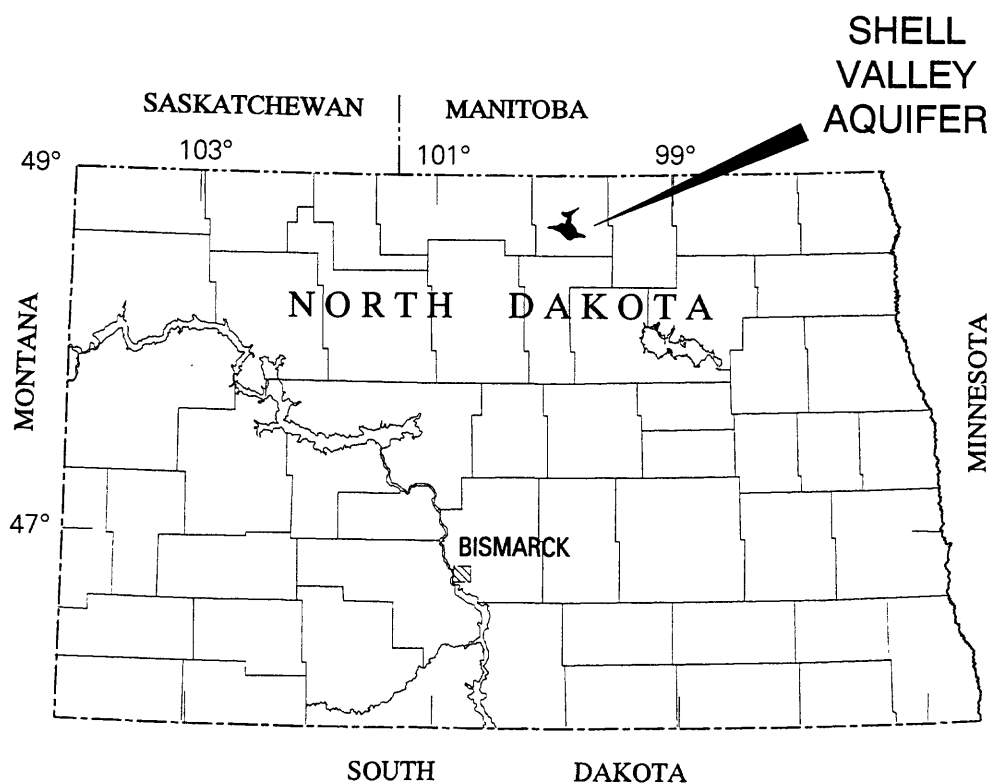


In cooperation with the Turtle Mountain Band of Chippewa Indians

Occurrence, Distribution, and Concentration of Hydrocarbons in and near the Shell Valley Aquifer, North Dakota

Open-File Report 99-194



**U.S. Department of the Interior
U.S. Geological Survey**

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By Wayne R. Berkas

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**Bismarck, North Dakota
2000**

U.S. DEPARTMENT OF THE INTERIOR
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U.S. GEOLOGICAL SURVEY
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Occurrence, Distribution, and Concentration of Hydrocarbons in and near the Shell Valley Aquifer, North Dakota

By Wayne R. Berkas

Abstract

Water samples from 27 wells completed in and near the Shell Valley aquifer were analyzed for benzene, toluene, ethylbenzene, and xylene (BTEX), polynuclear aromatic hydrocarbons (PAH), polychlorinated biphenyls (PCB), and pentachlorophenol (PCP) using the enzyme-linked immunoassay method. The analyses indicated the presence of PAH, PCB, and PCP in the study area. However, an individual compound at a high concentration or many compounds at low concentrations could cause the detections. Therefore, selected samples were analyzed using the gas chromatography (GC) method, which can detect individual compounds and determine the concentrations of those compounds. Concentrations for all compounds detected using the GC method were less than the minimum reporting levels (MRLs) for each constituent, indicating numerous compounds at low concentrations probably caused the immunoassay detections. The GC method also can detect compounds other than BTEX, PAH, PCB, and PCP. Concentrations for 81 of the additional compounds were determined and were less than the MRLs.

Four compounds that could not be quantified accurately using the requested analytical methods also were detected. Acetone was detected in 4 of the 27 wells, 2-butanone was detected in 3 of the 27 wells, prometon was detected in 1 of the 27 wells, and tetrahydrofuran was detected in 9 of the 27 wells. Acetone, 2-butanone, and tetrahydrofuran probably leached from the polyvinyl chloride (PVC) pipe and joint glue and probably are not contaminants from the aquifer. Prometon is a herbicide that controls most annual and many perennial broadleaf weeds and primarily is used on roads and railroad tracks. The one occurrence of prometon could be caused by overspraying for weeds.

INTRODUCTION

The Shell Valley aquifer (fig. 1) is located in north-central North Dakota and is a source of water for the Turtle Mountain Indian Reservation and the surrounding area. The aquifer is the sole source of water for the city of Belcourt and the primary source of water for most of the rural areas within and adjacent to the Turtle Mountain Indian Reservation. A well field located in the northern part of the aquifer and another located in the west-central part are used for municipal, domestic, and industrial needs on the Reservation.

A study conducted by the U.S. Geological Survey in cooperation with the Turtle Mountain Band of Chippewa Indians during 1995 indicated the presence of hydrocarbons, such as benzene, toluene, ethylbenzene, and xylene (BTEX), polynuclear aromatic hydrocarbons (PAH), polychlorinated biphenyls (PCB), and pentachlorophenol (PCP), in shallow ground water in the aquifer and in creeks and wetlands in the area of the aquifer. However, because the enzyme-linked immunoassay method used in that study detects compounds that are structurally similar, concentrations for the specific compounds could not be determined. Therefore, the U.S. Geological Survey conducted a study during 1997 in cooperation with the Turtle Mountain Band of Chippewa Indians to determine the occurrence, distribution, and concentration of hydrocarbons in and near the Shell Valley aquifer.

Purpose and Scope

The purpose of this study was to determine the occurrence, distribution, and concentration of hydrocarbons in and near the Shell Valley aquifer. Samples were collected during October 1997 from 27 wells screened across the water table and analyzed for hydrocarbons using the immunoassay method. Where hydrocarbons were detected, the gas chromatography (GC) method was used to identify the hydrocarbon compound and concentration. This report presents results of the study.

