EA Project CHV 820

REPORT OF INVESTIGATION
CHEVRON SS 9-7127
GRANT LINE ROAD AND INTERSTATE 580
TRACY, CALIFORNIA

Prepared for

Chevron U.S.A., Inc.
San Ramon, California

Prepared by

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13 Nov 87
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1. INTRODUCTION

1.1 SCOPE

At the request of Chevron U.S.A. Inc., EA Engineering, Science, and Technology, Inc. conducted a Soil Vapor Contaminant Assessment (SVCA) at Chevron Service Station 9-7127 in Tracy, California. This report describes the SVCA process, presents the results for the site survey, and makes recommendation for further actions based on these results.

1.2 SITE SETTING

Chevron Service Station 9-7127 is located near the Grant Line Road exit from Interstate 580 in Alameda County, California (Figure 1). It is located in an isolated area and is surrounded by pastures (Figure 2). There are no houses or businesses in close proximity to the site, the nearest structures being associated with a wind farm approximately 0.25 mile from the site. The site is on the top of a leveled hill, with steep sides on the east and southeast boundaries of the site. The Engineering Department of the City of Tracy did not know of any wells in the general vicinity of the site (Vincent 1987, personal communication).

1.3 PRINCIPLES OF SOIL VAPOR CONTAMINANT ASSESSMENT

The soil vapor survey, or SVCA, technique takes advantage of the behavior of hydrocarbon mixtures and the physicochemical properties of the individual components in the subsurface. Following a subsurface gasoline release, free product will migrate downwards towards the ground water, some of the gasoline will volatilize, and some will adsorb to the soils. In the case of a spill of sufficient volume to exceed the soil binding capacity, free

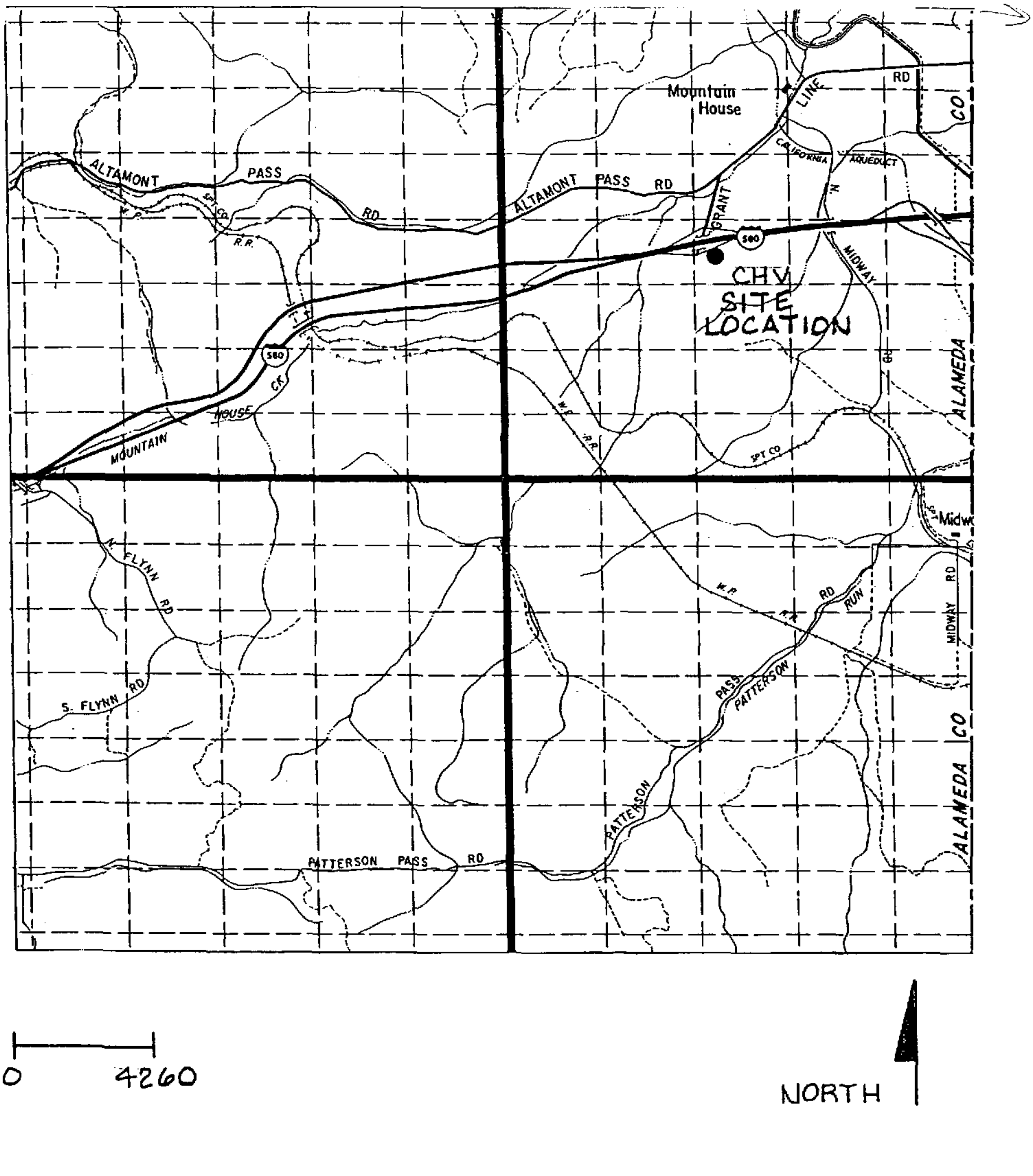

Figure 1: Location of Chevron Service Station 9-7127, Tracy, California.

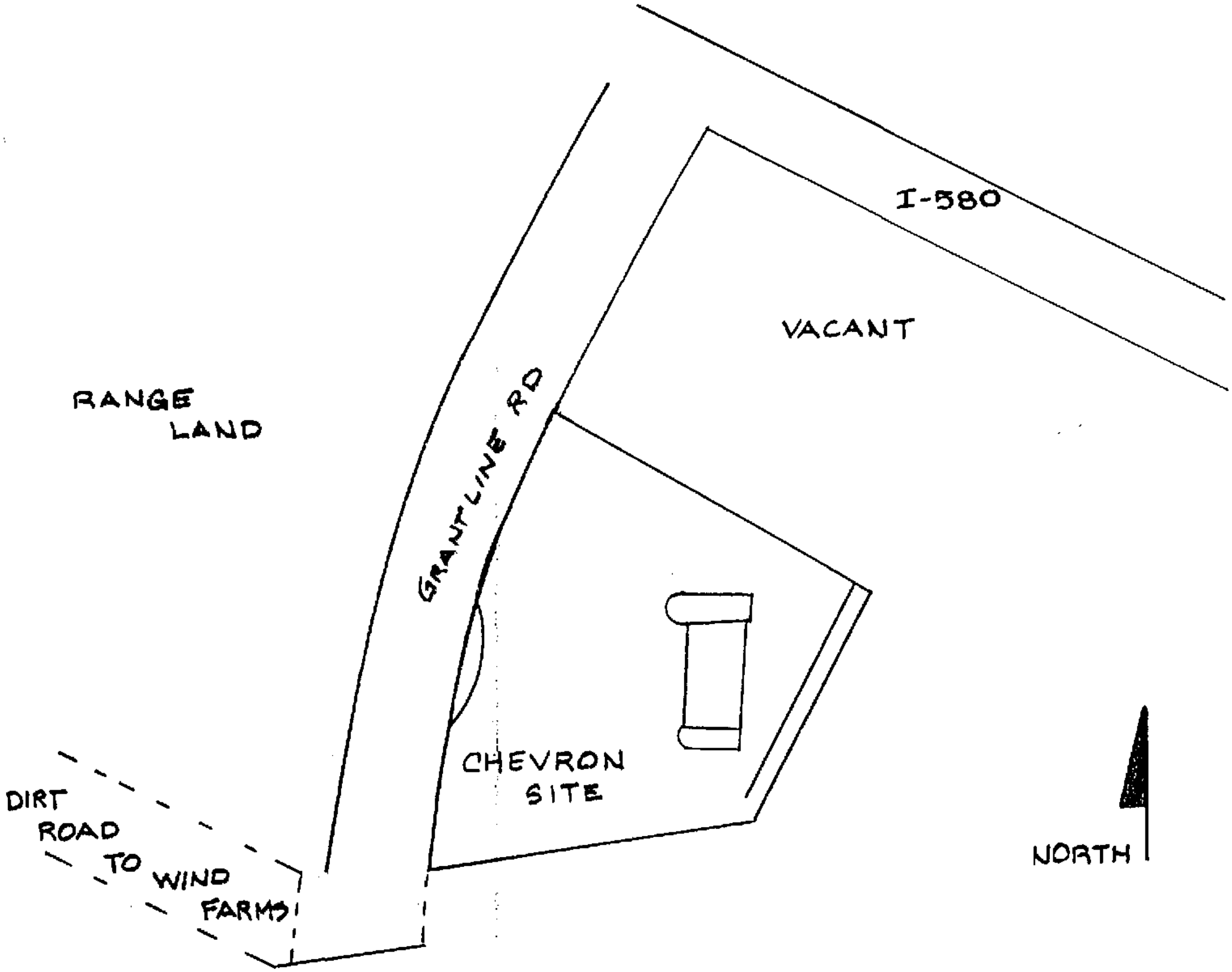

Figure 2: Land-Use in the vicinity of Chevron Service Station 9-7127, Tracy, California.

liquid will reach ground water, at which point it will float and may begin to vaporize and solubilize.

Like most hydrocarbon liquids, gasoline is a complex mixture of many compounds, each with its own physicochemical properties. The contaminants found in ground water located beneath a layer of floating hydrocarbon are generally less hydrophobic and are generally found in concentrations proportional to the hydrocarbon/water partition coefficient (i.e., the relative solubility of a given compound in the bulk hydrocarbon to its solubility in water) and to their percent composition in the gasoline. It may be noted that concentration of total benzene, toluene, and xylenes in product-saturated water may exceed 10-20 mg/L (API 1985).

Hydrocarbons will also volatilize into the air- or gas-filled soil interstices. Volatilization is largely a function of vapor pressure. The natures of the contaminant mixtures, in terms of specific component mixtures, in either the aqueous or vapor phase, are distinctly different from each other and from the gasoline. That is, the more hydrophilic hydrocarbons will be more likely to move into ground water, while the more volatile compounds are more likely to move into the vapor phase, and the compounds that are both less volatile and more hydrophobic are more likely to remain in the free product or be adsorbed to soils (Hinchee and Reisinger 1987).

Hydrocarbons not remaining in the free product will partition into either ground water or soil vapor and migrate as the result of a variety of interacting forces. In ground water, contaminants will migrate with the ground-water flow, interacting with the rock or soil geological medium. As the contaminants pass through a medium, organic constituents in the medium interact with the contaminants, and some are adsorbed or bound to particle surfaces (Bruell and Hoag 1986). The result is a net retardation in the velocity of movement of those compounds relative to that of the ground water in which they are dissolved. The process is analogous to laboratory chromatography. The compound with the least affinity for the porous medium is least retarded and therefore moves most rapidly. This compound, then, is present at the leading edge of a contaminant plume.

