PESTICIDE MOVEMENT TO GROUND WATER

VOLUME II: PESTICIDE CONTAMINATION IN THE SOIL PROFILE AT DBCP, EDB, SIMAZINE AND CARBOFURAN APPLICATION SITES

April 1984

ENVIRONMENTAL HAZARDS ASSESSMENT PROGRAM

State of California
Department of Food and Agriculture
Division of Pest Management, Environmental Protection
and Worker Safety
Unit of Environmental Monitoring and Pest Management
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by

F. Zalkin, M. Wilkerson, and R.J. Oshima

April 1984

Field Monitoring:	R. Sava, S. Simpson, F. Zalkin, R. Segawa, C. Garretson, J. Pratt, L. Herschberger, G. Baker
Sampling Methods and Preparation:	T. Mischke, J. Franz, V. Bunac, B. Winter, R. Teso
Chemical Analysis:	S. Fredrickson, T. Jackson, S. Margetich, P. Schlocker, R. Magkoski, J. Echelberry, E. Wong, D. Conrad
Soil Analysis:	C. Garretson, C. Poole, J. Pratt
Data Processing:	R. Segawa, M. Wilkerson
Programming:	M. Wilkerson
Graphics:	L. Neher, L. Heath, D. Duncan, J. Marade, H. Margolis.
Statistical Analysis:	T. Younglove, F. Zalkin
Study Design:	D. Weaver, S. Cohen
Word Processing:	M. Hoversten

ABSTRACT

Ethylene dibromide (EDB) was detected at depths ranging from 0 to 40 ft., and concentrations ranging from 0.1 to 31.1 ppb in soil profiles sampled. Both sampling sites had differing histories of pesticide application frequency. One site was associated with a well containing contaminated groundwater and the other with a well containing uncontaminated groundwater (documented in Volume I). EDB was statistically related to organic matter in the first 8 ft. of the soil profile and to clay at depths below 8 ft.

Simazine was detected at depths ranging from 0 to 28.3 ft., and concentrations ranging from 2 to 55 ppb in a soil profile associated with a contaminated well. Data from a second profile taken at a site associated with uncontaminated well water was of little value due to circumstances leading to an unusually high minimum detectable level during chemical analysis. Simazine was statistically related to organic matter in the first 8 ft. of the soil profile and to soil moisture at depths below 8 ft.

No DBCP (dibromo-chloro-propane) was detected in samples collected from two independent soil profiles associated with contaminated and uncontaminated wells. Previous applications of this pesticide had ceased 5 years prior to soil sampling.

No carbofuran was detected in a soil profile at a site receiving a single carbofuran application one year prior to sampling. This site was associated with a well that contained uncontaminated groundwater.

An empirical model was developed using discriminant analysis to predict pesticide contaminated sites. Time since the last application and percent organic content were found to be the best predictive variables. The model is specific to sandy soils representative of the study area.

This report is second in a series of three. Volume I discusses DBCP, EDB, simazine and carbofuran detection in water collected from wells in the San Joaquin Valley groundwater basin. Volume III combines and evaluates the results from volumes I and II, and examines possible interactions between agronomic variables and well characteristics influencing pesticide transport to groundwater.

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We would also like to express our appreciation to the County Agricultural Commissioner Offices of Fresno, Tulare, and Riverside counties for their assistance in site location and pesticide use information.

This study was also made possible through the assistance of the property owners who permitted access to their land and helped in locating the actual sample sites.

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Pesticide Movement to Groundwater

Volume II: Pesticide Contamination in the Soil Profile at DBCP, EDB, Simazine and Carbofuran Application Sites

I. INTRODUCTION

This report is the second in a series of three volumes reporting on a study to determine 1) whether selected pesticides are sufficiently mobile to percolate through soil into upper levels of groundwater and 2) whether known soil properties can be associated with pesticide location within the soil profile, and 3) whether known soil properties can be used to predict contamination at specific geographic locations.

Volume I: Survey of Groundwater Basins for DBCP, EDB, Simazine, and Carbofuran, discussed DBCP, EDB and simazine detected in water collected from wells in the San Joaquin Valley groundwater basin, and DBCP, simazine and carbofuran detected in well water samples in the Upper Santa Ana groundwater basin. This report, Volume II, describes the results of sampling the vadose zone at sites where the pesticides had been applied. The soil profile was sampled from the soil surface to the depth where groundwater was first encountered. The objectives were to determine the vertical distribution of pesticide in the soil profile and relate soil characteristics with pesticide levels. An additional report, Volume III, will evaluate the contribution of several agronomic variables influencing the movement of pesticides to groundwater at some of the sites discussed in this report, and will also provide an analysis and summary of results from all three volumes of the study.

The mobility of pesticides within the first several feet of soil has been studied in field situations and more extensively in the laboratory under controlled conditions (1). However, the deeper movement of pesticides from the soil surface to the first levels of groundwater has not yet received much investigation.

Previous studies in the upper layers of soil have revealed that adsorption may be the most important process governing the mobility of pesticides in soil (2). Many interacting factors influence the adsorption of pesticides to soil particles: soil properties (texture, organic matter content, moisture content, structure, pH, microbial activity, mineral content, cation exchange capacity, temperature, etc.); specific properties of the pesticide (solubility, volatility, formulation, degradation rates and pathways, etc.); rates of pesticide application, and irrigation practices. The main properties considered in this report are soil texture and percolation rates, organic matter content, and moisture content.

II. MATERIALS AND METHODS

A. SITE SELECTION

Drilling sites were selected on the basis of the geographical distribution of shallow groundwater contamination reported in Volume I. Site selection was also based on the comparison of an area where a specific pesticide had been applied and detected in the groundwater, to a second area, where the same pesticide had been applied but no groundwater contamination had been detected.

Eight drilling sites were sought, two sites for each of the four pesticides (DBCP, EDB, simazine and carbofuran). Sites were required to meet the following criteria: 1) documented applications of one of the pesticides, 2) located within a 10 mile radius of a sampled well, and 3) depth to groundwater less than 100 ft. Sites that had received more than one application of the specific pesticide were given preference. This information was obtained from pesticide use permits at County Agricultural Commissioners' offices and from growers. For each pesticide, a site was sought that was close to a well in which water contaminated with that pesticide had been detected (Volume I). An additional site was chosen near a well that showed no detectable levels of the pesticide in the groundwater. Another criterion for site selection was the depth to groundwater limitation imposed by the drilling equipment used in this study (100 ft.). Approximate depths to groundwater were determined from a map showing depths to water in wells in the San Joaquin Valley (3).

B. DRILLING OPERATION AND SAMPLE COLLECTION

The drilling and sampling were accomplished using a truck-mounted hydraulically driven drill and two types of samplers. The equipment consisted of a 1982 Mobil Drill, Model B-53, mounted on a 1982 International Harvester S1800

4x4 cab and chassis. Hollow stem augers [5 ft. long, 3 3/8 inches inside diameter (i.d.), 8 inches outside diameter (o.d.)] in conjunction with the Mobil Drill's Moss Wireline Sampling System were utilized in the drilling operation (Figure 1). The soil core segments were brought to the surface in either a Shelby Tube (Figure 2), a thin walled aluminum tube (30 inches long, 3 inches i.d.), or a Split Barrel sampler (Figure 3)(20 inches long, 2.5 inches i.d.). The Split Barrel sampler (Figure 2) contained three stainless steel liners that served as the actual collection tubes for the soil. Each liner was 6 inches long, 2.5 inches o.d. and 2.37 inches i.d. An additional 2 inches of soil lodged in the cutter shoe was added to the sample (6 inches of soil) collected directly above it.

The selected equipment allows core sampling to take place concurrently with the drilling process. The Moss sampling apparatus, which included either a Shelby Tube or a Split Barrel sampler, was loaded inside the augers and lowered until it mated with the latch body on the lead auger (Figure 1). The Moss System positioned the cutting edge of the sampler ahead of the auger cutter flights for undisturbed sampling. The winch cable, Moss sampling apparatus and the Shelby Tube or Split Barrel sampler remained in the hole while drilling the distance required to fill the sampler. The sampler did not rotate during drilling, but was pressed through the soil as the auger rotated and advanced downward. This method was designed to produce undisturbed soil samples.

Each time the sampling apparatus was placed in the ground, it advanced in increments equal to the length of the sampler used (30 inches for the Shelby Tube, 20 inches for the Split Barrel). In some highly expansive or hard soils (clay hardpan or calcareous soils), significant wall friction between the sampler and soil prevented the soil from completely filling the sampler. In these instances, the sample recovered was the upper portion of the production depth that was collected prior to the critical buildup of friction. The rest of the production (the lower portion) was lost. The lost soil was presumed to have been pushed aside and removed by the auger cutter head.

In addition to collecting soil samples, a collection method was designed to retrieve saturated soil in the last sample of the drilling operation. A polyethylene bag was cut to approximately 8x12 inches. This piece of plastic was then

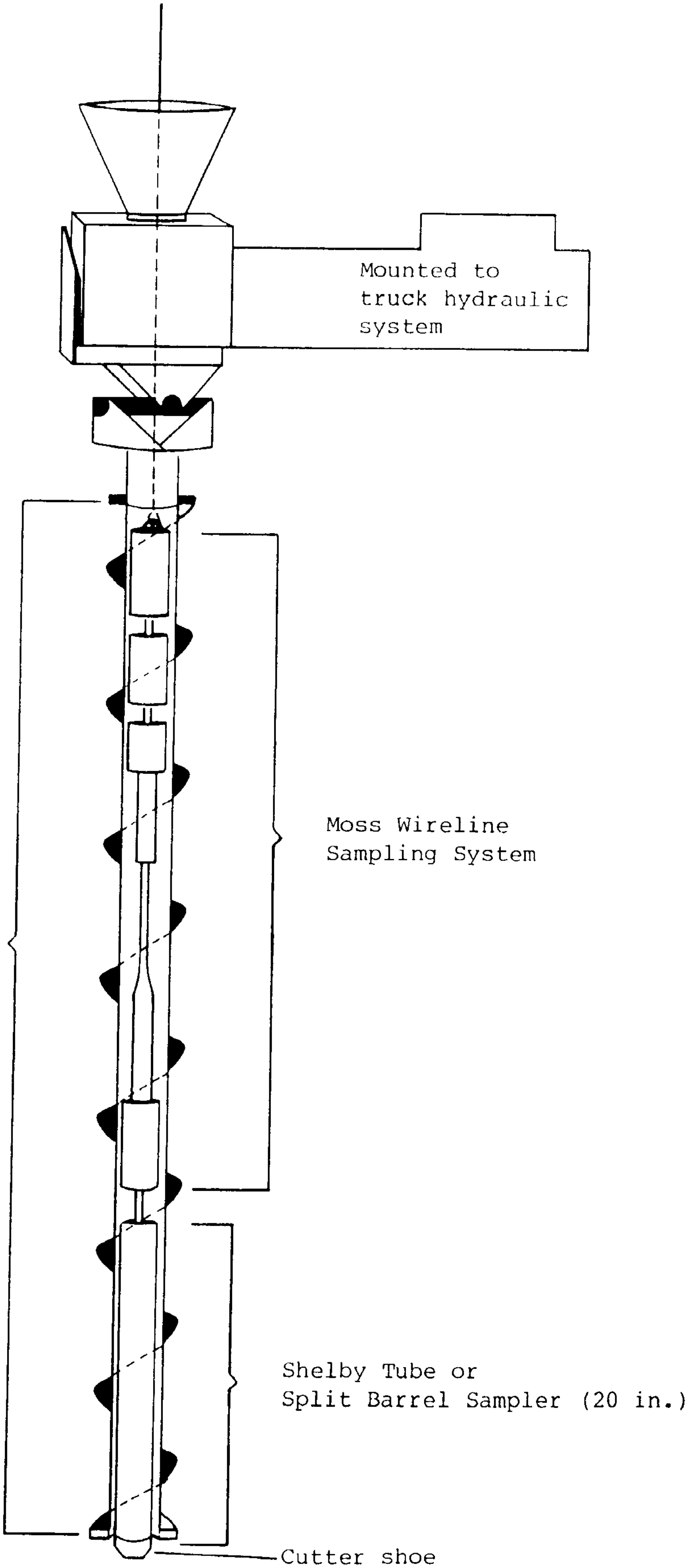

Figure 1. Mobile Drill/Moss Wireline Sampling Schematic

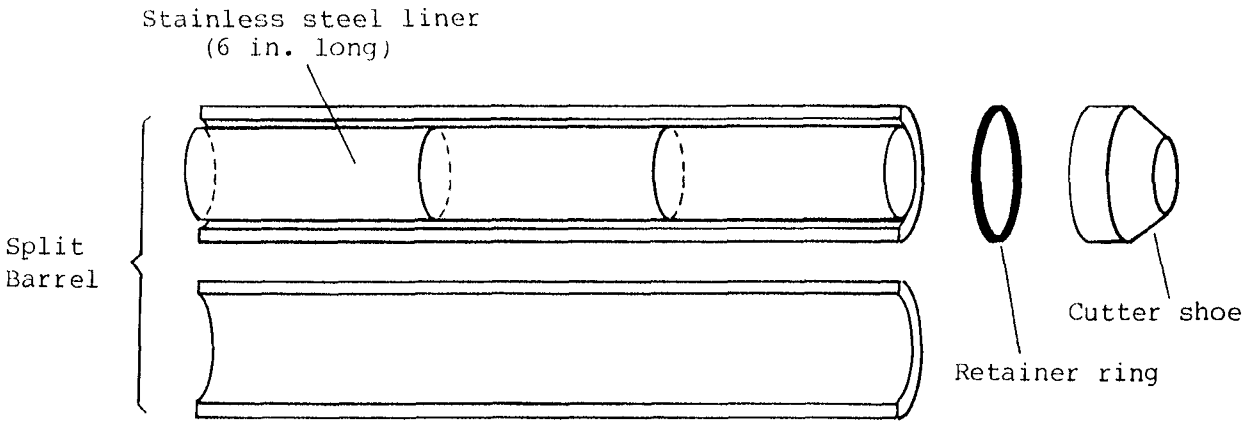

Figure 2. Split Barrel Sampler (soil)

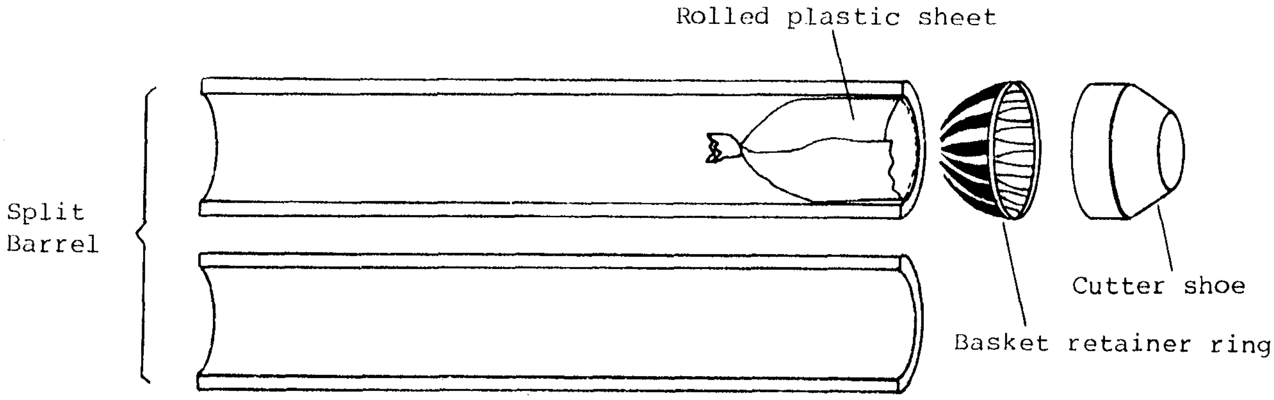

Figure 3. Split Barrel Sampler (water)

rolled into a cylinder and inserted into the bottom of the Split Barrel sampler by using a basket retainer ring to secure the plastic cylinder between the cutter shoe and the length of the first stainless steel liner (Figure 3). The sampler was lowered to the bottom of the hole and into the water. As the sampler was retrieved, the weight of the water and soil mixture collapsed the full plastic sheet against the basket retainer ring. The sample was then brought to the surface and emptied into a 1 qt. wide mouth canning jar and treated in a manner similar to the soil samples.

Two people were required to operate the drill and handle the sampler tooling. Once the sampler was brought out of the ground and disconnected from the Moss Sampling apparatus, it was handed over to three people who processed the samples and cleaned the sampler tooling. Sample processing was different for each of the two types of samplers used. The Shelby Tubes and Split Barrel samplers were cleaned between uses on site and recycled into the drilling operation. They were washed in a detergent mix, rinsed in water and rinsed again with ethyl acetate. This division of duties was useful in preventing cross-contamination of samples.

Soil was removed from the Shelby Tube samplers by a hydraulic extruder mounted on the chassis of the drilling rig. Samples were extruded in 6 inch increments. A subsample, 1/4-1/3 inch in depth, was cut from the length of each of the 6 inch samples and placed in a plastic bag. Shelby tubes allowed a consolidated subsample to be taken that represented the complete 6 inch segment in the soil profile. A disadvantage of using the Shelby Tube was that it exposed the soil sample to air during extrusion for a short period of time (5 to 10 minutes), allowing a fraction of the more volatile pesticides (DBCP and EDB) to escape from the sample. This could result in lower levels of pesticide detected in samples than were actually present in situ.

Each bag containing a subsample for soil analysis was sealed immediately after soil was placed in it. After drilling was completed at each site, the bags were transported to Fresno and kept in a refrigerator at 0 C until analyzed. These samples were later analyzed to determine the percentages of organic matter, moisture, sand, silt and clay present at the depth each sample represented. The remaining soil, the majority of the 6 inch sample, was placed in a 1 qt. wide mouth glass canning jar. Each jar was covered with a 4x4 inch square of aluminum foil, and sealed with a screw-type cap. The jars were placed in insulated containers, frozen with dry ice, and shipped to Sacramento for subsequent chemical analysis by the Chemistry Laboratory Services Unit of the California Department of Food and Agriculture.

Soil samples collected using the Split Barrel sampler were kept in their original 6 inch stainless steel liners. The liners were removed from the sampler and an attempt was made to scrape out a longitudinal section of soil representative of the entire 6 inch segment as a subsample for organic matter, moisture, and texture analyses. Using this technique, less of the sample surface area was exposed for pesticide volatilization. Each subsample was placed in a plastic bag and treated the same way as subsamples taken from the Shelby tube. Each stainless steel liner, with the remainder of the soil from the segment contained within it, was placed in a 1 qt. wide mouth glass canning jar which was handled in the same manner as the jars containing the samples taken from the Shelby Tube sampler.

The Split Barrel processing method was preferable to the Shelby Tube extrusion method because it allowed less exposure of the sample to air. This decreased the possible loss of the more volatile pesticides (DBCP and EDB). Consequently, the results from the chemical analyses of these pesticides may have been more accurate when the Split Barrel sampler was used.

C. CHAIN OF CUSTODY

Each soil sample was accompanied by a chain of custody filled out in the field at the time of sample collection. Included on the chain of custody were the date and time of sampling, site location, soil segment number, depth, segment length, pesticide to be analyzed, the persons who collected the sample and any comments pertinent to that particular sample (soil properties, equipment difficulties, etc.). An example of a chain of custody appears in Appendix I.

D. CHEMICAL ANALYSIS OF SOIL SAMPLES

All chemistry analyses were performed by the Chemistry Laboratory Services Unit of the Department of Food and

Agriculture at the Unit's main laboratory in Sacramento. Analytical methods are presented in Appendices II, III, IV, and V. Pesticide levels are reported in parts per billion (ppb) in both soil and water on a weight pesticide/weight sampling medium basis. Care must be exercised not to attempt comparisons between media because the densities of water and soil differ.

Chemical analyses were performed on subsamples taken from soil segments submitted to the laboratory. 50 grams used for DBCP and EDB, 100 grams for simazine and carbofuran analyses. The pesticide extraction efficiency from soil using the methods chosen by the Chemistry Laboratory Services Unit has been documented exceeding 80 percent. Ordinarily, quality control methods would include split sampling and analysis of a proportion of collected samples. This was done in well water samples documented in Volume I. Because of the already massive workload involved in sample processing, and associated costs, it was not feasible to analyze split samples. In each case where a pesticide was detected, the analysis of the positive subsample was confirmed using gas chromatography mass spectroscopy, or two column two detector analyses.

E. DETERMINATION OF SOIL MOISTURE, ORGANIC MATTER AND TEXTURE IN SOIL SAMPLES

The moisture content, percent organic matter, and percentages of sand, silt, clay and gravel for each 6 inch soil segment were determined by Environmental Hazards Assessment Program staff at the California Department of Food and Agriculture's Pesticide Enforcement Laboratory in Fresno. The procedures used in making these determinations are given in Appendices VI, VII and VIII.

The selection of methods for soil analyses was heavily tempered by the large number of samples to be processed (approximately 1,724) and the time constraints of the study. Emphasis was placed on minimizing sources of variation, simplicity, speed of operation, and reasonable facility requirements with some attendent sacrifice of precision and accuracy.

F. STATISTICAL METHODS

All statistical analyses were performed with the Biomedical Computer Programs (BMDP), using an IBM-4341 computer at the University of California-Riverside (4). Normal probability plots for the data sets were examined prior to analysis. All variable distributions met the requirements of sufficient normalcy for the selected analyses.

Analyses included Stepwise Multiple Linear Regression Analysis, Discriminant Analysis, Principal Component Analysis (PCA), and Linear Regression on Principal Component Factor loadings (4,5,6). Sample units included entire soil profiles as well as soil profile segments to explore both pesticide contamination characteristics between geographical areas and vertical distributions within sampling sites.

III. RESULTS

A. SITE DESCRIPTIONS

Seven drilling sites were selected using the criteria stated in MATERIALS AND METHODS. Two sites were found for DBCP, two for EDB, two for simazine and one for carbofuran.

Site	Contamination Status (Documented in Volume I)
D-0:	DBCP not detected in groundwater
D-1:	DBCP detected in groundwater
E-0:	EDB not detected in groundwater
E-1:	EDB detected in groundwater
S-0:	Simazine not detected in groundwater
S-1:	Simazine detected in groundwater
C-0:	Carbofuran not detected in groundwater

All sites were located in Fresno and Tulare counties (Figure 4). Only one site was located for carbofuran. No suitable site was found near the one well where carbofuran had been

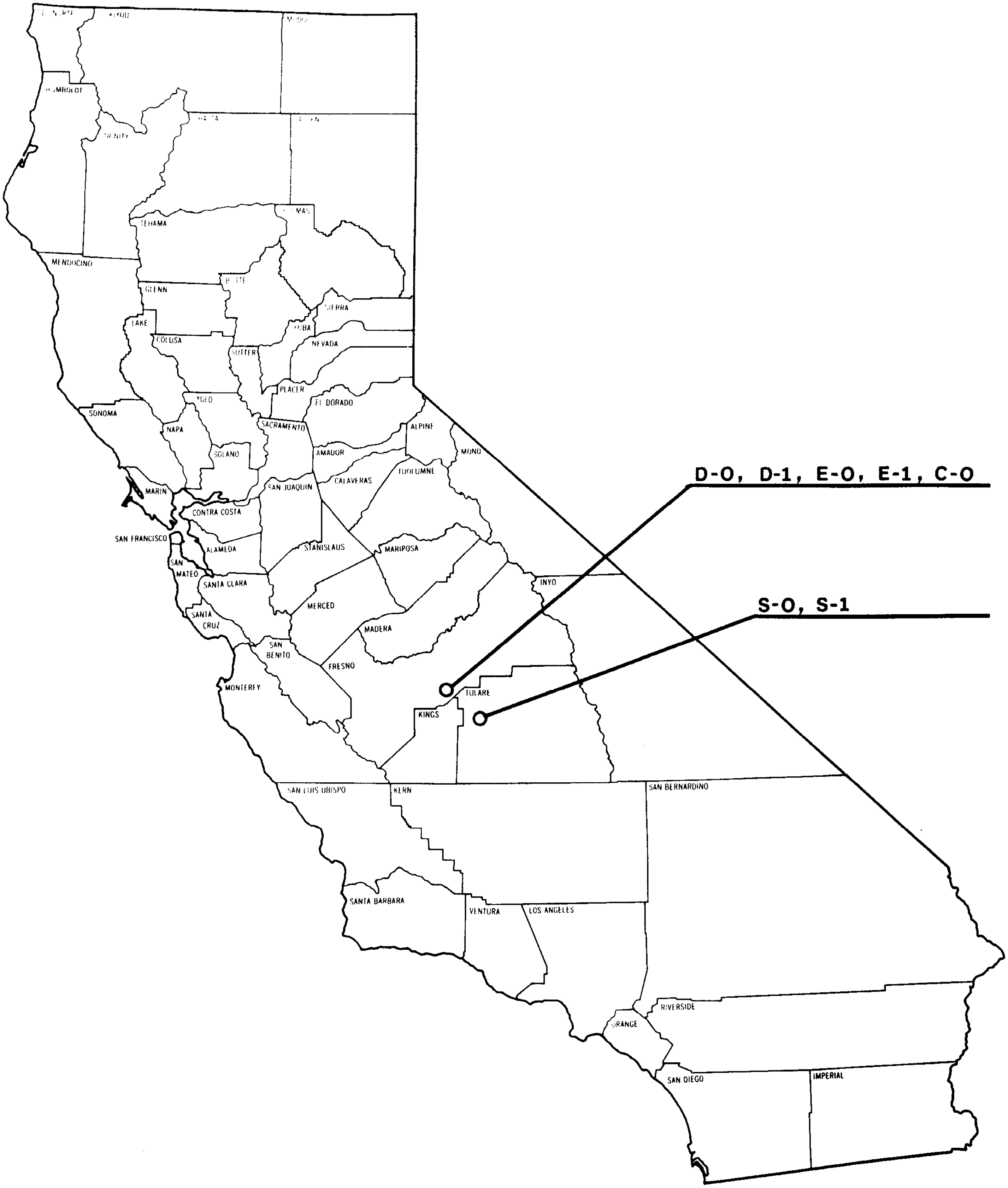

Figure 4. Geographical locations of drilling sites.

detected in Riverside county, because no application of carbofuran could be documented within a 10 mile radius of this well as required by site selection protocol (see MATERIALS AND METHODS, pg. 4). Descriptions of the sites are given in Table 1. These include crop type, irrigation method, location, and rate, method and frequency of pesticide application.

The amount of pesticide that could be found in the entire soil profile at each site was calculated from the concentrations of the pesticide detected in the soil samples and compared to the amount of pesticide theoretically applied to the specific area encompassed by the drilling operation. Figures 5-11 show the theoretical cumulative amounts of the particular pesticide applied to the surface of the soil (4.9 square inches, calculated from the diameter of the soil core) over time at each drilling site (see Appendix IX and X for calculation methods). It must be emphasized that these are theoretical calculations, based on several limiting assumptions, that were developed to give a rough comparison of the proportion of pesticide applied to the amount detected in the soil cores. In all but one case, either no pesticide was detected or only a very small percentage of the applied material was accounted for. However, a remarkable proportion of total simazine applied (8.2%, or 90.5% of one application) could be accounted for

Table 1. Characterization of drilling site locations.