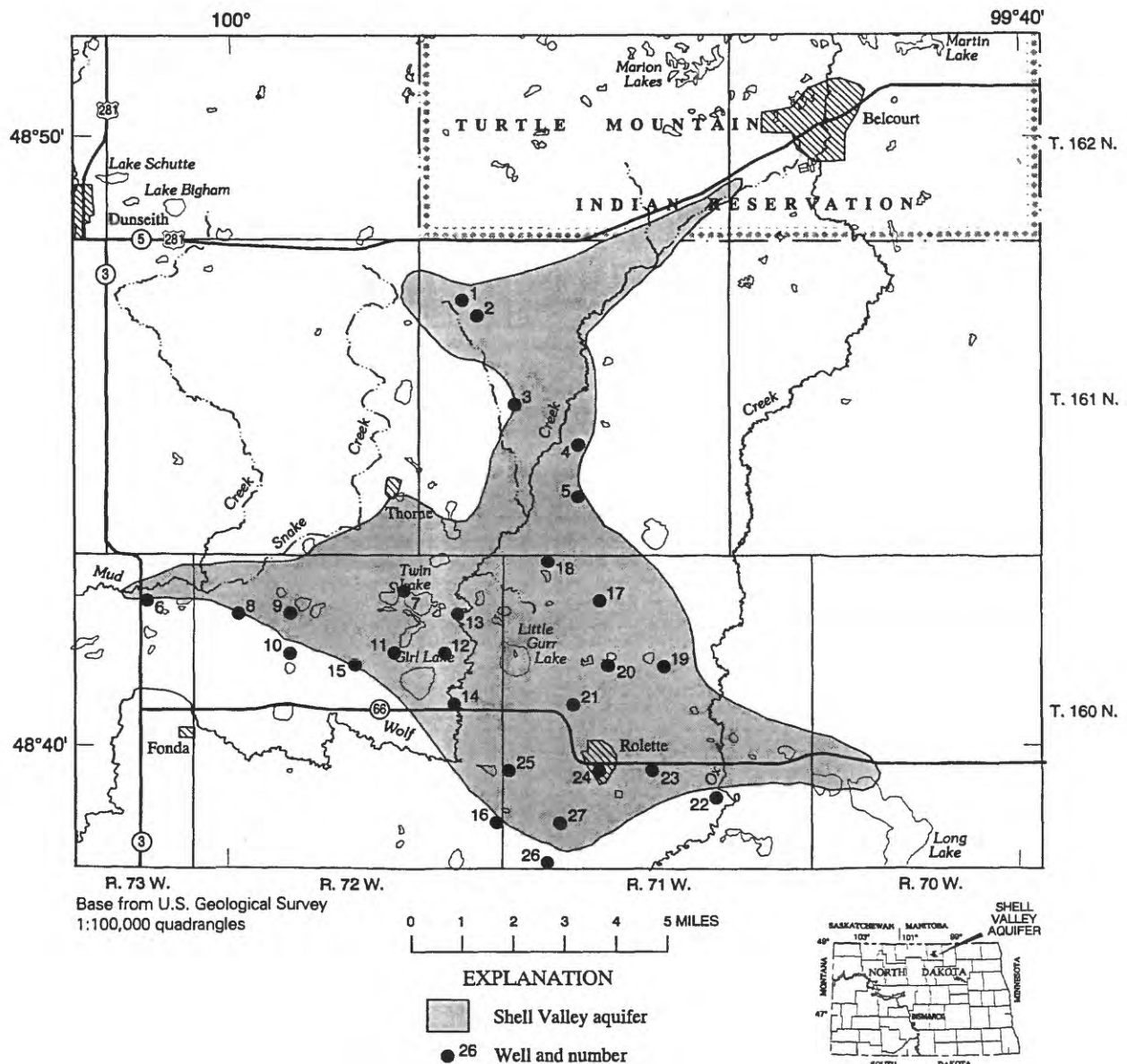


Figure 1. Location of the Shell Valley aquifer and locations of wells sampled for hydrocarbons, October and November 1997.

Location-Numbering System

The location-numbering system used in this report to identify wells sampled for hydrocarbons is based on the Federal system of rectangular surveys of the public lands (fig. 2). The first number denotes the township north of a base line, the second number denotes the range west of the fifth principal meridian, and the third number denotes the section in which the well is located. The letters A, B, C, and D designate, respectively, the northeast, northwest, southwest, and southeast quarter section, quarter-quarter section, and quarter-quarter-quarter section (10-acre tract); thus, well 160-071-28AAA2 would be located in the NE1/4NE1/4NE1/4 sec. 28, T. 160 N., R. 71 W. Consecutive terminal numbers are added if more than one well is located within a 10-acre tract.

Study Area

The Shell Valley aquifer lies south of the Turtle Mountain Indian Reservation in Rolette County (fig. 1). The aquifer is in a glacial outwash deposit that consists of some glacial tills and stratified silt, sand, and gravel deposits that were in

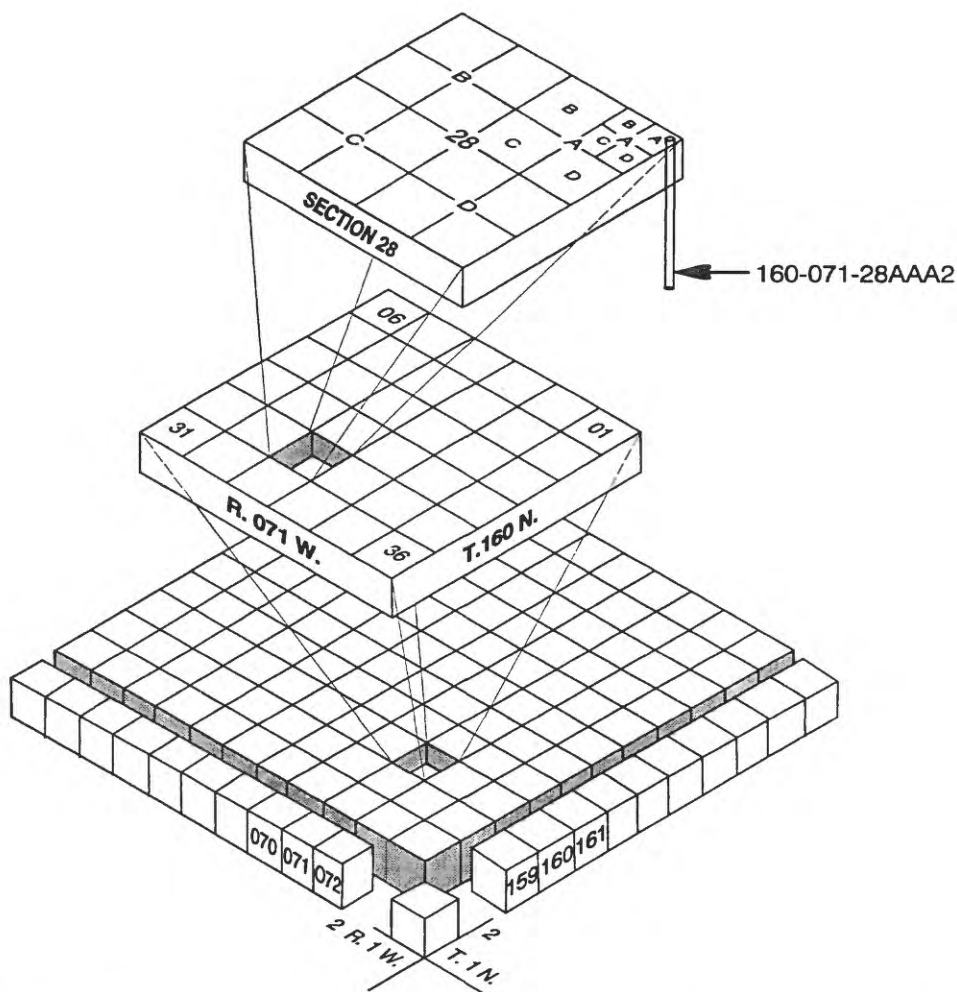


Figure 2. Township-range location-numbering system used to identify wells sampled for hydrocarbons.

contact with melting glacial ice (Randich, 1975). The sediments comprising the outwash deposit generally are less than 40 feet thick except for a buried valley where sediments exceed 120 feet. Generally, the outwash deposit is at land surface, but parts are overlain by clay or till deposits.

Water depth in the aquifer ranges from 6 to 117 feet and has an average of about 35 feet (Randich and Kuzniar, 1984). Water-level measurements made in 1995 indicate the water table varied from less than 1 foot below land surface to more than 40 feet below land surface (Strobel, 1997). The ground-water flow is predominately from northeast to southwest. Recharge to the aquifer is mainly from precipitation. Numerous lakes and wetlands in the southern part of the aquifer may act as areas of focused recharge. Recharge to the aquifer also occurs along Wolf and Ox Creeks (fig. 1).

Previous Studies

In 1990, Ecology and Environment, Inc., completed a preliminary assessment report on Turtle Mountain Manufacturing for the Turtle Mountain Band of Chippewa Indians and the U.S. Environmental Protection Agency (Pat Smith, U.S. Environmental Protection Agency, written commun., 1990). Turtle Mountain Manufacturing, a small factory that fabricates single-axle trailers for the Department of Defense, is located about 2.5 miles west of Belcourt on Highways 5 and 281. The preliminary assessment identified unlined lagoons on the Turtle Mountain Manufacturing property. Tribal and U.S. Environmental Protection Agency samples from wells downgradient from the lagoons indicated the presence of 1,1-dichloroethane, trichloroethene, and tetrachloroethene.

In 1995, the U.S. Geological Survey collected water samples from 13 ground-water wells completed in the Shell Valley aquifer and 9 surface-water sites in the area of the Shell Valley aquifer (Strobel, 1997). The water samples were analyzed for the presence of hydrocarbons using the immunoassay method. BTEX was detected in one ground-water sample and three surface-water samples (fig. 3). PAH was detected in five ground-water samples and nine surface-water samples. PCB was not detected in any ground-water samples but was detected in one surface-water sample. PCP was not detected in any ground-water samples but was detected in five surface-water samples. Generally, hydrocarbons tend to float on water and would be detected on the water table of the aquifer. Most of the ground-water samples for the 1995 study were collected near the bottom of the aquifer and did not contain any hydrocarbons. Also, the immunoassay method used in that study detects groups of structurally similar hydrocarbons but does not identify the specific compound or the concentration of that compound.

