2010421

TECHNICAL MEMORANDUM
Proposal for Ground Water Treatment System Operational Modifications and Pilot Study for Enhanced Bioremediation

Pacific Coast Pipeline (PCPL) Superfund Site
Fillmore, California

October 16, 2002

PREPARED FOR SUBMITTAL TO:

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Ms. Holly Hadlock (H-7-2)
U. S. Environmental Protection Agency
75 Hawthorne Street
San Francisco, California 94105-3901

Technical Memorandum
Proposal for Ground Water Treatment System Operational Modifications and Pilot Study for Enhanced Bioremediation
Pacific Coast Pipeline (PCPL) Superfund Site
Fillmore, California

Dear Ms. Hadlock:

On behalf of ChevronTexaco, enclosed is the Technical Memorandum for ground water treatment system operational modifications and pilot study for enhanced bioremediation at the Pacific Coast Pipeline (PCPL) Superfund Site in Fillmore, California. If you have any questions or require additional information, please do not hesitate to call.

Respectfully submitted,

ENGLAND GEOSYSTEM, INC.

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1.0 INTRODUCTION

ChevronTexaco Corporation is requests your authorization to implement ground water treatment system (GWTS) operational modifications and to proceed with a pilot study for enhanced bioremediation at the Pacific Coast Pipeline (PCPL) Superfund Site, located at 67 East Telegraph Road in Fillmore, California. This solicitation has previously been discussed with the lead agency and we currently seek your approval.

1.1 MODIFICATIONS REQUEST SUPPORT

Several issues have precipitated this request for a change in operational procedures for the PCPL GWTS:

- **Pump-and-Treat No Longer an Effective or Preferred Alternative** - Pump-and-treat remedial process has been ongoing at the PCPL site since 1993. The rate of decrease in the concentrations of the primary contaminant of concern (benzene) in the ground water has slowed significantly, and the effectiveness of the GWTS in remediating the on-site ground water contamination at PCPL has reached its practical and economic limit. Since the issuance of the *Record of Decision* (ROD) in the early 1990s, significant knowledge has been gained on the current and alternative treatment technologies. Pump-and-treat is no longer viewed as a preferred treatment technology by agencies or responsible parties (RPs). ChevronTexaco would like to collect site-specific data for alternative treatment technologies including intrinsic remediation (natural attenuation) and enhanced intrinsic remediation.

- **Stagnation Zone** – Benzene concentrations in the ground water were declining through natural forces even prior to the implementation of the GWTS at PCPL in 1993. Based on 12 years of monitoring data, natural degradation of benzene at the plume edge is occurring as fast or faster than plume migration outward. However, continuous operation of the GWTS has created a flow stagnation zone near the downgradient edge of the plume. This stagnation has decreased the off-site remediation through natural forces.

- **GWTS Discharge to Cease Under NPDES Permit** – The treated ground water from the GWTS is discharge to Pole Creek under a National Pollutant Discharge Elimination System (NPDES) permit. Implementation of the California Toxics Rule, which establishes more stringent limitations on NPDES permit discharges, has made renewal of the permit impossible. Following negotiations with the Los Angeles Regional Water Quality Control Board (RWQCB), ChevronTexaco

was granted permission to continue operating under the current NPDES permit, provided that we discontinue use of the permit prior to May 2003.

- **Iron Bacteria** - Iron bacteria growth in the four extraction wells that supply water to the GWTS has caused operational problems, which have not been successfully alleviated by commonly accepted treatment methods. Continued operation is exacerbating treatment efforts for iron bacteria.

1.2 SUMMARY OF PROPOSED ACTIONS

To continue and improve ground water remediation at the PCPL Superfund site in spite of the listed challenges, ChevronTexaco is proposing the following:

- **Limited GWTS Operations** - A change in operational parameters where the GWTS will be operated approximately four to eight hours every three months just prior to quarterly extraction well sampling.

- **Enhanced Biodegradation Pilot Study** – Implementation of a pilot study to evaluate enhanced biodegradation through the use of an in-situ oxidant (Oxygen Release Compound) in the stagnation zone and near the downgradient edges of the plume. Oxygen Release Compound (ORC) is a time-release formulation of magnesium peroxide that accelerates bioremediation of aerobically degradable contaminants through the release of oxygen for use as an electron acceptor.

- **Collect Additional Data Without GWTS Operations** - Additional ground water monitoring in the downgradient wells for evaluation of potential changes in benzene and bioattenuation parameters will be conducted without GWTS operations.

- **Contingency Plan** - Establish a contingency plan that will be implemented in the event that the benzene plumes remobilize. Implementation of the contingency plan will be based on concentration levels in sentry wells.

1.3 GOALS OF PROPOSED ACTIONS

The proposed ground water treatment system operational modifications and pilot study will allow:

- Evaluation of alternative remedial technologies, including intrinsic remediation and enhanced intrinsic remediation.

- Restoration of flow across the stagnation zone where remediation through natural forces has declined; biodegradation in this area will be enhanced with in-situ oxidants, thereby accelerating benzene plume remediation.

- Elimination of the NPDES permit required by the RWQCB. The ground water that is extracted during the quarterly operations and all purging and sampling activities will be treated and temporarily stored on site. The treated water will be transported to the sanitation district or the City of Fillmore water treatment plant.

- Treatment for iron bacteria in the four extraction wells to continue without disruption during the non-pumping periods.

1.4 SCHEDULE

ChevronTexaco would like to implement the plan immediately and operate the GWTS in this configuration for a period of two years, at which time the results of the pilot study and additional monitoring will be used to propose the next step. EPA will be kept apprised of the progress.

ChevronTexaco is proposing these changes ever mindful of its commitment to protect the health and well being of the public and the environment. Throughout the GWTS operational period, ChevronTexaco has enjoyed excellent relations with the citizens of the City of Fillmore. The proposed modifications will continue to protect them as well as accelerating the off-site ground water remediation.

1.5 REPORT ORGANIZATION

This report is organized as follows:

- Section 1 - Introduction
- Section 2 – Background Information
- Section 3 – Justification for Modifications
- Section 4 – Proposed Operational Modifications
- Section 5 – Summary and Conclusions

2.0 BACKGROUND INFORMATION

2.1 SITE LOCATION

The Pacific Coast Pipeline (PCPL) Superfund Site occupies approximately 60 acres just east of the City of Fillmore, in Ventura County, California. For reference purposes, a site location map is included as Figure 1 and a site plan, showing well locations, is included as Figure 2. The site was formerly an oil refinery, which operated from the early 1900s until the early 1950s when it was shut down and dismantled.

Site structures include buried pipelines, pumping equipment, aboveground storage tanks, and miscellaneous buildings. Other equipment on the property includes the GWTS and the soil vapor extraction (SVE) treatment system.

2.2 SITE HISTORY

The earliest known reference to refinery operations at the site prior to acquisition by Texaco was a reference to oil transported to the Ventura Refinery in 1917. In 1928, Texaco purchased the refinery and operated it until the early 1950s. An early reference indicates that Richfield Oil Co. operated a gas separator plant on a portion of the site in the early 1950s. Since closure of the refinery, the site has been used as a pumping station for crude oil produced from local oil fields.

2.3 REGIONAL GEOLOGY AND HYDROGEOLOGY

Geologically, the PCPL site lies along the northern boundary of the Santa Clara Trough, which contains sedimentary deposits over 40,000 feet thick ranging from Cretaceous to Recent in age. In the Fillmore area, the Trough is bordered on the north by the San Cayetano Fault and on the south by the Oakridge Fault. The San Cayetano Fault passes beneath the PCPL site approximately parallel to the eastern property boundary. Fracturing of bedrock along the fault has resulted in extensive land sliding. This fractured rock has also provided a conduit for naturally occurring hydrocarbons to reach the Earth's surface. Crude oil seeps and tar sands are common features in the site vicinity.

The PCPL site is located within the Fillmore Ground Water Basin. In the eastern portion of the basin where the PCPL site is located, the alluvial deposits and the underlying San Pedro Formation are the major water-bearing units. Ground water flow is to the west following the Santa Clara River. Maximum recorded long-term fluctuation in ground water levels is 50 feet, measured in a Ventura County Flood Control District well located near the site.

2.3.1 Regional Petroleum and Geology

The PCPL site lies within the eastern portion of the Ventura Basin petroleum province. Oil fields located within the site vicinity include the Fillmore, Shiells Canyon, and Bardsdale fields. In addition to the oil fields, several surface oil and tar sand accumulations or seeps have been mapped near the PCPL site. These occur in the fractured sands and shales of the Monterey Formation north of the site along Pole Creek and in recent landslide debris directly adjacent to the site. It is likely that the observed oil seeps resulted from the migration of hydrocarbons along fractures in the Monterey Formation associated with the San Cayetano Fault. Some of the seep material was analyzed and found to contain benzene.

2.3.2 Local Geology and Hydrogeology

The near-surface geology of the PCPL site can be characterized as consisting of laterally discontinuous interlayers of unconsolidated, fine- to coarse-grained detritus deposited in stream channel, alluvial fan, and mass wasting depositional environments. The extreme heterogeneity of the subsurface strata has created a complex hydrogeologic environment. There are three water-bearing zones beneath the PCPL site:

- Perched Zones -- At least three separate areas have been identified, which at various times have contained small amounts of perched water.
- Aquifer I -- Unconfined to semi-confined shallow aquifer.
- Aquifer II -- Partially confined to confined aquifer below aquifer I.

The perched zones are small in lateral extent and contain little to no water. The only wells that regularly contained perched water (MW-10P and MW-13P) consistently contained very little to no benzene, and these wells are not located above the aquifer I benzene plume

Benzene was rarely detected in aquifer II wells and in those few instances in the past where benzene was detected in aquifer II wells, the concentrations were very low and mainly attributed to an improperly constructed well, which have since been abandoned.

Aquifer I is the focus of the remedial efforts.

Historical ground water monitoring results indicate that flow occurs in a northwest direction across the site and then turns to the west after passing under Pole Creek. The most recent ground water elevation map (Spring 2002) is included as Figure 3. The average gradient across the site in aquifer I is approximately 0.006 ft/ft. Permeability ranges from 0.5 to 27 feet/day. The average seepage velocity is 120 feet/year.

Water level fluctuations of more than 30 feet were recorded at the PCPL site between April 1990 and April 1993. Ground water hydrographs are included in Figures 4a through 4e.

2.4 REGULATORY HISTORY

A chronology of the site regulatory history follows:

- **1980** – Investigation requested by the RWQCB.
- **1983 to 1989** – Voluntary ground water and soil assessment conducted under the Department of Health Services (DOHS) and the RWQCB.
- **1986** - Removed 38,000 tons of waste and contaminated soil from the former main waste pit and other small waste disposal areas.
- **1989** - Site added to National Priority List (NPL) by the United States Environmental Protection Agency (USEPA).
- **1990** to **1992** - *Remedial Investigation/Feasibility Study* (RI/FS) was completed (ENSR, 1991/1992). The RI/FS concluded that there were significant levels of total petroleum hydrocarbons (TPH), benzene, toluene, ethyl benzene, and xylenes (BTEX) in ground water and significant concentrations of TPH in the vadose zone, but very little evidence of BTEX in the vadose zone. The RI/FS concluded that ground water pump-and-treat coupled with limited SVE in the vadose zone were the appropriate remediation technologies for the site.
- **1992** - The ROD was issued in March 1992 (USEPA, 1992). The selected remedy included ground water pump-and-treat and SVE for those areas that threaten to contaminate ground water at levels above site cleanup standards. The ROD listed ground water cleanup levels for benzene, toluene, ethyl benzene, methylene chloride, and 1,2-DCA. Benzene and toluene are the only compounds that currently exceed the ground water cleanup standards.
- **1992** –A *Preliminary Design Work Plan* (ESI, 1992) was submitted and approved by the EPA in December 1992.
- **1993** – The *Consent Decree* was entered in August 1993. The *Phase 1 Design Report* (ESI, 1993) was completed in September 1993. The Phase 1 remedial program included pilot testing for SVE treatment and ground water extraction and treatment with granular activated carbon (GAC) and discharge to Pole Creek under an NPDES permit. Phase 1 ground water extraction and treatment began in December 1993.
- **1994** - Phase 1 vapor extraction began and the *Final Phase 2 Design Report* (England & Associates, 1994) was submitted and approved.

- **1995** – The *Final Phase 2 Remedial Action Work Plan* (England & Associates, 1995a) was submitted and approved. Phase 2 vapor extraction began using thermal oxidation for soil vapor treatment, and the GWTS operations were upgraded in capacity. The *Operation and Maintenance Plan* and the *Monitoring and Confirmation Sampling Plan* (England & Associates, 1995b and 1995c) were also submitted and approved.

- **1996** – An *Interim Remedial Action Plan Report* (England & Associates, 1996a) was submitted to fulfill the requirements for Construction Complete and Closeout Reporting required by the Consent Decree. System optimization measured were discussed with USEPA and documented in a letter (England & Associates, 1996b).

- **1997** – Permitting with local agencies was completed and system optimization measures were implemented, including the installation of a new well in an area of higher concentration. The ground water sampling program was modified as described in an approved technical memorandum (England & Associates, 1997).

- **1998** – Monitoring well network upgrades, including abandonment of damaged wells and wells that were no longer useful and installation of new wells, were completed (England & Associates, 1998a and 1998b).

- **2000 through 2002** –Texaco applied for renewal of the NPDES permit in March 2000. The RWQCB indicated that processing for new permits was on hold pending finalization of the California Toxics Rule (CTR) and that the existing permit requirements would remain in effect in the interim.. The CTR was finalized in May 2000 in Code of Federal Regulation (CFR) 40, Part 131 (USEPA, 2000). The CTR promulgates numeric criteria for priority pollutants and requires the state to issue compliance for new or revised NPDES permit limits. In response, the State Water Resources Control Board (SWRCB) adopted the State Implementation Plan (SIP) (SWRCB, 2000). As a result of the CTR and the SIP, more stringent limits would be required for the new permit. Many of the new limits are below naturally occurring background levels. Following negotiations with the RWQCB, ChevronTexaco was given permission to continue operating under the current NPDES permit limits but must discontinue discharge under the permit prior to May 2003 (England Geosystem, 2002b).

- **2001** –USEPA completed the *First Five-Year Review Report for Pacific Coast Pipeline Superfund Site* (USEPA, 2001). The report indicated that the treatment systems were operating as designed and the remedial action continues to be protective of human health and the environment.

- **2001 and 2002** – An early request for authorization to shut off the SVE system was submitted, as shutoff criteria were nearly met (England Geosystem, 2001b). In January 2002, the shutoff criteria were met and a technical memorandum detailing the SVE shutoff and monitoring plans was submitted (England Geosystem, 2002a and 2002c). The shutoff was approved on April 11 and the SVE system operations were discontinued on April 14. The benzene levels have remained below shutoff criteria to date.

2.5 SITE REMEDIATION REMEDY

The current remedy includes a GWTS to treat extracted ground water with GAC to levels that meet the current ROD cleanup standard. The treated water is discharged to Pole Creek under a NPDES permit. The remedy also includes soil vapor extraction and treatment for those areas that may threaten to contaminate ground water at levels above site cleanup standards.

During Consent Decree negotiations, it was agreed that the remedial design would be completed in two phases. The objective of the Phase 1 system was to provide data necessary for the design of the final Phase 2 system while achieving some degree of remediation in the process.

2.5.1 Ground Water Remedial Goal and Approach

The remedial goal is to achieve current ROD cleanup requirements while minimizing impact to the residential area from treatment equipment. The approach is to extract and treat from on-site wells located in the benzene hot spots and rely on natural forces to degrade benzene beyond the capture zone. Monitoring is conducted to observe concentrations within and beyond the capture zones.

The chosen remedial method for ground water is extraction from aquifer I using submersible pumps and GAC treatment. Except for treatment capacity, the design for the Phase 2 remediation system is similar to that for Phase 1. The Phase 2 system added prefilters, a water conditioner, and upgraded to three GAC vessels installed in series for ground water treatment.

The GWTS is located on the southwestern side of the site. Ground water is pumped from the extraction wells using electric submersible pumps and is transported from the wells to the treatment system with individual 2- to 4-inch Schedule 40 PVC pipes. The GWTS is constructed on a bermed concrete pad that is 37 feet long and 28 feet wide.

2.5.2 Soil Vapor Remedial Goal and Approach

The remedial goal is to reduce benzene concentrations in the vadose zone in those areas that may threaten to contaminate ground water at levels above site cleanup standards. Target areas were determined and described in the Final Phase 2 Remedial Action Work Plan. The approach is to

extract and treat soil vapor in the target area while continually evaluating potential contributions from naturally occurring gases (deep earth and seeps).

Several types of vapor extraction equipment were used at the site including a regenerative thermal oxidation unit (RETOX), internal combustion engines (VR Systems V3 and V4), and thermal oxidation units (King Buck/Hasstech and Baker Furnace). Each unit was operated under permit from the Ventura County Air Pollution Control District. Thermal oxidation was selected for Phase 2 operations. The King Buck/Hasstech thermal oxidizer remains on-site and is located just north of the GWTS pad.

2.5.3 Cleanup Standards

The ROD specified aquifer cleanup standards for five volatile organic compounds (VOCs). The five VOCs and their respective cleanup standards for ground water are listed below. No specific cleanup standards are established for soil.

Table 2-1
ROD Ground Water Cleanup Standards

Contaminant	Standard (ppb)
Benzene	1
1,2-Dichloroethane	0.5
Ethyl benzene	680
Methylene chloride	5
Toluene	100

Benzene and toluene are the only compounds that currently exceed the cleanup standards, and benzene exceeds its standard in more wells than toluene. In the few wells where toluene exceeds its cleanup standard, benzene is also present at concentrations above the cleanup level concentrations. Therefore, benzene is the primary target compound of the remedial program.

2.6 TREATMENT SYSTEM OPERATIONS

2.6.1 GWTS Operation

The GWTS has been in operation since late 1993. Ground water contaminated with hydrocarbons is extracted from on-site wells and treated with GAC. The carbon vessels are described and referred to as follows:

Vessel A – 10,000 pound carbon vessel (first in the series)
Vessel B – 10,000 pound carbon vessel (second in the series)
Vessel C – 2,000 pound carbon vessel (third in the series – optional)

The water is always treated by vessel A and B. Vessel C is used after breakthrough occurs between vessels A and B to improve hydrocarbon loading of the carbon while providing a safety buffer for the effluent.

The treated water is discharged to Pole Creek under an NPDES permit held with the RWQCB (permit number CA0063240).

Currently, ground water is extracted from four on-site wells EW-P2, EW-1, EW-4, and EW-5.

Table A-1 summarizes total GWTS operations and contaminant removal from the fourth quarter 1993 through the third quarter 2002. Since GWTS operation began in December 1993, over 140 million gallons of water have been treated, with approximately 4,900 pounds of TPHG and 300 pounds of benzene removed.

2.6.2 Light Non-Aqueous Phase Liquid (LNAPL) Removal

Slugs of LNAPL have periodically flowed into three of the ground water extraction wells (EW-1, EW-4, and EW-P2). LNAPL slugs located within the ground water capture zone of an extraction well move toward and into the well due to the gradient caused by continuous pumping at the well. When the slug approaches the well, the LNAPL thickness increases significantly. The LNAPL is monitored in the extraction wells on a weekly basis and removed, as necessary, using a small vacuum pump or bailer.

Table A-3 summarizes LNAPL removal from extraction and monitoring wells since LNAPL removal began in the first quarter 1994. Since the first quarter of 1994, approximately 520 gallons of LNAPL have been removed from site ground water wells. Of this, over 98 percent was from the three extraction wells listed above.

2.6.3 Vapor Extraction System

Remediation through vapor extraction was conducted from June 1994 through April 2002. In January 2002, the criteria set forth in the approved decision tree for SVE shutoff were met and approval was received from EPA in April to discontinue vapor extraction. Since shutoff, the soil gas levels (monitored monthly) have remain below the shutoff criteria.

Table A-2 summarizes estimated contaminant removal through SVE efforts through second quarter 2002 when vapor extraction and treatment was completed and discontinued. Approximately 1,387,000 pounds of total hydrocarbons and 2,191 pounds of benzene were removed.

2.7 BENZENE CONTAMINATION

2.7.1 Residual Hydrocarbons in the Saturated Zone

The 30-foot rise in water levels in the early 1990s resulted in residual LNAPL being entrained on the soil below the water table forming a hydrocarbon smear zone. The entrained LNAPL acts as a persistent source of benzene contamination to ground water. Hydrocarbon removal from the smeared zone in saturated condition will be relatively slow by dissolution of benzene and other hydrocarbons in the ground water since partitioning greatly favors the hydrocarbon phase. Also, biodegradation in the saturated zone is slow due to lack of oxygen. When water levels drop such that the smeared zone becomes unsaturated, the opportunity for benzene remediation is greatly improved. Water levels have been dropping and are currently approximately 7 feet below the historical high.

2.7.2 Potential for Benzene from Naturally Occurring Sources

Some hydrocarbon contamination, possibly including benzene, may have resulted from ground water and vapor contact with the Monterey Formation, which is known to contain oil seeps in this area and/or from contact with seeps or vapor migration that moves upward along the San Cayetano Fault Zone that traverses the site. Oil from a natural seep near the PCPL site was analyzed and found to contain benzene. Forensic sampling of a soil gas sample collected from the site during the design phases indicated the methane within the sample was mostly thermogenic (deep earth origin), but includes some biogenic (produced by biodegradation of hydrocarbons) methane.

2.7.3 Dissolved-Phase Benzene in Ground Water

2.7.3.1 Dissolved-Phase Plume Configuration

Aquifer I contains two separate dissolved-phase benzene plumes. The current plume configuration (Spring 2002) is shown in Figure 5. In the northern plume, the highest benzene concentration is 520 ug/L in well EW-P2, located just east of the former main waste pit. Currently, only one other well in this plume has a benzene concentration greater than 100 ug/L (MW-6S at 150 ug/L).

The southern benzene plume has a larger footprint. The highest benzene concentration is 690 ug/L in well MW-39S. All other wells in the southern plume had benzene concentrations lower than 100 ug/L during the Spring 2002 monitoring event.

2.7.3.2 Benzene Trends in Ground Water Over Time

Dissolved-phase benzene concentrations have been monitored on a routine basis since the RI in 1990. Graphs showing benzene concentration versus time are shown in Figures 6a through 6d. The graphs were constructed with the concentrations (Y-axis) on a log scale so that concentration

trends for wells with lower values can easily be observed. The data used to generate these graphs is included in Appendix B. The graphs show an overall decline in benzene versus time.

Figure 7 shows the changes in the benzene plumes in ground water from 1994 to 2002. The sequence demonstrates clearly that the overall concentrations of both the northern and southern plumes have decreased significantly over time. While the plume geometry of both plumes has changed, encompassing smaller areas, that change is not as significant or apparent as the decrease in concentrations. The lack of significant change in plume geometry is interpreted as being attributable to LNAPL source entrained in the unsaturated zones below the water table.

2.7.4 Benzene in Soil Gas

Concentrations of benzene in soil gas from the last vapor extraction target well, EW-P2, declined below the shutoff criteria and have remained below shutoff criteria. A graph showing benzene in soil gas from this well is included in Figure 8.

2.8 NATURAL ATTENUATION/BIOATTENUATION

2.8.1 Natural Attenuation Defined

According to EPA's *Monitored Natural Attenuation for Ground Water* (EPA, 1998), "natural forces" or natural attenuation include physical, chemical, or biological processes that act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants. This includes biodegradation, dispersion, dilution, sorption, volatilization, and chemical or biological stabilization or destruction of contaminants. EPA prefers the processes that degrade the contaminant, such as biodegradation or bioattenuation processes.

2.8.2 Biodegradation Background and Theory

Biodegradation occurs when microorganisms consume hydrocarbons, such as BTEX compounds, using an electron acceptor and yielding biomass, carbon dioxide, water, and the reduced form of the electron acceptor. Hydrocarbon biodegradation is an oxidation-reduction reaction wherein the hydrocarbon is oxidized (donates electrons) and an electron acceptor or electron sink is reduced (accepts electrons). There are a number of compounds that can act as electron acceptors or sinks such as: oxygen (O_2), nitrate (NO_3^{-1}), manganese (Mn^{+4}), ferric iron (Fe^{+3}), sulfate (SO_4^{-2}), and carbon dioxide (CO_2).

The energy yield from BTEX degradation varies with electron acceptor as follows:

$$\mathbf{O_2 > NO_3^{-1} > Mn^{+4} > Fe^{+3} > SO_4^{-2} > CO_2}$$

Oxygen is the preferred electron acceptor since it provides the greatest amount of energy to the microorganisms. Once oxygen is reduced to low levels (or eliminated), nitrate will be utilized (if available) until consumed, followed by manganese, ferric iron, sulfate, and carbon dioxide.

Biodegradation of aromatic hydrocarbons (BTEX) is generally grouped into one of three categories based on the amount of dissolved oxygen (DO) present during biodegradation. They are:

Aerobic - DO of 2 mg/L or more
Hypoxic - DO between 0.1 and 2 mg/L
Anaerobic - DO of 0.1 mg/L or less

Biodegradation occurs to a greater extent under aerobic conditions than hypoxic or anaerobic conditions. Under aerobic conditions, BTEX is transformed to carbon dioxide and water in a process referred to as aerobic respiration. Under hypoxic conditions, aerobic respiration may take place to a much lesser degree along with nitrate reduction (also called denitrification) in which nitrate is reduced to nitrogen (N_2) and carbon dioxide and water are also formed. Under anaerobic conditions, nitrate reduction, manganese reduction, iron reduction, sulfate reduction or methanogenesis can occur. The basic reactions and products are summarized in the following table.

Table 2-2
Biodegradation Processes and Products

Condition	Process	Electron Acceptor	Process Products *
Aerobic	aerobic respiration	oxygen (O_2)	carbon dioxide (CO_2) and water (H_2O)
Hypoxic	aerobic respiration and nitrate reduction	oxygen (O_2) nitrate (NO_3^{-1})	carbon dioxide (CO_2) and water (H_2O) nitrogen gas (N_2), carbon dioxide, and water
Anaerobic	nitrate reduction	nitrate (NO_3^{-1})	nitrogen gas (N_2), carbon dioxide, and water
	manganese reduction	manganese (Mn^{+4})	manganese (Mn^{+2}), carbon dioxide and water
	iron reduction	ferric iron (Fe^{+3})	ferrous iron (Fe^{+2}), carbon dioxide and water
	sulfate reduction	sulfate (SO_4^{-2})	hydrogen sulfide (H_2S), carbon dioxide and water
	methanogenesis	carbon dioxide (CO_2) and water	methane (CH_4)

* also produces biomass

Based on the above processes and the results of recent studies, the following ground water conditions found within and downgradient of the dissolved-phase hydrocarbon plume may indicate that biodegradation is occurring:

- a decrease in DO concentrations;
- a decrease in nitrate concentrations;
- an increase in soluble manganese (Mn+2) concentrations;
- an increase in soluble iron (Fe+2) concentrations;
- a decrease in sulfate concentrations;

- an increase in sulfide concentrations;
- an increase in carbon dioxide concentrations;
- the presence of hydrogen sulfide odor at the wellhead; or
- an increase in methane concentrations.

Because there are many factors or conditions that could alter or affect the processes described above, the occurrence of biodegradation should not be based solely on the results of one particular parameter. Several bioattenuation parameters should be compared in order to obtain a better understanding of the whole picture.

In addition to the above, a measure of the oxidation reduction potential (ORP) of the ground water can aid in assessing the occurrence of biodegradation. ORP is a measure of the free electrons (normally expressed as millivolts), which is useful in assessing the oxidation state of the biochemical reactions occurring. Normal ORP readings (slightly oxidizing conditions) are usually found upgradient and downgradient of a contaminant plume, and negative ORP readings (strongly reducing conditions) are found within the anaerobic portion of the plume, indicating microorganism activity. Temperature, pH, and conductivity can also provide information to aid in assessing bioattenuation in conjunction with the above parameters.

2.8.3 Conclusions From Past Bioattenuation Monitoring

Bioattenuation monitoring at the PCPL site was first conducted in the fourth quarter 1995. The initial program included field monitoring for ORP, DO, temperature, pH, conductivity, and ferrous iron in selected wells. In the first quarter 1996, field bioattenuation monitoring continued with the addition of laboratory analyses for nitrate, soluble manganese, sulfate, sulfide, and carbon dioxide. In the fourth quarter 1996, the soluble metals, nitrate, and carbon dioxide were dropped from the program and bioattenuation monitoring was continued on an annual basis.

The following conclusions were drawn from past bioattenuation monitoring results.

- *DO* has been depleted across the site. DO falls in the hypoxic to anaerobic range.

- *Nitrate* concentrations have also been depleted across the site. Nitrate concentrations are relatively high in ground water throughout the Fillmore area, but nitrate is absent in site wells. Nitrate was detected in only one site well and this well (MW-11S) is upgradient of the contaminant plume.

- Soluble metals (*manganese* and *ferric iron*) are not useful as indicators of biodegradation at this site. Because of the highly variable configuration of subsurface materials across the site due to the active depositional environment (fault zone, landsliding, channel deposits), deposits of manganese and iron are not continuous across the site; therefore, areas with elevated concentrations may reflect local manganese or iron content of the subsurface soil more than bio-

activity. Also, products from other reduction processes (such as sulfide) can react with iron and manganese altering the concentration.

- *Sulfate* and *sulfide* are good indicators of biodegradation at the site. Sulfate levels in ground water wells in the Fillmore area are typically over 500 mg/L. Within the benzene plume area, sulfate has been significantly reduced by biodegradation, and in several wells within the plume it is even nondetectable. Upgradient and downgradient of the plume, sulfate concentrations range from 750 to 1,000 mg/L. On the other hand, in the past, sulfide, a product of sulfate reduction, had been found within the plume area and had been nondetected elsewhere.

- *Carbon dioxide* concentrations were elevated in the southern portion of the southern plume; however, overall the results of carbon dioxide sampling were inconclusive relative to assessing biodegradation at this site.

- *ORP* is a good indicator of biodegradation. ORP is highly negative in the benzene plume area, while less negative and/or positive ORP values are measured upstream, downstream, and across gradient.

- *Hydrogen sulfide* odor has been noted at the wellhead of MW-45S and MW-18S.

The geochemical parameters monitored at the PCPL site fit the model of a plume undergoing bioattenuation.

3.0 JUSTIFICATION FOR MODIFICATIONS

ChevronTexaco has collected information from the PCPL site for over 17 years. During this period, an excellent understanding of site conditions has been developed. The following sections describe the justification for requesting the modification to PCPL site remediation.

3.1 PUMP-AND-TREAT NO LONGER AN EFFECTIVE OR PREFERRED ALTERNATIVE

Ground water pump-and-treat has been ongoing at the PCPL site since 1993. The rate of decrease of benzene concentration in the shallow ground water has slowed significantly and the effectiveness of the GWTS in remediating the on-site ground water contamination at PCPL has reached its practical and economic limit.

Figure 9 shows the benzene concentration versus time as measured at the extraction wells that are located in the identified on-site hot spots. The benzene concentrations declined initially but have remained relatively constant for the past 13 quarters.

A three-dimensional model of the benzene plume was constructed from the historical monitoring data to calculate the benzene plume mass and volume properties over time. The plume model was generated by incorporating monitoring well data at selected points and times into a grid. A kriging algorithm was then applied to the known data to estimate the concentration of benzene at unknown points. The mass was calculated on a quarterly basis beginning in the second quarter 1990 and ending in the third quarter 2002. When data did not exist for a particular quarter, a linear estimation of concentration was made between each pair of known data points.

The dissolved benzene mass within the benzene plumes was calculated for each grid in the model by multiplying the thickness of the plume by the area of the individual grid square by the mass concentration of the constituent. These values were then summed for all concentrations greater than 1 ug/L. A graph showing the percentage decrease of benzene over time is shown as Figure 10. The percentage is calculated from an arbitrary starting point in time. For this simulation, the calculated mass in the second quarter 1990 was used as the starting point.

There was a large decrease in benzene mass from 1990 to 1991. There was an increase in benzene mass from 1991 to 1993, which corresponds to the period of time when the water levels increased by 30 feet. As the water levels increased, LNAPL that had been floating on the water table could not keep up with the quick rise in water levels and became entrained on the soil particles below the water level. The entrained LNAPL released benzene into the ground water and resulted in an increase to the benzene mass. When the water levels stopped increasing, the mass again began to decrease. Since 1990, the benzene plume has lost approximately 82 percent of its initial mass. However, the rate of dissolved-phase benzene degradation appears to be decreasing to an asymptotic value, as shown by the dashed-exponential curve. The rate of

change in the percentage of dissolved mass in the benzene plumes has remained relatively constant for the past four years, as shown by the solid straight-line fit.

Since the issuance of the ROD in the early 1990s, significant knowledge and experience have been attained on using ground water pump-and-treat as a remedial option. Pump-and-treat is no longer viewed as a preferred treatment technology. ChevronTexaco would like to collect site-specific data for alternative treatment technologies, including intrinsic remediation (natural attenuation) and enhanced intrinsic remediation.

3.2 STAGNATION ZONE

The GWTS has altered the natural flow regime by creating a stagnation zone downgradient of the GWTS pumping wells beyond the capture zone.

The Final Phase 2 Design Report included a series of modeling simulations and capture zone analyses using the MODFLOW (McDonald, M.G. and Harbaugh, A. W., 1988) and MODPATH (Pollack, 1989) packages. The purpose of the simulations were to:

- Provide information on flow direction and velocity.
- Assist in identifying recharge/discharge volumes and locations.
- Provide base information for performing capture zone analyses.

The current GWTS was constructed based partially on the results of the capture zone simulations. Initially, the extraction system included MW-28S, EW-1, EW-2, EW-4, and EW-5. MW-28S was replaced with EW-P2 late in 1996 and EW-2 was dropped when concentrations approached nondetectable levels.

