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Evaluation of Water-Chemistry and Water-Level Data at the Henderson Road Superfund Site, Upper Merion Township, Montgomery County, Pennsylvania, 1991–2008

Scientific Investigations Report 2009–5101

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

Cover.

Aerial photograph of the Henderson Road Site (bottom center) and the Upper Merion Reservoir (top center), 2005 Photograph courtesy of the Delaware Valley Regional Planning Commission (DVRPC).

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U.S. Geological Survey

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KEN SALAZAR, Secretary

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Conversion Factors, Abbreviations, and Datums

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
acre	4,047	square meter (m^2)
acre	0.4047	square hectometer (hm^2)
acre	0.004047	square kilometer (km^2)
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
gallon (gal)	3.785	liter (L)
gallon (gal)	0.003785	cubic meter (m^3)
million gallons (Mgal)	3,785	cubic meter (m^3)
	Flow rate	
gallon per minute (gal/min)	0.06309	liter per second (L/s)
gallon per day (gal/d)	0.003785	cubic meter per day (m^3/d)
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)
	Hydraulic conductivity	
foot per day (ft/d)	0.3048	meter per day (m/d)

Vertical coordinate information is referenced to a local site benchmark at the Henderson Road Site and is given in feet above mean sea level. All data collected at the site since the 1980s was referenced to this benchmark.

Horizontal coordinate information is referenced to the North American Datum of 1988 (NAD 88).

Altitude, as used in this report, refers to distance above the vertical datum.

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (µg/L).

Evaluation of Water-Chemistry and Water-Level Data at the Henderson Road Superfund Site, Upper Merion Township, Montgomery County, Pennsylvania, 1991–2008

By Ronald A. Sloto

Abstract

Several shutdown-rebound tests have been conducted at the Henderson Road Superfund Site, which has been on the U.S. Environmental Protection Agency's National Priorities List since 1984. For a given test, the extraction wells are turned off, and water samples are collected from selected monitor wells at regular intervals before and during cessation of pumping to monitor for changes in chemical concentrations. A long-term shutdown-rebound test began on July 17, 2006. In support of this test, the U.S. Geological Survey conducted this study to determine the effects of shutting down on-site extraction wells on concentrations of selected contaminants and water levels. Concentrations were compared to ARARs (applicable relevant and appropriate requirements), which were set as remediation goals in the Henderson Road Site Record of Decision.

Water from 10 wells in and near the source area and to the north, northeast, and northwest of the source area sampled in 2008 exceeded the 5.52 µg/L (micrograms per liter) ARAR for benzene. The greatest changes in benzene concentration between pre-shutdown samples collected in July 2006 and samples collected in February and March 2008 (19 months after the shutdown) were for wells in and north of the source area; increases in benzene concentration ranged from 1.5 to 164 µg/L.

Water from five wells in the source area and to the north and northwest of the source area sampled in 2008 exceeded the 60 µg/L ARAR for chlorobenzene. The greatest changes in chlorobenzene concentration between pre-shutdown samples collected in July 2006 and samples collected in February and March 2008 were for wells north of the source area; increases in chlorobenzene concentration ranged from 6.9 to 99 µg/L. The highest concentrations of chlorobenzene were near or outside the northern site boundary, indicating chlorobenzene may have moved north away from the source area; however, no monitor well clusters are on the northern side of the Pennsylvania Turnpike, which is about 190 feet north of the source area. A much larger area was affected by chlorobenzene than benzene. Chlorobenzene concentrations decreased in the source area and increased at and beyond the site boundary.

Water from four wells in and northeast of the source area sampled in 2008 exceeded the 5.06 µg/L ARAR for 1,1-dichloroethane (1,1-DCA). Increases in 1,1-DCA concentration between pre-shutdown samples collected in July 2006 and samples collected in February 2008 ranged from 0.4 to 20 µg/L. Water from two wells in the source area sampled in 2008 exceeded the 175 µg/L ARAR for total xylene. The 1,1-DCA and xylene plumes appear to extend in an east-northeast direction from the source area.

Large drawdowns in the Upper Merion Reservoir during droughts in 1998 and 2001 affected water levels in the Chester Valley and at the Henderson Road Site, except for well HR-17-170. After the drought of 2001, water levels in the Chester Valley showed a protracted recovery lasting from September 2001 until June 2005 (46 months).

Water-level data were evaluated temporally for 1997–2008 and spatially for (1) June 16, 2003, when the extraction wells were pumping at the full rate prior to the start of the June 2003 shutdown test; (2) July 10, 2006, during the period of reduced pumping after the June 2003 shutdown test; and (3) February 25–29, 2008, when the extraction wells were not pumping. Except for well HR-5-195, wells were categorized as shallow, intermediate-depth, and deep wells. The potentiometric surface for shallow wells did not appear to be affected by pumping of the extraction wells. The general direction of ground-water flow was to the north. The potentiometric surface for intermediate-depth wells showed a cone of depression when the extraction wells were pumping at the full rate but did not show a cone of depression when the extraction wells were pumping at the reduced rate. The ground-water-flow direction was toward the north and northeast, similar to that when the extraction wells were pumping.

Water-level data were available for only four on-site deep wells when the extraction wells were pumping. The available water-level data showed a flat hydraulic gradient. When the wells were pumping at the full rate, the ground-water-flow direction was to the Henderson Road Site from the northwest; when the wells were pumping at the reduced rate, the ground-water-flow direction was reversed, and flow was away from

the Henderson Road Site to the northwest. When the extraction wells were not pumping, the ground-water-flow direction was away from the Henderson Road Site toward the north and northeast.

Benzene concentrations measured in water samples from shallow wells in February and March 2008 were above the ARAR only in the source area. Benzene concentrations measured in water samples from intermediate-depth wells were above the ARAR in the source area and beyond the northern site boundary. Benzene concentrations measured in water samples from deep wells were above the ARAR in the source area and at and beyond the northern site boundary. Benzene appears to have moved to the north away from the source area in the intermediate and deep zones.

Chlorobenzene concentrations measured in water samples from shallow wells collected in February and March 2008 were above the ARAR beyond the northern site boundary northwest of the source area. Chlorobenzene concentrations measured in water samples from intermediate-depth wells were above the ARAR in the source area and beyond the northern site boundary northwest of the source area. Chlorobenzene concentrations measured in water samples from deep wells collected in February and March 2008 were above the ARAR at and beyond the northern site boundary. Chlorobenzene appears to have moved to the north away from the source area in the shallow, intermediate, and deep zones.

Off-site wells were drilled to monitor the possible movement of chemicals of concern from the Henderson Road Site. Concentrations of benzene and chlorobenzene above the ARARs were measured in water samples from well cluster HR-7 at the northern site boundary and well cluster HR-6 beyond the northern site boundary on the southern side of the Pennsylvania Turnpike. No off-site monitor wells are located directly north of these well clusters on the northern side of the Pennsylvania Turnpike. Potentiometric-surface maps indicate the direction of ground-water flow from these well clusters is to the north. Additional monitor well clusters north of well clusters HR-6 and HR-7 on the northern side of the Pennsylvania Turnpike could help determine how far benzene or chlorobenzene have moved offsite and could be used to better define ground-water-flow directions north of the site.

Introduction

The Henderson Road Superfund Site, herein referred to as the Henderson Road Site, occupies approximately 7 acres in Upper Merion Township, Montgomery County, Pa. (fig. 1). Between December 1974 and March 1977, an on-site well (the injection well) was used to dispose of liquid industrial waste containing organic contaminants. In addition, an on-site landfill received industrial and municipal wastes. The site was listed on the U.S. Environmental Protection Agency (USEPA) National Priorities List on September 21, 1984.

A ground-water treatment plant was constructed and began operation in September 1991. The treatment plant utilized bioremediation to reduce organic contaminant levels and carbon adsorption to remove residual contaminants before the treated water was discharged to an adjacent intermittent stream. Initially, five ground-water extraction wells pumped contaminated ground water to the treatment plant.

Several shutdown-rebound tests were conducted on the site. The objective of a shutdown-rebound test is to determine whether chemical concentrations would increase or be stable in the absence of pumping. For a given test, the extraction wells are turned off, and water samples are collected from selected monitor wells at regular intervals before and during cessation of pumping to monitor for changes in chemical concentrations. A long-term shutdown-rebound test began on July 17, 2006. The U.S. Geological Survey (USGS) conducted this study for the USEPA in support of this extended shutdown-rebound test to determine the effects of shutting down the extraction wells on the concentrations of selected contaminants and on water levels.

All chemical and most water-level data used for this study were collected and furnished by RT Environmental Services, Inc., a contractor for the responsible parties at the Henderson Road Site. RT Environmental Services, Inc. has worked at the site since 1989. They designed and implemented the site-remediation system and operate the treatment plant.

Shutdown-Rebound Tests

In September 1991, the ground-water treatment plant began operation. Initially, five ground-water extraction wells (B-1, IW, HR-3-255, HR-3-295, and RE-205) pumped contaminated ground water to the treatment plant. Wells HR-24-476 and HR-26-457 were later added as extraction wells, and wells B-1 and HR-24-476 were discontinued as extraction wells.

Several shutdown-rebound tests were conducted to evaluate the effect of shutting down the extraction wells on chemical concentrations. Short tests (1 to 3 weeks in duration) were conducted in June 1995, April 1997, and April 1999. A longer, 5.5-month test was conducted from June 30 to December 12, 2003; this test is referred to as the 2003 shutdown test in this report. Following this test, the pumping rate for the extraction wells was reduced. A second, long-term shutdown-rebound test was started on July 17, 2006; this test is called the 2006–08 shutdown test in this report. The time line covered by this report is shown in figure 2.

Purpose and Scope

This report summarizes selected chemical and water-level data collected at the Henderson Road Site. Data for volatile organic compounds (VOCs) in ground-water samples collected from August 1991 to August 2008 and ground-water levels collected from May 1997 to August 2008 were

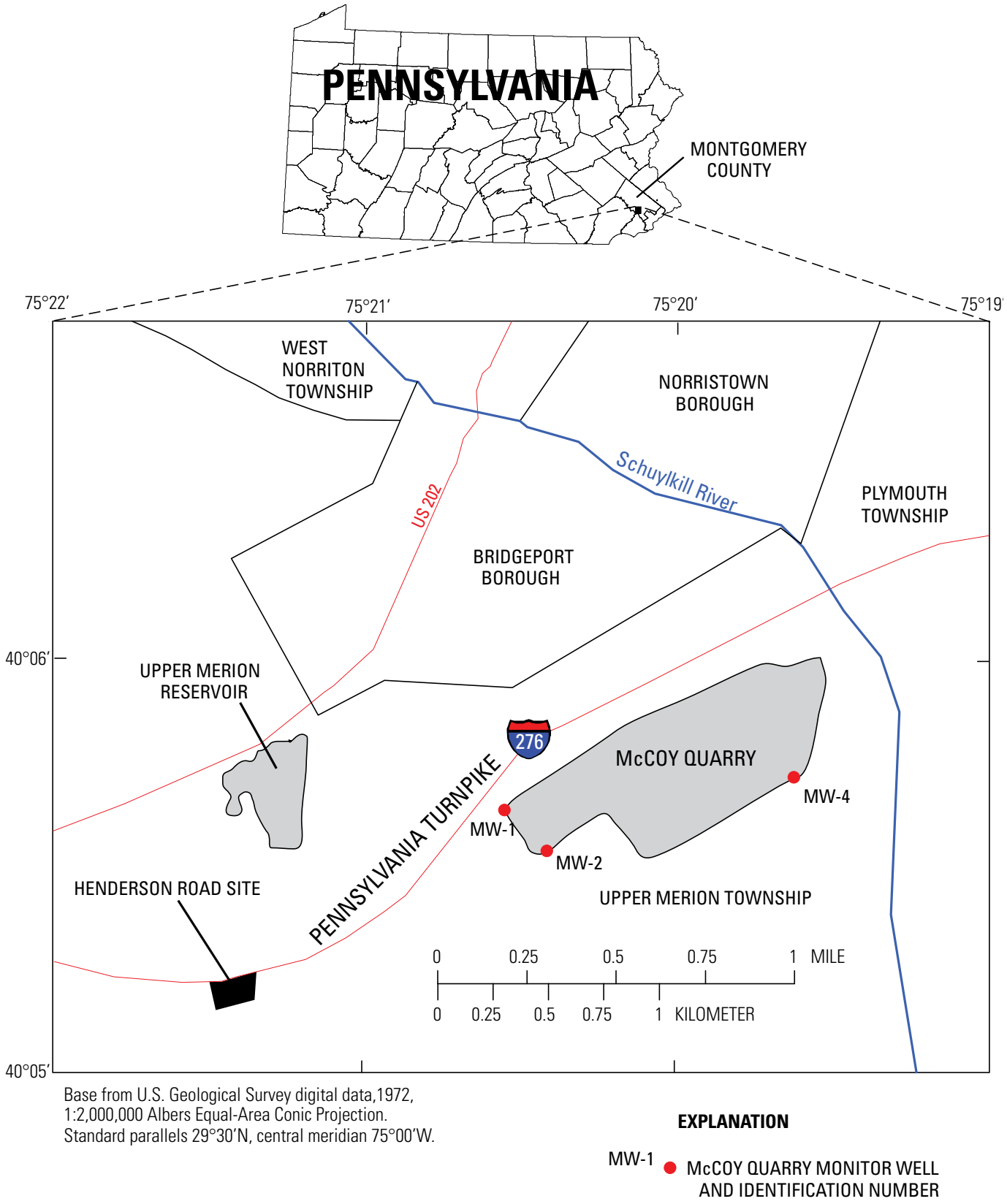


Figure 1. Location of the Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania.

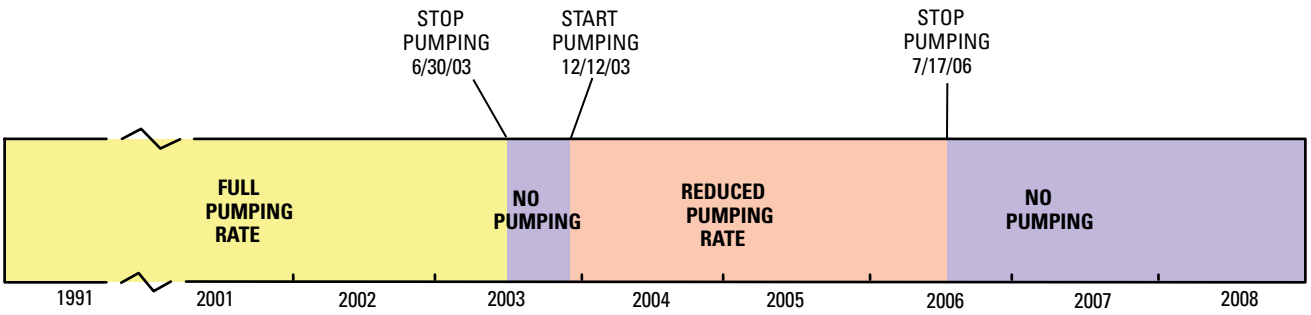


Figure 2. Shutdown-rebound test time line at the Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1991–2008.

compared graphically. Median VOC concentrations in ground-water samples were compared. The effects of the 2006–08 shutdown-rebound test on VOC concentrations and water levels in 41 monitor wells are discussed.

Well-Numbering System

The well-identification numbering system used in this report is that used by RT Environmental Services, Inc., to be consistent with previous site work. Most site well-identification numbers consist of the prefix HR (Henderson Road) followed by two numbers. The first number identifies the well cluster or group. The second number is the well depth. Well HR-6-377, for example, is a 377-ft deep well in well cluster 6. Other prefixes include RE (replacement well) and B (boring). The injection well is designated as IW. Well locations are shown on figure 3, and data for the wells are given in table 1. Wells south of the Pennsylvania Turnpike are considered to be on-site wells; wells north of the Pennsylvania Turnpike are considered to be off-site wells.

Site Geology

The Henderson Road Site is in a carbonate valley, known as Chester Valley (shown on fig. 4), in southwest Montgomery County near the Schuylkill River (fig. 1). The site is about 2,100 ft south of the Upper Merion Reservoir (fig. 1), which is operated by Aqua Pennsylvania, Inc. The Upper Merion Reservoir is a former dolomite quarry now used as a source of public water supply. Aqua Pennsylvania, Inc. supplies water to much of the Philadelphia suburban area. The water is treated for removal of VOCs prior to distribution. A large active quarry, the McCoy Quarry, is northeast of the Henderson Road Site.

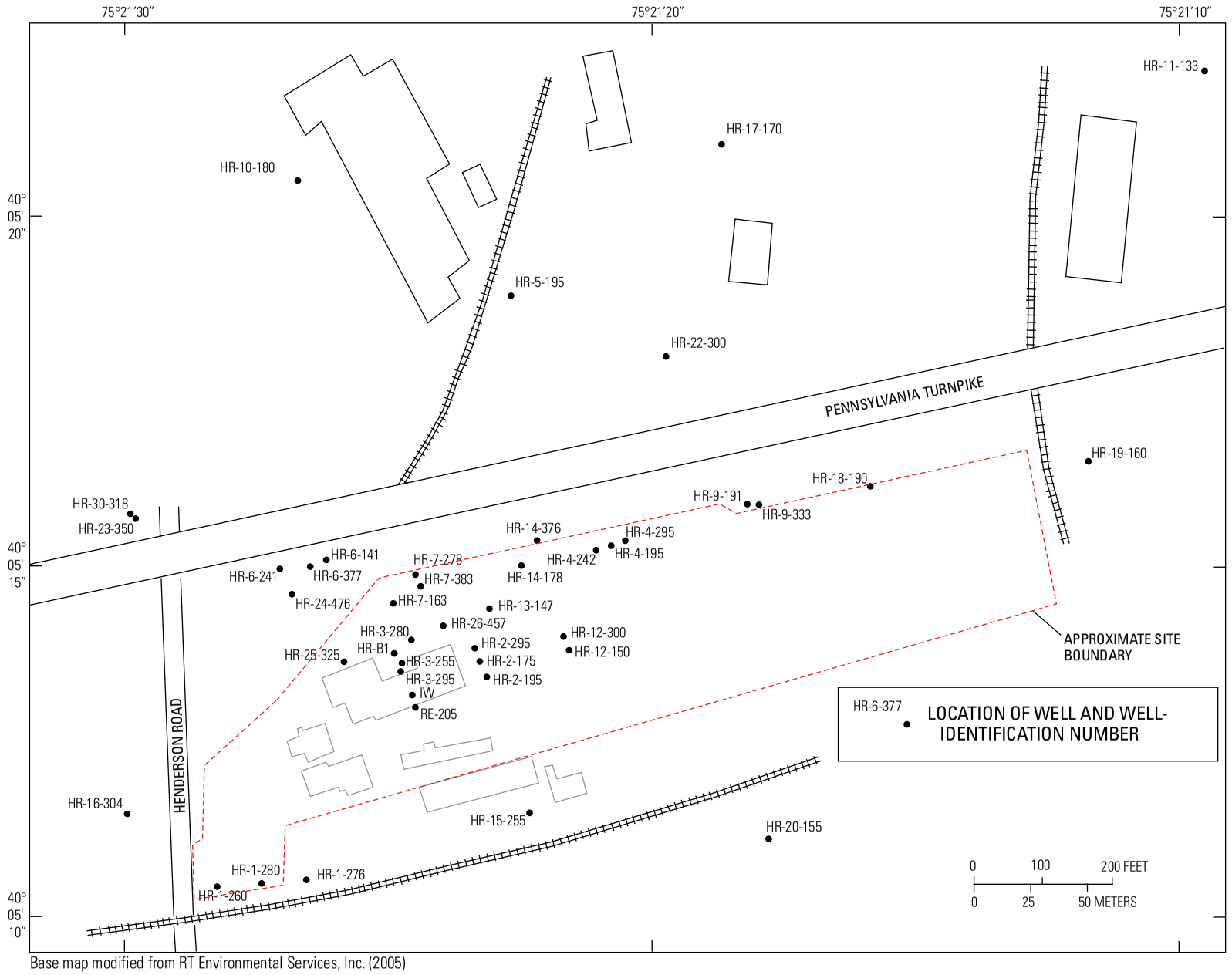
The Henderson Road Site is underlain by the Conestoga Limestone (fig. 4), which forms a complex, fractured, carbonate-rock aquifer. The Conestoga is a blue-gray, thin-bedded, argillaceous limestone with intervals of a purer, granular limestone. Mica coats most of the bedding and cleavage planes (Lyttle and Epstein, 1987). The impure part of the Conestoga has thin-bedded alterations of dark-gray, clayey, silty, slaty, micaceous layers and medium-gray, argillaceous limestone that impart a characteristic banded appearance to the rock. Some of the basal beds are a coarse limestone conglomerate containing large pebbles and irregular masses of coarse white marble in a gray limestone. The Conestoga Limestone is 500 to 800 ft thick and unconformably overlies the Elbrook Formation. At the Henderson Road Site, karst features such as solution channels, voids, and deep weathering are prevalent. Depth to water in wells on the Henderson Road Site measured in August 2008 ranged from 97 to 142 ft below land surface.

The Elbrook Formation lies between the Henderson Road Site and the Upper Merion Reservoir (fig. 4). The Elbrook is a light-gray to white, finely laminated, fine-grained, interbedded limestone and marble. The Elbrook is 300 to 800 ft thick. The lower contact is gradational with the Ledger Dolomite.

Ground-water flow in the region is influenced by the pumping of the Upper Merion Reservoir for water supply and by the McCoy Quarry for dewatering. The Upper Merion Reservoir and the McCoy Quarry are in the Ledger Dolomite (fig. 4). The Ledger is a white to light gray, massive to thick-bedded, granular, relatively pure dolomite with a high magnesium content. The dolomite is interbedded with some siliceous beds and laminated limestone. The Ledger contains a few beds of marble with a high calcium content. The Ledger is 660 to 1,000 ft thick.

Evaluation of Water-Chemistry Data

Wells at the Henderson Road Site have been sampled for VOCs (table 2) since 1991. Compounds analyzed and applicable or relevant and appropriate requirements (ARARs) set in the Record of Decision for the Henderson Road Site (U.S. Environmental Protection Agency, 1988a) are listed in table 2. Section 121(d) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) requires that on-site remedial actions attain or waive Federal environmental ARARs, or more stringent State environmental ARARs, upon completion of the remedial action. ARARs are identified on a site-by-site basis. A requirement under other environmental laws may be either



Base map modified from RT Environmental Services, Inc. (2005)

Figure 3. Location of wells at the Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania.

Table 1. Record of wells at the Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania.

[—, no data; *, major water-bearing fracture; >, greater than; < less than]

Well-identification number	Year drilled	Depth drilled (feet)	Depth cased (feet)	Yield (gallons per minute)	Depth of fracture or void (feet below land surface)	Screened (S) or open-hole (OH)	Screened or open-hole interval (feet below land surface)	Elevation of top of casing (feet above mean sea level)
B-1	1990	140	—	—	—	—	—	158.82
HR-1-260	1986	260	54	3	210, 215*	OH	54–260	161.83
HR-1-276	1986	280	31	15	270*	S	255.4–276.2	159.73
HR-1-280	1986	280	61	1	—	OH	61–280	160.73
HR-2-175	1986	175	107.5	> 50	94–102, 132, 161–164*	S	154.7–175.5	161.19
HR-2-195	1986	195	101	< 5	80–95, 108–112, 133–135	OH	101–158.3	161.35
HR-2-295	1986	300	101	> 30	148, 155*, 205–223, 278	S	274–294.8	161.01
HR-3-255	1986	255	137	< 1	67, 126*	OH	137–255	161.67
HR-3-280	1986	280	140	1	260*	OH	137–280	158.82
HR-3-295	1986	300	117	15	67, 132, 282*	S	274.7–295	161.39
HR-4-195	1986	220	143	—	153–160	S	174.1–194.9	160.35
HR-4-242	1986	280	116	—	228–230	S	221.4–242.2	160.17
HR-4-295	1986	300	300	> 30	161, 177–178, 181*, 280–300	S	274.4–295.2	160.37
HR-5-195	1986	200	179.2	10	—	S	181.3–192.1	156.20
HR-6-141	—	—	—	—	—	—	—	164
HR-6-241	1991	241	188	20	181, 201, 235*	OH	188–241	164.31
HR-6-377	1991	377	295	8	161, 277, 314, 357	OH	295–377	165.11
HR-7-163	1991	163.5	105	1	150*	OH	105–163.5	158.66
HR-7-278	1991	278	209	30	181, 221, 231, 261, 278*	OH	209–278	159.30
HR-7-383	1991	383	301	46	201, 208, 241, 301, 383	OH	301–383	159.08
HR-9-191	1991	191	9.5	2	95-99.5, 140, 181, 191	OH	9.5–191	171.50
HR-9-333	1991	333	273	20	181, 241, 261, 281, 301	OH	273–333	170
HR-10-180	1990	180	133	10	—	OH	133–180	173.81
HR-12-150	—	—	—	—	—	—	—	157.68
HR-12-300	1991	300	218	8	161, 171, 266*	OH	218–300	157.81
HR-13-147	—	147	124	5	—	OH	124–147	158.17
HR-14-178	1991	178.5	82	2	119, 129, 156, 178.5	OH	82–178.5	160.81
HR-14-376	1991	376	292.5	50	280, 336, 376	OH	292.5–376	158.87
HR-15-225	1991	225	200	10	160, 190, 200, 210, 215	OH	200–225	151.18
HR-16-304	1991	304	160	1.5	175, 185, 215, 250, 300	OH	160–304	—
HR-17-170	1991	170	69.5	3	86-93, 102–103	OH	69.5–154.55	151.20
HR-18-190	1991	190	35.5	1	109, 161, 190	OH	35.5–190	167.50
HR-19-160	1991	160	79	2	132, 160	OH	79–160	135.36
HR-20-155	1991	155	102	—	50–53, 59–61, 65–66, 89–95, 100–107, 112–114, 124.5–151	S	102–132	152.06
HR-22-300	1992	300	219	3	275*	OH	219–300	157.33
HR-23-350	—	—	—	—	—	—	—	174.47
HR-24-476	1992	476	78	60	195, 221, 260, 315*	OH	78–476	164.34
HR-25-325	1992	330	284	—	—	OH	284–330	159.76
HR-26-457	1992	457	50	10	201, 260, 340, 357, 424	OH	50–457	158.50
HR-30-318	2007	318	285	8	296	S	297.5–318	174.72
IW (Injection well)	—	165.5	81	> 50	90-93, 97–102, 164–165.5	OH	81–165.5	159.79
RE-205	1986	280	103	30	203–205	OH	103–280	161.38

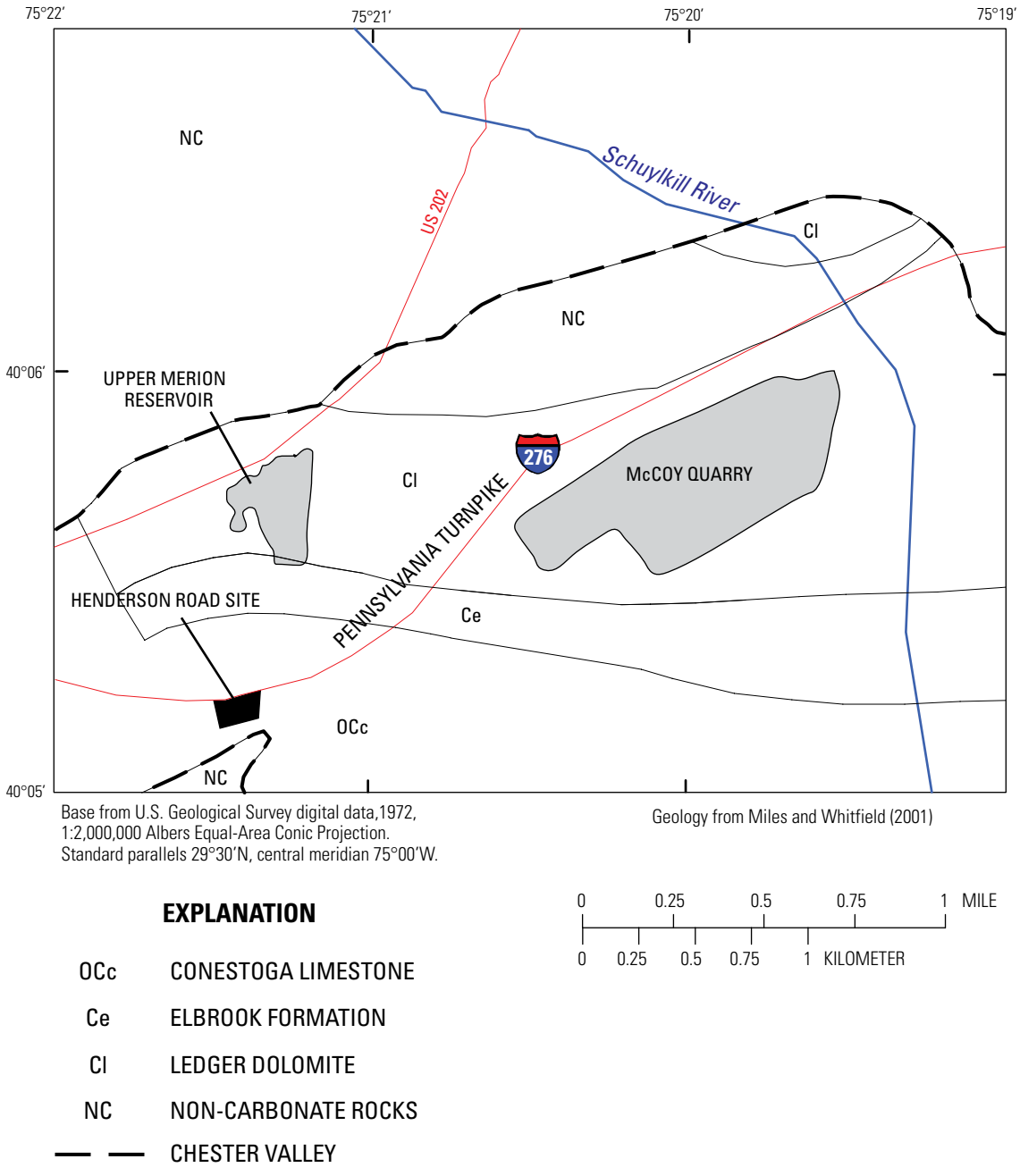


Figure 4. Geology in the vicinity of the Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania.

Table 2. Compounds analyzed, applicable or relevant and appropriate requirements (ARARs) set for volatile organic compounds at the Henderson Road Site in the Record of Decision (U.S. Environmental Protection Agency, 1988a), and U.S. Environmental Protection Agency maximum contaminant levels (MCLs) for drinking water.

[µg/L, micrograms per liter; —, no ARAR or MCL set]

Compound	ARAR (µg/L)	U.S Environmental Protection Agency MCL[1] (µg/L)
Benzene	5.52	5
Bromodichloromethane	100	—
2-Butanone	—	—
Carbon disulfide	—	—
Carbon tetrachloride	5	5
Chlorobenzene	60	100
Chloroethane	19,000	—
Chloroform	100	—
Chloromethane	—	—
Dibromochloromethane	100	—
1,1-Dichloroethane (1,1-DCA)	5.06	—
1,2-Dichloroethane (1,2-DCA)	6.02	5
1,1-Dichloroethene	7	7
cis-1,2-Dichloroethene (cis-1,2-DCE)	70	70
1,2-Dichloroethene	70	—
1,2-Dichloropropane	6.28	5
Ethylbenzene	680	700
2-Hexanone	—	—
Methylene chloride	47	—
Styrene	—	100
Tetrachloroethylene (PCE)	6.9	5
Toluene	2,000	1,000
Total xylene	175	10,000
1,1,1-Trichloroethane	200	200
Trichloroethylene (TCE)	25.8	5
Vinyl chloride	2	2
Trichloroflouromethane	12,000	—

[1]U.S. Environmental Protection Agency (2009).

"applicable" or "relevant and appropriate," but not both. Identification of ARARs must be done on a site-specific basis and involves a two-part analysis: first, a determination whether a given requirement is applicable; then, if it is not applicable, a determination whether it is nevertheless both relevant and appropriate. Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site. Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law that, although not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site (U.S. Environmental Protection Agency, 1988b).

Data for VOCs in ground water were provided by RT Environmental Services, Inc. The database consisted of 1,172 VOC analyses of 29 compounds for 27 wells over a period of 18 years. Detection limits were not provided and are not known. Concentrations below the detection limit were given as 0 (zero). For the statistics presented in this report, zero was used for concentrations below the detection limit. For the 2006–08 shutdown test, 13 wells were sampled quarterly and an additional 12 wells were sampled twice (May 2007 and February 2008) (table 3). Summary statistics for selected compounds are presented in table 7 (at the back of the report). Wells for which no compound exceeded the ARARs (HR-10-180, HR-17-170, and HR-30-318) are not listed in table 7. Not all wells were sampled for all dates.

Grouping of data for statistical analysis depended on the number of analyses available. If enough analyses were available, data were grouped into four general categories: (1) early full-pumping rate period, 1991 to 1999; (2) pre-2003 shutdown full-pumping rate, 2000 to June 2003; (3) 2003 shutdown test and pumping at the reduced rate, July 2003 to January 2007; and (4) most recent samples, May 2007 to August 2008. For 25 wells sampled in 2008, ARARs were exceeded for benzene (10 wells), chlorobenzene (5 wells), 1,1-dichloroethane (1,1-DCA) (4 wells), and total xylene (m-, p-, and o-xylene) (2 wells). No off-site downgradient well sampled during 2003–08 exceeded the ARARs.

Table 3. Wells sampled during the 2006–08 shutdown-rebound test, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania. (Well locations are shown on figure 3.)

Wells sampled quarterly	Wells sampled in May 2007 and February 2008
HR-3-280	HR-2-195
HR-4-295	HR-2-295
HR-6-141	HR-3-295
HR-6-241	HR-5-195
HR-6-377	HR-7-163
HR-7-383	HR-7-278
HR-14-376	HR-10-180
HR-17-170	HR-14-178
HR-18-190	HR-25-325
HR-20-155	HR-26-457
HR-22-380	Injection well
HR-24-476	RE-205
HR-30-318	

Injection Well

Between December 1974 and March 1977, an on-site well, known as the injection well (IW on fig. 3), was used to dispose of liquid industrial waste containing organic contaminants. In 1991, water samples from the injection well exceeded the ARARs for 13 of 22 compounds. In general, concentrations for all compounds except 1,2-dichloropropane and cis-1,2-dichloroethene (cis-1,2-DCE) have substantially decreased since the 1990s (table 7). The concentrations of most compounds increased around the time of the June 2003 shutdown and then decreased (figs. 5 and 6). Median concentrations of most compounds have substantially decreased since 1991 except for six compounds: chlorobenzene, cis-1,2-DCE, 1,2-dichloropropane, tetracloroethylene, trichloroethylene (TCE), and vinyl chloride (table 7, fig. 7).

Between May 2003 and August 2008, concentrations exceeded ARARs for nine compounds: benzene, chlorobenzene, 1,1-DCA, 1,2-dichloroethane (1,2-DCA), cis-1,2-DCE, 1,2-dichloropropane, tetrachloroethylene (PCE), vinyl chloride, and total xylene (table 7). Median concentrations of benzene and 1,1-DCA exceeded the ARARs. The ARAR for vinyl chloride was exceeded in 41 percent of samples. For the two samples collected in 2007–08, the ARAR was exceeded only for benzene and total xylene.

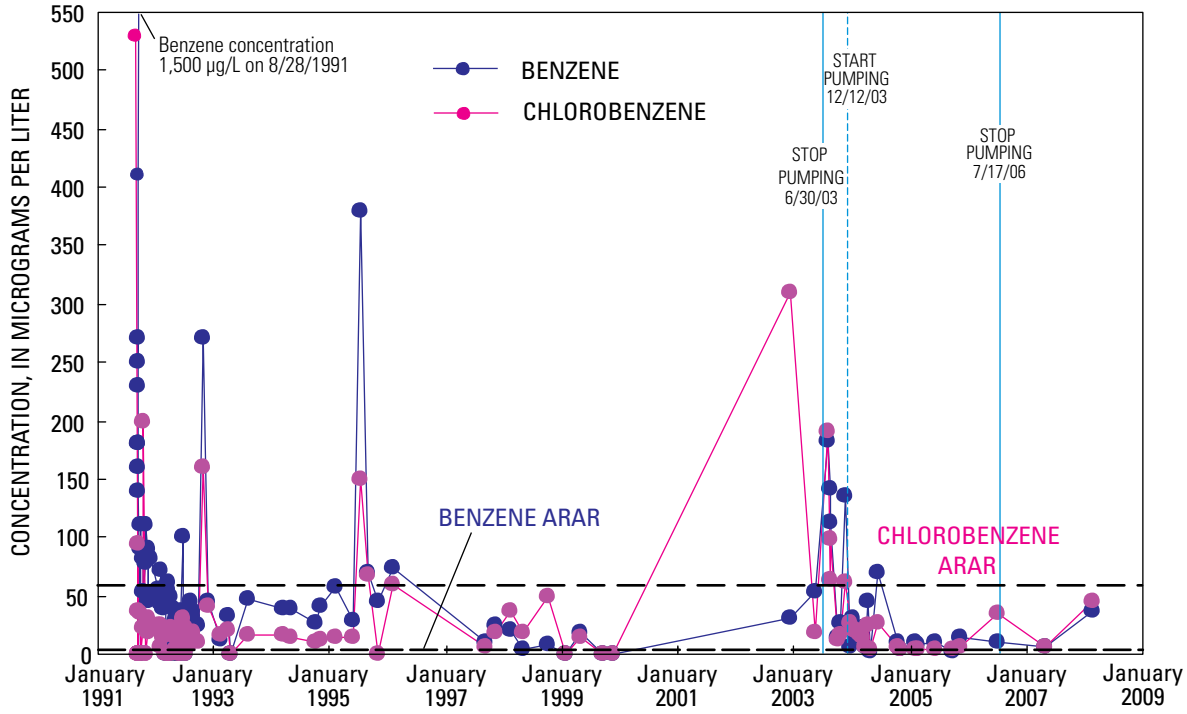


Figure 5. Concentrations of benzene and chlorobenzene in water samples from the injection well, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1991–2008. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

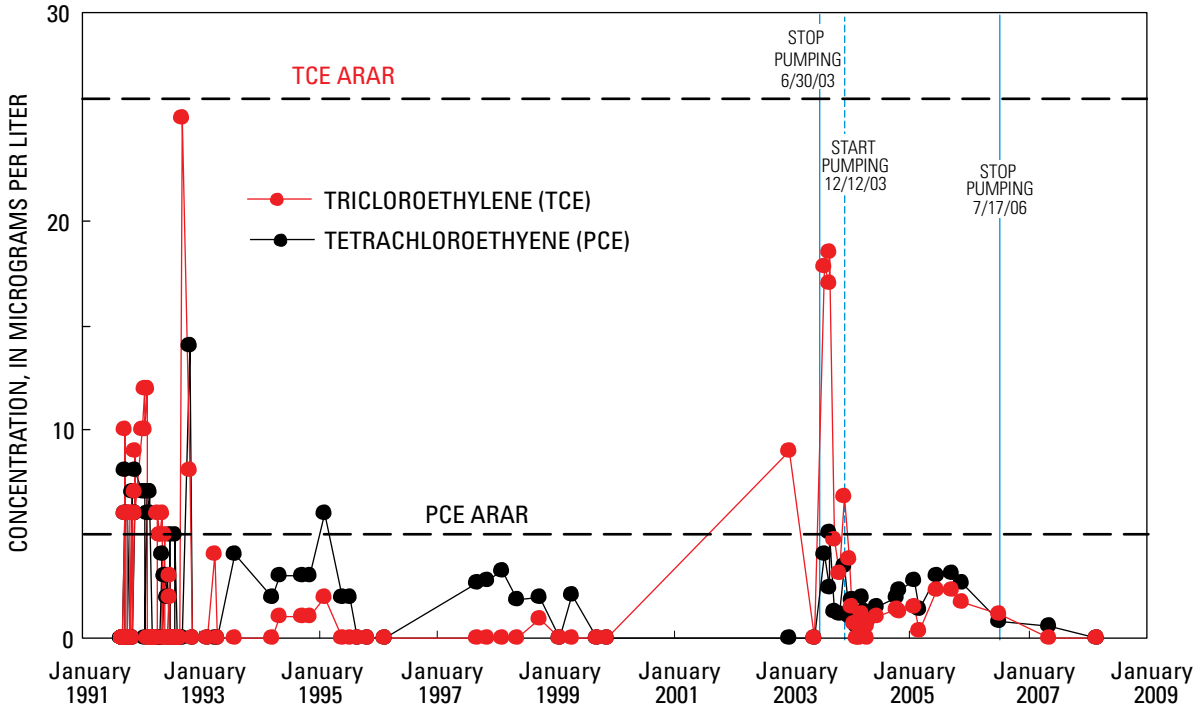


Figure 6. Concentrations of trichloroethylene and tetrachloroethylene in water samples from the injection well, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1991–2008. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

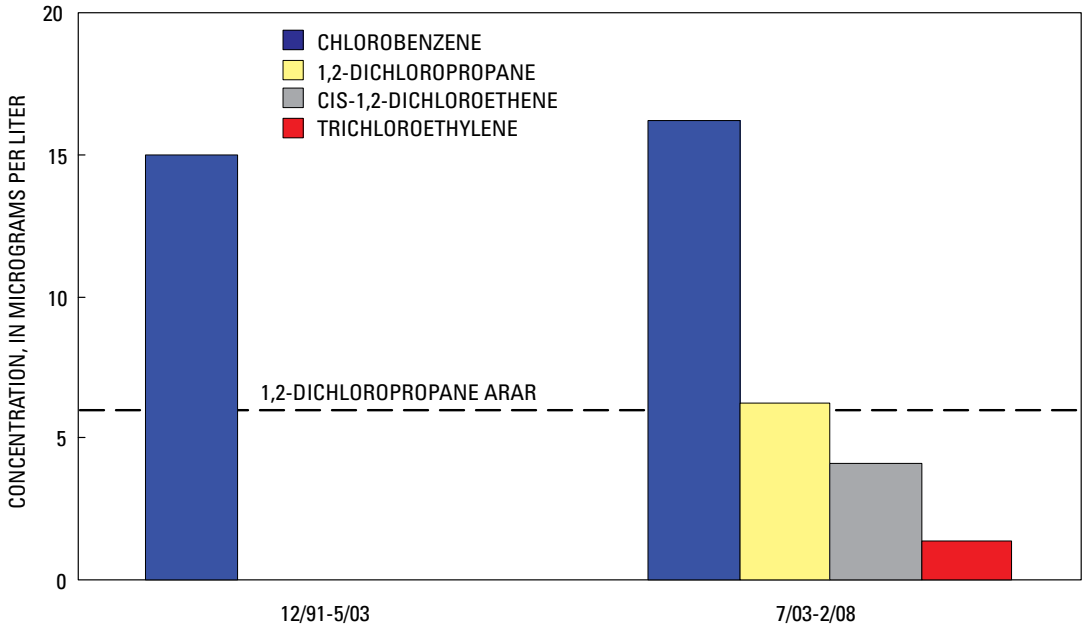


Figure 7. Concentrations of chlorobenzene,1,2-dichloropropane, cis-1,2-dichloroethene, and trichloroethylene in water samples from the injection well, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1991–2008. Median concentrations of 1,2-dichloropropane, cis-1,2-dichloroethene, and trichloroethylene were zero for 1991 to May 2003. ARARS for chlorobenzene, cis-1,2-dichloroethene, and trichloroethylene are 60, 70, and 25.8 micrograms per liter, respectively. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

HR-2 Cluster Wells

Well HR-2-175 was not sampled during the 2006–08 shutdown test; it was last sampled on June 15, 2005. Between July 2003 and June 2005, concentrations in water samples from well HR-2-175 exceeded the ARARs for benzene, 1,1-DCA (figs. 8 and 9), 1,2-dichloropropane, vinyl chloride (table 7), and total xylene (fig. 10). Median benzene concentrations were highest during 1992–99 (11 µg/L) (figs. 9 and 11), declined during August 2000 to May 2003 (4.1 µg/L), and then increased to greater than the ARAR during the 2003 shutdown test (7.5 µg/L) (fig. 11). Median concentrations of 1,1-DCA have remained about the same for the period 1992–2005 (fig. 11). The concentration of total xylene in water samples from well HR-2-175 dropped below the ARAR on August 25, 2003, and remained below the ARAR from August 2003 to June 2005 (fig. 10).

During the 2006–08 shutdown test, wells HR-2-195 and HR-2-295 were sampled twice (May 2007 and February 2008). Well HR-2-195 was sampled only three times prior to the June 2003 shutdown test; the benzene concentration was below the ARAR for all three samples. After the June 2003 shutdown, well HR-2-195 was sampled four times; the benzene concentration exceeded the ARAR for all four samples (fig. 12). The median benzene concentration in water samples from well HR-2-195 for 2005–08 was 41 µg/L (fig. 13). The median concentration for chlorobenzene in water samples from well HR-2-195 increased from 0 for 1992 to May 2003 to 17 µg/L for June 2005 to February 2008 (fig. 13); however, concentrations did not exceed the ARAR. For 1990–99, water samples from well HR-2-195 exceeded the ARARs for 1,1-DCA, cis-1,2-DCE, ethylbenzene, methylene chloride, toluene, and total xylene (table 7).

Well HR-2-295 was sampled three times prior to the June 2003 shutdown test and four times thereafter. The ARAR for benzene was exceeded for two of the three water samples collected before the 2003 shutdown. The concentrations of benzene in the four water samples collected after the start of the June 2003 shutdown were below the ARAR (fig. 14). The concentration of 1,1-DCA in six of the seven water samples from well HR-2-295 exceeded the ARAR (fig. 14). The median concentrations of benzene and 1,1-DCA were compared before and after the June 2003 shutdown test (fig. 15). The median concentration of benzene decreased from 7.5 to 3.4 µg/L, and the median concentration of 1,1-DCA increased from 5.8 to 6.2 µg/L.

