Cover photos: Ground-water samples being collected in Fishermans Cove, Ashumet Pond, Massachusetts (view looking west), and an aerial ortho photo of Ashumet Pond (2001 half-meter, 1:5,000 scale). Ortho photo from MassGIS; available on the Web at: http://maps.massgis.state.ma.us/MassGISColorOrthos/viewer.htm

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

Phosphorus in a Ground-Water Contaminant Plume Discharging to Ashumet Pond, Cape Cod, Massachusetts, 1999

By TIMOTHY D. MCCOBB, DENIS R. LEBLANC, DONALD A. WALTER,
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Water-Resources Investigations Report 02-4306

TOXIC SUBSTANCES HYDROLOGY PROGRAM

In cooperation with the
AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE

Northborough, Massachusetts
2003

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CONVERSION FACTORS

Multiply	By	To obtain
acre	4,047	square meter
cubic foot per day (ft^3/d)	0.02832	cubic meter per day
foot (ft)	0.3048	meter
foot per day (ft/d)	0.3048	meter per day
inch (in.)	2.54	centimeter
kilograms per year (kg/yr)	2.205	pounds per year
mile (mi)	1.609	kilometer

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F = (1.8 \times °C) + 32$$

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

$$°C = (°F - 32) / 1.8$$

HORIZONTAL AND VERTICAL DATUMS

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29). Altitude, as used in this report, refers to distance above or below the NGVD 29.

WATER-QUALITY INFORMATION

Chemical concentration is given in units of milligrams per liter (mg/L) or micrograms per liter (µg/L). Milligrams and micrograms per liter are units expressing the mass of the solute per unit volume (liter) of water. One thousand micrograms per liter is equivalent to 1 milligram per liter. Micrograms per liter is approximately equivalent to “parts per billion,” and milligrams per liter is approximately equivalent to “parts per million.”

ABBREVIATIONS

AFCEE	Air Force Center for Environmental Excellence
mL/min	milliliters per minute
mN	milliNormal
MMR	Massachusetts Military Reservation
MLS	multilevel sampler
PVC	polyvinyl chloride
USGS	U.S. Geological Survey
µS/cm	microsiemens per centimeter at 25 degrees Celsius

Phosphorus in a Ground-Water Contaminant Plume Discharging to Ashumet Pond, Cape Cod, Massachusetts, 1999

By Timothy D. McCobb, Denis R. LeBlanc, Donald A. Walter, Kathryn M. Hess, Douglas B. Kent, *and* Richard L. Smith

Abstract

The discharge of a plume of sewage-contaminated ground water emanating from the Massachusetts Military Reservation to Ashumet Pond on Cape Cod, Massachusetts, has caused concern about excessive loading of nutrients, particularly phosphorus, to the pond. The U.S. Air Force is considering remedial actions to mitigate potentially adverse effects on the ecological characteristics of the pond from continued phosphorus loading. Concentrations as great as 3 milligrams per liter of dissolved phosphorus (as P) are in ground water near the pond's shoreline; concentrations greater than 5 milligrams per liter of phosphorus are in ground water farther upgradient. Temporary drive-point wells were used to collect water samples from 2 feet below the pond bottom to delineate concentration distributions in the pore waters of the pond-bottom sediments. Measurements in the field of specific conductance and colorimetrically determined orthophosphate concentrations provided real-time data to guide the sampling.

The contaminant plume discharges to the Fishermans Cove area of Ashumet Pond as evidenced by elevated levels of specific conductance and boron, which are chemically conservative indicators of the sewage-contaminated ground water. Concentrations of nonconservative species, such as dissolved phosphorus, manganese, nitrate, and ammonium, also were elevated above background levels in ground water discharging to the pond, but in spatially complex distributions that reflect their distributions in ground water upgradient of the pond.

Phosphorus concentrations exceeded background levels (greater than 0.10 milligram per liter) in the pond-bottom pore water along 875 feet of shoreline. Greatest concentrations (greater than 2 milligrams per liter) occurred within 30 feet of the shore in an area about 225 feet long. Calculations of phosphorus flux in the aquifer upgradient of Ashumet Pond, as determined from water-flux estimates from a steady-state ground-water-flow model and phosphorus concentrations (in 1999) from multilevel samplers about 75 feet upgradient of the pond, indicate that dissolved phosphorus moves towards the pond and discharges to it with the inflowing ground water at a rate as high as about 316 kilograms per year.

INTRODUCTION

A plume of contaminated ground water has formed from the disposal of secondarily treated sewage to rapid-infiltration sand beds on the southern portion of the Massachusetts Military Reservation (MMR), Cape Cod, Massachusetts (LeBlanc, 1984b) (fig. 1). Sewage was disposed to the infiltration beds for 60 years, beginning in about 1936 and ending in December 1995. The plume extends south more than 18,000 ft downgradient from the MMR towards the coastal embayments along Vineyard Sound. The plume has been defined by increases in specific conductance and pH, and decreases in dissolved oxygen, relative to the levels in uncontaminated ground water, and by the presence of sewage-related constituents, such as boron, chloride, sodium, nitrate, ammonium, detergents, and phosphorus (LeBlanc, 1984b). The eastern edge of the plume intersects Ashumet Pond, a ground-water flow-through pond, in an area known as Fishermans Cove, about 1,700 ft southeast from the abandoned infiltration beds (fig. 2). Phosphorus and other sewage-related constituents are discharging with the ground water to this area of Ashumet Pond (LeBlanc, 1984a; K-V Associates, Inc., 1991; Walter and others, 1996).

Elevated levels of phosphorus in ground water upgradient of Ashumet Pond were measured in 1978–79 when the U.S. Geological Survey (USGS) first delineated the contaminant plume from the disposal of treated sewage (LeBlanc, 1984b). Dissolved phosphorus is present at concentrations greater than 0.1 mg/L as far as 2,500 ft downgradient from the infiltration beds. Dissolved phosphorus migrates more slowly in the aquifer than conservative constituents, such as boron and chloride, because of the adsorption of phosphorus to the aquifer sediments (Stollenwerk, 1996; Walter and others, 1996).

Concern about the adverse effects of excessive loading of nutrients, particularly phosphorus, on the ecological characteristics of Ashumet Pond has prompted the additional collection and analysis of ground water immediately upgradient of the pond, and the identification of discharge locations of phosphorus and other sewage-related constituents into the pond. Consequently, the USGS, as part of the Toxic Substances Hydrology Program, began this investigation in cooperation with the Air Force Center for Environmental Excellence (AFCEE).

This report describes the distribution of dissolved phosphorus within contaminated ground water downgradient from the abandoned infiltration beds and delineates the area at the bottom of Ashumet Pond over which contaminated water discharges. This information is used to estimate the flux of phosphorus to Ashumet Pond. The AFCEE will use this information to determine the fate of phosphorus in Ashumet Pond and to develop plans to mitigate any adverse effects on the pond ecosystem.

Background and Previous Investigations

Secondarily treated sewage was disposed onto the infiltration beds beginning in about 1936. Although the disposal record is incomplete, it is known that in 1984 disposal to the easternmost infiltration beds (fig. 2; beds A) was discontinued and disposal shifted to the eight southernmost beds (fig. 2; beds B) until all disposal ended in December 1995. Little is known about the loading history before 1984, especially to the infiltration beds to the west and northwest (fig. 2; beds C).

Many ground-water studies have been completed near Ashumet Pond to characterize the plume that was formed by the discharge of secondarily treated sewage to the aquifer. These studies found that uncontaminated ground water in the aquifer typically is characterized by pH less than 5.5, specific conductance less than 80 μS/cm, and dissolved oxygen concentrations greater than 8 mg/L. Concentrations of iron and manganese typically are less than 0.01 mg/L, phosphorus less than 0.1 mg/L, and boron, a common component of sewage, less than 0.05 mg/L (LeBlanc, 1984b; Savoie and LeBlanc, 1998). Constituent concentrations in the sewage-contaminated ground water vary according to geochemical conditions, distance from the infiltration beds, and the history of bed loading. LeBlanc (1984b) reported that indicators of sewage-contaminated ground water, including elevated specific conductance, extended at least 11,000 ft downgradient of the infiltration beds in a zone that was 3,500 ft wide and 75 ft thick. At that time (1979), elevated phosphorus concentrations, as much as 2 mg/L, were recorded at locations between the infiltration beds and Ashumet Pond. The adsorption of phosphorus to the sediments has created a reservoir of phosphorus on the aquifer sediments (LeBlanc, 1984b).

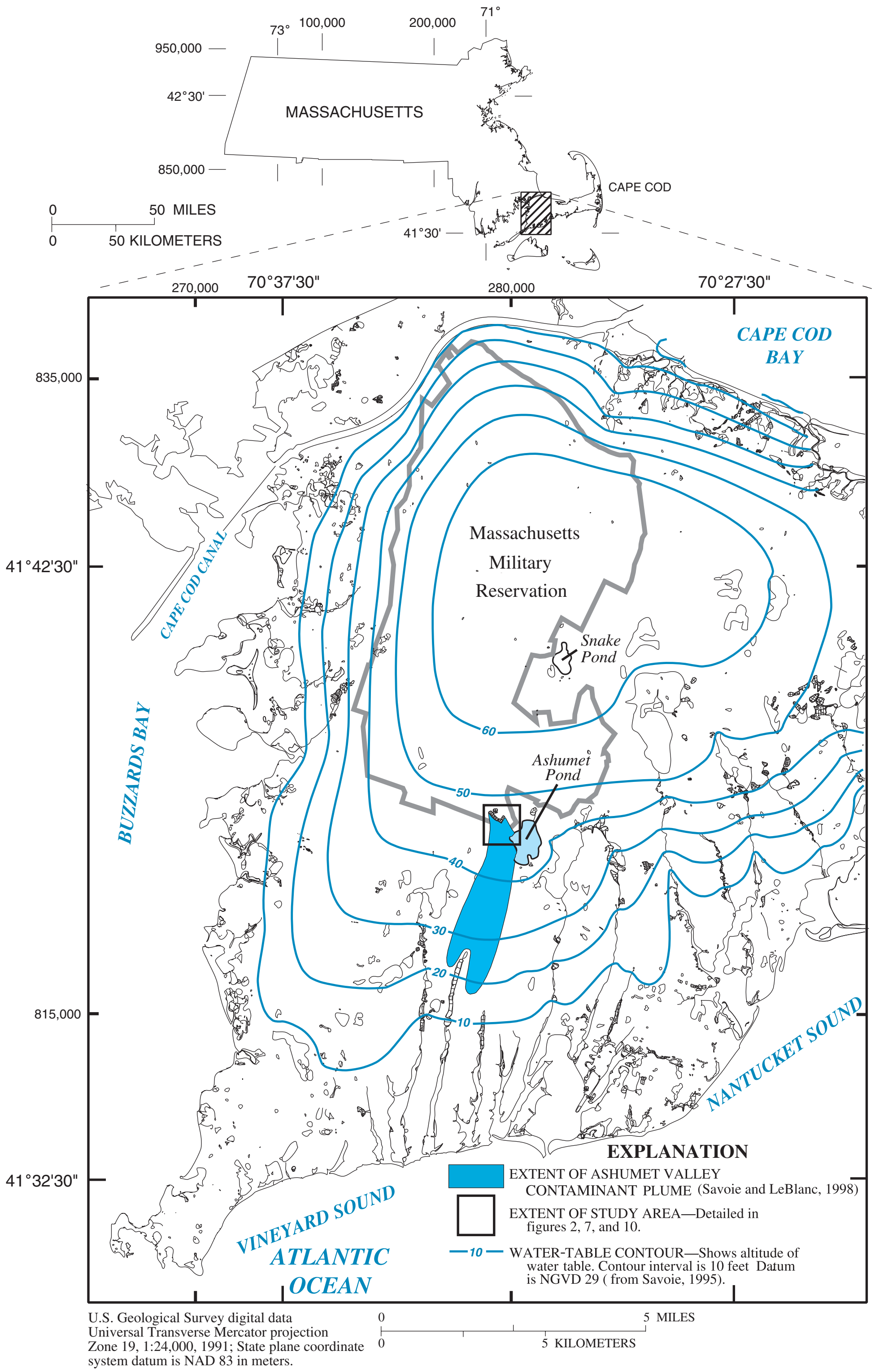


Figure 1. Location of the Massachusetts Military Reservation, extent of the contaminant plume, and the altitude of the water table, western Cape Cod, Massachusetts.

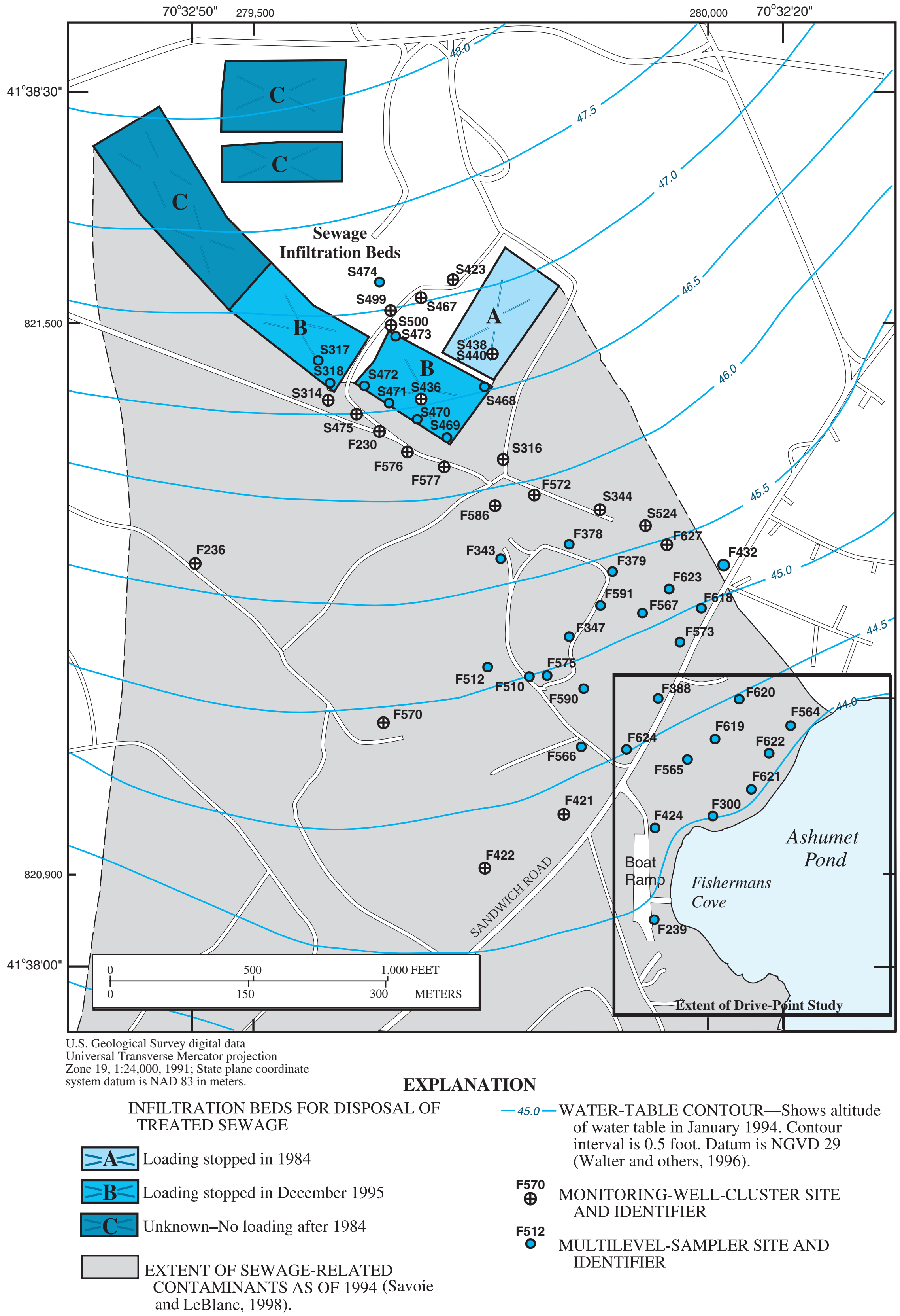


Figure 2. Extent of the contaminant plume in the study area, locations of multilevel and well-cluster sampling sites, and area of temporary in-pond drive-point sampling, Ashumet Pond, Massachusetts, May–October 1999.