The affinity of a compound for the soil porous medium is partly a function of the compound's hydrophobicity--that is, the more hydrophobic a compound the more likely it is to adsorb to the solid medium. Aqueous solubility is a good indicator of hydrophobicity: the more soluble a compound is, the less hydrophobic and more hydrophilic it is, and vice versa. Vapor pressure is a good indicator of volatility; compounds with higher vapor pressures are more volatile.

In determining the environmental fate of various hydrocarbon compounds in a hydrocarbon mixture such as gasoline, those which have a high vapor pressure are more likely to move into the vapor phase, or evaporate. Compounds with high solubility are more likely to move into ground water from the free product and, once in ground water, tend to move more rapidly. Compounds of low vapor pressure and low solubility tend to remain in the free product or be adsorbed to the solid matrix and remain relatively immobile.

Dissolved compounds will tend to volatilize from the aqueous phase. The Henry's Law constant is the equilibrium ratio of a compound's concentration in the vapor phase to its concentration in the aqueous phase. The higher a compound's Henry's Law constant, the greater its tendency to volatilize from water into air.

Figure 3 graphically illustrates the vapor pressure, aqueous solubility, and Henry's Law constants, and their relationships, for selected hydrocarbons typically found in gasoline. The

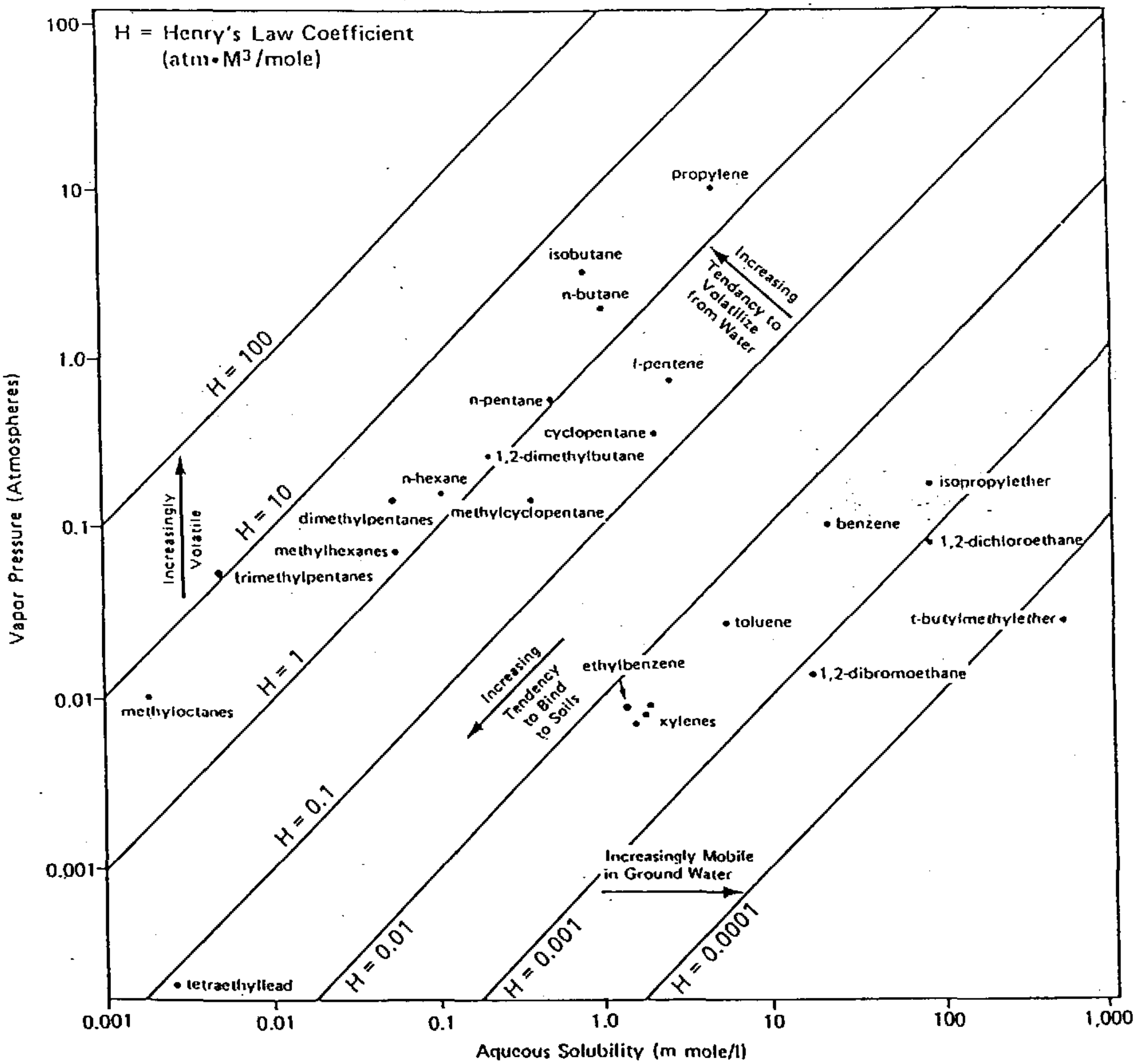

Figure 3. Vapor pressures, solubilities, and corresponding Henry's Law constants for major constituents of gasoline.

Henry's Law constant is approximated here as the ratio of vapor pressure to solubility.

The Henry's Law constant is directly related to the tendency of compounds to volatilize, as opposed to solubilizing. Compounds with Henry's Law constants greater than 0.001 ($atm \cdot m^3$/mole) volatilize from water into air very rapidly (Lyman et al. 1982); those with Henry's Law constants greater than 0.01 ($atm \cdot m^3$/mole) are generally volatilized so rapidly that they are seldom found in gasoline-contaminated ground water. It may be observed (Figure 3) that tetraethyl lead (TEL) has an extremely low solubility and a relatively low vapor pressure. As a result, this constituent would not be expected to solubilize and migrate in ground water, and although its low vapor pressure would indicate slow volatilization, its Henry's Law constant indicates that it may be more rapidly volatilized than solubilized. The fate of TEL would be expected to be long-term binding to the soil.

On the basis of these properties it can be seen that associated with any ground water, soil, or free-product contamination is vapor phase contamination. The SVCA technique takes advantage of this, and through the collection and analysis of soil vapor permits a rapid, cost-effective delineation of the extent of contamination.

2. FIELD INVESTIGATIONS

2.1 HYDROGEOLOGY

The specific soils and hydrology of the Tracy site have not been investigated. The site is in the San Joaquin Valley, where Cretaceous marine sediments dominate. The rock types are typically shales and cherts overlain by alluvial sands and gravels (DMG 1966).

2.2 SOIL VAPOR CONTAMINANT ASSESSMENT

On 27 October 1987, EA conducted an SVCA at the Tracy site. Soil gas samples were taken from 13 on-site locations and 2 off-site locations (Figure 4), at depths of 3 to 12 feet. At SVCA points V1 (near the tank field), V5 (at the northern end of the eastern pump island), and V8 (near the waste oil tank) vertical profiles of soil gas composition were taken. There is a well along the southeastern site boundary. Its purpose is unknown. A well headspace sample was not taken for analysis because the well could not be opened.

Before each sample was collected, a vacuum pump was used to purge previously collected vapor from the probe to ensure that soil vapor samples collected were not contaminated. The vacuum pressure reading on the purging apparatus was recorded. This vacuum pressure is related to the soil's gas permeability and is useful in data interpretation. The samples were collected through a septum with a microsyringe and injected into a Photovac 10S50 chromatograph for analysis.

The Photovac 10S50 is a portable, programmable, integrating gas chromatograph with a photoionization detector (PID). The PID is a nondestructive flow-through detector that uses high energy ultraviolet radiation as its ionization source. The high energy

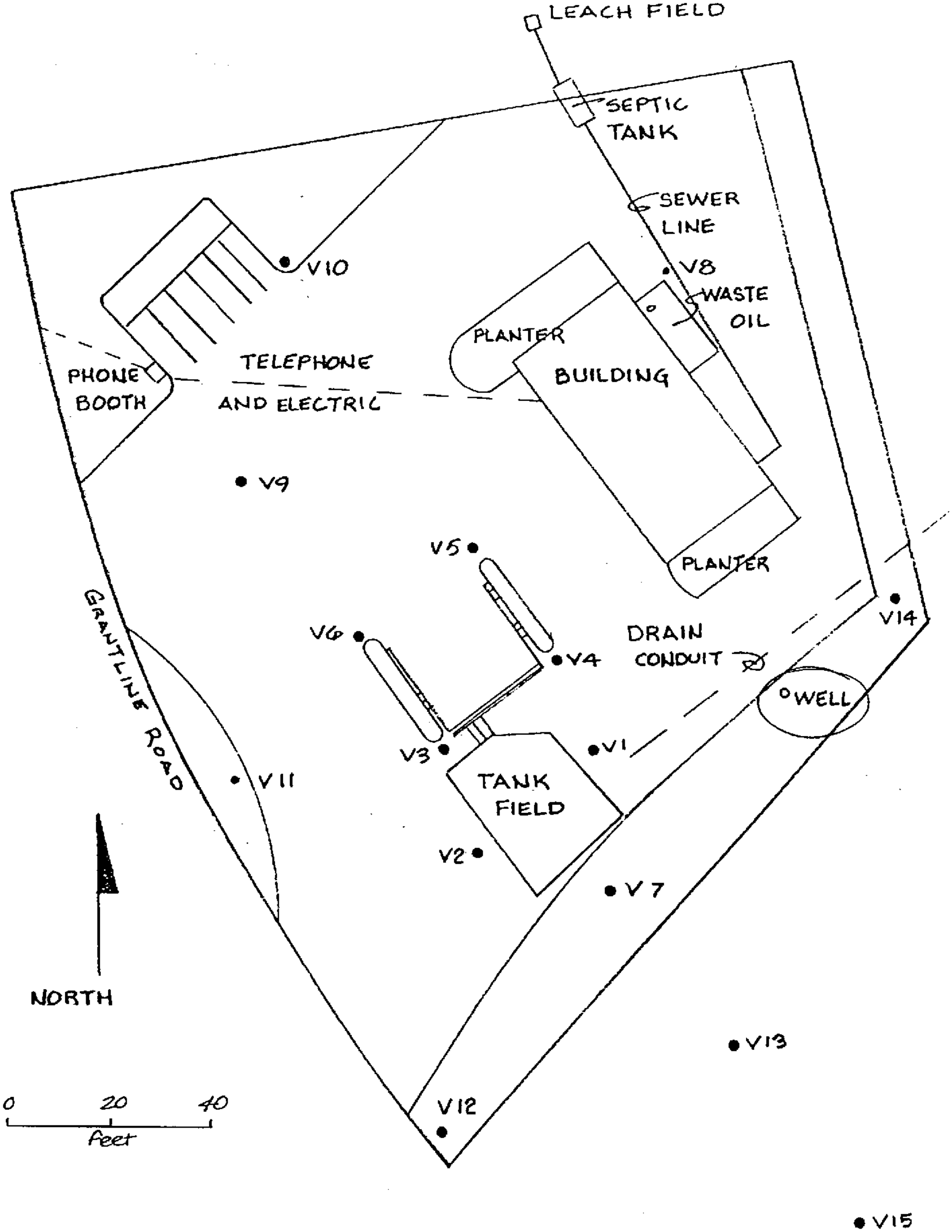

Figure 4. Site plan, with vapor sampling points, Chevron Service Station 9-7127, Tracy, California.

radiation ionizes compounds, generating an energy increase in the detector which appears as an electrical signal measured in volts; this is integrated across time by the instrument to give a value for the peak in volt-seconds (V-sec). The instrument is calibrated with standards consisting of known concentrations of hydrocarbon constituents (e.g., benzene) in air. For the reading of each standard, the instrument stores the known concentration and the V-sec response to it. The ratio for the standard, V-sec:ppm, is then used to quantify the concentrations of identifiable vapors in field samples according to their V-sec values.