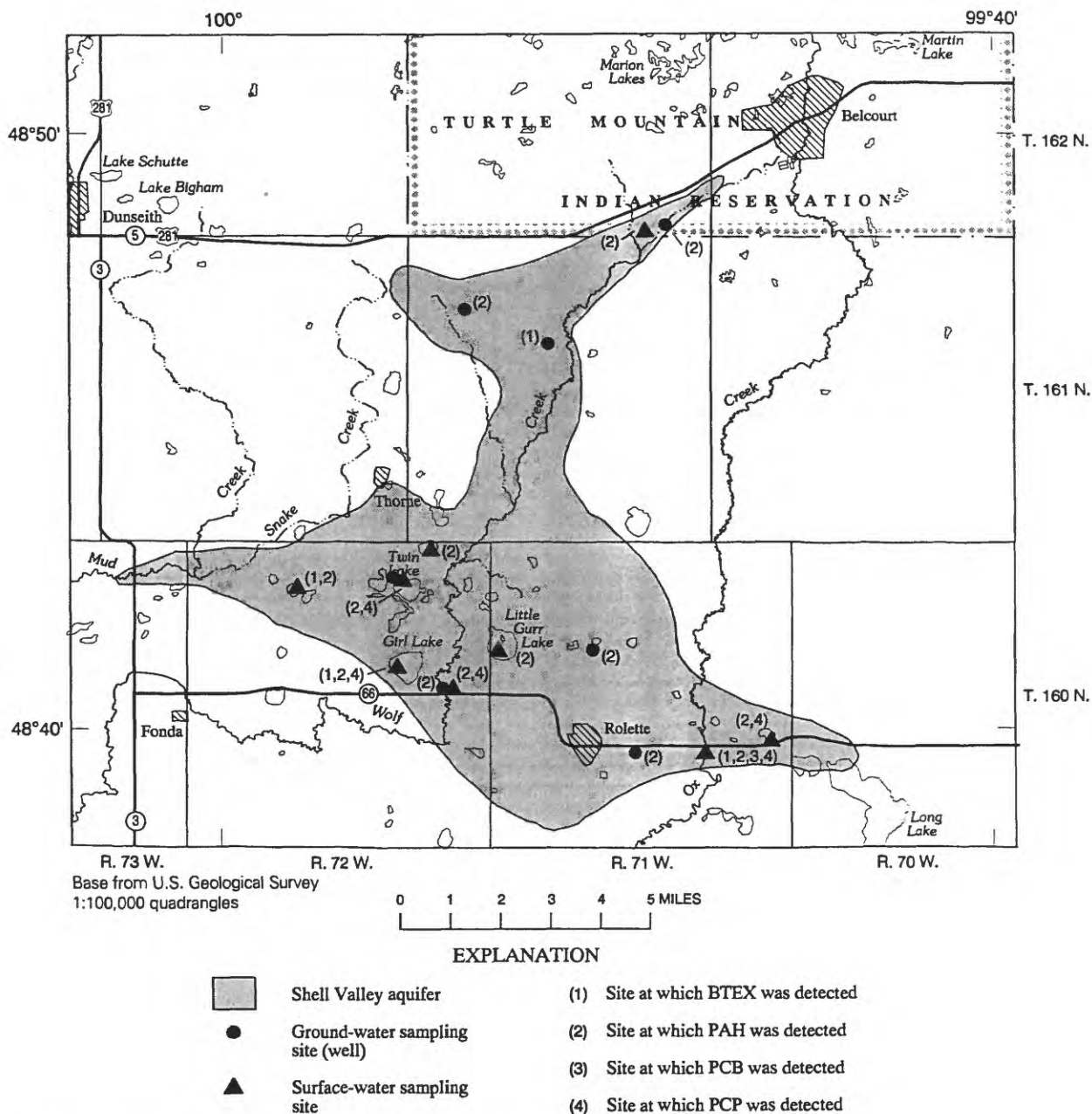


Figure 3. Locations of sites sampled for hydrocarbons, 1995. (Modified from Strobel, 1997.)

DATA COLLECTION AND ANALYSIS

In 1997, the U.S. Geological Survey collected water samples from 27 wells completed in and near the Shell Valley aquifer (fig. 1). The wells were screened across the water table, and samples were collected from the top of the aquifer. The wells were constructed of polyvinyl chloride (PVC) pipe and screen, and the joints were glued. The wells were pumped with a peristaltic pump equipped with teflon tubing. Before the water samples were collected, three volumes of well water were removed or the well was completely evacuated and allowed to recharge. Water from the well was placed into baked glass bottles and analyzed at the U.S. Geological Survey District laboratory in Bismarck, N. Dak. Duplicate samples were collected from 7 of the 27 wells. The pump tubing was washed with methanol and rinsed with organic-free water before each sample was collected.

Samples from all of the wells were analyzed for BTEX, PAH, PCB, and PCP using the immunoassay method. All samples were analyzed within 3 days of collection. If a value obtained during the analysis exceeded the minimum reporting level (MRL), samples were usually sent to the U.S. Geological Survey National Water Quality Laboratory (NWQL) in Arvada, Colo., and analyzed using the GC method.

The preparation of the water sample in the laboratory determined the suitability of that sample to be quantified by the GC method. A total of three separate water samples were collected to send to the NWQL. The first sample was to be analyzed for seven Aroclor PCBs using the GC method and an electron capture detector (ECD). The second sample was to be extracted using methylene chloride under basic conditions (base/neutral acid extraction) and analyzed using the GC method and a mass spectrometric (MS) detector. The final sample was to be extracted using purge-and-trap techniques and analyzed using the GC/MS method, which is capable of determining concentrations of numerous organic compounds that may or may not be in the groupings of BTEX, PAH, PCB, and PCP. Combinations of the three samples were sent to the NWQL if compounds were detected using the immunoassay method.

Because of the two distinct analytical methods (immunoassay and GC) used in this study, the MRLs are different. In some instances, the MRL for the immunoassay method is less than the MRL for a specific compound determined using the GC method. For example, the MRL for the immunoassay method for BTEX is 0.02 microgram per liter, which is less than the MRL of 3 micrograms per liter for benzene determined using the GC/MS method. The MRL is defined as the smallest measured concentration of a constituent that may be reported reliably using a given analytical method. If the extraction and preparation phase of the water sample includes something that will alter the method results, the MRL will change. For example, if a dilution is used to eliminate interferences, a dilution factor will be reflected in the MRL.

The GC method is different from the immunoassay method in that the immunoassay method detects the sum of numerous related compounds. An individual compound at a high concentration or many compounds at low concentrations could result in an immunoassay concentration exceeding the MRL. The GC method determines the concentrations of individual compounds, and all concentrations could be less than the MRL but, when added together (as in the immunoassay method), could exceed the MRL.

BTEX

BTEX is a suite of aromatic hydrocarbons that typically are associated with fuels and additives to boost octane (Fetter, 1993). Benzene is associated with detergents, solvents, and antiknock gasoline. Toluene is associated with adhesive solvents in plastics, solvents, aviation and high-octane fuels, diluents and thinners, explosives, and detergents. Ethylbenzene often is an intermediate state for the hydrocarbons and is associated with solvents and gasoline. Xylene is associated with aviation fuel, protective coatings, solvents, synthesis of organic chemicals, and gasoline. Samples to be analyzed for BTEX using the immunoassay method were placed in 40-milliliter septum bottles with teflon caps and no head space. After arrival at the U.S. Geological Survey District laboratory in Bismarck, N. Dak., the samples were prepared and analyzed using procedures outlined by the immunoassay manufacturer. The immunoassay method detects the sum of numerous BTEX-related hydrocarbons. The hydrocarbon compounds and products that the immunoassay method is sensitive to are as follow:

Compound	Product
Acenaphthene	Creosote
Anthracene	Diesel fuel
Benzene	Jet-A-Fuel
Cyclohexane	Kerosene
n-Decane	Mineral spirits
Ethylbenzene	
n-Heptane	
Hexachlorobenzene	
n-Hexane	
Methylene chloride	
Naphthalene	
n-Nonane	
n-Octane	
Phenanthrene	
n-Propylbenzene	
Styrene	
Toluene	
Trichloroethylene	
m-Xylene	
o-Xylene	
p-Xylene	
1,2,4-Trimethylbenzene	
1,3,5-Trimethylbenzene	

BTEX concentrations in all samples (table 1) were less than 0.02 microgram per liter, which is the MRL for the immunoassay method.

Although the immunoassay method indicated no presence of BTEX compounds, the compounds were detected in water samples analyzed for other types of compounds at the NWQL using the GC/MS method. The BTEX compounds were detected in the analyses for PAH compounds. Concentrations for all BTEX compounds detected using the GC/MS method (table 2) were less than the MRLs, which range from 3 to 6 micrograms per liter.

PAH

PAH is associated with the combustion of fossil fuels, asphalt, bituminous coal, and naturally occurring petroleum and may be associated with forest fires, burning grasses, or, possibly, industrial chemicals. Samples to be analyzed for PAH using the immunoassay method were diluted 3:1 with methanol (30 milliliters sample and 10 milliliters methanol) and placed in 40-milliliter septum bottles with teflon caps and no head space. After arrival at the U.S. Geological Survey District laboratory in Bismarck, N. Dak., the samples were prepared and analyzed using procedures outlined by the manufacturer. The immunoassay method detects the sum of numerous PAH-related hydrocarbons. The hydrocarbon compounds and products that the immunoassay method is sensitive to are as follow:

Compound	Product
Acenaphthalene	Creosote
Acenaphthylene	Diesel fuel
Anthracene	Fuel oil #1
Benzo[a]anthracene	Fuel oil #2
Benzo[a]pyrene	Fuel oil #4
Benzo[b]fluoranthene	Fuel oil #5
Benzo[g,h,i]perylene	Fuel oil #6
Benzo[k]fluoranthene	Gasoline
Chrysene	Heating fuel
Dibenzo[a,h]anthracene	JP-4
Fluoranthene	JP-5
Fluorene	Jet-A-Fuel
Indeno(1,2,3-c,d)pyrene	Kerosene
Naphthalene	Turbine fuel
Phenanthrene	
Pyrene	

PAH concentrations in wells 1, 3, 4, 11, 12, 15, 16, 17, 18, 20, and 23 (table 1) were greater than 1.24 micrograms per liter, which is the MRL for the immunoassay method. The areal distribution of PAH in the study area is shown in figure 4. A pattern to the distribution of PAH in the study area is not apparent.

