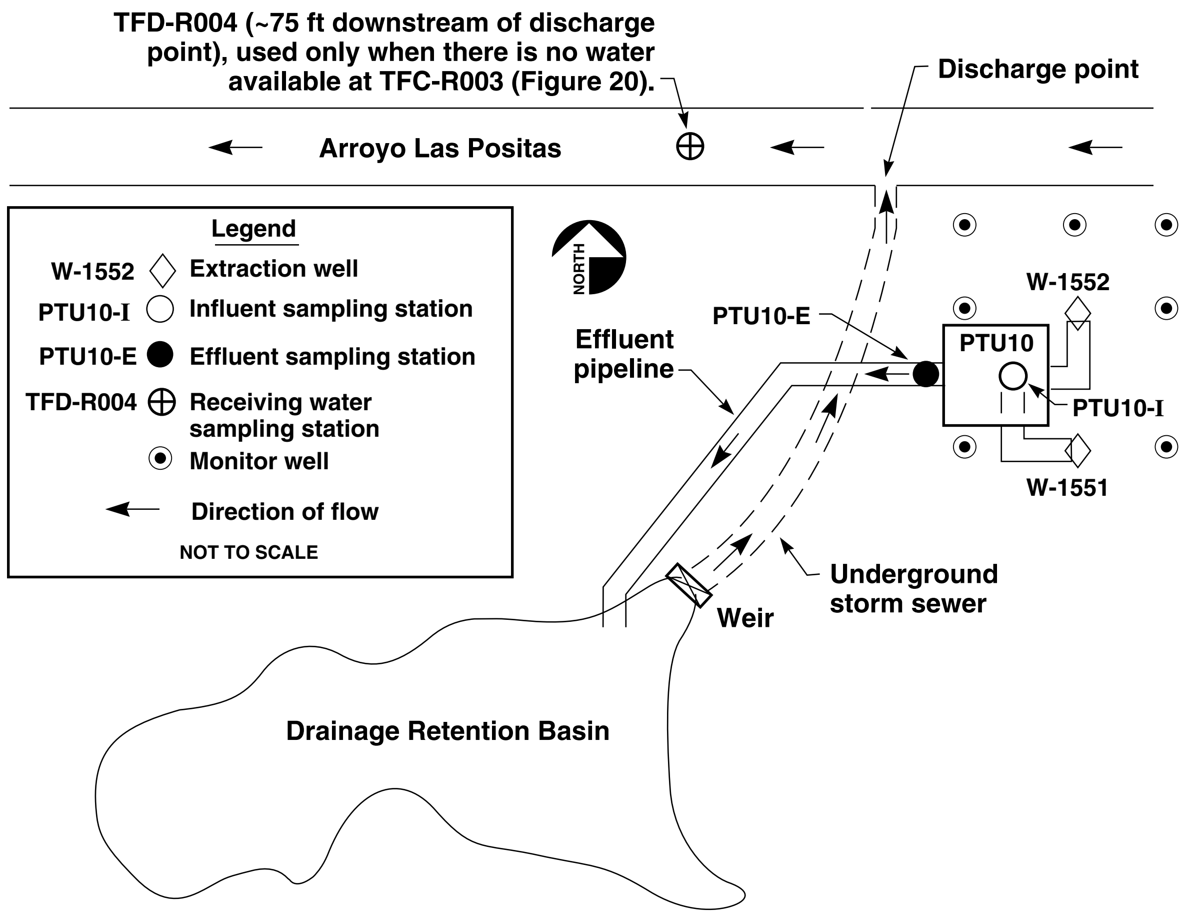


Figure 27. TFD Southshore extraction wells, pipelines and discharge location.



ERD-LSR-01-0028

Figure 28. TFD PTU10 extraction wells, pipelines and discharge location.

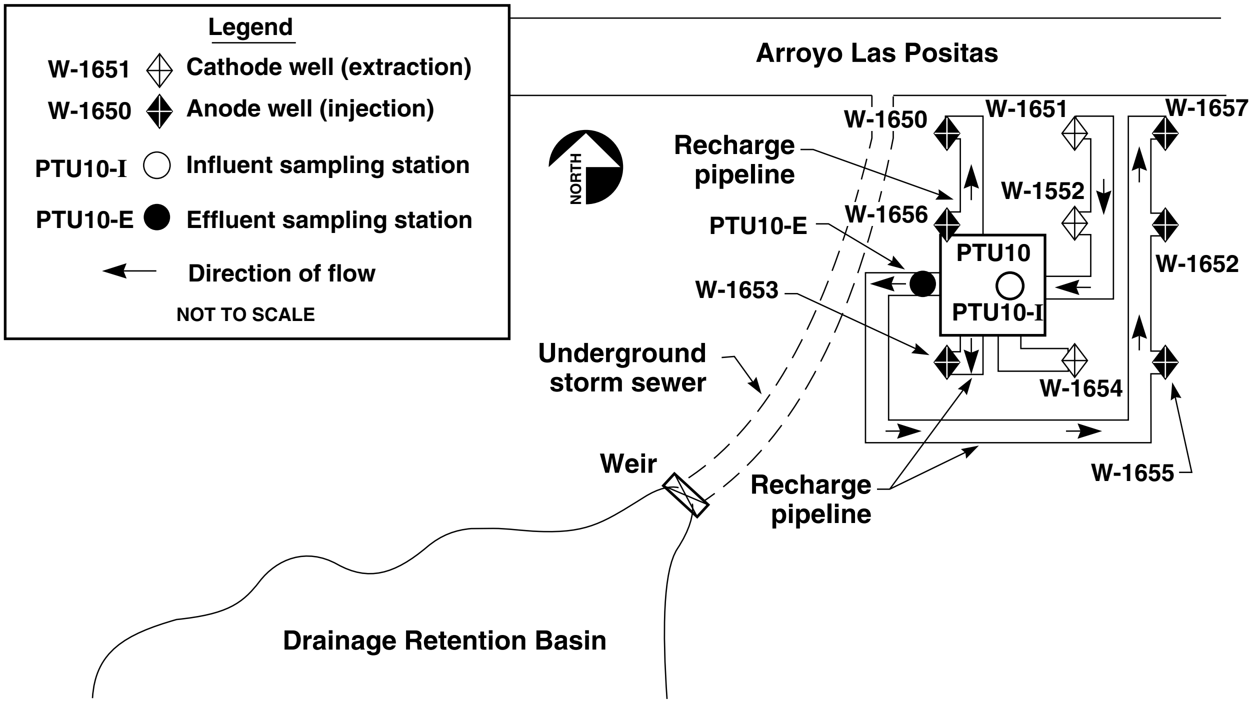
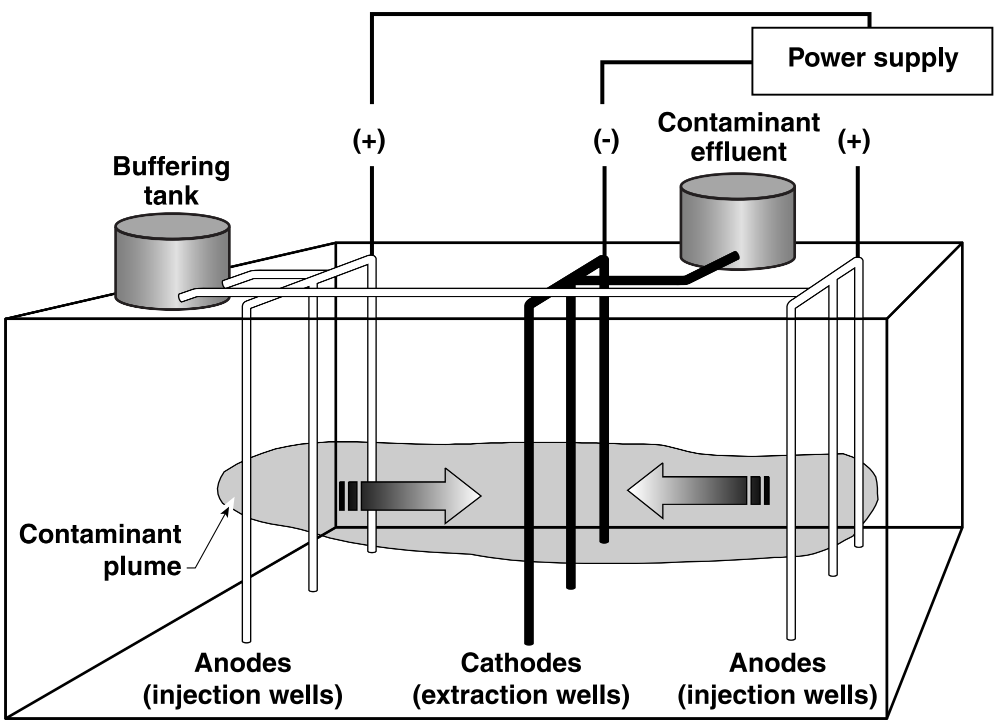
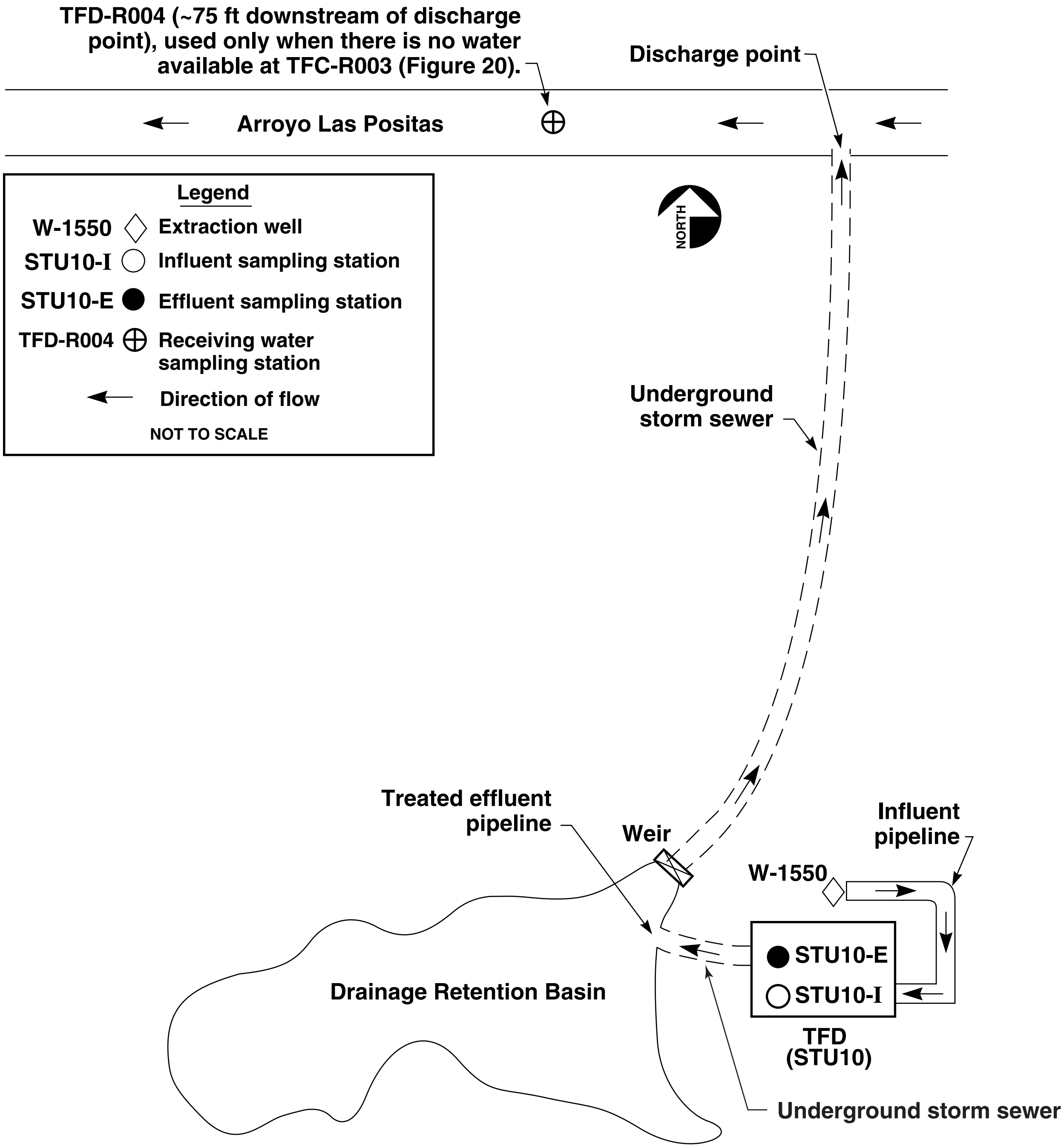


Figure 29A. TFD PTU10 wells and pipeline configuration for the electro-osmosis system.