Site	Pesticide	Crop	Acres	Irrigation Method	Location	Application Rate (formulation)	Frequency, year, and method of application
D-0	DBCP	vineyard	20	furrow	Parlier	5.0 gal/A	1 per 2 years, Oct - Nov, 1969 - 1977, shanked in
D-1	DBCP	vineyard	60	furrow	Fowler	3.0 gal/A	1 per year, Oct - Nov, 1968 - 1977, shanked in or dripped into irrigation water.
E-0	EDB	yams (recently harvested)	40	furrow	Selma	8.0 gal/A	1 per 2 years, Jan - Feb, 1972 - 1982, shanked in
E-1	EDB	open field (tomatoes in 1980)	1	furrow	Selma	5.0 gal/A	1 per year, March, shanked in
S-0	Simazine	orange orchard	47	furrow	Exeter	3.0 - 3.5 lb/A	1 per year, spring, 1962 - 1978 and 1980, sprayed on orchard floor w/ ground rig
S-1	Simazine	olive orchard	20	furrow drip(1979)	Woodlake	1.5 lb/A	1 per year, Sept - Nov, 1972 - 1982, sprayed on orchard floor with ground rig
C-0	Carbofuran	alfalfa	40	flood	Selma	1 pint/A	1 per year, March, 1981, aerial spray

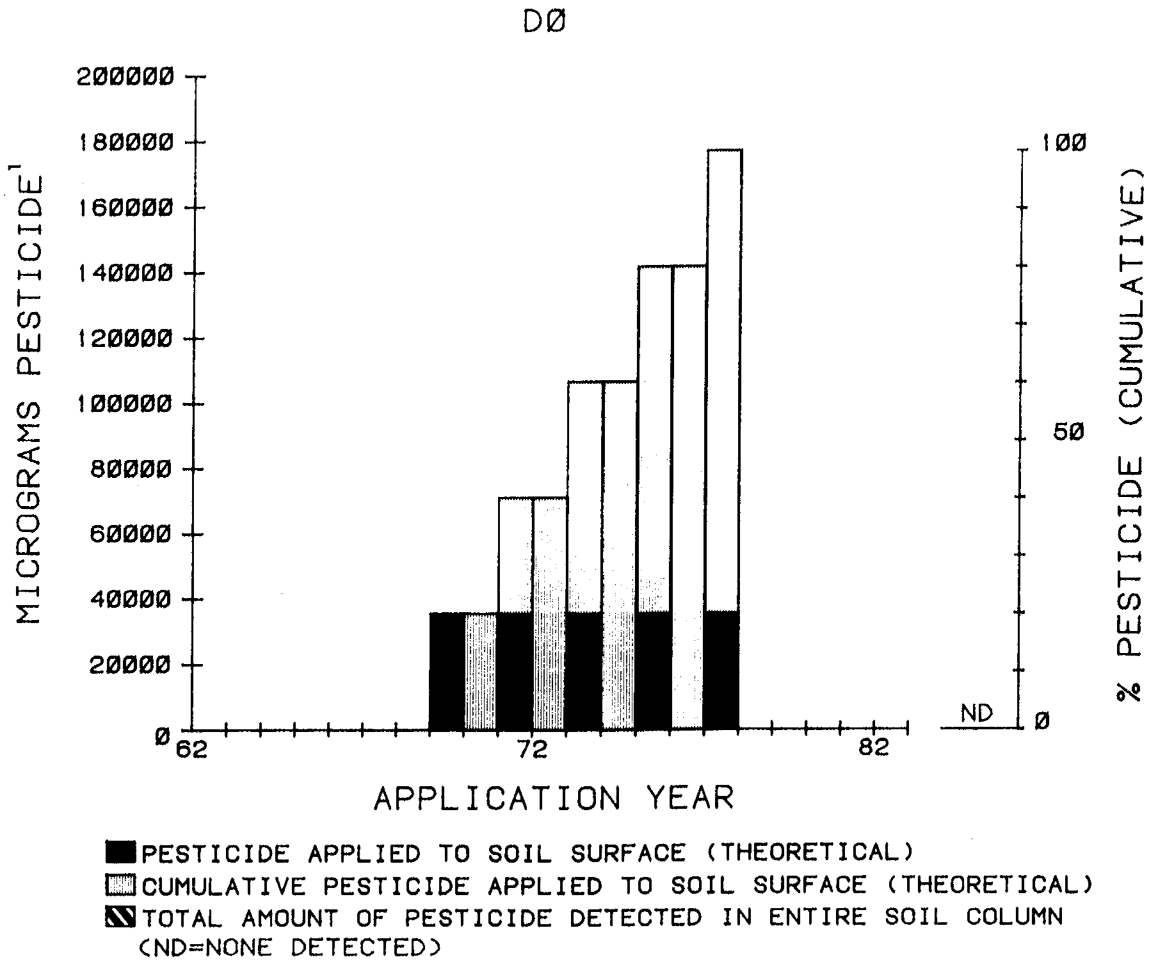

Figure 5. Summary of DBCP applied and detected at site D-0.

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[1] Concentration calculated for soil column with 4.9 sq. in. cross section.

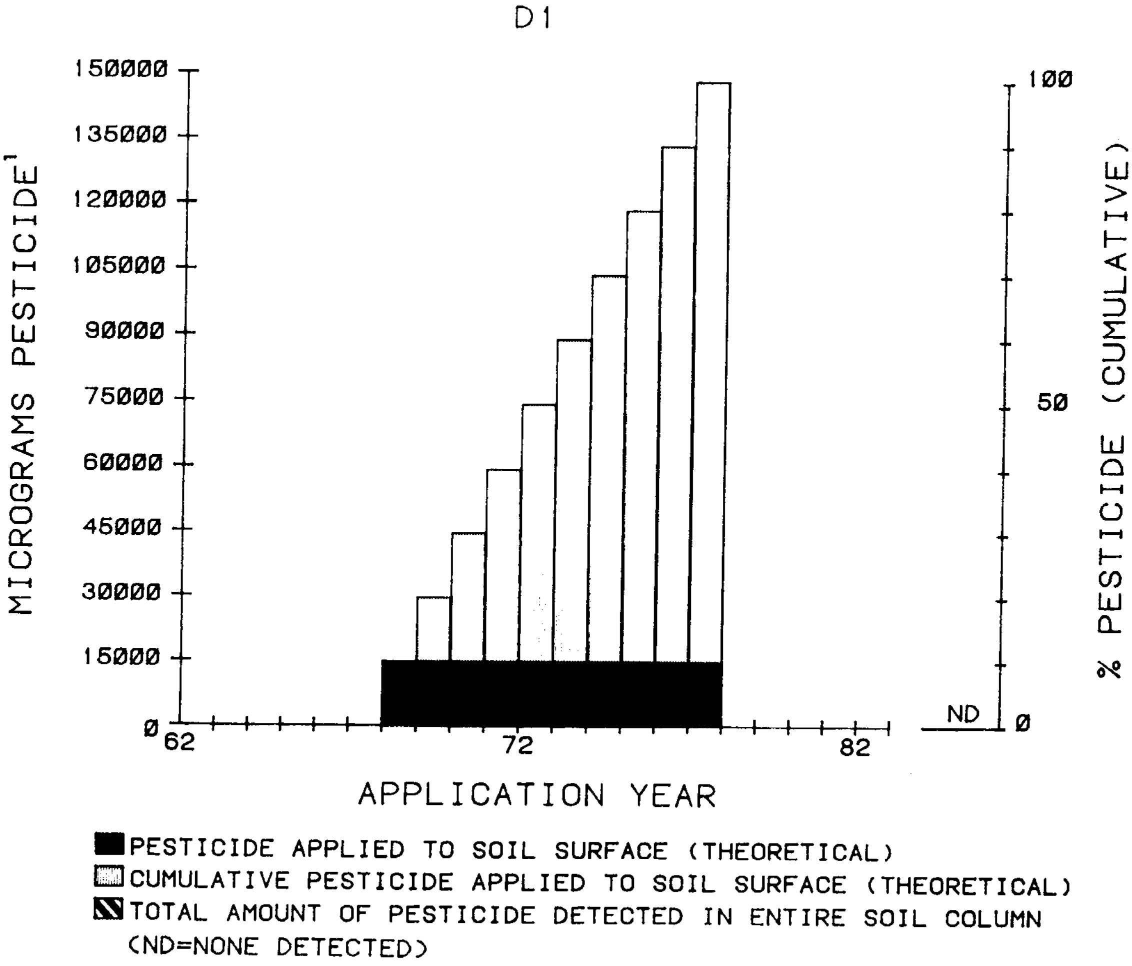

Figure 6. Summary of DBCP applied and detected at site D-1.

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[1] Concentration calculated for soil column with 4.9 sq. in. cross section.

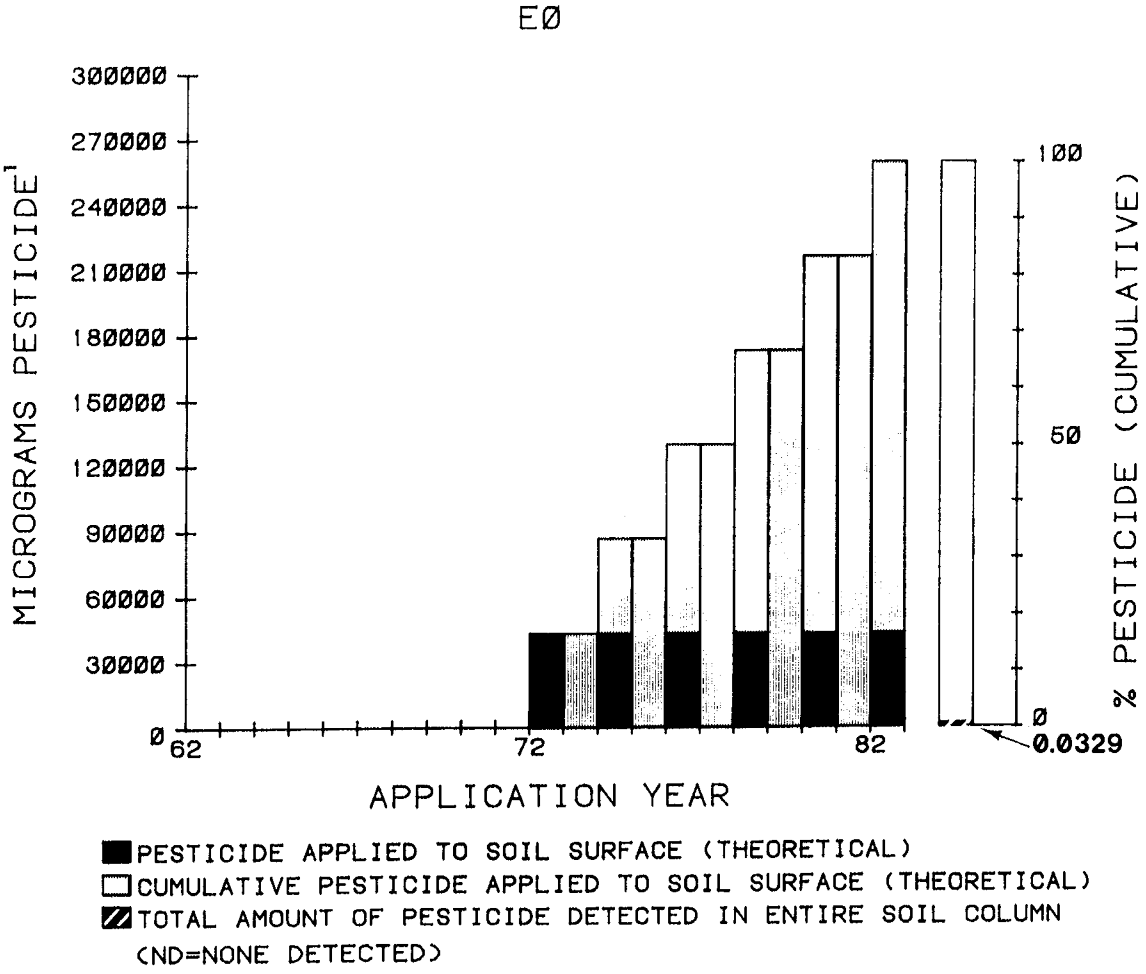

Figure 7. Summary of EDB applied and detected at site E-O.

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[1] Concentration calculated for soil column with 4.9 sq. in. cross section.

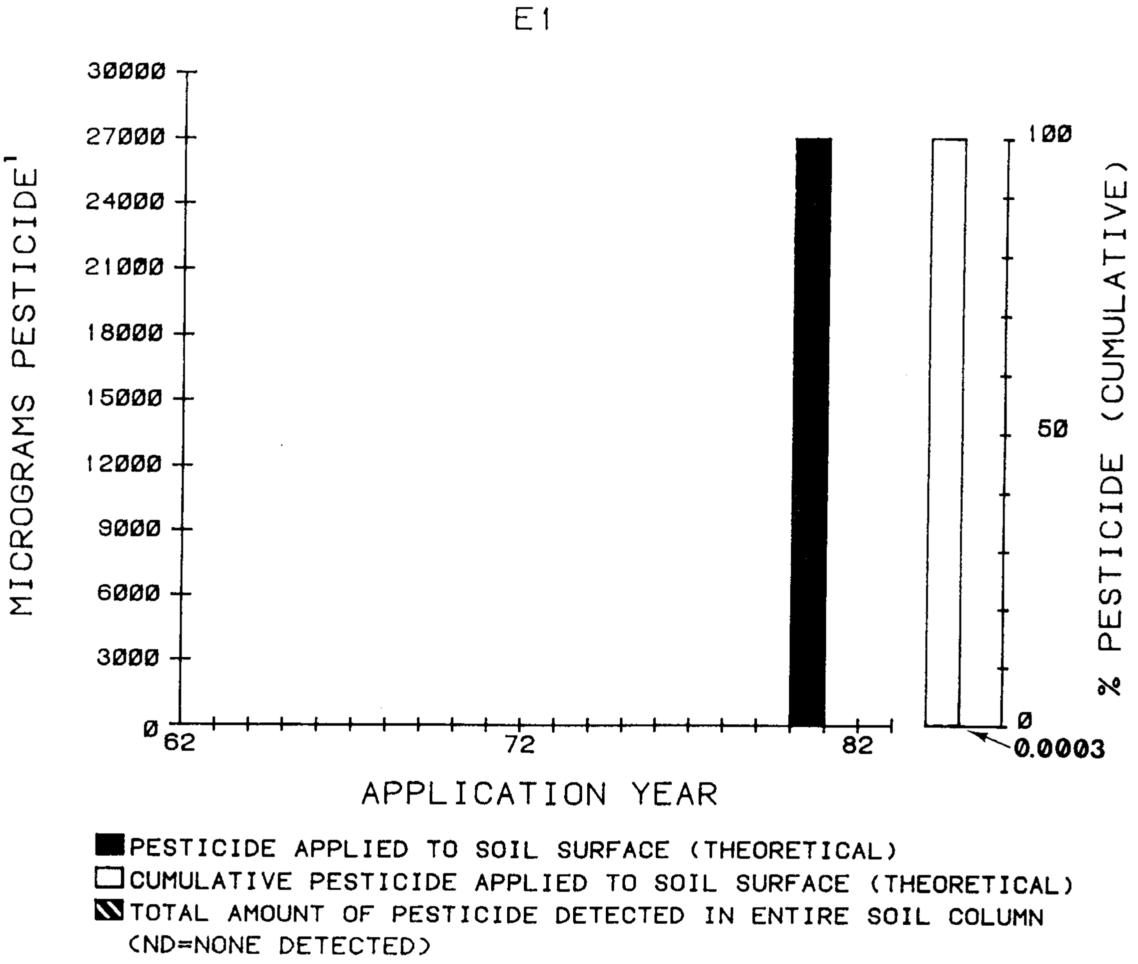

Figure 8. Summary of EDB applied and detected at site E-1.

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[1] Concentration calculated for soil column with 4.9 sq. in. cross section.

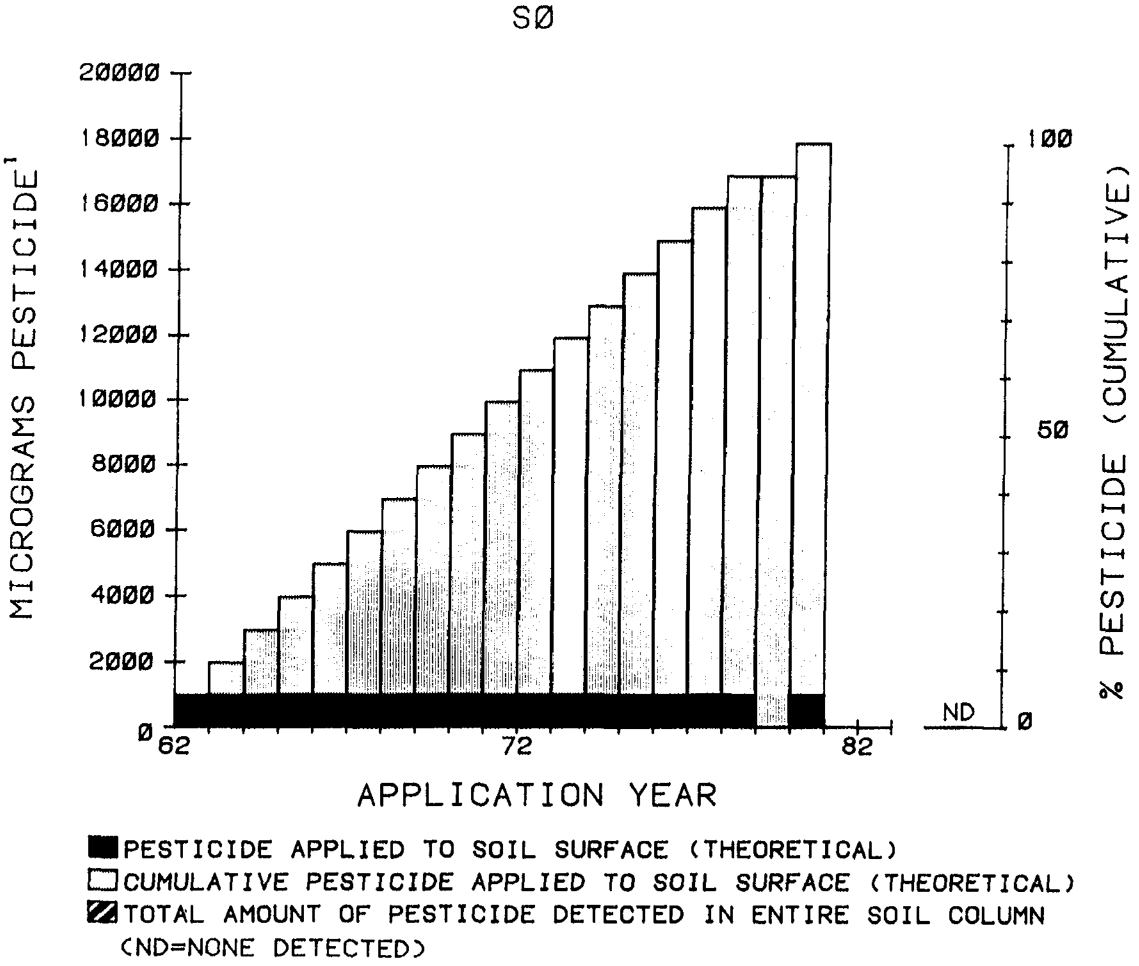

Figure 9. Summary of simazine applied and detected at site S-0.

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[1] Concentration calculated for soil column with 4.9 sq. in. cross section.

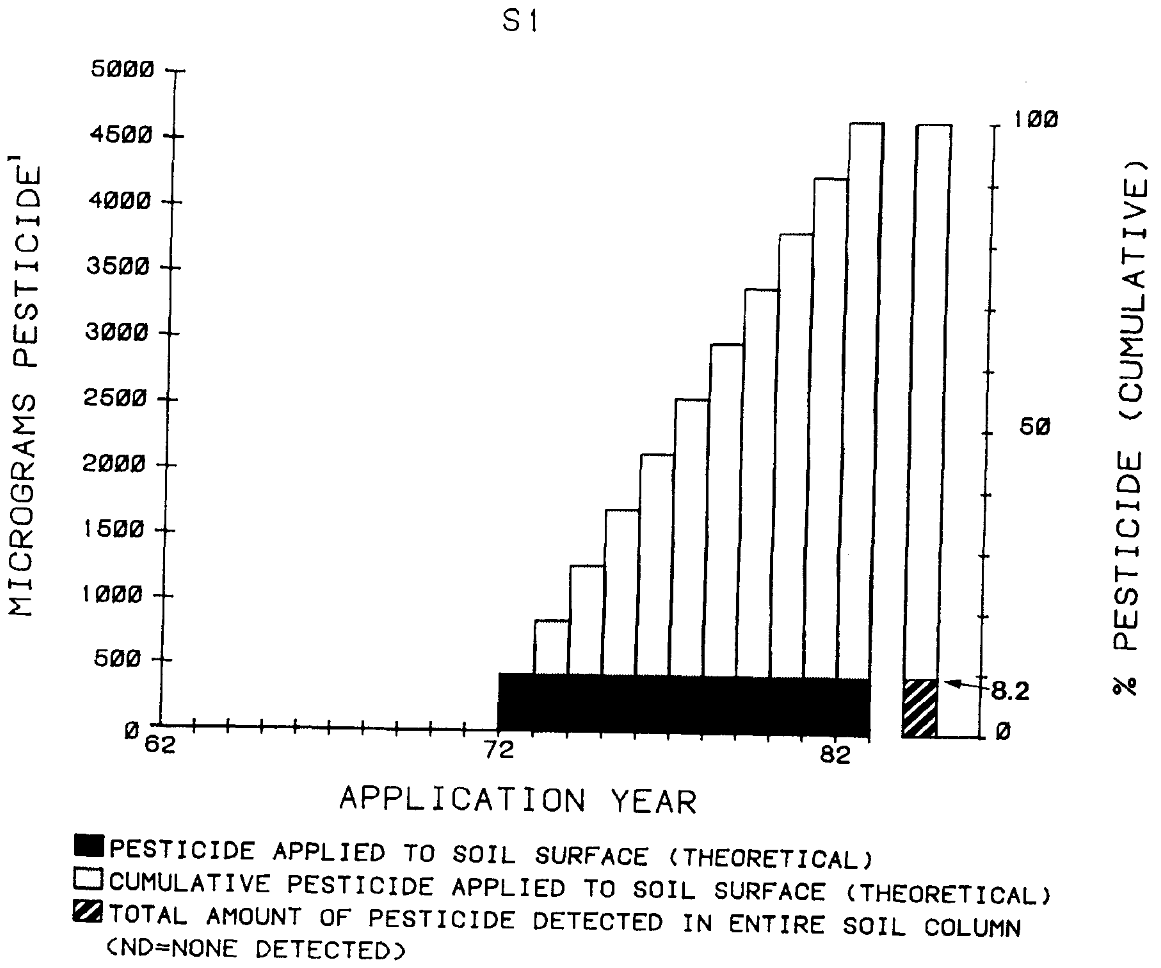

Figure 10. Summary of simazine applied and detected at site S-1.

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[1] Concentration calculated for soil column with 4.9 sq. in. cross section.

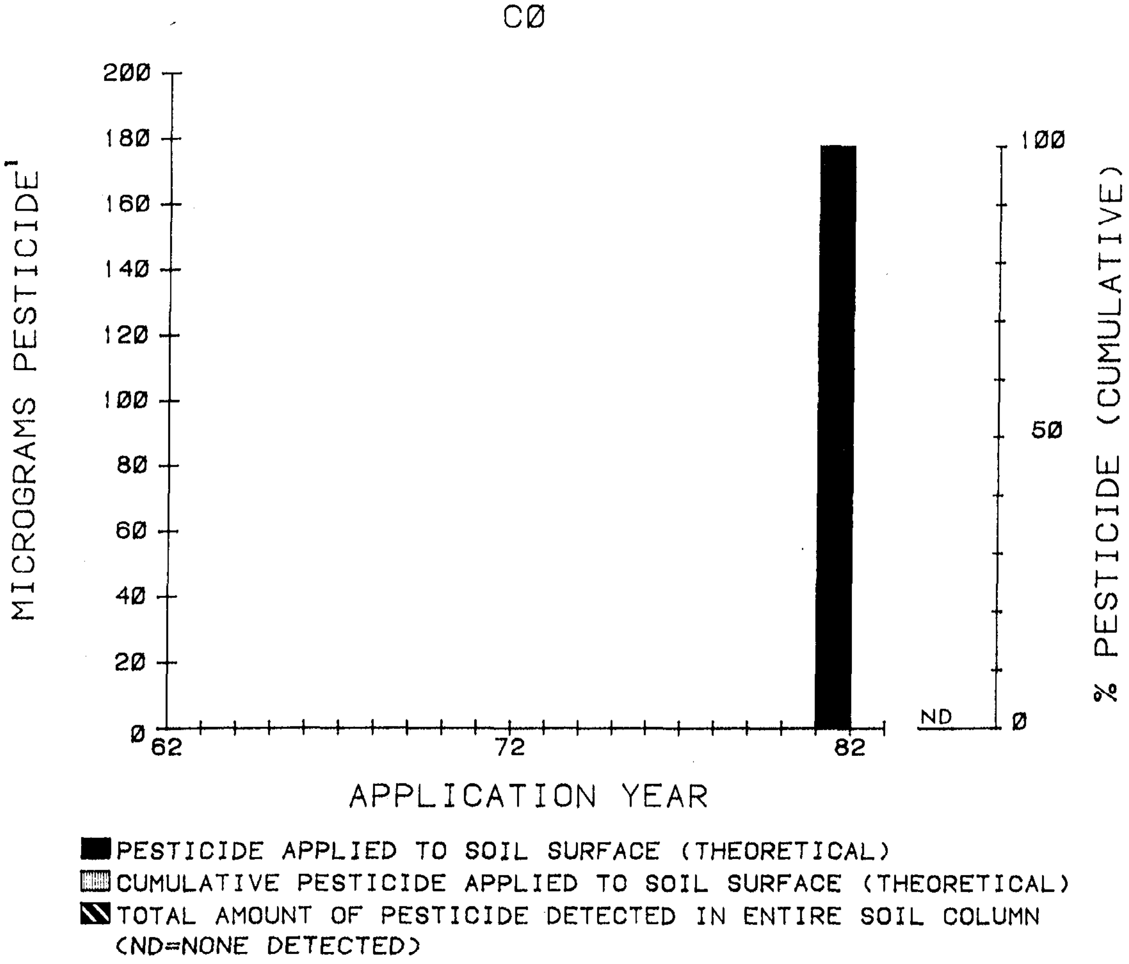

Figure 11. Summary of carbofuran applied and detected at site C-O.

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[1] Concentration calculated for soil column with 4.9 sq. in. cross section.

by the pesticide detected in the soil core at site S-1 (Figure 10). It would be dangerously misleading to speculate on the significance of this excercise. The calculations do not account for pesticide degradation or dispersion, bulk densities of soil components, or actual application rates. Figure 9 could be misleading since the minimum detectable level was 25 ppb, due to analytical instrumentation problems. This circumstance is unfortunate in view of the information revealed in Figure 10.

In Volume I, information about each of the seven wells sampled in this study was listed on a well log; a data sheet filled out by the well driller. The characteristics of each well that was associated with a drilling site were obtained from these logs and are shown in Table 2. The following discussion compares results from the soil coring sites to the wells sampled in Volume I.

It is possible that well samples were drawn from different water bearing deposits than those represented by the soil cores, considering the distance between sites, well depths, and core depths. Five of the seven wells had been sealed to

Table 2. Depth drilled to groundwater and depth characteristics of the well associated with each drilling site.