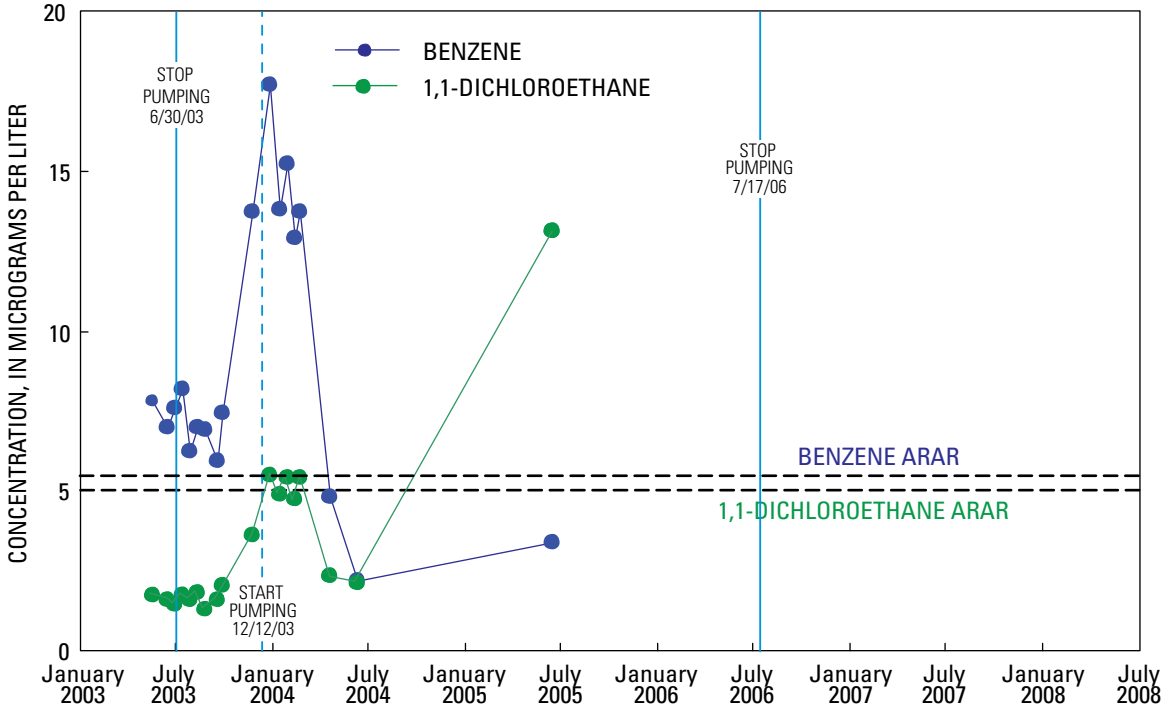


Figure 8. Concentrations of benzene and 1,1-dichloroethane in water samples from well HR-2-175, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 2003-05. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

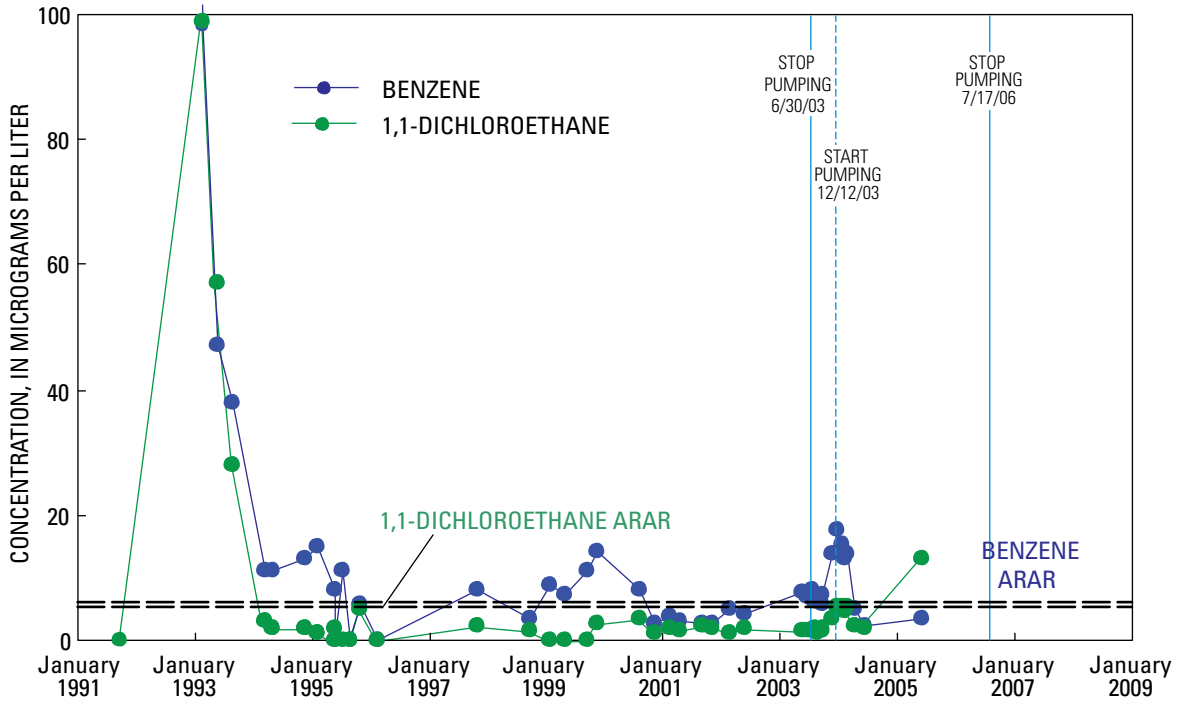


Figure 9. Concentrations of benzene and 1,1-dichloroethane in water samples from well HR-2-175, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1991–2005. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

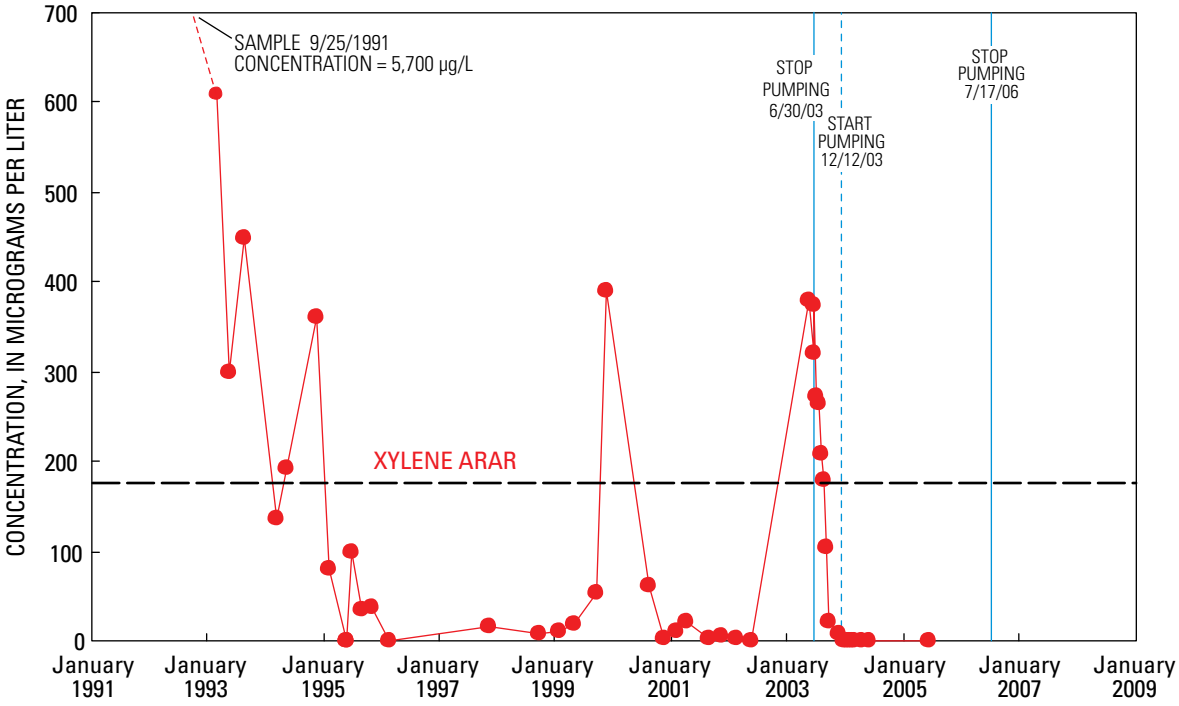


Figure 10. Concentrations of total xylene in water samples from well HR-2-175, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1991–2005. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

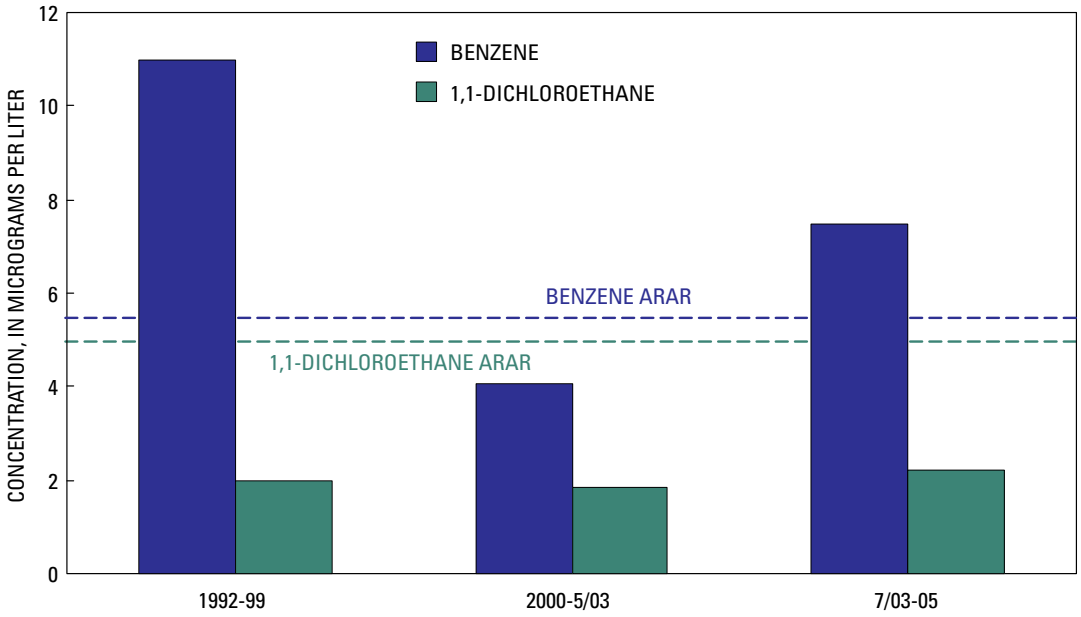


Figure 11. Median concentrations of benzene and 1,1-dichloroethane in water samples from well HR-2-175, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1992–2005. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

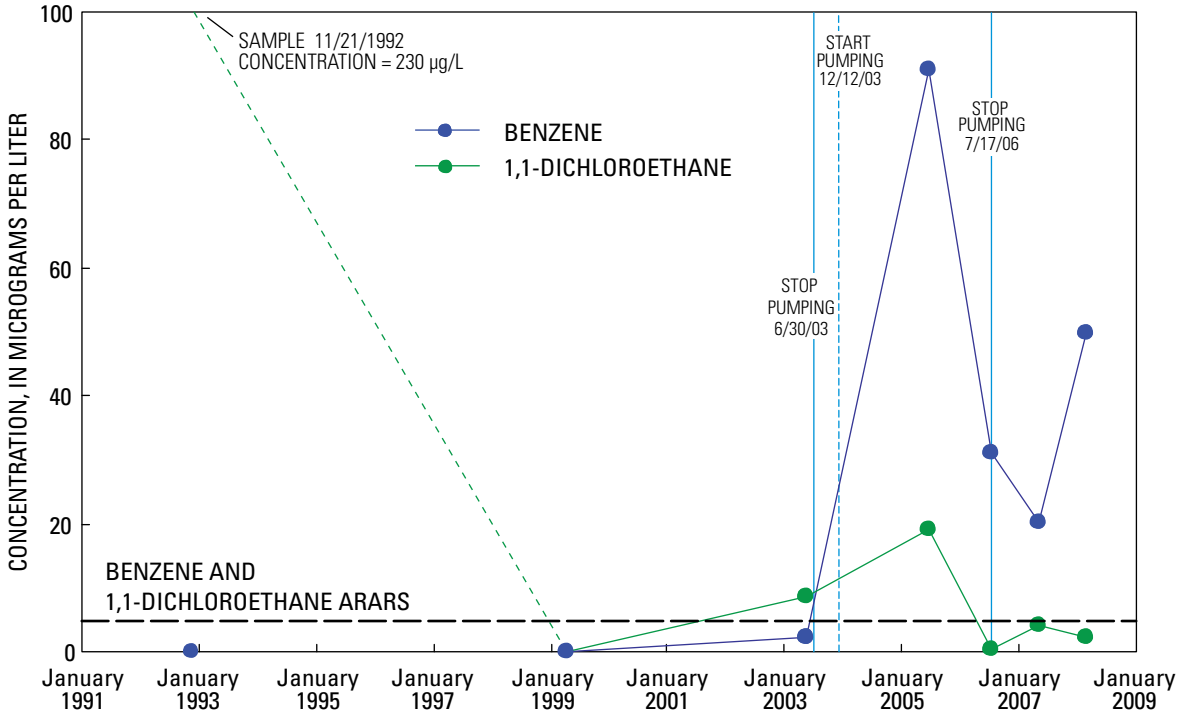


Figure 12. Concentrations of benzene and 1,1-dichloroethane in water samples from well HR-2-195 Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1992–2008. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

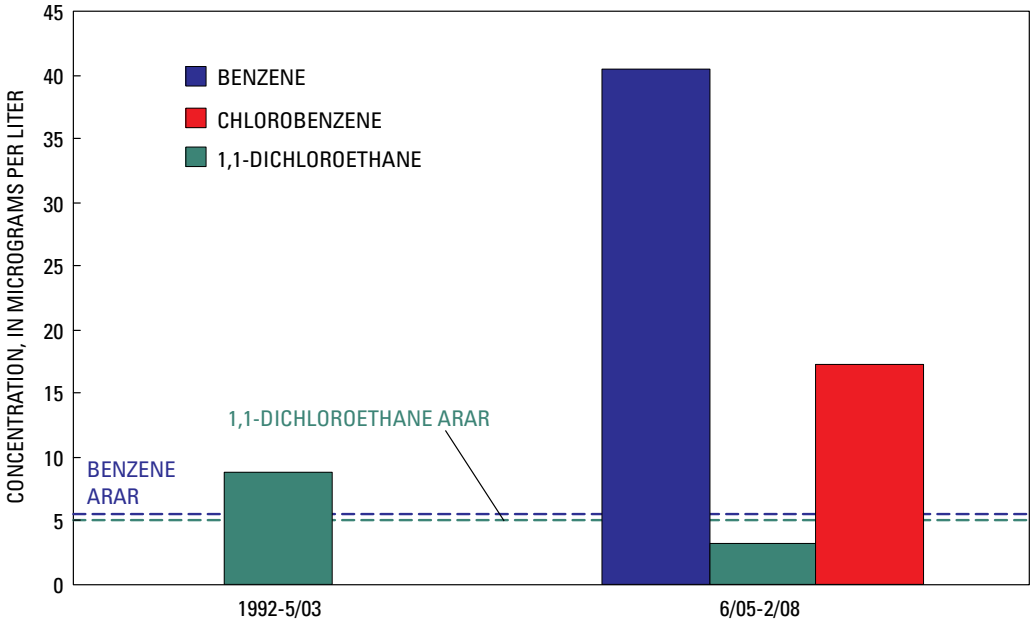


Figure 13. Median concentrations of benzene, chlorobenzene, and 1,1-dichloroethane in water samples from well HR-2-195, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1992–2008. Median concentrations of benzene and chlorobenzene were zero for 1992 to May 2003. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

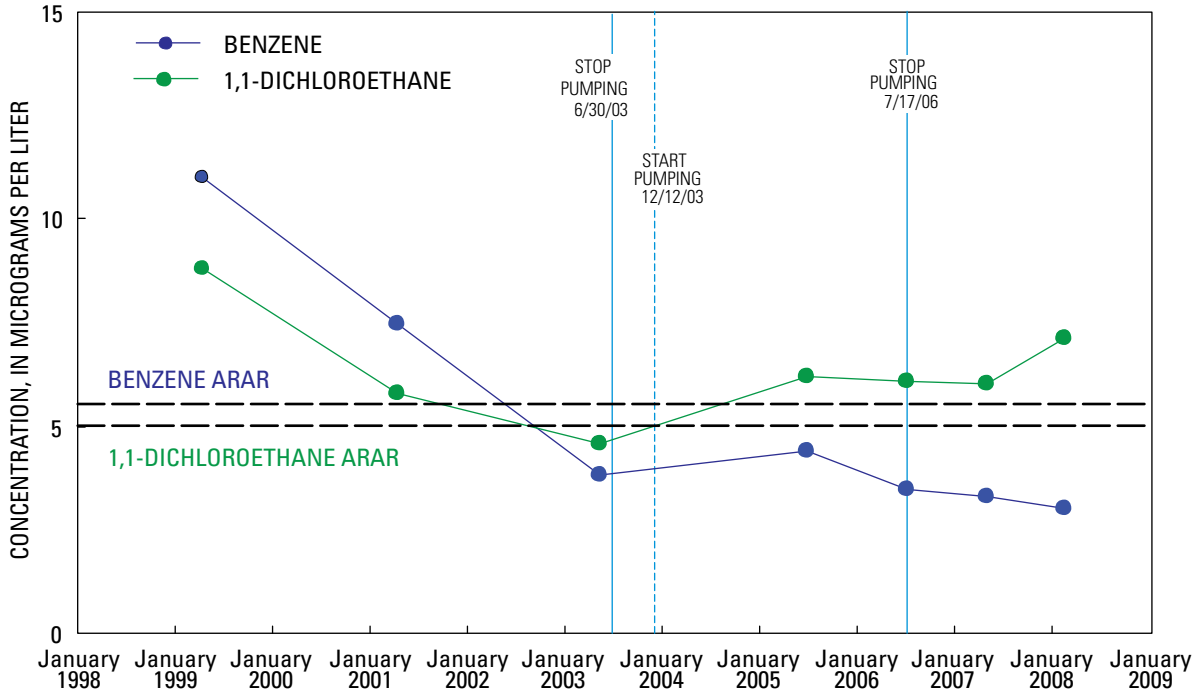


Figure 14. Concentrations of benzene and 1,1-dichloroethane in water samples from well HR-2-295 Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1999–2008. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

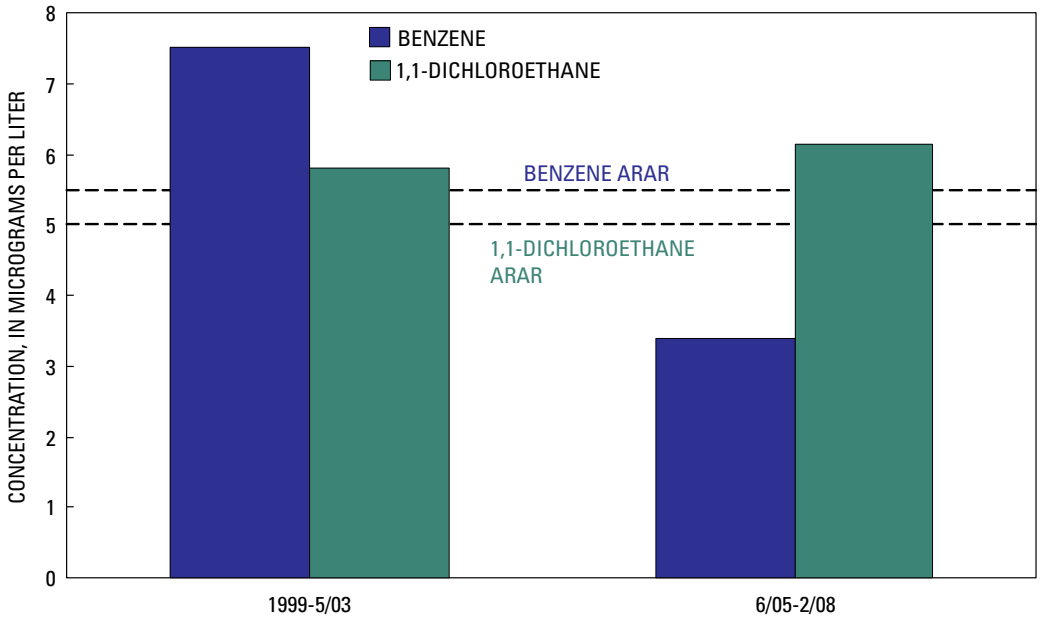


Figure 15. Median concentrations of benzene and 1,1-dichloroethane in water samples from well HR-2-295 Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1999–2008. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

HR-3 Cluster Wells and HR-26-457

During the 2006–08 shutdown test, well HR-3-280 was sampled quarterly; wells HR-3-255 and HR-3-295 were sampled once in May 2007 and once in February 2008. Despite the close proximity and similar depths of wells HR-3-255, HR-3-280, and HR-3-295, temporal benzene concentrations do not show a relation (fig. 16). Concentrations in water samples from all three wells exceeded the benzene ARAR during 2003–08. For well HR-3-255, the median benzene concentration was 110 µg/L for 1991–99, increased to 292 µg/L for May 2000 to June 2003, remained about the same (278 µg/L) for July 2003 to January 2007, and increased to 482 µg/L for May 2007 to February 2008 (table 7, fig. 17).

For well HR-3-280, the median benzene concentration was 285 µg/L for 1991–99, decreased to 29 µg/L for January 2000 to June 2003, increased to 39 µg/L for July 2003 to January 2007, and increased again to 182 µg/L for May 2007 to August 2008 (table 7, fig. 17). For well HR-3-295, the median benzene concentration was 85 µg/L for 1991–99, increased to 195 µg/L for May 2000 to June 2003, decreased to 19 µg/L for July 2003 to July 2006, and remained about the same (18 µg/L) for May 2007 to February 2008 (table 7, fig. 17).

Water samples from wells HR-3-255 and HR-3-295 also were elevated in the other BTX (benzene, toluene, xylene) compounds. Forty-two percent of the water samples from well HR-3-255 exceeded the ARAR for toluene between July 2003 and February 2008 (fig. 18). All water samples collected from well HR-3-255 between July 2003 and February 2008 exceeded the ARAR for total xylene (table 7, fig. 19); the maximum concentration was 32,100 µg/L. For well HR-3-255, the median total xylene concentration was 219 µg/L for 1991–99, increased to 1,360 µg/L for May 2000 to June 2003, increased to 9,145 µg/L for July 2003 to July 2006, and decreased to 1,955 µg/L for May 2007 to February 2008 (table 7, fig. 20). In general, concentrations of total xylene have declined since 2003 but remained substantially above the ARAR.

Water samples from wells HR-3-255 and HR-3-295 often exceeded the chlorobenzene ARAR during 2003–08 (fig. 21). Water samples from well HR-3-280 were below the chlorobenzene ARAR for most samples during 2003–08 (fig. 21). For well HR-3-255, the median chlorobenzene concentration was 65 µg/L for 1991–99, remained about the same (69 µg/L) for May 2000 to June 2003, increased to 94 µg/L for July 2003 to January 2007, and remained about the same (98 µg/L) for May 2007 to February 2008 (table 7, fig. 22). For well HR-3-280, the median chlorobenzene concentration was below the ARAR for 1991–2008. For well HR-3-295, the median chlorobenzene concentration was 52 µg/L for 1991–99, remained about the same (47 µg/L) for May 2000 to June 2003, increased to 117 µg/L for July 2003 to July 2006, and

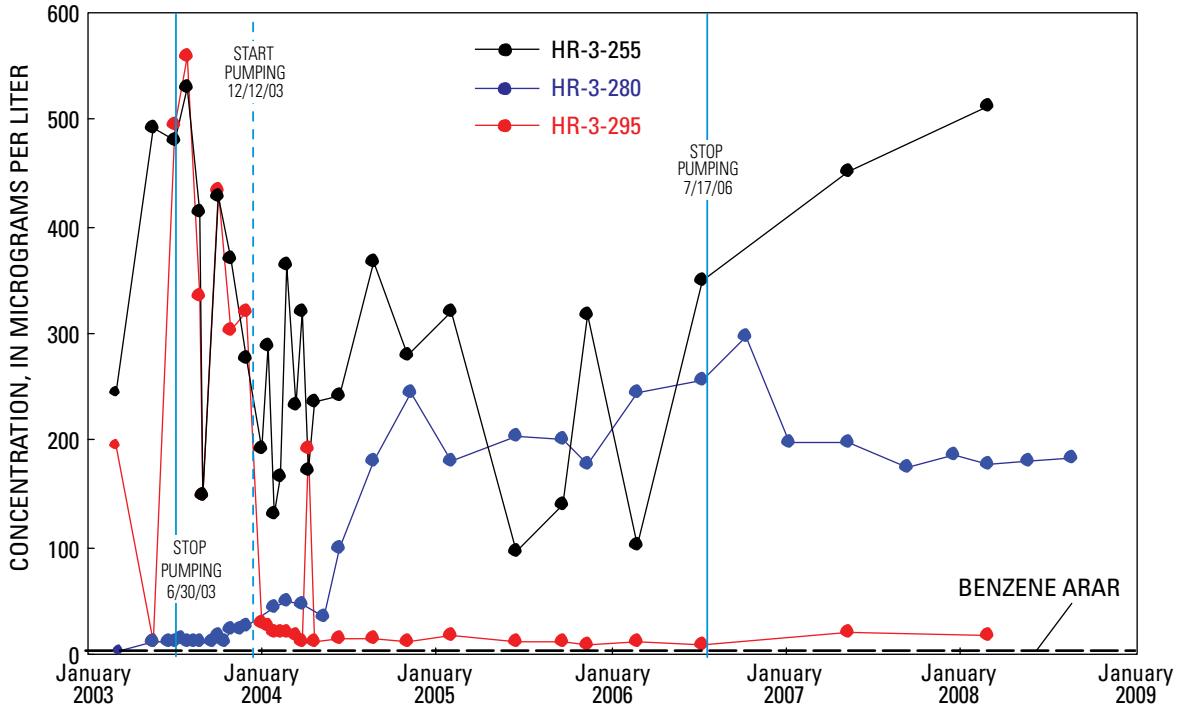


Figure 16. Concentrations of benzene in water samples from wells HR-3-255, HR-3-280, and HR-3-295, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 2003–08. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

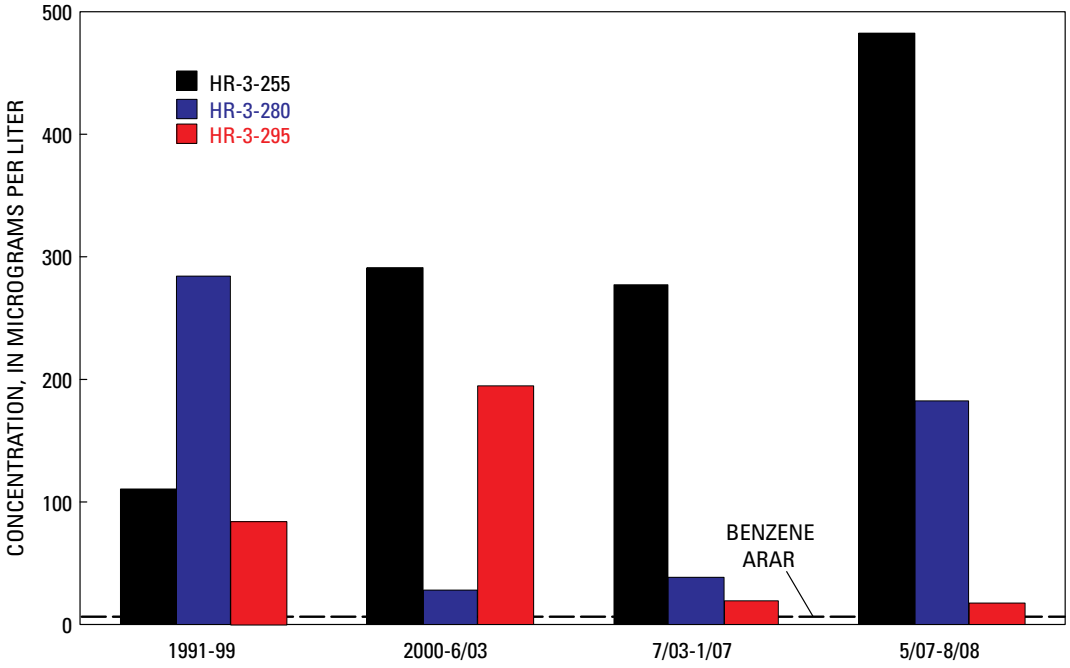


Figure 17. Median concentrations of benzene in water samples from wells HR-3-255, HR-3-280, and HR-3-295, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1991–2008. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

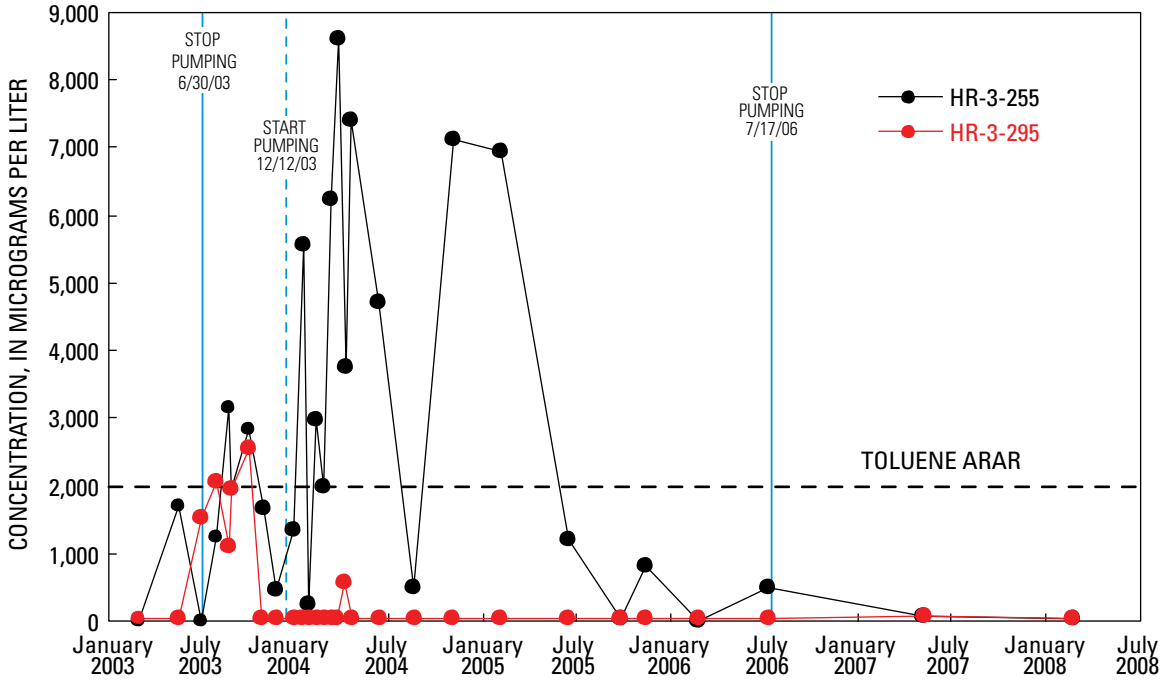


Figure 18. Concentrations of toluene in water samples from wells HR-3-255 and HR-3-295, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 2003–08. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

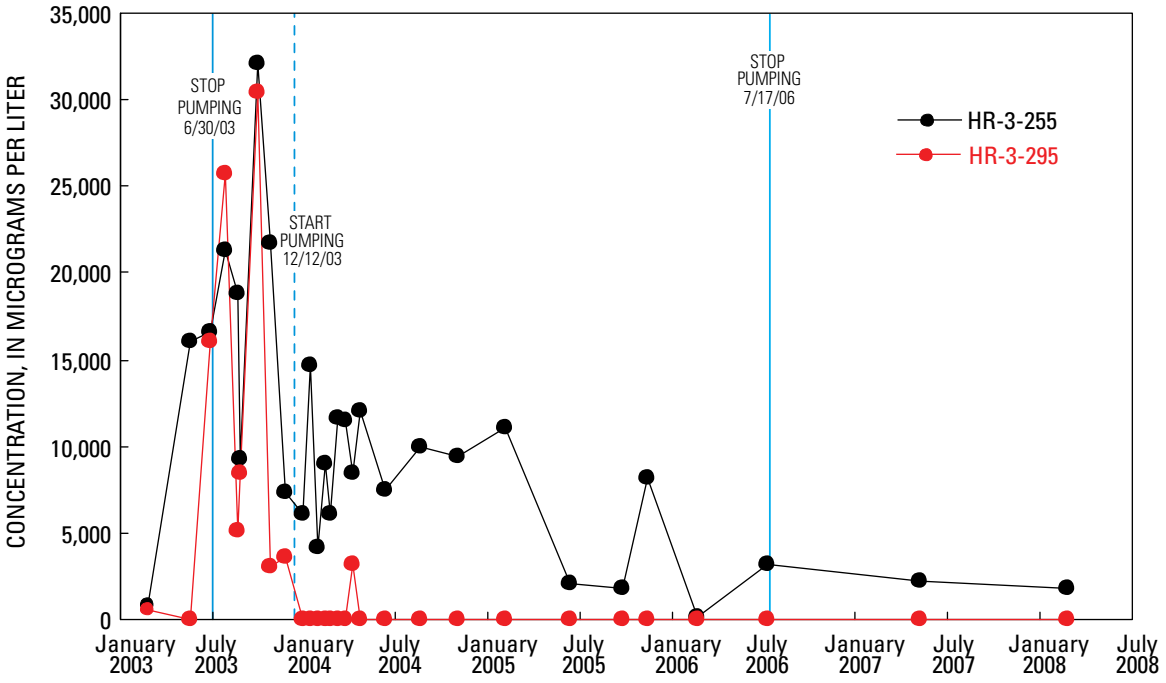


Figure 19. Concentrations of total xylene in water samples from wells HR-3-255 and HR-3-295, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 2003–08. The ARAR (the applicable or relevant and appropriate requirement) for xylene is 175 micrograms per liter. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

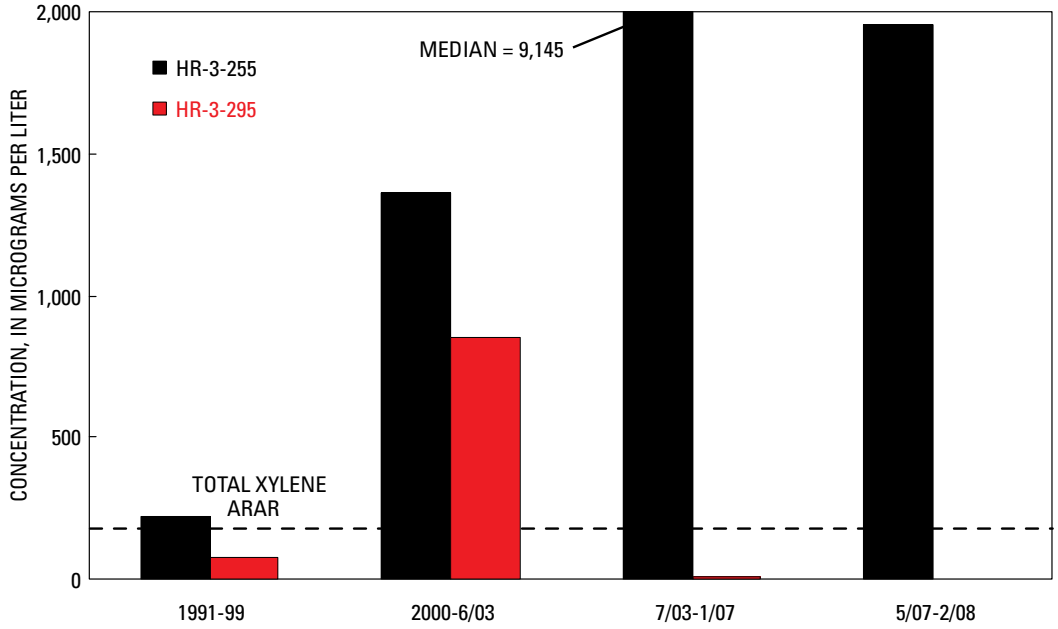


Figure 20. Median concentrations of total xylene in water samples from wells HR-3-255 and HR-3-295, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1991–2008 ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

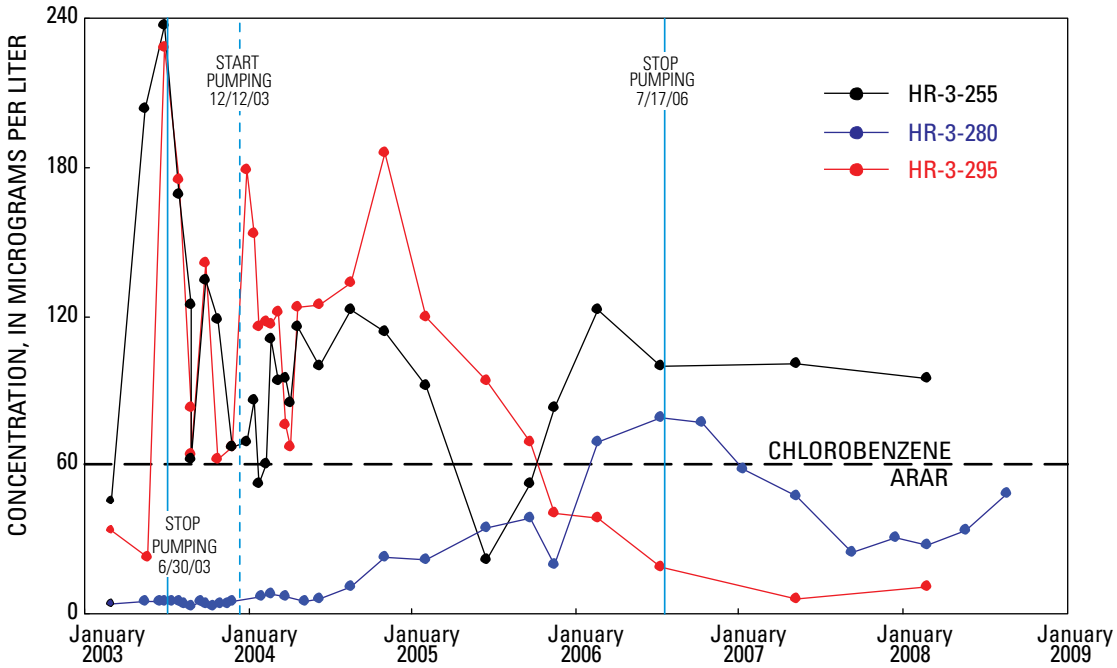


Figure 21. Concentrations of chlorobenzene in water samples from wells HR-3-255, HR-3-280, and HR-3-295, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 2003–08. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

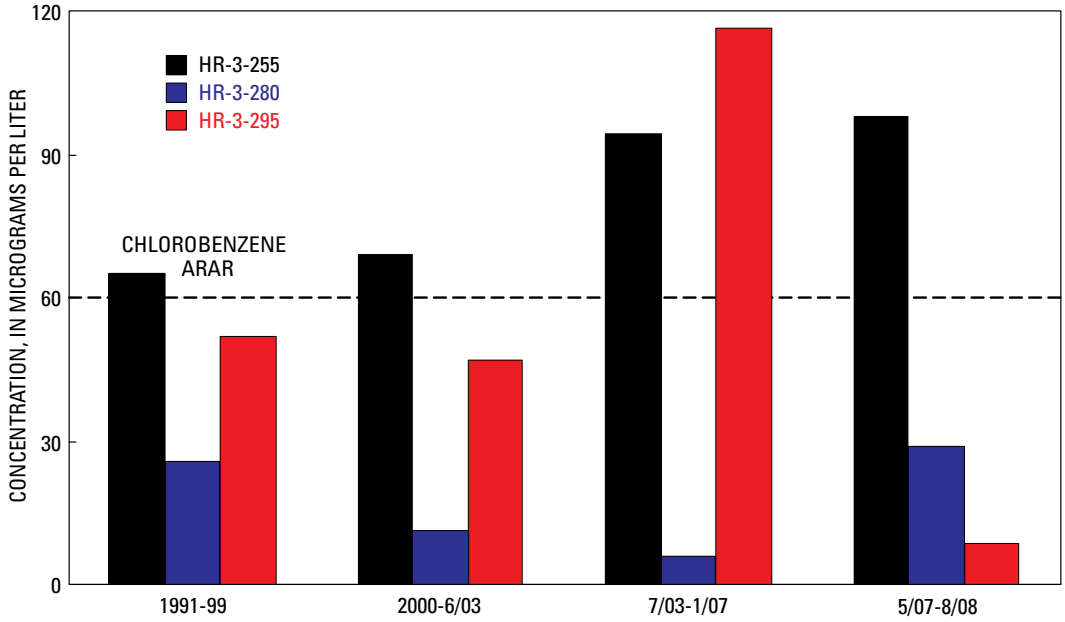


Figure 22. Median concentrations of chlorobenzene in water samples from wells HR-3-255, HR-3-280, and HR-3-295, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1991–2008. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

decreased to 8.6 µg/L for July 2007 to February 2008 (table 7, fig. 22).

For more than a year prior to the start of the June 2003 shutdown test, the concentrations of 1,1-DCA in water samples from wells HR-3-255, HR-3-280, and HR-3-295 were below the ARAR. During the June 2003 shutdown test, three of six water samples (50 percent) from well HR-3-255 exceeded the ARAR; the maximum concentration was 14 µg/L. Concentrations of 1,1-DCA in water samples from wells HR-3-280 and HR-3-295 were below the ARAR. When the extraction wells began pumping at the reduced rate in December 2003, the concentration of 1,1-DCA in water samples increased to a peak of 599 µg/L on February 24, 2004, for well HR-3-255 (fig. 23); increased to a peak of 68 µg/L on November 5, 2004, for well HR-3-280 (fig. 24); and increased to a peak of 135 µg/L on April 6, 2004, for well HR-3-295. Concentrations of 1,1-DCA in samples from all three wells have decreased since 2004. The concentration of 1,1-DCA in two water samples collected in 2007–08 from wells HR-3-255 and HR-3-280 were below the ARAR. Three of four water samples (75 percent) collected from well HR-3-280 exceeded the ARAR for 1,1-DCA for May 2007 to February 2008 (fig. 24).

For well HR-3-255, the median 1,1-DCA concentration was 5.7 µg/L for 1991–99, decreased to 1.1 µg/L for January 2000 to June 2003, increased to 93 µg/L for July 2003 to July 2006, and decreased to 1.1 µg/L for May 2007 to February 2008 (table 7, fig. 25). For well HR-3-280, the median 1,1-DCA concentration was 114 µg/L for 1991–99, decreased to 4.3 µg/L for November 2000 to June 2003, increased to 9.4 µg/L for July 2003 to January 2007, and increased again to 14 µg/L for May 2007 to August 2008. For well HR-3-295, the median 1,1-DCA concentration was 5.7 µg/L for 1991–99, decreased to 1.2 µg/L for May 2000 to June 2003, and remained about the same for July 2003 to July 2006 (2.5 µg/L) and May 2007 to February 2008 (1.9 µg/L) (table 7, fig. 25).

For more than a year prior to the start of the June 2003 shutdown test and during the shutdown, the concentrations of 1,2-DCA in water samples from wells HR-3-255, HR-3-280, and HR-3-295 were below the ARAR. When the extraction wells began pumping at the reduced rate in December 2003, the concentration of 1,2-DCA in water samples increased to a peak of 172 µg/L on February 24, 2004, for well HR-3-255; increased to a peak of 10.8 µg/L on February 2, 2005, for well HR-3-280; and increased to a peak of 27 µg/L on April 6, 2004, for well HR-3-295 (fig. 26). Concentrations of 1,1-DCA in water samples from all three wells have decreased since

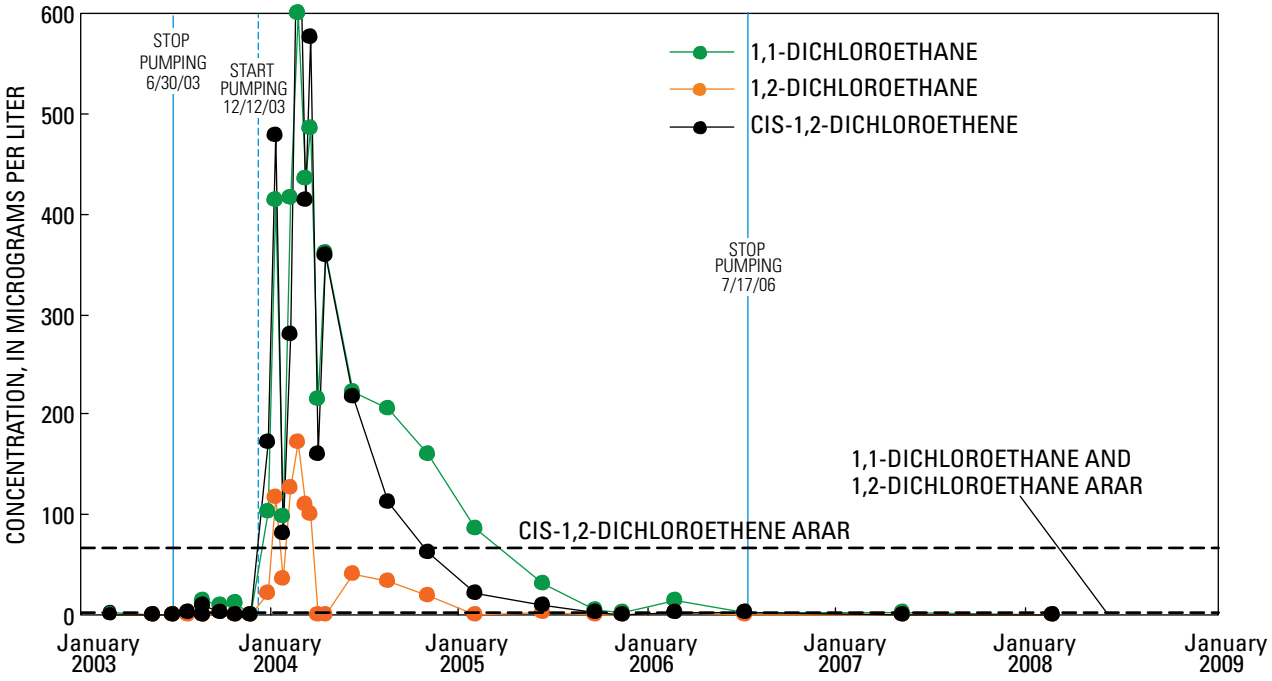


Figure 23. Concentrations of 1,1-dichloroethane, 1,2-dichloroethane, and cis-1,2-dichloroethene in water samples from well HR-3-255, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 2003–08. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

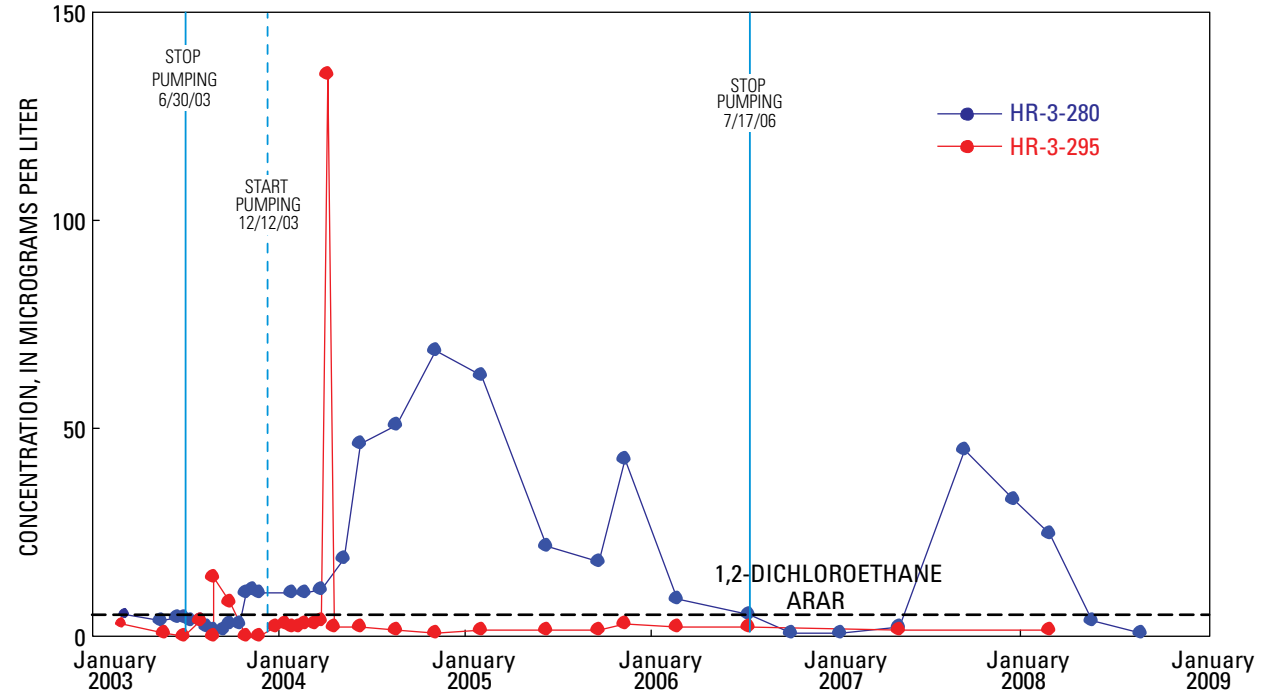


Figure 24. Concentrations of 1,1-dichloroethane in water samples from wells HR-3-280 and HR-3-295, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 2003–08. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

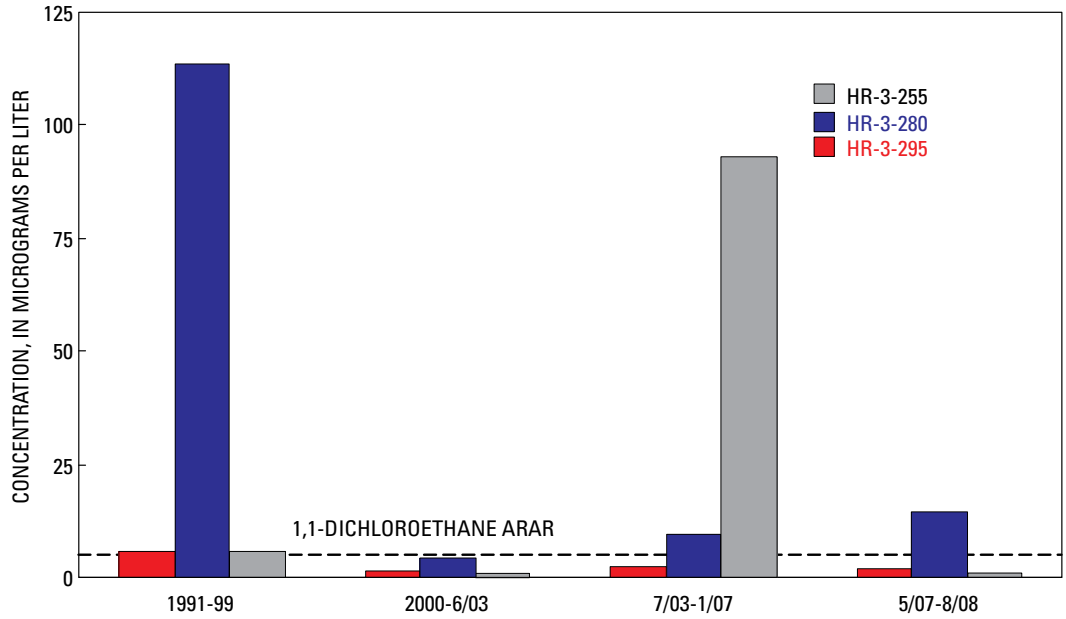


Figure 25. Median concentrations of 1,1-dichloroethane in water samples from wells HR-3-255, HR-3-280, and HR-3-295, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1991–2008. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

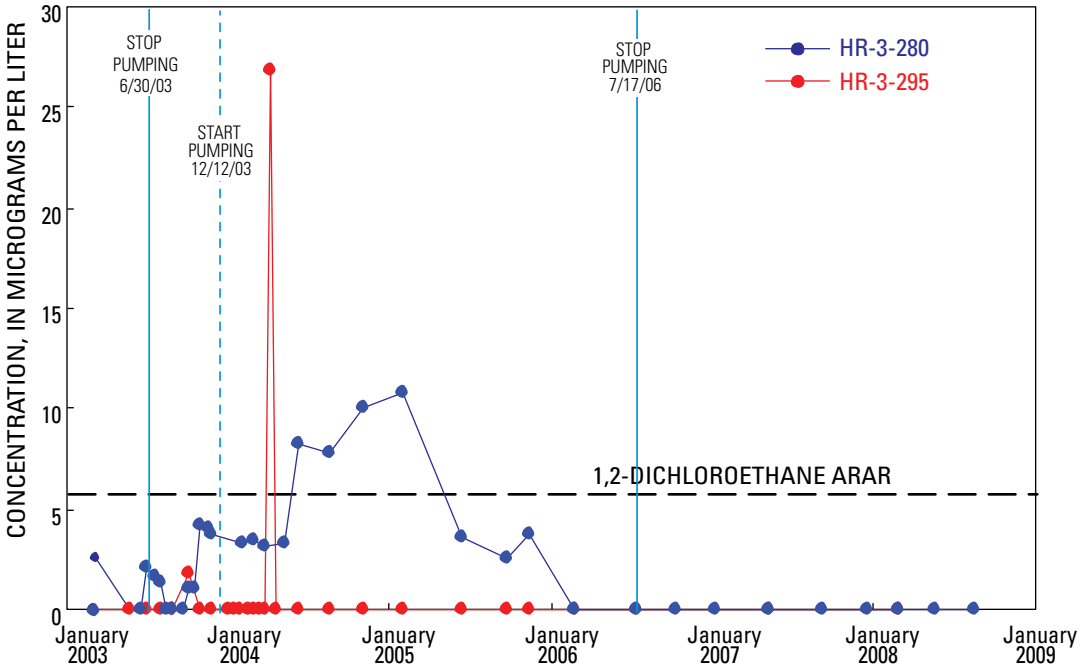


Figure 26. Concentrations of 1,2-dichloroethane in water samples from wells HR-3-280 and HR-3-295, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 2003–08. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

2005; samples collected in 2007–08 were below the ARAR (fig. 27).