Solute-transport modeling of boron indicated that as much as 65 percent of the treated sewage discharges to the pond; this percentage has varied over time and is sensitive to the loading pattern at the infiltration beds (LeBlanc, 1984a).

In January 1986, K-V Associates, Inc. (1991) studied specific conductance of the ground water beneath the pond bottom of the Fishermans Cove area to determine the discharge area of the contaminant plume into Ashumet Pond. Water samples were withdrawn from temporary points driven into the pond bottom at 49 locations and analyzed for specific conductance (fig. 3). The maximum pore-water conductance was greater than 400 µS/cm, which is consistent with the maximum values observed in the center of the sewage plume (LeBlanc, 1984b). The highest conductances were measured in the northern part of Fishermans Cove and extended along the northeastern shoreline.

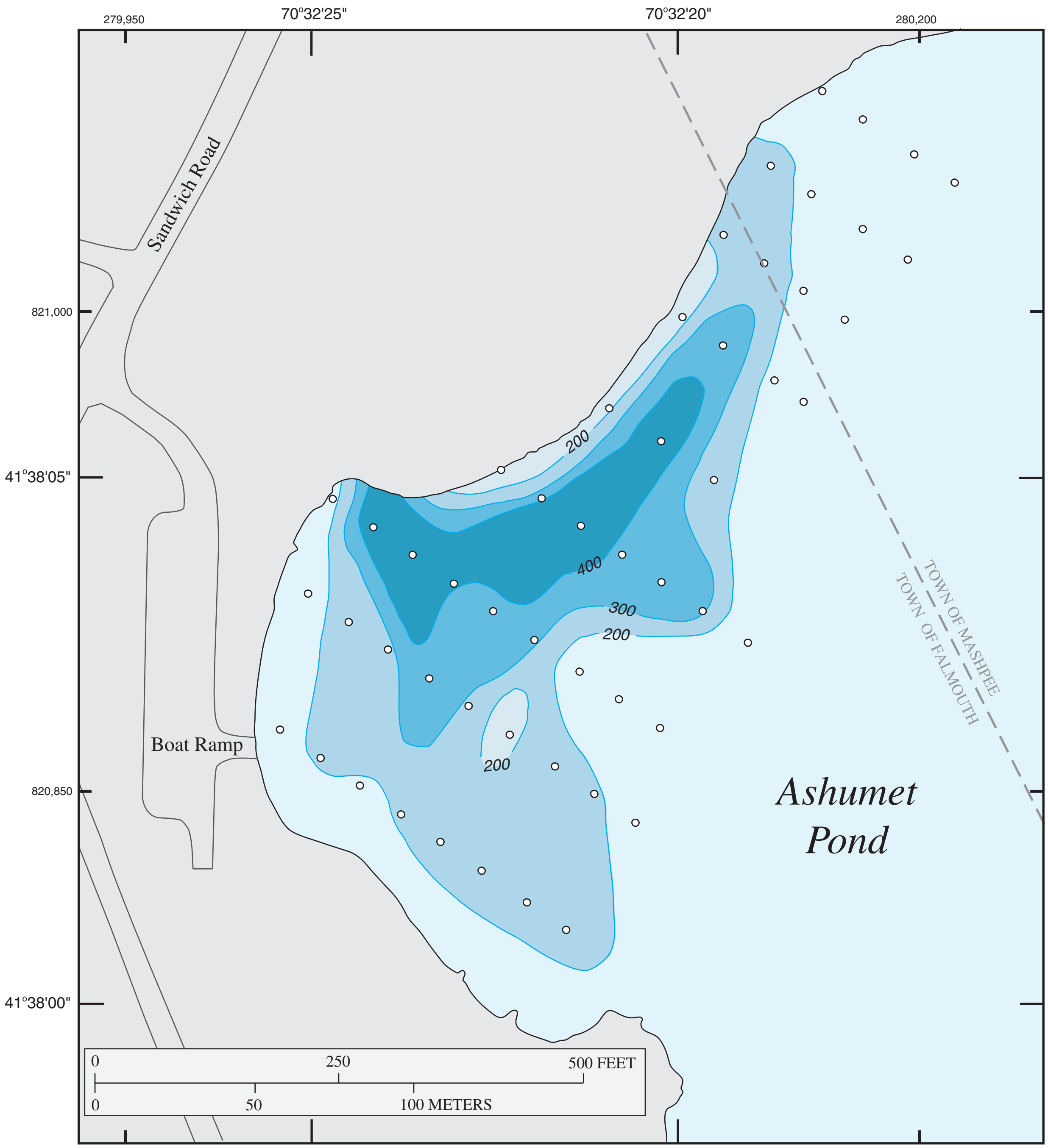
E.C. Jordan Co. (1988) and K-V Associates, Inc. (1991) completed ecological studies of Ashumet Pond, which indicated the pond was a mesotrophic system; temporal trends in trophic-state indicators, such as increases in the concentration of chlorophyll-*a* and decreases in the Secchi disk depth measurements suggested that the pond was transitioning to a eutrophic condition. Shanahan (1996) used data collected from these studies and contaminant-plume loading estimates from Walter and others (1996) to evaluate lake eutrophication with the Vollenweider (1968) analytical model on the basis of phosphorus loading. Using a variety of loading estimates, Shanahan concluded that concentrations of phosphorus in the pond water at that time (1993) ranged from 9 to 21 µg/L. Shanahan (1996) concluded that future increases in the phosphorus discharge to the pond would cause the pond to transition to a eutrophic or even hypereutrophic condition.

E.C. Jordan Co. (1988) also predicted that phosphorus levels discharging to the pond would increase from 0.1 mg/L (1988) to 1-2 mg/L within 1-3 years. K-V Associates, Inc. (1991) calculated that phosphorus from the sewage plume represents 30 percent of the total phosphorus loading to the pond and is the largest single source to the pond. Potential sources of phosphorus loading other than the sewage-contaminated ground water include background ground water, stormwater and surface-water runoff, direct precipitation, and internal recycling from the pond-bottom sediments (Air Force Center for Environmental Excellence, 2002a).

In 1993, Walter and others (1996) comprehensively studied the transport of phosphorus from the sewage-infiltration beds to Ashumet Pond. Suboxic conditions (dissolved oxygen less than 1 mg/L) were documented in the aquifer upgradient from the pond. A maximum concentration of dissolved phosphorus of 6.2 mg/L was measured in ground water about 750 ft from the pond (F567, fig. 2). Samples were obtained from below the pond bottom from 15 temporary drive-point samplers located in the pond about 10 ft from the shoreline. A comparison of hydraulic heads in the drive points to the pond level indicated a strong upward hydraulic gradient across the pond bottom near the shore. Elevated concentrations of phosphorus were detected in samples collected from the drive points in an area extending 400 to 800 ft north of the Fishermans Cove boat landing, with a maximum concentration of 1.9 mg/L at a site 700 ft north of the landing. Walter and others (1996) estimated that about 70 percent of phosphorus loading to the pond is from the contaminant plume and predicted that, following the end of loading to the beds in December 1995, phosphorus concentrations would increase for 8 to 30 years.

Using sediment-core samples obtained from the aquifer, Walter and others (1996) also found in laboratory experiments that phosphorus desorbs from the sediment when uncontaminated ground water with a low pH is introduced into the previously contaminated sediments. They concluded that the reservoir of phosphorus sorbed onto the aquifer sediments would remain a source for as long as 100 years. Walter and others (1996) measured phosphorus concentrations elevated above background levels in ground-water samples from sites on the eastern side of the sewage plume, where the specific conductance was low. These sites are downgradient of the infiltration beds that were abandoned in 1984, supporting the hypothesis that phosphorus desorbs as clean water flushes through the previously contaminated aquifer (Stollenwerk, 1996; Walter and others, 1999; Stollenwerk and Parkhurst, 1999).

In 1995, additional water samples were collected in a more detailed monitoring-well network upgradient of Ashumet Pond, particularly along the eastern side of the sewage plume. Bussey and Walter (1996) documented the temporal and spatial variability of phosphorus in the aquifer observed during this sampling.



U.S. Geological Survey digital data
Universal Transverse Mercator projection
Zone 19, 1:24,000, 1991; State plane coordinate
system datum is NAD 83 in meters.

Modified from K.V. Associates, Inc. (1991)

EXPLANATION

AREAL DISTRIBUTION OF SPECIFIC CONDUCTANCE IN POND-BOTTOM GROUND WATER (1986)—Interval is 100 microsiemens per centimeter at 25°Celsius

- >400
- 300–400
- 200–300
- >200

○ TEMPORARY POND-BOTTOM DRIVE-POINT SAMPLER

Figure 3. Distribution of specific conductance in pond-bottom ground water in 1986 as interpreted by K-V Associates, Inc., Ashumet Pond, western Cape Cod, Massachusetts.

The maximum concentration of phosphorus in the aquifer about 75 ft upgradient from Ashumet Pond (F300, fig. 2) was 1.8 mg/L, indicating little change in phosphorus concentrations near the pond between 1993 and 1995.

Annual sampling since 1993 has shown that the concentrations of phosphorus in ground water between the infiltration beds and the pond vary with time and space. At one site near the center of the phosphorus contamination (F567, fig. 2), maximum concentrations of phosphorus varied from 6.2 mg/L in 1993 to 3.1 mg/L in 1994 and back to 6.2 mg/L in 1998. In contrast, phosphorus concentrations at a site near the pond (F300, fig. 2) increased at a steady, slow rate from 1.4 mg/L in 1993 to 2.1 mg/L in 1998 (Walter and others, 1999). Laboratory studies have shown that dissolved phosphorus concentrations in geochemical equilibrium with phosphorus sorbed onto sediments can vary with changes in pH and ionic strength of the ground water. These studies also have shown thatshort-term variations in dissolved concentrations have little effect on the overall phosphorus mobility and the total mass of sediment-bound phosphorus (Walter and others, 1996; Stollenwerk, 1996).

Walter and LeBlanc (1997) discussed potential remediation strategies based on the understanding of the phosphorus plume at that time. They used a ground-water-flow model and the 1995 water-quality data to estimate that about 180 kg of phosphorus enter the pond each year by way of the contaminant-plume discharge.

The AFCEE (2002a) drilled boreholes from a barge in 1999 to depths as great as 100 ft below the pond bottom at 15 locations near Fishermans Cove. During drilling, water samples were collected every 10 ft and analyzed for phosphorus, manganese, nitrate, ammonium, and other sewage-related constituents. The results of this effort are described in the “Phosphorus in Shallow Ground Water Beneath the Pond Bottom” section.

During their investigation, the AFCEE (2002a) also extensively examined the trophic status of Ashumet Pond and concluded that discharge of contaminants from the plume, including phosphorus and nitrogen, could be adversely affecting the water quality of the pond. According to the AFCEE report (2002a), a large percentage (46 to 68 percent) of the phosphorus input to Ashumet Pond is from background ground water; 19 to 45 percent is from the plume discharge; and 2 to 16 percent is from precipitation. The evaluation of potential remedial actions, which include in-pond phosphorus inactivation by aluminum or iron compounds, installation of a geochemical barrier at the pond bottom where ground water discharges, and in-pond removal of phosphorus by hypolimnetic extraction, is also documented in the AFCEE report.

Hydrogeologic Setting

The study area is on a sand and gravel glacial-outwash plain on western Cape Cod, Massachusetts, known as the Mashpee Pitted Plain (Oldale and Barlow, 1986). Moraines bound the outwash plain to the north and west, an adjacent outwash plain is to the east, and Nantucket and Vineyard Sounds are to the south (fig. 1). The outwash-plain sediments consist of medium-to-coarse-grained glaciofluvial sand and gravel underlain by deposits of fine-to-medium glaciolacustrine sand and silt. Many ice-block collapse structures and kettle ponds, including Ashumet Pond, are within the outwash plain. The underlying bedrock consists primarily of granodiorite; it is considered relatively impermeable to ground-water flow.

Recharge from precipitation is the only source of freshwater to the aquifer on western Cape Cod and is estimated to be about 26 in/yr (Masterson and others, 1998). Regionally, ground water flows radially from a water-table mound, located east of the center of the MMR and north of Snake Pond, towards the coast, where it discharges to streams, ponds, and coastal embayments (fig. 1). The flow system is bounded by the Cape Cod Canal to the north, the Bass River to the east (located to the east of the area shown in fig. 1), Nantucket and Vineyard Sounds to the south, and Buzzards Bay to the west. Ground-water-flow velocities in the sand and gravel have been estimated in the range of 0.8 to 2.3 ft/d (LeBlanc, 1984b).

The phosphorus study area extends from the decommissioned infiltration beds in the southeastern corner of the MMR, along the average direction of ground-water flow, to Fishermans Cove at Ashumet Pond (fig. 2). Ground-water flow is virtually horizontal, except near Ashumet Pond, where upward gradients in head are measurable (LeBlanc, 1984b; Walter and others, 1996). Water-table altitudes in this area range from about 44 to 49 ft (NGVD 29). The direction of horizontal flow near the pond varies as much as 27 degrees between high and low ground-water-level conditions (Walter and others, 1996; McCobb and others, 1999).