		Well characteristics (ft.)[a]				
Site	Depth drilled to groundwater (ft.)	Well depth	Perforation depth	Gravel pack depth	Depth of seal	Distance from drilling site to well (miles)
D-0	33.0	80	69 - 79	20 - 80	0 - 20	0.1
D-1	24.5	84	60 - 84	20 - 85	0 - 20	0.2
E-0	51.7	120	none	b/	c/	3.5
E-1	26.7	117	99 - 117	20 - 120	0 - 20	1.5
S-0	60.5	80	none	none	d/	3.0
S-1	28.3	80	32 - 76	none	0 - 3	0.2
C-0	64.2	120	none	b/	c/	5.5

a/ Information about well characteristics obtained from well logs used in Volume I.

b/ Information not available.

c/ Not sealed.

d/ Sealed, but depth of seal not known.

prevent contamination from surface water. Each well was deeper than its corresponding drilling operation. Wells associated with sites D-0, D-1, E-1 and S-1 had perforations in their casings where water could enter the well. The perforations in the casing of each of the wells associated with drilling sites D-0, D-1, and E-1 were deeper (57 to 72 feet deeper) than the deepest sample taken at these corresponding drilling sites. These wells also had gravel packed around the casing from the bottom of the annular seal to the bottom of the well. Groundwater probably entered the well through perforations that were deeper than the last sample taken from the associated drilling operations. However, this groundwater may have included water that had moved down through the gravel from overlying soil layers (7). Therefore, contaminated water may have originated higher up in the soil profile than the depth of the perforations. In the well corresponding to site S-1, the casing was also perforated, but at a depth only a few feet lower than the last sample taken in the drilling operation. This well was not gravel packed, therefore, water entering the well may have come from approximately the same soil layers as the last sample taken in the drilling operation at S-1. The well in the same cell as site S-0 did not have perforations in its casing and was not gravel packed.

The most probable entry for water into this well was from the soil layers at the bottom of its casing. Water entering the well may have come from soil layers 20 ft. deeper in the soil profile than were sampled by the associated drilling operation.

B. DRILLING OPERATIONS AND SAMPLE COLLECTION

Drilling and sampling took place during August and September 1982. One day was required to drill and sample at each site. The types of samplers used at each drilling site are shown in Table 3. As complete a soil profile as possible was removed from the surface of the soil to groundwater. Figures 12-18 depict the results of the sample analyses at each drilling site. Appendix XIV contains a listing of all sample data. Missing segments, indicated by breaks in the columns, were due primarily to the loss of soil in the drilling process when a highly expansive or hard soil layer was encountered (see MATERIALS AND METHODS). Detailed descriptions of these results follow in subsequent sections.

Table 3. Type of sampler used at each drilling site.

Site	Type of Sampler
D-0	Shelby Tube
D-1	Shelby Tube (first 24 inches only) Split Barrel
E-0	Split Barrel
E-1	Split Barrel
S-0	Split Barrel
S-1	Split Barrel
C-0	Split Barrel

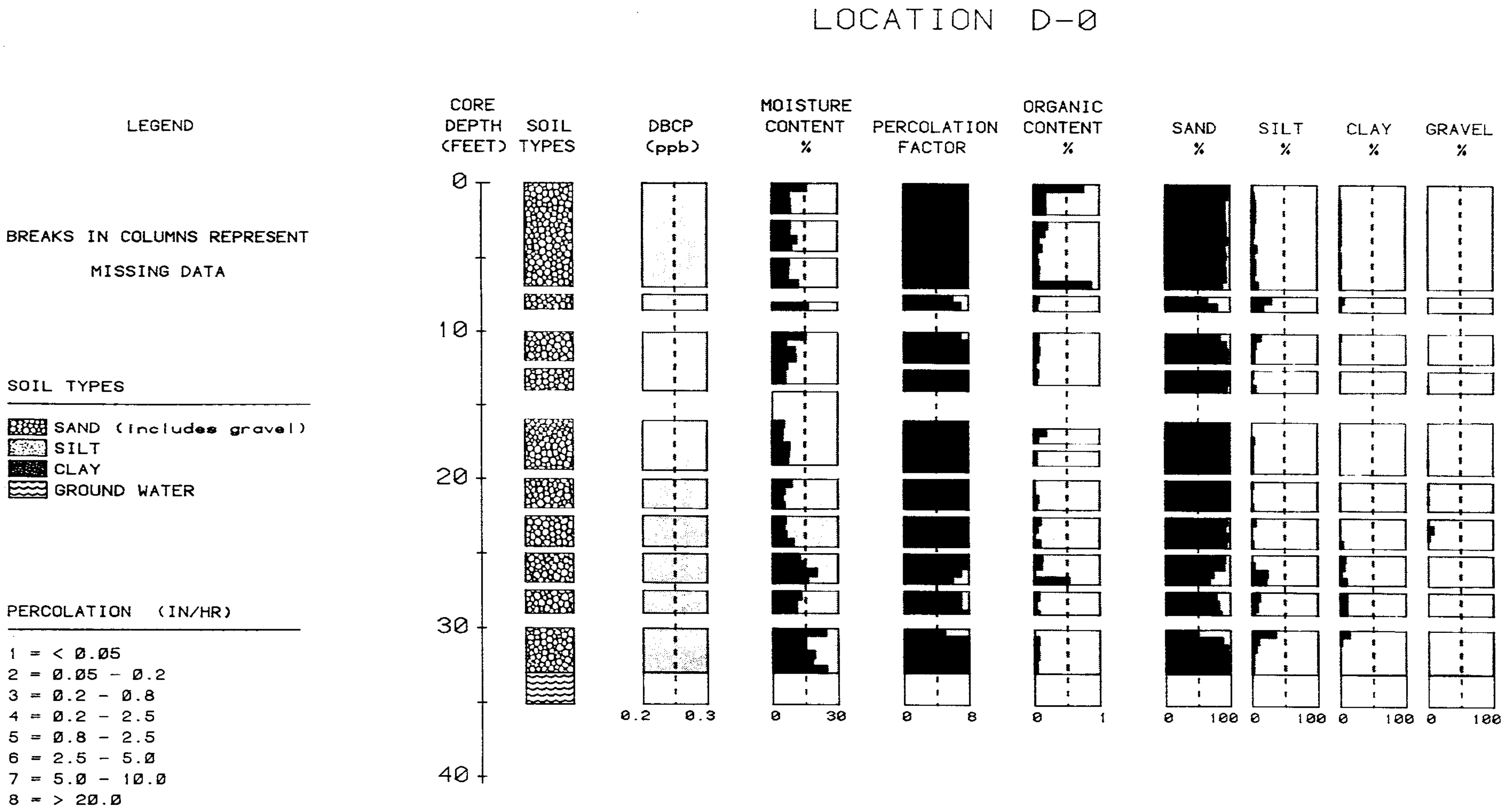
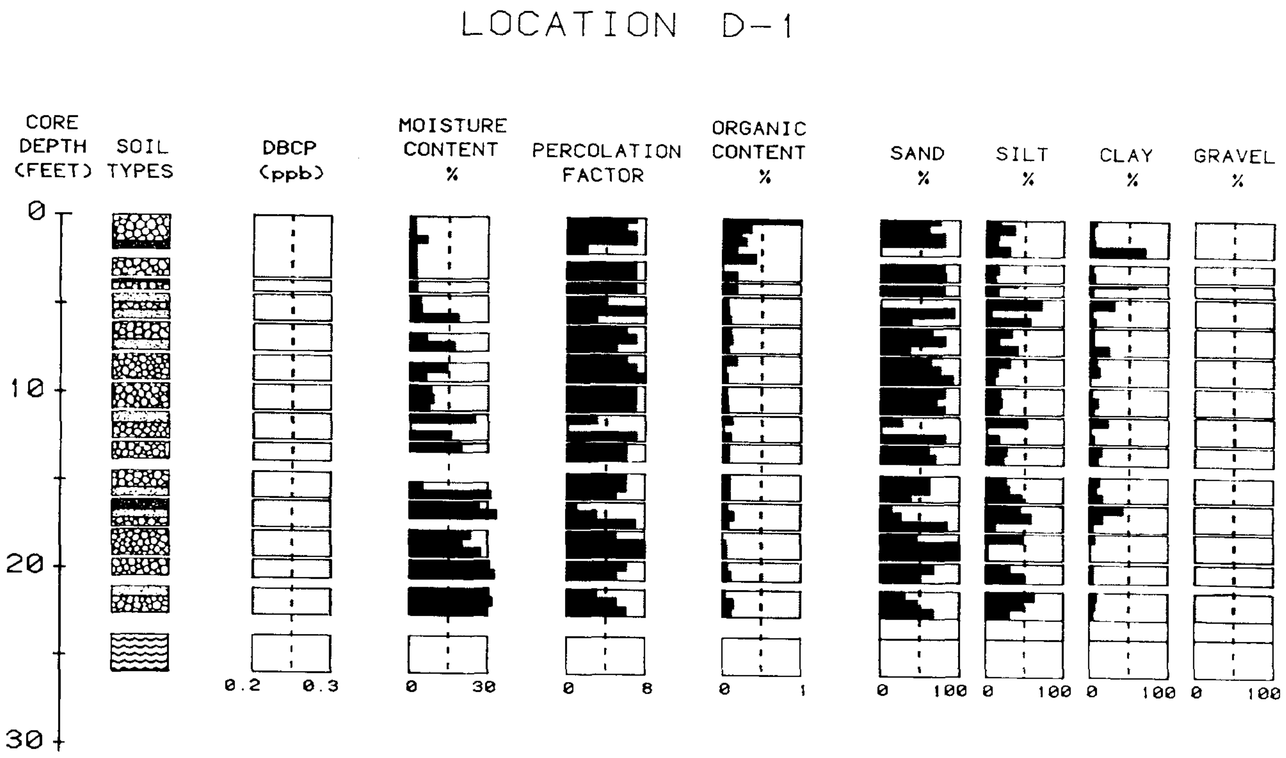


Figure 12. Results of chemical, moisture, organic matter and texture analysis at site D-O.

(See Appendix XIV for data listing.)



LEGEND

BREAKS IN COLUMNS REPRESENT
MISSING DATA

SOIL TYPES

▨ SAND (includes gravel)
░ SILT
▓ CLAY
≋ GROUND WATER

PERCOLATION (IN/HR)

1 = < 0.05
2 = 0.05 - 0.2
3 = 0.2 - 0.8
4 = 0.2 - 2.5
5 = 0.8 - 2.5
6 = 2.5 - 5.0
7 = 5.0 - 10.0
8 = > 20.0

Figure 13. Results of chemical, moisture, organic matter and texture analysis at site D-1.

(See Appendix XIV for data listing.)

LEGEND

BREAKS IN COLUMNS REPRESENT
MISSING DATA

SOIL TYPES

▨ SAND (includes gravel)
▨ SILT
▨ CLAY
▨ GROUND WATER

PERCOLATION (IN/HR)

1 = < 0.05
2 = 0.05 - 0.2
3 = 0.2 - 0.8
4 = 0.2 - 2.5
5 = 0.8 - 2.5
6 = 2.5 - 5.0
7 = 5.0 - 10.0
8 = > 20.0

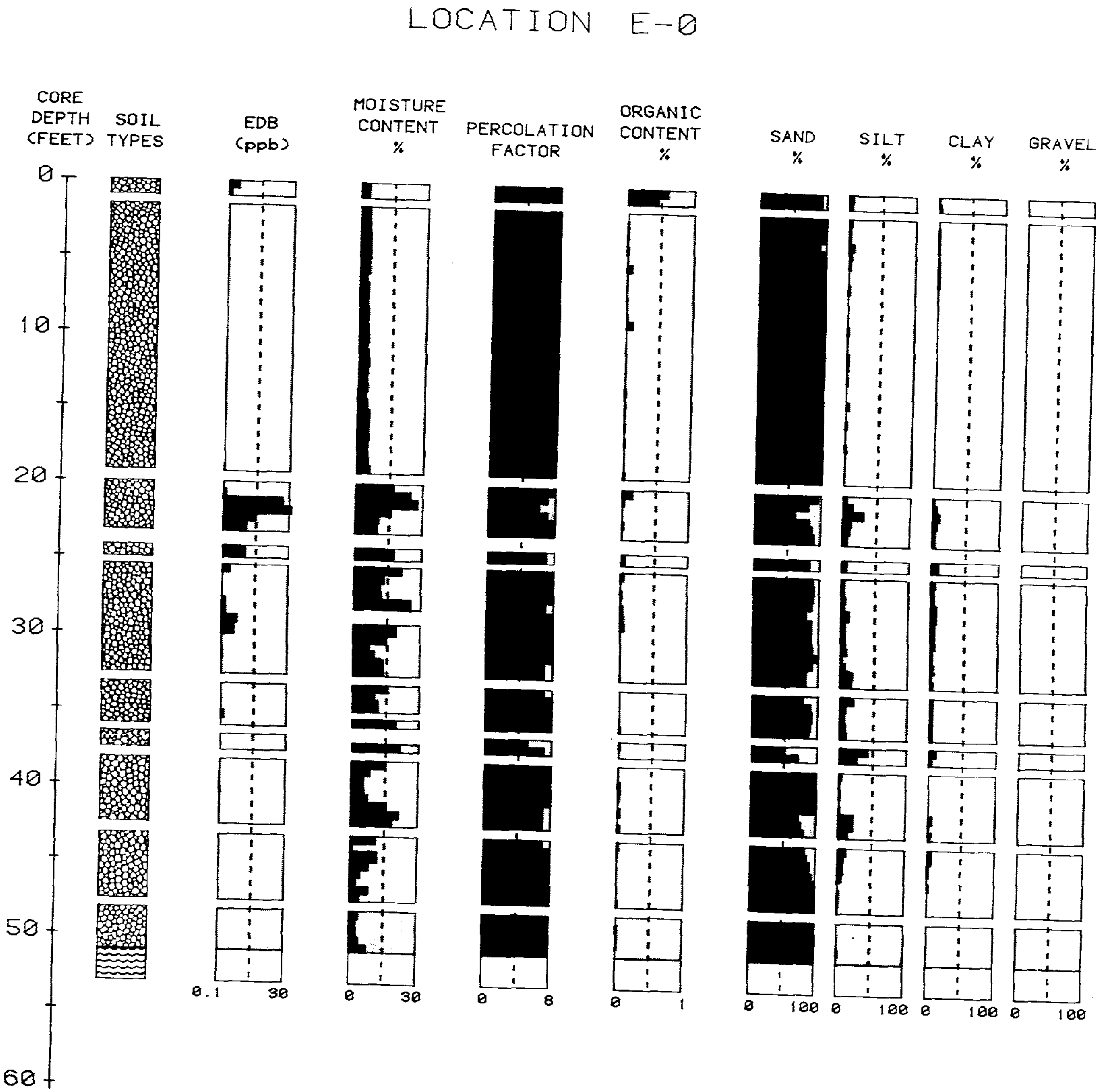


Figure 14.
Results of chemical, moisture, organic matter and texture analysis at site E-0.

(See Appendix XIV for data listing.)

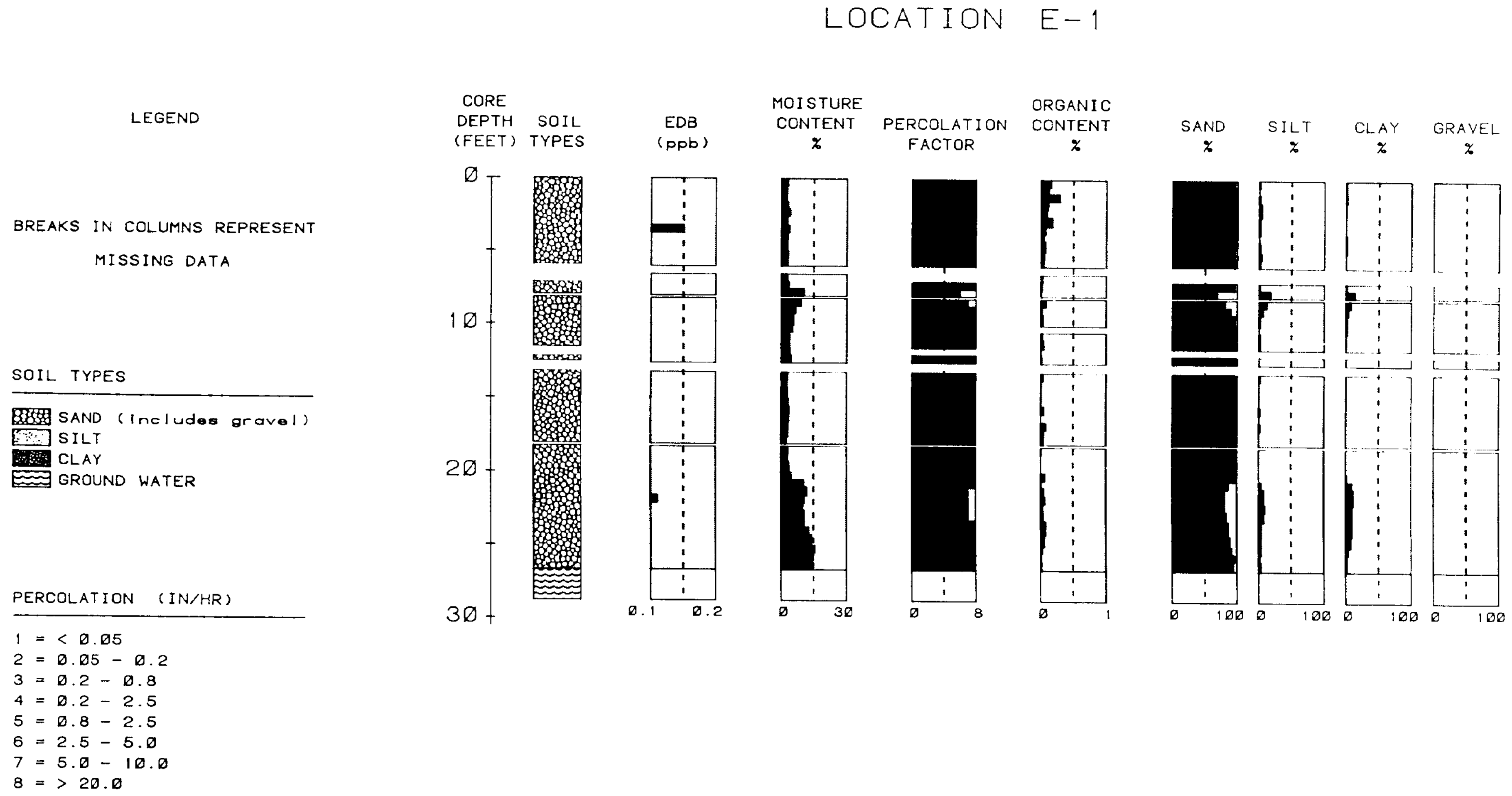


Figure 15. Results of chemical, moisture, organic matter and texture analysis at site E-1.

(See Appendix XIV for data listing.)

LEGEND

BREAKS IN COLUMNS REPRESENT
MISSING DATA

SOIL TYPES

- ▨ SAND (includes gravel)
- ░ SILT
- ▓ CLAY
- ≋ GROUND WATER

PERCOLATION (IN/HR)

1 = < 0.05
2 = 0.05 - 0.2
3 = 0.2 - 0.8
4 = 0.2 - 2.5
5 = 0.8 - 2.5
6 = 2.5 - 5.0
7 = 5.0 - 10.0
8 = > 20.0

* 3 ppb in water

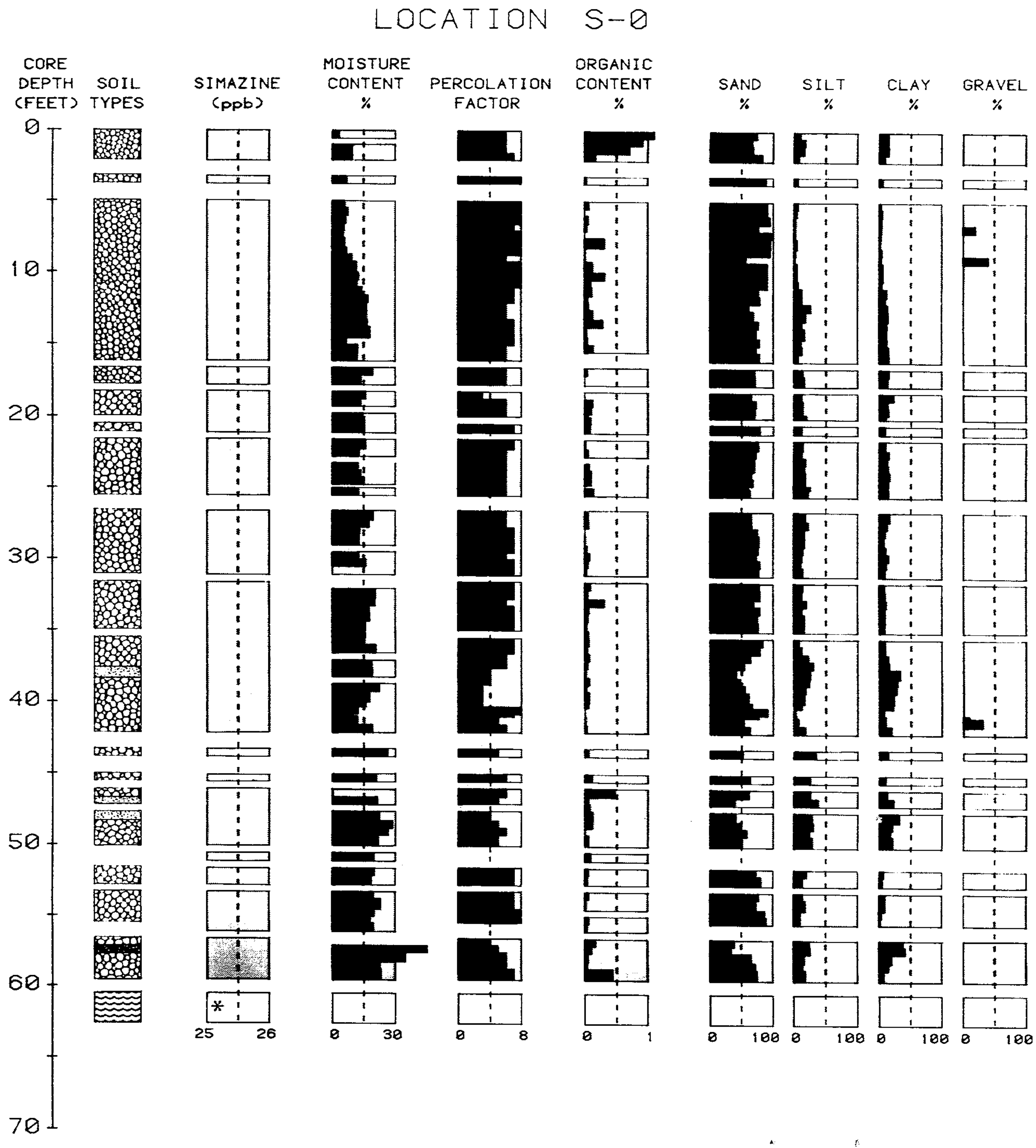


Figure 16.
Results of chemical, moisture, organic matter and texture analysis at site S-O.

(See Appendix XIV
for data listing.)

LEGEND

BREAKS IN COLUMNS REPRESENT MISSING DATA

SOIL TYPES

- ▨ SAND (includes gravel)
- ░ SILT
- ▓ CLAY
- ≋ GROUND WATER

PERCOLATION (IN/HR)

1 = < 0.05
2 = 0.05 - 0.2
3 = 0.2 - 0.8
4 = 0.2 - 2.5
5 = 0.8 - 2.5
6 = 2.5 - 5.0
7 = 5.0 - 10.0
8 = > 20.0

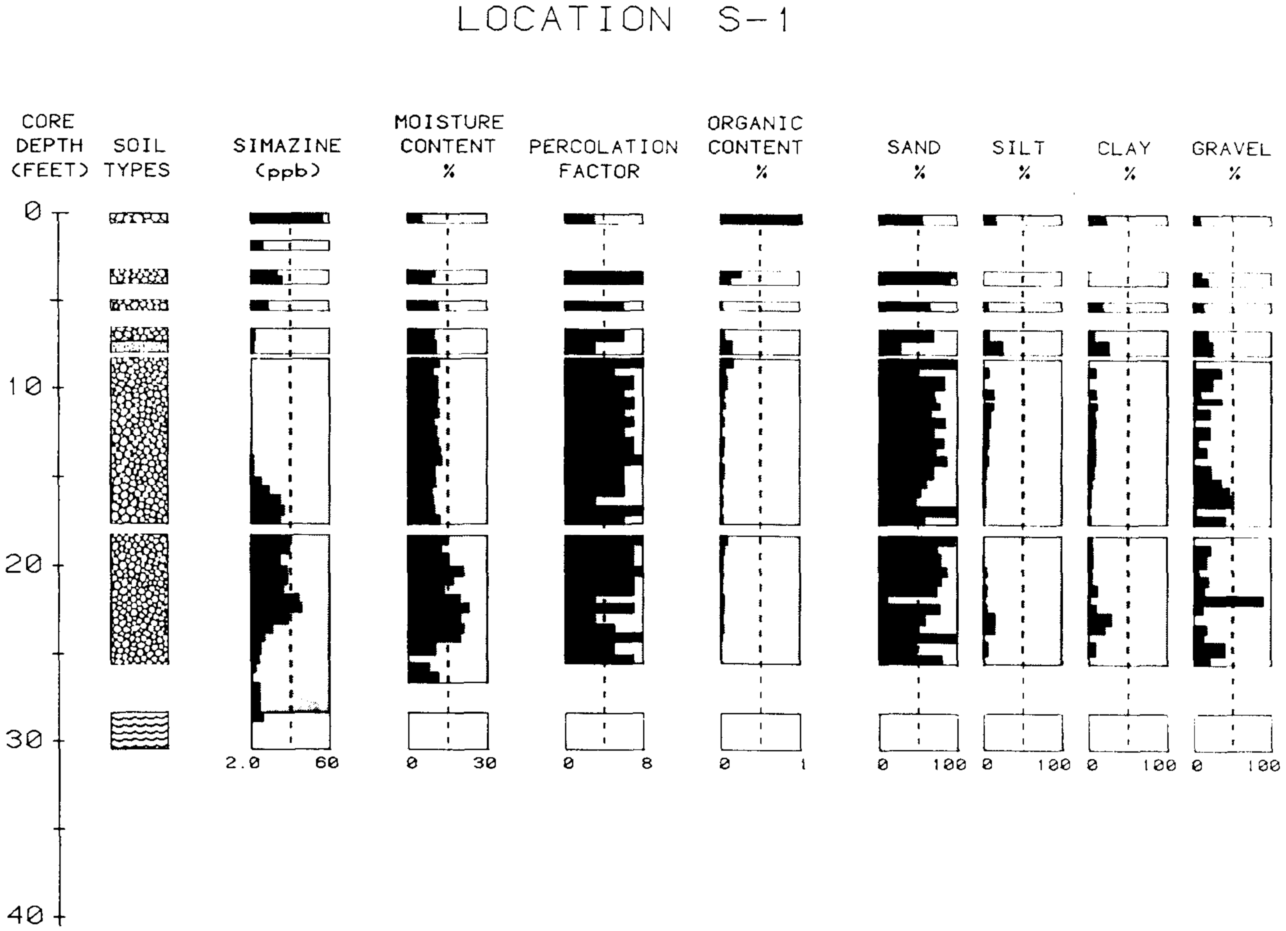


Figure 17. Results of chemical, moisture, organic matter and texture analysis at site S-1.

(See Appendix XIV for data listing.)

