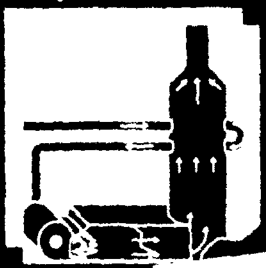
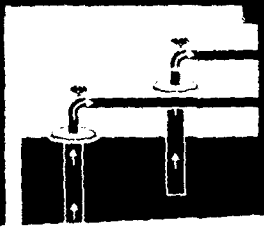
BASEWIDE
ENGINEERING EVALUATION-COST ANALYSIS FOR SOIL VAPOR EXTRACTION

SITE SPECIFIC DOCUMENT IC 1





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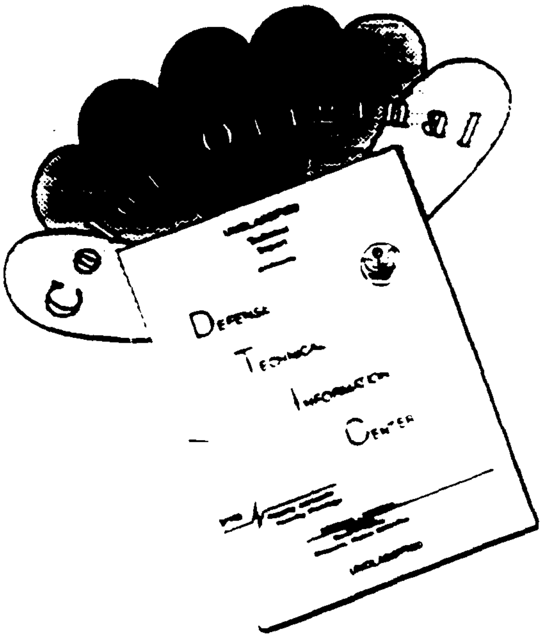

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MC Clellan AFB, CA 95652-1036

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McClellan Air Force Base

November 1993
Final

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INTRODUCTION

This document supports the use of soil vapor extraction (SVE) as the non-time-critical removal action for selected areas with high levels of volatile organic compound (VOC) contamination in Investigation Cluster 1 (IC 1), which is located near the center of Operable Unit B (OU B). This SVE removal action is part of the initial basewide SVE removal action at McClellan Air Force Base (McAFB). The principal objective of basewide SVE removal actions is to achieve early risk reduction by removing a significant quantity of VOCs from soils in the vadose zone, intercepting an exposure pathway, or preventing additional VOC flux to groundwater.

This document is a companion to the Basewide Engineering Evaluation-Cost Analysis (EE/CA) General Evaluation Document. The General Evaluation Document provides the long-term plan to standardize and streamline the use of SVE removal actions at McAFB by establishing SVE as the presumptive remedy for McAFB; outlining a site selection methodology for SVE removal actions; and providing a general SVE system configuration and cost estimate.

The site-specific EE/CA for IC 1 focuses on information to supplement the General Evaluation Document in support of the SVE removal action at IC 1. In particular, this document demonstrates that IC 1 satisfies the criteria listed in the site selection methodology of the General Evaluation Document. Since the General Evaluation Document establishes the case for treating SVE as the presumptive remedy, this document contains no evaluation of alternatives.

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SITE CHARACTERIZATION

Overview

IC 1 covers an area of 5.5 acres in the central portion of OU B, as shown in figure 2-1. The area, shown in more detail in figure 2-2, consists of three confirmed sites and a Potential Release Location (PRL): Site 36, Site 47, Site 48, and PRL L-5D (also identified as SS036, OT045, WP046, and OT162, respectively). A variety of industrial activities have occurred in the past, as summarized in table 2-1.

Significant amounts of data have been collected in recent sampling campaigns at IC 1, including geologic data and chemical analyses of the soil and soil gas (Radian, 1993a). These data have been analyzed to identify the various sources of contamination in IC 1, to model the subsurface lithology, to model the dispersion of the contaminant plumes, and to outline an SVE recovery system.

The effort to identify various sources and to separate them from one another was initiated with visual inspection of raw data and was followed by contouring and three-dimensional modeling of the geology and contamination. These analyses and modeling efforts led to the identification of the following zones of contamination (see figure 2-6):

- The main plume, under the degreaser and hard chrome pits (Site 47), which contains the highest concentrations of volatile organic compounds (VOCs) and most of the contaminant mass in IC 1
- VOC contamination along the industrial waste line that is separate from the main plume
- A small local zone of elevated VOC contamination north of Site 36
- A separate plume of freon 113 (FC113) and other VOCs south of Site 47

Based on this analysis, the plume at Site 47 is recommended for removal action; most of the subsequent discussion is focused on Site 47.

Data from recent soil borings were used to develop geologic models, which are needed to generate estimates of total VOC mass in soil and to assist in the design of the extraction system. Four silt and three sand bodies were identified throughout most of the contaminated area. The soil borings also provided information on the concentration of contaminants. Soil gas data are used in preference to direct soil measurements of VOCs, as outlined in McAFB's Soil Gas Consensus Statement (PTI, 1992). The geological model was integrated with the contaminant plume model to estimate the mass of

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Site 47, Electroplating Shop

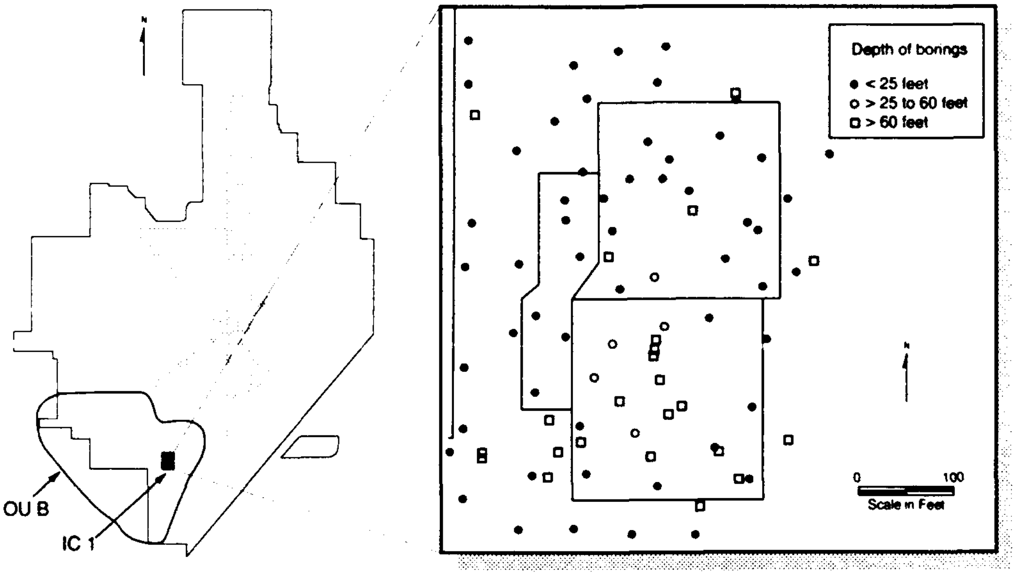

Figure 2-1
IC 1 Location Maps and Site Photograph

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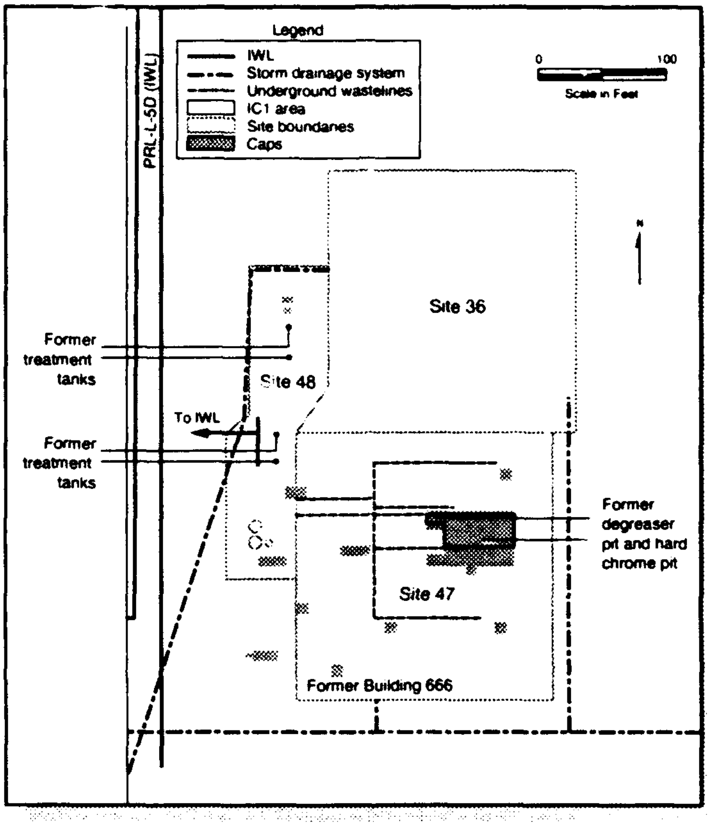

Figure 2-2
IC 1 Detailed Site Location Map

contaminant, which relies on the assumption that the gas, liquid, and solid phases are in equilibrium. As stated in the Soil Gas Consensus Statement, the accuracy of estimating soil VOC concentrations using soil gas data has not been verified. McAFB has initiated limited studies to compare collocated soil gas and soil samples that are specially preserved in the field. Results from these studies may require modifications to the equilibrium-based approach to mass estimating being used at this time. It is known that this equilibrium-based mass calculation underestimates the mass in the zones where there is free product; based on the conclusions of this analysis, it appears to overestimate the mass in vapor-dominated zones.