The flow modeling indicated that operating the GWTS would create a ground water flow stagnation zone located inside the respective benzene plumes downgradient of the pumping wells generally west of Pole Creek. However, based on the overall goal of minimizing impacts of remediation to the neighborhood, a remedial configuration of hot spot remediation was selected, allowing natural forces to provide remediation of the plume west of Pole Creek. The impact of that decision was to provide an impetus to operate the GWTS continuously at the maximum rate possible to capture as much of the source plume as possible. Because of this, pumping rates and configurations were not significantly varied over time to allow the stagnation zone to move or dissipate over time. In review of the benzene concentration versus time graphs (Figures 6a through 6d), most of the wells exhibit a large decrease in concentration from the time GWTS operations began (late 1993) to the present. Declines in benzene concentration were generally greater than 80 percent from late 1993 to 2002. However, there are three wells located in the stagnation zone that have not shown a significant decrease over time with GWTS operations. These wells are MW-6S, MW-42S, and MW-39S. Benzene concentrations versus time for these wells are shown on Figure 11.

By removing the stagnation zone, advective transport of the benzene plume will reoccur. In addition, there will be an influx of electron acceptors that have been depleted in the stagnation zone. The electron acceptors will allow the remediation of the plumes to reassert itself, thereby accelerating the remediation of the plumes in the stagnation zone.

In order to accelerate remediation of benzene in the stagnation zone even further, ChevronTexaco is proposing to use ORC in the water-bearing zone near these three wells.

3.3 SUPPORT FOR NATURAL ATTENUATION AS A REMEDIAL ALTERNATIVE

The chosen remedial alternative for the PCPL site is to minimize impacts of remediation activities in the neighborhoods immediately adjacent to the facility. To accomplish this, all active remedial actions to date have occurred on ChevronTexaco property, recognizing that off property natural forces including biodegradation are controlling impacts to the ground water in those areas.

Natural degradation and attenuation are limiting the size of the benzene plume downgradient of the site. Detectable benzene has never been found more than a few hundred feet downgradient of the site boundary. Bioattenuation monitoring data collected from site wells over the past seven years confirms that biodegradation is on going.

Natural attenuation of benzene was occurring prior to GWTS operations. Benzene levels measured during the early stages of site investigation, prior to the RI are shown in the following table. The pre-RI benzene levels are compared to benzene levels measured just prior to implementation of GWTS operations. The percent decline during this time period is also shown.

Table 3-1
Benzene Concentration Decline Prior to GWTS Operations

Well	Pre – RI Benzene Concentration (in ug/L with year measured in parenthesis)	Benzene Concentration in 1993 prior to GWTS Operations (in ug/L)	Benzene Concentration Percent Decline (Pre-RI to late 1993)
MW-2S	5,792 (1986)	450	92%
MW-3S	538 (1986)	62	88%
MW-6S	3,781 (1986)	<0.3	100%
MW-7S	3,859 (1986)	380	90%
MW-8S	439 (1987)	360	18%
MW-14S	227 (1987)	59	74%
MW-17S	2,630 (1988)	740	72%

Source for Pre-RI data: Remedial Investigation/Site Background Summary (ENSR, 1990)

The benzene concentration percent decline from 1986 to 1993, which represents a period of time prior to pump-and-treat, ranges from 18 to 100 percent. The average percent decline is 76 percent for these wells. Since benzene levels were declining prior to GWTS operations, levels should continue to decline without GWTS operations.

A paper published by the American Petroleum Institute entitled *Characteristics of Dissolved Hydrocarbon Plumes* (API, 1998) is included in Appendix C. This paper summarizes the results of four large-scale case studies. One of the four studies included 271 sites in California with benzene contamination. Historical case analysis of the 271 leaking underground fuel sites in California indicated the following:

- Benzene plume lengths stabilize at relatively short distances from the fuel hydrocarbon release area.
- Ninety percent of the sites had benzene plumes less than 255 feet wide.
- The plume lengths tend to change slowly with time, while the average plume concentrations decline more rapidly.
- Hydrogeologic parameters (e.g., hydraulic conductivity, gradient) appear to have little relation to plume length.
- While active remediation may help reduce plume benzene concentrations, significant reductions in benzene concentrations can occur over time even without active remediation.

Conditions observed at the PCPL site appear to match the findings of this study.

3.4 Required to Quit NPDES Discharge

ChevronTexaco must stop discharge under their NPDES permit since more stringent limits are required by the CTR. If required to continue operations under the current GWTS scenario, an alternative method of water disposal will need to be considered, such as reinjection, since the quantity of water generated under the current scenario would be too great to discharge to the existing sewer system.

ChevronTexaco has operated the GWTS on a continuous basis for nine years and treated over 140 million gallons of water. Investigating and implementing a reinjection scenario would be a very costly endeavor and would provide no discernible benefit. With the requirement to discontinue discharge under the NPDES permit looming in the near future, the timing for the proposed operational modifications is appropriate.

3.5 IRON BACTERIA

Ground water is currently extracted from four wells. Three of these wells have been operated continuously for eight years and one has been operated for six years. After many years of service, these wells have accumulated iron bacteria growth and calcium carbonate buildup. Over the last quarter, iron bacteria sludge has proliferated to the extent that the pump clogs after a few days of operation. In the third quarter of 2002, the wells were cleaned, redeveloped, and treated with chlorine in an attempt to clear the bacteria (chlorine shocks and kills the bacteria) and remove the calcium buildup. Following redevelopment and cleaning, several chlorine treatments were made, followed with a return to extraction and treatment. Unfortunately, the iron bacteria and subsequent clogging is persisting with this scenario of treatment and operation.

With the proposed operational changes, ongoing treatment for iron bacteria in the four extraction wells could continue without disruption during the non-operation periods.

If ChevronTexaco is required to continuously operate the GWTS as before, the extraction wells would have to be replaced. The cost of installing four new extraction wells and continuing to extract from the same approximate locations is not justified due to the lack of benefit for the expenditure.

4.0 PROPOSED OPERATIONAL MODIFICATIONS

The proposed operational modifications are designed to provide information that can be used to provide for a more effective remedial alternative. They include:

- Operate the GWTS only for a period of from 4 to 8 hours on a quarterly basis.
- Implement a pilot study to evaluate enhanced biodegradation through the use of ORC in the stagnation zone and near the downgradient edges of the plume.
- Establish a series of sentry wells and a monitoring program to evaluate the impact of the change in operational procedures on the downgradient portions of the benzene plume.
- Provide a proactive contingency plan including an implementation trigger guideline and a description of actions to be implemented in the event that significant change in the downgradient plume geometry or concentrations is noted during monitoring.

The operational modifications proposed will be implemented as soon as practical after review and approval by the EPA. The time period selected provides two full years of information spanning two full wet and dry seasons.

4.1 GWTS OPERATIONAL MODIFICATIONS

The GWTS has been operating continuously since December 1993 except for routine maintenance and minor down time. We propose to:

- Discontinue continuous GWTS operations and operate one day per quarter for a minimum of four and maximum of eight hours prior to quarterly sampling of the four extraction wells.
- Discharge the water generated from the ground water treatment system and purge water generated from ground water sampling to an on-site storage tank for later disposal with the local sanitation district or City of Fillmore water treatment plant.

The purpose of the intermittent operation is to satisfy current ROD requirements and to keep the equipment in working condition during the two-year evaluation period.

4.2 PILOT TESTING

The creation of the stagnation zone along the west side of Pole Creek has depleted the naturally occurring electron acceptors normally found in ground water in the area. To restore the balance as rapidly as possible so that the ROD-approved remediation of off-site plume migration through natural forces including bioattenuation can be restored:

- ChevronTexaco is proposing to inject ORC in the stagnation zone. The purpose of the oxidant injection is to accelerate the recovery of the stagnation zones, enhance remediation of the benzene plume that may exist beneath the neighborhood, and provide an electron acceptor rich barrier to any potential downgradient migration of the benzene plume that might occur immediately after intermittent operations.

ChevronTexaco will submit a work plan for injection of the in-situ oxidants to the EPA within 10 days of approval of the changes proposed in this technical memorandum.

Conceptually, ORC injection will occur in temporary borings near wells MW-6S, MW-42S, and MW-39S.

If, during the pilot study, ChevronTexaco observes that the actions are significantly improving the ground water quality, the pilot study may be expanded after review and approval of the EPA.

4.3 MONITORING PROGRAM

ChevronTexaco will institute a supplemental monitoring program that will occur coincident with the operation of the GWTS on an interim basis. This program is supplemental to the currently scheduled biannual monitoring program and is designed primarily for evaluation of downgradient benzene and bioattenuation parameters.

Sampling protocols have been previously outlined in the *Monitoring and Confirmation Sampling Plan* (England & Associates, 1995) and the *Revised Technical Memorandum - Recommended Modifications to the Ground Water Sampling Program* (England & Associates, 1997).

The program will be implemented on a monthly basis for a period of 12 months. The program will be modified to a sampling period of every other month for the second 12 months. Based on seepage velocity calculations, if benzene migration is reinitialized once the GWTS stops continuous operation, simple advective flow would cause notable increases in concentration at the trigger wells without bioattenuation.

The table below shows the sentry wells that will be included in the supplemental monitoring program. These locations were selected because they are all downgradient of the extraction wells.

Table 4-1
Proposed Supplemental Monitoring Program

Plume	Well Number	TPHG/BTEX EPA 8015m/8021b	Bioattenuation Parameters
Northern Plume	MW-6S	●	●
	MW-42S	●	●
	MW-48S	●	●
	MW-49S	●	●
Southern Plume	MW-20S	●	●
	MW-35S	●	●
	MW-39S	●	●
	MW-41S	●	●
	MW-44S	●	●
	MW-45S	●	●

Bioattenuation monitoring parameters will include:

- Field monitoring for dissolved oxygen (DO), ORP, temperature, pH, conductivity.
- Laboratory analyses for sulfate by EPA 300.

An email summarizing each monthly ground water monitoring event will be submitted to EPA within 20 days of each monitoring event. A full report of the results will be included in the Quarterly Status Reports. If any concentration values exceed those given in the contingency plan, the EPA will be notified by telephone and email within 24 hours of receiving the analytical results.

4.4 CONTINGENCY PLAN

The historical data in combination with the monitoring program described above establishes a basis for determining if the change in operational status has an adverse impact on the downgradient water quality. The contingency plan is plume-dependant. Therefore, if an action trigger is exceeded in one plume, the activities in the unaffected plume will not change.

4.4.1 Action Triggers

ChevronTexaco is aware of the EPA's desire to establish a monitoring action trigger that if exceeded, a remedial contingency plan will automatically be implemented. ChevronTexaco is proposing the following action triggers be adopted for the period of this plan:

Southern Plume:

- If the measured benzene concentration at MW-45S exceeds 150 ug/l (highest concentration in the past three years) or if the benzene concentration at MW-44S

or MW-35S exceeds 1 ug/L, the EPA will be notified within one working day of receipt of the chemical results verbally and the well will be resampled within five working days of receiving the results. Analytical results will be requested on a 48-hour turnaround. If the secondary results exceed the values listed above, the remedial contingency plan will be put into action.

Northern Plume:

- If the measured benzene concentration at MW-48S or MW-49S exceeds 20 ug/l, the EPA will be notified within one working day of receipt of the chemical results verbally and the well will be resampled within five working days of receiving the results. Analytical results will be requested on a 48-hour turnaround. If the secondary results exceed the values listed above, the remedial contingency plan will be put into action.

4.4.2 Remedial Contingency Plan

The plan consists of two actions:

- **Immediate Response** – to mitigate the flow of benzene further off-site, and
- **Secondary Response** – conduct an evaluation of alternative treatment technologies that can be applied within the affected areas to reduce benzene concentrations.

4.4.2.1 Immediate Response

If an action trigger is exceeded:

ChevronTexaco will:

- Provide temporary downgradient direct remediation of ground water quality using pump-and-treat technology until a secondary treatment scenario can be developed based on the existing conditions and the best available technology at the time.

One of the reasons to implement this operational change is that ChevronTexaco will no longer be able to discharge treated water to Pole Creek under the NPDES permit. Therefore, if any individual trigger is exceeded west of Pole Creek, there are few treatment options available that will not significantly disrupt life in the adjacent neighborhood.

If the action trigger value excursion occurs in the southern plume, ChevronTexaco will implement a contingency plan that includes installation of a portable pump-and-treat system on ChevronTexaco property located in the immediate vicinity of MW-39S. As an immediate measure, the water from MW-39S will be extracted and treated. If the action trigger value excursion occurs in the northern plume, ChevronTexaco will implement a contingency plan that

includes installation of a portable pump-and-treat system located in the immediate vicinity of MW-42S and water from MW-42S will be extracted and treated.

Once the magnitude and geometry of the plume expansion are reviewed, additional locations may be selected for additional treatment. The City of Fillmore is currently expanding their waste water treatment capacity, and discussions with Bert Rapp, the City Engineer for Fillmore, indicate that they would be willing to take treated water discharged to the local Publicly Owned Treatment Works (POTW).

4.4.2.2 Secondary Response

While the planned long-term secondary response is not well defined at this time, it will most likely involve additional efforts to stimulate the oxidation of the benzene plume in ground water. The long term viability and economic factors of pumping and treating are not desirable, nor is the disruption of the Fillmore neighborhoods desirable. On-site operation of the GWTS is not feasible due to the implementation of the CTR that makes it all but impossible to renew or obtain an NPDES permit for discharge from the facility. The limitation on discharge would force ChevronTexaco into a major construction and permitting project including crossing Pole Creek for any other treated water discharge option.

Should the contingency plan be implemented, a secondary treatment plan will be provided to the EPA within 90 days of the beginning of operation of the portable pump and treat system.

5.0 SUMMARY AND CONCLUSIONS

The ROD states the following:

> "It may become apparent, during implementation or operation of the ground water extraction system, that contaminant levels have ceased to decline and are remaining constant at levels higher than the cleanup standards. Based on performance data, operation of the extraction system will be adjusted as warranted if so determined by EPA"

Conventional ground water pump-and-treat technology has reached its effective limit at the PCPL Superfund Site. ChevronTexaco's proposal for modifying the operation of that system and investigating the implementation of enhanced natural attenuation as a replacement or supplement to that system will allow additional focused remediation and subsequent protection of the public health and safety.

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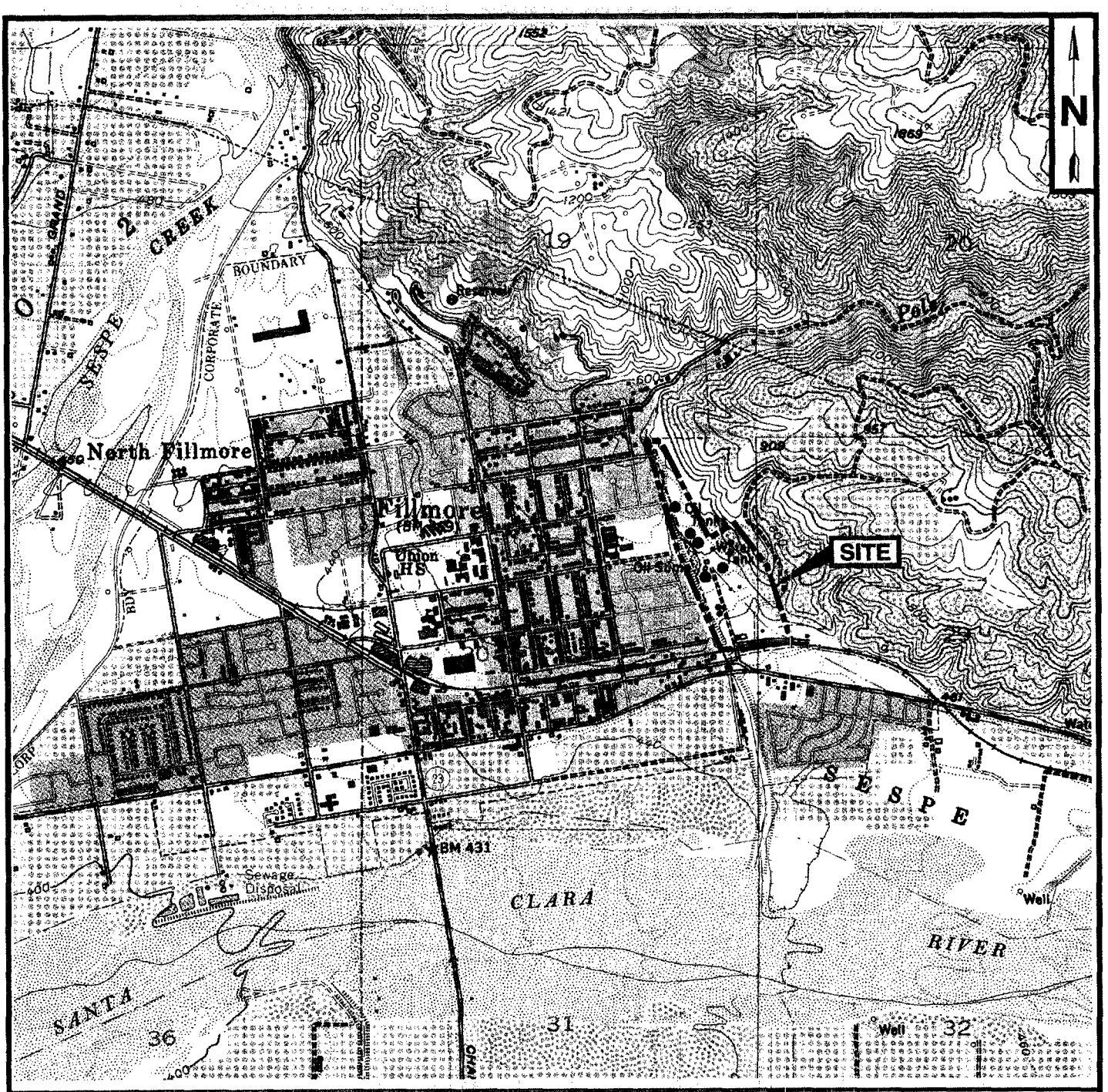
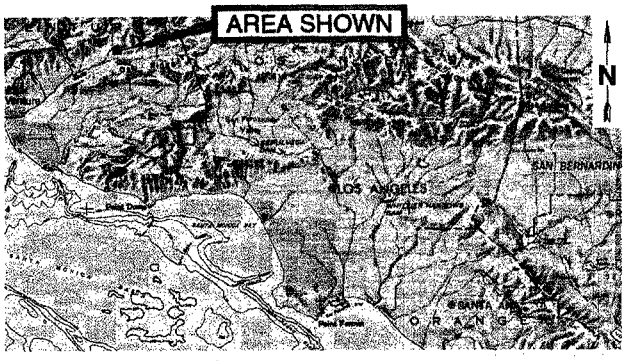
Figures

ENGLAND
GEOSYSTEM
ENVIRONMENTAL ENGINEERING

225.002\100\001\08/16/02





0 2000 4000 FEET

APPROXIMATE SCALE

FIGURE 1

SITE LOCATION MAP

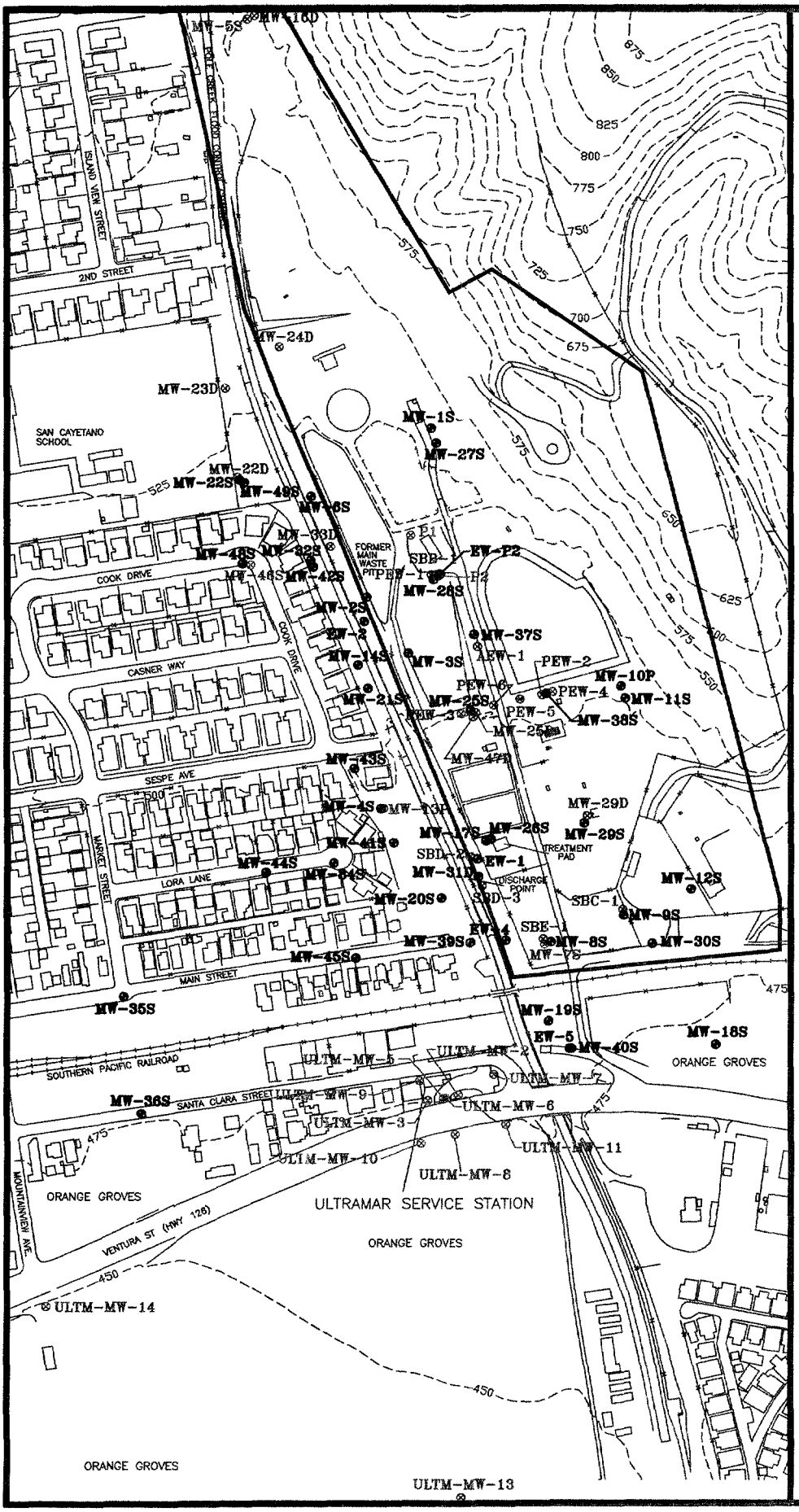
PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA

PREPARED FOR

CHEVRONTEXACO

ENGLAND GEOSYSTEM
ENVIRONMENTAL ENGINEERING

REFERENCE:
7.5 MINUTE U.S.G.S. TOPOGRAPHIC
MAP OF FILLMORE, CALIFORNIA
DATED: 1951
PHOTOREVISED: 1988



LEGEND

MW-12S	WELL LOCATION AND WELL ID
PEW-2	ABANDONED WELL LOCATION AND WELL ID
675	GROUND SURFACE ELEVATION CONTOUR (IN FEET ABOVE MEAN SEA LEVEL) CONTOUR INTERVAL 25 FEET
———	PROJECT AREA

NOTES

WELL ID PREFIX DESCRIPTIONS:

MW	MONITORING WELL
P	2-INCH DIAMETER PIEZOMETER
SB	SOIL BORING CONVERTED TO PERCHED ZONE WELL
EW	AQUIFER I EXTRACTION WELL
PEW	PERCHED EXTRACTION WELL
AEW	AIR EXTRACTION WELL
ULTM	ULTRAMAR MONITORING WELL

0 200 400 600 800

FEET

FIGURE 2

SITE PLAN

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA

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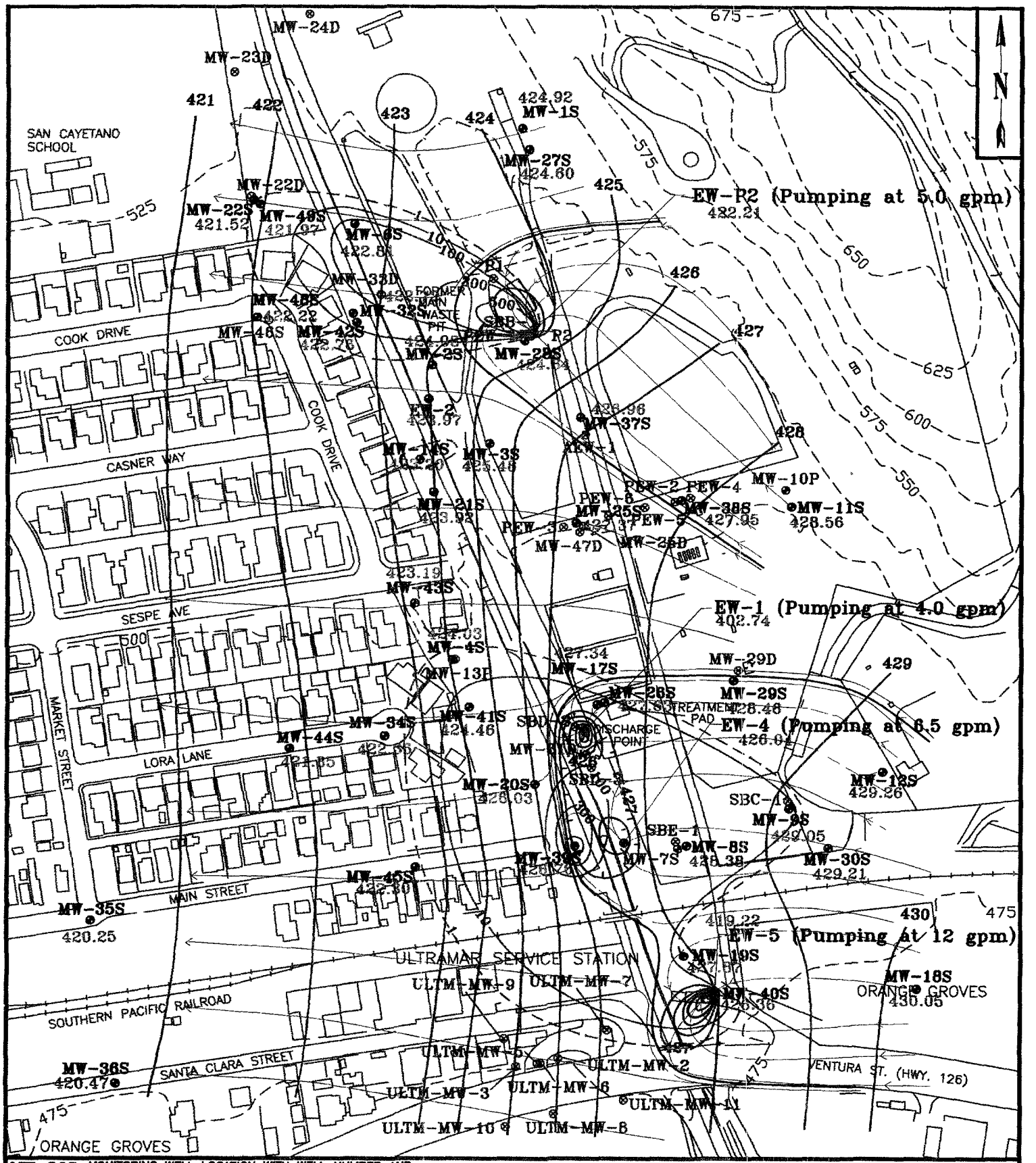
ENVIRONMENTAL ENGINEERING

sentry wells



MW-36S 420.47 — MONITORING WELL LOCATION WITH WELL NUMBER AND GROUND WATER ELEVATION IN FEET ABOVE MSL.

429 — AQUIFER I GROUND WATER SURFACE ELEVATION CONTOUR MEASURED MAY 27, 2002. CONTOUR INTERVAL 1 FOOT.

GROUND WATER FLOW LINES

CAPTURE ZONE

100 — AQUIFER I BENZENE CONCENTRATION CONTOUR IN UG/L, MEASURED MAY 2002. CONTOUR INTERVAL VARIABLE.

⊗ ABANDONED MONITORING WELL LOCATION

1. ULTRAMAR WELLS ABANDONED AFTER SITE CLOSURE. GROUND WATER CONTOURING IN THIS AREA IS BASED ON HISTORIC DATA.

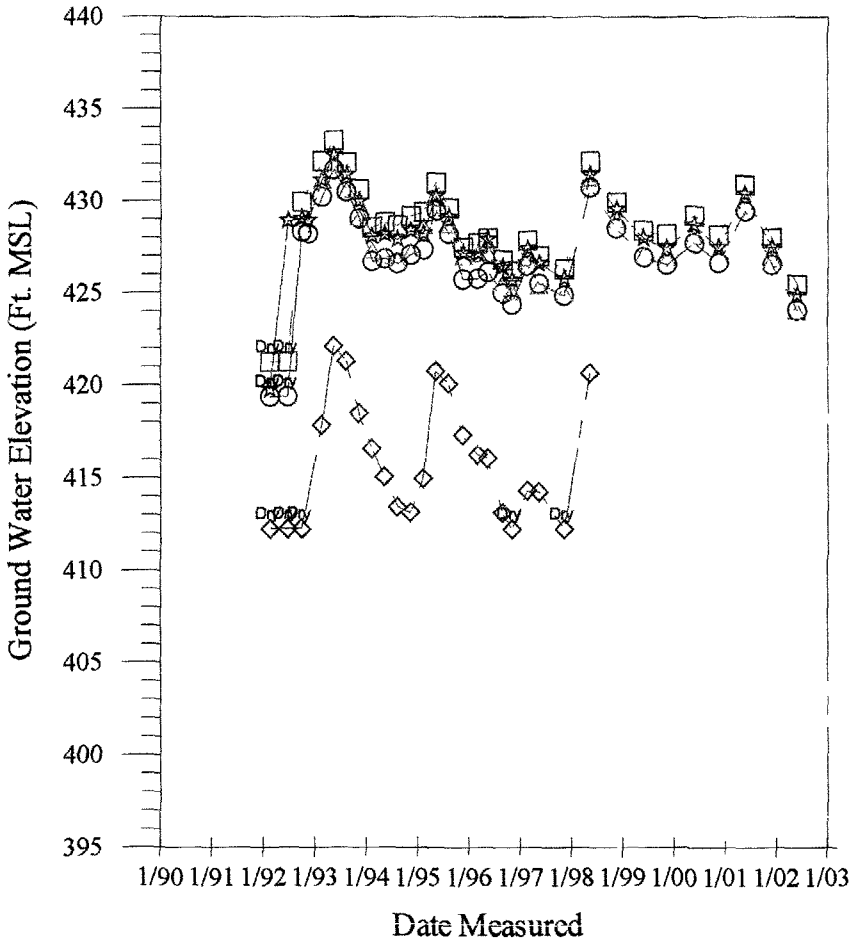
FIGURE 3

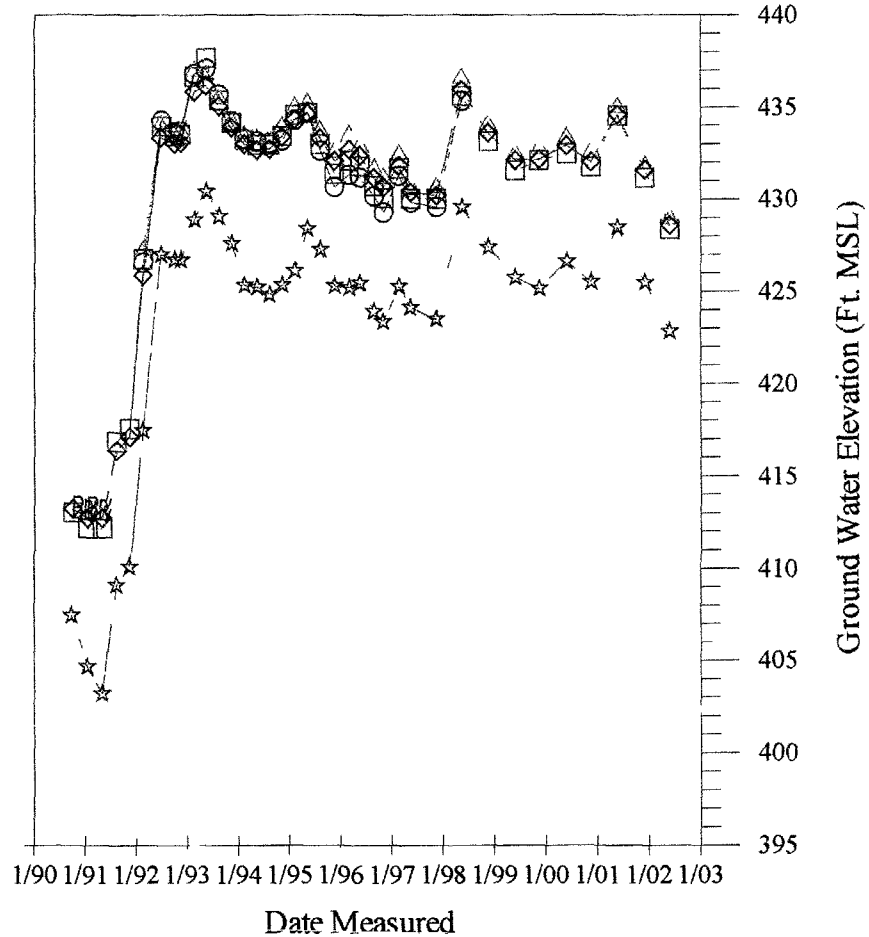
GROUND WATER ELEVATION MAP SPRING 2002

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE CALIFORNIA

PREPARED FOR
CHEVRONTEXACO

ENGLAND GEOSYSTEM
ENVIRONMENTAL ENGINEERING





Left Graph

- MW-1S
- MW-2S
- MW-3S
- MW-4S
- MW-5S

Right Graph

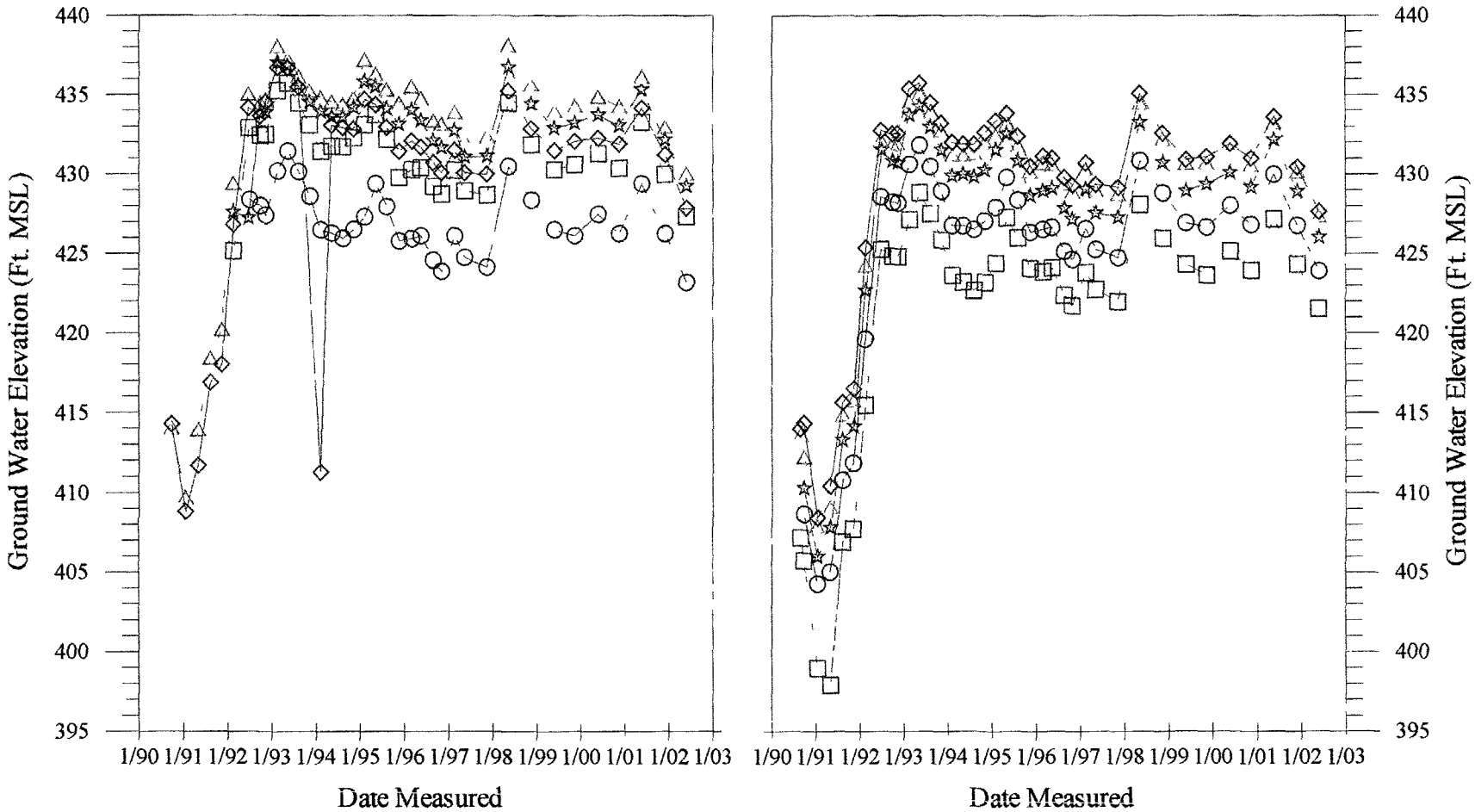
- MW-6S
- MW 7S
- MW-8S
- MW-9S
- MW 11S