LEGEND

BREAKS IN COLUMNS REPRESENT
MISSING DATA

SOIL TYPES

▩ SAND (includes gravel)
▒ SILT
▓ CLAY
〰 GROUND WATER

PERCOLATION (IN/HR)

1 = < 0.05
2 = 0.05 - 0.2
3 = 0.2 - 0.8
4 = 0.2 - 2.5
5 = 0.8 - 2.5
6 = 2.5 - 5.0
7 = 5.0 - 10.0
8 = > 20.0

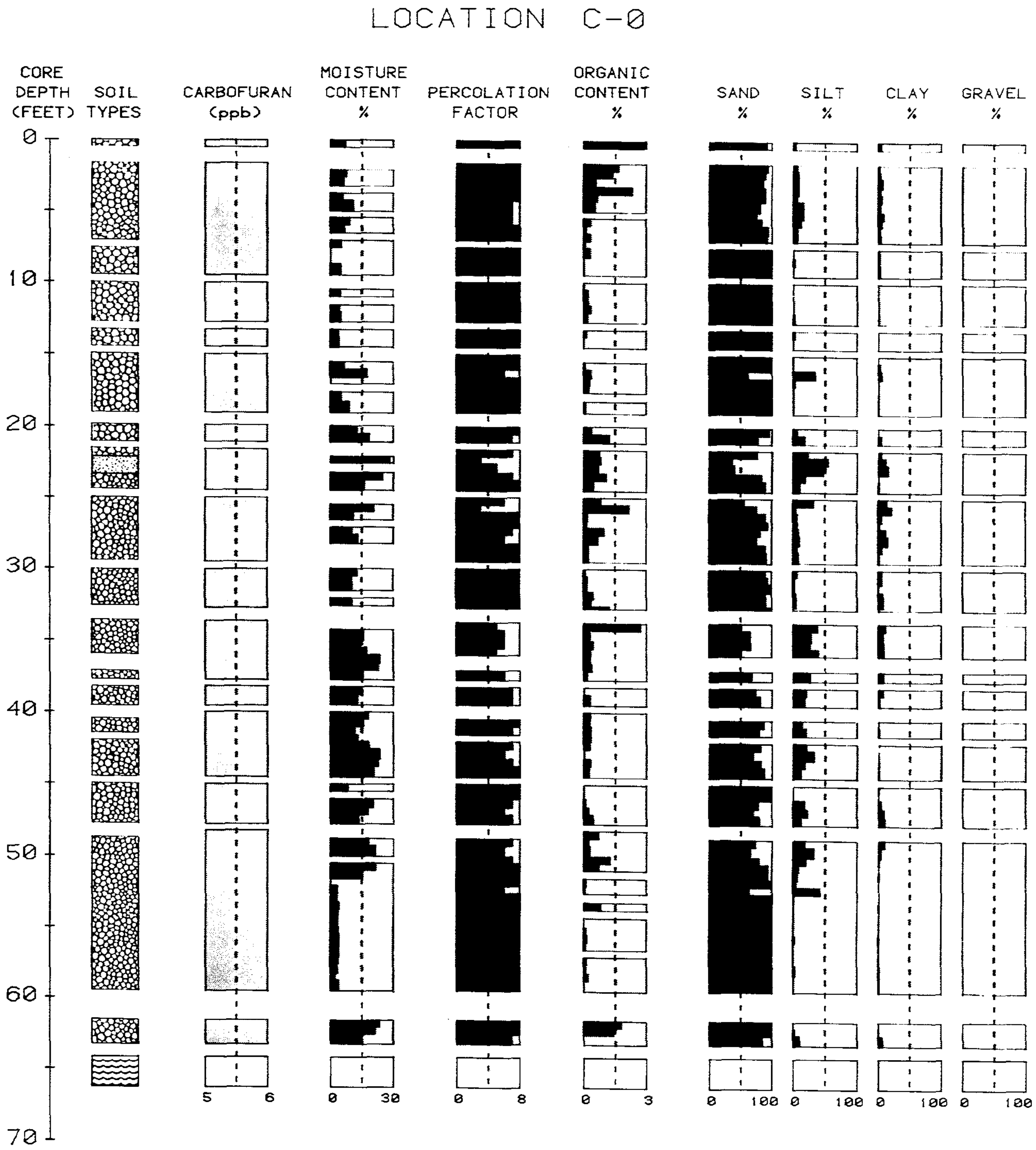


Figure 18.
Results of chemical, moisture, organic matter and texture analysis at site C-O.

(See Appendix XIV for data listing.)

C. CHEMICAL ANALYSES OF SOIL SAMPLES

Each 6 inch segment removed from the soil profile was analyzed for the pesticide applied at the particular site. Segments in the soil profile that were not sampled due to difficulties encountered in the drilling process are represented as blanks in the pesticide column in Figures 12-18. Pesticide residues were detected at four of the seven drilling sites (Table 4). EDB was found in soil samples at each of the two EDB drilling sites, E-0 and E-1. At site S-1, simazine was detected in soil samples and in a sample of water collected at the bottom of the soil profile. At site S-0, simazine was detected only in the water sample that was taken at the bottom of the soil profile.

Table 4. Pesticide concentration in samples taken from 6 inch soil segments and in groundwater.

		Soil Cores				Water
Site	Pesticide	Minimum detectable level (ppb)	Total number of samples	Number of contaminated samples	Range of contamination (ppb)	Pesticide contamination (ppb)[a]
D-0	DBCP	0.2	55	0	------------	0.0
D-1	DBCP	0.2	56	0	------------	0.6
E-0	EDB	0.1	83	17	0.10 - 31.0	0.0
E-1	EDB	0.1	46	2	0.11 - 0.15	0.1
S-0	Simazine	25.0	93	0[b]	------------	0.0
S-1	Simazine	2.0	41	29	2.00 - 55.00[c]	3.5
C-0	Carbofuran	5.0	96	0	------------	0.0

a/ Water samples collected from a well sampled near each drilling site (Volume I).

b/ Contamination in water, 3 ppb, taken from last sample of drilling operation (not in soil).

c/ Includes contamination in soil and groundwater taken from last sample of drilling operation.

Difficulties with laboratory instruments resulted in an extremely high minimum detectable level (25 ppb) for samples from site S-0 and the sample was lost before analysis could be performed again. It is impossible to draw conclusions about this site due to the quality of the data.

At site E-0 (Figure 14), the levels of EDB ranged from 0.1 to 31.1 ppb in the 17 contaminated soil samples recovered (20% of the soil samples collected) from the site. The EDB occurred in two distinct bands in the soil profile at site E-0: from 0 to 1 ft. and from 20.5 to 40 ft. with the highest levels of pesticide found between 21 and 25 ft.

At location E-1 (Figure 15), EDB was detected in 2 soil samples (4% of the soil samples recovered). The higher EDB level, 0.15 ppb, was detected in the soil sample taken from 3.3 to 3.8 ft. The lower EDB level, 0.11 ppb, was detected in the sample taken from 21.6 to 22.1 ft. These results were very close in magnitude to the minimum detectable level, 0.1 ppb.

At site S-1 (Figure 17) simazine was detected in 29 soil samples (70% of the soil samples collected). This pesticide also occurred in two separate sections of the soil profile:

from 0 to 8 ft. and from 13.8 to 28.3 ft. Levels ranged from 2 to 55 ppb, the highest levels occurring in the top 6 inches of the soil and at 22 ft. The simazine concentration in the water at the bottom of the soil column was 9 ppb. At site S-0 (Figure 16), 3 ppb simazine was detected in the water sampled from the bottom of the soil column.

The MDL for the chemical analyses performed on segments at each site is listed in Table 4 and stated on each of Figures 12-18. The minimum detectable levels remained constant for DBCP, EDB and carbofuran analyses, but varied in chemical analyses for simazine. At site S-0, the MDL was 25.0 ppb; at site S-1 it was 2.0 ppb. These different MDL's were due to background interference of substances that were present in the soil samples and daily variability in detector performance.

D. SOIL MOISTURE, ORGANIC MATTER, AND TEXTURE IN SOIL SAMPLES

The percent moisture, organic matter, sand, silt, clay and gravel determined in the soil samples at each site are shown in Figures 12-18. Gravel was observed only in soil samples taken from sites D-0, S-0, and S-1. A textural class and percolation rate were calculated for each segment from the percentages of sand, silt and clay determined by texture analysis (see Appendix XI for calculation methods). Missing data, represented by breaks in the columns, resulted when there was not enough soil in a sample to perform a specific analysis.

E. STATISTICAL ANALYSES

The complexity involved in evaluating the role of each independent variable characterizing soil, and every subsequent combination of variables relating to the concentration of pesticide, requires multivariate statistical procedures. Studies involving three variables are difficult enough to visualize, but analyzing the 8 dimensional problems defined by our data is impossible without the use of certain statistical tools.

This study used three statistical procedures to aid in the interpretation of the data: Stepwise Multiple Linear Regression Analysis, Discriminant Analysis, and Principal

Component Analysis. Each has specific advantages which make it a desirable tool, but the interpretation of the combined results of the three procedures is most valuable. All the selected statistical procedures are linear and additive and do not adequately address the problem of variable interactions. However, it is beyond the scope of this study to determine the proper non-linear methods most suitable for the analysis of our results given available resources. The distributions of the variables were determined to be sufficiently normal for valid use of the selected methods. Results of the procedures are presented in this section, and a broader evaluation is presented in the DISCUSSION section.

1) Stepwise Multiple Regression Analyses

a) Segments within soil profiles at sites E-0 and S-1.

Pesticide concentrations and soil properties of the 6 inch segments were entered into stepwise multiple regression analyses in an attempt to produce a model which would predict pesticide distribution in the soil. Although pesticides were detected at sites E-0, E-1, and S-1, analyses were performed only for sites E-0 and S-1. There were not enough contaminated segments to do this kind of analysis for site E-1 (n=2).

Three separate analyses were performed for each of these sites. Each analysis was based on a different division of segments from the soil profile: 1) all segments, 2) segments in the top 8 feet, and 3) segments below 8 feet (Tables 5 and 6). The first 8 feet in the soil profile were chosen to represent the top layer because 8 feet was the shallowest depth that provided a sufficient number of contaminated segments to do a stepwise multiple regression analysis without dividing a cluster of contaminated segments. In addition, many of the biological and physical processes and agricultural practices that may affect the removal of pesticide from the soil in the upper layers occur for the most part within this initial 8 feet of soil.

Site E-0 (Table 5)

The three regression equations developed from the data at site E-0 are significant at the 0.001 level. This indicates

Table 5. Summary of stepwise multiple regression analyses of soil characteristics on pesticide concentrations in soil segments at site E-0.

Portion of soil profile a/	F ratio	Independent variables	R^2	R^2 change	Standardized regression coefficient
All segments	23.74 ***	% clay	0.2356		0.485
Top segments (top 8.0 feet)	34.03 ***	% organic matter	0.8217		1.049
		% clay	0.8719	0.0502	-0.266
Bottom segments (below 8.0 feet)	19.72 ***	% clay	0.2355		0.485

a/ A separate regression analysis was done on each set of segments.

Regression equations: (y= predicted pesticide concentration, ppb)

All segments y = -0.5317 + 0.9491(% clay)

Top segments y = 0.1876 + 6.6653(% organic matter) - 0.2717(% clay)

Bottom segments y = -0.5091 + 0.9648(% clay) that at this site, clay and organic matter have statistically significant effects on EDB distribution. Analysis of segments from the top 8 feet at site E-0 revealed that percent organic matter was positively correlated with EDB levels in the soil. Organic matter, the most important single variable for explaining pesticide concentration, accounted for 82.2% of the variability of contamination in this upper soil layer. Percent clay was inversely correlated with EDB concentration and only accounted for an additional 5% of the variation in EDB concentration in this part of the soil profile.

In the bottom part of the profile, clay is highly significant but explains only a small proportion of the variability in EDB concentration; organic matter is insignificant. The low R values (below 25%) for the regressions on bottom segments and all segments at site E-0 suggest that the soil properties measured in this study are not adequate to explain a large portion of the variability in EDB contamination in these segments.

In comparing the results from above and below 8 feet, it appears that there are different processes influencing EDB accumulation in the two areas of the soil profile.

Table 6. Summary of stepwise multiple regression analyses of soil characteristics on pesticide concentrations in soil segments at site S-1.

Portion of soil profile	F ratio	Independent variables	R^2	R^2 change	Standardized regression coefficient
All segments	13.59 ***	% organic matter	0.2106		0.713
		% moisture	0.4801	0.2695	0.568
		% silt	0.5723	0.0922	-0.482
		percolation rate	0.6368	0.0645	-0.311
Top segments (top 8.0 feet)	23.34 ***	% organic matter	0.8293		1.013
		% silt	0.9397	0.1104	-0.348
Bottom segments (below 8.0 feet)	12.61 ***	% moisture	0.3979		0.666
		% silt	0.5154	0.01175	-0.442
		percolation rate	0.5926	0.0772	-0.295

a/ A separate regression analysis was done on each set of segments.

Regression equations: (y= predicted pesticide concentration, ppb)

All segments $y = 0.0800 + 0.6046(\%\text{ organic matter}) + 0.0198(\%\text{ moisture}) - 0.0122(\%\text{ silt}) - 0.0279(\text{percolation rate})$.

Top segments $y = 0.1148 + 0.5336(\%\text{ organic matter}) - 0.0072(\%\text{ silt})$

Bottom segments $y = 0.0663 + 0.0214(\%\text{ moisture}) - 0.0132(\%\text{ silt}) - 0.0267(\text{percolation rate})$

Site S-1 (Table 6)

At site S-1, the percent organic matter in each 6 inch segment was again positively correlated with pesticide concentration in the first 8 feet of soil. Percent silt was inversely correlated with levels of simazine in the soil in this layer. Organic matter alone accounted for 82.9% of the variability in pesticide concentration in soil segments in the first 8 feet of the profile. The inclusion of percent silt in the equation only brought the R in this layer up to 94%.

The stepwise multiple regression analyses performed on the other sets of segments at site S-1 show that the soil variables measured in this study do not explain the occurrence of simazine below 8 feet or in the total soil profile as well as they do its occurrence in the top 8 feet. In the soil below 8 feet, 59.3% of the simazine occurrence is accounted for by the combination of the presence of moisture, low levels of silt and low percolation rate. The standardized regression coefficients reveal that moisture is

1.5 and 2.3 times more important than % silt and percolation rate respectivley in predicting simazine concentration in the soil below 8 feet.

In the regression analysis performed on soil segments in the total soil profile, organic matter and moisture were positively correlated with simazine concentration while silt and percolation rate were negatively correlated with the level of simazine in the soil. The R shows that the combination of these four soil characteristics explains 63.7% of the occurrence of simazine in the total profile. Organic matter and moisture alone account for 48% of the simazine contamination in all the segments.

2. Discriminant Analysis

a) Segments within soil profiles at sites E-0 and S-1

Discriminant analysis uses stepwise linear regression methods to differentiate between contaminated and uncontaminated soil segments. The resulting model is referred to as a discriminate function. Discriminant classification functions characterizing contaminated and uncontaminated populations of segments were derived and utilized to predict the probability of categorizing a segment as either contaminated or uncontaminated. These classification functions can be applied to segments of any future drilling site to estimate the probabilities of contamination for the new segments. The classification functions for a pesticide should only be used to calculate probabilities for that specific pesticide. The results for site E-0 and S-1 given in Table 7 show that the models developed for the segments at each site were more successful in predicting a segment to be uncontaminated than contaminated. This indicates that some other variable or variables need to be measured and included to better predict segment contamination.

b) Soil core totals from all sites.

Discriminant analysis was performed to produce a model which would predict contaminated sites. Pesticide concentrations of entire soil cores and variables that characterized the cores were entered into the analysis for all the sites. The variables and values that were used to characterize each soil column are listed in Appendix XII. Table 8 shows that

Table 7. Summary of discriminant analysis to classify the soil segments at sites E-0 and S-1 as contaminated or uncontaminated.[a]

Site	Variables in equation [b]	Percent segments classified correctly [c] Contaminated	Uncontaminated
E-0	clay, organic matter, silt, moisture	62.5	83.3
S-1	moisture, organic matter	44.5	90.0

a/ Only sites E-0 and S-1 had sufficient numbers of contaminated segments to perform discriminant analyses.

b/ Variables that met the statistical criteria used in the analyses. Classification equations:

Site E-0:

$$\text{Contaminated Score} = -4.849 + 0.9035(\%\ \text{clay}) + 19.815(\%\ \text{organic matter}) - .824(\%\ \text{silt}) + 0.307(\%\ \text{moisture})$$

$$\text{Uncontaminated Score} = -1.453 + 0.004(\%\ \text{clay}) + 4.770(\%\ \text{organic matter}) + 0.004(\%\ \text{silt}) + 0.200(\%\text{moisture})$$

Site S-1:

$$\text{Contaminated Score} = -8.228 + 1.051(\%\ \text{moisture}) + 12.449(\%\ \text{organic matter})$$

$$\text{Uncontaminated Score} = -5.530 + 0.845(\%\ \text{moisture}) + 9.338(\%\ \text{organic matter})$$

c/ Probability equations:

$$P(c) = \frac{\exp(\text{contaminated score})}{\exp(\text{contaminated score}) + \exp(\text{uncontaminated score})}$$

$$P(uc) = \frac{\exp(\text{uncontaminated score})}{\exp(\text{uncontaminated score}) + \exp(\text{contaminated score})}$$

where $P(c)$:= Probability Contaminated
$P(uc)$:= Probability Uncontaminated

Table 8. Summary of discriminant stepwise multiple regression analysis of variables characterizing entire soil profiles on pesticide contamination of the drilling sites.

Independent variable a/	F ratio b/	R^2	R^2 change	Standardized regression coefficient
Elapsed time (years)		0.4260		-0.589
% organic matter	6.83(P<.06)	0.7735	0.3475	-0.649

a/ Regression equation

y = 1.0805 - 0.164(elapsed time in years) - 1164.7593(% organic matter)

y > 0.5(+/- s.e.) indicates a contaminated site.

y < 0.5(=/- s.e.) indicates an uncontaminated site.

b/ The F ratio for the regression equation is significant at the 6% level.

the combination of elapsed time from the last known pesticide application and total % organic matter produce a model that is significant at the 6% level of significance and has an R of 77%.

Contaminated sites were distinguished by short periods of time since the last pesticide application and low total organic matter content. Because levels of organic matter are higher in the top 20 inches of the soil profiles, the model should only be used for cumulative data of 120 inches or more. As apparent in Figures 12-18, the percent organic matter at the surface of the soil profile is usually much higher than that found in deeper segments. The percent organic matter relative to the entire profile decreases as a function of increasing soil mass (Table 9). When only a portion of a soil core is used to calculate the percent organic content, as opposed to the entire profile, the higher percentage may alter the prediction of the discriminant functions at some sites (Table 10).

Although probabilities of contamination do not change appreciably for sites D-0, D-1, S-0 and C-0, they are entirely changed for sites E-1, E-0 and S-1 at depths

Table 9. Percent cumulative organic matter at varying sampling depths. (For calculation method see Appendix XII).

	Site						
Depth (in)	D-0	D-1	E-1	E-0	S-1	S-0	C-0
0-15	0.00075	0.00093	0.00037	0.00106	0.00213	0.00191	0.00477
0-30	0.00051	0.00070	0.00031	0.00053	0.00138	0.00125	0.00322
0-60	0.00036	0.00053	0.00024	0.00024	0.00073	0.00107	0.00249
0-120	0.00039	0.00036	0.00016	0.00013	0.00034	0.00052	0.00013
0 - total	0.00021	0.00027	0.00010	0.00005	0.00011	0.00022	0.00095

Table 10. Classification function scores of segments at varying cumulative sampling depths. (See Table 7 for equations and calculation method).

Depth (in)	D-0		D-1		E-1		E-0		S-1		S-0		C-0	
	Yuc	Yc	Yuc	Yc	Yuc	Yc	Yuc	Yc	Yuc	Yc	Yuc	Yc	Yuc	Yc
0-15	50.7	12.6	61.6	14.5	7.8	4.9	34.5	9.6	97.8	21.0	98.6	21.2	260.9	50.3
0-30	36.4	10.1	48.1	12.1	3.7	4.1	3.4	4.1	53.4	13.0	59.6	14.2	169.2	33.8
0-60	28.0	8.6	41.3	10.9	-0.3	3.4	-13.8	1.0	14.9	6.2	48.9	12.2	126.0	26.1
0-120	29.3	8.8	27.9	8.6	-5.0	2.6	-20.5	-0.2	-8.3	1.9	16.2	6.4	58.0	13.9
0 - total														

Yuc = classification score of uncontaminated discriminate classification function.
Yc = classification score of contaminated discriminate classification function.

Table 11. Probabilities of contamination and uncontamination for cumulative samples at varying depths.

Depth (in)	D-0		D-1		E-1		E-0		S-1		S-0		C-0	
	Puc	Pc	Puc	Pc	Puc	Pc	Puc	Pc	Puc	Pc	Puc	Pc	Puc	Pc
0-15	1.00	0.00	1.00	0.00	0.95	0.05	1.00	0.00	1.00	0.00	1.00	0.00	1.00	0.00
0-30	1.00	0.00	1.00	0.00	0.41	0.59	0.30	0.60	1.00	0.00	1.00	0.00	1.00	0.00
0-60	1.00	0.00	1.00	0.00	0.02	0.98	0.00	1.00	0.99	0.01	1.00	0.00	1.00	0.00
0-120	1.00	0.00	1.00	0.00	0.00	1.00	0.00	1.00	0.00	0.99	0.99	0.00	1.00	0.00
0 - total	0.99	0.01	1.00	0.00	0.00	1.00	0.00	1.00	0.00	1.00	0.58	0.42	1.00	0.00

Puc = probability that site is uncontaminated.
Pc = probability that site is contaminated.

less than 120 inches (Table 11). Site E-1 requires a cumulative sampling depth of at least 60 inches to correctly predict its contamination status. Similarly, site E-0 requires a minimum sampling depth of 30 inches. The predicted probability of contamination for site S-1 is not consistent with experimental results until core totals have been computed for 120 inches of the profile.

Classification functions were derived to express site scores as probabilities. The functions predicted the contaminated and uncontaminated sites 100% accurately (Table 12). Probabilities for the status of all sites except S-0, whether contaminated or not, were very strong (>99%). Site S-0 was much less definitive because the model produced by the analysis indicated a 58% probability that the site was uncontaminated and a 41% probability of contamination. Although no simazine was detected in the soil at this site, pesticide was detected in the water sample taken at the bottom of the soil profile. The analysis of S-0 may not be relevant since the MDL for simazine was extemely high (25 ppb). S-0 may have had simazine within the soil strata at concentrations less than 25 ppb.

Table 12. Probability of sites falling into contamination groups based on results from discriminant analysis.

Site	Probability Uncontaminated	Probability Contaminated
D-0	0.993	0.007
D-1	1.000	0.000
E-0	0.000	1.000
E-1	0.000	1.000
S-0	0.584	0.416
S-1	0.000	1.000
S-0	1.000	0.000

a/ Classification equations:

Contaminated score = -1.06 + 0.57(elapsed time) + 4125.80(% organic matter).

Uncontaminated score = -8.74 + 2.68(elapsed time) + 19121.41(% organic matter).

b/ Probability equations:

$$P(c) = \frac{\exp(\text{contaminated score})}{\exp(\text{contaminated score}) + \exp(\text{uncontaminated score})}$$

$$P(uc) = \frac{\exp(\text{uncontaminated score})}{\exp(\text{uncontaminated score}) + \exp(\text{contaminated score})}$$

where P(c) := Probability Contaminated
P(uc) := Probability Uncontaminated

3. Principal Component Analysis

Principal component analysis is a statistical method often used to summarize many variables into the basic, underlying processes they represent. The number of principal components, or factors, derived from a data set is usually less than the number of variables measured. Principal components were determined for each site based on the soil characteristics measured in the samples collected. The interpretation of principal components is based upon the relative contributions of the factor loadings (eigenvectors). Principal components were identified that explained segment variability within each site, using the soil properties data (texture, % moisture, % organic matter, percolation class). Sites were then compared on the basis of the distribution of their individual variation among the principal components. Principal components for sites E-0 and S-1 were subsequently used as dependent variables in stepwise linear multiple regression analyses. The rotated factor loadings (Varimax rotation) were regressed on pesticide concentration to produce a model for predicting pesticide contamination.

a. Segments within soil profiles at all sites.

Five significant principal components were associated with segments in soil profiles from all sites. They accounted for 89.9% to 98.7% of the soil propterties variation in the segments at the seven sites (Table 13). Appendix XIII contains the results from each principal component analysis and the correlation matrix for the variables at each site. The principal components (PC's) are interpreted to be:

PC-A - soil texture dominating percolation rate
PC-B - fine particle type
PC-C - moisture content
PC-D - organic matter content
PC-E - gravel content (when present)

The following results are derived from an interpretation of the factor loadings in the specific analyses for each site (Appendix XIII).

PC-A is characterized by high positive factor loadings for sand and percolation and large negative factor loadings for silt and clay. Percolation rate is consistently found to have a high loading in this factor, although it may not be the factor's highest loading. For this reason, the PC is

Table 13. Percent variance in soil segments explained by five principal components at each of the seven drilling sites.[a]

Site	Principal components					
	Texture percolation (PC-A)	Fine particle (PC-B)	Moisture content (PC-C)	Organic matter (PC-D)	Gravel content (PC-E)	Total % variance accounted for
D-0	39.4	15.7	14.7	14.4	14.6	98.8
D-1	32.5	31.6	17.7	16.8	----	98.6
E-0	38.1	20.8	15.4	16.8	----	91.1
E-1	48.2	8.5	24.8	16.9	----	98.4
S-0	34.5	19.1	14.6	14.4	b/	98.7
S-1	33.3	33.3	14.5	15.0	b/	96.1
C-0	38.3	22.7	17.2	17.3	----	95.5

a/ See Appendix for tables showing the loadings for each of the variables and the correlations among the variables.

b/ Gravel content was included in the texture/percolation factor because gravel had its highest loading in this factor at site S-1. Gravel was negatively correlated with percolation rate; however, this may be misleading because the percolation rate was based only on the relative percentages of sand, silt and clay (see Appendix VIII). Therefore, when the gravel content of a segment increases, there is no corresponding increase in the percolation rate.

interpreted as texture exerting the most influence over percolation, rather than a general soil texture principal component.

PC-B is designated as a fine particle component because the high loadings for clay, silt, or clay and silt contribute almost exclusively to this principal component. The clay and/or silt loadings are positive and high, while the sand and percolation loadings are negative and lower. There may be an additional explanation for this PC that is associated with the clay fraction of the soil, such as cation exchange capacity, but data for this kind of interpretation was not collected.

The three remaining PC's each have a high loading for only one variable. PC-C (moisture content) is the PC in which % moisture has its highest loading. PC-D (organic matter content) is the principal component where the highest loading for % organic matter occurs. PC-E (gravel content) is present as a distinct PC for two of the sites, D-0 and S-0, that have gravel in the soil profile. Although site S-1 contained tha largest percentage of gravel, gravel was not expressed as its own principal component at this site, but was incorporated into PC-A, the texture/percolation PC.

Texture-percolation (PC-A) and fine particle type (PC-B) are the PC's that account for the largest percentage of variation at all sites except at site E-1, where moisture content appears to play a more important role than the fine particle PC in explaining variation in the segments. The remaining variation is distributed among the other two or three PC's.

b. Regression of Principal Components on Pesticide Concentration

Normally, use of Principal Component Analysis is restricted to data summarization or hypothesis generation for an individual data set. In these cases, researchers restrict the number of PC's presented to the first few that explain the most variance in the data. The most common method is to use only those principal components that have eigenvalues (% variance explained by each principal component) above a selected limit. Our use differs in that we conducted an additional analysis, regressing the PC's on pesticide concentration. We were interested in the predictive power of the PC's regardless of the variance explained by any particular PC. Tables 18-31 in Appendix XIII contain all factors produced by Principal Component Analysis and are not summarized versions. The rotated factor loadings within each PC for segments within a soil profile were used in a multiple linear regression to ascertain the effectiveness of the PC's in predicting pesticide concentration. Results from the analyses performed on the PC's at sites E-0 and S-1 are presented below.

