U.S. Department of Energy

Oakland Operations Office, Oakland, California 94612

Lawrence Livermore National Laboratory

University of California   Livermore, California 94551

UCRL-AR-126020-97

LLNL
Ground Water Project

1997 Annual Report

Technical Editors:

J. Hoffman*
M. Maley*
B. Qualheim
R. Bainer
E. Folsom
M. Dresen*

Contributing Authors:

J. Aarons
S. Bahowick
R. Blake
Z. Demir*
L. Berg*
K. Folks
R. Gelinas
F. Hoffman
G. Howard
G. Kumamoto
W. McNab
C. Noyes*
T. Pico
M. Ridley
S. Shukla

*Weiss Associates, Emeryville, California

Environmental Protection Department

Environmental Restoration Program and Division

Work performed under the auspices of the U. S. Department of Energy by Lawrence Livermore National Laboratory under Contract W-7405-Eng-48.

UCRL-AR-126020-97

LLNL
Ground Water Project

1997 Annual Report

Technical Editors:

J. Hoffman*
M. Maley*
B. Qualheim
R. Bainer
E. Folsom
M. Dresen*

Contributing Authors:

J. Aarons
S. Bahowick
R. Blake
Z. Demir*
L. Berg*
K. Folks
R. Gelinas
F. Hoffman
G. Howard
G. Kumamoto
W. McNab
C. Noyes*
T. Pico
M. Ridley
S. Shukla

*Weiss Associates, Emeryville, California

Table of Contents

List of Figures

List of Tables

Appendices

Summary

The major Livermore Site Ground Water Project (GWP) restoration activities conducted in 1997 are:

1. The Lawrence Livermore National Laboratory (LLNL) Livermore Site GWP produced two major Comprehensive Environmental Response, Compensation, and Liability Act documents in 1997 according to the Remedial Action Implementation Plan schedule (RAIP): The Five-Year Review, issued August 1, 1997 and finalized in December 1997; and Draft Remedial Design Report No. 4 (RD4) issued August 21, 1997. Two Explanations of Significant Differences (ESDs) were issued in April 1997 describing modifications to the remediation systems at Treatment Facilities A and B (TFA and TFB), and a change in metals discharge requirements. Twelve additional documents or letter reports were submitted to the regulatory agencies in 1997, consisting of 10 Remedial Project Managers Meeting Summaries, the GWP 1997 Annual Report, and an updated Quality Assurance Project Plan. All six Department of Energy (DOE)/LLNL/RAIP milestones 1997 were met ahead of schedule.

2. The Community Work Group met twice in 1997 to discuss topics including the DOE budget, progress on Livermore Site cleanup, the two ESDs, the Priority List/Consensus Statement, the Five-Year Review, and RD4.

3. In 1997, the GWP submitted 890 ground water samples for analyses, collected during 820 individual sampling events from 352 wells and piezometers.

4. The three-dimensional ground water flow and contaminant transport model developed in 1996 was expanded in 1997, and a summary of the preliminary results for the TFB area was completed in 1997. We began to change our primary modeling computer code to FEFLOW from CFEST. In 1998, FEFLOW will be used to expand a site-wide model for all hydrostratigraphic units.

5. LLNL began a project for the Alameda Flood Control and Water Conservation District Zone 7, to assess future ground water use in the basin surrounding LLNL by using the existing Livermore Site ground water models. A report to Zone 7 is being prepared for submittal in early 1998.

6. The 1997 extraction wells, extraction rates, and estimated volatile organic compound (VOC) mass removed at TFA, TFB, Treatment Facility C (TFC), Treatment Facility D (TFD), Treatment Facility E (TFE), Treatment Facility G (TFG), Treatment Facility 406 (TF406), and Vapor Treatment Facility 518 (VTF518) areas are summarized in Table Summ-1.

7. Construction activities in 1997 included:

    - Replacement of the ground water treatment system at TFA to a more cost-effective, large-capacity air-stripping system.
    - Construction of portable treatment unit stations at TFC Southeast, TFD West, TFD East, and Ground Water Treatment Facility 518 (TF518).

8. Sixteen wells installed in 1997 are listed in Table Summ-2.
9. Hydraulic tests conducted in 1997 are presented in Table Summ-3.
10. During 1997, DOE/LLNL operated TFA, TFB, TFC, TFD, TFE, TFG, TF406, and VTF518. By the end of 1997, a total of about 569 million gal of ground water and almost 6.2 million cubic ft of vapor have been processed, removing more than 334 kg of VOCs.

Table Summ-1. 1997 extraction wells, extraction rates and estimated VOC mass removed.

Treatment facility area	Extraction wells	Extraction rate	Estimated total VOC mass removed (kg)
TFA	W-109, W-262, W-408, W-415, W-457, W-518, W-520, W-522, W-601, W-602, W-603, W-609, W-614, W-712, W-903, W-904, W-1004, W-1009	270-340 gpm	18.4
TFB	W-357, W-610, W-620, W-621, W-655, W-704	40-45 gpm	6.8
TFC	W-701, W-1015, W-1102, W-1103, W-1104, W-1116, W-1213	45-55 gpm	9.4
TFD	W-351, W-906, W-907, W-1208, W-1215, W-1216, W-1301, W-1303, W-1306, W-1307	60-100 gpm	55.0
TFE	W-566, W-1109	15-20 gpm	15.9
TFG	W-1111	8 gpm	0.6
TF406	GSW-445, W-1114	4-20 gpm	0.9
VTF518	SVI-518-201, SVI-518-303	20-50 scfm	40.6
TF5475	W-1302	1-2 gpm	0.1
1997 Total			147.7

Notes:

kg = Kilograms.

gpm = Gallons per minute.

scfm = Standard cubic feet per minute.

Table Summ-2. Wells installed in 1997.

Treatment facility area	Well(s)
TFD	W-1303, W-1304, W-1306, W-1307, W-1308, W-1311, W-1401, W-1402, W-1403, W-1404, W-1405, W-1406, W-1407
TF406	W-1309, W-1310
TF5475	W-1302

Note:

TF5475 = Ground Water Treatment Facility 5475.

Table Summ-3. Summary of 1997 hydraulic tests.

Treatment facility area	Well(s)
TFA	W-1002, W-1003, W-1005, W-1006, W-1107, W-1214, W-1217, W-1227
TFB	W-1226
TFC	W-1224
TFD	W- 314, W-1218, W-1220, W-1301, W-1303, W-1304, W-1306, W-1307, W-1308, W-1311, W-1401, W-1402
TFE	W-1008, W-1219
TFF/TF406	W-1309, W-1310
TF518	W-211
T-5475	W-1225

Notes:

TF518 = Ground Water Treatment Facility 518.

TFF = Treatment Facility F.

1. Introduction

This report summarizes the 1997 Lawrence Livermore National Laboratory (LLNL) Livermore Site Ground Water Project (GWP) activities in six sections: Regulatory Compliance; Ground Water Sampling; Flow and Transport Modeling; Annual Summary of Remedial Action Program, including discussions of treatment facility activities; and Trends in Ground Water Analytical Results. The 1997 GWP quarterly self-monitoring reports (Lamarre and Littlejohn, 1997a; 1997b; Bainer and Littlejohn, 1997a; 1998) 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 and boreholes drilled in 1997 are shown in larger type.

Appendices A through D present Well Construction and Closure Data, Hydraulic Test Results, the 1998 Ground Water Sampling Schedule, and the 1997 Drainage Retention Basin Annual Monitoring Program Summary. Ground water volatile organic compound (VOC) analyses, water level elevations, and the Treatment Facility F/Treatment Facility 406 (TFF/TF406) area ground water VOC and fuel hydrocarbon (FHC) analyses are available on request.

2. Regulatory Compliance

In 1997, 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

During 1997, DOE/LLNL issued two CERCLA documents for the Livermore Site according to the amended schedule in the Remedial Action Implementation Plan (RAIP) (Dresen et al., 1993). The Five-Year Review (Berg et al., 1997a) was submitted to the regulatory agencies on August 1, 1997, and was subsequently finalized and approved by the U.S. Environmental Protection Agency (EPA) in December 1997. Draft Remedial Design Report No. 4 (RD4) (Berg et al., 1997b) was submitted on August 21, 1997.

In addition, DOE/LLNL prepared a status report presenting the hydrogeology, wellfield design, and treatability studies for the Treatment Facility 5475 (TF5475). The status report was issued one day ahead of scheduled on February 24, 1997 (Lamarre and Littlejohn, 1997c).

Two Explanations of Significant Differences (ESDs) were also prepared and approved by the regulatory agencies. The first ESD describes a change from ultraviolet light/hydrogen peroxide (UV/H_2O_2) and air stripping remediation to air stripping only at Treatment Facilities A and B (TFA and TFB) (Berg et al., 1997c). The second ESD was for a change in metals discharge requirements based on wet and dry season beneficial use (Berg et al., 1997d). Both ESDs were issued in April 1997.

A Draft Action Memorandum (Bainer and Berg, 1997) for an emergency removal action was prepared in response to the discovery of undocumented buried capacitors during excavation for the National Ignition Facility (NIF) in the northeast part of the Livermore Site. Appropriate public notification and information activities were conducted in support of this removal action. The Draft Action Memorandum was submitted on October 31, 1997 for a 30-day community review and comment period, and DOE/LLNL are currently responding to community comments. The final Action Memorandum will be issued in February 1998. A Closeout Report for the emergency removal action was submitted in December 1997 (Bainer and Littlejohn, 1997b).

As required by the FFA, DOE/LLNL issued the 1996 Ground Water Project Annual Report (Hoffman et al., 1997). DOE/LLNL also issued ten Remedial Project Managers' (RPMs') meeting summaries; the March and June (Lamarre and Littlejohn, 1997a; 1997b, respectively), and the September and December summaries (Bainer and Littlejohn, 1997a; 1998, respectively) included quarterly self-monitoring data. LLNL also prepared an updated Quality Assurance Project Plan (Dibley, 1997) for regulatory review and comment.

2.2. Milestones and Activities

Table 1 presents the 1997 RAIP milestones (Table 5 in Dresen et al., 1993) for the Livermore Site. All six milestones were completed ahead of schedule.

Livermore Site Environmental Restoration activities in 1997 also included the following:

- Implemented Engineered Plume Collapse (EPC) to accelerate mass removal and site cleanup. EPC incorporates hydrostratigraphic unit analysis, smart pump and treat, source isolation, Portable Treatment Unit (PTU) technology, and treatment of VOCs in fine-grained sediments.
- Gave presentations to the regulatory agencies on the hydrostratigraphy of the TF5475 area and catalytic reductive dehalogenation bench-scale studies.
- Designed a treatability test for treating ground water using granular activated carbon (GAC).
- Re-evaluated the sampling frequency of the guard wells listed in the Compliance Monitoring Plan and proposed a reduced sampling plan that is cost-effective and remains protective of human health and the environment (Lamarre and Littlejohn, 1997d). The regulatory agencies are still reviewing this proposal.
- Provided support for an infiltration study in the southwest part of the site funded through the Environmental Management Science Program. See Section 5.1 for further discussion.
- Negotiated a revised Livermore Site Consensus Statement/Priority List and the RAIP milestone schedule on July 17, 1997 (Lamarre and Littlejohn, 1997e).
- Prepared and submitted to the regulatory agencies Standard Operating Procedures (SOPs) for ground water sampling that included procedures for low-volume sampling (Bainer

and Littlejohn, 1997c), and incorporated EPA comments. The final low-volume sampling SOPs will be issued in 1998.

- Implemented a more efficient format to report data in the quarterly self-monitoring reports beginning with the second quarter report (Lamarre and Littlejohn, 1997b).
- Began operation of a high-efficiency air stripper at TFA on June 18, 1997. See Section 5.1 for further discussion.
- Changed the quarterly, semiannual and annual self-monitoring sampling schedule, with regulatory concurrence, to collect samples at the beginning of the reporting period to ensure the data are collected and analyzed in time to include in the quarterly reports (Bainer and Littlejohn, 1997d). In addition, DOE/LLNL changed the annual self-monitoring sampling for all treatment facilities to January of each year to help ensure that there is enough water to collect a receiving water sample.
- Began *in situ* pilot testing of catalytic reductive dehalogenation in the TF5475 area on August 8, 1997. See Section 5.10.2 for further discussion.
- Requested and was granted an increase in the TFA discharge rate from 350 gallons per minute (gpm) to 500 gpm (Bainer and Littlejohn, 1997e; Rochette, 1997).
- Started a treatability test on a Solar-powered Water Activated-carbon Treatment (SWAT) unit on August 13, 1997. See Section 5.4.3 for further discussion.
- Performed a removal action for buried drums and capacitors discovered during excavation for the NIF (Bainer and Berg, 1997).
- Performed geophysical surveys to determine the potential of finding more undocumented buried waste in the NIF construction area. Exploratory boreholes will be drilled in early 1998.
- Met with the Alameda County Flood Control and Conservation District, Zone 7 (Zone 7) to discuss a cooperative effort to model the water needs for Livermore Valley's increasing population and agriculture needs. See Section 4.4 for further discussion.
- Oversaw identification, stabilization, and excavation of mammoth bones at the NIF construction site.
- Started construction of ground water Treatment Facility 518 (TF518), which is scheduled to start operation by January 30, 1998.

2.3. Community Relations

In August 1997, DOE/LLNL held a celebration of five years of successful environmental restoration at the Livermore Site since the signing of the Record of Decision (U.S. DOE, 1992). The celebration was attended by elected officials, DOE, regulatory agencies, LLNL, and community representatives.

The Community Work Group (CWG) met twice in 1997 to discuss the DOE budget, progress of Livermore Site cleanup, the two ESDs, the Priority List/Consensus Statement, the Five-Year

Review, and RD4. There was ongoing correspondence and communication with CWG members throughout the year.

Other Livermore Site community relations activities in 1997 included communications and meetings with local, regional and national interest groups; other community organizations; public presentations including those to local Realtors, national and northern California peace leaders, and international student and business groups; producing and distributing the *Environmental Community Letter*; maintaining the Information Repositories and the Administrative Record; conducting tours of site environmental activities; and responding to public and news media inquiries. DOE/LLNL met three times with members of Tri-Valley Citizens Against a Radioactive Environment and their technical advisor as part of the activities funded by an EPA Technical Assistance Grant.

3. Ground Water Sampling

In 1997, the GWP submitted 890 ground water samples for analysis. These samples were collected during 820 individual sampling events from 352 sampling locations, consisting of 275 monitor wells, 55 source investigation piezometers, 13 TFF/TF406 wells and nine Zone 7 or domestic wells. The samples were analyzed for VOCs, FHCs, polychlorinated biphenyls, metals, radionuclides, or combinations of these analyses depending on the compounds of concern.

Livermore Site ground water sampling frequency recommendations are updated quarterly using a cost-effective sampling algorithm that evaluates trends in contaminant levels in each well over an 18-month period. The sampling frequency is determined by the treatment facility Task 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.
- Wells exhibiting moderate change (≥10 ppb but <30 ppb per year) are sampled semiannually.
- Wells showing large change (≥30 ppb) are sampled quarterly.
- Wells with less than 18 months of analytical history are sampled quarterly for the first 18 months, then the algorithm logic, and input from the Task Leaders for each treatment facility area, determine the sampling frequency.

Wells located at the leading edge of VOC plumes are sampled quarterly. The sampling schedule for 1998 is presented in Appendix C.

4. Ground Water Flow and Transport Modeling

Ground water flow and contaminant transport models are used at the Livermore Site to improve our ability to forecast, monitor, and interpret the progress of the ground water remediation program. Modeling results are also used to support ongoing subsurface characterization.

Ground water flow and transport modeling is part of our overall support of the design and performance evaluation of Livermore Site remediation systems. In 1997, we further developed our three-dimensional (3-D) ground water model for the Livermore Site. The 3-D model builds vertical resolution into the two-dimensional (2-D) model previously developed for the Livermore Site (Tompson, et al., 1995).

4.1. Treatment Facility B Model

In 1997, a 3-D ground water flow and contaminant transport model was developed that focused on the transport of dissolved trichloroethylene (TCE) in hydrostratigraphic units (HSUs) 1B and 2 in the TFB area. A technical note containing a description of the 3-D model calibration and a summary of the preliminary results was completed in August 1997 (Demir et al., 1997). This 3-D model was developed using the CFEST (Coupled Flow, Energy and Solute Transport) computer code (Gupta, 1987). The modeling was an extension of the TFA area model performed in 1996 (Vogele et al., 1996).

As described in Demir et al. (1997), the 3-D flow model was calibrated to measured ground water elevation data collected from the Livermore Site monitor wells. The contaminant transport portion of the model was calibrated to TCE ground water concentrations observed in the TFB area from 1988 through 1995. These simulations were comprised of a series of remedial pumping time steps that were constructed to reflect changes in extraction well flow rates. Results from the preliminary simulations were within plausible uncertainty limits of the model (Figs. 2 and 3).

The TFB model indicates that the current TFB extraction wells mitigate the offsite migration of the VOC plume. Results of the model analysis show that high pumping rates at TFA induce part of the TFB area plume to migrate towards TFA. Further model analysis indicates that this interference is controllable by adding extraction locations between TFA and TFB. The first of these new locations is planned for installation in early 1998.

4.2. Site-Wide Model for HSUs 1B and 2

The conceptual model used for the TFA and TFB areas was further expanded to simulate the migration of perchloroethylene (PCE), TCE and total VOC plumes in HSU-1B and HSU-2 for the entire Livermore Site. The results of these simulations will be presented in an interim report in early 1998. The site-wide simulations indicated the need for better characterization of the individual VOC plumes with respect to their historical behavior and the definition of the source areas.

4.3. Site-Wide Model for all HSUs

The development of a 3-D model for all Livermore Site HSUs will require detailed hydrogeological and contaminant data for the entire Livermore Site and adjacent areas. In 1997, work began on developing these site-wide data sets. To improve the accuracy of simulations and to better simulate the contaminant migration in the source areas, all available data regarding the subsurface hydraulic properties are being analyzed. The results of this work, together with the detailed HSU definitions, will be used to expand the current 3-D model analysis to include all HSUs beneath the Livermore Site.

An evaluation of the migration history of individual plumes was also begun in 1997. As a result of this work, plumes for 11 individual VOC constituents and total VOCs were generated for each quarter from 1987 to 1997 and displayed through a web-based graphical interface for analysis. This approach is being expanded to inorganic constituents which can serve as additional indicators to further understand ground water movement beneath the site and expedite cleanup.

In 1997, we began to change our primary modeling computer code from CFEST to FEFLOW. FEFLOW is similar to CFEST in that it is a finite element ground water flow and contaminant transport model. However, FEFLOW has superior graphical user interfaces and improved features for handling more complex hydrogeologic boundary conditions and parameters compared to CFEST. We are converting our previous models into FEFLOW and will be performing the site-wide model for all HSUs using FEFLOW.

4.4. Zone 7 Project

In 1997, Zone 7 approached LLNL about using the existing LLNL ground water models to provide assistance to Zone 7 on issues regarding future ground water use in the basin surrounding LLNL. The objective of this investigation is to determine the subsurface volume of ground water and the volume of potential subsurface storage in the basin to answer short- and long-term water resources management questions. For this preliminary investigation, the volume of ground water flow in the basin was estimated using the existing 2-D CFEST flow model (Tompson et. al., 1995). The model was also used to test the influence of different rates of extraction and reinjection within the basin. A volumetric calculation was performed to determine the volume of potential ground water storage in the basin, and a potential drawdown or buildup of ground water in the area of interest. A report to Zone 7 is being prepared and should be ready by early 1998.

5. Annual Summary of Remedial Action Program

This section summarizes activities performed during 1997 to support the Remedial Action Program at the Livermore Site, and includes treatment system design, new construction, modifications to existing systems, treatment facility performance, treatability tests, well installation, well abandonment, and hydraulic tests performed during 1997. The volume of ground water and soil vapor treated at the facilities and the estimated VOC mass removed from the subsurface during 1997 and historically is presented in Tables 2 and 3, respectively. A graph of VOC mass removal at the Livermore Site since 1989 is presented in Figure 4. Figures 5 through 9 show the hydraulic capture areas, based on December 1997 ground water elevation data, in the vicinity of the ground water extraction wells for HSUs 1B, 2, 3A, 4, and 5, respectively. Figures 10 through 14 show fourth quarter total VOC isoconcentrations in the same five HSUs. Figures 15 through 24 show treatment facility extraction wells, pipelines, discharge locations, and self-monitoring program sampling stations.

5.1. Treatment Facility A

TFA is located in the southwestern quadrant of the Livermore Site near Vasco Road and East Avenue (Fig. 1). In 1997, TFA treated ground water from 18 extraction wells, including six HSU 1B wells (W-262, W-408, W-520, W-601, W-602, and W-1004), eleven HSU 2 wells (W-109, W-415, W-457, W-518, W-520, W-603, W-609, W-614, W-903, W-904 and W-1009), and one HSU 3A well (W-712). TFA was operated at flow rates ranging from 270 to 340 gpm.

In June 1997, a new ground water treatment system was installed at TFA. From 1989 to mid 1997, TFA processed VOCs in ground water using a UV/H_2O_2 method that breaks down VOCs into carbon dioxide and chloride ions. The water was further processed with an air stripper to remove any remaining VOCs. In June, the UV/H_2O_2 system was replaced with a more cost-effective, large-capacity air-stripping system. The effluent air from the air stripper is passed through GAC to remove VOCs. The treated effluent air from the air stripper is discharged to the atmosphere. This new system is permitted to treat up to 500 gpm of ground water.

Treated ground water from 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 15). On several occasions in 1997, while attempting to maximize ground water treatment and capture with the UV/H_20_2 system, TFA exceeded its waste discharge requirement (WDR) limit of 5 ppb total VOCs in ground water effluent. These discharges were reported to the Regional Water Quality Control Board, and at no time did VOCs in TFA discharge exceed a Maximum Contaminant Level. Since startup of the new system, TFA has not exceeded the 5 ppb total VOC WDR limit.

From 1989 through 1994, TFA treated ground water extracted 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 (Fig. 15).

In 1997, in conjunction with LLNL’s Geosciences and Environmental Technology Division, a vadose zone study area was constructed in the southwest corner of the TFA area for conducting infiltration studies. In late October and early November, about 6,300 gallons of water containing noble gas isotopes were introduced into the vadose zone at a rate of about 0.4 gallons per minute. The infiltration was imaged using electrical resistance tomography (ERT), which showed that the water reached the water table (≈70 ft below ground surface [bgs]) within a day of being released. Changes in moisture content in the vadose zone were detected barometrically, and also electrically by monitoring resistance changes in gypsum blocks deployed to specific depths beneath the site. Preliminary results indicate that the dissolved noble gas tracers coming out of solution at the water table are rapidly dissipating in the vadose zone. Additional tracer and ERT experiments are planned for spring of 1998.

5.1.1. Performance Summary

During 1997, TFA treated more than 128 million gal of ground water containing an estimated 18.4 kg of VOCs (Table 2). Since system startup in 1989, TFA has treated nearly 391 million gal of ground water and removed about 94.3 kg of VOC mass from the subsurface (Table 3).

The TFA VOC plumes in HSUs 1B, 2, and 3A continue to be hydraulically controlled 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. 10, 11, and 12) for each HSU.

5.1.2. Field Activities

Sixteen boreholes were drilled in the TFA area in 1997 for the infiltration study. Three boreholes (SEA-INF-001, SEA-INF-002, and SEA-INF-003) were completed in the unsaturated zone using FLUTe liners. The FLUTe (formerly called SEAMIST) system is an impermeable, everted membrane that carries soil vapor sampling instrumentation down an unlined borehole (Keller and Lowry, 1991). Four boreholes (SIB-INF-004, SIB-INF-005, SIB-INF-006 and SIB-INF-007) were completed as unsaturated zone monitoring wells. Eight boreholes (SIB-INF-008, SIB-INF-009, SIB-INF-010, SIB-INF-011, SIB-INF-013, SIB-INF-014, SIB-INF-015, and SIB-INF-016) were completed as unsaturated zone instrumentation boreholes. One borehole (SIB-INF-012) was completed to 16 ft and was used as the infiltration well for the test.

In 1997, eight one-hour drawdown tests were conducted in the TFA area on wells W-1002, W-1003, W-1005, W-1006, W-1107, W-1214, W-1217, and W-1227. Results are presented in Appendix B. No other hydraulic tests were conducted in the TFA area during 1997.

5.2. Treatment Facility B

TFB is located north of Mesquite Way in the west-central portion of the Livermore Site (Fig. 1). In 1997, TFB treated ground water from six extraction wells, including three HSU 1B wells (W-610, W-620, and W-704), and three HSU 2 wells (W-357, W-621, and W-655). TFB was operated at flow rates ranging from 40 to 45 gpm in 1997.

TFB processes VOCs in ground water using a UV/H_2O_2 and air stripping system similar to TFA. The effluent air from the air stripper is treated using GAC prior to discharge to the atmosphere. Ground water is treated for hexavalent chromium by adding hydrogen peroxide and carbon dioxide.

Treated ground water from TFB is discharged into the north-flowing drainage ditch running parallel to Vasco Road that empties into Arroyo Las Positas to the north. TFB was in compliance with all permits throughout 1997.

From 1990 through 1995, TFB treated ground water extracted from wells W-357 and W-704. The TFB North Pipeline and TFB West Pipeline connected four additional extraction wells to TFB in September 1995 (Figs 1 and 16).

5.2.1. Performance Summary

During 1997, TFB treated about 16.9 million gal of ground water containing an estimated 6.8 kg of VOCs (Table 2). Since system startup in 1990, TFB has treated nearly 65.3 million gal of ground water and removed about 25.5 kg of VOC mass from the subsurface (Table 3).

The TFB VOC plumes in HSUs 1B and 2 continue to be hydraulically controlled 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. 10 and 11) for each HSU.

5.2.2. Field Activities

No boreholes or wells were drilled or installed in the TFB area during 1997.

In 1997, a one-hour drawdown test was conducted in the TFB area on well W-1226. Results are presented in Appendix B. No other hydraulic tests were conducted in the TFB area during 1997.

5.3. Treatment Facility C

Treatment Facility C (TFC) is located north of Westgate Drive and west of Avenue A in the northwest quadrant of the Livermore Site (Fig. 1). In 1997, TFC treated ground water from six HSU 1B extraction wells (W-701, W-1015, W-1102, W-1103, W-1104, and W-1116).

The PTU location TFC Southeast (TFC-SE) was activated on January 21, 1997, 10 days ahead of its RAIP milestone date. TFC-SE is located near the intersection of Avenue A and Sixth Street in the northwest quadrant of the Livermore Site (Fig. 1). TFC-SE treats ground water from HSU 1B well W-1213. The combined TFC facilities were operated at flow rates ranging from 45 to 55 gpm in 1997.

TFC and TFC-SE process VOCs in ground water using air stripping. The effluent air from the air stripper is treated using GAC prior to discharge to the atmosphere. Ground water is treated for hexavalent chromium using an ion-exchange unit. As with TFB, under the revised discharge permit (Bessette Rochette, 1996), TFC and TFC-SE require treatment for hexavalent chromium.

Treated ground water from TFC is discharged into the drainage ditch that flows northward and empties into Arroyo Las Positas (Fig. 17). Treated ground water from TFC-SE is discharged into a storm sewer that empties into Arroyo Las Positas to the north (Fig. 18). TFC was in compliance with all permits throughout 1997.

From 1993 through 1996, TFC treated ground water extracted from well W-701. The TFC North Pipeline connected five additional extraction wells to TFC in September 1996 (Fig. 17).

5.3.1. Performance Summary

During 1997, the combined TFC facilities treated more than 22.7 million gal of ground water containing an estimated 9.4 kg of VOCs (Table 2). Since 1993, the combined TFC facilities have treated nearly 35.6 million gal of ground water and removed about 15.4 kg of VOC mass from the subsurface (Table 3).

In the TFC area, VOCs are confined to HSU 1B. The VOC plumes in the TFC area continue to be hydraulically controlled based on the capture zone analysis shown on the ground water elevation contour map (Fig. 5) and the total VOC isoconcentration map (Fig. 10) for HSU 1B.

5.3.2. Field Activities

No boreholes or wells were drilled or installed in the TFC area during 1997.

In 1997, a one-hour drawdown test was conducted in the TFC area on well W-1224. Results are presented in Appendix B. No other hydraulic tests were conducted in the TFC area during 1997.

5.4. Treatment Facility D

Treatment Facility D (TFD) is located north of the Drainage Retention Basin (DRB) in the east-central portion of the Livermore Site (Fig. 1). In 1997, TFD treated ground water from four extraction wells, including one HSU 2 well (W-906) one HSU 3A well (W-1208) and two HSU 4 wells (W-351 and W-907).