Geostatistical analysis was applied to develop a model of contaminant distribution in the main plume. The model suggests that there is a core of contamination (currently not sampled) that extends from the surface to the water table about 95 feet below ground, and that the core could contain dissolved VOCs and free product VOCs. Emanating from this core zone is the remainder of the observed contamination in a gas phase, which appears to

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Site ID	Alternative Designation	Historical Usage	Chemicals of Concern	Current Status
Site 36		Airplane and truck parking (1946-1949) Open air storage area (after 1957)	Acids caustic, TCE	All storage removed by 1981 Most structures razed by 1982
Site 47	Building 666	Electroplating shop, radiator repair shop, and sandblasting shop (1957-1989) Hazardous waste storage (1980-1982)	Acetone, methylene chloride, TCE, PCE, freon 113, dichloromethane, petroleum products, paint remover	Demolished 1988; only foundation remains
Site 48	Industrial Wastewater Treatment Plant No. 4, Building 645	Pretest and process wastes (1957-1980), Store wastes (as late as 1985)		All structures dismantled by 1988; only concrete foundations remain
PRL-L-5D	Segment of the Industrial Waste Line	Carry wastewater from washracks, paint and solvent spray booths, and electroplating and paint stripping operations from outside IC 1	1988 investigation: acetone, 2-butone, 1,1-DCA, methylene chloride, PCE, 1,1,1-TCA, toluene	All identified leaks repaired in 1989

Table 2-1
Background Information for Sites at IC 1

References: Radian 1990a, 1990b, 1990c, 1990d, 1991a, 1991b, 1992

have been dispersed by diffusion outward from the core zone. At IC 1, it does not appear that the observed soil type ranging from silt to sand have a strong influence on the soil gas concentration or its distribution.

The models for lithology and the contaminant plume and soil gas permeability data (Radian, 1993b) indicate that the existing extraction well near the periphery of the suspected core zone of contamination can be used for SVE removal of VOCs. In addition, future actions could test a hypothesis that existing wells screened over large intervals (60 to 80 feet) and located peripheral to the source would be effective in permanently removing contamination in vapor-dominated areas away from the core zone.

Investigation Results

A total of 88 soil borings within and adjacent to Sites 36, 47, and 48 were made before 1992, as indicated in table 2-2. This analysis uses data from these pre-1992 borings only in a qualitative fashion and does not rely on it to model

Table 2-2
Summary of IC 1 Soil Investigations

Year	Designation	Number of Borings	Types of Information	Notes
1982	Walker	4		No VOC analysis Depths unknown
1985	McLaren	84	PID soil gas, Soil VOC, Geologic logs	Most borings less than 20 feet
1992/3	Radian	82	GC soil gas, soil VOC, geologic logs	Most borings less than 25 feet

References: Radian 1990a, 1990b, 1990c, 1990d, 1991a, 1991b, 1992

subsurface geology or contaminant distribution. The soils information from these borings was reported using a different classification scheme than that used in more recent investigations, so the two soil data sets could not be combined directly. Analytical data were not useful because there were no quantitative soil gas measurements taken before 1992.

Another 82 borings were drilled in 1992 and 1993, generating soils information and soil gas data that were used to develop the models that follow.

In the vicinity of IC 1, downgradient groundwater monitor wells (four in the A zone, and one each in the B and C zones) and four Hydropunch samples (collected around the periphery of the Site 47 concrete foundation in the A zone) indicate that groundwater is contaminated primarily by trichloroethene (TCE), tetrachloroethene (PCE), and chloroform. Based on data collected since 1986, the following A-zone concentrations have been reported: not detected to 3,500 µg/L for TCE, not detected to 370 µg/L for PCE, and not detected to 1.8 µg/L for chloroform. One Hydropunch sample contained 8,200 µg/l of TCE. In the B zone, TCE was reported once at the detection limit of 0.2 µg/L, and in the C zone, TCE, PCE, and chloroform were all reported at less than 1 µg/L from one round of sampling.

The nearest upgradient monitor wells are located about 1,100 feet northwest of IC 1. Groundwater from these wells primarily contains TCE (not detected to 7.1 µg/L), methylene chloride (not detected to 4.9 µg/L), and 1, 2-DCE (not detected to 4.9 µg/L) in the A, B, and C zones. High soil gas contaminant

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concentrations in the vadose zone are present to the water table at IC 1. It is therefore likely that IC 1, and particularly Site 47, is a source area contributing to groundwater contamination beneath OU B.

Soil gas permeability tests were performed in IC 1 and IC 7 of OU B. Information obtained will be used to support the design for the SVE system. Results of soil gas permeability testing (Radian, 1993b) indicate the following:

- Mean permeability for all piezometer nests is about 38 darcies.
- There is little apparent difference in permeability between silts and sands at IC 1.
- The average radius of influence calculated for well VW-1 is 266 feet.
- The presence of the concrete foundation and asphalt pavement (acting as a vapor barrier) greatly extends the radius of influence around well VW-1.

Soil gas samples were quantitatively analyzed by several methods including FPID (field gas chromatography [GC] using a photo ionization detector), FECD (field GC using an electron capture detector), SGVOC (field GC using both detectors), and EPA method TO-14 (GC/MS off-base laboratory full scan). Method TO-14 was used to investigate the most complete spectrum of compounds in ten samples collected throughout IC 1 and was used on duplicate samples to validate the other methods.

The results of the soil gas sampling from the 1992/93 phase I and II field efforts are summarized in tables 2-3a through 2-3d. Of the 48 analytes looked for, 31 were never detected (tables 2-3c and 2-3d), 8 were rarely detected (defined as being observed in less than 10 percent of analyzed samples), and 9 were detected commonly (table 2-3a), regardless of analytical method. Unidentified analytes (UNKs) are excluded from this tally. The most commonly observed compounds, and those with the highest concentrations, are chlorinated VOCs.

A quality review has been performed on the phase I chemical analysis of soil gas data used (Radian, 1993a). Based on quality control sample results, it was concluded that the data are valid, with some exceptions. For the field laboratory determinations, the quality was judged to be within the acceptance criteria for screening of volatile compounds in soil gas.

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Table 2-3a
Commonly Detected Analytes (ppbv)

Analyte	Method T0-14				Method FPID				Method FECD				Method SGVOC			
	Max	Min	Obs	Det	Max	Min	Obs	Det	Max	Min	Obs	Det	Max	Min	Obs	Det
TCE	2,100,000	3	10	10					1,900,000	12	113	99	7,100,000	7.6	198	189
PCE	3,700,000	1,200	10	9					6,900,000	16	113	89	5,400,000	5.2	196	183
FC113	81,000	510	10	7					270,000	19	89	78	130,000	18	173	71
DCE12C					3,600	10	113	85					990,000	2,800	159	3
DCE11					240	11	73	68								
BZME					1,300	1	113	40					210,000	11	168	23
UNK					120	63	284	3	63,000	62	269	52				
VC					1,200	54	113	51								
FC12									25,000	21	17	11	110,000	29	169	23
DCE12T					46	10	113	21					11	11	159	1

Table 2-3b
Rarely Detected Analytes (ppbv), < 10% of All Analyzed Samples

Analyte	Method T0-14				Method FPID				Method FECD				Method SGVOC			
	Max	Min	Obs	Det	Max	Min	Obs	Det	Max	Min	Obs	Det	Max	Min	Obs	Det
FC11	7.8	7.8	10	1												
BZ					28	11	113	7					29,000	34	161	8
XLP													330,000	10	161	13
XYLO													300,000	55	162	11
XYLMP					43	14	113	4					42,000	460	3	3
TCLME									250	180	113	2				
TCA111									14	14	113	1	140,000	11	166	3
TCA112	31,000	31,000	10	1												
DCE													990,000	990,000	1	1
UNK2									29,000	29,000	7	1				
UNK3									19,000	19,000	8	1				

Table 2-3c
Analytes Never Detected

Analyte	Method T0-14	Method FPID	Method FECD	Method SGVOC
	Number of Observations	Number of Observations	Number of Observations	Number of Observations
DCE12C	10		35	
DCE11	10		35	
BZME	10			
VC				158
FC12	10			
BZ	10			
XYLO	10	113		
XYLMP	10			
TCLME	10			166
TCA111	10			
CTCL	10		35	166
UNK2		8		
UNK3		8		

Table 2-3d
Additional Analytes Never Detected Using Only TO-14

ACE
BZLCL
CHLOROPR
DCBZ13
TCB124
MVC
DCP13C
DCBZ12
TBME
PROP
PCA
FC114
EDB
DCPA12
DCP13T
TCA112
DCBZ14
DCA11
CLEA
CLME
CLBZ
CBN
BRME
BUTDIENE 13
CYHEXANE
EBZ
MTLNCL
STY
TMAB124
TAMB135
DCA12

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For the TO-14 results, quality was judged to be within the acceptance criteria for the analysis of volatile compounds in soil gas by that method. The TO-14 results can be used for confirmation of field laboratory soil gas results, and to identify non-target analytes.

Vinyl chloride (VC) was commonly detected during the first phase of investigation using the FPID method. The phase I data assessment (Radian, 1993a) indicates that VC was misidentified (second column GC conformation was not performed) and that all reported values are qualified as unusable. However, VC results reported as not detected are accurate. In ten samples analyzed by method TO-14, VC was not detected above the method detection limit of 1,400 ppbv (MVC in table 2-3d). Based on these observations, it is assumed that the positive VC results reported under the method FPID are false positive results. Field GC determinations of VC for phase II samples also were qualified as unusable (Radian, 1993a).

During phase I, freon 113 was correctly identified, but quantification was inaccurate; all phase I results are qualified as estimated (Radian, 1993a).

The phase II quality assurance/quality control report is pending.

Geologic Data Interpretation

McAFB is underlain by a thick sequence of sand-, silt-, and clay-sized sediments, as well as mixtures of these fine and coarse materials. The deposits were laid down by streams, and there are considerable variations in sediment character both horizontally and vertically. Overall, there is a complex pattern of interfingering and overlapping bodies of rapidly changing coarse- and fine-grained sediments that are sometimes difficult to correlate between boreholes. As a result, the sequence of interpreted sedimentary units and the proportions of fine- and coarse-grained sediments at IC 1 cannot be extrapolated to other sites at McAFB.