Water samples from most wells in which PAH was detected using the immunoassay method were sent to the NWQL along with samples from site 26 to determine the concentrations of selected PAH compounds using the GC/MS method. Concentrations for all compounds detected using the GC/MS method (table 3) were less than the MRLs, which range from 3 to 10 micrograms per liter.

PCB

PCB is associated with industrial chemicals that do not break down easily, such as those in electrical transformers, heat-exchange and insulating fluids, lubrications and cutting oils, and some pesticides, paints, and inks. Samples to be analyzed for PCB using the immunoassay method were diluted 1:1 with methanol (20 milliliters sample and 20 milliliters methanol) and placed in 40-milliliter septum bottles with teflon caps and no head space. After arrival at the U.S. Geological Survey District laboratory in Bismarck, N. Dak., the samples were prepared and analyzed using procedures outlined by the manufacturer. The immunoassay method detects the sum of numerous PCB-related hydrocarbons. The hydrocarbon compounds that the immunoassay method is sensitive to are as follow:

Compound
Aroclor 1016
Aroclor 1221
Aroclor 1232
Aroclor 1242
Aroclor 1248
Aroclor 1254
Aroclor 1260
Aroclor 1262
Aroclor 1268

Table 1. Hydrocarbon concentrations, determined using the immunoassay method, in water samples from the study area, October 1997

[BTEx, benzene, toluene, ethylbenzene, and xylene; PAH, polynuclear aromatic hydrocarbons; PCB, polychlorinated biphenyls; PCP, pentachlorophenol; µg/L, micrograms per liter; <, less than minimum reporting level; --, not determined]

Well number	Station number	Township-range identification number	Date	BTEx, total (µg/L)	PAH, total (µg/L)	PCB, total (µg/L)	PCP, total (µg/L)
1	484728099535301	161-071-07AAA	10-21-97	<0.02	11.9	<0.2	<0.06
1	484728099535301	161-071-07AAA	10-21-97	<0.02	10.4	0.3	<0.06
2	484712099534702	161-071-08BCB2	10-22-97	<0.02	<1.24	<0.2	<0.06
2	484712099534702	161-071-08BCB2	10-22-97	<0.02	<1.24	<0.2	<0.06
3	484542099523401	161-071-20AAA	10-21-97	<0.02	2.69	0.3	<0.06
4	484452099511301	161-071-22CCC2	10-21-97	<0.02	14.9	0.5	<0.06
5	484359099511301	161-071-27CCC	10-21-97	<0.02	<1.24	0.4	<0.06
6	484217100021101	160-073-01CCC	10-21-97	<0.02	<1.24	<0.2	<0.06
7	484231099553702	160-072-02CBC2	10-21-97	<0.02	<1.24	<0.2	<0.06
8	484216099593601	160-072-07AAA	10-20-97	<0.02	<1.24	<0.2	<0.06
9	484216099581701	160-072-08AAA	10-21-97	<0.02	<1.24	<0.2	<0.06
10	484125099581801	160-072-08DDD	10-21-97	<0.02	<1.24	1.5	<0.06
11	484124099554001	160-072-10DDD	10-21-97	<0.02	4.22	3.8	<0.06
12	484124099542201	160-072-11DDD	10-21-97	<0.02	1.36	<0.2	<0.06
13	484215099541901	160-072-12BBB	10-21-97	<0.02	<1.24	<0.2	<0.06
13	484215099541901	160-072-12BBB	10-21-97	<0.02	<1.24	<0.2	<0.06
14	484034099541902	160-072-13CCC2	10-21-97	<0.02	<1.24	<0.2	<0.06
15	484124099565701	160-072-15BBB	10-21-97	<0.02	2.01	<0.2	<0.06
16	483847099530301	160-072-36AAA	10-20-97	<0.02	6.92	1.4	<0.06
17	484217099502901	160-071-05DDD	10-20-97	--	2.91	1.2	--
17	484217099502901	160-071-05DDD	10-20-97	<0.02	1.63	<0.2	<0.06
18	484307099514801	160-071-06AAA	10-21-97	<0.02	3.26	<0.2	<0.06
18	484307099514801	160-071-06AAA	10-21-97	<0.02	<1.24	<0.2	<0.06
19	484123099490801	160-071-15BBB	10-20-97	<0.02	<1.24	<0.2	1.34
20	484119099502402	160-071-16BBB2	10-20-97	<0.02	4.77	<0.2	<0.06
21	484032099512901	160-071-17CCD	10-20-97	<0.02	<1.24	<0.2	<0.06
22	483914099475001	160-071-26CBB	10-20-97	<0.02	<1.24	<0.2	<0.06
23	483935099491602	160-071-28AAA2	10-20-97	<0.02	<1.24	<0.2	<0.06
23	483935099491602	160-071-28AAA2	10-20-97	<0.02	12.1	<0.2	<0.06
24	483939099502901	160-071-29AAA	10-20-97	<0.02	<1.24	<0.2	<0.06
25	483939099530101	160-071-30BBB	10-20-97	<0.02	<1.24	<0.2	<0.06
25	483939099530101	160-071-30BBB	10-20-97	<0.02	<1.24	<0.2	<0.06
26	483755099514801	160-071-31DDD	10-21-97	<0.02	<1.24	5.3	<0.06
27	483846099514701	160-071-32BBB	10-20-97	<0.02	<1.24	<0.2	<0.06

PCB concentrations in wells 1, 3, 4, 5, 10, 11, 16, 17, and 26 (table 1) were greater than 0.2 microgram per liter, which is the MRL for the immunoassay method. The areal distribution of PCB in the study area is shown in figure 5. A pattern to the distribution of PCB in the study area is not apparent.

Water samples from wells in which PCB was detected using the immunoassay method were sent to the NWQL along with samples from sites 15, 18, 20, and 23 to determine the concentrations of selected PCB compounds using the GC/ECD method. Sample bottles from sites 5 and 10 were broken in transit to the laboratory. Concentrations for all compounds detected using the GC/ECD method (table 4) were less than the MRLs, which were 0.1 microgram per liter.

Table 2. Gas chromatography/mass spectrography analyses of selected water samples for BTEX compounds

[Water samples were analyzed at the U.S. Geological Survey National Water Quality Laboratory in Arvada, Colo.; all compounds are in micrograms per liter; --, no data; <, less than minimum reporting level]

Well number	Station number	Date	Acenaphthene, total	Anthracene, total	Benzene, total	Ethylbenzene, total	Hexachlorobenzene, total	Methylene chloride, total	Naphthalene, total	Phenanthrene, total	Propylbenzene, total	Styrene, total	Toluene, total	Trichloroethylene, total	Xylene, total	1,2,4-Trimethylbenzene, total	1,3,5-Trimethylbenzene, total
1	484728099535301	10-21-97	--	--	<6	<6	--	<6	<6	--	<6	<6	<6	<6	<6	<6	<6
		10-21-97	--	--	<3	<3	--	<3	<3	--	<3	<3	<3	<3	<3	<3	<3
		11-06-97	<5	<5	--	--	<5	--	<5	<5	--	--	--	--	--	--	--
3	484542099523401	10-21-97	<5	<5	<3	<3	<5	<3	<3	<5	<3	<3	<3	<3	<3	<3	<3
4	484452099511301	10-21-97	<5	<5	<3	<3	<5	<3	<3	<5	<3	<3	<3	<3	<3	<3	<3
11	484124099554001	10-21-97	<5	<5	<3	<3	<5	<3	<3	<5	<3	<3	<3	<3	<3	<3	<3
15	484124099565701	10-21-97	--	--	<6	<6	--	<6	<6	--	<6	<6	<6	<6	<6	<6	<6
		11-06-97	<5	<5	--	--	<5	--	<5	<5	--	--	--	--	--	--	--
16	483847099530301	10-20-97	<5	<5	<3	<3	<5	<3	<3	<5	<3	<3	<3	<3	<3	<3	<3
17	484217099502901	10-20-97	<5	<5	<6	<6	<5	<6	<6	<5	<6	<6	<6	<6	<6	<6	<6
		10-21-97	<5	<5	<6	<6	<5	<6	<6	<5	<6	<6	<6	<6	<6	<6	<6
18	484307099514801	10-21-97	--	--	<3	<3	--	<3	<3	--	<3	<3	<3	<3	<3	<3	<3
		10-21-97	--	--	<3	<3	--	<3	<3	--	<3	<3	<3	<3	<3	<3	<3
		11-06-97	<5	<5	--	--	<5	--	<5	<5	--	--	--	--	--	--	--
20	484119099502402	10-20-97	--	--	<3	<3	--	<3	<3	--	<3	<3	<3	<3	<3	<3	<3
		11-06-97	<5	<5	--	--	<5	--	<5	<5	--	--	--	--	--	--	--
23	483935099491602	10-20-97	<5	<5	<3	<3	<5	<3	<3	<5	<3	<3	<3	<3	<3	<3	<3
26	483755099514801	10-21-97	<5	<5	<6	<6	<5	<6	<6	<5	<6	<6	<6	<6	<6	<6	<6