Two additional extraction locations, TFD West (TFD-W) and TFD East (TFD-E), were activated in 1997 using PTUs. TFD-W is located south of the North Inner Loop Road in the central portion of the Livermore Site (Fig. 1). TFD-W treats ground water from two HSU 2 extraction wells (W-1215 and W-1216). TFD-E is located east of the DRB in the east-central portion of the Livermore Site (Fig. 1). 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). The combined TFD facilities were operated at flow rates ranging from 60 to 100 gpm in 1997.

TFD, TFD-W, and TFD-E process ground water for treatment of VOCs using air stripping. The effluent air from the air stripper is treated using GAC prior to discharge to the atmosphere. Treated ground water from TFD and TFD-E is discharged into the underground pipeline downstream of the DRB weir, and flows northward to Arroyo Las Positas (Figs. 19 and 20). Treated ground water from TFD-W is discharged into a nearby storm sewer that also empties into Arroyo Las Positas (Fig. 21). All TFD facilities were in compliance with all permits throughout 1997.

TFD began operation in September 1994 and treated ground water extracted from wells W-351, W-906, and W-907. In January 1997, well W-1208 was connected to TFD. PTU location TFD-W was activated on April 22, 1997, three days ahead of its RAIP milestone date. PTU location TFD-E was activated on September 16, 1997, 14 days ahead of its RAIP milestone date.

5.4.1. Performance Summary

During 1997, the combined TFD facilities treated more than 48.1 million gal of ground water containing an estimated 55.0 kg of VOCs (Table 2). Since 1994, the combined TFD facilities have treated nearly 60.5 million gal of ground water and removed about 73.4 kg of VOC mass from the subsurface (Table 3).

The TFD area extraction wells hydraulically control VOCs in HSUs 2, 3A, and 4 associated with the East Traffic Circle Landfill and Helipad source areas based on the capture zone analysis shown on the ground water elevation contour maps (Figs. 6, 7, and 8) and the total VOC isoconcentration maps (Figs. 11, 12, and 13) for each HSU.

5.4.2. Field Activities

Thirteen wells were installed in the TFD area during 1997. Extraction wells W-1303 and W-1306 were installed in HSUs 2 and 3A, and W-1307 was installed in HSU-4. These three wells were connected to the TFD-E PTU in 1997. Monitor wells W-1304 and W-1402 were completed in HSU 3A in the TFD-E area. Monitor wells W-1311 and W-1401 were completed in HSU 2 in the TFD-W area.

Extraction well W-1308 was installed in HSU 2 and is planned to be connected to the TFD-Southeast (TFD-SE) PTU location in March 1998 (Fig. 1). Monitor wells W-1404, W-1405, and W-1407 were completed in HSU 2, and wells W-1403 and W-1406 were completed in HSU 4 in the TFD-SE area. Well construction details are provided in Table A-1.

Well W-352 was sealed and abandoned to accommodate expansion of Building 451 (Fig. 1). The well was properly sealed in December 1997 by pressure grouting. Well closure data are presented in Table A-2 of Appendix A.

The TFD-South PTU is scheduled to begin operation in June 1998 (Fig. 1). TFD-South will treat water pumped from wells W-1218 and W-1220.

In 1997, seven one-hour drawdown tests were conducted in the TFD area on wells W-1304, W-1306, W-1307, W-1308, W-1311, W-1401, and W-1402. Seven long-term (72-hour) hydraulic tests were performed in the TFD area to evaluate the effectiveness of proposed extraction wells. Tests were performed on wells W-1301, W-1303, and W-1306 in the TFD-E PTU location, W-1308 and W-314 in the TFD-SE PTU location, and W-1218 and W-1220 in the TFD-South PTU location. The results of these tests indicated that the location and flow rates for all seven of these wells were suitable for use as extraction wells. Results are presented in Appendix B.

5.4.3. Field Scale Pilot Tests

A treatability test of the SWAT unit was conducted from August 13 through November 5, 1997 on well W-361, south of the DRB (Fig. 1). A solar powered pump was used to extract ground water, which was then passed through a series of three 30-lb GAC canisters for treatment. The treated ground water was discharged into the DRB. During the treatability tests in 1997, the SWAT unit treated about 107,000 gal of ground water containing an estimated 1.0 kg of VOCs.

In addition, a PTU was operated at well W-352 from January to August 1997 as part of a pilot test to demonstrate expedited site cleanup. Well W-352 is located north of the South Inner Loop road near Southgate Drive (Fig. 1). Well W-352 was pumped at a rate of about 30 gpm, and about 8 million gal of ground water containing an estimated 7.7 kg of VOCs was treated.

5.5. Treatment Facility E

Multiple PTUs will be located in the Treatment Facility E (TFE) area in the southeastern quadrant of the Livermore Site. In 1997, one PTU, TFE East (TFE-E), was operating in the area. TFE-E is located west of Avenue H near Third Street in the east-central portion of the Livermore Site (Fig. 1). TFE-E, activated in November 1996, treats ground water from two extraction wells, W-1109 (HSU 2) and W-566 (HSU 5). TFE-E was operated at flow rates ranging from 15 to 20 gpm in 1997.

TFE-E processes ground water for treatment of VOCs using an air stripper, and the effluent air is treated using GAC to remove VOCs prior to discharge to the atmosphere. Treated ground water from TFE-E is discharged into a drainage ditch flowing north into the DRB (Fig. 22). TFE-E was in compliance with all permits throughout 1997.

5.5.1. Performance Summary

During 1997, TFE-E treated about 9.5 million gal of ground water containing an estimated 15.9 kg of VOCs (Table 2). Since system startup in 1996, TFE-E has treated nearly 9.9 million gal of ground water and removed about 17.1 kg of VOC mass from the subsurface (Table 3).

The TFE-E extraction wells provide hydraulic control of VOC source areas in HSUs 2 and 5 in the TFE area based on the capture zone analysis shown on the ground water elevation contour maps (Figs. 6 and 9) and the total VOC isoconcentration maps (Figs. 11 and 14) for each HSU.

5.5.2. Field Activities

No boreholes or wells were drilled or installed in the TFE area during 1997.

In 1997, two one-hour drawdown tests were conducted in the TFE area on wells W-1008 and W-1219. Results are presented in Appendix B. No other hydraulic tests were conducted in the TFE area during 1997.

5.6. Treatment Facility G

Multiple PTUs will be located in the Treatment Facility G Area in the south-central portion of the Livermore Site. In 1997, one PTU, Treatment Facility G-1 (TFG-1), was operating in the TFG area. TFG-1 is located near Avenue B, about 300 ft north of East Avenue in the south-central part of the Livermore Site (Fig. 1). TFG-1, activated in April 1996, treats ground water from extraction well W-1111 (HSU 2) and was operated at a flow rate of about 8 gpm in 1997.

TFG-1 processes ground water for VOC treatment using an air stripper, and the effluent air is treated using GAC to remove VOCs prior to discharge to the atmosphere. Ground water is treated for hexavalent chromium using an ion-exchange unit. As with TFB and TFC, under the revised discharge permit (Bessette Rochette, 1996), TFG-1 requires treatment for hexavalent chromium.

Treated ground water from TFG-1 is discharged to a storm drain located about 50 ft north of TFG-1 (Fig. 23), which empties into Arroyo Seco. TFG-1 was in compliance with all permits throughout 1997.

5.6.1. Performance Summary

During 1997, TFG-1 treated about 3.3 million gal of ground water containing an estimated 0.6 kg of VOCs (Table 2). Since system startup in 1996, TFG-1 has treated nearly

4.3 million gal of ground water and removed about 0.8 kg of VOC mass from the subsurface (Table 3).

TFG-1 extraction well W-1111 provides hydraulic control of the VOC source areas 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 (Fig. 11) for HSU 2.

5.6.2. Field Activities

No boreholes or wells were drilled or installed in the TFG area during 1997. No hydraulic tests were conducted on TFG wells during 1997.

5.7. Treatment Facility 406

TF406 is located east of Southgate Drive near East Avenue in the south-central part of the Livermore Site (Fig. 1). In 1997, TF406 treated ground water from two extraction wells, GSW-445 (HSU 4) and W-1114 (HSU 5). TF406 was operated at flow rates ranging from 4 to 20 gpm in 1997.

TF406 processes ground water for VOC treatment using an air stripper, and the effluent air is treated using GAC to remove VOCs prior to discharge to the atmosphere. All treated ground water is discharged to a storm drain that flows to Arroyo Las Positas (Fig. 24). TF406 was in compliance with all permits throughout 1997.

TF406, activated in August 1996, processes ground water from extraction wells GSW-445 and W-1114. In April 1997, well W-1114 was damaged beyond repair during the drilling of new borehole B-1305. Borehole B-1305 was intended as an additional extraction well for TF406. Both wells were subsequently destroyed. Two new extraction wells (W-1309 and W-1310) were installed in 1997 to replace well W-1114 and borehole B-1305. TF406 is scheduled to begin processing ground water from wells W-1309 and W-1310 in February 1998. Cumulative flow from the three wells is projected to be about 30 to 35 gpm. The TF406 extraction wells will provide hydraulic control of VOC plumes in HSUs 4 and 5.

Passive bioremediation continued to be implemented in this area during 1997. Active ground water extraction and treatment for residual dissolved FHCs using TFF was permanently discontinued in 1996 (Hoffman et al., 1997).

5.7.1. Performance Summary

During 1997, TF406 processed about 2.3 million gal of ground water from wells W-1114 and GSW-445 containing an estimated 0.9 kg of VOCs (Table 2). Since system startup in 1996, TF406 has treated nearly 2.7 million gal of ground water and removed about 1.1 kg of VOC mass from the subsurface (Table 3).

5.7.2. Field Activities

Two wells were installed in the TF406 area during 1997. HSU 4 extraction well W-1309 was installed adjacent to the TF406 PTU and will augment extraction from well GSW-445. HSU 5 extraction well W-1310 was installed next to well W-1309 and replaces well W-1114.

Both W-1114 and B-1305 were pressure grouted and properly sealed. Well construction details are provided in Table A-1 and well closure data are presented in Table A-2.

Two one-hour drawdown tests were performed on extraction wells W-1309 and W-1310. Results are presented in Appendix B. No other hydraulic tests were conducted in the TF406 area during 1997.

5.8. Vapor Treatment Facility 518

VTF518 is located in the southeastern quadrant of the Livermore Site, north of East Avenue and near Avenue H (Fig. 1). Soil vapor is extracted at VTF518 from the vadose zone using a vapor extraction system. VOCs are removed from the vapor at VTF518 using GAC canisters. The treated effluent air from the air stripper is discharged to the atmosphere. VTF518 was in compliance with the Bay Area Air Quality Management District permit throughout 1997.

VTF518 was activated in September 1995 by treating soil vapor from extraction well SVI-518-201. An additional vapor extraction well, SVI-518-303 was added in March 1997. The VTF518 facility was operated at flow rates ranging from 20 to 50 standard cubic feet per minute in 1997.

5.8.1. Performance Summary

During 1997, VTF518 processed about 4,330,000 cubic feet (ft^3) of soil vapor, removing an estimated 40.6 kg of VOCs (Table 2). Since VTF518 began operating in September 1995, about 106.9 kg of VOC mass has been removed from approximately 6,187,000 ft^3 of soil vapor (Table 3).

5.8.2. Field Activities

Two FLUTe instrumented/sampling wells, SEA-518-301 and SEA-518-304, continue to be used to monitor vadose zone remediation in the VTF518 area. The FLUTe system is used to collect vapor, pressure, soil temperature, soil moisture, and soil vapor concentration data from various discrete depths. VOC vapor concentrations at SEA-518-301, the FLUTe system borehole nearest VTF518 vapor extraction well SVI-518-201, have declined from an average of 111 parts per million by volume (ppmv) in September 1995 to an average of 34 ppmv in December 1997.

5.8.3. Soil Vapor Extraction Treatability

A treatability test was conducted at VTF518 to evaluate the impact of extracting simultaneously from vapor extraction well SVI-518-201 and proposed vapor extraction well SVI-518-303. The test indicated that higher influent concentrations resulted when pumping from both wells. Accordingly, soil vapor is now being extracted from both wells.

5.9. Ground Water Treatment Facility 518

TF518 is located in the southeastern quadrant of the Livermore Site, north of East Avenue and near Avenue H, adjacent to VTF518 (Fig. 1). TF518 was constructed in 1997 and is scheduled to begin operating by its RAIP milestone date of January 30, 1998.

TF518 will process ground water for VOC treatment using an air stripper, and the effluent air will be treated using GAC to remove VOCs prior to discharge to the atmosphere. All treated ground water will be discharged to a storm drain located about 250 ft north of TF518 that ultimately empties into Arroyo Las Positas.

TF518 will process ground water from HSU 5 extraction well W-112 and HSU 6 extraction well W-211. Well W-112 will provide hydraulic control of VOC source areas in HSU 5. Well W-211 will serve as an HSU 6 extraction well since TCE concentrations in well W-211 exceeded 5 ppb on one sampling event (5.9 ppb, September 1997). Cumulative flow from the two wells is projected to be about 25 gpm.

No ground water wells were drilled or completed in the TF518 area in 1997.

A 72-hr drawdown test was conducted on proposed TF518 extraction well W-211 to evaluate VOC concentrations in HSU 6 and the integrity of the well's annular seal. While not definitive, the test results suggest that TCE at well W-211 may be the result of a leaky annular seal. Results of this test are provided in Appendix B.

5.10. Treatment Facility 5475

The TF5475 area is located in the southeastern quadrant of the Livermore Site (Fig. 1). The operation of TF5475 will start by September 30, 1998.

5.10.1. Field Activities

One dual-screened well, W-1302, was installed in the TF5475 area during 1997. Well W-1302 is a test well designed to use the down-hole in-situ treatment technology catalytic reductive dehalogenation (CRD). Well W-1302 is intended to be the first TF5475 extraction well scheduled to begin full operation in September 1998. Well construction details are provided in Table A-1 of Appendix A.

In 1997, a one-hour drawdown test was conducted in the T5475 area on well W-1225. A series of step-drawdown tests were also conducted on well W-1302. Results are presented in Appendix B. No other hydraulic tests were conducted in the TF5475 area during 1997.

5.10.2. Ground Water Treatability Test

In 1997, pilot testing began at well W-1302 for the down-hole in-situ CRD technology for the treatment of VOCs in ground water. This technology is based upon the reaction of dissolved hydrogen with VOCs on a palladium-alumina catalyst to form ethane and chloride. Hydrogen is provided by electrolysis of water under an applied voltage potential or compressed hydrogen gas. The treatment takes place during one pass through the treatment unit because of the high reaction rates of CRD, allowing the treatment unit to be placed in the well casing. Because well W-1302 is a dual-screened well, the unit extracts from one screened interval and injects treated water into the other. In August 1997, a program of short- and long-term testing was initiated to assess the following issues:

- Scale-up of the treatment technology from bench-top experiments to the higher flow rates encountered in field implementation.
- Optimization of operating parameters (e.g., flow rate vs. applied voltage).
- Evaluation of long-term performance.

Results from these initial tests indicate that the VOC removal efficiency is generally greater than 95%. The high total VOC influent concentrations (about 4,000 to 5,000 ppb) at well W-1302 resulted in high mass removal rates per unit volume of ground water treated. Some tests have shown that the electrolyzer is converting a portion of the chloroform found in the ground water into a maximum of 1.9 ppb chloroethane, 19 ppb chloromethane, and 21 ppb methylene chloride. This may exclude the use of the electrolyzer in the presence of chloroform. Scaling issues are still being evaluated. The unit is designed for a treatment capacity of approximately 3 gpm; however, the local hydrogeologic conditions at well W-1302 constrain the actual rates used during the test to between 1 to 2 gpm.

During the pilot tests, about 5,289 gal of ground water was treated, and an estimated 0.08 kg of VOCs were removed (Table 2).

6. Trends in Ground Water Analytical Results

Notable results of VOC analyses of ground water received from January 1997 through December 1997 are discussed below. Figures 10 through 14 show isoconcentration contours for total VOCs underlying the Livermore Site and vicinity within HSU 1B, HSU 2, HSU 3A, HSU4, and HSU 5, respectively.

1. The TCE concentration in well W-011 has decreased. Well W-011 is located in the eastern portion of the Sandia National Laboratory Site about 500 ft south of East Avenue, and is screened from 136 to 141 ft bgs in HSU 5. In April 1983, <5 ppb of TCE was reported in the initial analysis. Since that time, the TCE increased to a high of 160 ppb in October of 1991, but has decreased to 9.6 ppb as of July 1997.
2. The PCE concentration in well W-602 has gradually decreased. Well W-602 is located in the southwest corner of the Livermore Site, near the intersection of East Avenue and Vasco Road, and is screened from 90 to 100 ft bgs in HSU 1B. In November 1989, 430 ppb PCE was reported in the initial analysis. Since that time, the PCE has gradually decreased to 19 ppb as of May 1997.
3. The TCE concentration in well W-903 has decreased. Well W-903 is located approximately 300 ft west of the Livermore Site near the corner of Vasco Road and East Avenue, and is screened from 132 to 140 ft in HSU 2. In February 1995, 130 ppb TCE was reported in the initial analysis. Since that time, the TCE concentration has gradually decreased to 41 ppb as of May 1997.

References

Bainer, R. W., and L. L. Berg (Eds.) (1997), *Draft Action Memorandum for an Emergency Removal Action at the National Ignition Facility Construction Site, Lawrence Livermore National Laboratory, Livermore Site*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-128728 DR).

Bainer, R. W., and J. Littlejohn (1997a), Letter Report: LLNL Livermore Site September 9, 1997 Remedial Program Managers' Meeting Summary and Third Quarter Self-Monitoring Report, dated November 26, 1997.

Bainer, R. W., and J. Littlejohn (1997b), Letter from LLNL/DOE to Mike Gill of the EPA transmitting the NIF Closeout Report, dated December 5, 1997.

Bainer, R. W., and J. Littlejohn (1997c), Letter from LLNL/DOE transmitting revised Standard Operating Procedures for ground water sampling, dated August 19, 1997.

Bainer, R. W., and J. Littlejohn (1997d), Letter Report: LLNL Livermore Site July 17, 1997 Remedial Program Managers' Meeting Summary, dated September 18, 1997.

Bainer, R. W., and J. Littlejohn (1997e), Letter from LLNL/DOE to Michael Rochette of the RWQCB requesting approval to increase Treatment Facility A's discharge, dated September 16, 1997.

Bainer, R. W., and J. Littlejohn (1998), Letter Report: LLNL Livermore Site December 16, 1997 Remedial Program Managers' Telephone Conference Summary and Fourth Quarter Self-Monitoring Report, dated February 27, 1998.

Berg, L. L., M. D. Dresen, R. W. Bainer, E. N. Folsom, and A. L. Lamarre (Eds.) (1997a), *Five-Year Review for the Lawrence Livermore National Laboratory, Livermore Site,* Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-126935).

Berg, L. L., M. D. Dresen, R. W. Bainer, E. N. Folsom, and A. L. Lamarre (Eds.) (1997b), *Remedial Design Report No. 4 for the Trailer 5475 Treatment Facilities, Lawrence Livermore National Laboratory, Livermore Site,* Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-126014 DR).

Berg, L. L., E. N. Folsom, M. D. Dresen, R. W. Bainer, and A. L. Lamarre (Eds.) (1997c), *Explanation of Significant Differences for Treatment Facilities A and B, Lawrence Livermore National Laboratory, Livermore Site*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-125555).

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

Bessette Rochette, M. (1997), Letter from Michael Bessette Rochette, RWQCB Remedial Project Manager, approving DOE/LLNL's request for a discharge increase at TFA, dated December 16, 1997.

Demir, Z., R. J. Gelinas, P. F. McKereghan, and T. J. Vogele (1997), *Preliminary 3-D Simulations of Contaminant Migration in Ground Water Beneath LLNL Livermore Site: Second Interim Report - The TFB Area*, Lawrence Livermore National Laboratory, Livermore, Calif. (ERD/LS/3DIR:2).

Dibley, V. (1997), *Quality Assurance Project Plan, Livermore Site and Site 300 Environmental Restoration Projects,* Lawrence Livermore National Laboratory, Livermore Calif. (UCRL-AR-103160 Rev. 3).

Dresen, M. D., J. P. Ziagos, A. J. Boegel, and E. M. Nichols (Eds.) (1993), *Remedial Action Implementation Plan for the LLNL Livermore Site*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-110532)(Page 43 revised September 2, 1993; Table 5 revised July 1997).

Gupta, S. K., C. R. Cole, C. T. Kincaid, and A. M. Monti (1987), *Coupled Fluid, Energy, and Solute Transport (CFEST) Model: Formulation and User's Manual*, Office of Nuclear Waste, Battelle Memorial Institute, Columbus, Ohio (Report BMI/ONWI-660).

Hoffman, J., P. McKereghan, B. Qualheim, R. Bainer, E. Folsom, and M. Dresen (Eds.) (1997), *LLNL Ground Water Project 1996 Annual Report*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-126020).

Keller C., and B. Lowry (1991), "A New Vadose Zone Fluid Sampling System for Uncased Holes," in *Proceedings of the Fourth National Outdoor Action Conference on Aquifer Restoration, Ground Water Monitoring and Geophysical Methods*, pp. 3–10, May 4–17, 1991, Las Vegas, Nev., presented by the Association of Ground Water Scientists and Engineers (division of the National Ground Water Association).

Lamarre, A. L., and J. Littlejohn (1997a), Letter Report: LLNL Livermore Site March 5, 1997 Remedial Program Managers' Meeting Summary and First Quarter Self-Monitoring Report, dated May 23, 1997.

Lamarre, A. L., and J. Littlejohn (1997b), Letter Report: LLNL Livermore Site June 13, 1997 Remedial Program Managers' Meeting Summary and Second Quarter Self-Monitoring Report, dated August 29, 1997.

Lamarre, A. L., and J. Littlejohn (1997c), Letter from LLNL/DOE transmitting *Remedial Design Report No. 4 Status Report* to the regulatory agencies, dated February 24, 1997.

Lamarre, A. L., and J. Littlejohn (1997d), Letter from LLNL/DOE to the regulatory agencies proposing changes in guard well sampling and analysis at Lawrence Livermore National Laboratory, Livermore Site, dated May 5, 1997.

Lamarre, A. L., and J. Littlejohn (1997e), Letter from LLNL/DOE transmitting the Consensus Statement and Remedial Action Implementation Plan Table 5 to the regulatory agencies, dated July 17, 1997.

Tompson, A. F. B., P. F. McKereghan, and E. M. Nichols (Eds.) (1995), *Preliminary Simulation of Contaminant Migration in Ground Water at the Lawrence Livermore National Laboratory,* Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-ID-115991).

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

Vogele, T. J., A. Kulresthra, J. J. Nitao, and K. Lee (1996a), *Simulation of Soil Vapor Extraction at Building 518*, *Lawrence Livermore National Laboratory Livermore Site*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-124995).

Figures

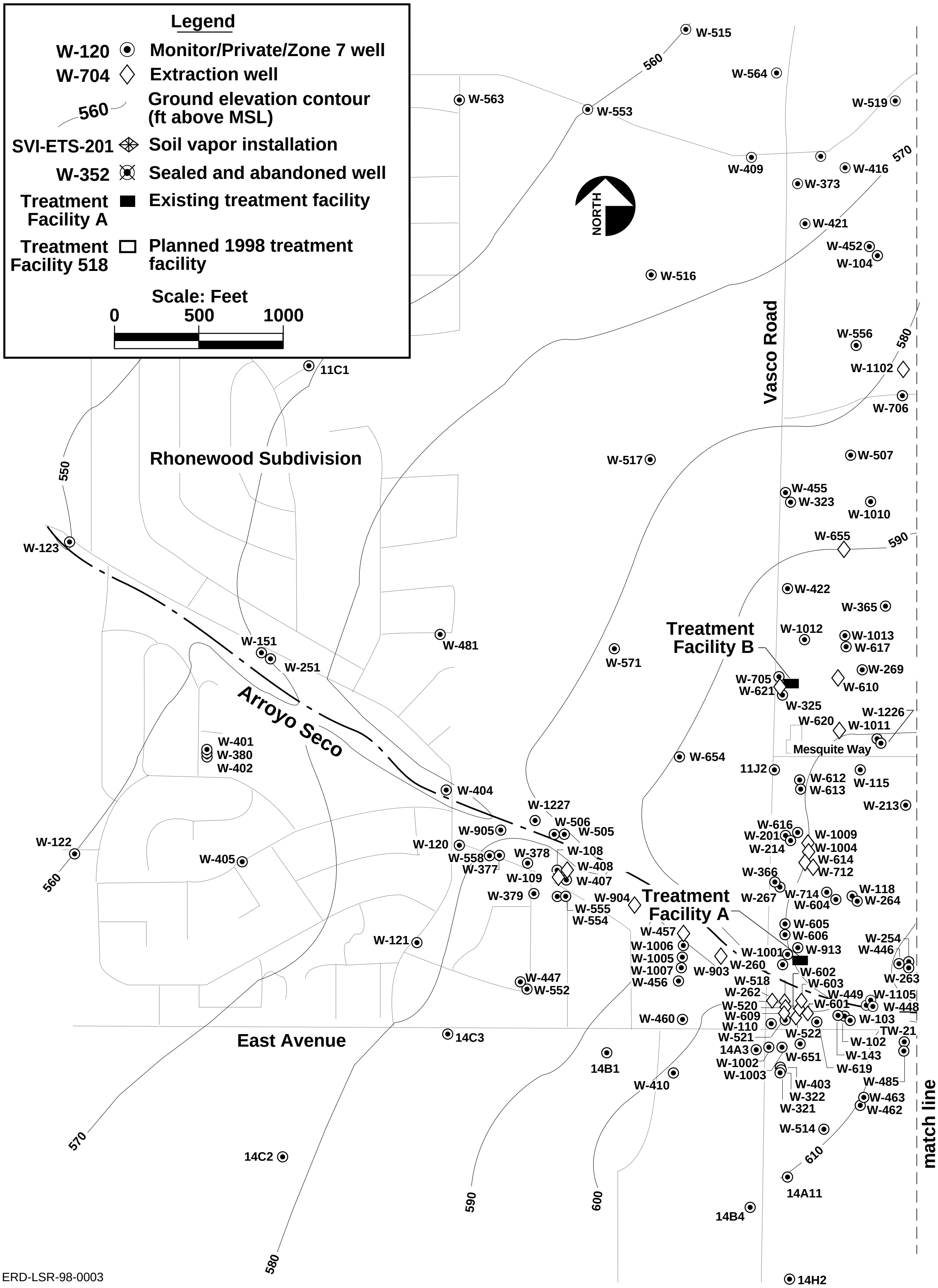


Figure 1. Locations of Livermore Site monitor wells, extraction wells and treatment facilities, December 1997.