FIGURE 4a

HYDROGRAPHS

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA
PREPARED FOR
CHEVRONTEXACO

ENGLAND GEOSYSTEM
ENVIRONMENTAL ENGINEERING



Left Graph	
☆	MW-12S
○	MW-14S
□	MW-17S
△	MW-18S
◇	MW-19S*

Right Graph	
☆	MW-20S
○	MW-21S
□	MW-22S
△	MW-25S
◇	MW-26S

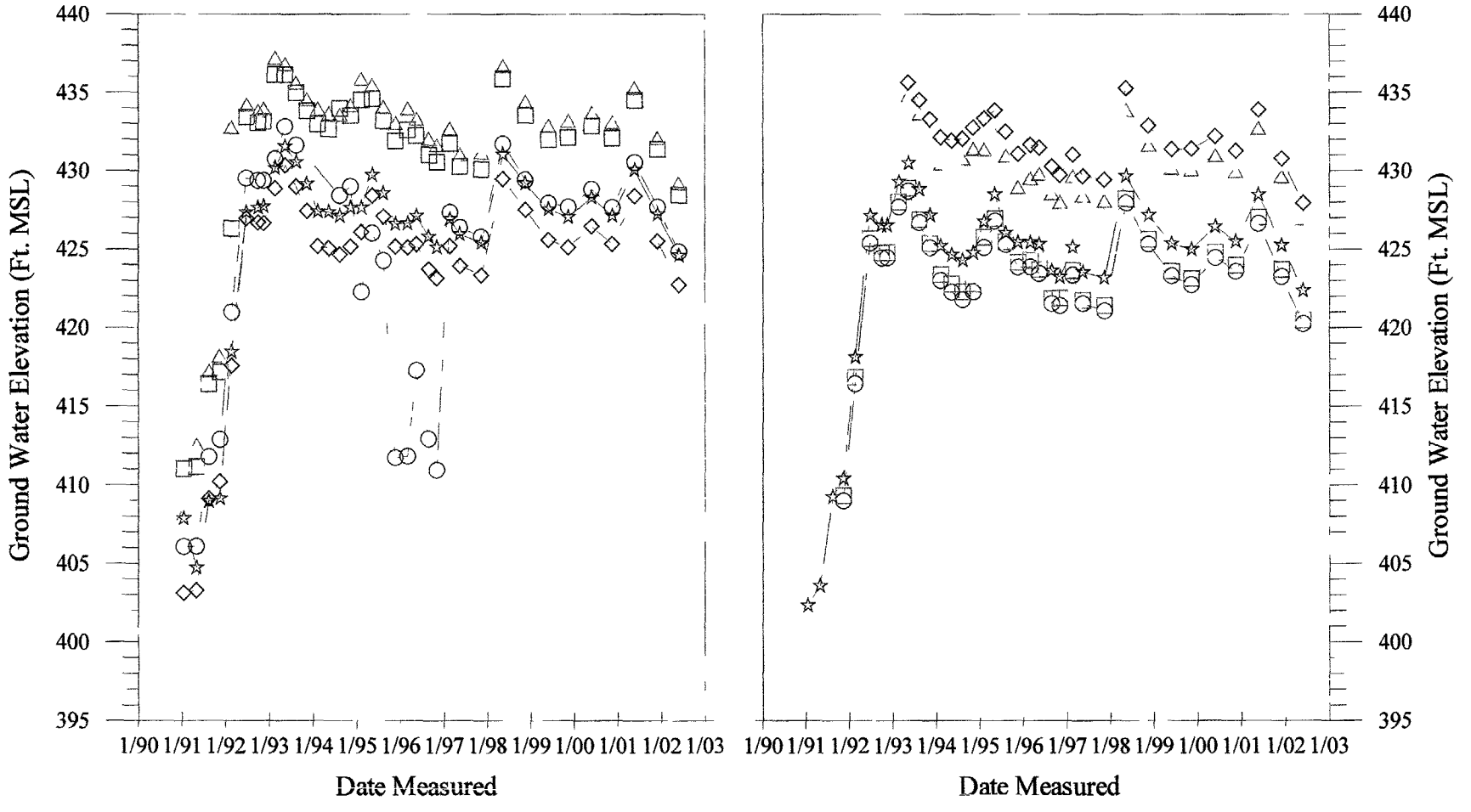
*Former pumping well

FIGURE 4b

HYDROGRAPHS

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA
PREPARED FOR
CHEVRONTEXACO

ENGLAND GEOSYSTEM
ENVIRONMENTAL ENGINEERING



Left Graph
- MW-27S
- MW-28S*
- MW 29S
- MW-30S
- MW 32S

Right Graph
- MW 34S
- MW-35S
- MW 36S
- MW-37S
- MW 38S

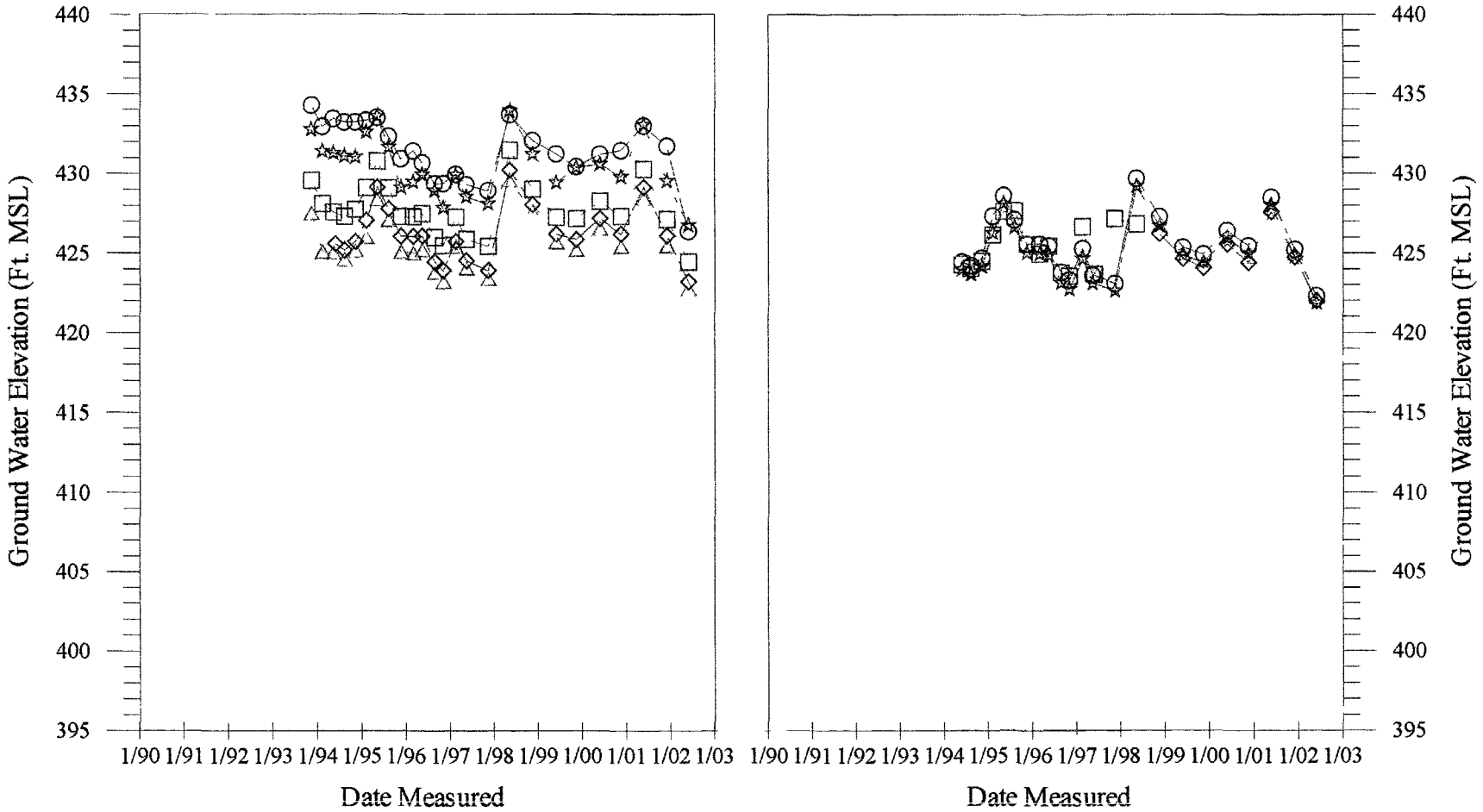
*Former pumping well

FIGURE 4c

HYDROGRAPHS

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA
PREPARED FOR
CHEVRONTEXACO

ENGLAND GEOSYSTEM



Left Graph

- MW-39S
- MW-40S
- MW-41S
- MW-42S
- MW-43S

Right Graph

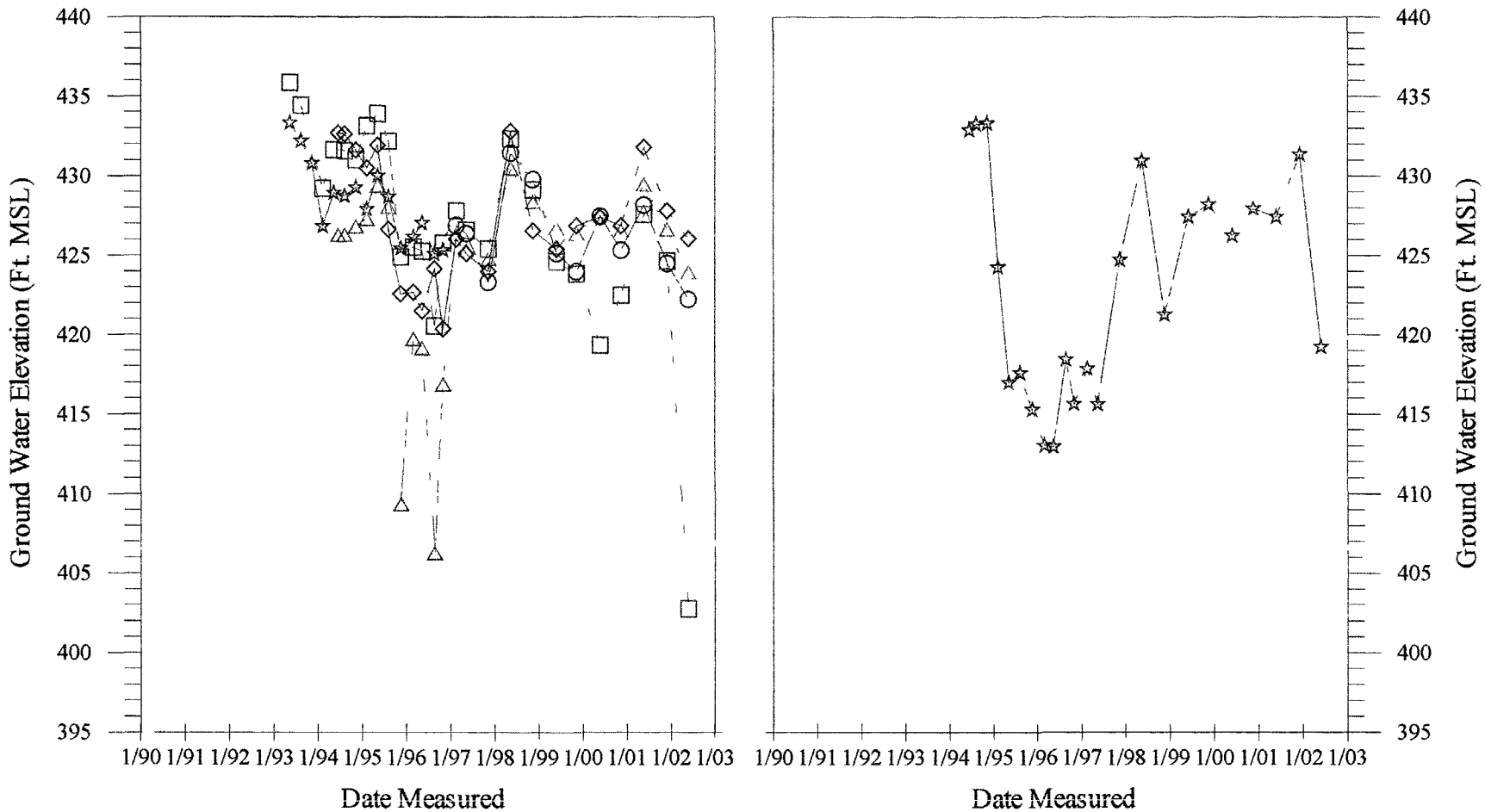
- MW-44S
- MW-45S
- MW-46S
- MW-48S
- MW-49S

FIGURE 4d

HYDROGRAPHS

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA
PREPARED FOR
CHEVRONTEXACO

ENGLAND GEOSYSTEM
ENVIRONMENTAL ENGINEERING



Left Graph
- P2*
- EW-P2*
- EW-1*
- EW-2*
- EW-4*

Right Graph
- EW-5*

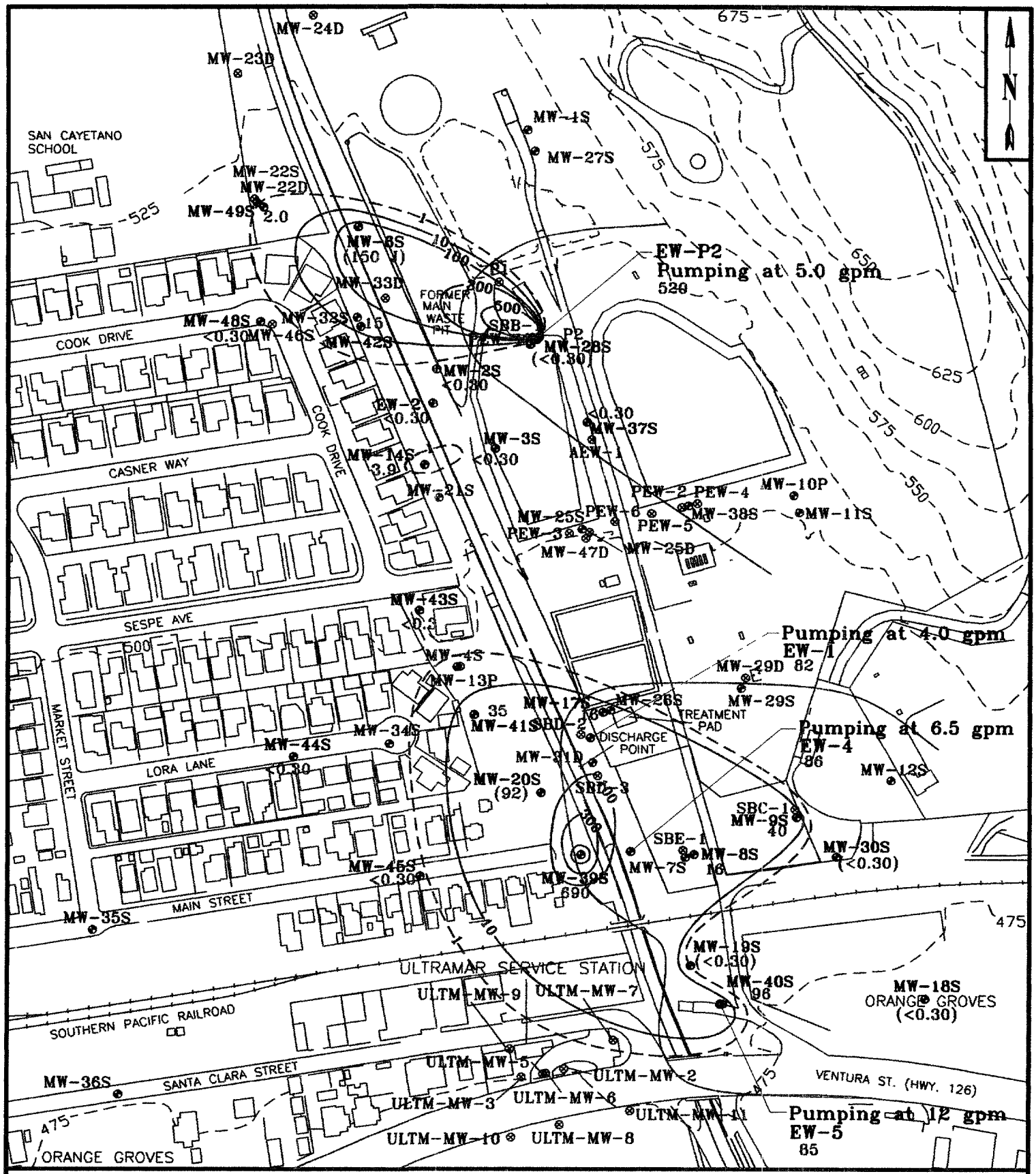
*Pumping well or former pumping well

FIGURE 4e

HYDROGRAPHS

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA
PREPARED FOR
CHEVRONTEXACO

ENGLAND GEOSYSTEM
ENVIRONMENTAL ENGINEERING



MW-45S <0.3 — MONITORING WELL LOCATION AND BENZENE CONCENTRATION IN UG/L. CONCENTRATION IN WELLS WITH SUBMERGED SCREEN ZONES ARE SHOWN IN PARENTHESIS.

⊗ ABANDONED MONITORING WELL LOCATION

100 — AQUIFER I BENZENE CONCENTRATION CONTOUR IN UG/L MEASURED MAY 2002. CONTOUR INTERVAL VARIABLE.

675 — GROUND SURFACE ELEVATION CONTOUR CONTOUR CONTOUR INTERVAL 25 FEET.

0 250 500 FEET

NOTES:

1. BENZENE ANALYZED BY EPA 8021B, J = ESTIMATED.
2. CONTOURING IN THE VICINITY OF THE ULTRAMAR STATION IS BASED ON HISTORIC DATA.
3. J = ESTIMATED VALUE

CAPTURE ZONE

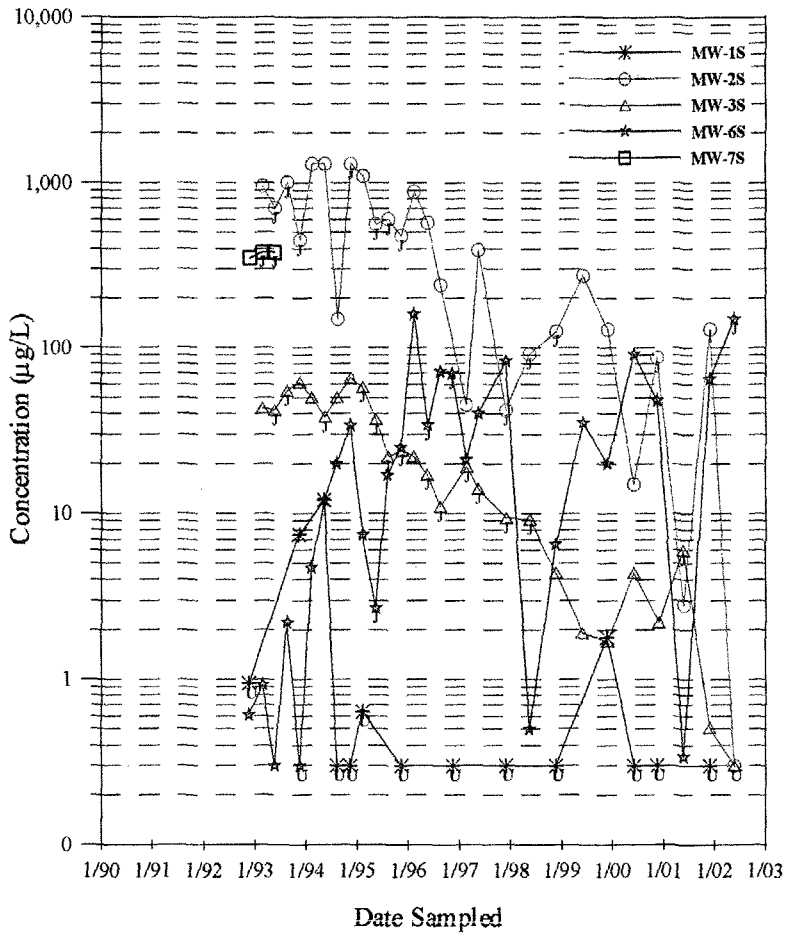
FIGURE 5

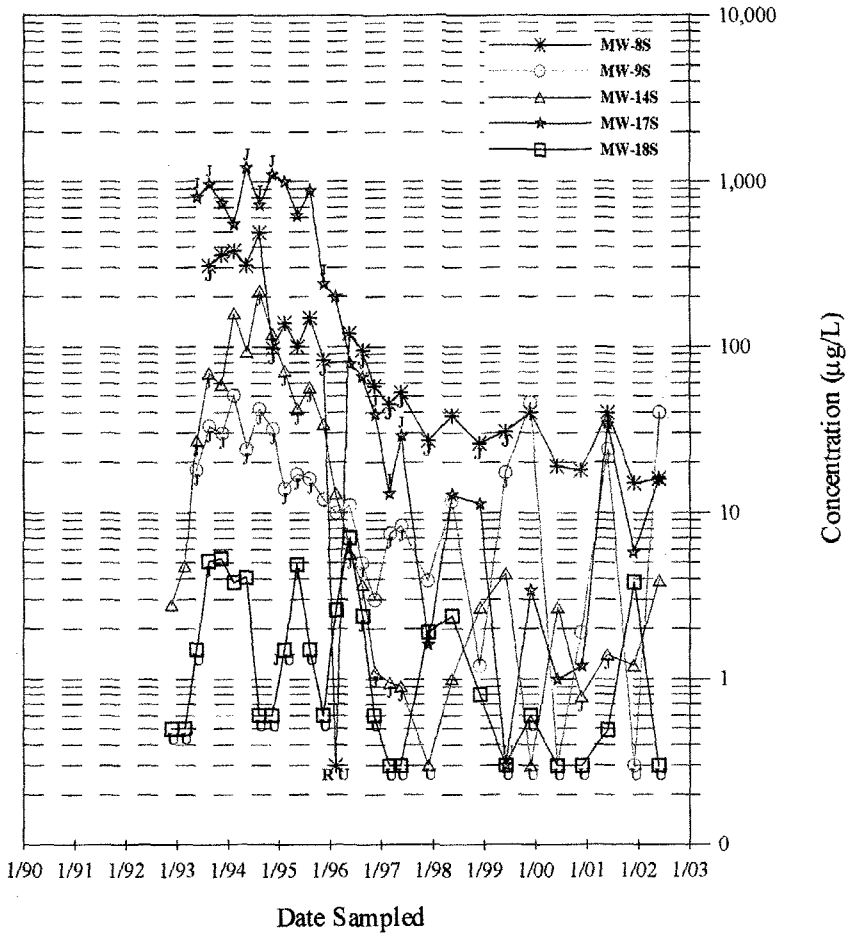
BENZENE DISTRIBUTION IN AQUIFER I WELLS SPRING 2002

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA

PREPARED FOR
CHEVRONTEXACO

ENGLAND GEOSYSTEM
ENVIRONMENTAL ENGINEERING





Data Qualifier: U = Not Detected, J = Estimated, R = Unusable

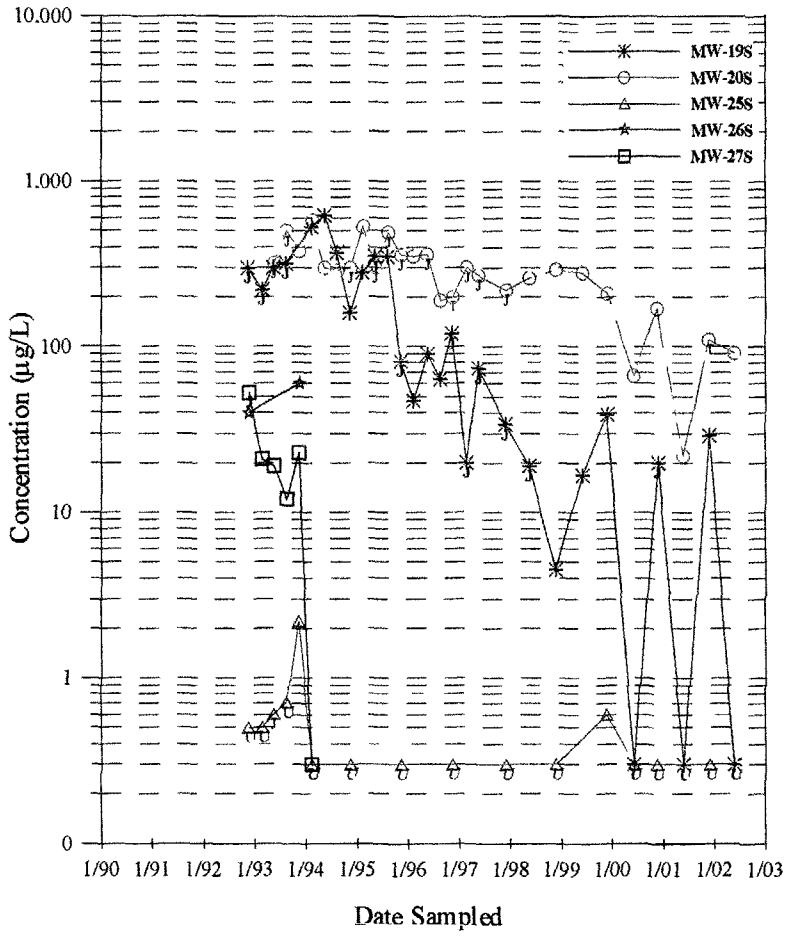
Benzene not detected in the following wells: MW-4S, MW-11S, MW-12S, MW-21S, MW-22S, MW-34S, MW-35S, MW-36S, MW-44S

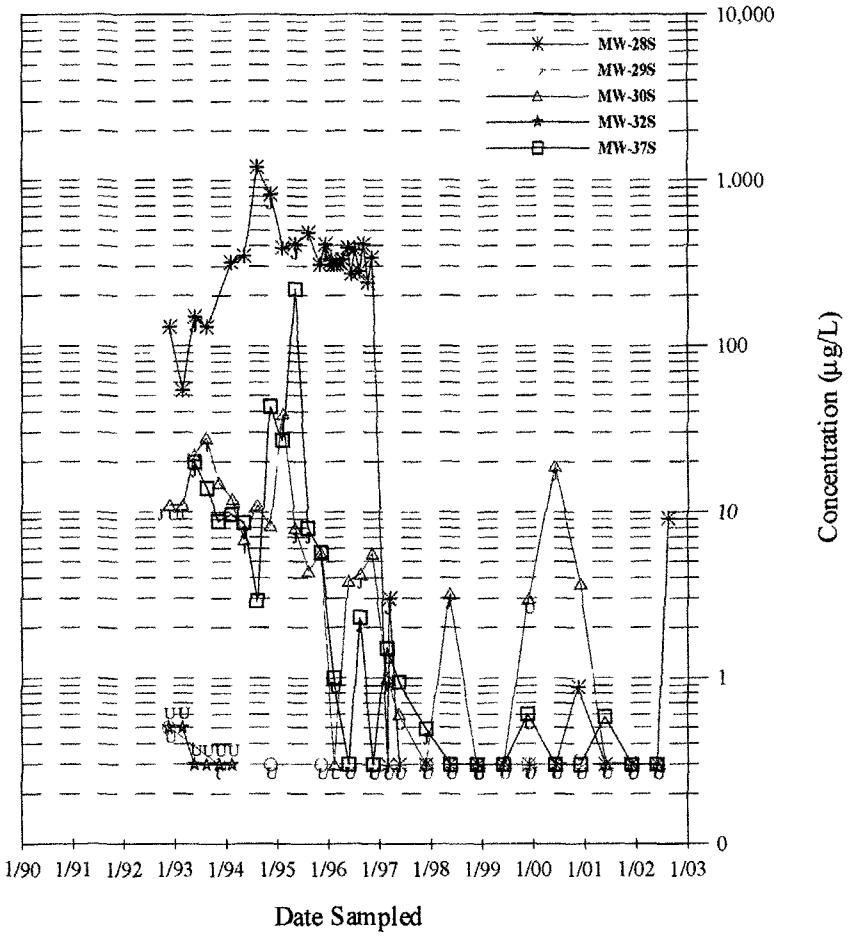
FIGURE 6a

BENZENE CONCENTRATION vs TIME

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA
PREPARED FOR
CHEVRONTEXACO

ENGLAND GEOSYSTEM
ENVIRONMENTAL ENGINEERING





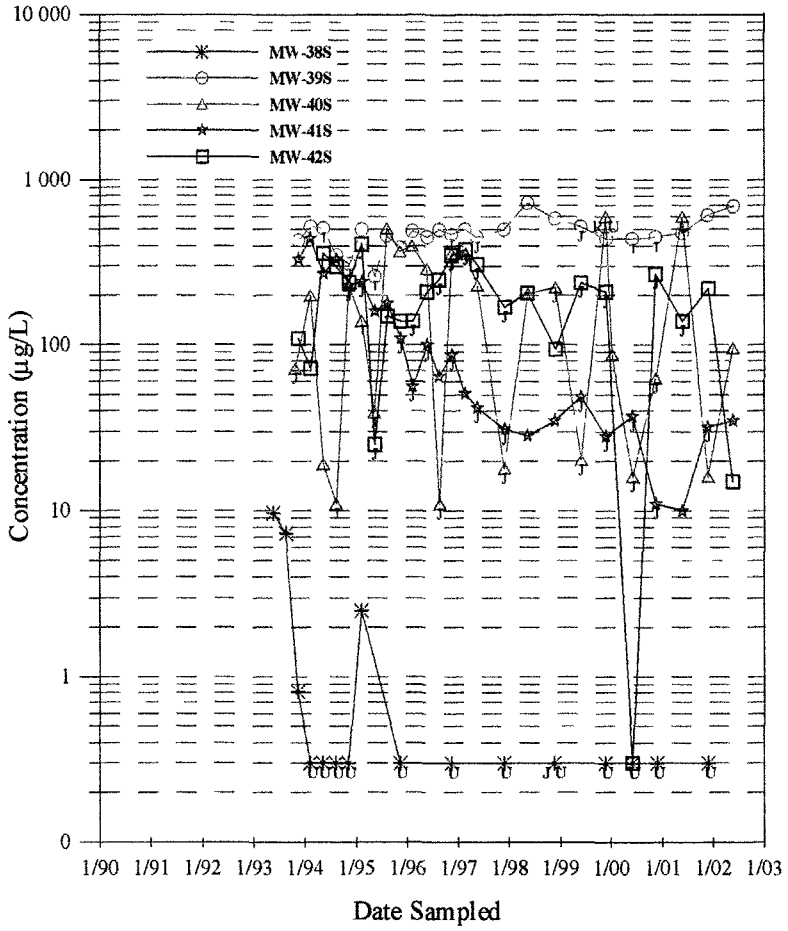
Data Qualifier U = Not Detected, J = Estimated
Benzene not detected in the following wells MW-4S, MW-11S, MW-12S, MW-21S, MW-22S, MW-34S, MW-35S, MW-36S, MW-44S