Ashumet Pond is a 217-acre, flow-through kettle pond with an average stage of about 44 ft (NGVD 29) and a maximum depth of about 65 ft. Physical and hydrologic characteristics of Ashumet Pond are tabulated in table 1. There are no significant surface-water inlets or outlets. The pond is recharged primarily by ground-water inflow and precipitation. Water leaves the pond only by discharge to the ground-water system and evaporation. A conceptual diagram of typical ground-water-flow patterns in the vicinity of a kettle pond is shown in figure 4. Ground-water inflow occurs in the northwestern half of the pond, and ground-water outflow occurs in the southeastern half of the pond, with the line dividing inflow and outflow areas extending from slightly south of Fishermans Cove to the northeast side of the pond (see fig. 1-2 in AFCEE, 2000). Observations of ground-water flow into Ashumet Pond are consistent with the findings of other

Table 1. Physical and hydrologic properties of Ashumet Pond, Cape Cod, Massachusetts

[Source of surface area, volume, mean depth, and inflow term is Air Force Center for Environmental Excellence (2002a); source of hydraulic residence times are E.C. Jordan Co. (1988), K.V. Associates Inc. (1991), and Air Force Center for Environmental Excellence (2002a). Approximate inflow includes input from ground-water inflow, precipitation, surface runoff, stormwater discharge (Air Force Center for Environmental Excellence, 2002a). NGVD 29, National Geodetic Vertical Datum of 1929]

Property	Value
Surface area (acres)	217
Volume (cubic feet)	221,000,000
Mean depth (feet)	23.4
Maximum depth (feet)	63.0
Average altitude (NGVD 29)	43.8
Hydraulic residence time (years)	1–2
Approximate inflow (cubic feet per year)	170,000,000

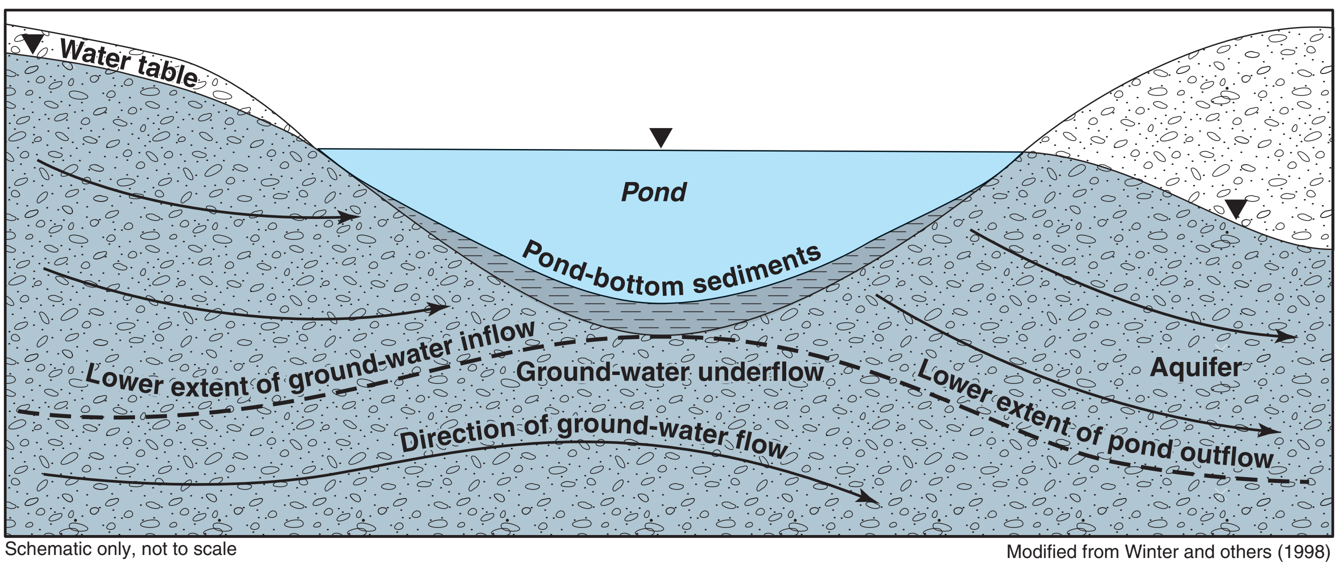


Figure 4. Conceptual model of the ground-water-flow system near a glacial-kettle ground-water flow-through pond.

studies that indicate ground-water discharge to the pond is likely to be greatest near shore, with decreasing discharge as distance from the shoreline increases (Winter and others, 1998; McBride and Pfannkuch, 1975). Walter and others (1996) showed that the strong upward hydraulic gradients diminish at about 500 ft southeast of the Fishermans Cove boat landing; this area indicates the approximate southern limit of the ground-water-discharge area.

The shoreline and nearshore pond-bottom sediments consist mostly of sand, gravel, and cobbles, with a rocky bottom often visible to depths of 10 ft or more (K-V Associates, Inc., 1991). At many locations in Fishermans Cove, bottom sediments include fine sand and silt.

Acknowledgments

The authors thank Spence Smith, formerly of the Air Force Center for Environmental Excellence, and Jonathan Blount of Portage Engineering for their support and advice; Joseph Sawicki and Lindsay Anderson, formerly of the USGS, for their assistance with the collection and analysis of data; and Mr. John McMahon and the Burns family for granting the USGS access to the area near Ashumet Pond.

STUDY DESIGN AND METHODOLOGY

Analyses of ground-water samples collected from monitoring wells and multilevel samplers (MLSs) upgradient of Ashumet Pond and samples from temporary drive points in the Fishermans Cove area of the pond were used to delineate the distribution of dissolved phosphorus in ground water between the decommissioned infiltration beds at the MMR and the pond.

Ground-Water Sampling upgradient of the Pond

Ground-water samples were collected from 349 sampling points from May to August 1999 (tables 2 and 4; table 4 at the back of the report) to define the distribution of phosphorus in the ground water upgradient of Ashumet Pond. Of these samples, 305 were collected from 27 MLSs. Each MLS consists of 15 separate color-coded sampling tubes screened at different vertical locations. All 15 sampling tubes run down the center of a 1.25-in-diameter polyvinyl chloride (PVC) pipe and out sampling portholes drilled in the pipe at designated depths. The open bottom end of each sampling tube is screened with a fine nylon fabric (LeBlanc and others, 1991). The MLSs were installed at seven new sites in 1999 to improve definition of the phosphorus plume immediately upgradient of Ashumet Pond. Three MLSs (F618, F623, and F624) were installed along Sandwich Road, and four MLSs (F619, F620, F621, and F622) were installed between Sandwich Road and the pond (fig. 2). These new MLSs enhance definition along three cross-sections of the plume to better determine phosphorus concentrations and geochemical conditions along the northeastern side of the contaminant plume and directly upgradient of the pond. The remaining 44 samples were collected from single-screen monitoring wells. The wells were clustered at 11 sites with 1 to 8 monitoring wells at each site.

Table 2. Altitudes of screened intervals for monitoring wells used to collect ground-water samples upgradient of Ashumet Pond, Massachusetts, May–July 1999

[Altitude in feet relative to NGVD 29. FSW and SDW abbreviated to F and S in text and figures]

Local site identifier		Altitude of land surface (feet)	Altitude of top of screen (feet)	Altitude of bottom of screen (feet)
FSW 230	-0042	87.06	46.70	44.70
	-0049	86.14	38.70	36.70
	-0058	85.93	29.90	27.90
	-0068	86.33	20.24	18.24
	-0078	86.46	10.51	8.54
	-0088	86.35	.32	-1.68
	-0108	86.13	-20.02	-22.02
	-0127	86.06	-39.33	-41.33
FSW 236	-0070	98.05	30.15	28.15
	-0089	98.16	11.16	9.16
	-0106	98.00	-4.90	-7.90
	-0121	98.09	-20.61	-22.61
	-0141	97.69	-41.21	-43.21
FSW 421	-0031	56.66	27.50	25.50
FSW 422	-0045	73.33	30.00	28.00
	-0065	73.40	10.30	8.30
	-0085	73.41	-9.70	-11.70
	-0105	73.26	-30.00	-32.00
FSW 570	-0056	95.98	42.36	40.39
	-0073	96.17	25.01	23.04
	-0091	96.10	7.40	5.43
	-0111	96.17	-12.56	-14.53
FSW 572	-0055	95.65	42.10	40.30
	-0071	95.94	27.10	25.20
	-0086	95.99	12.40	10.40
	-0101	96.08	-2.70	-5.00
	-0115	95.95	-17.00	-19.00
	-0131	95.70	-33.00	-35.00
	-0146	95.83	-48.00	-50.00
FSW 576	-0047	88.44	43.66	41.69
	-0056	88.98	35.26	33.29
	-0065	88.93	26.36	24.39
	-0077	89.35	14.10	12.12
	-0093	89.45	-1.14	-3.12
	-0107	89.39	-16.02	-18.00
	-0122	89.49	-30.80	-32.78
	-0138	89.94	-45.65	-47.63
FSW 577	-0051	94.31	45.41	43.44
	-0061	94.73	35.72	33.75
	-0071	94.26	25.44	23.47
	-0081	94.61	15.41	13.44
	-0097	95.18	.15	-1.82
	-0111	94.36	-14.98	-16.95
	-0126	94.64	-29.88	-31.85
	-0142	95.09	-44.65	-46.62
FSW 586	-0058	99.40	43.15	41.18
	-0068	99.52	33.24	31.27
	-0078	99.71	23.42	21.45
	-0088	99.65	13.60	11.63
	-0098	99.57	3.16	1.19
	-0133	99.76	-11.26	-13.23
	-0128	99.70	-26.48	-28.45
	-0143	99.52	-41.45	-43.42
FSW 627	-0060	82	24	22
	-0079	82	5	3
	-0097	82	-13	-15
	-0114	82	-30	-32
SDW 314	-0035	78.00	45.70	43.70
	-0051	78.09	28.79	26.79
	-0075	77.85	5.25	3.25
	-0098	77.78	-17.92	-19.92
	-0108	77.94	-25.00	-30.00
SDW 316	-0051	95.50	46.30	44.30
	-0066	95.47	31.67	29.67
	-0082	95.42	15.12	13.12
	-0100	95.39	-3.11	-5.11
	-0114	95.72	-13.64	-17.96
	-0134	95.07	-36.63	-38.63
	-0148	95.70	-47.57	-52.35
	-0163	95.59	-62.92	-67.69
SDW 344	-0038	79.87	43.37	41.37
	-0051	80.29	31.35	29.38
	-0061	80.13	21.14	19.14
	-0071	80.27	11.42	9.45

Table 2. Altitudes of screened intervals for monitoring wells used to collect ground-water samples upgradient of Ashumet Pond, Massachusetts, May–July 1999—*Continued*

Local site identifier		Altitude of land surface (feet)	Altitude of top of screen (feet)	Altitude of bottom of screen (feet)
SDW 344—*Continued*				
	-0080	80.04	1.33	-0.67
	-0091	80.19	-8.73	-10.70
	-0100	79.99	-18.11	-20.00
	-0111	80.09	-28.84	-30.81
SDW 423	-0058	87.34	34.08	29.08
	-0098	87.58	-5.71	-10.71
SDW 436	-0028	69.23	51	41
	-0056	69.38	15.09	13.12
	-0066	69.23	4.88	2.92
	-0076	68.89	-5.17	-7.13
SDW 438	-0041	79.14	48	38
SDW 440	-0078	79.56	3.74	1.77
SDW 467	-0058	81.42	25.09	23.12
SDW 499	-0059	78.93	22.03	20.06
	-0068	78.87	12.86	10.88
	-0079	78.99	2.23	0.26
SDW 500	-0060	79.36	21.56	19.60
	-0070	79.67	11.87	9.91
	-0080	79.53	1.66	-0.30
SDW 524	-0060	85	27	25
	-0078	85	9	7
	-0096	85	-9	-11
	-0114	85	-27	-29

The samples were collected with methods described in Savoie and LeBlanc (1998). The collection equipment used for the MLSs included a peristaltic suction pump fitted with Norprene tubing, which was connected directly to the top of the sampling tube at land surface. Each MLS port was pumped until at least three volumes of water were evacuated from the sampling tube. Field parameters were measured for each sample, including specific conductance, temperature, pH, and dissolved oxygen, to provide general indications of geochemical conditions in the ground water surrounding the MLS port. Specific conductance and temperature were measured with an Orion Model 130A portable conductivity meter with an Orion Model 013610 Duraprobe conductivity cell. Values of pH were determined with an Orion Model 250A portable pH meter with an Orion Model 9107 pH electrode. Dissolved oxygen concentrations less than 0.8 mg/L were measured in the field by a quantitative colorimetric method that uses CHEMetrics self-filling reagent ampoules (VACU-vial Model 7553) and a CHEMetrics VVR multi-analyte photometer. The ampoule was filled in the flowing output from the peristaltic pump, and the color of the resulting mixture in the ampoule was measured in the calibrated photometer (American Public Health Association and others, 1998). Samples with dissolved oxygen concentrations greater than 0.8 mg/L were collected in biological oxygen demand bottles in the field, kept chilled and dark, and measured the same day in the laboratory with a Yellow Springs Instrument Model 58 dissolved-oxygen meter and Model 5739 field probe. The results of the chemical analyses are given in tables 3 and 4.

Shallow Pond-Bottom Ground-Water Sampling

The objective of the in-pond work was to sample ground water immediately below the pond bottom. Ground-water-flow model simulations (AFCEE, 2002b; Walter and LeBlanc, 1997) and seepage-meter observations (Rosenberry and Morin, in press), coupled with hydraulic gradients measured during this study, indicate that ground water flows upward in the Fishermans Cove area and discharges to Ashumet Pond through the pond bottom. Projected flow paths of the contaminant plume and previous investigations in Ashumet Pond (K-V Associates, 1991; Walter and others, 1996) were used to design the detailed sampling array.