ERD-LSR-01-0062

Figure 29B. Electro-osmosis schematic diagram.



ERD-LSR-01-0017

Figure 30. TFD STU10 extraction well, pipeline and discharge location.

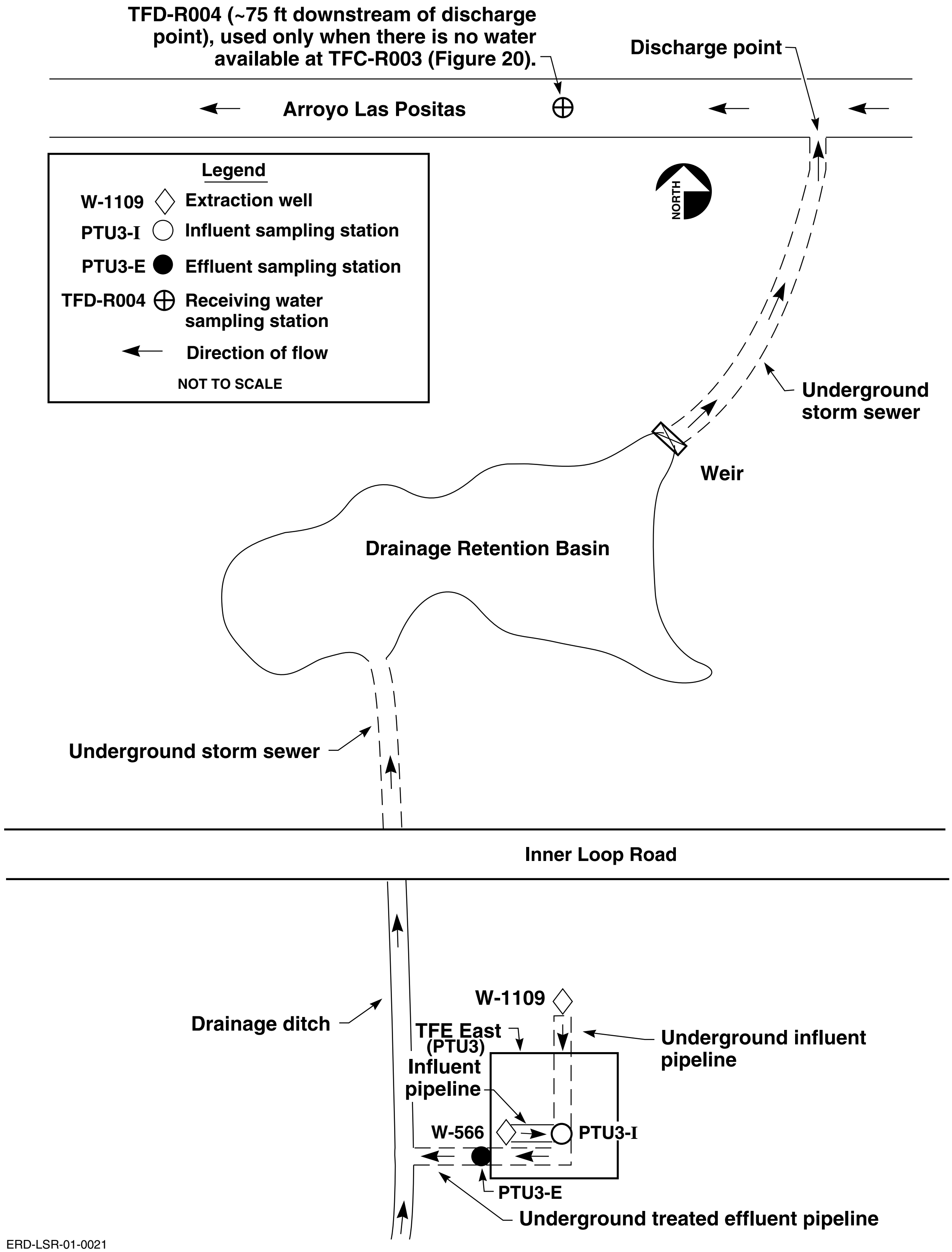


Figure 31. TFE East extraction wells, pipelines and discharge location.

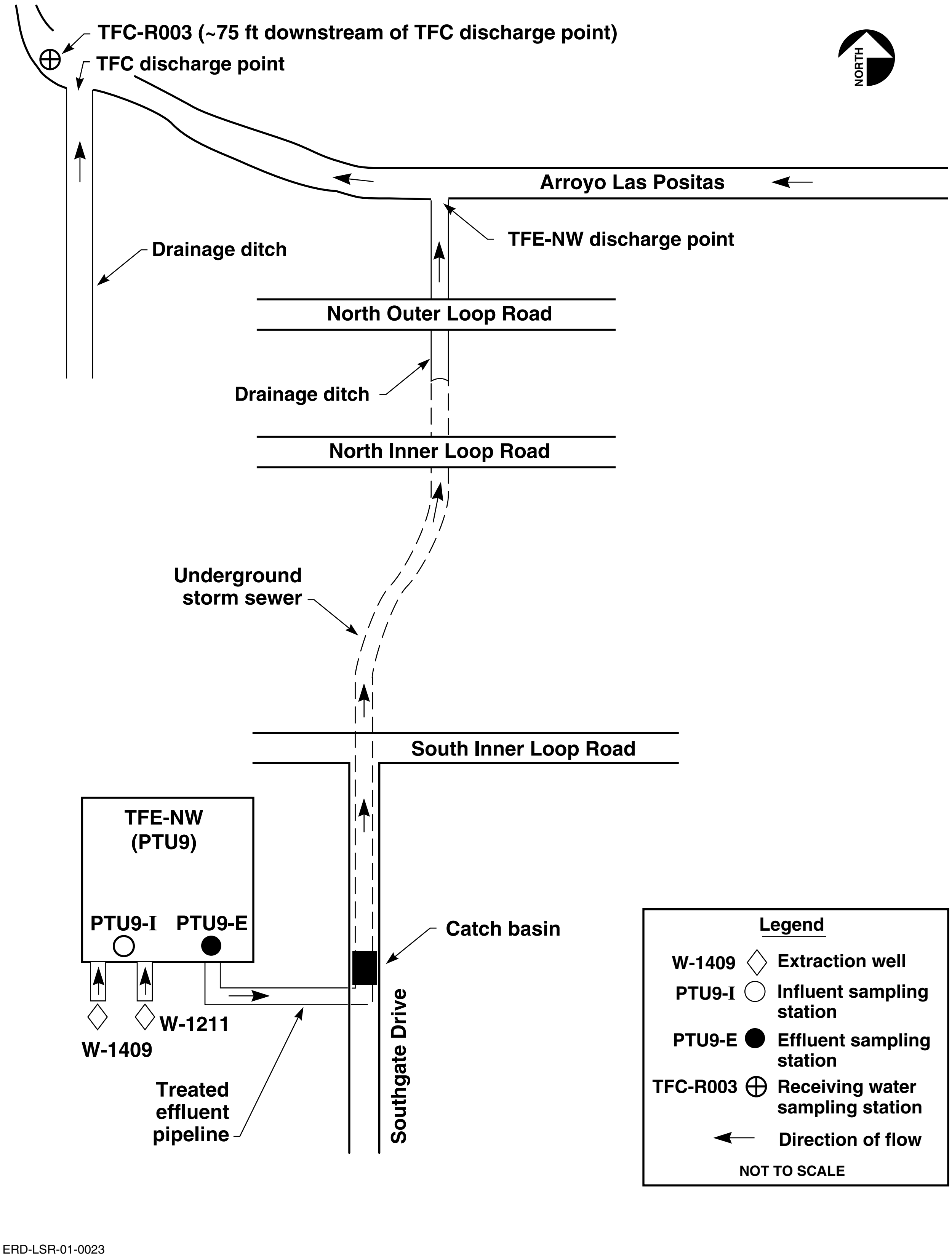


Figure 32. TFE Northwest extraction wells, pipelines and discharge location.