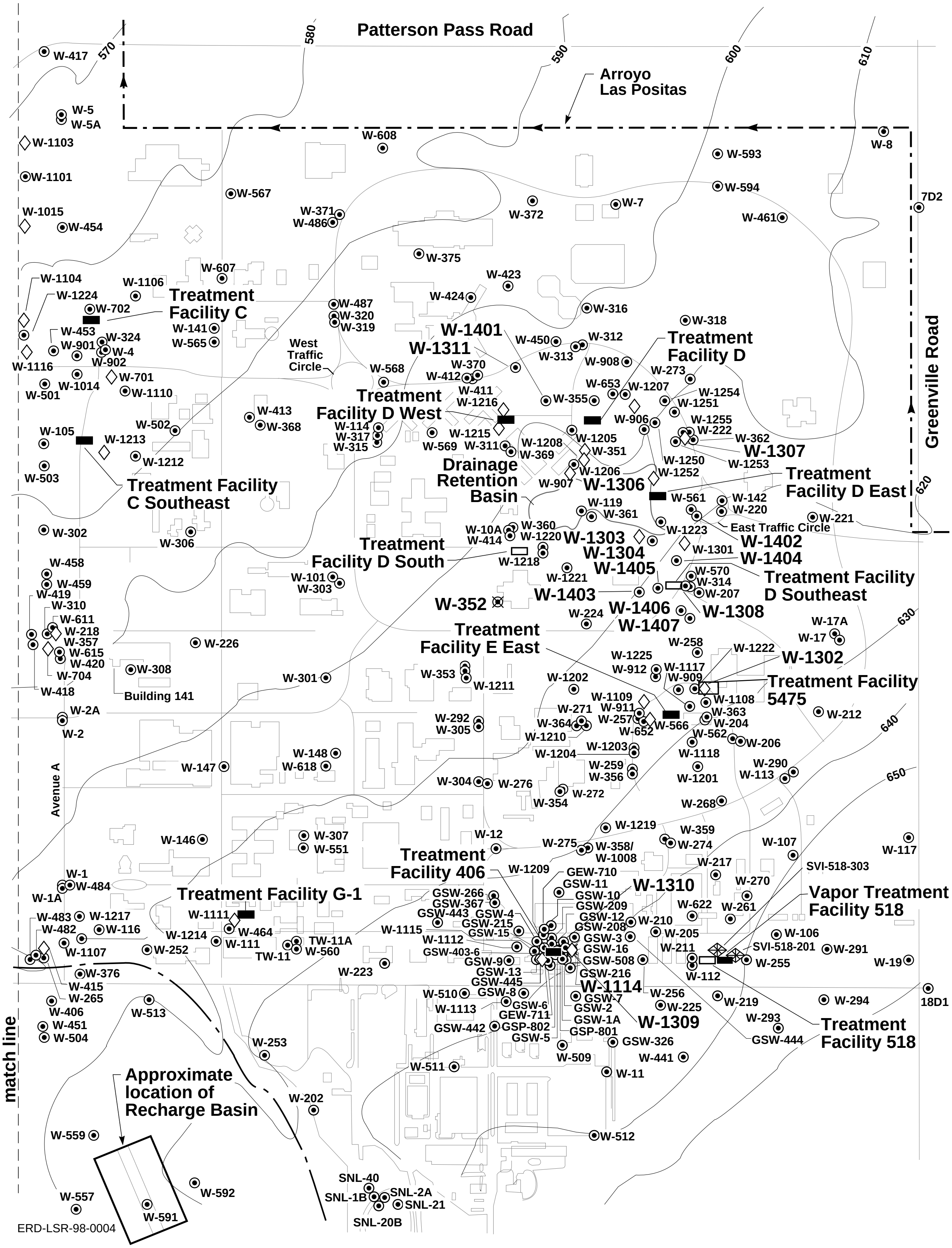
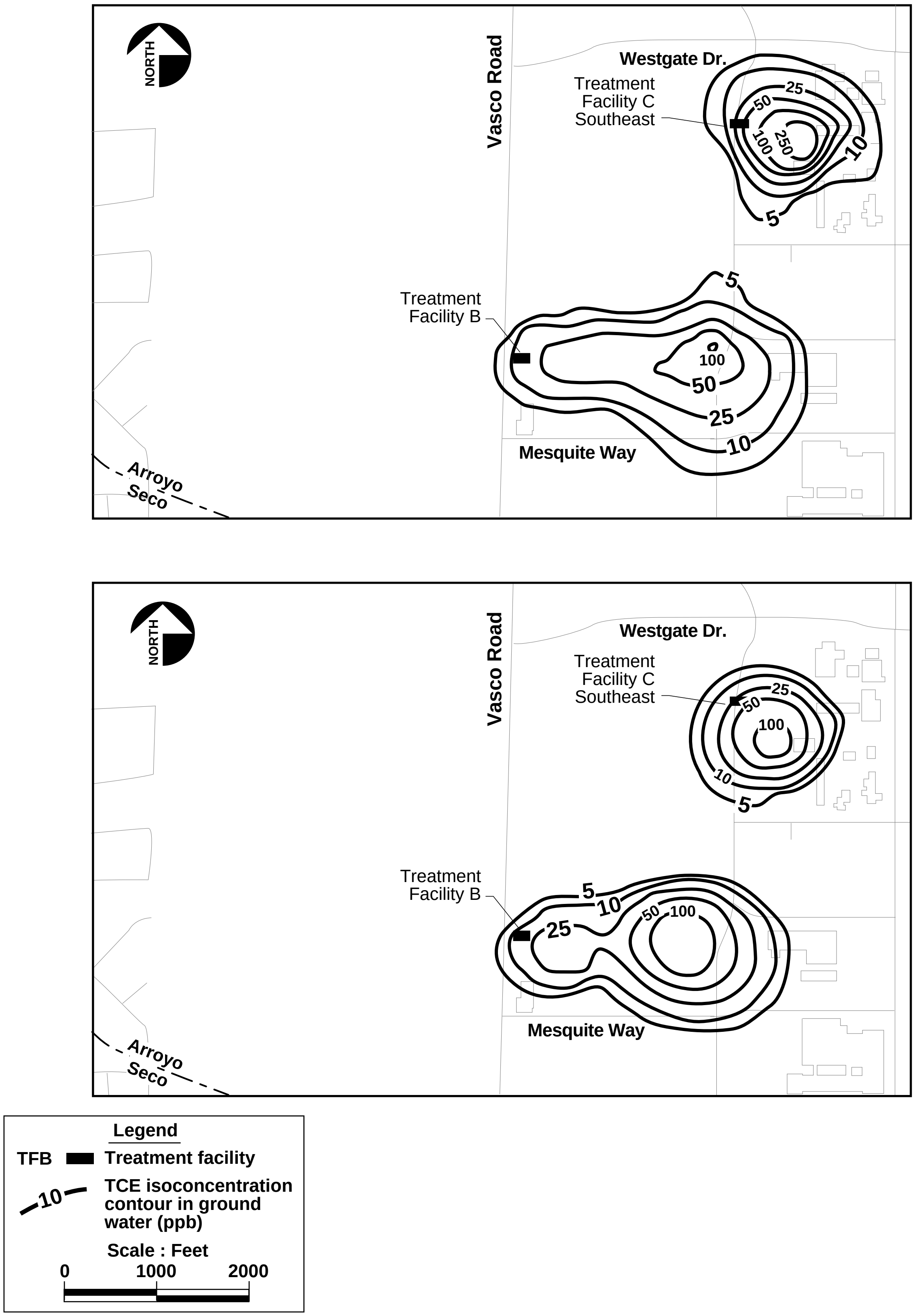
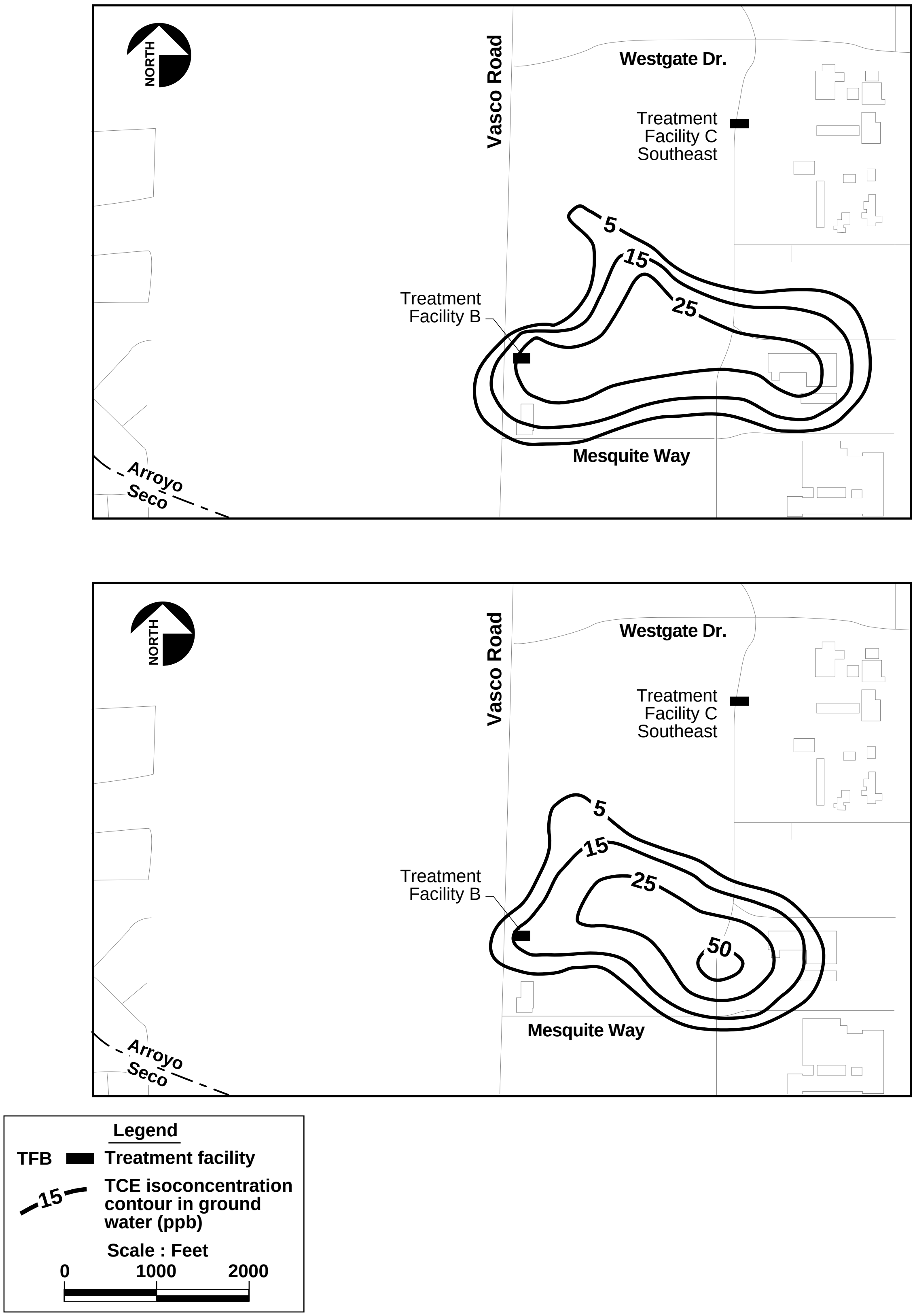


Figure 1 (continued).



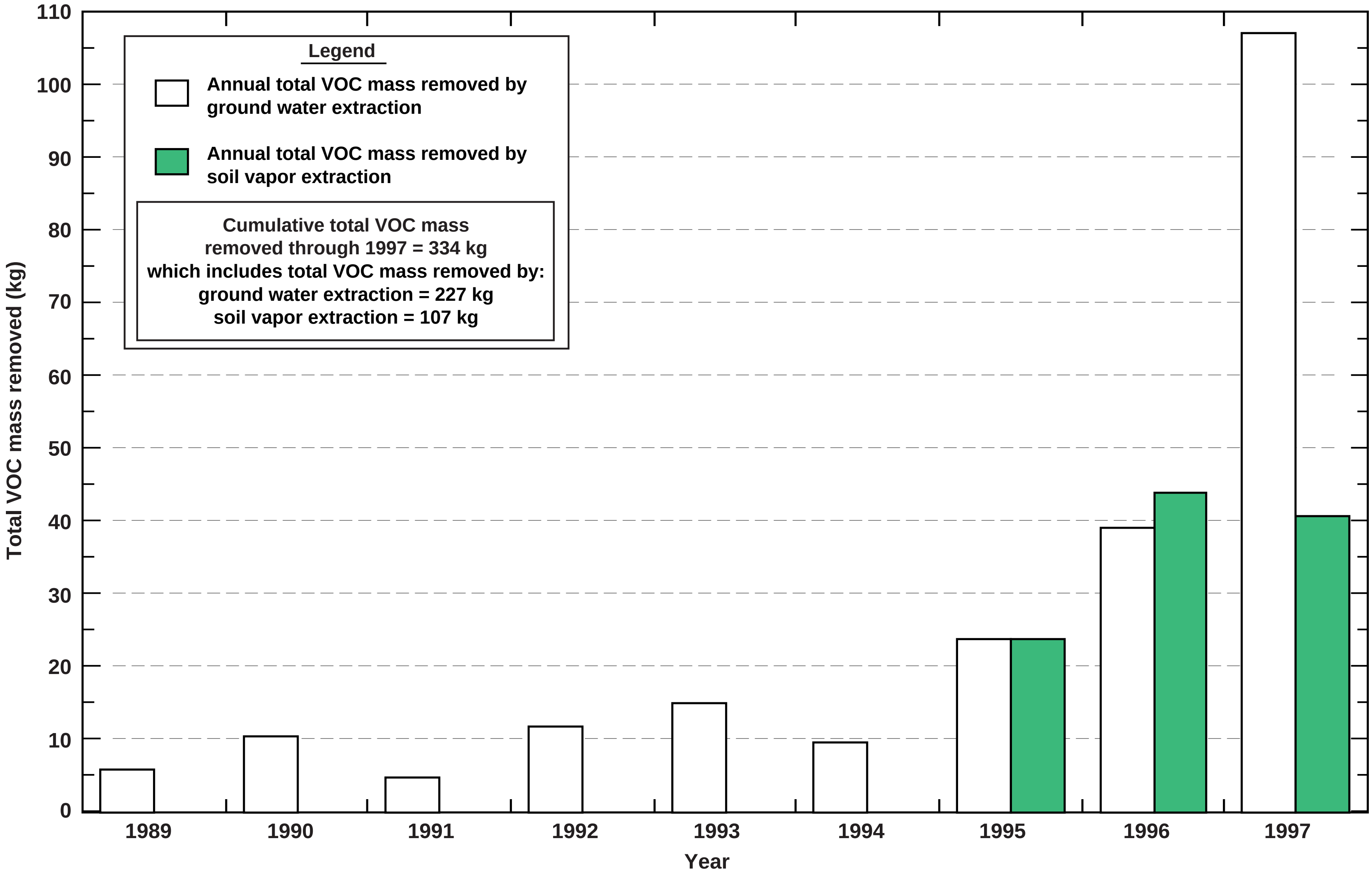
ERD-LSR-98-0026

Figure 2. Comparison of measured (top) and simulated (bottom) aqueous TCE concentrations in HSU 1B for 1996.



ERD-LSR-98-0027

Figure 3. Comparison of measured (top) and simulated (bottom) aqueous TCE concentrations in HSU 2 for 1996.



ERD-LSR-98-0025

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

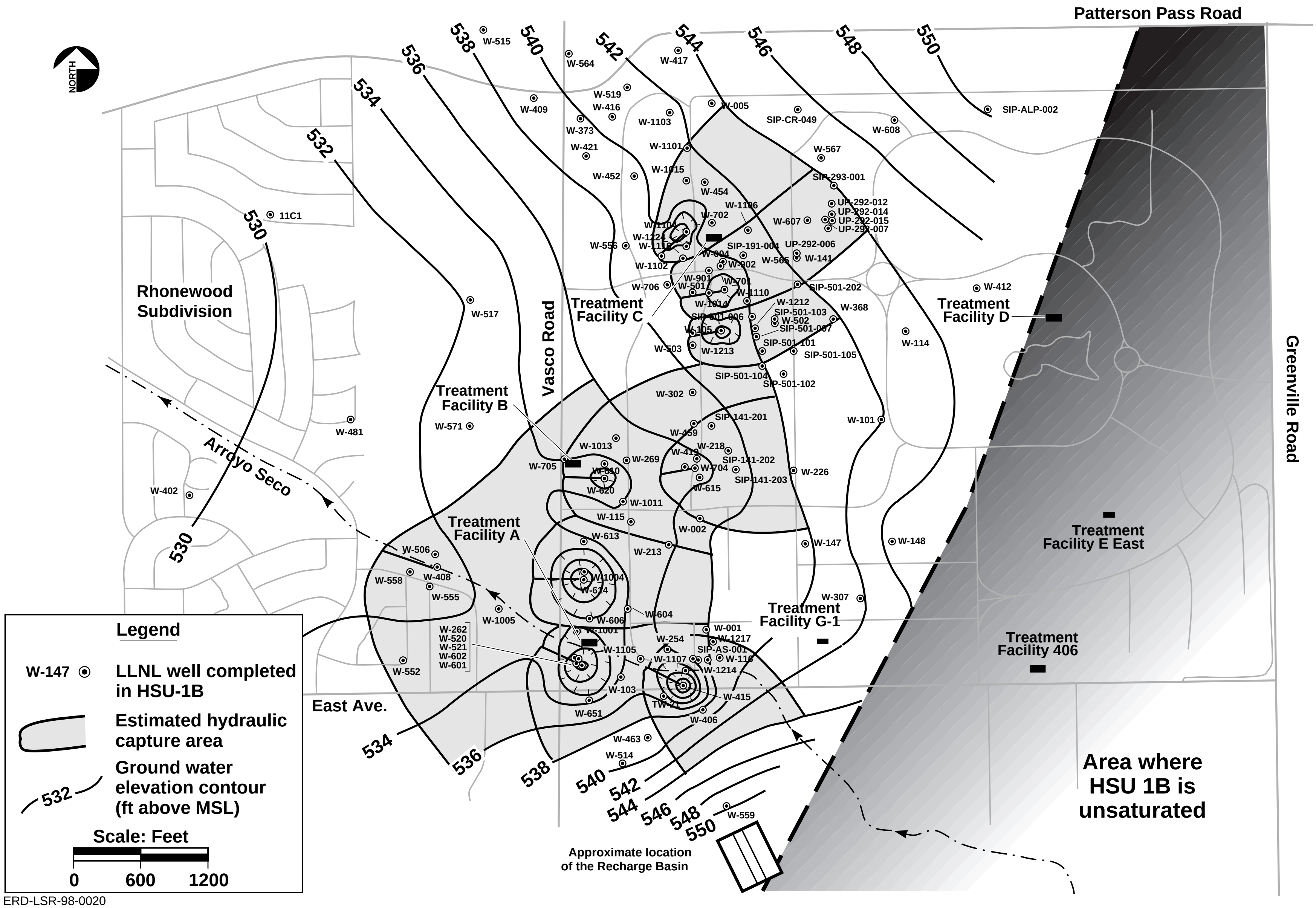
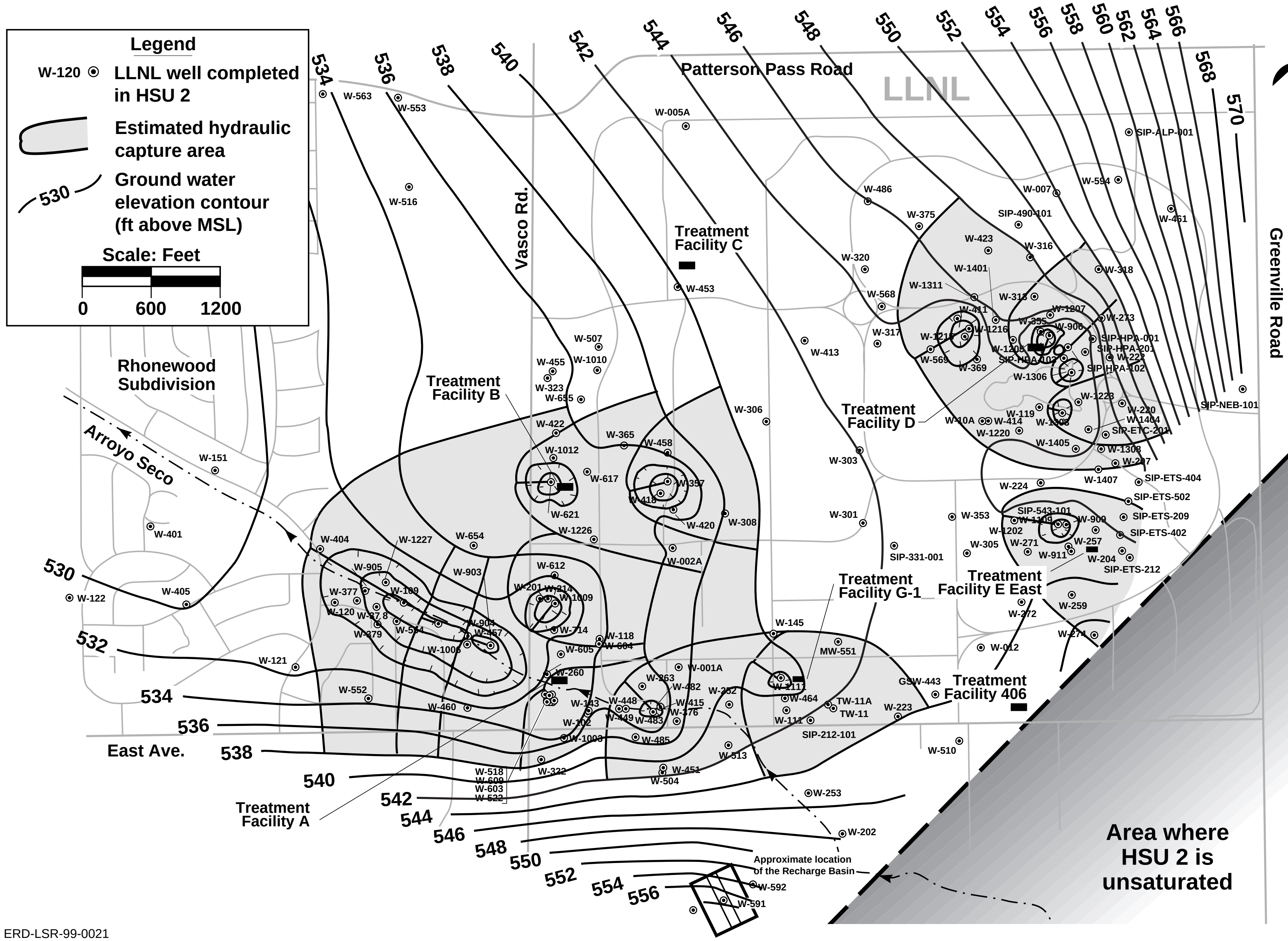


Figure 5. Ground water elevation contour map based on water levels collected from 126 wells completed within HSU 1B showing estimated hydraulic capture areas, LLNL and vicinity, December 1997.



ERD-LSR-99-0021

Figure 6. Ground water elevation contour map based on water levels collected from 152 wells completed within HSU 2 showing estimated hydraulic capture areas, LLNL and vicinity, December 1997.

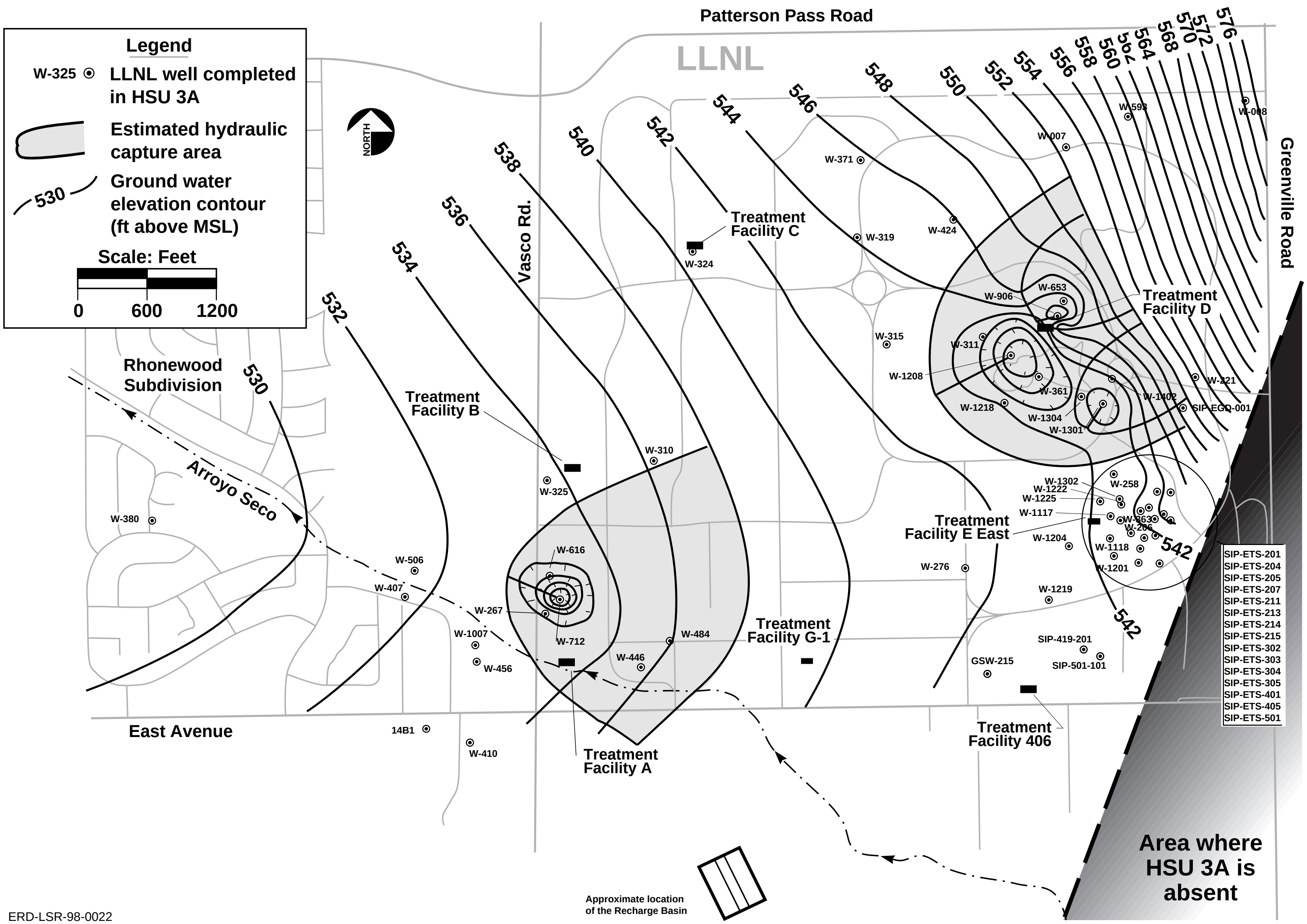


Figure 7. Ground water elevation contour map based on water levels collected from 60 wells completed within HSU 3A showing estimated hydraulic capture areas, LLNL and vicinity, December 1997.

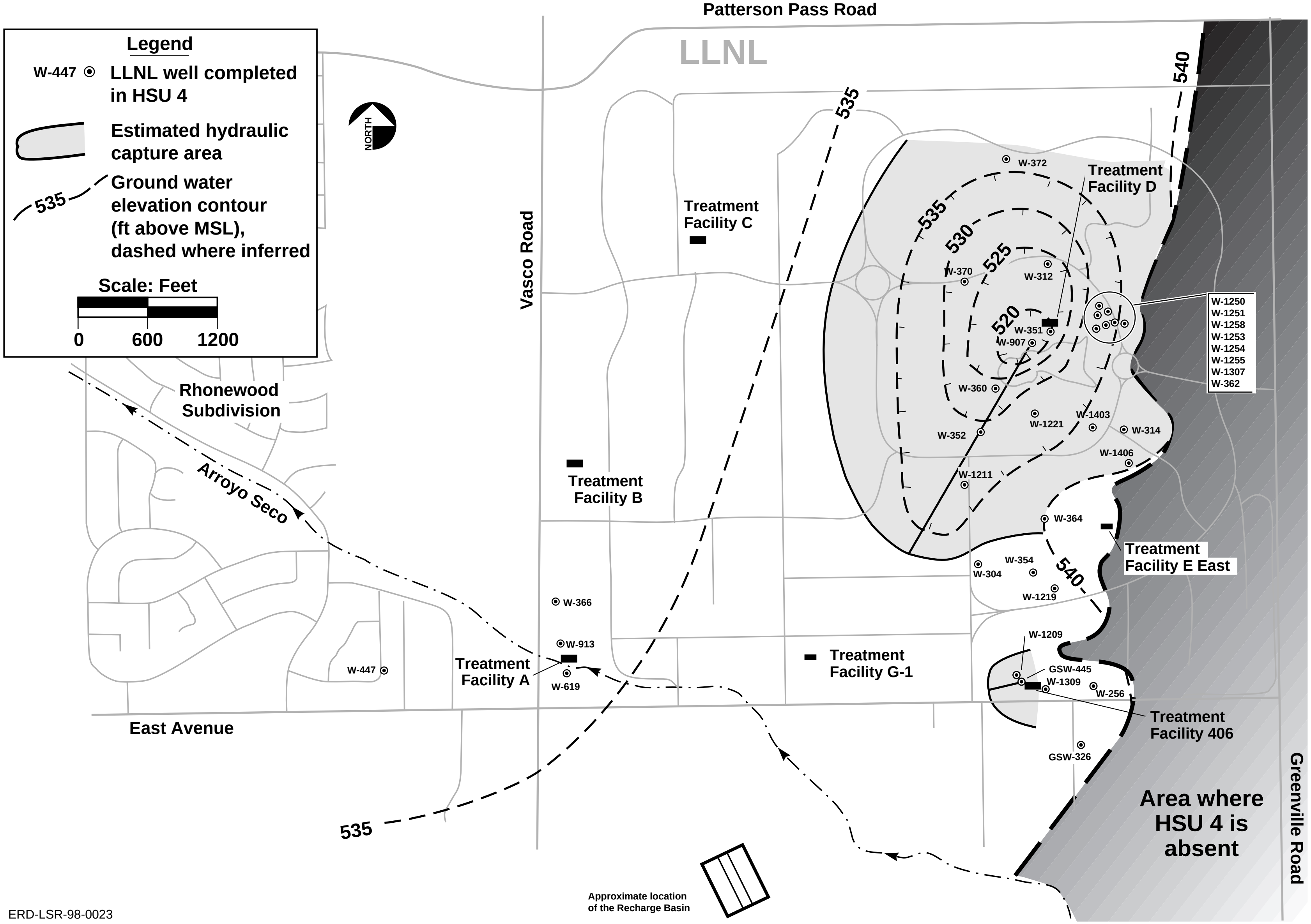


Figure 8. Ground water elevation contour map based on water levels collected from 23 wells completed within HSU 4 showing estimated hydraulic capture areas, LLNL and vicinity, December 1997.