Concentrations of ethylbenzene in water samples from wells HR-3-255 and HR-3-295 increased during the 2003 shutdown test (fig. 28). The concentration of ethylbenzene in water samples from well HR-3-255 increased to a peak of 7,490 µg/L on September 30, 2003, and the concentration of ethylbenzene in water samples from well HR-3-295 increased to a peak of 8,160 µg/L on July 30, 2003. The median concentration of ethylbenzene in water samples from well HR-3-255 was greatest during July 2003 to July 2006 and exceeded the ARAR during that time (fig. 29).

Vinyl chloride concentrations increased substantially in water samples from wells HR-3-255, HR-3-280, and HR-3-295 following the restart of pumping in December 2003 and then began to decline (fig. 30). From December 2003 to August 2008, the ARAR for vinyl chloride was exceeded for 16 of 20 water samples (80 percent) from well HR-3-255. Concentrations of vinyl chloride in water samples collected from wells HR-3-255 and HR-3-295 since December 2003 were higher than those collected during 1991 to November 2003 when the extraction wells were pumped at the full rate (table 7).

Well HR-26-457 is in close proximity to the HR-3 well cluster. During the 2006–08 shutdown test, well HR-26-457 was sampled once in May 2007 and once in February 2008. Chlorobenzene concentrations in water samples from well HR-26-457 for 2003–07 were highly variable and exceeded the ARAR some of the time (fig. 31). Benzene concentrations were below the ARAR during the June 2003 shutdown test, rose above the ARAR after the start of pumping at the reduced rate, and exceeded the ARAR for 75 percent of the samples. Median concentrations of benzene and chlorobenzene have decreased with time; however, median concentrations of benzene were above the ARAR (fig. 32).

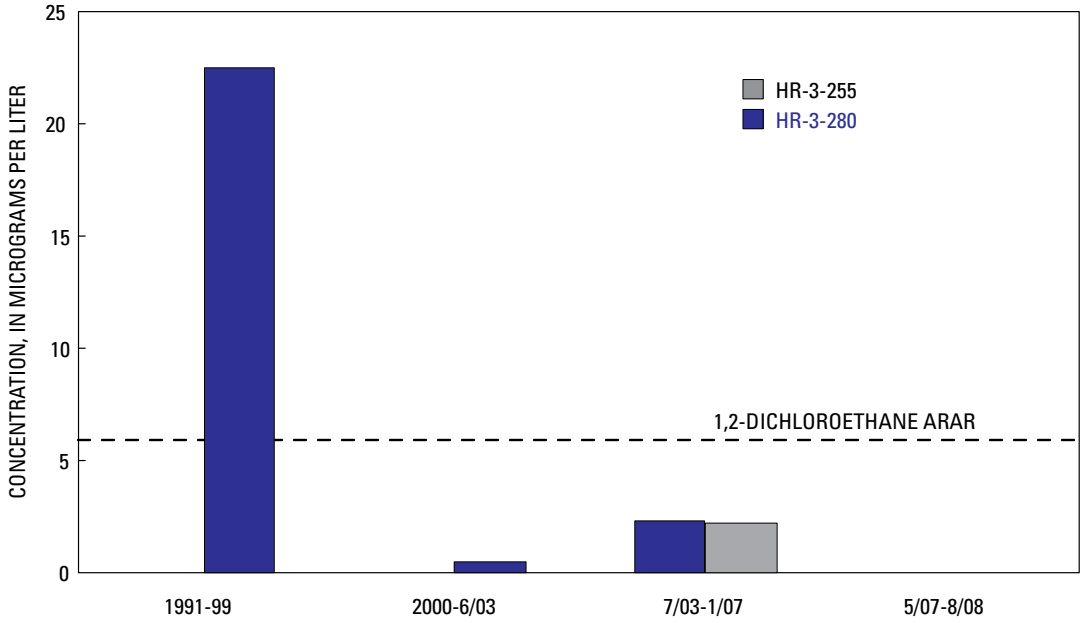


Figure 27. Median concentrations of 1,2-dichloroethane in water samples from wells HR-3-255 and HR-3-280, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1991–2008. Median concentrations of 1,2-dichloroethane were zero for 1991 to June 2003 and May 2007 to August 2008 for well HR-3-255. The meidan concentrations of 1,2-dichloroethane were zero for May 2007 to August 2008 for well HR-3-280. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

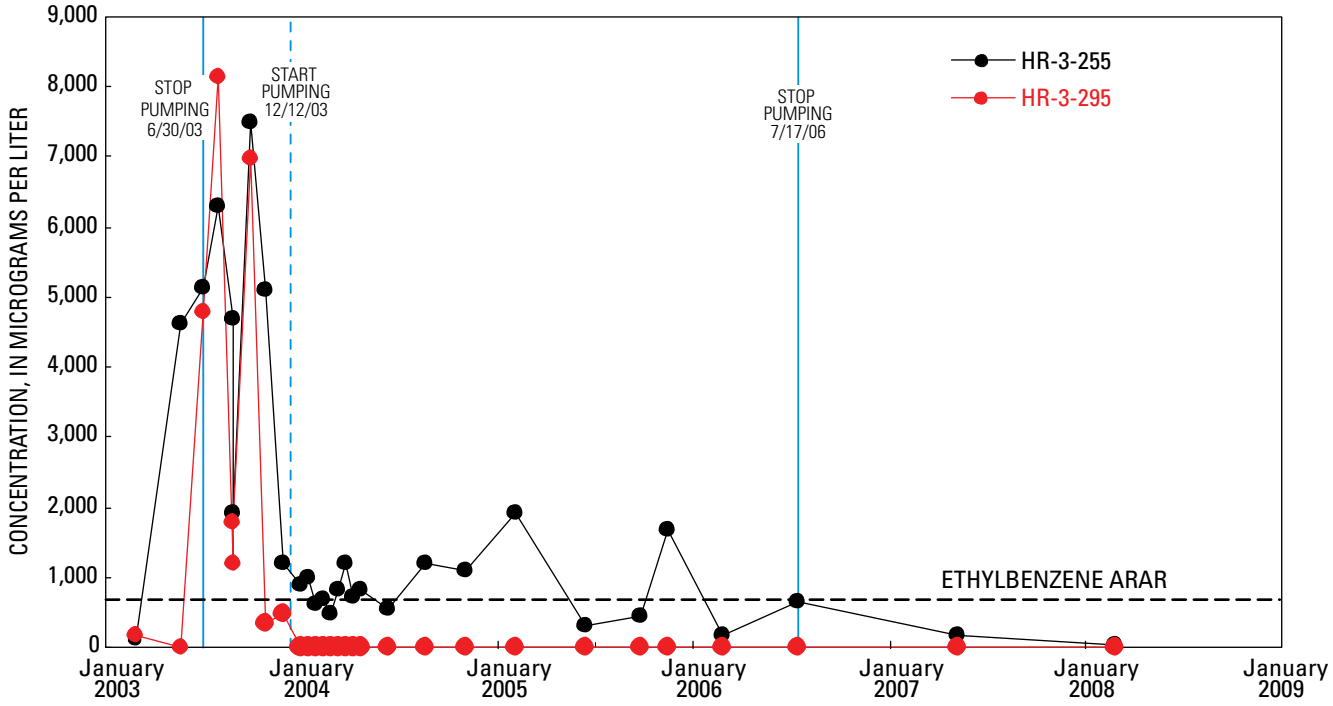


Figure 28. Concentrations of ethylbenzene in water samples from wells HR-3-255 and HR-3-295, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 2003–08. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

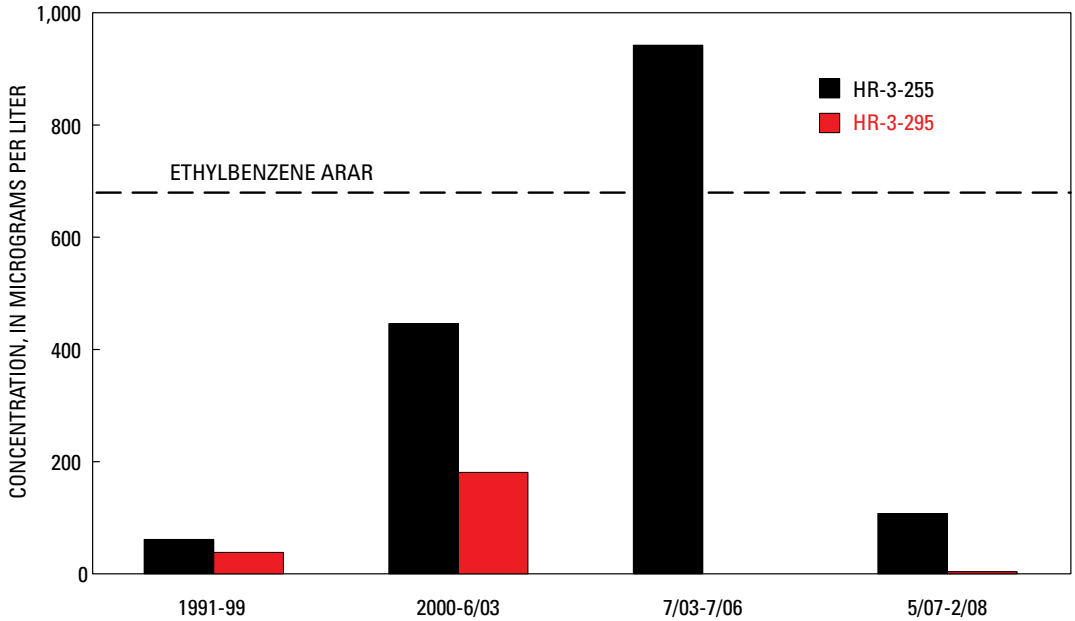


Figure 29. Median concentrations of ethylbenzene in water samples from wells HR-3-255 and HR-3-295, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1991–2008. The median concentration of ethylbenzene was zero for July 2003 to July 2006 for well HR-3-295. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

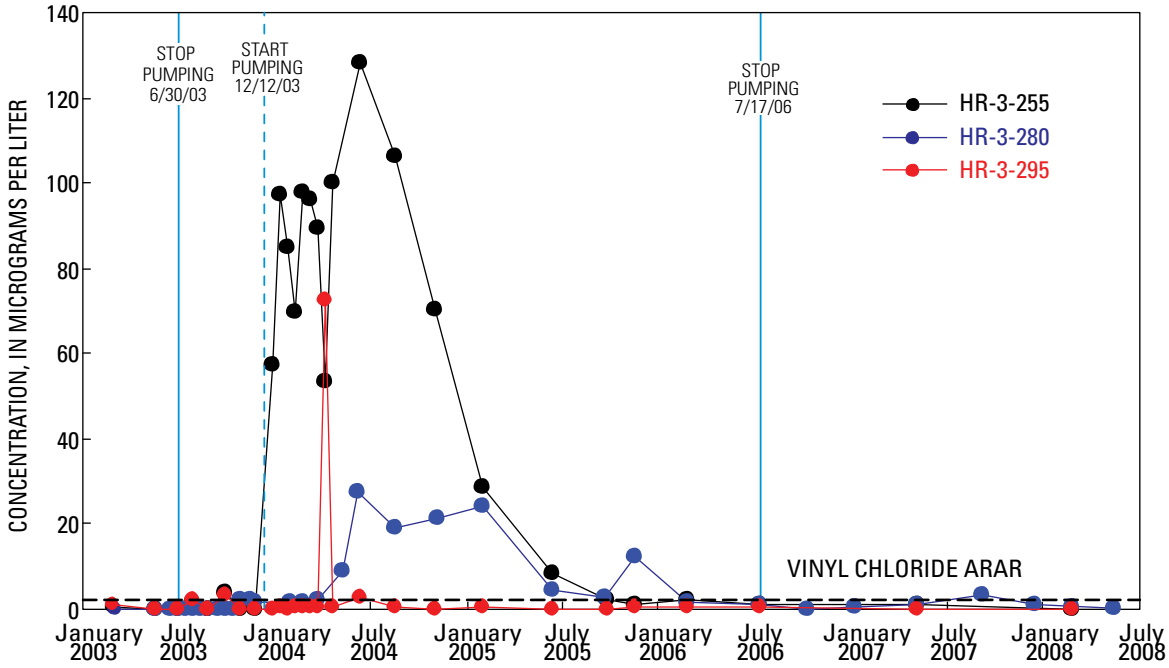


Figure 30. Concentrations of vinyl chloride in water samples from wells HR-3-255, HR-3-280, and HR-3-295, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 2003–08. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

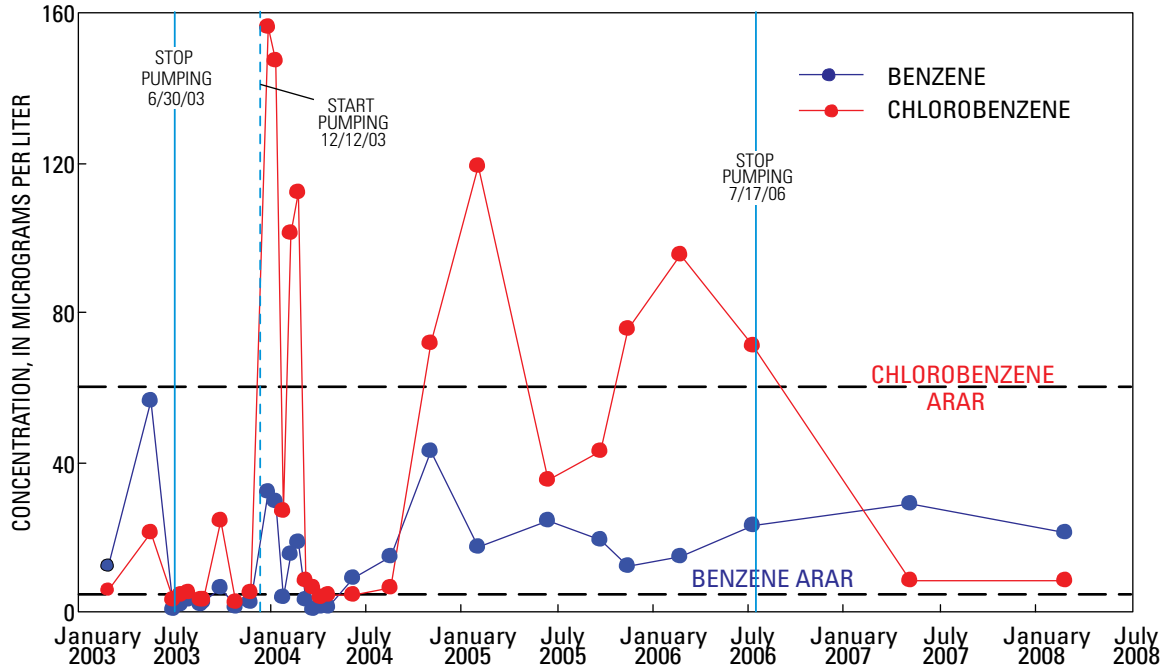


Figure 31. Concentrations of benzene and chlorobenzene in water samples from well HR-26-457, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 2003–08. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

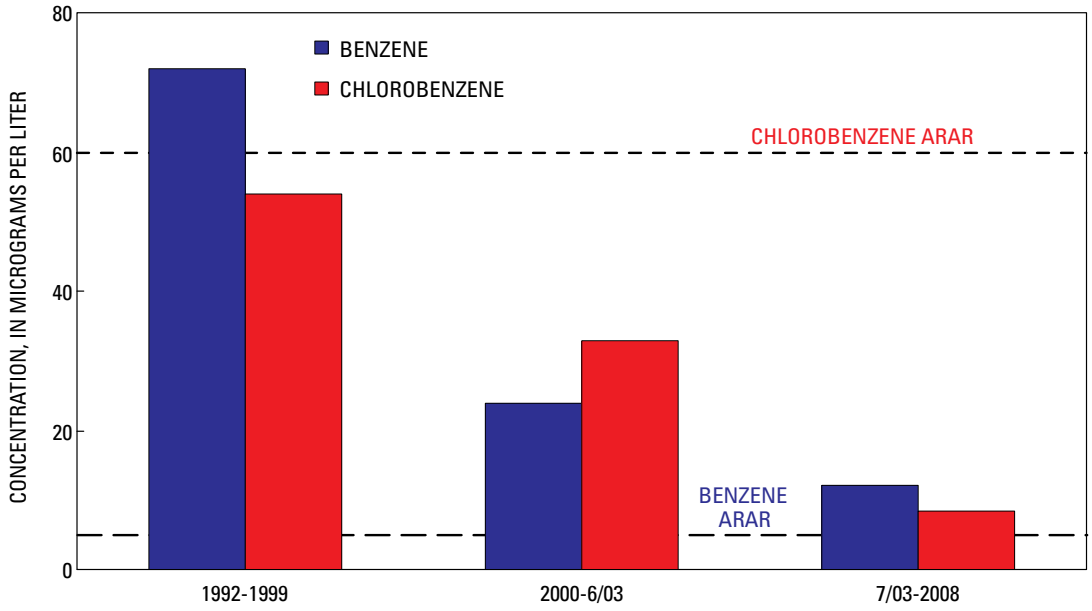


Figure 32. Median concentrations of benzene and chlorobenzene in water samples from well HR-26-457, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1992–2008. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

HR-4 Cluster Wells

During the 2006–08 shutdown test, well HR-4-295 was sampled quarterly. Wells HR-4-195 and HR-4-242 were not sampled for the 2006–08 shutdown test but were sampled during and after the June 2003 shutdown test. Water samples from well HR-4-242 did not exceed the ARARs. Water samples from well HR-4-195 did not exceed the ARAR for 1,1-DCA during 2003–06; however, this ARAR was exceeded during 1991–93 and once in 2001 (fig. 33).

Water samples from well HR-4-295 exceeded the ARAR for benzene twice during 2003 (fig. 34). Since 2003, benzene concentrations have been decreasing. Benzene concentrations were greater prior to 1998 than after 1998 (fig. 35). For well HR-4-295, the median benzene concentration was 5.5 µg/L for 1991–99, decreased to 2.4 µg/L for November 2000 to June 2003, increased to 3.3 µg/L for June 2003 to January 2007, and decreased to 1 µg/L for May 2007 to August 2008 (table 7, fig. 36).

Thirteen out of 15 (87 percent) water samples from well HR-4-295 exceeded the ARAR for 1,1-DCA during November 2003 to May 2007 (fig. 37). Since September 2007, the concentrations of 1,1-DCA in water samples from well HR-4-295 have been below the ARAR. For well HR-4-295, the median 1,1-DCA concentration was 3 µg/L for 1991–99, remained about the same (3.2 µg/L) for November 2000 to June 2003, increased to 7.4 µg/L for June 2003 to January 2007, and decreased to 4.5 µg/L for May 2007 to August 2008 (table 7, fig. 36).

The concentrations of 1,2-DCA in water samples from well HR-4-295 exceeded the ARAR following the June 2003 and July 2006 shutdowns (fig. 38). Concentrations of 1,2-DCA have been below the ARAR since May 2007. For well HR-4-295, the median 1,2-DCA concentration was 0 µg/L for 1991–99, remained about the same (0.7 µg/L) for November 2000 to June 2003, increased to 5.2 µg/L for June 2003 to January 2007, and decreased to 0.3 µg/L for May 2007 to August 2008 (table 7, fig. 36).

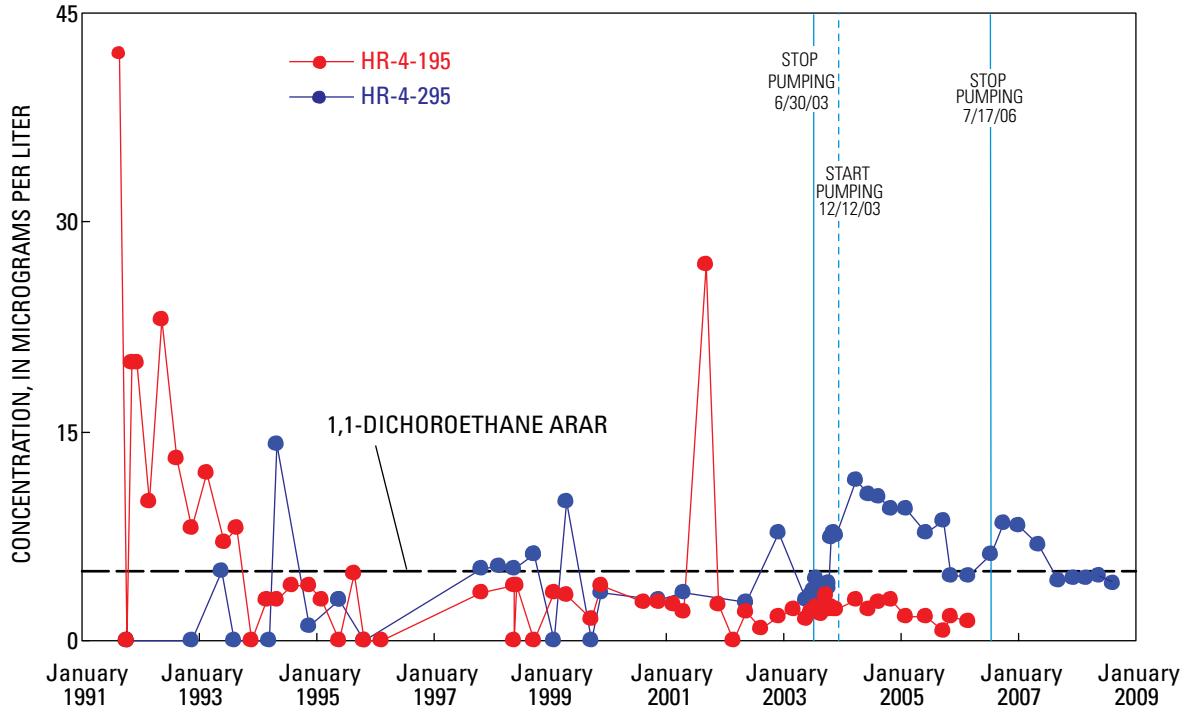


Figure 33. Concentrations of 1,1-dichloroethane in water samples from wells HR-4-195 and HR-4-295, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1991–2008. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

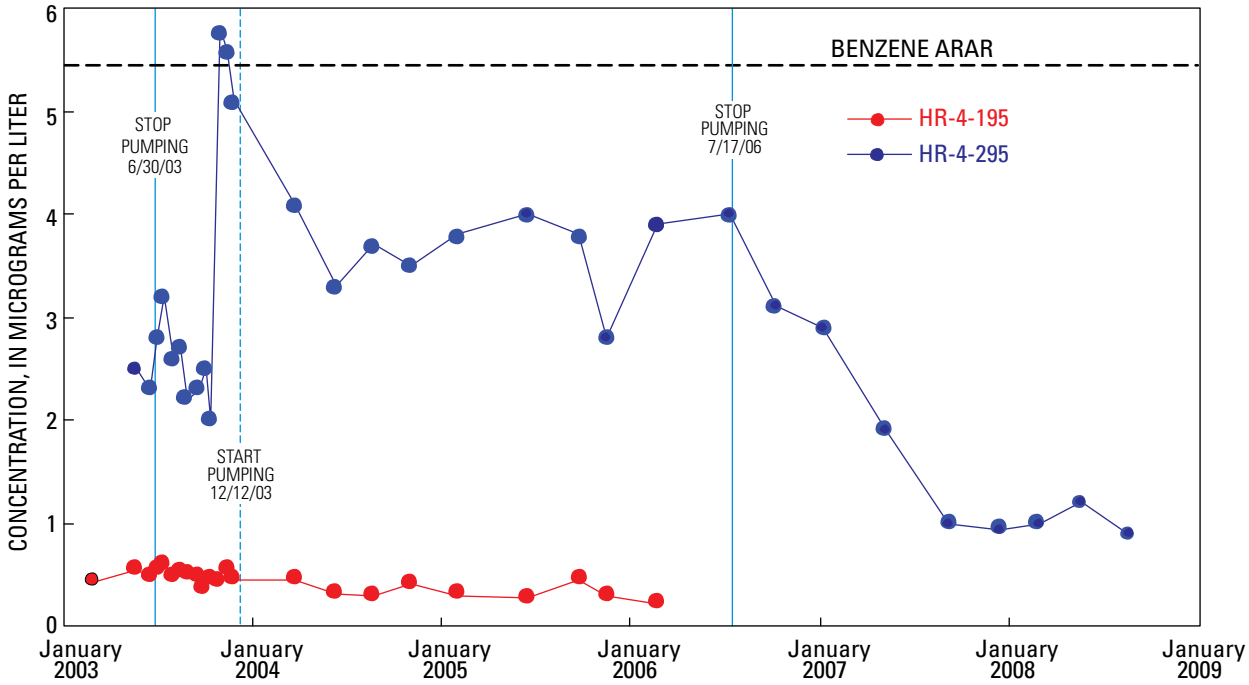


Figure 34. Concentrations of benzene in water samples from wells HR-4-195 and HR-4-295, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 2003–08. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

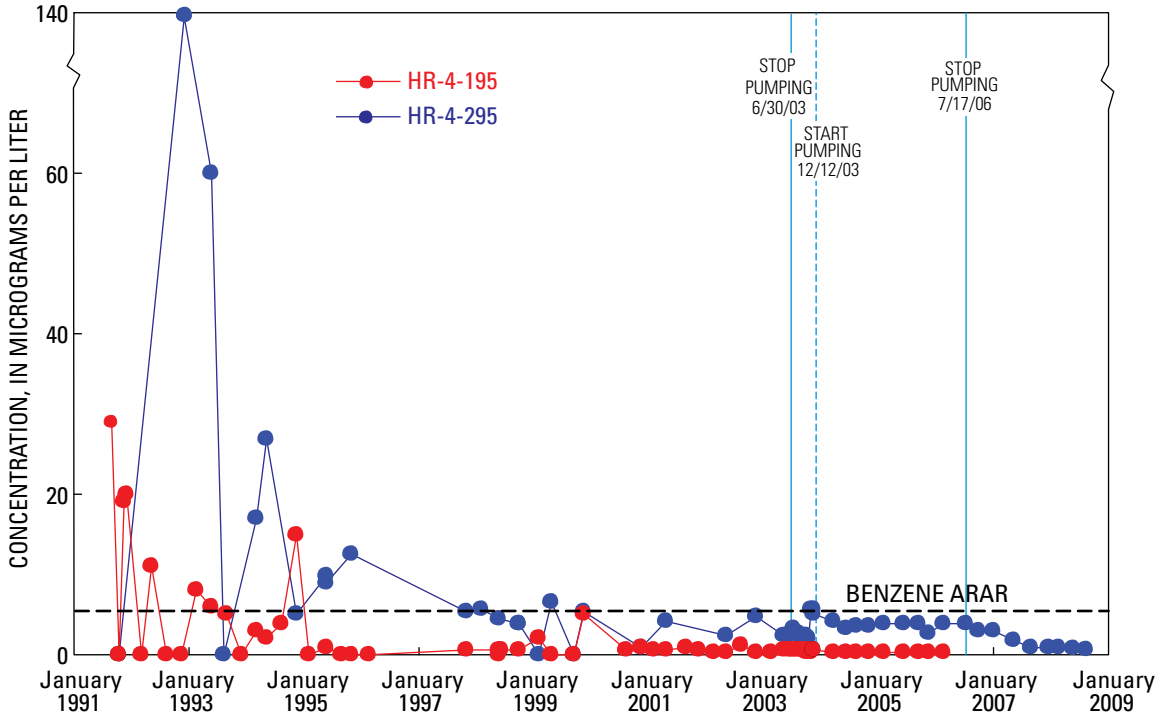


Figure 35. Concentrations of benzene in water samples from wells HR-4-195 and HR-4-295, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1991–2008. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

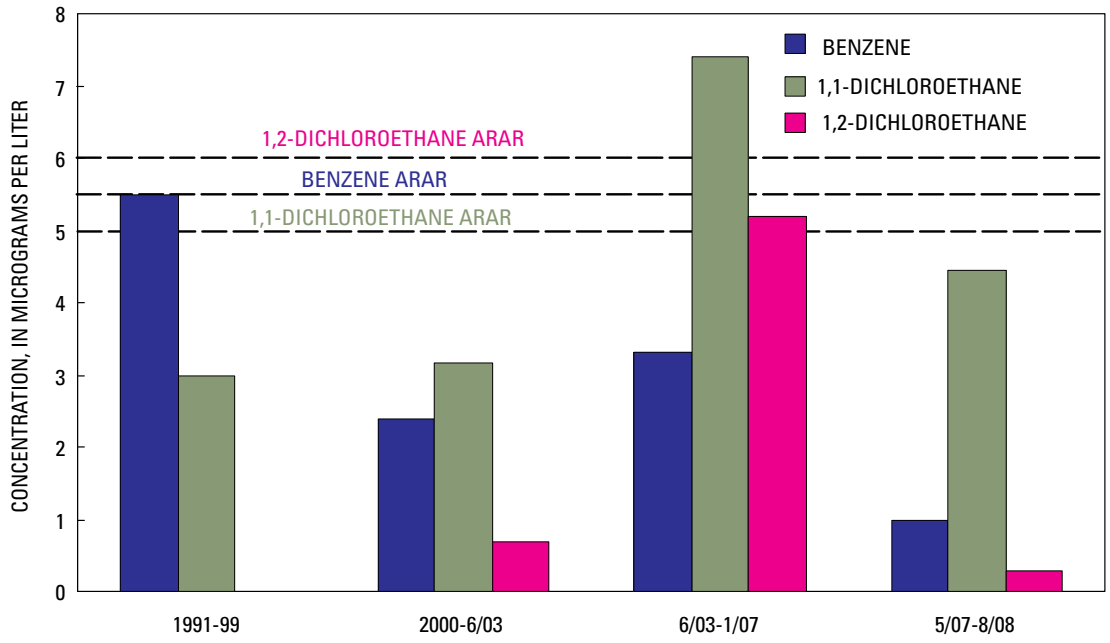


Figure 36. Median concentrations of benzene, 1,1-dichloroethane, and 1,2-dichloroethane in water samples from well HR-4-295, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1991–2008. Median concentration of 1,2-dichloroethane was zero for 1991-99. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

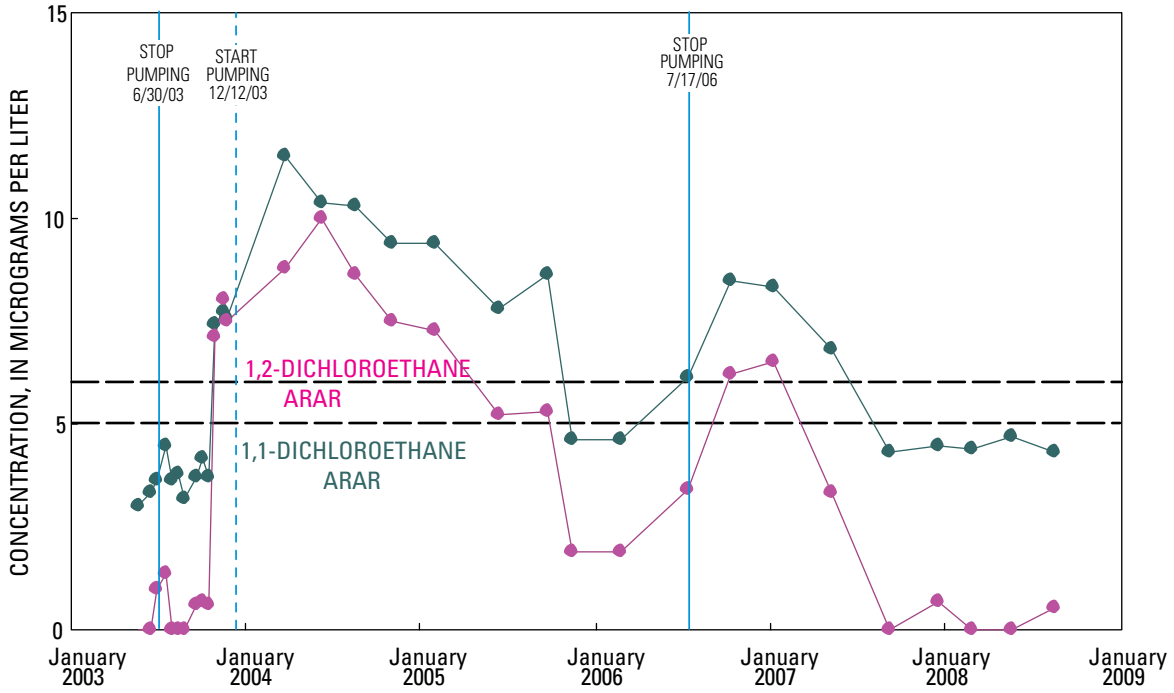


Figure 37. Concentrations of 1,1-dichloroethane, and 1,2-dichloroethane in water samples from well HR-4-295, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 2003–08. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

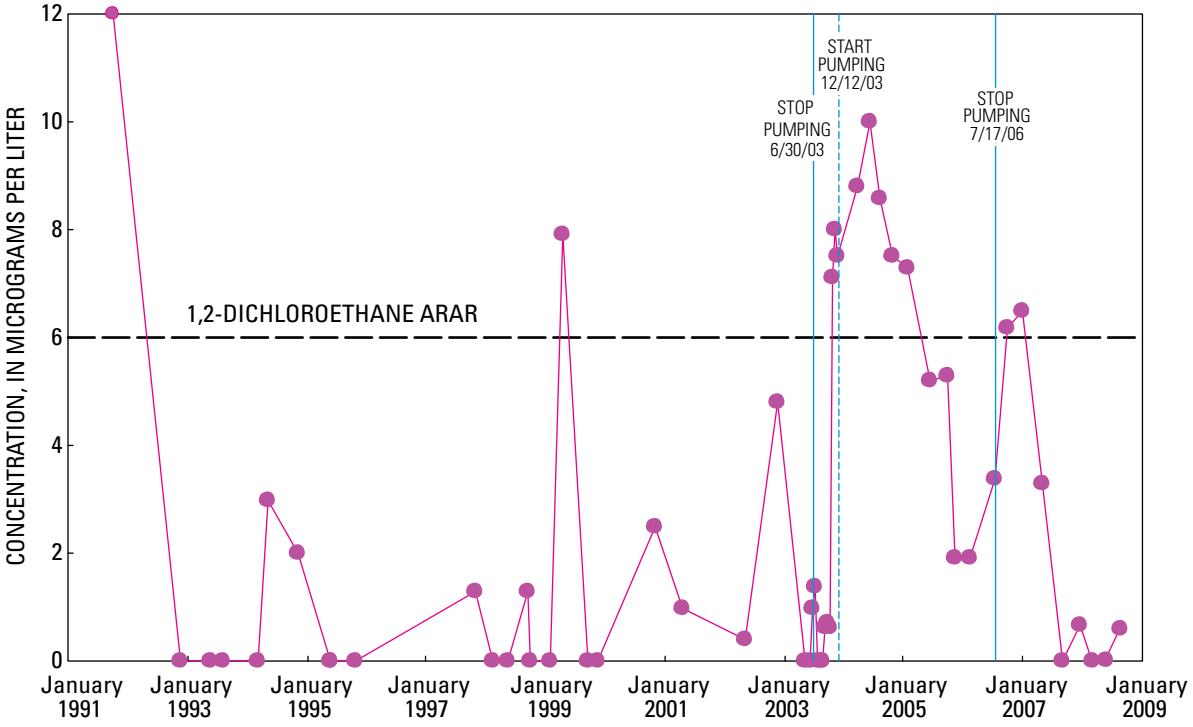


Figure 38. Concentrations of 1,2-dichloroethane in water samples from well HR-4-295, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 2003–08. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

HR-6 Cluster Wells and HR-24-476

Wells HR-6-241, HR-6-377, and HR-24-476 were sampled quarterly during the 2006–08 shutdown test; well HR-6-141 was sampled once in 1999 and five times in 2007–08. The first water sample collected from well HR-6-241 was in May 2003. For May 2007 to August 2008, all six water samples from well HR-6-377 and five of the six (83 percent) water samples from well HR-6-241 exceeded the benzene ARAR (figs. 39 and 40). For well HR-6-241, the benzene concentration increased to above the ARAR during the 2003 shutdown test and then decreased to below the ARAR when pumping resumed. The benzene concentration increased to above the ARAR following the July 2006 shutdown and remained above the ARAR except for the September 2007 sample (figs. 40 and 41). Concentrations of benzene in water samples from well HR-6-377 generally were greater for 2003–08 than for 1991–2002, and concentrations of benzene in water samples from well HR-24-476 generally were less for 2003–08 than for 1991–2002 (fig. 41). For well HR-6-377, the median benzene concentration was 23 µg/L for 1991–99, decreased to 8.6 µg/L for November 2000 to June 2003, increased to 231 µg/L for July 2003 to January 2007, and decreased to 129 µg/L for May 2007 to August 2008 (table 7, fig. 42). For well HR-24-476, the median benzene concentration was 23 µg/L for 1991–99, decreased to 0.7 µg/L for March 2000 to May 2003, increased to 2 µg/L for August 2003 to January 2007, and remained about the same (2.2 µg/L) for May 2007 to August 2008 (table 7, fig. 42).

For May 2007 to August 2008, all six water samples from wells HR-6-241 and HR-24-476 exceeded the chlorobenzene ARAR (table 7, fig. 43). Three out of five (60 percent) water samples from well HR-6-141 exceeded the chlorobenzene ARAR. Chlorobenzene concentrations were substantially greater after the June 2003 shutdown than before the shutdown. Since the start of the 2006–08 shutdown test, chlorobenzene concentrations in water samples from wells HR-6-241 and HR-24-476 have been above the ARAR (fig. 43).

For well HR-6-377, the median chlorobenzene concentration was 11 µg/L for 1991–99, decreased to 7.1 µg/L for January 2000 to June 2003, increased to 50 µg/L for July 2003 to January 2007, and decreased to 43 µg/L for May 2007 to August 2008 (table 7, fig. 44). For well HR-24-476, the median chlorobenzene concentration was 12 µg/L for 1991–99, decreased to 2.1 µg/L for November 2000 to May 2003, increased to 52 µg/L for August 2003 to January 2007, and increased again to 104 µg/L for May 2007 to August 2008 (table 7, fig. 44).

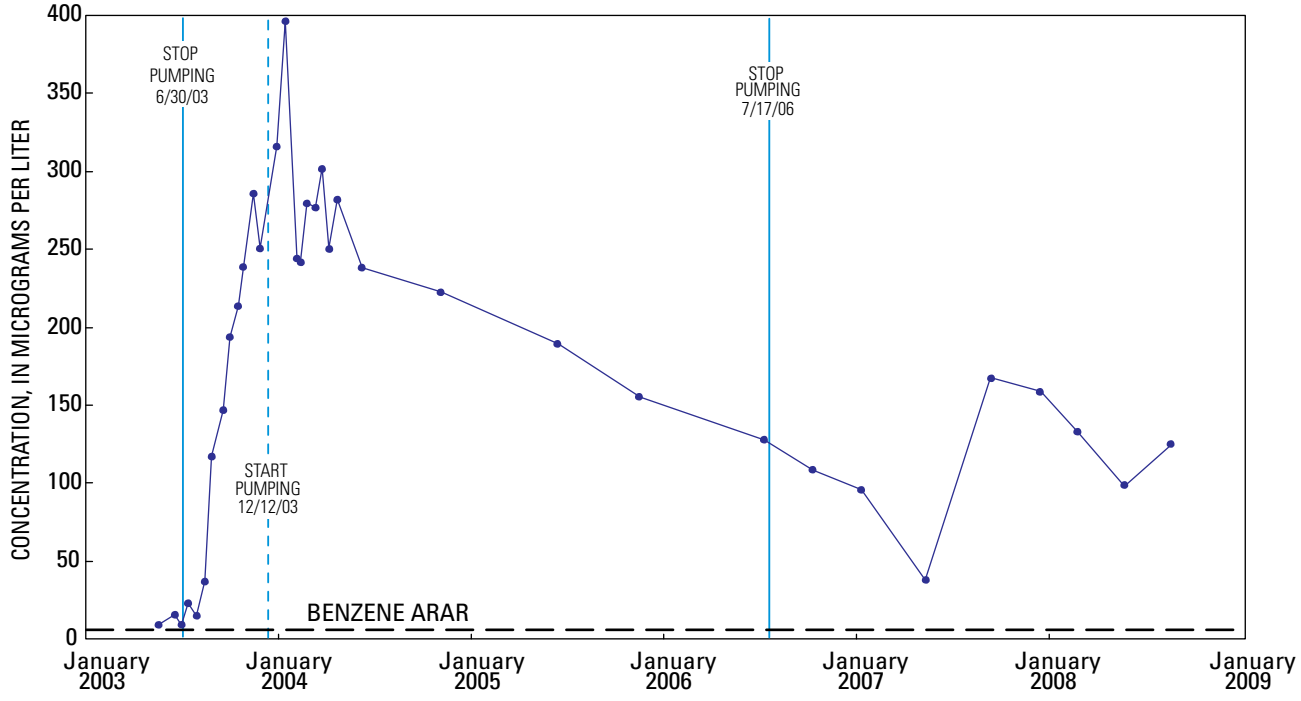


Figure 39. Concentrations of benzene in water samples from well HR-6-377, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 2003–08. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

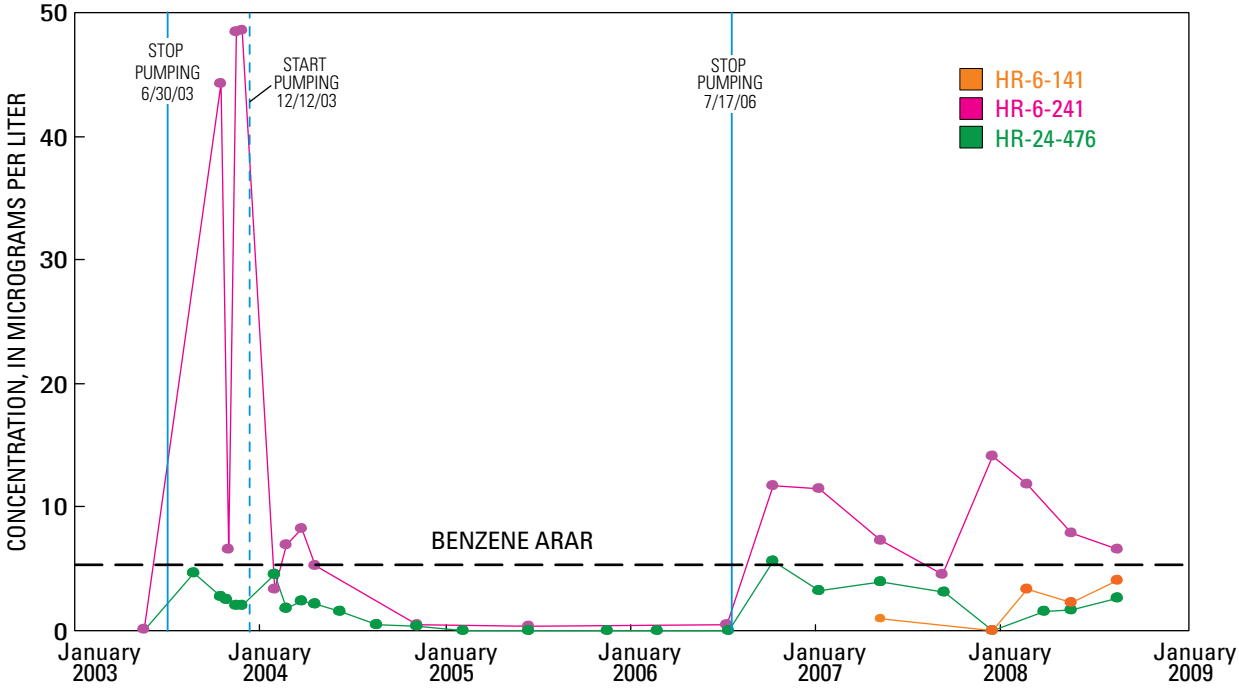


Figure 40. Concentrations of benzene in water samples from wells HR-6-141, HR-6-241,and HR-24-476, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 2003–08. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

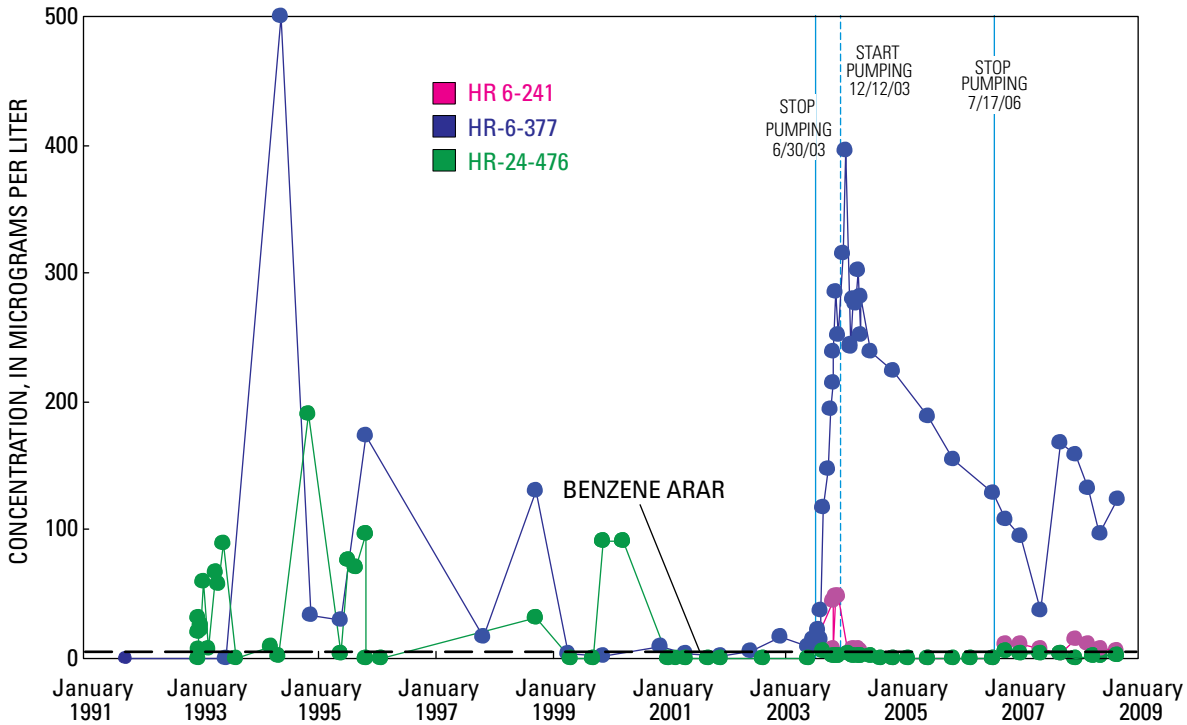


Figure 41. Concentrations of benzene in water samples from wells HR-6-241, HR-6-377, and HR-24-476, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1991–2008. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

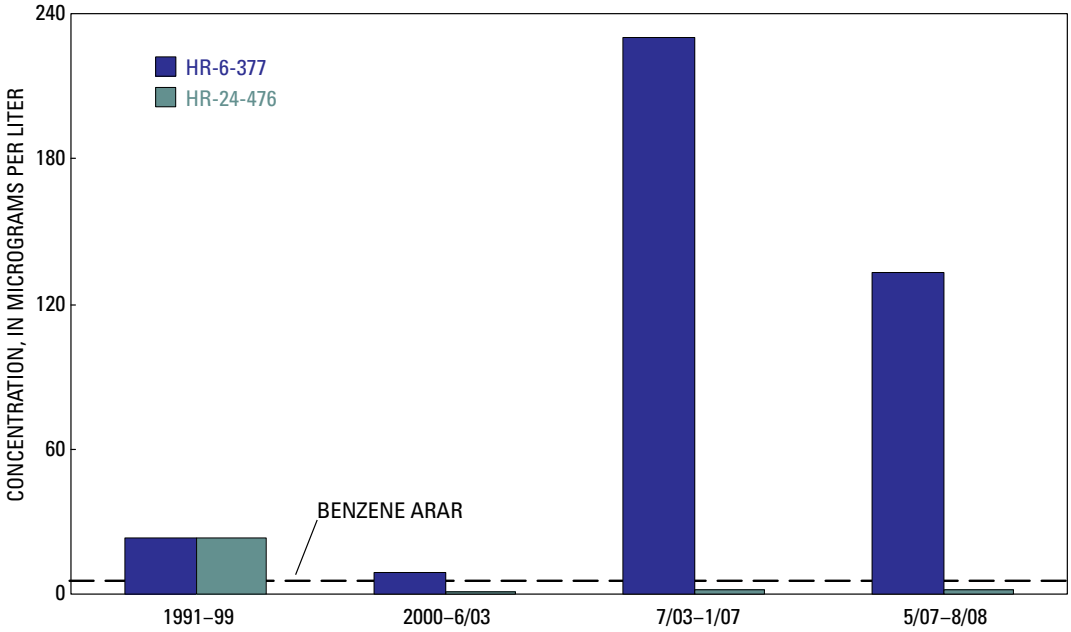


Figure 42. Median concentrations of benzene in water samples from wells HR-6-377 and HR-24-476, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1991–2008. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

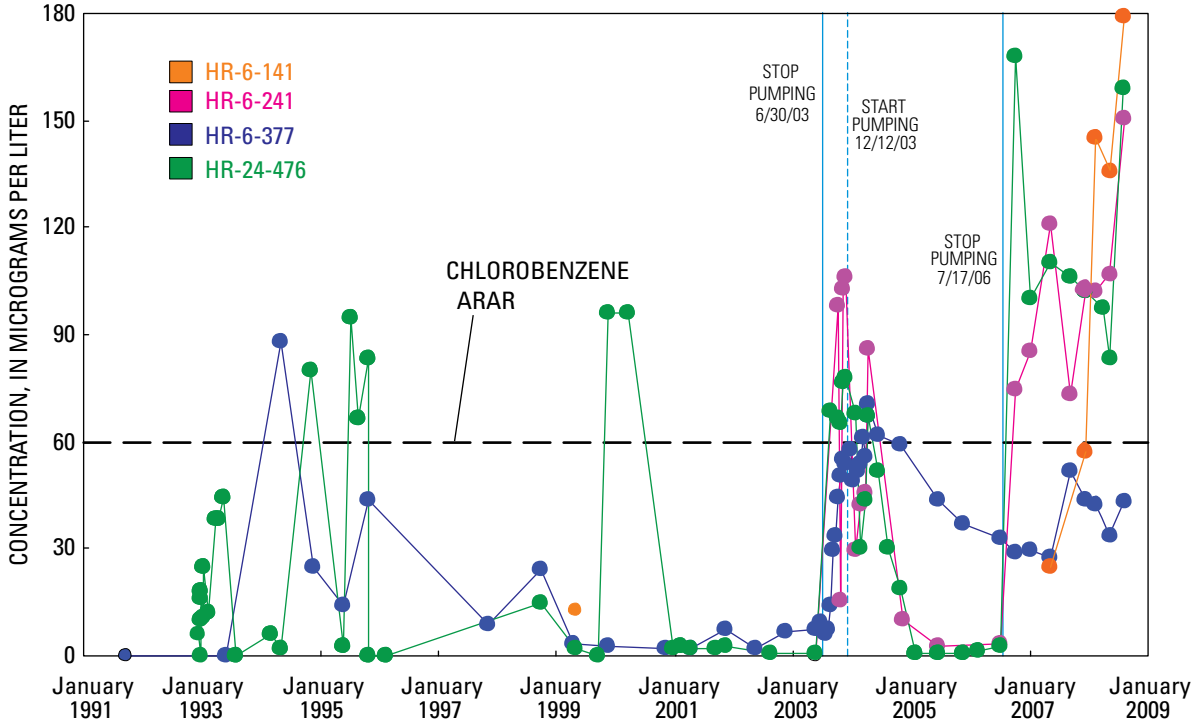


Figure 43. Concentrations of chlorobenzene in water samples from wells HR-6-141, HR-6-241, HR-6-377, and HR-24-476, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1991–2008. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

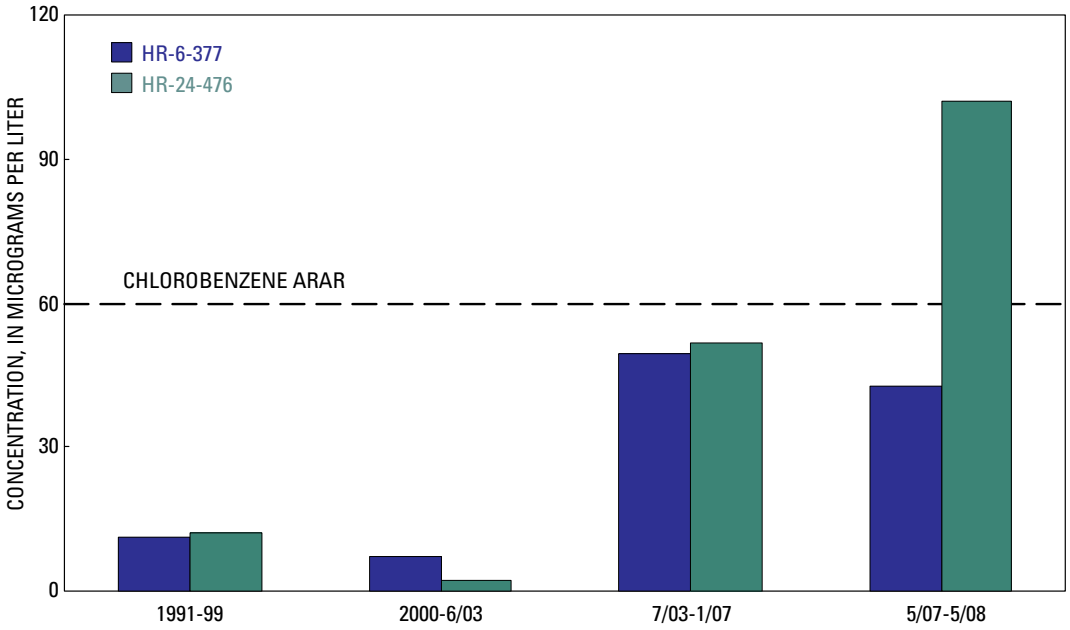


Figure 44. Median concentrations of chlorobenzene in water samples from wells HR-6-377 and HR-24-476, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1991–2008. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

HR-7 Cluster Wells

During the 2006–08 shutdown test, well HR-7-383 was sampled quarterly, and wells HR-7-163 and HR-7-278 were sampled once in May 2007 and once in February 2008. Well HR-7-278 was sampled 11 times since 1998. Water samples from well HR-7-278 exceeded the benzene ARAR three times prior to October 2003 and the chlorobenzene ARAR once (72 µg/L on September 29, 1998).