Table 3. Field parameters and selected laboratory analyses of ground-water samples collected from monitoring wells near Ashumet Pond, Massachusetts, May–July 1999

[Source of phosphorus, boron, iron, and manganese data: Douglas B. Kent, U.S. Geological Survey, National Research Program. Source of nitrogen data: Richard L. Smith, U.S. Geological Survey, National Research Program. Location of sites shown in figure 2. **Altitude of midpoint of screen:** Is in feet relative to NGVD 29. ft, foot; mg/L, milligram per liter; µS/cm, microsiemen per centimeter at 25°Celsius; <, actual value is less than method detection limit; --, no analysis]

Local site identifier		Altitude of mid-point of screen	Date	Specific conduc-tance (µS/cm)	pH (stan-dard units)	Oxygen, dis-solved (mg/L)	Phos-phorus, dis-solved (mg/L)	Boron, dis-solved (mg/L)	Iron, dis-solved (mg/L)	Manga-nese, dis-solved (mg/L)	Nitrogen, nitrate, dissolved (mg/L as N)	Nitrogen, ammo-nium, dissolved (mg/L as N)
FSW 230	-0042	45.70	7-08-99	83	5.25	7.17	0.50	0.027	<0.01	0.07	1.91	0.04
	-0049	37.70	7-08-99	86	5.65	.80	.91	.013	<.01	.04	.76	--
	-0058	28.90	7-08-99	88	5.46	4.22	.52	.011	<.01	.05	.53	.03
	-0068	19.24	7-08-99	82	5.18	.10	<.10	.010	.01	.04	.67	<.03
	-0078	9.53	7-08-99	94	5.53	.16	<.10	.015	<.01	.09	1.98	.04
	-0088	-.68	7-08-99	147	5.40	5.31	<.10	.030	.02	.08	.78	.06
	-0108	-21.02	7-08-99	78	5.53	8.26	<.10	.009	<.01	<.01	.32	--
	-0127	-40.33	7-08-99	69	5.43	11.00	<.10	.012	<.01	.02	.49	.03
FSW 236	-0070	29.15	5-26-99	63	5.82	9.30	<.10	.011	<.01	<.01	.22	.09
	-0089	10.16	5-26-99	106	5.55	10.50	<.10	.020	<.01	.02	.17	.04
	-0106	-6.40	5-26-99	145	5.43	10.10	<.10	.015	.13	.05	1.00	.10
	-0121	-21.61	5-26-99	175	5.31	11.00	<.10	.012	<.01	.07	.97	<.03
	-0141	-42.21	5-26-99	74	5.65	11.40	<.10	.017	<.01	<.01	.55	.07
FSW 421	-0031	26.50	5-28-99	84	6.32	9.35	.74	.052	<.01	.06	.26	.04
FSW 422	-0045	29.00	5-28-99	56	5.76	11.32	<.10	.012	<.01	<.01	.09	.05
	-0065	9.30	5-28-99	428	5.95	.25	<.10	.325	<.01	1.93	17.54	.08
	-0085	-10.70	5-28-99	274	5.77	.18	.36	.328	<.01	2.29	8.99	.19
	-0105	-31.00	5-28-99	316	5.88	.18	<.10	.275	<.01	4.47	14.94	.41
FSW 570	-0056	41.38	7-14-99	48	5.82	11.26	<.10	.007	<.01	<.01	<.03	.03
	-0073	24.03	7-14-99	120	6.30	3.36	<.10	.069	<.01	.08	1.11	.04
	-0091	6.42	7-14-99	335	5.99	.11	.47	.122	<.01	.97	7.95	<.03
	-0111	-13.55	7-14-99	525	6.04	.10	.32	.077	<.01	5.52	1.40	.56
FSW 572	-0055	41.20	5-12-99	168	6.05	.23	3.17	.087	.01	.08	<.03	--
	-0071	26.15	5-12-99	139	6.11	.23	2.26	.030	.02	.12	<.03	.16
	-0086	11.40	5-12-99	123	6.36	.00	.65	.062	11.21	.16	<.03	.11
	-0101	-3.85	5-12-99	178	5.76	4.96	.20	.047	.02	.06	1.35	<.03
	-0131	-34.00	5-12-99	131	5.82	8.65	<.10	.013	<.01	.09	.74	.07
	-0146	-49.00	5-12-99	82	5.96	9.15	.29	.012	<.01	.07	.75	.08
FSW 576	-0047	42.68	6-30-99	111	5.62	.62	2.41	.035	<.01	.02	2.30	.22
	-0056	34.28	6-30-99	120	5.74	.12	1.40	.034	<.01	.03	.05	.06
	-0065	25.38	6-30-99	115	5.74	.15	1.21	.026	<.01	.04	.06	.03
	-0077	13.11	6-30-99	144	5.82	.12	.98	.034	<.01	.07	1.64	.06
	-0093	-2.13	6-30-99	185	5.73	.25	.67	.039	<.01	.10	.39	.54
	-0107	-17.01	6-30-99	91	5.82	6.06	.22	.013	<.01	.02	.55	.09
	-0122	-31.79	6-30-99	86	5.85	10.80	.14	.015	<.01	<.01	.05	.09
	-0138	-46.64	6-30-99	81	5.82	10.46	.16	.015	<.01	<.01	.51	.06

Table 3. Field parameters and selected laboratory analyses of ground-water samples collected from monitoring wells near Ashumet Pond, Massachusetts, May–July 1999—*Continued*

Local site identifier		Altitude of mid-point of screen	Date	Specific conductance (µS/cm)	pH (standard units)	Oxygen, dissolved (mg/L)	Phosphorus, dissolved (mg/L)	Boron, dissolved (mg/L)	Iron, dissolved (mg/L)	Manganese, dissolved (mg/L)	Nitrogen, nitrate, dissolved (mg/L as N)	Nitrogen, ammonium, dissolved (mg/L as N)
FSW 577	-0051	44.43	6-30-99	106	5.63	3.52	2.38	0.041	<0.01	0.04	5.37	0.09
	-0061	34.74	6-30-99	151	6.11	.28	2.89	.041	<.01	.05	.06	.14
	-0071	24.46	6-30-99	164	6.21	.18	2.97	.026	.06	.09	.07	.09
	-0081	14.43	6-30-99	185	6.18	.55	2.88	.028	.08	.22	<.03	.17
	-0097	-.84	6-30-99	202	6.19	.19	1.52	.031	.09	.24	<.03	.09
	-0111	-15.97	6-30-99	96	5.93	1.93	.51	.014	<.01	.02	.27	.06
	-0126	-30.87	6-30-99	58	5.84	10.88	<.10	.009	<.01	<.01	.55	.07
	-0142	-45.64	6-30-99	70	5.84	10.79	.27	.009	<.01	<.01	.40	.04
FSW 586	-0058	42.17	7-12-99	125	5.68	.85	2.07	.050	<.01	.07	3.41	.07
	-0068	32.26	7-12-99	177	6.03	.09	2.66	.052	<.01	.14	.07	.06
	-0078	22.44	7-12-99	212	6.17	.11	2.30	.033	.02	.24	<.03	.07
	-0088	12.62	7-12-99	187	6.35	.14	1.59	.043	.03	.11	<.03	.63
	-0098	2.18	7-12-99	192	6.25	.13	1.09	.027	.20	.12	.05	.54
	-0133	-12.25	7-12-99	144	5.89	.18	< .10	.018	.01	.06	.10	< .03
	-0128	-27.47	7-12-99	69	5.71	10.53	< .10	.013	< .01	< .01	.54	.03
	-0143	-42.44	7-12-99	72	5.70	11.19	.19	.018	< .01	< .01	.42	.06
FSW 627	-0061	23	5-18-99	129	5.97	4.59	.84	.021	< .01	.09	.53	.13
	-0079	4	5-18-99	120	6.10	5.35	.28	.031	< .01	.10	.72	.10
	-0097	-14	5-18-99	184	6.14	1.44	.42	.021	1.57	.24	.27	.22
	-0115	-31	5-18-99	151	5.76	9.19	< .10	.012	< .01	.04	.57	.07
SDW 314	-0035	44.70	7-13-99	127	5.78	3.92	2.23	.052	< .01	.01	4.60	.08
	-0051	27.79	7-13-99	105	5.96	2.49	1.74	.021	< .01	< .01	.38	.11
	-0075	4.25	7-13-99	153	5.73	6.85	.46	.020	< .01	.04	.60	.08
	-0098	-18.92	7-13-99	93	5.56	10.66	.12	.013	< .01	< .01	.50	.06
	-0108	-27.50	7-13-99	83	5.71	10.11	< .10	.009	< .01	< .01	.48	.06
SDW 316	-0051	45.30	5-13-99	87	5.17	7.72	.49	.038	< .01	.04	1.79	.04
	-0066	30.67	5-13-99	171	6.05	.15	1.51	.027	< .01	.08	--	--
	-0082	14.12	5-13-99	124	5.76	.36	.60	.034	.08	.14	< .03	.03
	-0100	-4.11	5-13-99	183	6.54	.00	2.95	.055	12.74	.17	< .03	.11
	-0114	-15.80	5-13-99	113	5.76	9.56	.52	.022	.02	.02	.48	.10
	-0134	-37.63	5-13-99	128	5.79	9.48	.29	.016	< .01	.02	.69	.15
	-0148	-49.96	5-13-99	73	5.76	9.97	.33	.015	< .01	< .01	.46	.11
	-0163	-65.31	5-13-99	70	5.63	9.97	.21	.019	< .01	.02	.50	.13
SDW 344	-0038	42.37	5-12-99	75	5.86	9.03	.78	.015	< .01	< .01	.62	.11
	-0051	30.37	5-12-99	158	6.17	.19	2.10	.035	.01	.15	< .03	.08
	-0061	20.14	5-12-99	148	6.28	.10	2.00	.025	.06	.05	< .03	.12
	-0071	10.44	5-12-99	160	6.63	.00	3.58	.023	11.44	.19	< .03	.18

Table 3. Field parameters and selected laboratory analyses of ground-water samples collected from monitoring wells near Ashumet Pond, Massachusetts, May–July 1999—*Continued*

Local site identifier		Altitude of mid-point of screen	Date	Specific conduc-tance (µS/cm)	pH (stan-dard units)	Oxygen, dis-solved (mg/L)	Phos-phorus, dis-solved (mg/L)	Boron, dis-solved (mg/L)	Iron, dis-solved (mg/L)	Manga-nese, dis-solved (mg/L)	Nitrogen, nitrate, dissolved (mg/L as N)	Nitrogen, ammo-nium, dissolved (mg/L as N)
SDW 344—*Continued*												
	-0080	0.33	5-12-99	177	6.79	0.00	3.90	0.031	10.01	0.18	<0.03	<0.03
	-0091	-9.72	5-12-99	177	6.85	.00	2.59	.030	8.23	.15	< .03	< .03
	-0100	-19.06	5-12-99	194	6.82	.00	2.61	.026	8.77	.16	< .03	< .03
	-0111	-29.83	5-12-99	136	6.79	.00	1.19	.021	5.64	.12	< .03	.23
SDW 423	-0058	31.58	7-14-99	77	5.49	7.76	< .10	.018	< .01	< .01	.24	< .03
	-0098	-8.21	7-14-99	82	5.73	10.99	< .10	.011	< .01	< .01	.35	.03
SDW 436	-0028	46	7-13-99	121	5.52	5.83	1.05	.024	< .01	.04	2.15	--
	-0056	14.11	7-13-99	126	5.67	.06	.70	.030	< .01	.02	.69	1.12
	-0066	3.90	7-13-99	164	5.90	.10	.54	.035	.04	.10	< .03	2.34
	-0076	-6.15	7-13-99	107	6.01	.03	.45	.027	< .01	1.00	< .03	.46
SDW 438	-0041	43	7-15-99	164	5.45	1.69	1.24	.032	< .01	.04	7.45	.08
SDW 440	-0078	2.76	7-15-99	94	5.42	4.21	.49	.036	< .01	.03	.59	.04
SDW 467	-0058	24.11	7-14-99	132	5.41	.25	< .10	.021	.02	.02	.04	.07
SDW 499	-0059	21.05	7-12-99	148	5.86	.90	< .10	.036	< .01	3.32	.07	1.23
	-0068	11.87	7-12-99	103	5.92	.23	< .10	.022	< .01	.94	< .03	.43
	-0079	1.25	7-12-99	59	5.90	.16	< .10	.014	< .01	.27	< .03	.21
SDW 500	-0060	20.58	7-08-99	172	5.89	.08	< .10	.039	< .01	3.86	.06	1.50
	-0070	10.89	7-08-99	125	5.93	.10	< .10	.023	< .01	1.74	.06	.60
	-0080	.68	7-08-99	73	6.00	.03	< .10	.016	.05	.50	< .03	.24
SDW 524	-0058	26	5-25-99	108	6.11	3.50	1.05	.019	< .01	.09	.34	.14
	-0076	8	5-25-99	127	6.23	.77	.54	.028	.11	.14	.35	.37
	-0096	-10	5-25-99	185	6.29	.00	1.09	.024	5.32	.17	.04	.17
	-0114	-28	5-25-99	162	5.53	9.70	< .10	.011	< .01	.04	.66	< .03

Drive-point sampling in the pond was accomplished with a 0.625-in-diameter, slotted-steel temporary well-point sampler. The target location of a given sample was first determined by measurement from reference points along the shore. Water depth was measured with a folding rule, and the horizontal position was determined with a global positioning system with submeter accuracy. The drive-point sampler was then driven with a sliding hammer about 2 ft below the pond bottom. Samples were collected through a 3/16-in-diameter polyethylene tube inserted inside the sampler opposite the 0.85-ft-long slotted screen. Several volumes of the tubing were purged through the peristaltic pump once a hydraulic connection with the aquifer was established. Field measurements were made at all ample locations, including specific conductance, temperature, and concentrations of dissolved oxygen, ferrous iron, and orthophosphate (PO_4^{-3}). Specific conductance, temperature, and dissolved oxygen concentration were measured with the same methods described in the “Ground-Water Sampling upgradient of the Pond” section. Ferrous iron and orthophosphate concentrations were determined by colorimetric methods described in the section “Colorimetric Field Screening for Orthophosphate and Ferrous Iron.”

A total of 135 locations in Ashumet Pond were sampled along 20 transects (table 5 at back of report, fig. 5). The sampling area extended along the shoreline from about the boundary between the Towns of Falmouth and Mashpee to about 500 ft south of the boat ramp and included most of Fishermans Cove. The shoreline position (fig. 5) was measured on August 20, 1999, with a global positioning system. Pond-bottom sediments were cobbly and rocky along the northern portion of the study area, in contrast to sediments in the vicinity of Fishermans Cove, which ranged from fine silts to medium sands. The pond bottom in the northern, inner section of Fishermans Cove consisted of soft organic sediment, with some algal growth observed. The maximum depth of water in the study area was about 17 ft (table 5, fig. 5); the pond bottom sloped gently in Fishermans Cove and more steeply in the region to the north with the cobbly bottom.

Sampling was completed in three stages. The first stage (August 16–23, 1999) included sampling from 10 lines spaced 100 ft apart. For each line, samples were collected at 10 and 25 ft from the shoreline and then at 25-ft intervals until significant phosphate values were not detected with the field colorimetric method. The second stage of sampling (August 24–26, 1999) included additional sampling between the first stage sampling lines where significant phosphate was detected or additional definition was required. These additional lines are labeled a, b, or c in figure 5 and table 5. The third stage of sampling was finished on October 5, 1999, at which time a barge was used to collect samples at 12 locations where water depths were greater than about 5 ft. All samples are identified in table 5 by a line number followed by the distance from the pond shore in feet.

Collection and Laboratory Analysis of Selected Inorganic Solutes, Nitrate, and Ammonium

All samples from the wells, MLSs, and drive points were collected through in-line 0.45-µm filters (Millex HV) and preserved for analysis of selected inorganic solutes, nitrate, and ammonium. Selected inorganic-solute concentrations (including boron, manganese, iron, and phosphorus) were determined at the USGS Branch of Regional Research Laboratory in Menlo Park, California. Each sample was collected in a 20-mL polyethylene scintillation vial and preserved immediately after collection by amendment of 6N nitric acid to pH less than 2. Samples were shipped to the laboratory and analyzed by inductively coupled plasma atomic emission spectroscopy as described by Coston and others (1998).

Each sample for analysis of nitrate was collected in a 60-mL polyethylene bottle, frozen, and shipped to the USGS Branch of Regional Research Laboratory in Boulder, Colorado. These samples were analyzed with ion chromatography (Dionex Model DX-500) by use of a Dionex AS15 Ion Pac analytical column and an AG15 guard column with a 34 mN potassium hydroxide eluant at a flow rate of 2 mL/min.

Each sample for analysis of ammonium was collected in a 60-mL polyethylene bottle and preserved during collection with sulfuric acid (H_2SO_4). The samples were analyzed by ion chromatography (Dionex Model DX-300) by use of a Dionex CS12A Ion Pac analytical column and a CG12A guard column with a gradient elution of 2.5 to 25 mN H_2SO_4 at a flow rate of 1.5 mL/min.