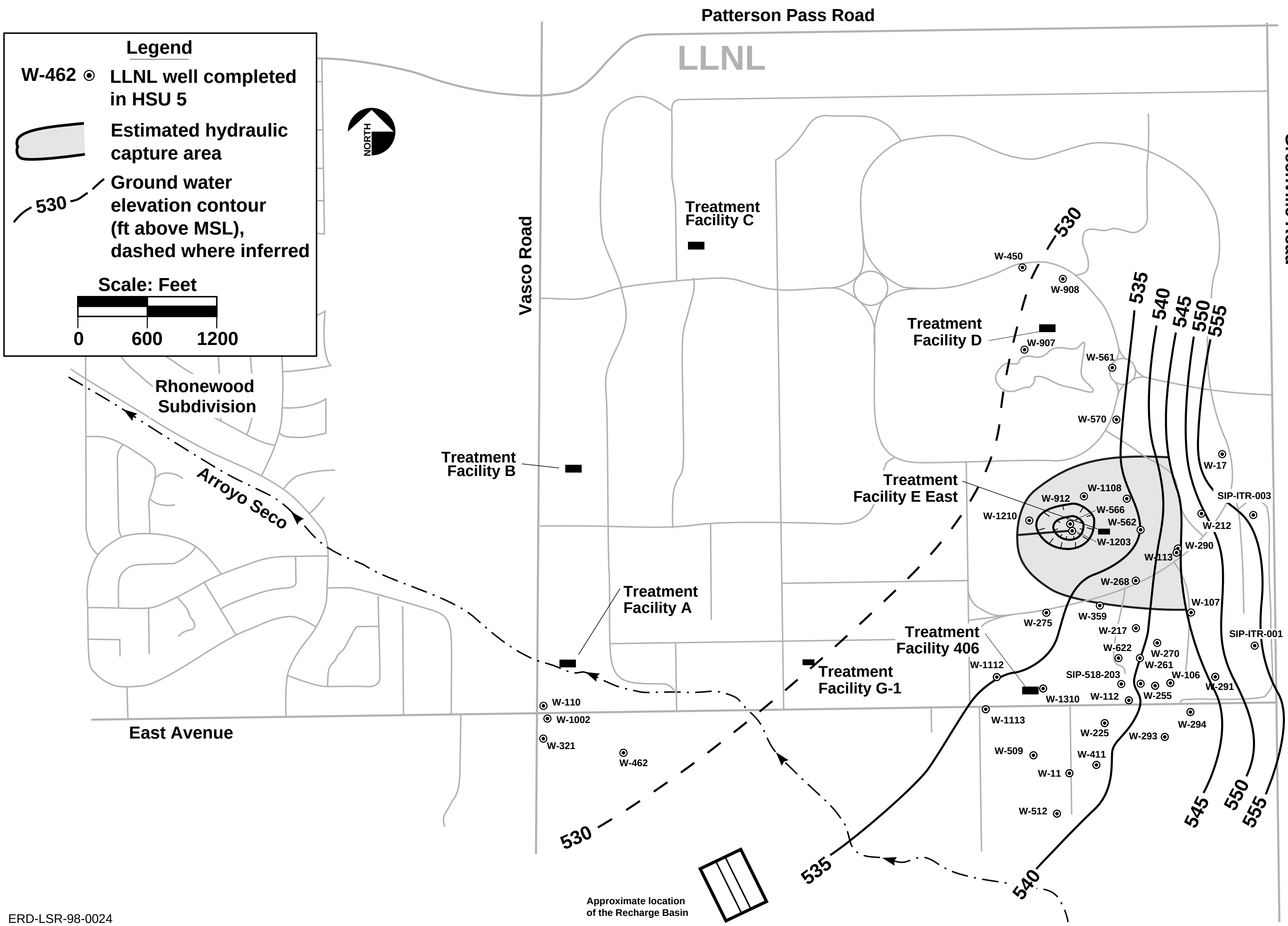


Figure 9. Ground water elevation contour map based on water levels collected from 43 wells completed within HSU 5 showing estimated hydraulic capture areas, LLNL and vicinity, December 1997.

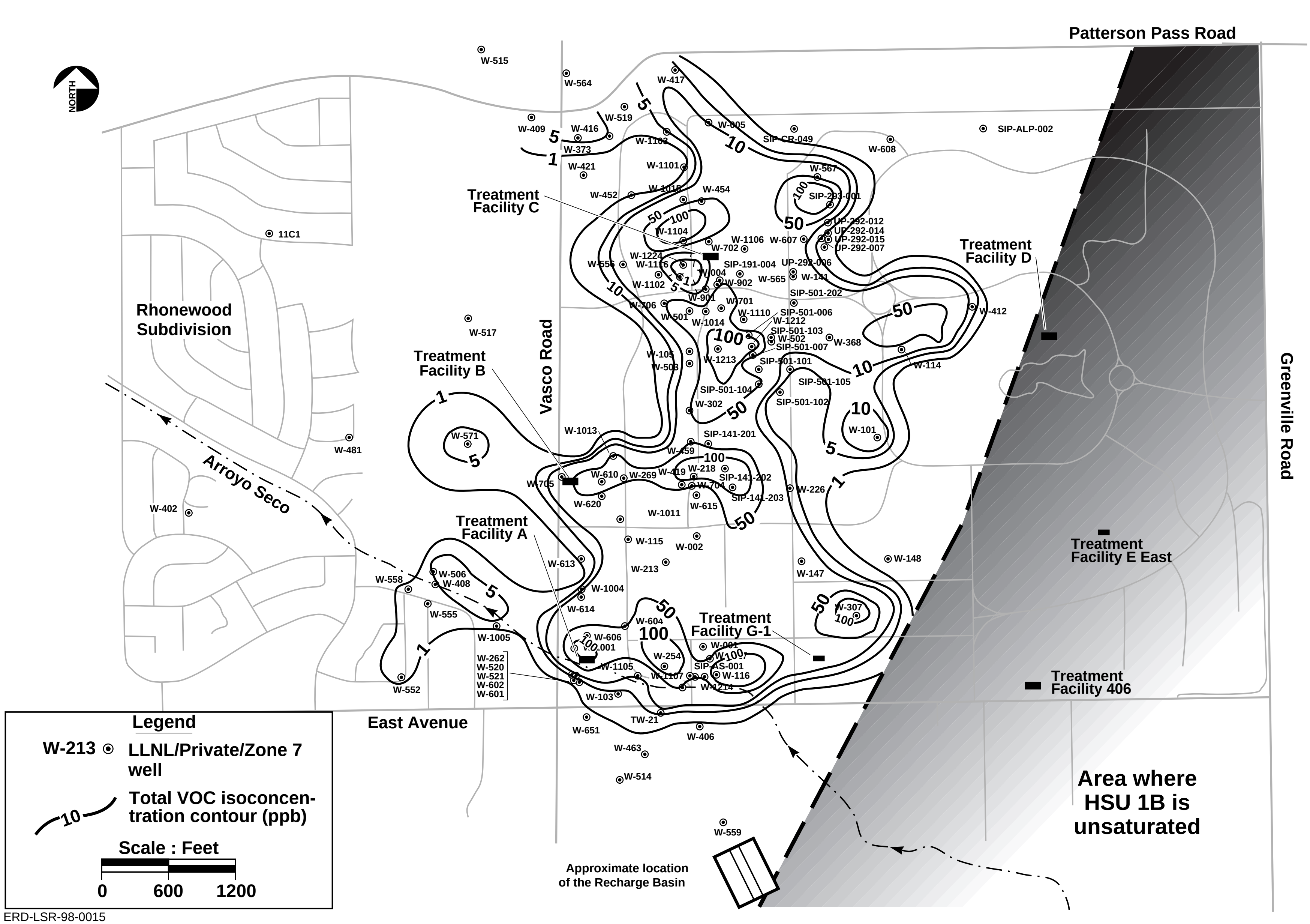
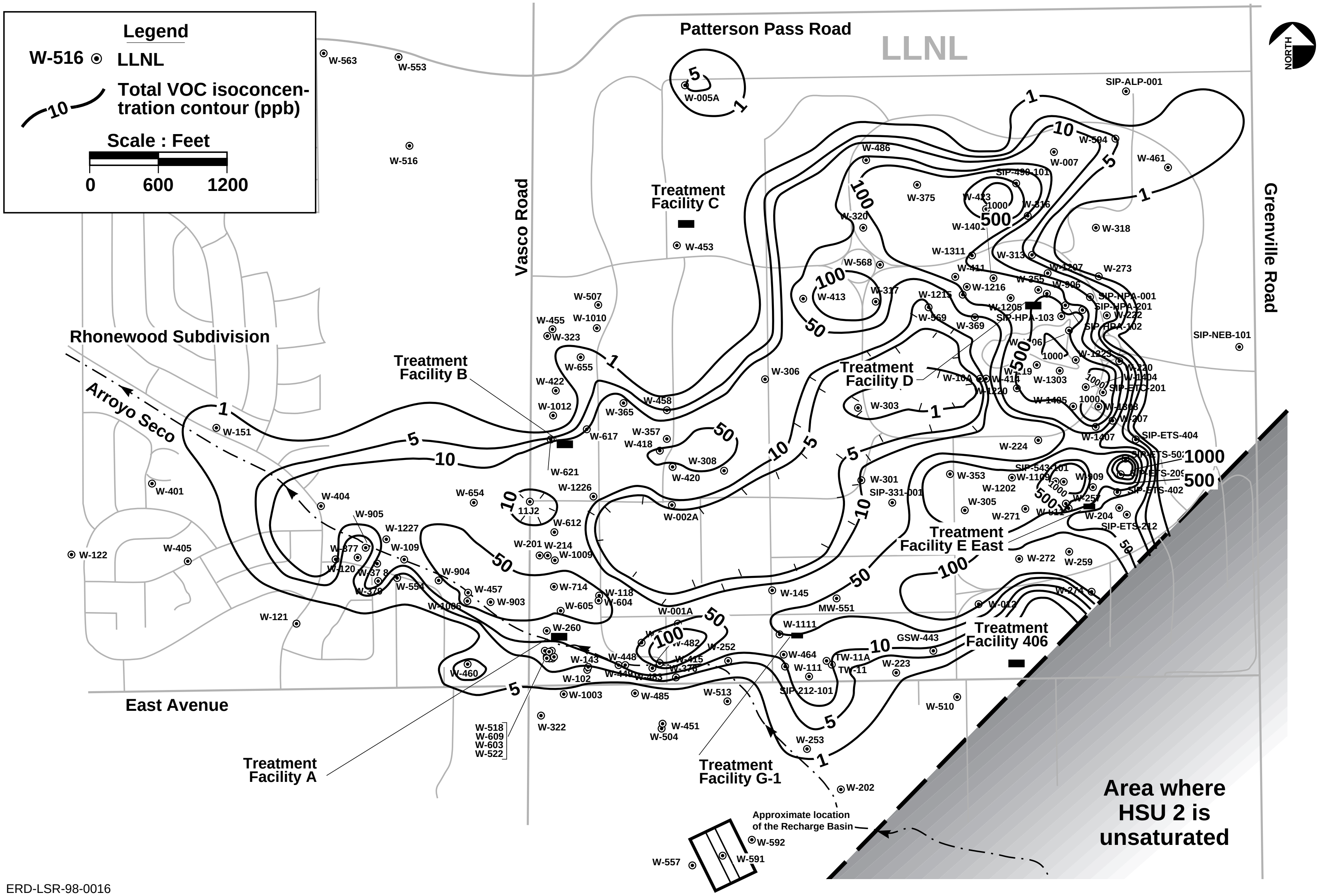
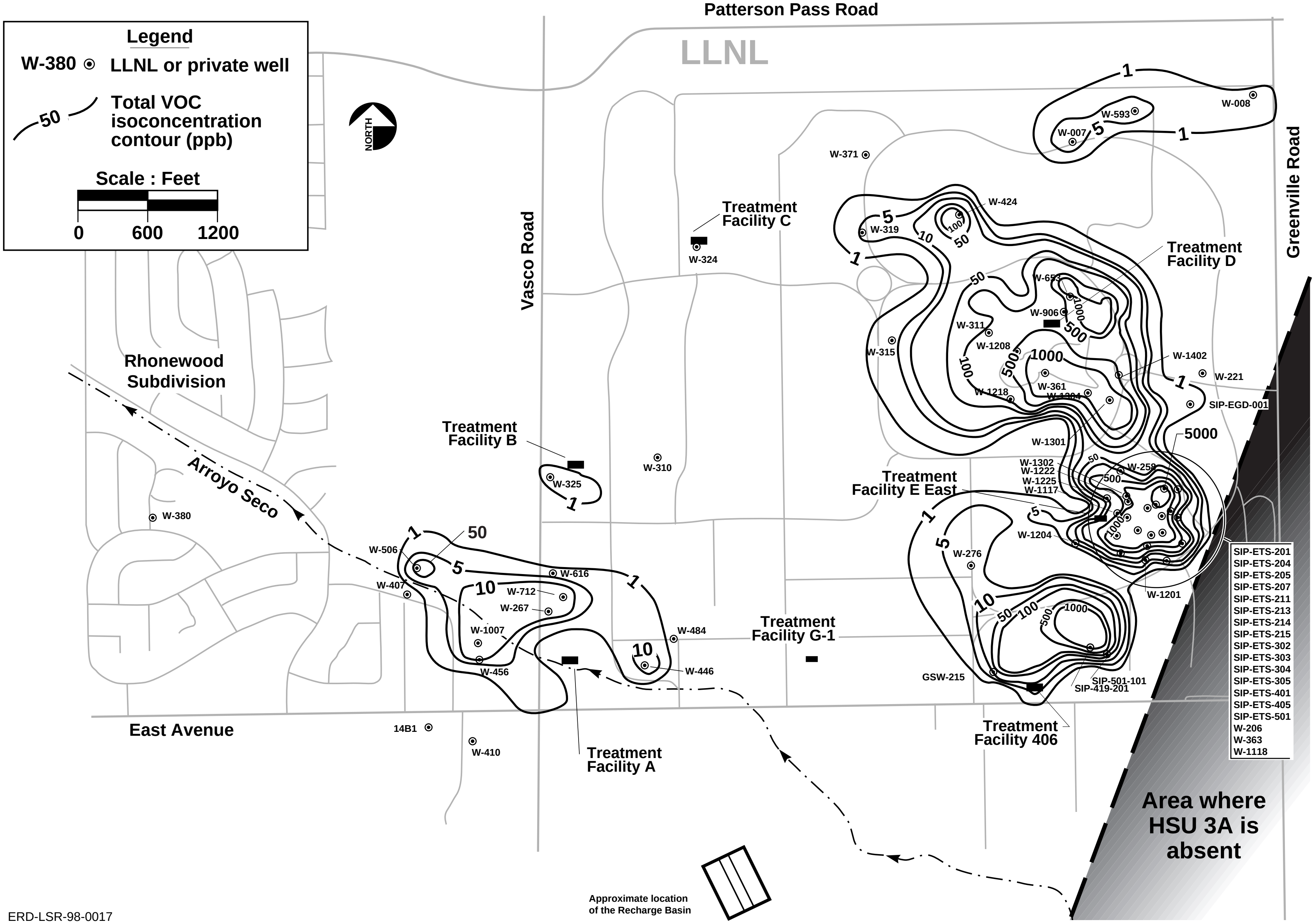


Figure 10. Isoconcentration contour map of total VOCs for 128 wells completed within HSU 1B based on samples collected in the fourth quarter of 1997 (or the next most recent data.)



ERD-LSR-98-0016

Figure 11. Isoconcentration contour map of total VOCs for 170 wells completed within HSU 2 based on samples collected in the fourth quarter of 1997 (or the next most recent data.)



ERD-LSR-98-0017

Figure 12. Isoconcentration contour map of total VOCs for 71 wells completed within HSU 3A based on samples collected in the fourth quarter of 1997 (or the next most recent data.)

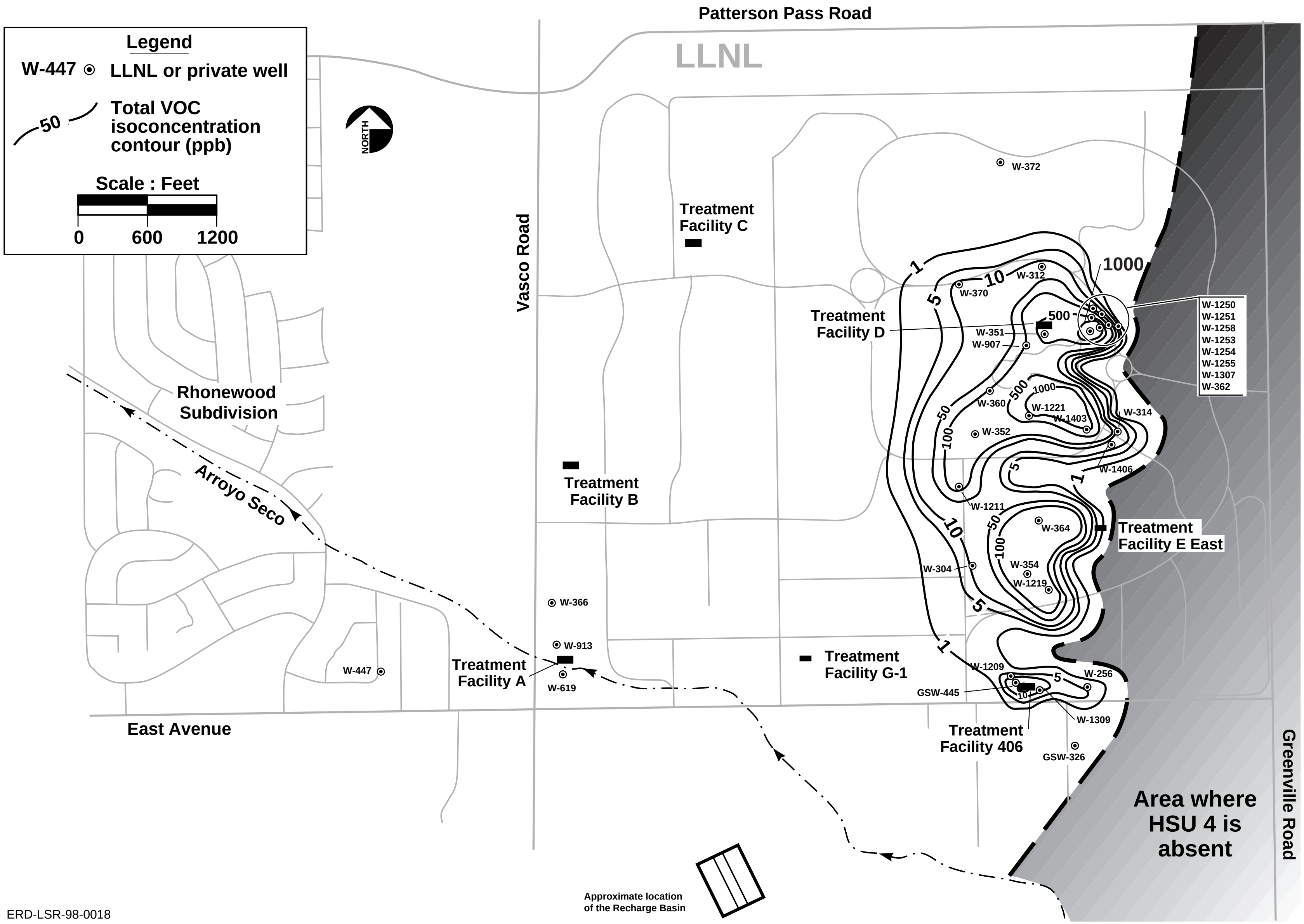


Figure 13. Isoconcentration contour map of total VOCs for 37 wells completed within HSU 4 based on samples collected in the fourth quarter of 1997 (or the next most recent data.)

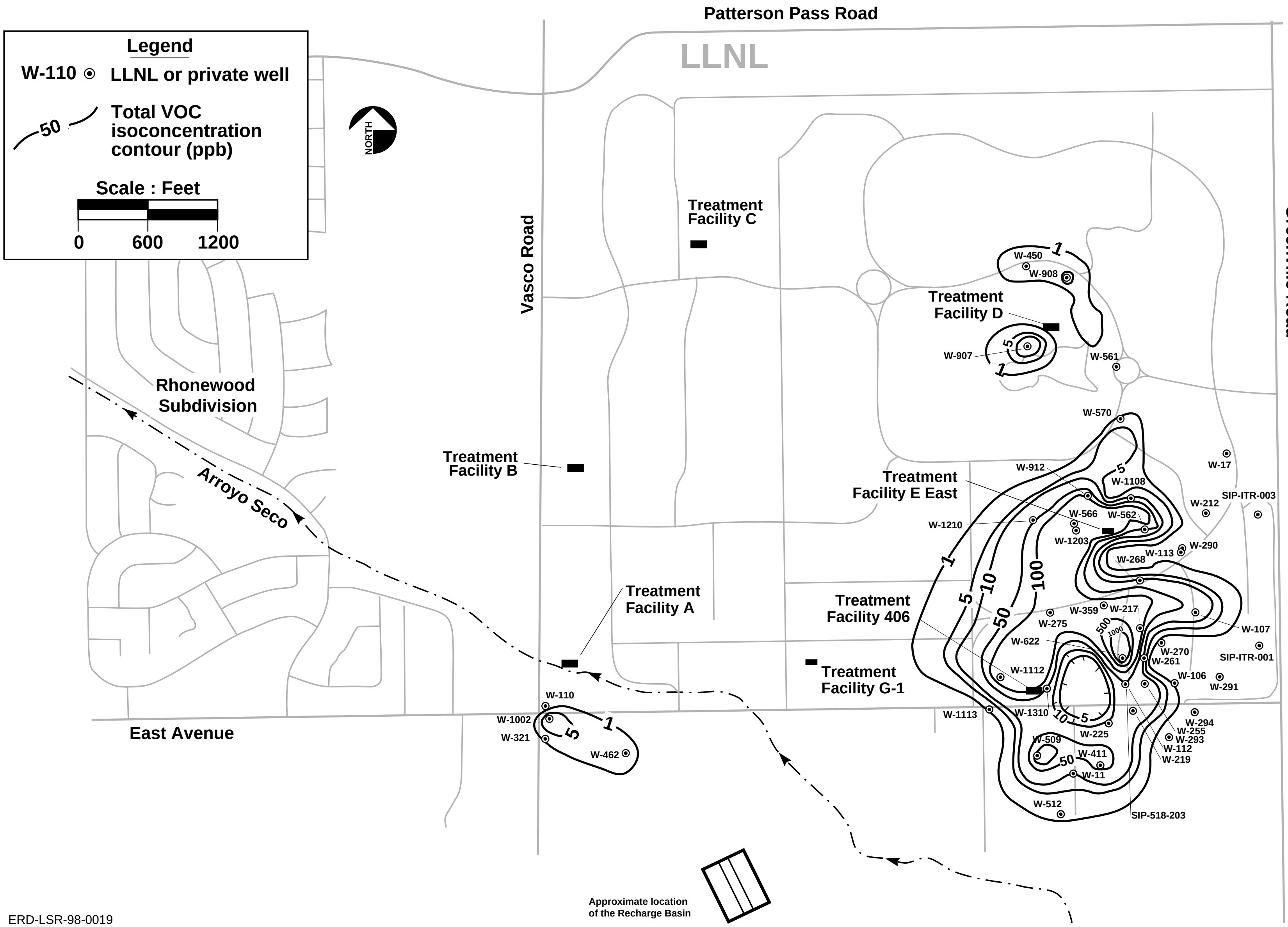


Figure 14. Isoconcentration contour map of total VOCs for 45 wells completed within HSU 5 based on samples collected in the fourth quarter of 1997 (or the next most recent data.)

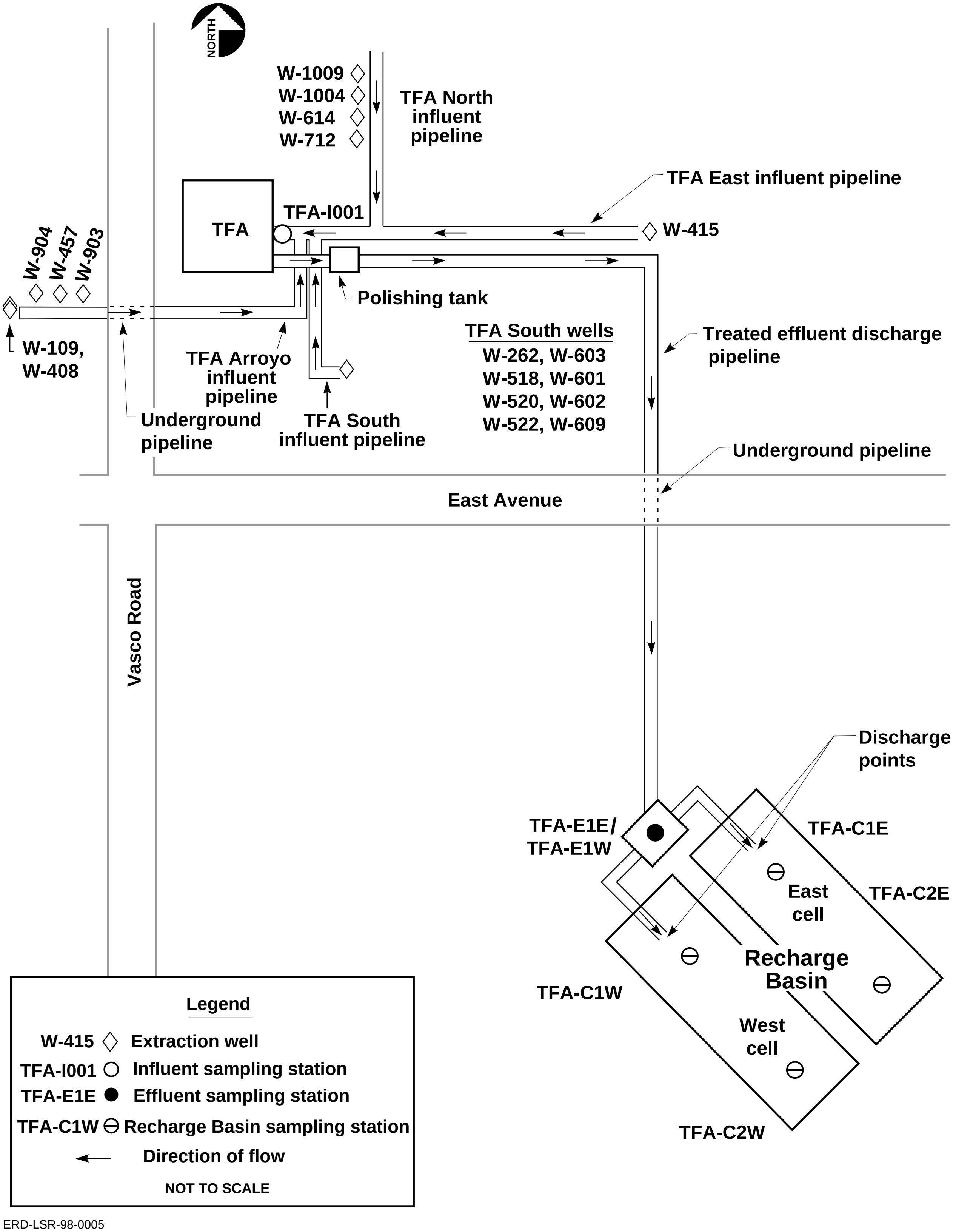


Figure 15. 1997 TFA extraction wells, pipelines and discharge location.