Since the start of the June 2003 shutdown test, the benzene concentration in water samples from well HR-7-383 exceeded the benzene ARAR (fig. 45). Benzene concentrations in water samples from well HR-7-163 exceeded the ARAR during the June 2003 shutdown test and fell below the ARAR before the end of the test; concentrations have remained below the ARAR since then. For well HR-7-383, the median benzene concentration was 12 µg/L for 1998 to May 2003, increased to 60 µg/L for October 2003 to July 2006, and decreased to 54 µg/L for May 2007 to February 2008 (table 7, fig. 46). For well HR-7-163, the median benzene concentration was 80 µg/L for 1991–97, decreased to 0.1 µg/L for 1998 to June 2003, increased to 7.6 µg/L for July 2003 to July 2006, and decreased to 4.5 µg/L for May 2007 to February 2008 (table 7, fig. 46).

The chlorobenzene concentration in water samples from well HR-7-383 began to increase in October 2006 and exceeded the ARAR in September 2007 (fig. 47). Median chlorobenzene concentrations in water samples from well HR-7-383 have been increasing (fig. 48). For well HR-7-383, the median chlorobenzene concentration was 7.1 µg/L for 1998 to May 2003, increased to 24 µg/L for October 2003 to January 2007, and increased to 82 µg/L for May 2007 to February 2008 (table 7, fig. 48). Since 2000, the chlorobenzene concentration in water samples from well HR-7-163 exceeded the ARAR only once (62 µg/L on May 10, 2007).

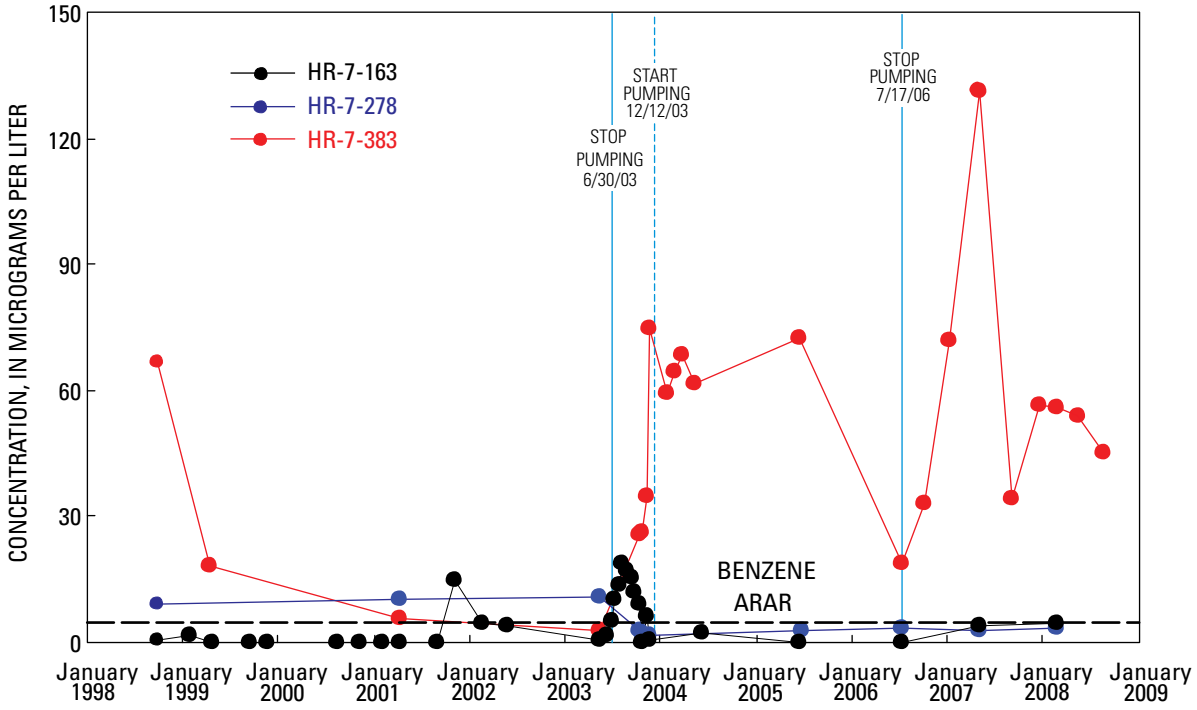


Figure 45. Concentrations of benzene in water samples from wells HR-7-163, HR-7-278, and HR-7-383, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1998–2008. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

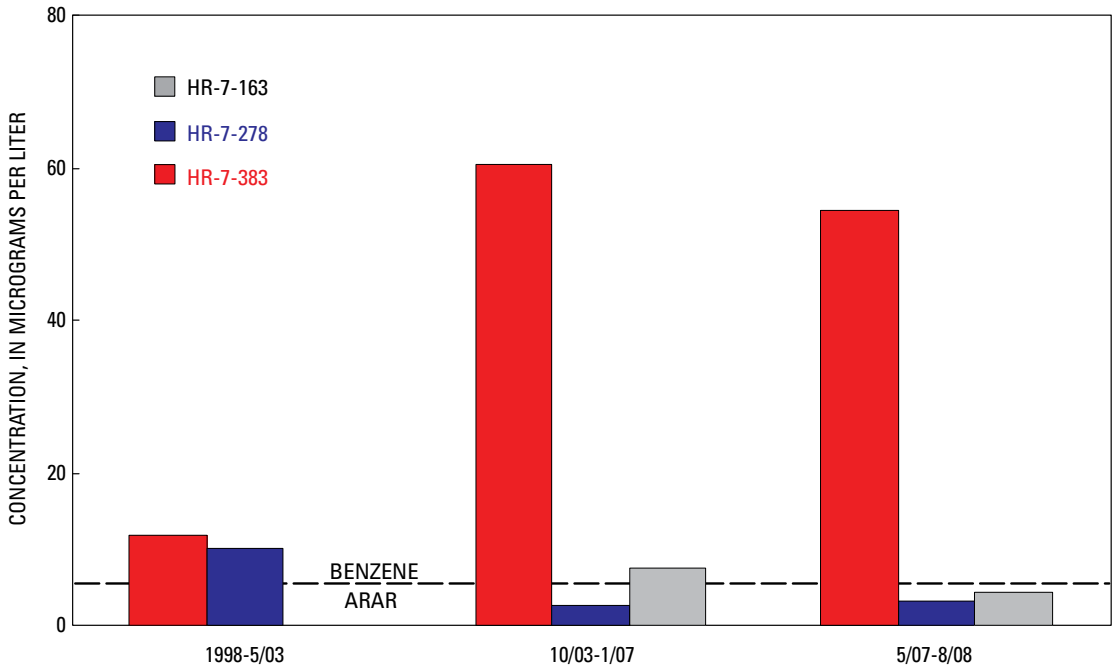


Figure 46. Median concentrations of benzene in water samples from wells HR-7-163, HR-7-278, and HR-7-383, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1998–2008. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

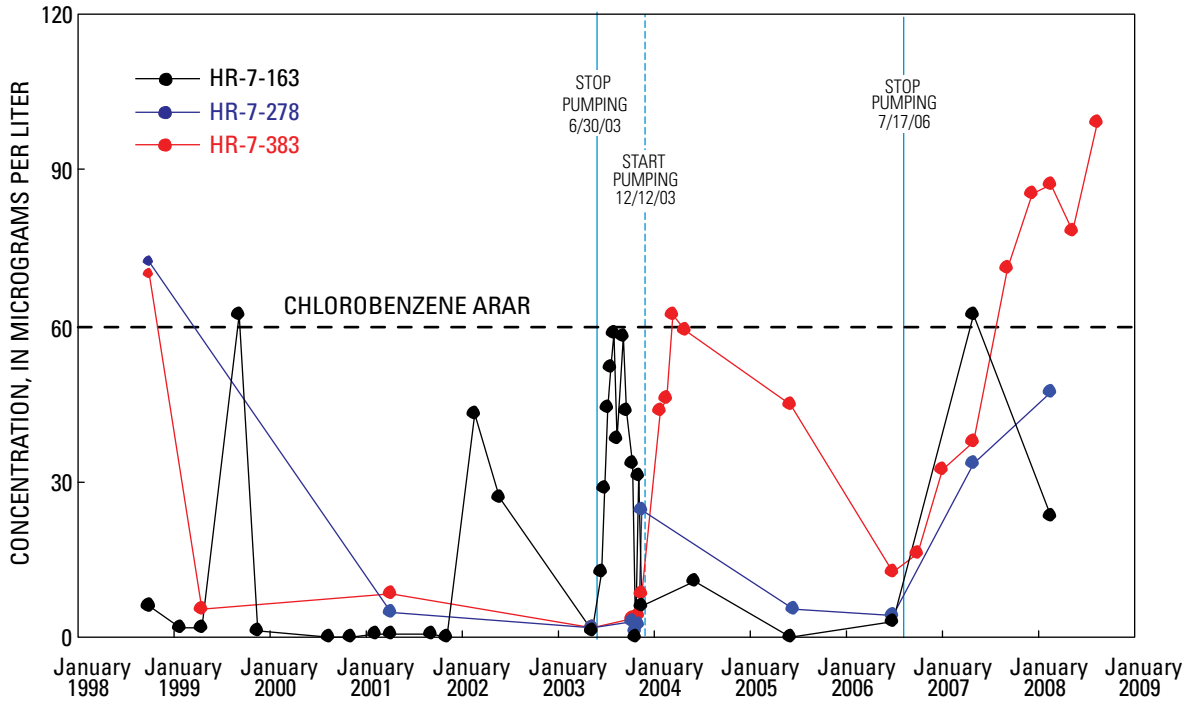


Figure 47. Concentrations of chlorobenzene in water samples from wells HR-7-163, HR-7-278, and HR-7-383, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1998–2008. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

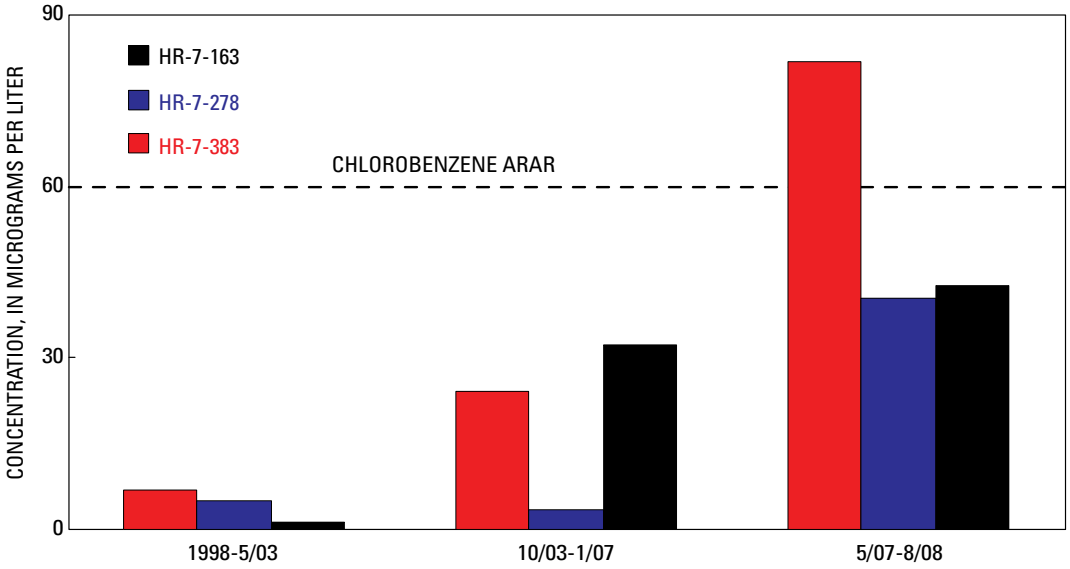


Figure 48. Median concentrations of chlorobenzene in water samples from wells HR-7-163, HR-7-278, and HR-7-383, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1998–2008. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

HR-9 Cluster Wells

Wells HR-9-191 and HR-9-333 were not sampled during the 2006–08 shutdown test. Well HR-9-333 was sampled six times during 1998–2005; the water samples did not exceed the ARARs. Water samples from well HR-9-191 exceeded the ARAR for 1,1-DCA following the June 2003 shutdown test (fig. 49). Vinyl chloride concentrations in water samples from well HR-9-191 exceeded the ARAR in 1997. Vinyl chloride concentrations increased in 2005 (fig. 50).

HR-12 Cluster Wells

Wells HR-12-150 and HR-12-300 were not sampled during the 2006–08 shutdown test. Well HR-12-150 was sampled only twice (April 22, 1999, and April 16, 2001). Water samples from well HR-12-150 exceeded ARARs for benzene, 1,1-DCA, vinyl chloride, and total xylene in 1999 and exceeded the ARAR for 1,1-DCA in 2001 (table 7). Well HR-12-300 was sampled 19 times during 2003–06. Seventeen of the 19 (89 percent) water samples exceeded the ARAR for 1,1-DCA (fig. 51); the median 1,1-DCA concentration was 10 µg/L (table 7). The concentration of benzene in water samples from well HR-12-300 generally exceeded the ARAR during the June 2003 shutdown test and exceeded the ARAR for four of nine samples (44 percent) since the end of the test (fig. 51).

HR-14 Cluster Wells

During the 2006–08 shutdown test, well HR-14-376 was sampled quarterly, and well HR-14-178 was sampled once in May 2007 and once in February 2008. Since the start of the June 2003 shutdown test, well HR-14-178 exceeded the ARAR for 1,1-DCA twice (fig. 52). The median concentration of 1,1-DCA in water samples from well HR-14-178 was 0 µg/L for 1993–99, increased to 2.7 µg/L for November 2000 to May 2003, decreased to 1.3 µg/L for October 2003 to July 2006, and increased to 5.7 µg/L for May 2007 to February 2008 (table 7).

All water samples from well HR-14-376 exceeded the benzene ARAR, except for one sample collected on October 30, 2003 (fig. 53). Only 10 percent of water samples from well HR-14-376 exceeded the chlorobenzene ARAR (fig. 53). About 8 months after the December 2003 start of pumping at the reduced rate, benzene and chlorobenzene concentrations increased and then decreased (fig. 53).

Median benzene and chlorobenzene concentrations in water samples from well HR-14-376 have been decreasing (table 7, fig. 54). For well HR-14-376, the median benzene concentration was 50 µg/L for 1998 to June 2003, decreased to 28 µg/L for July 2003 to January 2007, and decreased to 13 µg/L for May 2007 to August 2008. For well HR-14-376, the median chlorobenzene concentration was 26 µg/L for 1998 to June 2003, decreased to 21 µg/L for July 2003 to January 2007, and decreased to 8.9 µg/L for May 2007 to August 2008.

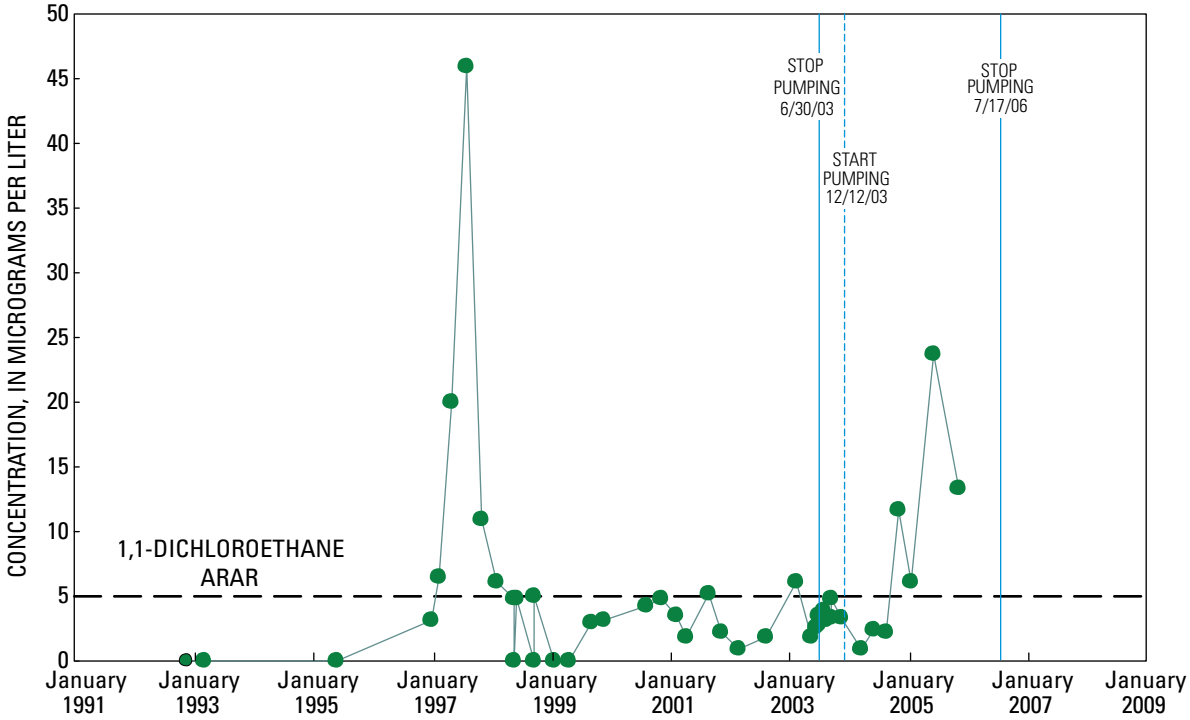


Figure 49. Concentrations of 1,1-dichloroethane in water samples from well HR-9-191, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1992–2005. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

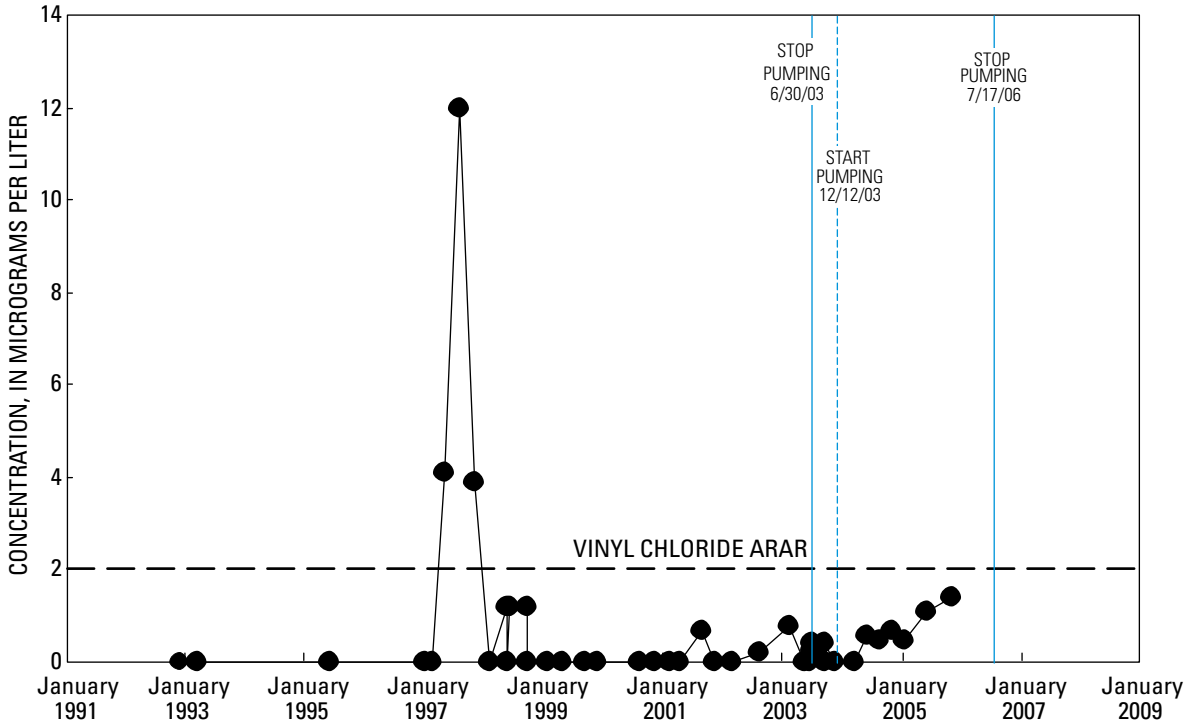


Figure 50. Concentrations of vinyl chloride in water samples from well HR-9-191, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1992–2005. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

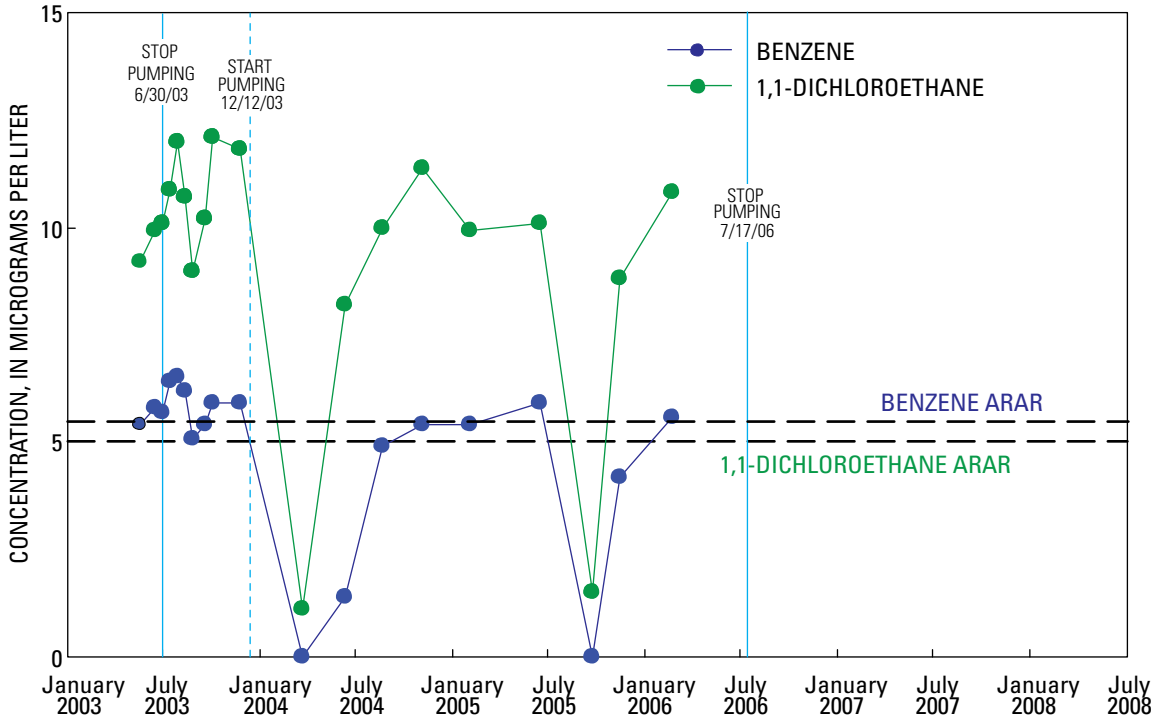


Figure 51. Concentrations of benzene and 1,1-dichloroethane in water samples from well HR-12-300, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 2003–06. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

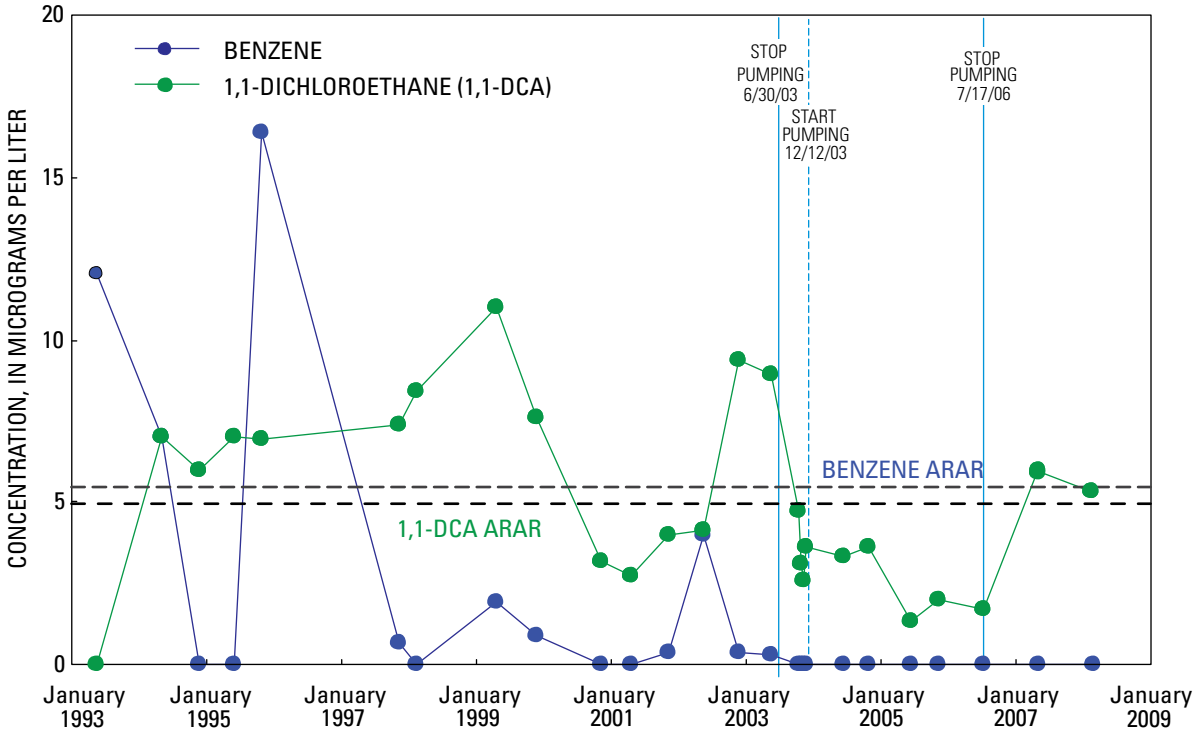


Figure 52. Concentrations of benzene and 1,1-dichloroethane in water samples from well HR-14-178, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1993–2008. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

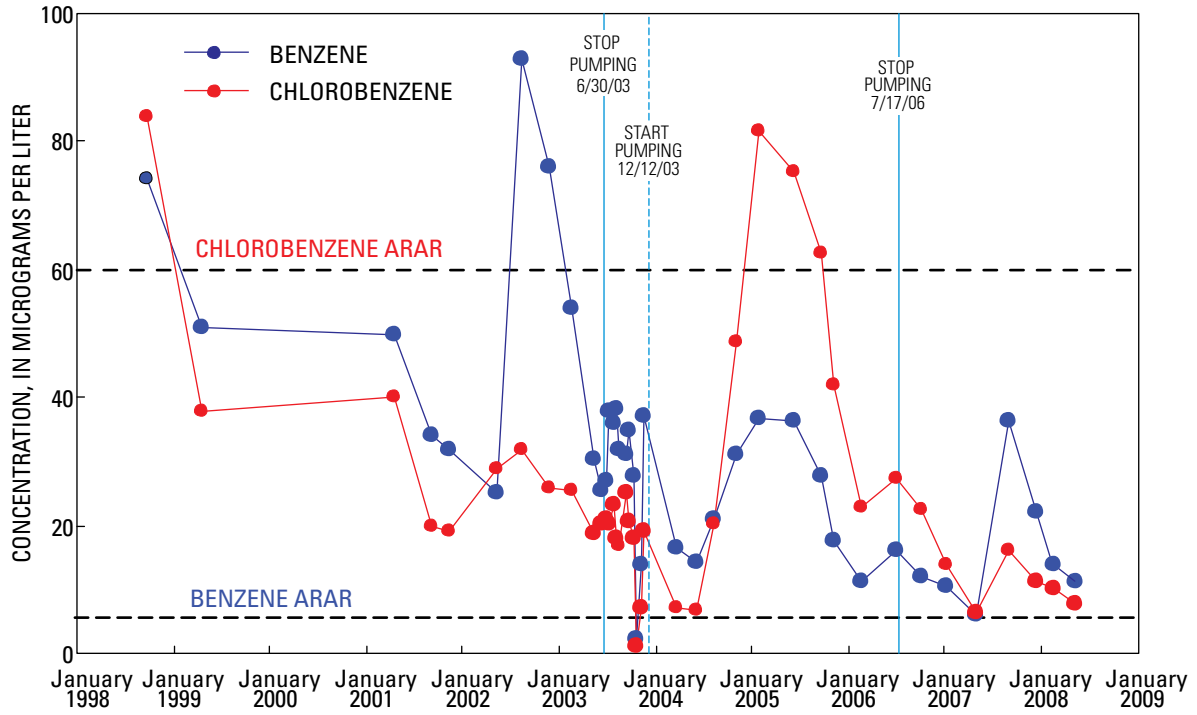


Figure 53. Concentrations of benzene and chlorobenzene in water samples from well HR-14-376, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1998–2008. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

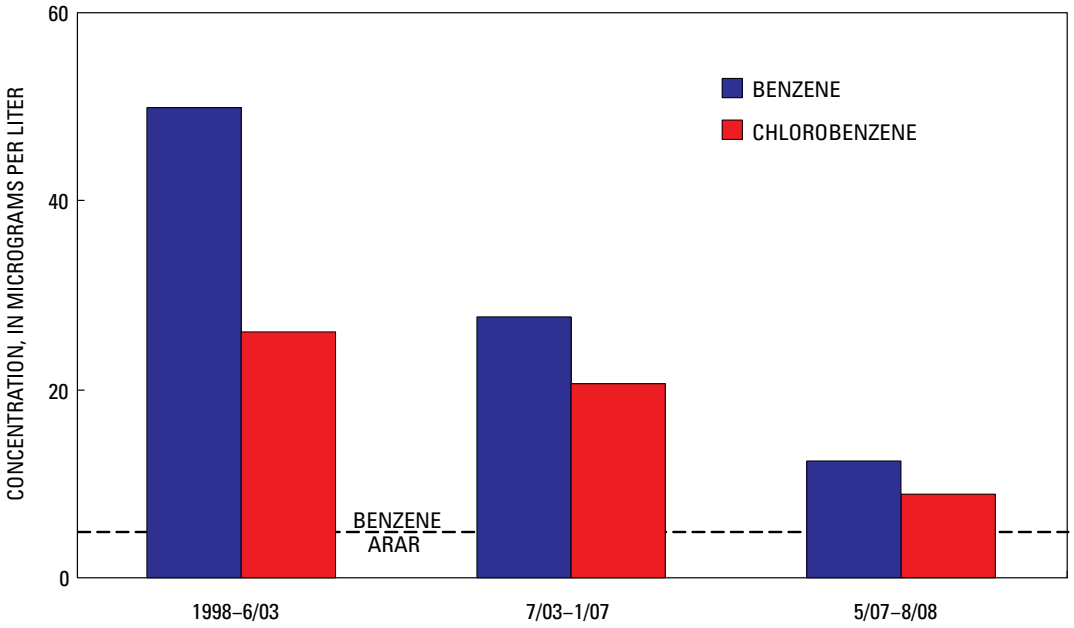


Figure 54. Median concentrations of benzene and chlorobenzene in water samples from well HR-14-376, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1998–2008. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

Well HR-18-190

During the 2006–08 shutdown test, well HR-18-190 was sampled quarterly. During 2003–08, water samples from well HR-18-190 exceeded the ARAR for 1,1-DCA much of the time (fig. 55). The TCE concentration, although below the ARAR, usually exceeded the USEPA maximum contaminant level (MCL) of 5 µg/L. Concentrations of 1,1-DCA and TCE were about the same after the June 2003 shutdown as before the shutdown (fig. 56). For well HR-18-190, the median 1,1-DCA concentration was fairly stable; it was 6.2 µg/L for 1992–99, 4.8 µg/L for May 2000 to May 2003, 6.1 µg/L for October 2003 to January 2007, and 5.5 µg/L for May 2007 to August 2008 (table 7, fig. 57). The median TCE concentration was 7.1 µg/L for 1992–99, decreased to 2.9 µg/L for May 2000 to June 2003, increased to 9.7 µg/L for July 2003 to January 2007, and remained about the same (9.3 µg/L) for May 2007 to August 2008 (fig. 57).

Well RE-205

During the 2006–08 shutdown test, well RE-205 was sampled once in May 2007 and once in February 2008; water samples did not exceed the ARARs. Concentrations of benzene and chlorobenzene in water samples from well RE-205 exceeded the ARARs following the June 2003 shutdown (fig. 58). Median concentrations of benzene, chlorobenzene, and 1,1-DCA generally have been decreasing with time (table 7, fig. 59).

Off-Site Downgradient Wells

Off-site downgradient wells include wells HR-5-195, HR-11-133, HR-10-180, HR-17-170, HR-22-300, HR-23-350, and HR-30-318. Locations of these wells are shown on figure 3. No off-site downgradient well sampled during 2003–08 exceeded the ARARs.

Well HR-22-300 was sampled four times during 1999–2001, once in 2005, and quarterly during the 2006–08 shutdown test. For 1999–2001, the benzene ARAR was exceeded for three of four samples (75 percent) (fig. 60). For 2005–08, the benzene concentration was below the ARAR and was below the detection limit for the last seven samples. Concentrations of chlorobenzene, 1,1-DCA, and 1,2-DCA increased after the start of the 2006–08 shutdown test and then began to decline (fig. 60). Comparing the 1999–2001 samples with the 2005–08 samples, median concentrations of benzene and chlorobenzene decreased and median concentrations of 1,1-DCA and 1,2-DCA increased (fig. 61).

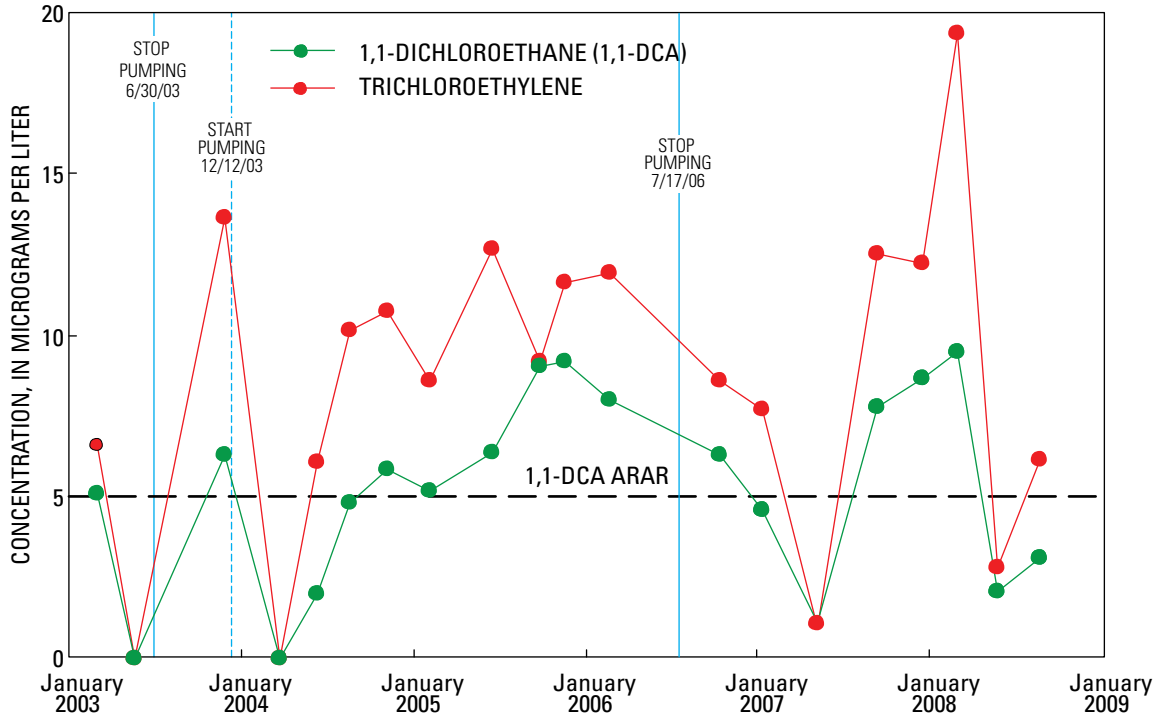


Figure 55. Concentrations of 1,1-dichoroethane and trichloroethylene in water samples from well HR-18-190, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 2003–08. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). The ARAR for trichloroethylene is 25.8 micrograms per liter. Data provided by RT Environmental Services, Inc.

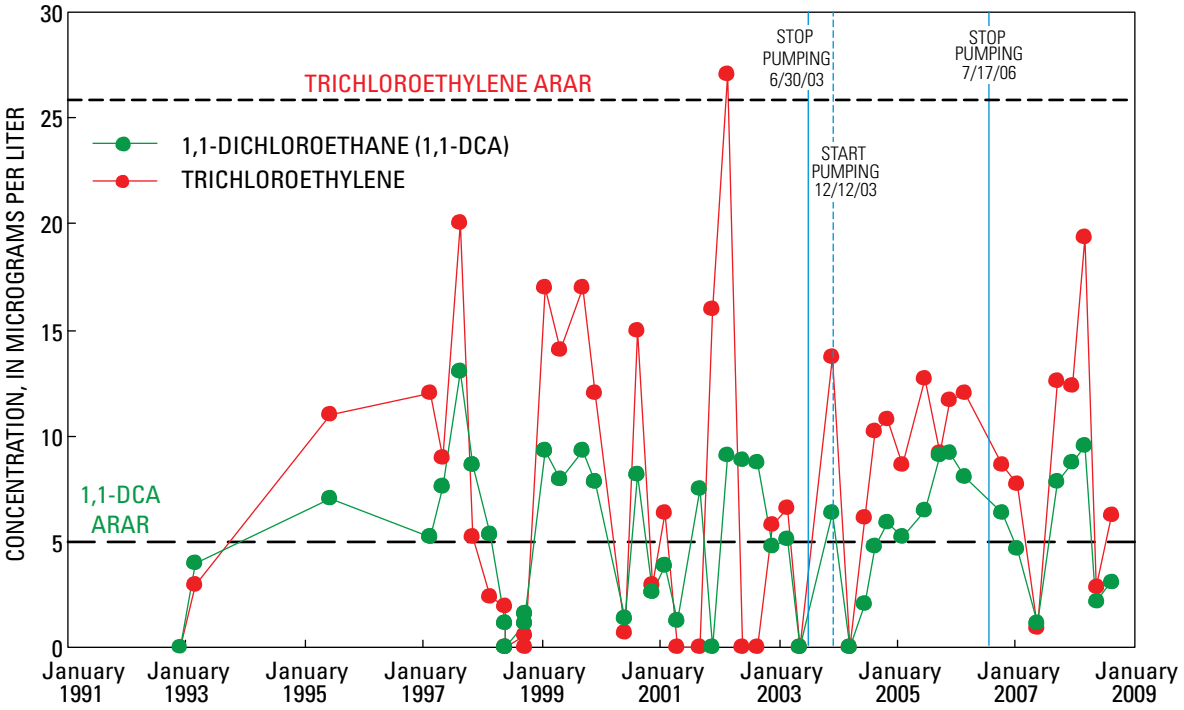


Figure 56. Concentrations of 1,1-dichoroethane and trichloroethylene in water samples from well HR-18-190, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1992–2008. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

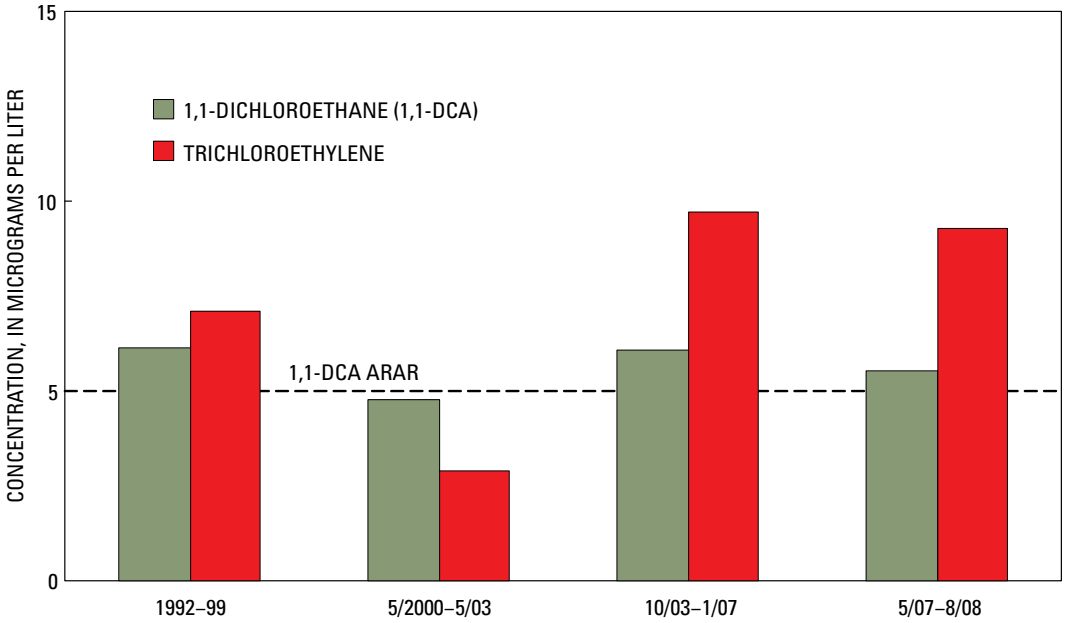


Figure 57. Median concentrations of trichloroethylene and 1,1-dichloroethane in water samples from well HR-18-190, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1992–2008. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). The ARAR for trichloroethylene is 25.8 micrograms per literData provided by RT Environmental Services, Inc.

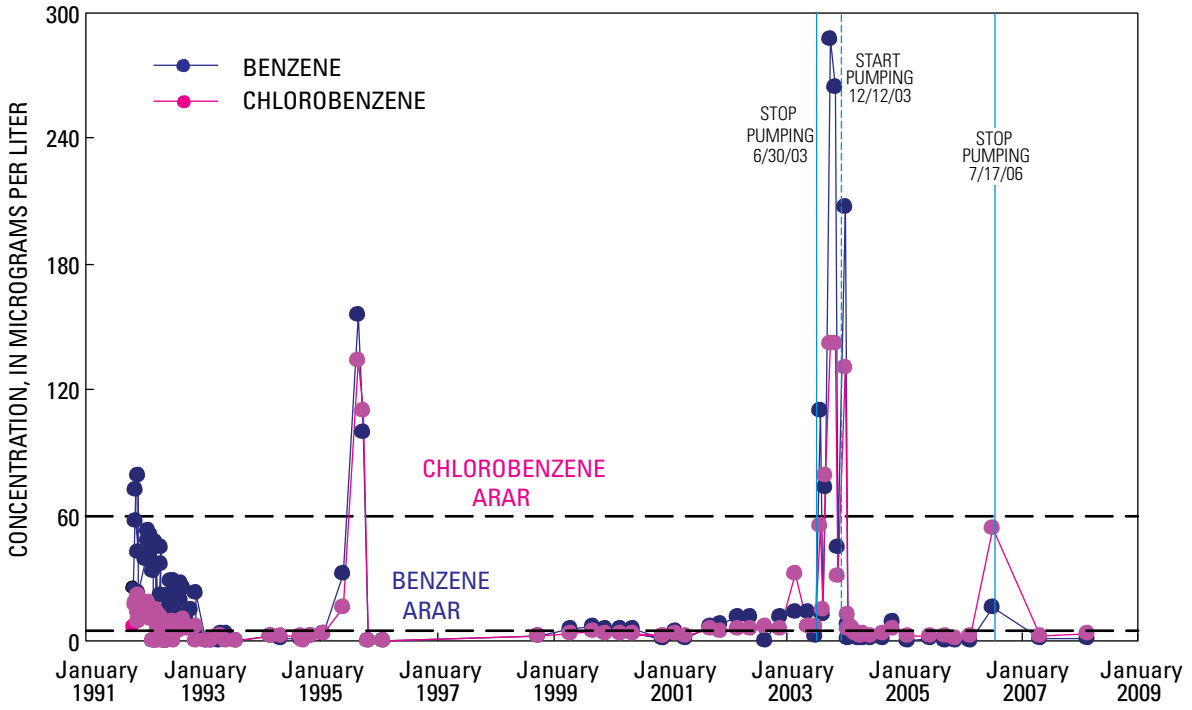


Figure 58. Concentrations of benzene and chlorobenzene in water samples from well RE-205, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1991–2008. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

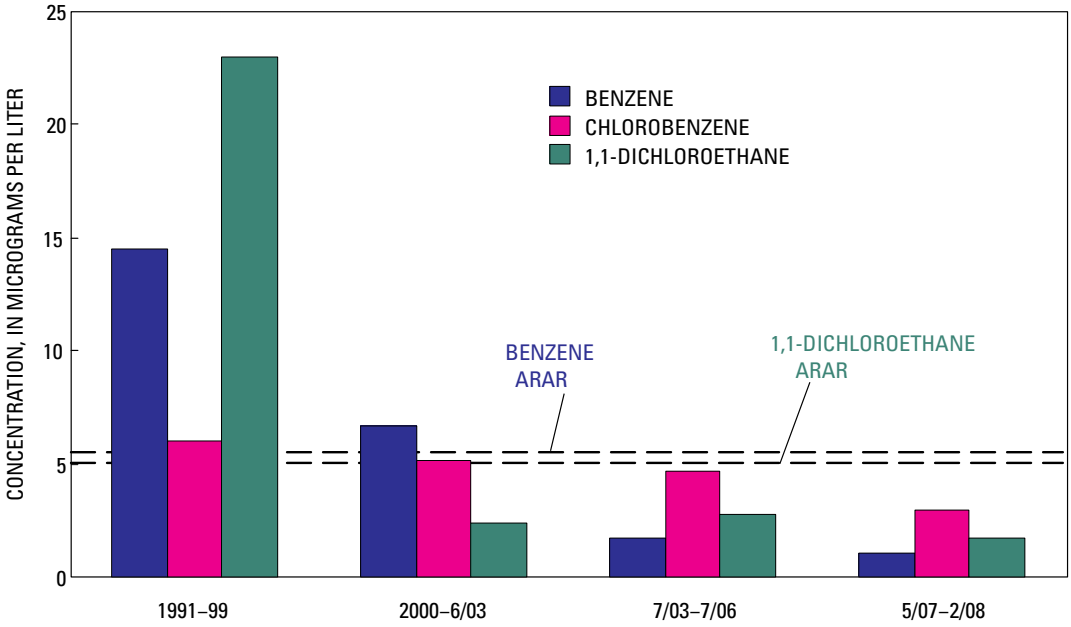


Figure 59. Median concentrations of benzene, chlorobenzene, and 1,1-dichloroethane in water samples from well RE-205, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1991–2008. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). The ARAR for chlorobenzene is 60 micrograms per liter. Data provided by RT Environmental Services, Inc.