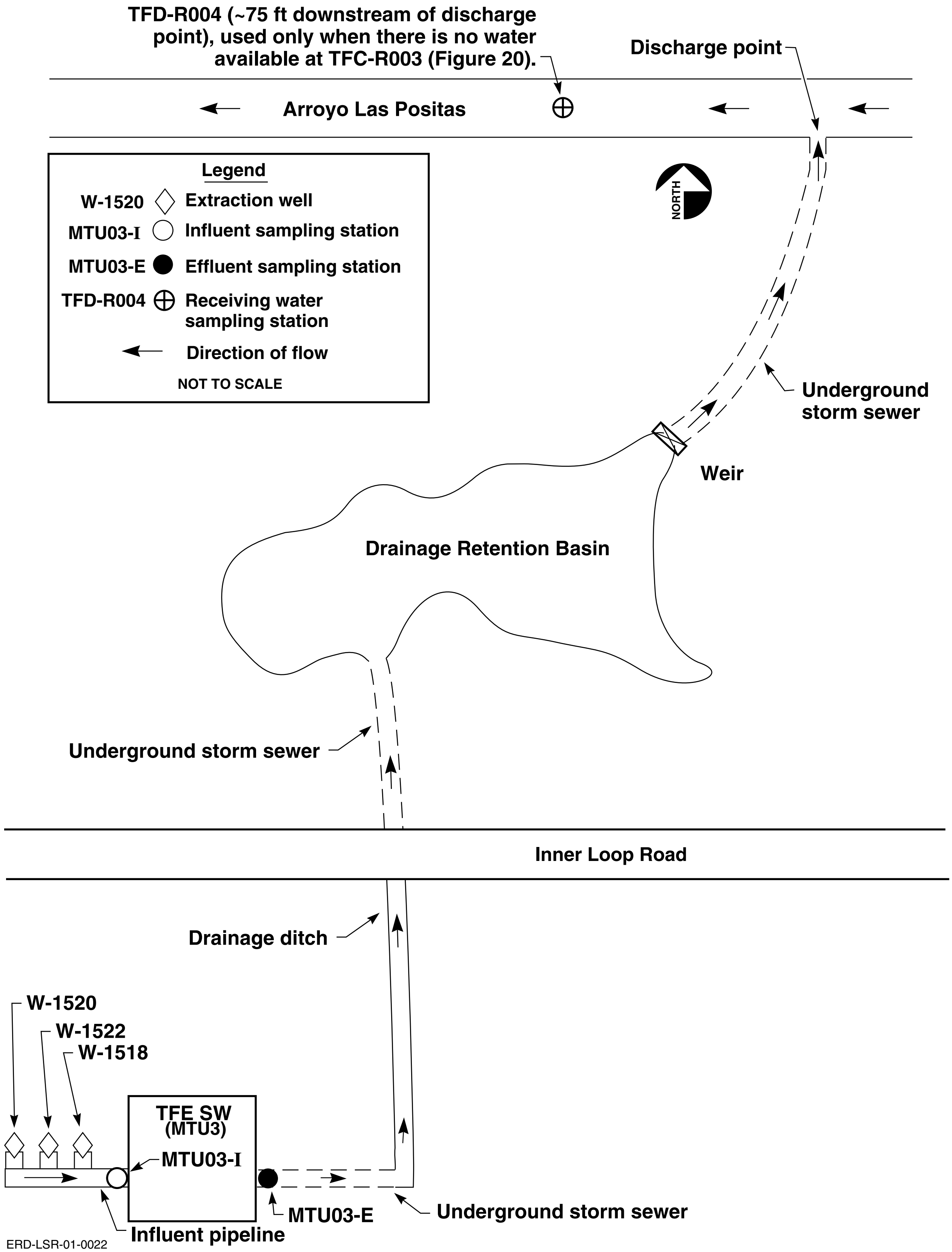
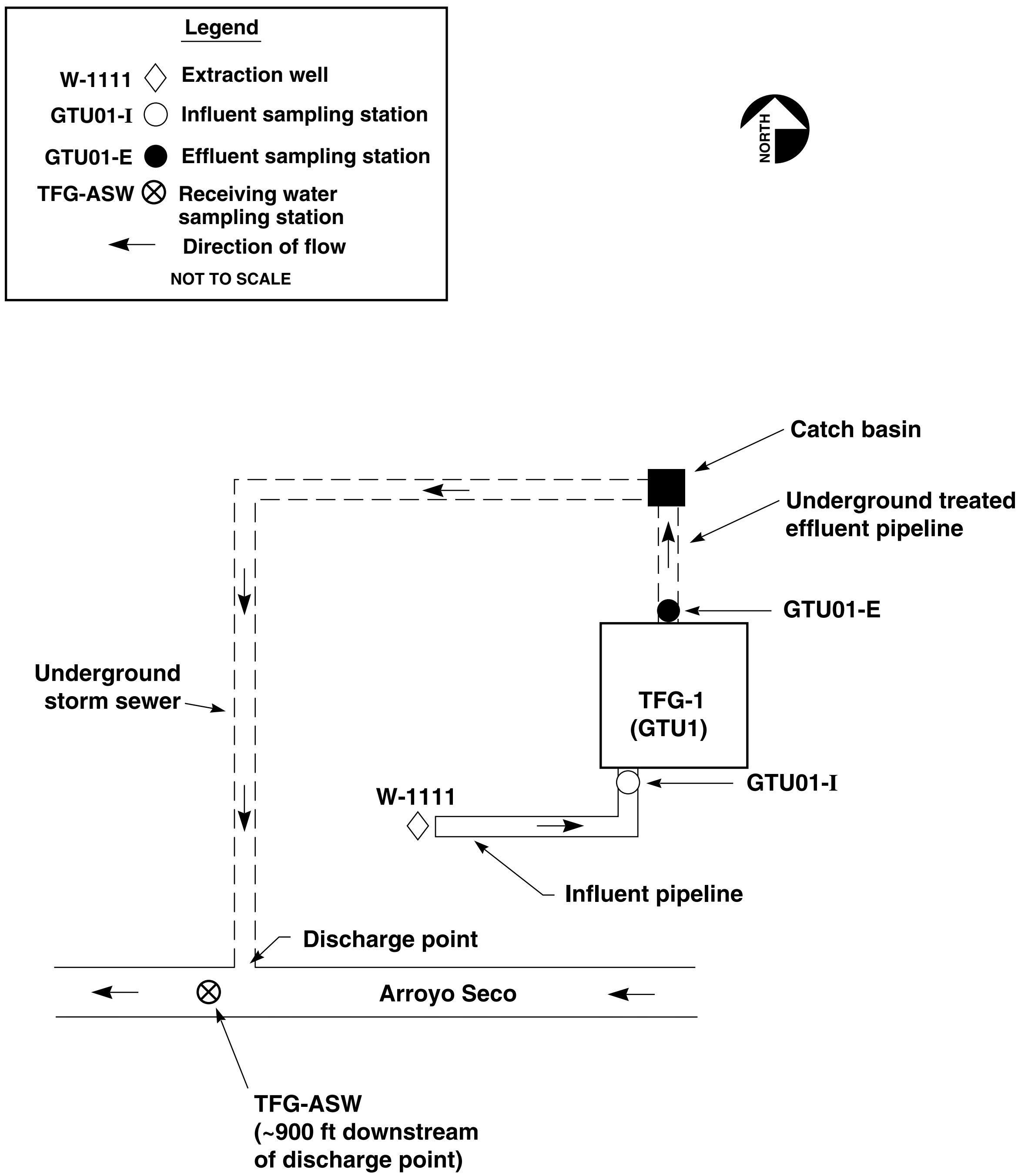


Figure 33. TFE Southwest extraction wells, pipelines and discharge location.



ERD-LSR-01-0024

Figure 34. TFG-1 extraction well, pipelines and discharge location.

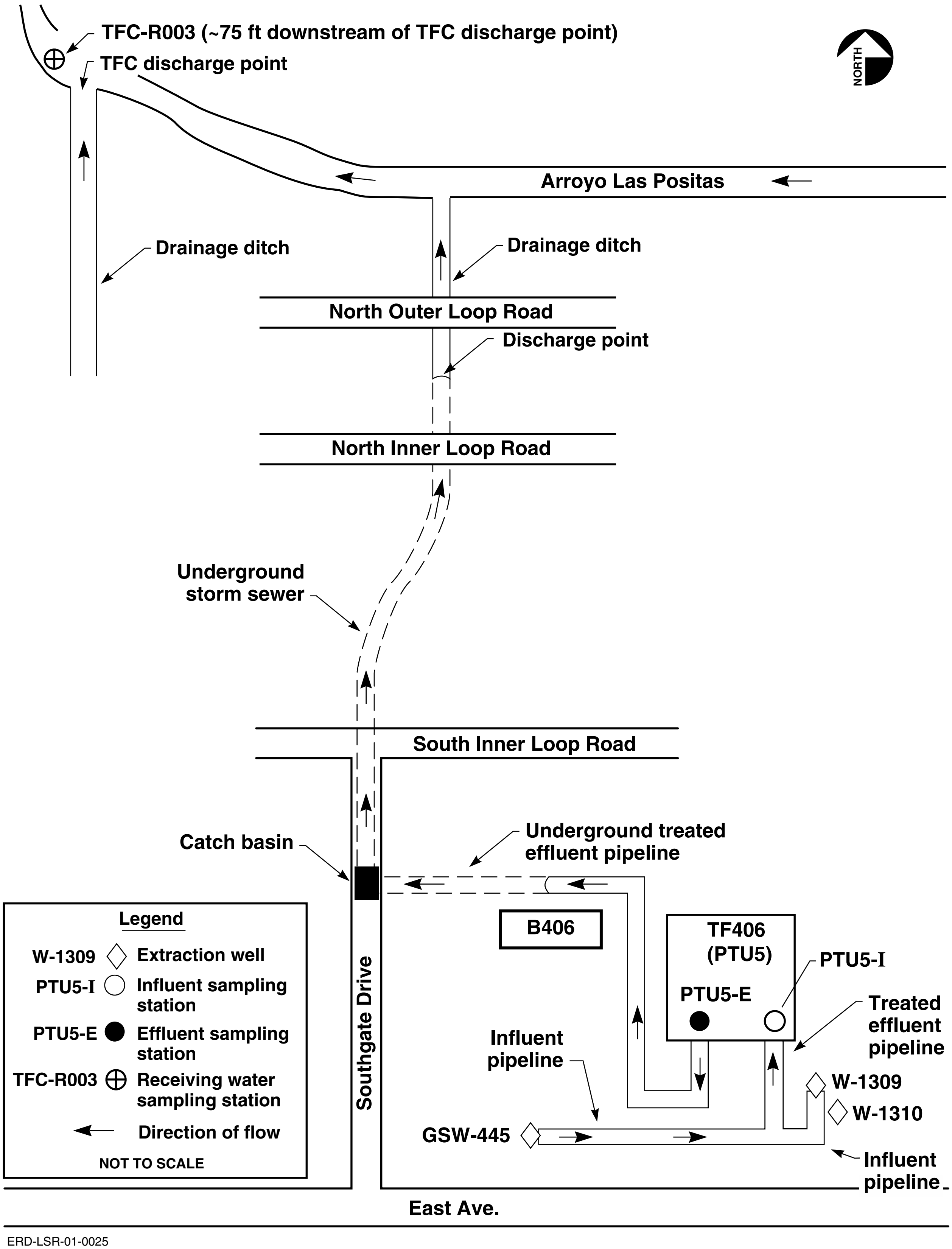


Figure 35. TF406 extraction wells, pipelines and discharge location.

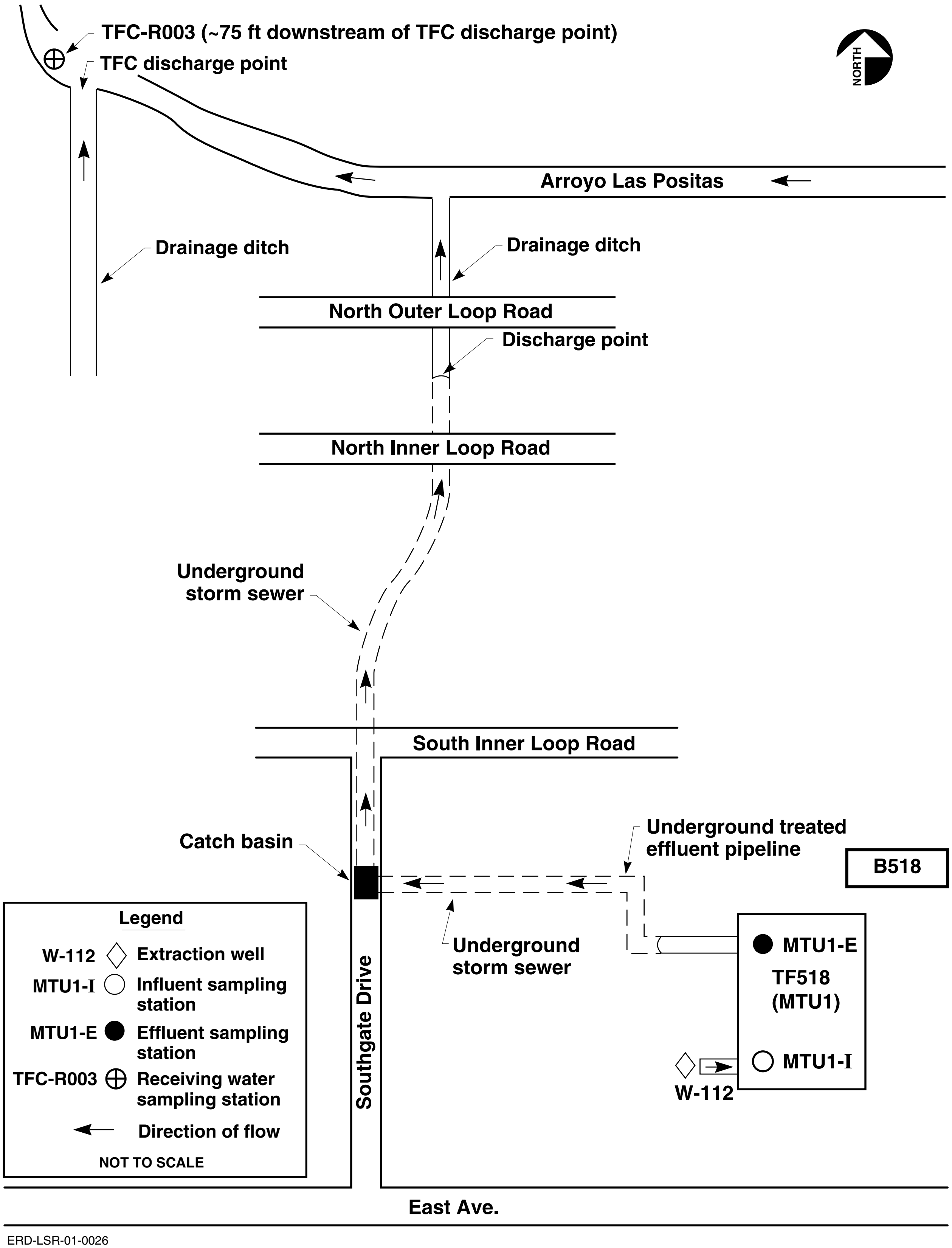


Figure 36. TF518 extraction well, pipelines and discharge location.