The concentrations of unidentified compounds are calculated in a similar manner. Although petroleum hydrocarbons produce variable instrumental responses, the assumption may be made that all of the hydrocarbon constituents have response-to-concentration ratios approximately equivalent to that of benzene and that all quantifications may be based on the ratio for benzene. In the table of results, the column entitled "Peaks Prior to Benzene" represents the sum of the responses in V-sec for all peaks eluting prior to benzene, proportioned to the calibrated V-sec response for benzene. Similarly, the column entitled "Total Detected Petroleum Hydrocarbons" or "Total Volatile Hydrocarbons" represents the sum of all V-sec responses, proportioned to that for benzene.

The gas chromatograph is operated in backflush mode to prevent contamination of the analytical column with high concentrations of interfering compounds. Blanks are run to ensure that the system was free of contamination. As necessary, the instrument is re-calibrated by injecting standards and by running ambient air blanks approximately every two hours through the day. This re-calibration ensures that the system is operating consistently and that parametric changes caused by temperature changes through the day are accounted for. These data, along with multiple standard runs, ensure system reproducibility.

Table 1 presents the results of the SVCA. Figures 5 through 8 show isoconcentrations contours for several constituents. Moderate-to-high levels of hydrocarbon contamination of the shallow soil gas were detected. As can be seen from Figures 5 through 8, there appears to be a concentration of hydrocarbons in the vicinity of the tank field and perhaps another one near the western pump island. The soil gas hydrocarbon plumes appear to extend beyond site boundary to the southeast.

Although there are no ground-water data for contamination at this site, the SVCA results can be used to make order-of-magnitude estimates of potential dissolved benzene and toluene concentrations. A Henry's Law constant (H) is the ratio of a chemical's concentration in air to its concentration in water at equilibrium. It can be estimated by:

$$H = C_{SV}/C_W \qquad \text{(Equation 1)}$$

where

H = Henry's Law constant, atm·L/mole;
C_{SV} = vapor concentration, atm; and
C_W = water concentration, mole/L.

For estimating ground water concentrations, equation 1 can be rearranged as:

$$C_W = C_{SV}/H \qquad \text{(Equation 2)}$$

To make the units compatible, the following conversions are used:

1 ppm soil vapor = $1x10^{-6}$ atmosphere
1 mole = mole weight expressed in milligrams

The molecular weights of benzene and toluene are $78x10^3$ mg/mole and $92x10^3$ mg/mole, respectively; their Henry's Law constants are 5.6 and 6.4 atm·L/mole (EPA 1986). Using these data and Equation

TABLE 1 CONCENTRATIONS OF HYDROCARBON CONSTITUENTS IN SOIL VAPOR AT CHEVRON SS 9-7127, I-580 AND GRANT LINE ROAD, TRACY, CALIFORNIA, 27 OCTOBER 1987

Sample Location	Depth (ft)	Peaks[a] Prior to Benzene (ppm)	Benzene (ppm)	Toluene (ppm)	Total[a] Detected Hydrocarbons (ppm)
V1	3	<5	<1	<1	<5
V1/B	5	3,700	650	3,200	7,500
V1/C	8	18,000	600	2,800	20,000
V2	5	130	<5	30	160
V3	3	10	5	10	30
V3/B	5	<5	1	10	15
V4	3	20,000	3,200	5,200	28,500
V4/B	5	120	130	1,900	2,000
V5	5	1	<1	<5	<5
V5/B	7	620	40	<1	750
V6	5	1,150	540	160	7,300
V7	5	1,300	<5	<5	1,400
V8	3	<1	<1	<1	<1
V8/B	8	<1	<1	<1	<1
V9	8	1	<1	<10	10
V10	8	<1	<1	<1	<1
V11	5	<1	<1	<1	<1
V12	8	<1	<1	<1	<1
V13	12	20	<1	<1	25
V14	8	<1	<1	<1	<1
V15	12	<1	<1	<1	<1

BLANK DATA

Test Time	Peaks Prior to Benzene (ppm)	Benzene (ppm)	Toluene (ppm)
0948	<0.1	<0.1	<0.1
1256	<0.1	<0.1	<0.1

PERCENTAGE OF STANDARD RECOVERED

Test	Standard	
Time	Benzene	Toluene
1001	100	100
1306	100	100
1447	101	99

a. Quantification based on the volt-second:ppm response ratio for benzene; see text.

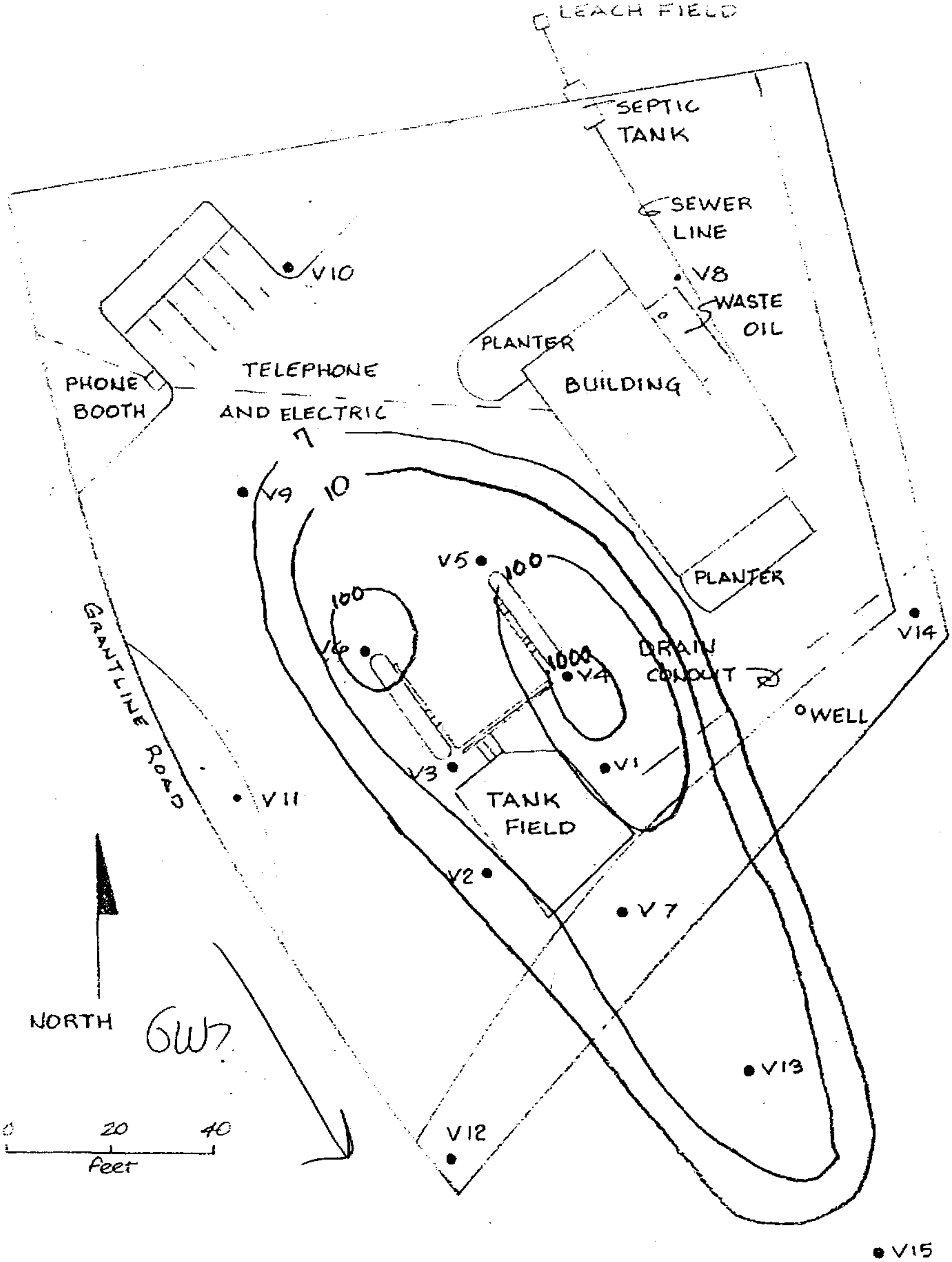

Figure 5. Isoconcentration contours of [redacted] with shallow soil gas at Chevron Service Station 9-7127, Tracy, California.