Segments from soil profile at site E-0 (Table 14).
The principal components that were used in the regression equation to predict EDB concentration at site E-0 accounted for only 20% of the occurrence of this pesticide in the soil samples. Apparently, a combination of variables measured in the independent data set was inadequate to explain the majority of the pesticide distribution at this site.

Segments from soil profile at site S-1 (Table 15)

Organic matter content, moisture content and another, unidentified PC (unidentified because of low factor loadings for all variables) were used in the regression equation to predict simazine concentration at site S-1. These were positively correlated with pesticide concentration indicating that simazine would most likely be found in

Table 14. Summary of stepwise multiple regression analysis of principal components on pesticide contamination of soil segments at site E-0.[a]

Principal Component	F ratio	% of variance	R^2	R^2 change	Standardized regression coefficient
Fine particle type		20.8	0.1381		0.372
Unidentified[b]	9.84***	9.0	0.2057	0.0676	-0.260

---

a/ % of variance for each factor was calculated in initial principal component analysis (see Table 22, Appendix XIII).

b/ In the initial principal component analysis this factor contained low loadings for all the variables or explained less than 10% of the variance in the segments (see Table 22, Appendix XIII).

Table 15. Summary of stepwise multiple regression analysis of principal components on pesticide contamination of soil segments at site S-1.

Principal Component	F ratio	% of variance[a/]	R^2	R^2 change	Standardized regression coefficient
Organic matter	16.32 ***	15.0	0.3381		0.582
Moisture content		14.5	0.5301	0.1920	0.438
Unidentified[b/]		1.8	0.6047	0.0746	0.273

a/ % of variance for each factor was calculated in intitial principal component analysis (see Table 28, Appendix XIII).

b/ In the initial principal component analysis this factor contained low loadings for all the variables and it explained less than 10% of the variance in the segments (see Table 28, Appendix XIII).

segments with high organic and moisture contents. In combination, these components accounted for 60% of the occurrence of simazine contamination in the soil segments at this site even though they explained only 31.3% of the total variance in the entire independent data set. The amount of variance in the independent data explained by a PC was therefore not related to the ability of this PC to predict simazine concentration.

IV. DISCUSSION

The area represented in this study is characterized by porous, sandy soils primarily used for vineyards, deciduous fruit and nut crops, field crops, and alfalfa. This area was previously documented to have groundwater contaminated by DBCP (8). The sandy, well drained nature of the soil profile is evident from the information given in Figures 12-18. Soil profile totals, calculated from the samples taken at each site, show that the soil at these sites contained small amounts of fine textured material (clay and silt). This indicates that relatively large pore spaces and high percolation rates existed in the soil profile at these sites. The soil at these sites is sandy and well drained and is not representative of areas that have higher silt and clay contents in the soil.

It must be stressed that the statistical models presented here are derived from a very small number of sites. Application of these models to other geographic locations, or even to other sites at the same locations, must be made with caution. Characteristics useful in distinguishing the sites containing contaminated soil from sites with uncontaminated soil are presented first in this discussion. This is followed by an evaluation of the similarities in pesticide presence at the contaminated sites. The last part of the discussion focuses on the four individual pesticides.

A. Characteristics Distinguishing Contaminated and Uncontaminated Sites

The model developed from discriminant analysis using entire soil profile variables indicated that sites containing pesticide contaminated soil were distinguished by: 1/ a short period of time between the last known pesticide application and sampling, and 2/ a low percent total organic matter.

Contaminated sites had received pesticide applications within the previous 4 years. The elapsed time factor supports the premise that volatilization of the pesticide, degradative processes, and vertical leaching over time may remove substantial quantities of pesticide from the soil. The discriminant model was developed from, and is applicable to, the sandy, porous soils found at the seven sites. Extension of its use should be undertaken after verification is completed from other soil profiles. This model may be specific to the soils in this study area.

B. Similarities at Pesticide Contaminated Sites

Only two sites, E-0 and S-1, had a sufficient number of contaminated segments to allow developement of statistical models for predicting pesticide concentration. The multiple linear regression analyses on soil segments at these sites show that there are similarities in the properties influencing the concentrations of EDB and simazine in the top 8 feet. Organic matter and either clay or silt are positively correlated with pesticide concentration and account for most of the variation in the pesticide contamination in this top portion of the soil profile for both EDB and simazine, even though these pesticides are dissimilar in their chemical properties (Table 16). This is in agreement with studies that have been performed on the top layers of the soil profile that indicate organic matter as the most significant property determining adsorption coefficients for soils (1),(2). The discriminant analysis model based on soil profile totals reveals that low amounts of organic matter in an entire profile are important in identifying sites of probable contamination. This suggests that the fate of a pesticide in the upper layers of the soil may be influenced by a different set of factors than in the lower layers of the profile.

The presence of a pesticide below 8 feet in the soil profile seemed to be controlled by factors which were more specific to the pesticide involved. The equations developed from the linear regression analyses for the segments below 8 feet at sites E-0 and S-1 revealed that the occurrence of simazine is best predicted by the presence of moisture and that none of the variables measured in this study were successful in accounting for much of the variation in EDB concentrations in this part of the soil profile (although clay was significantly associated with EDB concentrations below 8 ft.)(Tables 5 and 6).

Table 16. Chemical properties of DBCP, EDB, simazine and carbofuran (9, 10).

Pesticide	Chemical name	Chemical class	Solubility in water	Vapor pressure	Chemical hydrolysis
DBCP (dibromochloropropane)	1,2-dibromo-3-chloropropane	low molecular weight chlorinated hydrocarbon	600 ppm (at 25 C)	0.8 mm Hg (at 21 C)	Minor (greater under alkaline conditions)
EDB (ethylene dibromide)	1,2-dibromoethane	low molecular weight chlorinated hydrocarbon	4300 ppm (at 30 C)	11.0 mm Hg (at 25 C)	Minor
Simazine	2-chloro-4,6-bis (ethylamino)-1,3,5-triazine	triazine	5 ppm (at 20 C)	6.1 x 10^{-9} mm Hg (at 20 C)	Variable
Carbofuran	2,3-dihydro-2,2-dimethyl-benzo-furan-7-yl methylcarbamate	carbamate	700 ppm (at 25 C)	2.0 x 10^{-5} mm Hg (at 33 C)	Major (greater under alkaline conditions)

Another similarity independent of the type of pesticide was the occurrence of pesticide contamination in two distinct (although not necessarily equal in magnitude) bands in the soil profiles, one near the soil surface and the other beginning at least five feet deeper. This phenomenon was independent of the frequency or magnitude of pesticide application and may reflect pesticide transport linked to soil moisture movement. Relatively few studies of pesticide transport through layers greater than 5 feet have been reported to draw upon in interpreting this behaviour. The comparison of predicted pesticide distribution using mass transport models may be enlightening, but is outside the scope of this volume.

C. DBCP

DBCP is a relatively stable, low molecular weight halogenated hydrocarbon with moderate volatility and low solubility, which does not hydrolyze readily.

No DBCP was detected in soil at the sampling sites where it had been applied even though one of the sites was within 0.2

mile of a well found to be contaminated with 0.6 ppb DBCP (Table 2). However, the most recently reported application of DBCP to these sites was in 1977, five years before the sampling reported in this study took place. In 1980, the California Department of Health Services conducted a study on the movement of DBCP through soil in the same geographical area focused on in this study (11). The report from this earlier investigation documented DBCP concentrations, up to approximately 9.0 ppb, at several depths in the soil profile. It is possible that DBCP may have previously been in the soil at the DBCP drilling sites, D-0 and D-1, but the amount of time elapsed since the last application of the pesticide was long enough for any DBCP residues to be depleted from the soil.

An additional reason for not finding DBCP in the soil at sites D-0 and D-1 relates to the sampling equipment used only at these two sites. The Shelby Tube sampler was used exclusively at site D-0 and for the first 24 inches sampled at site D-1 (Table 3). These were the first sites drilled and the use of this sampling method was discontinued due to the disadvantages related above. The increased exposure of the samples to air when Shelby Tubes were used may have resulted in the immediate loss of DBCP through volatilization. Therefore, the amount of DBCP in the soil samples when they were sent for chemical analysis may not have been a true reflection of the amount of pesticide in the soil before the samples were removed from the ground.

The wells associated with the DBCP drilling sites were similar to each other in that their well casings were perforated below the depths that soil was sampled at their associated drilling sites. This means that water from soil layers deeper than those sampled in this study could enter the wells. Because these layers were not sampled, it is not known if they contained DBCP. If DBCP was in these deeper layers, it could account for the presence of the pesticide in the water sample from the well associated with site D-1, even though DBCP was not detected in the 24.5 feet of soil sampled at site D-1.

There are however, differences in the soil properties at sites D-0 and D-1 that indicate DBCP may have passed more quickly through the soil at the site near the uncontaminated well (D-0) than through the soil near the contaminated well (D-1). It has been noted that DBCP moves faster through soils with larger pore spaces (12). Larger pore spaces are found in soils composed of the larger textured soil articles such as sand. Principal component analysis has shown that the amount of fine particles, and consequently the quantity of smaller pore spaces, varied to a greater degree in the soil segments at site D-1 than at site D-0. Soil profile totals also give a measure of the relative pore space at the sites. The site near the contaminated well contained a larger percentage of silt and clay and had a much lower overall percolation rate than the site near the uncontaminated well (Appendix XII).

The fact that DBCP was applied by the injection method at site D-0 may also have caused the pesticide to move through the soil more rapidly than at site D-1 where DBCP was applied through the irrigation systems for some applications and by injection method for others. Studies on DBCP movement in the first 30 inches of the soil profile have shown that the injection method of application results in

DBCP moving more rapidly and deeper in the soil than when the pesticide is applied through an irrigation system (13). DBCP moving slowly through the soil may have provided a continuous source for groundwater contamination over a longer period of time than when DBCP passed quickly through the soil. This may explain the contamination of the water in the well associated with site D-1, and the uncontaminated water in the well associated with site D-0.

D. EDB

Ethylene dibromide is a low molecular weight halogenated hydrocarbon that is quite soluble in water, does not hydrolyze readily and can persist in the soil for long periods of time (Table 16)(14).

The results from site E-1, the site near the contaminated well, show that a small percentage of EDB persisted in the soil for two years following the single application of EDB (Figure 8). It is important to note however, that the amounts detected were extremely low (0.2 ppb) and only a very small fraction of the total amount applied. The levels of EDB were greater (up to 31.1 ppb) in the soil at site E-0, the site near the uncontaminated well. It is difficult to determine whether the EDB in the soil at this site was due to persistence from cumulative applications, or was a fraction of EDB that had been applied during the same year that samples were taken (Figure 7). At both sites, EDB was shown to migrate in the soil profile to a depth of at least 20 feet after application (Figures 7, 8, 14 and 15). One could speculate either that EDB was accumulating at the 20 ft. depth or that this represents the leading edge of the pesticide slug migrating downwards.

As noted earlier in the discussion, organic matter was the variable measured in this study that explained most of the variability in occurrence of EDB in the upper 8 feet of the soil profile. According to the linear regression model, EDB levels would tend to be greater with increasing amounts of organic matter in the soil in this upper layer. For soil below 8 ft., the regression analysis identified clay to be positively correlated with pesticide concentration. However, this variable only accounted for about a fifth of the total variation in EDB concentration in the soil at these depths. Considering the high solubility of EDB, the pesticide may have dissolved into available water and migrated with it through the soil profile, appearing in soil segments composed of fine textured particles such as clay. Because of their low porosity, these soil segments would tend to retain water and any EDB dissolved in it. However, this hypothesis remains unsupported by the statistical analyses; they did not show an association of pesticide concentration with moisture.

Comparison of the two EDB application sites to determine the reason EDB contaminated groundwater was found in one well and not in another is difficult to explain based on the results from this study. The manner in which both wells were constructed allowed them to draw water from layers of soil that were deeper than those sampled in this study (Table 2). The possibility that EDB may have been present, either in water or adsorbed to particles in these deeper soil layers and that these layers served as a source of contamination for the well associated with site E-1 could not be documented by the results of the sampling at this site.

The site that was associated with the uncontaminated well (E-0) had more EDB contaminated soil and higher concentrations of the pesticide than the site near the contaminated well (E-1). However, the fact that more applications of EDB were applied to site E-0 and these applications were made more recently than those at site E-1 must be taken into consideration. According to the discriminant model, the longer period of time since the last EDB application at site E-1 decreased the likelihood of finding the pesticide in the soil at this site.

E. Simazine

Simazine is a triazine herbicide of low solubility and volatility. It hydrolyzes readily (Table 16).

The significance of the data from site S-0 is questionable because of the high minimum detectable level (MDL) in the chemical analyses of the samples from this site. The MDL of 25 ppb at site S-0 precluded detection of simazine at levels comparable to samples from site S-1. Associations between soil variables and simazine were therefore lost. The results of the discriminant model for sites show that the model was able to clearly classify all sites except S-0 as contaminated or uncontaminated (Table 12). It is of interest however, that a water sample taken at the base of the soil profile at site S-0 contained 3 ppb simazine while the well water sampled 3 miles from the drilling site contained no detectable residues of simazine (0.5 ppb MDL in water). However, examination of the information available on the construction of this well showed that it was drawing water from soil layers that were nearly 20 feet deeper than those that were sampled in the corresponding drilling operation. Due to this fact, and the distance of the well from drilling site S-0, the contaminated water detected at the bottom of the soil profile in this study may not have represented water that was entering the associated well.

The well associated with site S-1 was only 0.2 mile from this drilling site (Table 2). The construction of the well allowed it to draw water from soil layers just below (less than 2.7 ft.) the depth of the last sample taken in the drilling operation at site S-1. This fact, in addition to the well's proximity to the site sampled, indicates that water entering the well could have come from a contaminated soil layer that was sampled in this study.

A theoretical 8.2% of all applied simazine could be accounted for in the S-1 soil profile (Figure 10). This was surprising, considering the small percentages (theoretical) of EDB accounted for at sites E-0 and E-1 and the reported propensity of simazine to hydrolyze. The highest concentration of simazine was found at the soil surface (>50 ppb) but levels greater than 30 ppb were detected from 22 to 24 feet in the soil profile (Figure 17).

Simazine was the most predictable of the pesticide distributions in association with organic matter and moisture content. Two independent statistical analyses, 1) multiple linear regression, and 2) regression of principal components on simazine concentration, relate these two independent variables to simazine. The linear regression analysis produced good coefficients of determination (R) for all segments, segments within the upper 8 feet of the soil profile and segments below the upper 8 feet of the soil profile. Organic matter was strongly associated and positively correlated with pesticide concentration in the upper 8 feet of soil. This association was less for the entire soil profile. The regression on the entire profile was probably greatly influenced by the strong association in the shallow layers. Linear regression analysis identified moisture content as a variable associated with pesticide concentration in the soil at depths greater than 8 feet.

This association was also revealed in the principal components regression analysis.

F. Carbofuran

Carbofuran is a carbamate characterized by moderate solubility in water and low volatility. It may be readily hydrolyzed under alkaline conditions (Table 15).

The history of site C-0 indicates that a single year's application occurred in 1981. No carbofuran was detected at any level in the soil strata, to a depth exceeding 60 feet, and none was detected in groundwater sampled from a well 5.5 miles from the sampling location. The vertical migratory properties of carbofuran in soil cannot be evaluated from our results.

V. CONCLUSION

1. EDB and simazine are sufficiently mobile in the soils characteristic of the study area to occur at depths of 0 - 40 ft. and 0 - 28.3 ft. respectively.

2. The presence of EDB and simazine were associated with the higher percentages of organic matter in the upper 8 feet of the soil. Below 8 feet, simazine concentration was associated with the higher percentages of moisture in the soil. Clay was the only variable measured that was directly related to the presence of EDB in the soil at these depths. However, clay accounted for only a small part of the variation in the EDB concentrations detected.

3. An empirical model was developed which may predict the presence of a pesticide at a specific geographic location. Low total organic matter content and a short time interval from last pesticide application to profile sampling were associated with contaminated sites. The model was developed from data taken during this study and must be tested with independent soil core data.

4. Results from this study were inadequate to determine whether the presence of DBCP, EDB, simazine and carbofuran in the soil profile is directly related to the presence of these pesticides in water sampled from wells in the immediate area.

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APPENDIX I

Chain of Custody for Chemical Analysis

STATE OF CALIFORNIA
DEPARTMENT OF FOOD
AND AGRICULTURE

ENVIRON. MONITORING & PEST MGMT.
ENVIRON. HAZARDS ASSESSMENT
1220 N STREET, ROOM A-149
SACRAMENTO CA 95814

CHAIN OF CUSTODY RECORD

(Use ball point pen only)

Study #					Cell #				Sample #							Segment Depths (Feet)												Date Collected											Segment Length (In.)
									Location			Segment				Upper Depth					Lower Depth							Mo		Day		Yr.		Time					
-	-	1	6	■				■			-				■				.		-				.		■					8	2					■	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40

Pesticide Use																																							
Simazine		Carbofuran		DBCP		EDB										Atrazine					Units	Carbofuran					Units	DBCP					Units	EDB					Units
41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80

People Collecting:

Owner:

Address:

Observations, remarks:

Lab Results: SAVE EXTRACTS

Compound	Amount	Chemist	Date
Atrazine			
Simazine			
DBCP			
EDB			

Relinquished by: *(Signature)*	Date/Time	
Received by *(Signature)*	Relinquished by *(Signature)*	Date/Time
Received by: *(Signature)*	Relinquished by: *(Signature)*	Date/Time
Received by: *(Signature)*	Relinquished by: *(Signature)*	Date/Time
Received for Laboratory by: *(Signature)*	Date/Time	Lab #

Cell #: Ventara = 000

Pesticide Use: 00 = No use
01 = Low use
02 = Med. use
03 = High use

Distribution: Original and one copy accompanies shipment; one copy to Field Files

APPENDIX II

Determination of DBCP in Crops, Soil, Water Bark and Leaves

DETERMINATION OF DBCP
(1,2-dibromo-3-chloropropane)
IN CROPS, SOIL, WATER BARK AND LEAVES

Scope:

This method has been checked for the quantitative recovery of DBCP (1,2-dibromo-3-chloropropane) from crops, soil, water, peeling, leaves, and bark samples. It is suspected that this method would also apply to assays of many similar materials such as ethylene dibromide (EDB) and possibly compounds such as DDVP and Dibrom.

Principle:

Crop samples are prepared by chopping in a frozen state. Other samples are thoroughly mixed and sampled directly. Leaf punches are stripped and prepared by the Sur-ten strip method. A suitable size sample is codistilled with ethyl acetate from an aqueous mixture of sample, ethyl acetate, and water. The recovered ethyl acetate (plus any DBCP from sample) is dried with sodium sulfate and determined quantitatively through the use of gas-liquid chromatography (G-LC) with electron capture (e.c.) detector.

Equipment:

1. Hobart food chopper, Model 8181D or equivalent.
2. One-pint wide mouth, tapered fruit jars with rings, lids and solvent washed foil liners. Mason, Bull, Kerr or equivalent.
3. Nalgene scoop or similar device to remove sample from Hobart. Homemade or stainless steel restaurant supply.
4. Balance, sensitive to 10 mg.
5. Distillation Receiver - Barrett trap 25 ml capacity with 24/40 joints.
6. Heating Mantle controlled by variable transformer, 500 boiling flask capacity.
7. 500 ml flat or round bottomed boiling flask with 24/40 joint. (If many bark or leaf samples are to be run, it may be desirable to substitute a larger joint such as 45/50 with adapters to 24/40).
8. Condenser, Allihn type: 250 to 300 mm jacket with 24/40 lower joint and drip tip.
9. Gas Chromatograph with electron capture detector.
   Temperatures: °C
   Column: 90

Injector: 125
Detector: 280 or 220*
*Nickel or Tritium respectively
Flows: Nitrogen carrier gas, 20-30 ml/min
Columns: Glass, 6' x 2 mm i.d.
10% OV 101 or 50/50 mix of 6% OV 101 and
4% OV 210 or 10% Tenax, or
4% OV 275 on Chromosorb WHP
or Gas Chrom Q 80/100 mesh
solid support.

10. Glass stoppered test tubes or auto sampler vials fitted with Teflon faced septa for holding samples.

11. Pipette, 10 ml T.D. or 10 ml repipet.

12. Graduate, 250 ml capacity.

13. Syringes, assorted microliter syringes for injection on gas chromatograph. Suggested sized 1,5, and 10 microliter.

<u>Reagents</u>:

1. Analytical standard or DBCP.
   Contact Dr. E. Feichtmeir, Shell Development Company,
   P.O. Box 4248, Modesto, CA 95352.

   a. Stock standard - Prepare 1 mg/ml in ethyl acetate.

   b. Working standards - Dilute stock standard to several working standards covering the linear range of specific e.c. detector used. Typically in the range of 0.02 - 1.0 nanogram/microliter.

   c. Ethyl acetate - nanograde or better. Test for interferences before use.

   d. Acetone - Nanograde or better for prerinsing and drying equipment.

   e. Anhydrous sodium sulfate, granular. Suggest Mallinkrodt. Pretest for interferences. Ethyl acetate wash or heat in muffle furnace if interferences are found. If interferences are not removed, use sulfate from a different source.

   f. Antifoam - Silicone antifoam agent for organics or mixed aqueous and organics.
   Note: Use only if absolutely necessary. Will depress recovery of DBCP.

g. Distilled water - Good quality distilled water stored in glass. Test water with a reagent blank for extraneous peaks and large solvent front.

Procedure:

A. Sample Preparation.

1. Crops.

   a. Place crop sample and broken chunks of dry ice into Hobart bowl. Add both in small quantities at a time to quickly freeze the macerated crop tissue. (1)

   b. Add up to 60% by weight of dry ice to sample (this varies with the moisture content and nature of sample) until sample in chopper forms a homogeneous friable mixture.

   c. Place subsample into the wide mouthed fruit jar. Cover jar with solvent washed aluminum foil and a ring. An inverted lid may also be used but do not secure lid tight as an explosion of the jar will result.

   d. If samples are to be run immediately after chopping, take an aliquot of sample and weigh until sample weight is constant. Agitation helps speed CO_2 removal.

2. Leaf Punches

   a. For total residue, weigh directly into boiling flask.

   b. For penetrated and dislodgeable, use and modified Sur-ten stripping procedure for foliage samples (2) to wash leaves. Run aqueous washings and the washed leaves.

B. SAMPLE DISTILLATION

1. Weigh sample into boiling flask. (10 to 50 grams or more, depending on interferences. For example, 25 grams of citrus, 50 grams of soil, 100-150 ml of water sample).

2. Add several prewashed glass beads, approximately 160 ml of distilled water, and exactly 10.0 ml of ethyl acetate. If experience has indicated that sample will foam uncontrollably, add 1 drop of antifoam. If antifoam is

used the recoveries must be rechecked with antifoam in fortified samples.

3. Place the boiling flask into the heating mantle and assemble the Barrett trap and condenser (with flowing water) in place.

4. Apply full voltage to heating mantle until mixture starts to boil (approximately 5 to 7 minutes), then reduce voltage to 1/4 to 1/2 and allow to reflux for 15 minutes.

5. Check graduations on Barrett trap to determine if all of the ethyl acetate has been distilled over. If it hasn't, continue refluxing in 5 minute intervals, otherwise, remove heat from flask and wash down condenser and trap neck with a few mls of distilled water. Leave cool (approximately 5 minutes).

6. Drain off lower aqueous layer from trap and discard.

7. Drain ethyl acetate layer into glass stoppered test tube for analysis.

C. Sample Clean-up and Analysis

1. Add a small amount of sodium sulfate to the test tube and shake well to remove entrapped water.

2. The sample is ready for injection on the gas chromatograph. It has normally been considered that this extract cannot be concentrated without loss of DBCP. However, verbal communication with EPA labs in Beltsville, Maryland, has indicated the possible concentration by means of a gentle flowing stream of nitrogen at room temperature.
   Note: We normally attempt to match standards in peak height and area to the peak height and area of DBCP peak in samples.

3. It has been reported that further sample clean-up may be obtained by adding 0.25 grams of Merk Silica gel 60 per ml of extract and shaking. (We have not currently checked this step out).

Calculations:

Due to the levels of DBCP currently found, results are calculated on a ppb basis. Soils are calculated on a dry weight basis. Dislodgeable leaf punches are calculated on a surface area and weight of punch basis.

$$\text{ppb} = \frac{(\text{Area or height of sample peak})\ (\text{Nanogram std})\ (10^{-3})}{\text{Area or height of standard peak})\ \left(\frac{\text{grams sample}}{\text{mls extract}}\right)\ (\lambda\ \text{injected})\ (\text{Recovery factor})}$$

References:

1. Personal discussions with Dr. W. Winterland of University of California-Davis; Dr. J.T. Leffingwell of University of California-Berkeley; Dr. J. Knaak, California Department of Food and Agriculture; and others regarding preparation of samples by macerating with dry ice.

2. Iwata, V., et. al., "Procedure for the Determination of Dislodgeable Pesticide Residues on Foliage", Bulletin of Environmental Contamination and Toxicology, Vol. 18, No. 6 (1977)

3. A Method for the Estimation of 1,2-Dibromo-ethane in Vegetables, Hargreaves, et.al., Pesticide Science 5:22S (1974)

4. "Residue Determination of Dibromo-chloropropane in crops, soil, and water", Shell Development Co., Biological Sciences Research Center, Modesto, California. Method #MMS-R-272-3 (September 1976)

5. "Final Report - Development of a Method for the Specific Determination of Low Level Residues of Ethylene Dibromide", Bionetics Division of Litton Industries (October 1976)

6. Malone, B., "Analysis of Grains for Multiple Residues of Organic Fumigants", Journal of Association of Official Analytical Chemists, Vol. 52, No. 4, pp 800-805 (1969)

APPENDIX III

Determination of EDB in Crops, Soil, Water, Bark, and Leaves

DETERMINATION OF EDB
(1,2- dibromoethane)
IN CROPS, SOIL, WATER, BARK AND LEAVES

Scope:

This method has been checked for the quantitative recovery of EDB (1,2-dibromoethane) from crops, soil, water, and fruit peelings. It is suspected that this method would also apply to the assay of other materials such as leaves and other plant parts.

Principal:

Crop samples are prepared by chopping in a frozen state. Other samples are thoroughly mixed and sampled directly. Leaf punches are stripped and prepared by the Sur-ten strip method. A suitable size sample is codistilled with ethyl acetate from an aqueous mixture of sample, ethyl acetate, and water. The recovered ethyl acetate (plus any EDB from sample) is died with sodium sulfate and determined quantitatively through the use of gas-liquid chromatography with electron capture (e.c.) detector.

Equipment:

1. Hobart food chopper, Model 8181D or equivalent.
2. One-pint, wide mouth, tapered fruit jars with rings, lids and solvent washed foil liners. Mason, Ball, Kerr, or equivalent.
3. Nalgene scoop or similar device to remove sample from Hobart. Cut from 500 ml Nalgene squirt bottle.
4. Balance, sensitive to 10 mg.
5. Distillation receiver - Barrett trap 25 ml capacity with 24/40 joints.
6. Heating mantle controlled by variable transformer, 500 boiling flask capacity.
7. 500 ml flat or round bottomed boiling flask with 24/40 joint. (If many bark or leaf samples are to be run, it may be desirable to substitute a larger joint such as 45/50 with adapters to 24/40.)
8. Condenser, Allihn type: 250 to 300 mm jacket with 24/40 lower joint and drip tip.
9. Gas chromatograph with Ni^{63} electron capture detector. Note: At this time, it is beleieved H^{3} detectors cannot be substituted. The different emission frequency detects an interference peak at the EDB elution time on the suggested columns.