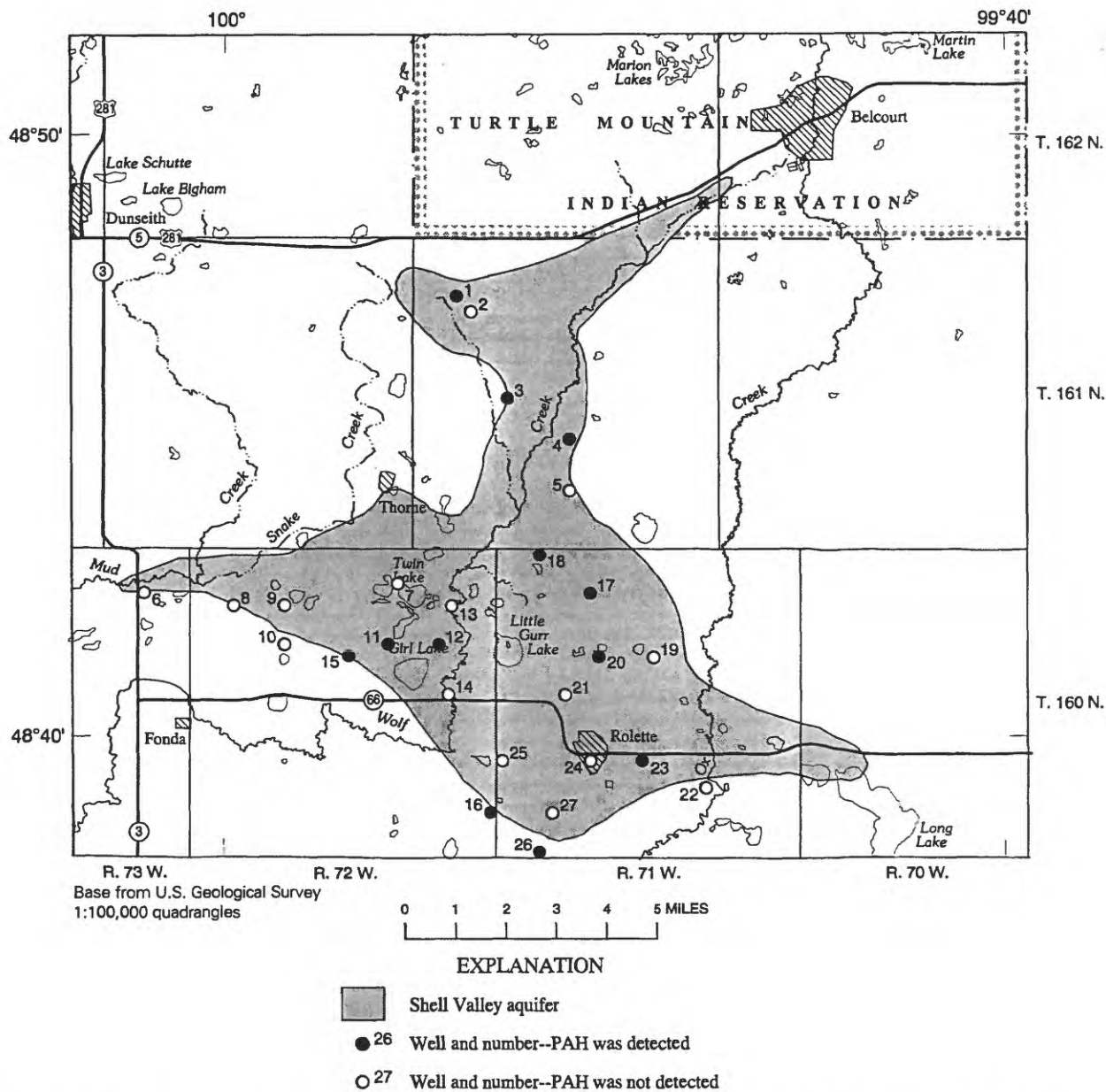


Figure 4. Areal distribution of PAH, detected using the immunoassay method, in the study area, October 1997.

PCP

PCP is associated with agricultural uses, such as insecticides, fungicides, bactericides, algicides, herbicides, and wood preservatives. Samples to be analyzed using the immunoassay method were placed in 40-milliliter septum bottles with teflon caps and no head space. After arrival at the U.S. Geological Survey District laboratory in Bismarck, N. Dak., the samples were prepared and analyzed using procedures outlined by the manufacturer. The immunoassay method detects the sum of numerous PCP-related hydrocarbons. The hydrocarbon compounds that the immunoassay method is sensitive to are as follow:

Compound
2,3-Dichlorophenol
2,4-Dichlorophenol
2,5-Dichlorophenol
2,6-Dichlorophenol
3,5-Dichlorophenol
Hexachlorobenzene
Hexachlorocyclohexane
Pentachlorophenol
Tetrachlorohydroquinone
2,3,4,6-Tetrachlorophenol
2,3,5,6-Tetrachlorophenol
2,3,4-Trichlorophenol
2,3,5-Trichlorophenol
2,3,6-Trichlorophenol
2,4,5-Trichlorophenol
2,4,6-Trichlorophenol

PCP was detected only in well 19, which is located in the southeast part of the study area (fig. 6). The PCP concentration in well 19 (table 1) was greater than 0.06 microgram per liter, which is the detection limit for the immunoassay method.

Although the water sample from well 19 was not sent to the NWQL, PCP compounds at some sites were detected in the analyses for PAH compounds. Concentrations for all compounds detected using the GC/MS method (table 5) were less than the minimum reporting levels, which range from 5 to 30 micrograms per liter.

Additional Compounds

The GC/MS method can detect numerous compounds in addition to those to which the immunoassay method is sensitive and can determine the concentrations of those compounds. Concentrations for 81 of the additional compounds that are not considered PAH or PCP compounds were determined using the GC/MS method (table 6). Concentrations for all compounds were less than the MRL, which range from 1 to 40 micrograms per liter.

Four compounds that could not be quantified accurately using the requested analytical methods also were detected. Estimated concentrations for these compounds--acetone, 2-butanone, prometon, and tetrahydrofuran--are listed in table 7.

Acetone is used as a solvent for fats, oils, waxes, resins, rubber, plastics, lacquers, varnishes, rubber cements, etc. (Budavari, 1989). Inhalation may produce headaches, fatigue, bronchial irritation, and, in large amounts, narcosis. Serious poisoning is rare. 2-butanone, also known as methyl ethyl ketone, is used as a solvent in the surface-coating industry, and tetrahydrofuran is used as a solvent for high polymers, especially polyvinyl chloride (Budavari, 1989). High concentrations of tetrahydrofuran can cause narcosis.

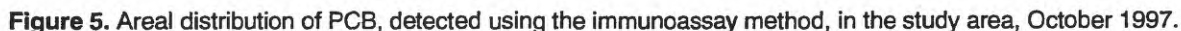
The estimated concentrations of acetone, 2-butanone, and tetrahydrofuran were large enough to cause concern. However, the wells used in this study were constructed of PVC pipe and screen, and the joints were glued. Other investigations indicate that glued PVC pipe leaches 2-butanone and tetrahydrofuran into the well water (Lapham and others, 1997). Acetone could be part of the glue formation used to join the PVC pipe. Thus, the occurrence of acetone, 2-butanone, and tetrahydrofuran could be caused by the glued PVC pipe used in constructing the well.

Prometon is a herbicide that controls most annual and many perennial broadleaf weeds and primarily is used on roads and railroad tracks. Most of the wells used in this study are located in ditches, and the one occurrence of prometon could be caused by overspraying for weeds.