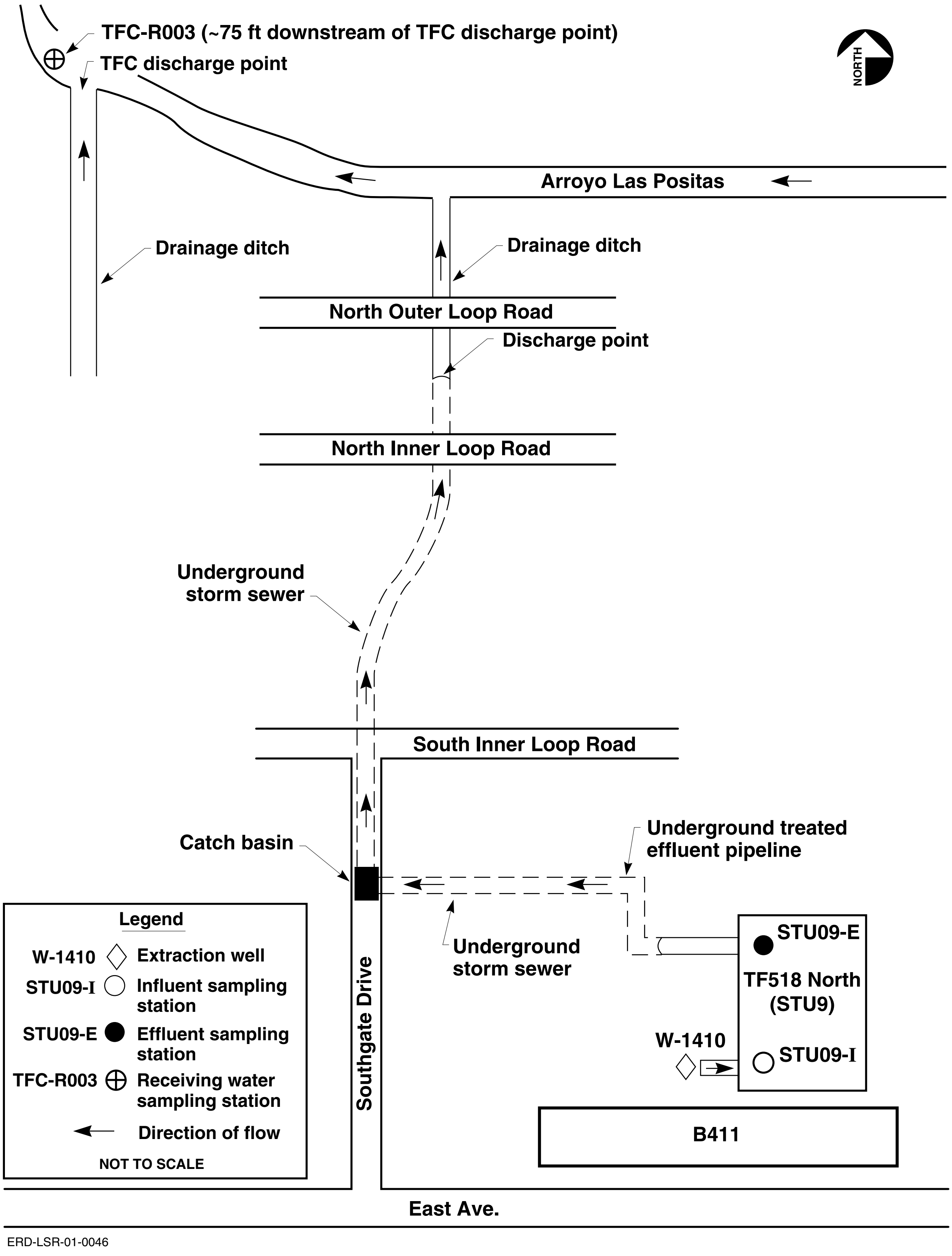


Figure 37. TF518 North extraction well, pipeline and discharge location.

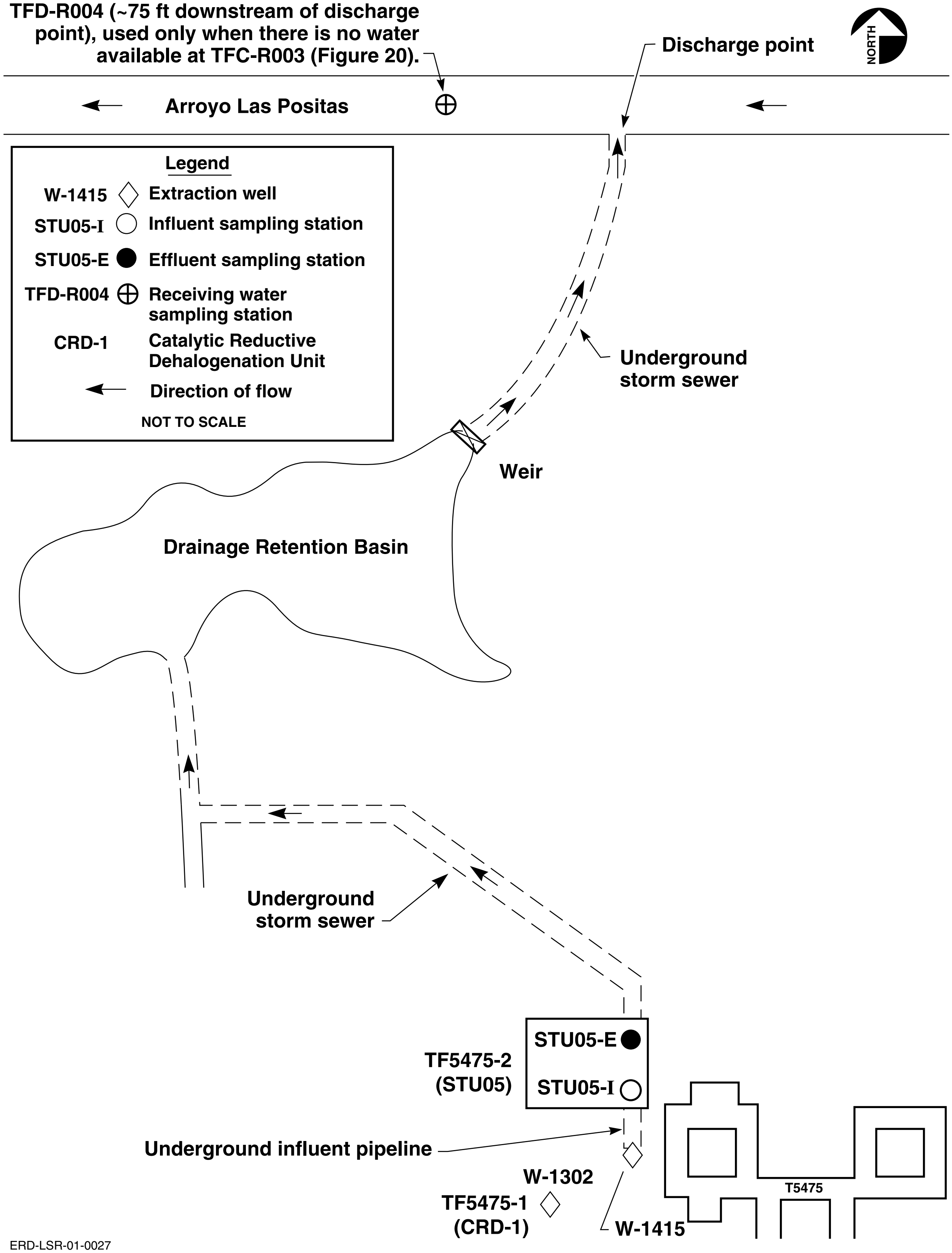


Figure 38. TF5475-2 extraction well, pipeline and discharge location.

Tables

Table 1. 2000 Livermore Site Remedial Action Implementation Plan milestones.

Milestone	Milestone date	Completion date
Begin operation of TF518 North solar treatment unit	01/28/00	01/26/00
Begin operation of Treatment Facility D Southshore miniature treatment unit (MTU)	03/31/00*	06/30/00*
Begin operation of Treatment Facility E Southeast MTU	06/30/00	06/27/00
Begin operation of TF5475-3 catalytic reductive dehalogenation unit	09/29/00	09/27/00

*Delayed with regulatory agency concurrence.

Table 2. Summary of 2000 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	141.6	–	13.8
TFB	27.6	–	7.1
TFC	24.9	–	7.9
TFD	66.3	–	107
TFE	28.1	–	23.8
TFG	3.9	–	0.8
TF406	12.5	–	1.6
TF5475	0.1	–	0.9
VTF5475	–	7,549	102
TF518	2.9	–	1.7
VTF518	–	138	2.8
Total	307.9	7,687	269.4

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	793.7	–	137.0
TFB	141.4	–	45.0
TFC	108.4	–	40
TFD	250.2[a]	–	342[a]
TFE	81.2	–	95
TFG	13.9	–	2.7
TF406	34.6	–	5.8
TF5475	0.31	–	3.2
VTF5475	–	9,642	197.7
TF518	6.6	–	3.0
VTF518	–	14,907	150.1
Total	**1,430**	**24,549**	**1,021.5**

Notes:

kg = Kilograms.

Kft^3 = Thousands of cubic feet.

Mgal = Millions of gallons.

[a] Includes data from field-scale pilot tests.

Table 4. Summary of 2000 ground water discharged to the Recharge Basin.

Treatment facility area	Facility	Volume of ground water discharged (Mgal)	Maximum flow rate (gpm)	Estimated average flow rate (gpm)
TFA	TFA	143	350	267
Total		**143 Mgal**		**267 gpm**

Notes:

gpm = Gallons per minute.

Mgal = Millions of gallons.

Table 5. Summary of 2000 ground water discharged to Arroyo Las Positas.