Colorimetric Field Screening for Orthophosphate and Ferrous Iron

Colorimetric analysis of orthophosphate and ferrous iron was completed in the field. For orthophosphate, two drops of stannous chloride were added to a vial containing 25 mL of the ground-water sample. A self-filling CHEMetrics VACU-vial ampoule (Model 8513) was then opened in the vial. The sample filled the ampoule, and the mixture was allowed to react for 3 minutes. In this method, phosphate in the water sample reacts with ammonium molybdate in the ampoule and is then reduced by stannous chloride to form a blue complex. The blue complex within the ampoule is measured with a field photometer (CHEMetrics VVR multi-analyte photometer) to determine the orthophosphate concentration in milligrams per liter (American Public Health Association and others, 1998).

For samples with dissolved oxygen concentrations near 0 mg/L, ferrous iron was measured with a similar colorimetric analysis. A self-filling CHEMetrics VACU-vial ampoule (Model 6003) was opened in the flowing output from the peristaltic pump, as was done for the dissolved oxygen analysis. Within the ampoule, thioglycolic acid reduces ferric iron in the sample to the ferrous state, which then reacts with 1,10-phenanthroline to form a red solution. The solution is then measured with the field photometer to determine the ferrous iron concentration in milligrams per liter (American Public Health Association and others, 1998).

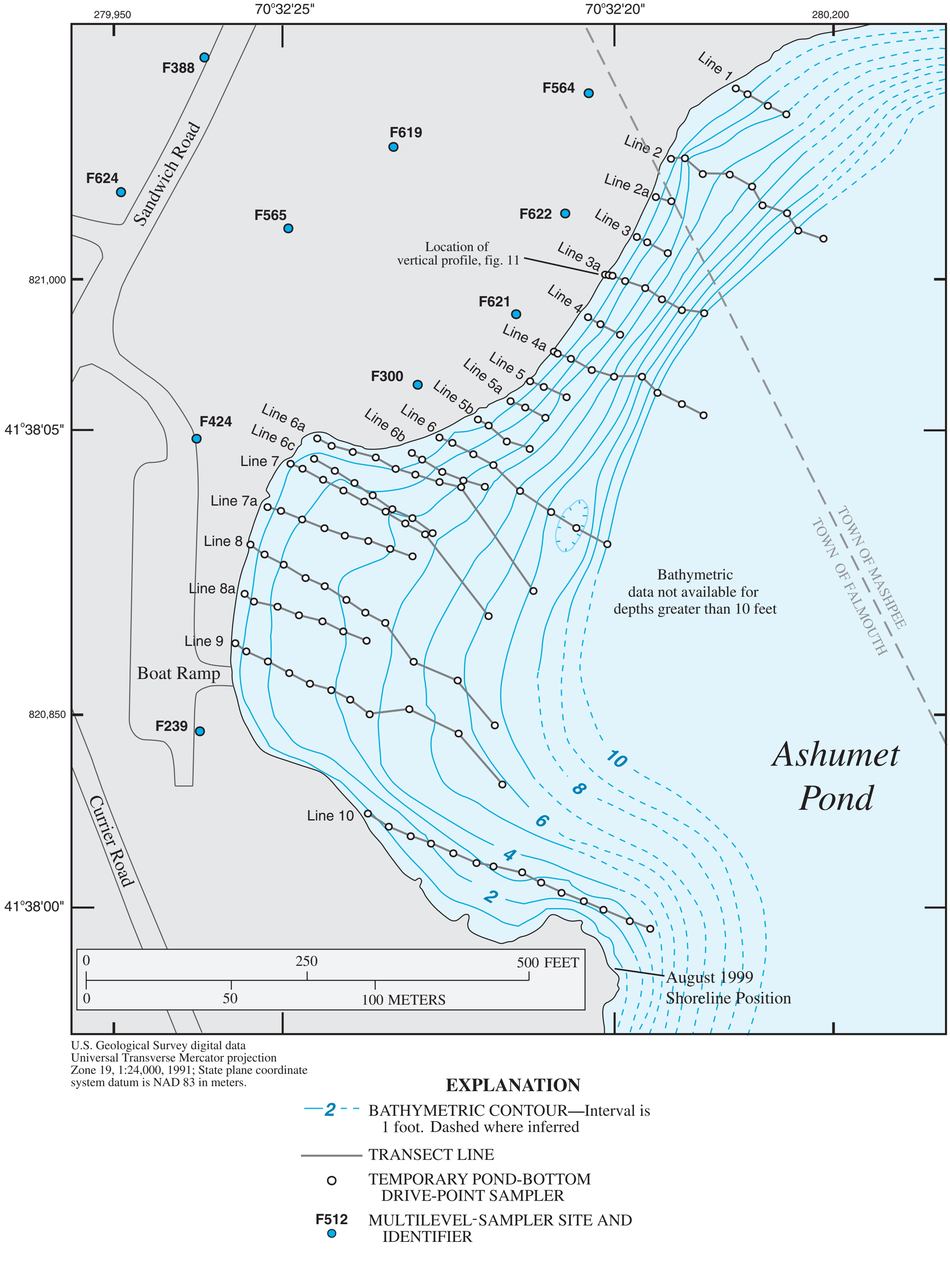


Figure 5. Nearshore bathymetry in the Fishermans Cove area of Ashumet Pond, Massachusetts, and locations of temporary drive points installed in August–October 1999 to delineate the phosphorus discharge area.

Colorimetric measurements done in the field of orthophosphate, up to the maximum detection limit of 1.97 mg/L as P, enabled real-time decisions about spatial sampling. Colorimetric data from the first phase of sampling provided a preliminary evaluation of phosphate distributions in the discharge area of the contaminant plume. From these data, it was possible to obtain additional samples between the original lines of sampling locations in the area where phosphate concentrations were the greatest. The use of field data allowed crews to efficiently sample in areas that were outside the phosphorus discharge area and allowed for detailed surveys of the area with the greatest phosphorus concentrations.

Comparison of laboratory analysis and the colorimetric field screening showed close correlation ($R^2 = 0.9667$) of the two data sets for samples with field measurements less than 1.97 mg/L as P and greater than the detection limits of 0.10 mg/L for laboratory analysis and 0.20 mg/L for field screening (fig. 6). This finding indicates that the colorimetric analysis is an accurate method of field screening for phosphorus in these waters.

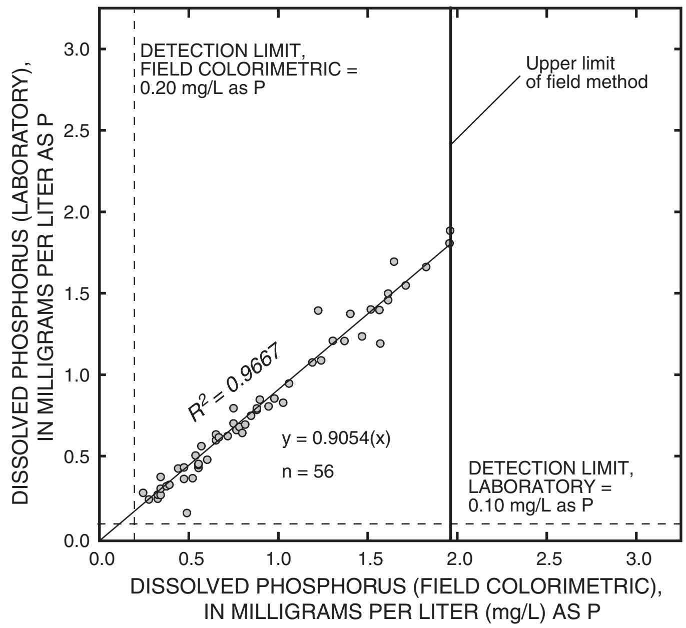


Figure 6. Comparison of field- and laboratory-determined dissolved phosphorus concentrations in pond-bottom ground water in the contaminant-plume discharge area, Ashumet Pond, Massachusetts, 1999.

DISTRIBUTION OF PHOSPHORUS AND OTHER CONTAMINANT-PLUME CONSTITUENTS

The distribution of dissolved phosphorus in the aquifer near Ashumet Pond was determined on the basis of the methods described in the “Study Design and Methodology” section. In general, the distribution of dissolved phosphorus in the contaminant plume is consistent with findings of previous investigations, and the distribution of dissolved phosphorus beneath the pond bottom reflects the upgradient observations. Other sewage-related constituents investigated include specific conductance, boron, manganese, nitrate, and ammonium.

Phosphorus in the Aquifer upgradient of Ashumet Pond

The area of phosphorus concentrations greater than the background level of 0.10 mg/L as P extends from the infiltration beds to Fishermans Cove (fig. 7). Concentrations greater than 0.5 mg/L were detected as far south as the boat ramp, or about 1,700 ft from the beds. The data for the newly installed MLSs (table 4 and fig. 7) show phosphorus concentrations as high as about 3.1 mg/L at about 75 ft upgradient of the pond shore (site F621), with a concentration of about 4.6 mg/L at about 300 ft upgradient of the pond (site F619), or about half the distance between Sandwich Road and the pond. Previous studies (Walter and others, 1996; Bussey and Walter, 1996) did not find phosphorus concentrations greater than 1.9 mg/L southeast of Sandwich Road, presumably because of the sparser sampling network available at that time.

Section *A-A′* is a longitudinal section that follows the general direction of ground-water flow along the center of the area of elevated phosphorus concentrations (fig. 7). The section extends from slightly northwest of site F591 to Ashumet Pond. Section *A-A′* indicates that phosphorus concentrations greater than 0.1 mg/L are in a zone that is 80–100 ft thick (fig. 8). Near the pond, the phosphorus-containing zone is overlain by about 6 to 8 ft of ground water derived from recharge along the path of the plume. Upward movement of the phosphorus plume as it approaches Ashumet Pond is not clearly evident from the concentration distribution shown in figure 8.

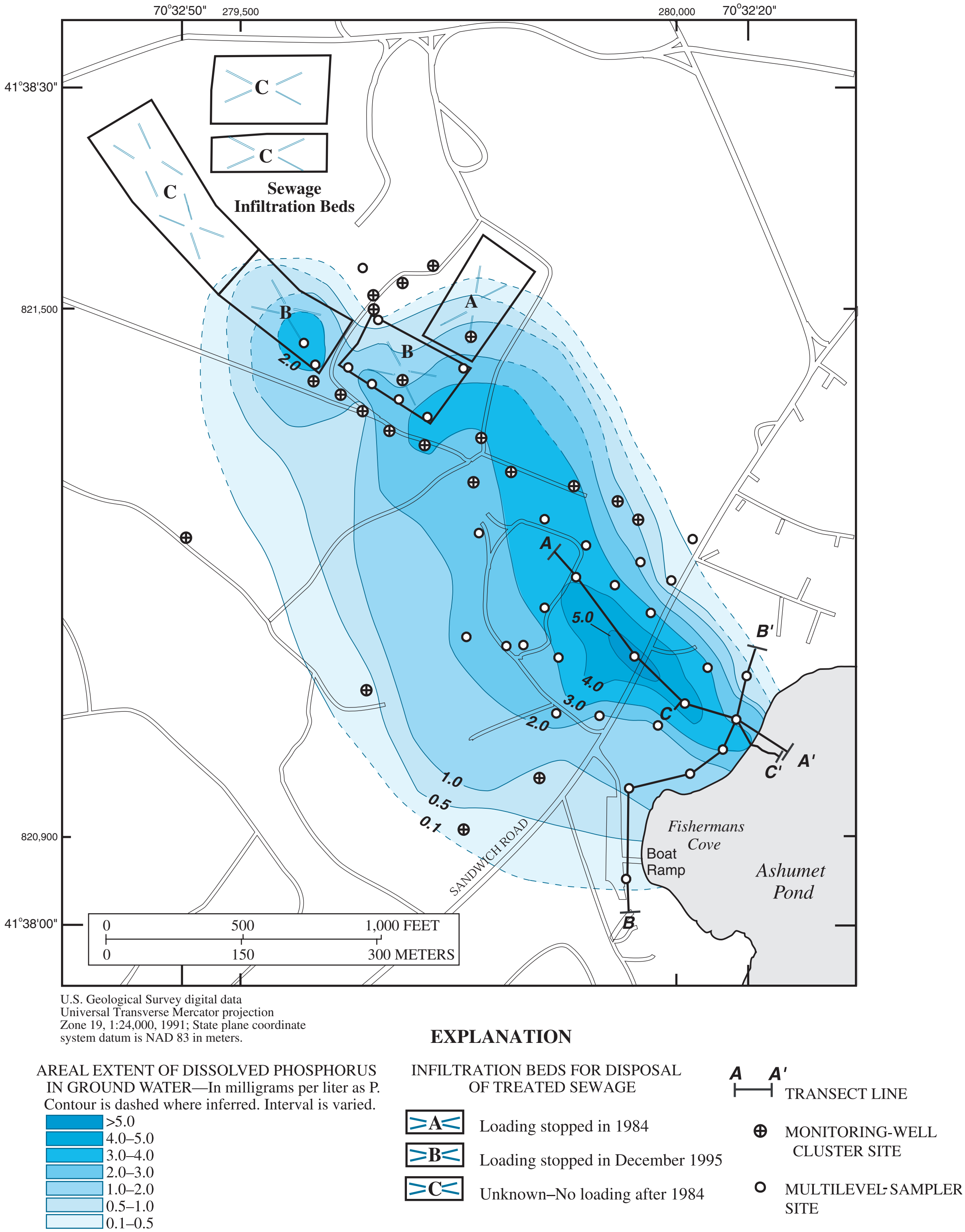


Figure 7. Areal distribution of maximum dissolved phosphorus concentrations in ground water upgradient of Ashumet Pond, Massachusetts, April–July 1999.