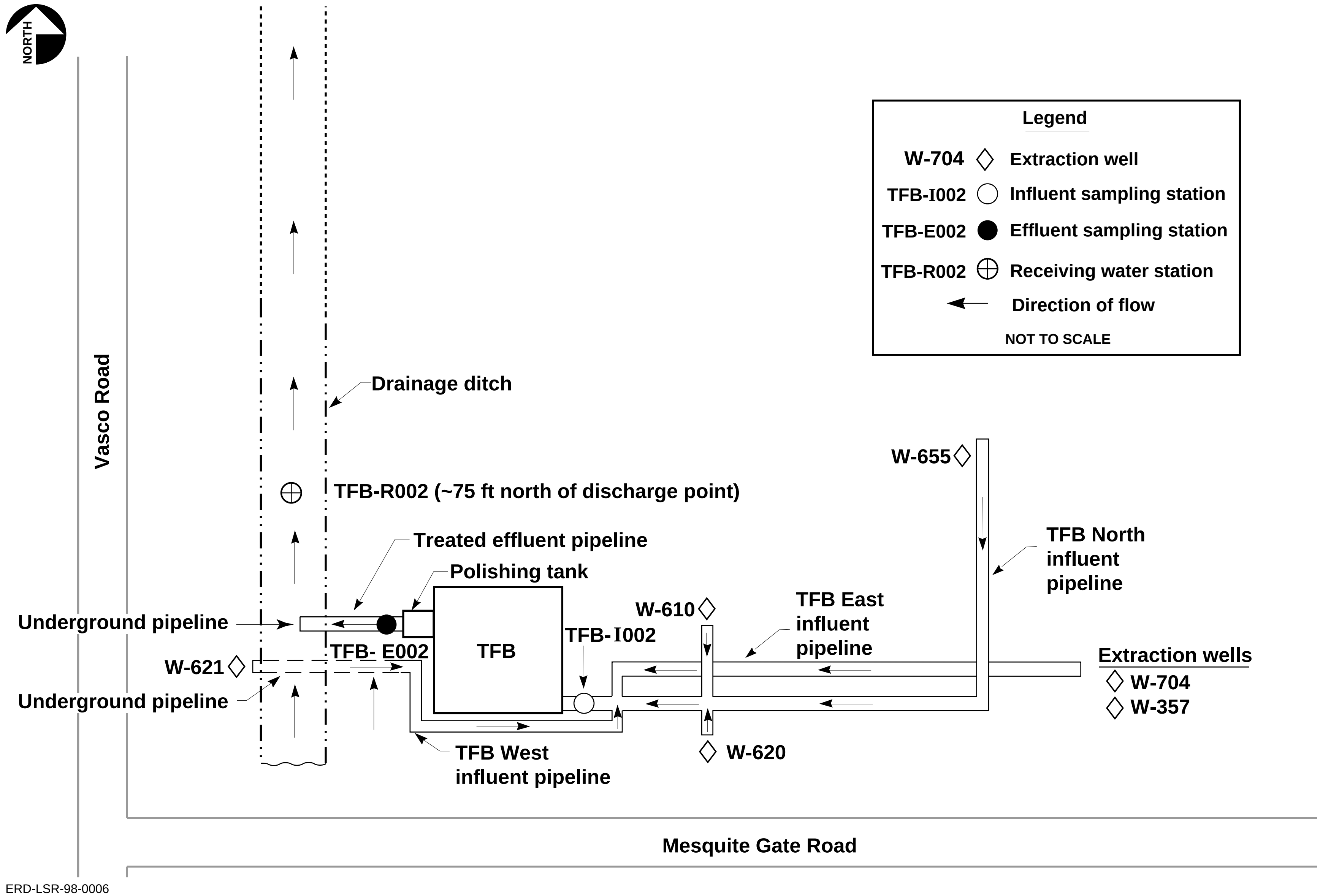


Figure 16. 1997 TFB extraction wells, pipelines and discharge location.

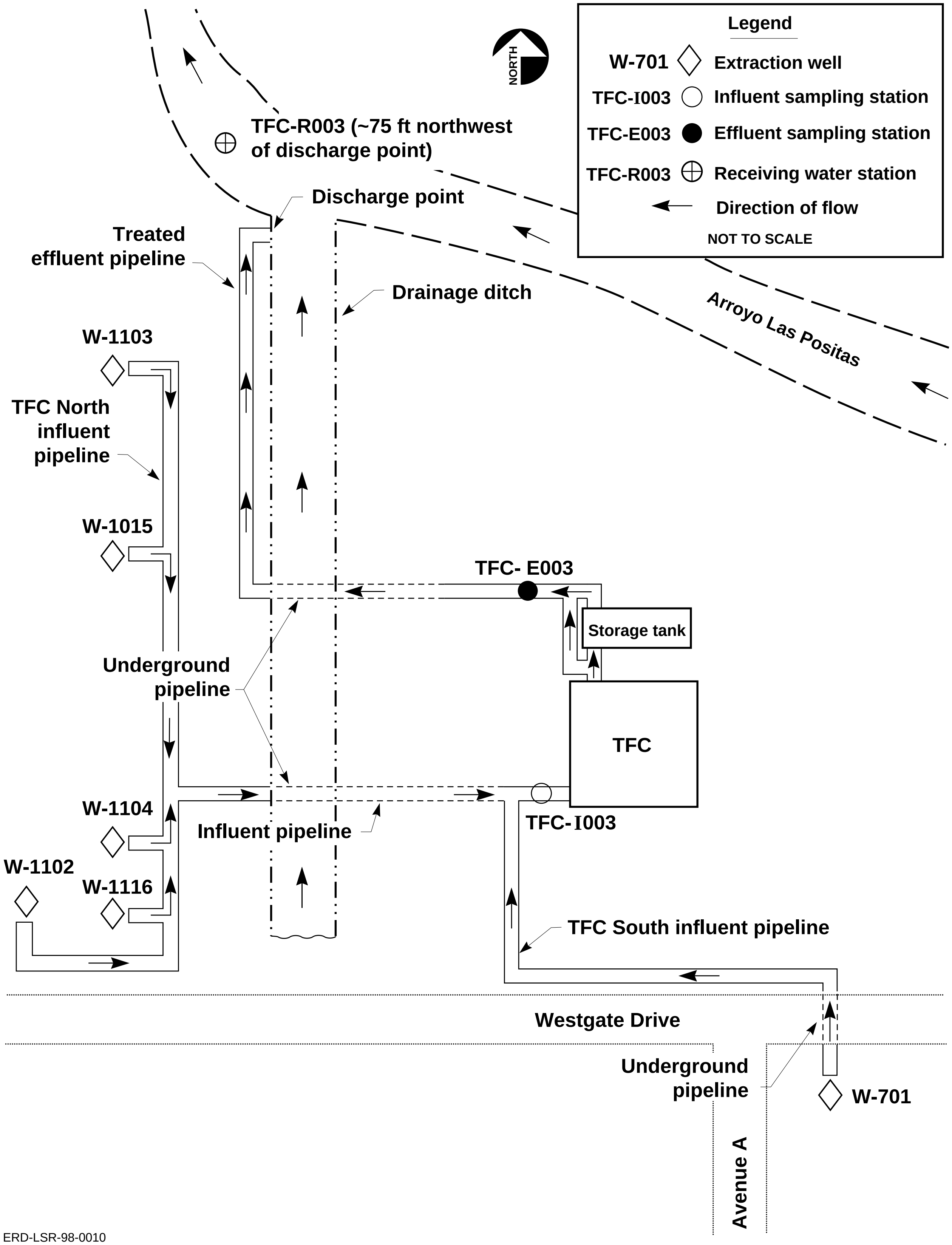


Figure 17. 1997 TFC extraction wells, pipelines and discharge location.

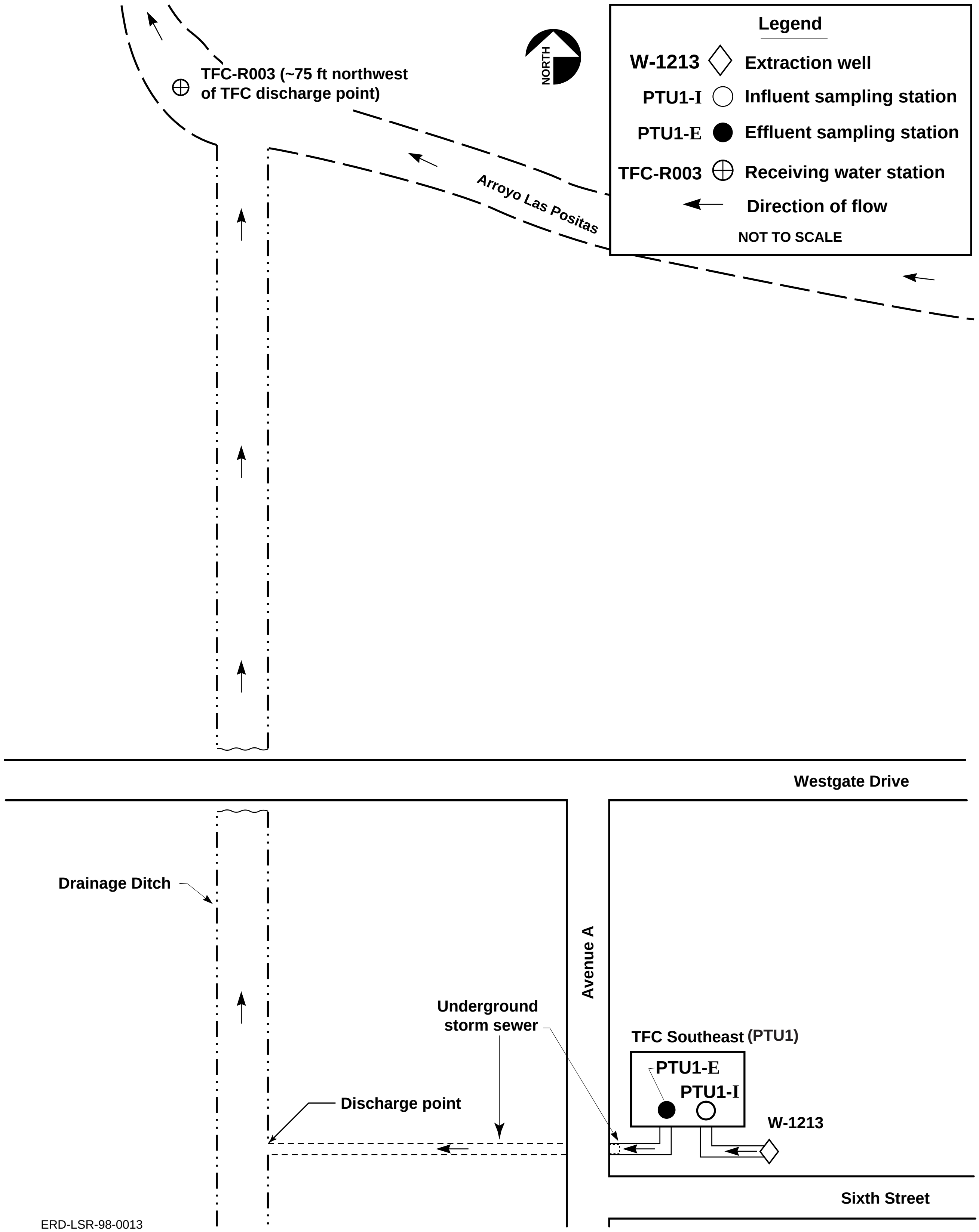


Figure 18. 1997 TFC Southeast extraction wells, pipelines and discharge location.

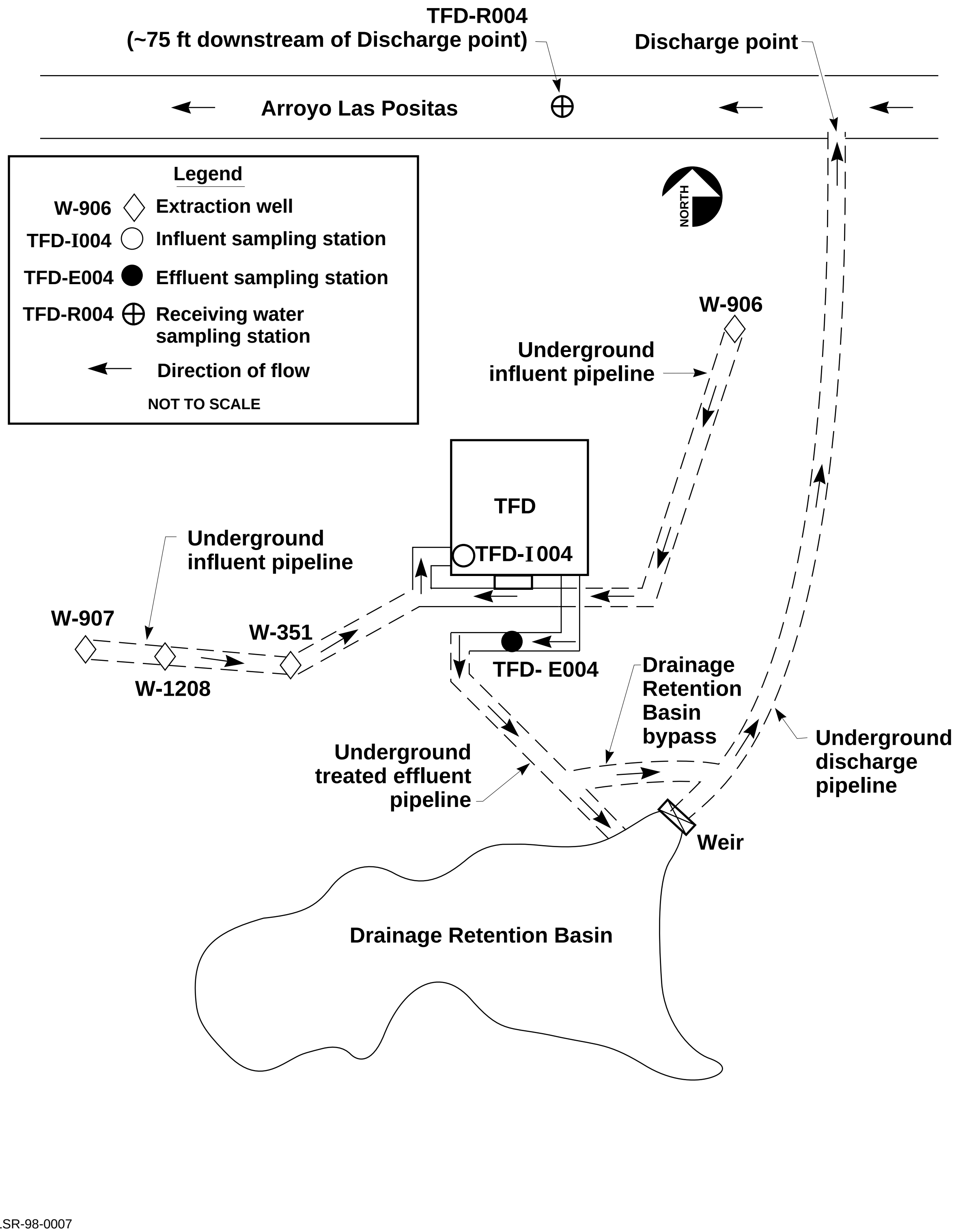


Figure 19. 1997 TFD extraction wells, pipelines and discharge location.

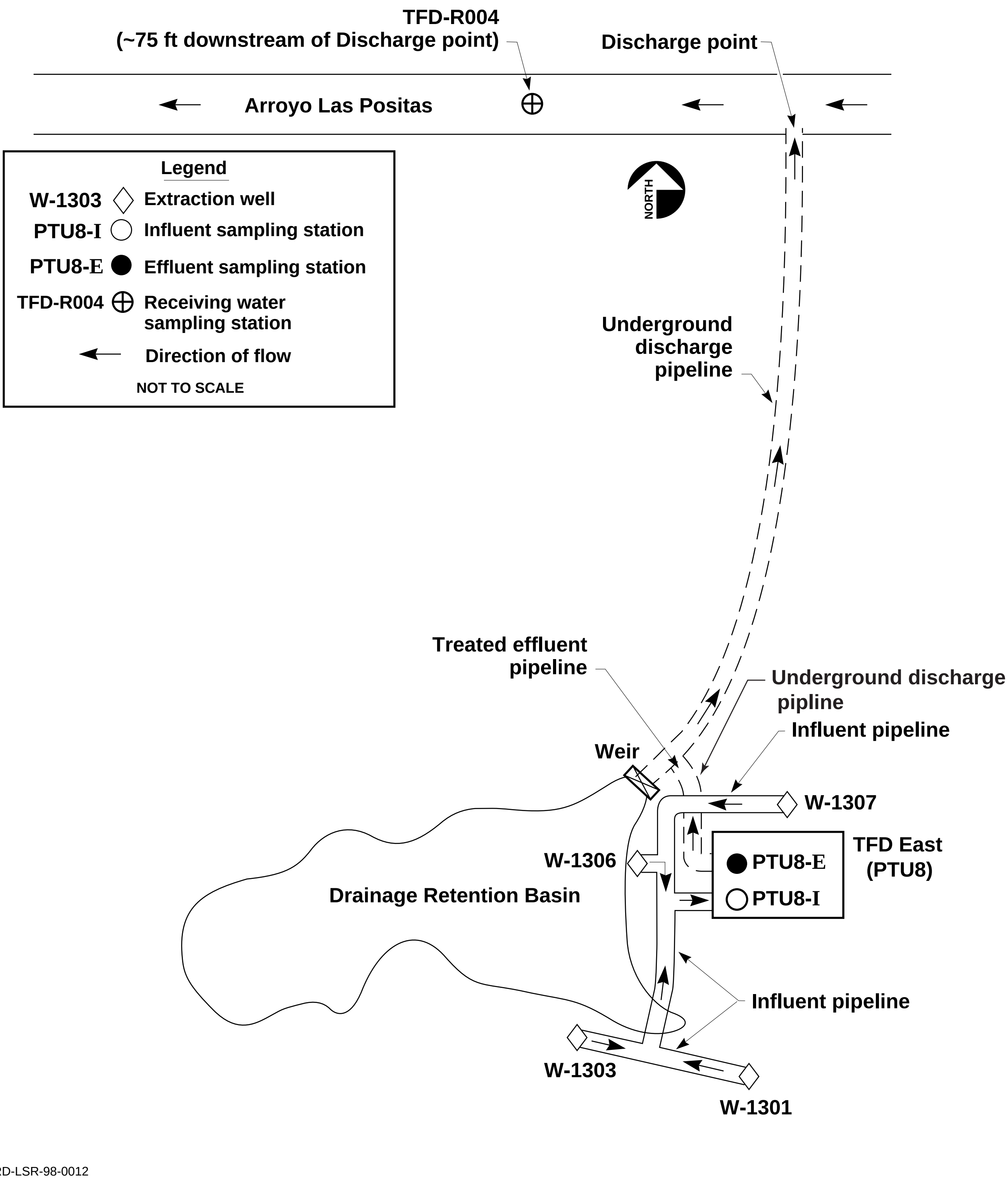


Figure 20. 1997 TFD East extraction wells, pipelines and discharge location.

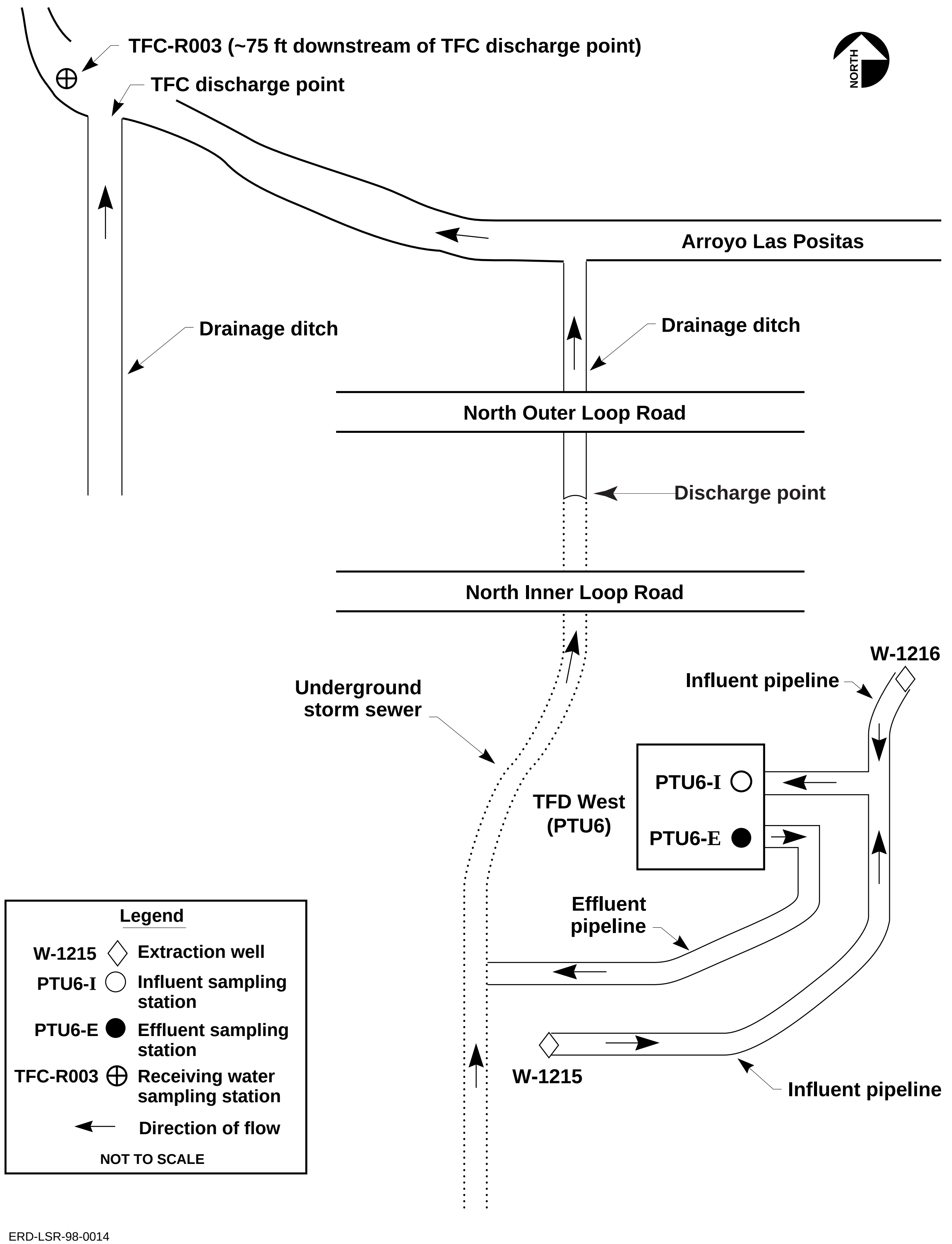


Figure 21. 1997 TFD West extraction wells, pipelines and discharge location.

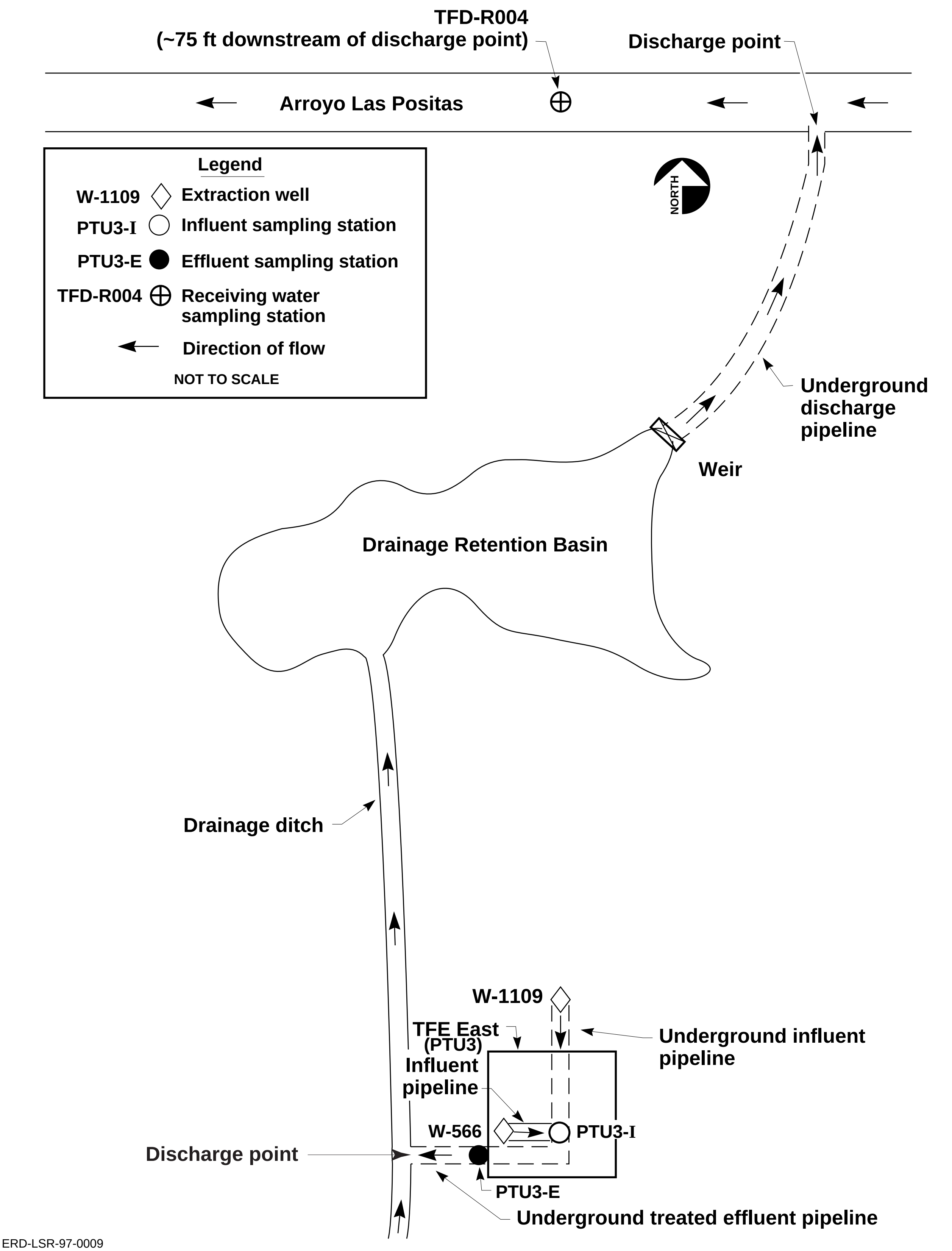


Figure 22. 1997 TFE East extraction wells, pipelines and discharge location.

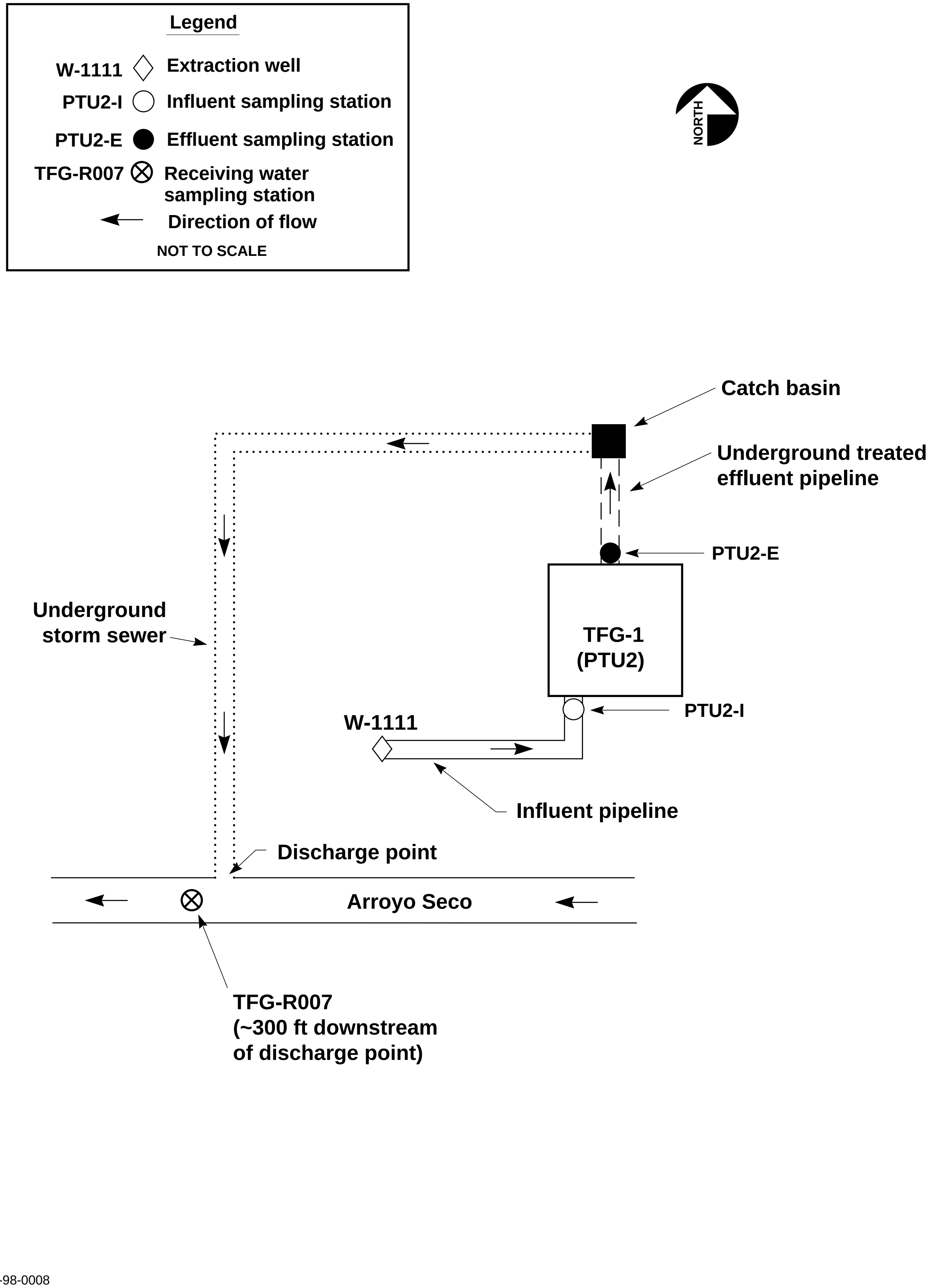


Figure 23. 1997 TFG-1 extraction well, pipelines and discharge location.