Treatment facility area	Facility	Volume of ground water discharged (Mgal)	Maximum flow rate (gpm)	Estimated average flow rate (gpm)
TFB	TFB	27.6	90	57
TFC	TFC	20.5	60	43
TFC-SE	PTU1	4.3	6	8.2
TFD	TFD	24.2	70	46
TFD-West	PTU6	6.9	21	13
TFD-East	PTU8	8.6	25	16
TFD-South	PTU2	13.2	25	25
TFD-Southeast	PTU11	10.9	25	21
TFD-Helipad	PTU10	1.6	5	4.6
TFD	STU10	1.2	3	2.5
TFD-Southshore	MTU2	1.1	20	9.9
TFE-East	PTU5	9.0	45	14.6
TFE	PTU4	6.3	30	12
TFE-Northwest	PTU9	11.2	45	23
TFE-Southwest	MTU3	1.6	25	7.3
TF406	PTU5	12.5	45	24
TF5475-2	STU05	0.07	1.5	1.5
TF518	MTU1	0.4	25	1
TF518-North	STU09	2.5	8	4.5
Total		163.7 Mgal		344 gpm

Notes:

gpm = Gallons per minute.

Mgal = Millions of gallons.

Table 6. Summary of 2000 ground water discharged to the Arroyo Seco.

Treatment facility area	Facility	Volume of ground water discharged (Mgal)	Maximum flow rate (gpm)	Estimated average flow rate (gpm)
TFA-E	STU07	0.4	1.5	0.7
TFG-1	GTU1	3.9	15	8.5
Total		4.3 Mgal		9.2 gpm

Appendix A

Well Construction and Closure Data

Table A-1. Well construction data, LLNL Livermore Site and vicinity, Livermore, California.

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated intervals (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**
W-115	**03-Jun-85**	**106.0**	**95.0**	**88–95**	**1B**	**1.1**

Table A-1. Well construction data, LLNL Livermore Site and vicinity, Livermore, California (Cont.).

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated intervals (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
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. Well construction data, LLNL Livermore Site and vicinity, Livermore, California (Cont.).

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated intervals (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

Table A-1. Well construction data, LLNL Livermore Site and vicinity, Livermore, California (Cont.).

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated intervals (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
W-303	28-Oct-86	197.0	128.0	124–128	2	15
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

Table A-1. Well construction data, LLNL Livermore Site and vicinity, Livermore, California (Cont.).

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated intervals (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
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
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

Table A-1. Well construction data, LLNL Livermore Site and vicinity, Livermore, California (Cont.).

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated intervals (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
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
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-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-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

Table A-1. Well construction data, LLNL Livermore Site and vicinity, Livermore, California (Cont.).

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated intervals (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
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
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

Table A-1. Well construction data, LLNL Livermore Site and vicinity, Livermore, California (Cont.).

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated intervals (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
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
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-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

Table A-1. Well construction data, LLNL Livermore Site and vicinity, Livermore, California (Cont.).

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated intervals (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
W-1014	12-Jul-94	99.0	89.0	65–89	1B	30
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-1207	13-Dec-95	92.0	90.0	70–90	2	<0.5
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-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
W-1227	09-Oct-96	200.0	134.0	126–134	2	11

Table A-1. Well construction data, LLNL Livermore Site and vicinity, Livermore, California (Cont.).

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated intervals (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
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-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
W-1502	28-Oct-98	204.0	98.7	88–98	2	1.7

Table A-1. Well construction data, LLNL Livermore Site and vicinity, Livermore, California (Cont.).

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated intervals (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
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-1519	28-Jul-99	245	238	222–237	5	30
W-1553	12-Aug-99	153	130	98–125	3A/3B	0.5
W-1604	30-Nov-99	194	148.7	138–148	4	8
W-1605	07-Mar-00	120.5	112	90–107	3A	<0.5
W-1607	10-Feb-00	155.4	112	90–107	3A	<0.5
W-1609	17-Apr-00	155	135	110–130	5	0.5
W-1610	04-May-00	155.3	135	110–130	5	0.5
W-1613	27-Apr-00	219	174.3	168.5–173.5	3B	7
W-1614	18-May-00	100	89.8	79–89	1B	3
W-1615	17-Aug-00	55	48	15–48	1B/2	NA
W-1616	16-Aug-00	55	NA	NA	1B/2	NA
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
GSW-1A	12-Jun-86	208.0	133.0	115–133	3B	12

Table A-1. Well construction data, LLNL Livermore Site and vicinity, Livermore, California (Cont.).

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated intervals (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
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. Well construction data, LLNL Livermore Site and vicinity, Livermore, California (Cont.).

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated intervals (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
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. Well construction data, LLNL Livermore Site and vicinity, Livermore, California (Cont.).

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated intervals (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
HW-GP-003	20-May-92	119.0	76.5	66.5–76.5	2	NA
			119.0	109–119	3A	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						
GSW-445	09-Dec-87	319.0	161.0	155–161	4	3
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

Table A-1. Well construction data, LLNL Livermore Site and vicinity, Livermore, California (Cont.).

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated intervals (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
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
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-1206	06-Dec-95	220.0	191.0	174–186	4	40+
W-1208	09-Jan-96	166.0	163.0	135–163	3A/3B	40

Table A-1. Well construction data, LLNL Livermore Site and vicinity, Livermore, California (Cont.).

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated intervals (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
W-1211	05-Mar-96	273.0	205.0	185–200	4	25+
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
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-1410	20-Feb-98	205.0	133.0	126–131	3B/4	8
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-1518	6-Jul-99	184	112	84–107	2	3
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-1551	8-Jul-99	153	129	93–124	3A/3B	10.5

Table A-1. Well construction data, LLNL Livermore Site and vicinity, Livermore, California (Cont.).

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated intervals (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
W-1552	27-Jul-99	153.5	130	97–125	3A/3B	2
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-1606	27-Jan-00	175	112	90–107	3A	<0.5
W-1608	25-Feb-00	155	112	90–107	3A	<0.5
W-1650	03-Jan-00	145	126	96–121	3A/3B	2
W-1651	27-Jan-00	145	129	94–124	3A/3B	1
W-1652	09-Feb-00	145	127	92–122	3A/3B	0.33
W-1653	24-Feb-00	145	124.5	93.5–119.5	3A/3B	1.2
W-1654	25-Feb-00	146.5	128	93–123	3A/3B	0.8
W-1655	08-Mar-00	145	125	90–125	3A/3B	1.3
W-1656	14-Mar-00	145	125	95–120	3A/3B	5
W-1657	23-Mar-00	145	128	95–123	3A/3B	<1
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
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	–

Table A-1. Well construction data, LLNL Livermore Site and vicinity, Livermore, California (Cont.).

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated intervals (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
				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	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
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

Table A-1. Well construction data, LLNL Livermore Site and vicinity, Livermore, California (Cont.).

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated intervals (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
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
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-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

Table A-1. Well construction data, LLNL Livermore Site and vicinity, Livermore, California (Cont.).

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated intervals (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
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
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

Table A-1. Well construction data, LLNL Livermore Site and vicinity, Livermore, California (Cont.).

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated intervals (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
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
SEA-518-304	11-Sep-95	100	50	NA[e]	1B/2/5	NA
SEA-ETS-305	03-Sep-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

Table A-1. Well construction data, LLNL Livermore Site and vicinity, Livermore, California (Cont.).

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated intervals (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
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.

Appendix B

Hydraulic Test Results

Table B-1. Results of Livermore Site 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	Long-term	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	Long-term	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	Long-term	13.2	3,100	260	Fair
W-112	5-Nov-96	Long-term	13.7	3,300	260	Fair

Table B-1. Results of Livermore Site hydraulic tests[a] (Cont.).

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	Long-term	1.0	44	15	Fair
W-211	16-Sep-97	Long-term	1.1	14	1.4	Good

Table B-1. Results of Livermore Site hydraulic tests[a] (Cont.).

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-212	12-May-86	Drawdown	0.8	18	3.1	Poor
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	Long-term	7.7	4,000	670	Good
W-219	15-Jul-86	Drawdown	4.3	620	76	Good
W-219	23-Feb-87	Long-term	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	Long-term	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	Long-term	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	Long-term	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	Long-term	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	Long-term	22.0	2,750	340	Good
W-262	27-Apr-87	Long-term	23.1	6,800	810	Good

Table B-1. Results of Livermore Site hydraulic tests[a] (Cont.).

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-263	22-Apr-86	Drawdown	1.2	37	7.4	Poor
W-263	4-Nov-86	Long-term	1.8	76	15	Excel
W-264	7-May-86	Drawdown	8.1	930	100	Good
W-264	29-Oct-86	Long-term	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	Long-term	5.5	830	170	Fair
W-276	21-Nov-86	Drawdown	13.0	960	110	Good
W-276	4-May-87	Long-term	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	Long-term	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

Table B-1. Results of Livermore Site hydraulic tests[a] (Cont.).

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-311	19-Mar-87	Drawdown	9.8	130	12	Good
W-311	17-Nov-87	Long-term	9.9	370	26	Good
W-312	27-Mar-87	Drawdown	20.5	1,800	300	Poor
W-312	3-Nov-87	Long-term	18.8	1,700	280	Good
W-313	25-Mar-87	Drawdown	7.9	3,000	600	Good
W-313	5-Oct-87	Long-term	9.6	3,400	680	Good
W-314	10-Apr-87	Drawdown	26.4	2,900	390	Good
W-314	13-Jul-87	Long-term	13.6	2,500	330	Fair
W-314	14-Oct-97	Long-term	12	1,400	100	Fair
W-315	9-Apr-87	Drawdown	15.4	150	11	Good
W-315	5-Jan-85	Long-term	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	Long-term	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	Long-term	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	Long-term	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	Long-term	4.9	230	57	Poor
W-357	18-Feb-87	Drawdown	15.0	1,300	110	Good

Table B-1. Results of Livermore Site hydraulic tests[a] (Cont.).

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-357	21-Jul-87	Long-term	9.2	210	18	Good
W-358	18-Mar-87	Drawdown	9.2	210	32	Excel
W-359	9-Mar-87	Long-term	19.0	2,800	290	Fair
W-359	20-Mar-87	Drawdown	18.6	1,100	110	Good
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	Long-term	5.3	178	30	Good
W-362	23-Mar-87	Drawdown	16.4	470	49	Good
W-362	21-Sep-87	Long-term	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	Long-term	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	Long-term	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

Table B-1. Results of Livermore Site hydraulic tests[a] (Cont.).

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-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
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	Long-term	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

Table B-1. Results of Livermore Site hydraulic tests[a] (Cont.).

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-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
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	Long-term	22.5	2,580	520	Fair

Table B-1. Results of Livermore Site hydraulic tests[a] (Cont.).

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-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
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	Long-term	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

Table B-1. Results of Livermore Site hydraulic tests[a] (Cont.).

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-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
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	Long-term	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

Table B-1. Results of Livermore Site hydraulic tests[a] (Cont.).

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-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	Long-term	11.6	1,000	70	Poor
W-1109	26-Jun-95	Drawdown	8.7	460	33	Fair
W-1109	4-Jun-96	Long-term	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	Long-term	11.2	160	7.9	Poor
W-1112	24-May-96	Drawdown	6.4	94	10	Fair
W-1113	26-Aug-96	Drawdown	1	5.5	0.6	Good
W-1114	27-Oct-95	Long-term	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	Long-term	1.3	85	3.6	Poor
W-1213	22-Jul-96	Drawdown	11.6	500	42	Fair
W-1213	30-Jul-96	Long-term	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	Long-term	9.8	3,000	300	Poor
W-1216	14-Aug-96	Drawdown	11.4	210	6.9	Good
W-1216	15-Oct-96	Long-term	11.1	160	5.4	Poor
W-1218	11-Nov-96	Drawdown	5.8	83	4.6	Fair
W-1218	8-Jul-97	Long-term	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

Table B-1. Results of Livermore Site hydraulic tests[a] (Cont.).