Table 3. Gas chromatography/mass spectrography analyses of selected water samples for PAH compounds

[Water samples were analyzed at the U.S. Geological Survey National Water Quality Laboratory in Arvada, Colo.; all compounds are in micrograms per liter; --, no data; <, less than minimum reporting level]

Well number	Station number	Date	Acenaphthene, total	Acenaphthylene, total	Anthracene, total	Benzo[a]anthracene 1,2-benzanthracene, total	Benzo[a]pyrene, total	Benzo[b]fluoranthene, total	Benzo[k]fluoranthene, total	2-Chloronaphthalene, total	Chrysene, total	1,2,5,6-Dibenzanthracene, total	Fluoranthene, total	Indeno(1,2,3-c,d)pyrene, total	Naphthalene, total	Phenanthrene, total	Pyrene, total
1	48472809953301	10-21-97	--	--	--	--	--	--	--	--	--	--	--	--	<6	--	--
		10-21-97	--	--	--	--	--	--	--	--	--	--	--	--	<3	--	--
		11-06-97	<5	<5	<5	<10	<10	<10	<10	<5	<10	<10	<5	<10	<5	<5	<5
3	484542099523401	10-21-97	<5	<5	<5	<10	<10	<10	<10	<5	<10	<10	<5	<10	<3	<5	<5
4	484452099511301	10-21-97	<5	<5	<5	<10	<10	<10	<10	<5	<10	<10	<5	<10	<3	<5	<5
11	484124099554001	10-21-97	<5	<5	<5	<10	<10	<10	<10	<5	<10	<10	<5	<10	<3	<5	<5
15	484124099565701	10-21-97	--	--	--	--	--	--	--	--	--	--	--	--	<6	--	--
		11-06-97	<5	<5	<5	<10	<10	<10	<10	<5	<10	<10	<5	<10	<5	<5	<5
16	483847099530301	10-20-97	<5	<5	<5	<10	<10	<10	<10	<5	<10	<10	<5	<10	<3	<5	<5
17	484217099502901	10-20-97	<5	<5	<5	<10	<10	<10	<10	<5	<10	<10	<5	<10	<6	<5	<5
		10-21-97	<5	<5	<5	<10	<10	<10	<10	<5	<10	<10	<5	<10	<6	<5	<5
18	484307099514801	10-21-97	--	--	--	--	--	--	--	--	--	--	--	--	<3	--	--
		10-21-97	--	--	--	--	--	--	--	--	--	--	--	--	<3	--	--
		11-06-97	<5	<5	<5	<10	<10	<10	<10	<5	<10	<10	<5	<10	<5	<5	<5
20	484119099502402	10-20-97	--	--	--	--	--	--	--	--	--	--	--	--	<3	--	--
		11-06-97	<5	<5	<5	<10	<10	<10	<10	<5	<10	<10	<5	<10	<5	<5	<5
23	483935099491602	10-20-97	<5	<5	<5	<10	<10	<10	<10	<5	<10	<10	<5	<10	<3	<5	<5
26	483755099514801	10-21-97	<5	<5	<5	<10	<10	<10	<10	<5	<10	<10	<5	<10	<6	<5	<5



Water samples from 27 wells completed in and near the Shell Valley aquifer were analyzed for benzene, toluene, ethylbenzene, and xylene (BTEX), polynuclear aromatic hydrocarbons (PAH), polychlorinated biphenyls (PCB), and pentachlorophenol (PCP) using the enzyme-linked immunoassay method. The analyses indicated the presence of PAH, PCB, and PCP in the study area. However, an individual compound at a high concentration or many compounds at low concentrations could cause the detections. Therefore, selected samples were analyzed using the gas chromatography (GC) method, which can detect individual compounds and determine the concentrations of those compounds. Concentrations for all compounds detected using the GC method were less than the minimum reporting levels (MRLs) for each constituent, indicating numerous compounds at low concentrations probably caused the immunoassay detections. The GC method also can detect compounds other than BTEX, PAH, PCB, and PCP. Concentrations for 81 of the additional compounds were determined and were less than the MRLs.

Table 4. Gas chromatography/electron capture detector analyses of selected water samples for PCB compounds

[Water samples were analyzed at the U.S. Geological Survey National Water Quality Laboratory in Arvada, Colo.; all compounds are in micrograms per liter; <, less than minimum reporting level]

Well number	Station number	Date	Aroclor 1016, total	Aroclor 1221, total	Aroclor 1232, total	Aroclor 1242, total	Aroclor 1248, total	Aroclor 1254, total	Aroclor 1260, total
1	484728099535301	10-21-97	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
		10-21-97	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
		11-06-97	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
3	484542099523401	10-21-97	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
4	484452099511301	11-06-97	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
11	484124099554001	11-06-97	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
15	484124099565701	10-21-97	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
16	483847099530301	11-06-97	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
17	484217099502901	10-20-97	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
		10-21-97	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
18	484307099514801	10-21-97	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
		11-06-97	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
20	484119099502402	11-06-97	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
23	483935099491602	10-20-97	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
		10-20-97	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
26	483755099514801	10-21-97	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

Table 5. Gas chromatography/mass spectrography analyses of selected water samples for PCP compounds

[Water samples were analyzed at the U.S. Geological Survey National Water Quality Laboratory in Arvada, Colo.; all compounds are in micrograms per liter; <, less than minimum reporting level]

Well number	Station number	Date	2,4-Dichlorophenol, total	Hexachlorobenzene, total	Pentachlorophenol, total	2,4,6-Trichlorophenol, total
1	484728099535301	11-06-97	<5	<20	<5	<30
3	484542099523401	10-21-97	<5	<20	<5	<30
4	484452099511301	10-21-97	<5	<20	<5	<30
11	484124099554001	10-21-97	<5	<20	<5	<30
15	484124099565701	11-06-97	<5	<20	<5	<30
16	483847099530301	10-20-97	<5	<20	<5	<30
17	484217099502901	10-20-97	<5	<20	<5	<30
		10-21-97	<5	<20	<5	<30
18	484307099514801	11-06-97	<5	<20	<5	<30
20	484119099502402	11-06-97	<5	<20	<5	<30
23	483935099491602	10-20-97	<5	<20	<5	<30
26	483755099514801	10-21-97	<5	<20	<5	<30

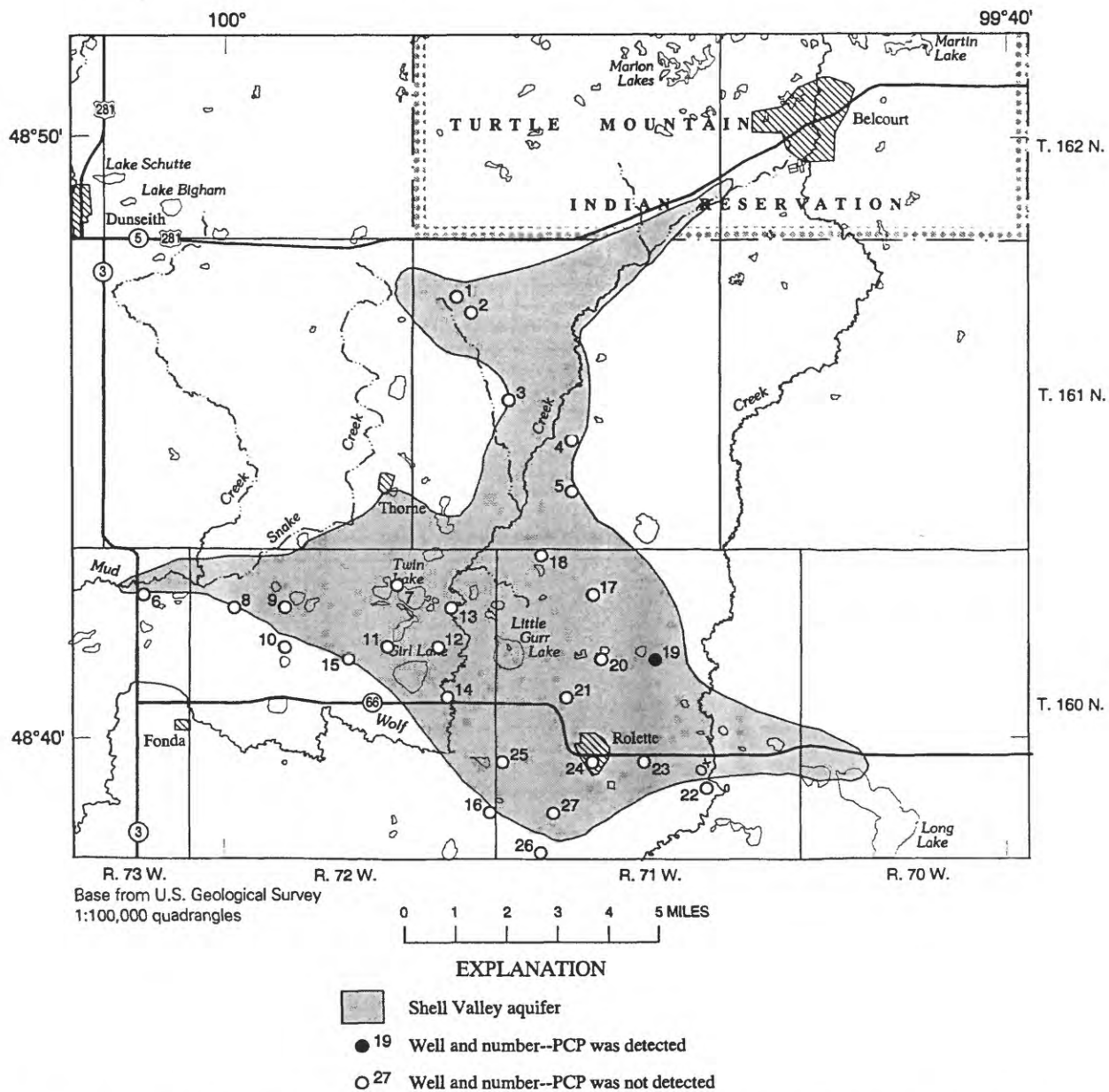


Figure 6. Areal distribution of PCP, detected using the immunoassay method, in the study area, October 1997.