Temperatures - Injector: 125
Detector: 280

Column: 20' x 1/8' O.D. nickel tubing
10% SP-2100 on 100/120 chromosorb W-HP
58 C, 10 cc/min N_2
EDB retention time approximately 10 minutes

Column: 6' x 2 mm I.D. glass
80/100 Poropak Q
190 C, 40 cc/min N_2
EDB retention time approximately 8.2 minutes

Note: Several other columns have been tried without success. The problem is that ethyl acetate has an interference peak that is very difficult to separate from EDB. These columns include 10% FFAP, 3% OV-275, 4% OV-101/6% OV-210, and 6% OV-210.

10. Glass stoppered test tubes or auto sampler vials fitted with Teflon faced septa for holding samples.
11. Pipette, 10 ml T.D. or 10 ml repipet.
12. Graduate, 250 ml capacity.
13. Syringes, assorted microliter syringes for injection on gas chromatograph. Suggested sized 1,5 and 10 microliter.

<u>Reagents</u>:

1. Analytical standard of EDB.
    a. Stock standard - Prepare 1 mg/ml in ethyl acetate.
    b. Working standards - Dilute stock standard to several working standards covering the linear range of specific e.c. detector used. Typically in the range of 0.02 - 1.0 nanogram/microliter.
    c. Ethyl acetate - Nanograde or better. Test for interferences before use.
    d. Acetone - nanograde or better for prerinsing and drying equipment.
    e. Anhydrous sodium sulfate, granular. Suggest Mallinkrodt. Pretest for interferences. Ethyl acetate wash or heat in muffle furnace if interferences are found. If

interferences are not removed, use sulfate from a different source.

f. Antifoam - Silicone antifoam agent for organics or mixed aqueous and organics.
Note: Use only if absolutely necessary. Will depress recovery of EDB.

g. Distilled water - Good quality distilled water stored in glass. Test water with a reagent blank for extraneous peaks and large solvent front.
Note: It has been necessary to pre-extract water using the outlined co-distillation method in order to remove materials interfering with the G-LC analysis.

<u>Procedure</u>:

A. Sample Preparation

1. Crops.

   a. Place crop sample and broken chunks of dry ice into Hobart bowl. Add both in small quantities at a time to quickly freeze the macerated crop tissue. (1)

   b. Add up to 60% by weight of dry ice to sample (this varies with the moisture content and nature of sample) until sample in chopper forms a homogenous friable mixture.

   c. Place subsample into the wide mouthed fruit jar. Cover jar with solvent washed aluminum foil and a ring. An inverted lid may also be used but do not secure lid tight as an explosion of the jar will result.

   d. If samples are to be run immediately after chopping, take an aliquot of sample and weigh until sample weight is constant. Agitation helps speed CO removal.

2. Leaf Punches.

   a. For total residue, weigh directly into boiling flask.

   b. For penetrated and dislodgeable, use the modified Sur-ten stripping procedure for foliage samples (2) to wash leaves. Run aqueous washings and the washed leaves.

3. Bark. Sliver bark into thin strips.

4. Soil and similar samples. Mix well, sieve if necessary to remove stones, twigs or clumps, and weigh directly into boiling flsk. Run a duplicate soil sample for moisture determination. Calculate soil results on dry weight basis.

B. Sample Distillation

1. Weigh sample into boiling flask. (10 to 50 grams or more, depending on interferences. For example, 25 grams of citrus, 50 grams of soil, 100-150 ml of water sample.)

2. Add several prewashed glass beads, approximately 160 ml of distilled water, and exactly 10.0 ml of ethyl acetate. If experience has indicated that sample will foam uncontrollably, add 1 drop of antifoam. If antifoam is used the recoveries must be rechecked with antifoam in the fortified samples.

3. Place the boiling flask into the heating mantle and assemble the Barrett trap and condenser (with flowing water) in place.

4. Apply full voltage to heating mantle until mixture starts to boil (approximately 5 to 7 minutes), then reduce voltage to 1/4 to 1/2 and allow to reflux for 15 minutes.

5. Check graduations on Barrett trap to determine if all of the ethyl acetate has been distilled over. If it hasn't, continue refluxing in 5 minute intervals, otherwise, remove heat from flask and wash down condenser and trap neck with a few mls of distilled water. Let cool (approximately 5 minutes).

6. Drain off lower aqueous layer from trap and discard.

7. Drain ethyl acetate layer into galss stoppered test tube for analysis.

C. Sample Clean-up and Analysis

1. Add a small amount of sodium sulfate to the test tube and shake well to remove entrapped water.

2. The sample is ready for injection on the gas chromatograph. It has norammly been considered that this extract cannot be concentrated without loss of EDB. However, verbal communication with EPA labs in

Beltsville, Maryland, has indicated the possible concentration by means of a gentle flowing stream of nitrogen at room temperature.
Note: We normally attempt to match standards in peak height and area to the peak height and area of EDB peak in samples.

3. It has been reported that further sample clean-up may be obtained by adding 0.25 grams of Merk Silica gel 60 per ml of extract and shaking. (We have not currently checked this step out.)

Calculations:

Due to the levels of EDB currently found, results are calculated on a ppb basis. Soils are calculated on a dry weight basis. Dislodgeable leaf punches are calculated on a surface area and weight of punch basis.

$$\text{ppb} = \frac{(\text{Area or height sample peak})\ (\text{Nanogram std})\ (10^{3})}{(\text{Area of height std. peak})\ \left(\frac{\text{grams sample}}{\text{mls extract}}\right)\ (\lambda\ \text{injected})\ (\text{Recovery factor})}$$

References:

1. Personal discussions with Dr. W. Winterland of University of California-Davis; Dr. J. T. Leffingwell of University of California-Berkeley; Dr. J. Knaak, California Department of Food and Agriculture; and others regarding preparation of samples by macerating with dry ice.

2. Iwata, V., et al., "Procedure for the Determination of Dislodgeable Pesticide Residues on Foliage," Bulletin of Environmental Contamination and Toxicology, Vol. 18, No. 6 (1977)

3. A Method for the Extimationof 1,2-Dibromoethane in Vegetables, Hargreaves, et. al., Pesticide Science 5:22S (1974)

4. "Residue Determination of Dibromo-chloropropane in crops, soil and water, "Shell Development Co., Biological Sciences Research Center, Modesto, CAlifornia. Method #MMS-R-272-3 (September 1976)

5. "Final Report - Development of a Method for the specific Determination of Low Level Residues of Ethylene Dibromide," Bionetics Division of Litton Industries (October 1972)

6. Malone, B., "Analysis of Grains for Multiple Residues of Organic Fumigants," Journal of Association of Official Analytical Chemists, Vol. 52, No. 4, pp 800-805 (1969)

7. Kennett, et.al., "Determination of Ethylene Dibromide in Fumigated Fruit," Journal of Agricultural and Food Chemistry, Vol. 5, No. 3, pp 201-203 (1957)

8. Heuser, et. al., "Selective Determination of Ionized Bromide and Organic Bromides in Foodstuffs by Gas-Liquid Chromatography with Special Reference to Fumigant Residues," Pesticide Science, Vol. 1, pp 244-249, November-December (1970)

A. Scott Fredrickson
Agricultural Chemist II

APPENDIX IV

Analysis of Simazine in Soil

ANALYSIS OF SIMAZINE IN SOIL

Scope:

This method is for the determination of simazine in soil.

Principle:

The soil was extracted with acetonitrile using an ultrasonic bath. The acetonitrile extracts were vacuum filtered through filter paper, evaporated to dryness, brought up to 5 milliliters volume in ethyl acetate, and gas chromatographed using ECD, TSD, and Hall conductivity detectors.

Reagents and Equipment:

1. Acetonitrile, MCB omnisolve (non-uv)
2. Ethyl acetate, MCB omnisolve
3. Sodium sulfate, anhydrous, Mallinckrodt #8024
4. Mettler PC4400 top loading balance
5. Kimble #27060-1000, filter flasks
6. Corning #6060-90 Buchner funnels, perforated plate
7. S&S #589 red ribbon filter paper
8. Branson B-72 ultrasonic cleaner bath
9. Kimble #28017A-5 volumetric flask
10. Kimble #25055-500 flat bottomed boiling flask
11. Buchi RE-120 rotary evaporator with Duraire #PV-200 diaphragm vacuum pump and Neslab CFT-75 refrigerated recirculator.
12. Varian 3700 GLC with hall conductivity detector in chloride mode; column: 6 ft. long 10% SP2100 on 100/120 supelcoport; 190 degree centigrade column; 210 degree injector and detector; attenuation: 10 x 10, CDS 111= X 8; nitrogen carrier = 25 cc/min; approximately 4 minutes retention time.
13. Varian 3700 GLC with TSD detector; column: 2 ft. long 10% SP2250 on 100/120 supelcoport; 170 degrees centigrade column; 200 degree injector; 210 degree detector; attenuation: 60 x 10E-12 amps/millivolt; nitrogen carrier = 20 cc/min; TSD bead heat setting = 370; approximately 4 minutes retention time.

Procedure:

A. Sample Preparation

1. The frozen soil core samples were removed from 20 degrees centigrade storage and thawed at room temperature for several hours.

2. Each sample was removed from its stainless steel casing and mixed to produce a relatively homogeneous mixture.

B. Determination of Moisture Content

1. Approximately 10 grams of soil were weighed into a preweighed aluminum weighing pan. The pan with soil was dried for approximately 16 hours at 100 degrees centigrade and then placed in a dessicator for cooling before reweighing.

C. Determination of Simazine

1. A 100 gram portion of the non-dried soil sample was placed into a 500 milliliter bottle along with 100 milliliters of acetonitrile.

2. After sealing with aluminum foil and a screwcap top, the bottle and its contents were ultrasonicated for 1 hour.

3. The soil and acetonitrile were decanted into a 90 mm perforated plate Buchner funnel containing S&S 589 red ribbon filter paper covered with approximately 2 cm anhydrous sodium sulfate; the funnel mounted on a 1 liter filter flask connected to vacuum.

4. The 500 milliliter sample bottle and the Buchner funnel's contents were further rinsed twice with 50 milliliters acetonitrile.

5. The total filtrate was transfered to a 500 milliliter flat bottomed boiling flask and rotary evaporated to dryness at 55 degrees centigrade under approximately 20 inches of Hg vacuum.

6. Ten milliliters of ethyl acetate was added to the flat bottomed flask, and the flask was rotary evaporated to dryness again.

7. Step #6 was repeated once more.

8. The sample was transferred to a 5.0 milliliter volumetric flask, and brought to volume, with ethyl acetate.

9. Gas chromatography was performed upon the sample extract.

Desorption Coefficient:

Recoveries are approximately 80% at the 10 ppb level.

Calculations:

$$\% \text{ moisture} = 100 \times \frac{[(\text{weight of dried sample + pan}) - (\text{weight of pan})]}{[(\text{weight of undried sample}) - (\text{weight of pan})]}$$

$$\text{ppm simazine} = \frac{\text{nanograms simazine}}{\text{milligrams sample represented by injection.}} \; /$$

Peter L. Schlocker
Agricultural Chemist II

APPENDIX V

Analysis of Carbofuran in Soil

ANALYSIS OF CARBOFURAN IN SOIL

Scope:

This method is for the determination of carbofuran in soil.

Principle:

The well core soils were extracted with an acetonitrile/HCL water mixture using an ultrasonic bath. The acetonitrile extracts were vacuum filtered through filter paper, evaporated to dryness, brought up to 5 ml volume in ethyl acetate, and gas chromatographed using a TSD, and a Hall nitrogen mode conductivity detector.

Reagents and Equipment:

1. Acetonitrile, MCB omnisolve (non-uv)
2. Ethyl acetate, MCB omnisolve
3. Sodium sulfate, anhydrous, Mallinckrodt #8024
4. Mettler PC4400 top loading balance
5. Kimble #27060-1000, filter flasks
6. Corning #6060-90 Buchner funnels, perforated plate
7. S&S #589 Red ribbon filter paper
8. Branson B-72 ultrasonic cleaner bath
9. Kimble #28017A-5 volumetric flask
10. Kimble #25055-500 flat bottomed boiling flask
11. Buchi RE-120 rotary evaporator with Duraire #PV-200 diaphragm vacuum pump and Neslab CFT-75 refrigerated recirculator.
12. Organomation Associates Meyer N-EVAP Model #112 analytical vaporator.
13. Varian 3700 GLC with Hall conductivity detector in nitrogen mode; column: 2 ft. long 10% SP2250 on 100/120 supelcoport; column=180 degrees centigrade; injector and detector=210 degrees centigrade; hall attenuation: 10 x 10, CDS-111 attenuation = x 8; helium carrier = 25 cc/min; approximately 4 minutes retention time.
14. Varian 3700 GLC with TSD detector; column: 2 ft. long 10% SP2250 on 100/120 supelcoport; column = 180 degrees

centigrade; injector = 220 degrees centigrade; detector = 210 degrees centigrade; GLC attenuation: 1 x 10E-12 amps/millivolt; Hewlett Packard 3390 A recording integrator attenuation = x 6: nitrogen carrier = 20 cc/min; TSD bead heat setting = 400; approximately 4 minutes retention time.

Procedure:

A. Sample Preparation

1. The frozen soil core samples were removed from 20 degrees centigrade storage and thawed for several hours.
2. Each sample was removed from its stainless steel casing and mixed to produce a relatively homogeneous mixture.

B. Determination of moisture content

1. Approximately 30 grams of soil were weighed into a preweighed aluminum weighing pan. The pan with soil was dried for approximately 16 hours at 100 degrees centigrade and then placed in a dessicator for cooling before reweighing.

C. Determination of Carbofuran

1. A 100 gram portion of the non-dried soil sample was placed into a 500 ml bottle along with 100 ml of acetonitrile plus 2 ml of aqueous 0.25N HCL.
2. After sealing with a screwcap top, the bottle and its contents were ultrasonicated for 1 hour.
3. The soiland acetonitrile were decanted into a 90 mm perforated plate Buchner funnel containing S&S 589 red ribbon filter paper covered with approximately 2 cm anhydrous sodium sulfate; the funnel mounted on a 1 liter filter flask connected to vacuum.
4. The 500 ml sample bottle, Buchner funnel, and its contents were further rinsed twice with 50 ml acetonitrile.
5. The total filtrate was transferred to a 500 ml flat bottomed boiling flask and rotary evaporated to dryness at 55 degrees centigrade and approximately 20 inches of ug vacuum.
6. Ten ml of ethyl acetate was added to the flat bottomed flask, and the flask was rotary evaporated to dryness

again.

7. Step #6 was repeated once more.

8. The sample was transferred to a 5.0 ml volumetric flask and brought to volume with ethyl acetate.

9. Occasionally the acetonitrile is not removed sufficiently for the TSD or Hall nitrogen mode detectors by steps 5, 6, & 7. Then the ethyl acetate has to be evaporated to dryness under a stream of nitrogen using the Organomation analytical evaporator. The sample extract is brought back up to volume with ethylacetate.

10. Gas chromatography is then performed upon the sample extract.

Desorption Coefficient:

Recoveries are approximately 90% at the 0.2 ppm level.

Calculations:

$$\% \text{ moisture} = 100 \times \frac{[(\text{weight of dried sample + pan}) - (\text{weight of pan})}{[(\text{weight of undried sample}) - (\text{weight of pan})]}$$

ppm carbofuran = nanograms carbofuran/milligrams sample injected.

Peter L. Schlocker
Agricultural Chemist II

APPENDIX VI

Procedure for Soil Moisture Determination

PROCEDURE FOR SOIL MOISTURE DETERMINATION

Equipment:

Quadruple beam balance
Soil drying cans with lids
Spatula
Oven with thermometer
Asbestos gloves

Procedure:

1. Make all weight measurements to 0.1 gram.
2. Record tare weight of weighing cans.
3. Knead soil inside plastic bag to incorporate condensed moisture clinging to the plastic.
4. Add approximately 25 grams of soil sample to drying can and record weight (this is wet wt. of soil plus can wt.).
5. Place can with soil in it uncovered in 105 - 110 C oven for 24 hours.
6. Remove and place cap on can. Let sit half an hour or more until it has cooled to room temperature.
7. Record weight (this is dry wt. of soil plus can wt.).

Calculations:

$$\% \text{ moisture} = 100 \times \frac{(\text{wet wt.} - \text{tare wt.}) - (\text{dry wt.} - \text{tare wt.})}{(\text{dry wt.} - \text{tare wt.})}$$

References:

Millar, C.E., L.M. Turk and H.D. Foth. 1965. Fundamentals of Soil Science. 4th edition. John Wiley and Sons, New York.

APPENDIX VII

Procedure for Determination of Percent Organic Matter in Soil

PROCEDURE FOR DETERMINATION OF PERCENT ORGANIC MATTER IN SOIL

Equipment:

Quadruple beam balance
Mortar and pestle
0.5 mm screen with bottom catchpan and lid
Fisher burner
Asbestos glove
Exhaust hood
Thermometer (to 200 C)
500 ml Erlenmeyer flasks (50)
1 liter volumetric flasks (3)
100 ml volumetric flask (1)
250 ml graduated cylinder (1)
100 ml graduated cylinder (1)
20 ml pipette (2)
10 ml pipette (2)
5 ml pipette (1)
Measuring spatulas
Wax paper
Plastic water bottle with squirt nozzle
50 ml burettes (2) with stand
Magnetic stirring plate
Eye dropper
Protective gloves and goggles and lab coat
Steam distilled water

Reagents:

1. Potassium dichromate solution, 1 ON. Dissolve 49.04of dry reagent grade potassium dichromate ($K_2Cr_2O_7$) is distilled water and dilute to 1 liter in volumetric flask.

2. Sulfuric acid-silver sulfate solution. Dissolve 25.00 g of reagent grade silver sulfate (Ag_2SO_4) in 1 liter of technical grade (reagent grade preferred) concentrated 36N (93%) sulfuric acid.

3. Ortho-phenanthroline ferrous sulfate indicator solution. Dissolve 1.485 g of 1,10-phenanthroline monohydrate and 0.695 g of ferrous sulfate ($FeSO_4$) in distilled water and dilute to 100 ml in vol. flask.

4. Ferrous sulfate solution 0.5N. Dissolve 140.00 g of ferrous sulfate ($FeSO_4 . 7H_2O$) in distilled water, add 15 ml concentrated H_2SO_4 and dilute to 1 liter in volumetric flask.

Procedure:

All references to water mean distilled water.
All glassware was rinsed three times with distilled water between each use.
All weight measurements were made to hundredths of a gram (except Reagent 3 which was measured to thousandths).
Burettes were marked to tenths of a milliliter and read to hundredths.

1. Prepare reagents (using magnetic stirring plate).

2. Lay out about 10 g of each soil sample on waxed paper, mark with sample number and air dry overnight.

3. Grind soil to pass through 0.5 mm screen.

4. Weigh 5.00 g of soil into 500 ml Erlenmeyer flask and mark with sample number.

5. Add 10 ml potassium dichromate solution (Reagent 1) by pipette.

6. Add 20 ml sulfuric acid-silver sulfate solution (Reagent 2) by pipette.

7. Swirl and heat over Fisher burner under hood to reach a temperature of 150 C in one minute. With a blue flame this result may be reached by swirling the flask about 1-1/2 inches above the burner and the desired temperature is reached when the solution just brizzles (foams) prior to boiling. The proper distance to hold the flask above the burner may be determined by running a few trials checking the time and temperature on each.

8. Remove from heat and cool.

9. Add approximately 200 ml of water.

10. Add 6 drops of ortho-phenanthroline ferrous sulfate solution (Reagent 3). 6 drops were added instead of 3 to 4 called for in the procedure because it resulted in a more distinct endpoint without filtering. The blanks were also standardized using the 6 drops of indicator.

11. Titrate from a 50 ml burette with ferrous sulfate solution (Reagent 4) to a sharp red endpoint. Actually sharp red was not alwoays visible though a distinct color change did occur. The finer grained the soil, the less visible was the true red color. Each sample followed a consistent color change sequence prior to the endpoint; orange to light green to dark green to aquamarine to the reddish brown endpoint. Record ml titration as "A"

12. Standardize ferrous sulfate solution for each set of samples by running a blank (a flask without soil) through the procedure. Record ml titration as "B"

Calculations:*

$$\% \text{ organic matter} = (B-A) \times \frac{10}{B} \times 0.58/\text{g of soil used}$$

*Values that were less than zero percent (as low as -11%) were truncated to zero percent.

References:

California Soil Testing Procedures Manual. California Fertilizer Association. Sacramento.

APPENDIX VIII

Procedure for Determination of Soil Texture

6. Disconnect mixing cup and wash contents into soil cylinder with water and fill with more water to 1 liter mark on cylinder.

7. Plunge soil suspension 10 times (or 20 seconds) keeping plunger underwater and immediately record starting time.

8. Place hydrometer in cylinder at least one minute prior to taking a reading to let hydrometer stabilize.

9. Record hydrometer reading at 4 minutes (E) and at 2 hours (F) from starting time.

10. After 4 minute reading, remove hydrometer and rinse with water.

11. Repeat this procedure for each sample.

Calculations:

% gravel = visual estimate of % gravel in sample

$$\% \text{ sand} = 100 - [\,100\,(E - 6.5 + T) / 50\,]\ \ \% S$$

$$\% \text{ clay} = 100\ \ [(F - 6.5 + T) / 50\,]\ \ \% S$$

$$\% \text{ silt} = [\,100 - (\% \text{ sand} + \% \text{ clay})\,]\ \ \% S$$

Where:
E = 4 minute hydrometer reading
F = 2 hour hydrometer reading
% S = % of sample not containing gravel; 1 - gravel
T = temperature correction factor

T = 0.00 if temperature = 20° C
T = 0.72 if temperature = 22° C
T = 1.08 if temoerature = 23° C
T = 1.44 if temperature = 24° C

* Values that were greater than 100 percent sand (up to 113 %) and less than zero percent silt and clay (as low as - 12 %) were truncated to 100 percent and zero percent respectively. These outlying values fall within the 25 % margin of error that is associated with this method when it is used on soils that are low in clay content (16).

References:

Bouyoucos, G.J. 1962. Hydrometer method improved for making particle size analyses of soils. Agronomy Journal 54: 464-465.

APPENDIX IX

Cumulative Amount of Pesticide Applied to the Soil Surface

APPENDIX IX

CUMULATIVE AMOUNT OF PESTICIDE APPLIED TO THE SOIL SURFACE

(Pesticide applied to the specific area of the soil surface encompassed by the drilling operation based on all known previous applications of the pesticide.)

Total µg pesticide = (µg pesticide applied to soil surface in one application) x (number of applications)

Where:

µg pesticide in one application = (soil surface area) x (active ingredient pesticide applied/acre)

Soil surface area = $(\pi r^2)/43{,}560$ sq. ft.

Active ingredient applied/acre for DBCP, EDB, and carbofuran = $V \times D \times 10$

Active ingredient applied/acre for simazine = $W \times 453.592$ g $\times 10$

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r = radius
V = volume (ml) of active ingredient applied/acre
D = density (g/ml) of active ingredient
W = weight (lb) of active ingredient applied/acre

Densities:

DBCP	2.08	g/ml
EDB	2.172	g/ml
Carbofuran	1.18	g/ml

Active ingredient applied/acre at each site:

D-0	4	gal	(15,140 ml)
D-1	2.4	gal	(9,084 ml)
E-0	6.72	gal	(25,435 ml)
E-1	4.2	gal	(15,897 ml)
S-0	2.8	gal	
S-1	1.2	lb	
C-0	0.0508	gal	(192.3 ml)

APPENDIX X

Total Amount of Pesticide in the Soil Profile (Theoretical)

TOTAL AMOUNT OF PESTICIDE IN THE SOIL PROFILE
(Theoretical)

(Based on pesticide detected in samples from soil segments)

Total µg in soil column = sum of the µg in the soil segments.

Where:

µg in a soil segment = ppb x 10^{-3} x mass of segment

Mass = (density) x (volume)

Volume = (πr^2) x (D)/0.061

Density = (dSA x %SA)+(dSI x %SI)+(dCL x %CL)+(dGV x %GV)

r = radius of sampling tube (2.5 in)
D = length of segment (in)

dSA = bulk density of sand (1.48 g/cm)
%SA = percent sand in segment

dSI = bulk density of silt (1.22 g/cm)
%SI = percent silt in segment

dCL = bulk density of clay (1.05 g/cm)
%CL = percent clay in segment

dGV = bulk density of gravel (1.65 g/cm)
%GV = percent gravel in segment

APPENDIX XI

Calculation of Textural Classes and Percolation Rates

CALCULATION OF TEXTURAL CLASSES AND PERCOLATION RATES.

Soil morphology analysis results were the basis for the textural classification and percolation rate of each soil segment. The USDA recognizes 12 dominant soil textures. Information on expected percolation rates, or permeabilities, associated with soil textures was obtained from the USDA Soil Conservation Survey of the Eastern Fresno area. Segments were also classified into 3 general textures (sand, silt, or clay) for statistical purposes.

Percolation Class	Average Perc.	Percolation (in/hr)	General Texture	Dominant USDA Texture
1	0.025	< 0.05	Clay	Clay, Silty clay
2	0.125	0.05 - 0.20	Clay	Sandy clay
3	0.50	0.20 - 0.80	Silt	Sandy clay Loam, Silt, Silt loam
4	1.35	0.20 - 2.50	Silt	Silty clay Loam, Clay loam
5	1.65	0.80 - 2.50	Silt	Loam
6	3.75	2.50 - 5.00	Sand	Sandy loam
7	7.50	5.00 - 10.0	Sand	Loamy sand
8	20	> 20.0	Sand	Sand

APPENDIX XII

Description and Calculation of Soil Profile Totals

Table 17. Soil profile totals

Variable	D-0	D-1	E-1	E-0	S-1	S-0	C-0
µg pesticide (a)	0.0	0.0	0.084	85.24	384.32	0.0	0.0
% sand (a)	92.89	66.89	95.35	93.73	60.99	76.48	89.51
% silt (a)	5.04	25.15	2.51	4.65	3.45	12.41	8.32
% clay (a)	1.55	7.86	2.14	1.62	4.56	9.21	2.17
% gravel (a)	0.52	0.00	0.00	0.00	30.99	1.89	0.00
% moisture (b)	0.0965	0.1308	0.0602	0.0809	0.1233	0.1400	0.0858
% organic matter (c)	0.00172	0.00115	0.00049	0.00023	0.00062	0.00105	0.00409
Average percolation (d)	>20	3.7	>20	>20	>20	3.7	>20
Elapsed time (yrs) (e)	5	5	2	0	0	2	1
% sand:silt interfaces (f)	0	33	0	0	50	43	50
% sand:clay interfaces (f)	0	11	0	0	0	0	0
% silt:sand interfaces (f)	0	33	0	0	50	29	50
% silt:clay interfaces (f)	0	6	0	0	0	14	0
% clay:sand interfaces (f)	0	11	0	0	0	14	0
% clay:silt interfaces (f)	0	6	0	0	0	0	0

DESCRIPTION AND CALCULATION OF SOIL PROFILE TOTALS

a/ quantities expressed as percentages of concentrations are relative to the total mass of the soil in the soil profile.

b/ % moisture in soil profile =

$$\frac{\text{sum of moisture (grams) in each of the segments}}{\text{total mass of soil profile}}$$

grams moisture in segment = volume x dS x %SM

Where: Volume = volume of segment
dS = density of soil segment
%SM = percent soil moisture in segment

c/ % organic matter in soil profile =

$$\frac{\text{sum of organic matter (grams) in each of the segments}}{\text{total mass of soil profile}}$$

grams organic matter in segment = volume x dS x %OM

Where: Volume = volume of segment
dS = density of soil segment.
%OM = percent organic matter in segment

d/ Average percolation was calculated by determining an average value for each percolation class (see Appendix XI), and obtaining the mean percolation of all core segments.

e/ Elapsed time is the number of whole years since the last known pesticide application.

f/ Textural interfaces are defined as the junction of two out of the three general soil types considered; sand, silt, or clay. Percentages of each type of interface was recorded for each site.

d/ Average percolation was calculated by determining an average value for each percolation class (see Appendix XI), and obtaining the mean percolation of all core segments.

e/ Elapsed time is the number of whole years since the last known pesticide application.

f/ Textural interfaces are defined as the junction of two out of the three general soil types considered; sand, silt, or clay. Percentages of each type of interface was recorded for each site.