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-1220	15-Jul-97	Long-term	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	Long-term	18.9	1,130	110	Fair
W-1301	10-Mar-97	Long-term	4.7	120	15	Fair
W-1303	18-Mar-97	Long-term	7.8	490	21	Fair
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	Long-term	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-97	Long-term	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	Excel
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

Table B-1. Results of Livermore Site hydraulic tests[a] (Cont.).

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-1417	16-Jul-98	Step	5.9	150	13	Fair
W-1418	25-Sep-98	Drawdown	10.7	78	6.5	Excel
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	Excel
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	Excel
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	Long-term	5.8	440	90	Good
W-1515	18-Jan-00	Drawdown	1.5	26	1.5	Poor
W-1515	2-Feb-00	Long-term	1.1	75	4.1	Fair
W-1518	22-Mar-00	Step	6.0	440	19	Good
W-1520	21-Mar-00	Long-term	4.0	165	20	Poor
W-1522	20-Mar-00	Step	10.5	3,500	235	Good
W-1550	28-Dec-99	Drawdown	10.0	330	35	Fair
W-1601	25-Feb-00	Drawdown	3.0	35	3.6	Good
W-1602	3-Mar-00	Drawdown	8.3	3,100	310	Fair
W-1610	14-Jul-00	Injection	2.0	17	0.8	Good
W-1610	17-Jul-00	Injection	3.0	17	0.8	Excel

Table B-1. Results of Livermore Site hydraulic tests[a] (Cont.).

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-1614	25-Aug-00	Drawdown	1.9	75	8.3	Good
W-1654	20-Apr-00	Drawdown	0.5	12	2.0	Good
W-1655	21-Apr-00	Drawdown	1.5	27	4.9	Good
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	Long-term	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
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

Table B-1. Results of Livermore Site hydraulic tests[a] (Cont.).

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]
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	Long-term	29.5	1,780	18	Good
11J4	10-Jun-88	Drawdown	17.0	1,000	15	Excel
11J4	14-Jun-85	Long-term	16.0	1,100	16	Good
13D1	9-Feb-85	Long-term	50.0	4,800	48	Excel

[a] 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; "LONG-TERM" 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

2001 Ground Water Sampling Schedule

Table C-1. 2001 LLNL Livermore Site ground water sampling schedule.

Well number	2000 VOC sampling frequency	Next quarter sample date	VOCs	Additional Analytes (Q1-01)
W-001	E	2-02	E601	
W-001A	A	1-01	E601	
W-002	E	4-02	E601	
W-002A	E	1-02	E601	
W-004	E	2-02	E601	WGMG/NPDES
W-005	E	2-02	E601	
W-005A	O	4-01	E601	
W-007	E	4-02	E601	
W-008	E	2-02	E601	WGMG
W-010A	E	2-02	E601	
W-011	A	1-01	E601	
W-012	S	1-01	E601	
W-017	E	4-02	E601	WGMG
W-017A	E	4-02	E601	
W-019	E	4-02	E601	
W-101	A	1-01	E601	WGMG
W-102	O	2-01	E601	
W-103	E	4-02	E601	
W-104	Q	1-01	E601	
W-105	S	2-01	E601	
W-106	E	4-02	E601	
W-107	E	2-02	E601	
W-108	O	3-01	E601	
W-110	Q	1-01	E601	
W-111	A	2-01	E601	E906
W-113	E	4-02	E601	
W-114	S	2-01	E601	
W-115	A	4-01	E601	
W-116	Q	1-01	E601	
W-117	E	4-02	E601	
W-118	A	4-01	E601	
W-119	Q	1-01	E601	WGMG
W-120	Q	1-01	E601	
W-121	Q	1-01	E601	WGMG
W-122	E	1-02	E601	
W-123	E	1-02	E601	
W-141	E	2-02	E601	

Table C-1. 2001 LLNL Livermore Site ground water sampling schedule (Cont.)

Well number	2000 VOC sampling frequency	Next quarter sample date	VOCs	Additional analytes (Q1-01)
W-142	O	1-01	E601	
W-143	A	4-01	E601	
W-146	A	4-01	E601	
W-147	A	4-01	E601	WGMG
W-148	A	4-01	E601	WGMG
W-151	Q	1-01	E601	WGMG
W-201	O	4-01	E601	
W-202	A	1-01	E601	
W-203	E	2-02	E601	
W-204	S	1-01	E601	E906/WGMG
W-205	Q	1-01	E601	
W-206	Q	1-01	E601	E906
W-207	Q	1-01	E601	
W-210	A	1-01	E601	E906/WGMG
W-211	A	4-01	E601	
W-212	E	4-02	E601	
W-213	E	4-02	E601	
W-214	E	2-02	E601	
W-217	S	1-01	E601	
W-218	Q	1-01	E601	
W-219	A	4-01	E601	
W-220	A	1-01	E601	
W-221	A	2-01	E601	WGMG
W-222	Q	1-01	E601	
W-223	E	1-02	E601	
W-224	A	1-01	E601	
W-225	A	4-01	E601	
W-226	A	2-01	E601	WGMG/NPDES
W-251	Q	1-01	E601	
W-252	A	4-01	E601	
W-253	O	1-01	E601	
W-255	A	2-01	E601	
W-256	A	2-01	E601	
W-257	Q	1-01	E601	E906
W-258	Q	1-01	E601	E906
W-259	Q	1-01	E601	E906
W-260	S	1-01	E601	

Table C-1. 2001 LLNL Livermore Site ground water sampling schedule (Cont.)

Well number	2000 VOC sampling frequency	Next quarter sample date	VOCs	Additional analytes (Q1-01)
W-261	O	1-01	E601	
W-263	Q	1-01	E601	
W-264	A	2-01	E601	
W-265	O	3-01	E601	
W-267	A	2-01	E601	
W-268	Q	1-01	E601	E906
W-269	S	1-01	E601	
W-270	A	4-01	E601	
W-271	Q	1-01	E601	
W-272	S	1-01	E601	
W-273	A	4-01	E601	
W-274	Q	1-01	E601	
W-275	A	4-01	E601	
W-276	S	2-01	E601	WGMG
W-277	S	2-01	E601	
W-290	E	4-02	E601	
W-291	O	1-01	E601	
W-292	A	1-01	E601	
W-293	A	2-01	E601	
W-294	O	2-01	E601	
W-301	A	3-01	E601	WGMG
W-302	A	1-01	E601	
W-303	E	2-02	E601	
W-304	A	4-01	E601	
W-305	Q	1-01	E601	WGMG
W-306	A	2-01	E601	WGMG/NPDES
W-307	S	2-01	E601	WGMG/NPDES
W-308	A	1-01	E601	
W-310	E	3-00	E601	
W-311	A	4-01	E601	
W-312	E	2-02	E601	
W-313	S	2-01	E601	
W-315	Q	1-01	E601	
W-316	Q	1-01	E601	
W-317	S	2-01	E601	
W-318	Q	1-01	E601	
W-319	A	1-01	E601	

Table C-1. 2001 LLNL Livermore Site ground water sampling schedule (Cont.)

Well number	2000 VOC sampling frequency	Next quarter sample date	VOCs	Additional analytes (Q1-01)
W-320	S	1-01	E601	
W-321	A	4-01	E601	
W-322	Q	1-01	E601	
W-323	Q	1-01	E601	
W-324	E	2-02	E601	
W-325	E	4-01	E601	
W-353	S	2-01	E601	
W-354	Q	1-01	E601	
W-355	S	2-01	E601	
W-356	Q	1-01	E601	E906
W-359	Q	1-01	E601	E906/WGMG
W-360	Q	1-01	E601	
W-361	Q	1-01	E601	
W-362	O	3-01	E601	
W-363	Q	1-01	E601	E906/WGMG
W-364	Q	1-01	E601	E906
W-365	S	2-01	E601	
W-366	O	2-01	E601	
W-368	A	1-01	E601	
W-369	S	1-01	E601	
W-370	A	4-01	E601	
W-371	O	3-01	E601	
W-372	O	3-01	E601	
W-373	A	2-01	E601	WGMG
W-375	Q	1-01	E601	E906
W-376	A	2-01	E601	
W-377	A	2-01	E601	
W-378	S	2-01	E601	
W-379	A	4-01	E601	
W-380	O	1-01	E601	
W-401	E	2-02	E601	
W-402	O	1-01	E601	
W-403	O	1-01	E601	
W-404	Q	1-01	E601	
W-405	Q	1-01	E601	
W-406	E	4-02	E601	
W-407	Q	1-01	E601	

Table C-1. 2001 LLNL Livermore Site ground water sampling schedule (Cont.)

Well number	2000 VOC sampling frequency	Next quarter sample date	VOCs	Additional analytes (Q1-01)
W-409	A	4-01	E601	
W-410	Q	1-01	E601	
W-411	Q	1-01	E601	
W-412	A	2-01	E601	
W-413	A	2-01	E601	E906
W-414	O	3-01	E601	
W-416	O	2-01	E601	
W-417	O	3-01	E601	
W-418	A	2-01	E601	
W-419	Q	4-01	E601	
W-420	A	1-01	E601	
W-421	A	4-01	E601	
W-422	O	3-01	E601	
W-423	Q	1-01	E601	
W-424	Q	1-01	E601	
W-446	O	4-01	E601	
W-447	A	4-01	E601	
W-448	A	2-01	E601	
W-449	A	4-01	E601	
W-450	A	1-01	E601	
W-451	E	1-02	E601	
W-452	E	4-02	E601	
W-453	E	4-02	E601	
W-454	E	2-02	E601	WGMG/NPDES
W-455	A	4-01	E601	
W-458	E	4-02	E601	
W-459	A	2-01	E601	
W-461	Q	1-01	E601	
W-462	E	4-02	E601	
W-463	E	1-02	E601	
W-464	A	2-01	E601	
W-481	Q	1-01	E601	
W-482	S	2-01	E601	
W-483	A	2-01	E601	
W-484	E	4-02	E601	
W-485	E	2-02	E601	
W-486	A	2-01	E601	E906

Table C-1. 2001 LLNL Livermore Site ground water sampling schedule (Cont.)

Well number	2000 VOC sampling frequency	Next quarter sample date	VOCs	Additional analytes (Q1-01)
W-487	A	1-01	E601	
W-501	A	4-01	E601	WGMG/NPDES
W-502	A	2-01	E601	
W-503	A	4-01	E601	
W-504	O	4-01	E601	
W-505	A	2-01	E601	
W-506	A	1-01	E601	
W-507	O	2-01	E601	
W-509	S	1-01	E601	
W-510	O	2-01	E601	
W-511	O	1-01	E601	
W-512	A	1-01	E601	
W-513	A	2-01	E601	
W-514	A	4-01	E601	
W-515	Q	1-01	E601	
W-516	O	1-01	E601	
W-517	Q	1-01	E601	
W-519	O	4-01	E601	
W-521	A	1-01	E601	
W-551	S	1-01	E601	
W-552	A	2-01	E601	
W-553	E	4-02	E601	
W-554	E	2-02	E601	
W-555	O	2-01	E601	
W-556	A	2-01	E601	WGMG
W-557	E	4-02	E601	
W-558	Q	1-01	E601	
W-559	O	4-01	E601	
W-560	O	4-01	E601	
W-561	E	2-02	E601	
W-562	A	2-01	E601	E906
W-563	A	2-01	E601	
W-564	Q	1-01	E601	
W-565	E	4-02	E601	
W-567	A	4-01	E601	E906
W-568	S	2-01	E601	
W-569	A	1-01	E601	

Table C-1. 2001 LLNL Livermore Site ground water sampling schedule (Cont.)