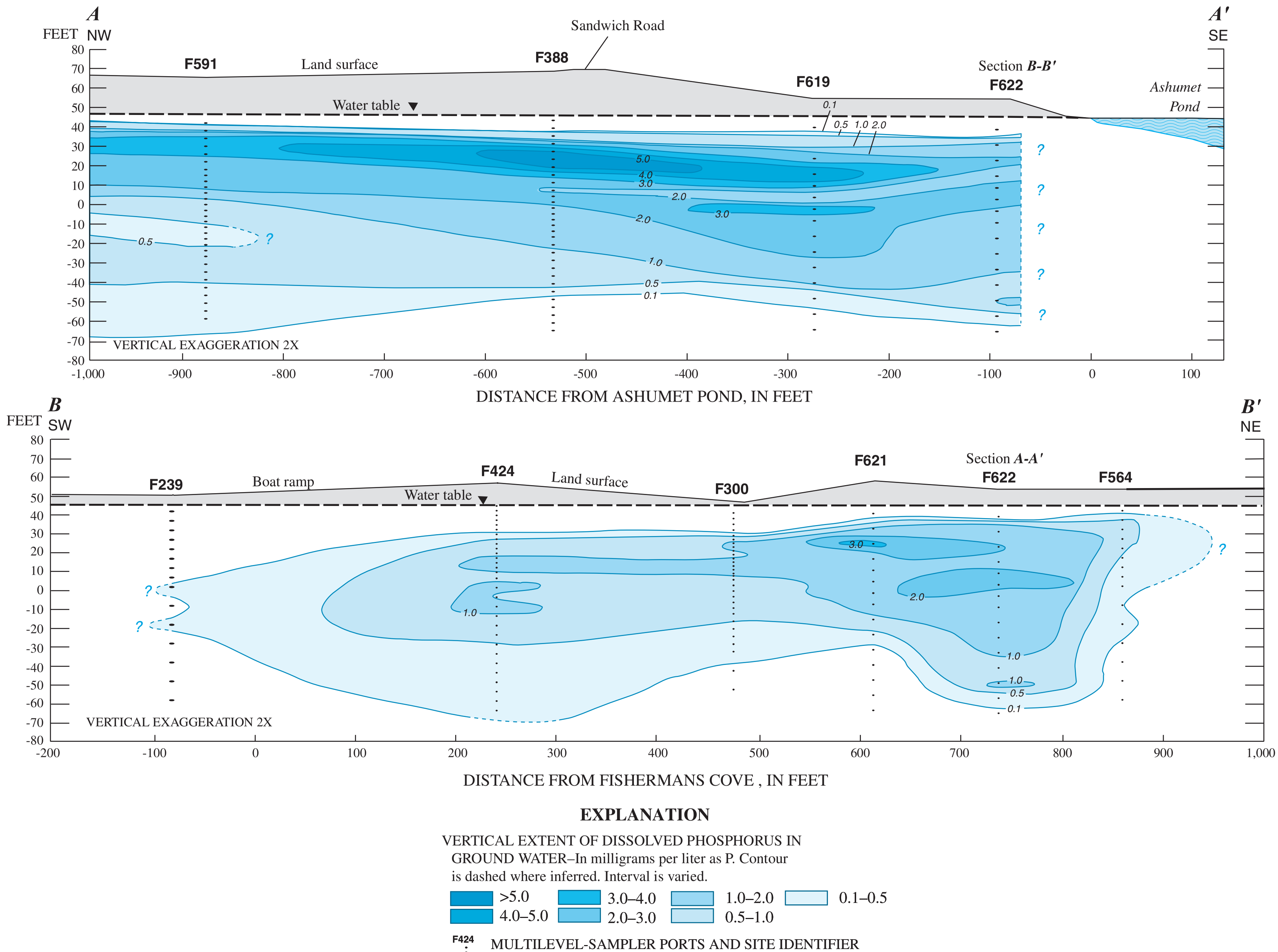


Figure 8. Vertical distribution of dissolved phosphorus concentrations along sections A-A′ and B-B′ upgradient of Ashumet Pond, Massachusetts, April–July 1999 (locations of the sections shown in fig. 7).

Concentrations at site F622, which is only 75 ft upgradient of the pond shore, show some upward curvature of the concentration contours relative to the concentration distribution at F619 located 225 ft upgradient, but the overall thickness of the phosphorus-containing zone remains about 100 ft.

The transverse section *B-B′*, which extends along the shoreline from site F239 to site F564 (fig. 7), shows phosphorus concentrations greater than 0.1 mg/L along the pond in a zone with a shoreline width greater than 1,000 ft (fig. 8). The thickness of the phosphorus-containing zone ranges from 30 to 100 ft.

Phosphorus in Shallow Ground Water beneath the Pond Bottom

The areal extent of elevated phosphorus concentrations (greater than 0.1 mg/L) in ground water beneath the pond bottom was delineated by analysis of ground-water samples collected from approximately 2 ft below the pond bottom. Previous investigations showing upward hydraulic gradients below the pond bottom, coupled with the detection of sewage-related constituents, indicate that these samples are representative of the ground water about to discharge into the pond, although chemical and biological processes may attenuate constituent concentrations as the ground water discharges into the pond.

Phosphorus concentrations in samples from ground water beneath the pond bottom ranged from less than 0.01 mg/L in uncontaminated water to 3.1 mg/L in contaminated water. The concentration data indicate that ground water with elevated phosphorus concentrations was discharging in 1999 along about 875 ft of shoreline northeast of the Fishermans Cove boat ramp (fig. 9). The discharge area in which phosphorus concentrations were greater than 2.0 mg/L extended along about 225 ft of shoreline and was located about 5 to 30 ft from the shoreline (fig. 9). This location of greatest phosphorus concentrations in ground water discharging to the pond was consistent with the location of the greatest concentrations in ground-water samples taken upgradient of the shoreline in the aquifer (fig. 10). Phosphorus concentrations greater than 1.0 mg/L were found along about 280 ft of shoreline (fig. 9), and all detections greater than 1.0 mg/L were located within 40 ft of the shore. All phosphorus detections above 0.10 mg/L were within 75 ft from shore and no samples collected from Fishermans Cove exceeded 0.8 mg/L of phosphorus.

A vertical profile of water samples collected with the drive-point method at one position at the shoreline (fig. 5) provided data to 10 ft below land surface (fig. 11). The samples were collected at vertical intervals of 1 ft. Limitations of the drive-point sampling method prevented sampling to a greater depth. Data from the shoreline profile are labeled "3a-00-ST#" in table 5, with # representing the depth below land surface in feet. The profile showed a trend of increasing phosphorus concentration with depth (fig. 11). The minimum phosphorus concentration in the vertical profile was 0.30 mg/L at 1 ft below land surface, which was significantly greater than the background concentration (reported as less than the detection limit of 0.1 mg/L). The maximum concentration was 1.81 mg/L at 10 ft below land surface. Oxic conditions existed down to 7 ft, below which suboxic conditions (less than 1 mg/L of dissolved oxygen) prevailed. More than 2 ft of low-conductance ground water (less than 100 µS/cm) overlies water with conductance typical of the sewage plume (175–400 µS/cm). The low level of dissolved phosphorus in the otherwise uncontaminated ground water may reflect the earlier presence of the plume at this depth.

The distribution of phosphorus in ground water near the pond and beneath the pond bottom is consistent with the conceptual model of ground-water discharge into Ashumet Pond and other kettle-hole ponds (fig. 4). Section *C-C′* (fig. 12) illustrates the vertical distribution of phosphorus drawn with no vertical exaggeration. The zone of elevated phosphorus concentrations has a vertical thickness of about 94 ft at site F622 and emerges along the pond bottom across a width of about 75 ft. Ground-water flowlines bend upward and converge as ground water discharges to the pond. Section *C-C′* passes through the location of the greatest phosphorus concentration in the pond-bottom samples (3a-25) but passes northeast of the MLS with the greatest concentration in the aquifer (site F621) immediately upgradient of the pond. The section, therefore, may not be aligned exactly along a flow path, and phosphorus concentrations exceeding 3 mg/L probably would be found in the aquifer between sites F621 and F622 (fig. 7).

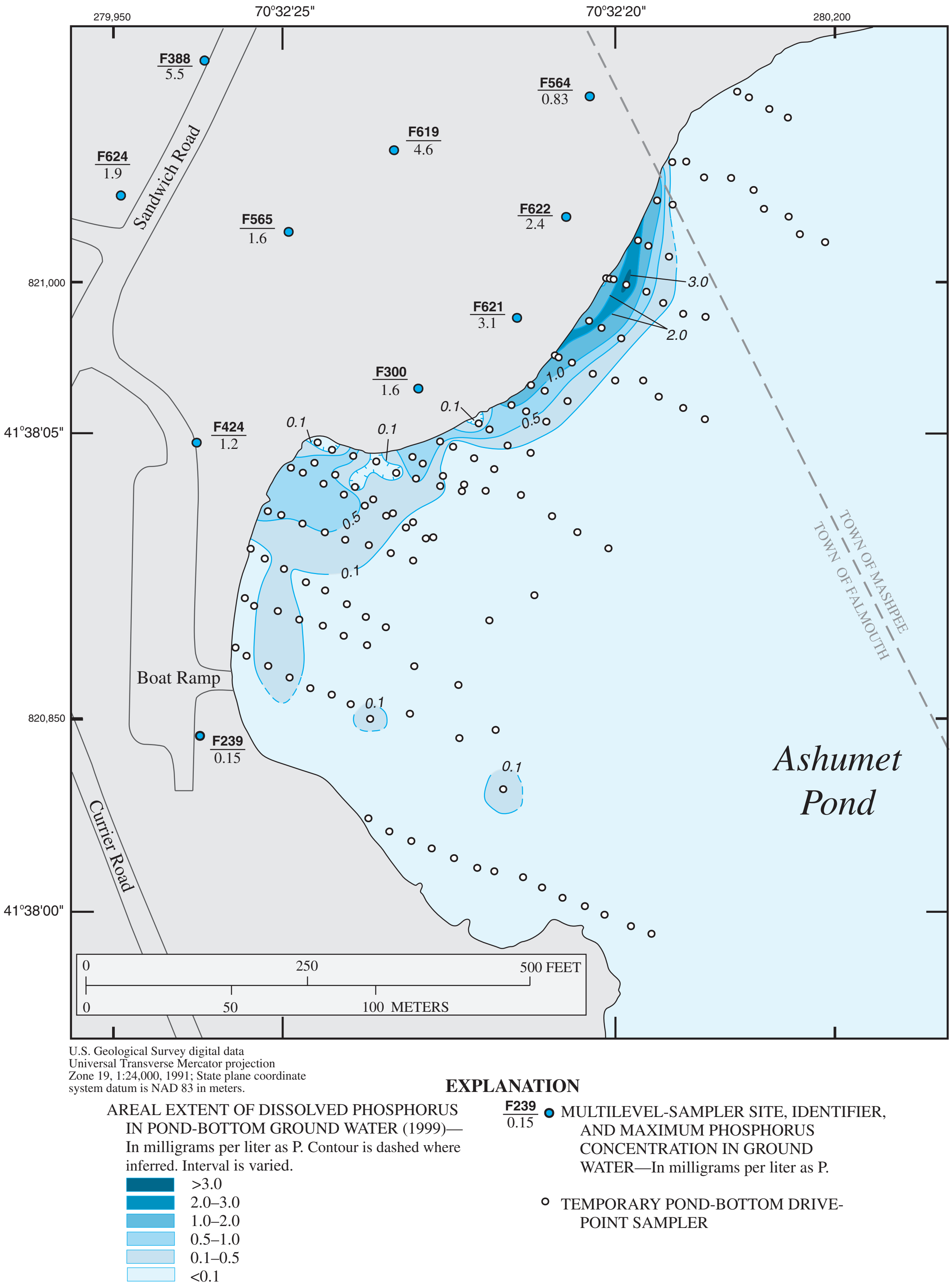


Figure 9. Areal distribution of dissolved phosphorus in pond-bottom ground water in the contaminant-plume discharge area and maximum dissolved phosphorus concentrations measured in ground water at upgradient multilevel-sampling sites, Ashumet Pond, Massachusetts, August–October 1999.

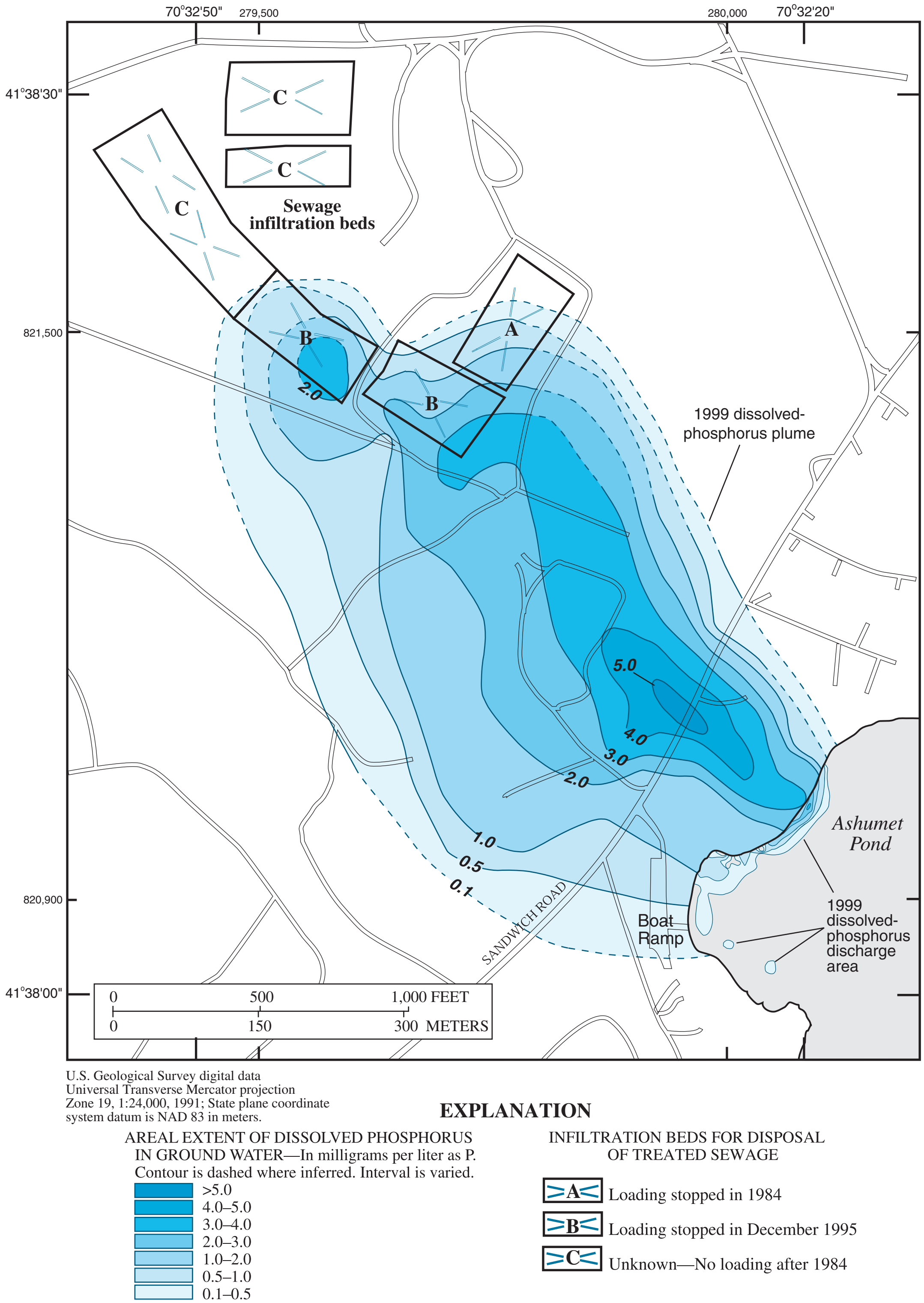


Figure 10. Areal distribution of dissolved phosphorus in ground water near Ashumet Pond, Massachusetts, May–October 1999.