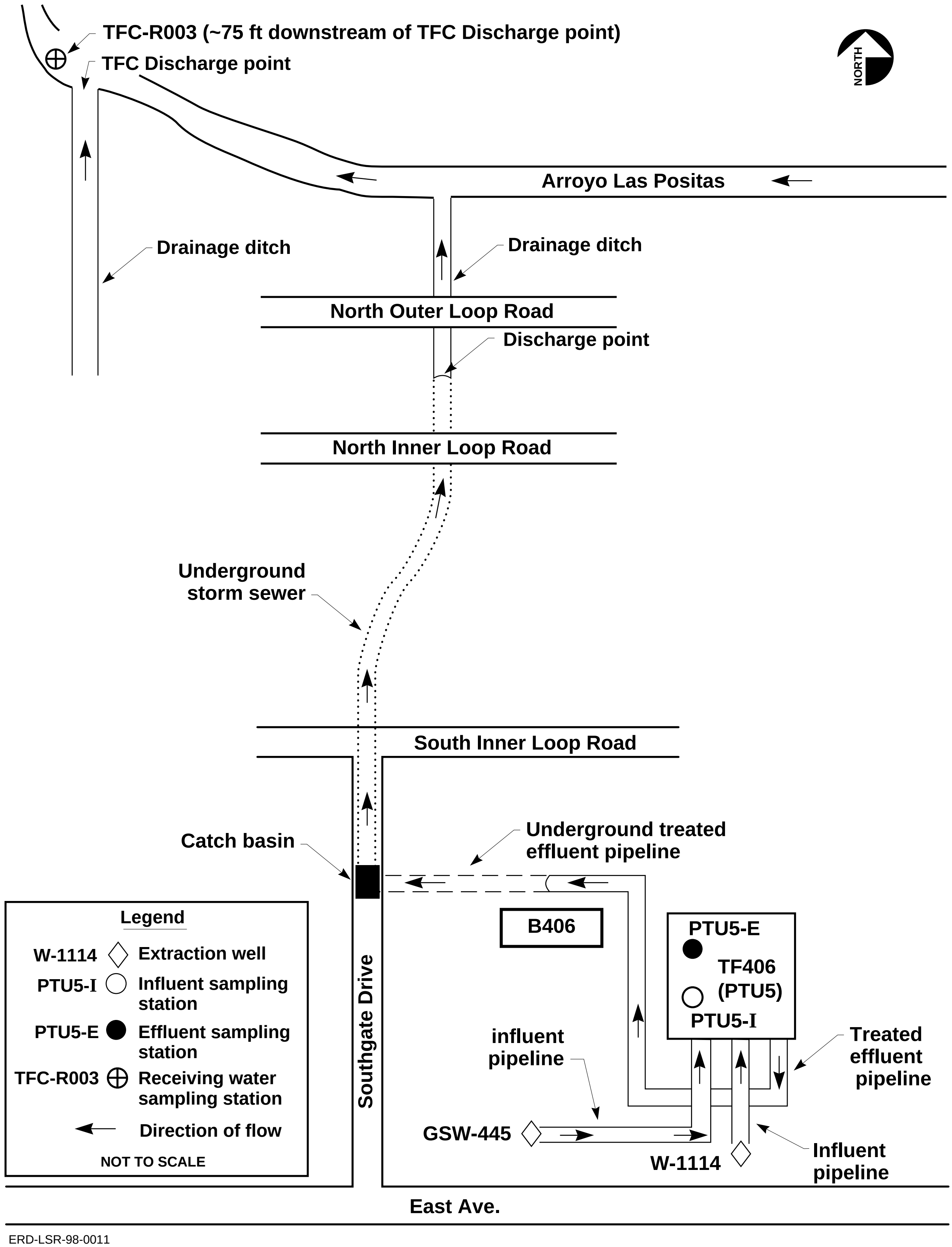


Figure 24. 1997 TF406 extraction wells, pipelines and discharge location.

Tables

Table 1. 1997 Livermore Site Remedial Action Implementation Plan milestones.

Milestone	Milestone date	Completion date
Begin operation of TFC southeast PTU	01/31/97	01/21/97
Begin operation of TFD West PTU	04/25/97	04/22/97
Five-Year Review	08/05/97	08/01/97
Submit Draft RD4 to the regulatory agencies and the community	08/25/97	08/21/97
Begin operation of TFD East PTU	10/03/97	09/16/97
Receive regulatory comments on Draft RD4	11/04/97	11/03/97

Table 2. Summary of 1997 Livermore Site VOC remediation.

Treatment facility	Volume of ground water treated (Mgal)	Volume of soil vapor treated (Kft^3)	Estimated total VOC mass removed (kg)[a]
TFA	128.1	–	18.4
TFB	16.9	–	6.8
TFC	22.7	–	9.4
TFD	48.1	–	55.0
TFE	9.5	–	15.9
TFG	3.3	–	0.6
TF406	2.3	–	0.9
VTF518	–	4,330	40.6
TF5475	5.3 Kgal	–	0.1
Total	230.9	4,330	147.7

Notes:

kg = Kilograms.

Kft^3 = Thousands of cubic feet.

Kgal = Thousands of gallons.

Mgal = Millions of gallons.

[a] Masses are calculated using monthly flow volumes and total VOC concentrations.

Table 3. Summary of cumulative Livermore Site VOC remediation.

Treatment facility	Volume of ground water treated (Mgal)	Volume of soil vapor treated (Kft^3)	Estimated total VOC mass removed (kg)[a]
TFA	391.0	–	94.3
TFB	65.3	–	25.5
TFC	35.6	–	15.4
TFD	60.5	–	73.4
TFE	9.9	–	17.1
TFG	4.3	–	0.8
TF406	2.7	–	1.1
VTF518	–	6,187	106.9
TF5475	5.3 Kgal	–	0.1
Total	569.3	6,187	334.6

Notes:

kg = Kilograms.

Kft^3 = Thousands of cubic feet.

Mgal = Millions of gallons.

[a] Masses are calculated using monthly flow volumes and total VOC concentrations.

Appendix A

Well Construction and Closure Data

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

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
Monitor Wells						
W-1	21-Oct-80	122.5	116.0	95-100	1B/2	NA
W-1A	12-Apr-84	180.0	156.0	145-156	2	NA
W-2	29-Aug-80	102.5	101.0	86-101	1B	NA
W-2A	02-Apr-84	185.0	164.0	150-164	2	NA
W-4	28-Jul-80	92.0	90.0	75-90	1B	NA
W-5	24-Oct-80	93.5	90.0	56-71 81-86	1B	NA
W-5A	09-Apr-84	115.0	105.0	95-105	2	NA
W-7	03-Oct-80	110.5	100.5	76-81 88-98	2/3A	NA
W-8	14-May-81	110.0	105.0	72-77 92-102	3A/3B	NA
W-10A	08-Sep-80	110.7	110.0	85-95 100-105	2	NA
W-11	03-Jun-81	252.0	191.0	136-141 177-187	5	NA
W-12	14-Aug-80	115.75	115.0	99-114	2	NA
W-17	08-Oct-80	114.0	114.0	94-109	5	NA
W-17A	20-May-81	181.4	160.0	127-132 147-157	7	NA
W-19	19-Sep-80	164.75	161.0	147-157	7	NA
W-101	25-Jan-85	77.0	72.0	62-72	1B	1
W-102	12-Feb-85	396.5	171.5	151.5-171.5	2	40
W-103	14-Feb-85	96.0	89.5	79.5-89.5	1B	5
W-104	21-Feb-85	61.5	56.5	38.75-56.5	1B	2.5
W-105	26-Feb-85	69.0	62.0	42-62	1B	0.7
W-106	06-Mar-85	144.0	134.5	127.5-134.5	5	0.1-0.2
W-107	13-Mar-85	128.0	122.0	115-122	5	1-3
W-108	21-Mar-85	113.5	69.0	57-69	1A	10
W-110	26-Apr-85	371.0	365.0	340-365	5	6
W-111	02-May-85	122.0	117.0	97-117	2	1.5
W-112	10-May-85	129.0	123.5	111-123.5	5	4
W-113	16-May-85	124.0	115.0	100-115	5	0.9

Table A-1. (Continued)

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

Table A-1. (Continued)

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
W-223	15-Aug-86	202.0	153.0	146-153	2	5.2
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-254	21-Nov-85	277.0	91.5	84.5-91.5	1B	5
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

Table A-1. (Continued)

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
W-302	22-Oct-86	191.0	83.5	78-83.5	1B	2
W-303	28-Oct-86	197.0	128.0	124-128	2	15
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-314	20-Mar-87	228.0	142.0	129-142	4	9.5
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-359	10-Feb-87	195.0	150.5	138-150.5	5	10
W-360	24-Feb-87	260.0	204.5	181.5-204.5	4	30
W-361	05-Mar-87	257.0	135.0	125-135	3A	4
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

Table A-1. (Continued)

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
W-368	06-May-87	206.0	78.0	70-78	1B	3
W-369	14-May-87	204.0	113.0	107-113	2	2
W-370	29-May-87	286.0	208.0	196.5-208	4	5
W-371	12-Jun-87	233.0	162.0	155-162	3A	1.5
W-372	25-Jun-87	218.0	152.5	147.5-152.5	4	1
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

Table A-1. (Continued)

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
W-446	18-Dec-87	202.0	196.0	186-196	3A	3
W-447	05-Feb-88	353.0	274.0	256-274	4	5
W-448	17-Feb-88	235.0	127.5	120.5-127.5	2	15
W-449	07-Mar-88	172.0	165.0	152-165	2	3
W-450	21-Mar-88	300.0	200.0	193-200	5	2
W-451	06-Apr-88	202.0	112.0	106-112	2	1.5
W-452	15-Apr-88	210.0	79.5	64-79.5	1B	5
W-453	27-Apr-88	185.0	130.3	121-130	2	4
W-454	09-May-88	196.0	83.5	73-83.5	1B	3
W-455	19-May-88	184.0	162.5	148-162.5	2	5
W-456	09-Jun-88	343.0	180.5	172-180.5	3A	2
W-458	30-Jun-88	212.5	116.0	108-116	2	2
W-459	20-Jul-88	76.0	73.0	59.5-73	1B	1.5
W-460	22-Jul-88	361.0	140.5	135-140.5	2	30
W-461	16-Aug-88	133.0	51.5	41.5-51.5	2	<0.5
W-462	12-Sep-88	385.0	336.5	331-336.5	5	5
W-463	16-Sep-88	93.0	92.5	87-92.5	1B	5
W-464	30-Sep-88	253.0	104.5	96-104.5	2	3.5
W-481	04-Nov-88	224.5	105.0	100-105	1B	2
W-482	15-Jan-88	218.0	170.0	165-170	2	<0.5
W-483	26-Jan-88	140.0	130.0	115-130	2	2.5
W-484	11-Feb-88	255.0	188.0	185-188	3A	0.5
W-485	25-Feb-88	249.0	157.0	151-157	2	2
W-486	11-Mar-88	167.0	108.0	100-108	2	2
W-487	17-Mar-88	180.0	151.0	148-151	3B	1
W-501	13-Oct-88	174.0	92.0	84-92	1B	6.5
W-502	25-Oct-88	158.0	59.0	55-59	1B	<0.5
W-503	02-Nov-88	187.0	80.0	74-80	1B	1
W-504	21-Nov-88	358.0	167.0	157-167	2	3
W-505	15-Dec-88	278.0	180.0	167-180	3A	60
W-506	22-Dec-88	120.0	115.0	101-115	1B	30
W-507	18-Jan-89	158.0	139.0	129-139	2	50
W-508	17-Feb-89	316.0	305.0	287-305	7	60
W-509	03-Mar-89	305.0	184.0	179-184	5	1
W-510	15-Mar-89	300.0	119.0	111-119	2	<0.5

Table A-1. (Continued)

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
W-511	31-Mar-89	316.0	176.0	167-176	3B	1
W-512	13-Apr-89	261.0	176.0	166-176	5	2.5
W-513	26-Apr-89	259.0	115.0	102-115	2	1
W-514	17-May-89	386.0	115.5	92-115.5	1B	2
W-515	30-May-89	211.0	78.0	68-78	1B	3.5
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-605	08-Dec-89	246.0	136.0	130-136	2	10

Table A-1. (Continued)

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
W-606	21-Dec-89	145.0	89.0	73-89	1B	2
W-607	24-Jan-90	186.0	55.0	49-55	1B	3
W-608	07-Feb-90	162.0	66.0	55-66	1B	3
W-611	04-Apr-90	161.0	98.0	87.5-98	1B	2
W-612	19-Apr-90	222.0	136.0	126-136	2	10
W-613	02-May-90	93.0	88.0	81.5-88	1B	7
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	126.00	90.0	77-90	1B	2
W-706	16-Jan-91	178.0	84.0	71-84	1B	2
W-714	02-Jul-91	135.0	128.0	107-128	2	7.5
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	113.5	73.5-108.5	2	3
W-912	07-Oct-93	239	174	168-174	5	3
W-913	08-Dec-93	454	255	235-255	4	25
W-1001	20-Dec-93	105	92	85-92	1B	1.4
W-1002	31-Jan-94	292.5	260	246-260	5	16
W-1003	08-Feb-94	184.0	147	140-147	2	1.5
W-1005	14-Mar-94	192.0	110.0	98-110	1B	20

Table A-1. (Continued)

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
W-1006	10-Mar-94	154.0	149.0	141-149	2	15
W-1007	31-Mar-94	199.5	182.0	172-182	3A	2
W-1008	13-Apr-94	246	238	229.5-238	7	10
W-1010	24-May-94	463	142	128-142	2	20
W-1011	06-Jun-94	106	89	75-89	1B	3
W-1012	20-Jun-94	161	117	96-112	2	5
W-1013	29-Jun-94	147	73	65-73	1B	1.4
W-1014	12-Jul-94	99	89	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	93	78-93	1B	3.5-4
W-1106	08-Feb-95	245	86	76-85	1B	15
W-1107	06-Mar-95	199.5	93	74-88	1B	<0.5
W-1108	27-Mar-95	250	156	142-156	5	12
W-1110	04-May-95	252	92.2	68-92	1B	7
W-1112	28-Jun-95	263	210	201-210	5	3
W-1113	18-Jul-95	260	214	204-214	5	2.5
W-1115	12-Oct-95	126.5	118.2	108-118	3A	1
W-1117	11-Sep-95	154	132.3	122-132	3A	1
W-1118	27-Sep-95	225	125	115-125	3A	3.5
W-1201	18-Oct-95	225	133	125-133	3A	1
W-1202	26-Oct-95	99.3	99	83-99	2	5^+
W-1203	07-Nov-95	224	206.2	196-206	5	18^+
W-1204	20 Nov-95	225	126.2	118-126	3A	2.5
W-1205	27-Nov-95	91	82	72-82	2	<0.5
W-1206	06-Dec-95	220	191	174-186	4	40^+
W-1207	13-Dec-95	92	90	70-90	2	<0.5
W-1208	09-Jan-96	166	163	135-163	3A/3B	40
W-1209	26-Jan-96	210	164	148-164	4	3
W-1210	12-Feb-96	250	223	213-223	5	3
W-1211	05-Mar-96	273	205	185-200	4	25^+
W-1212	19-Mar-96	150	75	52-75	1B	3
W-1213	02-Apr-96	129	76	64-76	1B	5^+
W-1214	22-Apr--96	180	100	80-100	1B	2
W-1215	17-Apr-96	175	120	103-120.5	2	8.5

Table A-1. (Continued)

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
W-1216	07-May--96	200	124	94-124	2	14
W-1217	15-May--96	182	98.5	78-98	1B	<0.5
W-1218	29-May-96	240	145.5	127-145	3A	6.7
W-1219	04-Jun-96	201	142	138-142	4	<0.5
W-1220	12-Jun-96	120	117	90-112	2	18
W-1221	01-Jul-96	220	172	162-172	4	4
W-1222	26-Jun-96	175	125.5	115-125	3A	6
W-1223	23-Jul-96	175	102	87-97	2	4
W-1224	05-Sep-96	125	104.5	99-104	1B	4.3
W-1225	14-Aug-96	150	121.2	113-121	3A	2
W-1226	06-Aug-96	155	126.5	116-126	2	1
W-1227	09-Oct-96	200	134	126-134	2	11
W-1250	07-Jun-96	210	200	130-135	4	0.85
W-1251	03-Jul-96	210	200	134-139	4	1.3
W-1252	25-Jul-96	208	202.3	135-140	4	<0.5
W-1253	15-Aug-96	206	200.1	127-132	4	<0.5
W-1254	15-Aug-96	125	200	131-141	4	26
W-1255	27-Aug-96	208	200.7	124-129	4	<0.5
W-1301	04-Dec-96	180	120.3	112-120	3A	15
W-1302	21-Jan-97	145	138.9	116.5-122.2	3A	7.5
				125.8-133.8		
W-1304	20-Feb-97	149.5	125	120-125	3A	0.75
W-1308	22-Jul-97	150	116	81-111	2	7
W-1309	11-Aug-97	220	157	142-152	4	6.0
W-1310	08-Sep-97	220	198	173-193	5	28
W-1311	25-Sep-97	153	120.5	100-120	2	14
W-1401	15-Oct-97	250	120	105-120	2	7
W-1402	04-Nov-97	135	112	102-112	3A	4
W-1403	12-Nov-97	175	142	132-142	4	3.5
W-1404	20-Nov-97	162	97.8	87-97	2	3.1
W-1405	24-Nov-97	100	97.8	87-97	2	4.5
W-1406	15-Dec-97	201	150.0	139.2-149.2	4	9.2
W-1407	12-Dec-97	224	118	105-118	2	1.5

Table A-1. (Continued)

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
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
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-10	29-Apr-86	205.5	127.5	114-127.5	3B	8
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

Table A-1. (Continued)

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

Table A-1. (Continued)

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
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
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			
Extraction Wells						
W-109	02-Apr-85	289.0	147.0	137-147	2	12
W-262	20-Mar-86	256.0	100.0	91-100	1B	7
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-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-609	21-Feb-90	120.0	112.0	104-112	2	4

Table A-1. (Continued)

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

Table A-1. (Continued)

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
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	
				226	3A	
				230	3B	
				234	3B	
14B4	Aug-60	NA	260	143-148	2	NA
				155-159	2	
				186-189	3A	
				205-215	3A	
				245-250	4	
14B7	NA	NA	NA	NA	NA	NA
14H1	NA	NA	288	NA	NA	NA
14H2[d]	NA	NA	NA	NA	NA	
18D1[d]	NA	NA	NA	NA	7	NA
Source Investigation Piezometers						
SIP-141-201	02-Feb-96	77	74.2	57-74	1B	NA
SIP-141-202	12-Feb-96	80	74	64-74	1B	NA
SIP-141-203	20-Feb-96	87	83	72-83	1B	NA
SIP-191-001	15-Apr-94	50	45	40-45	1A	NA
SIP-191-002	21-Apr-94	50	61	45-61	1B	NA
SIP-191-003	26-Apr-94	50.5	45	35-45	1B	NA
SIP-191-004	29-Apr-94	57.5	53.5	47.5-53.5	1B	NA

Table A-1. (Continued)

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
SIP-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-419-201	29-Feb-96	126	107	97-107	3A/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
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

Table A-1. (Continued)

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
SIP-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-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-207	11-Jul-91	103.5	98.5	89.75-98.5	3A	5
SIP-ETS-209	25-Jul-91	96.6	90	79.75-90	2	NA
SIP-ETS-211	06-Aug-91	103	98.5	95-98.5	3A	NA
SIP-ETS-212	14-Aug-91	106.5	1023	97.5-1023	2	NA
SIP-ETS-213	15-Nov-91	118.5	116.5	108.5-116.5	3A	NA
SIP-ETS-214	22-Nov-91	101	101	86-101	3A	NA
SIP-ETS-215	03-Dec-91	94.5	94.5	84.5-94.5	3A	NA
SIP-ETS-302	30-Mar-92	117.4	113	97-113	3A	NA
SIP-ETS-303	02-Apr-92	110.7	102	95-102	3A	NA
SIP-ETS-304	27-Aug-92	100	97	90-97	3A	NA
SIP-ETS-306	11-Sep-92	101	93	80-5-93	3A	NA
SIP-ETS-401	02-Aug-95	122	121	116-121	3A	NA
SIP-ETS-402	08-Aug-95	110	107	97-107	2	NA
SIP-ETS-404	22-Aug-95	99	95.5	83.5-95.5	2	NA
SIP-ETS-405	29-Aug-95	126	123	114.5-123	3A	NA
SIP-ETS-501	16-Nov-95	110	106.5	100-1006.5	3A	NA
SIP-ETS-502	05-Dec-95	95	88	80-88	2	NA
SIP-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-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

Table A-1. (Continued)

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
UP-292-007	26-Nov-90	71	56	46-56	1B	NA
UP-292-012	31-Oct-91	67.7	60	45-60	1B	NA
UP-292-014	07-Nov-91	66	66	50-66	1B	NA
UP-292-015	11-Nov-91	61.5	60.5	49.5-60.5	1B	NA
UP-292-020	30-Oct-92	68.5	64	56.5-64	1B	NA
SIP-PA-002	29-Jan-90	16.5	16.5	4-16.5	1B	NA
SIP-PA-003	26-Jan-90	18	14	4-14	1B	NA
SIP-PA-005	04-Jan-90	11.5	8	3-8	1B	NA
SIP-PA-006	04-Jan-90	13.5	12	5-12	1B	NA
SIP-PA-007	04-Jan-90	11.5	5	1-5	1B	NA
SIP-PA-010	25-Jan-90	11.5	9	3-9	1B	NA
SIP-PA-012	29-Jan-90	11.5	9	2-9	1B	NA
SIP-PA-013	24-Jan-90	16.5	13	8-13	1B	NA
SIP-PA-015	25 -Jan-90	21.5	17.5	2-17.5	1B	NA
SIP-PA-016	24 -Jan-90	11.5	11.5	7-11.5	1B	NA
SIP-PA-017	24 -Jan-90	16.5	14	7-14	1B	NA
SIP-PA-018	25 -Jan-90	11.5	8	6-8	1B	NA
SIP-PA-019	26 -Jan-90	16.5	12	2-12	1B	NA
SIP-PA-021	23 -Jan-90	11.5	10	2-10	1B	NA
SIP-PA-024	23 -Jan-90	16.5	15	5-15	1B	NA
SIP-PA-025	23 -Jan-90	11.5	7	4-7	1B	NA
SIP-PA-026	29 -Jan-90	11.5	10	2-10	1B	NA
SIP-PA-027	29 -Jan-90	8.5	7	2-7	1B	NA
SIP-PA-028	23 -Jan-90	11	8	5-8	1B	NA
SIP-PA-030	24 -Jan-90	11.5	8	4-8	1B	NA
SIP-PA-034	04-Jan-90	6.5	5	3-5	1B	NA
SIP-PA-035	04 -Jan-90	11.5	11.5	6.5-11.5	1B	NA
Soil Vapor Installations						
SVI-518-101	21-Sep-90	125	61	55-61	2	NA
SVI-518-201	03-Mar-93	59.8	50	34-50	1B/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
SVI-518-303	29-Jun-95	104.5	42	6-40	1B	NA
SEA-518-304	11-Sep-95	100	50	NA[e]	1B/2/5	NA

Table A-1. (Continued)

Well number	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU[a] monitored	Well development flow rate (gpm)[b]
SEA-ETS-305	03-9-92	85	85	NA[e]		NA
SVI-ETS-504	09-Jul-96	76.5	67	42-67	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	NA[e]	1B/2	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. The screened intervals listed therefore 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] FLUTe/SEAMIST membranes with vapor ports set at varying depths.

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

Well number	Date installed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU monitored	Closure date
Monitor Wells						
W-14A	26-Aug-80	111.0	109.0	80,95,105	2	11-Dec-87
W-15	17-Nov-80	285.0	267.0	239-265	7	13-May-88
W-18	22-Aug-80	161.0	152.5	80-90	2	11-Nov-85
				100-105	2	
				112-117	3A	
				128-133	5	
				143-153	5	
GSW-1	05-Feb-85	112.0	109.0	85-106	3A	06-Jun-86
GSW-20	18-May-84	134.0	101.3	95-101.3	3A	03-Sep-87
W-149	23-Aug-85	201.0	169.0	161-169	2	29-Aug-96
W-150	13-Sep-85	212.0	162.0	157-162	2	11-Apr-90
W-352	29-Oct-86	235.0	201.0	181-201	4	18-Dec-97
W-358	04-Feb-87	248.0	239.0	230-239	7	15-Apr-94
W-1114	07-Aug-95	223	205	177-200	5	22-Apr-97
Extraction Wells						
GEW-711	24-May-91	167.5	157.0	94-137	3A,3B	16-Jun-92
Other Wells						
1N1	15-Jan-48	600	600	427-442	7	21-Oct-88
				450-453	1B	
				465-469	NA	
				500-515	NA	
				575-588	NA	
11A1	08-Jun-76	66	64.7	54.7-59.7	NA	18-Aug-88
2R9 (11A5)[a]	NA	NA	NA	NA	NA	19-Jul-88
11BA[b]	NA	NA	NA	NA	NA	10-Jun-87
11H1	04-Nov-41	NA	519	157-161	NA	31-Oct-88
				169-177	NA	
				224-228	NA	
				243-245	NA	
				254-256	NA	
				306-314	NA	
				319-327	NA	

Table A-2. (Continued)

Well number	Date installed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU monitored	Closure date
				339-342	NA	
				414-419	NA	
				424-431	NA	
				477-479	NA	
11H4	05-Apr-60	272	272	166-170	NA	07-Oct-88
				174-176	NA	
				183-185	NA	
				200-202	NA	
				211-214	NA	
				224-230	NA	
				250-252	NA	
				260-265	NA	
11J1	1941	160	NA	NA	NA	03-Aug-88
11J4[c]	1965	NA	NA	NA	NA	11-Oct-88
11K1	06-Jan-42	NA	621	247-255	NA	26-Sep-88
				272-276	NA	
				297-304	NA	
				322-339	NA	
				554-557	NA	
				580-602	NA	
11K2	NA	NA	232	NA	NA	03-Oct-88
11Q2	NA	NA	264	NA	NA	16-Aug-88
11Q3	NA	NA	120	NA	NA	10-Aug-88
11Q6[c]	NA	NA	280	NA	NA	11-Jan-89
11R3	08-May-61	140	117	NA	NA	03-Sep-85
11R4	NA	NA	NA	NA	NA	03-Sep-85
11R5[c]	NA	NA	NA	NA	NA	26-Jul-85
12M1	09-Dec-42	702	702	375-378	NA	15-Apr-84
				420-426	NA	
				452-473	NA	
				560-564	NA	
				609-621	NA	
				626-657	NA	
12N1	14-Apr-42	702	681	392-399	NA	24-Jan-89
				514-518	NA	

Table A-2. (Continued)

Well number	Date installed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU monitored	Closure date
				527-536	NA	
				666-670	NA	
				678-681	NA	
13D1[c]	29-Oct-56	NA	400	200-400	NA	23-Aug-88
14A1[c]	12-Jul-43	246	227	102-107	NA	13-Sep-88
				113-119	NA	
				144-148	NA	
				176-179	NA	
				188-190	NA	
				192-194	NA	
				219-222	NA	
				223-227	NA	
14A2[c]	15-Nov-56	NA	229	122-130	NA	12-Sep-88
				140-150	NA	
				160-180	NA	
14A4[c]	15-Jun-59	NA	252	167-170	NA	29-Aug-88
				175-179	NA	
				192-202	NA	
				235-246	NA	
14A8	NA	NA	86	NA	NA	22-Jul-88
14B2	22-Aug-56	NA	312	185-312	NA	11-Nov-88
14B8	NA	NA	385	NA	NA	23-Oct-89
TEP-GP-001	21-Jan-92	165.0	97.0 117.0 160.5	87-97 107-117	3A 3B	09-Feb-93
TEP-GP-003	28-Jan-92	161.0	129.5 161.0	124.5-129.5	3B	13-Feb-93
TEP-GP-004	05-Feb-92	161.0	106.0 134.0 161.0	96-106 124-134	3A 3B	13-Feb-93
TEP-GP-005	18-Feb-92	161.0	124.5 161.0	114.5-124.5	3B	13-Feb-93
TEP-GP-006	26-Feb-92	161.0	127.0 161.0	107-127	3B	13-Feb-93
TEP-GP-007	13-Mar-92	161.0	161.0			NA

Table A-2. (Continued)

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

Note:

NA = Not applicable or not available.