Well number	2000 VOC sampling frequency	Next quarter sample date	VOCs	Additional analytes (Q1-01)
W-570	E	4-02	E601	
W-571	O	2-01	E601	WGMG
W-591	E	4-02	E601	
W-592	O	3-01	E601	
W-593	O	1-01	E601	WGMG
W-594	O	1-01	E601	
W-604	A	3-01	E601	
W-606	S	2-01	E601	
W-607	S	2-01	E601	E906
W-608	O	2-01	E601	
W-611	Q	1-01	E601	
W-612	A	2-01	E601	
W-613	A	2-01	E601	
W-615	A	2-01	E601	
W-616	E	1-02	E601	
W-617	A	4-01	E601	
W-618	Q	1-01	E601	
W-619	O	3-01	E601	
W-622	Q	1-01	E601	E906
W-651	Q	1-01	E601	
W-652	E	2-02	E601	
W-653	Q	1-01	E601	
W-654	S	2-01	E601	
W-702	A	1-01	E601	
W-705	S	2-01	E601	
W-706	O	3-01	E601	
W-750	Q	1-01	E601	
W-901	A	2-01	E601	
W-902	A	4-01	E601	WGMG/NPDES
W-905	O	3-01	E601	
W-908	A	1-01	E601	
W-909	Q	1-01	E601	E906
W-911	Q	1-01	E601	
W-912	S	2-01	E601	E906
W-913	Q	1-01	E601	
W-1002	S	2-01	E601	
W-1003	O	4-01	E601	

Table C-1. 2001 LLNL Livermore Site ground water sampling schedule (Cont.)

Well number	2000 VOC sampling frequency	Next quarter sample date	VOCs	Additional analytes (Q1-01)
W-1008	E	4-02	E601	
W-1010	O	4-01	E601	
W-1011	A	2-01	E601	
W-1012	O	2-01	E601	WGMG
W-1013	A	3-01	E601	
W-1014	S	1-01	E601	
W-1101	A	2-01	E601	
W-1105	A	2-01	E601	
W-1106	A	2-01	E601	E906
W-1107	S	2-01	E601	
W-1108	Q	1-01	E601	E906
W-1110	A	1-01	E601	
W-1112	Q	1-01	E601	
W-1113	S	1-01	E601	
W-1115	A	2-01	E601	E602
W-1117	Q	1-01	E601	E906
W-1118	Q	1-01	E601	E906
W-1201	Q	1-01	E601	E906
W-1202	Q	1-01	E601	
W-1203	Q	1-01	E601	E906
W-1204	Q	1-01	E601	E906
W-1205	Q	1-01	E601	
W-1207	A	4-01	E601	
W-1209	S	1-01	E601	
W-1210	A	4-01	E601	E906
W-1212	Q	1-01	E624	
W-1214	Q	1-01	E601	
W-1217	Q	1-01	E601	
W-1218	Q	1-01	E601	
W-1219	Q	1-01	E601	E906
W-1220	S	2-01	E601	
W-1221	Q	1-01	E601	
W-1222	Q	1-01	E601	E906
W-1223	Q	1-01	E601	E906
W-1224	A	1-01	E601	
W-1225	Q	1-01	E601	E906
W-1226	A	4-01	E601	

Table C-1. 2001 LLNL Livermore Site ground water sampling schedule (Cont.)

Well number	2000 VOC sampling frequency	Next quarter sample date	VOCs	Additional analytes (Q1-01)
W-1227	A	2-01	E601	
W-1250	Q	1-01	E601	
W-1251	Q	1-01	E601	
W-1252	Q	1-01	E601	
W-1253	Q	1-01	E601	
W-1254	Q	1-01	E601	
W-1255	Q	1-01	E601	
W-1304	Q	1-01	E601	
W-1311	Q	1-01	E601	
W-1401	Q	1-01	E601	
W-1402	Q	1-01	E601	
W-1403	Q	1-01	E601	
W-1404	Q	1-01	E601	
W-1405	Q	1-01	E601	
W-1406	Q	1-01	E601	E906
W-1407	Q	1-01	E601	
W-1408	Q	1-01	E601	E906
W-1411	A	1-01	E601	
W-1412	Q	1-01	E601	E906
W-1413	A	1-01	E601	
W-1414	Q	1-01	E601	E906/WGMG
W-1415	Q	1-01	E601	E906
W-1416	S	2-01	E601	
W-1417	Q	1-01	E601	
W-1419	S	2-01	E601	
W-1420	S	1-01	E601	
W-1421	Q	1-01	E601	
W-1424	Q	1-01	E601	
W-1425	Q	1-01	E601	
W-1426	S	1-01	E601	
W-1427	Q	1-01	E601	
W-1428	A	4-01	E601	
W-1501	A	3-01	E601	
W-1502	A	4-01	E601	
W-1505	S	2-01	E601	
W-1506	S	2-01	E601	
W-1507	S	2-01	E601	

Table C-1. 2001 LLNL Livermore Site ground water sampling schedule (Cont.)

Well number	2000 VOC sampling frequency	Next quarter sample date	VOCs	Additional analytes (Q1-01)
W-1508	Q	1-01	E601	
W-1509	A	4-01	E601	
W-1511	Q	1-01	E601	E906
W-1512	Q	1-01	E601	
W-1513	Q	1-01	E601	
W-1514	Q	1-01	E601	
W-1515	Q	1-01	E601	
W-1516	Q	1-01	E601	
W-1517	Q	1-01	E601	
W-1519	Q	1-01	E601	
W-1553	Q	1-01	E601	
W-1603	Q	1-01	E601	
W-1604	Q	1-01	E601	E906
W-1605	Q	1-01	E601	E906
W-1609	Q	1-01	E601	
W-1610	Q	1-01	E601	
W-1613	Q	1-01	E601	
W-1614	Q	1-01	E601	
TW-11	S	1-01	E601	
TW-11A	S	1-01	E601	
TW-21	A	2-01	E601	
11C1	E	4-02	E601	
14A11	O	1-01	E601	
14A3	E	3-02	E601	
14B1	E	3-02	E601	WGMG
14B4	O	2-01	E601	
14C1	E	2-02	E601	
14C2	O	4-01	E601	
14C3	A	3-01	E601	
14H1	E	2-02	E601	
18D1	O	2-01	E601	
GEW-710	S	1-01	E601	
GSW-006	A	2-01	E601	E602
GSW-007	O	4-01	E601	
GSW-008	O	2-01	E601	
GSW-009	Q	1-01	E601	
GSW-011	Q	1-01	E601	WGMG

Table C-1. 2001 LLNL Livermore Site ground water sampling schedule (Cont.)

Well number	2000 VOC sampling frequency	Next quarter sample date	VOCs	Additional analytes (Q1-01)
GSW-013	O	2-01	E601	
GSW-215	Q	1-01	E601	
GSW-216	A	1-01	E601	WGMG
GSW-266	Q	1-01	E601	
GSW-326	O	1-01	E601	
GSW-367	S	2-01	E601	
GSW-442	E	4-02	E601	
GSW-443	A	2-01	E601	
GSW-444	S	2-01	E601	

Notes:

O = Odd years.

A = Annual.

S = Semiannual.

Q = Quarterly.

E = Even years.

E601 = EPA Method 601 for purgeable halocarbons.

E602 = EPA Methods 602 for aromatic volatile compounds.

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

E906 = EPA Method 906 for tritium.

NPDES = National Pollutant Discharge Elimination System.

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

2000 Drainage Retention Basin Annual Monitoring Program Summary

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2000 Drainage Retention Basin Annual Monitoring Program Summary

This Appendix summarizes the 2000 LLNL Operations and Regulatory Affairs Division routine maintenance activities, maintenance monitoring, and discharge data for the Drainage Retention Basin (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 discharges.

Discharge samples are collected at the first planned release of the rainy season and, at a minimum, in conjunction with one additional storm water monitoring event, as requested by the California Regional Water Quality Control Board (RWQCB)–San Francisco Bay Region. In addition, samples of each dry season release event are collected. 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, 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). Maintenance samples are used as the basis 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 should be considered.

Complete analytical results of samples collected within the basin and from releases are reported in the LLNL Livermore Site Project Quarterly Self-Monitoring Reports for 2000.

D-1. Drainage Retention Basin Maintenance Monitoring

Samples collected during 2000 at sample location CDBE did not meet the MALs for ammonia nitrogen, chemical oxygen demand, dissolved oxygen, fecal coliform, nitrate (as nitrogen), oxygen saturation, pH, specific conductance, temperature, total dissolved solids, total phosphorus (as phosphorus), and turbidity as summarized in Table D-1.

Table D-1. Constituents that exceeded Management Action Levels (MALs) in 2000.

Parameter	MAL	Maximum value	Minimum value	Samples not meeting MALs/ samples collected
Ammonia Nitrogen (mg/L)	>0.1	0.18	0.03	3/11
Chemical Oxygen Demand (mg/L)	>20	43	37	3/4
Dissolved Oxygen (% saturation)	<80%	165	34	16/48
Dissolved Oxygen (mg/L)	<5	15.2	3.36	2/50
Fecal Coliform (MPN/100)	>400	540	<2	1/4
Nitrate (as N) (mg/L)	>0.2	2.1	0.1	9/11
pH (units)	<6.0 and >9.0	9.15	7.97	9/11
Specific conductance	900	1160	720	7/11
Temperature (degrees C)	<15 and > 26	27.5	11.5	16/48
Total Dissolved Solids (mg/L)	>360	693	483	11/11
Total Phosphorous (as P) (mg/L)	>0.02	0.46	<0.05	10/11
Turbidity (meters)	<0.914	2	0.33	30/49

In general, the water quality in the DRB improved during 2000 over previous years. This may be related to a new management strategy that focused on stabilizing water levels to reduce the stress to the overall aquatic system, which facilitated a greater variety and quantity of submerged and emergent vegetation. By the end of the first year of this new management strategy, DRB monitoring indicated substantially increased water clarity, lower chlorophyll "a" concentrations (indicating less biomass during algae blooms), and decreasing nutrient concentrations.

Ammonia exceeded its MAL three times in 2000. The presence of ammonia in the water usually indicates that anaerobic activity is occurring. The low dissolved oxygen levels in the middle and lower levels of the DRB support this evidence of anaerobic activity. The low dissolved oxygen readings are believed to be due to the inability of the circulation pumps to adequately supply enough oxygen to meet the DRB oxygen demand. Chemical oxygen demand was above the MAL for three of the four quarters during 2000, most likely as a result of increasing organic debris associated with annual algae bloom cycles and decaying organic debris washed in during winter storms.

Total phosphorous also continued to be above the MAL throughout 2000. Phosphorous concentration reached a maximum of 0.46 mg/L in February 2000. Although this concentration is still well above MAL of 0.02 mg/L, it is substantially below the maximum 1998 concentration of 1.9 mg/L. The lower total phosphorus is a result of changing the method of treating corrosion in the treatment units from *JP-7* (a phosphate based anti corrosion agent) to *Belsperse 161.*

Nitrate as nitrogen concentrations also continued to exceed the MAL during 2000. Nitrate is introduced into the DRB with winter storm flows and in treated ground water discharges.

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 1.3 µg/L to 42.7 µg/L in 2000. An aquatic system is considered to be eutrophic when chlorophyll "a" levels exceed 10 µg/L. However, the chlorophyll "a" concentration (and therefore the algae mass) decreased from last year's high of 82.7 µg/L to 42.7 µg/L. Toxicity tests collected in April and October 2000 showed only a small amount of toxicity for algae (2 toxic units) in April and the water flea in October (2 toxic units).