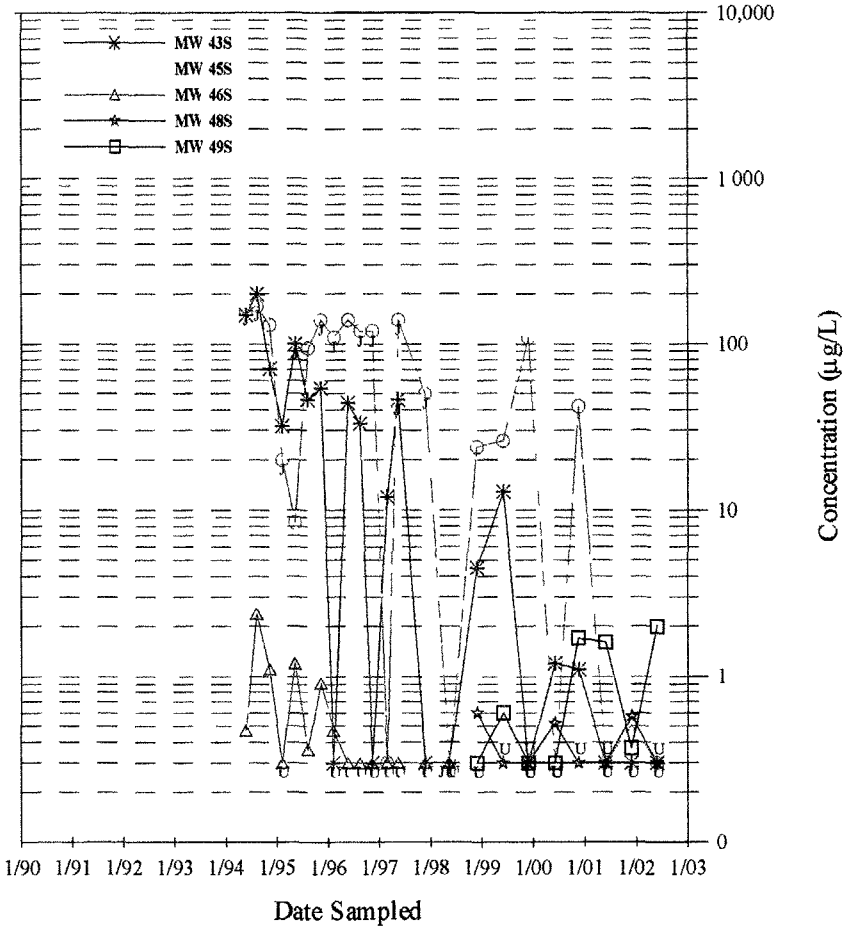
FIGURE 6b

BENZENE CONCENTRATION vs TIME

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA
PREPARED FOR
CHEVRONTEXACO

ENGLAND GEOSYSTEM
ENVIRONMENTAL ENGINEERING





Data Qualifier U = Not Detected, J = Estimated, R = Unusable

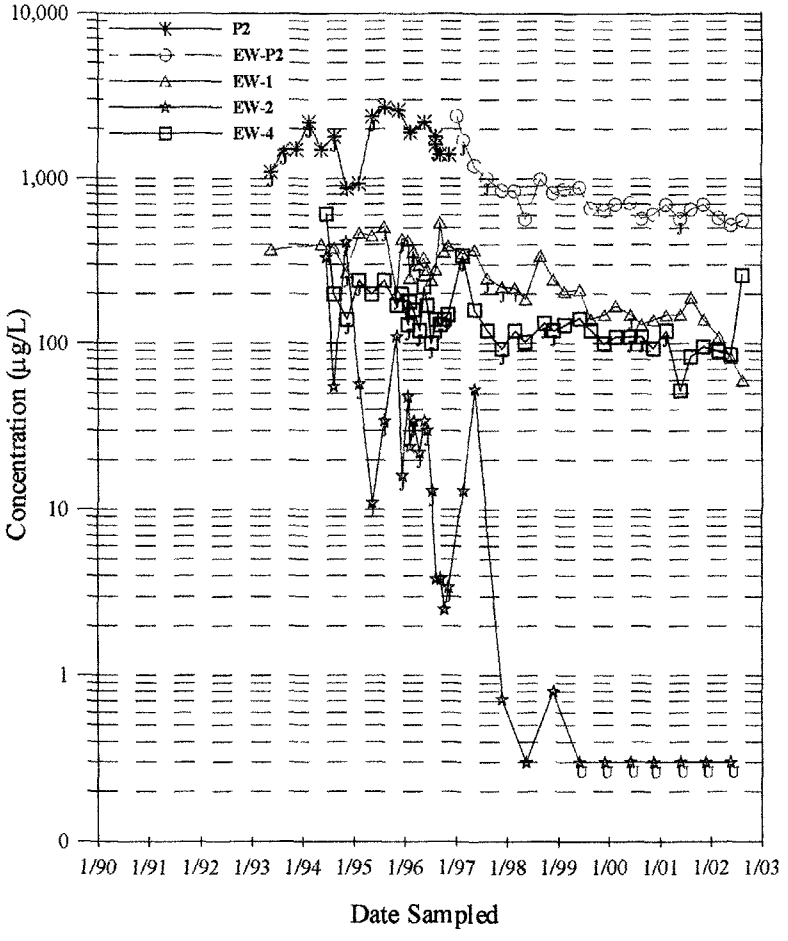
Benzene not detected in the following wells MW-4S, MW-11S, MW-12S, MW-21S, MW-22S, MW-34S, MW-35S, MW-36S, MW-44S

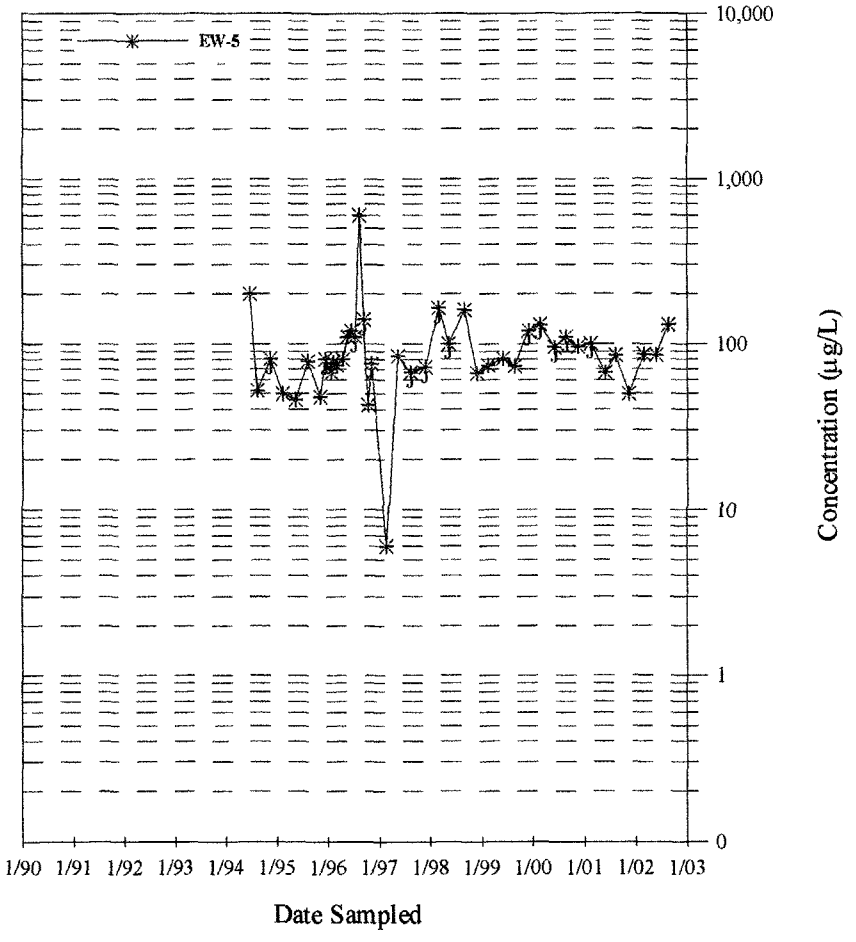
FIGURE 6c

BENZENE CONCENTRATION vs TIME

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA
PREPARED FOR
CHEVRONTEXACO

ENGLAND GEOSYSTEM
ENVIRONMENTAL ENGINEERING





Data Qualifier U = Not Detected, J = Estimated, R = Unusable

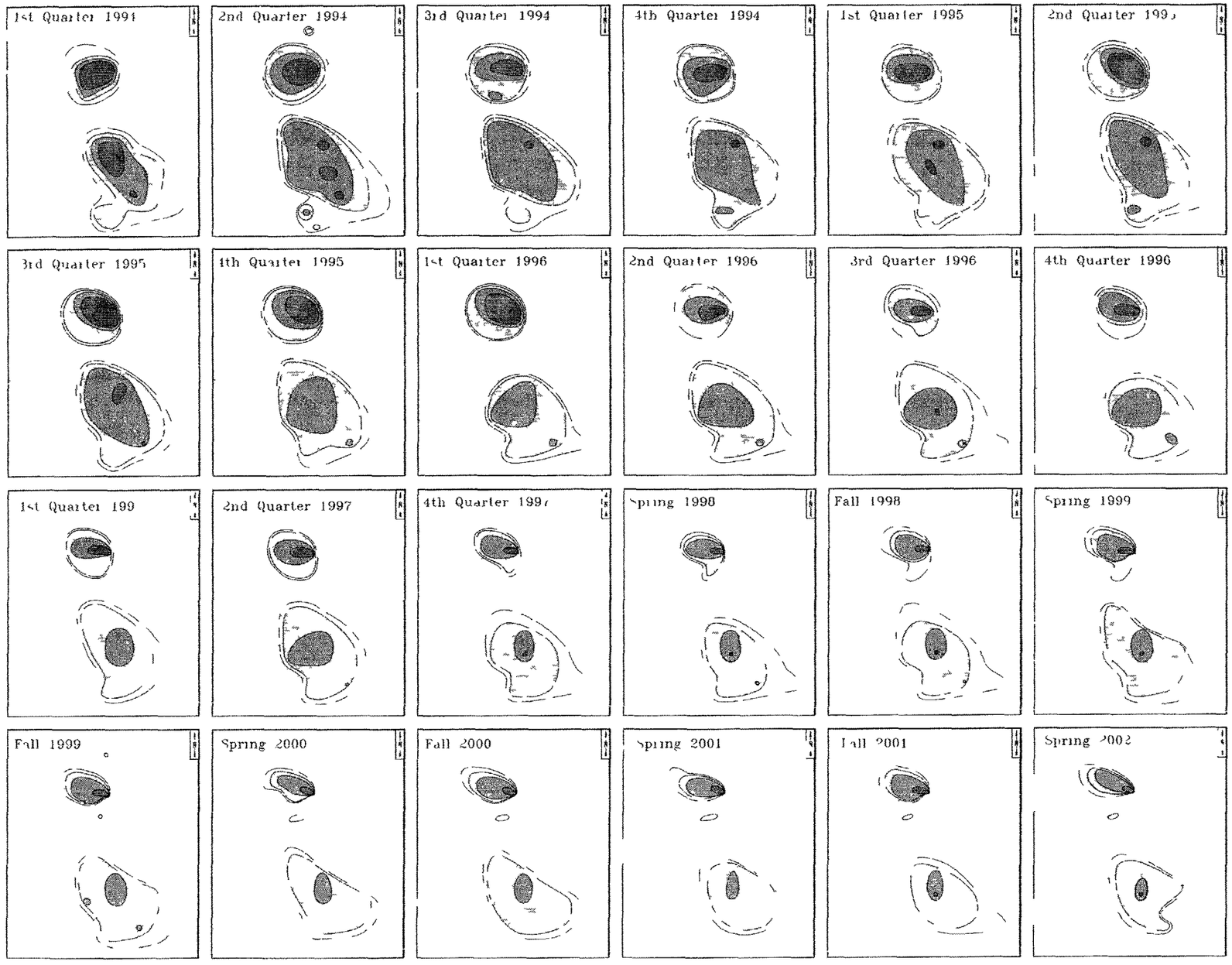
Benzene not detected in the following wells MW-4S, MW-11S, MW-12S, MW-21S, MW-22S, MW-34S, MW-35S, MW-36S, MW-44S

FIGURE 6d

BENZENE CONCENTRATION vs TIME

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA
PREPARED FOR
CHEVRONTEXACO

ENGLAND GEOSYSTEM
ENVIRONMENTAL ENGINEERING



Greater than 500 ppb

Between 100 and 500 ppb

Between 10 and 100 ppb

Between 1 and 10 ppb

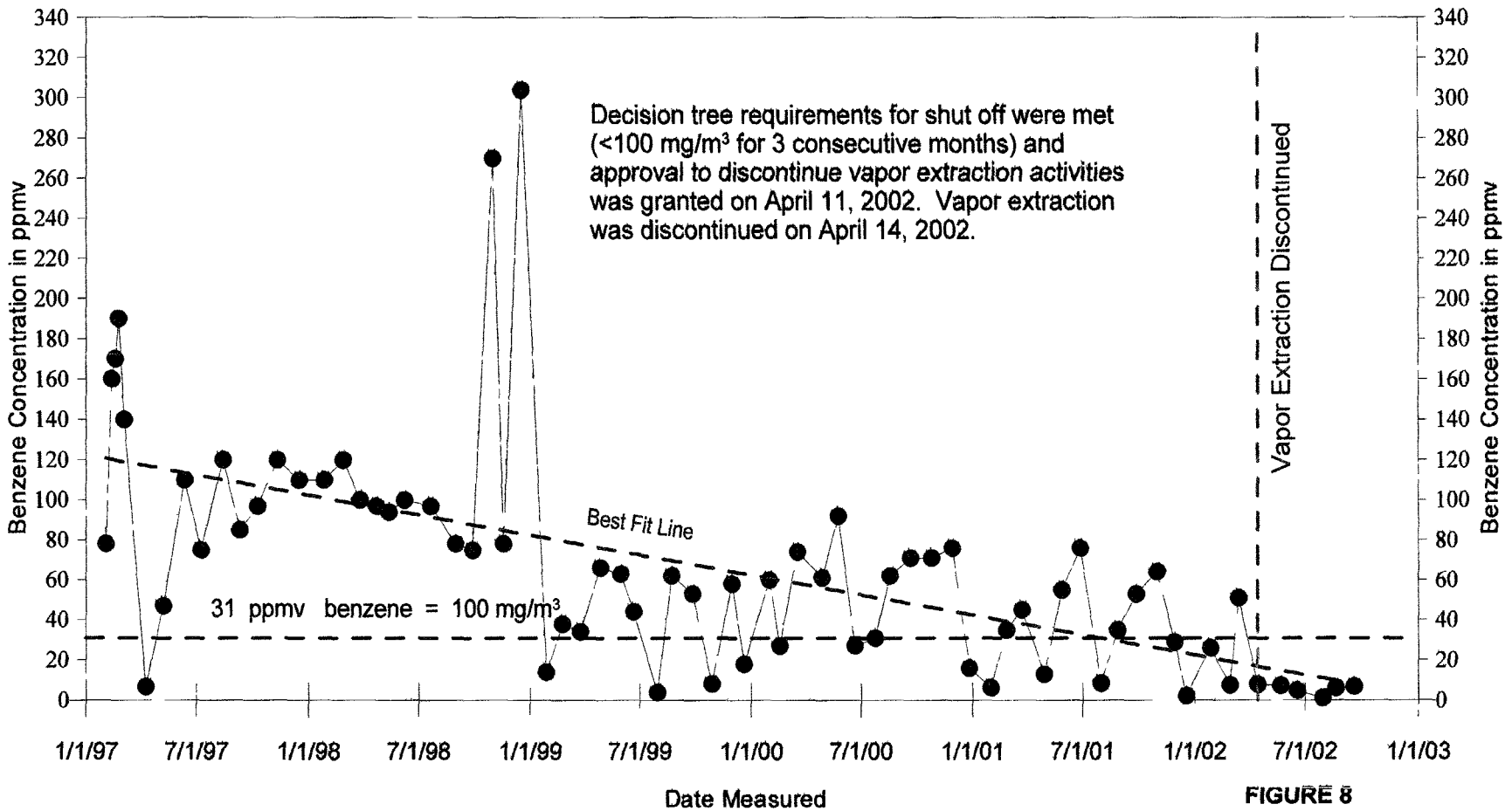
FIGURE 7

BENZENE IN GROUND WATER 1994 TO 2002

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE CALIFORNIA

PREPARED FOR

CHEVRONTEXACO



ND = not detected, detection limit shown
ppmv = parts per million by volume
mg/m³ = milligrams per cubic meter

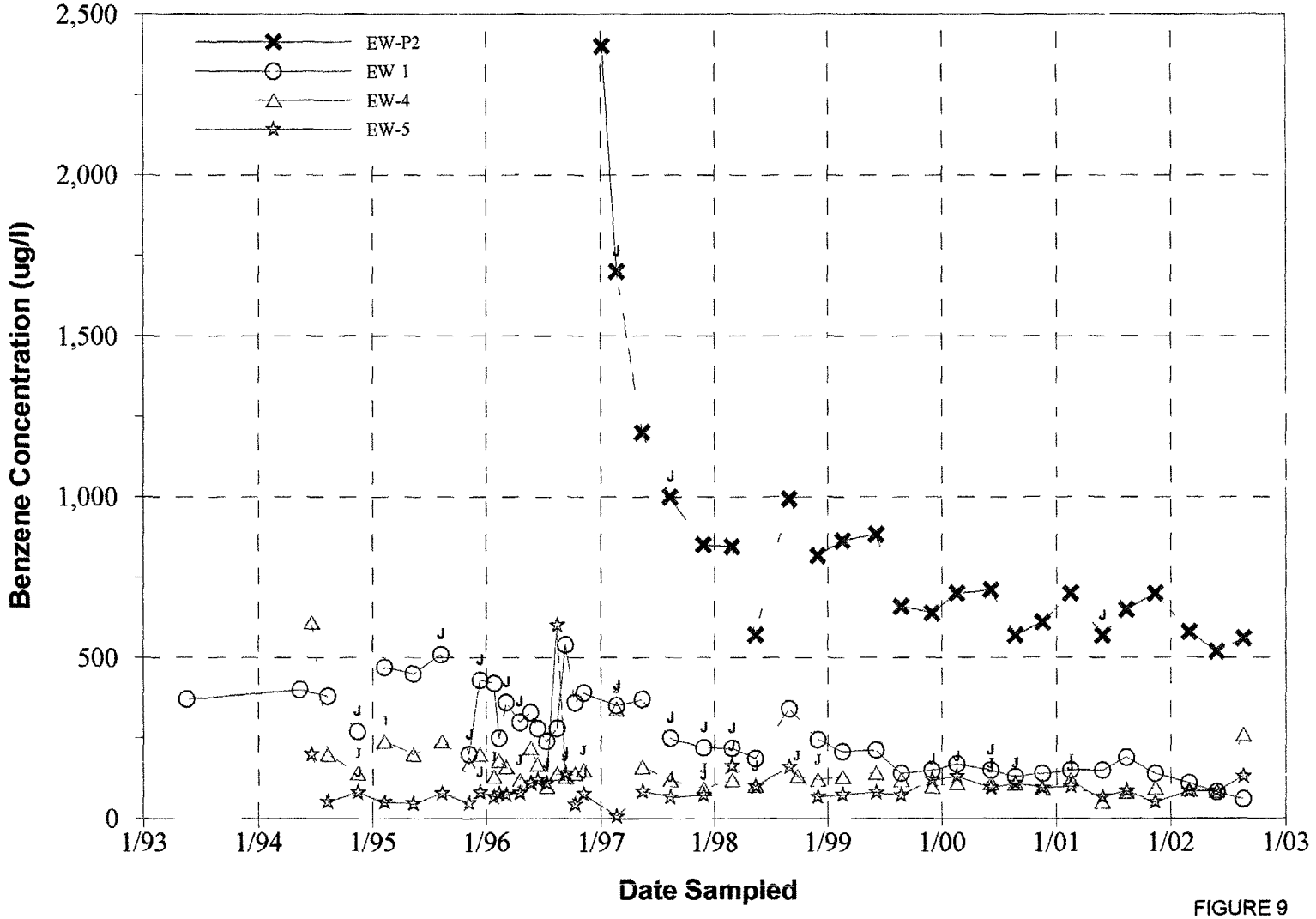
FIGURE 8

CONCENTRATIONS OF BENZENE IN SOIL GAS FROM WELL EW-P2

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA

PREPARED FOR
CHEVRONTEXACO

ENGLAND GEOSYSTEM



Data Qualifiers J = Estimated

FIGURE 9

BENZENE TRENDS IN EXTRACTION WELLS

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA

PREPARED FOR
CHEVRONTEXACO

ENGLAND GEOSYSTEM
ENVIRONMENTAL ENGINEERING

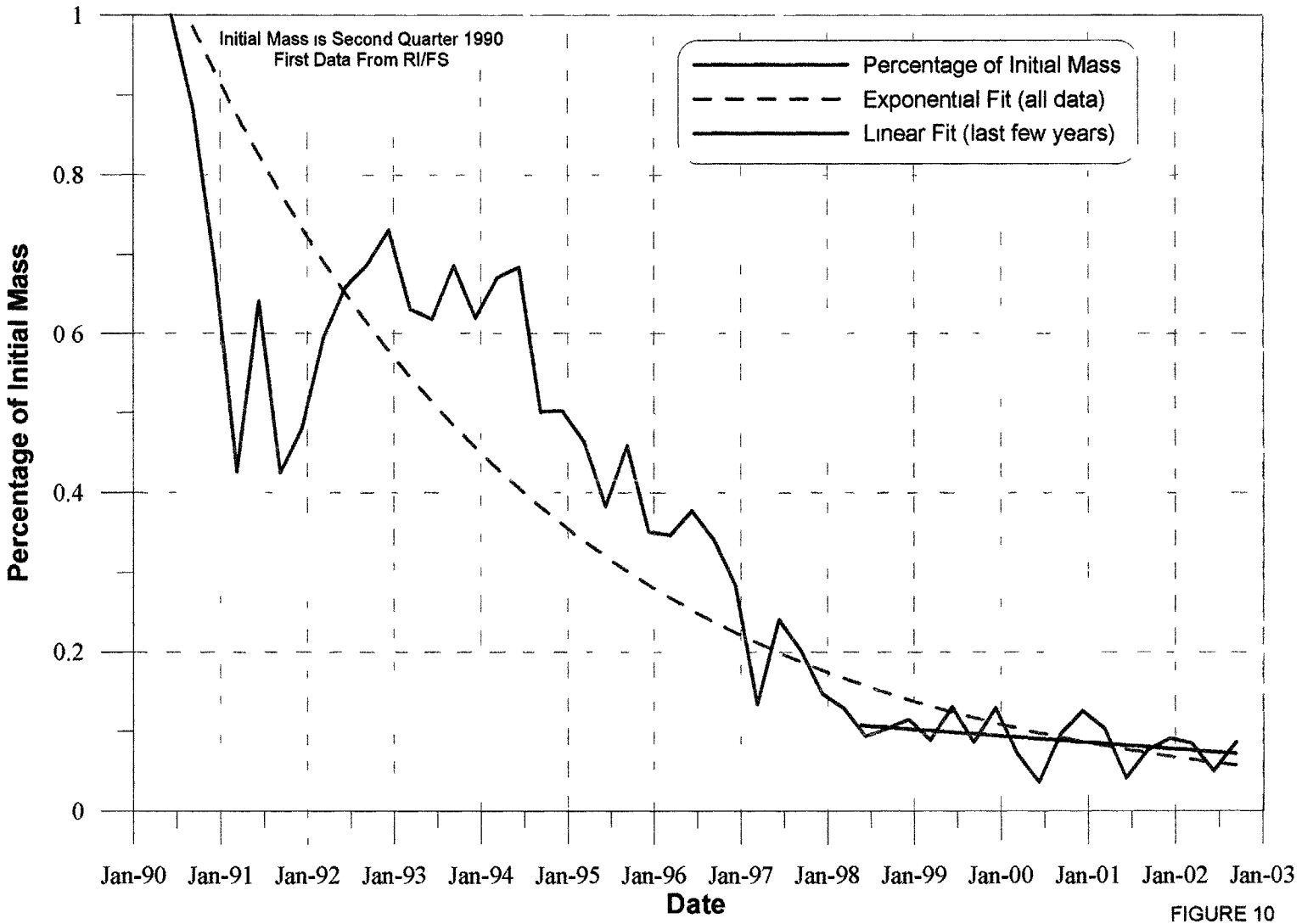


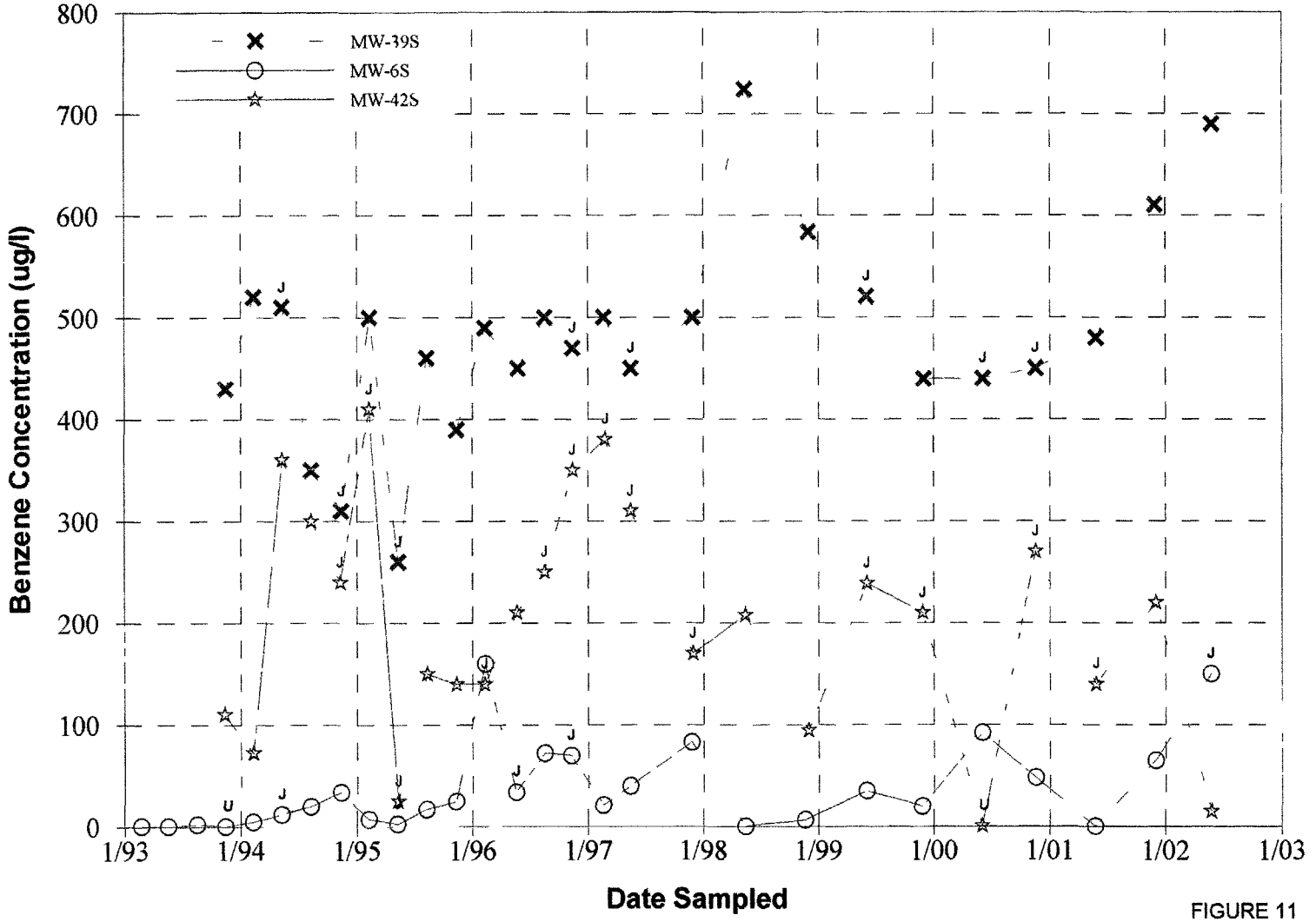
FIGURE 10

PERCENTAGE DECREASE OF DISSOLVED BENZENE MASS IN GROUND WATER VS. TIME

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA

PREPARED FOR
CHEVRONTEXACO

ENGLAND GEOSYSTEM
ENVIRONMENTAL ENGINEERING



Data Qualifiers J = Estimated, U = Non-Detected

FIGURE 11

BENZENE TRENDS IN STAGNATION ZONE

PACIFIC COAST PIPELINE SUPERFUND SITE
FILLMORE, CALIFORNIA
PREPARED FOR
CHEVRONTEXACO

ENGLAND GEOSYSTEM
ENVIRONMENTAL ENGINEERING

Appendix A

Operational History

ENGLAND
GEOSYSTEM
ENVIRONMENTAL ENGINEERING

Table A-1
Summary of Ground Water Treatment System Operation and Contaminant Removal
PCPL Superfund Site

Year	Quarter	Month	Extraction Wells Connected	Volume of Water Treated (gallons)	Average Concentrations (ug/L)		Mass Removal (pounds)	
					TPHG	Benzene	TPHG	Benzene
1993	4th	Dec	EW-1, MW-19S, MW-28S	891,190	3,700	340	27	3
1994	1st	Jan	EW-1, MW-19S, MW-28S	1,671,880	3,900	370	54	5
		Feb	EW-1, MW-19S, MW-28S	1,067,190	4,600	440	41	4
		Mar	System off due to upset	0	-	-	0	0
	2nd	Apr	"	0	-	-	0	0
		May	"	0	-	-	0	0
		Jun	"	0	-	-	0	0
	3rd	Jul	EW-2, EW-4, EW-5	106,140	1,300	130	1	0.1
		Aug	EW-2, EW-4, EW-5	439,280	1,700	140	6	0 5
		Sept	EW-2, EW-4, EW-5	202,350	2,000	100	3	0 2
	4th	Oct	EW-4	71,070	3,700	140	2	0 1
		Nov	EW-4, EW-5, MW-28S	678,760	2,500	120	14	0.7
		Dec	EW-4, EW-5, MW-28S	1,751,630	2,400	225	35	3.3
1995	1st	Jan	EW-4, EW-5, MW-28S	1,877,660	2,900	210	45	3.3
		Feb	EW-4, EW-5, MW-28S	1,955,050	3,300	240	54	3 9
1995	1st	Mar	EW-4, EW-5, MW-28S	1,426,650	3,400	290	40	3.4
	2nd	Apr	EW-4, EW-5, MW-28S	1,902,540	3,400	280	54	4 4
		May	EW-4, EW-5, MW-28S	2,131,960	3,100	300	55	5 3
		Jun	EW-4, EW-5, MW-28S	1,917,190	3,100	230	49	3.7
	3rd	Jul	EW-4, EW-5, MW-28S	1,734,940	2,400	220	35	3 2
		Aug	EW-4, EW-5, MW-28S	2,155,060	2,800	260	50	4.7
		Sep	EW-4, EW-5, MW-28S	1,573,990	3,100	270	41	3.5
	4th	Oct	EW-4, EW-5, MW-28S	2,187,940	3,450	235	63	4.3
		Nov	EW-1, EW-2, EW-4, EW-5, MW-28S	3,833,160	4,150	285	132	9.1
		Dec	EW-1, EW-2, EW-4, EW-5, MW-28S	3,720,060	4,500	250	139	7.7
1996	1st	Jan	EW-1, EW-2, EW-4, EW-5, MW-28S	1,702,140	3,000	190	42	2.7
		Feb	EW-1, EW-2, EW-4, EW-5, MW-28S	3,081,240	3,100	210	79	5.4
		Mar	EW-1, EW-2, EW-4, EW-5, MW-28S	3,313,380	3,100	235	85	6.5
	2nd	Apr	EW-1, EW-2, EW-4, EW-5, MW-28S	2,570,670	3,000	190	64	4.1
		May	EW-1, EW-2, EW-4, EW-5, MW-28S	2,648,050	4,300	260	95	5.7
		Jun	EW-1, EW-2, EW-4, EW-5, MW-28S	2,803,882	3,600	200	84	4.7
	3rd	Jul	EW-1, EW-2, EW-4, EW-5, MW-28S	1,961,608	3,000	165	49	2 7
		Aug	EW-1, EW-2, EW-4, EW-5, MW-28S	2,297,569	3,300	210	63	4 0
		Sep	EW-1, EW-2, EW-4, EW-5, MW-28S, P2	2,423,731	3,800	210	77	4.2
	4th	Oct	EW-1, EW-2, EW-4, EW-5, MW-28S	2,730,890	2,600	175	59	4 0
		Nov	EW-1, EW-2, EW-4, EW-5, MW-28S	2,567,960	4,000	245	85	5 2
		Dec	EW-1, EW-4, EW-5, MW-28S	1,268,130	4,500	180	47	1.9

Table A-1
Summary of Ground Water Treatment System
Operation and Contaminant Removal
PCPL Superfund Site