At IC 1, the sequence of alternating sediments consists primarily of sands ranging from fine- to coarse-grained, silty sands that are generally closely associated with sands, silts, and minor clay bodies that are too small and discontinuous to be interpreted. Four distinct and laterally continuous bodies of silt and three bodies of sand/silty sand have been identified, as illustrated in figure 2-3. The silt bodies appear to be more continuous horizontally than the sand bodies, and there are indications that the silt bodies merge and become more continuous vertically near the western boundary of IC 1 (left side of figure 2-3). Soil gas permeability measurements indicate little difference in results between silt and sand (Radian, 1993). The effectiveness of VOC removal within and between different lithologic units is unknown. Differences between units may impact the design of the SVE system. However, any impact needs to be evaluated by SVE operations before conclusions can be reached.

As modeled, silts constitute approximately 51 percent, silty sands about 15 percent, and sands about 30 percent by volume of the sediments below IC 1. The remaining 4 volume percent is associated with unidentified soil types which generally are found at or near the surface. Due to the difference in the degree to which data can be extrapolated, the geologic volume modeled is much smaller than the modeled volume for soil gas. To estimate contaminant mass, soil type-specific volumes (volumes of lithologic units) are needed. For these estimations, it is assumed that similar percentages of various soil types extend throughout IC 1, although the geologic model is significantly smaller than the IC 1 boundaries. The percentages derived from this geologic model will therefore be used to calculate contaminant mass, and the stratigraphic succession of various soil bodies will be used in the fate and transport model (VAPOUR-T).

Soil Gas Data Interpretation

Information from soil gas sampling was interpreted in two steps:

- Raw concentration data for individual compounds and total soil gas VOC concentrations (sum of all reported compounds) were reviewed at several depths to identify various zones of contamination.
- Geostatistics and concepts of spatial continuity were applied to interpolate and extrapolate from the available data.

Interpretation of raw and contoured concentration data has identified four potential sources within IC 1.

A large soil gas plume (hereafter referred to as the main plume) has been identified under the degreaser and hard chrome pits at Site 47. The results of modeling the total VOC plume are shown in figure 2-4, which indicates the extent of the main plume. Concentrations in figure 2-4 are displayed for an elevation of 60 feet above sea level (about 3 feet below ground); the nearest actual field data were collected at an elevation of about 43 feet.

Another separate zone of contamination is the Industrial Waste Line (IWL) at PRL L-5D along the western boundary of IC 1. As indicated in figure 2-5, borings located between the IWL and Sites 36, 47, and 48 contain very little or no contamination in soil gas. The contamination centered on Site 47 appears to be separate from contamination associated with the IWL.

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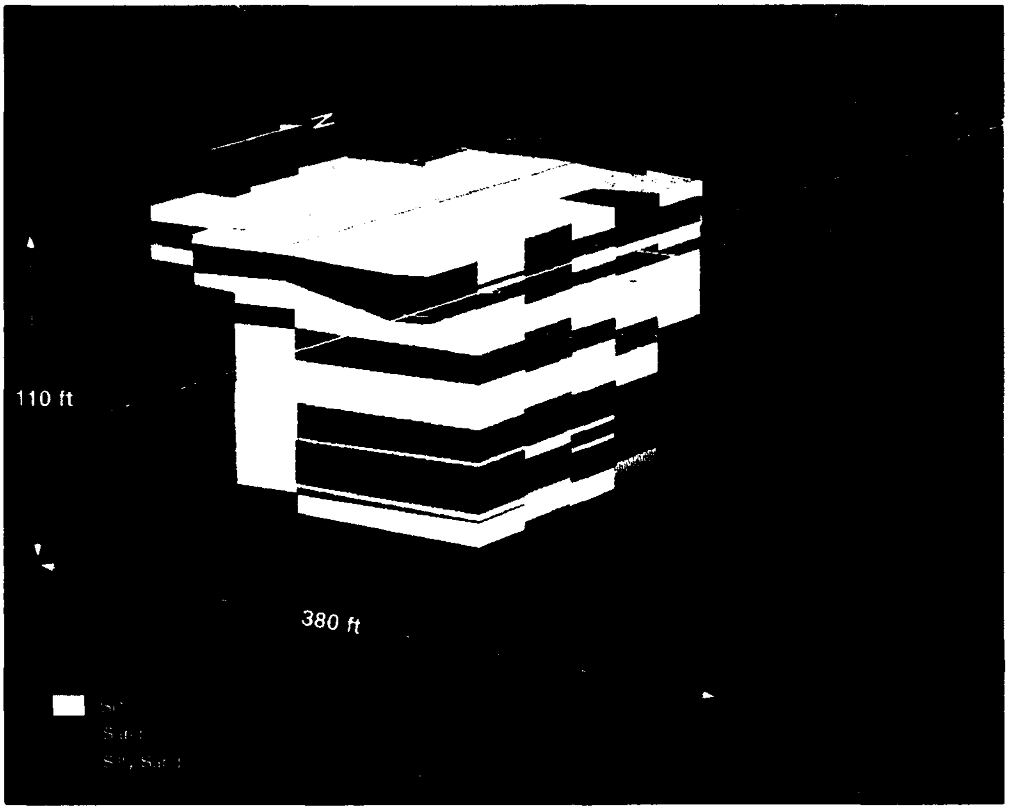

Figure 2-3
IC 1—Three-Dimensional Model of Geology

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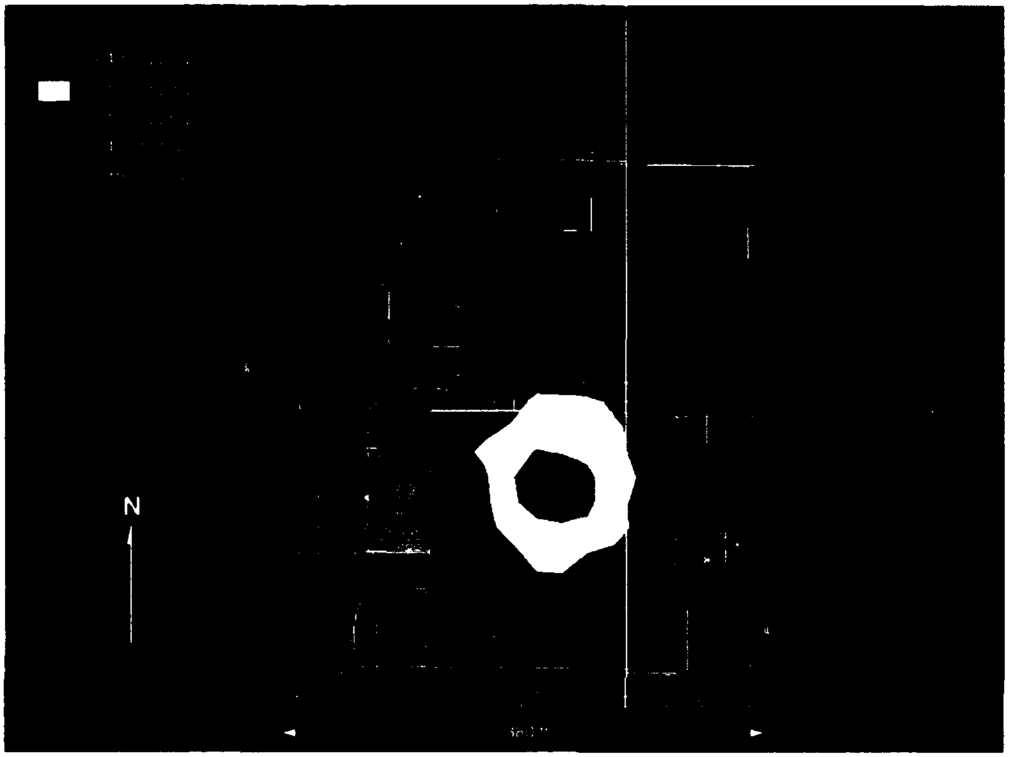

Figure 2-4
IC 1--Plan View of Total VOC in Soil Gas at an Elevation of 60 Feet, Regardless of Soil Type

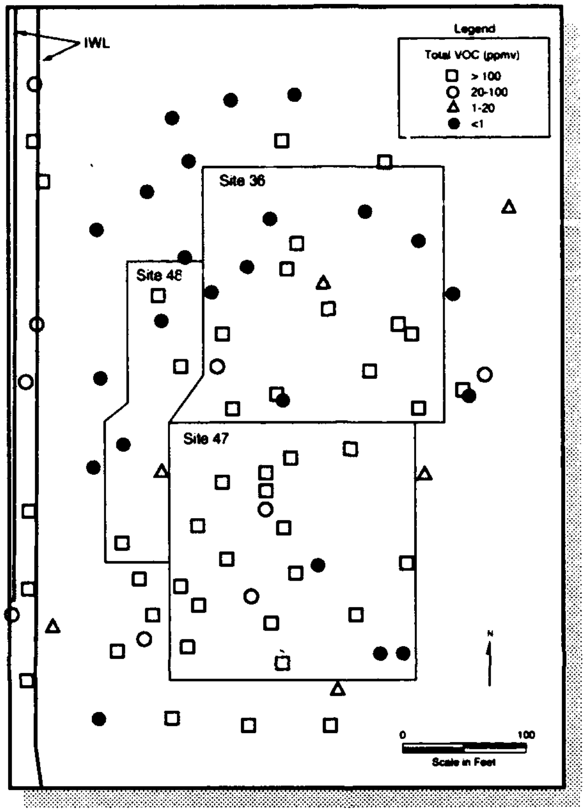

Figure 2-5
IC 1 Total VOC Concentration at an Elevation of 43 feet (Zone of Low Concentrations)

A third area of contamination is indicated along the southern boundary of IC 1, where commingling of contamination from Site 47 and the IWL cannot be separated. The distribution of freon 113 (FC113) indicates that a source for this contamination may exist south of the IC 1 boundary. The concentration of FC113 decreases toward the north in the direction of the center of contamination originating at Site 47, whereas the concentration of both TCE and PCE decreases uniformly toward the south.