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

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

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

11J81 ------> 1J4

11R81 ------> 11R5

11Q81 ------> 11Q6

13D81 ------> 13D1

14A81 ------> 14A1

14A82 ------> 14A2

14A83 ------> 14A4

Appendix B

Hydraulic Test Results

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

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

Table B-1. (Continued)

Well	Date	Type of test[b]	Flow rate (Q) (gpm)	Transmis-sivity (T) (gpd/ft)	Hydraulic conductivity (K)[c] (gpd/sq ft)	Data quality[d]
W-112	5-Nov-96	Longterm	13.7	3,300	260	Fair
W-113	17-Apr-86	Slug	0.0	7.4	1.2	Excel
W-115	5-Mar-86	Drawdown	1.1	180	30	Good
W-116	24-Dec-85	Slug	0.0	37	7.5	Good
W-117	20-Feb-86	Slug	0.0	2	0.4	Good
W-118	5-Mar-86	Drawdown	10.0	2,100	230	Good
W-119	8-Aug-85	Drawdown	2.0	1,600	110	Good
W-120	22-Apr-86	Drawdown	1.1	23	5.6	Poor
W-121	10-Sep-85	Drawdown	2.0	120	7.5	Good
W-121	23-Sep-85	Drawdown	4.0	23	1.5	Excel
W-121	14-Oct-85	Drawdown	3.0	34	2.2	Excel
W-121	15-Oct-85	Drawdown	4.5	45	3.0	Excel
W-122	28-Oct-85	Drawdown	10.8	490	49	Good
W-123	28-Oct-85	Drawdown	5.8	40	4.4	Poor
W-142	3-Mar-88	Slug	0.0	2,600	330	Excel
W-143	3-Mar-88	Slug	0.0	1,200	240	Excel
W-149	9-Sep-85	Drawdown	4.0	120	19	Good
W-149	11-Sep-85	Drawdown	8.0	95	16	Excel
W-149	11-Oct-85	Drawdown	4.8	58	9.7	Excel
W-149	11-Oct-85	Drawdown	7.0	70	12	Good
W-150	2-Oct-85	Drawdown	3.1	640	210	Fair
W-150	3-Oct-85	Drawdown	6.0	720	240	Fair
W-150	10-Oct-85	Drawdown	8.8	630	210	Fair
W-150	10-Oct-85	Drawdown	12.0	620	210.	Fair
W-151	28-Oct-85	Drawdown	5.8	550	61	Poor
W-201	5-Mar-86	Drawdown	10.0	740	86	Excel
W-203	2-Mar-88	Drawdown	6.6	1,100	110	Good
W-204	23-Jan-86	Drawdown	1.9	100	15	Fair
W-205	14-Feb-86	Slug	0.0	5.9	1.9	Good
W-205	18-Feb-86	Slug	0.0	5.9	1.9	Good
W-206	14-Apr-86	Slug	0.0	120	11	Good
W-207	2-Mar-88	Slug	0.0	380	32	Excel
W-210	9-Jun-86	Slug	0.0	0.6	0.1	Good
W-211	22-Oct-86	Drawdown	2.9	37	12	Fair
W-211	8-Dec-86	Longterm	1.0	44	15	Fair

Table B-1. (Continued)

Well	Date	Type of test[b]	Flow rate (Q) (gpm)	Transmis-sivity (T) (gpd/ft)	Hydraulic conductivity (K)[c] (gpd/sq ft)	Data quality[d]
W-211	16-Sep-97	Longterm	1.1	14	1.4	Good
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	Longterm	7.7	4,000	670	Good
W-219	15-Jul-86	Drawdown	4.3	620	76	Good
W-219	23-Feb-87	Longterm	5.2	66	8.0	Fair
W-220	21-Aug-86	Slug	0.0	28	5.5	Excel
W-221	5-Aug-86	Drawdown	2.1	120	16	Fair
W-222	12-Aug-86	Drawdown	16.0	1,700	160	Excel
W-222	8-Mar-85	Longterm	7.7	1,100	180	Good
W-223	27-Aug-86	Drawdown	4.0	510	110	Good
W-224	28-Oct-86	Drawdown	7.6	3,600	400	Excel
W-225	23-Oct-86	Drawdown	4.0	85	11	Good
W-225	12-Jan-87	Longterm	2.0	62	8.5	Fair
W-226	31-Mar-87	Slug	0.0	1,700	160	Fair
W-252	4-Nov-85	Drawdown	4.0	920	50	Fair
W-252	19-Nov-85	Drawdown	5.6	800	43	Fair
W-254	27-Jan-86	Drawdown	4.2	340	38	Fair
W-254	27-Feb-86	Drawdown	3.2	370	41	Good
W-255	21-Jan-86	Drawdown	5.0	2,800	250	Fair
W-255	21-Jan-86	Drawdown	6.0	2,000	180	Fair
W-255	6-Jan-87	Longterm	2.0	400	36	Fair
W-256	11-Apr-86	Slug	0.0	11	5.5	Good
W-257	15-Apr-86	Slug	0.0	120	24	Good
W-258	5-Jun-86	Slug	0.0	35	9.0	Excel
W-258	29-Oct-86	Slug	0.0	32	8.0	Good
W-259	26-Mar-88	Slug	0.0	15	5.0	Good
W-260	25-Mar-86	Drawdown	3.0	140	22	Good
W-260	1-Oct-86	Longterm	1.4	120	18	Good
W-261	27-May-86	Slug	0.0	7	2.3	Excel
W-262	11-Apr-86	Drawdown	12.5	2,000	250	Excel
W-262	23-Sep-86	Longterm	22.0	2,750	340	Good

Table B-1. (Continued)

Well	Date	Type of test[b]	Flow rate (Q) (gpm)	Transmis-sivity (T) (gpd/ft)	Hydraulic conductivity (K)[c] (gpd/sq ft)	Data quality[d]
W-262	27-Apr-87	Longterm	23.1	6,800	810	Good
W-263	22-Apr-86	Drawdown	1.2	37	7.4	Poor
W-263	4-Nov-86	Longterm	1.8	76	15	Excel
W-264	7-May-86	Drawdown	8.1	930	100	Good
W-264	29-Oct-86	Longterm	23.0	480	50	Good
W-265	19-May-86	Drawdown	0.7	180	34	Fair
W-267	2-Jun-86	Drawdown	0.5	420	85	Poor
W-268	14-Nov-86	Drawdown	5.0	230	18	Good
W-269	14-Jul-86	Drawdown	5.0	570	95	Good
W-270	30-Dec-86	Slug	0.0	14	2.0	Good
W-271	4-Aug-86	Drawdown	5.5	340	76	Fair
W-272	19-Aug-86	Drawdown	0.8	150	30	Fair
W-273	27-Aug-86	Drawdown	3.2	600	90	Good
W-274	25-Mar-85	Slug	0.0	38	7.6	Fair
W-275	30-Oct-86	Drawdown	7.0	730	150	Fair
W-275	2-Mar-87	Longterm	5.5	830	170	Fair
W-276	21-Nov-86	Drawdown	13.0	960	110	Good
W-276	4-May-87	Longterm	24.0	2,700	300	Fair
W-277	3-Nov-86	Drawdown	0.9	74	25	Fair
W-290	5-Jan-87	Slug	0.0	14	4.0	Excel
W-291	27-Jan-87	Slug	0.0	25	7.1	Fair
W-292	28-Aug-86	Drawdown	6.0	400	56	Excel
W-294	29-Dec-86	Drawdown	5.3	5,300	29	Fair
W-294	29-Dec-86	Drawdown	5.9	5,400	300	Good
W-301	30-Oct-86	Drawdown	6.0	460	100	Good
W-302	18-Nov-86	Drawdown	1.0	100	27	Good
W-302	18-Nov-86	Drawdown	2.0	76	21	Fair
W-303	12-Nov-86	Drawdown	11.1	210	70	Good
W-304	13-Mar-87	Drawdown	0.9	74	25	Fair
W-305	26-Nov-86	Drawdown	19.0	720	72	Excel
W-305	18-May-87	Longterm	20.1	640	64	Excel
W-306	31-Mar-87	Drawdown	9.5	270	68	Good
W-307	26-Mar-87	Drawdown	0.9	66	33	Fair
W-308	4-Dec-87	Drawdown	2.6	27	5.4	Good
W-310	17-Feb-87	Drawdown	6.7	58	850	Good

Table B-1. (Continued)

Well	Date	Type of test[b]	Flow rate (Q) (gpm)	Transmis-sivity (T) (gpd/ft)	Hydraulic conductivity (K)[c] (gpd/sq ft)	Data quality[d]
W-311	19-Mar-87	Drawdown	9.8	130	12	Good
W-311	17-Nov-87	Longterm	9.9	370	26	Good
W-312	27-Mar-87	Drawdown	20.5	1,800	300	Poor
W-312	3-Nov-87	Longterm	18.8	1,700	280	Good
W-313	25-Mar-87	Drawdown	7.9	3,000	600	Good
W-313	5-Oct-87	Longterm	9.6	3,400	680	Good
W-314	10-Apr-87	Drawdown	26.4	2,900	390	Good
W-314	13-Jul-87	Longterm	13.6	2,500	330	Fair
W-314	14-Oct-97	Longterm	12	1,400	100	Fair
W-315	9-Apr-87	Drawdown	15.4	150	11	Good
W-315	5-Jan-85	Longterm	24.5	571	41	Excel
W-316	4-May-87	Drawdown	7.8	1,400	280	Good
W-317	12-May-87	Drawdown	12.1	300	43	Fair
W-317	15-Dec-87	Longterm	8.2	120	17.1	Good
W-318	7-Aug-87	Slug	0.0	120	16	Good
W-319	29-Jul-87	Drawdown	48.0	7,200	1,500	Good
W-320	15-May-87	Drawdown	1.8	58	17	Fair
W-320	15-May-87	Drawdown	3.0	22	3.7	Fair
W-320	26-Jun-87	Drawdown	2.1	49	14	Fair
W-321	28-Jul-87	Drawdown	40.0	6,600	450	Good
W-322	3-Aug-87	Drawdown	3.1	85	15	Good
W-323	11-Aug-87	Drawdown	3.4	205	59	Good
W-324	10-Sep-87	Drawdown	6.6	200	50	Good
W-325	10-Sep-87	Drawdown	6.0	160	13	Excel
W-351	12-Nov-86	Drawdown	5.7	27	14	Poor
W-352	30-Dec-86	Drawdown	20.0	280	14	Good
W-352	7-Jul-87	Longterm	19.5	120	6.0	Excel
W-353	20-Nov-86	Drawdown	2.1	60	17	Good
W-354	30-Dec-86	Drawdown	17.6	2,000	220	Fair
W-354	30-Dec-86	Drawdown	18.0	2,400	260	Good
W-354	20-Apr-87	Longterm	17.8	310	34	Good
W-355	29-Dec-86	Drawdown	2.1	19	5.0	Fair
W-356	17-Mar-87	Drawdown	5.7	180	59	Good
W-356	16-Jul-96	Longterm	4.9	230	57	Poor
W-357	18-Feb-87	Drawdown	15.0	1,300	110	Good

Table B-1. (Continued)

Well	Date	Type of test[b]	Flow rate (Q) (gpm)	Transmis-sivity (T) (gpd/ft)	Hydraulic conductivity (K)[c] (gpd/sq ft)	Data quality[d]
W-357	21-Jul-87	Longterm	9.2	210	18	Good
W-358	18-Mar-87	Drawdown	9.2	210	32	Excel
W-359	9-Mar-87	Longterm	19.0	2,800	290	Fair
W-359	20-Mar-87	Drawdown	18.6	1,100	110	Good
W-360	22-May-87	Drawdown	30.0	4,800	210	Excel
W-361	16-Mar-87	Drawdown	4.3	67	11	Good
W-361	12-Jan-85	Longterm	5.3	178	30	Good
W-362	23-Mar-87	Drawdown	16.4	470	49	Good
W-362	21-Sep-87	Longterm	13.6	370	39	Good
W-363	24-Jul-87	Slug	0.0	20	3.0	Excel
W-364	8-Apr-87	Drawdown	8.6	51	10	Fair
W-364	1-Jun-87	Longterm	4.8	110	22	Good
W-365	14-May-87	Drawdown	10.0	36	15	Fair
W-366	11-May-87	Drawdown	19.0	780	92	Fair
W-368	11-May-87	Drawdown	2.9	81	8.5	Fair
W-369	25-Jun-87	Drawdown	7.0	580	96	Good
W-369	10-Nov-87	Longterm	5.5	89	18	Good
W-370	23-Jun-87	Drawdown	4.4	84	10	Fair
W-371	24-Jun-87	Drawdown	3.3	15	3.0	Good
W-372	23-Nov-87	Slug	0.0	310	62	Excel
W-373	28-Jul-87	Drawdown	4.0	660	77	Fair
W-373	28-Jul-87	Drawdown	6.5	50	6.0	Poor
W-376	26-Jan-88	Drawdown	2.9	65	8.5	Fair
W-380	23-Oct-87	Drawdown	4.0	33	4.7	Excel
W-401	23-Oct-87	Drawdown	42.0	950	24	Excel
W-402	22-Oct-87	Drawdown	41.0	13,500	1,400	Good
W-403	3-Dec-87	Drawdown	9.7	370	26	Good
W-404	4-Feb-85	Drawdown	45.0	3,200	530	Good
W-405	16-Feb-85	Drawdown	47.2	546	14	Good
W-406	28-Jan-85	Drawdown	7.4	7,500	940	Fair
W-407	23-Feb-85	Drawdown	14.4	75	7.5	Fair
W-408	5-Apr-85	Drawdown	45.0	43,000	3,100	Good
W-409	22-Mar-85	Drawdown	20.0	230	38	Good
W-410	28-Apr-85	Drawdown	35.0	6,800	570	Fair
W-411	5-May-85	Drawdown	14.0	50	83	Good

Table B-1. (Continued)

Well	Date	Type of test[b]	Flow rate (Q) (gpm)	Transmis-sivity (T) (gpd/ft)	Hydraulic conductivity (K)[c] (gpd/sq ft)	Data quality[d]
W-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	27Jun-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	Longterm	14.0	470	52	Good
W-447	26-Feb-88	Drawdown	7.1	124	850	Poor
W-448	24-Mar-85	Drawdown	24.5	4,200	600	Good
W-449	21-Mar-85	Drawdown	6.2	170	11	Good
W-450	14-Apr-88	Drawdown	3.3	38	650	Fair
W-451	27-Apr-88	Drawdown	2.1	80	16	Good
W-452	2-May-88	Drawdown	5.2	310	21	Excel
W-453	3-May-88	Drawdown	5.8	67	7.4	Fair
W-455	22-Jun-88	Drawdown	5.8	160	13	Good
W-456	14-Jul-85	Drawdown	4.5	260	33	Fair
W-457	29-Jul-85	Drawdown	20.5	450	24	Excel
W-458	2-Aug-85	Drawdown	0.8	24	150	Fair
W-460	1-Sep-85	Drawdown	17.0	1,900	380	Fair
W-461	7-Sep-85	Slug	0.0	690	140	Good
W-462	27-Sep-85	Drawdown	19.0	360	60	Good
W-463	11-Oct-85	Drawdown	24.0	1,600	200	Good
W-464	8-Nov-88	Drawdown	9.0	370	53	Good
W-481	2-Dec-87	Drawdown	1.1	8	1.7	Good
W-486	23-Mar-85	Drawdown	6.0	230	30	Good
W-487	14-Apr-88	Drawdown	2.2	45	15	Good
W-501	21-Oct-85	Drawdown	9.7	170	21	Good
W-502	14-Nov-85	Slug	0.0	12	30	Good
W-503	11-Nov-88	Drawdown	1.3	15	3.0	Fair

Table B-1. (Continued)

Well	Date	Type of test[b]	Flow rate (Q) (gpm)	Transmis-sivity (T) (gpd/ft)	Hydraulic conductivity (K)[c] (gpd/sq ft)	Data quality[d]
W-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	Longterm	22.5	2580	520	Fair

Table B-1. (Continued)

Well	Date	Type of test[b]	Flow rate (Q) (gpm)	Transmis-sivity (T) (gpd/ft)	Hydraulic conductivity (K)[c] (gpd/sq ft)	Data quality[d]
W-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	Longterm	14	230	40	Good
W-613	23-May-90	Drawdown	4.8	2,550	360	Good
W-614	7-Jun-90	Drawdown	6.7	1,650	130	Good
W-615	21-Jun-90	Drawdown	1.3	130	19	Fair
W-616	27-Jun-90	Drawdown	2.0	390	40	Fair
W-617	12-Jul-90	Drawdown	2.8	53	6.8	Good
W-618	1-Aug-90	Drawdown	1.9	24	4.8	Fair
W-619	30-Aug-90	Drawdown	11.8	190	11	Good
W-620	1-Oct-90	Drawdown	5.8	6,500	650	Good
W-621	4-Oct-90	Drawdown	3.8	310	39	Good
W-622	12-Oct-90	Slug	0.0	130	16	Fair
W-651	16-Mar-90	Slug	0.0	530	180	Fair
W-652	22-Mar-90	Drawdown	1.0	11	3.8	Good
W-653	11-Apr-90	Drawdown	0.3	2	1.9	Fair
W-654	25-Apr-90	Drawdown	21.7	390	25	Fair

Table B-1. (Continued)

Well	Date	Type of test[b]	Flow rate (Q) (gpm)	Transmis-sivity (T) (gpd/ft)	Hydraulic conductivity (K)[c] (gpd/sq ft)	Data quality[d]
W-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	Longterm	15.1	1440	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. (Continued)

Well	Date	Type of test[b]	Flow rate (Q) (gpm)	Transmis-sivity (T) (gpd/ft)	Hydraulic conductivity (K)[c] (gpd/sq ft)	Data quality[d]
W-1108	3-Nov-95	Drawdown	12.3	950	68	Good
W-1108	25-Jun-96	Longterm	11.6	1,000	70	Poor
W-1109	26-Jun-95	Drawdown	8.7	460	33	Fair
W-1109	4-Jun-96	Longterm	6.8	760	40	Poor
W-1110	22-Jan-96	Drawdown	6.3	690	29	Fair
W-1111	20-Oct-95	Drawdown	15.8	2,100	95	Good
W-1111	9-Dec-96	Longterm	11.2	160	7.9	Poor
W-1112	24-May-96	Drawdown	6.4	94	10	Fair
W-1113	26-Aug-96	Drawdown	1	5.5	0.6	Good
W-1114	27-Oct-95	Longterm	15.1	270	12	Fair
W-1116	23-Feb-96	Drawdown	6.6	290	11	Fair
W-1117	23-Aug-96	Drawdown	0.7	3.4	0.34	Fair
W-1118	18-Jan-96	Drawdown	5.6	350	35	Good
W-1201	1-Nov-96	Drawdown	1	8.3	0.92	Poor
W-1203	2-May-96	Drawdown	18.8	900	90	Good
W-1204	22-Feb-96	Drawdown	1.3	17	2.2	Poor
W-1205	27-Nov-96	Slug	0	330	33	Fair
W-1207	27-Nov-96	Slug	0	900	45	Poor
W-1209	17-May-96	Drawdown	0.98	11	0.69	Good
W-1210	30-May-96	Drawdown	3.8	7.3	0.73	Fair
W-1211	26-Jul-96	Drawdown	28.6	5,000	330	Good
W-1212	14-May-96	Drawdown	1.9	35	2.5	Good
W-1212	10-Sep-96	Longterm	1.3	85	3.6	Poor
W-1213	22-Jul-96	Drawdown	11.6	500	42	Fair
W-1213	30-Jul-96	Longterm	9.6	440	37	Poor
W-1214	28-Apr-97	Drawdown	2.2	110	5.4	Fair
W-1215	15-Aug-96	Drawdown	11.6	610	61	Fair
W-1215	8-Oct-96	Longterm	9.8	3,000	300	Poor
W-1216	14-Aug-96	Drawdown	11.4	210	6.9	Good
W-1216	15-Oct-96	Longterm	11.1	160	5.4	Poor
W-1218	11-Nov-96	Drawdown	5.8	83	4.6	Fair
W-1218	8-Jul-97	Longterm	4.8	210	12	Fair
W-1219	27-May-97	Drawdown	0.4	2.5	0.63	Poor
W-1220	13-Nov-96	Drawdown	20.3	2,600	120	Good
W-1220	15-Jul-97	Longterm	20	4,700	210	Fair

Table B-1. (Continued)

Well	Date	Type of test[b]	Flow rate (Q) (gpm)	Transmis-sivity (T) (gpd/ft)	Hydraulic conductivity (K)[c] (gpd/sq ft)	Data quality[d]
W-1221	27-Dec-96	Drawdown	3.1	29	2.9	Fair
W-1222	31-Oct-96	Drawdown	6.1	430	43	Good
W-1224	22-May-97	Drawdown	5	55	11	Good
W-1225	31-Mar-97	Drawdown	4.1	83	10	Good
W-1226	27-Feb-97	Drawdown	2.2	14	1.4	Excel
W-1227	11-Apr-97	Drawdown	15.1	380	48	Fair
W-1254	19-Nov-96	Longterm	18.9	1,130	110	Fair
W-1301	10-Mar-97	Longterm	4.7	120	15	Fair
W-1303	18-Mar-97	Longterm	7.8	490	21	Fair
W-1304	2-Jul-97	Drawdown	0.7	2.6	0.52	Poor
W-1306	30-Apr-97	Drawdown	2.8	24	1.2	Good
W-1306	18-Jun-97	Longterm	1.6	54	2.7	Poor
W-1307	31-Jul-97	Drawdown	11.6	1,100	110	Good
W-1308	14-Aug-97	Drawdown	6.5	150	5.1	Good
W-1308	7-Oct-977	Longterm	4	530	18	Fair
W-1309	15-Oct-97	Drawdown	9.1	90	8.9	Fair
W-1310	10-Mar-97	Drawdown	27.9	1,060	53	Good
W-1311	29-Oct-97	Drawdown	12.2	290	15	Good
W-1401	11-Nov-97	Drawdown	7	100	6.8	Excel
W-1402	12-Dec-97	Drawdown	2.6	100	10.2	Fair
TW-11	24-Jan-85	Drawdown	0.3	200	20	Good
TW-11A	24-Jan-85	Drawdown	10.0	3,100	110	Fair
GSW-01	11-Dec-85	Slug	0.0	72	0.2	Fair
GSW-01A	14-Jul-86	Drawdown	13.4	12,000	790	Good
GSW-02	17-Dec-85	Slug	0.0	240	10	Good
GSW-03	23-Dec-85	Slug	0.0	510	41	Good
GSW-04	19-Dec-85	Slug	0.0	17	0.9	Good
GSW-05	12-Feb-86	Slug	0.0	99	9	Excel
GSW-06	23-Iun-86	Drawdown	25.0	4,800	310	Good
GSW-06	16-Jun-87	Longterm	20.0	5,500	350	Good
GSW-07	3-Apr-86	Drawdown	4.3	230	23	Excel
GSW-08	19-Nov-86	Drawdown	2.0	230	38	Good
GSW-09	28-May-86	Drawdown	1.9	500	63	Poor
GSW-10	22-May-86	Drawdown	14.3	21,000	2,000	Good
GSW-11	2-Jun-86	Drawdown	4.7	390	45	Excel

Table B-1. (Continued)

Well	Date	Type of test[b]	Flow rate (Q) (gpm)	Transmis-sivity (T) (gpd/ft)	Hydraulic conductivity (K)[c] (gpd/sq ft)	Data quality[d]
GSW-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
GEW-710	23-Sept-91	Step	36.0	4,800	220	Excel
GEW-816	15-Aug-92	Drawdown	39.0	12,000	1,100	Good
11H4	15-Jan-85	Drawdown	24.6	2,000	77	Good
11H4	19-Jan-85	Longterm	29.5	1,780	18	Good
11J4	10-Jun-88	Drawdown	17.0	1,000	15	Excel
11J4	14-Jun-85	Longterm	16.0	1,100	16	Good
13D1	9-Feb-85	Longterm	50.0	4,800	48	Excel

Footnotes appear on the following page.

Table B-1. (Continued)

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

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

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

[d] **Hydraulic test quality criteria:**

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

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

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

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

References

Boulton, N. S. (1963), “Analysis of Data from Non-Equilibrium Pumping Tests Allowing for Delayed Yield from Storage,” Proc. Inst. Civ. Eng. 26, 469-482.

Cooper, H. H., Jr., J. D. Bredehoeft, and I. S. Papadopulos (1967), “Response of a Finite-Diameter Well to an Instantaneous Charge of Water,” Water Resour. Res. 3, 263-269.

Cooper, H. H., and C. E. Jacob (1946), “A Generalized Graphical Method of Evaluating Formation Constants and Summarizing Well Field History,” Am. Geophys. Union Trans. 27, 526-534.

Hantush, M. S. (1960), “Modification of the Theory of Leaky Aquifers,” The J. of Geophys. Res. 65, 3173-3725.

Hantush, M. S., and C. E. Jacob (1955), “Non-Steady Radial Flow in an Infinite Leaky Aquifer,” Am. Geophys. Union Trans. 36 (1), 95-100.

Papadopulos, I. S., and H. H. Cooper, Jr. (1967), “Drawdown in a Well of Large Diameter,” Water Resour. Res. 3, 241-244.

Theis, C. V. (1935), “The Relation Between the Lowering of the Piezometric Surface and the Rate and Duration of Discharge of a Well Using Ground-Water Storage,” Am. Geophys. Union Trans. 16, 519-524.

Appendix C

1998 Ground Water Sampling Schedule

Table C-1. 1998 LLNL Livermore Site ground water sampling schedule.