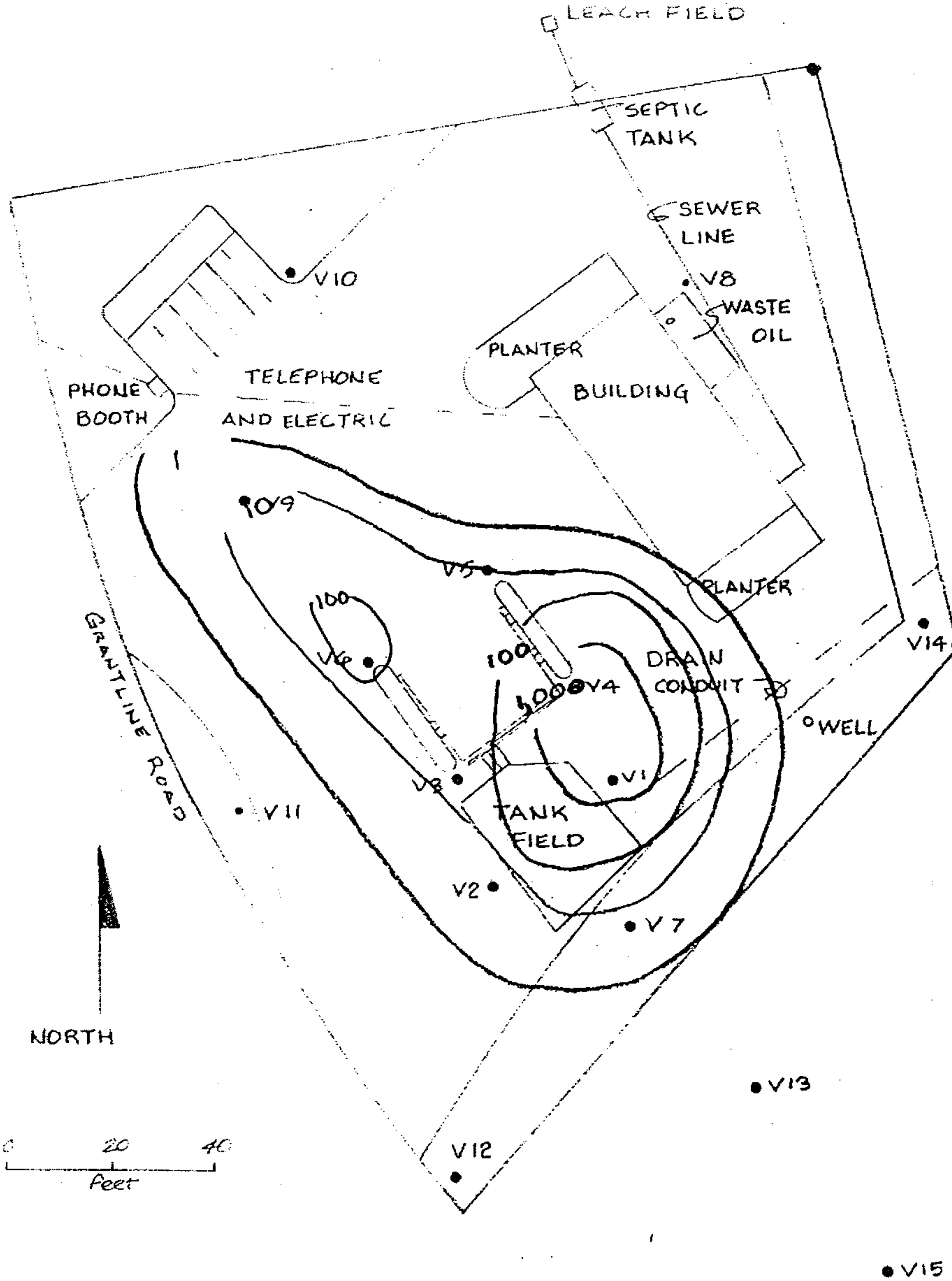

Figure 6. Isoconcentration contours of toluene (ppm) with the shallow soil gas at Chevron Service Station 9-7127, Tracy, California.

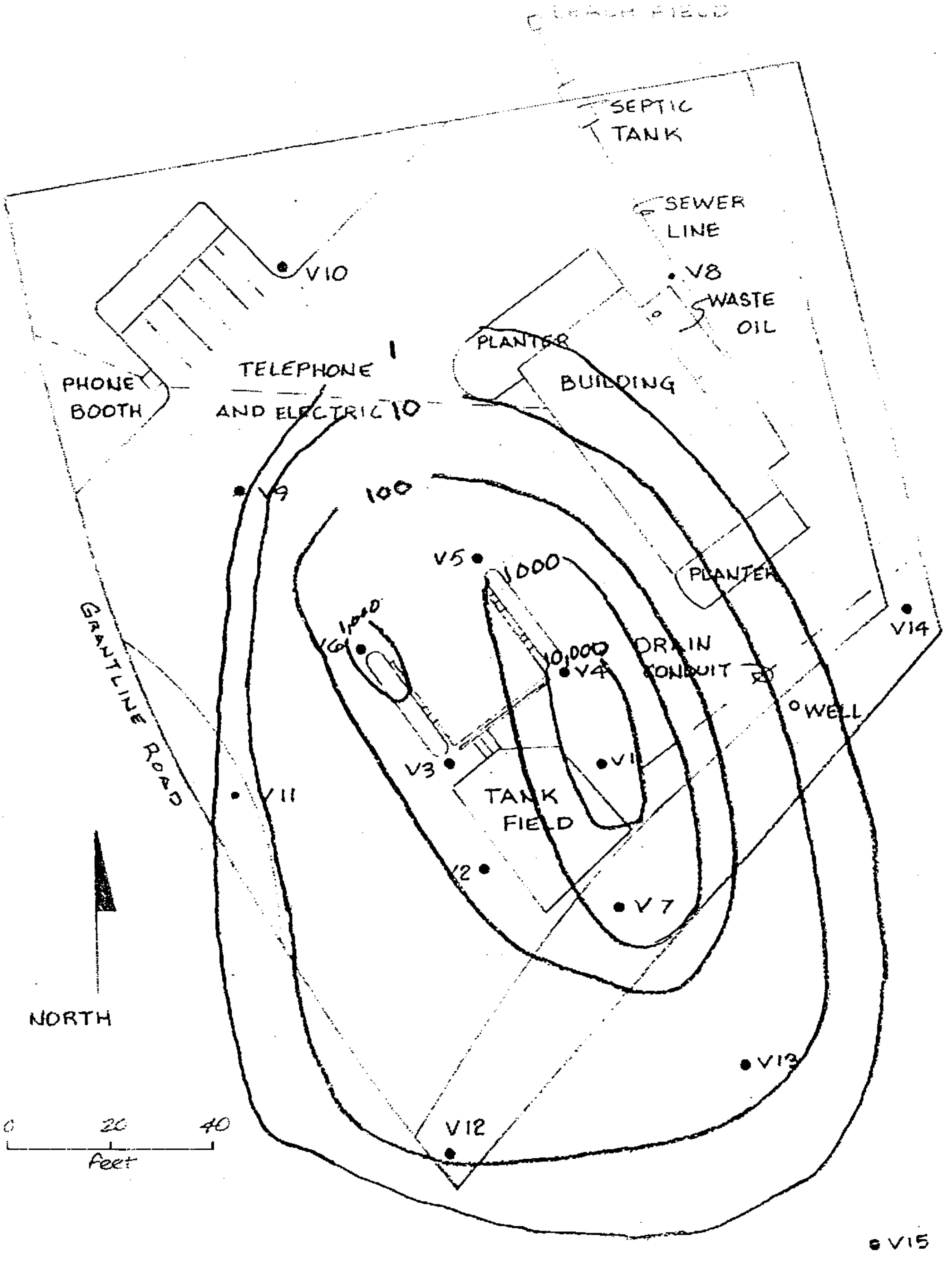

Figure 7. Isoconcentration contours of compounds which elute prior to benzene (ppm) in the shallow soil gas at Chevron Service Station 9-7127, Tracy, California.

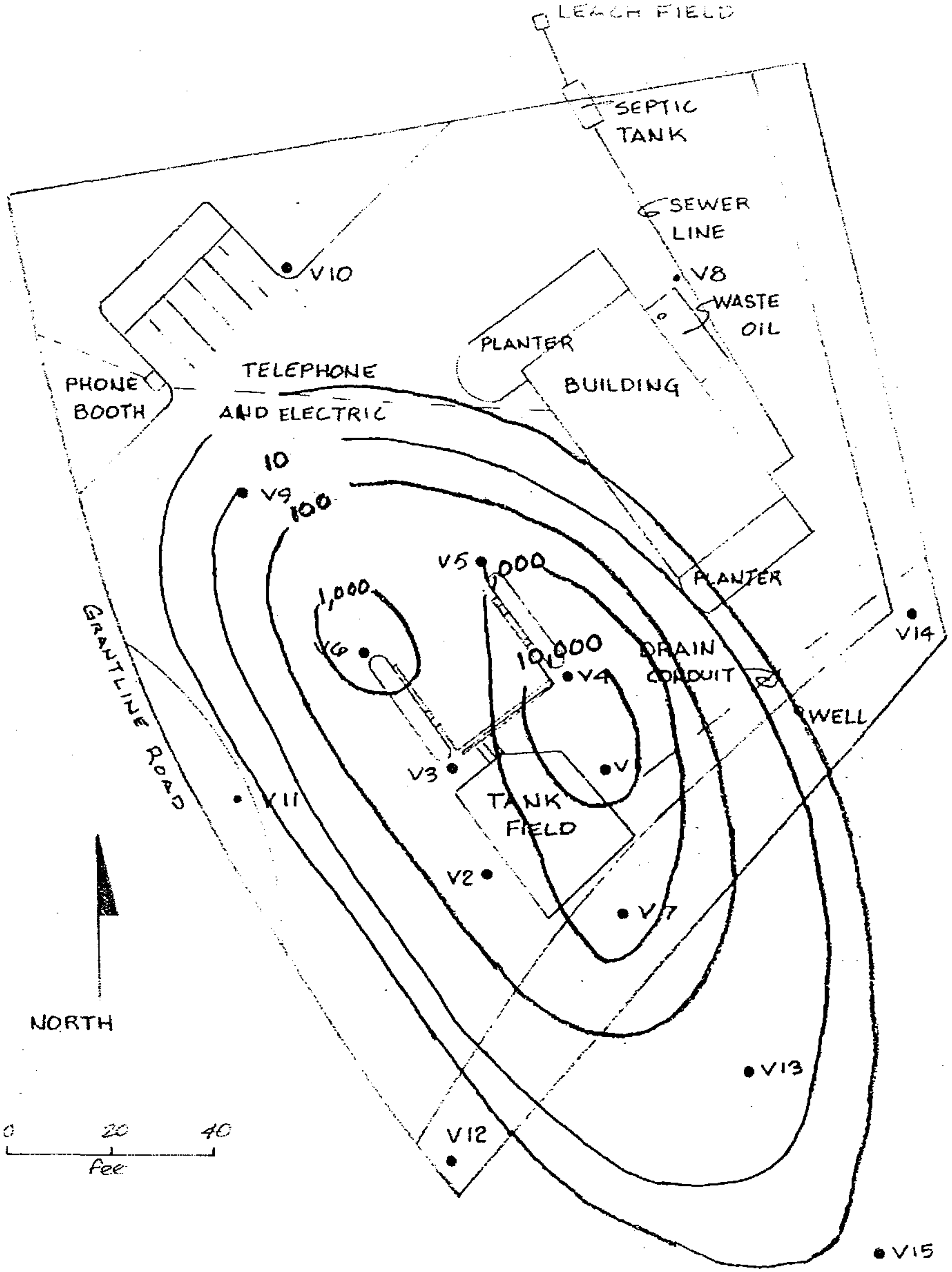

Figure 8. Isoconcentration contours of total volatile hydrocarbon (ppm) in the shallow soil gas at Chévron Service Station 9-7127, Tracy, California.