A fourth area of contamination might exist just outside the northern boundary of Site 36, where two boreholes contain locally elevated total VOC concentrations, and surrounding borings contain little or no contamination at an elevation of 43 feet.

All four potential source areas are shown in plan view in figure 2-6. The conclusions regarding separation of potential source areas were developed on the basis of analyses of four individual constituents: TCE, PCE, FC113, and

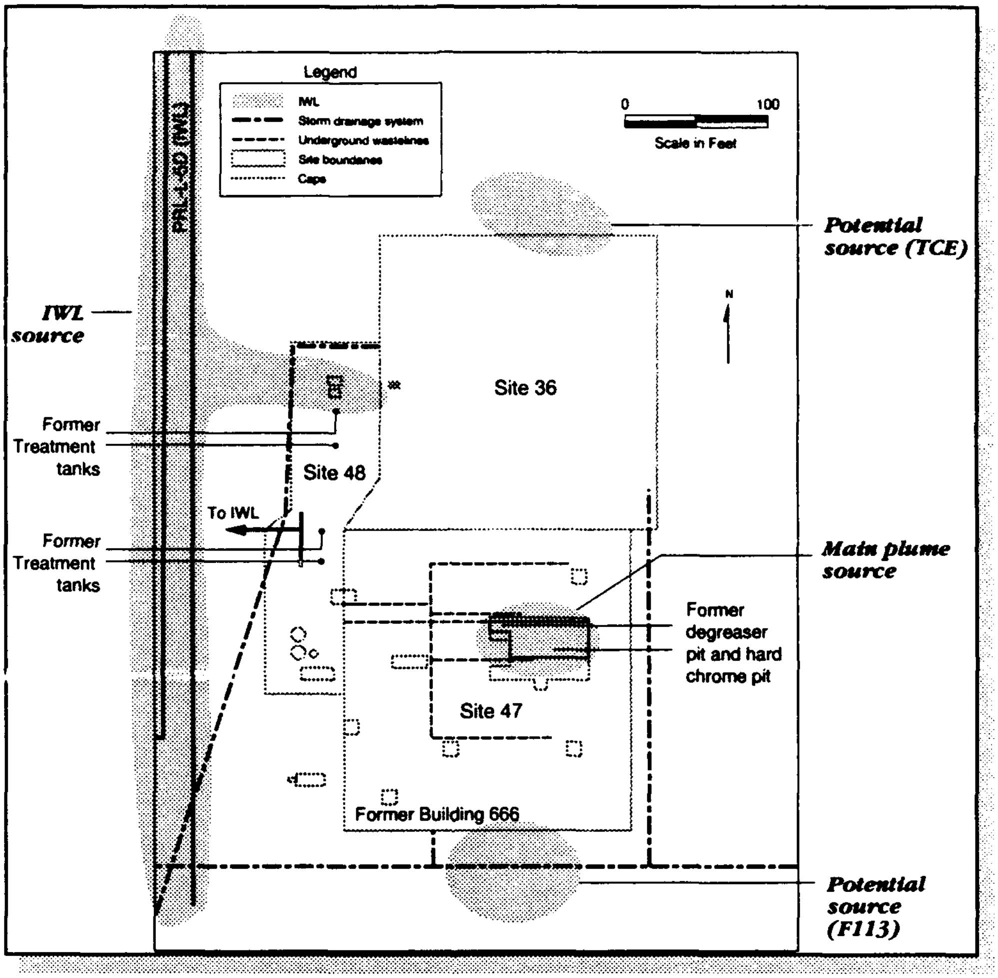

Figure 2-6
IC 1
Potential Source Areas

DCE12C. Isoconcentration results for these analytes are shown in figures 2-4, 2-7 a-d, 2-8, and 2-9. These results are based on three-dimensional distributive modeling that incorporates information from actual data points located above, below, or laterally away from the node for which a concentration is calculated. Therefore, at the lower elevations, with fewer actual data points (for example in figure 2-7a at an elevation of -27 feet), concentration estimates are still possible using data from samples at shallower depth. Supporting information and analytical results for each of these constituents follows.

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TCE Figure 2-7a indicates that at isoconcentrations of 1 and 20 ppmv, the TCE plume at all depths is elongated in the northeast-southwest direction. The elongation towards the northeastern end of the plume may result, in part, from the overlap of two plumes. Likewise, elongation in the southwestern direction may be the result of commingled contamination from the IWL, the main plume at Site 47, and the plume suggested by the FC113 contamination at the southern edge of IC 1.

Concentration gradients for TCE away from the center of the main plume at constant elevation are steep, changing about 500 ppmv over a distance of 100 feet. In the vertical direction, the highest concentrations near the center of the main plume are constant to about 50 feet and then drop from an average of about 1,000 ppmv at 50 feet to about 750 ppmv at 90 feet. The area inside the 100 ppmv isoconcentration line is about 1.4 acres, while the 20 ppmv area exceeds 3.0 acres.

PCE The PCE plume shown in figure 2-7b is more symmetrical than the TCE plume. At an isoconcentration of 1,000 ppmv, the PCE plume covers a larger area than does the 1,000 ppmv TCE plume.

FC113 As shown in figure 2-7c, FC113 (estimated concentration) is present sporadically at low concentrations in the northern two thirds of IC 1, but it forms a cohesive pattern towards the south. This finding suggests a potential source south of the IC 1 boundary where FC113 concentrations reach well over 100 ppmv. The FC113 distribution at the south boundary is defined only to a depth of the deepest sample location, 31 feet below ground.

DCE12C Although DCE12C never reaches very high concentrations (maximum of 3.6 ppmv), analysis of this constituent is important because its dispersion pattern within IC 1 is different from the other common VOCs. This is important in understanding separation of sources. The highest concentrations of DCE12C in IC 1 are associated with the northern two thirds of the IWL, as indicated in figure 2-8. This observation helped identify the IWL as a separate source area and led to investigations of other constituents. In the main plume, the highest DCE12C concentrations are north of the center for the TCE and PCE plumes. The qualitative nature of this interpretation is further emphasized by the observation that DCE12C was never detected by the TO-14 analyses.

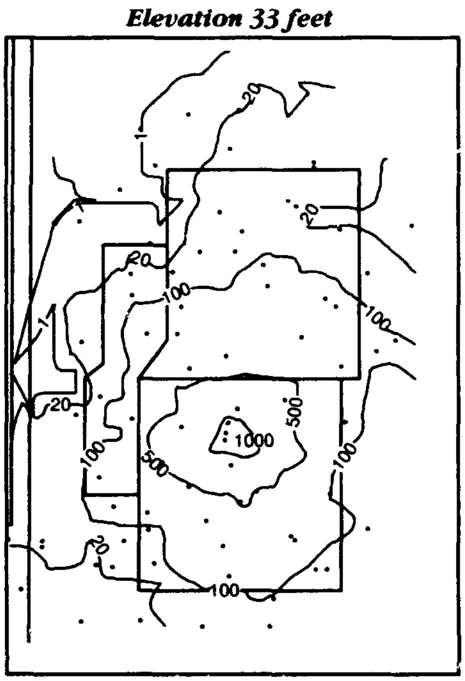

Figure 2-7a
IC 1
Distribution of TCE in Soil Gas Regardless of Soil Type (ppmv)

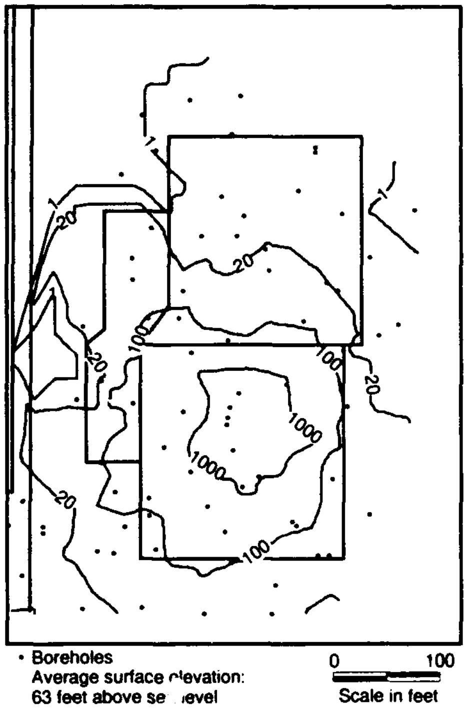

Figure 2-7b
IC 1
Distribution of PCE in Soil Gas Regardless of Soil Type (ppmv)