APPENDIX XIII

Principal Component Analyses

Table 18. Principal component analysis of soil segments at site D-0[a]

Variable	Principal Component (Factor) 1	2	3	4	5	6	7
% Moisture	-0.353[b]	0.132	0.916	-0.127	0.045	-0.009	-0.000
Percolation rate	0.881	-0.320	-0.210	0.018	0.018	0.276	-0.001
% Organic matter	-0.026	0.018	0.036	-0.054	0.997	0.002	-0.000
% Sand	0.868	-0.430	-0.229	-0.014	-0.043	-0.078	0.042
% Silt	-0.947	0.130	0.245	-0.110	0.042	0.106	0.027
% Clay	-0.448	0.880	0.133	-0.078	0.024	-0.018	0.002
% Gravel	0.049	-0.052	-0.101	0.991	-0.055	-0.000	-0.001
Eigenvalues	2.755	1.099	1.025	1.019	1.004	0.094	0.002
% of variance	39.37	15.70	14.65	14.56	14.35	1.34	0.03
Cumulative % of variance	39.37	55.07	69.72	84.28	98.63	99.97	100.00

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[a] 83% of the soil profile is represented in this analysis. Soil segments with incomplete data sets were not included in this analysis.

[b] Rotated factor loadings.

Table 19. Correlations among variables measured in soil segments at site D-O[a/]

Variables	% Moisture	Percolation rate	% Organic matter	% Sand	% Silt	% Clay	% Gravel
% Moisture	1.000						
Percolation rate	-0.550	1.000					
% Organic matter	0.097	-0.019	1.000				
% Sand	-0.572	0.928	-0.081	1.000			
% Silt	0.591	-0.900	0.084	-0.941	1.000		
% Clay	0.407	-0.710	0.061	-0.796	0.579	1.000	
% Gravel	-0.246	0.098	-0.114	0.077	-0.189	-0.610	1.000

---

a/ 83% of the soil profile is represented in this analysis. Soil segments with incomplete data sets were not included in this analysis.

Table 20. Principal component analysis of soil segments at site D-1[a/]

	Principal Component (Factor)				
Variable	1	2	3	4	5
% Moisture	0.222[b/]	-0.052	0.955	-0.191	-0.016
Percolation rate	-0.664	-0.662	-0.200	0.035	0.283
% Organic matter	-0.032	-0.018	-0.170	0.985	0.003
% Sand	-0.722	-0.687	-0.082	0.030	-0.016
% Silt	0.945	0.216	0.242	-0.040	0.012
% Clay	0.215	0.968	-0.127	-0.008	0.015
Eigenvalues	1.951	1.896	1.061	1.010	0.081
% of variance	32.52	31.61	17.69	16.83	1.35
Cumulative % of variance	32.52	64.13	81.82	98.65	100.00

[a/] 60% of the soil profile is represented in this analysis. Soil segments with incomplete data sets were not included in this analysis.

[b/] Rotated factor loadings.

Table 21. Correlations among variables measured in soil segments at site D-1[a/]

Variables	% Moisture	Percolation rate	% Organic matter	% Sand	% Silt	% Clay
% Moisture	1.000					
Percolation rate	-0.315	1.000				
% Organic matter	-0.357	0.103	1.000			
% Sand	-0.208	0.946	0.079	1.000		
% Silt	0.437	-0.817	-0.115	-0.852	1.000	
% Clay	-0.122	0.383	-0.011	-0.810	0.383	1.000

a/ 60% of the soil profile is represented in this analysis. Soil segments with incomplete data sets were not included in this anlaysis.

Table 22. Principal component analysis of soil segments at site E-0[a]

Variable	Principal Component (Factor) 1	2	3	4	5	6
% Moisture	0.468[b]	0.373	-0.060	0.782	-0.165	-0.000
Percolation rate	-0.663	-0.289	0.051	-0.239	0.646	0.000
% Organic matter	-0.001	0.036	0.999	-0.028	0.017	-0.000
% Sand	-0.812	-0.457	-0.021	-0.309	0.187	0.025
% Silt	0.909	0.245	0.000	0.285	-0.180	0.014
% Clay	0.372	0.868	0.063	0.282	-0.158	0.001
Eigenvalues	2.284	1.246	1.008	0.925	0.537	0.001
% of variance	38.06	20.77	16.80	15.41	8.95	0.01
Cumulative % of variance	38.06	58.83	75.63	91.04	99.99	100.00

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[a] 86% of the soil profile is represented in this analysis. Soil segments with incomplete data sets were not included in this analysis.

[b] Rotated factor loadings.

Table 23. Correlations among variables measured in soil segments at site E-O[a]

Variables	% Moisture	Percolation rate	% Organic matter	% Sand	% Silt	% Clay
% Moisture	1.000					
Percolation rate	-0.715	1.000				
% Organic matter	-0.072	0.059	1.000			
% Sand	-0.822	0.864	-0.025	1.000		
% Silt	0.769	-0.858	-0.003	-0.972	1.000	
% Clay	0.741	0.660	0.083	-0.817	0.660	1.000

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[a] 86 % of the soil profile is represented in this analysis. Soil segments with incomplete data sets were not included in this analysis.

Table 24. Principal component analysis of soil segments at site E-1[a/]

	Principal Component (Factor)					
Variable	1	2	3	4	5	6
% Moisture	-0.281[b/]	0.943	-0.119	0.132	0.013	-0.001
Percolation rate	0.963	-0.131	0.073	-0.121	0.188	-0.010
% Organic matter	0.007	-0.079	0.997	0.007	0.005	-0.000
% Sand	0.804	-0.451	-0.027	-0.372	-0.096	0.035
% Silt	-0.914	0.324	0.037	0.094	0.221	0.002
% Clay	-0.636	0.515	0.024	0.574	-0.012	0.005
Eigenvalues	2.893	1.486	1.016	0.510	0.094	0.001
% of variance	48.21	24.77	16.93	8.50	1.57	0.02
Cumulative % of variance	48.21	72.98	89.91	98.41	99.98	100.00

[a/] 89% of the soil profile is represented in this analysis. Soil segments with incomplete data sets were not included in this analysis.

[b/] Rotated factor loadings.

Table 25. Correlations among variables measured in soil segments at site E-1[a/]

Variables	% Moisture	Percolation rate	% Organic matter	% Sand	% Silt	% Clay
% Moisture	1.000					
Percolation rate	-0.417	1.000				
% Organic matter	-0.194	0.090	1.000			
% Sand	-0.698	0.858	0.011	1.000		
% Silt	0.573	-0.890	0.006	-0.939	1.000	
% Clay	0.737	-0.750	-0.018	-0.957	0.800	1.000

[a/] 89% of the soil profile is represented in this analysis. Soil segments with incomplete data sets were not included in this analysis.

Table 26 . Principal component analysis of soil segments at site S-0[a/]

	Principal Component (Factor)					
Variable	1	2	3	4	5	6
% Moisture	-0.317	0.266	-0.102	0.893	-0.143	0.004
Percolation rate	0.935	-0.225	-0.777	-0.175	-0.001	0.197
% Organic matter	-0.015	0.015	-0.060	-0.102	0.993	0.001
% Sand	0.706	-0.617	-0.231	-0.243	0.001	-0.094
% Silt	-0.355	0.875	-0.208	0.253	0.021	0.203
% Clay	-0.903	0.244	-0.169	0.235	0.021	0.203
% Gravel	-0.009	-0.084	0.991	-0.078	-0.061	-0.007
Eigenvalues	2.414	1.335	1.128	1.023	1.011	0.090
% of variance	34.48	19.07	16.11	14.61	14.44	1.29
Cumulative % of variance	34.48	53.56	69.67	84.28	98.72	100.00

[a/] 85% of the soil profile is represented in this analysis. Soil segments with incomplete sets were not included in this analysis.

Table 27. Correlations among variables measured in soil segments of site S-0[a/]

Variables	% Moisture	Percolation rate	% Organic matter	% Sand	% Silt	% Clay	% Gravel
% Moisture	1.000						
Percolation rate	-0.503	1.000					
% Organic matter	-0.218	0.004	1.000				
% Sand	-0.581	0.840	0.019	1.000			
% Silt	0.588	-0.561	0.031	-0.802	1.000		
% Clay	0.576	-0.887	0.024	-0.825	0.625	1.000	
% Gravel	-0.182	-0.054	-0.113	-0.164	-0.298	-0.201	1.000

[a/] 73% of the soil profile is represented in this analysis. Soil segments with incomplete data sets were not included in this analysis.

Table 28. Principal component analysis of soil segments at site S-1.[a]

	Principal Component (Factor)						
Variable	1	2	3	4	5	6	7
% Moisture	0.023[b]	0.022	-0.175	0.984	0.002	0.009	-0.000
Percolation rate	-0.502	0.763	-0.197	0.031	0.353	-0.034	0.002
% Organic matter	0.181	0.009	0.965	-0.189	-0.022	0.006	-0.001
% Sand	-0.367	0.927	0.006	-0.001	-0.014	-0.026	0.068
% Silt	0.963	-0.084	0.121	-0.059	0.005	-0.218	-0.009
% Clay	0.938	-0.077	0.163	0.099	-0.076	0.270	-0.009
% Gravel	-0.327	-0.936	-0.085	-0.023	0.057	-0.036	0.065
Eigenvalues	2.334	2.332	1.049	1.019	0.135	0.123	0.009
% of variance	33.34	33.30	14.98	14.56	1.93	1.76	0.13
Cumulative % of variance	33.34	66.64	81.62	96.18	98.11	99.87	100.00

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[a] 73% of the soil profile is represented in this analysis. Soil segments with incomplete data sets were not included in this analysis.

[b] Rotated factor loadings.

Table 29. Correlations among variables measured in soil segments at site S-1[a]

Variables	% Moisture	Percolation rate	% Organic matter	% Sand	% Silt	% Clay	% Gravel
% Moisture	1.000						
Percolation rate	0.070	1.000					
% Organic matter	-0.350	-0.287	1.000				
% Sand	0.009	0.887	-0.052	1.000			
% Silt	-0.060	-0.565	0.300	-0.426	1.000		
% Clay	0.091	-0.595	0.311	-0.421	0.864	1.000	
% Gravel	-0.036	-0.512	-0.147	-0.744	-0.238	-0.265	1.000

---

a/ 73% of the soil profile is represented in this analysis. Soil segments with incomplete data sets were not included in this analysis.

Table 30. Principal component analysis of soil segments at site C-0[a]

	Principal Component (Factor)					
Variable	1	2	3	4	5	6
% Moisture	-0.350	0.134	0.186	0.906	-0.065	-0.000
Percolation rate	0.645	-0.517	-0.115	-0.221	0.504	0.000
% Organic matter	0.029	0.150	0.977	0.145	-0.029	-0.000
% Sand	0.882	-0.388	-0.007	-0.257	0.075	0.029
% Silt	-0.959	0.098	0.051	0.252	-0.068	0.019
% Clay	-0.244	0.945	0.176	0.111	-0.072	-0.001
Eigenvalues	2.296	1.360	1.036	1.032	0.275	0.001
% of variance	38.27	22.67	17.26	17.20	4.58	0.02
Cumulative % of variance	38.27	60.94	78.20	95.40	99.98	100.00

[a] 86% of the soil profile is represented in this analysis. Soil segments with incomplete data sets were not included in this analysis.

[b] Rotated factor loadings.

Table 31. Correlations among variables measured in soil segments at site C-0[a/]

Variables	% Moisture	Percolation rate	% Organic matter	% Sand	% Silt	% Clay
% Moisture	1.000					
Percolation rate	-0.550	1.000				
% Organic matter	0.325	-0.218	1.000			
% Sand	-0.600	0.865	-0.079	1.000		
% Silt	0.572	-0.753	-0.024	-0.952	1.000	
% Clay	0.350	-0.727	0.325	-0.616	0.350	1.000

[a/] 77% of the soil profile is represented in this analysis. Soil segments with incomplete data sets were not included in this analysis.

2-003	0.00	08.31	00	91.8	05.9	02.2	4.415	012-018	8
2-004	0.00	08.50	00	91.8	05.9	02.2	4.534	018-024	8
2-005	0.00	------	00	91.8	05.9	02.2	------	024-030	8
2-006	0.00	08.43	00	93.8	03.9	02.2	5.191	030-036	8
2-007	0.00	08.14	00	93.8	03.9	02.2	4.117	036-042	8
2-008	0.00	11.23	00	95.8	01.9	02.2	1.955	042-048	8
2-009	0.00	09.10	00	91.8	07.9	00.2	2.923	048-054	8
2-010	0.00	------	00	93.8	03.9	02.2	1.222	054-060	8
2-011	0.00	07.86	00	91.8	05.9	02.2	1.512	060-066	8
2-012	0.00	07.55	00	93.8	05.9	00.2	2.118	066-072	8
2-013	0.00	07.41	00	93.8	03.9	02.2	1.864	072-078	8
2-014	0.00	11.90	00	87.8	09.9	02.2	21.85	078-084	8
2-015	0.00	------	---	-----	-----	-----	------	084-090	-
2-016	0.00	------	00	63.8	29.9	6.16	1.902	090-096	6
2-017	0.00	16.34	00	79.8	17.9	02.2	1.252	096-102	7
2-018	0.00	------	---	-----	-----	-----	------	102-108	-
2-019	0.00	15.42	00	83.8	13.9	02.2	1.796	120-126	7
2-020	0.00	06.32	00	93.8	05.9	00.2	1.536	126-132	8
2-021	0.00	10.38	00	95.8	03.9	00.2	2.148	132-138	8

Sample number	DBCP concentration (ppb)	% Moisture	% Gravel	% Sand	% Silt	% Clay	% Organic matter	Depth (inches)	Percolation class
2-022	0.00	10.74	00	95.8	03.9	00.2	1.640	138-144	8
2-023	0.00	06.98	00	------	------	------	.5653	144-150	8
2-024	0.00	05.89	00	97.8	01.9	00.2	1.585	150-156	8
2-025	0.00	05.90	00	100.	0.00	0.00	1.102	156-162	8
2-026	0.00	------	01	94.8	5.93	0.00	------	162-168	8
2-027	0.00	------	------	------	------	------	------	186-192	-
2-028	0.00	05.46	00	100.	0.00	0.00	------	192-198	8
2-029	0.00	04.89	00	99.8	0.00	00.2	4.699	198-204	8
2-030	0.00	04.62	00	97.8	03.9	0.00	1.551	204-210	8
2-031	0.00	07.94	00	99.8	01.9	0.00	------	210-216	8
2-032	0.00	07.64	00	100.	01.9	0.00	1.074	216-222	8
2-033	0.00	07.29	01	98.8	1.97	0.00	.9994	222-228	8
2-034	0.00	------	00	100.	01.9	0.00	------	228-234	8
2-035	0.00	08.88	01	96.8	1.97	.158	.0916	240-246	8
2-036	0.00	05.56	00	100.	0.00	0.00	.1986	246-252	8
2-037	0.00	04.82	01	98.8	0.00	.158	1.551	252-258	8
2-038	0.00	05.61	00	97.8	01.9	00.2	.9494	258-264	8
2-039	0.00	06.04	01	94.8	5.93	0.00	2.416	270-276	8
2-040	0.00	05.34	08	91.8	0.00	.147	1.192	276-282	8
2-041	0.00	06.30	02	99.8	0.00	0.00	.1833	282-288	8

Sample number	DBCP concentration (ppb)	% Moisture	% Gravel	% Sand	% Silt	% Clay	% Organic matter	Depth (inches)	Percolation class
2-042	0.00	09.50	00	93.8	01.9	4.16	2.267	288-294	8
2-043	0.00	12.22	00	91.8	0.00	8.16	3.028	300-306	8
2-044	0.00	14.85	00	89.8	03.9	6.16	2.700	306-312	8
2-045	0.00	20.10	00	73.8	23.9	02.2	.1833	312-318	7
2-046	0.00	16.07	00	67.8	21.9	10.1	13.18	318-324	6
2-047	0.00	12.98	00	77.8	11.9	10.1	1.805	330-338	7
2-048	0.00	10.86	00	81.8	07.9	10.1	.7486	338-345	7
2-049	0.00	10.97	00	85.8	03.9	10.1	1.917	345-348	8
2-050	0.00	24.17	00	49.8	35.9	14.1	0.000	360-366	5
2-051	0.00	13.77	00	87.8	09.9	02.2	1.685	366-372	8
2-052	0.00	14.92	00	95.8	05.9	0.00	1.344	372-378	8
2-053	0.00	19.01	00	97.8	01.9	00.2	1.581	378-384	8
2-054	0.00	17.95	00	97.8	01.9	00.2	.9208	384-390	8
2-055	0.00	24.55	00	97.8	01.9	00.2	.9398	390-396	8

Sample number	DBCP concentration (ppb)	% Moisture	% Gravel	% Sand	% Silt	% Clay	% Organic matter	Depth (inches)	Percolation class
3-001	0.00	1.667	00	74.1	17.9	7.88	24.51	000-004	7
3-002	0.00	1.714	00	60.1	35.9	3.88	8.997	004-009	6
3-003	0.00	1.916	00	80.1	15.9	3.88	5.706	009-014	7
3-004	0.00	6.473	00	80.1	13.9	5.88	7.382	014-019	7
3-005	0.00	2.287	00	00.0	30.0	70.0	4.418	019-024	2
3-006	0.00	2.165	00	--------	--------	--------	10.49	024-030	-
3-007	0.00	2.331	00	80.1	15.9	3.88	--------	030-036	7
3-008	0.00	2.417	00	82.1	11.9	5.88	4.574	036-042	7
3-009	0.00	--------	--------	--------	--------	--------	--------	042-044	--
3-010	0.00	2.880	00	00.0	40.0	60.0	3.970	044-046	2
3-011	0.00	2.843	00	80.1	15.9	3.88	4.589	046-052	7
3-012	0.00	--------	--------	--------	--------	--------	--------	052-054	--
3-013	0.00	3.809	00	00.0	70.0	30.0	1.412	054-060	4
3-014	0.00	4.210	00	92.1	5.99	1.88	1.751	060-066	8
3-015	0.00	18.38	00	38.1	55.9	5.88	2.324	066-072	3
3-016	0.00	--------	--------	--------	--------	--------	--------	072-074	--
3-017	0.00	--------	00	64.1	31.9	3.88	2.385	074-080	6
3-018	0.00	6.428	00	80.1	15.9	3.88	2.732	080-086	7
3-019	0.00	16.87	00	36.1	39.9	23.8	1.705	086-092	5
3-020	0.00	--------	--------	--------	--------	--------	--------	092-094	-
3-021	0.00	--------	00	62.1	29.9	7.88	4.242	094-100	6

Sample number	DBCP concentration (ppb)	% Moisture	% Gravel	% Sand	% Silt	% Clay	% Organic matter	Depth (inches)	Percolation class
3-022	0.00	14.10	00	74.1	13.9	11.8	.8806	100-106	7
3-023	0.00	6.061	00	90.1	9.99	0.00	1.343	106-112	8
3-024	0.00	------	--	------	------	------	------	112-114	-
3-025	0.00	8.125	00	80.1	17.9	1.88	1.177	114-120	7
3-026	0.00	8.932	00	70.1	19.9	9.88	1.351	120-126	7
3-027	0.00	7.388	00	80.1	15.9	3.88	1.690	126-132	7
3-028	0.00	------	--	------	------	------	------	132-134	-
3-029	0.00	24.93	00	26.1	51.9	21.8	2.883	134-140	3
3-030	0.00	15.52	00	80.1	15.9	3.88	2.370	146-152	7
3-032	0.00	19.56	00	60.1	25.9	13.8	1.781	154-160	6
3-033	0.00	------	00	68.1	21.9	9.88	1.781	160-166	6
3-034	0.00	------	--	------	------	------	------	166-174	-
3-035	0.00	------	00	62.1	25.9	11.8	2.339	174-180	6
3-036	0.00	4.909	00	62.1	29.9	7.88	2.173	180-186	6
3-037	0.00	31.17	00	38.1	45.9	15.8	2.370	186-192	5
3-038	0.00	------	--	------	------	------	------	192-194	-
3-039	0.00	26.51	00	14.1	43.9	41.8	1.494	194-200	1
3-040	0.00	33.33	00	26.1	57.9	15.8	3.457	200-206	3
3-041	0.00	------	00	84.1	11.9	3.88	1.932	206-212	7
3-042	0.00	------	--	------	------	------	------	212-214	-

Sample number	DBCP concentration (ppb)	% Moisture	% Gravel	% Sand	% Silt	% Clay	% Organic matter	Depth (inches)	Percolation class
3-043	0.00	23.27	00	46.1	47.9	5.88	------	214-220	5
3-044	0.00	20.01	00	98.1	1.99	0.00	1.102	220-226	8
3-045	0.00	26.90	00	98.1	1.99	0.00	1.108	226-232	8
3-046	0.00	------	------	------	------	------	------	232-234	-
3-047	0.00	30.59	00	66.1	29.9	3.88	1.434	234-240	6
3-048	0.00	32.48	00	48.1	47.9	3.88	2.521	240-246	5
3-049	0.00	------	------	------	------	------	------	246-254	-
3-050	0.00	30.37	00	30.1	61.9	7.88	.5921	254-260	3
3-051	0.00	31.64	00	46.1	47.9	5.88	3.260	260-266	5
3-052	0.00	29.85	00	66.1	29.9	3.88	2.565	266-272	6
3-053	------	------	------	------	------	------	------	272-274	-
3-054	------	------	------	------	------	------	------	274-280	-
3-055	------	------	------	------	------	------	------	280-286	-

Sample number	EDB concentration (ppb)	% Moisture	% Gravel	% Sand	% Silt	% Clay	% Organic matter	Depth (inches)	Percolation class
4-001	0.00	3.007	00	96.1	1.99	1.88	3.934	000-006	8
4-002	0.00	2.459	00	98.1	0.00	1.88	2.900	006-012	8
4-003	0.00	2.375	00	96.1	1.99	1.88	7.048	012-018	8
4-004	0.00	3.050	00	96.1	3.99	0.00	2.763	020-026	8
4-005	0.00	4.036	00	96.1	3.99	0.00	2.262	026-032	8
4-006	0.00	2.838	00	98.1	1.99	0.00	4.463	032-040	8
4-007	0.15	3.691	00	98.1	1.99	0.00	1.698	040-046	8
4-008	0.00	2.965	00	98.1	0.00	1.88	1.147	046-052	8
4-009	0.00	2.711	00	96.1	1.99	1.88	1.639	052-060	8
4-010	0.00	3.135	00	96.1	3.99	0.00	1.381	060-066	8
4-011	0.00	2.923	00	98.1	1.99	0.00	1.132	066-072	8
4-012	0.00	2.796	00	-----	-----	-----	.5513	080-086	-
4-013	0.00	3.519	00	96.1	1.99	1.88	.3725	086-092	8
4-014	0.00	10.47	00	68.1	17.9	13.8	.0607	092-098	6
4-015	0.00	9.170	00	80.1	11.9	7.88	1.897	100-106	7
4-016	0.00	6.518	00	90.1	5.99	3.88	.4403	106-112	8
4-017	0.00	5.663	00	96.1	1.99	1.88	.7086	112-120	8
4-018	0.00	5.174	00	98.1	0.00	1.88	------	120-126	8
4-019	0.00	3.820	00	98.1	1.99	0.00	.5364	126-132	8
4-020	0.00	3.777	00	98.1	1.99	0.00	1.245	132-140	8
4-021	0.00	3.993	00	-----	-----	-----	.1214	140-146	-

Sample number	EDB concentration (ppb)	% Moisture	% Gravel	% Sand	% Silt	% Clay	% Organic matter	Depth (inches)	Percolation class
4-022	0.00	4.471	00	100.	0.00	0.00	.3188	146-152	8
4-023	0.00	2.880	00	98.1	1.99	0.00	.8198	160-166	8
4-024	0.00	2.753	00	100.	0.00	0.00	.2086	166-162	8
4-025	0.00	2.796	00	100.	0.00	0.00	.1214	172-180	8
4-026	0.00	3.348	00	100.	0.00	0.00	.1062	180-186	8
4-027	0.00	3.648	00	98.1	1.99	0.00	1.229	186-192	8
4-028	0.00	3.605	00	100.	0.00	0.00	0.000	192-200	8
4-029	0.00	3.135	00	100.	1.99	0.00	1.973	200-206	8
4-030	0.00	3.092	00	100.	0.00	0.00	1.047	206-212	8
4-031	0.00	2.459	00	100.	0.00	0.00	.8654	212-218	8
4-032	0.00	3.135	00	100.	0.00	0.00	.1973	220-226	8
4-033	0.00	3.050	00	100.	0.00	0.00	0.000	226-232	8
4-034	0.00	3.648	00	100.	0.00	0.00	0.000	232-240	8
4-035	0.00	4.558	00	98.1	0.00	1.88	1.654	240-246	8
4-036	0.00	10.52	00	86.1	3.99	9.88	.1490	246-252	8
4-037	0.00	12.00	00	80.1	7.99	11.8	1.245	252-260	7
4-038	0.11	10.66	00	80.1	7.99	11.8	1.670	260-266	7
4-039	0.00	10.18	00	80.1	9.99	9.88	.6557	266-272	7
4-040	0.00	10.61	00	82.1	7.99	9.88	.7743	272-280	7
4-041	0.00	10.66	00	86.1	3.99	9.88	1.867	280-286	8
4-042	0.00	12.76	00	86.1	3.99	9.88	1.791	286-292	8

Sample number	EDB concentration (ppb)	% Moisture	% Gravel	% Sand	% Silt	% Clay	% Organic matter	Depth (inches)	Percolation class
4-043	0.00	13.99	00	88.1	3.99	7.88	1.503	292-300	8
4-044	0.00	15.58	00	92.1	3.99	3.88	.5215	300-306	8
4-045	0.00	14.88	00	96.1	1.99	1.88	.1670	306-312	8
4-046	0.00	14.46	00	94.1	3.99	1.88	.3188	312-320	8

5-002	01.1	3.391	00	92.1	3.99	3.88	11.19	006-012	8
5-003	00.0	3.777	00	96.1	3.99	0.00	0.000	020-026	8
5-004	00.0	3.734	00	96.1	1.99	1.88	.3099	026-032	8
5-005	00.0	4.036	00	96.1	1.99	1.88	.3099	032-040	8
5-006	00.0	4.297	00	90.1	7.99	1.88	.0309	040-046	8
5-007	00.0	4.340	00	96.1	3.99	0.00	.4649	046-052	8
5-008	00.0	4.427	00	96.1	1.99	1.88	0.000	052-060	8
5-009	00.0	3.950	00	98.1	0.00	1.88	1.698	060-066	8
5-010	00.0	4.123	00	98.1	0.00	1.88	0.000	066-072	8
5-011	00.0	2.965	00	98.1	1.99	0.00	0.000	072-080	8
5-012	00.0	3.863	00	100.	0.00	0.00	0.000	080-086	8
5-013	00.0	3.820	00	100.	0.00	0.00	.0745	086-092	8
5-014	00.0	3.434	00	100.	0.00	0.00	0.000	092-100	8
5-015	00.0	3.863	00	100.	0.00	0.00	.2533	100-106	8
5-016	00.0	3.562	00	98.1	1.99	0.00	2.324	106-112	8
5-017	00.0	3.906	00	100.	0.00	0.00	0.000	112-120	8
5-018	00.0	4.384	00	100.	0.00	0.00	0.000	120-126	8
5-019	00.0	3.476	00	98.1	1.99	0.00	.0149	126-132	8
5-020	00.0	4.123	00	98.1	1.99	0.00	0.000	132-140	8
5-021	00.0	4.602	00	100.	0.00	0.00	0.000	140-146	8