2, the expected ground-water concentration of benzene can be estimated as:

$$C_{w\text{-Benzene}} = \frac{(C_{sv})\ (1\text{x}10^{-6}\ \text{atm/ppm})\ (78\text{x}10^{3}\ \text{mg/mole})}{(5.6\ \text{atm}\cdot\text{L/mole})}$$

$$= 0.014\ C_{sv}$$

For toluene, the ground-water concentration can be estimated by:

$$C_{w\text{-toluene}} = \frac{(C_{sv})\ (1\text{x}10^{-6}\ \text{atm/ppm})\ (92\text{x}10^{3}\ \text{mg/mole})}{(6.4\ \text{atm}\cdot\text{L/mole})}$$

$$= 0.014\ C_{sv}$$

The area between the eastern pump island and the tank field (SVCA point V4) had a benzene concentration of 3,200 ppm and a toluene concentration of 5,200 ppm. Based on these soil gas concentrations, the ground water may contain 45 mg/L benzene and 70 mg/L toluene. A study sponsored by the San Francisco Bay Regional Water Quality Board (1985) found that gasoline-saturated water may contain as high as 40 mg/L of benzene and 9-76 mg/L of toluene. A similar study sponsored by the American Petroleum Institute (1985) suggested that the sum concentration of benzene, toluene, xylenes, and ethylbenzene in gasoline-saturated ground water will be at least 10-20 mg/L. Thus, the SVCA results at the Tracy site suggest there could be free product at this site.

3. CONCLUSIONS AND RECOMMENDATIONS

On 27 October 1987, EA conducted a SVCA survey at Chevron Service Station 9-7127 in Tracy, California. The results of the survey suggested that there could be floating free product in the area of the tank field and pump island. It is recommended that five ground-water monitoring wells be installed on the site (Figure 9). One well should be placed between SVCA points V4 and V1, to confirm the contamination in this area. The second and third wells should be along the southern site boundary, opposite the tank field, to delineate any contaminant plume. Two wells should be placed on the northern and western side boundaries to establish background concentrations. During well construction it is recommended that soil samples be taken every five feet for chemical analysis. If there is no floating product, ground-water samples should be taken. Soil and ground-water samples should be analyzed for total petroleum hydrocarbons, benzene, toluene, xylenes, and ethylbenzene.

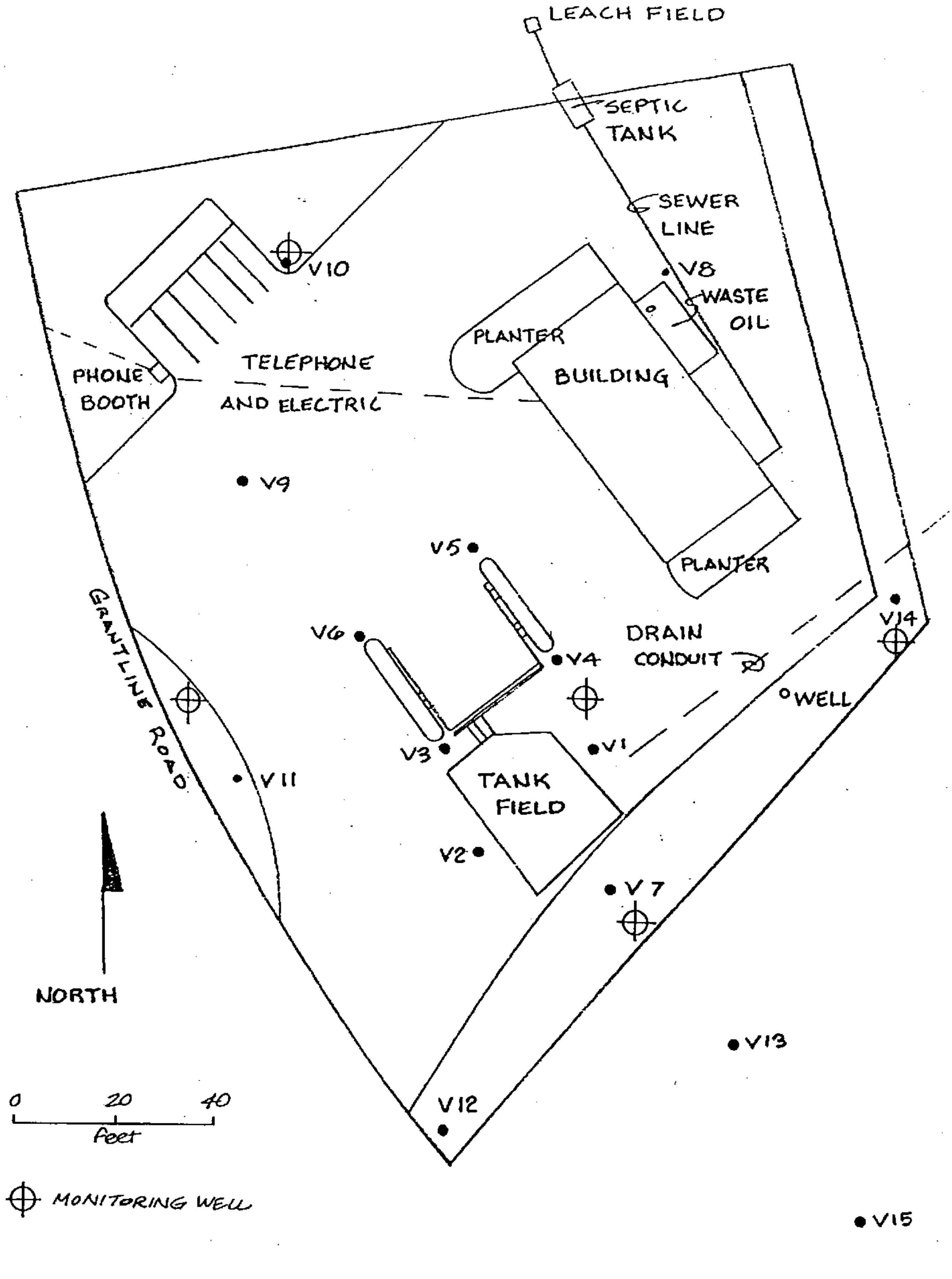

Figure 9. Proposed locations for monitoring wells at Chevron Service Station 9-7127, Tracy, California.

4. REFERENCES

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EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

559-7127-001/F/27/10/SH

SVCA DATA SHEET

Project Number: CHV

Date: 27 October 1987

Project Manager:

Analysts: CAP/RMEI/PS

Site Location: Grant Line Rd. + I-580 Tracy CA

Pump Number: 9-7127

Grid Location	Time	Depth (ft)	OVA. (ppm)	Purge Time	Vacuum Reading	Soil Type	Comments asphalt covering
V1		3		10	25 in Hg	X	tank area
V3		3		10	27	X	
V1/B		5		10	3		noticable vacuum decrease
V4		3		10	7		
V1/C		8		10	3		
V4/B		5		10	15		
V7		5		10	0		
V2		5		10	7		
V3/B		5		10	10		
V5		5		10	12	X	
V6		5		10	3		
V5/B		7		10	10		
V8		3		10	25	X	waste oil
V9		8		10	10	X	
V8/B		8		10	5		
V10		9		10	0		Soil cover

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

SVCA DATA SHEET

Project Number: CHV

Date: 27 Oct 1987

Project Manager:

Analysts: [illegible]

Site Location: Grant Line Rd @ I-580 Tracy, CA

Pump Number: 9-7127

Grid Location	Time	Depth (ft)	OVA (ppm)	Purge Time	Vacuum Reading	Soil Type	Comments
V11		5		10	7		soil cover encounter impenetrable soil
V12		8		10	3		soil cover
V13		see comment		10	3		3' below surface 12' below site surface
V14		8		10	4		soil cover
V15		see comment		10	4		3' below surface 12' below site surface

PROJECT NUMBER: ____________

DATE: 27 Oct

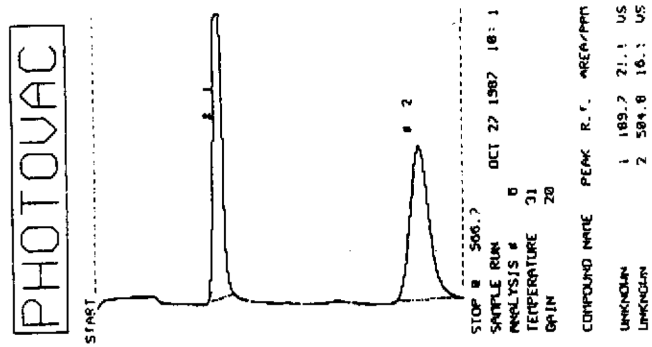
Chemist: GAP

Standard Volume Injection: 100 µl

STATION NUMBER: 9-7127

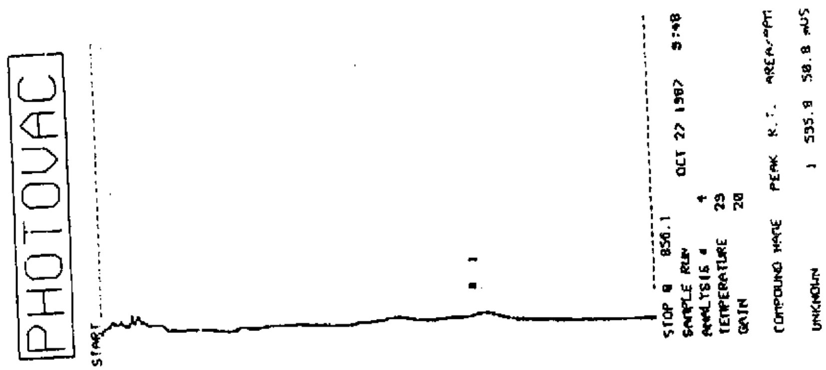
Sample: STANDARD

Volume Injected: 100 µl



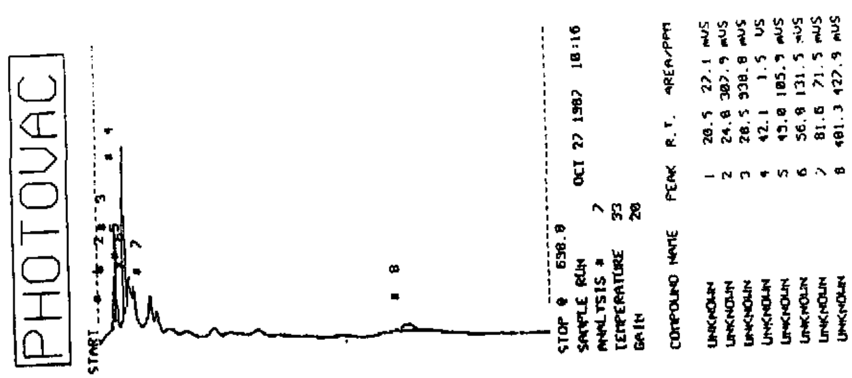
Sample: BLANK

Volume Injected: —



Sample: V1

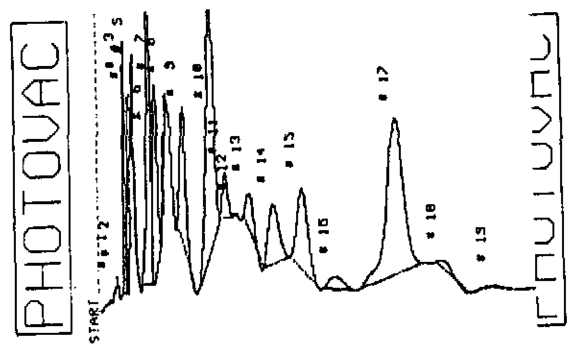
Volume Injected: 50 µl



PROJECT NUMBER: CHV
DATE: 27 Oct 1987
Chemist: CAP
Standard Volume Injection: 100 µl