Four compounds that could not be quantified accurately using the requested analytical methods also were detected. Acetone was detected in 4 of the 27 wells, 2-butanone was detected in 3 of the 27 wells, prometon was detected in 1 of the 27 wells, and tetrahydrofuran was detected in 9 of the 27 wells. Acetone, 2-butanone, and tetrahydrofuran probably leached from the polyvinyl chloride (PVC) pipe and joint glue and probably are not contaminants from the aquifer. Prometon is a herbicide that controls most annual and many perennial broadleaf weeds and primarily is used on roads and railroad tracks. The one occurrence of prometon could be caused by overspraying for weeds.

Table 6. Gas chromatography/mass spectrography analyses of selected water samples for additional organic compounds

[Water samples were analyzed at the U.S. Geological Survey National Water Quality Laboratory in Arvada, Colo.; all compounds are in micrograms per liter, <, less than minimum reporting level; --, no data]

Well number	Station number	Date	Benzene, isopropyl-, total	Benzene, n-butyl-, total	Benzene, sec-butyl-, total	Benzene, tert-butyl-, total	Benzene, 1,2,3-trichloro-, total	Benzidine, total	Bis (2-chloroethyl) ether, total	Bis (2-chloroisopropyl) ether, total	Bis (2-chloroethoxy) methane, total	Bis (2-ethylhexyl) phthalate, total	Bromobenzene, total	Bromochloromethane, total	Bromoform, total	n-Butylbenzyl phthalate, total	4-Bromophenylphenylether, total	Carbon tetrachloride, total	Chlorobenzene, total	Chlorodibromomethane, total	Chloroethane, total	Chloroform, total
1	48472809535301	10-21-97	<6	<6	<6	<6	<6	--	--	--	--	--	<6	<6	<6	<6	--	<6	<6	<6	<6	<6
		10-21-97	<3	<3	<3	<3	<3	--	--	--	--	--	<3	<3	<3	--	--	<3	<3	<3	<3	<3
		11-06-97	--	--	--	--	--	<40	<5	<5	<5	<5	--	--	--	<5	<5	--	--	--	--	--
3	48454209523401	10-21-97	<3	<3	<3	<3	<3	<40	<5	<5	<5	<5	<3	<3	<3	<5	<5	<3	<3	<3	<3	<3
4	484452099511301	10-21-97	<3	<3	<3	<3	<3	<40	<5	<5	<5	<5	<3	<3	<3	<5	<5	<3	<3	<3	<3	<3
11	484124099554001	10-21-97	<3	<3	<3	<3	<3	<40	<5	<5	<5	<5	<3	<3	<3	<5	<5	<3	<3	<3	<3	<3
15	484124099565701	10-21-97	<6	<6	<6	<6	<6	--	--	--	--	--	<6	<6	<6	--	--	<6	<6	<6	<6	<6
		11-06-97	--	--	--	--	--	<40	<5	<5	<5	<5	--	--	--	<5	<5	--	--	--	--	--
16	483847099530301	10-20-97	<3	<3	<3	<3	<3	<40	<5	<5	<5	<5	<3	<3	<3	<5	<5	<3	<3	<3	<3	<3
17	484217099502901	10-20-97	<6	<6	<6	<6	<6	<40	<5	<5	<5	<5	<6	<6	<6	<5	<5	<6	<6	<6	<6	<6
		10-21-97	<6	<6	<6	<6	<6	<40	<5	<5	<5	<5	<6	<6	<6	<5	<5	<6	<6	<6	<6	<6
18	484307099514801	10-21-97	<3	<3	<3	<3	<3	--	--	--	--	--	<3	<3	<3	--	--	<3	<3	<3	<3	<3
		10-21-97	<3	<3	<3	<3	<3	--	--	--	--	--	<3	<3	<3	--	--	<3	<3	<3	<3	<3
		11-06-97	--	--	--	--	--	<40	<5	<5	<5	<5	--	--	--	<5	<5	--	--	--	--	--
20	484119099502402	10-20-97	<3	<3	<3	<3	<3	--	--	--	--	--	<3	<3	<3	--	--	<3	<3	<3	<3	<3
		11-06-97	--	--	--	--	--	<40	<5	<5	<5	<5	--	--	--	<5	<5	--	--	--	--	--
23	483935099491602	10-20-97	<3	<3	<3	<3	<3	<40	<5	<5	<5	<5	<3	<3	<3	<5	<5	<3	<3	<3	<3	<3
26	483755099514801	10-21-97	<6	<6	<6	<6	<6	<40	<5	<5	<5	<5	<6	<6	<6	<5	<5	<6	<6	<6	<6	<6

Table 6. Gas chromatography/mass spectrography analyses of selected water samples for additional organic compounds--Continued

[Water samples were analyzed at the U.S. Geological Survey National Water Quality Laboratory in Arvada, Colo.; all compounds are in micrograms per liter, <, less than minimum reporting level; --, no data]

Well number	Station number	Date	2-Chlorophenol, total	4-Chlorophenylphenylether, total	0-Chlorotoluene, total	2,2-Dichloropropane, total	1,1-Dichloropropene, total	Cis-1,2-dichloroethene, total	Cis-1,3-dichloropropene, total	Dibromochloropropane, total	1,2-Dibromoethane, total	Dibromomethane, total	1,2-Dichlorobenzene, total	1,3-Dichlorobenzene, total	1,4-Dichlorobenzene, total	3,3-Dichlorobenzidine, total	Dichlorobromomethane, total	Dichlorodifluoromethane, total	1,1-Dichloroethane, total	1,2-Dichloroethane, total	1,1-Dichloroethylene, total	1,2-Dichloropropane, total	Diethyl phthalate, total
1	484728099535301	10-21-97 10-21-97 11-06-97	-- -- <5	-- -- >5	<6 <3 --	<6 <3 --	<6 <3 --	<6 <3 --	<6 <3 --	<2 <1 --	<6 <3 --	<6 <3 --	<6 <3 <5	<6 <3 <5	<6 <3 <5	-- -- <20	<6 <3 --	<6 <3 --	<6 <3 --	<6 <3 --	<6 <3 --	<6 <3 --	<6 <3 --
3	484542099523401	10-21-97	<5	<5	<3	<3	<3	<3	<3	<1	<3	<3	<3	<3	<3	<20	<3	<3	<3	<3	<3	<3	<3
4	484452099511301	10-21-97	<5	<5	<3	<3	<3	<3	<3	<1	<3	<3	<3	<3	<3	<20	<3	<3	<3	<3	<3	<3	<3
11	484124099554001	10-21-97	<5	<5	<3	<3	<3	<3	<3	<1	<3	<3	<3	<3	<3	<20	<3	<3	<3	<3	<3	<3	<3
15	484124099565701	10-21-97 11-06-97	-- <5	-- <5	<6 --	<6 --	<6 --	<6 --	<6 --	<2 --	<6 --	<6 --	<6 <5	<6 <5	<6 <5	-- <20	<6 --	<6 --	<6 --	<6 --	<6 --	<6 --	<6 --
16	483847099530301	10-20-97	<5	<5	<3	<3	<3	<3	<3	<1	<3	<3	<3	<3	<3	<20	<3	<3	<3	<3	<3	<3	<3
17	484217099502901	10-20-97 10-21-97	<5 <5	<5 <5	<6 <6	<6 <6	<6 <6	<6 <6	<6 <6	<2 <2	<6 <6	<6 <6	<6 <6	<6 <6	<6 <6	<20 <20	<6 <6	<6 <6	<6 <6	<6 <6	<6 <6	<6 <6	<6 <6
18	484307099514801	10-21-97 10-21-97 11-06-97	-- -- <5	-- -- <5	<3 <3 --	<3 <3 --	<3 <3 --	<3 <3 --	<3 <3 --	<1 <1 --	<3 <3 --	<3 <3 --	<3 <3 <5	<3 <3 <5	<3 <3 <5	-- -- <20	<3 <3 --	<3 <3 --	<3 <3 --	<3 <3 --	<3 <3 --	<3 <3 --	-- -- <5
20	484119099502402	10-20-97 11-06-97	-- <5	-- <5	<3 --	<3 --	<3 --	<3 --	<3 --	<1 --	<3 --	<3 --	<3 <5	<3 <5	<3 <5	-- <20	<3 --	<3 --	<3 --	<3 --	<3 --	<3 --	<3 --
23	483935099491602	10-20-97	<5	<5	<3	<3	<3	<3	<3	<1	<3	<3	<3	<3	<3	<20	<3	<3	<3	<3	<3	<3	<5
26	483755099514801	10-21-97	<5	<5	<6	<6	<6	<6	<6	<2	<6	<6	<6	<6	<6	<20	<6	<6	<6	<6	<6	<6	<5