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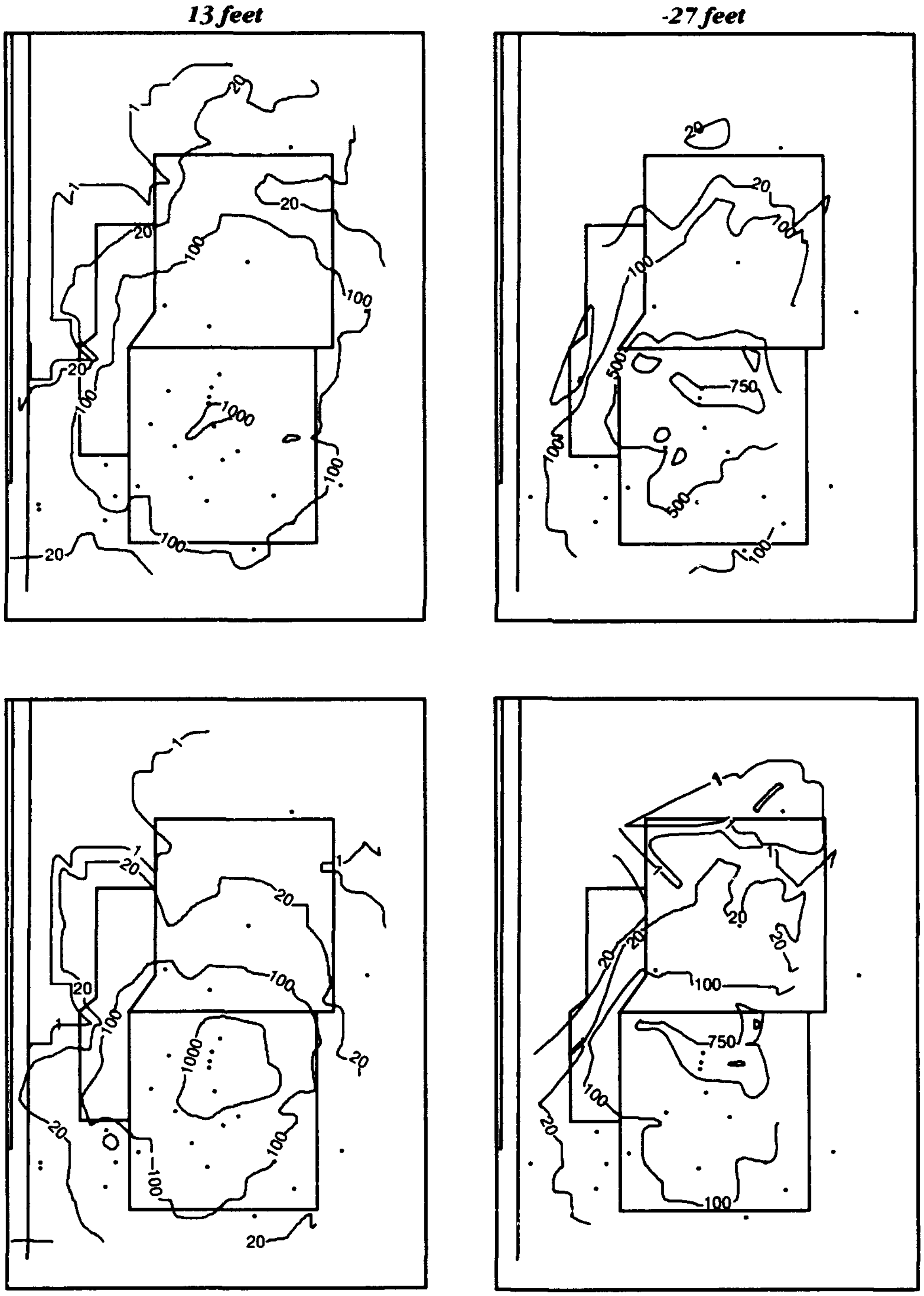

13 feet

-27 feet

Elevation 33 feet

Figure 2-7c
IC 1
Distribution of Freon in Soil Gas Regardless of Soil Type (ppmv)

FC113

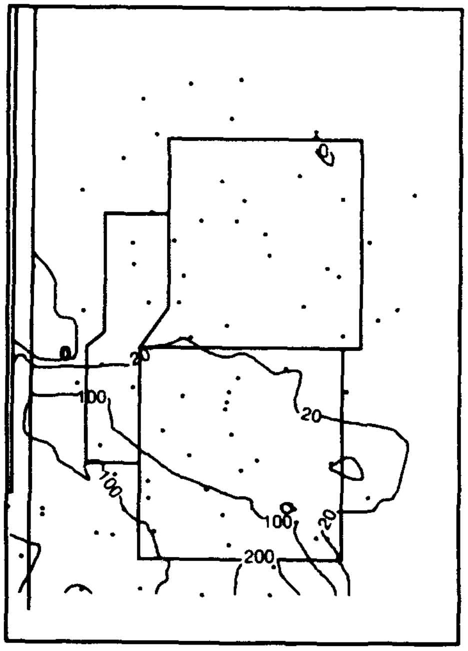
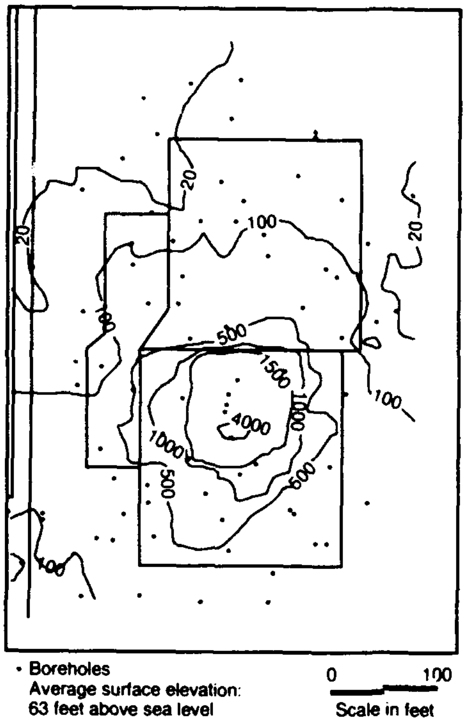


Figure 2-7d
IC 1
Distribution of Total VOC in Soil Gas Regardless of Soil Type (ppmv)

Total VOC



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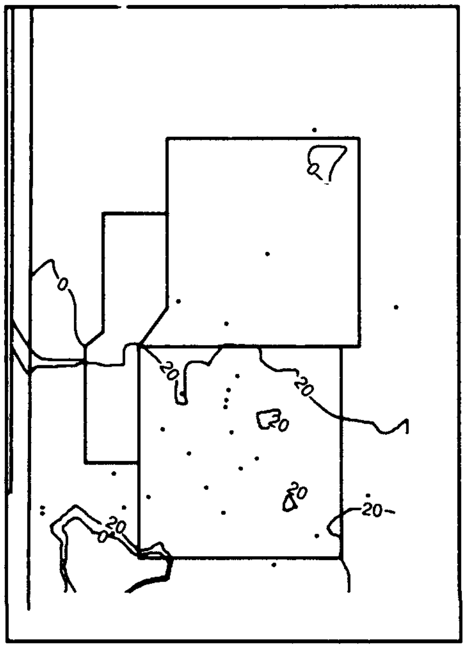
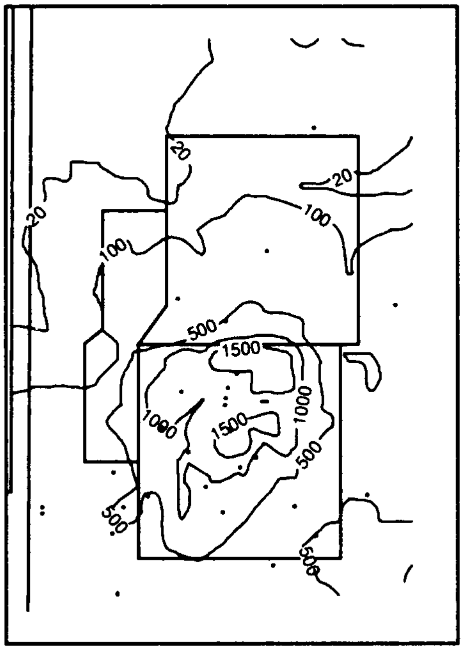
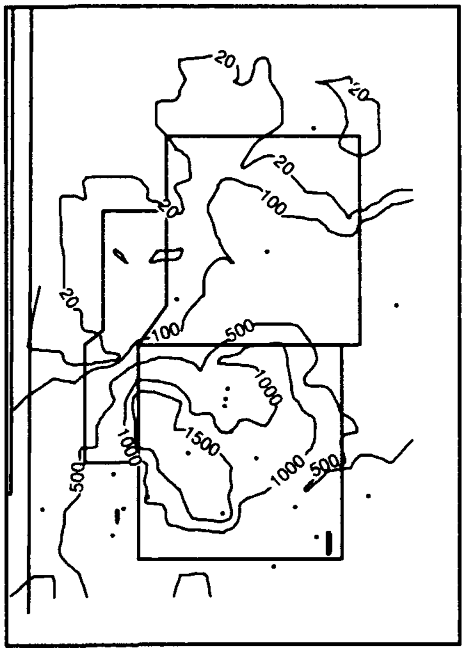
13 feet ***-27 feet***







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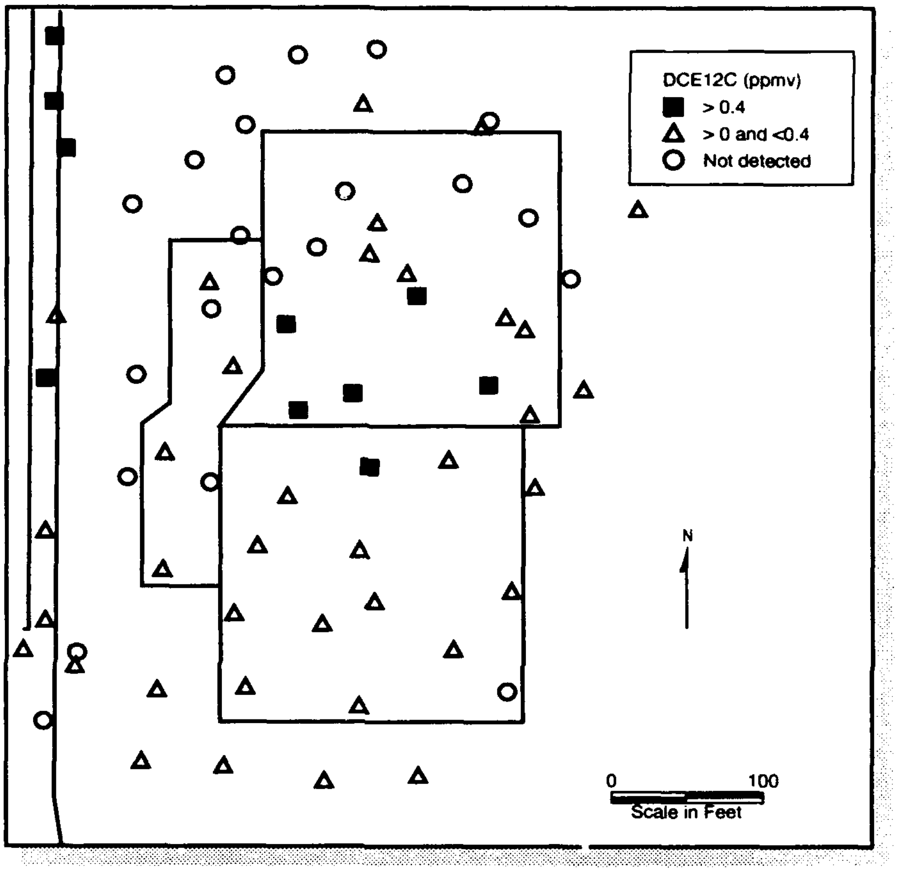

Figure 2-8
IC 1
Distribution of DCE12C in Soil Gas

Once it was recognized that the main soil gas plume centered on Site 47 was separate and distinguishable from most of the contamination along the IWL, data from the northern portion of the IWL were excluded from subsequent development of geostatistical models. However, a localized anomaly just north of Site 36 has been included in the present model.