STATION NUMBER: 9-7127

Sample: V3
Volume Injected: 100 µl

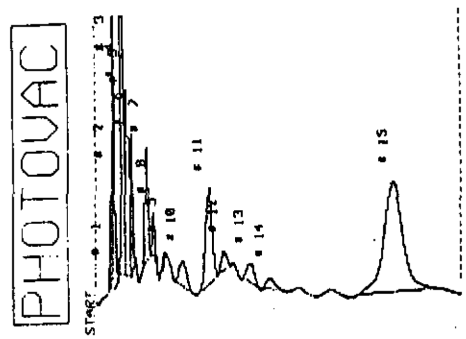


CALIBRATED PEAK 17, TOLUENE

SAMPLE RUN OCT 27 1987 10:34
ANALYSIS # 8
TEMPERATURE 33
GAIN 20

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	24.0	25.9 mUS
UNKNOWN	2	28.5	87.9 mUS
UNKNOWN	3	41.5	2.6 US
UNKNOWN	4	48.6	1.0 US
UNKNOWN	5	55.9	1.1 US
UNKNOWN	6	79.7	2.7 US
UNKNOWN	7	90.1	4.0 US
UNKNOWN	8	106.4	492.0 mUS
UNKNOWN	9	134.3	4.7 US
BENZENE	10	176.5	5.536 PPM
UNKNOWN	11	199.7	1.2 US
UNKNOWN	12	215.3	24.0 mUS
UNKNOWN	13	235.9	1.9 US
UNKNOWN	14	273.2	3.6 US
UNKNOWN	15	317.9	4.7 US
UNKNOWN	16	367.7	974.3 mUS
TOLUENE	17	463.7	9.989 PPM
UNKNOWN	18	536.3	560.8 mUS
UNKNOWN	19	611.9	118.0 mUS

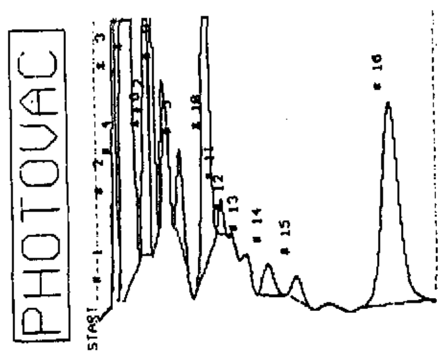
Sample: V1/B
Volume Injected: 100 µl
1:400 dilution



STOP @ 562.3
SAMPLE RUN OCT 27 1987 10:45
ANALYSIS # 9
TEMPERATURE 34
GAIN 20

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	20.9	143.0 mUS
UNKNOWN	2	25.8	1.1 US
UNKNOWN	3	28.2	3.2 US
UNKNOWN	4	41.5	6.9 US
UNKNOWN	5	48.4	3.6 US
UNKNOWN	6	55.9	1.8 US
UNKNOWN	7	79.7	2.0 US
UNKNOWN	8	89.6	865.2 mUS
UNKNOWN	9	105.5	79.9 mUS
UNKNOWN	10	134.1	986.4 mUS
BENZENE	11	175.9	1.705 PPM
UNKNOWN	12	198.9	563.6 mUS
UNKNOWN	13	239.6	809.2 mUS
UNKNOWN	14	271.4	519.7 mUS
TOLUENE	15	463.7	8.101 PPM

Sample: V4
Volume Injected: 100 µl
1:400 dilution



STOP @ 527.5
SAMPLE RUN OCT 27 1987 10:57
ANALYSIS # 10
TEMPERATURE 33
GAIN 20

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	2	24.6	675.1 mUS
UNKNOWN	3	29.6	7.1 US
UNKNOWN	4	37.2	872.8 mUS
UNKNOWN	5	48.4	78.9 US
UNKNOWN	6	78.6	11.5 US
UNKNOWN	7	88.6	6.2 US
UNKNOWN	8	104.9	583.6 mUS
UNKNOWN	9	131.9	3.3 US
BENZENE	10	173.7	8.178 PPM
UNKNOWN	11	156.3	933.0 mUS
UNKNOWN	12	210.7	81.7 mUS
UNKNOWN	14	268.7	1.6 US
UNKNOWN	15	312.8	1.3 US
TOLUENE	16	458.5	13.38 PPM

Tot 14,700 v

prior 8000 v

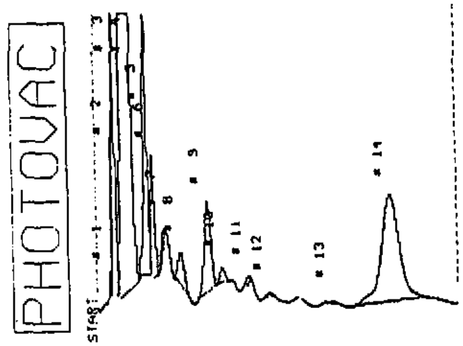
Prior 100 vs

PROJECT NUMBER: CHV
DATE: 27 Oct
Chemist: CAF
Standard Volume Injection: 100 µl

STATION NUMBER: 9-7127

Prior 90 US 36000
Tot 104.8 US 41,600 ✓

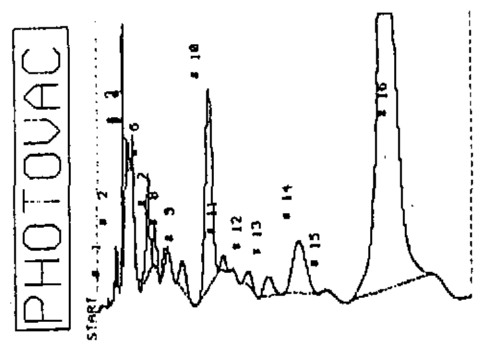
Sample: V1/C
Volume Injected: 100 µl
1:400 dilution



STOP @ 558.0
SAMPLE RUN OCT 27 1987 11: 8
ANALYSIS # 11
TEMPERATURE 34
GAIN 20

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	20.5	162.4 mUS
UNKNOWN	2	24.6	1.2 US
UNKNOWN	3	28.0	4.9 US
UNKNOWN	4	47.9	24.9 US
UNKNOWN	5	78.9	5.6 US
UNKNOWN	6	88.6	2.4 US
UNKNOWN	7	145.7	221.7 mUS
UNKNOWN	8	131.9	1.2 US
BENZENE	9	174.1	1.593 PPM
UNKNOWN	10	196.1	412.0 mUS
UNKNOWN	11	236.1	93.6 mUS
UNKNOWN	12	268.1	69.4 mUS
UNKNOWN	13	362.5	31.9 mUS
TOLUENE	14	457.3	7.236 PPM

Sample: V4/B
Volume Injected: 100 µl
1:40 dilution



STOP @ 577.4
SAMPLE RUN OCT 27 1987 11:22
ANALYSIS # 13
TEMPERATURE 34
GAIN 20

COMPOUND NAME PEAK R.T. AREA/PPM

[illegible] 12.4 23.2 mUS

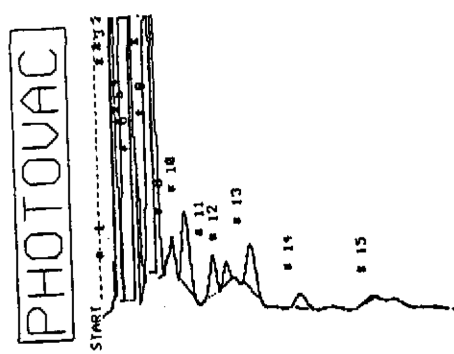
CALIBRATED PEAK 16, TOLUENE

SAMPLE RUN OCT 27 1987 11:24
ANALYSIS # 13
TEMPERATURE 34
GAIN 20

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	12.4	23.2 mUS
UNKNOWN	2	29.6	83.5 mUS
UNKNOWN	3	41.5	1.9 US
UNKNOWN	4	47.5	220.4 mUS
UNKNOWN	5	55.1	538.1 mUS
UNKNOWN	6	78.5	1.8 US
UNKNOWN	7	88.3	257.1 mUS
UNKNOWN	8	105.3	182.9 mUS
UNKNOWN	9	138.7	1.0 US
BENZENE	10	172.1	3.586 PPM
UNKNOWN	11	193.9	382.7 mUS
UNKNOWN	12	232.3	548.3 mUS
UNKNOWN	13	265.4	957.4 mUS
UNKNOWN	14	312.8	3.9 US
UNKNOWN	15	356.3	27.2 mUS
TOLUENE	16	449.4	48.55 PPM 175

Prior 3?0 US
Tot. 3.3 US 93.1 / 3.75

Sample: V7
Volume Injected: 100 µl
1:40 dilution



STOP @ 553.9
SAMPLE RUN OCT 27 1987 11:45
ANALYSIS # 17
TEMPERATURE 34
GAIN 20

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	20.5	248.6 mUS
UNKNOWN	2	24.3	2.6 US
UNKNOWN	3	27.9	4.9 US
UNKNOWN	4	44.6	33.1 US
UNKNOWN	5	54.7	5.2 US
UNKNOWN	6	61.8	1.6 US
UNKNOWN	7	77.8	12.3 US
UNKNOWN	8	87.7	6.3 US
UNKNOWN	9	111.1	73.0 mUS
UNKNOWN	10	132.1	3.0 US
BENZENE	11	174.3	0.618 PPM
UNKNOWN	12	195.3	595.3 mUS
UNKNOWN	13	233.7	2.2 US
UNKNOWN	14	310.1	701.0 mUS
UNKNOWN	15	422.9	184.3 mUS

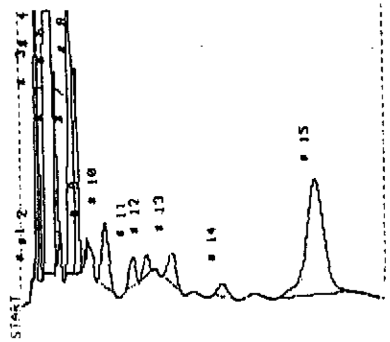
8

STATION NUMBER: 9-7127

PROJECT NUMBER: ______
DATE: 27 Oct 1987
Chemist: [illegible initials]
Standard Volume Injection: 100 µl

Sample: V2
Volume Injected: 1 ml
1:40 dilution
∴ x4 dilution

PHOTOVAC



STOP @ 564.5
SAMPLE RUN OCT 27 1987 11:56
ANALYSIS # 18
TEMPERATURE 34
GAIN 20

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	17.4	71.6 mVS
UNKNOWN	2	21.0	162.7 mVS
UNKNOWN	3	25.0	2.7 VS
UNKNOWN	4	28.1	4.1 VS