Year	Quarter	Month	Extraction Wells Connected	Volume of Water Treated (gallons)	Average Concentrations (ug/L)		Mass Removal (pounds)	
					TPHG	Benzene	TPHG	Benzene
1997	1st	Jan	MW-28S, EW-P2, EW-1, EW-4, EW-5	1,527,870	3,800	225	48	2 9
		Feb	EW-P2, EW-1, EW-4, EW-5	1,492,250	5,700	525	71	6 5
		Mar	EW-P2, EW-1, EW-4, EW-5	1,037,240	6,900	420	59	3.6
	2nd	Apr	EW-P2, EW-1, EW-4, EW-5	1,374,469	5,700	415	65	4.7
		May	EW-P2, EW-1, EW-4, EW-5	1,741,440	5,100	345	74	5.0
		Jun	EW-P2, EW-1, EW-4, EW-5	1,901,813	3,800	270	60	4 3
	3rd	Jul	EW-P2, EW-1, EW-4, EW-5	1,542,778	4,300	250	55	3 2
		Aug	EW-P2, EW-1, EW-4, EW-5	1,245,910	6,100	380	63	3.9
		Sep	EW-P2, EW-1, EW-4, EW-5	822,125	7,200	460	49	3 1
	4th	Oct	EW-P2, EW-1, EW-4, EW-5	1,621,555	5,100	260	69	3.5
		Nov	EW-P2, EW-1, EW-4, EW-5	1,364,290	5,100	260	58	2 9
		Dec	EW-P2, EW-1, EW-4, EW-5	1,430,620	5,400	250	64	3 0
1998	1st	Jan	EW-P2, EW-1, EW-4, EW-5	1,483,470	5,500	290	68	3 6
		Feb	EW-P2, EW-1, EW-4, EW-5	971,490	4,800	270	39	2 2
		Mar	EW-P2, EW-1, EW-4, EW-5	1,464,850	3,500	260	43	3.2
	2nd	Apr	EW-P2, EW-1, EW-4, EW-5	1,324,170	4,400	280	48	3 1
		May	EW-P2, EW-1, EW-4, EW-5	1,319,570	5,800	310	64	3 4
		Jun	EW-P2, EW-1, EW-4, EW-5	1,412,090	3,700	280	43	3 3
	3rd	Jul	EW-P2, EW-1, EW-4, EW-5	857,260	6,300	432	45	3.1
		Aug	EW-P2, EW-1, EW-5	583,890	7,000	487	34	2.4
		Sep	EW-P2, EW-1, EW-4, EW-5	644,940	8,270	726	44	3 9
	4th	Oct	EW-P2, EW-1, EW-4, EW-5	1,300,670	4,000	186	43	2 0
		Nov	EW-P2, EW-1, EW-4, EW-5	1,555,570	4,700	304	61	3.9
		Dec	EW-P2, EW-1, EW-4, EW-5	1,131,040	5,170	193	49	1 8
1999	1st	Jan	EW-P2, EW-1, EW-4, EW-5	1,514,450	4,050	182	51	2 3
		Feb	EW-P2, EW-1, EW-4, EW-5	1,381,150	4,080	269	47	3 1
		Mar	EW-P2, EW-1, EW-4, EW-5	1,599,590	3,225	211	43	2.8
	2nd	Apr	EW-P2, EW-1, EW-4, EW-5	1,468,610	3,745	250	46	3.1
		May	EW-P2, EW-1, EW-4, EW-5	1,491,250	3,760	349	47	4.3
		Jun	EW-P2, EW-1, EW-4, EW-5	1,425,650	3,610	266	43	3 2
	3rd	Jul	EW-P2, EW-1, EW-4, EW-5	1,252,770	3,850	280	40	2 9
		Aug	EW-P2, EW-1, EW-4, EW-5	1,238,720	4,000	235	41	2.4
		Sep	EW-P2, EW-1, EW-4, EW-5	926,510	4,135	230	32	1.8
	4th	Oct	EW-P2, EW-1, EW-4, EW-5	1,272,970	4,515	240	48	2.5
		Nov	EW-P2, EW-1, EW-4, EW-5	616,180	5,200	230	27	1.2
		Dec	EW-P2, EW-1, EW-4, EW-5	896,890	5,600	240	42	1 8

Table A-1
Summary of Ground Water Treatment System
Operation and Contaminant Removal
PCPL Superfund Site

Year	Quarter	Month	Extraction Wells Connected	Volume of Water Treated (gallons)	Average Concentrations (ug/L)		Mass Removal (pounds)	
					TPHG	Benzene	TPHG	Benzene
2000	1st	Jan	EW-P2, EW-1, EW-4, EW-5	1,381,240	4,870	253	56	2.9
		Feb	EW-P2, EW-1, EW-4, EW-5	921,480	3,800	220	29	1 7
		Mar	EW-P2, EW-1, EW-4, EW-5	1,183,920	3,825	170	38	1.7
	2nd	Apr	EW-P2, EW-1, EW-4, EW-5	1,171,730	4,700	250	46	2.4
		May	EW-P2, EW-1, EW-4, EW-5	1,051,670	4,290	210	37	1.8
		Jun	EW-P2, EW-1, EW-4, EW-5, tank 1	1,550,060	3,850	200	50	2.6
	3rd	Jul	EW-P2, EW-1, EW-4, EW-5	998,210	5,300	250	44	2 1
		Aug	EW-P2, EW-1, EW-4, EW-5, tank 1	750,050	5,103	167	32	1.0
		Sep	EW-P2, EW-1, EW-4, EW-5	1,004,170	4,500	200	38	1.7
	4th	Oct	EW-P2, EW-1, EW-4, EW-5	1,184,020	4,900	235	48	2 3
		Nov	EW-P2, EW-1, EW-4, EW-5	1,010,580	4,500	245	38	2.1
2000	4th	Dec	EW-P2, EW-1, EW-4	927,570	4,650	230	36	1 8
2001	1st	Jan	EW-P2, EW-1, EW-4, EW-5	949,500	5,005	265	39	2 1
		Feb	EW-P2, EW-1, EW-4, EW-5	1,042,010	4,850	280	42	2.4
		Mar	EW-P2, EW-1, EW-4, EW-5	1,176,040	4,290	225	42	2 2
	2nd	Apr	EW-P2, EW-1, EW-4, EW-5	979,370	4,800	230	39	1.9
		May	EW-P2, EW-1, EW-4, EW-5	1,114,750	5,600	215	52	2.0
		Jun	EW-P2, EW-1, EW-4, EW-5	1,103,590	5,650	245	52	2 2
	3rd	Jul	EW-P2, EW-1, EW-4, EW-5	1,219,720	5,950	285	60	2.9
		Aug	EW-P2, EW-1, EW-4, EW-5	987,270	5,750	240	47	2.0
		Sep	EW-P2, EW-1, EW-4, EW-5	827,960	3,700	290	25	2.0
	4th	Oct	EW-P2, EW-1, EW-4, EW-5	293,700	14,000	590	34	1.4
		Nov	EW-P2, EW-1, EW-4, EW-5	1,013,040	6,000	270	51	2.3
		Dec	EW-P2, EW-1, EW-4, EW-5	856,545	6,200	250	44	1.8
2002	1st	Jan	EW-P2, EW-1, EW-4, EW-5	918,210	10,300	460	79	3 5
		Feb	EW-P2, EW-1, EW-4, EW-5	1,228,530	4,650	215	47	2.2
		Mar	EW-P2, EW-1, EW-4, EW-5	1,334,310	4,650	185	52	2.1
	2nd	Apr	EW-P2, EW-1, EW-4, EW-5	581,450	4,200	185	20	0.9
		May	EW-P2, EW-1, EW-4, EW-5	1,187,640	3,700	200	37	2.0
		Jun	EW-P2, EW-1, EW-4, EW-5	1,080,000	3,700	200	33	1.8
	3rd	Jul	EW-P2, EW-1, EW-4, EW-5	81,780	4,200	220	3	0.1
		Aug	EW-P2, EW-1, EW-4, EW-5	60,610	4,800	310	2	0 2
		Sep	EW-P2, EW-1, EW-4, EW-5	105,705	5,300	250	5	0.2
Total				140,237,680			4,893	300.7

Table A-2
Summary of Estimated Contaminant Removal from Soil Vapor Extraction
PCPL Superfund Site

Vapor Extraction Well	Extraction Period	Estimated Pounds Removed	
		Total Hydrocarbons	Benzene
PEW-2	June 1994 – February 1995	95,000	40
PEW-1	March 1995 – January 1997	612,000	911
EW-4	May 1996 – November 1996	54,500	6
EW-P2	February 1997 – March 2002	625,729	1,234
Total	June 1994 – March 2002	1,387,229	2,191

Table A-3
Summary of LNAPL Removal in Gallons
PCPL Superfund Site

Year	Quarter	Ground Water Extraction Wells			Ground Water Monitoring Wells					LNAPL Condensate from Vapor Extraction Wells	Totals
		EW-1	EW-4	EW-P2	MW-9S	MW-17S	MW-20S	MW-40S	Perched Wells		
1994	1st	none	-	-	none	none	none	none	none	25.00	25.00
	2nd	2.99	none	-	0.36	0.06	0.06	none	none	none	3.47
	3rd	0.11	1.00	-	0.21	none	none	none	none	none	1.32
	4th	none	none	-	0.06	0.03	0.03	none	0.6	2.00	2.72
1995	1st	none	19.40	-	0.13	0.08	0.03	none	0.36	10.40	30.40
	2nd	none	15.40	-	0.70	0.37	0.11	none	0.22	none	16.80
	3rd	none	2.00	-	0.05	0.05	none	0.06	0.04	none	2.20
	4th	2.8	none	-	0.27	none	none	none	none	none	3.07
1996	1st	3.5	none	-	0.38	0.05	none	none	0.11	17.00	21.04
	2nd	9.5	0.03	-	0.11	0.05	none	none	none	0.50	10.19
	3rd	2.75	none	-	0.16	none	none	none	none	none	2.91
	4th	1.72	none	-	none	none	none	none	none	8.00	9.72
1997	1st	22.94	6.44	none	none	none	none	none	none	29.00	58.38
	2nd	27.40	11.31	none	0.27	none	none	none	none	1.00	39.98
	3rd	7.96	none	none	0.11	none	none	none	none	none	8.07
	4th	5.15	none	none	0.11	none	none	none	none	none	5.26
1998	1st	29.81	2.10	none	0.22	none	none	none	none	94.00	126.13
	2nd	27.00	21.40	none	0.27	none	none	none	none	9.50	58.17
	3rd	16.00	3.25	8.00	0.11	none	none	none	none	none	27.36
	4th	10.6	13.25	10.75	0.05	none	none	none	none	none	34.65
1999	1st	8.45	8.75	5.80	0.16	none	none	none	none	8.00	31.16
	2nd	6.60	6.80	5.70	0.22	none	none	none	none	9.00	28.32
	3rd	4.30	3.90	3.00	none	none	none	none	none	2.00	13.20
	4th	3.80	4.00	2.50	0.32	none	none	none	none	none	10.62
2000	1st	3.50	3.00	1.50	0.05	none	none	none	none	none	8.05
	2nd	2.65	3.70	2.00	0.11	none	none	none	none	none	8.46
	3rd	2.00	2.20	1.70	0.05	none	none	none	none	none	5.95
	4th	3.45	4.00	2.85	0.05	none	none	none	none	none	10.35
2001	1st	1.80	1.50	1.40	0.16	none	none	none	none	none	4.86
	2nd	4.00	4.00	2.50	0.11	none	none	none	none	none	10.61
	3rd	18.50	20.00	12.50	0.16	none	none	none	none	none	51.16
	4th	9.30	8.20	7.40	0.16	none	none	none	none	none	25.06
2002	1st	8.40	7.10	6.30	0.11	none	none	none	none	none	21.91
	2nd	6.5	5.45	4.80	0.05	none	none	none	none	none	16.80
	3rd	0.8	0.5	0.9	none	none	none	none	none	none	2.20
Totals		254.28	178.68	79.60	5.28	0.69	0.23	0.06	1.33	215.40	735.55
		512.56 (extraction wells)			7.59 (monitoring wells)						
		520.15 (total removed from ground water wells)									

ENGLAND GEOSYSTEM
ENVIRONMENTAL ENGINEERING

Appendix B

Historical BTEX Results Summary Table

ENGLAND
GEOSYSTEM
ENVIRONMENTAL ENGINEERING

Table B-1
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Ground Water
Concentrations in ug/L

Well Number	Date Sampled	Benzene	Toluene	Ethyl Benzene	Xylenes (total)	Method
MW-1S	2/26/92	5.0 J	<10	<10	<10	EPA 8240
	6/26/92	14	<10	<10	<10	EPA 8240
	9/23/92	4.0 J	<10	<10	<10	EPA 8240
	11/19/92	<0.94	<0.50	<0.50	<1.0	EPA 8020
	11/12/93	7.5	<0.30	<0.50	0.54	EPA 8020
	5/10/94	12	1.0	0.32	<0.60	EPA 8020
	8/9/94	<0.30	2.7	<0.30	<0.60	EPA 8020
	11/11/94	<0.30	<0.30	<0.30	<0 60	EPA 8020
	2/8/95	<0.64	<0.30	<0.30	<0.60	EPA 8020
	11/12/95	<0.30	<0.30	<0.30	<0.60	EPA 8020
	11/12/96	<0.30	<0.30	<0.30	<0.60	EPA 8020
	11/27/97	<0.30	<0.30	<0.30	<0.60	EPA 8020
	11/20/98	<0.3	<0.3	<0.3	<0 6	EPA 8020
	11/24/99	1.8	<0.3	<0.3	<0.6	EPA 8021B
	6/5/00	<0.30	<0.30	<0.30	<0.60	EPA 8021B
	11/15/00	<0.30	0.46	<0.30	<0.60	EPA 8021B
	11/29/01	<0.30	<0.30	<0.30	<0.60	EPA 8021B
MW-2S	2/22/93	950	60	24	50	EPA 8020
	5/20/93	700 J	40 J	18 J	66 J	EPA 8020
	8/17/93	1000 J	76 J	29 J	57 J	EPA 8020
	11/16/93	450 J	100 J	29 J	22 R	EPA 8020
	2/11/94	1300	100	23	110	EPA 8020
	5/12/94	1300	75	23	75	EPA 8020
	8/12/94	150	66	<6.0	100	EPA 8020
	11/15/94	1300 J	93	<30	94 J	EPA 8020
	2/10/95	1100	87	20	89	EPA 8020
	5/11/95	560 J	61 J	12 J	65 J	EPA 8020
	8/10/95	600 J	60 J	15 J	75 J	EPA 8020
	11/9/95	480 J	46 J	14 J	68 J	EPA 8020
	2/10/96	880	51	<9.9	77	EPA 8020
	5/17/96	570	160	63	87	EPA 8020
	8/16/96	240	42	<6.0	56	EPA 8020
	2/18/97	45	12	9.5	33	EPA 8020
	5/15/97	390	99	<6.0	65	EPA 8020
	11/27/97	42 J	24 J	<0.60	18 J	EPA 8020
	5/16/98	91.9 J	4.0 J	3.3 J	<6.0 J	EPA 8020
	11/20/98	126 J	12.0 J	8.4 J	21.6 J	EPA 8020
	6/2/99	274	57	22.7 J	66.2 J	EPA 8021B
	11/26/99	130	8.8	11	49	EPA 8021B
	11/26/99	160	<10	13	31	EPA 8260
	6/3/00	15	4.5	1	9.7 J	EPA 8021B
	11/17/00	87 J	40 J	9.7 J	50 J	EPA 8021B
	5/25/01	2.8	0.9	0 35	3.8	EPA 8021B

Table B-1
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Ground Water
Concentrations in ug/L

Well Number	Date Sampled	Benzene	Toluene	Ethyl Benzene	Xylenes (total)	Method
MW-2S	11/30/01	130	53	9 3	67	EPA 8021B
	5/24/02	<0.30	<0.30	<0 30	2	EPA 8021B
MW-3S	2/22/93	43	<3.6	1.2	<3.0	EPA 8020
	5/19/93	42 J	4.0 J	1.0 J	2.0 J	EPA 8020
	8/17/93	55 J	6.7 J	<0.85	<3 9	EPA 8020
	11/16/93	62	23	18	6.6	EPA 8020
	2/10/94	50	4.7 J	23 J	4.7	EPA 8020
	5/11/94	38 J	5.2 J	<0.30	16 J	EPA 8020
	8/10/94	50	7.9	<0.99	23	EPA 8020
	11/14/94	66	11	<3.0	23	EPA 8020
	2/8/95	58 J	12 J	<0.99	25 J	EPA 8020
	5/10/95	37 J	13 J	<0.75	14 J	EPA 8020
	8/11/95	22 J	11 J	<1.5	14 J	EPA 8020
	11/16/95	24 J	15 J	<1.5	15 J	EPA 8020
	2/8/96	22	15	<6.0	14	EPA 8020
	5/18/96	17 J	33 J	12 J	33 J	EPA 8020
	8/15/96	11 J	6.4 J	<0.60	14 J	EPA 8020
	2/24/97	19 J	4.2 J	<1.5	28 J	EPA 8020
	5/15/97	14 J	10 J	<0.60	<12	EPA 8020
	11/27/97	9.4 J	23 J	<0.30	18 J	EPA 8020
	5/16/98	9.2 J	3.9 J	0.5 J	1.8 J	EPA 8020
	11/20/98	4.4	2.3	<0.3	5.6	EPA 8020
	5/30/99	1.9	<0.3	<0 3	<0.6	EPA 8021B
	11/25/99	1.7	1.5	0.4	3.6	EPA 8021B
	6/2/00	4.4	2.6	0 58	9.3	EPA 8021B
	11/27/00	2.2	2.7	1.3	6.4	EPA 8021B
	5/25/01	6 J	5.6 J	1.3 J	12 J	EPA 8021B
	11/29/01	0.51	0.54	<0.30	1.8	EPA 8021B
	5/24/02	<0.30	<0.30	<0 30	<0.60	EPA 8021B
MW-4S	2/23/93	<0.50	<0.50	<0.50	<1.0	EPA 8020
MW-6S	9/25/90	20	<2.0	<1.0	<1.0	EPA 8240
	1/18/91	<1.0	<2.0	<1.0	<1.0	EPA 8240
	5/3/91	<1.0	<2.0	<1.0	<1.0	EPA 8240
	8/13/91	<10	<10	<10	<10	EPA 8240
	11/14/91	<10	<10	<10	<10	EPA 8240
	2/25/92	<10	<10	<10	<10	EPA 8240
	6/24/92	<10	<10	<10	1.0 J	EPA 8240
	9/18/92	<10	<10	<10	<10	EPA 8240
	11/17/92	0.61	<0.50	<0.50	<1.0	EPA 8020
	2/23/93	0.92	<2.2	0.58	<2.0	EPA 8020
	5/18/93	0.30	<0.30	0.30	9.0	EPA 8020
	8/17/93	2.2	<0.48	2.2	<2.0	EPA 8020

Table B-1
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Ground Water
Concentrations in ug/L

Well Number	Date Sampled	Benzene	Toluene	Ethyl Benzene	Xylenes (total)	Method
MW-6S	11/15/93	<0.30	<0.30	<0.50	6.0	EPA 8020
	2/9/94	4.7	0.42	<0 30	15	EPA 8020
	5/10/94	12 J	17	8.9	0.92	EPA 8020
	8/10/94	20	0 94	<0.30	14	EPA 8020
	11/11/94	34	35	<0.60	19	EPA 8020
	2/8/95	7.5	<0.79	0.39	9.1	EPA 8020
	5/10/95	2.7 J	<0.30	<0.30	10 J	EPA 8020
	8/8/95	17	1.8	2.6	6.3	EPA 8020
	11/9/95	25	2.0	<0.60	16	EPA 8020
	2/10/96	160	9.6	<3.0	56	EPA 8020
	5/17/96	34 J	32 J	20	8.8 J	EPA 8020
	8/16/96	72	4.0	<0.75	26	EPA 8020
	11/8/96	70 J	4.0 J	<0.60	14 J	EPA 8020
	2/18/97	21	0.93	<0.30	10	EPA 8020
	5/15/97	40	39	<0.60	8.6	EPA 8020
	11/25/97	83	71	18	15	EPA 8020
	11/25/97	120	8 6	<2.0	2.2	EPA 8240
	5/15/98	0.5	<0.3	<0.3	<0.6	EPA 8020
	11/20/98	6.5	0.7	<0.3	8 2	EPA 8020
	6/2/99	35.1	<0.3	2.1	<0 6	EPA 8021B
	11/26/99	20	3.4	<0.3	8.8	EPA 8021B
	6/3/00	92	12	1.6	36	EPA 8021B
	11/17/00	48	8.2	0.71	25 J	EPA 8021B
	5/25/01	0.34	0.8	0.85	1.4	EPA 8021B
	11/30/01	65	9.4	<3.0	29	EPA 8021B
	5/24/02	150 J	28 J	<0.30	99 J	EPA 8021B
MW-7S	2/28/92	220	59	<50	27 J	EPA 8240
	6/29/92	240	41	4.0 J	17 J	EPA 8240
	9/24/92	75	14	<10	<10	EPA 8240
	11/25/92	350	63	7.9	26	EPA 8020
	11/25/92	250	54	5.0	20	EPA 8240
	2/24/93	380 J	110 J	44 J	140 J	EPA 8020
	5/20/93	380 J	80 J	9.0 J	60 J	EPA 8020
MW-8S	10/4/90	230	74	6.0	25	EPA 8240
	8/15/91	150	10 J	<50	7.0 J	EPA 8240
	11/15/91	190	21	<10	3.0 J	EPA 8240
	2/28/92	75	17	<10	16	EPA 8240
	6/30/92	150	29	<20	14 J	EPA 8240
	9/24/92	240	38	<20	3.0 J	EPA 8240
	8/17/93	310 J	74 J	9.8 J	25 J	EPA 8020
	11/16/93	360	66	28	21	EPA 8020
	2/10/94	380	51 J	36 J	29	EPA 8020
	5/11/94	310	46	<7.5	23	EPA 8020

Table B-1
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Ground Water
Concentrations in ug/L

Well Number	Date Sampled	Benzene	Toluene	Ethyl Benzene	Xylenes (total)	Method
MW-8S	8/11/94	490	180	45	50	EPA 8020
	11/15/94	98 J	47 J	7.6 J	49 J	EPA 8020
	2/9/95	140	36	14	35	EPA 8020
	5/10/95	100	36	15	37	EPA 8020
	8/8/95	150	56	10	48	EPA 8020
	11/16/95	83 J	29 J	8.0 J	31 J	EPA 8020
	2/9/96	<0.30 R	<0.30 R	<0.30 R	<0.60 R	EPA 8020
	5/14/96	120	40	11	45	EPA 8020
	8/15/96	95 J	28 J	6.8 J	21 J	EPA 8020
	11/12/96	58	30	19	25	EPA 8020
	2/20/97	45 J	19 J	6.2 J	15 J	EPA 8020
	5/18/97	53 J	27 J	6.9 J	24 J	EPA 8020
	11/25/97	27 J	12 J	5.1 J	7.7 J	EPA 8020
	5/14/98	38.3	26.1	8.3	18.2	EPA 8020
	11/21/98	26.0 J	16 8 J	4.8 J	15.8 J	EPA 8020
	5/30/99	30.8 J	10 J	4.1 J	15.5 J	EPA 8021B
	11/24/99	40	21	6.1	18	EPA 8021B
	6/3/00	19	9.9	5.4	19	EPA 8021B
	11/17/00	18	14	2.3	12	EPA 8021B
	5/26/01	40 J	57 J	17 J	53 J	EPA 8021B
	11/30/01	15	5.3	<3.0	7.1	EPA 8021B
	5/26/02	16	9	4.2	23	EPA 8021B
MW-9S	2/25/92	54	11	7.0 J	<10	EPA 8240
	6/29/92	18	12	3.0 J	11	EPA 8240
	9/23/92	17	9.0 J	2.0 J	7.0 J	EPA 8240
	5/21/93	18 J	11 J	14 J	30 J	EPA 8020
	8/17/93	33 J	89 J	28 J	160 J	EPA 8020
	11/17/93	30 J	17 J	11 J	23 J	EPA 8020
	2/11/94	51	29	14	34	EPA 8020
	5/11/94	24 J	47	<6.0	<12	EPA 8020
	8/11/94	42 J	15 J	9.4 J	22 J	EPA 8020
	11/15/94	32 J	11 J	<3.0	14 J	EPA 8020
	2/9/95	14 J	8.0 J	8.1 J	20 J	EPA 8020
	5/12/95	17 J	12 J	6.9 J	16 J	EPA 8020
	8/11/95	16 J	8.7 J	6.3 J	11 J	EPA 8020
	11/16/95	12	<1.5	11	16	EPA 8020
	2/9/96	10	4.9	3.6	<6.0	EPA 8020
	5/18/96	11	4.6	5.7	6.7	EPA 8020
	8/17/96	5.0 J	1.3 J	2.1 J	4.1 J	EPA 8020
	11/12/96	3.0	1.5	7.5	9.5	EPA 8020
	2/25/97	7.5 J	7.6 J	3.8 J	8.1 J	EPA 8020
	5/18/97	8.3 J	2.5 J	2.3 J	<0.60	EPA 8020
	11/25/97	3.9	2.2	1.7	3.2	EPA 8020

Table B-1
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Ground Water
Concentrations in ug/L

Well Number	Date Sampled	Benzene	Toluene	Ethyl Benzene	Xylenes (total)	Method
MW-9S	5/15/98	11.7	8.7	7.8	14.5	EPA 8020
	11/28/98	1 2	4 6	2 5	7.2	EPA 8020
	6/2/99	17.3 J	3.1 J	11.4 J	33.8 J	EPA 8021B
	11/24/99	46	21	35	44	EPA 8021B
	6/3/00	<0.30	0.63	0.89	2.4	EPA 8021B
	11/17/00	1.9	1.4	<0.30	0.74	EPA 8021B
	5/26/01	24 J	84 J	13 J	30 J	EPA 8021B
	11/30/01	<0.30	<0.30	<0.30	7.5	EPA 8021B
	5/26/02	40	<3.0	29	57	EPA 8021B
MW-11S	10/3/90	<1.0	<2.0	<1.0	<1.0	EPA 8240
	8/15/91	<10	<10	<10	<10	EPA 8240
	11/14/91	<100	<100	<100	<100	EPA 8240
	2/21/92	<40	<40	<40	<40	EPA 8240
	6/25/92	<10	<10	<10	<10 J	EPA 8240
	9/22/92	<10	<10	<10	<10	EPA 8240
	11/18/92	<0.50	<0.50	<0.50	<1.0	EPA 8020
	11/11/93	<0.30	<0.30	<0.50	<0.50	EPA 8020
MW-12S	2/24/92	<10	<10	<10	<10	EPA 8240
	6/25/92	<10	<10	<10	<10 J	EPA 8240
	9/22/92	<10	<10	<10	<10	EPA 8240
	11/18/92	<0.50	<0.50	<0.50	<1.0	EPA 8020
	11/11/93	<0.30	<0.30	<0.50	<0.50	EPA 8020
MW-14S	6/30/92	<10	<10	<10	<10	EPA 8240
	9/18/92	5.0 J	2.0 J	<10	1.0 J	EPA 8240
	11/17/92	2.8	<0.50	<0.50	<1.0	EPA 8020
	2/23/93	4.8	<0.70	<0.50	<1.1	EPA 8020
	5/17/93	27 J	4.0 J	<0.30	5.0 J	EPA 8020
	8/17/93	69 J	12 J	1.3 J	10 J	EPA 8020
	11/15/93	59	7.3	6.8	6.4	EPA 8020
	2/10/94	160	31 J	9.4 J	9.4	EPA 8020
	5/12/94	93	15	<0.75	12	EPA 8020
	8/11/94	220 J	37 J	<3.0	28 J	EPA 8020
	11/10/94	120 J	19 J	1.5 J	18 J	EPA 8020
	2/9/95	72 J	10 J	<3.0	8.9 J	EPA 8020
	5/11/95	42 J	6.7 J	<0.60	5.9 J	EPA 8020
	8/10/95	57 J	12 J	<1.5	13 J	EPA 8020
	11/11/95	34	9.5	<3.0	6.1	EPA 8020
	2/8/96	13	3.0	<1.0	4.0	EPA 8020
	5/23/96	5.7 J	2.1 J	<0.30	3.2 J	EPA 8020
	8/16/96	3.7 J	2.7 J	<0.30	3.8 J	EPA 8020
	11/14/96	1.1 J	1.2 J	<0.30	2.8 J	EPA 8020
	2/25/97	0.95 J	1.1 J	<0.30	3.1 J	EPA 8020

Table B-1
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Ground Water
Concentrations in ug/L

Well Number	Date Sampled	Benzene	Toluene	Ethyl Benzene	Xylenes (total)	Method
MW-14S	5/16/97	0.90 J	1.2 J	<0.60	2.9 J	EPA 8020
	11/28/97	<0.30	0.45 J	<0.30	1.8 J	EPA 8020
	5/14/98	1.0	<0 3	<0 3	<0.6	EPA 8020
	11/30/98	2.7	<0.3	<0.3	3.2	EPA 8020
	6/2/99	4.3	1.2	<0.3	1 6	EPA 8021B
	11/27/99	<0.3	<0 3	<0.3	<0.6	EPA 8021B
	6/3/00	2.7	1	<0.30	1.6	EPA 8021B
	11/17/00	0.78 J	0 6	<0.30	0.93	EPA 8021B
	5/27/01	1.4 J	<0.30 J	<0.30 J	<0.60 J	EPA 8021B
	11/28/01	1 2	0.74	<0.30	2.5	EPA 8021B
	5/26/02	3.9	<0.30	<0.30	1 9	EPA 8021B
MW-17S	2/26/92	370	58	12 J	33 J	EPA 8240
	5/21/93	800 J	47 J	9.8 J	20 J	EPA 8020
	8/18/93	960 J	63 J	16 J	60 J	EPA 8020
	11/17/93	740	41	<17 R	19 J	EPA 8020
	2/11/94	550	32	<15	37	EPA 8020
	5/12/94	1200 J	84 J	81 J	<30 J	EPA 8020
	8/12/94	720 J	35 J	<15	<30	EPA 8020
	11/15/94	1100 J	<60	<60	<120	EPA 8020
	2/10/95	1000	54	<30	<60	EPA 8020
	5/12/95	620	66 J	28	61 J	EPA 8020
	8/11/95	880	71	<15	47	EPA 8020
	11/17/95	240 J	3.3 J	13 J	<6.0	EPA 8020
	2/7/96	200	6.6 J	11	12 J	EPA 8020
	5/23/96	79	5.0	4.4	10	EPA 8020
	8/17/96	66 J	8.5 J	4.3	15 J	EPA 8020
	11/14/96	39 J	<1.5	<1.5	5.9 J	EPA 8020
	2/25/97	13 J	1.7 J	3.9 J	4.5 J	EPA 8020
	5/18/97	29 J	3.3 J	<0.60	6.7 J	EPA 8020
	11/27/97	1.6 J	0.70 J	1.5 J	3.0 J	EPA 8020
	5/16/98	12.8	2.3	1.6	<0.6	EPA 8020
	11/29/98	11.3	1.9	1.2	6 5	EPA 8020
	6/2/99	<0.3	3.9	1.2	5.0	EPA 8021B
	11/25/99	3.4	<0.3	<0.3	<0.6	EPA 8021B
	6/2/00	0.99	<0.30	1	4.7	EPA 8021B
	11/27/00	1.2	3.4	2	5.6	EPA 8021B
	5/25/01	34	8.1	3.4	11	EPA 8021B
	11/27/01	5.8	2.1	3	10	EPA 8021B
	5/27/02	16	4.2	1.9	2.9	EPA 8021B
MW-18S	9/26/90	<1.0	<2.0	1.0 J	3.0	EPA 8240
	1/17/91	<1.0	<2.0	<1.0	<1.0	EPA 8240
	5/3/91	<1.0	<2.0	<1.0	<1.0	EPA 8240
	8/13/91	<100	<100	<100	<100	EPA 8240

Table B-1
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Ground Water
Concentrations in ug/L

Well Number	Date Sampled	Benzene	Toluene	Ethyl Benzene	Xylenes (total)	Method
MW-18S	11/13/91	<10	<10	<10	<10	EPA 8240
	2/24/92	<10	<10	<10	<10	EPA 8240
	6/29/92	<10	<10	<10	<10	EPA 8240
	9/22/92	<10	<10	<10	<10	EPA 8240
	11/19/92	<0.50	<16 J	9.9 J	<18 J	EPA 8020
	2/24/93	<0.50	<0.50	3.1 J	6.8 J	EPA 8020
	5/21/93	<1.5	<7.8	9.8 J	<11	EPA 8020
	8/17/93	5.1 J	12 J	16 J	18 J	EPA 8020
	11/15/93	5.3	3.0	4.8	7.5	EPA 8020
	2/10/94	3.8	<0.75	1.7	8.3	EPA 8020
	5/11/94	4.1	7.4	6.4	18	EPA 8020
	8/10/94	<0.60	4.1	3.0	3.1	EPA 8020
	11/11/94	<0.60	2 2	1.9	1.7	EPA 8020
	2/9/95	<1.5 J	<0.30 J	2.0 J	3.5 J	EPA 8020
	5/10/95	4.9 J	3.0 J	2.1 J	2.2 J	EPA 8020
	8/11/95	<1.5	3.4 J	3.1 J	4.4 J	EPA 8020
	11/12/95	<0.60	<0.60	<0.60	<1.2	EPA 8020
	2/9/96	2.6	3.6	0.98	1 1	EPA 8020
	5/17/96	7.1 J	<1.5 J	3.6 J	7.1 J	EPA 8020
	8/15/96	2.4 J	2.4 J	1.7 J	5.1 J	EPA 8020
	11/9/96	<0.60	1.7 J	14 J	23 J	EPA 8020
	2/24/97	<0.30	<0.30	<0.30	<0.60	EPA 8020
	5/16/97	<0.30	3.3 J	<0.30	2.8 J	EPA 8020
	11/27/97	1.9 J	0.80 J	0.79 J	4.4 J	EPA 8020
	5/14/98	2.4	4 7	<0.6	5.0	EPA 8020
	11/29/98	0.8	0.4	1.1	2.9	EPA 8020
	6/1/99	<0.3	3.2	<0.3	2.4	EPA 8021B
	11/25/99	<0.6	<0.6	<0.6	2.4	EPA 8021B
	6/4/00	<0.30	<0.30	0.84	1.5	EPA 8021B
	11/27/00	<0.30	2.1	0 69	1.4	EPA 8021B
	5/26/01	0.49	4.2	2.6	3.9	EPA 8021B
	11/30/01	3.8	0.62	0.9	2.9	EPA 8021B
	5/24/02	<0.30	2.6	1.1	2.7	EPA 8021B
MW-19S	9/26/90	540	80	<3.0	70	EPA 8240
	1/17/91	320	52	6.0	30	EPA 8240
	5/1/91	280	37	4.0	17	EPA 8240
	8/13/91	50	7.0 J	<20	6.0 J	EPA 8240
	11/15/91	370	36	10 J	29	EPA 8240
	2/28/92	100	7.0 J	<10	5.0 J	EPA 8240
	6/30/92	260	32	7.0 J	23	EPA 8240
	9/24/92	240	30	7.0 J	19 J	EPA 8240
	11/16/92	300 J	39 J	12 J	19 J	EPA 8020
	11/16/92	190 J	28 J	5.0 J	21 J	EPA 8240

Table B-1
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Ground Water
Concentrations in ug/L