Geostatistical analyses were performed for TCE, PCE, and total VOCs. The results of the total VOC modeling are shown in figures 2-7d and 2-9 and observations on the main plume are summarized below:

- Modeling of the main plume below the degreaser and hard chrome pits at Site 47 indicates that contaminants in the soil gas plume are dispersed in a regular pattern laterally away from a source column of contamination.

Figure 2-9
IC 1—Three-Dimensional Model of Total VOC

Section 2

- Near the center of the plume where the total VOC concentration is greater than 500 ppmv, vertical zonation of contamination is pronounced. In this portion of the plume, the shapes of isoconcentration surfaces resemble a molar tooth with nested shells of successively lower concentrations as depth and distance increase away from the presumed surface source.
- A zone where total VOC concentration exceeds 4000 ppmv bottoms out at about 30 to 40 feet below ground, but in at least one root of the molar shape, concentrations exceeding 1500 ppmv are to be found down to the water table, as indicated by the model.
- The core of the main plume is expected to be relatively small, and it may contain VOCs both dissolved in water and as free product. This core zone, which may be less than 50 feet in diameter, has not been sampled.

Additional observations can be made by investigating the spatial continuity of the VOC data:

- A plot of raw total VOC concentration data against distance from an assumed plume center reveals the regular pattern of decreasing concentration shown in figure 2-10. There is a noticeable rapid and regular decline in concentration horizontally away from the suspected source.

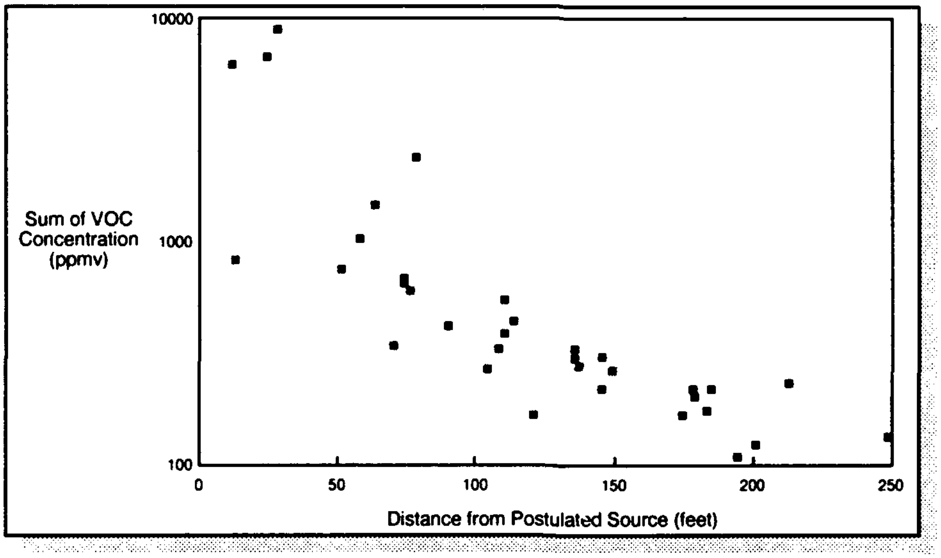

Figure 2-10
Total VOC Concentration Versus Distance from Postulated Source at an Elevation of 43 Feet

- The change in concentration with distance from the source appears to be independent of the soil types from which the soil gas sample was collected. Soils included silt, sandy silt, silty sand, and sand (figure 2-10).
- The geostatistical analysis suggests that soil gas distribution can be represented by a model that is homogeneous with respect to direction.
- There is a nearly vertical configuration of isoconcentration surfaces that trend across the various silt and sand units.

These observations suggest that contaminants were dispersed by diffusion from a central core below the surface disposal location. If vapor-state diffusion was the mode of dispersion, then most of the mass of contamination may still be present in the soil gas, with lesser quantities dissolved in retained interstitial water that comes in contact with the soil gas, and a small quantity sorbed to soil particles in contact with contaminated interstitial water. That the sorbed component of the total mass of a contaminant should be small is also indicated by the absence of detectable quantities of total organic carbon (detection limit is 0.1 percent) in the sediments below IC 1.

To test the hypothesis that most of the VOC contamination outside the core zone may be present only in the soil gas, an extraction test could be performed in one of the existing wells that is located away from the center of the plume (VW-8, VW-9, VW-10, VW-11 or VW-12 in figure 2-11). If contaminant concentrations decline quickly during extraction and concentrations do not build up significantly after a period of quiescence, then it could be argued that contamination is present predominantly in soil gas.

Test results could be used for several purposes:

- Influence the selection of future EE/CA sites
- Demonstrate that cleanup can be accomplished quickly for the bulk of the plume which lies outside the core zone
- Suggest modifications in the design and spacing of extraction wells at future sites

Contaminant Mass Calculations

If nonaqueous-phase liquids are absent, contaminant mass can be estimated for individual compounds using the soil gas concentration of an analyte based on the assumption that in-situ equilibrium exists among the gas, liquid, and solid phases. If nonaqueous-phase liquids are present (i.e., free product of a solvent in the soil), this approach underestimates the mass of contaminants.

Section 2

The equation requires the additional parameters listed in table 2-4 and volumetric estimates of soil types present. At IC 1, distributed averaged concentrations for the main plume were found for TCE, PCE, and total VOC (including unknowns); the results are shown in table 2-5.

Average concentrations of TCE and PCE present in the soil gas above a concentration cutoff of 1 ppmv (table 2-5) were then used to calculate concentrations in two soil types. Because of data limitations (total organic carbon was not detected above the detection limit of 0.1 percent), contaminant mass calculations were made for silt and sand, where sand includes silty sands and all other intermediate mixtures. Total soil mass estimates for each soil type were derived by apportioning the total volume of soil that corresponds to the average concentration into silt (51 percent) and sand (49 percent) and converting to mass using reported bulk densities for these two soil types.

The estimated total mass of PCE plus TCE in soil, based on equilibrium calculations, equals about 1,425 kg (3,100 pounds). Nearly 90 percent of the mass of each compound in silt and about 80 percent of the mass in sand is calculated to occur in the liquid and solid phases. Assuming that in the vapor-dominated portion of the plume the mass of TCE or PCE inside the 1 ppmv

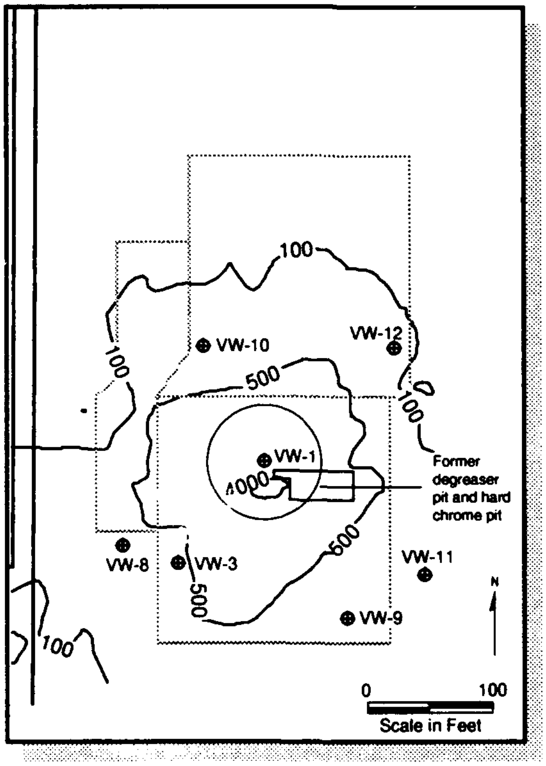

Figure 2-11
Location of Extraction Wells in Relation to the Distribution of Total VOC (ppmv)

Table 2-4
IC 1 Parameters for Mass Calculations

Parameter	Soil Type	
	Silt	Sand*
TOC	0.10 **	0.03
K_{OC} (DCE12C)	49	49
K_{OC} (TCE)	126	126
K_{OC} (PCE)	364	364
H (DCE12C)	0.123	0.123
H (TCE)	0.297	0.297
H (PCE)	0.546	0.546
$\varnothing_W$	.34	.23
$\varnothing_A$	.16	.24
ρ_B	1.36	1.44

Reference: Radian, 1993c

* Sand includes all samples identified as SP, SW, SM and mixtures (SP/ML or ML/SP, SM/SP, etc.)