Semiannual and annual maintenance sampling was conducted during April and October 2000. Quarterly sampling was conducted in January, April, July, and October. Results for oil and grease, VOCs, total organic carbon, gross alpha, gross beta, and tritium all met their MALs. Only two organic compounds, 1,2 dichloroethane (1.3 µg/L) and chloromethane (1.3 µg/L), were found in samples collected from the DRB on April 12, 2000. No herbicides were detected during routine monitoring of the DRB water.

In 1997, LLNL began quarterly microbiological monitoring as a tool to evaluate the nature and health of the DRB aquatic community as an indication of water quality. LLNL also began semi-annual biological monitoring to evaluate the impact the DRB has on downstream ecosystems. During 1999 and 2000, LLNL discontinued the microbiological monitoring due to lack of resources to collect and analyze samples. Semi-annual biological monitoring continued. Data for the biological monitoring are reported in the LLNL *Site Annual Environmental Report.*

Early in the second quarter, moribund and dead catfish were observed in the DRB. LLNL contacted the U.S. Department of Fish and Game's Fish Pathology Laboratory in Sacramento. The fish pathologist indicated the catfish were dying from a parasite called Ich (*Ichthyophthirius multifiliis*) - a common aquarium disease. The fish pathologist indicated that the DRB would likely experience outbreaks of Ich whenever temperatures and fish populations were sufficient to sustain an outbreak. Catfish are a scaleless fish and are particularly vulnerable to Ich. The outbreak of Ich was reported to the RWQCB on April 11, 2000.

D-2. Drainage Retention Basin Discharge Monitoring

Releases from the DRB occurred throughout the year except during brief periods to coordinate work within the DRB or downstream. Discharges from the DRB did not occur in late April and early May while when an engineered outfall structure was constructed within the DRB. The weir gate was shut from August through the third week of September when LLNL conducted maintenance work within Arroyo Las Positas. The gate was shut again in late September through the middle of October when water was held in the DRB to coordinate with Zone 7 work conducted in Arroyo Las Positas downstream of LLNL. Starting December 15, 2000 through January 5, 2001 the DRB was completely dewatered as part of an LLNL's bullfrog management strategy.

The first release sample of the wet season was collected on October 25, 2000. Discharges from the DRB were below discharge limits for all parameters except pH and turbidity. Discharge samples collected at CDBX exceeded the pH limit of 8.5 units in six of the seven monitoring events. The minimum pH value was 8.56 and the maximum value was 9.16. Corresponding samples collected at the site outfall (WPDC) exceeded the discharge limit in two of the seven sampling events. The minimum pH value at the outfall was 7.91 and the maximum pH value was 8.62.

Discharged water was sampled for both VOCs and herbicides. The only organic compound above detection limits was glyphosate. Glyphosate was detected in the March release sample at both sample location CDBX (11 µg/L) and WPDC (12 µg/L). Glyphosate is the active ingredient in *Round Up* and *Rodeo.*

During the winter dewatering effort, LLNL followed a work plan submitted to and approved by the RWQCB. The work plan identified discharge limits specifically for the dewatering activity. LLNL monitored discharges twice a day for the duration of the dewatering activity. On the last day of discharge, one of the soil-filled bags that LLNL installed to remove sediments burst. As a result, the last reading collected on January 5, 2001, exceeded the discharge limit for turbidity. To prevent additional sediment discharge to Arroyo Las Positas, the remaining discharge from the DRB was redirected away from the storm drainage system to an open area where the water percolated into the ground.

D-3. Future Activities

LLNL is in the process of evaluating alternate methods to manage the DRB. Currently LLNL is considering changing the current open water configuration of the DRB into a managed wetland system to achieve improved water quality. LLNL has contracted the design of a wetland and is exploring possible funding sources. The *Drainage Retention Basin Management Plan* will be amended to reflect any change to the DRB operations.

D-4. References

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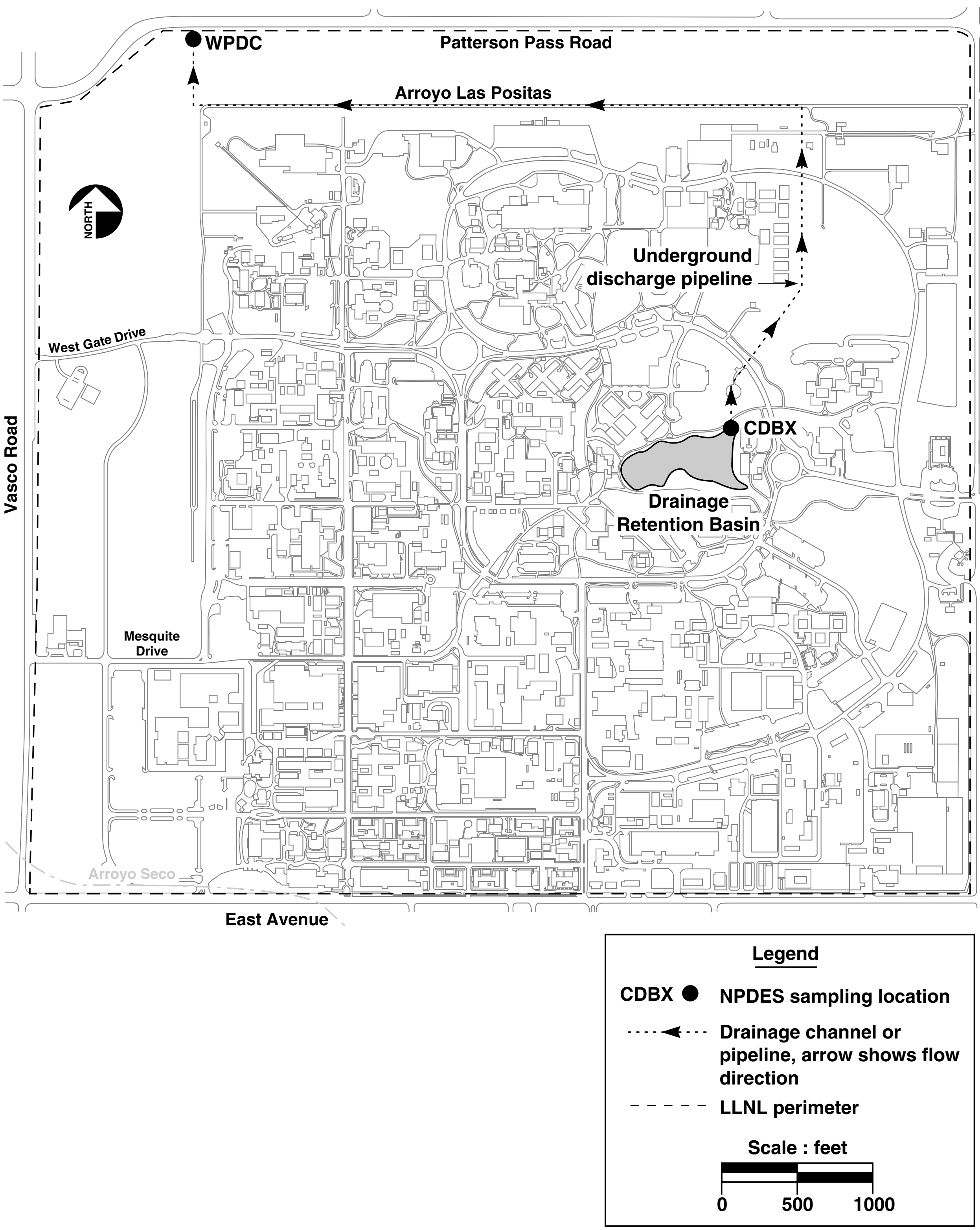

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Figure D-1. Location of the Drainage Retention Basin showing discharge sampling locations.

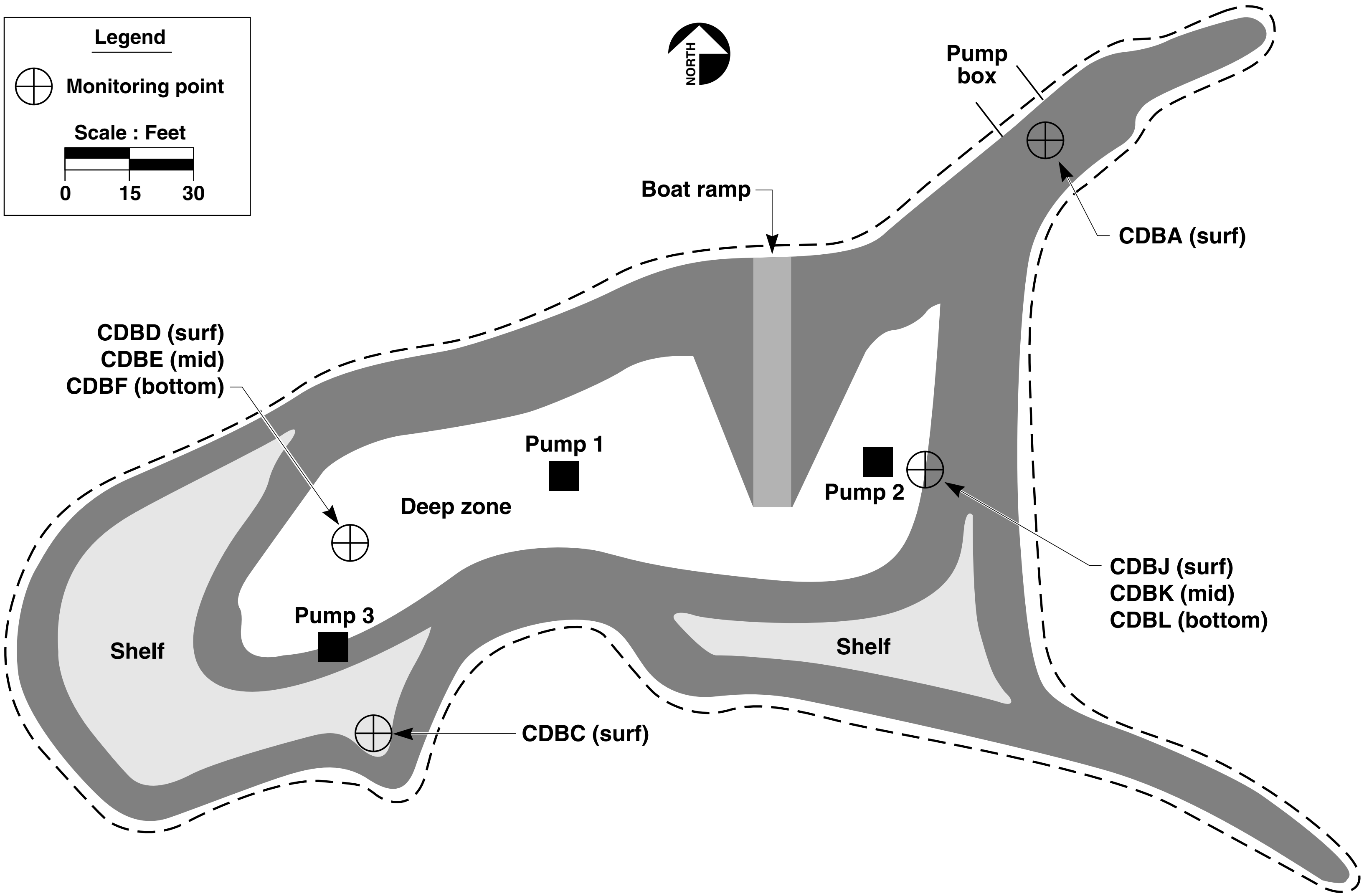

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Figure D-2. Monitoring locations in the Drainage Retention Basin.