Table 6. Gas chromatography/mass spectrography analyses of selected water samples for additional organic compounds--Continued

[Water samples were analyzed at the U.S. Geological Survey National Water Quality Laboratory in Arvada, Colo.; all compounds are in micrograms per liter, <, less than minimum reporting level; --, no data]

Well number	Station number	Date	Dimethyl phthalate, total	2,4-Dimethylphenol, total	Di-N-butylphthalate, total	4,6-Dinitroorthocresol, total	2,4-Dinitrophenol, total	2,4-Dinitrotoluene, total	2,6-Dinitrotoluene, total	Di-N-octyl phthalate, total	1,2-Diphenylhydrazine, total	Freon 113, total	Hexachlorobutadiene, total	Hexachlorocyclopentadiene, total	Hexachloroethane, total	Isophorone, total	p-Isopropyltoluene, total	Methyl tert-butyl ether (MTBE), total	Methyl bromide, total	Methyl chloride, total	n-Nitroso di-n-propylamine, total	n-Nitroso dimethylamine, total
1	484728099535301	10-21-97	--	--	--	--	--	--	--	--	--	<6	<6	--	--	--	<6	<6	<6	<6	--	--
		10-21-97	--	--	--	--	--	--	--	--	--	<3	<3	--	--	--	<3	<3	<3	<3	--	--
		11-06-97	<5	<5	<5	<30	<20	<5	<5	<10	<5	--	<5	<20	<5	<5	--	--	--	--	<5	<5
3	484542099523401	10-21-97	<5	<5	<5	<30	<20	<5	<5	<10	<5	<3	<3	<20	<5	<5	<3	<3	<3	<3	<5	<5
4	484452099511301	10-21-97	<5	<5	<5	<30	<20	<5	<5	<10	<5	<3	<3	<20	<5	<5	<3	<3	<3	<3	<5	<5
11	484124099554001	10-21-97	<5	<5	<5	<30	<20	<5	<5	<10	<5	<3	<3	<20	<5	<5	<3	<3	<3	<3	<5	<5
15	484124099565701	10-21-97	--	--	--	--	--	--	--	--	--	<6	<6	--	--	--	<6	<6	<6	<6	--	--
		11-06-97	<5	<5	<5	<30	<20	<5	<5	<10	<5	--	<5	<20	<5	<5	--	--	--	--	<5	<5
16	483847099530301	10-20-97	<5	<5	<5	<30	<20	<5	<5	<10	<5	<3	<3	<20	<5	<5	<3	<3	<3	<3	<5	<5
17	484217099502901	10-20-97	<5	<5	<5	<30	<20	<5	<5	<10	<5	<6	<6	<20	<5	<5	<6	<6	<6	<6	<5	<5
		10-21-97	<5	<5	<5	<30	<20	<5	<5	<10	<5	<6	<6	<20	<5	<5	<6	<6	<6	<6	<5	<5
18	484307099514801	10-21-97	--	--	--	--	--	--	--	--	--	<3	<3	--	--	--	<3	<3	<3	<3	--	--
		10-21-97	--	--	--	--	--	--	--	--	--	<3	<3	--	--	--	<3	<3	<3	<3	--	--
		11-06-97	<5	<5	<5	<30	<20	<5	<5	<10	<5	--	<5	<20	<5	<5	--	--	--	--	<5	<5
20	484119099502402	10-20-97	--	--	--	--	--	--	--	--	--	<3	<3	--	--	--	<3	<3	<3	<3	--	--
		11-06-97	<5	<5	<5	<30	<20	<5	<5	<10	<5	--	<5	<20	<5	<5	--	--	--	--	<5	<5
23	48393509951602	10-20-97	<5	<5	<5	<30	<20	<5	<5	<10	<5	<3	<3	<20	<5	<5	<3	<3	<3	<3	<5	<5
26	483755099514801	10-21-97	<5	<5	<5	<30	<20	<5	<5	<10	<5	<6	<6	<20	<5	<5	<6	<6	<6	<6	<5	<5

Table 6. Gas chromatography/mass spectrography analyses of selected water samples for additional organic compounds--Continued

[Water samples were analyzed at the U.S. Geological Survey National Water Quality Laboratory in Arvada, Colo.; all compounds are in micrograms per liter, <, less than minimum reporting level; --, no data]

Well number	Station number	Date	n-Nitrosodiphenylamine, total	Nitrobenzene, total	2-Nitrophenol, total	4-Nitrophenol, total	Parachlorometa cresol, total	Parachlorotoluene, total	Phenol (CGH-50), total	Propane, 1,3-dichloro-, total	Styrene, total	1,1,2-Tetrachloroethane, total	1,1,2,2-Tetrachloroethane, total	Tetrachloroethylene, total	Trans-1,3-dichloropropene, total	1,2-Transdichloroethene, total	1,2,4-Trichlorobenzene, total	1,1,1-Trichloroethane, total	1,1,2-Trichloroethane, total	Trichlorofluoromethane, total	1,2,3-Trichloropropane, total	Vinylchloride, total
1	48472809535301	10-21-97	--	--	--	--	--	<6	--	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6	<2
		10-21-97	--	--	--	--	--	<3	--	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<1
		11-06-97	<5	<5	<5	<30	<30	--	<5	--	--	--	--	--	--	--	>5	--	--	--	--	--
3	484542099523401	10-21-97	<5	<5	<5	<30	<30	<3	<5	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<1
4	484452099511301	10-21-97	<5	<5	<5	<30	<30	<3	<5	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<1
11	484124099554001	10-21-97	<5	<5	<5	<30	<30	<3	<5	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<1
15	484124099565701	10-21-97	--	--	--	--	--	<6	--	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6	<2
		11-06-97	<5	<5	<5	<30	<30	--	<5	--	--	--	--	--	--	--	<5	--	--	--	--	--
16	483847099530301	10-20-97	<5	<5	<5	<30	<30	<3	<5	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<1
17	484217099502901	10-20-97	<5	<5	<5	<30	<30	<6	<5	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6	<2
		10-21-97	<5	<5	<5	<30	<30	<6	<5	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6	<2
18	484307099514801	10-21-97	--	--	--	--	--	<3	--	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<1
		10-21-97	--	--	--	--	--	<3	--	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<1
		11-06-97	<5	<5	<5	<30	<30	--	<5	--	--	--	--	--	--	--	<5	--	--	--	--	--
20	484119099502402	10-20-97	--	--	--	--	--	<3	--	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<1
		11-06-97	<5	<5	<5	<30	<30	--	<5	--	--	--	--	--	--	--	<5	--	--	--	--	--
23	483935099491602	10-20-97	<5	<5	<5	<30	<30	<3	<5	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<1
26	483755099514801	10-21-97	<5	<5	<5	<30	<30	<6	<5	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6	<2

Table 7. Estimated concentrations of selected organic compounds that were detected using the gas chromatography/mass spectrography method

[Water samples were analyzed at the U.S. Geological Survey National Water Quality Laboratory in Arvada, Colo.; µg/L, micrograms per liter; >, greater than; --, not determined]

Well number	Station number	Date	Acetone (µg/L)	2-Butanone (µg/L)	Prometon (µg/L)	Tetrahydrofuran (µg/L)
1	484728099535301	10-21-1997	>1,200	--	--	>10,000
1	484728099535301	10-21-1997	>600	--	--	>14,000
3	484542099523401	10-21-1997	--	--	--	>600
4	484452099511301	11-03-1997	--	--	--	>800
11	484124099554001	10-21-1997	--	--	--	>600
15	484124099565701	10-21-1997	>7,800	74.5	--	>20,000
15	484124099565701	11-06-1997	--	--	1.0	--
16	483847099530301	11-03-1997	--	--	--	>6,300
17	484217099502901	10-20-1997	>1,600	--	--	>20,000
17	484217099502901	10-21-1997	>6,900	61	--	>21,000
18	484307099514801	10-21-1997	--	--	--	>200
18	484307099514801	10-21-1997	--	--	--	>200
26	483755099514801	10-21-1997	>8,900	110	--	>20,000

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