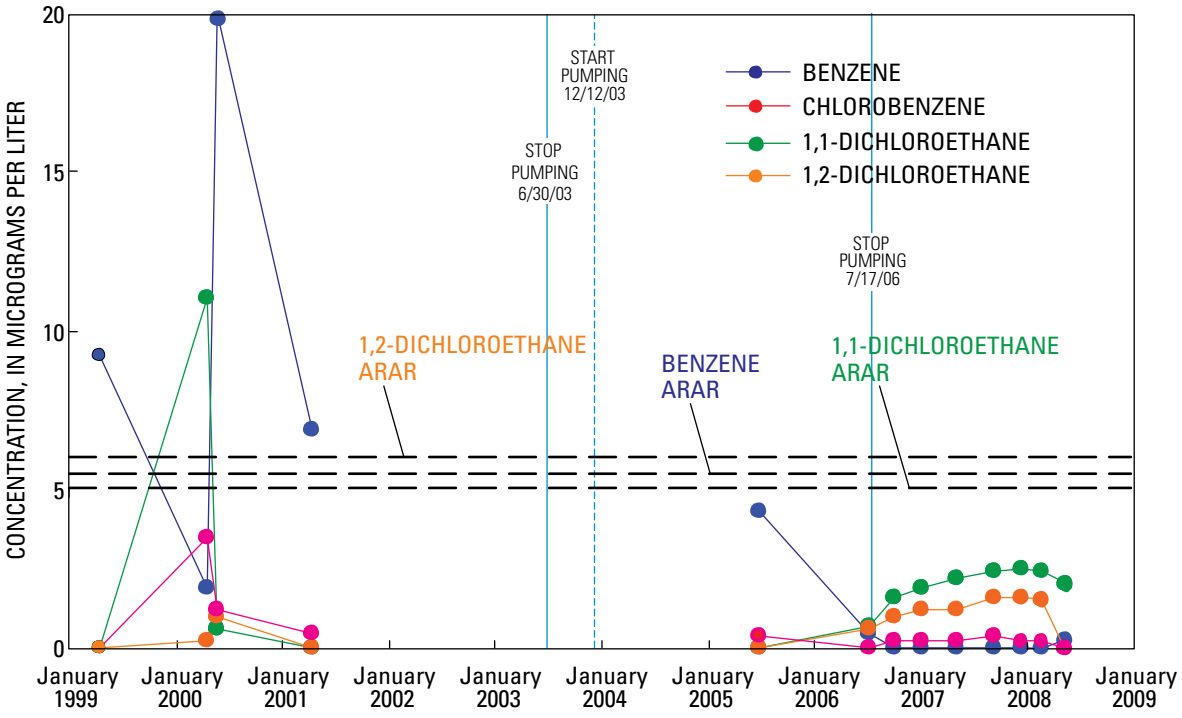


Figure 60. Concentrations of benzene, chlorobenzene, 1,1-dichloroethane, and 1,2-dichloroethane in water samples from well HR-22-380, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1999–2008. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc. The ARAR for chlorobenzene is 60 micrograms per liter.

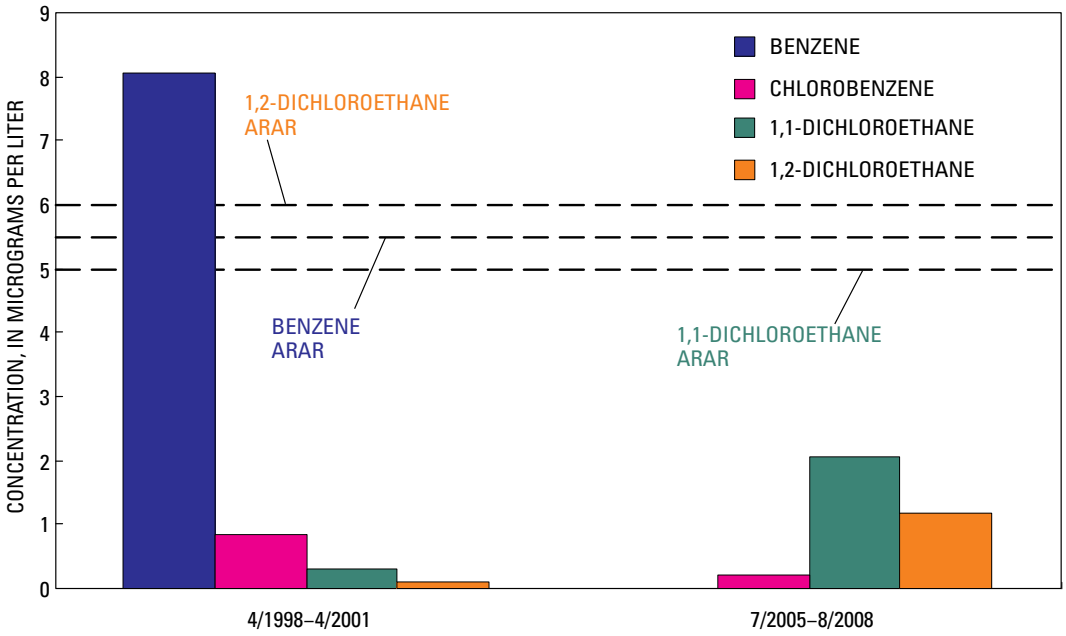


Figure 61. Median concentrations of benzene, chlorobenzene, 1,1-dichloroethane, and 1,2-dichloroethane in water samples from well HR-22-380, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1999–2008. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). The ARAR for chlorobenzene is 60 micrograms per liter. The median concentration of benzene was zero for July 2005 to August 2008. Data provided by RT Environmental Services, Inc.

Upgradient Wells

Upgradient wells include wells HR-1-260, HR-1-276, HR-1-280, HR-15-255, and HR-20-155. Locations of these wells are shown on figure 3. Only well HR-20-155 was sampled during the 2006–08 shutdown test. The concentration of total VOCs was less than 2 µg/L during 2006–08.

Areal Distribution of Volatile Organic Compounds

The areal distribution of benzene, chlorobenzene, chloroethane, 1,1-DCA, cis-1,2-DCA, vinyl chloride, and total xylene was evaluated using data from February and March 2008 because more wells were sampled for that time period than for other dates. All wells, except wells HR-6-377 and HR-24-476, were sampled February 25–29; well HR-6-377 was sampled on March 25, and well HR-24-476 was sampled on March 28, 2008. Data for February and March 2008 for these compounds are given in table 4. Changes in constituent concentrations between pre-shutdown samples collected in July 2006 and samples collected in February and March 2008 are given in table 5.

The highest concentrations of benzene measured in water samples in February and March 2008 were from wells HR-3-255 (513 µg/L), HR-3-280 (178 µg/L), HR-6-377 (133 µg/L), and HR-7-383 (56 µg/L) (table 4, fig. 62). The approximate area where the benzene ARAR was exceeded and the approximate area affected by benzene contamination are shown on figure 62. The benzene plume appears to extend in a northwestern direction from the source area (fig. 62). The source area, as used in this report, is the area around the injection well and the HR-3 well cluster. The map indicates the benzene has moved toward the north, but no monitor wells are directly north of the HR-6 and HR-7 well clusters. The downgradient extent of the benzene plume is unknown. Concentrations of benzene appear to be somewhat depth related, and the plume appears to be dipping to the north (fig. 63). The greatest changes in benzene concentration between the pre-shutdown samples collected in July 2006 and the samples collected in February and March 2008 were for wells HR-3-255 (an increase of 164 µg/L), HR-7-383 (an increase of 37 µg/L), the injection well (an increase of 26 µg/L), and HR-3-280 (a decrease of 79 µg/L) (table 5, fig. 64).

The highest concentrations of chlorobenzene measured in water samples in February and March 2008 were from wells HR-6-141 (145 µg/L), HR-6-241 (102 µg/L), HR-24-276 (97 µg/L), HR-3-255 (95 µg/L), and HR-7-383 (87 µg/L)

Table 4. Concentrations of selected volatile organic compounds in ground-water samples from the Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, February and March 2008.

[ARAR, applicable or relevant and appropriate requirements; Concentrations in micrograms per liter; concentrations above ARAR are in bold type]

Compound	ARAR	HR-2-195	HR-2-295	HR-3-255	HR-3-280	HR-3-295	HR-4-295	HR-5-195	HR-6-141	HR-6-241	HR-6-377
		2/26/08	2/26/08	2/27/08	2/28/08	2/27/08	2/29/08	2/26/08	2/25/2008	2/25/2008	3/25/2008
Benzene	5.52	**50**	3	**513**	**178**	**16**	1	0	3.3	**12**	**133**
Chlorobenzene	60	16	3.2	**95**	28	10.9	2	2.6	**145**	**102**	43
Chloroethane	19,000	197	4.2	79	180	17	1.8	0	.83	43	4.1
1,1-Dichloroethane	5.06	2.1	**7.1**	.6	**25**	1.7	4.4	1.1	0	.39	0
cis-1,2-Dichloroethane	70	.73	1.8	0	.27	.46	.37	.32	0	0	0
Vinyl chloride	2	.74	1.1	0	.58	0	.75	0	0	0	0
Total xylene	175	82	.53	**1,730**	0	3.6	0	0	0	0	.51

Compound	ARAR	HR-7-163	HR-7-278	HR-7-383	HR-10-180	HR-14-178	HR-14-376	HR-17-170	HR-18-190	HR-20-155	HR-22-300
		02/28/08	2/28/08	2/28/08	2/29/08	2/26/08	2/26/2008	2/27/2008	2/29/2008	2/25/2008	2/27/2008
Benzene	5.52	4.8	3.4	**56**	0	0	**14**	0	0	0	0
Chlorobenzene	60	24	47	**87**	0	.44	10	0	.99	0	.21
Chloroethane	19,000	0	0	52	0	0	9.4	0	0	0	0
1,1-Dichloroethane	5.06	.68	.92	.56	0	**5.4**	**8.4**	0	**9.5**	0	2.4
cis-1,2-Dichloroethane	70	0	0	.32	0	3.6	.31	0	3.7	0	0
Vinyl chloride	2	0	0	0	0	0	0	0	.44	0	0
Total xylene	175	0	0	0	0	0	0	0	.92	0	0

Compound	ARAR	HR-24-476	HR-26-457	HR-30-318	RE-205	Injection well
		3/28/08	2/27/08	2/27/08	2/27/08	2/27/08
Benzene	5.52	1.5	**21**	0	0.93	**36**
Chlorobenzene	60	**97**	8.3	.53	3.6	46
Chloroethane	19,000	0	28	0	.35	53
1,1-Dichloroethane	5.06	.26	1.5	1.4	1.8	1.4
cis-1,2-Dichloroethane	70	0	.61	.48	.74	.95
Vinyl chloride	2	0	.32	0	1.1	.86
Total xylene	175	0	2.3	0	0	**185**

Table 5. Change in concentration of selected volatile organic compounds between July 2006 and February and March 2008, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania.

[Change given in micrograms per liter; ND, compound not detected in either sample; —, unable to compute statistic]

Compound	HR-2-195		HR-2-295		HR-3-255		HR-3-280		HR-3-295		HR-4-295	
	Change	Percent change	Change	Percent change	Change	Percent change	Change	Percent change	Change	Percent change	Change	Percent change
Benzene	18.9	61	-0.50	-14	164	47	-79	-31	8.1	100	-3.0	-75
Chlorobenzene	-3.2	-17	.8	33	-4.3	-4	-51	-65	-8.3	-43	-2.9	-59
1,1-Dichloroethane	1.6	357	1.0	16	-1.9	-76	20	410	-.30	-15	-1.7	-28
cis-1,2-Dichloroethene	.37	103	.10	6	-1.3	-100	-1.3	-83	-.54	-54	-.83	-69
Ethylbenzene	41	227	-.60	-100	-619	-95	-.39	-46	-.59	-49	ND	ND
Toluene	11	329	-1.3	-84	-447	-90	6.0	316	-.75	-68	ND	ND
Vinyl chloride	.4	118	.10	10	-1	-100	-.72	-55	-.33	-100	-.45	-38
Total xylenes	37	83	-.08	-13	-1,410	-45	-278	-100	-3.1	-46	ND	ND

Compound	HR-5-195		HR-6-241		HR-6-377		HR-7-163		HR-7-278		HR-7-383	
	Change	Percent change	Change	Percent change	Change	Percent change	Change	Percent change	Change	Percent change	Change	Percent change
Benzene	ND	ND	11	2,188	5.0	4	4.8	—	-0.10	-3	37	198
Chlorobenzene	1.7	177	99	3,190	9.6	29	21	770	43	1,080	74	579
1,1-Dichloroethane	-.20	-15	-2.1	-84	ND	ND	.4	143	-.58	-39	-.02	-3
cis-1,2-Dichloroethene	-.18	-36	-.95	-100	ND	ND	ND	ND	-.77	-100	.09	39
Ethylbenzene	ND	ND	ND	ND	-.09	-20	ND	ND	ND	ND	.31	—
Toluene	ND	ND	.63	—	-.20	-15	ND	ND	.02	—	.97	422
Vinyl chloride	ND	ND	-.64	-100	ND	ND	ND	ND	-.56	-100	ND	ND
Total xylenes	ND	ND	ND	ND	-.04	-7	ND	ND	ND	ND	ND	ND

Table 5. Change in concentration of selected volatile organic compounds between July 2006 and February and March 2008, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania. —Continued

[Change given in micrograms per liter; ND, compound not detected in either sample; —, unable to compute statistic]

Compound	HR-10-180		HR-14-178		HR-14-376		HR-17-170		HR-18-190		HR-20-155	
	Change	Percent change	Change	Percent change	Change	Percent change	Change	Percent change	Change	Percent change	Change	Percent change
Benzene	ND	ND	ND	ND	-2.3	-14	ND	ND	ND	ND	ND	ND
Chlorobenzene	ND	ND	-0.04	-8	-18	-64	ND	ND	-0.61	-38	ND	ND
1,1-Dichloroethane	ND	ND	3.7	218	6.2	282	ND	ND	1.5	19	-0.51	-100
cis-1,2-Dichloroethene	ND	ND	3.1	567	.31	—	ND	ND	1.9	106	ND	ND
Ethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	-0.43	-100	ND	ND	-.07	-20	ND	ND	ND	ND	ND	ND
Vinyl Chloride	ND	ND	ND	ND	ND	ND	ND	ND	-.17	-28	ND	ND
Total Xylenes	ND	ND	ND	ND	ND	ND	ND	ND	.92	—	ND	ND

Compound	HR-22-300		HR-24476		HR-25-325		HR-26-457		RE-205		Injection well	
	Change	Percent change	Change	Percent change	Change	Percent change	Change	Percent change	Change	Percent change	Change	Percent change
Benzene	-0.46	-100	1.5	—	-0.99	-100	5.2	22	-15	-94	26	253
Chlorobenzene	.21	—	95	3,958	-.27	-100	-63	-88	-51	-93	9.7	27
1,1-Dichloroethane	1.7	264	-1.0	-80	0	ND	-.5	-21	-.7	-28	-.90	-39
cis-1,2-Dichloroethene	ND	ND	-.75	-100	0	ND	-.5	-42	-.36	-33	-.05	-5
Ethylbenzene	ND	ND	ND	ND	0	ND	.9	15	-5.2	-100	56	1,114
Toluene	ND	ND	ND	ND	-3.7	-100	77	6,425	-.63	-45	102	8,483
Vinyl Chloride	ND	ND	ND	ND	ND	ND	.52	—	1.1	—	.50	139
Total Xylenes	ND	ND	ND	ND	ND	ND	-19	-59	-28	-100	165	844

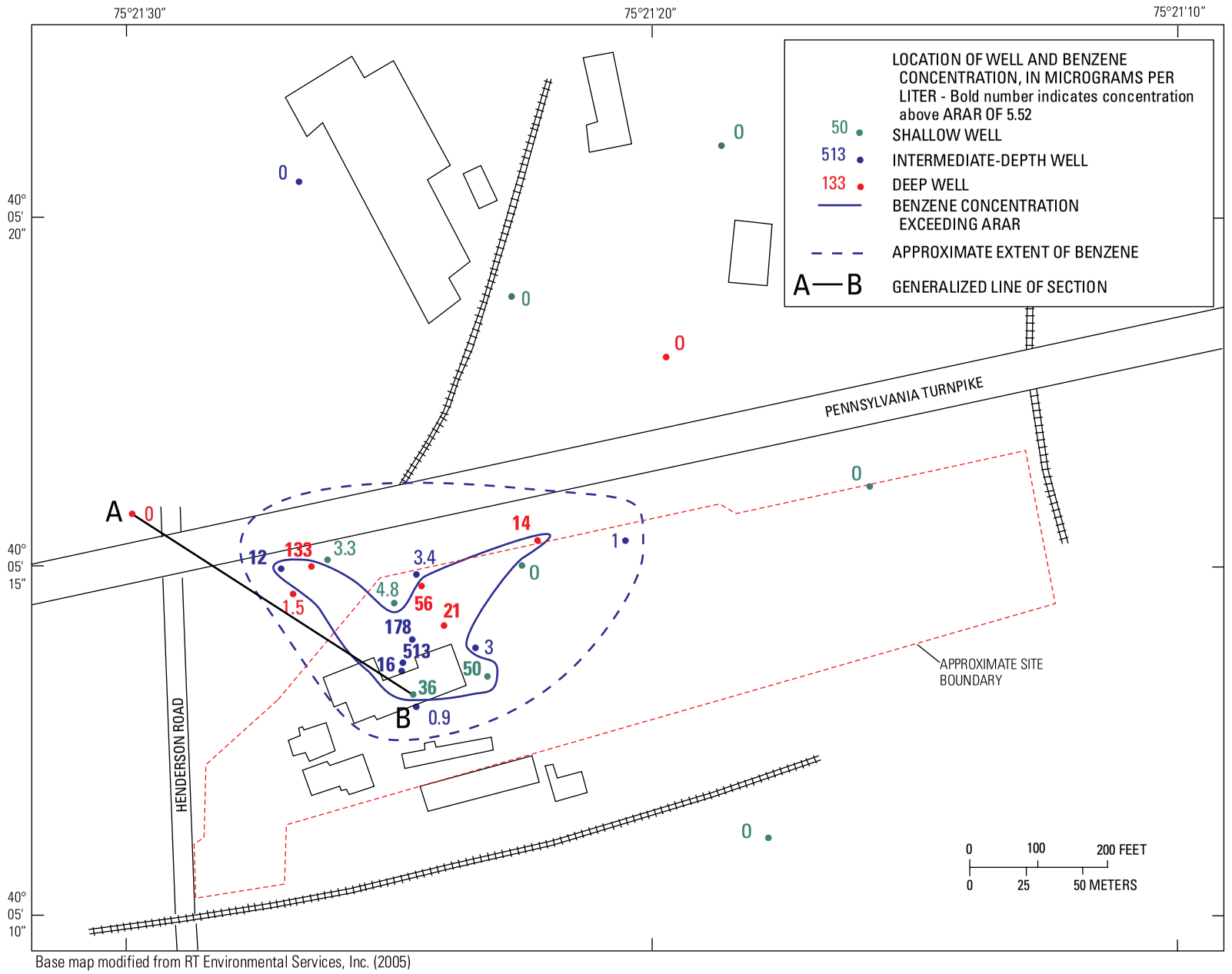


Figure 62. Concentrations of benzene measured in water samples from wells, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, February and March 2008. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Cross section along generalized line of section A-B is shown on figure 63. Data provided by RT Environmental Services, Inc.

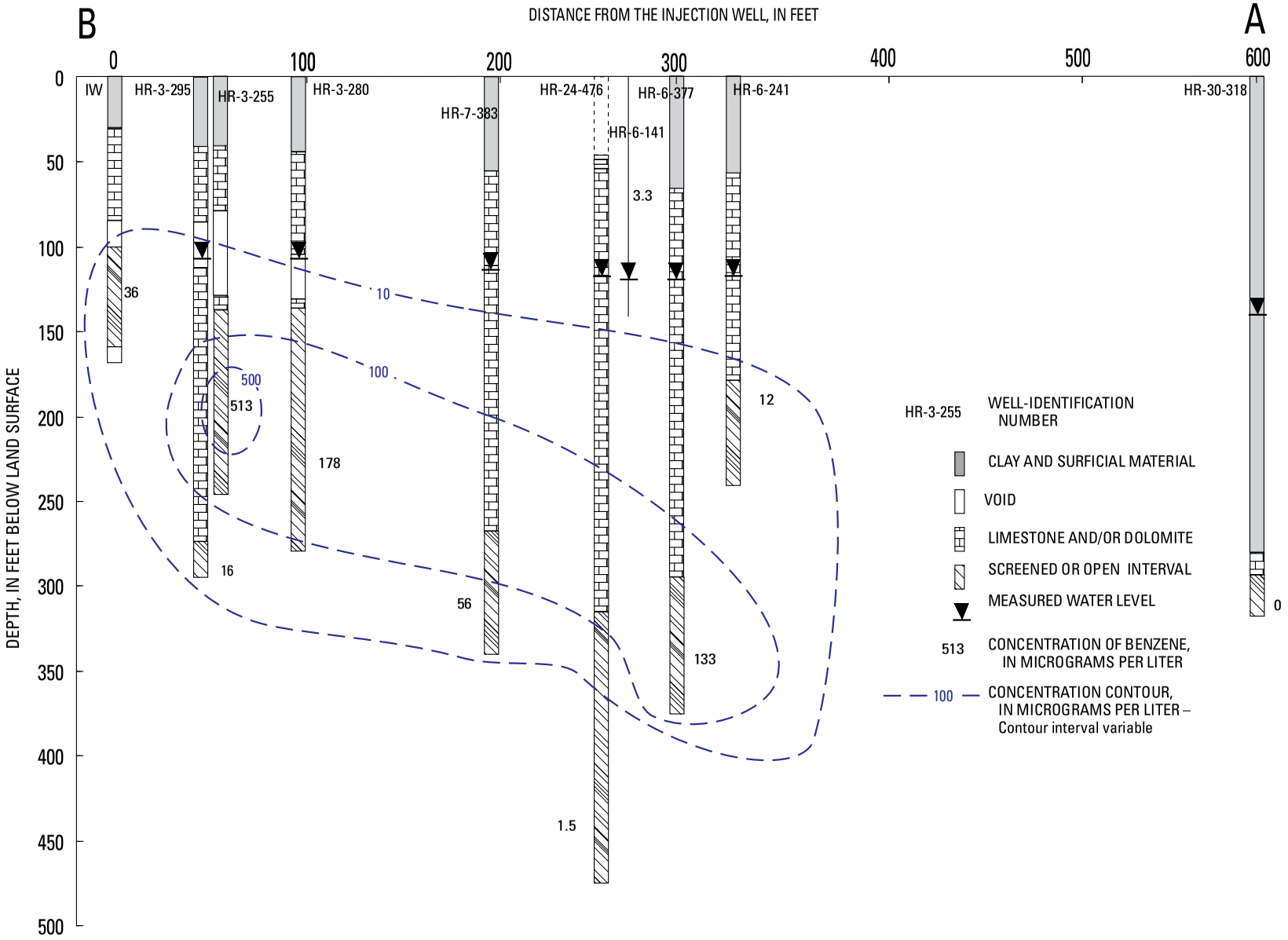


Figure 63. Concentrations of benzene measured in water samples from wells, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, February and March 2008. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Cross section along generalized line of section A-B is shown on figure 63. Data provided by RT Environmental Services, Inc.

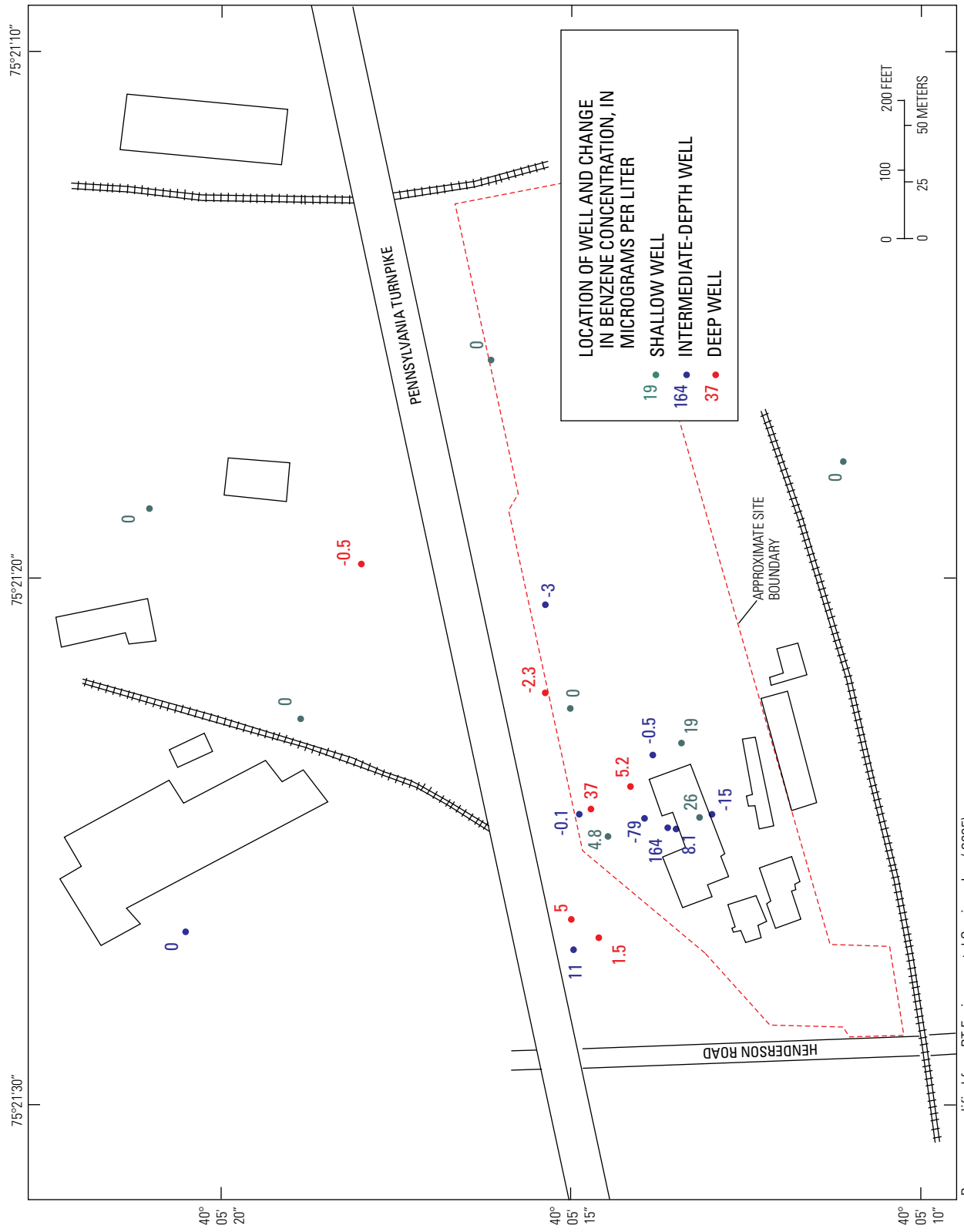


Figure 64. Change in benzene concentration measured between July 2006 and February 2008 in water samples from wells, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania. Data provided by RT Environmental Services, Inc.

(table 4, fig. 65). The approximate area where the chlorobenzene ARAR was exceeded and the approximate area affected by chlorobenzene contamination are shown on figure 65. A much larger area is affected by chlorobenzene than benzene. The chlorobenzene plume appears to extend northwest and north from the source area (fig. 65). The greatest concentrations of chlorobenzene are near and beyond the site boundary away from the source area (figs. 65 and 66). The map indicates chlorobenzene has moved toward the north, but no monitor wells are directly north of the HR-6 and HR-7 well clusters. The downgradient extent of the chlorobenzene plume is unknown. The greatest changes in chlorobenzene concentration between the pre-shutdown samples collected in July 2006 and the samples collected in February and March 2008 were for wells HR-6-241 (an increase of 99 µg/L), HR-24-476 (an increase of 95 µg/L), HR-7-383 (an increase of 74 µg/L), HR-7-278 (an increase of 43 µg/L), HR-26-457 (a decrease of 63 µg/L), HR-3-280 (a decrease of 51 µg/L), and RE-205 (a decrease of 51 µg/L) (table 5, fig. 67). Chlorobenzene concentrations decreased in the source area and increased at the northern site boundary at well clusters HR-6 and HR-7.

The highest concentrations of 1,1-DCA measured in water samples in February and March 2008 were from wells HR-3-280 (25 µg/L), HR-18-190 (9.5 µg/L), HR-14-376 (8.4 µg/L), and HR-2-295 (7.1 µg/L) (table 4, fig. 68); the ARAR was exceeded in water samples from these wells. Increases in 1,1-DCA concentration between the pre-shutdown samples collected in July 2006 and the samples collected in February 2008 (19 months after the shutdown) ranged from 0.4 to 20 µg/L. The greatest increases were measured in water samples from wells HR-3-280 (20 µg/L), HR-14-376 (6.2 µg/L), and HR-14-178 (3.7 µg/L). The approximate area where the 1,1-DCA ARAR was exceeded and the approximate area affected by 1,1-DCA contamination are shown on figure 68. The area affected by 1,1-DCA appears to extend east-northeast from the source area (fig. 68). It is possible that the source of 1,1-DCA in water from well HR-18-190 is from the landfill south of the well.

Concentrations of TCE and PCE were below the ARAR for all water samples for 2003–08; however, breakdown products of TCE and PCE exceeded ARARs for 2003–08. Anaerobic bacteria convert PCE to TCE by reductive dechlorination. By the same process, TCE is reduced to cis-1,2-DCE and trans-1,2-DCE, which are reduced to vinyl chloride. For water samples collected on the Henderson Road Site during 1991–2008, the TCE and PCE concentrations generally were below the detection limit. A water sample collected from the injection well in June 1979 contained 1,200 µg/L TCE and 2,900 µg/L PCE (BCM Engineers, 1988, p. 85), a water sample collected from well HR-2-175 in June 1986 contained 610 µg/L TCE and 291 µg/L PCE (BCM Engineers, 1988, p. 89), and a water sample collected from well HR-2-195 in June 1986 contained 140 µg/L TCE and 9,800 µg/L PCE (BCM Engineers, 1988, p. 89). It appears that biodegradation has substantially reduced concentrations of TCE and PCE.

The highest concentrations of cis-1,2-DCA measured in water samples in February and March 2008 were from wells HR-18-190 (3.7 µg/L) and HR-14-178 (3.6 µg/L) (table 4, fig. 69). Concentrations of cis-1,2-DCA measured during February and March 2008 did not exceed the ARAR. The approximate area affected by cis-1,2-DCA contamination is shown on figure 69. The area affected by cis-1,2-DCA appears to extend north and northeast from the source area (fig. 69).

The highest concentrations of vinyl chloride measured in water samples in February and March 2008 were from wells HR-2-295 (1.1 µg/L) and RE-205 (1.1 µg/L) (table 4, fig. 70). Concentrations of vinyl chloride measured during February and March 2008 did not exceed the ARAR. The approximate area affected by vinyl chloride contamination is shown on figure 70. The area affected by vinyl chloride appears to extend east-northeast from the source area (fig. 70).

The highest concentrations of total xylene measured in water samples in February and March 2008 were from wells HR-3-255 (1,730 µg/L), the injection well (185 µg/L), and HR-2-195 (82 µg/L) (table 4, fig. 71); water samples from wells HR-3-255 and the injection well exceeded the ARAR for total xylene. The greatest change in total xylene concentration between the pre-shutdown samples collected in July 2006 and the samples collected in February 2008 (19 months after the shutdown) was an increase of 165 µg/L in water samples from the injection well and a decrease of 1,410 µg/L in water samples from well HR-3-255. The approximate area where the total xylene ARAR was exceeded and the approximate area affected by xylene are shown on figure 71. The area affected by xylene appears to mainly extend east-northeast from the source area (fig. 71).

The concentration maps appear to show two overlapping plumes (fig. 72), a benzene-chlorobenzene plume and a PCE/TCE breakdown-products plume. The benzene-chlorobenzene plume extends northeast and northwest from the source area. The PCE/TCE breakdown products plume extends east and northeast from the source area.

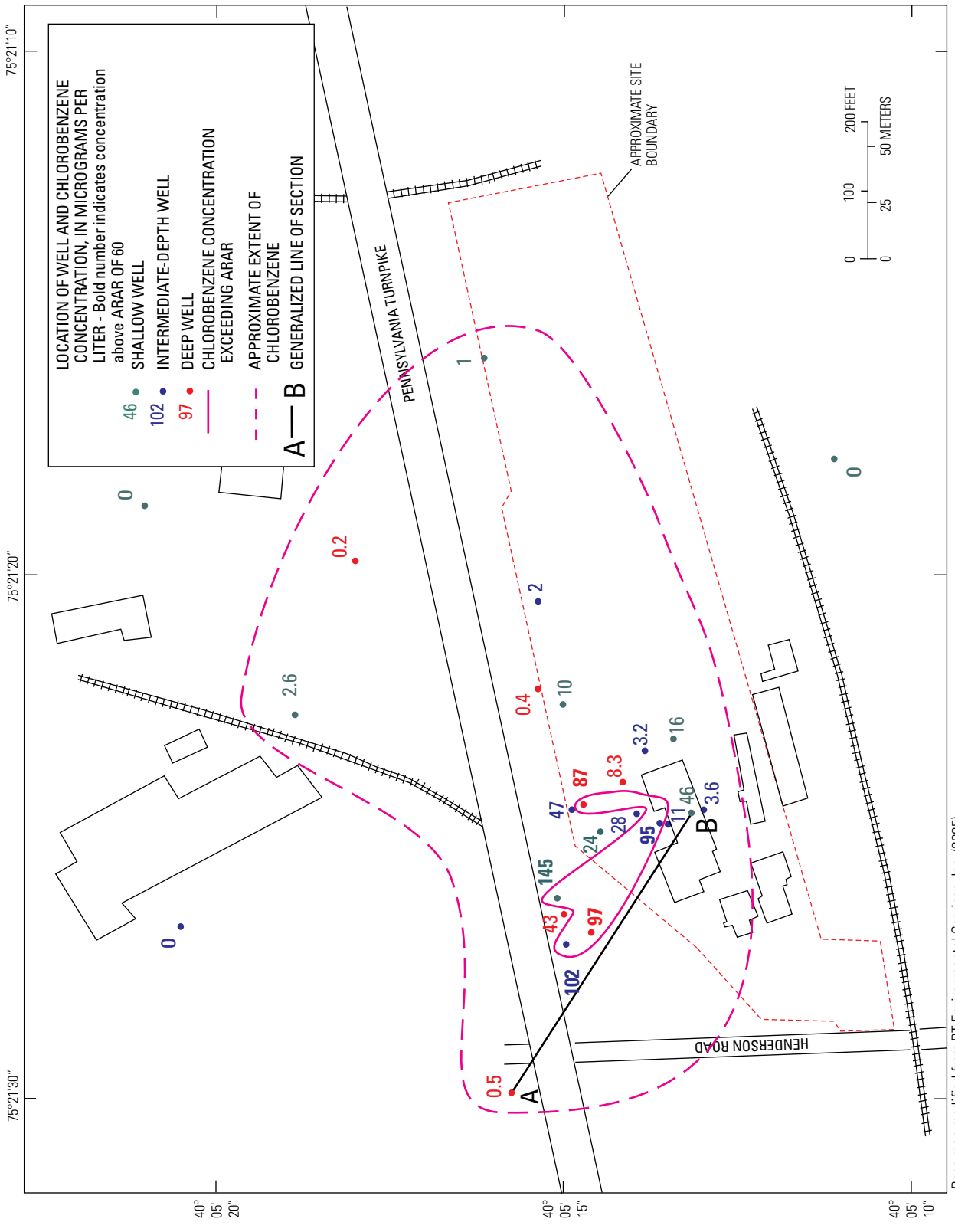


Figure 65. Concentrations of chlorobenzene measured in water samples from wells, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, February and March 2008. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Cross section along generalized line of section A-B is hsown on figure 66. Data provided by RT Environmental Services, Inc.

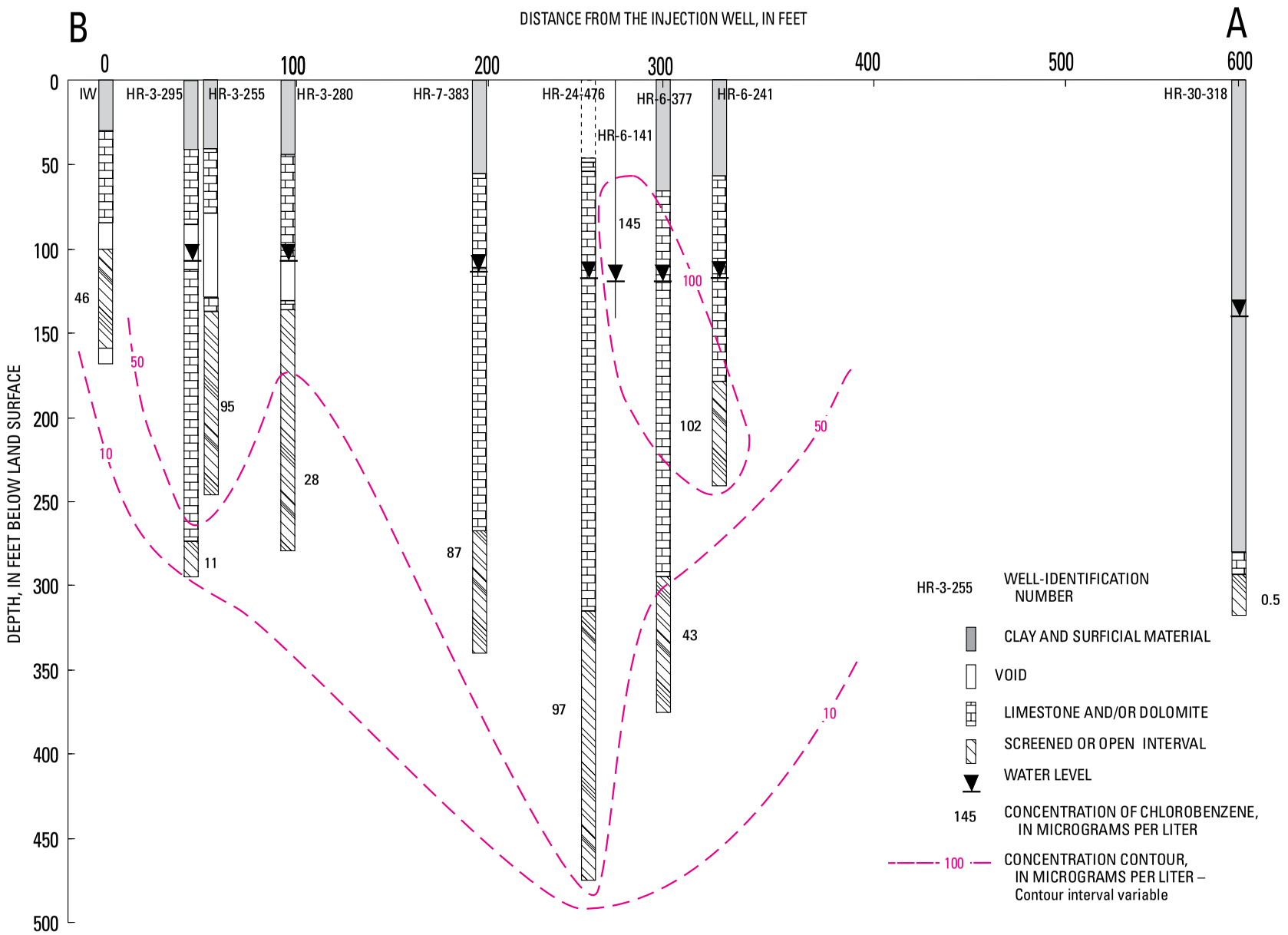


Figure 66. Concentrations of chlorobenzene in water samples from wells along section A-B, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, February and March 2008. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). The ARAR for chlorobenzene is 60 micrograms per liter. Generalized line of section A-B is shown on figure 65. Data provided by RT Environmental Services, Inc.

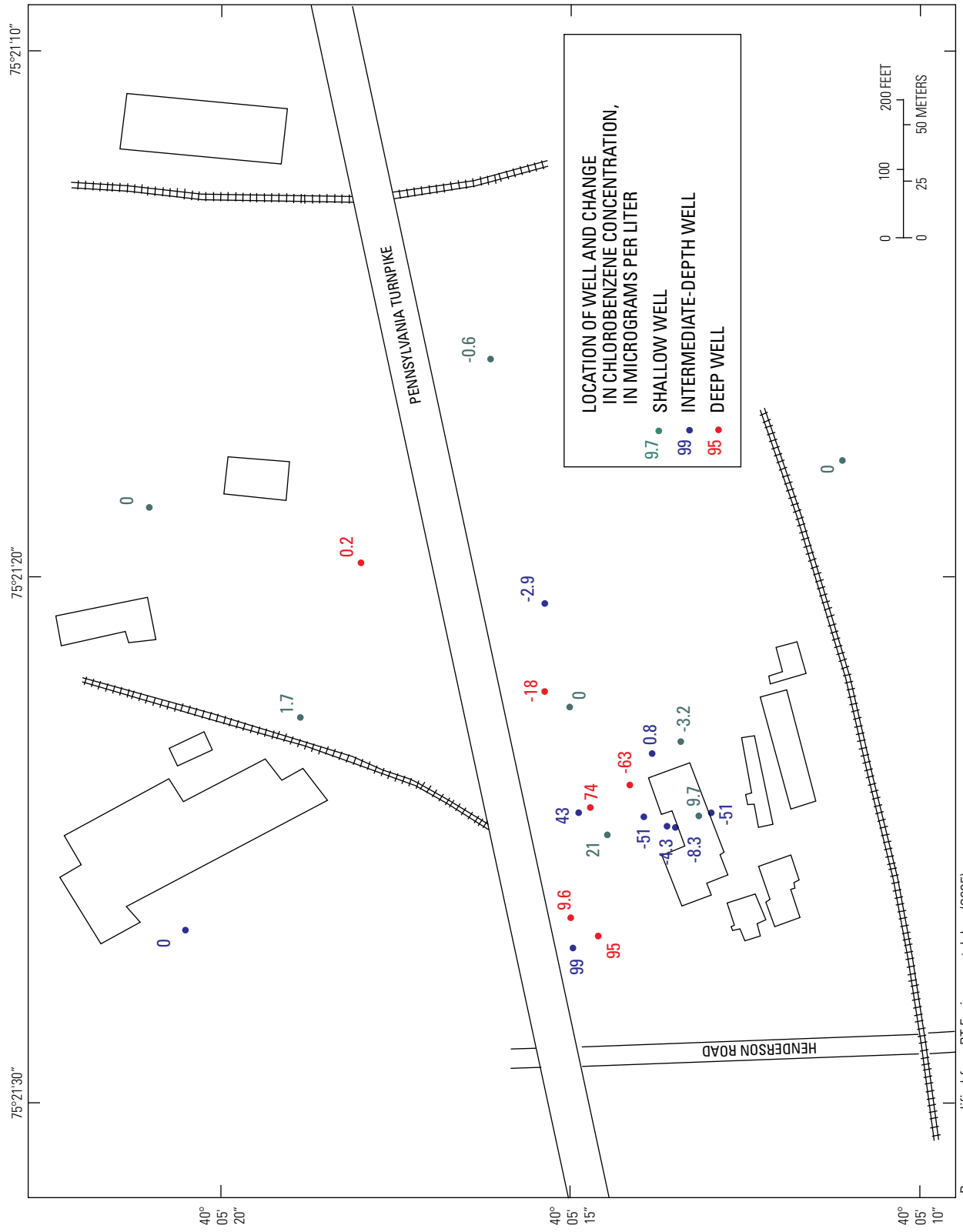
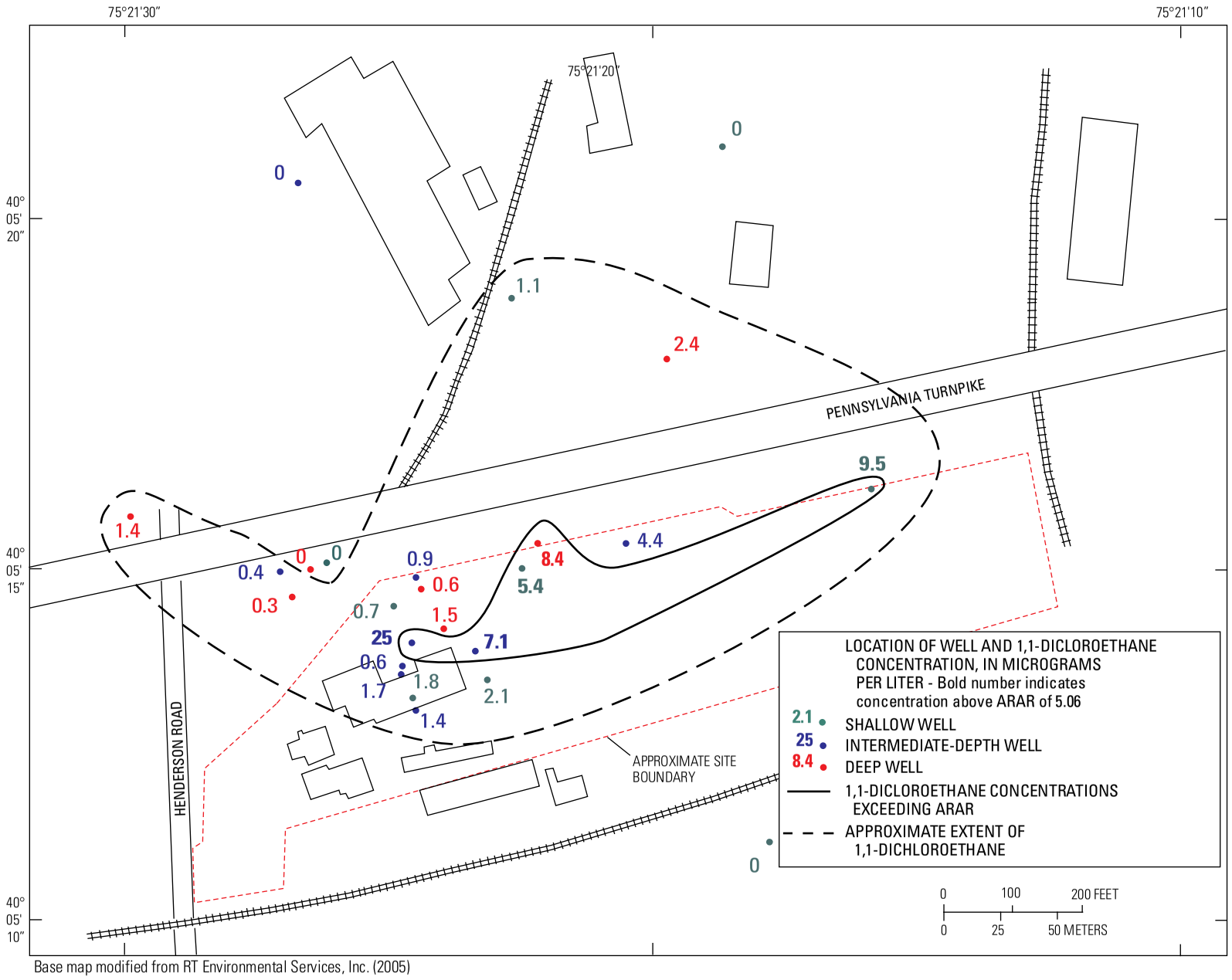


Figure 67. Change in chlorobenzene concentration measured between July 2006 and February 2008 in water samples from wells, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania. Data provided by RT Environmental Services, Inc.