** TOC was not detected in any samples above the detection limit of 0.1%
Values for silt and sand were assigned arbitrarily

Definitions:

TOC = Total organic carbon (percent)
K_{OC} = Soil partitioning coefficient (ml/g)
H = Henry's law constant (dimensionless)
$\varnothing_W$ = Water satuated soil porosity
$\varnothing_A$ = Air saturated porosity
ρ_B = Bulk density of soil (g/cc)
C_T = Soil VOC concentration, mg/kg
C_G = Soil gas VOC concentration, ng/ml

Equilibrium Equation:

$$C_T = 0.001\ C_G \left[0.01 \times \rho_B \times K_{OC} \times TOC \times 1/H + \varnothing_W \times 1/H + \varnothing_A \right] \times 1/\rho_B$$

Concentration Cutoff (ppmv)	TCE		PCE		Total VOCs	
	Soil Volume (1000s of cubic feet)	Average Concentration (ppmv)	Soil Volume (1000s of cubic feet)	Average Concentration (ppmv)	Soil Volume (1000s of cubic feet)	Average Concentration (ppmv)
1	25,183	190.85	14,763	202,51	20,895	379.37
20	12,674	226.50	9,692	303,89	19,559	404.41
50	9,780	283.89	6,190	456.98	*	*
100	6,960	368.69	4,026	66.07	13,336	570.16
500	1,980	717.27	1,738	1200.02	*	*
1000	152	113.61	710	1935.42	1,980	1720.83
1500	0	0	438	2404.62	880	2377.46
2000	0	0	268	2839.14	388	3188.47
4000	0	0	0	0	86	4636.14

* Not Estimated

Table 2-5
IC 1 Soil Volume Estimates and Average Soil Gas Concentrations

isoconcentration surface represents essentially 100 percent of the dispersed contamination, fractions of total mass at different cutoffs can be calculated; these calculations are shown in table 2-6. The mass of both TCE and PCE is reduced by about 10 percent if the cutoff is changed from 1 to 100 ppmv.

These mass calculations in the vapor-dominated portion of the plume may overestimate the contamination for two reasons: overestimation of total organic carbon and effective water-filled porosity. Total organic carbon was not detected in any sample above the detection limit of 0.1 percent. However, in order to calculate mass, values of 0.1 percent for silt and 0.03 percent for sand were used to estimate the sorbed component. Calculations suggest that about 36 percent of the total TCE plus PCE mass is associated with the sorbed component. Moreover, this conclusion is relatively insensitive to the assumptions about total organic carbon.

About 50 percent of the total TCE plus PCE mass is derived from the liquid component in the equation. In the model, it is assumed that all the moisture

Concentration Cutoff (ppmv)	TCE			PCE		
	Area of Contamination (Acres)	Contained Mass (kg)	Percent of Total	Area of Contamination (Acres)	Contained Mass (kg)	Percent of Total
1	3.7	663	100	3.7	759	100
100	1.4	599	90	0.9	695	92
500	0.3	330	50	0.3	530	70
1000	0.03	24	4	0.2	349	46

Table 2-6
IC 1 Contained Mass of Contaminants, Site 47 Plume

in the soil is exposed to soil gas containing contaminants and that the gas and the liquid are in equilibrium. If it can be argued that not all of the retained moisture is in contact with soil gas, then mass estimates using total water-filled porosity overestimate the contamination. The fraction of the total porosity that is filled with soil gas is about 30 percent in silts and about 50 percent in sands. Therefore, a significant quantity of soil moisture may be present in isolated pores that are not in contact with soil gas or with contaminated liquids. As a result, the "effective" water-filled porosity that should be used to calculate mass of contamination may be considerably less than the total water-filled porosity.

Mass estimates based on equilibrium assumptions are significantly affected by the conceptual model that describes the dispersion and subsequent interaction of contaminants with the soil and soil moisture. The model developed from the soil gas distribution in the main plume at Site 47 suggests that dispersion of contaminants occurs primarily by diffusion in available air-filled pore space. In this model, equilibrium may be established relatively quickly with the liquid that comes in contact with the contaminant vapor, but equilibrium may be slow or nonexistent between contaminated liquid and solids. As a result, total soil mass calculations may significantly overestimate contamination in circumstances where contaminants are dispersed primarily in the vapor phase.

In any portion of the contaminant plume dominated by vapor dispersion, total contaminant mass may be less than 50 percent of the calculated value; this assumes that the sorbed and dissolved components do not represent equilibrium conditions. Total mass could be as low as the mass contained only in the soil gas.

Contaminant mass could be significantly higher in the core zone that is estimated from the available data. The core zone was not sampled and the current estimates are based on the assumption that nonaqueous-phase liquids are absent. A core zone not more than 40 feet in radius around the disposal pits is suspected. If free products of nonaqueous-phase liquids are present total contaminant mass could be significantly higher. Using recent experience at OUD Site S, the actual mass at IC 1 may be as much as an order of magnitude higher than the current estimate.

More than 90 percent of the total estimated TCE plus PCE mass in the vapor-dominated portion of the plume is contained in an area of about 1.4 acres. Table 2-6 suggests that TCE is more widely dispersed into the outer portions of the vapor dominated plume than is PCE (about 92 percent of the PCE mass is contained in 0.9 acres). Although mass cannot be calculated for total VOCs, total VOC mass is not likely to be more than 10 percent greater than the total mass for TCE and PCE. The area inside the 1 ppmv concentration cutoff for total VOC is about 4.4 acres, compared to 3.7 acres for both TCE and PCE; at 1,000 ppmv total VOC cutoff, the area is about 0.3 acres.

Conclusions

The conceptual model of the main plume at Site 47 has a core zone of contamination that is likely to contain VOCs both dissolved in water and dispersed as free product through the column of soil underneath the degreaser and hard chrome plating pits. Surrounding this suspected core zone is a much larger plume dominated by vapor-dispersed VOCs. The horizontal dimensions of the core zone are unknown, but the zone appears to be no more than 25 to 40 feet in radius around the center of the pits. For this main plume, the core zone may contain a significantly greater mass of contamination than the vapor-dominated plume sampled by most of the borings drilled to date.

SVE removal action will be focused initially on the core zone of the main plume. The existing extraction well (VW-1) located about 25 feet from the degreaser pit will be used for the removal action; the well is screened over an 80-foot zone.

There are six additional existing extraction wells, variously screened over intervals ranging from 60 to 80 feet, that are outside the 500 ppmv total VOC concentration surface (figure 2-11). These wells will be used for testing and extraction in the area outside the core zone, as appropriate.

Section 3
JUSTIFICATION OF SVE REMOVAL ACTION

As discussed in section 4 of the General Evaluation Document, justification of a removal action using SVE as the presumptive remedy is dependent on site-specific information. The first consideration is evaluation of the feasibility of applying SVE at the site, which is based on satisfying criteria regarding contaminant volatility, air permeability in soil, and depth of significant contamination.

At IC 1, the primary contaminants are TCE and PCE, both of which meet the physical-chemical requirements to classify them as volatile compounds. A soil gas permeability was recently conducted in IC 1. The average air permeability was estimated to be 39 darcies, which is five orders of magnitude higher than the criteria of 10^{-3} darcies. Therefore, the soil is favorable for the application of SVE. Finally, as demonstrated by soil gas measurements, the depth of VOC contamination in the vadose zone is approximately 100 feet; this is greater than the threshold of 5 feet.

The second consideration is an evaluation of the need for removal action. The soil-gas contaminant plume underlying the main plume at Site 47 averages about 1,000 ppmv TCE at a depth of 50 feet below ground surface. This plume is a continuing source of contamination to groundwater underlying the site. In addition, screening risk analysis indicates there is potential for an unacceptably high level of risk associated with the observed high concentrations of TCE and PCE if these contaminants are not removed (Radian, 1993c). This analysis has produced two screening results: a cancer risk of 2×10^{-2} and a hazard index of 1.4×10^{2}. Screening generally overestimates the actual risk because it relies on conservative assumptions when actual values are not known (MITRE, 1993). Nonetheless, the screening results are significantly higher than the generally accepted values for cancer risk (10^{-6} to 10^{-4}) and hazard index (1). Therefore, the main plume at IC 1 is a candidate for removal action.

In summary, using the criteria set out in the General Evaluation Document, the main plume near Site 47 at IC 1 has been determined to be a candidate site for a removal action using SVE as the presumptive remedy.

Section 4
REMOVAL ACTION OBJECTIVES

Scope

The removal action is aimed at removing VOCs from the main plume at Site 47. This includes the initial extraction of VOC from the core zone, followed by testing and operation of extraction wells in areas outside the core zone.

ARARs

Chemical-specific ARARs:	As identified in the General Evaluation Document
Action-specific ARARs:	As identified in the General Evaluation Document
Location-specific ARARs:	None

Section 5
CONCEPTUAL DESIGN AND COST

Conceptual Design

The removal action for Site 47 at IC 1 involves the use of one extraction well near the core zone (screened from 17 to 97 feet below ground), and potentially involves the use of six additional existing extraction wells in the main plume but outside the core zone. The well near the core zone reaches the top of the capillary zone, thereby limiting this removal action to the vadose zone. Integrated groundwater removal will not be considered.

The vacuum system for Site 47 entails the use of two positive displacement blowers, each nominally rated at 800 scfm maximum flow rate at 7 inches of mercury. Two individual blowers permit operating flexibility (e.g., cycling operation of each well) and also increase the overall system availability. Motor-driven blowers also permit some adjustment to optimum flow rates at the lowest practicable vacuum levels (up to 7 inches mercury).

Using recent experience at the OU D Site S Treatability Investigation, where over 46,000 pounds of volatile contaminants were extracted over eight weeks, total project duration at IC 1 is not expected to exceed six months and could be complete in as little as three months. The preferred option for vapor treatment would therefore be the base metal, fluid bed catalytic oxidation system. This system could effectively accommodate the expected high initial contaminant loadings, as well as any vinyl chloride. Experience at Site S also indicates that vinyl chloride is quickly removed, so if vinyl chloride is present at IC 1, the thermal system will be able to treat it. Because of the limited duration, changeover to carbon adsorption is not recommended.