Well Number	Date Sampled	Benzene	Toluene	Ethyl Benzene	Xylenes (total)	Method
MW-19S	2/24/93	220 J	37 J	8 8 J	29 J	EPA 8020
	5/14/93	300	48	14	40	EPA 8020
	8/12/93	320 J	53 J	14 J	44 J	EPA 8020
	2/8/94	530	81	4.0	63	EPA 8020
	5/10/94	620	140	24	<30	EPA 8020
	8/9/94	370	72	6.2	26	EPA 8020
	11/8/94	160	34	<6 0	23	EPA 8020
	11/8/94	110	31	<2 0	10	EPA 8240
	2/7/95	280	49	9.0	34	EPA 8020
	5/9/95	350 J	63 J	11 J	37 J	EPA 8020
	8/8/95	350	64	<15	40	EPA 8020
	11/7/95	100	46	<20	<20	EPA 8240
	11/7/95	82 J	38 J	7.5 J	27 J	EPA 8020
	2/6/96	47	24	<15	<30	EPA 8020
	5/19/96	90	37	<6.0	18	EPA 8020
	8/15/96	64	21	5 7	22	EPA 8020
	11/8/96	120 J	38 J	6 5 J	20 J	EPA 8020
	11/8/96	130	39	<10	<10	EPA 8240
	2/20/97	20 J	16 J	1.2 R	10 J	EPA 8020
	5/18/97	74 J	25 J	7 4 J	18 J	EPA 8020
	11/27/97	34 J	16 J	7 3 J	17 J	EPA 8020
	5/15/98	19 J	11 7 J	4.9 J	7.0 J	EPA 8020
	11/20/98	4.5	<0 3	<0 3	3 0	EPA 8020
	6/1/99	16.8	2 6	0.8	6.4	EPA 8021B
	11/26/99	39	13	4.4	12	EPA 8021B
	6/4/00	<0.30	<0.30	<0.30	<0 60	EPA 8021B
	11/27/00	20 J	10 J	3 J	11 J	EPA 8021B
	5/26/01	<0.30	0.45	<0.30	1.6	EPA 8021B
	11/30/01	29	10	2.9	10	EPA 8021B
	5/24/02	<0 30	<0.30	<0.30	1 8	EPA 8021B
MW-20S	9/25/90	5 0	4.0	3.0	1.0	EPA 8240
	1/17/91	11	7 0	39	3 0	EPA 8240
	5/1/91	4.0	<2.0	8 0	2.0	EPA 8240
	8/22/91	21	10	49	16	EPA 8240
	11/13/91	3.0 J	<10	3.0 J	<10	EPA 8240
	2/20/92	180	36	<20	16 J	EPA 8240
	6/30/92	270	59	12 J	24	EPA 8240
	5/21/93	320 J	130 J	33 J	120 J	EPA 8020
	8/18/93	500 J	120 J	27 J	58 J	EPA 8020
	11/17/93	380	130	31	41	EPA 8020
	11/17/93	300	91	14	45	EPA 8240
	2/11/94	580	130	32	83	EPA 8020
	5/11/94	300	100	8 6	55	EPA 8020

Table B-1
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Ground Water
Concentrations in ug/L

Well Number	Date Sampled	Benzene	Toluene	Ethyl Benzene	Xylenes (total)	Method
MW-20S	8/11/94	290	88	29	59	EPA 8020
	11/14/94	300 J	79 J	38 J	60 J	EPA 8020
	2/9/95	530	85	<30	60	EPA 8020
	5/11/95	300 J	90	36	83 J	EPA 8020
	8/10/95	490 J	110 J	21 J	72 J	EPA 8020
	11/11/95	360 J	66	23 J	50 R	EPA 8020
	2/10/96	350	79	17	47	EPA 8020
	5/18/96	360 J	92	15 J	54	EPA 8020
	8/16/96	190	63	21	44	EPA 8020
	11/9/96	200 J	56 J	17 J	43 J	EPA 8020
	2/25/97	300 J	79 J	14 J	49 J	EPA 8020
	5/16/97	270 J	81 J	20 J	58 J	EPA 8020
	11/29/97	220 J	54 J	13 J	44 J	EPA 8020
	11/29/97	200	70	8.5	41	EPA 8240
	5/15/98	260	77.1	12.0	33.5	EPA 8020
	11/27/98	291	87	16	63	EPA 8020
	11/27/98	237	88	12	50	EPA 8260
	6/3/99	281	81	17	57	EPA 8021B
	11/28/99	210	57	12	33 J	EPA 8021B
	6/4/00	67	19	3	15	EPA 8021B
	11/17/00	170	56	15	48	EPA 8021B
	5/25/01	22	11	3	7.4	EPA 8021B
	11/27/01	110 J	38 J	14 J	38 J	EPA 8021B
	5/26/02	92	34	8.7	33	EPA 8021B
MW-21S	9/26/90	<1.0	<2.0	<1.0	<1.0	EPA 8240
	1/16/91	<1.0	<2.0	<1.0	<1 0	EPA 8240
	5/3/91	<1.0	<2.0	<1.0	<1.0	EPA 8240
	8/14/91	<10	<10	<10	<10	EPA 8240
	11/8/91	<10	<10	<10	<10	EPA 8240
	2/19/92	<10	<10	<10	<10	EPA 8240
	6/23/92	<10	<10	<10	<10	EPA 8240
	9/17/92	<10	<10	<10	<10	EPA 8240
MW-22S	8/29/90	<5.0	<5.0	<5.0	<5.0	EPA 8240
	9/27/90	<1.0	<2.0	<1.0	<1.0	EPA 8240
	1/18/91	<1.0	<2.0	<1.0	<1.0	EPA 8240
	5/2/91	<1.0	<2.0	<1.0	<1.0	EPA 8240
	8/14/91	<10	<10	<10	<10	EPA 8240
	11/8/91	<10	<10	<10	<10	EPA 8240
	2/19/92	<10	<10	<10	<10	EPA 8240
	6/22/92	<10	<10	<10	<10	EPA 8240
	9/17/92	<10	<10	<10	<10	EPA 8240
MW-25S	8/28/90	<5.0	<5.0	<5 0	<5.0	EPA 8240

Table B-1
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Ground Water
Concentrations in ug/L

Well Number	Date Sampled	Benzene	Toluene	Ethyl Benzene	Xylenes (total)	Method
MW-25S	9/28/90	<1.0	<2.0	<1.0	<1.0	EPA 8240
	1/14/91	<1.0	<2.0	<1.0	<1 0	EPA 8240
	4/30/91	<1.0	<2.0	<1.0	<1.0	EPA 8240
	8/12/91	3.0 J	<10	<10	<10	EPA 8240
	11/11/91	<10	<10	<10	<10	EPA 8240
	2/21/92	2.0 J	<10	<10	<10	EPA 8240
	6/26/92	<10	<10	<10	<10	EPA 8240
	9/22/92	1.0 J	3.0 J	<10	4 0 J	EPA 8240
	11/18/92	<0.50	<0.50	<0.50	9.0	EPA 8020
	2/23/93	<0.50	<0.50	1.4	<4 8 J	EPA 8020
	5/18/93	0.60 J	<0.30	1.0 J	1.5 J	EPA 8020
	8/16/93	<0.71	<0.30	0 77 J	5.8 J	EPA 8020
	11/12/93	2.2	<0.30	<0.50	0.75	EPA 8020
	2/10/94	<0.30	0.44	0.89	3.0	EPA 8020
	11/11/94	<0.30	<0.30	<0.30	<0.60	EPA 8020
	11/8/95	<0.30	<0.30	<0.30	<0.60	EPA 8020
	11/9/96	<0.30	<0.30	<0.30	<0.60	EPA 8020
	11/28/97	<0.30	<0.30	<0.30	1 3	EPA 8020
	11/21/98	<0.3	<0.3	<0.3	<0.6	EPA 8020
	11/24/99	0.6	<0.3	0.4	<0.6	EPA 8021B
	6/2/00	<0.30	<0 30	<0.30	<0.60	EPA 8021B
	11/15/00	<0.30	<0.30	<0.30	<0.60	EPA 8021B
	11/30/01	<0.30	<0.30	<0.30	<0.60	EPA 8021B
MW-26S	8/28/90	720	73	14	28	EPA 8240
	9/25/90	21 J	110	15	49	EPA 8240
	1/16/91	49	6.0	2.0	5.0	EPA 8240
	5/1/91	4.0	<2.0	<1.0	<1.0	EPA 8240
	8/12/91	3.0 J	<20	<20	<20	EPA 8240
	11/14/91	9.0 J	<10	<10	<10	EPA 8240
	2/26/92	4.0 J	<10	<10	<10	EPA 8240
	6/26/92	150	10	3.0 J	4.0 J	EPA 8240
	9/24/92	410	27 J	6.0 J	9.0 J	EPA 8240
	11/24/92	40	3.4	5.1	3.5	EPA 8020
	11/24/92	36	3.0	<1 0	<1.0	EPA 8240
	11/16/93	60	11	5.1	3.3	EPA 8020
	11/16/93	57	6.0	<2.0	<2.0	EPA 8240
MW-27S	1/14/91	<1.0	<2.0	<1.0	<1.0	EPA 8240
	4/30/91	63	47	150	55	EPA 8240
	8/12/91	5.0 J	2.0 J	5.0 J	2.0 J	EPA 8240
	11/14/91	4.0 J	2.0 J	10	3.0 J	EPA 8240
	2/26/92	36	<10	<10	<10	EPA 8240
	6/26/92	42	<10	<10	<10	EPA 8240
	9/23/92	47	<10	1.0 R	<10	EPA 8240

Table B-1
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Ground Water
Concentrations in ug/L

Well Number	Date Sampled	Benzene	Toluene	Ethyl Benzene	Xylenes (total)	Method
MW-27S	11/23/92	53 J	1.6 J	2 1 R	4.9 J	EPA 8020
	11/23/92	55 J	<2.0	<1.0	1.0 R	EPA 8240
	2/23/93	21	<0.67	0 76	<1 0	EPA 8020
	5/18/93	19	<0.30	0.5	2.0	EPA 8020
	8/16/93	12	<1.6	1.7	<1.0	EPA 8020
	11/12/93	4.0	<2.0	<2.0	<2.0	EPA 8240
	11/12/93	23	1.3	2.1	3.5	EPA 8020
	2/10/94	<0.30	2.2	2.8	1.8	EPA 8020
MW-28S	1/15/91	110	27	16	29	EPA 8240
	5/1/91	35	9.0	6.0	12	EPA 8240
	8/12/91	120	27	26	43	EPA 8240
	11/14/91	17	<10	3.0 J	3.0 J	EPA 8240
	2/26/92	51	3 0 J	7.0 J	6.0 J	EPA 8240
	6/29/92	53	2.0 J	5 0 J	2.0 J	EPA 8240
	9/23/92	270	11 J	41	10 J	EPA 8240
	11/23/92	130	4 1	15	14	EPA 8020
	11/23/92	110	3.0	12	3.0	EPA 8240
	2/24/93	54	<2.6	6.0	<3.4 J	EPA 8020
	5/19/93	150 J	7 0 J	20 J	17 J	EPA 8020
	8/17/93	130	9.2	25	37	EPA 8020
	2/8/94	320	52	51	76	EPA 8020
	5/13/94	350	54	120	130	EPA 8020
	8/12/94	1200	180	230	<300	EPA 8020
	11/14/94	820 J	110	130	110	EPA 8020
	2/9/95	390	81	120	95	EPA 8020
	5/12/95	410 J	73 J	100 J	73 J	EPA 8020
	8/11/95	480	84	87	78	EPA 8020
	11/6/95	310	67	66	82	EPA 8020
	12/11/95	410 J	88 J	75 J	92 J	EPA 8020
	1/25/96	330	79	70	75	EPA 8020
	2/10/96	310	72	66	81	EPA 8020
	3/5/96	310	82	77	87	EPA 8020
	4/16/96	330	77	64	72	EPA 8020
	5/21/96	390	92	81	120	EPA 8020
	6/12/96	270	140	110	61	EPA 8020
	7/11/96	380	88	72	86	EPA 8020
	8/13/96	280	160	120	89	EPA 8020
	9/10/96	410	97	74	100	EPA 8020
	10/10/96	240	130	87	70	EPA 8020
	11/7/96	340	79	57	87	EPA 8020
	2/24/97	<0.30	<0.30	0.33	1.7	EPA 8020
	3/11/97	3.0 J	0.47 J	0.50 J	2.8 J	EPA 8020
	5/18/97	<0.30	<0.30	<0.30	<0.78	EPA 8020

Table B-1
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Ground Water
Concentrations in ug/L

Well Number	Date Sampled	Benzene	Toluene	Ethyl Benzene	Xylenes (total)	Method
MW-28S	11/24/97	<0.30	<0.30	<0.30	0 67	EPA 8020
	5/15/98	<0.3	0.5	<0.3	0.9	EPA 8020
	11/30/98	<0.3	<0.3	<0.3	<0 6	EPA 8020
	5/30/99	<0.3	<0 3	<0.3	<0.6	EPA 8021B
	11/30/99	<0.3	<0.3	<0.3	<0.6	EPA 8021B
	6/5/00	<0.30	<0.30	<0.30	<0 60	EPA 8021B
	11/15/00	0.88	<0.65	0.58	<2.4	EPA 8021B
	5/27/01	<0.30	<0 30	<0.30	<0.60	EPA 8021B
	11/26/01	<0.30	<0.30	<0.30	<0.60	EPA 8021B
	5/25/02	<0.30	<0.30	<0.30	<0.60	EPA 8021B
	8/19/02	9.1	0 44	0.51	1 5	EPA 8021B
MW-29S	1/15/91	2.0	<2.0	<1.0	<1.0	EPA 8240
	4/30/91	40	4.0	<1.0	3.0	EPA 8240
	8/13/91	<10	1.0 J	<10	<10	EPA 8240
	11/15/91	<10	<10	<10	<10	EPA 8240
	2/21/92	<10	<10	<10	<10	EPA 8240
	6/24/92	<10	<10	<10	1.0 J	EPA 8240
	9/21/92	<10	<10	<10	<10	EPA 8240
	11/18/92	<0.50	<0.50	<0.50	<1.0	EPA 8020
	11/11/93	<0.30	<0.30	<0.50	<0.50	EPA 8020
	11/9/94	<0.30	<0.30	<0.30	<0.60	EPA 8020
	11/8/95	<0.30	<0.30	<0.30	<0.60	EPA 8020
	11/9/96	<0.30	<0.30	<0.30	<0.60	EPA 8020
	11/24/97	<0.30	<0.30	<0.30	<0.60	EPA 8020
	11/21/98	<0.3	<0.3	<0.3	<0 6	EPA 8020
	11/24/99	<0.3	<0.3	<0.3	<0.6	EPA 8021B
	6/2/00	<0.30	<0 30	<0.30	<0.60	EPA 8021B
	11/28/00	0.32	<0.30	1.2	7.8	EPA 8021B
	11/30/01	<0.30	<0.30	<0.30	<0.60	EPA 8021B
MW-30S	1/15/91	3.0	<2.0	<1.0	<1.0	EPA 8240
	5/3/91	<1.0	<2.0	<1.0	<1.0	EPA 8240
	8/13/91	<10	<10	<10	<10	EPA 8240
	11/7/91	<10	<10	<10	<10	EPA 8240
	2/25/92	5.0 J	2.0 J	<10	<10	EPA 8240
	6/25/92	18	7.0 J	3.0 J	7.0 J	EPA 8240
	9/23/92	10	6.0 J	2.0 J	5.0 J	EPA 8240
	11/19/92	<11 J	<12 J	<3.1 J	8.8 J	EPA 8020
	2/24/93	11 J	12 J	3.3 J	10 J	EPA 8020
	5/19/93	22 J	18 J	26 J	36 J	EPA 8020
	8/16/93	28 J	27 J	28 J	35 J	EPA 8020
	11/12/93	15	8.0	6.0	11	EPA 8020
	2/10/94	12	<0.30	3.5	7.4	EPA 8020
	5/11/94	6.8 J	4.3 J	2.3 J	5.5 J	EPA 8020

Table B-1
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Ground Water
Concentrations in ug/L

Well Number	Date Sampled	Benzene	Toluene	Ethyl Benzene	Xylenes (total)	Method
MW-30S	8/10/94	11	4.8	3.2	6.5	EPA 8020
	11/14/94	8.3	<3 0	<3.0	7.2	EPA 8020
	2/9/95	39 J	8.8 J	13 J	25 J	EPA 8020
	5/10/95	8.0 J	2.9 J	3.4 J	5.5 J	EPA 8020
	8/11/95	4.4	4.5	2.8	5.5	EPA 8020
	11/9/95	5.7 J	1.8 J	2.3 J	4.4 J	EPA 8020
	2/10/96	<0.30	<0.30	<0.30	<0.60	EPA 8020
	5/21/96	3.8	5.7	6.2	9.6	EPA 8020
	8/15/96	4.2 J	3.4 J	3.6 J	8.7 J	EPA 8020
	11/8/96	5.6	2.0	2.5	4.9	EPA 8020
	2/20/97	1 0 J	2.2 J	1.5 J	3 0 J	EPA 8020
	5/18/97	<0.60	2.7 J	2.0 J	3.9 J	EPA 8020
	11/24/97	<0.30	<0.30	<0.30	<0.60	EPA 8020
	5/14/98	3.2 J	1.8 J	1.2 J	2.4 J	EPA 8020
	11/20/98	<0.3	<0.3	<0.3	<0.6	EPA 8020
	6/1/99	<0.3	<0.3	<0.3	<0.6	EPA 8021B
	11/26/99	<3.0	6.0	<3.0	11	EPA 8021B
	6/3/00	19 J	10 J	8 9 J	20 J	EPA 8021B
	11/28/00	3.7	3	3.6	11	EPA 8021B
	5/27/01	<0.30	<0.30	<0.30	<0.60	EPA 8021B
	11/30/01	<0 30	<0.30	<0.30	<0.60	EPA 8021B
	5/27/02	<0 30	<0.30	<0.30	<0.60	EPA 8021B
MW-32S	1/16/91	58	7.0	3.0	6.0	EPA 8240
	5/1/91	4.0	<2.0	<1.0	<1.0	EPA 8240
	8/14/91	<10	<10	<10	<10	EPA 8240
	11/14/91	<10	<10	<10	<10	EPA 8240
	2/20/92	<10	<10	<10	<10	EPA 8240
	6/23/92	<10	<10	<10	<10 J	EPA 8240
	9/17/92	<10	<10	<10	<10	EPA 8240
	11/16/92	<0.50	<0.50	<0.50	<1.0	EPA 8020
	2/22/93	<0.50	<0.50	<0.50	<1.0	EPA 8020
	5/17/93	<0.30	<0.30	<0.30	1.1	EPA 8020
	8/12/93	<0.30	<0.30	<0.50	<1.4	EPA 8020
	11/11/93	<0.30	0.73	2.2	0.63	EPA 8020
	2/9/94	<0.30	<0.30	<0.30	2.2	EPA 8020
MW-34S	1/16/91	<1.0	<2.0	<1.0	<1.0	EPA 8240
	5/1/91	<1.0	<2.0	<1.0	<1.0	EPA 8240
	8/14/91	<10	<10	<10	<10	EPA 8240
	11/13/91	<10	<10	<10	<10	EPA 8240
	2/19/92	<10	<10	<10	<10	EPA 8240
	6/23/92	<10	<10	<10	<10	EPA 8240
	9/21/92	<10	<10	<10	<10	EPA 8240
	11/16/92	<0.50	<0.50	<0.50	<1.0	EPA 8020

Table B-1
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Ground Water
Concentrations in ug/L

Well Number	Date Sampled	Benzene	Toluene	Ethyl Benzene	Xylenes (total)	Method
MW-34S	2/22/93	<0.50	<0.50	<0.50	<1.0	EPA 8020
	5/17/93	<0.30	<0.30	<0.30	<0 60	EPA 8020
	8/12/93	<0.30	<0.30	<0.50	<0.53	EPA 8020
	11/11/93	<0.30	<0.30	<0.50	<0.50	EPA 8020
	2/9/94	<0.30	<0.30	<0.30	<0.60	EPA 8020
MW-35S	11/11/91	<10	<10	<10	<10	EPA 8240
	2/18/92	<10	<10	<10	<10	EPA 8240
	6/23/92	<10	1.0 J	<10	2.0 J	EPA 8240
	9/21/92	<10	<10	<10	<10	EPA 8240
	11/18/92	<0.50	<0.50	<0.50	<1.0	EPA 8020
	11/10/93	<0.30	<0.30	<0.50	<0.50	EPA 8020
	11/9/94	<0.30	<0.30	<0.30	<0.60	EPA 8020
	11/11/95	<0.30	<0.30	<0.30	<0.30	EPA 8020
	11/8/96	<0.30	<0.30	<0.30	<0.60	EPA 8020
	11/24/97	<0.30	<0.30	<0.30	<0.60	EPA 8020
	11/27/98	<0.3	0.4	<0.3	<0.6	EPA 8020
	11/28/99	<0.3	<0.3	<0.3	<0 6	EPA 8021B
	6/5/00	<0.30	<0.30	<0.30	<0 60	EPA 8021B
	11/17/00	<0.30	<0.30	<0.30	< 0.60	EPA 8021B
	11/27/01	<0.30	<0.30	<0.30	<0 60	EPA 8021B
MW-36S	11/11/91	<10	<10	<10	<10	EPA 8240
	2/18/92	<10	<10	<10	<10	EPA 8240
	6/23/92	<10	<10	<10	<10	EPA 8240
	9/21/92	<10	<10	<10	<10	EPA 8240
	11/18/92	<0.50	<0.50	<0.50	<1.0	EPA 8020
	11/10/93	<0.30	<0.30	<0.50	<0.50	EPA 8020
MW-37S	5/19/93	20 J	3.8 J	7.7 J	13 J	EPA 8020
	5/19/93	22	4.0	7.0	8.0	EPA 8240
	8/16/93	14	<2.2	11	17	EPA 8020
	11/12/93	8.8	1.0	2.8	3.3	EPA 8020
	2/10/94	9.7	5.6	3.9	8.6	EPA 8020
	5/11/94	8.6 J	2.4 J	4.0 J	7.9 J	EPA 8020
	8/10/94	2.9	1.5	1.6	15	EPA 8020
	11/11/94	43	4.9	10	16	EPA 8020
	2/8/95	27	0.81	5.1	6.4	EPA 8020
	5/10/95	220	<6.0	<6.0	<12	EPA 8020
	5/10/95	170	4.0	<2.0	3.0	EPA 8240
	8/11/95	8.0 J	6.1 J	3.7	<6.0	EPA 8020
	11/12/95	5.7	0.68	3.8	4.6	EPA 8020
	11/12/95	6.1	<2.0	<2.0	<2.0	EPA 8240
	2/6/96	<1.0	<1.0	1.8	<2.0	EPA 8020
	5/23/96	<0.30	<0.30	<0.30	3.3	EPA 8020

Table B-1
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Ground Water
Concentrations in ug/L

Well Number	Date Sampled	Benzene	Toluene	Ethyl Benzene	Xylenes (total)	Method
MW-37S	8/15/96	2.3 J	7.1 J	3.0 J	44 J	EPA 8020
	11/12/96	<0.30	2 8 J	1.6 J	2.2 J	EPA 8020
	11/12/96	<2.0	<2.0	<2.0	<2.0	EPA 8240
	2/20/97	<1.5	<1.5	3.0	3.9	EPA 8020
	5/15/97	0.94	2.7	2.1	<1.2	EPA 8020
	11/28/97	0.49 J	1 6 J	2.0 J	5.9 J	EPA 8020
	5/16/98	<0.3	<0.3	1.9	2.5	EPA 8020
	11/21/98	<0.3	1.8	1 0	0.9	EPA 8020
	5/30/99	0.3	<0.3	1.2	2.7	EPA 8021B
	11/24/99	<0.6	<0.6	<0.6	3.9	EPA 8021B
	6/2/00	<0.30	<0.30	<0.30	<0.60	EPA 8021B
	11/28/00	<0.30	2.5	2 2	5.3	EPA 8021B
	5/25/01	0.58	<0.30	3.7	6.5	EPA 8021B
	11/29/01	<0.30	<0.30	<0.30	2.1	EPA 8021B
	5/24/02	<0.30	2.5	1.4	1.2	EPA 8021B
MW-38S	5/19/93	14	6.0	2.0	13	EPA 8240
	5/19/93	9.7	4.0	1 4	8.5	EPA 8020
	8/16/93	7.3	<0.30	1.1	<0 51	EPA 8020
	11/12/93	0.81	2.1	0.90	0 53	EPA 8020
	2/9/94	<0.30	<0.30	<0.30	<0 60	EPA 8020
	5/10/94	<0.30	<0.30	<0.30	<0.60	EPA 8020
	8/9/94	<0.30	<0.30	<0.30	<0.60	EPA 8020
	11/8/94	<0.30	<0.30	<0.30	<0.60	EPA 8020
	2/7/95	2.5	<0.30	<0.30	<0.60	EPA 8020
	11/12/95	<0.30	<0.30	<0.30	<0.60	EPA 8020
	11/12/96	<0.30	<0.30	<0.30	<0.60	EPA 8020
	11/25/97	<0.30	<0.30	<0.30	<0.60	EPA 8020
	11/21/98	<0.3 J	<0 3 J	<0.3 J	<0.6 J	EPA 8020
	11/24/99	<0.3	<0.3	<0.3	<0.6	EPA 8021B
	6/2/00	<0.30	<0.30	<0.30	<0.60	EPA 8021B
	11/28/00	<0.30	<0.30	<0.30	0.74	EPA 8021B
	11/30/01	<0.30	<0.30	<0.30	<0.60	EPA 8021B
MW-39S	11/15/93	430	120	130	83	EPA 8020
	11/15/93	270	120	110	58	EPA 8240
	2/11/94	520	200	110	100	EPA 8020
	5/11/94	510 J	230 J	66 J	65 J	EPA 8020
	8/11/94	350	180	99	110	EPA 8020
	11/14/94	310 J	130 J	84 J	74 J	EPA 8020
	11/14/94	250	130	65	56	EPA 8240
	2/10/95	500	150	37	89	EPA 8020
	5/11/95	260 J	82 J	46 J	<60 J	EPA 8020
	8/8/95	460	160	47	76	EPA 8020
	11/11/95	400 J	170 J	47 J	57 J	EPA 8240

Table B-1
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Ground Water
Concentrations in ug/L

Well Number	Date Sampled	Benzene	Toluene	Ethyl Benzene	Xylenes (total)	Method
MW-39S	11/11/95	390	130	52	68	EPA 8020
	2/9/96	490	140	31	66	EPA 8020
	5/23/96	450	140	41	78	EPA 8020
	8/17/96	500	150	63	84	EPA 8020
	11/13/96	470 J	150 J	47 J	79 J	EPA 8020
	11/13/96	420	170	39	77	EPA 8240
	2/20/97	500	140	34	72	EPA 8020
	5/16/97	450 J	130 J	32 J	63 J	EPA 8020
	11/28/97	500	120	29	100	EPA 8020
	5/14/98	724	169	33.1	65.9	EPA 8020
	11/30/98	584	124	27	83	EPA 8020
	6/2/99	521 J	139 J	16 3 J	98.7 J	EPA 8021B
	11/30/99	440	96	19	67	EPA 8021B
	6/4/00	440 J	110 J	24 J	73 J	EPA 8021B
	11/17/00	450 J	110 J	22 J	74 J	EPA 8021B
	5/27/01	480	83	<6.0	49 J	EPA 8021B
	11/28/01	610	100	27	84	EPA 8021B
	5/26/02	690	98	22	85	EPA 8021B
MW-40S	10/21/93	64	17	<2.0	20	EPA 8240
	10/21/93	72 J	21 J	21 J	27 J	EPA 8020
	10/26/93	37	17	<2.0	15	EPA 8240
	2/8/94	200	42	3.1	38	EPA 8020
	5/10/94	19	11	11	<12	EPA 8020
	8/9/94	11 J	9.0 J	7.1 J	19 J	EPA 8020
	11/8/94	230	46	<9.9	26	EPA 8020
	2/7/95	140 J	26 J	12 J	30 J	EPA 8020
	5/9/95	39 J	18 J	11 J	25 J	EPA 8020
	8/8/95	510	67	<15	36	EPA 8020
	11/7/95	370	53	8 7	31	EPA 8020
	2/6/96	400	61	<15	<30	EPA 8020
	5/19/96	290	56	11	39	EPA 8020
	8/17/96	11 J	13 J	3.8 J	23 J	EPA 8020
	11/14/96	360	60	13	44	EPA 8020
	2/25/97	360	71	<6.0	32	EPA 8020
	5/18/97	230	47	<15	39 J	EPA 8020
	11/26/97	18 J	8 0 J	4.1 J	24 J	EPA 8020
	11/26/97	11	8.2	<2.0	7.6	EPA 8240
	5/15/98	205	53.3	<3.0	24 7	EPA 8020
	11/28/98	183	63	<10	29 J	EPA 8260
	11/28/98	224 J	58 J	14 J	41 J	EPA 8020
	6/1/99	20 2 J	<0.3	2 2 J	18.6 J	EPA 8021B
	11/28/99	<600 R	<600 R	<600 R	28000 R	EPA 8021B
	1/7/00	88	95	85	220	EPA 8021B

ENGLAND GEOSYSTEM
ENVIRONMENTAL ENGINEERING

Table B-1
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Ground Water
Concentrations in ug/L

Well Number	Date Sampled	Benzene	Toluene	Ethyl Benzene	Xylenes (total)	Method
MW-40S	6/4/00	16 J	8.7 J	4.8 J	13 J	EPA 8021B
	11/17/00	63 J	33 J	5.9 J	25 J	EPA 8021B
	5/27/01	12	2.0	9.8	9.7	EPA 8260B
	5/27/01	<600	<600	<600	1,700 R	EPA 8021B
	11/27/01	16	10	8.9 J	20 J	EPA 8021B
	5/24/02	96	37	9.2	28	EPA 8021B
MW-41S	11/15/93	330	26	<13	34	EPA 8020
	11/15/93	310	25	<5.0	6.0	EPA 8240
	2/10/94	440	42 J	13 J	40	EPA 8020
	5/12/94	270	12	<6.0	12	EPA 8020
	8/11/94	330	22	<3.0	18	EPA 8020
	11/10/94	230 J	15 J	5.2 J	21 J	EPA 8020
	2/9/95	240 J	13 J	6.3 J	18 J	EPA 8020
	5/11/95	160	90	<6.0	12	EPA 8020
	8/10/95	180 J	8 0 J	7.2 J	19 J	EPA 8020
	11/11/95	110 J	13 J	5.1 J	17 J	EPA 8020
	2/8/96	56 J	4 9 J	6.0 J	15 J	EPA 8020
	5/22/96	100 J	14 J	8.2 J	22 J	EPA 8020
	8/16/96	65	14	9.6	19	EPA 8020
	11/14/96	87 J	9.7 J	<3.0	20 J	EPA 8020
	2/20/97	51	7.3	<6.0	15	EPA 8020
	5/16/97	42 J	10 J	5.2 J	13 J	EPA 8020
	11/29/97	31 J	25 J	5.6 J	11 J	EPA 8020
	5/14/98	28.2	3.6	4.1	<3.0	EPA 8020
	11/27/98	34.8	7.1	4 1	13.9	EPA 8020
	6/3/99	48.7 J	12 J	2.6 J	18.4 J	EPA 8021B
	11/28/99	28 J	8.1 J	4.7 J	14 J	EPA 8021B
	6/4/00	37 J	12 J	4.6 J	12 J	EPA 8021B
	11/17/00	11 J	4.5 J	2.3 J	13 J	EPA 8021B
	5/25/01	10	6.6	1.1	5.9	EPA 8021B
	11/27/01	32 J	9.1 J	7.1 J	20 J	EPA 8021B
	5/27/02	35	9.9	6.7 J	20	EPA 8021B
MW-42S	11/12/93	71	11	<4.0	9.0	EPA 8240
	11/12/93	110	60	24	9.3	EPA 8020
	2/10/94	72	67 J	25 J	<15	EPA 8020
	5/12/94	360	150	44	<6.0	EPA 8020
	8/11/94	300	23	<6.0	52	EPA 8020
	11/10/94	240 J	24 J	<3.0	52 J	EPA 8020
	2/9/95	410 J	32 J	<6.0	56 J	EPA 8020
	5/11/95	25 J	2.5 J	<0 30	7.0 J	EPA 8020
	8/10/95	150	15	<6.0	41	EPA 8020
	11/11/95	140	16	<3.0	44	EPA 8020
	11/11/95	110 J	16 J	2.0 J	7.7 J	EPA 8240

Table B-1
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Ground Water
Concentrations in ug/L

Well Number	Date Sampled	Benzene	Toluene	Ethyl Benzene	Xylenes (total)	Method
MW-42S	2/8/96	140 J	24 J	2.2 J	46 J	EPA 8020
	5/20/96	210	30	<3.0	76	EPA 8020
	8/16/96	250 J	37 J	28 J	71 J	EPA 8020
	11/14/96	350 J	50 J	<6.0	98 J	EPA 8020
	2/24/97	380 J	60 J	4.5 J	84 J	EPA 8020
	5/16/97	310 J	45 J	3.3 J	59 J	EPA 8020
	11/29/97	170 J	25 J	2.4 J	35 J	EPA 8020
	5/14/98	208	17.8	3.3	<6.0	EPA 8020
	11/30/98	94.5	11.6	1.7	23.9	EPA 8020
	6/3/99	239 J	34.6 J	20.2 J	38 6 J	EPA 8021B
	11/27/99	210 J	34 J	4.9 J	56 J	EPA 8021B
	11/27/99	280	48	7.2	40.3	EPA 8260
	6/3/00	<0.30	<0.30	<0.30	<0.60	EPA 8021B
	11/17/00	270 J	50 J	7.1 J	76 J	EPA 8021B
	5/27/01	140 J	27 J	4.8	44 J	EPA 8021B
	11/30/01	220	40	6.6	60	EPA 8021B
	5/25/02	15	3 6	<0.60	12	EPA 8021B
MW-43S	5/25/94	150	12	1.8	17	EPA 8020
	5/25/94	110	9.2	<2.0	8.4	EPA 8240
	8/11/94	200	14	<3.0	25	EPA 8020
	11/10/94	71	4.7	<1.5	12	EPA 8020
	2/10/95	32	<1.4	<0.99	5.2	EPA 8020
	5/11/95	100 J	6.8 J	<1.5	16 J	EPA 8020
	8/10/95	46	3.8	<0.99	7.9	EPA 8020
	11/11/95	51 J	<4.0	<4.0	<4.0	EPA 8240
	11/11/95	54	2.2 J	2 3 J	7.0 J	EPA 8020
	2/7/96	<0.30	<0.30	<0.30	<0.60	EPA 8020
	5/22/96	44	4.1	0 64	7.2	EPA 8020
	8/16/96	33	4.9	1.5	10	EPA 8020
	11/13/96	<0.30	<0.30	<0.30	<0.60	EPA 8020
	2/25/97	12	0.84	<0.60	1.8	EPA 8020
	5/16/97	46 J	3.5 J	0.77 J	5.7 J	EPA 8020
	11/26/97	<0 30	<0.30	<0.30	<0.60	EPA 8020
	5/14/98	<0.3	<0.3	<0.3	<6 0	EPA 8020
	11/29/98	4.5	1.1	<0.3	3.3	EPA 8020
	6/3/99	12.9	21	0.9	5.4	EPA 8021B
	11/27/99	<0.3	<0.3	<0.3	<0.6	EPA 8021B
	6/3/00	1 2	<0.30	<0 30	<0.60	EPA 8021B
	11/17/00	1.1	<0.30	<0.30	<0.60	EPA 8021B
	5/26/01	<0.30	<0.30	<0.30	<0.60	EPA 8021B
	11/28/01	<0.30	<0.30	<0.30	<0.60	EPA 8021B
	5/26/02	<0.30	<0.30	<0.30	<0.60	EPA 8021B
MW-44S	5/25/94	<2.0	<2.0	<2.0	<2.0	EPA 8240