Base map modified from RT Environmental Services, Inc. (2005)

Figure 68. Concentrations of 1,1-dichloroethane measured in water samples from wells, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, February and March 2008. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

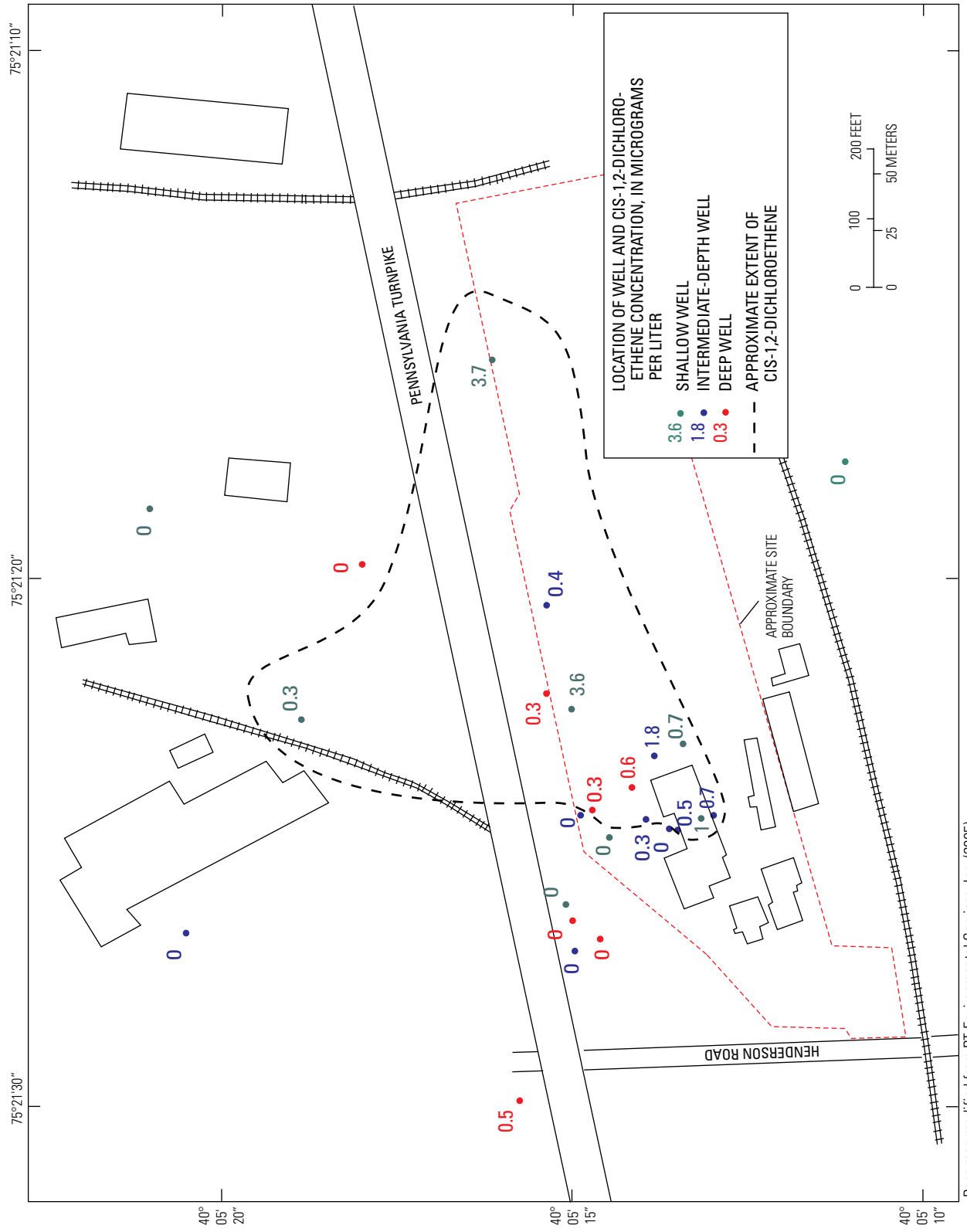


Figure 69. Concentrations of cis-1,2-dichloroethene measured in water samples from wells, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, February and March 2008. Data provided by RT Environmental Services, Inc.

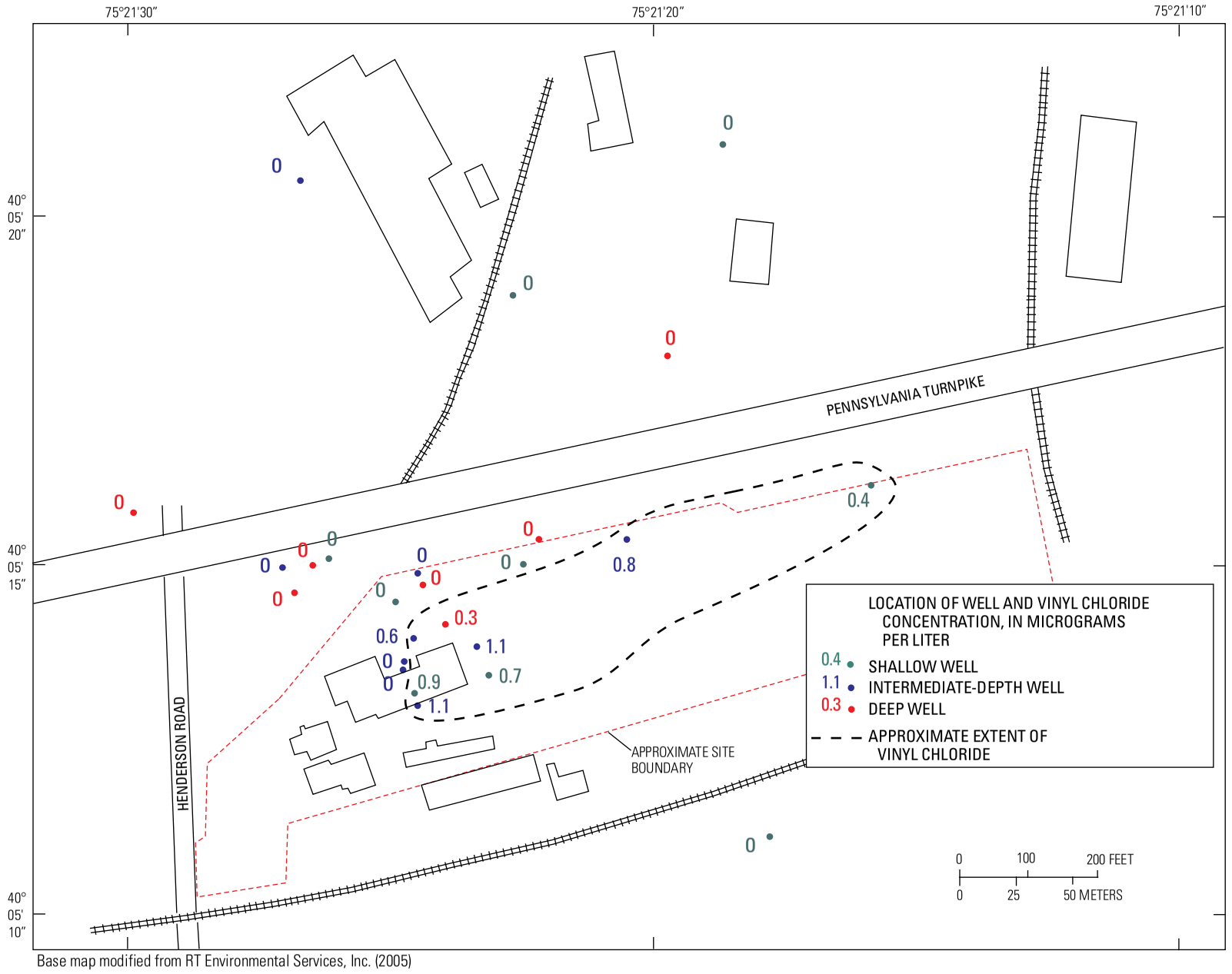


Figure 70. Concentrations of vinyl chloride measured in water samples from wells, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, February and March 2008. Data provided by RT Environmental Services, Inc.

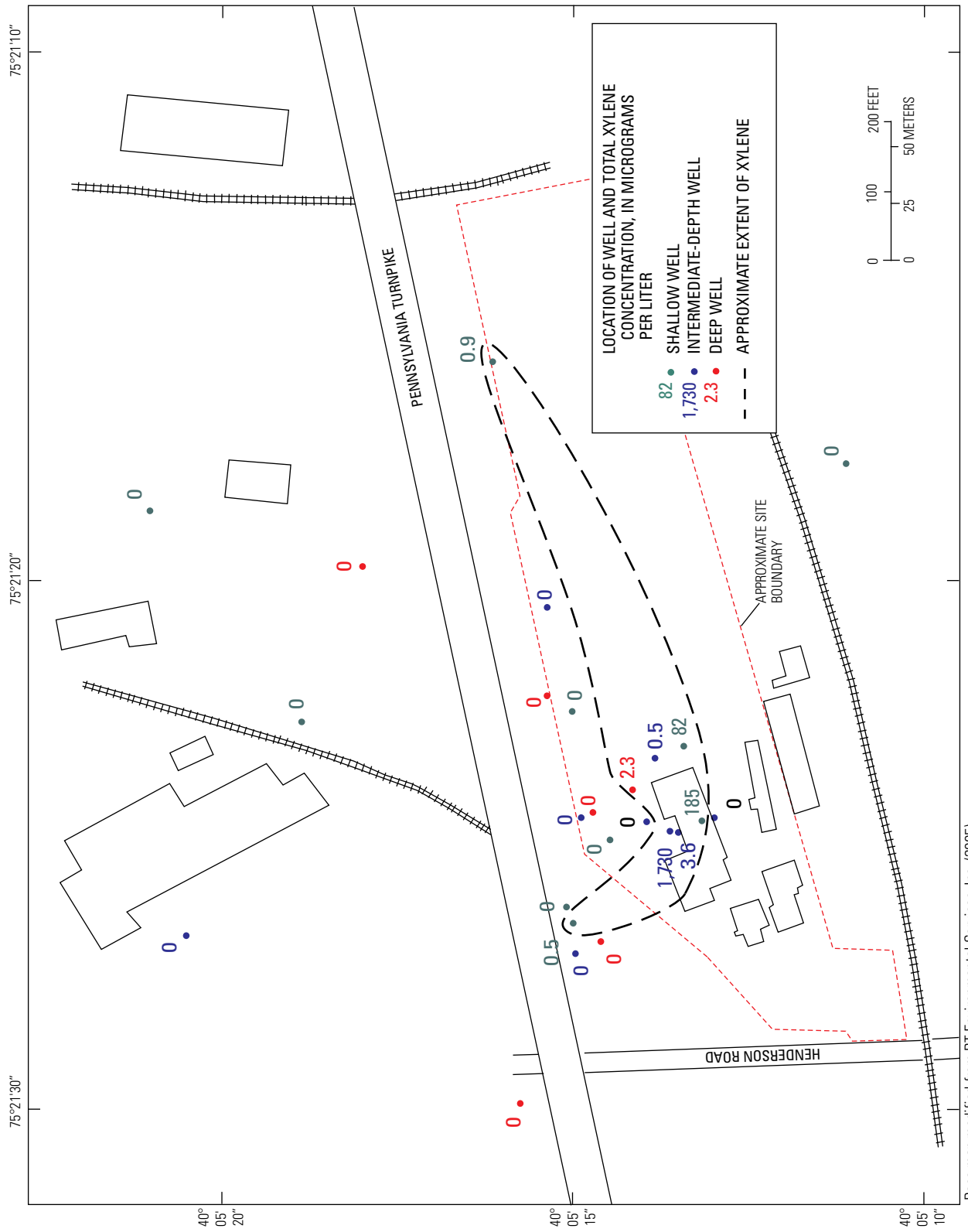


Figure 71. Concentrations of total xylene measured in water samples from wells, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, February and March 2008. Data provided by RT Environmental Services, Inc.

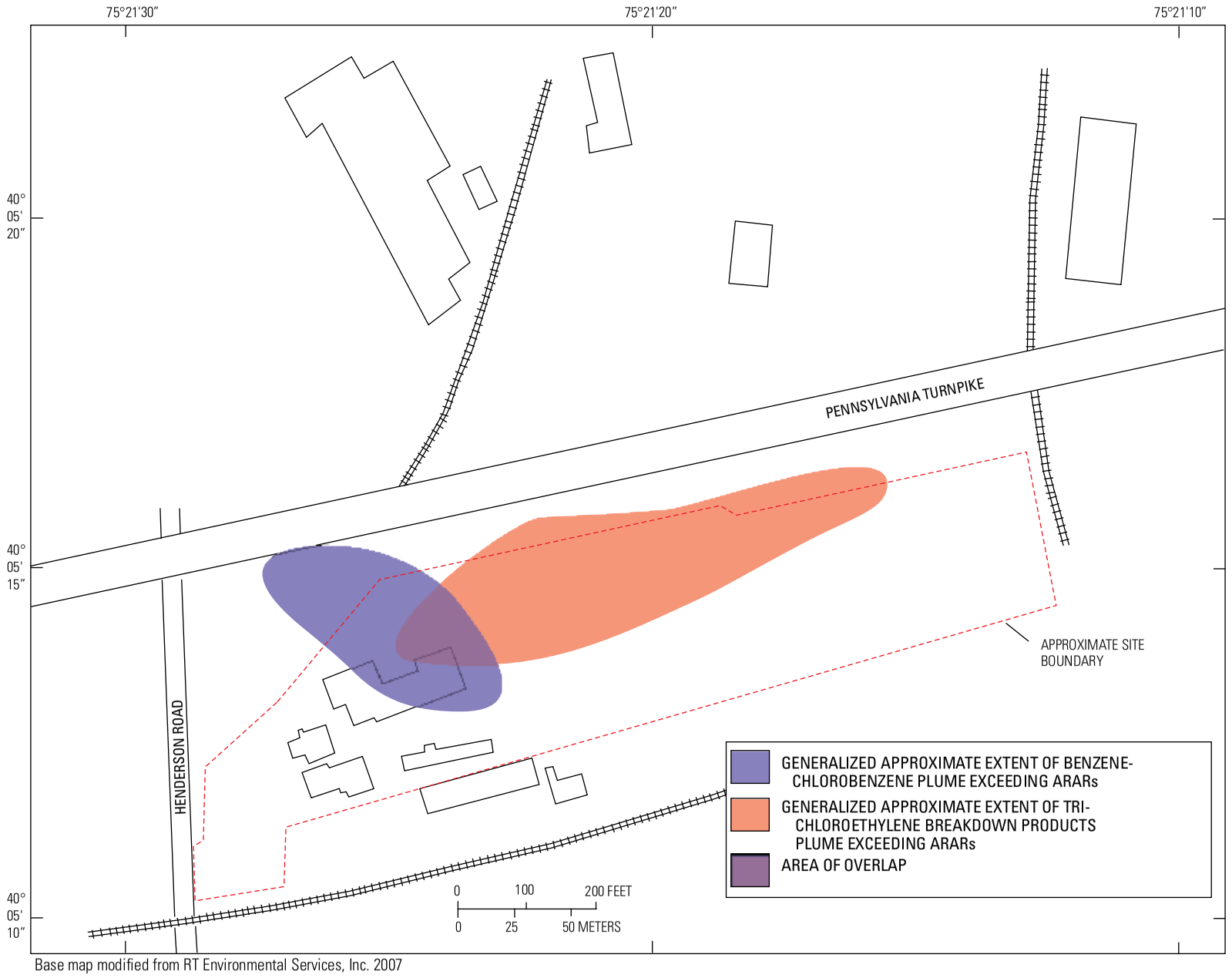


Figure 72. Generalized approximate extent of area exceeding ARARs, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, February and March 2008. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

Evaluation of Water-Level Data

Water-level data for the Henderson Road Site were provided by RT Environmental Services, Inc. for May 1997 through August 2008. The datum is a site benchmark at well HR-2-295, and water-level altitudes are referenced to that benchmark and reported in feet above mean sea level (see note on Conversion Factors page). Water-level data were evaluated temporally for 1997–2008 and spatially for June 16, 2003; July 10, 2006; and February 25–29, 2008. Water-level data for selected dates are given in table 6.

Water levels measured in Chester Valley were compared to water levels measured in USGS observation wells in Montgomery (well MG-917) and Bucks (well BK-1020) Counties (fig. 73). The USGS wells were plotted on figure 73 with an arbitrary datum; however, the range of fluctuation with respect to the Y-axis is correct. Water-level measurements made in the Upper Merion Reservoir on file at Aqua Pennsylvania, Inc. indicate that large drawdowns in the Upper Merion Reservoir occurred during droughts in 1998 and 2001. A long period of water-level recovery followed the drought of 2001. The hydrographs for the USGS observation wells do not show the same extended water-level recovery from drought as the water levels in the Chester Valley. For the drought of 2001, water levels in Chester Valley, except for McCoy Quarry monitor well MW-4 and well HR-17-170, show a protracted recovery from September 2001 until June 2005 (46 months). Water levels in wells MW-1 and MW-2 on the eastern side of the McCoy Quarry and water levels in wells at the Henderson Road Site, except for well HR-17-170, show the same extended recovery. This indicates the water level in the Upper Merion Reservoir affects water levels at the Henderson Road Site, except for well HR-17-170.

Temporal Changes in Water Levels

Water-level hydrographs for wells at the Henderson Road Site are presented for May 1997 through August 2008 (figs. 74–79). Not all wells were measured for each point in time. For most wells, only one water-level measurement was available between February 1, 2004, and July 10, 2006. A few wells had two water-level measurements during this 30-month period.

HR-3 Cluster Wells and HR-26-457

The HR-3 well cluster includes wells HR-3-255, HR-3-280, and HR-3-295. Well HR-26-457 is in close proximity to the HR-3 well cluster. Water levels in the HR-3 well cluster and well HR-26-457 reflect the regional rise in water levels during and after the June 2003 shutdown test (fig. 74). Water levels measured on June 16, 2003, prior to the start of the June 2003 shutdown test, were compared to water levels measured February 25–29, 2008; the water level in well HR-3-280 was 23.5 ft higher, the water level in well HR-3-295 was 23.76 ft higher, and the water level in well HR-26-457 was 27.95 ft higher in February 2008 than on June 16, 2003. In February 2008, the water level in well HR-3-295 was 1.88 ft lower than the water level in well HR-3-280 and 1.36 ft lower than the water level in well HR-26-457.

HR-4 Cluster Wells

The HR-4 well cluster includes wells HR-4-195, HR-4-242, and HR-4-295. Data were available for well HR-4-242 from December 29, 2003, to September 13, 2005, only. The water levels in wells HR-4-195 and HR-4-295 reflect the regional rise in water levels during and after the June 2003 shutdown test (fig. 75). Water levels measured on June 16, 2003, prior to the start of the 2003 shutdown test, were compared to water levels measured February 25–29, 2008; the water level in well HR-4-195 was 25.44 ft higher, and the water level in well HR-4-295 was 25.25 ft higher in February 2008 than on June 16, 2003. Water levels in wells HR-4-195 and HR-4-242 were within 0.3 ft of each other in February 2008; the water level in well HR-4-295 was about 2 ft lower.

HR-6 Cluster Wells and HR-24-476

The HR-6 well cluster includes wells HR-6-141, HR-6-241, and HR-6-377. Well HR-24-476 is in close proximity to the HR-6 well cluster. Few water-level data were available for wells HR-6-241 and HR-24-276. The water level in well HR-6-377 reflects the regional rise in water levels during and after the June 2003 shutdown test (fig. 76). The water level measured in well HR-6-377 on June 16, 2003, prior to the start of the 2003 shutdown test, was compared to the water level measured February 25–29, 2008; the water level was 24.27 ft higher in February 2008 than on June 16, 2003. In February 2008, the water level in well HR-6-141 was 1.81, 1.18, and 1.05 ft lower than the water levels in wells HR-6-241, HR-6-377, and HR-24-476, respectively.

HR-7 Cluster Wells

The HR-7 well cluster includes wells HR-7-163, HR-7-278, and HR-7-383. No data were available for well HR-7-383 prior to December 29, 2003. The water level in wells HR-7-163 and HR-7-278 reflect the regional rise in water levels during and after the June 2003 shutdown test (fig. 77). Water levels measured on June 16, 2003, prior to the start of the 2003 shutdown test, were compared to water levels measured February 25–29, 2008; the water level in well HR-7-163 was 23.66 ft higher, and the water level in well HR-7-278 was 24.09 ft higher in February 2008 than on June 16, 2003. In February 2008, the water level in well HR-7-383 was 2.09 ft lower than the water level in well HR-7-163 and 0.38 ft lower than the water level in well HR-7-278. The water levels indicate a downward hydraulic gradient at the HR-7 well cluster.

Table 6. Elevation of water level measured in wells at the Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, for selected dates 2003–08.

[—, no measurement]

Well-identification number	Date of water-level measurment						Change in water level between 6/16/03 and 2/27/08 (feet)
	6/16/03	12/9/03	12/29/03	7/10/06	2/27/08	8/20/08	
	Water level, in feet above mean sea level						
HR-1-260	—	—	—	—	53.41	—	—
HR-1-276	30.31	36.19	—	53.63	52.04	50.01	21.73
HR-1-280	—	—	—	—	51.88	—	—
HR-2-175	29.61	39.56	43.41	—	51.34	—	21.73
HR-2-195	—	—	—	—	51.54	50.08	—
HR-2-295	26.01	36.83	39.65	45.53	49.91	48.44	23.90
HR-3-255	25.17	37.12	19.96	46.72	—	—	—
HR-3-280	26.82	37.76	39.72	47.92	50.32	49.07	23.50
HR-3-295	24.68	36.28	25.91	48.19	48.44	47.01	23.76
HR-4-195	17.05	28.33	31.73	42.05	42.49	—	25.44
HR-4-242	—	—	26.50	—	42.79	—	—
HR-4-295	15.34	25.98	30.06	40.94	40.59	38.46	25.25
HR-5-195	-6.10	6.74	—	19.00	16.41	14.38	22.51
HR-6-141	—	—	—	—	47.01	45.32	—
HR-6-241	—	—	37.58	46.73	45.20	43.61	—
HR-6-377	22.11	34.40	35.22	47.43	46.38	44.86	24.27
HR-7-163	24.95	35.86	37.79	47.10	48.61	47.23	23.66
HR-7-278	22.00	32.66	35.66	47.73	46.09	44.59	24.09
HR-7-383	—	—	36.12	47.03	45.71	44.06	—
HR-9-191	22.80	33.29		48.50	48.35	47.04	25.55
HR-9-333	—	—	—	—	35.94	—	—
HR-10-280	—	—	—	—	35.29	—	—
HR-12-150	—	—	36.64		50.97	—	—
HR-12-300	20.93	33.25	36.30	48.10	49.25	48.26	28.32
HR-13-147	28.43	37.43	34.40	48.37	50.03	48.91	21.60
HR-14-178	21.41	34.22	35.64	46.86	46.77	45.20	25.36
HR-14-376	21.49	30.94	35.84	47.07	46.42	44.92	24.93
HR-15-255	—	—	43.06	—	51.63	—	—
HR-17-170	27.20	26.33	—	28.30	28.09	27.81	.89
HR-18-190	—	—	—	—	48.69	46.23	—
HR-19-160	—	—	—	—	53.26	—	—
HR-20-155	—	—	—	—	56.12	54.77	—
HR-22-380	—	—	—	—	17.77	15.65	—
HR-23-350	—	—	—	—	34.27	32.56	—
HR-24-476	—	—	—	—	46.25	44.89	—
HR-25-325	—	—	—	—	50.18	47.14	—
HR-26-457	21.85	35.69	33.17	—	49.80	48.34	27.95
HR-30-318	—	—	—	—	36.55	34.99	—

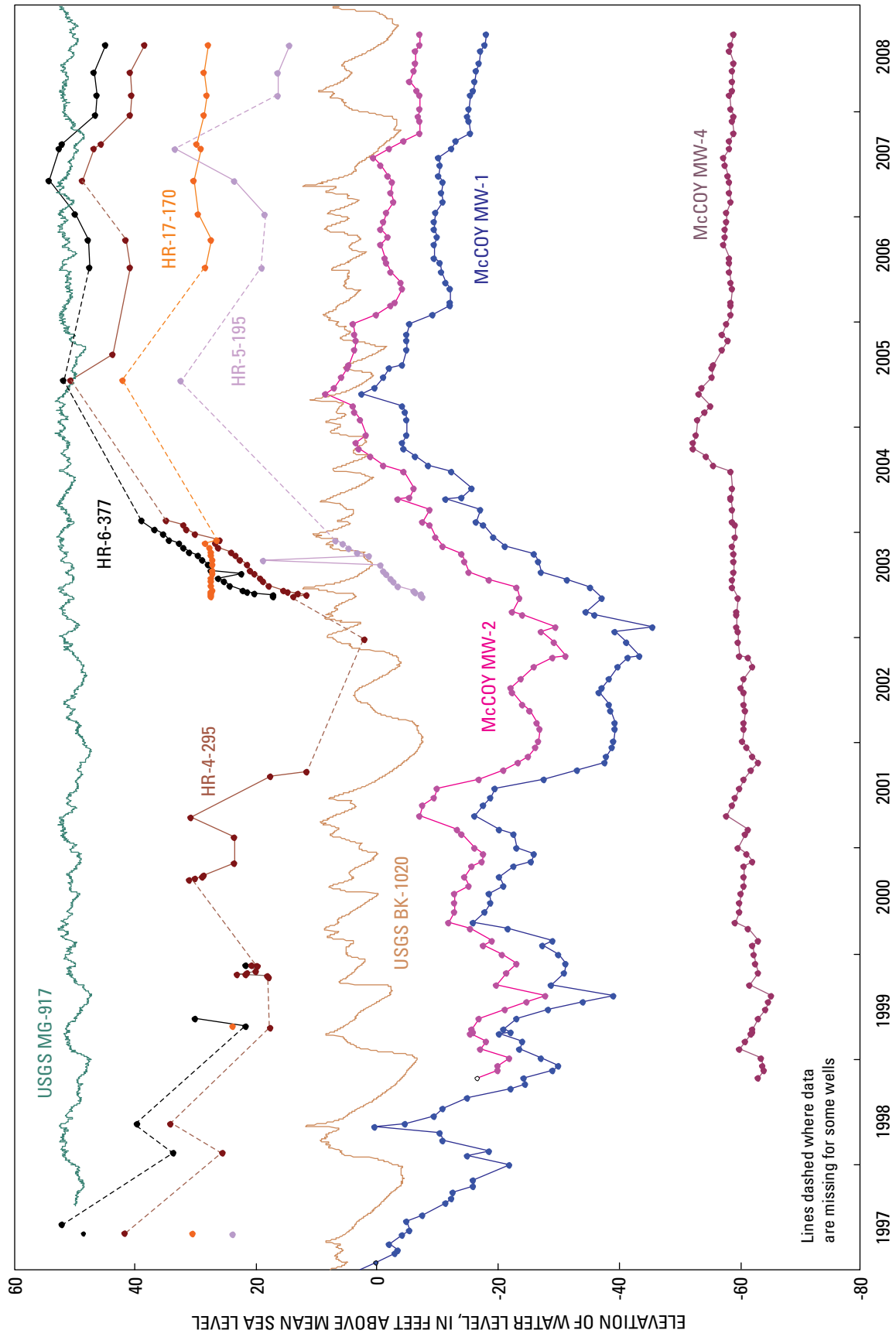


Figure 73. Water levels measured in wells HR-4-295, HR-6-377, and HR-17-170 at the Henderson Road Site; wells MW-1, MW-2, and MW-4 at the McCoy Quarry; and U.S. Geological Survey observation wells BK-1020 and MG-917, 1996–2008. Data provided by RT Environmental Services, Inc., and Glasgow, Inc.

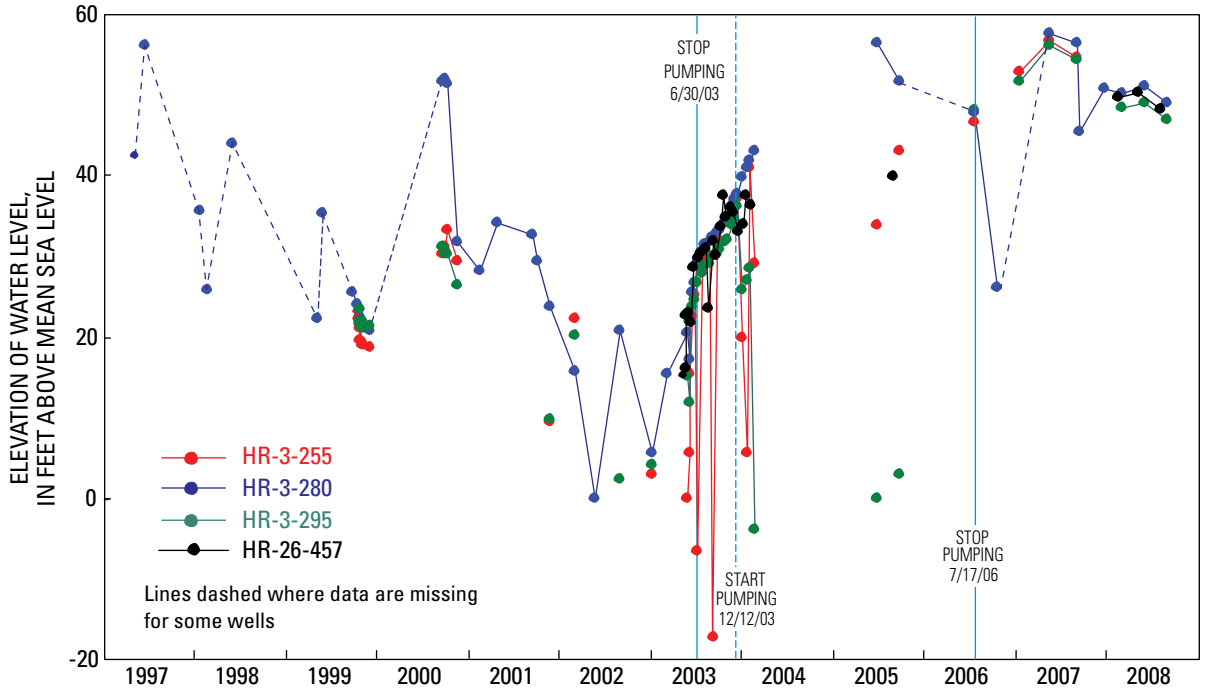


Figure 74. Elevation of water levels measured in wells HR-3-255, HR-3-280, and HR-3-295, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1997–2008. Data provided by RT Environmental Services, Inc.

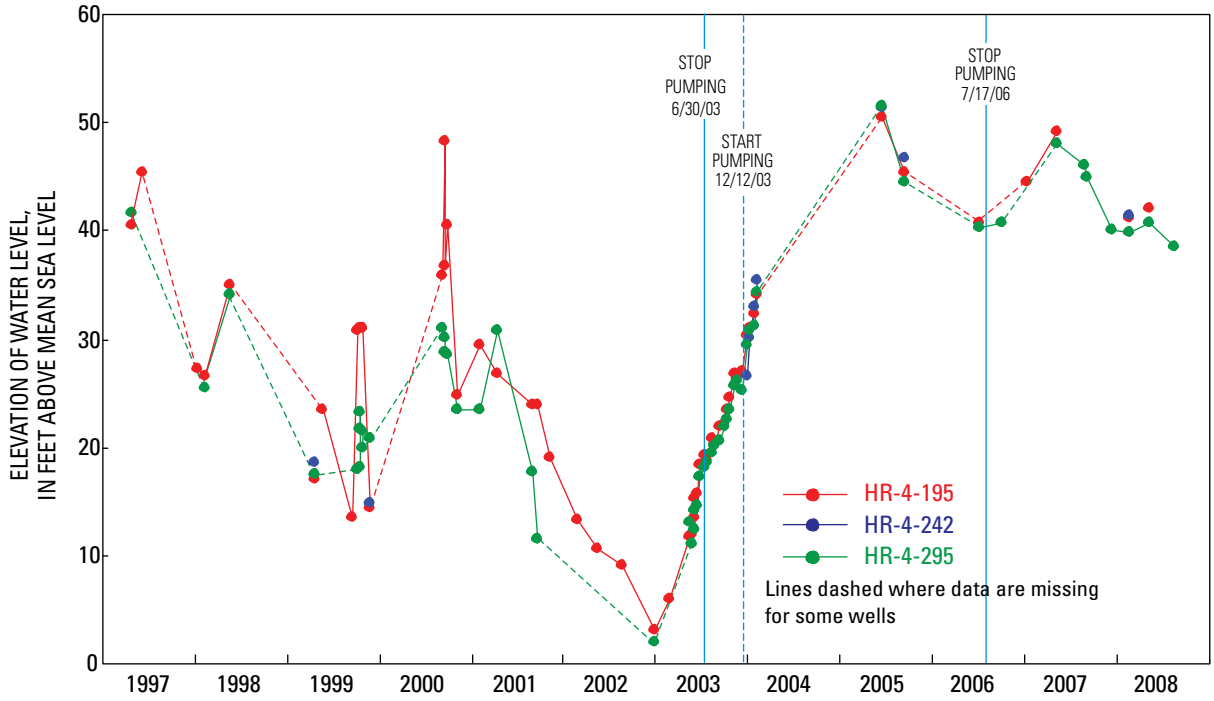


Figure 75. Elevation of water levels measured in wells HR-4-195, HR-4-242, and HR-4-295, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1997–2008. Data provided by RT Environmental Services, Inc.

Figure 76. Elevation of water levels measured in wells HR-6-141, HR-6-241, HR-6-377, and HR-24-276, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1997–2008. Data provided by RT Environmental Services, Inc.

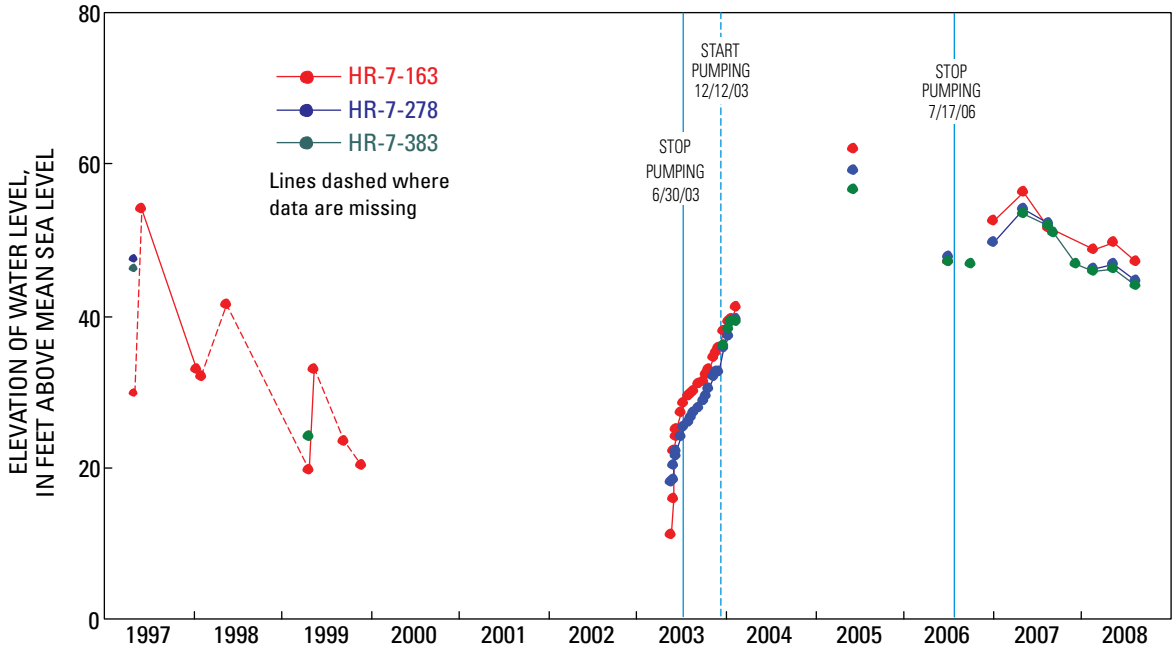


Figure 77. Elevation of water levels measured in wells HR-7-163, HR-7-278, and HR-7-383, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1997–08. Data provided by RT Environmental Services, Inc.

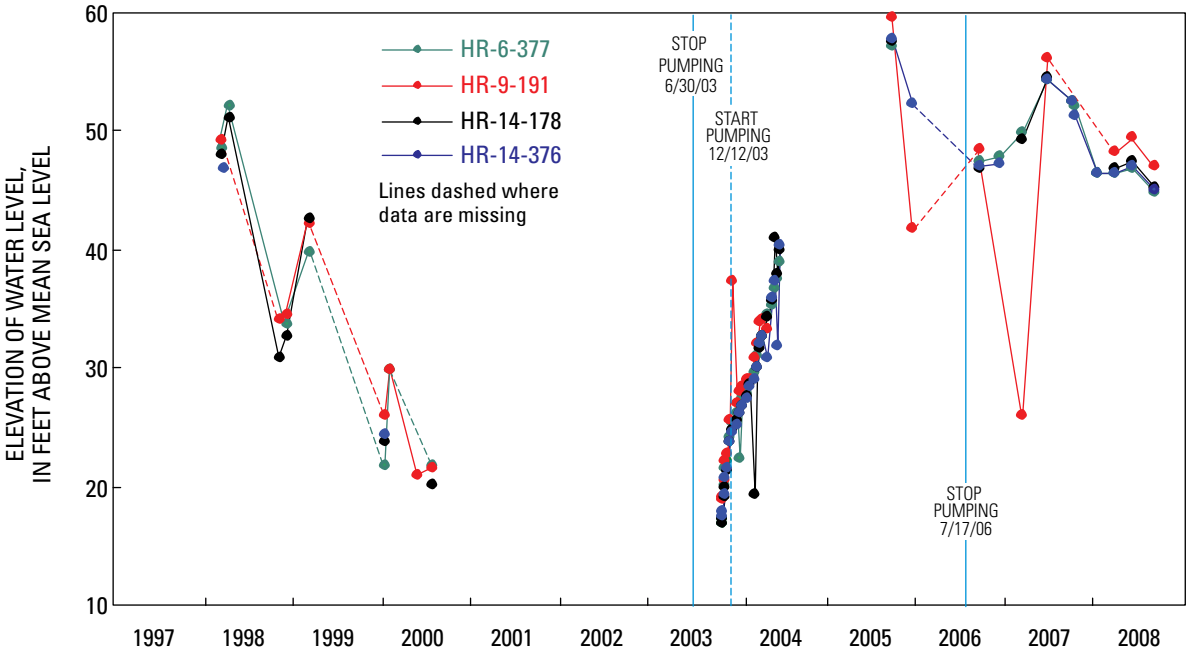


Figure 78. Elevation of water levels measured in wells HR-6-377, HR-9-191, HR-14-178, and HR-14-378, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1997–2008. Data provided by RT Environmental Services, Inc.

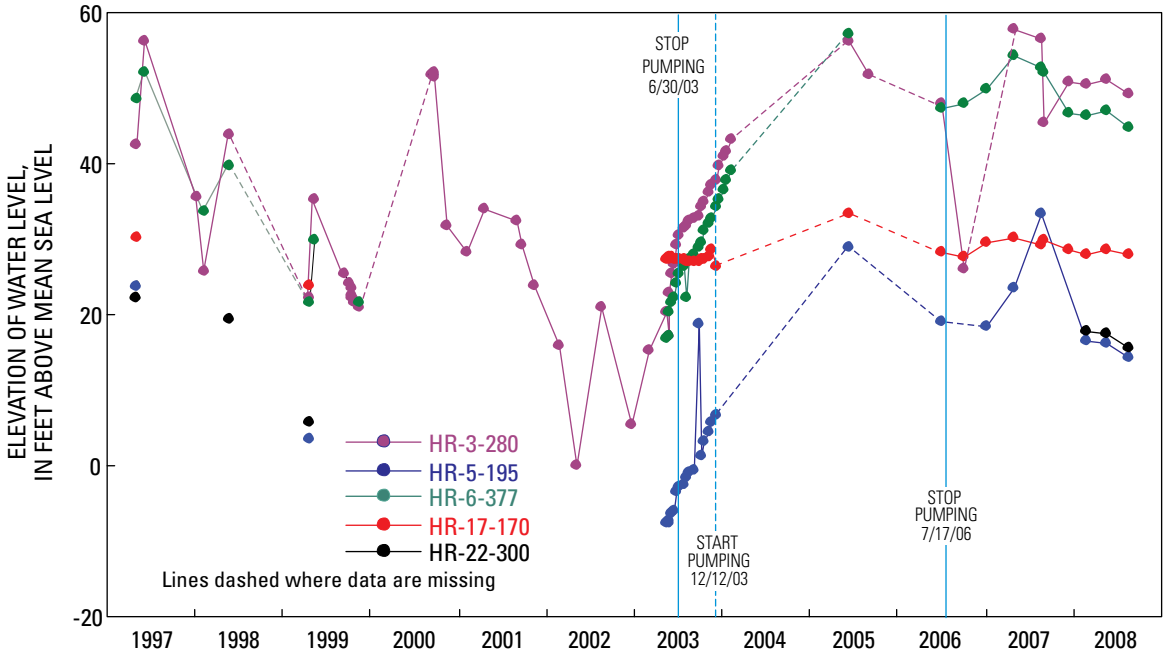


Figure 79. Elevation of water levels measured in wells HR-3-280, HR-5-195, HR-6-377, HR-17-170, and HR-22-380, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1997–2008. Data provided by RT Environmental Services, Inc.

Other On-Site Wells

Sufficient data were available to plot hydrographs for wells HR-9-191, HR-14-178, and HR-14-376 (fig. 78). The hydrograph for well HR-6-377 is shown on figure 78 for comparison. The water level in wells HR-9-191, HR-14-178, and HR-14-376 reflect the regional recovery in water levels during and after the June 2003 shutdown test (fig. 78). Water levels measured on June 16, 2003, prior to the start of the 2003 shutdown test, were compared to water levels measured February 25–29, 2008; the water level in well HR-9-191 was 25.55 ft higher, the water level in well HR-14-178 was 25.36 ft higher, and the water level in well HR-14-376 was 24.93 ft higher in February 2008 than on June 16, 2003.

Off-Site Wells

Few water-level data were available for off-site wells HR-10-180, HR-11-133, HR-19-160, HR-22-300, and HR-23-350. Hydrographs for wells HR-5-195 and HR-17-170 and six available measurements for well HR-22-300 are shown on figure 79. The hydrograph for well HR-6-377 is shown on figure 79 for comparison. Water levels measured in well HR-17-170 did not show the regional recovery from 2001 to 2005 that was shown by the water levels in all other wells at the Henderson Road site (figs. 73–79). Water levels measured on June 16, 2003, prior to the start of the 2003 shutdown test, were compared to water levels measured February 25–29, 2008; the water level in well HR-17-170 was 0.89 ft higher in February 2008 than on June 16, 2003. The water-level fluctuations are similar to that of the McCoy Quarry monitor well MW-4 (fig. 73), which is on the southeastern side of the quarry (fig. 1) and does not appear to be influenced by the water level in the Upper Merion Reservoir. It is unlikely that well HR-17-170 is affected by the Upper Merion Reservoir or pumping at the Henderson Road Site.

Water levels in well HR-5-195 are much lower than water levels measured in other shallow wells; however, the water levels are similar to those measured in nearby deep well HR-22-300 (fig. 79). During drilling of well HR-5-195, 179 ft of clay was encountered overlying fractured bedrock. Well HR-5-195 may be hydraulically connected to a deeper flow system. Water levels measured in well HR-5-195 reflect the regional recovery in water levels, and the hydrograph from well HR-5-195 is similar to hydrographs from other Henderson Road Site wells. Water levels measured on June 16, 2003, prior to the start of the 2003 shutdown test, were compared to water levels measured February 25–29, 2008; the water level in well HR-5-195 was 22.51 ft higher in February 2008 than on June 16, 2003.

Potentiometric Surface

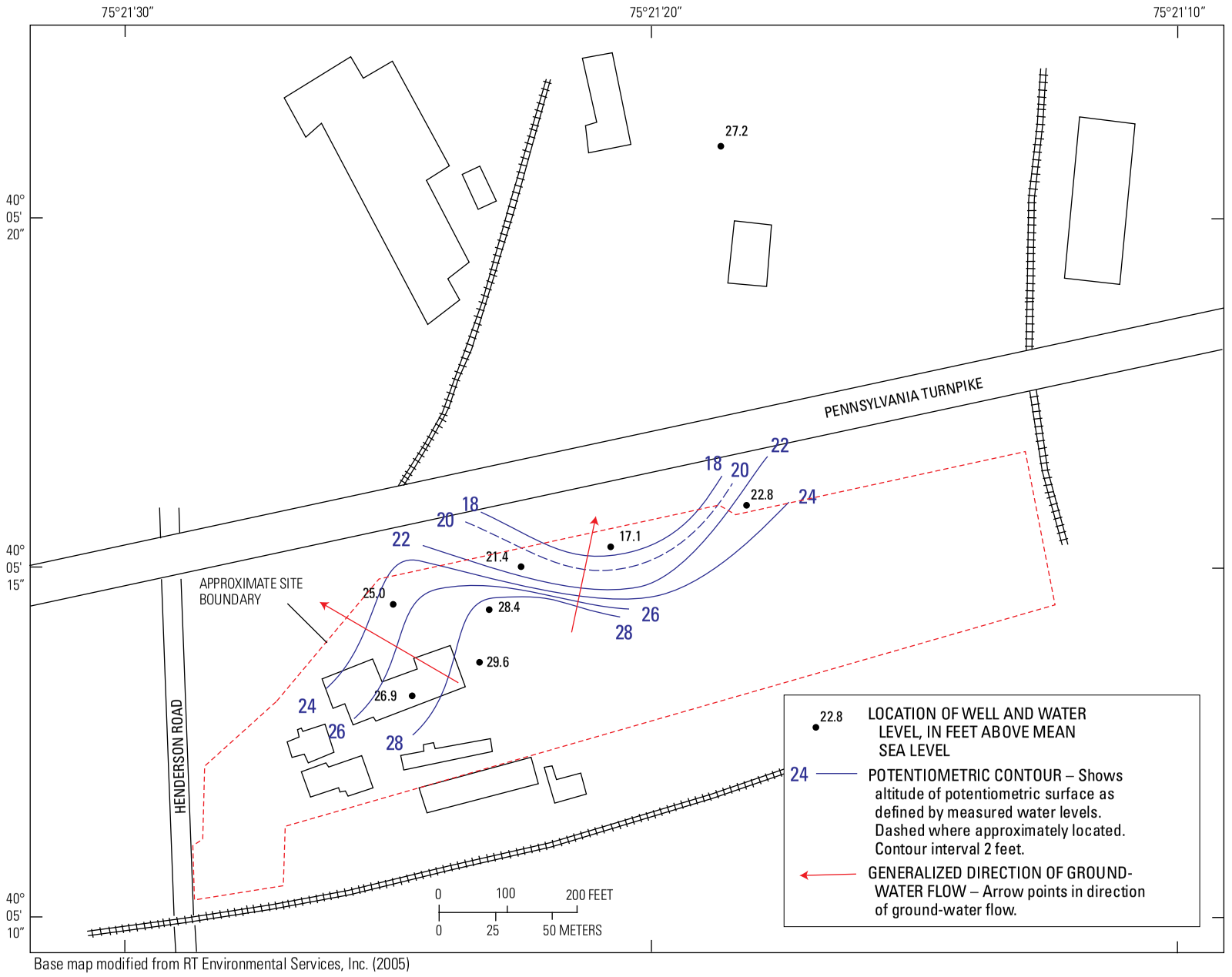
The potentiometric surface was contoured for (1) June 16, 2003, when the extraction wells were pumping at the full rate prior to the start of the June 2003 shutdown; (2) July 10, 2006, when the extraction wells were pumping at the reduced rate prior to the start of the July 2006 shutdown; and (3) February 25–29, 2008, during the 2006–08 shutdown test when the extraction wells were not pumping. Water levels in most wells on the site were measured during February 25–29, 2008. Except for well HR-5-195, wells were divided into shallow wells (less than 200 ft deep), intermediate-depth wells (200–299 ft deep), and deep wells (greater than 299 ft deep) following the designations used by RT Environmental Services, Inc. (2004). Because the water level in well HR-5-195 is much deeper than water levels in other shallow wells and is similar to water levels in deep well HR-22-300, well HR-5-195 was grouped with the deep wells.

June 16, 2003 (Full-Pumping Rate)

The potentiometric surface was contoured for shallow wells (fig. 80), intermediate-depth wells (fig. 81), and deep wells (fig. 82) for June 16, 2003. The extraction wells were pumping at the former full-pumping rate. The potentiometric surface for shallow wells (fig. 80) does not appear to be affected by extraction-well pumping. The ground-water-flow direction was to the northeast and northwest. The potentiometric surface for intermediate-depth wells (fig. 81) shows a cone of depression caused by extraction-well pumping. The ground-water-flow direction was from the southwest toward the pumping wells and toward the northeast away from the pumping wells. Data for only four deep on-site wells were available. The available water-level data for the deep wells (fig. 82) show a flat gradient. The ground-water-flow direction was to the Henderson Road Site from the northwest.

July 10, 2006 (Reduced-Pumping Rate)

The potentiometric surface was contoured for shallow wells (fig. 83), intermediate-depth wells (fig. 84), and deep wells (fig. 85) for July 10, 2006. The recovery wells were pumping at the reduced rate. Water levels were measured prior to cessation of pumping for the 2006–08 shutdown test. Water levels are about 25 ft higher than those measured on June 16, 2003. The potentiometric surface for shallow wells (fig. 83) does not appear to be affected by extraction-well pumping. The ground-water-flow direction was to the northeast. The pattern generally is similar to that when the extraction wells were pumping at the full rate (fig. 80). The potentiometric surface for intermediate-depth wells (fig. 84) does not show a cone of depression caused by extraction-well pumping as it did when the extraction wells were pumping at the full rate (fig. 81). The ground-water-flow direction was from the south-southwest toward the pumping wells and toward the northeast away from the pumping wells, similar to that when the extraction wells were pumping at the full rate. Data for only four deep on-site wells were available. The available water-level data for the deep wells (fig. 85) show a flat gradient. The ground-water-flow direction was to the northwest; this is the reverse of the flow direction when the extraction wells were pumping at the full rate.