PHOTOVAC

CALIBRATED PEAK 15, TOLUENE

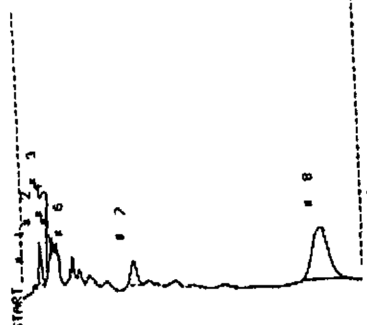
SAMPLE RUN OCT 27 1987 11:59
ANALYSIS # 18
TEMPERATURE 34
GAIN 20

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	17.4	71.6 mVS
UNKNOWN	2	21.0	162.7 mVS
UNKNOWN	3	25.0	2.7 VS
UNKNOWN	4	28.1	4.1 VS
UNKNOWN	5	44.6	40.4 VS
UNKNOWN	6	55.6	2.4 VS
UNKNOWN	7	70.5	9.1 VS
UNKNOWN	8	88.6	4.0 VS
UNKNOWN	9	104.0	123.4 mVS
UNKNOWN	10	133.1	2.5 VS
BENZENE	11	170.3	0.491 PPM
UNKNOWN	12	197.1	622.4 mVS
UNKNOWN	13	236.3	1.4 VS
UNKNOWN	14	314.0	672.9 mVS
TOLUENE	15	460.5	7.763 PPM

prior 260 Tot 320

Sample: V3/B
Volume Injected: 1 ml
1:40 dilution
∴ 1:4 dilution

PHOTOVAC



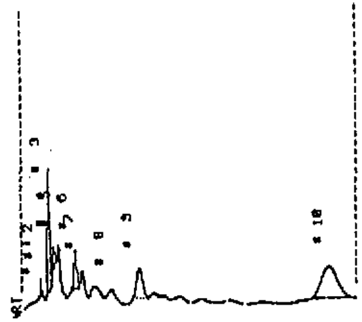
STOP @ 527.2
SAMPLE RUN OCT 27 1987 12:10
ANALYSIS # 19
TEMPERATURE 34
GAIN 20

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	2	28.3	623.3 mVS
UNKNOWN	3	41.7	753.7 mVS
UNKNOWN	4	48.6	88.5 mVS
UNKNOWN	5	55.8	133.4 mVS
UNKNOWN	6	75.5	64.0 mVS
BENZENE	7	176.5	0.394 PPM
TOLUENE	8	465.3	3.316 PPM

Prior 5 ✓ 1.5 0 Tot 30 ✓ 15 ρ

Sample: V5
Volume Injected: 100 µl

PHOTOVAC



STOP @ 515.8
SAMPLE RUN OCT 27 1987 12:20
ANALYSIS # 20
TEMPERATURE 33
GAIN 20

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	2	28.8	103.0 mVS
UNKNOWN	3	42.3	1.0 VS
UNKNOWN	4	49.2	112.2 mVS
UNKNOWN	5	57.0	233.1 mVS
UNKNOWN	6	81.5	500.4 mVS
UNKNOWN	7	91.7	37.1 mVS
UNKNOWN	8	137.1	24.6 mVS
BENZENE	9	180.9	0.473 PPM
UNKNOWN	10	476.1	2.7 VS

PHOTOVAC

CALIBRATED PEAK 10, TOLUENE

SAMPLE RUN OCT 27 1987 12:21
ANALYSIS # 20
TEMPERATURE 33
GAIN 20

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	2	28.8	103.0 mVS
UNKNOWN	3	42.3	1.0 VS
UNKNOWN	4	49.2	112.2 mVS
UNKNOWN	5	57.0	233.1 mVS
UNKNOWN	6	81.5	580.4 mVS
UNKNOWN	7	91.7	37.1 mVS
UNKNOWN	8	137.1	24.6 mVS
BENZENE	9	180.9	0.473 PPM
TOLUENE	10	476.1	1.861 PPM

pr: tot

PROJECT NUMBER: CHV

DATE: 27 Oct 1987

Chemist: GAP

Standard Volume Injection: 100 µl

STATION NUMBER: 9-7127

Sample: BLANK

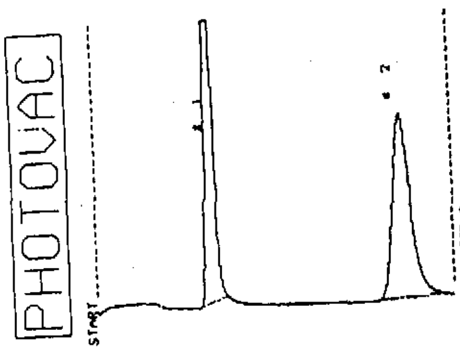
Volume Injected: 100 µl

STOP @ 705.0
SAMPLE RUN OCT 27 1987 12:58
ANALYSIS # 2
TEMPERATURE 33
GAIN 20

COMPOUND NAME PEAK R.T. AREA/PPM

Sample: STANDARD

Volume Injected: 100 µl



STOP @ 553.0
SAMPLE RUN OCT 27 1987 13: 6
ANALYSIS # 3
TEMPERATURE 33
GAIN 20

COMPOUND NAME	PEAK	R.T.	AREA/PPM	
UNKNOWN	1	170.0	24.4	VS
UNKNOWN	2	477.3	15.3	VS

PHOTOVAC

CALIBRATED PEAK 2, TOLUENE

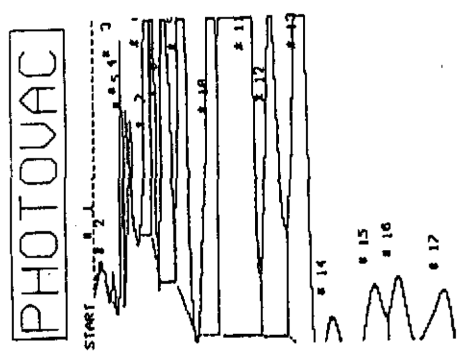
SAMPLE RUN OCT 27 1987 13: 6
ANALYSIS # 3
TEMPERATURE 33
GAIN 20

COMPOUND NAME	PEAK	R.T.	AREA/PPM	
BENZENE	1	170.0	10.00	PPM
TOLUENE	2	477.3	10.00	PPM

Sample: V6

Volume Injected: 100 µl

1:400 dilution



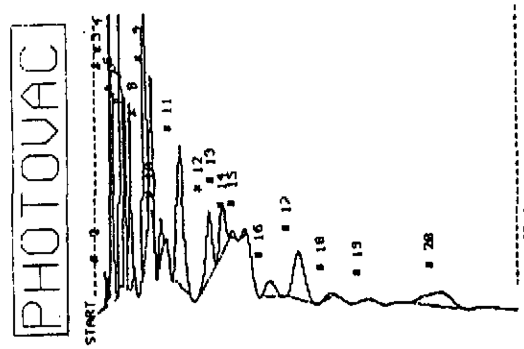
STOP @ 626.7
SAMPLE RUN OCT 27 1987 14: 0
ANALYSIS # 11
TEMPERATURE 34
GAIN 20

COMPOUND NAME	PEAK	R.T.	AREA/PPM	
UNKNOWN	1	10.4	108.4	*US
UNKNOWN	2	23.0	557.4	*US
UNKNOWN	3	42.2	3.4	US
UNKNOWN	4	45.4	2.1	US
UNKNOWN	5	56.6	083.5	*US
UNKNOWN	6	80.5	10.7	US
UNKNOWN	7	98.4	7.1	US
UNKNOWN	8	106.8	10.3	US
UNKNOWN	9	135.4	23.0	US
BENZENE	10	181.0	13.81	PPM
UNKNOWN	11	213.7	100.7	US
UNKNOWN	12	274.5	26.9	US
UNKNOWN	13	319.4	53.6	US
UNKNOWN	14	370.5	5.1	US
UNKNOWN	15	435.3	9.6	US
TOLUENE	16	471.3	1.445	PPM
UNKNOWN	17	541.8	10.2	US

PROJECT NUMBER: CHV
DATE: 27 Oct 1987
Chemist: CAP
Standard Volume Injection: 100 µl

STATION NUMBER: 9-7127

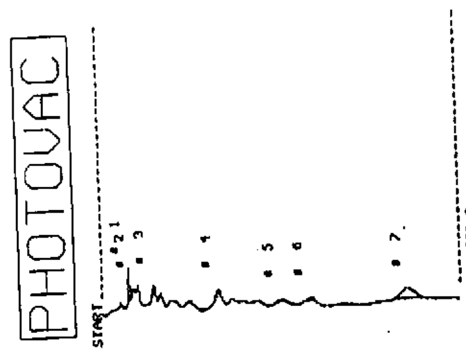
Sample: V5/B
Volume Injected: 100 µl
1:40 dilution



SAMPLE RUN OCT 27 1987 13:38
ANALYSIS # 7
TEMPERATURE 33
GAIN 20

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	16.6	162.4 mVS
UNKNOWN	2	20.3	166.1 mVS
UNKNOWN	3	24.2	2.0 VS
UNKNOWN	4	27.5	3.2 VS
UNKNOWN	5	40.8	7.5 VS
UNKNOWN	6	48.0	2.4 VS
UNKNOWN	7	55.5	2.2 VS
UNKNOWN	8	70.5	5.3 VS
UNKNOWN	9	88.5	2.4 VS
UNKNOWN	10	103.3	644.5 mVS
UNKNOWN	11	132.9	5.1 VS
BENZENE	12	170.1	0.311 PPM
UNKNOWN	13	190.1	1.3 VS
UNKNOWN	14	213.5	135.8 mVS
UNKNOWN	15	232.1	77.6 mVS
UNKNOWN	16	271.7	805.5 mVS
UNKNOWN	17	316.1	2.9 VS
UNKNOWN	18	368.1	141.3 mVS
UNKNOWN	19	426.1	70.3 mVS
UNKNOWN	20	534.8	1.8 VS

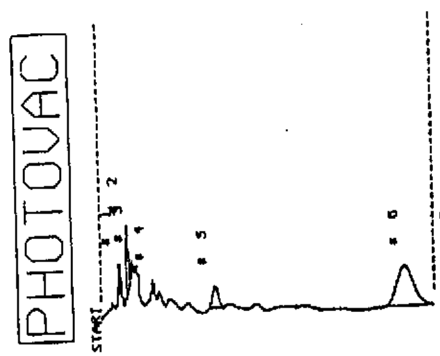
Sample: V8
Volume Injected: 100 µl



SAMPLE RUN OCT 27 1987 14:12
ANALYSIS # 12
TEMPERATURE 33
GAIN 20

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	41.9	252.0 mVS
BENZENE	4	180.7	0.037 PPM
TOLUENE	7	476.1	0.448 PPM