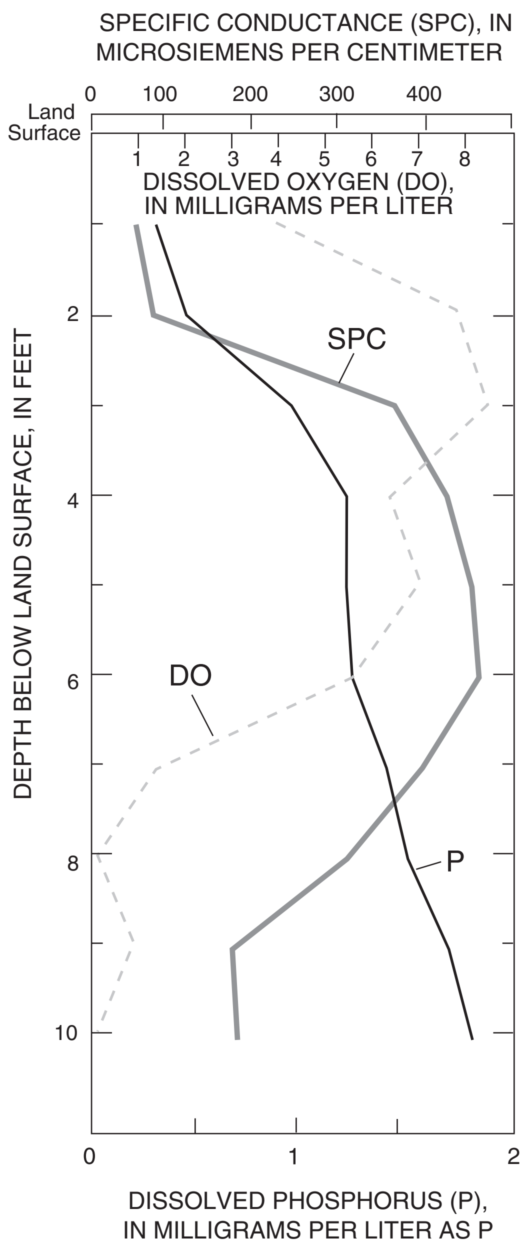


Figure 11. Distribution of dissolved phosphorus, specific conductance, and dissolved oxygen at a vertical profile (3a-00-ST) at the shoreline of Ashumet Pond, Massachusetts, August 24, 1999 (location of profile shown in fig. 5).

The map of phosphorus concentrations in pond-bottom samples shown in figure 9 is consistent with the data collected by AFCEE (2002a) from 15 boreholes drilled in the Fishermans Cove area. In that investigation, the phosphorus concentrations reported for the ground-water samples collected several feet below the pond bottom at seven boreholes located within about 50 ft of shore showed high phosphorus concentrations that persisted to depths of as much as 50 ft below the pond bottom. The phosphorus concentrations in five boreholes drilled in the pond more than 200 ft from the shore, however, showed only low levels of phosphorus, supporting the hypothesis that the phosphorus-contaminated ground water discharges close to shore.

Sewage-Related Constituents in Shallow Ground Water beneath the Pond Bottom

The spatial distributions of conservative and nonconservative chemical species found in the plume are indicative of a sporadic loading history at the infiltration beds and consequent variation in the geochemistry of ground water near Ashumet Pond. Specific conductance, a measure of total dissolved solids in ground water, is a reliable conservative indicator of the effects of treated sewage in the study area. Boron is commonly found in sewage because of its use in cleaning agents. In this aquifer, it is transported conservatively (LeBlanc, 1984b). Manganese is a reactive species that occurs naturally as manganese oxide coatings on sediment. Dissolved manganese can be in ground water where reducing geochemical conditions exist, such as in sewage-contaminated ground water. Nitrogen in the contaminant plume is in two predominant forms: nitrate and ammonium. The species of nitrogen in the ground water depend on the redox conditions in the aquifer, which vary spatially in the contaminated zone. Characterization of the concentrations and spatial distribution of these chemical species and properties in pond-bottom water samples provided information on their current (1999) discharge into Ashumet Pond.

Specific Conductance

The specific conductance of the treated sewage that was applied to the infiltration beds was four to five times higher than the maximum conductance (50 to 90 μS/cm) that is typically found in uncontaminated ground water in the aquifer. In 1979, elevated conductance (greater than 200 μS/cm) was measured in the aquifer in a zone more than 2,000 ft wide and 8,000 ft long (LeBlanc, 1984b), and conductances greater than 400 μS/cm were measured near Ashumet Pond. In 1993, Walter and others (1996) measured conductance values from pond-bottom sampling of greater than 400 μS/cm at one location about 700 ft north of the Fishermans Cove boat ramp. Maximum conductance in ground water at sites between the beds and the pond sampled in 1995 was near 400 μS/cm (Bussey and Walter, 1996).

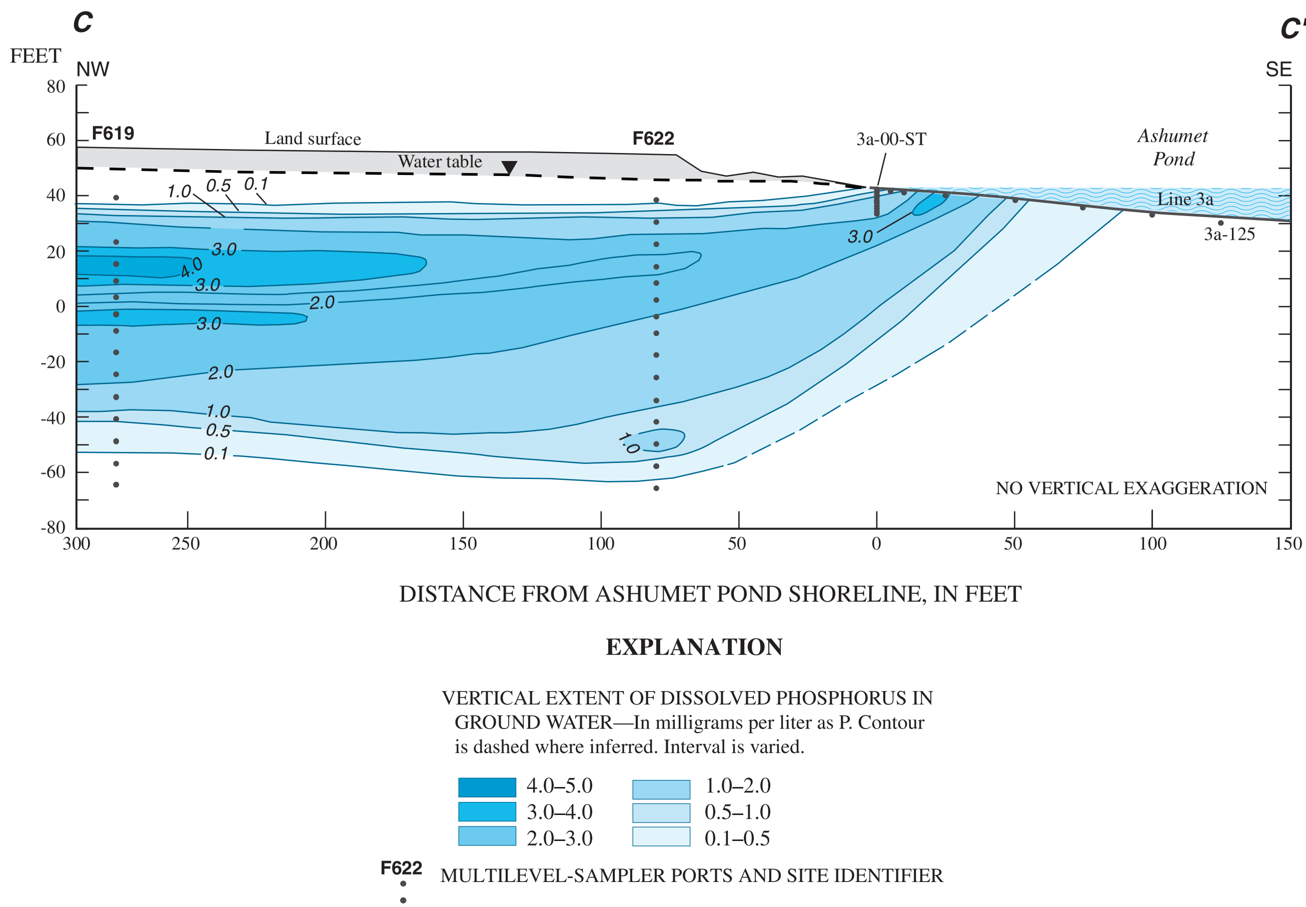


Figure 12. Vertical distribution of dissolved phosphorus concentrations along section C-C′ from multilevel sampler F619 to pond-bottom location 3a-125, Ashumet Pond, Massachusetts, April–October 1999 (location of profile shown in fig. 7).

The conservative species have begun to flush out of the aquifer since disposal of treated sewage ended in December 1995. LeBlanc and others (1999) show that specific conductance under the infiltration beds decreased to less than 200 µS/cm about 1.5 years after disposal ended. The ground-water-travel time between the infiltration beds and the pond is estimated to be about 3.5 years (on the basis of a travel distance of 1,700 feet and an average velocity of 1.4 ft/day) (LeBlanc and others, 1999). Consequently, early effects of the cessation of sewage disposal in December 1995 were expected to be observed in samples collected from locations around the pond in the summer of 1999. It is less clear how earlier events, such as the shift in disposal location from the eastern to the southern beds in 1984, affect plume characteristics.

Ground-water sampling upgradient of the pond in 1999 (fig. 13) showed conductance values near 400 µS/cm at a site near the pond shore about 250 ft north of the boat ramp (site F424). The maximum specific conductance decreased to the northeast in samples collected nearest to the shore. Sampling at the most northerly MLS near the shore (site F564) yielded a maximum conductance of 151 µS/cm.

The sampling from drive points in the pond showed a similar spatial trend. Elevated conductance (greater than 100 µS/cm) was found along about 1,400 ft of shoreline from about 900 ft north of the boat ramp to the southern extent of the pond-bottom sampling area (fig. 13). Conductance values greater than 400 µS/cm were measured at five drive-point locations in the center of Fishermans Cove, in an area that is downgradient from site F424 where similarly high values were measured on shore. Elevated specific conductance values greater than 200 µS/cm were measured at five locations north of Fishermans Cove in the area of greatest phosphorus concentrations.

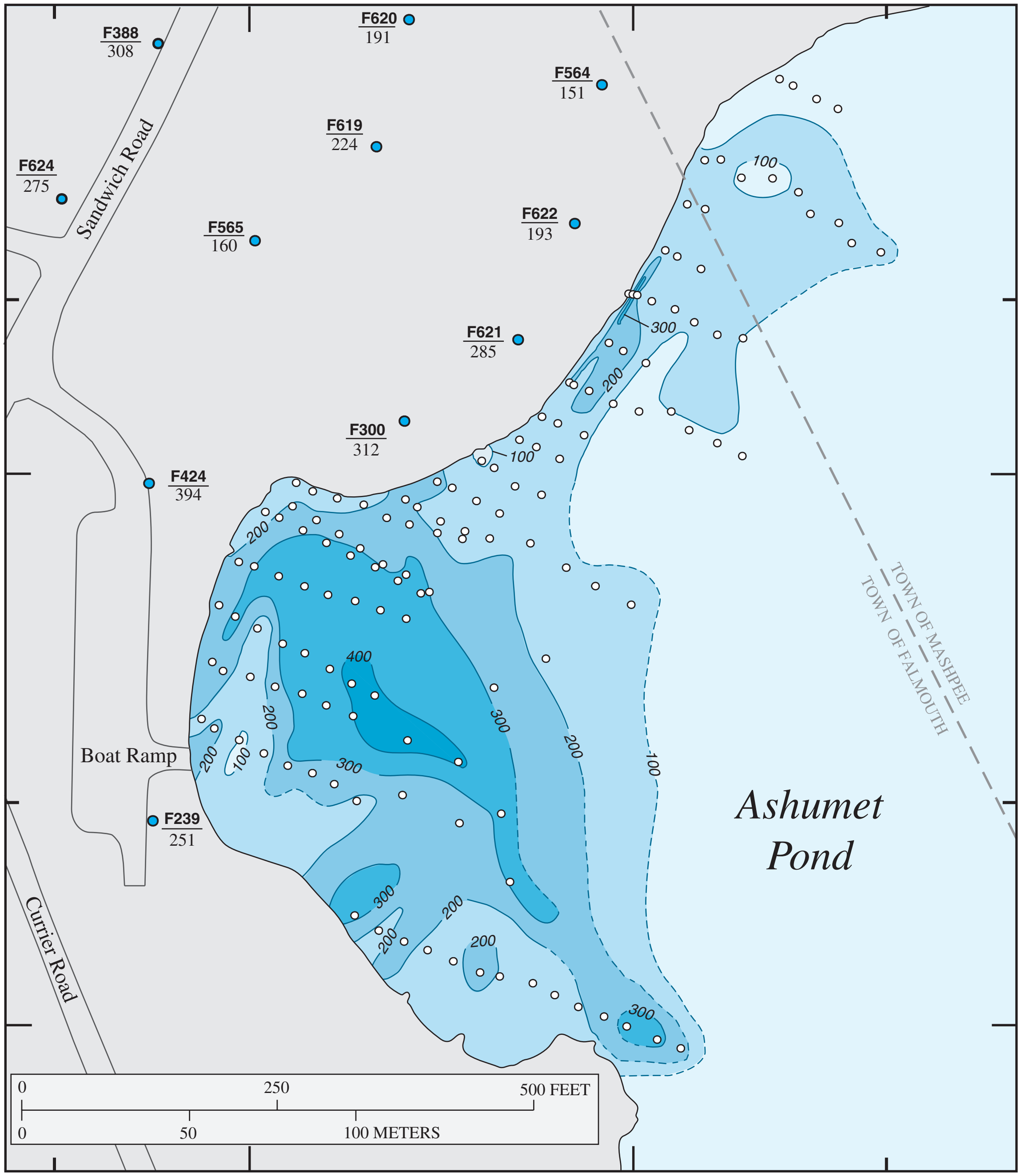
The area of specific conductance greater than 400 µS/cm in the pond-bottom water was smaller and farther to the south in 1999 than the area observed in 1986 (K-V Associates, 1991) (figs. 3 and 13). The southward shift between 1986 and 1999 may reflect the shift in disposal location in 1984 from the eastern to the southern beds and the subsequent cessation of disposal in 1995. The 1986 sampling was also sparse in the area of highest conductance in 1999; this difference in sampling locations may also explain the perceived differences in distribution.

Boron

Previous studies have used dissolved boron concentrations to show the extent of the sewage-related contaminants (LeBlanc, 1984b; Bussey and Walter, 1996). Dissolved boron attenuates primarily by dilution and dispersion; it is transported in this aquifer with no significant retardation by chemical reactions with the aquifer sediments (LeBlanc, 1984a). The treated-sewage effluent applied to the infiltration beds contained boron at a concentration of 0.42 mg/L when sampled in 1994 (Savoie and LeBlanc, 1998). Maximum boron concentrations in ground water along Ashumet Pond in 1995 were as great as 0.44 mg/L at site F424; concentrations decreased progressively to the northeast to a low maximum value of 0.04 mg/L at site F564 (Bussey and Walter, 1996).