Base map modified from RT Environmental Services, Inc. (2005)

Figure 80. Elevation of water levels measured in shallow wells (less than 200 feet deep) at the Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, June 16, 2003 (full-pumping rate). Data provided by RT Environmental Services, Inc.

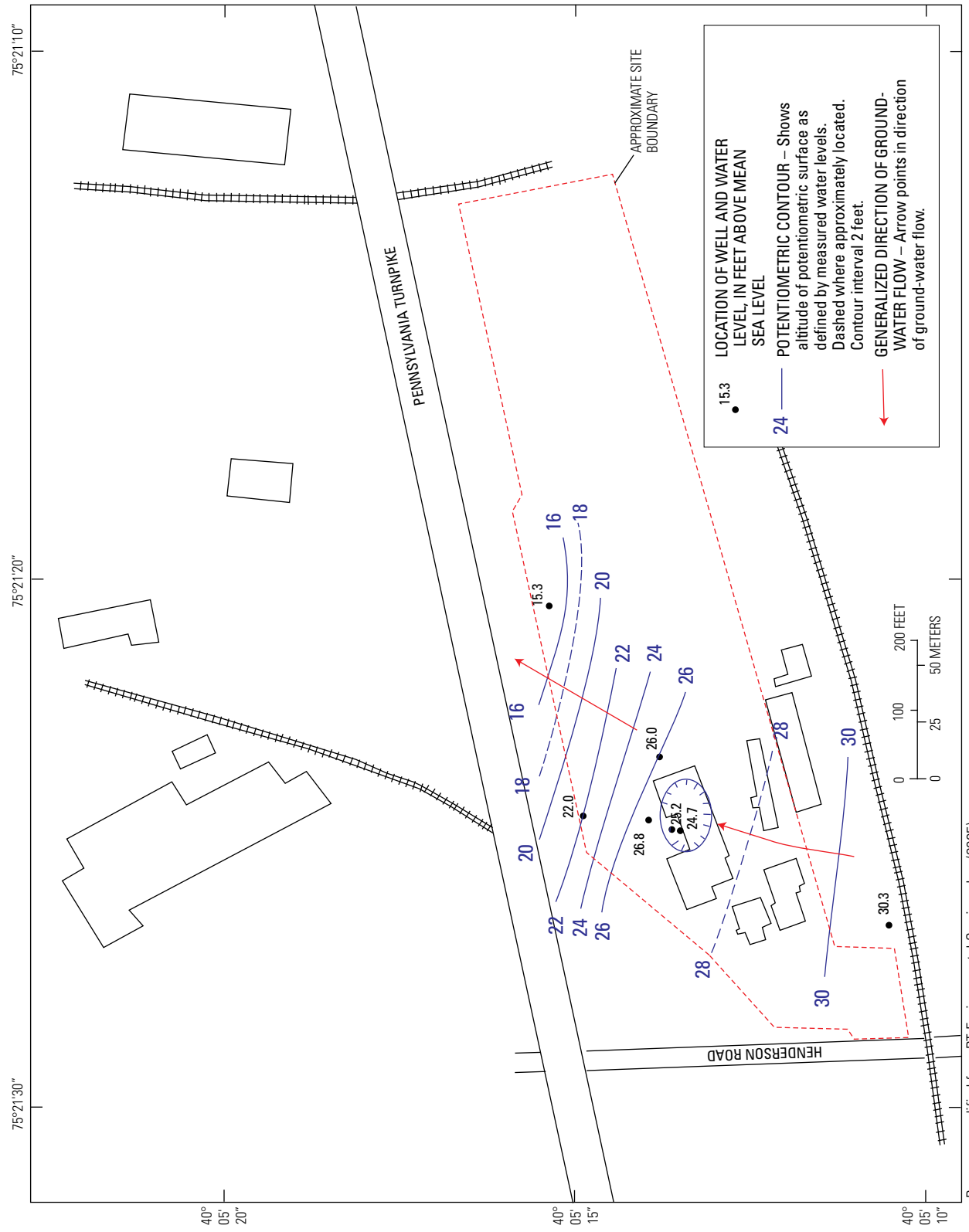


Figure 81. Elevation of water levels measured in intermediate depth wells (200 to 299 feet deep) at the Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, June 16, 2003 (full-pumping rate). Data provided by RT Environmental Services, Inc.

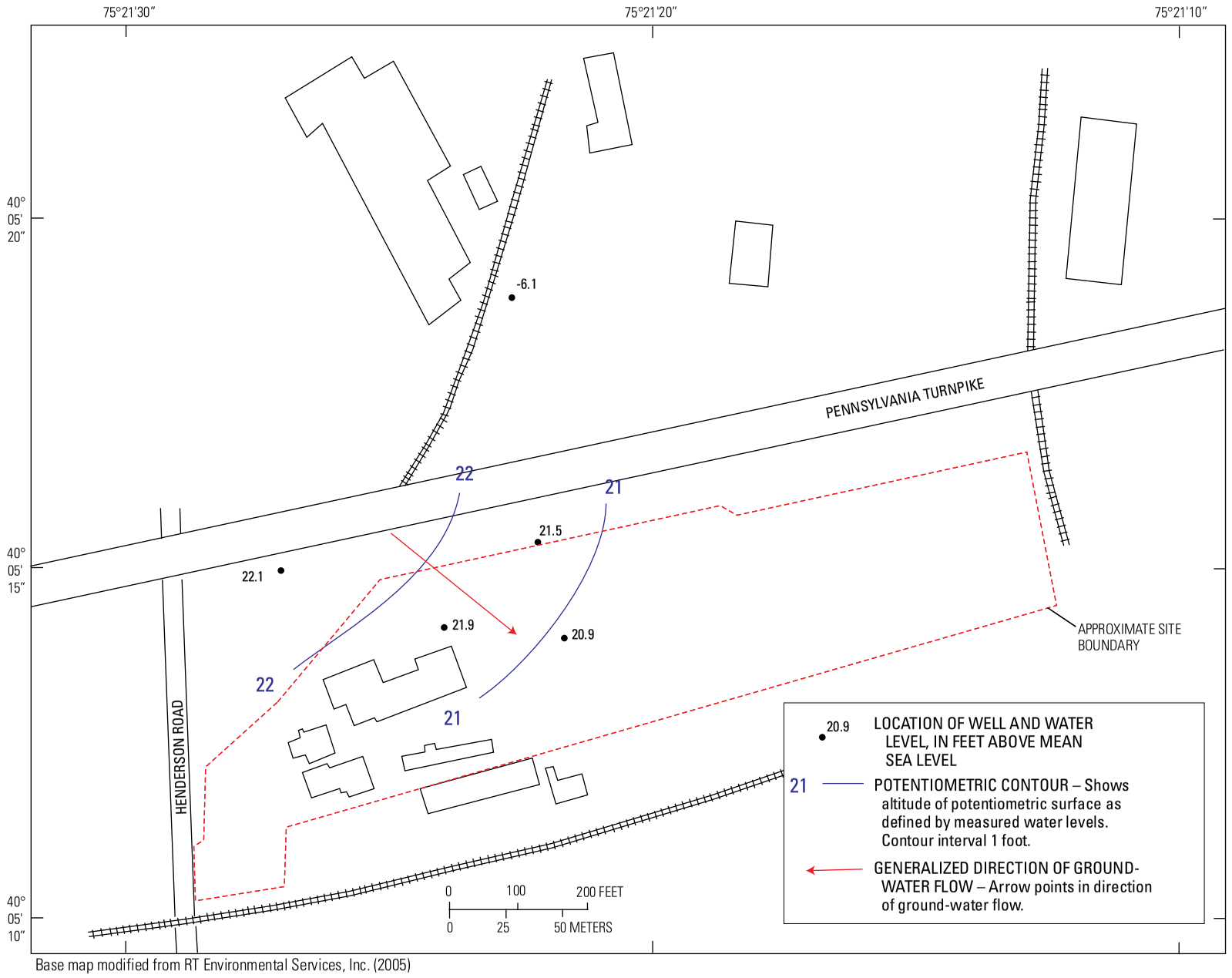


Figure 82. Elevation of water levels measured in deep wells (greater than 299 feet deep) at the Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, June 16, 2003 (full-pumping rate). Data provided by RT Environmental Services, Inc.

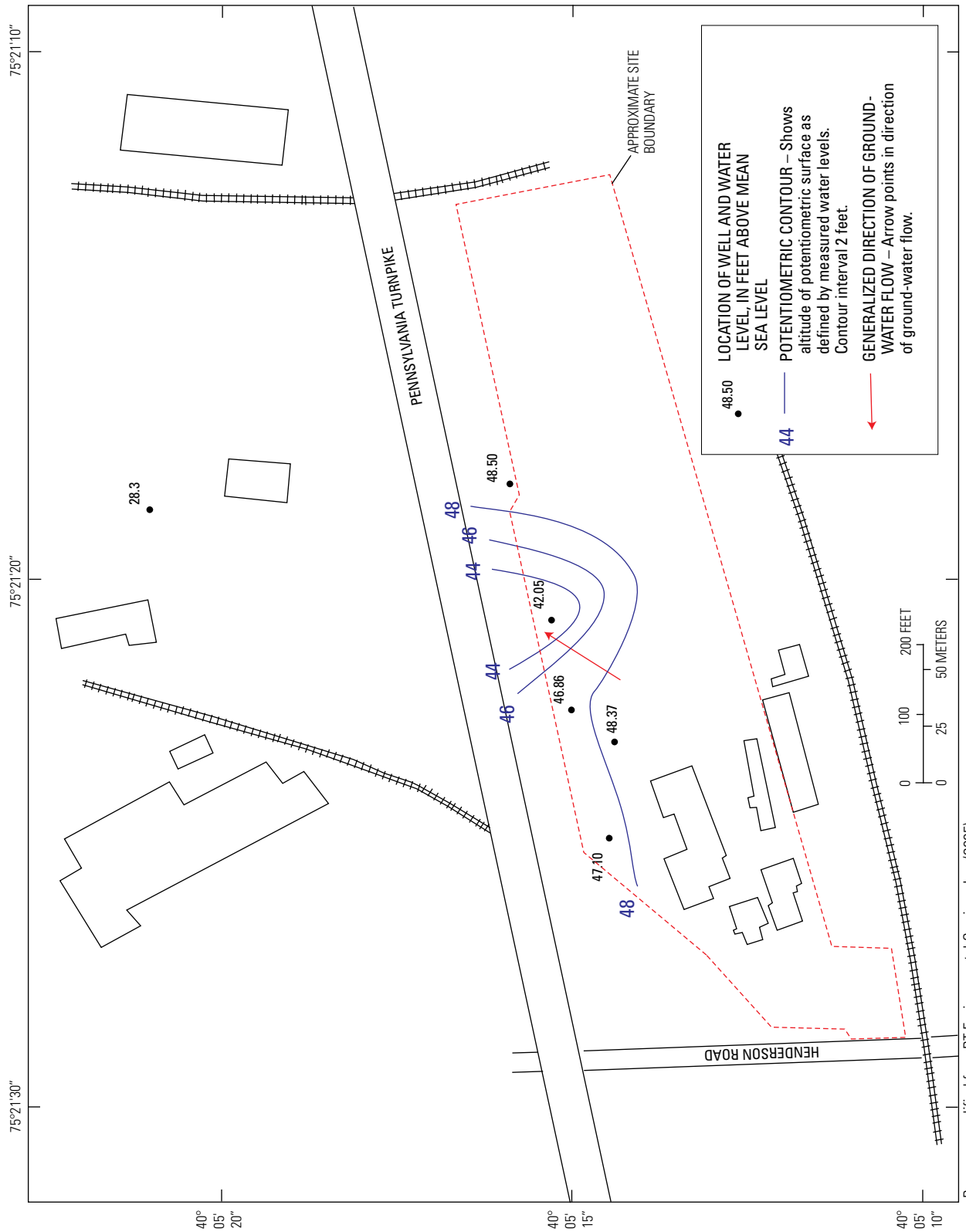
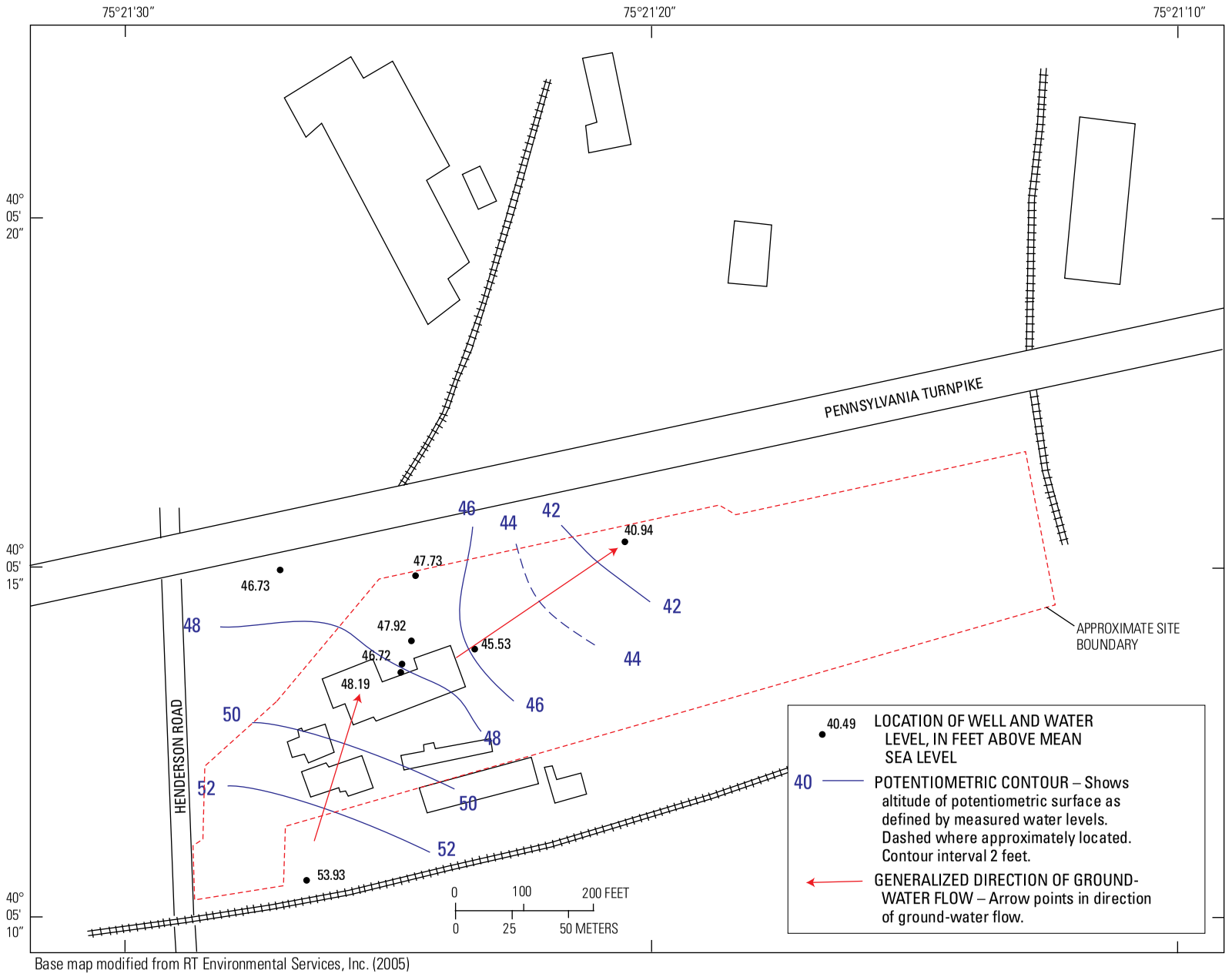
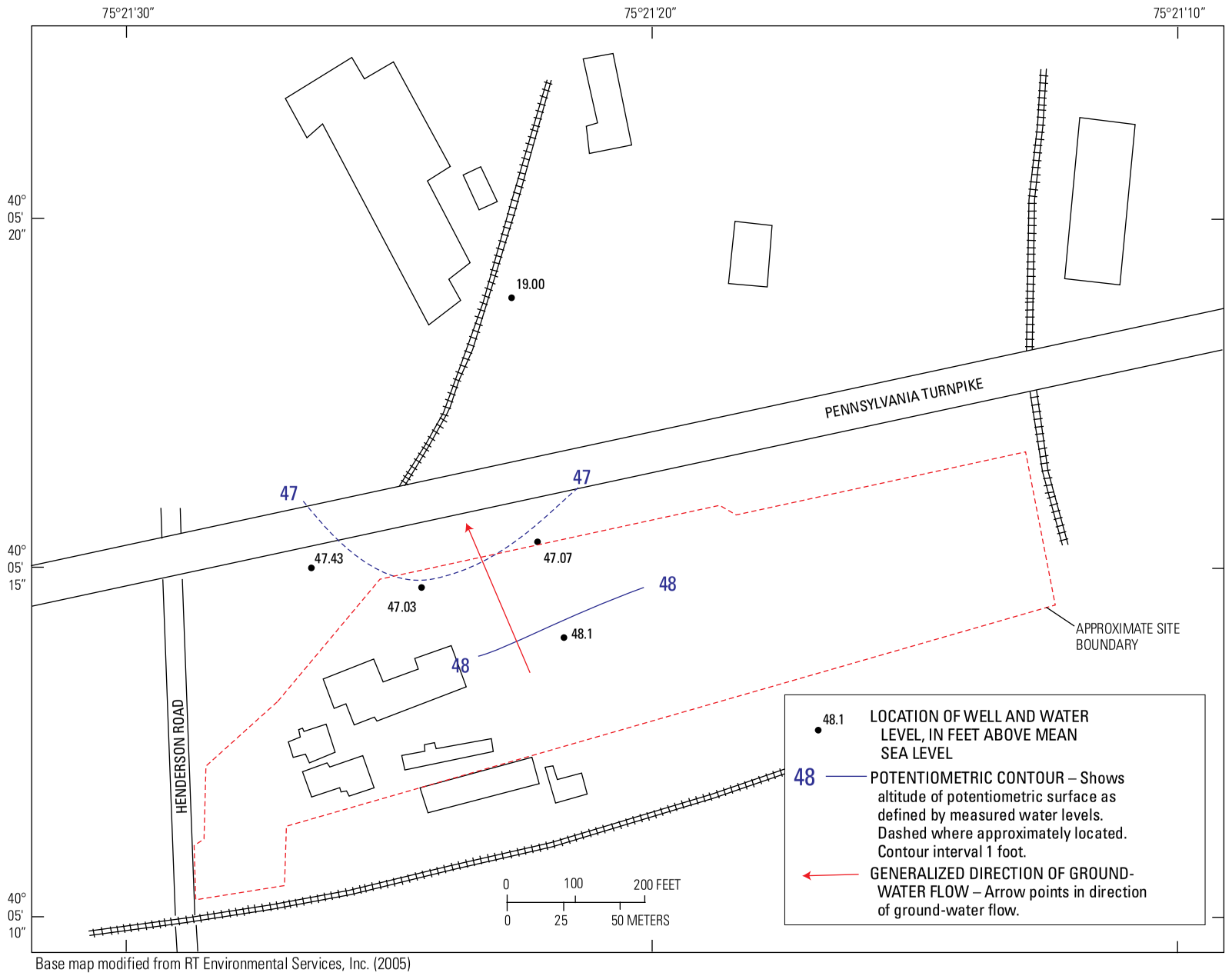


Figure 83. Elevation of water levels measured in shallow wells (less than 200 feet deep) at the Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, July 10, 2006 (reduced-pumping rate). Data provided by RT Environmental Services, Inc.



Base map modified from RT Environmental Services, Inc. (2005)

Figure 84. Elevation of water levels measured in intermediate depth wells (200 to 299 feet deep) at the Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, July 10, 2006 (reduced-pumping rate). Data provided by RT Environmental Services, Inc.



Base map modified from RT Environmental Services, Inc. (2005)

Figure 85. Elevation of water levels measured in deep wells (greater than 299 feet deep) at the Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, July 10, 2006 (reduced-pumping rate). Data provided by RT Environmental Services, Inc.

February 25–29, 2008 (No Pumping)

The potentiometric surface was contoured for shallow wells (fig. 86), intermediate-depth wells (fig. 87), and deep wells (fig. 88) for February 25–28, 2008. This time period was chosen because water levels were measured in most wells on the site. The extraction wells were not pumping. The potentiometric surface for shallow wells (fig. 86) shows that the ground-water-flow direction was toward the north-northeast. The flow direction generally is similar to that when the extraction wells were pumping. Water-level altitudes are similar to those when the extraction wells were pumping at the reduced rate and about 24 ft higher than those measured on June 16, 2003. The potentiometric surface for intermediate-depth wells (fig. 87) shows that the ground-water-flow direction was toward the north and northeast, similar to that when the extraction wells were pumping. Water-level altitudes are similar to those when the extraction wells were pumping at the reduced rate and about 24 ft higher than those measured on June 16, 2003. Data for 12 deep wells were available. The potentiometric surface for deep wells (fig. 88) shows that the ground-water-flow direction was toward the north and northeast; this is the reverse of the flow direction when the extraction wells were pumping at the full rate (fig. 82).

Movement of Contaminants

Ground-water flow at and in the vicinity of the Henderson Road Site is through open fractures (bedding planes and joints) and solution features in the carbonate bedrock. Ground-water flow is controlled by hydraulic gradients created by recharge and discharge points. Because of the fractured nature of the bedrock, ground-water flow is unlikely to be in a straight line but instead follows the direction of bedding and fractures as it moves down the hydraulic gradient. Discharge points in the area include natural discharge points, such as the Schuylkill River, and human-made discharge points, such as pumping wells and quarries where water is withdrawn for water supply and dewatering, respectively. Differences in permeability among geologic materials also control ground-water movement.

Off-site wells were drilled to monitor the possible off-site movement of chemicals of concern. Wells HR-23-350 and HR-30-318 were drilled on a northwest-trending fracture (the northwest fracture) identified by RT Environmental Services, Inc. (2005, p. 7). During drilling of well HR-30-318, 296 ft of clay and weathered rock were encountered before competent bedrock was reached. The thick clay in the vicinity of well HR-30-318 may prevent contaminant migration to the northwest. Well HR-5-195 penetrated 179 ft of clay before encountering competent bedrock. It is possible that a thick clay north of the turnpike restricts movement of contaminants to the north. Well HR-10-180 was drilled approximately 920 ft north-northwest of the injection well. Few water-level data were available for well HR-10-180, making it difficult to evaluate.

Off-site wells HR-22-300 and HR-17-170 were drilled on a northeast-trending fracture (the northeast fracture) identified by RT Environmental Services, Inc. (2005, p. 6). Well HR-5-195 appears to be drilled on a fracture that intersects the northeast fracture (RT Environmental Services, Inc., 2005, fig. 25). Water levels in well HR-5-195 are much lower than water levels measured in other shallow wells; however, the water levels are similar to those measured in nearby deep well HR-22-300. Well HR-5-195 may be hydraulically connected to a deeper flow system. Water levels measured in well HR-17-170 did not show the 2001–05 regional recovery shown by water levels in all other wells at the Henderson Road Site. The water-level fluctuations are similar to that of McCoy Quarry monitor well MW-4 (fig. 73), which is on the southeastern side of the quarry. It appears unlikely that well HR-17-170 is affected by the Upper Merion Reservoir or the Henderson Road Site. Few water levels were available for well HR-22-300, making it difficult to evaluate.

Benzene concentrations measured in water samples from shallow wells collected in February and March 2008 were above the ARAR only in the source area (fig. 89). The direction of ground-water flow in the shallow zone is to the north-northeast (fig. 89). Benzene concentrations measured in water samples from intermediate-depth wells collected in February and March 2008 were above the ARAR in the source area and outside the northern site boundary northwest of the source area (fig. 90). The direction of ground-water flow in the intermediate zone is to the north-northeast and northeast (fig. 90). Benzene concentrations measured in water samples from deep wells collected in February and March 2008 were above the ARAR in the source area, at the northern site boundary northeast of the source area, and outside the site boundary north of the source area (fig. 91). The direction of ground-water flow in the deep zone is to the north-northwest, north, and north-northeast (fig. 91). Benzene appears to have moved to the north from the source area in the intermediate and deep zones.

Chlorobenzene concentrations measured in water samples from shallow wells collected in February and March 2008 are above the ARAR outside the northern site boundary northwest of the source area (fig. 92). The direction of ground-water flow in the shallow zone is to the north-northeast (fig. 92). Chlorobenzene concentrations measured in water samples from intermediate-depth wells collected in February and March 2008 were above the ARAR in the source area and outside the northern site boundary northwest of the source area (fig. 93). The direction of ground-water flow in the intermediate zone is to the north-northeast and northeast (fig. 93). Chlorobenzene concentrations measured in water samples from deep wells collected in February and March 2008 were above the ARAR at and outside the northern site boundary north of the source area (fig. 94). The direction of ground-water flow in the deep zone is to the north-northwest, north, and north-northeast (fig. 94). Chlorobenzene appears to have moved to the north from the source area in the shallow, intermediate, and deep zones.

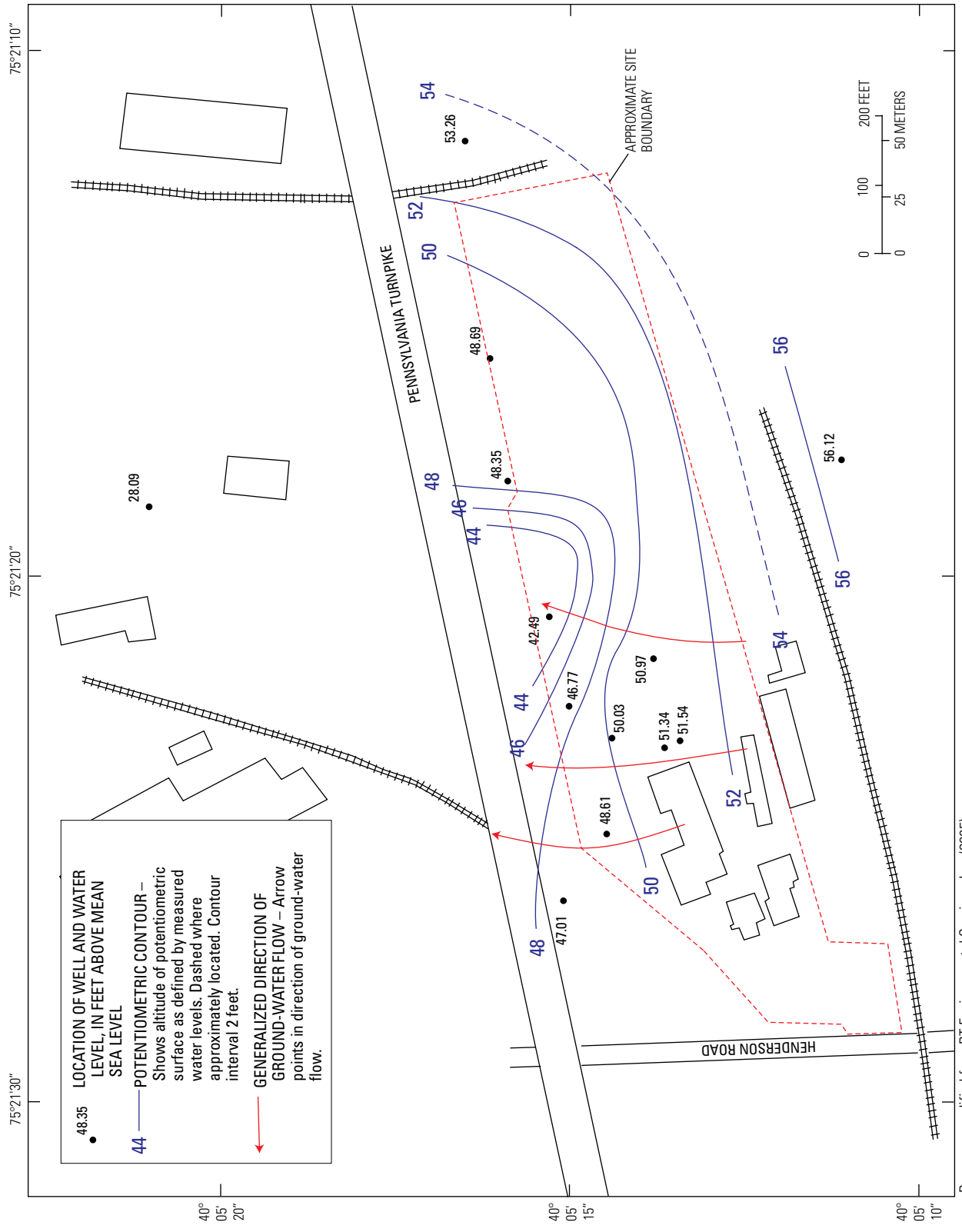
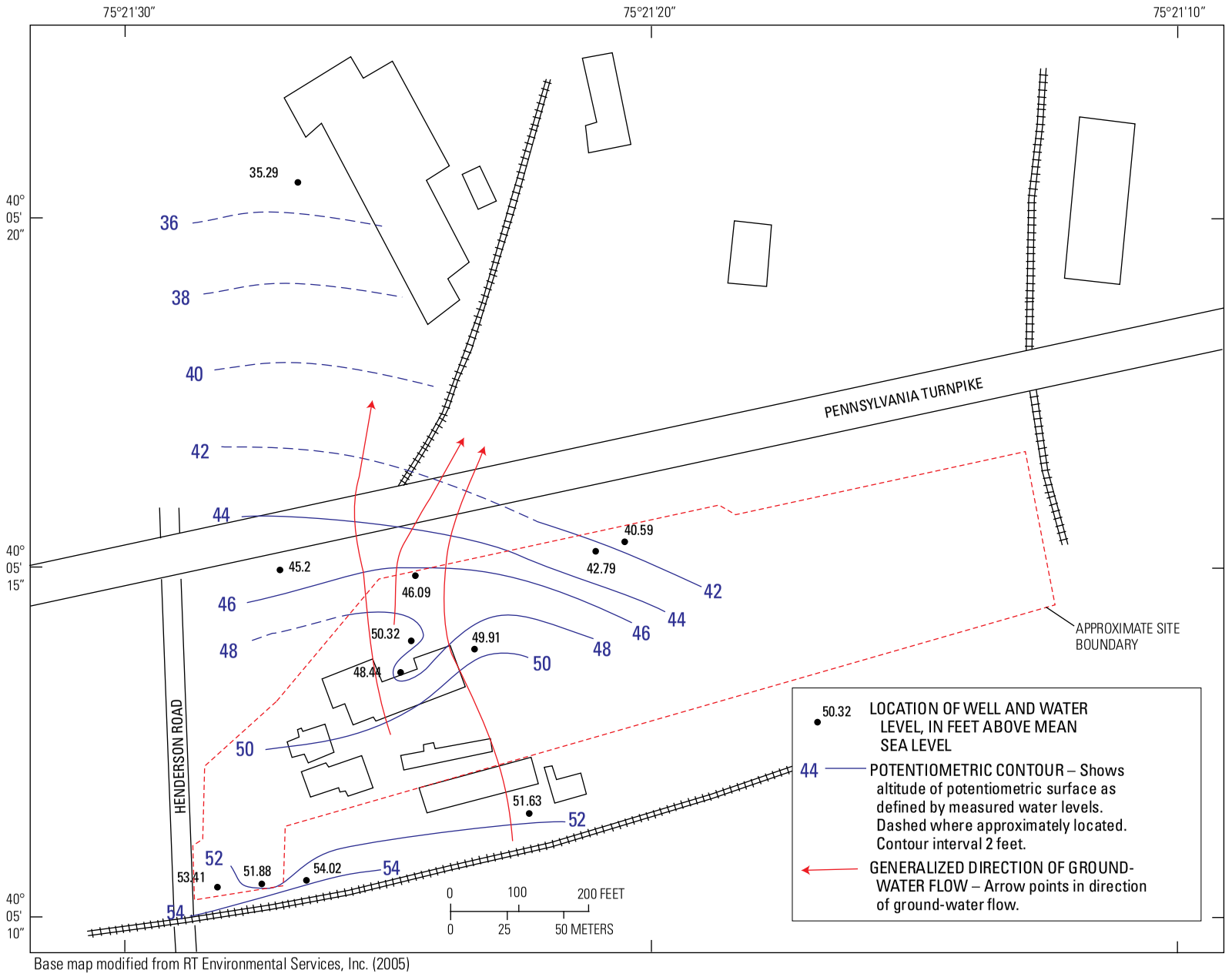


Figure 86. Elevation of water levels measured in shallow wells (less than 200 feet deep) at the Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, February 25–28, 2008 (no pumping). Data provided by RT Environmental Services, Inc.



Base map modified from RT Environmental Services, Inc. (2005)

Figure 87. Elevation of water levels measured in intermediate depth wells (200 to 299 feet deep) at the Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, February 25–28, 2008 (no pumping). Data provided by RT Environmental Services, Inc.

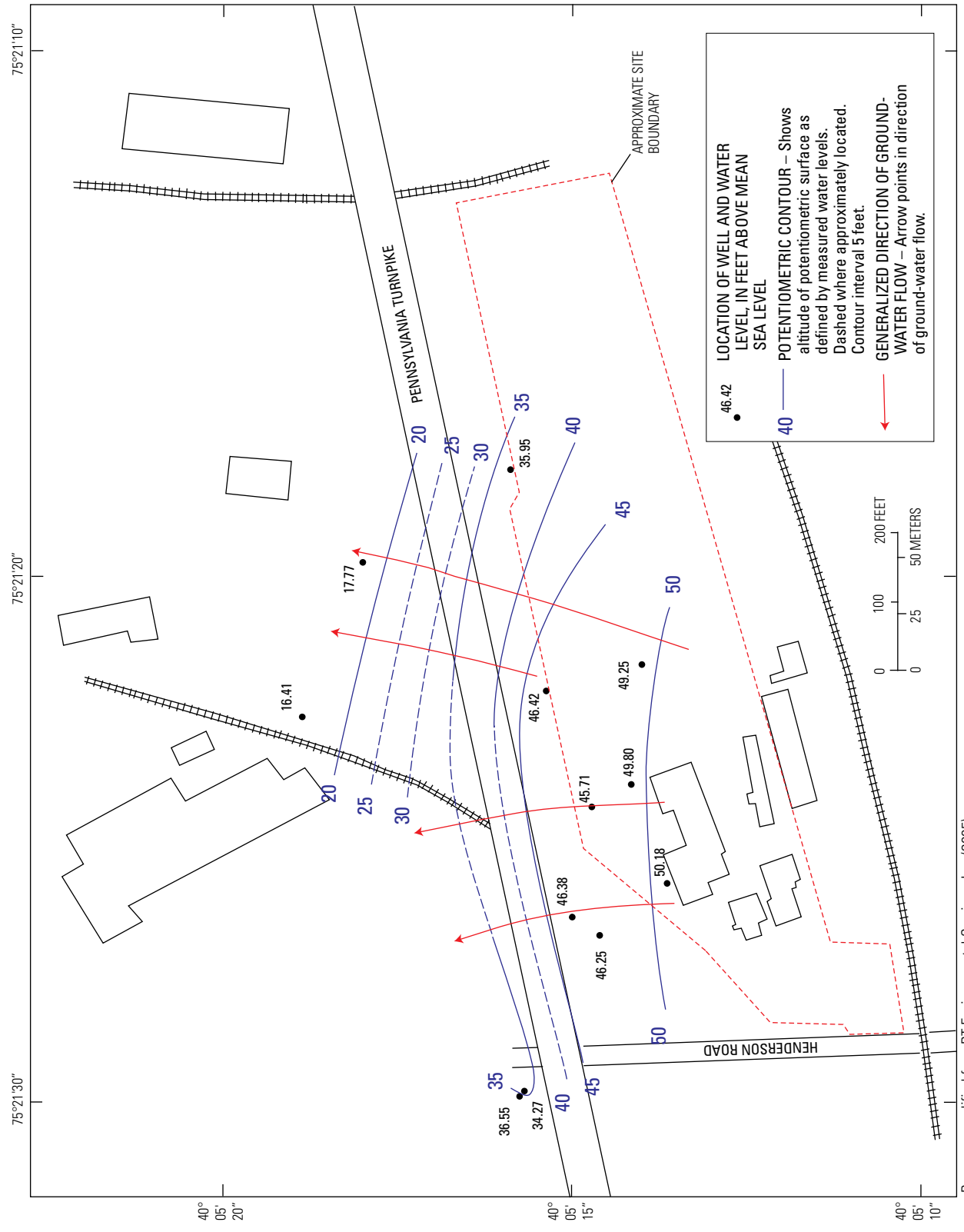
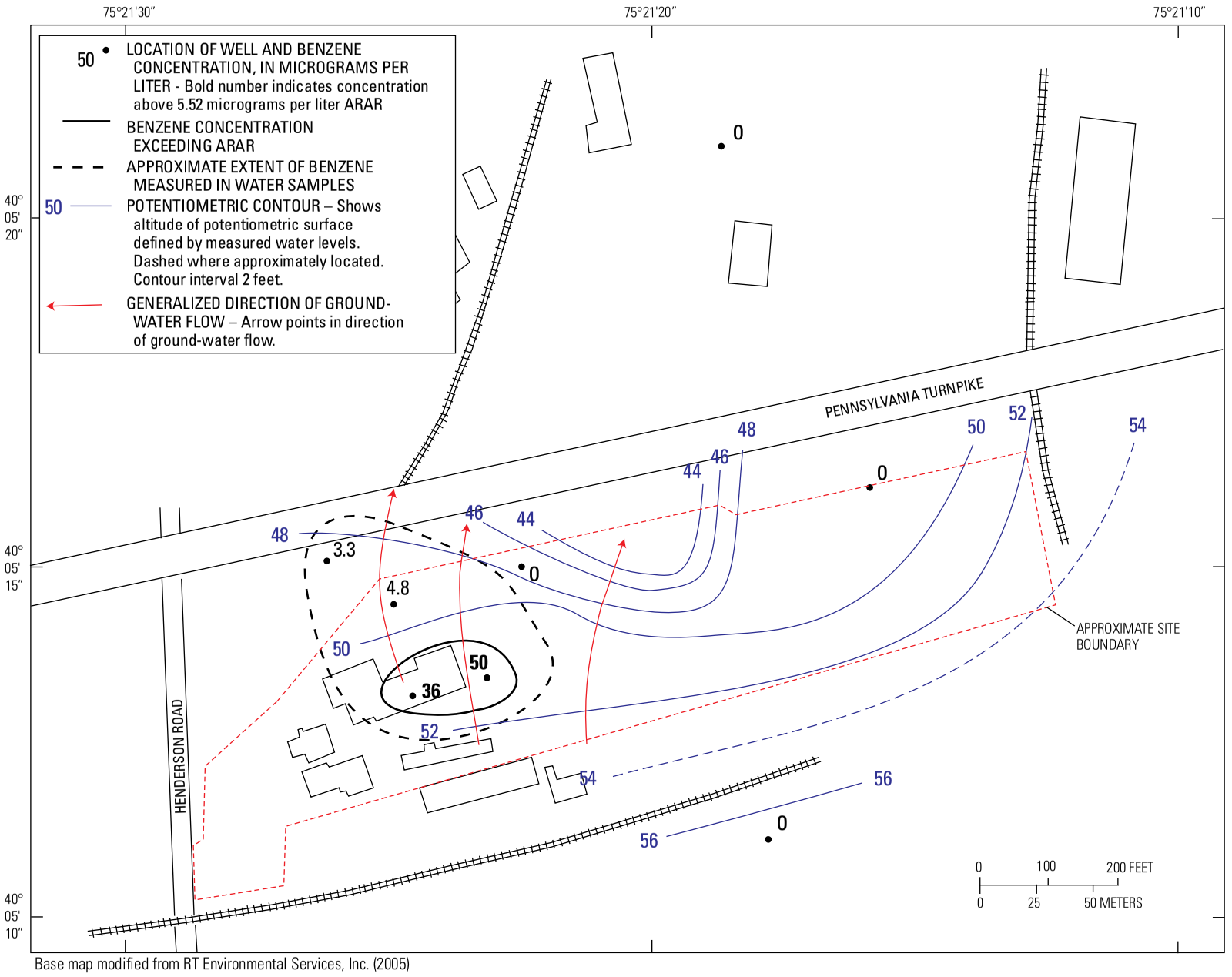


Figure 88. Elevation of water levels measured in deep wells (greater than 299 feet deep) at the Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, February 25–28, 2008 (no pumping). Data provided by RT Environmental Services, Inc.



Base map modified from RT Environmental Services, Inc. (2005)

Figure 89. Concentrations of benzene measured in water samples from shallow wells and generalized direction of ground-water flow, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, February and March 2008. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

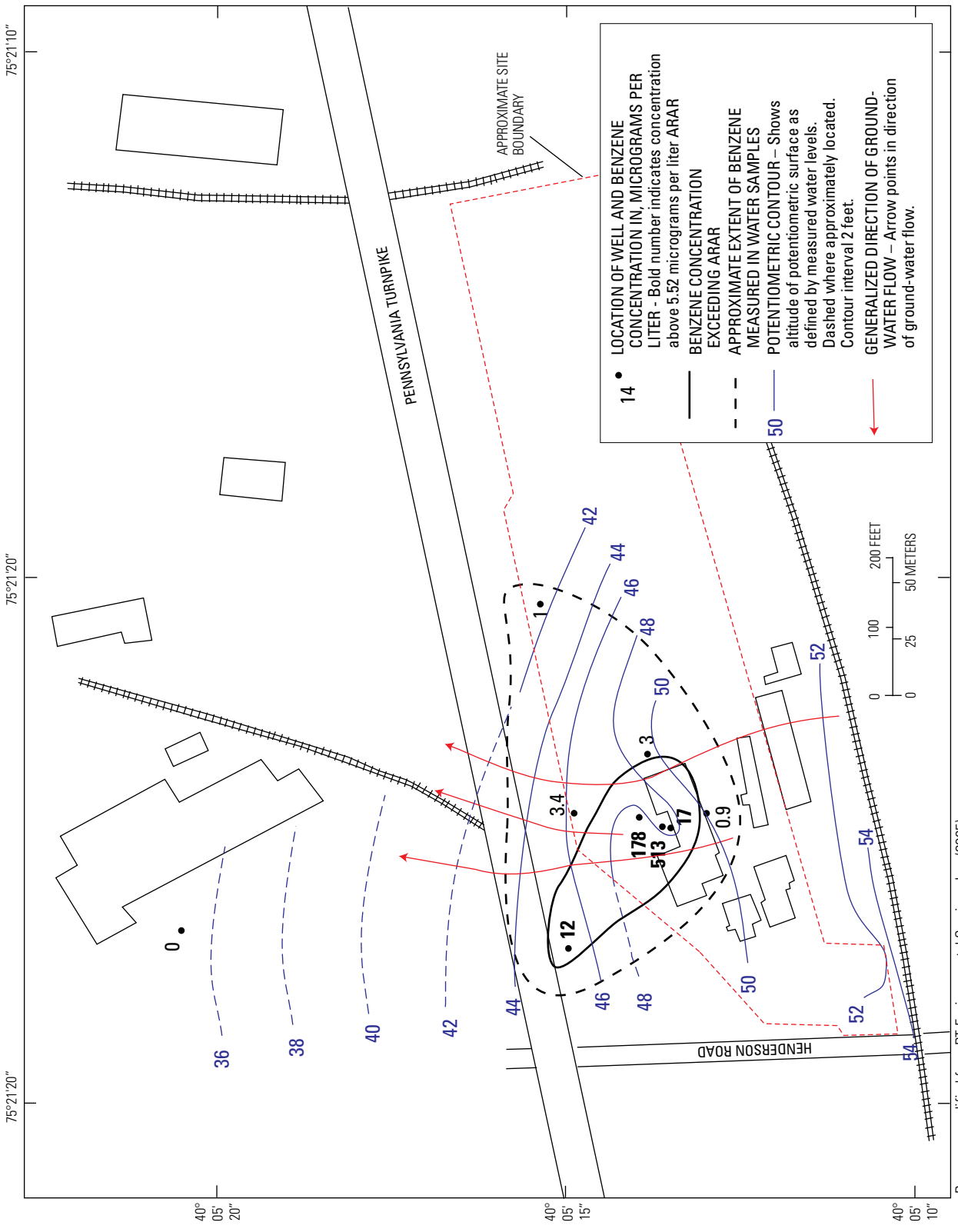
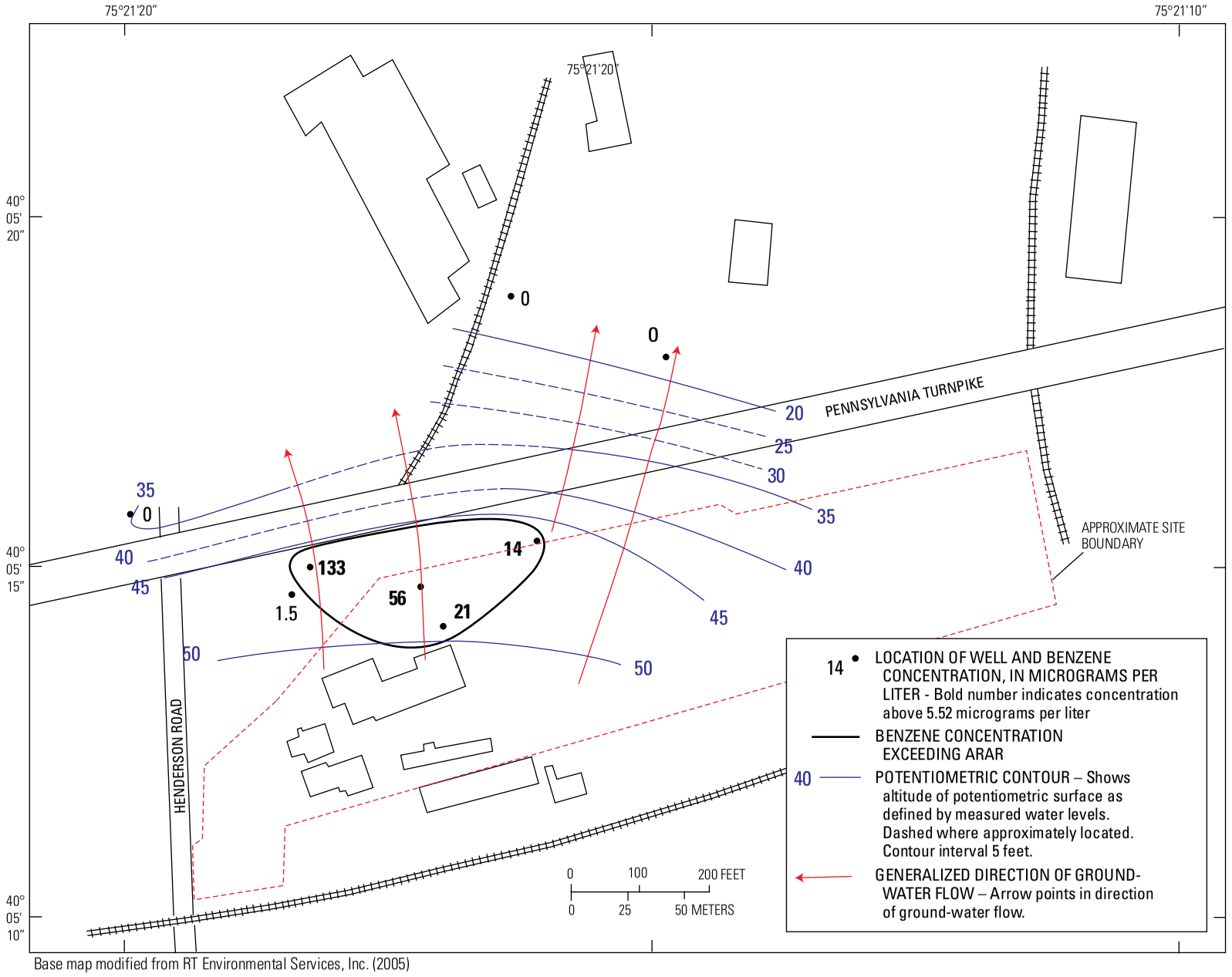
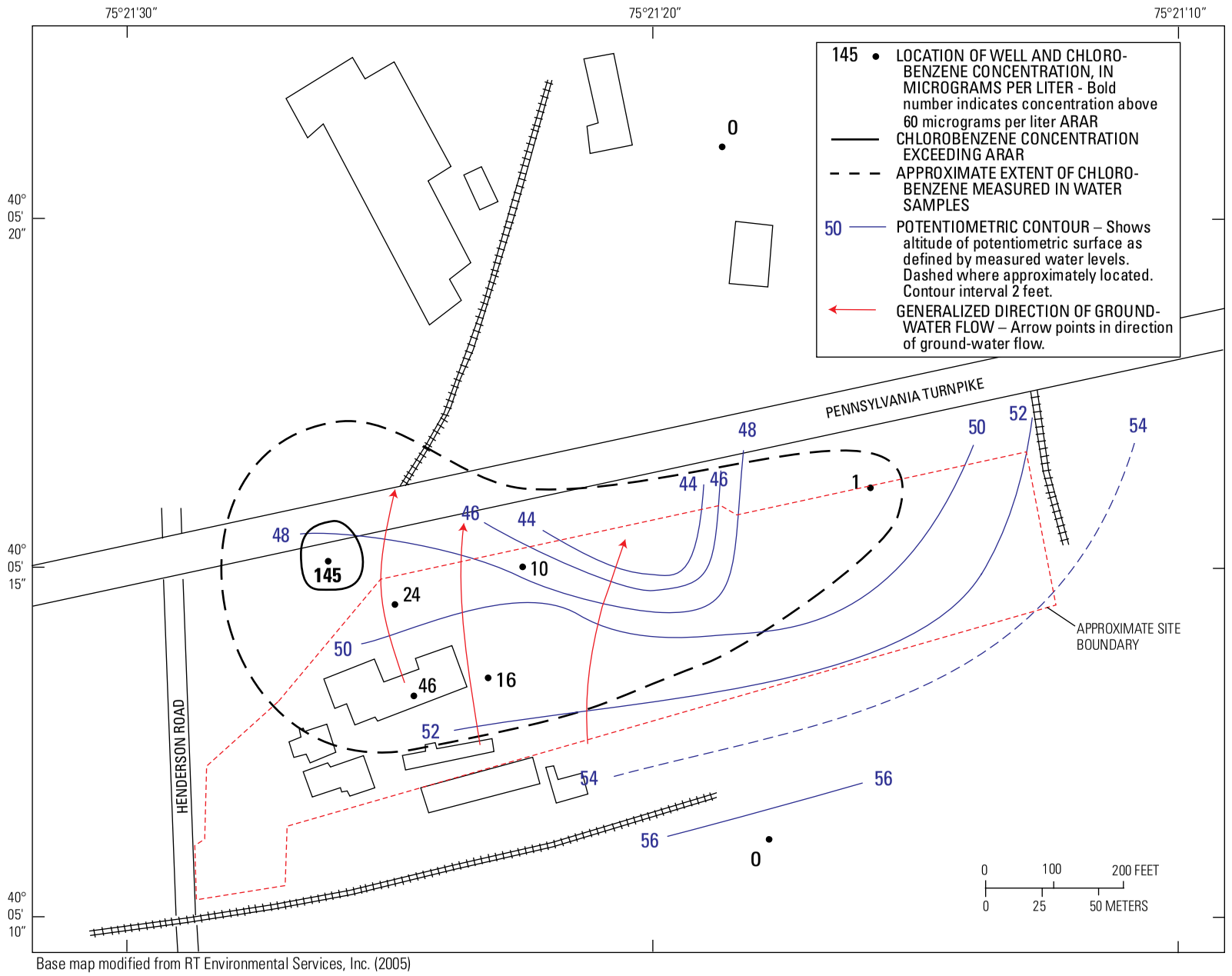


Figure 90. Concentrations of benzene measured in water samples from intermediate-depth wells and generalized direction of ground-water flow, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, February and March 2008. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.