Sample: V9
Volume Injected: 1ml ~~[illegible]~~ µl
1:40 dilution
1:4 dilution



SAMPLE RUN OCT 27 1987 14:25
ANALYSIS # 14
TEMPERATURE 34
GAIN 20

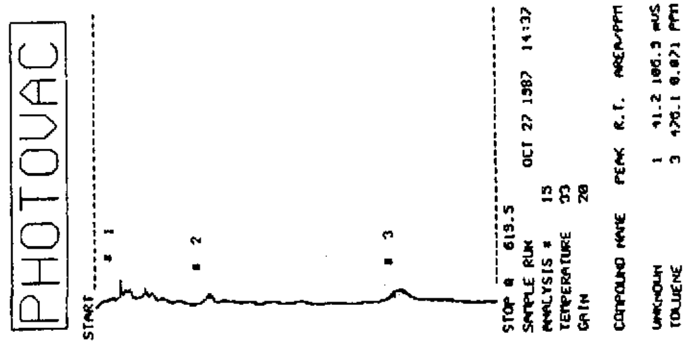
COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	29.8	113.1 mVS
UNKNOWN	2	42.0	676.0 mVS
UNKNOWN	4	80.4	52.4 mVS
BENZENE	5	179.3	0.276 PPM
TOLUENE	6	472.8	2.058 PPM

9.7

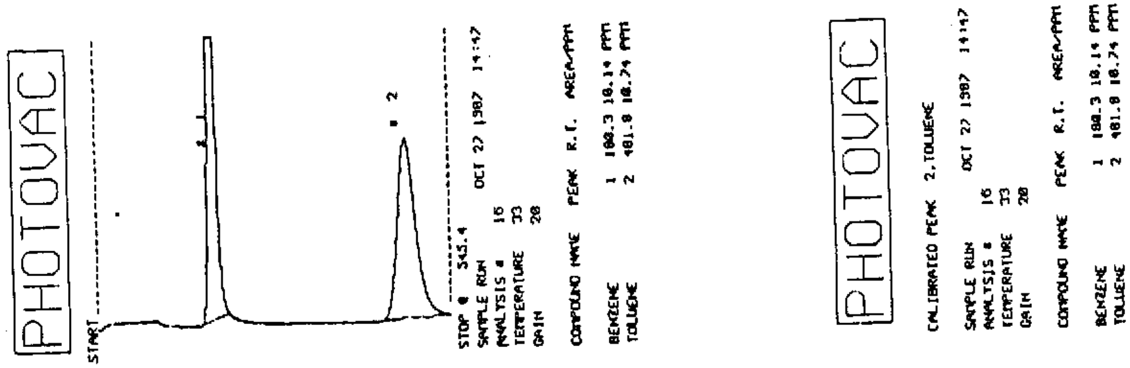
PROJECT NUMBER: CHV
DATE: 27 Oct 1987
Chemist: CAP
Standard Volume Injection: 100 µl

STATION NUMBER: 9-7127

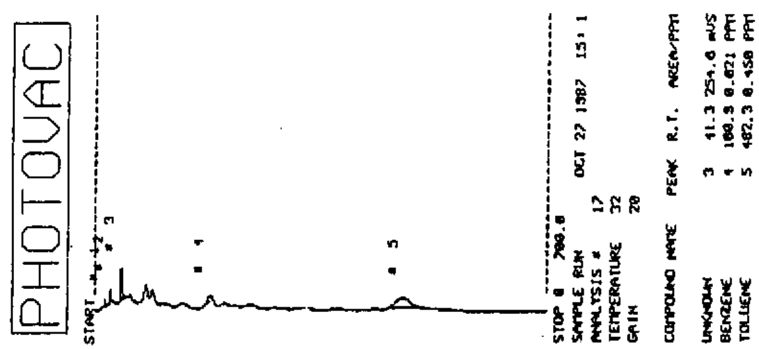
Sample: V8/B
Volume Injected: 100 µl



Sample: STANDARD
Volume Injected: 100 µl



Sample: V10
Volume Injected: 100 µl

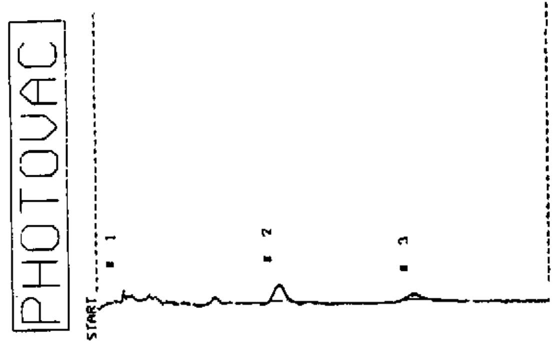


1

PROJECT NUMBER: CHV
DATE: 27 Oct 1987
Chemist: CM
Standard Volume Injection: 100 µl

STATION NUMBER: 9-7127

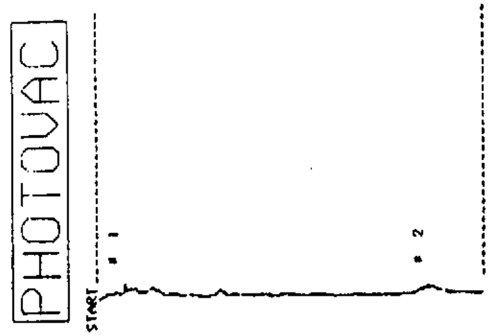
Sample: V11
Volume Injected: 100 µl



STOP @ 700.0
SAMPLE RUN OCT 27 1987 15:13
ANALYSIS # 18
TEMPERATURE 32
GAIN 20

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	2	285.5	505.4 mVS
UNKNOWN	3	457.3	407.3 mVS

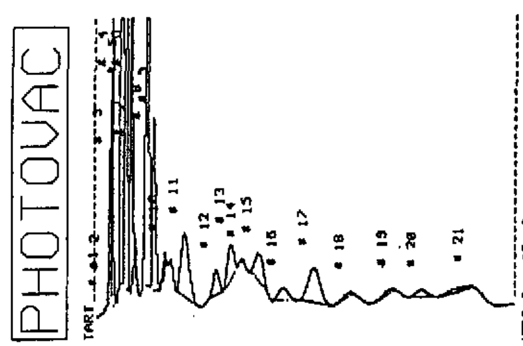
Sample: V12
Volume Injected: 100 µl



STOP @ 598.1
SAMPLE RUN OCT 27 1987 15:37
ANALYSIS # 19
TEMPERATURE 31
GAIN 20

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	2	516.0	97.1 mVS

Sample: V13
Volume Injected: 100 µl



STOP @ 651.2
SAMPLE RUN OCT 27 1987 15:49
ANALYSIS # 20
TEMPERATURE 32

CALIBRATED PEAK 12,BENZENE

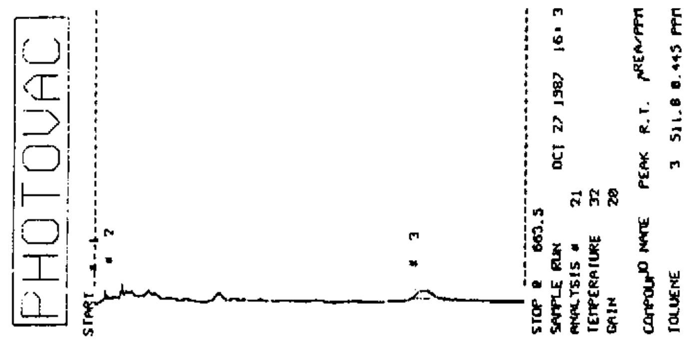
SAMPLE RUN OCT 27 1987 15:51
ANALYSIS # 20
TEMPERATURE 31
GAIN 20

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	2	20.5	140.0 mVS
UNKNOWN	3	24.0	1.4 VS
UNKNOWN	4	28.1	2.9 VS
UNKNOWN	5	42.5	12.4 VS
UNKNOWN	6	49.7	5.5 VS
UNKNOWN	7	57.7	4.5 VS
UNKNOWN	8	82.6	7.5 VS
UNKNOWN	9	93.4	3.5 VS
UNKNOWN	10	110.4	111.9 mVS
UNKNOWN	11	141.9	2.6 VS
BENZENE	12	198.9	0.325 PPM
UNKNOWN	13	213.3	1.0 VS
UNKNOWN	15	250.1	1.4 VS
UNKNOWN	16	294.5	600.0 mVS
UNKNOWN	17	341.9	2.2 VS
UNKNOWN	18	400.1	152.0 mVS
UNKNOWN	19	467.3	216.5 mVS
TOLUENE	20	512.8	0.243 PPM
UNKNOWN	21	584.3	282.2 mVS

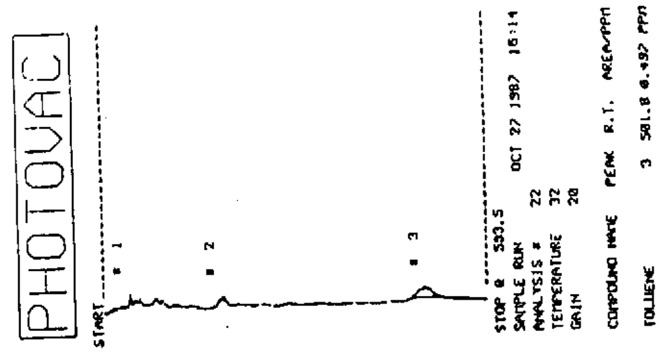
PROJECT NUMBER: CHV
DATE: 27 Oct 1987
Chemist: CAP
Standard Volume Injection: 100 µl

STATION NUMBER: 9-7127

Sample: V14
Volume Injected: 100 µl



Sample: V15
Volume Injected: 100 µl



Sample:
Volume Injected:

To make the units compatible, the following conversions are used:

1 ppm soil vapor = 1×10^{-6} atmosphere

1 mole = mole weight expressed in milligrams

The molecular weights of benzene and toluene are 78×10^3 mg/mole and 92×10^3 mg/mole, respectively; their Henry's Law constants are 5.6 and 6.4 atm·L/mole (EPA 1986). Using these data and Equation 2, the expected ground-water concentration of benzene can be estimated as:

$$C_{w\text{-Benzene}} = \frac{(C_{sv})\ (1 \times 10^{-6}\ \text{atm/ppm})\ (78 \times 10^3\ \text{mg/mole})}{(5.6\ \text{atm·L/mole})}$$

$$= 0.014\ C_{sv}$$

For toluene, the ground-water concentration can be estimated by:

$$C_{w\text{-toluene}} = \frac{(C_{sv})\ (1 \times 10^{-6}\ \text{atm/ppm})\ (92 \times 10^3\ \text{mg/mole})}{(6.4\ \text{atm·L/mole})}$$

$$= 0.014\ C_{sv}$$

The area between the eastern pump island and the tank field (SVCA point V4) had a benzene concentration of 3,200 ppm and a toluene concentration of 5,200 ppm. Based on these soil gas concentrations, the ground water may contain 45 mg/L benzene and 70 mg/L toluene. A study sponsored by the San Francisco Bay Regional Water Quality Board (1985) found that gasoline-saturated water may contain as high as 40 mg/L of benzene and 9-76 mg/L of toluene. A similar study sponsored by the American Petroleum Institute (1985) suggested that the sum concentration of benzene, toluene, xylenes, and ethylbenzene in gasoline-saturated ground water will be at least 10-20 mg/L. Thus, the SVCA results at the Tracy site suggest there could be free product at this site.