Sample number	EDB concentration (ppb)	% Moisture	% Gravel	% Sand	% Silt	% Clay	% Organic matter	Depth (inches)	Percolation class
5-022	00.0	3.906	00	98.1	1.99	0.00	0.000	146-152	8
5-023	00.0	3.648	00	100.	0.00	0.00	0.000	152-160	8
5-024	00.0	4.079	00	100.	0.00	0.00	.4023	160-166	8
5-025	00.0	3.263	00	96.1	3.99	0.00	0.000	166-172	8
5-026	00.0	3.906	00	100.	0.00	0.00	.0447	172-180	8
5-027	00.0	5.130	00	98.1	1.99	0.00	0.000	180-186	8
5-028	00.0	4.865	00	100.	0.00	0.00	.2169	186-192	8
5-029	00.0	4.733	00	100.	0.00	0.00	0.000	192-200	8
5-030	00.0	4.953	00	98.1	1.99	0.00	.2980	200-206	8
5-031	00.0	4.558	00	100.	0.00	0.00	0.000	206-212	8
5-032	00.0	4.340	00	100.	0.00	0.00	0.000	212-220	8
5-033	00.0	4.777	00	100.	0.00	0.00	0.000	220-226	8
5-034	00.1	5.708	00	100.	0.00	0.00	.5114	226-232	8
5-035	00.0	16.71	00	94.1	3.99	1.88	3.704	240-246	8
5-036	00.2	24.44	00	80.1	13.9	5.88	.5114	246-252	7
5-037	26.9	27.55	00	60.1	29.9	9.88	0.000	252-260	6
5-038	31.1	15.74	00	82.1	11.9	5.88	0.000	260-266	7
5-039	14.7	10.13	00	86.1	9.99	3.88	.4470	266-272	8
5-040	10.5	9.601	00	90.1	5.99	3.88	.0596	272-280	8
5-041	10.1	17.26	00	84.1	5.99	9.88	1.296	292-300	7
5-042	03.4	21.00	00	90.1	3.99	5.88	.9686	306-312	8
5-043	00.0	13.12	00	92.1	3.99	3.88	0.000	312-320	8

Sample number	EDB concentration (ppb)	% Moisture	% Gravel	% Sand	% Silt	% Clay	% Organic matter	Depth (inches)	Percolation class
5-044	00.0	11.74	00	90.1	5.99	3.88	.4339	320-326	8
5-045	00.0	12.10	00	88.1	3.99	7.88	0.000	326-332	8
5-046	01.4	25.18	00	80.1	11.9	7.88	.8989	332-340	7
5-047	01.6	-----	00	88.1	5.99	5.88	1.162	340-346	8
5-048	06.9	-----	00	88.1	5.99	5.88	1.415	346-352	8
5-049	05.7	18.82	00	88.1	5.99	5.88	0.000	352-360	8
5-050	00.0	14.73	00	90.1	7.99	1.88	0.000	360-366	8
5-051	00.0	6.837	00	96.1	1.99	1.88	0.000	366-372	8
5-052	00.2	9.122	00	90.1	5.99	3.88	0.000	372-378	8
5-053	00.0	12.05	00	82.1	11.9	5.88	0.000	378-380	7
5-054	00.0	13.07	00	80.1	17.9	1.88	0.000	380-386	7
5-055	00.0	13.27	00	80.1	15.9	3.88	.0298	386-392	7
5-056	00.0	15.52	00	76.1	19.9	3.88	0.000	400-406	7
5-057	00.0	9.457	00	88.1	7.99	3.88	0.000	406-412	8
5-058	00.0	11.20	00	90.1	5.99	3.88	0.000	412-420	8
5-059	01.4	-----	00	88.1	7.99	3.88	0.000	420-426	8
5-060	00.0	19.16	00	86.1	9.99	3.88	.5960	426-432	8
5-061	00.0	-----	00	48.1	41.9	9.88	.4768	440-446	5
5-062	00.0	21.18	00	70.1	25.9	3.88	0.000	446-452	7
5-063	00.0	15.04	00	96.1	3.99	0.00	0.000	460-466	8
5-064	00.0	8.038	00	98.1	1.99	0.00	0.000	466-472	8

Sample number	EDB concentration (ppb)	% Moisture	% Gravel	% Sand	% Silt	% Clay	% Organic matter	Depth (inches)	Percolation class
5-065	00.0	5.130	00	98.1	1.99	0.00	.8196	472-480	8
5-066	00.3	5.307	00	100.	0.00	0.00	.2086	480-486	8
5-067	00.0	7.020	00	98.1	1.99	0.00	0.000	486-492	8
5-068	00.0	15.58	00	72.1	21.9	5.88	.7004	492-500	7
5-069	00.0	21.18	00	76.1	21.9	1.88	0.000	500-506	7
5-070	00.0	18.25	00	80.1	13.9	5.88	.7439	506-512	7
5-071	00.0	11.01	00	82.1	11.9	5.88	.5066	520-526	7
5-072	00.0	.5631	00	86.1	7.99	5.88	.2533	526-532	8
5-073	00.0	11.80	00	90.1	7.99	1.88	0.000	532-540	8
5-074	00.0	8.038	00	94.1	5.99	0.00	0.000	540-546	8
5-075	00.0	4.297	00	98.1	0.00	1.88	0.000	546-552	8
5-076	00.0	2.501	00	100.	1.99	0.00	0.000	552-560	8
5-077	00.0	7.851	00	98.1	1.99	0.00	0.000	560-566	8
5-078	00.0	4.036	00	100.	0.00	0.00	.4470	566-572	8
5-079	00.0	3.605	00	100.	0.00	0.00	0.000	580-586	8
5-080	00.0	2.585	00	100.	0.00	0.00	.4917	586-592	8
5-081	00.0	2.923	00	100.	0.00	0.00	.2980	592-600	8
5-082	00.0	3.734	00	100.	1.99	0.00	0.000	600-606	8
5-083	00.0	7.343	00	100.	0.00	0.00	0.000	606-612	8

Sample number	Simazine concentration (ppb)	% Moisture	% Gravel	% Sand	% Silt	% Clay	% Organic matter	Depth (inches)	Percolation class
6-001	55.0	5.351	08	55.3	14.7	21.9	25.8	000-006	3
6-002	09.0	-----	-----	-----	-----	-----	-----	020-026	-
6-003	20.0	10.27	10	99.1	0.00	0.00	6.46	040-044	8
6-004	24.0	8.648	18	90.2	0.00	0.00	3.15	044-048	8
6-005	13.0	11.32	12	65.2	5.27	17.4	.519	060-066	6
6-006	03.0	9.793	18	68.9	6.55	6.46	1.03	080-088	6
6-007	02.0	10.66	24	26.6	24.3	25.0	3.60	088-096	3
6-008	00.0	11.75	01	100.	0.00	0.00	3.95	100-106	8
6-009	00.0	9.409	35	49.4	6.49	9.02	1.31	106-112	5
6-010	00.0	11.25	24	83.6	0.00	0.00	2.04	112-120	7
6-011	00.0	11.45	08	70.0	12.8	9.08	.993	120-126	6
6-012	00.0	10.86	35	71.5	0.00	0.00	.489	126-130	7
6-013	00.0	10.57	02	76.5	11.7	9.68	1.08	130-134	7
6-014	00.0	11.50	20	65.6	7.99	6.30	.139	134-140	6
6-015	00.0	9.553	00	84.1	7.99	7.88	.850	140-146	7
6-016	00.0	10.57	20	68.8	4.79	6.30	0.00	146-154	6
6-017	00.0	11.35	05	81.8	5.69	7.48	.964	154-160	7
6-018	00.0	12.05	16	72.3	3.35	8.29	.881	160-166	7
6-019	02.0	12.71	00	86.1	5.99	7.88	0.00	166-172	8
6-020	02.0	10.08	22	68.7	3.11	6.14	1.02	172-180	6
6-021	08.0	10.27	35	59.8	1.29	3.82	.386	180-186	6

Sample number	Simazine concentration (ppb)	% Moisture	% Gravel	% Sand	% Silt	% Clay	% Organic matter	Depth (inches)	Percolation class
6-022	13.0	8.695	45	51.7	1.09	2.13	0.00	186-192	6
6-023	22.0	9.361	50	46.0	1.99	1.94	.386	192-200	3
6-024	25.0	9.841	02	100.	0.00	0.00	0.00	200-206	8
6-025	22.0	11.90	40	57.6	0.00	2.32	.618	206-212	6
6-026	30.0	14.94	00	96.1	0.00	3.88	2.05	220-226	8
6-027	29.0	12.41	21	74.3	0.00	4.64	1.11	226-232	7
6-028	22.0	15.31	16	79.0	0.00	4.93	.680	232-240	7
6-029	27.0	20.71	06	86.5	3.75	3.64	.463	240-246	8
6-030	27.0	16.82	18	78.8	0.00	3.18	.178	246-252	7
6-031	24.0	13.43	13	73.1	3.47	10.3	.059	252-260	7
6-032	36.0	19.33	89	9.69	.439	.866	.890	260-266	3
6-033	38.0	22.72	11	76.6	3.55	8.79	.771	266-272	7
6-034	28.0	19.61	00	58.1	13.9	27.8	.341	272-280	3
6-035	16.0	20.88	16	50.5	13.4	20.0	.786	280-286	5
6-036	10.0	19.56	12	96.9	0.00	0.00	.077	286-292	8
6-037	07.0	10.22	40	46.8	4.79	8.32	0.00	292-300	5
6-038	06.0	0.000	20	80.0	0.00	0.00	-----	300-306	7
6-039	03.0	7.665	---	-----	-----	-----	-----	306-312	-
6-040	00.0	11.16	---	-----	-----	-----	-----	312-320	-
6-041	09.0	-----	---	-----	-----	-----	-----	320-340	-

Sample number	Simazine concentration (ppb)	% Moisture	% Gravel	% Sand	% Silt	% Clay	% Organic matter	Depth (inches)	Percolation class
7-001	0.00	3.007	00	74.1	9.99	15.8	27.50	000-006	6
7-002	0.00	-----	00	66.8	17.9	15.1	22.87	006-012	6
7-003	0.00	9.217	00	68.1	15.9	15.8	17.54	012-020	6
7-004	0.00	9.313	00	82.8	7.99	9.16	4.220	020-026	7
7-005	0.00	6.791	00	88.1	5.99	5.88	.5874	040-046	8
7-006	0.00	5.752	00	90.8	5.99	3.16	1.646	060-066	8
7-007	0.00	7.204	00	90.8	3.99	5.16	0.000	066-072	8
7-008	0.00	6.067	00	94.1	1.99	3.88	1.320	072-080	8
7-009	0.00	5.351	19	76.2	1.61	3.14	.6647	080-086	7
7-010	0.00	4.953	00	96.1	1.99	1.88	0.000	086-092	8
7-011	0.00	5.708	00	94.8	3.99	1.16	7.624	092-100	8
7-012	0.00	6.564	00	94.1	1.99	3.88	.1708	100-106	8
7-013	0.00	9.122	40	56.4	1.19	2.32	.2521	106-112	6
7-014	0.00	11.25	00	90.1	3.99	5.88	3.020	112-120	8
7-015	0.00	12.46	00	90.1	3.99	5.88	7.700	120-126	8
7-016	0.00	11.54	00	90.1	5.99	3.88	2.301	126-132	8
7-017	0.00	13.99	00	76.1	11.9	11.8	2.744	132-140	7
7-018	0.00	16.82	00	78.8	11.9	9.16	1.082	140-146	7
7-019	0.00	16.29	00	60.8	25.9	13.1	1.484	146-152	6
7-020	0.00	16.33	00	68.1	17.9	13.8	3.147	152-160	6
7-021	0.00	16.55	00	76.1	11.9	11.8	7.099	160-166	7

Sample number	Simazine concentration (ppb)	% Moisture	% Gravel	% Sand	% Silt	% Clay	% Organic matter	Depth (inches)	Percolation class
7-022	0.00	17.92	00	72.8	15.9	11.1	.5785	166-174	7
7-023	0.00	6.292	00	78.1	9.99	11.8	.8965	174-180	7
7-024	0.00	12.05	00	72.8	11.9	15.1	3.210	180-186	6
7-025	0.00	11.75	00	78.1	5.99	15.8	0.000	186-194	6
7-026	0.00	19.10	00	70.1	13.9	15.8	.8965	200-206	6
7-027	0.00	13.42	00	70.8	15.9	13.1	-----	206-214	6
7-028	0.00	15.79	00	64.8	11.9	23.1	0.000	220-226	3
7-029	0.00	13.35	00	72.8	13.9	13.1	3.020	226-232	6
7-030	0.00	-----	00	70.8	13.9	15.1	2.426	232-238	6
7-031	0.00	14.52	00	69.5	19.9	10.4	1.273	238-240	6
7-032	0.00	15.24	00	-----	-----	-----	2.179	240-246	8
7-033	0.00	15.15	00	78.8	11.9	9.16	1.917	246-254	7
7-034	0.00	15.74	00	76.1	13.9	9.88	.1780	260-268	7
7-035	0.00	12.61	00	72.1	11.9	15.8	1.246	268-274	6
7-036	0.00	0.000	00	69.5	17.9	12.4	-----	274-280	6
7-037	0.00	12.12	00	69.5	15.9	14.4	1.654	280-286	6
7-038	0.00	13.38	00	64.8	17.9	17.1	2.532	286-292	6
7-039	0.00	15.09	00	67.5	17.9	14.4	2.371	292-298	6
7-040	0.00	-----	00	60.1	25.9	13.8	0.000	298-300	6
7-041	0.00	12.41	00	62.8	21.9	15.1	3.445	300-306	6
7-042	0.00	19.38	00	64.8	17.9	17.1	1.335	320-327	6

Sample number	Simazine concentration (ppb)	% Moisture	% Gravel	% Sand	% Silt	% Clay	% Organic matter	Depth (inches)	Percolation class
7-043	0.00	17.44	00	65.5	21.9	12.4	1.468	327-333	6
7-044	0.00	12.87	00	74.8	15.9	9.16	0.000	333-340	7
7-045	0.00	12.61	00	76.8	15.9	7.16	.1631	340-348	7
7-046	0.00	------	00	75.5	13.9	10.4	.7265	348-354	7
7-047	0.00	12.57	00	72.8	11.9	15.1	1.869	354-360	6
7-048	0.00	15.90	00	78.8	9.99	11.1	1.190	360-366	7
7-049	0.00	0.000	00	76.8	13.9	9.16	.5410	366-374	7
7-050	0.00	0.000	00	77.5	13.9	8.44	2.122	380-386	7
7-051	0.00	20.30	00	78.8	11.9	9.16	1.112	386-393	7
7-052	0.00	20.07	00	68.8	19.9	11.1	7.539	393-400	6
7-053	0.00	17.45	00	78.8	11.9	9.16	1.527	400-406	7
7-054	0.00	17.68	00	74.8	15.9	9.16	1.128	406-413	7
7-055	0.00	15.55	00	75.5	15.9	8.44	.6028	413-420	7
7-056	0.00	15.52	00	------	------	------	1.346	420-426	8
7-057	0.00	15.21	00	82.8	7.99	9.16	1.498	426-432	7
7-058	0.00	20.54	00	78.8	11.9	9.16	.8306	432-440	7
7-059	0.00	------	00	63.5	21.9	14.4	1.639	440-446	6
7-060	0.00	18.53	00	53.5	29.9	16.4	.8965	446-452	6
7-061	0.00	18.87	00	40.8	25.9	33.1	.2782	452-460	4
7-062	0.00	0.000	00	47.5	23.9	28.4	1.623	460-466	4

Sample number	Simazine concentration (ppb)	% Moisture	% Gravel	% Sand	% Silt	% Clay	% Organic matter	Depth (inches)	Percolation class
7-063	0.00	22.14	00	54.8	17.9	27.1	.3864	466-472	3
7-064	0.00	17.64	00	60.8	15.9	23.1	1.557	472-480	3
7-065	0.00	15.90	00	66.1	11.9	21.8	1.319	480-485	3
7-067	0.00	12.05	00	90.8	1.99	7.16	0.000	485-491	8
7-068	0.00	9.413	10	76.3	3.59	10.0	0.000	491-493	7
7-066	0.00	11.85	30	52.8	6.99	10.1	.2009	493-500	5
7-069	0.00	18.92	00	62.8	17.9	19.1	.6002	500-506	6
7-070	0.00	26.23	00	51.5	33.9	14.4	1.438	520-526	5
7-071	0.00	21.00	00	63.5	25.9	10.4	2.773	540-546	6
7-072	0.00	0.006	00	61.5	25.9	12.4	11.62	552-560	6
7-073	0.00	21.35	00	38.8	37.9	23.1	1.335	560-566	5
7-074	0.00	------	---	-----	-----	-----	1.824	566-572	-
7-075	0.00	22.24	00	40.1	27.9	31.8	3.001	572-580	4
7-076	0.00	28.46	00	49.5	29.9	20.4	2.888	580-586	5
7-077	0.00	26.39	00	58.1	23.9	17.8	.0593	586-592	6
7-078	0.00	21.70	00	50.8	27.9	21.1	1.329	592-600	5
7-079	0.00	------	---	-----	-----	-----	------	600-606	-
7-080	0.00	19.73	00	-----	-----	-----	2.225	606-614	8
7-081	0.00	19.89	00	72.8	19.9	7.16	1.364	620-626	7
7-082	0.00	18.42	00	80.8	13.9	5.16	.8656	626-634	7
7-083	0.00	19.56	00	76.8	13.9	9.16	1.498	640-646	7
7-084	0.00	22.92	00	72.8	17.9	9.16	.3856	646-654	7

Sample number	Simazine concentration (ppb)	% Moisture	% Gravel	% Sand	% Silt	% Clay	% Organic matter	Depth (inches)	Percolation class
7-085	0.00	19.82	00	86.8	9.99	3.16	-----	654-660	8
7-086	0.00	18.03	00	88.8	9.99	1.16	1.514	660-666	8
7-087	0.00	19.44	00	-----	-----	-----	.7110	666-674	8
7-088	0.00	------	00	38.1	23.9	37.8	4.079	680-686	4
7-089	0.00	45.26	00	32.8	25.9	41.1	2.566	686-692	5
7-090	0.00	34.69	00	64.8	15.9	19.1	1.082	692-700	6
7-091	0.00	22.48	00	71.5	13.9	14.4	.6526	700-706	6
7-092	0.00	22.91	00	74.8	17.9	7.16	10.59	706-714	7
7-093	-----	-----	-----	-----	-----	-----	-----	720-726	-

Sample number	Carbofuran concentration (ppb)	% Moisture	% Gravel	% Sand	% Silt	% Clay	% Organic matter	Depth (inches)	Percolation class
8-001	0.00	7.158	00	91.5	3.99	4.44	75.47	000-006	8
8-002	0.00	-----	00	93.0	5.99	1.00	41.35	020-026	8
8-003	0.00	7.582	00	89.0	7.99	3.00	34.12	026-032	8
8-004	0.00	6.202	00	85.5	7.99	6.44	14.27	032-040	8
8-005	0.00	-----	00	89.0	7.99	3.00	57.82	040-046	8
8-006	0.00	5.865	00	89.0	5.99	5.00	15.83	046-052	8
8-007	0.00	10.86	00	81.0	15.9	3.00	12.99	052-060	7
8-008	0.00	------	00	75.5	15.9	8.44	-----	060-066	7
8-009	0.00	9.122	00	83.0	11.9	5.00	7.938	066-072	7
8-010	0.00	6.564	00	93.0	5.99	1.00	2.192	072-080	8
8-011	0.00	-----	00	91.0	5.99	3.00	7.524	080-086	8
8-012	0.00	4.987	00	---------------			1.362	086-092	-
8-013	0.00	------	00	99.0	0.00	1.00	7.287	092-100	8
8-014	0.00	------	00	97.0	1.99	1.00	-----	100-106	8
8-015	0.00	4.821	00	97.5	0.00	2.44	0.000	106-114	8
8-016	0.00	------	00	100.	0.00	0.00	.2342	120-126	8
8-017	0.00	4.726	00	100.	0.00	0.00	4.743	126-132	8
8-018	0.00	------	00	100.	0.00	0.00	4.621	132-140	8
8-019	0.00	4.158	00	100.	0.00	0.00	8.093	140-146	8
8-020	0.00	4.865	00	97.5	1.99	.440	3.923	146-154	8
8-021	0.00	3.686	00	99.0	1.99	0.00	2.873	160-166	8

Sample number	Carbofuran concentration (ppb)	% Moisture	% Gravel	% Sand	% Silt	% Clay	% Organic matter	Depth (inches)	Percolation class
8-022	0.00	4.036	00	100.	0.00	0.00	0.000	166-174	8
8-023	0.00	------	00	100.	0.00	0.00	------	180-186	8
8-024	0.00	6.518	00	97.5	0.00	2.44	1.481	186-192	8
8-025	0.00	17.20	00	61.0	33.9	5.00	8.679	192-200	6
8-026	0.00	------	00	99.0	1.99	0.00	6.576	200-206	8
8-027	0.00	------	00	100.	0.00	0.00	5.336	206-212	8
8-028	0.00	4.865	00	99.5	0.00	.440	------	212-220	8
8-029	0.00	8.742	00	99.5	0.00	.440	1.756	220-228	8
8-030	0.00	12.56	00	95.0	5.99	0.00	9.265	240-246	8
8-031	0.00	18.42	00	77.5	17.9	4.44	30.61	246-254	7
8-032	0.00	------	00	75.0	21.9	3.00	18.32	260-266	7
8-033	0.00	28.00	00	35.0	53.9	11.0	19.55	266-272	3
8-034	0.00	------	00	39.0	45.9	15.0	16.83	272-280	5
8-035	0.00	24.56	00	83.0	17.9	0.00	26.40	280-286	7
8-036	0.00	15.90	00	89.0	9.99	1.00	10.96	286-294	8
8-037	0.00	------	00	55.0	31.9	13.0	19.96	300-306	6
8-038	0.00	20.64	00	75.0	3.99	21.0	53.77	306-312	3
8-039	0.00	10.96	00	89.5	5.99	4.44	4.684	312-320	8
8-040	0.00	------	00	93.0	5.99	1.00	2.725	320-326	8
8-041	0.00	10.21	00	81.0	7.99	11.0	23.94	326-332	7
8-042	0.00	13.01	00	75.0	9.99	15.0	16.33	332-340	6

Sample number	Carbofuran concentration (ppb)	% Moisture	% Gravel	% Sand	% Silt	% Clay	% Organic matter	Depth (inches)	Percolation class
8-043	0.00	-----	00	89.0	5.99	5.00	5.445	340-346	8
8-044	0.00	-----	00	91.0	7.99	1.00	5.621	346-354	8
8-045	0.00	12.60	00	89.0	5.99	5.00	1.993	360-366	8
8-046	0.00	10.11	00	93.0	1.99	5.00	3.969	366-372	8
8-047	0.00	10.42	00	99.0	1.99	0.00	3.630	372-380	8
8-048	0.00	------	00	89.0	3.99	7.00	11.20	380-386	8
8-049	0.00	10.18	00	89.0	3.99	7.00	7.997	386-392	8
8-050	0.00	------	00	100.	0.00	0.00	29.85	392-394	8
8-051	0.00	-----	00	51.0	37.9	11.0	67.73	406-412	5
8-052	0.00	15.68	00	65.0	27.9	7.00	7.168	412-420	6
8-053	0.00	14.20	00	65.5	25.9	8.44	11.37	420-426	6
8-054	0.00	17.09	00	51.0	39.9	9.00	7.858	426-432	5
8-055	0.00	23.33	00	----	----	----	7.506	432-440	-
8-056	0.00	22.68	00	----	----	----	9.360	440-446	-
8-057	0.00	15.20	00	67.0	25.9	7.00	3.162	446-454	6
8-058	0.00	14.67	00	73.5	19.9	6.44	0.000	460-466	7
8-059	0.00	12.73	00	81.0	17.9	1.00	7.154	466-474	7
8-060	0.00	17.72	00	----	----	----	7.389	480-486	-
8-061	0.00	15.52	00	87.0	13.9	0.00	6.744	486-492	8
8-062	0.00	11.45	00	79.0	19.9	1.00	8.151	492-500	7

Sample number	Carbofuran concentration (ppb)	% Moisture	% Gravel	% Sand	% Silt	% Clay	% Organic matter	Depth (inches)	Percolation class
8-063	0.00	12.87	00	-----	-----	-----	8.080	500-506	-
8-064	0.00	18.03	00	81.0	19.9	0.00	6.626	506-512	7
8-065	0.00	23.15	00	69.0	31.9	0.00	------	512-520	6
8-066	0.00	22.42	00	81.5	17.9	.440	7.623	520-526	7
8-067	0.00	20.36	00	87.5	11.9	.440	5.805	526-534	8
8-068	0.00	8.084	00	99.5	0.00	.440	0.000	540-546	8
8-069	0.00	------	00	100.	0.00	0.00	0.000	546-552	8
8-070	0.00	20.19	00	77.5	17.9	4.44	2.132	552-560	7
8-071	0.00	17.81	00	69.5	21.9	8.44	5.855	560-566	6
8-072	0.00	13.27	00	79.0	11.9	9.00	10.89	566-574	7
8-073	0.00	------	00	-----	-----	-----	17.03	580-586	-
8-074	0.00	18.09	00	73.0	17.9	9.00	5.331	586-592	7
8-075	0.00	21.32	00	65.0	31.9	3.00	6.792	592-600	6
8-076	0.00	------	00	79.0	19.9	1.00	30.85	600-606	7
8-077	0.00	21.44	00	93.0	7.99	0.00	17.65	606-612	8
8-078	0.00	15.15	00	93.0	5.99	1.00	------	612-620	8
8-079	0.00	------	00	97.0	3.99	0.00	2.400	620-626	8
8-080	0.00	3.177	00	63.0	41.9	0.00	1.184	626-632	6
8-081	0.00	2.796	00	100.	0.00	0.00	------	632-640	8
8-082	0.00	3.691	00	99.5	0.00	.440	19.55	640-646	8

Sample number	Carbofuran concentration (ppb)	% Moisture	% Gravel	% Sand	% Silt	% Clay	% Organic matter	Depth (inches)	Percolation class
8-083	0.00	3.275	00	100.	0.00	0.00	------	646-652	8
8-084	0.00	3.177	00	100.	0.00	0.00	0.000	652-660	8
8-085	0.00	3.431	00	100.	0.00	0.00	2.014	660-666	8
8-086	0.00	3.820	00	97.5	1.99	.440	3.396	666-672	8
8-087	0.00	3.691	00	100.	0.00	0.00	1.581	672-680	8
8-088	0.00	3.747	00	100.	0.00	0.00	------	680-686	8
8-089	0.00	3.375	00	100.	0.00	0.00	2.986	686-692	8
8-090	0.00	3.050	00	97.5	1.99	.440	1.658	692-700	8
8-091	0.00	1.750	00	99.5	0.00	.440	4.684	700-706	8
8-092	0.00	3.519	00	99.5	0.00	.440	0.000	706-714	8
8-093	0.00	23.21	00	100.	0.00	0.00	44.67	740-746	8
8-094	0.00	21.12	00	99.0	1.99	0.00	35.60	746-752	8
8-095	0.00	15.20	00	84.1	9.99	5.88	------	752-760	7
8-096	------	------	---	------	------	------	------	760-770	-