Table B-1
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Ground Water
Concentrations in ug/L

Well Number	Date Sampled	Benzene	Toluene	Ethyl Benzene	Xylenes (total)	Method
MW-44S	5/25/94	<0.30	<0 30	<0.30	<0.60	EPA 8020
	8/10/94	<0.30	<0.30	<0.30	<0.60	EPA 8020
	11/9/94	<0 30	<0.30	<0.30	<0.60	EPA 8020
	2/8/95	<0.30	<0.30	<0.30	<0.60	EPA 8020
	5/9/95	<0.30	<0.30	<0.30	<0 60	EPA 8020
	8/9/95	<0.30	<0.30	<0.30	<0.60	EPA 8020
	11/10/95	<0.30	<0.30	<0.30	<0.60	EPA 8020
	2/7/96	<0.30	<0.30	<0.30	<0.60	EPA 8020
	5/21/96	<0.30	<0.30	<0.30	<0.60	EPA 8020
	8/16/96	<0 30	<0.30	<0.30	<0.60	EPA 8020
	11/13/96	<0.30	<0.30	<0.30	<0.60	EPA 8020
	2/25/97	<0.30	<0.30	<0.30	<0.60	EPA 8020
	5/16/97	<0.30	<0.30	<0.30	<0.60	EPA 8020
	11/26/97	<0.30	<0.30	<0.30	<0.60	EPA 8020
	5/15/98	<0.3	<0.3	<0.3	<6.0	EPA 8020
	11/29/98	<0.3	<0.3	<0.3	<0 6	EPA 8020
	6/3/99	<0.3	<0.3	<0.3	<0.6	EPA 8021B
	11/30/99	<0 3	<0.3	<0.3	<0.6	EPA 8021B
	6/4/00	<0.30	<0.30	<0.30	<0.60	EPA 8021B
	11/17/00	<0.30	<0.30	<0.30	<0.60	EPA 8021B
	5/27/01	<0 30	<0.30	<0.30	1.3	EPA 8021B
	11/28/01	<0.30	0.33	<0.30	<0.60	EPA 8021B
	5/27/02	<0.30	<0.30	<0.30	<0.60	EPA 8021B
MW-45S	5/25/94	160 J	38 J	7.9 J	15 J	EPA 8020
	5/25/94	120	27	<2.0	6.8	EPA 8240
	8/11/94	170 J	28	6.0 J	40 J	EPA 8020
	11/9/94	130	22	3.8 J	13	EPA 8020
	2/10/95	20 J	<3.0 J	<3.0 J	<6 0 J	EPA 8020
	5/9/95	8.4	62	59	86	EPA 8020
	8/10/95	94	12	5.4	10	EPA 8020
	11/10/95	140 J	21 J	14 J	16 J	EPA 8020
	2/8/96	110 J	16	7.5	13	EPA 8020
	5/21/96	140	15	6.4	14	EPA 8020
	8/16/96	120 J	18 J	5.9 J	13 J	EPA 8020
	11/13/96	120 J	14 J	3.9 J	10 J	EPA 8020
	2/25/97	<0.30	<0.30	0.67	<0.60	EPA 8020
	5/16/97	140 J	15 J	3.5 J	8 6 J	EPA 8020
	11/26/97	50 J	5.6 J	2.1 J	3.0 J	EPA 8020
	5/14/98	<0.3	<0.3	<0.3	<6.0	EPA 8020
	11/27/98	23.9	2.0	<0.3	2.1	EPA 8020
	6/3/99	26	0.7	0.5	1.7	EPA 8021B
	11/28/99	110	12	2.9	6.3	EPA 8021B
	11/28/99	150	19	<10	<20	EPA 8260

Table B-1
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Ground Water
Concentrations in ug/L

Well Number	Date Sampled	Benzene	Toluene	Ethyl Benzene	Xylenes (total)	Method
MW-45S	6/4/00	<0.30	<0.30	<0.30	<0.60	EPA 8021B
	11/17/00	42	5 7	1.6	3 7	EPA 8021B
	5/26/01	<0.30	<0.30	<0.30	<0 60	EPA 8021B
	11/28/01	0.51	<0.30	<0.30	<0 60	EPA 8021B
	5/26/02	<0.30	<0.30	<0.30	<0.60	EPA 8021B
MW-46S	5/25/94	<2 0	<2.0	<2.0	<2.0	EPA 8240
	5/25/94	0.47	<0 30	<0.30	<0.60	EPA 8020
	8/10/94	2.4	0.58	0.45	2.3	EPA 8020
	11/9/94	1.1	<0.30	1.4	2.6	EPA 8020
	2/8/95	<0.30	<0 45	1.5	1.5	EPA 8020
	5/9/95	1.2	<0.30	38	<0.60	EPA 8020
	8/10/95	0.36	<0 30	<0.30	1.9	EPA 8020
	11/10/95	0.91	0.82	1.8	2.6	EPA 8020
	2/7/96	0.47	0.40	0.96	0.69	EPA 8020
	5/21/96	<0.30	<0.30	<0.30	1 9	EPA 8020
	8/16/96	<0.30	0.42	0.40	2.7	EPA 8020
	11/13/96	<0.30	3 4	<0.30	1.9	EPA 8020
	2/25/97	<0.30	0 35	<0.30	2.6	EPA 8020
	5/16/97	<0.30	<0 30	<0.30	<0.60	EPA 8020
	11/25/97	<0.30	<0 30	2.5	<0.60	EPA 8020
	5/15/98	<0.3 J	<0.3 J	<0.3 J	<6 0 J	EPA 8020
MW-48S	11/29/98	0.6	0.3	<0.3	9.0	EPA 8020
	11/29/98	<0.5	<1.0	<1.0	<2 0	EPA 8260
	6/3/99	<0.3	0.6	<0.3	1.1	EPA 8021B
	11/27/99	<0.3	<0.3	<0 3	9 5	EPA 8021B
	6/4/00	0 52	<0.30	<0.30	<0.60	EPA 8021B
	11/17/00	<0.30	<0 30	<0.30	2.8	EPA 8021B
	5/26/01	<0.30	<0.30	<0.30	<0.60	EPA 8021B
	11/28/01	0.57	0.55	<0.30	7.8	EPA 8021B
	5/27/02	<0.30	<0.30	<0.30	0.66	EPA 8021B
MW-49S	11/29/98	<0.5	<1.0	<1.0	<2.0	EPA 8260
	11/29/98	<0.3	<0.3	<0.3	4.1	EPA 8020
	6/3/99	0.6	<0.3	<0.3	1.9	EPA 8021B
	11/30/99	<0.3	<0.3	<0.3	<2.9	EPA 8021B
	6/5/00	<0.30	<0.30	<0.30	<0.60	EPA 8021B
	11/15/00	1.7	<0.30	<0.30	<6.1	EPA 8021B
	5/27/01	1.6	<0.30	<0.30	<0.60	EPA 8021B
	11/26/01	0.37	<0.36	<0.30	<0.60	EPA 8021B
	5/25/02	2	<0.30	<0.30	<0.60	EPA 8021B
P2	5/19/93	1100 J	64 J	220 J	130 J	EPA 8020
	8/18/93	1500 J	130 J	330 J	210 J	EPA 8020
	11/16/93	1500	340	400	110 J	EPA 8020

Table B-1
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Ground Water
Concentrations in ug/L

Well Number	Date Sampled	Benzene	Toluene	Ethyl Benzene	Xylenes (total)	Method
P2	2/11/94	2200 J	470 J	570 J	190 J	EPA 8020
	5/12/94	1500	220	430	320	EPA 8020
	8/12/94	1800 J	130 J	<30	150	EPA 8020
	11/14/94	870	200	320	210	EPA 8020
	2/10/95	930	130	98	130	EPA 8020
	5/11/95	2400 J	210	87 J	<60	EPA 8020
	8/11/95	2700	450	530	320	EPA 8020
	11/16/95	2600	480	490	320	EPA 8020
	2/10/96	1900	450	500	350	EPA 8020
	5/20/96	2200	510	570	420	EPA 8020
	8/7/96	1800	510	520	350	EPA 8020
	8/13/96	1600 J	510	540	580	EPA 8020
	9/10/96	1400	460	480	350	EPA 8020
	11/12/96	1400	460	590	580	EPA 8020
EW-P2	1/6/97	2400	560	510	300	EPA 8020
	2/21/97	1700 J	540 J	640 J	430 J	EPA 8020
	5/14/97	1200	710	650	360	EPA 8020
	8/12/97	1000 J	550 J	570 J	340 J	EPA 8020
	11/28/97	730	250	320	200	EPA 8240
	11/28/97	850	520	230 J	280	EPA 8020
	2/27/98	845	274	377	255	EPA 8020
	5/13/98	571	158	204	178	EPA 8020
	8/30/98	993	258	349	314	EPA 8020
	11/30/98	816	202	248	243	EPA 8020
	11/30/98	893	267	335	216	EPA 8260
	2/17/99	864	238	309	260	EPA 8021B
	6/4/99	883	240	140	264	EPA 8021B
	8/23/99	660	180	230	190	EPA 8021B
	11/30/99	640	190	220	230	EPA 8021B
	2/18/00	700	210	260	280	EPA 8021B
	6/5/00	710	200	230	240	EPA 8021B
	8/23/00	570	160	180	210	EPA 8021B
	11/17/00	610	190	210	220	EPA 8021B
	2/15/01	700	190	220	250	EPA 8021B
	5/28/01	570 J	160 J	170 J	200 J	EPA 8021B
	8/12/01	650	180	190	210	EPA 8021B
	11/12/01	700	190	200	260	EPA 8021B
	2/28/02	580	170	170	220	EPA 8021B
	5/27/02	520	170	160	210	EPA 8021B
	8/19/02	560	150	190	250	EPA 8021B
EW-1	5/19/93	370	93	13	58	EPA 8020
	5/19/93	510	160	21	83	EPA 8240
	5/13/94	400	93	8 5	80	EPA 8020

Table B-1
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Ground Water
Concentrations in ug/L

Well Number	Date Sampled	Benzene	Toluene	Ethyl Benzene	Xylenes (total)	Method
EW-1	8/12/94	380	70	10	77	EPA 8020
	11/14/94	270 J	50 J	12 J	68 J	EPA 8020
	2/9/95	470	130	18	97	EPA 8020
	5/11/95	450	140	<30	100	EPA 8020
	8/8/95	510 J	160 J	22 J	120 J	EPA 8020
	11/6/95	200 J	56 J	8.7 J	53 J	EPA 8020
	12/11/95	430 J	70 J	<9.9	74 J	EPA 8020
	1/25/96	420	63	<9.9	68	EPA 8020
	2/10/96	250	61	21	67	EPA 8020
	3/5/96	360 J	61 J	12 J	63 J	EPA 8020
	4/16/96	300 J	63 J	13 J	70 J	EPA 8020
	5/21/96	330	63	12	67	EPA 8020
	6/12/96	280	80	21	54	EPA 8020
	7/11/96	240	69	19	70	EPA 8020
	8/13/96	280	58	36	70	EPA 8020
	9/10/96	540	85	<30	62	EPA 8020
	10/10/96	360	71	43	69	EPA 8020
	11/7/96	390	49	7.9	51	EPA 8020
	2/21/97	350 J	64 J	14 J	64 J	EPA 8020
	5/14/97	370	100	<15	68	EPA 8020
	8/12/97	250 J	60 J	13 J	58 J	EPA 8020
	11/28/97	220 J	52 J	8.5 J	46 J	EPA 8020
	2/27/98	218 J	60.8 J	13.3 J	63.2 J	EPA 8020
	5/13/98	187	40.5	7.2	30.5	EPA 8020
	8/30/98	341	78	<15	88	EPA 8020
	11/30/98	245	50	8	53	EPA 8020
	2/17/99	208	43	9	50	EPA 8021B
	6/4/99	212	44.1	5.2	46.4	EPA 8021B
	8/23/99	140	28	8.3	31	EPA 8021B
	11/30/99	150	31	7.9	39	EPA 8021B
	2/18/00	170	38	8.8	55	EPA 8021B
	6/5/00	150 J	37 J	8.2 J	41 J	EPA 8021B
	8/23/00	130	30	6.7	36	EPA 8021B
	11/17/00	140	31	5.9	37	EPA 8021B
	2/15/01	150	34	8.2	40	EPA 8021B
	5/28/01	150	69	52	56	EPA 8021B
	8/12/01	190	49	<7.5	39	EPA 8021B
	11/12/01	140	33	9.7	51	EPA 8021B
	2/28/02	110	32	10	41	EPA 8021B
	5/27/02	82	20	5	38	EPA 8021B
	8/19/02	60	20	7.6	27	EPA 8021B
EW-2	6/20/94	330	100	28	<24	EPA 8020
	6/20/94	230	17	4.9	16	EPA 8240

Table B-1
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Ground Water
Concentrations in ug/L

Well Number	Date Sampled	Benzene	Toluene	Ethyl Benzene	Xylenes (total)	Method
EW-2	8/12/94	55	3.6	<1.5	11	EPA 8020
	11/9/94	410 J	31 J	<6.0	38 J	EPA 8020
	2/10/95	57 J	9.5 J	<1.5	12 J	EPA 8020
	5/12/95	11 J	5.7 J	<1.5	9.2 J	EPA 8020
	8/8/95	34 J	10 J	2.2 J	22 J	EPA 8020
	11/6/95	130	16	<10	<10	EPA 8240
	11/6/95	110	17	2.8	27	EPA 8020
	12/11/95	16 J	2.9 J	<0.60	7 5 J	EPA 8020
	1/25/96	48 J	6.1 J	<1.5	13 J	EPA 8020
	2/10/96	24	3.5	<3.0	<6.0	EPA 8020
	3/5/96	34 J	3.1 J	0.68 J	8.2 J	EPA 8020
	4/16/96	22 J	2.1 J	<1.0 J	7.6 J	EPA 8020
	5/21/96	34	4.1	1.2	7.6	EPA 8020
	6/12/96	30 J	16 J	8.8 J	16 J	EPA 8020
	7/11/96	13 J	2.4 J	0.40 J	4.0 J	EPA 8020
	8/13/96	3.8	1 8	<0.30	7.0	EPA 8020
	9/10/96	3.8	1.8	<1.5	3.1	EPA 8020
	10/10/96	2.5	2.4	2.3	7.9	EPA 8020
	11/7/96	3.4 J	1 9 J	<0.30	3.2 J	EPA 8020
	11/7/96	<5.0	<5.0	<5.0	<5 0	EPA 8240
	2/21/97	13	<6.0	<6.0	<12	EPA 8020
	5/15/97	53	19	<6.0	26	EPA 8020
	11/28/97	0.72	<0.30	0.58	7.3	EPA 8020
	5/16/98	0.3	<0.3	<0.3	<0.6	EPA 8020
	11/28/98	0.8	0.4	<0.3	3.3	EPA 8020
	6/2/99	<0.3	<0.3	<0.3	<0.6	EPA 8021B
	11/30/99	<0.3	<0.3	<0.3	<0.6	EPA 8021B
	6/5/00	<0.30	<0.30	<0.30	1.1	EPA 8021B
	11/16/00	<0.30	<0.81	<0.30	<5.2	EPA 8021B
	5/27/01	<0.30	<0.30	<0.30	<0.60	EPA 8021B
	11/26/01	<0.30	<0.30	<0.30	<0.60	EPA 8021B
	5/25/02	<0.30	1.1	0.36	3.1	EPA 8021B
EW-4	6/20/94	320 J	100 J	<4.0 J	49 J	EPA 8240
	6/20/94	610	200 J	33 J	45	EPA 8020
	8/12/94	200	72	12	26	EPA 8020
	11/15/94	140 J	35	5.6 J	28	EPA 8020
	2/9/95	240 J	44 J	<7.5	39 J	EPA 8020
	5/12/95	200	50	10	32	EPA 8020
	8/11/95	240	52	<15	33	EPA 8020
	11/6/95	170	44	<6.0	28	EPA 8020
	12/11/95	200	44	7.0	31	EPA 8020
	1/25/96	130 J	33 J	7.4 J	25 J	EPA 8020
	2/10/96	180	35	6.9	32	EPA 8020

Table B-1
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Ground Water
Concentrations in ug/L

Well Number	Date Sampled	Benzene	Toluene	Ethyl Benzene	Xylenes (total)	Method
EW-4	3/5/96	160	34	6.3	25	EPA 8020
	4/16/96	120 J	29 J	5.7 J	25 J	EPA 8020
	5/21/96	220	51	17	53	EPA 8020
	6/12/96	170	54	11	32	EPA 8020
	7/11/96	100 J	38 J	7.1 J	30 J	EPA 8020
	8/13/96	140	47	8.7	30	EPA 8020
	9/10/96	130 J	47 J	11 J	42 J	EPA 8020
	10/10/96	140	41	8.5	18	EPA 8020
	11/7/96	150 J	31 J	5.9 J	21 J	EPA 8020
	2/21/97	340 J	9.9 J	10 J	20	EPA 8020
	2/21/97	190	51	5 2	20	EPA 8240
	5/14/97	160	60	<10	39	EPA 8020
	8/12/97	120	34	4.1	19	EPA 8020
	11/28/97	93 J	28 J	4.1 J	20 J	EPA 8020
	2/27/98	120	31 5	8.6	21.4	EPA 8020
	5/13/98	103	37.7	6.9	21.6	EPA 8020
	9/25/98	133 J	58.8 J	12.1 J	52.3 J	EPA 8020
	11/30/98	120 J	30 7 J	5.6 J	26.8 J	EPA 8020
	2/17/99	130	36	8	34	EPA 8021B
	6/4/99	142	34.4	7.7	31	EPA 8021B
	8/23/99	120	28	6.0	24	EPA 8021B
	11/30/99	100	27	5.5	24	EPA 8021B
	2/18/00	110	32	6.2	26	EPA 8021B
	6/5/00	110 J	31 J	5.8 J	27 J	EPA 8021B
	8/23/00	110 J	29 J	8 J	31 J	EPA 8021B
	11/17/00	94	28	5	17 J	EPA 8021B
	2/15/01	120 J	29 J	7.9 J	31 J	EPA 8021B
	5/28/01	52	20	4.3	20	EPA 8021B
	8/12/01	83	26	6.4	21	EPA 8021B
	11/12/01	96	30	8.1	30	EPA 8021B
	2/28/02	90	26	6.5	25	EPA 8021B
	5/27/02	86	25	5.4	20	EPA 8021B
	8/19/02	260	54	13	50	EPA 8021B
EW-5	6/20/94	75	18	<2.0	15	EPA 8240
	6/20/94	200	79	13	12	EPA 8020
	8/12/94	52	9.4	2.2	6.0	EPA 8020
	11/15/94	81 J	14	<3.0	11	EPA 8020
	2/9/95	50	6.8	<1.5	6.0	EPA 8020
	5/12/95	46	53	12	45	EPA 8020
	8/11/95	78	10	2.1	9.0	EPA 8020
	11/6/95	48	9.7	<1.5	6.1	EPA 8020
	12/11/95	81 J	12 J	2.7 J	10 J	EPA 8020
	1/25/96	67	11	<3.0	6.5	EPA 8020

Table B-1
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Ground Water
Concentrations in ug/L

Well Number	Date Sampled	Benzene	Toluene	Ethyl Benzene	Xylenes (total)	Method
EW-5	2/10/96	77	14	<3.0	9 3	EPA 8020
	3/5/96	74	11	2 4	9.4	EPA 8020
	4/16/96	80	13	2.1	9 6	EPA 8020
	5/21/96	110	18	2.4	11	EPA 8020
	6/12/96	120	27	8.2	17	EPA 8020
	7/11/96	110 J	19 J	2.9 J	14 J	EPA 8020
	8/13/96	600	760	190	980	EPA 8020
	9/10/96	140 J	22 J	4.2 J	16 J	EPA 8020
	10/10/96	43	8.8	1.3	4.6	EPA 8020
	11/7/96	76 J	11 J	2.1 J	9.2 J	EPA 8020
	2/21/97	6.0	16	2 6	11	EPA 8020
	5/14/97	84	18	3.8	12	EPA 8020
	8/12/97	67 J	15 J	3.2 J	12 J	EPA 8020
	11/28/97	72 J	17 J	2.3 J	11 J	EPA 8020
	2/27/98	164 J	47.0 J	9.1 J	38.4 J	EPA 8020
	5/13/98	100 J	26 J	3.9 J	18.8 J	EPA 8020
	8/30/98	161	42	<8	38	EPA 8020
	11/30/98	66 3	15.8	2.5	12.4	EPA 8020
	2/17/99	74	20	4	18	EPA 8021B
	6/4/99	81.1	15	2.8	18.1	EPA 8021B
	8/23/99	73	12	4.7	16	EPA 8021B
	11/30/99	120 J	36 J	5.9 J	26 J	EPA 8021B
	11/30/99	150	57	5.8	31.1	EPA 8260
	2/18/00	130 J	33 J	5.6 J	26 J	EPA 8021B
	6/5/00	95 J	30 J	4.8 J	23 J	EPA 8021B
	8/23/00	110 J	36 J	6.4 J	30 J	EPA 8021B
	11/16/00	96	41	5.6	31	EPA 8021B
	2/15/01	100 J	34 J	7.7 J	31 J	EPA 8021B
	5/28/01	67	25	3.8	19	EPA 8021B
	8/12/01	85	28	5.5	16	EPA 8021B
	11/12/01	50	19	4.8	19	EPA 8021B
	2/28/02	86	31	5.9	23	EPA 8021B
	5/27/02	85	31	5.6	24	EPA 8021B
	8/19/02	130	51	19	36	EPA 8021B
ULTM-MW-2	9/29/92	3.0 J	<10	<10	<10	EPA 8240
ULTM-MW-3	2/28/92	<10	<10	<10	<10	EPA 8240
	7/2/92	<10	<10	<10	<10	EPA 8240
	9/29/92	<10	<10	<10	<10	EPA 8240
ULTM-MW-6	2/28/92	21	7.0 J	6.0 J	17	EPA 8240
	7/2/92	10	<10	3.0 J	3.0 J	EPA 8240
	9/29/92	30	9.0 J	11	31	EPA 8240
	11/16/92	6.0	4.2	3.9	<6.0	EPA 8020

Table B-1
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Ground Water
Concentrations in ug/L

Well Number	Date Sampled	Benzene	Toluene	Ethyl Benzene	Xylenes (total)	Method
ULTM-MW-6	2/18/93	84	94	65	170	EPA 8020
	5/14/93	110	37	65	80	EPA 8020
	8/12/93	40 J	11 J	24 J	23 J	EPA 8020
	11/10/93	22	11	8.0	24	EPA 8020
	2/8/94	25	12	16	35	EPA 8020
	5/10/94	7.5	3.7	1.6	4.1	EPA 8020
	8/9/94	21	6.7	2.5	10	EPA 8020
	11/8/94	12	3.9	1 3	3 6	EPA 8020
	2/7/95	7.8	3.3	1.9	9.0	EPA 8020
ULTM-MW-7	2/28/92	3.0 J	20	<10	27	EPA 8240
	7/2/92	2 0 J	6.0 J	<10	4.0 J	EPA 8240
	9/29/92	3.0 J	10	4.0 J	14	EPA 8240
	11/16/92	<0.50	17 J	23 J	22 J	EPA 8020
	2/18/93	5.4 J	25 J	14 J	39 J	EPA 8020
	5/14/93	44	13	35	37	EPA 8020
	8/12/93	40 J	27 J	15 J	33 J	EPA 8020
	11/10/93	120	96	14	31	EPA 8020
	2/8/94	96	13	15	53	EPA 8020
	5/10/94	6.5	20	27	47	EPA 8020
	8/9/94	<6 0	24	34	55	EPA 8020
	11/8/94	77	12	26	37	EPA 8020
	2/7/95	43	74	<3.0	22	EPA 8020
	5/9/95	47 J	6 3 J	18 J	22 J	EPA 8020
	8/8/95	64	21	25	39	EPA 8020
	11/7/95	8.2	17	14	21	EPA 8020
	2/6/96	51	17	18	<30	EPA 8020
ULTM-MW-8	8/14/91	20 J	<50	<50	<50	EPA 8240
	11/20/91	<10	<10	<10	1.0 J	EPA 8240
	2/28/92	31	29	<10	6.0 J	EPA 8240
	7/2/92	5.0 J	4.0 J	130	380	EPA 8240
	9/29/92	3.0 J	3.0 J	3.0 J	7.0 J	EPA 8240
	11/16/92	8.7 J	5.0 J	4.4 J	14 J	EPA 8020
	2/18/93	8.1 J	<4.8 J	17 J	18 J	EPA 8020
	5/14/93	11 J	<5.0	18 J	15 J	EPA 8020
	8/12/93	190 J	120 J	41 J	110 J	EPA 8020
	11/10/93	24	24	5.2	7.1	EPA 8020
	2/8/94	28	7.2	<0.75	16	EPA 8020
	5/10/94	30	9.5	<1.5	15	EPA 8020
	8/9/94	7.6	6.7	6.4	12	EPA 8020
	11/8/94	25 J	4.8 J	2 5 J	7.8 J	EPA 8020
	2/7/95	9 7	20	<3.0	6.9	EPA 8020
ULTM-MW-9	5/1/91	280	82	26	23	EPA 8240

Table B-1
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Ground Water
Concentrations in ug/L

Well Number	Date Sampled	Benzene	Toluene	Ethyl Benzene	Xylenes (total)	Method
ULTM-MW-9	8/14/91	260	64 J	<200	27 J	EPA 8240
	11/20/91	250	78	15 J	28	EPA 8240
	2/28/92	110	40	7 0 J	13	EPA 8240
	7/2/92	200	70	10 J	22	EPA 8240
	9/29/92	270	94	17 R	27	EPA 8240
	11/16/92	190 J	61 J	28 J	49 J	EPA 8020
	11/16/92	90	22 J	5 0 J	9 0	EPA 8240
	2/18/93	90 J	27 J	8 1 J	17 J	EPA 8020
	5/14/93	80	20	11	23	EPA 8020
	8/12/93	170 J	91 J	39 J	76 J	EPA 8020
	11/10/93	95	51	7 5	15	EPA 8020
	11/10/93	78	28	<2.0	11	EPA 8240
	2/8/94	99	13	28	17	EPA 8020
	5/10/94	130	10	26	14	EPA 8020
	8/9/94	70	12	17	13	EPA 8020
	11/8/94	120	11	20	13	EPA 8020
	2/7/95	89	7 6	18	13	EPA 8020
	5/9/95	130	15	19	<12	EPA 8020
	8/8/95	88	8 0	16	12	EPA 8020
	11/7/95	67	12	11	6 6	EPA 8020
	2/6/96	69	14	11	<12	EPA 8020
ULTM-MW-10	5/1/91	54	28	5 0	13	EPA 8240
	8/14/91	11	5.0 J	<10	3.0 J	EPA 8240
	11/20/91	33	22	3 0 J	13	EPA 8240
	2/28/92	12	<10	<10	<10	EPA 8240
	7/2/92	3.0 J	<10	2 0 J	<10	EPA 8240
	9/29/92	<10	<10	<10	<10	EPA 8240
	11/16/92	<0.50	<0 50	0 88	<1.0	EPA 8020
	11/16/92	<1 0	<2 0	<1.0	<1 0	EPA 8240
	2/18/93	0.87	<2.3	0 49 J	<2 7 J	EPA 8020
	5/14/93	2.1 J	<0 50	2.2 J	1.7 J	EPA 8020
	8/12/93	6.3 J	17 J	4.0 J	27 J	EPA 8020
	11/10/93	5 2	3.3	2.1	6.1	EPA 8020
	11/10/93	3.0	2.0	<2.0	7 0	EPA 8240
	2/8/94	4.0	2 9	<0.30	8.5	EPA 8020
	5/10/94	2.8	3.1	1 5	36	EPA 8020
	8/9/94	1.3	0.83	2.1	2.3	EPA 8020
	11/8/94	<0.60	<0.60	1.1 J	1.3	EPA 8020
	11/8/94	<2 0	<2.0	<2.0	<2.0	EPA 8240
	2/7/95	0.66	<0.30	1.6	2.1	EPA 8020
ULTM-MW-11	8/14/91	10 J	<100	<100	<100	EPA 8240
	7/2/92	<10	1 0 J	<10	2.0 J	EPA 8240
	9/29/92	1.0 J	<10	<10	2 0 J	EPA 8240

Table B-1
Pacific Coast Pipeline Superfund Site, Fillmore, California
Summary of Benzene, Toluene, Ethyl Benzene, and Xylene Concentrations in Ground Water
Concentrations in ug/L

Well Number	Date Sampled	Benzene	Toluene	Ethyl Benzene	Xylenes (total)	Method
ULTM-MW-11	11/16/92	24 J	11 J	15 J	29 J	EPA 8020
	2/18/93	8.5 J	7.1 J	19 J	12 J	EPA 8020
	5/14/93	10	<7.5	<7 5	21	EPA 8020
	8/12/93	21 J	31 J	15 J	44 J	EPA 8020
	11/10/93	4.6	2.5	0.88	4.5	EPA 8020
	2/8/94	2.2	3.2	6.6	7.6	EPA 8020
	5/10/94	1.5	2.5	3.1	14	EPA 8020
	8/9/94	2.4	1 2	7.1	33	EPA 8020
	11/8/94	<3.0	4.0 J	3.9 J	9.8 J	EPA 8020
	2/7/95	<3.0	<3.0	<3.0	<6.0	EPA 8020
ULTM-MW-13	11/20/91	<10	<10	<10	<10	EPA 8240
	2/28/92	<10	<10	<10	<10	EPA 8240
	7/2/92	<10	<10	<10	<10	EPA 8240
	9/29/92	<10	<10	<10	<10	EPA 8240
	11/16/92	<0.50	<0.50	<0.50	<1.6	EPA 8020
	11/10/93	<0 30	<0.30	<0.50	<0.50	EPA 8020
ULTM-MW-14	11/20/91	<10	<10	<10	<10	EPA 8240
	2/28/92	<10	<10	<10	<10	EPA 8240
	7/2/92	<10	<10	<10	<10	EPA 8240
	9/29/92	<10	<10	<10	<10	EPA 8240
	11/16/92	<0.50	<0.50	<0.50	<1.0	EPA 8020
	11/10/93	<0.30	<0.30	<0.50	<0.50	EPA 8020
MCL		1	150	700	1750	
Rod Cleanup Goal		1	100	680	-	

MCL = Maximum Contaminant Level for drinking water (Title 22 California Administrative Code)
ROD = Record of Decision (ROD) Cleanup Goals
NA = Not Analyzed, J = Estimated, R = Unusable

ENGLAND GEOSYSTEM
ENVIRONMENTAL ENGINEERING

Appendix C

Characteristics of Dissolved Petroleum Hydrocarbon Plumes (API, 1998)

ENGLAND
GEOSYSTEM
ENVIRONMENTAL ENGINEERING

American Petroleum Institute

December 1998. Vers. 1.1

CHARACTERISTICS OF DISSOLVED PETROLEUM HYDROCARBON PLUMES

RESULTS FROM FOUR STUDIES

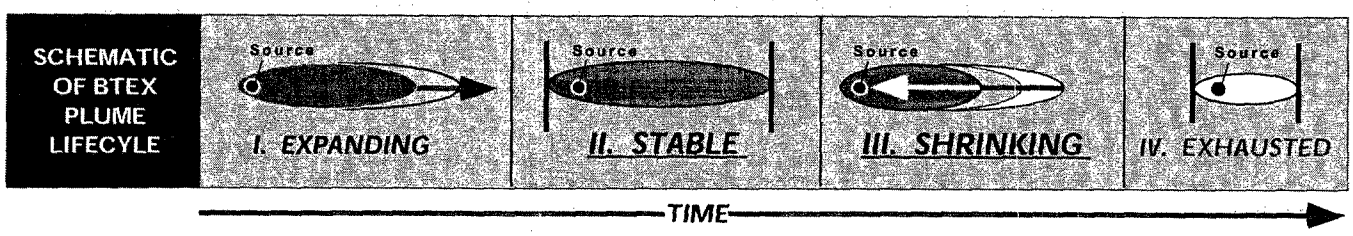
C.J. Newell and J.A. Connor, Groundwater Services, Inc.

API Soil / Groundwater Technical Task Force

EXECUTIVE SUMMARY

Recent studies of over 600 groundwater contamination sites throughout the U.S. provide important information regarding the fate and transport of petroleum hydrocarbons in the subsurface. This API research summary examines the findings of four independent research studies and addresses several key technical issues regarding the assessment and remediation of BTEX (benzene, toluene, ethylbenzene, xylene) plumes. On-going research regarding MTBE plume characteristics will be addressed in a future bulletin as data become available.

Key Finding: Most BTEX groundwater plumes are less than 200 ft in length and are in a STABLE or SHRINKING condition.