Well number	1998 VOC sampling frequency	Next quarter sample date	Metals, RAD, etc. (1-98)	VOCs
W-001	O	4-99		E601
W-001A	O	4-99		E601
W-002	O	3-99		E601
W-002A	A	4-98		E601
W-004	O	4-99		E601
W-005	A	1-98		E601
W-005A	O	3-99		E601
W-007	O	3-99		E601
W-008	A	4-98	WGMG	E601
W-010A	S	1-98		E601
W-011	S	1-98		E601
W-012	Q	1-98		E601
W-017	E	4-98		E601
W-017A	E	3-98		E601
W-019	E	4-98		E601
W-101	A	1-98		E601
W-102	O	2-99		E601
W-103	O	3-99		E601
W-104	Q	1-98		E601
W-105	Q	1-98		E601
W-106	E	3-98		E601
W-107	O	2-99		E601
W-108	O	2-99		E601
W-110	Q	1-98		E601
W-111	S	2-98		E601
W-113	E	4-98		E601
W-114	A	1-98		E601
W-115	O	3-99		E601
W-116	Q	1-98		E601
W-117	E	4-98		E601
W-118	A	1-98		E601
W-119	Q	1-98	WGMG	E601
W-120	Q	1-98		E601
W-121	Q	1-98		E601
W-122	A	1-98		E601
W-123	E	1-98		E601

Table C-1. (Continued)

Well number	1998 VOC sampling frequency	Next quarter sample date	Metals, RAD, etc. (1-98)	VOCs
W-141	E	2-98		E601
W-142	A	2-98		E601
W-143	S	2-98		E601
W-146	A	4-98		E601
W-147	A	4-98		E601
W-148	O	4-99		E601
W-151	Q	1-98		E601
W-201	O	4-99		E601
W-202	E	4-98		E601
W-203	E	2-98		E601
W-204	O	1-99	WGMG	E601
W-205	Q	1-98		E601
W-206	Q	1-98		E601
W-207	Q	1-98		E601
W-210	A	4-98	E906	E601
W-212	E	4-98		E601
W-213	O	3-99		E601
W-214	O	2-99		E601
W-217	Q	1-98		E601
W-219	Q	1-98		E601
W-220	A	1-98		E601
W-221	O	3-99	WGMG	E601
W-222	Q	1-98		E601
W-223	A	1-98		E601
W-224	A	1-98		E601
W-225	S	2-98		E601
W-226	O	3-99		E601
W-251	Q	1-98		E601
W-252	O	2-99		E601
W-253	O	4-99		E601
W-254	Q	1-98		E601
W-255	Q	1-98		E601
W-256	O	1-99		E601
W-257	Q	1-98	E906	E601
W-258	O	2-99		E601
W-259	Q	1-98	E906	E601

Table C-1. (Continued)

Well number	1998 VOC sampling frequency	Next quarter sample date	Metals, RAD, etc. (1-98)	VOCs
W-260	S	1-98		E601
W-261	E	3-98		E601
W-263	Q	1-98		E601
W-264	A	2-98		E601
W-265	O	2-99		E601
W-267	S	1-98		E601
W-268	A	2-98		E601
W-269	A	4-98		E601
W-270	O	1-99		E601
W-271	Q	1-98		E601
W-272	S	1-98		E601
W-273	O	4-99		E601
W-274	Q	1-98		E601
W-275	S	2-98		E601
W-276	A	3-98		E601
W-277	A	1-98		E601
W-290	E	4-98		E601
W-291	O	2-99		E601
W-292	A	1-98		E601
W-293	E	2-98		E601
W-294	O	2-99		E601
W-301	O	4-99		E601
W-302	O	3-99		E601
W-303	A	1-98		E601
W-304	O	3-99		E601
W-305	Q	1-98		E601
W-306	O	3-99		E601
W-307	S	2-98		E601
W-308	E	4-98		E601
W-310	E	3-98		E601
W-311	Q	1-98		E601
W-312	A	2-98		E601
W-313	A	1-98		E601
W-315	Q	1-98		E601
W-316	Q	1-98		E601
W-317	A	4-98		E601

Table C-1. (Continued)

Well number	1998 VOC sampling frequency	Next quarter sample date	Metals, RAD, etc. (1-98)	VOCs
W-318	O	2-99		E601
W-319	E	4-98		E601
W-320	A	1-98		E601
W-321	O	1-99		E601
W-322	Q	1-98		E601
W-323	Q	1-98		E601
W-324	E	2-98		E601
W-325	E	4-98		E601
W-353	S	2-98		E601
W-354	Q	1-98		E601
W-355	Q	1-98		E601
W-356	Q	1-98		E601
W-359	Q	1-98		E601
W-360	S	2-98		E601
W-361	Q	1-98		E601
W-362	O	2-99		E601
W-363	Q	1-98	WGMG	E601
W-364	Q	1-98		E601
W-365	O	3-99		E601
W-366	O	2-99		E601
W-368	A	1-98		E601
W-369	Q	1-98		E601
W-370	A	2-98		E601
W-371	E	3-98		E601
W-372	E	3-98		E601
W-373	O	4-99	WGMG	E601
W-375	Q	1-98		E601
W-376	O	2-99		E601
W-377	O	2-99		E601
W-378	O	4-99		E601
W-379	A	2-98		E601
W-380	E	4-98		E601
W-401	E	2-98		E601
W-402	E	4-98		E601
W-403	E	3-98		E601
W-404	Q	1-98		E601

Table C-1. (Continued)

Well number	1998 VOC sampling frequency	Next quarter sample date	Metals, RAD, etc. (1-98)	VOCs
W-405	Q	1-98		E601
W-406	A	1-98		E601
W-407	Q	1-98		E601
W-409	A	2-98		E601
W-410	Q	1-98		E601
W-411	Q	1-98		E601
W-412	A	1-98		E601
W-413	A	1-98		E601
W-414	E	3-98		E601
W-416	E	2-98		E601
W-417	E	2-98		E601
W-418	A	4-98		E601
W-419	Q	1-98		E601
W-420	A	2-98		E601
W-421	Q	1-98		E601
W-422	A	3-98		E601
W-423	Q	1-98		E601
W-424	S	2-98		E601
W-446	A	4-98		E601
W-447	A	3-98		E601
W-448	O	2-99		E601
W-449	A	4-98		E601
W-450	A	1-98		E601
W-451	e	1-98		E601
W-452	E	4-98		E601
W-453	E	3-98		E601
W-454	S	2-98		E601
W-455	A	1-98		E601
W-456	O	2-99		E601
W-458	E	4-98		E601
W-459	A	4-98		E601
W-460	O	4-99		E601
W-461	A	2-98		E601
W-462	O	3-99		E601
W-463	A	1-98		E601
W-464	A	3-98		E601

Table C-1. (Continued)

Well number	1998 VOC sampling frequency	Next quarter sample date	Metals, RAD, etc. (1-98)	VOCs
W-481	Q	1-98		E601
W-482	A	4-98		E601
W-483	S	2-98		E601
W-484	O	3-99		E601
W-485	O	2-99		E601
W-486	A	1-98	E906	E601
W-487	A	1-98		E601
W-501	S	2-98		E601
W-502	O	2-99		E601
W-503	O	2-99		E601
W-504	O	4-99		E601
W-505	O	2-99		E601
W-506	S	1-98		E601
W-507	E	3-98		E601
W-509	S	1-98		E601
W-510	E	3-98		E601
W-511	O	3-99		E601
W-512	O	4-99		E601
W-513	A	2-98		E601
W-514	O	2-99		E601
W-515	Q	1-98		E601
W-516	E	4-98		E601
W-517	Q	1-98		E601
W-519	O	3-99		E601
W-521	A	4-98		E601
W-551	S	2-98		E601
W-552	O	4-99		E601
W-553	E	4-98		E601
W-554	O	2-99		E601
W-555	O	2-99		E601
W-556	O	4-99		E601
W-557	E	3-98		E601
W-558	Q	1-98		E601
W-559	E	3-98		E601
W-560	O	4-99		E601
W-561	E	2-98		E601

Table C-1. (Continued)

Well number	1998 VOC sampling frequency	Next quarter sample date	Metals, RAD, etc. (1-98)	VOCs
W-562	A	4-98		E601
W-563	E	2-98		E601
W-564	Q	1-98		E601
W-565	E	4-98		E601
W-567	A	1-98		E601
W-568	S	1-98		E601
W-569	S	1-98		E601
W-570	O	2-99		E601
W-571	O	2-99		E601
W-591	E	3-98		E601
W-592	O	3-99		E601
W-593	O	4-99		E601
W-594	O	1-99		E601
W-604	S	2-98		E601
W-605	A	3-98		E601
W-606	S	1-98		E601
W-607	O	2-99		E601
W-608	O	1-99		E601
W-611	S	2-98		E601
W-612	O	2-99		E601
W-613	A	1-98		E601
W-615	A	2-98		E601
W-616	O	4-99		E601
W-617	A	3-98		E601
W-618	Q	1-98		E601
W-619	O	3-99		E601
W-622	Q	1-98		E601
W-651	Q	1-98		E601
W-652	O	1-99		E601
W-653	Q	1-98		E601
W-654	S	1-98		E601
W-702	S	2-98		E601
W-705	S	1-98		E601
W-706	O	3-99		E601
W-750	Q	1-98		E601
W-714	A	4-98		E601

Table C-1. (Continued)

Well number	1998 VOC sampling frequency	Next quarter sample date	Metals, RAD, etc. (1-98)	VOCs
W-901	Q	1-98		E601
W-902	Q	1-98		E601
W-905	O	4-99		E601
W-908	Q	1-98		E601
W-909	Q	1-98		E601
W-911	Q	1-98		E601
W-912	Q	1-98		E601
W-913	Q	1-98		E601
W-1001	Q	1-98		E601
W-1002	A	2-98		E601
W-1003	O	4-99		E601
W-1005	S	1-98		E601
W-1006	Q	1-98		E601
W-1007	A	1-98		E601
W-1008	E	4-98		E601
W-1010	O	4-99		E601
W-1011	O	2-99		E601
W-1012	O	4-99	WGMG	E601
W-1013	A	3-98		E601
W-1014	Q	1-98		E601
W-1101	O	2-99		E601
W-1105	O	1-99		E601
W-1106	S	1-98		E601
W-1107	Q	1-98		E601
W-1108	Q	1-98		E601
W-1110	S	1-98		E601
W-1112	Q	1-98		E601
W-1113	S	1-98		E601
W-1115	Q	1-98		E601
W-1117	Q	1-98		E601
W-1118	S	2-98		E601
W-1201	Q	1-98		E601
W-1202	Q	1-98		E601
W-1203	Q	1-98		E601
W-1204	Q	1-98		E601
W-1205	Q	1-98		E601

Table C-1. (Continued)

Well number	1998 VOC sampling frequency	Next quarter sample date	Metals, RAD, etc. (1-98)	VOCs
W-1207	Q	1-98		E601
W-1209	Q	1-98		E601
W-1210	S	1-98		E601
W-1211	Q	1-98		E601
W-1212	Q	1-98		E624
W-1214	S	2-98		E601
W-1217	Q	1-98		E601
W-1218	Q	1-98		E601
W-1219	Q	1-98		E601
W-1220	Q	1-98		E601
W-1221	Q	1-98		E601
W-1222	Q	1-98		E601
W-1223	Q	1-98	E906	E601
W-1224	Q	1-98		E601
W-1225	Q	1-98		E601
W-1226	Q	1-98		E601
W-1227	Q	1-98		E601
W-1250	Q	1-98		E601
W-1251	S	2-98		E601
W-1252	S	2-98		E601
W-1253	Q	1-98		E601
W-1254	S	2-98		E601
W-1255	Q	1-98		E601
W-1304	Q	1-98		E601
W-1401	Q	1-98		E601
W-1402	Q	1-98		E601
TW-11	O	2-99		E601
TW-11A	A	4-98		E601
TW-21	A	4-98		E601
11J2	A	4-98		E601
11C1	E	1-98		E601
14A11	O	4-99		E601
14A3	A	3-98		E601
14B1	O	3-99		E601
14B4	O	2-99		E601
14C1	O	3-99		E602

Table C-1. (Continued)

Well number	1998 VOC sampling frequency	Next quarter sample date	Metals, RAD, etc. (1-98)	VOCs
14C2	O	3-99		E602/14d
14C3	A	4-99		E601
14H1	E	2-98		E602/14d
18D1	E	2-98		E602/14d
7D2	O	4-98		E602/14d
GEW-710	A	4-98		E602/14d
GSW-006	A	4-98	E602	E602/14d
GSW-007	O	4-99		E602/14d
GSW-008	O	4-99	E602	E601
GSW-009	Q	1-98	E602	E601
GSW-011	S	1-98		E601
GSW-013	O	4-99	E602	E624
GSW-215	Q	1-98	E602	E601
GSW-266	A	4-98	E602	E601
GSW-326	E	4-98		E601
GSW-367	S	1-98		E601
GSW-442	A	4-98		E601
GSW-443	A	2-98		E601
GSW-444	O	2-99		E601

Notes:

O = Odd years.
A = Annual.
S = Semiannual.
Q = Quarterly.
E = Even years.
E601 = EPA Method 601 for purgeable halocarbons.
WGMG = Water Guidance and Monitoring Group.
E906 = EPA Method 906 for tritium.
E624 = EPA Method 624 for VOCs.
E602 = EPA Method 602 for aromatic volatile compounds.

Appendix D

1997 Drainage Retention Basin Annual Monitoring Program Summary

Appendix D

1997 Drainage Retention Basin Annual Monitoring Program Summary

This Appendix summarizes the 1997 LLNL Operations and Regulatory Affairs Division routine maintenance activities, maintenance monitoring, and discharge data for the Drainage Retention Basin (DRB). The DRB, located in the central portion of the Livermore Site (Fig. D-1), is an artificial water body with about 43 acre-ft (approximately 1.4×10^7 gal) capacity. It was designed to receive storm water runoff and treated ground water.

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 Regional Water Quality Control Board-San Francisco Bay Region (RWQCB-SF). 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 current discharge limits. Discharge limits are established in the CERCLA *Record of Decision for the Lawrence Livermore National Laboratory, Livermore Site* (Department of Energy, 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 implemented. In most cases, short-term variances outside the normal range are not significant, and management response is required only if the objective is substantially exceeded.

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 1997.

D.1. Drainage Retention Basin Maintenance Monitoring

Samples collected during 1997 within the DRB at sample location CDBE did not meet the MALs for ammonia, chemical oxygen demand, dissolved oxygen, fecal coliform, nitrate (as nitrogen), pH, temperature, total dissolved solids, total phosphorus (as phosphorus) and turbidity. Results of the October 15, 1997, CDBE radiological analyses are still pending and will be reported in the first quarterly self-monitoring report of calendar year 1998. A summary of these constituents is provided in table D-1.

Table D-1. Constituents monitored at CDBE exceeding Management Action Levels (MALs).

Analysis	Management action level	Maximum value	Minimum value	Samples exceeding MALs/ samples collected
Ammonia Nitrogen (mg/L)	>0.1	0.44	<0.02	03/11
Chemical Oxygen Demand (mg/L)	>20	52.2	27	04/04
Dissolved Oxygen (mg/L)	<80% or < 5	14.9	3.4	11/39
Fecal Coliform (MPN)	>400	1,600	<2	01/04
Nitrate (as N) (mg/L)	>0.2	0.84	<0.1	08/11
pH (units)	<6.0 and >9.0	9.2	7.24	01/11
Temperature (degrees F)	<15 and > 26	26.7	6.3	15/39
Total Dissolved Solids (mg/L)	>400	463	200	03/11
Total Phosphorous (as P) (mg/L)	>0.02	0.66	0.2	29/29
Turbidity (meters)	<0.914	1.372	0.25	27/32

MPN = Most Probable Number.

Ammonia continued to occasionally exceed its MAL. Ammonia is an indication of anaerobic activity occurring within the DRB which was supported by several low dissolved oxygen readings obtained in 1997. The dissolved oxygen readings are believed to be low for two reasons. The first reason is the pumps to circulate the DRB were left off longer than usual in an effort to increase water clarity. Water clarity, measured by turbidity, is typically low in the winter when storm runoff increases sediment load. Water clarity was successfully improved with turbidity levels coming near or within the MAL for the first time since 1994. However, once the recirculation pumps were turned on to increase dissolved oxygen levels, water clarity began to decrease. The second reason for low dissolved oxygen readings was due to mechanical problems with the dissolved oxygen meter. Comparison sampling with rental meters indicate the dissolved oxygen readings using LLNL's ICM might be as much as 2 mg/L low.

Chemical oxygen demand was above the MAL for the first time during 1997. The maximum value occurred during first quarter monitoring. Heavy rains and runoff occurring last year at the end of December 1996 and beginning of January 1997 most likely introduced organic material into the DRB increasing oxygen demand. Oxygen demand within the DRB decreased over the course of the year. Fecal coliform measured high for the first time since the DRB began to operate during the first quarter monitoring event. High total coliform (1,600 Most Probable Number) was also reported in this sample. Subsequent coliform samples were substantially lower, below the MAL.

Total phosphorous continued to be above the MAL throughout 1997. Phosphorous concentration increases were correlated with times when Treatment Facility D (TFD) was diverted into the DRB to accommodate down stream construction activities. Nitrate as nitrogen concentrations also continued to exceed the MAL during 1997.

Although nutrient levels have been high since 1994, chlorophyll "a", which indicates the level of algae growth, remains well below the 10 mg/L MAL, ranging from <0.0013 mg/L to

0.0151 mg/L. Though the chlorophyll "a" levels did not increase significantly from last year, algae growth was visibly evident in 1997 for the first time since the fall of 1995 when toxicity tests indicated the water within the DRB had a toxic effect on the algae Selanastrum capricornutum.

In March 1995, LLNL began monitoring for active ingredients of commonly used herbicides which could inhibit algae growth. Quarterly monitoring in 1996 detected low levels of Bromocil (13 to 36 µg/L) and Diuron (7 to 23 µg/L). During the first part of 1997 both Diuron and Bromocil levels were reduced below detection levels. This coincided with the increase of algae growth in the DRB. LLNL began a toxicity study in August of 1996 that roughly followed the procedures of a Toxicity Reduction Evaluation (TRE). The toxicity study was completed in the fall of 1997. The results of the toxicity study indicate the toxicity in the DRB was not a result of metal concentrations but resulted from organic constituents. Further study confirmed a strong toxicity effect from concentrations of Diuron and Bromocil found in the DRB in March 1997 and a weak toxic effect from leachate derived from tanbark spread around the DRB. These studies indicate that the introduction of Bromocil and Diuron occurring in the fall of 1995 resulting from upstream use of these pesticides was most likely the caused the algae growth inhibition.

During September 1995, LLNL conducted chronic toxicity tests on algae and fish to determine if the lack of algae growth was the result of factors other than turbidity. The results of the test using the algae Selanastrum capricornutum, indicated algae growth inhibition occurred at a 12.5% concentration of DRB water. The test using the fathead minnow, Pimephales promelas showed no chronic toxicity in up to 100% DRB water. Follow-up chronic toxicity testing in September 1996 indicated that DRB water had no chronic toxicity to the fathead minnow, and actually had a growth inducing effect on the algae. However, the results contradicted what was observed regarding the lack of algae growth in the DRB. Three species were used in the chronic toxicity testing conducted in October 1997, Selanastrum capricornutum, Ceriodaphnia dubia, and Pimephales promelas. The results of these tests showed no toxic effects on the Pimephales promelas and Ceriodaphnia dubia. However, Selanastrum capricornutum showed greater than 16 toxic units for growth with a No Observable Effect Concentration (NOEC) at <6.25% concentration of DRB water and the Lowest Observable Effect Concentration (LOEC) at a 6.25% concentration of DRB water. This observed toxicity coincides with re-introduction of Diuron (33 micrograms per liter) detected in samples collected at CDBE in October. The introduction of Diuron came from the use of KARMEX DF herbicide for weed control in an upgradient storm water drainage swale.

Semiannual and annual maintenance sampling was conducted during April and October 1997. Quarterly sampling was conducted in January, April, July, and October. Results for oil and grease, volatile organic compounds, semi-volatile organic compounds, total petroleum hydrocarbons, polynuclear aromatic compounds, ethylene dibromide and total organic carbon all met their MALs. Radiological results for the October sample are still pending. Acute fish toxicity test using the fathead minnow (95% survival) met the 90% survival MAL.

In 1997, LLNL began quarterly microbiological monitoring as a tool to evaluate the nature and health of the DRB aquatic community as an expression of water quality. LLNL also began semi-annual biological monitoring to evaluate the impact the operation of the DRB has on surrounding and downstream ecosystems.

D-2. Drainage Retention Basin Discharge Monitoring

Four DRB release samples were collected in 1997 representing 37.6 million gallons of water discharged. Three releases occurred during the wet weather season (October 1 through May 31) totaling 30.1 million gallons. One discharge occurred during the dry weather (June 1 through September 30) totaling 7.5 million gallons. Discharges during 1997 occurred from the DRB in January, February, September, November, and December. The largest single day discharge occurred on January 2, 1997 (3.5 million gallons).

The dry season release occurred on September 17, 1997. The three wet season releases occurred January 15, November 26, and December 8, 1997. The September 17, 1997 release was necessary because of water discharged to the DRB from TFD to allow for construction activities in the discharge pipeline from the DRB. TFD discharges were diverted into the DRB until the construction activities were complete. The November 26, 1996 release was a manual release and was the first of the rainy season. The release was necessary to prevent flooding of areas around the DRB and the upstream channels. The January 15, 1996, and December 8, 1997, samples were collected from storm water overflowing the lowered weir gate and occurred concurrent with 1996/97 and 1997/98 storm water sampling events. Samples were collected during this release from locations CDBX and WPDC. Dry season (April 1–November 30) limits were used to evaluate the compliance of the September and November releases, wet weather limits (December 1–March 31) were used to evaluate the compliance of the January and December releases.

All samples collected from CDBX were below discharge limits except total petroleum hydrocarbons diesel (81 mg/L). The concentration of diesel fuel exceeded the discharge limit of 50 mg/L. Sample results are still pending for radiological samples. Diuron was found in samples collected at both CDBX (40 µg/L) and WPDC (42 µg/L). Diuron was also seen in influent sample coming on to the LLNL site (11 µg/L and 47 µg/L).

D-3. References

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

Lamarre, A., J. Littlejohn (1997), Letter from Lamarre to Remedial Project Managers, LLNL Livermore Site Remedial Project Managers' Meeting Summary and Quarterly Self-Monitoring Reports, dated May 23, 1997, August 29, 1997, November 26, 1997.

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

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

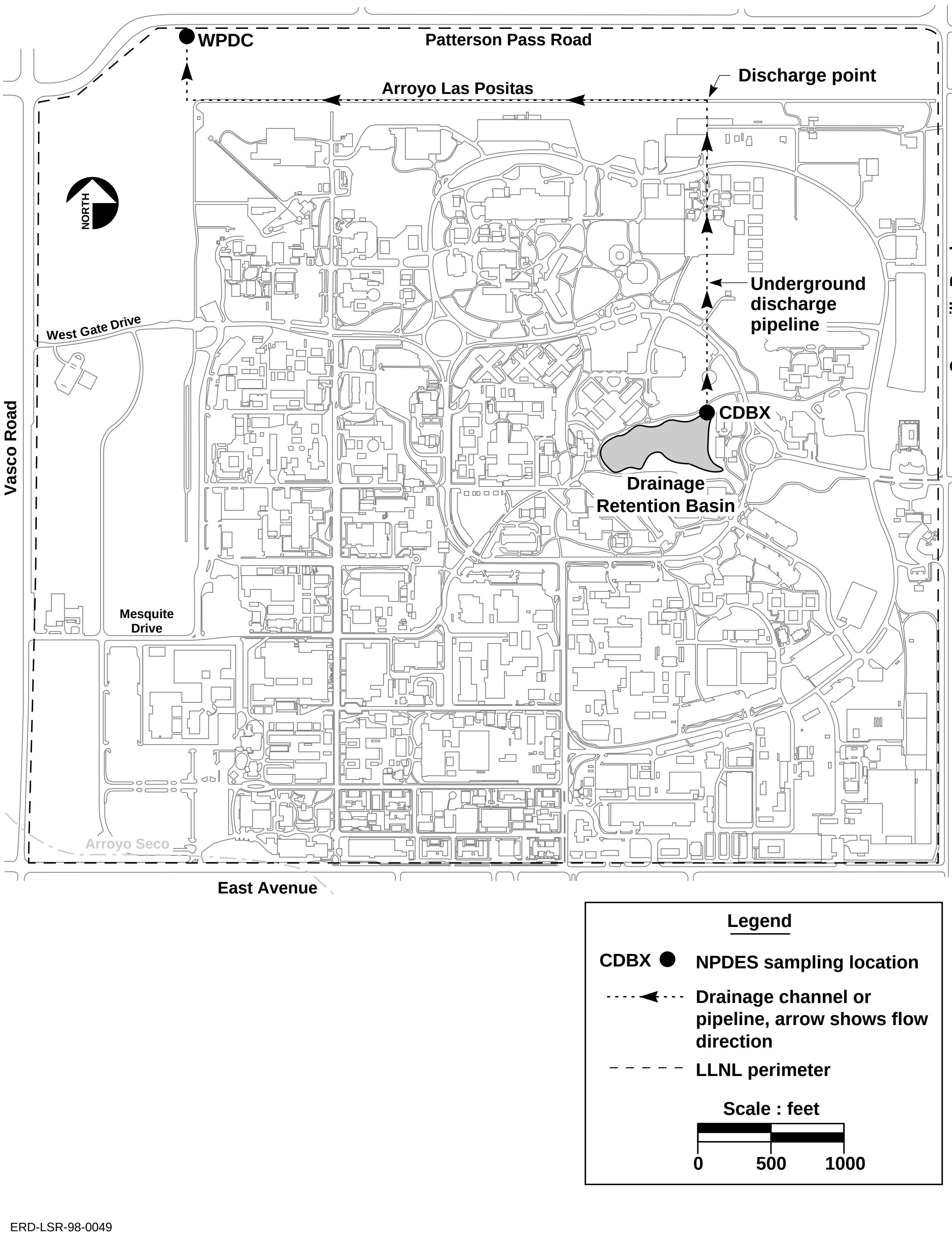
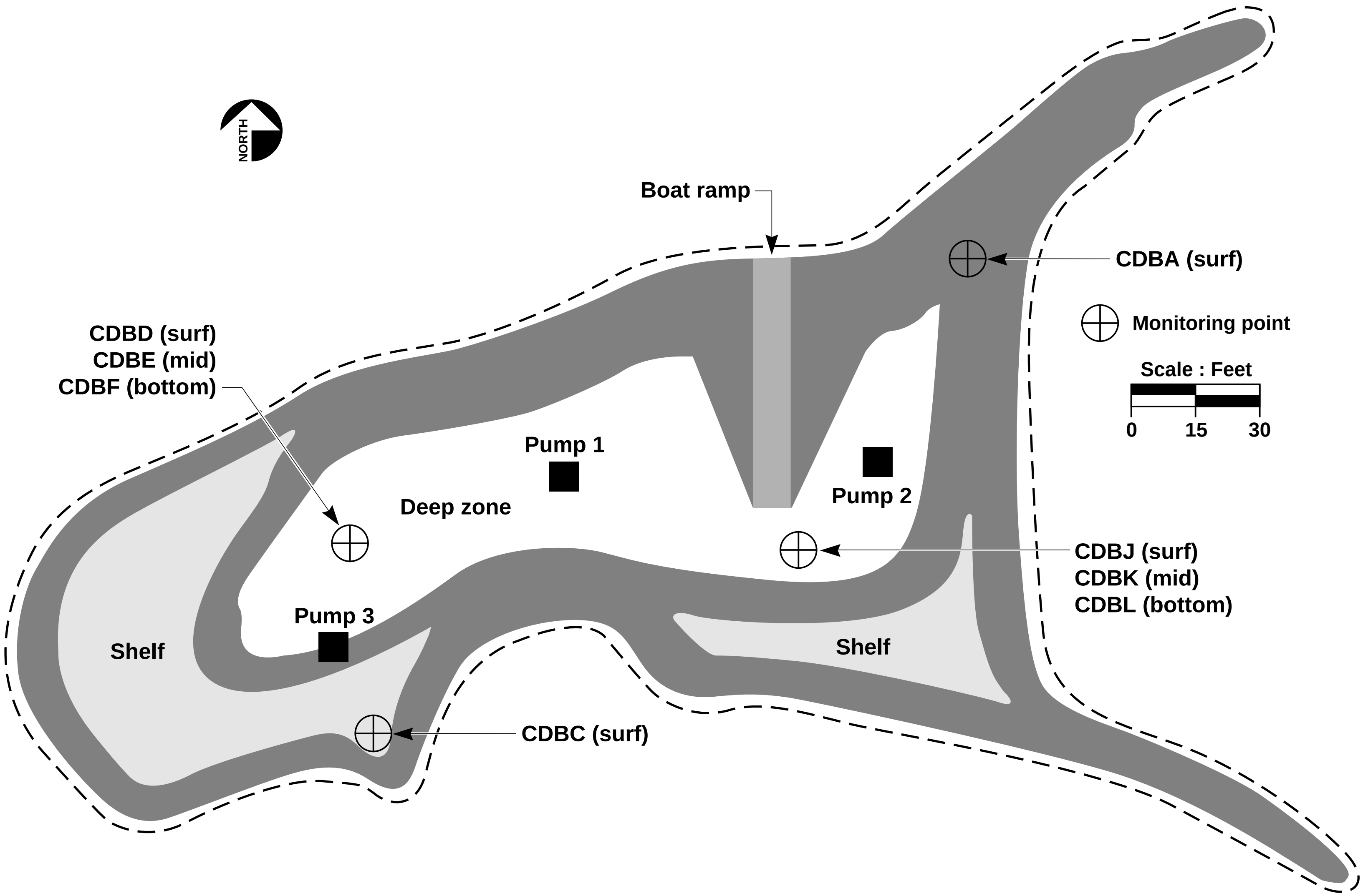


Figure D-1. Location of the Drainage Retention Basin showing discharge locations.



ERD-LSR-98-0050

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