Cost Estimate

The itemized cost estimate for remediating IC 1 is presented in table 5-1. IC 1 is located in an industrial area, so utilities should be present near the location of the SVE equipment. Construction of a concrete pad is not necessary because the existing pad located at the site can be used during the removal action. A base metal, fluid bed catalytic oxidizer equipped with a scrubber will be used to control emissions and destroy the chlorinated contaminants. Because the core zone of the contamination is very narrow, a single well should be sufficient to remediate the site. If the contamination is not removed within six months of SVE operation, the additional existing wells (up to six) can be connected to the SVE system. If the equipment is purchased, the cost of the removal action is estimated to be approximately $1 million. Because of the anticipated short duration of the removal action, using activated carbon to control emissions after the initial contaminant concentration decreases to less than 1,000 ppmv should not be considered, and would probably not be cost-effective.

Section 5

Item	Design Basis	Unit Cost	Item Cost
Site Preparation:			
Gas Connection	200 feet of 2-inch polyurethane line	$7.50/foot	$1,500
Electrical Connection	200 feet of buried 4-inch conduit	$5.00/foot	1,000
Transformer	12 kv to 440 v unit	$13,000	13,000
Water Connection	200 feet of buried 2-inch PVC pipe	$14.00/foot	2,800
Equipment:			
Vacuum blowers	2 blowers rated 500-800 scfm at 7-12 inches of Hg	$17,000	34,000
Air -Water Separator	1 unit: 2000 scfm rated at 18 inches of Hg	$4,000	4,000
Manifold and Piping	500 feet of 4-8 inch PVC pipe, fittings and support	$30.00/foot	15,000
Emission Control System	Catalytic oxidizer with scrubber	$355,000	355,000
Engineering	10% of site and equipment cost		42,000
Mobilization	10% of site and equipment cost		42,000
			Total: $511,200
Operation and Maintenance:	90% uptime, 648 hours per month		*Monthly Operating Cost:*
Natural Gas	2,425 scfh	$3.50/1,000 scf	$5,500
Electricity	105 kw	$.075/kWh	5,100
Water	617 gph	$1.00/1,000 gal	400
Scrubber Chemicals	254 pph	$350/ton	28,800
Waste Disposal	500 gph	$3.00/1,000 gal	1,000
Testing and Monitoring	1 stack test per month, 9 well analyses per month	$2,500/sample	25,000
Operating Labor	90 hours for 2 part-time techs and part-time sample collector	$70/hour	6,300
Reporting	1 monthly operations report and prorated summary report	$6,000/month	6,000
		Monthly Operating Cost:	$78,100
		Operating Cost for 6 Months:	$468,600

Table 5-1
SVE Cost Estimate for IC 1

Section 6
IMPLEMENTATION PLAN FOR SVE REMOVAL ACTION

The schedule for preparing the documents to support an SVE removal action at IC 1 is shown in figure 6-1. The IC 1 draft final document was made available for public comment on 1 September 1993. This is followed by a 30-day public review period and a 15-day extension if requested, for a total of 45 days. A 45-day period is planned for McAFB to respond to public comments, finalize the EE/CA, and prepare the responsiveness summary and the action memorandum. The responsiveness summary addresses public comments and the action memorandum is the primary decision document for removal action. All these documents will be placed in the Information Repository and Administrative Record.

A schedule for implementing an SVE system is shown in figure 6-2 to illustrate the sequence of milestone events: design, procurement, off-site equipment assembly, installation, operation, and termination. The SVE design will begin after the date of contract award. An eight-month design period is planned for the traditional design cycle of 10, 40, 90, and 100 percent design submittals and reviews. A one-month interval between the completion of the design and the beginning of equipment installation is allowed for equipment procurement. A three-month period is planned for equipment assembly, which can be done off-site, and a one-month period is planned for on-site installation. The period of operation will be determined as part of the periodic reviews of SVE system performance, currently set for six-month intervals

The SVE removal action for IC 1 is part of a basewide removal action including five areas: IC 1, IC7, OU C1, OU D/Site S, and OU D/Site 3. SVE equipment will be installed sequentially at these sites rather than at all sites concurrently. McAFB has not developed an integrated schedule for all five areas, but intends to start the SVE system installation for the last of these five areas before 1 October 1994.

McAFB is not liable for delays in any planned activity in the event of Force Majeure, which is an unforeseen condition as described in the Interagency Agreement among the Air Force, Region 9 of the U.S. Environmental Protection Agency, and the state of California.

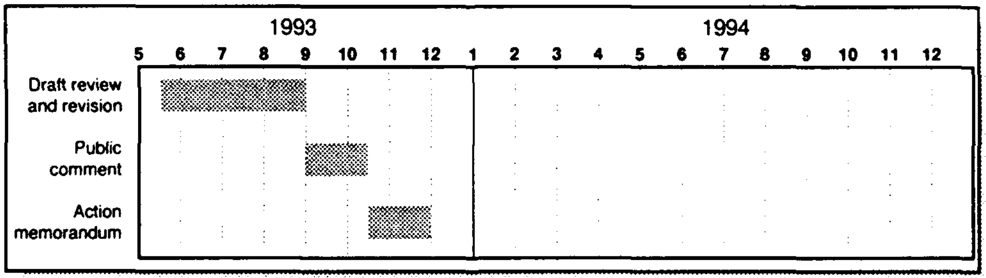

Figure 6-1
Schedule for EE/CA Site Specific Document for IC 1

Section 6

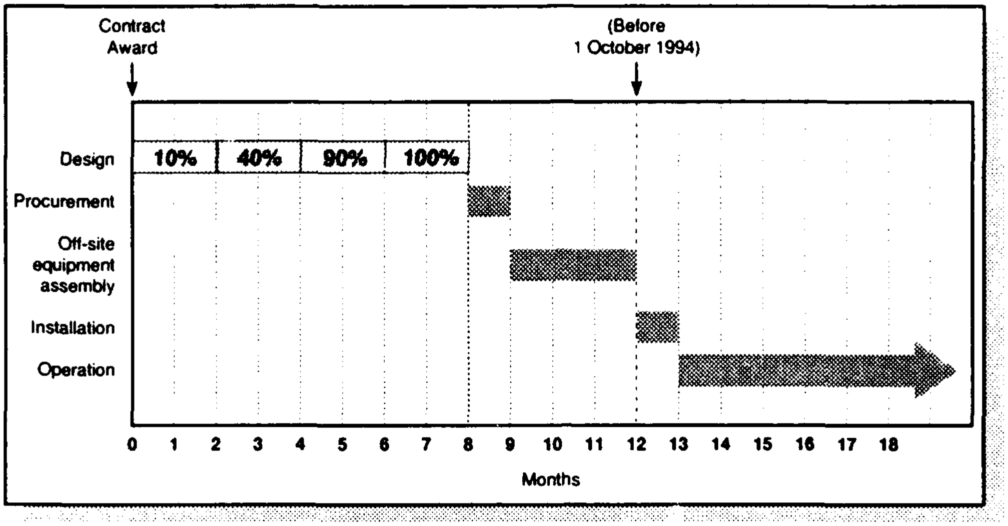

Figure 6-2
Generic Schedule for Implementing an SVE System

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GLOSSARY

Chemical Codes

ACE	acetone
BRME	bromomethane
BUTADIEN	1,3-butadiene, erythrene
BZ	benzene
BZLCL	benzyl chloride
BZME	toluene
C8N	n-octane
CHLOROPR	2-chloro-1,3-butadiene
CLBZ	chlorobenzene
CLEA	chloroethane
CLME	chloromethane
CO	carbon monoxide
CTCL	carbon tetrachloride
CYHEXANE	cyclohexane
DCA11	1,1-dichloroethane
DCA12	1,2-dichloroethane
DCBZ12	1,2-dichlorobenzene
DCBZ13	1,3-dichlorobenzene
DCBZ14	1,4-dichlorobenzene
DCE11	1,1-dichloroethene
DCE12C	cis-1,2-dichloroethene
DCE12T	trans-1,2-dichloroethene
DCP13C	cis-1,3-dichloropropene
DCP13T	trans-1,3-dichloropropene
DCPA12	1,2-dichloropropane
EBZ	ethylbenzene
EDB	1,2-dibromoethane (ethylene dibromide)
FC11	trichlorofluoromethane
FC113 or F113	1,1,2-trichloro-1,2,2-trifluoroethane
FC12	dichlorodifluoromethane
FC114	freon 114, dichlorotetrafluoroethane
MTLNCL	methylene chloride
MVC	vinyl chloride, monovinylchloride
NOx	nitrogen oxides
PCA	1,1,2,2-tetrachloroethane
PCE	tetrachloroethene
PROP	propylene, propene
SOx	Sulfur Oxides
STY	styrene
TBME	bromoform

GLOSSARY

TCA111	1,1,1-trichloroethane
TCA112	1,1,2-trichloroethane
TCB124	1,2,4-trichlorobenzene
TCE	trichloroethene
TCLME	chloroform
TMB124	1,2,4-trimethylbenzene
TMB135	1,3,5-trimethylbenzene (mesitylene)
UNK	unknown compounds
VC	vinyl chloride
XYLMP	m,p-xylene (sum of isomers)
XYLO	o-xylene (1,2-dimethylbenzene)
XYLP	p-xylene (1,4-dimethylbenzene)

General

ARAR	Applicable or relevant and appropriate requirement
cfm	Cubic feet per minute
EE/CA	Engineering Evaluation-Cost Analysis
EPA	U.S. Environmental Protection Agency
IAG	Interagency Agreement
IC	Investigative cluster
IRP	Installation Restoration Program
IWL	Industrial waste line
IWTP	Industrial wastewater treatment plant
MCAFB	McClellan Air Force Base
OU	Operable Unit
ppb	parts per billion
ppm	parts per million
ppmv	parts per million by volume
PRL	Potential release location
scfm	standard cubic feet per minute
SVE	Soil vapor extraction
SMAQMD	Sacramento Metropolitan Air Quality Management District
TOC	Total organic carbon
TRC	Technical Review Committee
VOC	Volatile organic compound