THE FOUR STUDIES

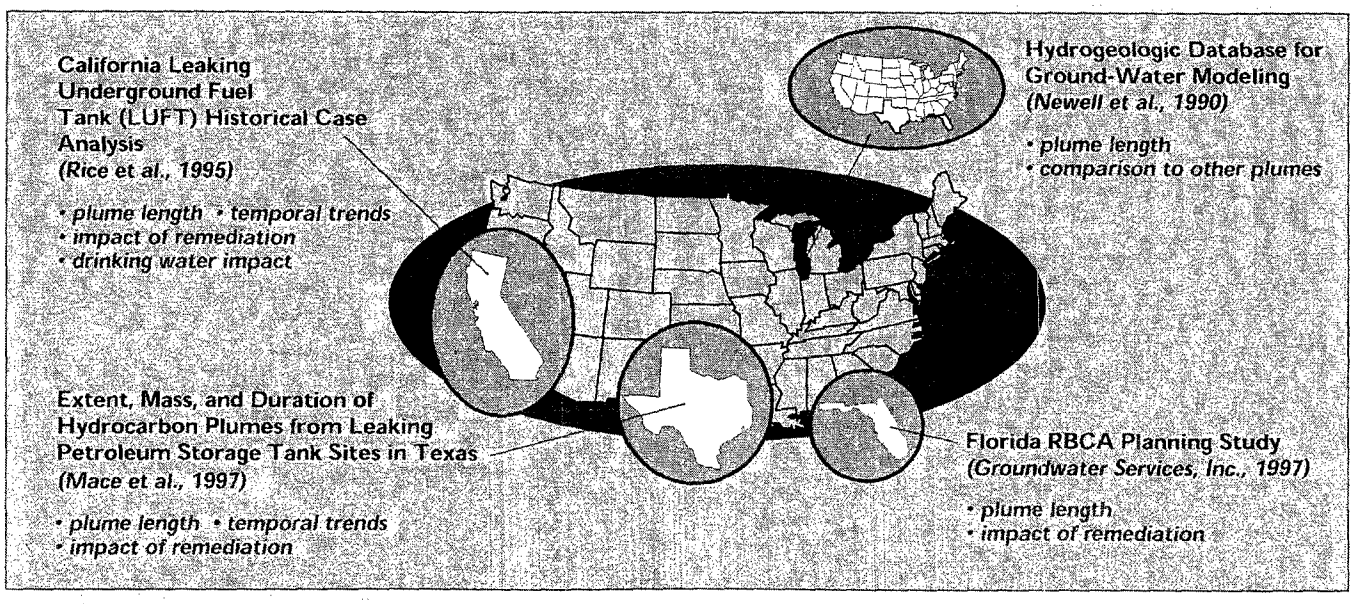
This bulletin summarizes information from four separate multi-site plume studies. Each study involved detailed analysis of data from a large number of sites (primarily underground storage tank facilities) to identify the key characteristics of groundwater contaminant plumes caused by petroleum hydrocarbon releases. Two comprehensive studies (California and Texas) evaluated how dissolved petroleum hydrocarbon plumes change over time.

In all four studies, detailed technical information regarding groundwater flow parameters and plume characteristics for each site were compiled from technical reports or questionnaires completed by site hydrogeologists or engineers. In combination, the four studies define the typical features of a dissolved hydrocarbon plume based on a cumulative database of 604 sites.

This API bulletin reviews the general methodology and principal conclusions of each study and uses these findings to answer several important questions related to the assessment and remediation of groundwater impacts associated with petroleum releases.

Technical Issues Regarding Dissolved BTEX in Groundwater:

- Typical plume length
- Persistence over time
- Effect of remediation
- Key factors in plume length
- Plume stability condition
- BTEX vs. other contaminants
- Drinking water impacts



California Leaking Underground Fuel Tank (LUFT) Historical Case Analysis

Rice, D.W., R.D. Grose, J.C. Michaelsen, B.P. Dooher, D.H. MacQueen, S.J. Cullen, W.E. Kastenberg, L.G. Everett, M.A. Marino. CA Environmental Protection Dept., Nov. 16, 1995.

APPROACH: This study, also referred to as the Lawrence Livermore National Laboratory (LLNL) Study, involved compilation and analysis of a detailed electronic database for 271 LUFT sites. Groundwater flow gradients and the average length and concentration of benzene plume were characterized on the basis of static water level data and groundwater time-series sampling records.

KEY RESULTS: Plume lengths "change slowly and stabilize at relatively short distances from the FHC (fuel hydrocarbon) release site" (90% of sites less than 255 ft). The median plume length was 101 ft for one of the two methods of calculation (see the following page) Plume lengths tend to change slowly with time, while average plume concentrations decline more rapidly. Hydrogeologic parameters (e.g., hydraulic conductivity, gradient) appear to have little relationship to plume length. Finally, "while active remediation may help reduce plume benzene concentrations, significant reductions in benzene concentrations can occur over time, even without active remediation."

Extent, Mass, and Duration of Hydrocarbon Plumes from Leaking Petroleum Storage Tank Sites in Texas

Mace, R.E., R.S. Fisher, D.M. Welch, and S.P. Parra. Bureau of Economic Geology, University of Texas at Austin, Austin, Texas. Geologic Circular 97-1, 1997.

APPROACH: The Texas Bureau of Economic Geology (BEG) evaluated groundwater impacts from fuel hydrocarbon releases at 217 sites in Texas. Groundwater plume lengths and concentration trends were analyzed in a manner similar to the California study (see Rice et al., above). In addition, hydraulic gradient and groundwater flow directions were characterized for various hydrogeologic and climatic regions of Texas

KEY RESULTS: Most benzene plumes (75%) are less than 250 ft long and have either stabilized or are decreasing in length and concentration The median plume length was 181 ft. Only 14% are increasing in concentration, and only 3% are increasing in length. The length of a benzene plume cannot be predicted on the basis of either site hydrogeology or previous remediation activities. Benzene plume characteristics are not statistically different between sites where groundwater remediation activities have or have not been implemented, although the authors state that these activities should "logically shorten the time required to decrease plume length and concentration."

Florida RBCA Planning Study

Groundwater Services, Inc Prepared for Florida Partners in RBCA Implementation, Groundwater Services, Inc., Houston, Texas. 1997. www.GSI-net.com

APPROACH: The Florida RBCA (Risk-Based Corrective Action) Planning Study involved collection and analysis of groundwater data from 117 leaking underground storage tank (LUST) sites distributed throughout 33 counties in Florida. Using these data, the report addresses the cost significance of various policy decisions related to development of the Florida RBCA regulations. For use in this bulletin, the plume maps and detailed site questionnaires compiled for 74 sites were reanalyzed to define typical plume properties.

KEY RESULTS: The median plume length among these Florida LUST sites is 90 ft based on available benzene and BTEX data. The shorter plume lengths observed in this database may be related to the varying detection limits used for plume delineation For plumes delineated to a 50 ppb benzene limit (51 sites), median plume length was 90 ft, compared to 120 ft for plumes delineated to 1 ppb benzene (21 sites). In addition, 51% of the Florida database sites are currently or had previously been subject to groundwater remediation efforts

A Hydrogeologic Database for Ground-Water Modeling

Newell, C.J., L.P. Hopkins, and P.B. Bedient. Ground Water, Vol. 28, No. 5, Sept./Oct. 1990. pp. 703-714.
API, 1989. Hydrogeologic Data Base for Groundwater Modeling, API Publication No. 4476, Washington, D.C.

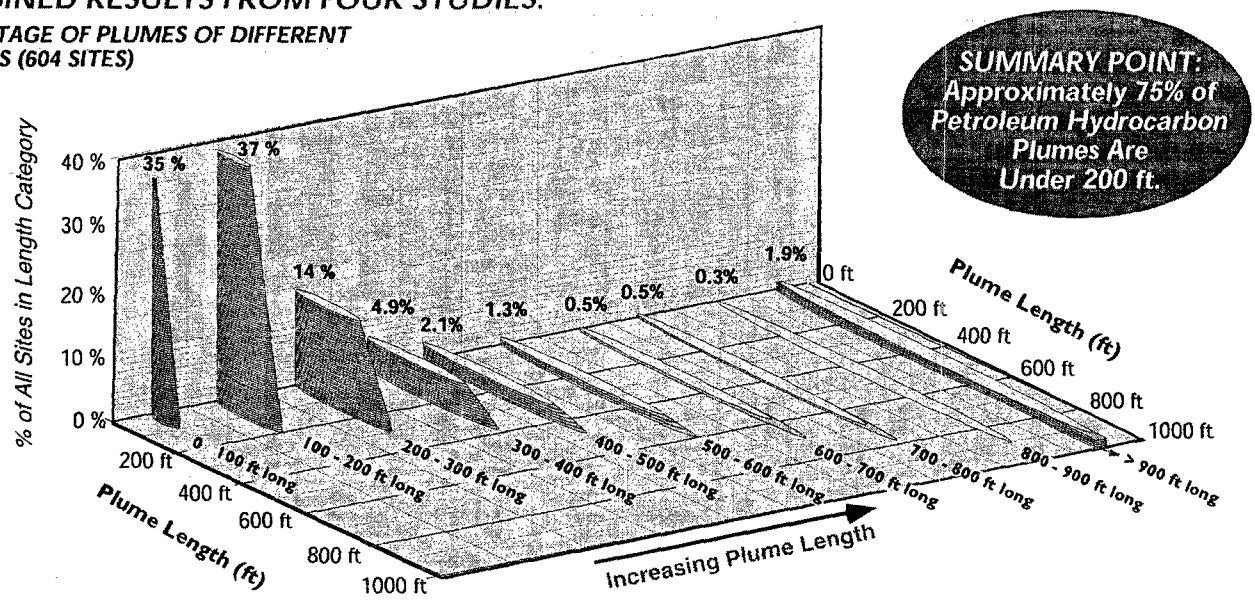
APPROACH: Hydrogeologic and chemical information from 400 site investigations across the U.S. was obtained in a national survey of National Ground Water Association members conducted in 1990. This 400-site database (available in spreadsheet form from the API Information Specialist, ehs@api.org) includes groundwater plume dimensions for a broad range of groundwater contaminants, including 42 service station BTEX sites, 40 non-service station BTEX sites, 78 chlorinated ethene sites, 25 non-ethene solvent sites, and 21 inorganic sites. For use in this bulletin, these data were reanalyzed to define typical plume properties for each chemical class.

KEY RESULTS: The 42 service station sites show a median benzene/BTEX plume length of 213 ft This database includes a higher percentage of longer plumes, with six BTEX plume lengths greater than 900 ft. On average, however, BTEX plumes are significantly smaller than the other chemical classes reported in this study, as discussed later in this Bulletin

WHAT IS THE LIMIT OF MIGRATION OF DISSOLVED PETROLEUM HYDROCARBON PLUMES?

COMBINED RESULTS FROM FOUR STUDIES:

PERCENTAGE OF PLUMES OF DIFFERENT LENGTHS (604 SITES)



INDIVIDUAL STUDY RESULTS:

ALL SITES	CALIFORNIA 271 Sites	TEXAS 217 Sites	FLORIDA 74 Sites	HGDB 42 Sites
SUMMARY - ALL SITES	**Summary**	**Summary**	**Summary**	**Summary**
Maximum Length: 3020 ft	Max 1713 ft	Max 1619 ft	Max 600 ft	Max 3020 ft
90th Percentile: 319 ft	90th % 255 ft	90th % 382 ft	90th % 211 ft	90th % 945 ft
75th Percentile: 203 ft	75 % 146 ft	75 % 250 ft	75 % 158 ft	75 % 400 ft
MEDIAN LENGTH: 132 ft	**MEDIAN 101 ft**	**MEDIAN 181 ft**	**MEDIAN 90 ft**	**MEDIAN 213 ft**
25th Percentile: 80 ft	25th % 66 ft	25th % 137 ft	25th % 60 ft	25th % 85 ft
Minimum Length: 8 ft	Min 8 ft	Min 54 ft	Min 12 ft	Min 15 ft

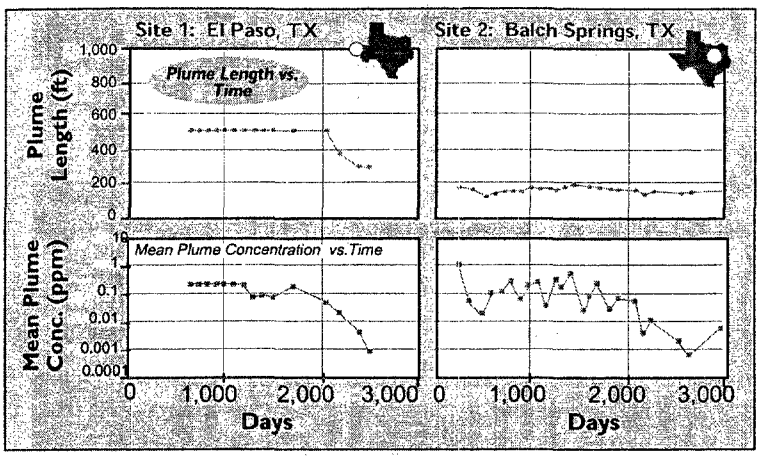
• LOCATION OF SITES:	CALIFORNIA	TEXAS	FLORIDA	ENTIRE U.S.
• **Plume constituent(s):**	Benzene	Benzene	Benzene, BTEX	Mostly benzene, BTEX constituents
• **Plume Delineation Limit:**	10 ppb	10 ppb	1 - 50 ppb	Not reported; probably analytical detection limit
• **Types of Sites:**	UST sites with affected groundwater. No fractured rock sites.	UST sites with affected groundwater. Includes limestone aquifers.	UST sites with affected groundwater.	UST sites at service stations located in various hydrogeologic settings.
• **Method For Determining Plume Length:**	***Modeled:*** Length extrapolated from 2-D transport models fit to site monitoring data. Reported results for exponential and error-function equations (summary stats above from error function).	***Modeled:*** Length extrapolated from 2-D GW transport model fit to site monitoring data. Used exponential equation only.	***Measured:*** Length derived from site plume maps. Data analyzed as part of this bulletin.	***Reported:*** Plume lengths reported by site consultants in survey questionnaires. Data analyzed as part of this bulletin.
• **Sites w/ Soil Vapor Extract.**	— Not reported	— 105 of 479 (22%)	— Not reported	— Not reported
• **Sites w/ GW Pump & Treat**	— 53 of 208 sites (26 %)	— 92 of 479 sites (19 %)	— 32 of 74 sites (43 %)	— Not reported
• **Sites w/ GW Sparging**	— Not reported	— 22 of 479 sites (5 %)	— 6 of 74 sites (8 %)	— Not reported

(note different #s of sites reported)

HOW MANY PETROLEUM PLUMES ARE SHRINKING? STABLE? EXPANDING?

APPROACH

Both the California and the Texas studies (Rice et al., 1995; Mace et al., 1997) analyzed changes over time in the length and average concentration of dissolved hydrocarbon plumes. For the California study, these evaluations were conducted on a subset of sites having at least 6 wells and 8 sampling episodes extending over multiple years. Typical monitoring records for the Texas study ranged from 4 to 7 years as shown in data from two typical sites to the right.



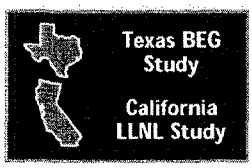
Plume stability trends were determined as follows:

Plume Length Trend: For each sampling episode, the plume length from the source to the 10 ppb concentration point was extrapolated using a 2-D groundwater transport model calibrated to the site monitoring data. Length vs. time was plotted for each site to define change over time.

Plume Concentration Trend: *For each sampling episode, the average benzene concentration in the plume area was estimated using* Delauney triangulation (Isaaks and Srivastava, 1989), an area-weighted averaging procedure involving subdivision of the plume area into triangular segments defined by adjacent wells. Average concentration vs. time was plotted for each site to define change over time.

These methods do not account for plume spreading beyond the area described by the monitoring well array. However, both studies found this approach to be sufficiently robust to accurately characterize plume trends over time.

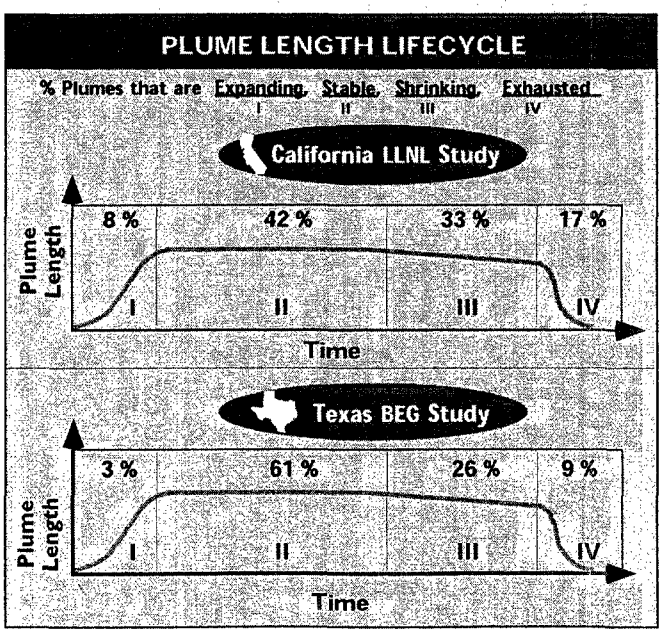
KEY RESULTS

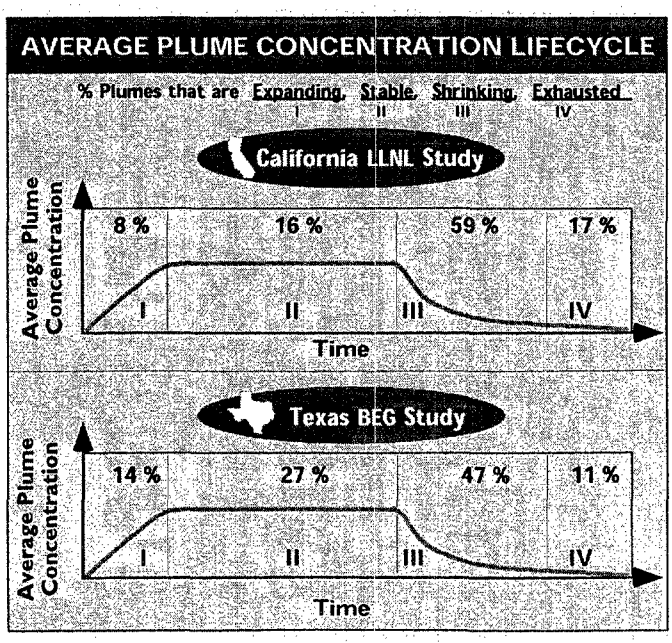


Based on the observed trends, the studies grouped the plumes into four categories:

- ***Expanding:*** Residual source present. Mass flux of contaminants exceeds assimilative capacity of aquifer.
- ***Stable:*** Insignificant changes. Active or passive remediation processes are controlling plume length.
- ***Shrinking:*** Residual source nearly exhausted, and active or passive remediation processes significantly reducing plume mass.
- ***Exhausted:*** Average plume concentration very low (e.g., 1 ppb) and unchanging over time. Final stages of source zone dissolution over a relatively small area at a site.

As shown in the conceptual plume lifecycle figures below, of the nearly 500 sites addressed by this analysis, nearly 75% were found to be in either a stable or shrinking condition, based on analyses of both plume length and concentration. Plume concentrations were predominantly shrinking (47 to 59%), whereas lengths were frequently stable (42 to 61%). These results suggest that dissolved hydrocarbon plumes tend to reduce more rapidly in concentration than in length. Similar results were observed in a plume study performed by Buscheck et al. (1996), where 67% of 119 plumes in northern California were found to be stable/shrinking in length, and 91% had stable/diminishing concentrations.





Figures adapted from Rice et al., 1996.

HOW LONG WILL BTEX PLUMES PERSIST?

CALIFORNIA & TEXAS STUDIES: *90% Attenuation of Average Concentration of Shrinking Plumes*

For those plumes characterized as **shrinking** (see page 4), both the California and Texas studies (Rice et al., 1995; Mace et al., 1997) included an evaluation of the time required for the average plume concentration to reduce by 90%. The rates of change calculated for each data set are shown in the table to the right.

Time Required for 90% Attenuation in Average Concentration for Shrinking Plumes:

161 SITES	MEDIAN SITE IN CALIFORNIA:	3.2 yrs
	10th Percentile:	1.5 yrs
	90th Percentile:	7 yrs

90 SITES	MEDIAN SITE IN TEXAS:	1.4 yrs
	10th Percentile:	0.7 yrs
	90th Percentile:	2.7 yrs

Note that, in these analyses, the ***average concentration*** term corresponds to an area-weighted average BTEX concentration derived using the Delauney triangulation method for each groundwater sampling episode. Consequently, trends in this concentration term should be representative of the total plume mass. Data from the California and Texas studies show that, once a dissolved BTEX plume begins to shrink (a condition observed at roughly 50 - 60% of the LUST sites in these studies), the rate of decline in plume mass is relatively rapid. Based on the median rate of mass reduction reported in these studies, *for a shrinking plume, only 5 to 10 years are required for the average plume BTEX concentration to drop from an initial level of 1 ppm down to 1 ppb.* (This assumes a first order decay model applies over three orders of magnitude of concentration reduction.) At this point, the plume reaches an ***exhausted*** condition, which may represent low levels of BTEX persisting in source-area wells for an extended time period thereafter.

WHAT IS THE EFFECT OF REMEDIATION ON BTEX PLUMES?

Three of the four studies evaluated the performance of remediation efforts in reducing or controlling petroleum hydrocarbon plumes. Based on a review of large site populations, the studies consistently draw a conclusion that runs counter to expectations: soil and groundwater remediation efforts did not result in smaller BTEX plumes.

QUOTES

(Rice et. al, 1995)

"While active remediation may help reduce plume benzene concentrations, significant reductions in benzene concentrations can occur with time, even without active remediation." (pg. EX-2)

"At low concentration sites, pump and treat increases the probability of having a negative average benzene concentration trend by roughly a factor of two, while it has essentially no impact on probability at high concentration sites." (pg. 13)

"An analysis of plume length categories shows that none of the remediation treatment variables have a significant impact on the relative frequencies of the different categories." (pg. 13)

PROBABILITY (P) OF DECREASING CONCENTRATION TREND*

Pump & Treat Site?	Site Over-Excavated?	P
–	–	52 %
√	–	71 %
–	√	64 %
√	√	80 %

* 208 Sites > 1 ppb avg. conc.

(Mace et. al, 1997)

"The use of active ground-water remediation has not yet resulted in a lower median plume length at LPST sites throughout the state where corrective action is under way. This does not mean that remediation does not improve ground-water conditions at individual sites, but that when all LPST sites are reviewed, plume lengths at sites with remediation do not appear different from plume lengths at sites without remediation." (pg. 34)

"This probably means that significant spills occur before being detected and that most plumes are in place and in equilibrium before active remediation takes effect." (pg. 34)

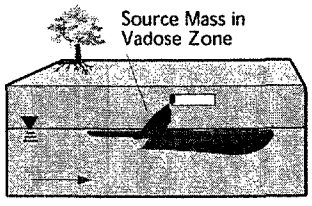
% OF PLUMES THAT ARE:

	Stable	Shrinking	Exhaus.
67 Sites WITH Pump & Treat	35 %	61 %	4 %
117 WITHOUT Pump & Treat	38 %	52 %	10 %

"We found no difference in plume length between different remediation techniques and sites with no remedial action." (pg. 33)

(GSI, 1997)

"Of the 117 sites included in this study, affected soils have been previously removed at 28 sites. For these 28 sites, the estimated median groundwater source mass is approximately 34% lower than the median groundwater source mass where overlying soils have not yet been removed. These data suggest that, while the soil removal actions have served to reduce groundwater impacts, a significant percentage of the contaminant source (66%) remains in place in the saturated, water-bearing unit." (pg. 21)



"..soil removal would not significantly affect groundwater remediation requirements." (pg. 21)

WHAT ARE THE FACTORS THAT CONTROL BTEX PLUME LENGTH?

TEXAS AND CALIFORNIA STUDIES

The California and Texas studies attempted to correlate plume length with various hydrogeologic factors. In both studies, plumes were segregated into two subsets (shallow vs. deep) and correlation coefficients were calculated for plume length vs. a range of site parameters. Results of these analyses are summarized below.

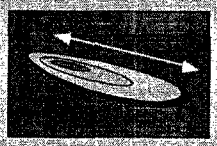
RESULTS: TEXAS STUDY

The Texas study (Mace et al., 1997) concluded that **plume length could not be predicted** by the following variables:

- *Depth to water*
- *Hydraulic gradient*
- *% Organic Carbon in water-bearing zone*
- *Thickness of sweep (smear) zone*
- *Hydrogeologic setting (in unconsolidated media)*
- *Previous remediation activities (see page 5)*

The authors concluded that "hydrogeologic site characteristics and site activities considered in this study do not explain the variation in average plume length or plume mass and concentration."

The report identifies other factors, such as the amount of spilled fuel and natural biodegradation rate, as having a greater influence than hydrogeology or previous remediation activities.



RESULTS: CALIFORNIA STUDY

The California study (Rice et al., 1995) concluded that **plume length was not correlated to:**

- *Groundwater depth*
- *Saturated thickness*
- *Free product thickness*
- *Hydraulic gradient*
- *Number of site layers*
- *Previous remediation activities (see page 5)*

The authors concluded that: "Individual or combinations of other hydrogeologic variables have little apparent relationship to plume characteristics. Correlations among a variety of hydrogeologic variables and plume length show no indications of interaction. Transport indices that in theory should affect plume length, such as groundwater flow velocity, show no correlation."

They attributed the lack of correlation to the presence of controlling but not measured variables (such as source mass and biodegradation rate), scatter in the hydrogeologic data, and cyclical change in hydrogeologic variables that causes a delayed effect on plume length, and general site complexity wherein each site has a unique set of controlling variables.

These studies suggest that the size of the release is probably one of the key variables that controls plume length. Larger sources (in terms of mass, width, and affected soil volume) mean that more dissolved-phase constituents are transferred to groundwater, creating longer dissolved phase plumes.

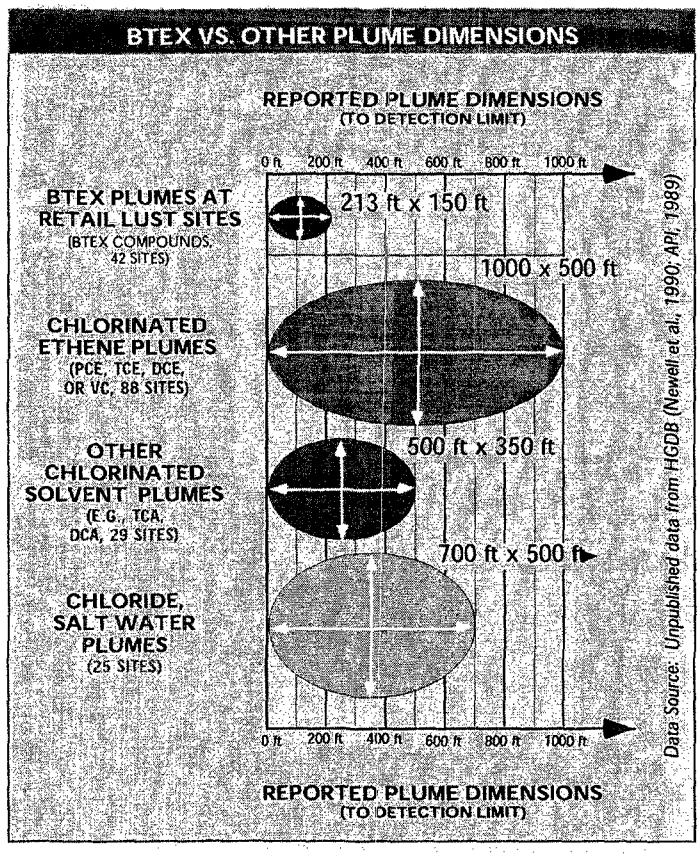
HOW MUCH GROUND WATER IS AFFECTED BY BTEX PLUMES?

An upper-range estimate of the total volume of groundwater resources impacted by releases from LUST sites can be obtained using a calculation method described in the California study (Rice et al., 1995). In this method, the 95th percentile BTEX plume volume observed in the California study (i.e., 0.7 acre ft. or 230,000 gallons) is multiplied by the total number of reported LUST sites to obtain a total affected groundwater volume. Dividing this value by the total groundwater basin storage capacity provides an estimate of the percentage of resources impacted by LUST sites. Results for both California and the U.S. are provided below. Note that LUST sites usually affect shallow water table aquifers not typically used for public supply.

BTEX Plume Volume (95%)	X	No. of LUST Sites	=	Total BTEX GW Volume	÷	Total GW Resource Volume	=	% Total GW Resource Impacted
0.7 acre-ft		10,000		7000 acre-ft		1.3 billion acre-ft		0.0005 %
0.7 acre-ft.		358,000 (U.S. EPA, 1998)		250,000 acre-ft		614.3 billion acre-ft (Lehr, 1985)		0.00004 %

HOW ARE BTEX PLUMES DIFFERENT FROM OTHER PLUMES?

The HGDB Study (Newell et al., 1990) provides plume length data for a variety of contaminants, including BTEX, chlorinated solvents, and brine releases. This chart shows plume widths and lengths as reported by HGDB respondents. As shown, BTEX plumes are much smaller than other types of plumes. Likely causes for this difference include: i) the smaller source zone area associated with BTEX releases from LUST sites, and ii) the more biodegradable nature of BTEX constituents relative to the other contaminants. Note that other studies are in progress to characterize other types of plumes (e.g., Happel et al., 1998; Mace, 1998; Newell et al., 1998).



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API Soil & Groundwater Research Publications

Publ *4668*, Delineation and Characterization of the Borden MTBE Plume: An Evaluation of Eight Years of Natural Attenuation Processes, June 1998
In 1988, a natural gradient tracer test was performed in the shallow sand aquifer at Canada Forces Base (CFB) Borden to investigate the fate of a methyl-tertiary-butyl-ether (MTBE) plume introduced into the aquifer. Solutions of groundwater mixed with oxygenated gasoline were injected below the water table along with chloride (Cl^-), a conservative tracer. The migration of benzene, toluene, ethylbenzene, the xylenes (BTEX); MTBE; and Cl^- was monitored in detail for about 16 months. The mass of BTEX in the plume diminished significantly with time due to intrinsic biodegradation. MTBE, however, was not measurably attenuated. In 1995-96, a comprehensive groundwater sampling program was undertaken to define the mass of MTBE still present in the aquifer. Only about 3 percent of the initial MTBE mass was found, and it is hypothesized that biodegradation played an important role in its attenuation. Additional evidence is necessary to confirm this possibility. Pages: 88.
Order Number: I46680, Price: $30.00

Publ *4657*, Effects of Sampling and Analytical Procedures on the Measurement of Geochemical Indicators of Intrinsic Bioremediation: Laboratory and Field Studies, November 1997
This study evaluates the effects of various sampling and analytical methods of collecting groundwater geochemical data for intrinsic bioremediation studies. Sampling and analytical methods were tested in the laboratory and in the field. Several groundwater sampling and analytical methods may be appropriate for measuring geochemical indicators of intrinsic bioremediation. The methods vary in accuracy, level of effort, and cost. Pages: 86.
Order Number: I46570, Price: $30.00

Publ *4658*, Methods for Measuring Indicators of Intrinsic Bioremediation: Guidance Manual, November 1997
This guidance manual is intended to be a resource for practitioners of intrinsic bioremediation in allowing selection of sampling and analytical methods that meet project-specific and site-specific needs in scoping field investigations, provides procedures that will improve the representative quality of the collected data, and considers potential biases introduced into data through the sampling and analytical techniques employed in the site investigation. Pages: 96.
Order Number: I46580, Price: $35.00

Publ *4654*, Field Studies of BTEX and MTBE Intrinsic Bioremediation, October 1997
A gasoline release field site in the Coastal Plain of North Carolina was monitored for more than three years to allow calculation of in situ biodegradation rates. Laboratory microcosm experiments were performed to further characterize the biodegradation of BTEX and MTBE under ambient, in situ conditions. Finally, groundwater modeling studies were conducted to facilitate the interpretation of field data and to evaluate various approaches for predicting the fate and effects of these gasoline constituents in the subsurface. Pages: 244.
Order Number: I46540, Price: $40.00

Publ *4627*, *In Situ* and On-Site Biodegradation of Refined and Fuel Oils: A Review of Technical Literature 1988-1991, June 1995
This report reviews more than 200 technical articles published between 1988 and 1991 in the area of on-site and in situ bioremediation of petroleum hydrocarbons. It focuses specifically on current field and laboratory research related to petroleum hydrocarbon biodegradation including biodegradation of crude oil and solvents. Recent work in fate and transport modeling that can be applied to petroleum hydrocarbon contamination in groundwater is also covered. The review is designed to complement an earlier (pre-1988) review published by the U.S. Navy. Pages: 146.
Order Number: I46270, Price: $30.00

DR *200*, Modeling Aerobic Biodegradation of Dissolved Hydrocarbons in Groundwater, April 1995
This report describes a 3-D groundwater transport model that accurately characterizes the nature of aerobic biodegradation, i.e., the mixing of oxygen and dissolved hydrocarbons at plume edges of petroleum spills to the subsurface. The report also demonstrates the differences between spreading and mixing phenomena. The approaches in this report will be used to develop user-friendly biodegradation models which will be helpful in site-specific evaluations. The use of such models could lead to shorter and less expensive cleanups at some sites. Pages: 76.
Order Number: I00200, Price: $30.00

Publ *4593*, Transport and Fate of Non-BTEX Petroleum Chemicals in Soils and Groundwater, September 1994
Order Number: I45930, Price: $40.00

Publ *4601*, Transport and Fate of Dissolved Methanol, MTBE and Monoaromatic Hydrocarbons in a Shallow Sand Aquifer, April 1994
Order Number: I46010, Price: $65.00

Publ *4551*, Treatment of Gasoline-Contaminated Groundwater Through Surface Application: Laboratory Experiments, July 1994
Order Number: I45510, Price: $55.00

Publ *4552*, Treatment of Gasoline-Contaminated Groundwater through Surface Application: A Prototype Field Study, July 1994
Order Number: I45520, Price: $40.00

Publ *4415*, Literature Survey: Unassisted Natural Mechanisms to Reduce Concentrations of Soluble Gasoline Components, August 1985
Order Number: I44150, Price: $25.00

Publ *4476*, Hydrogeologic Data Base for Groundwater Modeling, February 1989
Order Number: I44760, Price: $25.00

NOTE: ***Prices are subject to change.***

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