Base map modified from RT Environmental Services, Inc. (2005)

Figure 91. Concentrations of benzene measured in water samples from deep wells and generalized direction of ground-water flow, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, February and March 2008. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.



Base map modified from RT Environmental Services, Inc. (2005)

Figure 92. Concentrations of chlorobenzene measured in water samples from shallow wells and generalized direction of ground-water flow, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, February and March 2008. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

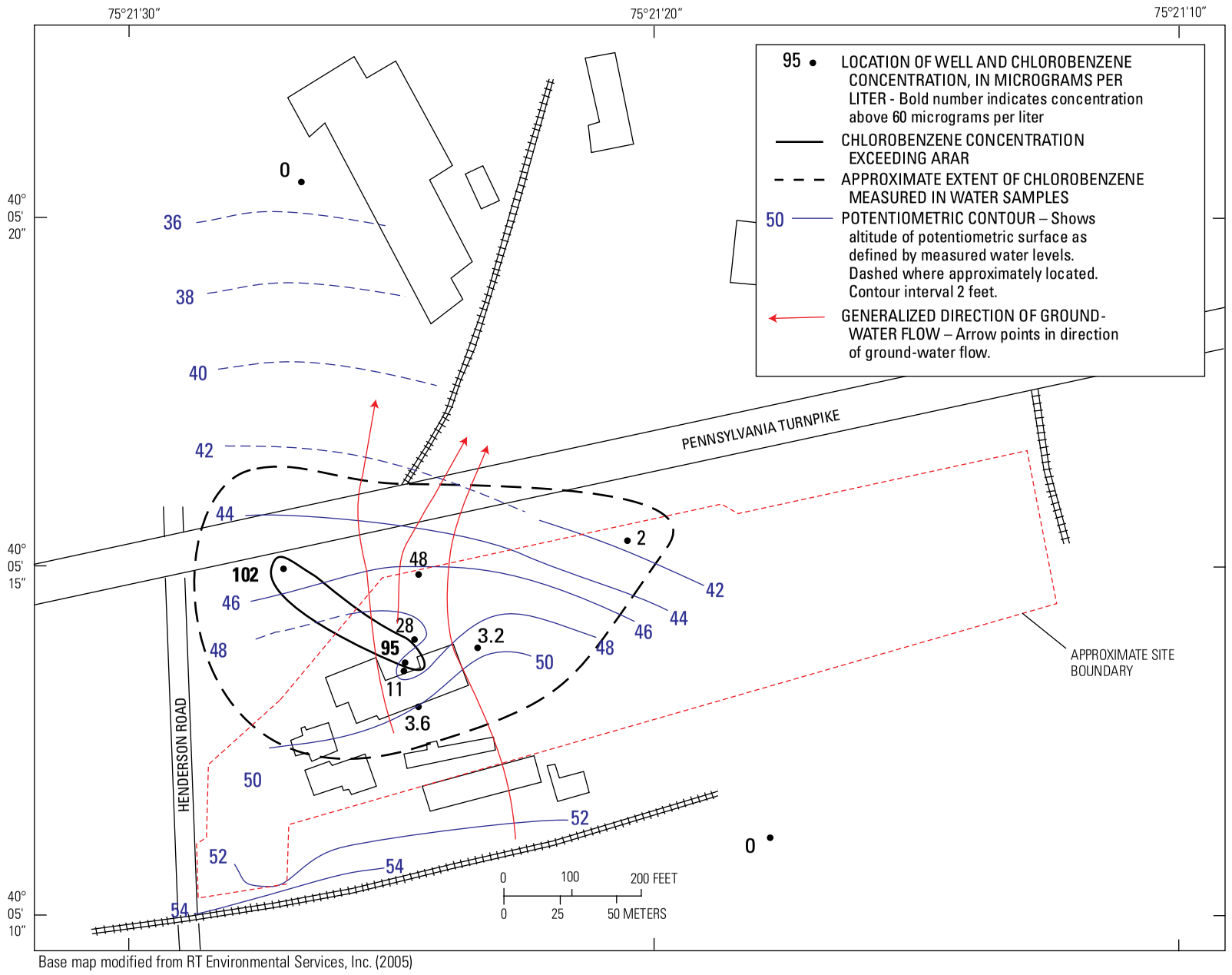


Figure 93. Concentrations of chlorobenzene measured in water samples from intermediate-depth wells and generalized direction of ground-water flow, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, February and March 2008. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

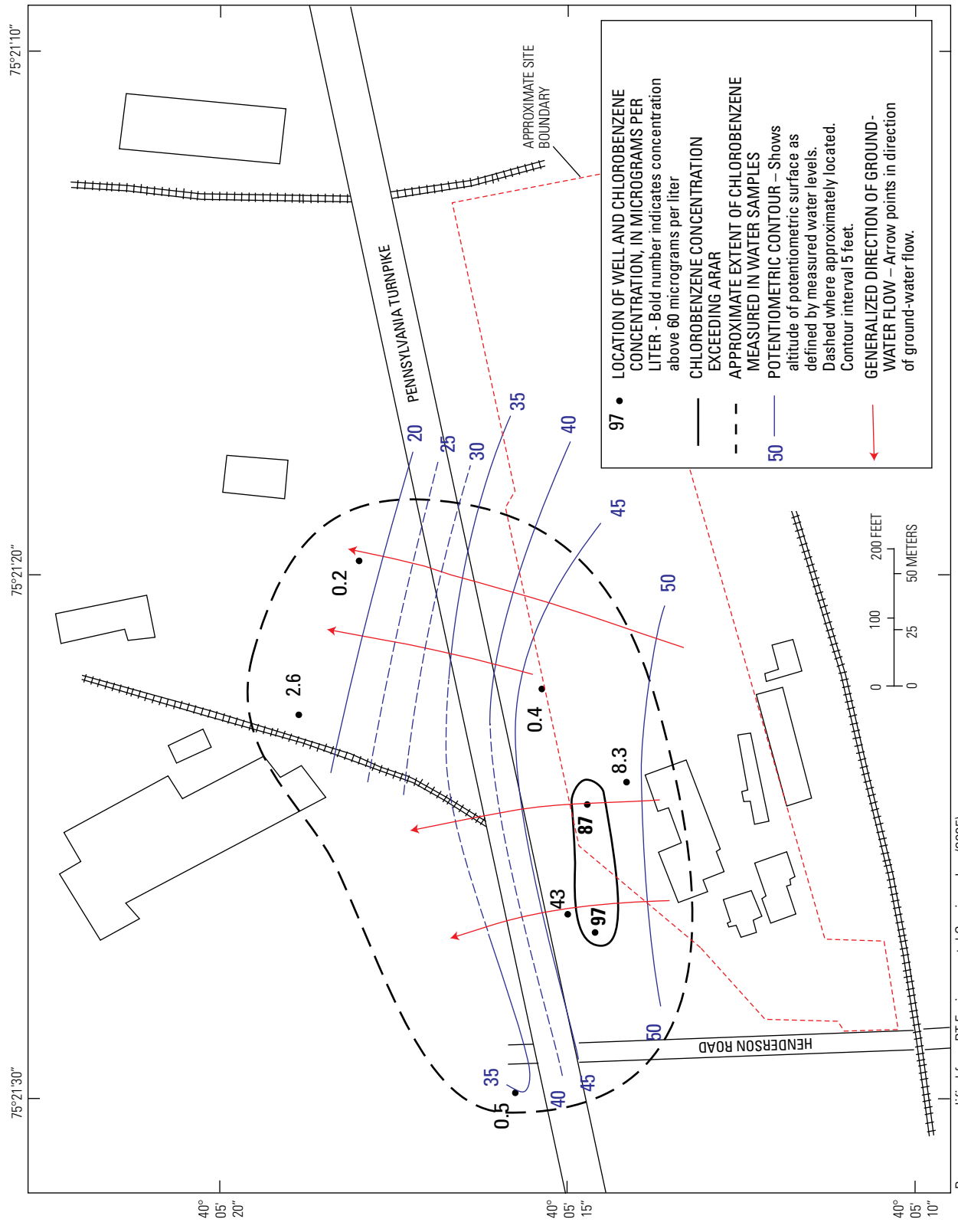


Figure 94. Concentrations of chlorobenzene measured in water samples from deep wells and generalized direction of ground-water flow, Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, February and March 2008. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

Concentrations of benzene and chlorobenzene above the ARARs were measured in water samples from the HR-6 and HR-7 well clusters at and near the northern site boundary on the south side of the Pennsylvania Turnpike (figs. 89 through 94). Potentiometric-surface maps indicate the direction of ground-water flow from these well clusters is to the north; however, no off-site monitor wells are located directly north of these well clusters on the north side of the Pennsylvania Turnpike. Off-site well HR-10-180 is 180 ft deep and is about 580 ft north of the HR-6 well cluster. Only three water levels were available for well HR-10-180 from 1997 to 2008; the depth to water was 138.52 ft in February 2008. The depth of water-bearing zones in well HR-10-180 is unknown. Well HR-10-180 may be too shallow to intercept contamination from the Henderson Road Site. Additional monitor well clusters north of well clusters HR-6 and HR-7 on the north side of the Pennsylvania Turnpike could help determine how far benzene and chlorobenzene have moved offsite and could be used to better define ground-water-flow directions north of the site.

Summary and Conclusions

Two shutdown-rebound tests were conducted from 2003 to 2008 at the Henderson Road Site to determine whether concentrations of selected volatile organic compounds (VOCs) would stabilize or otherwise change when the extraction wells stopped pumping. A long-term shutdown-rebound test began on July 17, 2006. The U.S. Geological Survey (USGS) conducted this study for the U.S. Environmental Protection Agency (USEPA) in support of this test to determine the effects of shutting down the extraction wells on concentrations of selected contaminants and water levels. Concentrations were compared to ARARs (applicable relevant and appropriate requirements), which were set as remediation goals in the Henderson Road Site Record of Decision.

Wells at the Henderson Road Site have been sampled for VOCs since 1991. For 25 wells sampled in 2008, ARARs were exceeded for benzene (10 wells), chlorobenzene (5 wells), 1,1-dichloroethane (1,1-DCA) (4 wells), and total xylene (2 wells). Water samples from off-site downgradient wells sampled during 2003–08 did not exceed ARARs. Chemical concentration maps show two overlapping plumes, a benzene-chlorobenzene plume and a PCE/TCE (tetrachloroethylene/trichloroethylene) breakdown-products plume. The benzene-chlorobenzene plume extended northeast and northwest from the source area, and the PCE/TCE breakdown-products plume extended east and northeast from the source area; this plume may receive some input from the former landfill on the Henderson Road Site.

Water from 10 wells sampled in 2008 exceeded the 5.52 µg/L ARAR for benzene. Concentrations of benzene exceeding the ARAR were measured in water samples from wells in and near the source area (injection well, HR-2-195, HR-3-255, HR-3-280, and HR-3-295) and to the north (HR-7-383), northeast (HR-14-376), and northwest (HR-6-241 and HR-6-377) of the source area. The highest benzene concentrations measured in water samples from wells away from the source area were for wells HR-6-377 (133 µg/L) and HR-7-383 (56 µg/L). Benzene concentrations increased in water samples from wells HR-6-241 and HR-7-383. The greatest changes in benzene concentration between pre-shutdown samples collected in July 2006 and samples collected in February and March 2008 (19 months after the shutdown) were for source-area wells HR-3-255 and the injection well and wells north of the source area (HR-6 and HR-7 well clusters, except well HR-7-278); increases in benzene concentration ranged from 1.5 to 164 µg/L. The greatest increases in benzene concentration were in water samples from wells HR-3-255 (164 µg/L), HR-7-383 (37 µg/L), injection well (26 µg/L), and HR-6-241 (11 µg/L). Benzene appears to have moved from the source area to the north; however, no monitor well clusters are north of well clusters HR-6 and HR-7 on the north side of the Pennsylvania Turnpike. The 296-ft thick clay encountered at well HR-30-318 may prevent the plume from moving to the northwest.

Water from five wells sampled in 2008 exceeded the 60 µg/L ARAR for chlorobenzene. Concentrations of chlorobenzene exceeding the ARAR were measured in wells in the source area (HR-3-255) and north (HR-7-383) and northwest (HR-6-141, HR-6-241 and HR-24-476) of the source area. The highest chlorobenzene concentrations in water samples from wells away from the source area were measured in wells HR-6-141 (180 µg/L), HR-24-476 (133 µg/L), HR-6-241 (150 µg/L), HR-6-141 (136 µg/L), and HR-7-383 (87 µg/L). The greatest changes in chlorobenzene concentration between pre-shutdown samples collected in July 2006 and samples collected in February and March 2008 (19 months after the shutdown) were for wells north of the source area (HR-6 and HR-7 well clusters); increases in chlorobenzene concentration ranged from 6.9 to 99 µg/L. The greatest increases were in water samples from wells HR-6-241 (99 µg/L), HR-24-476 (95 µg/L), and HR-7-383 (74 µg/L).

For May 2007 to August 2008, all six water samples from wells HR-6-241 and HR-24-476 and 60 percent of the water samples from well HR-6-141 exceeded the chlorobenzene ARAR. Chlorobenzene concentrations were substantially greater after the June 2003 shutdown test than before the test. Median chlorobenzene concentrations in water samples from well HR-7-383 have been increasing over time. For well HR-7-383, the median chlorobenzene concentration was 7.1 µg/L for 1998 to May 2003, increased to 24 µg/L for October 2003 to January 2007, and increased to 82 µg/L from May 2007 to February 2008. For well HR-24-476, the median chlorobenzene concentration was 12 µg/L for 1991–99, decreased to 2.1 µg/L for January 2000 to May 2003, increased to 52 µg/L for August 2003 to January 2007, and increased again to 104 µg/L for May 2007 to February 2008.

Chlorobenzene appears to have moved from the source area to the north. The highest concentrations of chlorobenzene were near or outside the northern site boundary, indicating

chlorobenzene may have moved north away from the source area. A much larger area was affected by chlorobenzene than benzene. Chlorobenzene concentrations decreased in the source area and increased at the site boundary at well cluster HR-7 and beyond the site boundary at well cluster HR-6. No monitor well clusters are north of well clusters HR-6 and HR-7 on the north side of the Pennsylvania Turnpike. The 296-ft thick clay encountered at well HR-30-318 may prevent the plume from moving to the northwest.

Water from four wells sampled in 2008 exceeded the 5.06 µg/L ARAR for 1,1-DCA. Concentrations of 1,1-DCA exceeding the ARAR were measured in wells in and near the source area (HR-2-295 and HR-3-280) and northeast of the source area (HR-14-376 and HR-18-190). The highest concentrations were measured in water samples from wells HR-3-380 (25 µg/L), HR-18-190 (9.5 µg/L), HR-14-376 (8.4 µg/L), HR-2-295 (7.1 µg/L), and HR-14-178 (5.4 µg/L). Increases in 1,1-DCA concentration between pre-shutdown samples collected in July 2006 and samples collected in February 2008 (19 months after the shutdown) ranged from 0.4 to 20 µg/L. The greatest increases were measured in water samples from wells HR-3-280 (20 µg/L), HR-14-376 (6.2 µg/L), and HR-14-178 (3.7 µg/L). The concentration of 1,1-DCA in a water sample from off-site well HR-22-300 was 1.7 µg/L. The 1,1-DCA plume extended in an east-northeast direction from the source area.

Water from two wells sampled in 2008 exceeded the 175 µg/L ARAR for total xylene. Both wells (injection well and HR-3-255) are in the source area. The highest concentrations of total xylene measured in 2008 were in water samples from well HR-3-255 (1,730 µg/L) and the injection well (185 µg/L). The greatest changes in total xylene concentration between pre-shutdown samples collected in July 2006 and samples collected in February 2008 (19 months after the shutdown) were an increase of 165 µg/L in water samples from the injection well and a decrease of 1,410 µg/L in water samples from well HR-2-155. The xylene plume extended in an east-northeast direction from the source area.

Large drawdowns in the Upper Merion Reservoir during droughts in 1998 and 2001 affected water levels in Chester Valley and at the Henderson Road Site. For the drought of 2001, water levels in the Chester Valley, except for McCoy Quarry monitor well MW-4 and well HR-17-170, showed a protracted recovery from September 2001 until June 2005 (46 months). Water levels in wells MW-1 and MW-2 on the eastern side of the McCoy Quarry and water levels in wells at the Henderson Road Site, except for well HR-17-170, showed the same extended recovery, indicating the water level in the Upper Merion Reservoir affected water levels on the Henderson Road Site, except for well HR-17-170.

Water-level data were evaluated temporally for 1997–2008 and spatially for (1) June 16, 2003, when the extraction wells were pumping at the full rate prior to the start of the June 2003 shutdown test; (2) July 10, 2006, when the extraction wells were pumping at the reduced rate prior to the start of the July 2006 shutdown test; and (3) February 25–29, 2008, during the 2006–08 shutdown test when the extraction wells were not pumping. Except for well HR-5-195, wells were divided into shallow wells (less than 200 ft deep), intermediate-depth wells (200–299 ft deep), and deep wells (greater than 299 ft deep), following the designations used by RT Environmental Services, Inc. The potentiometric surface for shallow wells did not appear to be affected by pumping of the extraction wells. The general direction of ground-water flow in the shallow zone was to the north.

The potentiometric surface for intermediate-depth wells for June 16, 2003, showed a cone of depression caused by the extraction wells pumping at the full rate. The ground-water-flow direction was from the southwest toward the pumping wells and toward the northeast away from the pumping wells. During the period of reduced pumping (July 10, 2006), the potentiometric surface for intermediate-depth wells did not show a cone of depression as it did when the extraction wells were pumping at the full rate. The ground-water-flow direction was from the south-southwest toward the pumping wells and toward the northeast away from the pumping wells, similar to that when the extraction wells were pumping at the full rate. The ground-water-flow direction when the extraction wells were not pumping (February 25–29, 2008) was toward the north and northeast, similar to that when the extraction wells were pumping.

Water-level data were available for only four on-site deep wells for June 16, 2003 (full-pumping rate), and July 10, 2006 (reduced-pumping rate), when the extraction wells were pumping. The available water-level data showed a flat hydraulic gradient. When the wells were pumping at the full rate (June 16, 2003), the ground-water-flow direction was to the Henderson Road Site from the northwest. When the wells were pumping at the reduced rate (July 10, 2006), the ground-water-flow direction was away from the Henderson Road Site to the northwest, the reverse of the direction of flow when the extraction wells were pumping at the full rate. During February 25–29, 2008, water levels in 11 deep wells were measured; the ground-water-flow direction was away from the Henderson Road Site toward the north and northeast.

Benzene concentrations measured in water samples collected in February and March 2008 from shallow wells were above the 5.52 µg/L ARAR for benzene only in the source area. Benzene concentrations measured in water samples from intermediate-depth wells were above the ARAR in the source area and beyond the northern site boundary northwest of the source area at well cluster HR-6; the direction of ground-water flow in the intermediate zone was to the north-northeast and northeast. Benzene concentrations measured in water samples from deep wells were above the ARAR in the source area, at the northern site boundary northeast of the source area at well cluster HR-7, and outside the site boundary north of the source area at well cluster HR-6. The general direction of ground-water flow in the deep zone is to the north. Benzene appears to have moved to the north away from the source area in the intermediate and deep zones.

Chlorobenzene concentrations measured in water samples collected in February and March 2008 from shallow wells were above the 60 µg/L ARAR for chlorobenzene beyond the northern site boundary northwest of the source area at well cluster HR-6. Chlorobenzene concentrations measured in water samples from intermediate-depth wells were above the ARAR in the source area and beyond the northern site boundary northwest of the source area at well cluster HR-6. Chlorobenzene concentrations measured in water samples from deep wells were above the ARAR at the northern site boundary at well cluster HR-7 and beyond the northern site boundary at well cluster HR-6. Chlorobenzene appears to have moved to the north away from the source area in the shallow, intermediate, and deep zones.

Off-site wells were drilled to monitor the possible movement of chemicals of concern from the Henderson Road Site. Concentrations of benzene and chlorobenzene above the ARARs were measured in water samples from well cluster HR-7 at the northern site boundary and well cluster HR-6 beyond the northern site boundary on the southern side of the Pennsylvania Turnpike. No off-site monitor wells are directly north of these well clusters on the northern side of the Pennsylvania Turnpike. Potentiometric-surface maps indicate the direction of ground-water flow from these well clusters was to the north. Off-site well HR-10-180 is about 580 ft north of the HR-6 well cluster; however, this well may be too shallow to intercept contamination from the Henderson Road Site. Additional monitor well clusters north of well clusters HR-6 and HR-7 on the northern side of the Pennsylvania Turnpike could help determine how far benzene or chlorobenzene have moved off-site and could be used to better define ground-water-flow directions north of the site.

During drilling of well HR-30-318, 296 ft of clay and weathered rock were encountered before competent bedrock was reached. Well HR-5-195 penetrated 179 ft of clay before encountering competent bedrock. It is possible that a thick clay north of the turnpike restricts movement of contaminants to the north.

Acknowledgments

Chemical and water-level data for the Henderson Road Site used in this study were provided by RT Environmental Services, Inc. In addition, RT Environmental Services, Inc. was kind enough to provide well-casing elevations and other data necessary for this study. Glasgow, Inc. provided water-level data for the McCoy Quarry monitor wells. Randall Conger and Melvin Mathes of the USGS provided critical reviews of this report.

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Table 7. Summary of concentrations of selected volatile organic compounds in water samples from the Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1991–2008. Only compounds exceeding the applicable or relevant and appropriate requirement (ARAR) are included. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.

[n, number of samples; µg/L, micrograms per liter; —, too few data to compute statistic ;concentrations above ARAR are in bold type]

Compound	ARAR (µg/L)	HR-2-175 4/90–11/99, n=21			HR-2-175 8/00–5/03, n=10			HR-2-175 7/03–6/05, n=16		
		Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)
Benzene	5.52	0	**900**	**11**	2.6	**8.1**	4.1	2.2	**18**	7.5
Carbon tetrachloride	5	0	**52**	0	0	0	0	0	0	0
Chlorobenzene	60	0	**230**	6.2	2.6	13	4.9	4.1	12	8.5
1,1-Dichloroethane	5.06	0	**210**	2	1	3.5	1.9	1.3	**13**	2.2
1,2-Dichloroethane	6.02	0	**100**	0	0	0	0	0	1.5	0
1,1-Dichloroethene	7	0	**470**	0	0	0	0	0	.45	0
1,2-Dichloroethene	70	0	**810**	0	0	1.1	0	0	.45	0
1,2-Dichloropropane	6.28	0	.50	0	0	0	0	0	**6.4**	0
Ethylbenzene	680	0	**2,600**	21	0	61	2.7	0	29	0
Tetrachloroethylene	6.9	0	**9.0**	0	0	0	0	0	.51	0
Toluene	2,000	0	**61,000**	11	0	1.8	.32	0	.78	0
Total xylenes	175	0	**5,700**	54	0	**379**	7.6	0	**374**	4.0
Trichloroethylene	5	0	**72**	0	0	0	0	0	2.5	0
Vinyl chloride	2	0	**200**	0	0	1	0	0	**3**	.43

Compound	ARAR (µg/L)	HR-2-195 11/92–5/03, n=3			HR-2-195 6/05–2/08, n=4		
		Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)
Benzene	5.52	0	2.4	0	**20**	**91**	**41**
1,1-Dichloroethane	5.06	0	**230**	**8.8**	.46	**19**	3.2
cis-1,2-Dichloroethene	70	2.8	**350**	**240**	.36	5.8	.77
Ethylbenzene	680	8.1	**930**	480	5.2	59	14
Methylene chloride	47	0	**170**	2	.11	1.4	.96
Toluene	2,000	2.6	**22,000**	**8,200**	.49	15	3.2
Total xylenes	175	5.3	**5,700**	**5,300**	2	82	25

Table 7. Summary of concentrations of selected volatile organic compounds in water samples from the Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1991–2008. Only compounds exceeding the applicable or relevant and appropriate requirement (ARAR) are included. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.—Continued

[n, number of samples; µg/L, micrograms per liter; —, too few data to compute statistic ;concentrations above ARAR are in bold type]

Compound	ARAR (µg/L)	HR-2-295 4/99–5/03, n=3			HR-2-295 6/05–08, n=4		
		Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)
Benzene	5.52	3.8	**11**	**7.5**	3.0	4.4	3.4
1,1-Dichloroethane	5.06	4.6	**8.8**	**5.8**	6.0	7.1	6.2

Compound	ARAR (µg/L)	HR-3-255 8/91–11/99, n=35			HR-3-255 5/00–6/03, n=14			HR-3-255 7/03–7/06, n=24			HR-3-255 5/07–2/08, n=2		
		Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)
Benzene	5.52	0	**1,800**	**110**	**54**	**850**	**292**	**95**	**530**	**278**	**452**	**513**	—
Carbon tetrachloride	5	0	**36**	0	0	0	0	0	0	0	0	0	—
Chlorobenzene	60	0	**480**	**65**	33	**321**	**69**	22	**169**	**94**	**95**	**101**	—
1,1-Dichloroethane	5.06	0	**1,100**	**5.7**	0	**279**	1.1	0	**599**	**93**	.6	1.5	—
1,2-Dichloroethane	6.02	0	**250**	0	0	**34**	0	0	**172**	2.2	0	0	—
1,1-Dichloroethene	7	0	**300**	0	0	0	0	0	.61	0	0	0	—
cis-1,2-Dichloroethene	70	0	0	0	0	**134**	.35	0	**774**	42	0	.78	—
1,2-Dichloroethene	70	0	**160**	0	0	2.0	0	0	1.7	0	.40	.60	—
1,2-Dichloropropane	6.28	0	**160**	0	0	**75**	0	0	**462**	**16**	0	5	—
Ethylbenzene	680	0	**3,400**	63	41	**5,130**	**446**	178	**7,490**	**944**	30	186	—
Methylene chloride	47	0	**67**	0	0	**28**	2.0	0	**60**	3.3	0	0	—
Tetrachloroethylene	6.9	0	**11**	0	0	.50	0	0	1.6	0	0	0	—
Toluene	2,000	0	**14,000**	44	0	**8,590**	27	15	**8,600**	1,975	50	54	—
Total xylenes	175	0	**28,880**	**219**	**216**	**18,100**	**1,360**	**192**	**32,100**	**9,145**	**1,730**	**2,180**	—
Vinyl chloride	2	0	**82**	0	0	**113**	.25	0	**128**	**41**	0	1.0	—

Table 7. Summary of concentrations of selected volatile organic compounds in water samples from the Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1991–2008. Only compounds exceeding the applicable or relevant and appropriate requirement (ARAR) are included. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.—Continued

[n, number of samples; µg/L, micrograms per liter; —, too few data to compute statistic ;concentrations above ARAR are in bold type]

Compound	ARAR (µg/L)	HR-3-280 8/91–11/99, n=28			HR-3-280 11/00–6/03, n=12			HR-3-280 7/03–1/07, n=28			HR-3-280 5/07–8/08, n=6		
		Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)
Benzene	5.52	0	**2,300**	**285**	0	**99**	**29**	**11.2**	**298**	**39**	**174**	**198**	**182**
Carbon tetrachloride	5	0	**900**	**55**	0	0	0	0	0	0	0	0	0
Chlorobenzene	60	0	**430**	26	2.1	23	12	3	**79**	5.8	**24.4**	**49**	**32**
Chloroform	100	0	**1,400**	6	0	64	0	0	.89	0	0	0	0
1,1-Dichloroethane	5.06	0	**2,700**	**114**	1.9	**19**	4.3	.38	**68**	**9.4**	.64	**45**	**14**
1,2-Dichloroethane	6.02	0	**2,600**	**23**	0	**8.0**	.50	0	**11**	2.4	0	0	0
1,1-Dichloroethene	7	0	**5,200**	0	0	0	0	0	0	0	0	0	0
1,2-Dichloroethene	70	0	**200**	0	0	1.0	0	0	1.4	0	0	1	.47
1,2-Dichloropropane	6.28	0	**85**	0	0	**6.4**	1.5	0	**88**	1.9	0	0	0
Ethylbenzene	680	0	**4,500**	434	.31	46	.57	0	20	.32	.45	2	.62
Methylene chloride	47	0	**920**	7	0	1.9	.98	0	9.6	1.0	0	1	.43
Tetrachloroethylene	6.9	0	**91**	0	0	0	0	0	.39	0	0	0	0
Toluene	2,000	0	**54,000**	1,270	.14	5.1	1.1	0	9.2	.20	.68	8	1.5
Total xylenes	175	0	**14,000**	**445**	0	91	.92	0	**278**	.79	0	0	.21
Vinyl chloride	2	0	**86**	1.9	0	1.8	0	0	**28**	1.8	0	**4**	.77

Table 7. Summary of concentrations of selected volatile organic compounds in water samples from the Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1991–2008. Only compounds exceeding the applicable or relevant and appropriate requirement (ARAR) are included. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.—Continued

[n, number of samples; µg/L, micrograms per liter; —, too few data to compute statistic ;concentrations above ARAR are in bold type]

Compound	ARAR (µg/L)	HR-3-295 8/91–11/99, n=37			HR-3-295 5/00–6/03, n=13			HR-3-295 7/03–7/06, n=24			HR-3-295 7/07–2/08, n=2		
		Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)
Benzene	5.52	0	**1,800**	**85**	0.4	**583**	**195**	**8.1**	**559**	**19**	**16**	**20**	—
Carbon tetrachloride	5	0	**33**	0	0	0	0	0	0	0	0	0	—
Chlorobenzene	60	0	**730**	52	2.6	**228**	47	19.2	**186**	**117**	6.2	11	—
1,1-Dichloroethane	5.06	0	**390**	**5.7**	0	**16**	1.2	0	**135**	2.5	1.7	2	—
1,2-Dichloroethane	6.02	0	**70**	0	0	**7**	0	0	**27**	0	0	0	—
cis-1,2-Dichloroethene	70	0	1.9	0	0	**112**	.7	0	**93**	.89	.46	1	—
1,2-Dichloropropane	6.28	0	**56**	0	0	**55**	0	0	**72**	0	0	0	—
Ethylbenzene	680	0	**3,800**	40	0	**4,790**	181	0	**8,160**	0	.61	3	—
Methylene chloride	47	0	**67**	0	0	10	1.5	0	21	0	0	0	—
Tetrachloroethylene	6.9	0	**10**	0	0	.9	0	0	0	0	0	0	—
Toluene	2,000	0	**19,000**	11	0	**8,920**	14	0	**2,550**	.62	.35	48	—
Total xylenes	175	0	**15,000**	**79**	0	**16,000**	**852**	0	**30,500**	0	3.6	6	—
Vinyl chloride	2	0	**18**	0	0	**29**	0	0	**73**	.51	0	0	—

Table 7. Summary of concentrations of selected volatile organic compounds in water samples from the Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1991–2008. Only compounds exceeding the applicable or relevant and appropriate requirement (ARAR) are included. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.—Continued

[n, number of samples; µg/L, micrograms per liter; —, too few data to compute statistic ;concentrations above ARAR are in bold type]

Compound	ARAR (µg/L)	HR-4-195 8/91–11/99, n=37			HR-4-195 5/00–6/03, n=13			HR-4-195 7/03–7/06, n=24		
		Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)
Benzene	5.52	0	**27**	0.70	0.30	1	0.54	0.22	0.6	0.44
1,1-Dichloroethane	5.06	0	**42**	4.0	0	**27**	2.0	.75	3.2	2.2
Methylene chloride	47	0	**77**	0	0	0	0	0	0	0

COMPOUND	ARAR (µg/L)	HR-4-295 10/91–11/99, n=19			HR-4-295 11/00–6/03, n=6			HR-4-295 6/03–1/07, n=23			HR-4-295 5/07–8/08, n=6		
		Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)
Benzene	5.52	0	**140**	**5.5**	.90	4.9	2.4	2.0	**5.8**	3.3	.9	1.9	1.0
Chlorobenzene	60	0	**100**	3.9	.50	3.7	3.3	2.8	5.6	3.5	0	.5	0
1,1-Dichloroethane	5.06	0	**14**	3.0	2.8	**7.8**	3.2	3.2	**12**	**7.4**	**4.3**	**6.8**	4.5
1,2-Dichloroethane	6.02	0	**12**	0	0	4.8	.70	0	**10**	5.2	0	3.3	.28
1,1-Dichloroethene	7	0	**38**	0	0	0	0	0	0	0	0	0	0
Total xylenes	175	0	**311**	0	0	0	0	0	.50	0	0	0	0

Table 7. Summary of concentrations of selected volatile organic compounds in water samples from the Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1991–2008. Only compounds exceeding the applicable or relevant and appropriate requirement (ARAR) are included. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.—Continued

[n, number of samples; µg/L, micrograms per liter; —, too few data to compute statistic ;concentrations above ARAR are in bold type]

Compound	ARAR (µg/L)	HR-5-195 4/99–5/03, n=4			HR-5-195 7/05–2/08, n=7		
		Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)
Benzene	5.52	0	**51**	0.21	0	1	0

Compound	ARAR (µg/L)	HR-6-141 4/99–8/08, n=6		
		Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)
Benzene	5.52	0	**41**	2.8
Chlorobenzene	60	13	**180**	**98**

Compound	ARAR (µg/L)	HR-6-241 5/03–01/07, n=17			HR-6-241 5/07–8/08, n=6		
		Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)
Benzene	5.52	.36	**49**	**6.9**	4.6	**14**	**7.6**
Chlorobenzene	60	3.0	**106**	46	**73**	**150**	**105**

Compound	ARAR (µg/L)	HR-6-377 9/91–11/99, n=10			HR-6-377 11/00–6/03, n=8			HR-6-377 7/03–1/07, n=26			HR-6-377 5/07–8/08, n=6		
		Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)
Benzene	5.52	0	**500**	**23**	2.1	**17**	**8.6**	**15**	**396**	**231**	**38**	**168**	**129**
Chlorobenzene	60	0	**88**	11	1.8	9.1	7.1	6.2	**70**	50	28	52	43
Total xylenes	175	0	**520**	66	0	2.0	1.4	0	27	.54	0	.73	.26

Table 7. Summary of concentrations of selected volatile organic compounds in water samples from the Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1991–2008. Only compounds exceeding the applicable or relevant and appropriate requirement (ARAR) are included. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.—Continued

[n, number of samples; µg/L, micrograms per liter; —, too few data to compute statistic ;concentrations above ARAR are in bold type]

Compound	ARAR (µg/L)	HR-7-163 8/91–11/97, n=24			HR-7-163 9/98–6/03, n=16			HR-7-163 7/03–7/06, n=16			HR-7-163 5/07–2/08, n=2		
		Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)
Benzene	5.52	0	**860**	**80**	0	**15**	0.10	0	**19**	**7.6**	4.1	4.8	—
Carbon tetrachloride	5	0	**9.3**	0	0	1.0	0	0	0	0	0	0	—
Chlorobenzene	60	0	**400**	35	0	**62**	1.2	0	59	32	24	**62**	—
1,1-Dichloroethane	5.06	0	**23**	0	0	**9.2**	2.9	0	2.0	.87	0	.68	—
1,2-Dichloroethane	6.02	0	**11**	0	0	1.3	0	0	.41	0	0	0	—
1,1-Dichloroethene	7	0	**8.0**	0	0	.40	0	0	0	0	0	0	—
Ethylbenzene	680	0	**1,900**	2.1	0	17	0	0	.18	0	0	0	—
Tetrachloroethylene	5	0	**10**	0	0	1.7	0	0	1.2	.11	0	0	—
Toluene	2,000	0	**3,900**	6.0	0	26	.20	0	.77	0	0	0	—
Total xylenes	175	0	**4,530**	27	0	74	0	0	.71	0	0	0	—
Vinyl chloride	2	0	**2.2**	0	0	1.2	0	0	.45	0	0	0	—

Compound	ARAR (µg/L)	HR-7-278 9/98–5/03, n=3			HR-7-278 10/03–7/06, n=8			HR-7-278 5/07–2/08, n=2		
		Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)
Benzene	5.52	**9.1**	**11**	**10**	.87	3.5	2.4	2.8	3.4	—
Chlorobenzene	60	1.6	**72**	4.9	.93	24	3.5	34	47	—

Table 7. Summary of concentrations of selected volatile organic compounds in water samples from the Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1991–2008. Only compounds exceeding the applicable or relevant and appropriate requirement (ARAR) are included. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.—Continued

[n, number of samples; µg/L, micrograms per liter; —, too few data to compute statistic ;concentrations above ARAR are in bold type]

Compound	ARAR (µg/L)	HR-7-383 9/98–5/03, n=4			HR-7-383 10/03–1/07, n=12			HR-7-383 5/07–2/08, n=6		
		Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)
Benzene	5.52	2.9	**67**	**12**	**19**	**75**	**60**	**34**	**131**	**54**
Chlorobenzene	60	1.6	**70**	7.1	3.4	**62**	24	38	**99**	**82**

Compound	ARAR (µg/L)	HR-9-191 11/92–11/99, n=19			HR-9-191 8/00–6/03, n=6			HR-9-191 6/03–11/05, n=27		
		Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)
Benzene	5.52	0	**510**	3.9	0	1.8	.80	0	2.6	.33
Chlorobenzene	60	0	**350**	2.5	0	3.9	3.0	.72	4.0	2.6
1,1-Dichloroethane	5.06	0	**46**	3.2	1	**6.2**	2.6	1.0	**24**	3.4
1,2-Dichloroethane	6.02	0	3.6	1.4	0	**7.1**	2.1	0	3.2	2.5
1,1-Dichloroethene	7	0	**11**	0	0	0	0	0	0	0
Total xylenes	175	0	**1,440**	0	0	.20	0	0	.94	0
Vinyl chloride	2	0	**12**	0	0	.79	0	0	1.4	.40

Compound	ARAR (µg/L)	HR-12-150 4/99–4/01, n=2		
		Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)
Benzene	5.52	2.1	**14**	—
1,1-Dichloroethane	5.06	17	**40**	—
Total xylenes	175	0	**730**	—
Vinyl chloride	2	.71	**4**	—

Table 7. Summary of concentrations of selected volatile organic compounds in water samples from the Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1991–2008. Only compounds exceeding the applicable or relevant and appropriate requirement (ARAR) are included. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.—Continued

[n, number of samples; µg/L, micrograms per liter; —, too few data to compute statistic ;concentrations above ARAR are in bold type]

Compound	ARAR (µg/L)	HR-12-300 5/03–2/06, n=19		
		Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)
Benzene	5.52	0	**6.5**	5.4
1,1-Dichloroethane	5.06	1.1	**12**	**10**
Vinyl chloride	2	0	**2.7**	1.7

Compound	ARAR (µg/L)	HR-14-178 5/93–11/99, n=9			HR-14-178 11/00–5/03, n=6			HR-14-178 10/03–7/06, n=11			HR-14-178 5/07–2/08, n=2		
		Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)
Benzene	5.52	0	**16**	0	0	4.0	0	0	0	0	0	0	—
1,1-Dichloroethane	5.06	0	**11**	0	2.7	**9.4**	2.7	1.3	4.7	1.3	**5.4**	**6.0**	—
Methylene chloride	47	0	**1,500**	0	0	0	0	0	0	0	0	0	—

Compound	ARAR (µg/L)	HR-14-376 9/98–6/03, n=11			HR-14-376 7/03–1/07, n=23			HR-14-376 5/07–8/08, n=6		
		Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)
Benzene	5.52	**25**	**93**	**50**	2.4	**38**	**28**	5.3	**22**	**13**
Chlorobenzene	60	19	**84**	26	.98	**82**	21	6.3	11	8.9
1,1-Dichloroethane	5.06	0	3.0	1.1	.4	3.0	1.5	1.5	**8.4**	**5.2**

Compound	ARAR (µg/L)	HR-18-190 11/92–11/99, n=16			HR-18-190 5/00–5/03, n=13			HR-18-190 10/03–1/07, n=16			HR-18-190 5/07–8/08, n=6		
		Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)
1,1-Dichloroethane	5.06	0	**13**	**6.2**	0	**9**	4.8	0	**9.2**	**6.1**	1.1	**10**	**5.5**
1,2-Dichloroethane	6.02	0	**6.3**	0	0	4.5	1.9	0	2.4	1.8	0	2.8	1.7
Vinyl chloride	2	0	**3.0**	0	0	1.3	0	0	.84	.13	0	0	0

Table 7. Summary of concentrations of selected volatile organic compounds in water samples from the Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1991–2008. Only compounds exceeding the applicable or relevant and appropriate requirement (ARAR) are included. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.—Continued

[n, number of samples; µg/L, micrograms per liter; —, too few data to compute statistic ;concentrations above ARAR are in bold type]

Compound	ARAR (µg/L)	HR-20-155 11/92–/08, n=39		
		Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)
Benzene	5.52	0	**6.0**	0
1,2-Dichloroethane	6.02	0	**12**	0
Vinyl chloride	2	0	**36**	0

Compound	ARAR (µg/L)	HR-22-300 4/98–4/01, n=4			HR-22-300 7/05–8/08, n=10		
		Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)
Benzene	5.52	1.9	**20**	**8.1**	0	4.3	0
1,1-Dichloroethane	5.06	0	**11**	.30	0	2.5	2.1

Compound	ARAR (µg/L)	HR-24-476 12/92–11/99, n=25			HR-24-476 3/00–5/03, n=8			HR-24-476 8/03–1/07, n=19			HR-24-476 5/07–8/08, n=6		
		Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)
Benzene	5.52	0	**190**	**23**	0	**91**	.74	0	**5.6**	2.0	0	4.0	2.2
Carbon tetrachloride	5	0	**6.0**	0	0	0	0	0	0	0	0	0	0
Chlorobenzene	60	0	**96**	12	.50	**96**	2.1	.54	**168**	52	**83**	**110**	**104**
1,1-Dichloroethane	5.06	0	**28**	3.0	1.8	**6.5**	3.0	0	1.6	.64	0	0	0
1,2-Dichloroethane	6.02	0	**21**	0	0	0	0	0	0	0	0	0	0
Total xylenes	175	0	**394**	8.0	0	11	0	0	0	0	0	0	0
Vinyl chloride	2	0	**3.0**	0	0	.70	.30	0	0	0	0	0	0

Table 7. Summary of concentrations of selected volatile organic compounds in water samples from the Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1991–2008. Only compounds exceeding the applicable or relevant and appropriate requirement (ARAR) are included. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.—Continued

[n, number of samples; µg/L, micrograms per liter; —, too few data to compute statistic ;concentrations above ARAR are in bold type]

Compound	ARAR (µg/L)	HR-26-457 12/92–11/99, n=29			HR-26-457 11/00–6/03, n=11			HR-26-457 7/03–2/08, n=27		
		Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)
Benzene	5.52	0	**6,000**	**72**	0.94	**66**	**24**	0.79	**42.6**	**12**
Carbon tetrachloride	5	0	**18**	0	0	0	0	0	0	0
Chlorobenzene	60	0	**430**	54	2.9	**92**	33	2.5	**156**	8.3
1,1-Dichloroethane	5.06	0	**82**	**12**	0	**6.4**	3.5	1.3	**21**	3.1
1,2-Dichloroethane	6.02	0	**140**	0	0	1.3	0	0	2.4	0
1,1-Dichloroethene	7	0	**12**	0	0	.31	0	0	0	0
cis-1,2-Dichloroethene	70	0	4.1	0	0	2.2	.99	0	**75**	.76
1,2-Dichloropropane	6.28	0	**11**	0	0	2.6	0	0	**7.8**	0
Ethylbenzene	680	0	**1,500**	110	0	9.8	2.8	0	6.8	.3
Tetrachloroethylene	6.9	0	**7.0**	0	0	1.1	0	0	.68	0
Toluene	2,000	0	**9,700**	180	.39	6.7	1.6	0	78	0
Total xylenes	175	0	**4,200**	**220**	0	28	6.2	0	32	0
Vinyl chloride	2	0	**5.9**	0	0	.65	0	0	**22**	.52

Table 7. Summary of concentrations of selected volatile organic compounds in water samples from the Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1991–2008. Only compounds exceeding the applicable or relevant and appropriate requirement (ARAR) are included. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.—Continued

[n, number of samples; µg/L, micrograms per liter; —, too few data to compute statistic ;concentrations above ARAR are in bold type]

Compound	ARAR (µg/L)	IW 12/91–5/03, n=85			IW 7/03–2/08, n=25		
		Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)
Benzene	5.52	0	**1,500**	**41**	1.1	**141**	**14**
Carbon tetrachloride	5	0	**580**	1.5	0	0	0
Chlorobenzene	60	0	**530**	15	3.2	**99**	16
1,1-Dichloroethane	5.06	0	**4,200**	**43**	0	**60**	**5.8**
1,2-Dichloroethane	6.02	0	**520**	5.5	0	**21**	0
1,1-Dichloroethene	7	0	**190**	0	0	.41	0
cis-1,2-Dichloroethene	70	0	3.8	0	.92	**95**	4.1
1,2-Dichloroethene	70	0	**320**	0	0	.25	0
1,2-Dichloropropane	6.28	0	5.1	0	0	**132**	6.2
Ethylbenzene	680	0	**2,300**	53	.44	100	16
Methylene chloride	47	0	**79**	0	0	6.5	0
Tetrachloroethylene	6.9	0	**25**	0	0	**19**	1.3
Toluene	2,000	0	**50,000**	685	1.2	1,910	65
Total xylenes	175	0	**5,500**	125	.58	**926**	35
Vinyl chloride	2	0	**97**	0	.36	**24**	1.1

Table 7. Summary of concentrations of selected volatile organic compounds in water samples from the Henderson Road Site, Upper Merion Township, Montgomery County, Pennsylvania, 1991–2008. Only compounds exceeding the applicable or relevant and appropriate requirement (ARAR) are included. ARAR is the applicable or relevant and appropriate requirement that is set in the Record of Decision (ROD) for the site (U.S. Environmental Protection Agency, 1988a). Data provided by RT Environmental Services, Inc.—Continued

[n, number of samples; µg/L, micrograms per liter; —, too few data to compute statistic ;concentrations above ARAR are in bold type]

Compound	ARAR (µg/L)	RE-205 12/91–5/03, n=85			RE-205 7/03–2/08, n=25			RE-205 12/91–5/03, n=85			RE-205 7/03–2/08, n=25		
		Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Median (µg/L)
Benzene	5.52	0	**156**	**15**	0	**14**	**6.7**	0	**287**	1.8	0.93	1.1	—
Carbon tetrachloride	5	0	**16**	0	0	0	0	0	0	0	0	0	—
Chlorobenzene	60	0	**134**	6.0	2.2	33	5.2	1.7	**142**	4.7	2.4	3.6	—
1,1-Dichloroethane	5.06	0	**210**	**23**	0	7.1	2.4	1.1	**165**	2.8	1.7	1.8	—
1,2-Dichloroethane	6.02	0	**24**	0	0	0	0	0	**41**	0	0	0	—
1,1-Dichloroethene	7	0	**67**	0	0	.80	0	0	.56	0	0	0	—
cis-1,2-Dichloroethene	70	0	2.8	0	0	3.0	2	.26	**209**	1.7	.74	.94	—
1,2-Dichloropropane	6.28	0	3.0	0	0	0	0	0	**283**	0	0	0	—
Methylene chloride	47	0	**73**	0	0	0	0	0	16	0	0	0	—
Tetrachloroethylene	6.9	0	**10**	0	0	**16**	.6	0	**19**	.87	0	0	—
Toluene	2,000	0	**2,300**	108	0	16	4.5	0	**2,260**	0	.71	.77	—
Total xylenes	175	0	**1,196**	29	0	12	2.7	0	**620**	0	0	0	—
Vinyl chloride	2	0	**46**	0	0	1.0	.60	0	**43**	.99	1.1	1.5	—