Boron concentrations in ground water downgradient of the infiltration beds have decreased since disposal ended in 1995 as the conservatively transported species, such as boron, are flushed away by natural ground-water flow (LeBlanc and others, 1999; Barber and Keefe, 1999). Water samples collected from wells and MLSs in 1999 showed spatial trends in boron concentrations in the aquifer that are similar to those observed by Bussey and Walter (1996) in 1995 near Ashumet Pond. A maximum concentration of 0.37 mg/L was measured at site F424, and maximum concentrations decreased to the north to 0.02 mg/L at site F564 (fig. 14).

Analysis of pond-bottom ground-water samples showed a discharge pattern of elevated boron concentrations (greater than 0.10 mg/L; fig. 14) that was similar to that of specific conductance. Due to the gradual flushing of contaminated water from the northeastern portion of the sewage-contaminated zone, the predominant area of boron discharge was in Fishermans Cove; however, low but detectable levels of boron persisted as far northeastward as line 3a (table 5).



U.S. Geological Survey digital data
Universal Transverse Mercator projection
Zone 19, 1:24,000, 1991; State plane coordinate
system datum is NAD 83 in meters.

EXPLANATION

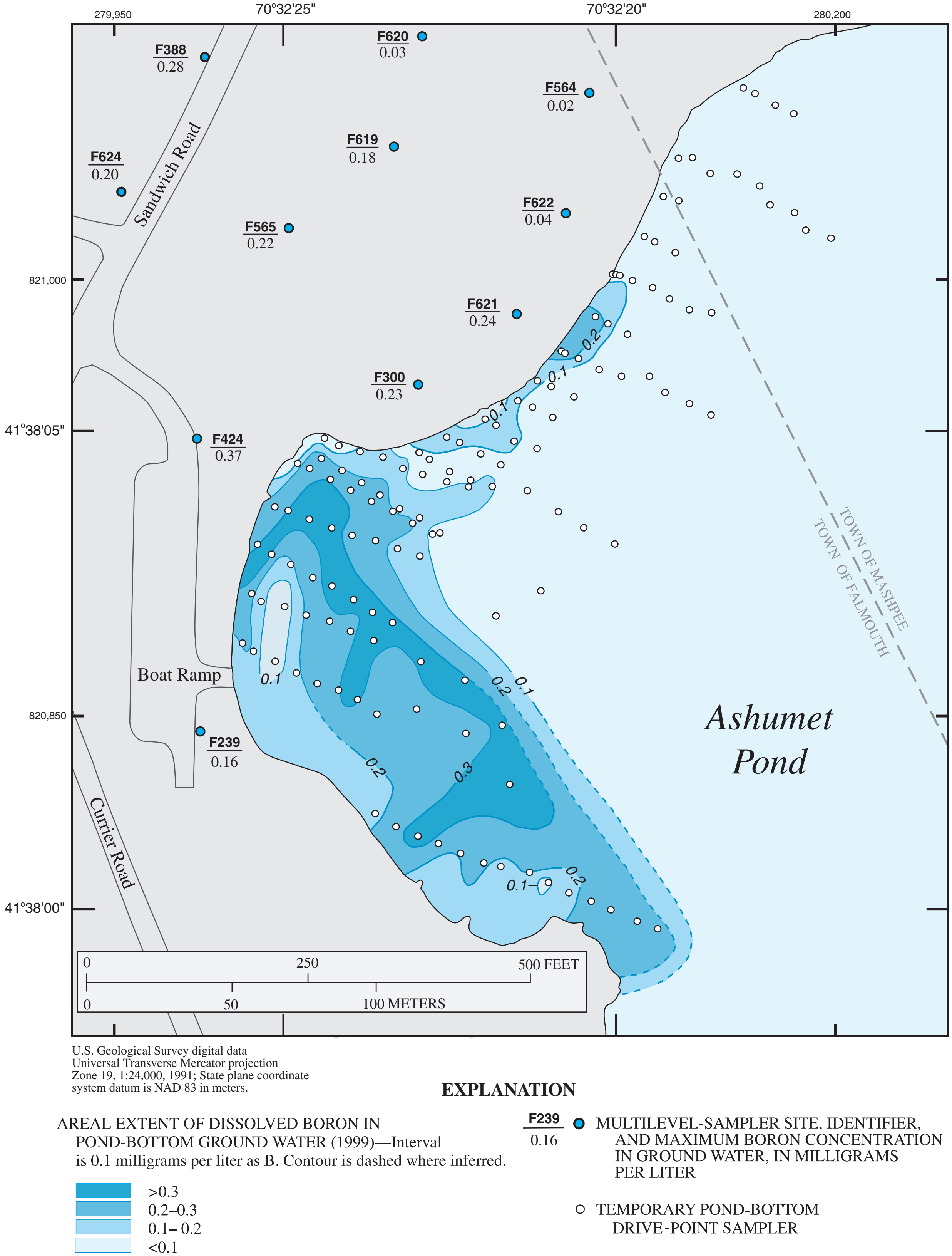
AREAL EXTENT OF SPECIFIC CONDUCTANCE IN POND-BOTTOM GROUND WATER (1999)—Interval is 100 microsiemens per centimeter at 25°Celsius. Contour is dashed where inferred.

- >400
- 300–400
- 200–300
- 100–200
- <100

F239 / 251 — MULTILEVEL-SAMPLER SITE, IDENTIFIER, AND MAXIMUM SPECIFIC CONDUCTANCE IN GROUND WATER, IN MICROSIEMENS PER CENTIMETER

TEMPORARY POND-BOTTOM DRIVE-POINT SAMPLER

Figure 13. Areal distribution of specific conductance in pond-bottom ground water in the contaminant-plume discharge area and maximum specific conductance measured in ground water at upgradient multilevel-sampling sites, Ashumet Pond, Massachusetts, August–October 1999.



U.S. Geological Survey digital data
Universal Transverse Mercator projection
Zone 19, 1:24,000, 1991; State plane coordinate
system datum is NAD 83 in meters.

Figure 14. Areal distribution of dissolved boron in pond-bottom ground water in the contaminant-plume discharge area and maximum dissolved boron concentrations measured in ground water at upgradient multilevel-sampling sites, Ashumet Pond, Massachusetts, August–October 1999.

Manganese

Dissolved manganese has been detected upgradient of the pond in the areas of the aquifer where suboxic conditions occur. Concentrations in 1994 ranged from less than 0.01 mg/L at uncontaminated locations to as great as 32 mg/L in the sewage-contaminated area (Savoie and LeBlanc, 1998). In 1993, the zone in which dissolved manganese was greater than 1 mg/L was thickest (about 80 ft), and concentrations were greatest, at sites immediately upgradient of the pond (Walter and others, 1996). Dissolved manganese concentrations exceeded 5 mg/L at three MLS sites along the shore at Fishermans Cove.

The 1995 shutdown of sewage disposal has only minimally affected the distribution of dissolved oxygen downgradient of the infiltration beds (LeBlanc and others, 1999; Barber and Keefe, 1999). The reservoir of organic carbon associated with the aquifer sediment because of 60 years of sewage disposal continues to support microbial consumption of oxygen that enters the sewage-contaminated zone with the natural ground-water flow. Therefore, there has been little effect on the distribution of redox sensitive species, such as manganese, between the infiltration beds and the pond.

Water samples collected from wells and MLSs in 1999 showed maximum dissolved manganese concentrations near Ashumet Pond ranging from about 1.9 to 7.6 mg/L (fig. 15). The greatest concentrations were detected at site F300 on the northern side of Fishermans Cove.

Dissolved manganese concentrations were determined in samples taken from pond-bottom drive points in August-October 1999 (fig. 15). Elevated levels of manganese (greater than 2 mg/L) were detected along about 550 ft of shoreline and as far as 300 ft offshore. The area of greatest concentration was in the north-central portion of Fishermans Cove, with concentrations as high as 10.3 mg/L, opposite site F300 where the greatest concentrations were measured onshore.

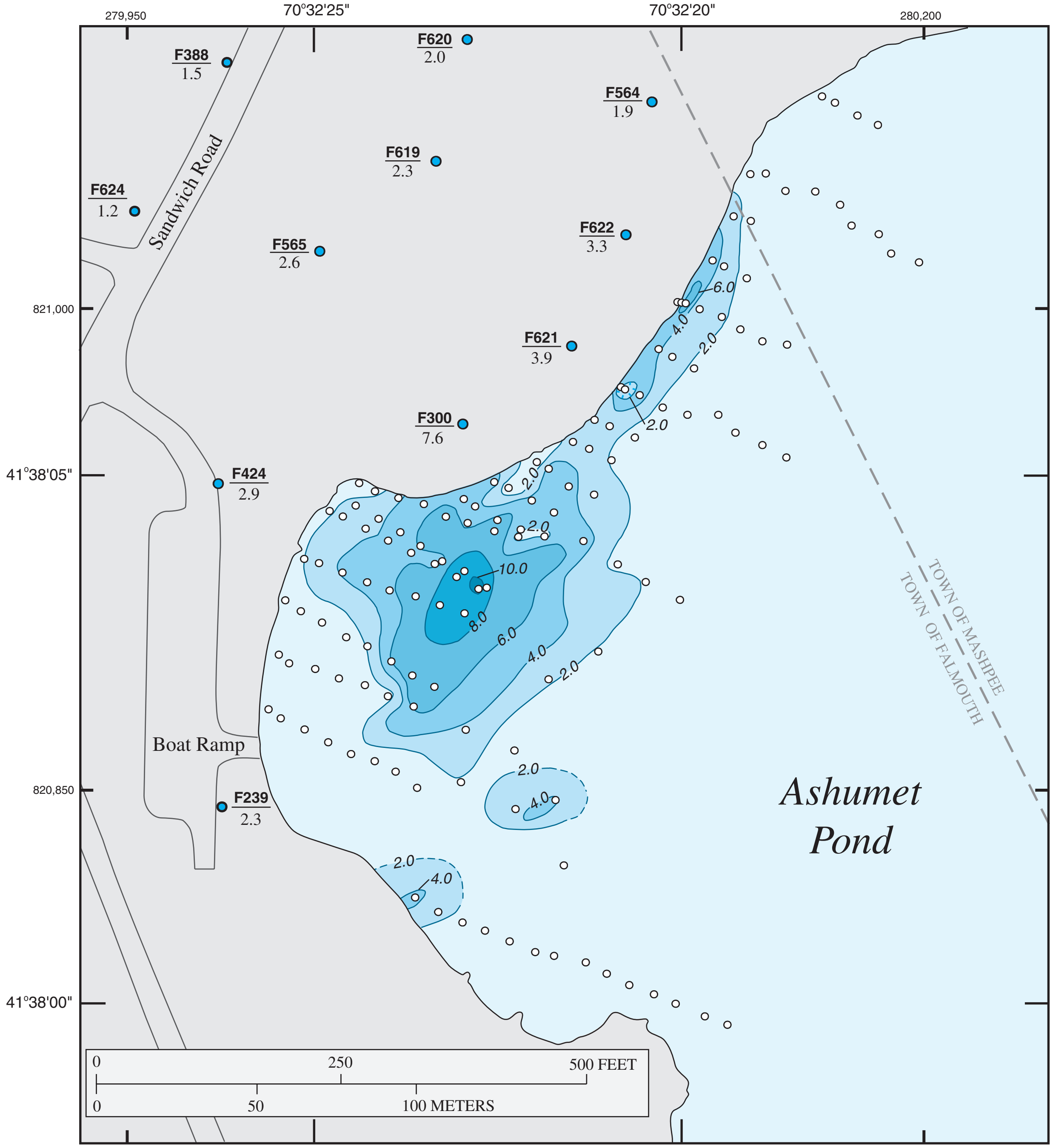
The area with the greatest manganese concentrations in the ground water beneath the pond bottom was located between the areas of the greatest boron (fig. 14) and phosphorus concentrations (fig. 9). The absence of elevated manganese concentrations in the southern portion of Fishermans Cove, where boron and specific conductance are elevated, may reflect the downgradient extent of suboxic conditions that are sufficiently reducing to mobilize manganese in the contaminated zone.

The lower but still elevated levels of manganese opposite sites F621 and F622 (fig. 14), where phosphorus levels below the pond bottom are greatest, may reflect the relatively recent flushing of sewage-contaminated ground water from this area. The black sand and rocks that form the pond bottom in this area may be visual evidence for this discharge. The black color is caused by coatings formed by precipitation of manganese oxide where the contaminants have discharged to the pond (Lee and Bennett, 1998). The manganese-coated sand and rocks that form the pond bottom near sites F621 and F622 indicate that suboxic sewage-contaminated ground water has discharged to the pond in this area.

Nitrate and Ammonium

Nitrogen in the sewage-contaminated aquifer occurs predominantly as nitrate (NO_3^-) and ammonium (NH_4^+) (LeBlanc, 1984b; Smith and others, 1999). In the aquifer upgradient of the pond, nitrogen occurs as ammonium in the suboxic to anoxic core of the sewage-contaminated zone. This core is surrounded by nitrate-containing ground water in the oxic to suboxic edges. Denitrification of nitrate to nitrogen gas takes place in the core where dissolved oxygen is absent. The nitrogen distribution in samples from wells and MLSs at sites near the pond shore typically has these same spatial features. In May 1999, dissolved nitrate at site F300 was greater than 0.3 mg/L as N in a 25-ft-thick zone at the top of the sewage-contaminated zone and in a 46-ft-thick zone that extended to the deepest sampling port (table 4). A zone of elevated levels of dissolved ammonium (greater than 0.3 mg/L as N) at least 70 ft thick was in the core, also extending to the deepest sampling port (table 3). The zone of high nitrogen concentrations typically extends deeper than the zone of high phosphorus concentrations.

Analysis of pond-bottom ground-water samples showed elevated nitrogen concentrations throughout the sampled area. Elevated nitrate (greater than 1 mg/L) was measured along more than 1,000 ft of shoreline (fig. 16). Two general regions of elevated nitrate (greater than 1 mg/L) were detected, one within 50 ft of shore and another about 100 to 300 ft from shore. The greatest nitrate concentrations (more than 10 mg/L as N) were at three locations in the center of Fishermans Cove. An area of nitrate concentrations of 2 to 4 mg/L that stretched along the region of elevated phosphorus concentrations but was farther from the shore also was detected (figs. 9 and 16).



U.S. Geological Survey digital data
Universal Transverse Mercator projection
Zone 19, 1:24,000, 1991; State plane coordinate
system datum is NAD 83 in meters.

EXPLANATION

AREAL EXTENT OF DISSOLVED MANGANESE IN POND-BOTTOM GROUND WATER (1999)—Interval is 2.0 milligrams per liter as Mn. Contour is dashed where inferred.

- >10.0
- 8.0–10.0
- 6.0–8.0
- 4.0–6.0
- 2.0–4.0
- <2.0

F239 / 2.3 — MULTILEVEL-SAMPLER SITE, IDENTIFIER, AND MAXIMUM MANGANESE CONCENTRATION IN GROUND WATER, IN MILLIGRAMS PER LITER

TEMPORARY POND-BOTTOM DRIVE-POINT SAMPLER

Figure 15. Areal distribution of dissolved manganese in pond-bottom ground water in the contaminant-plume discharge area and maximum dissolved manganese concentrations measured in ground water at upgradient multilevel-sampling sites, Ashumet Pond, Massachusetts, August–October 1999.

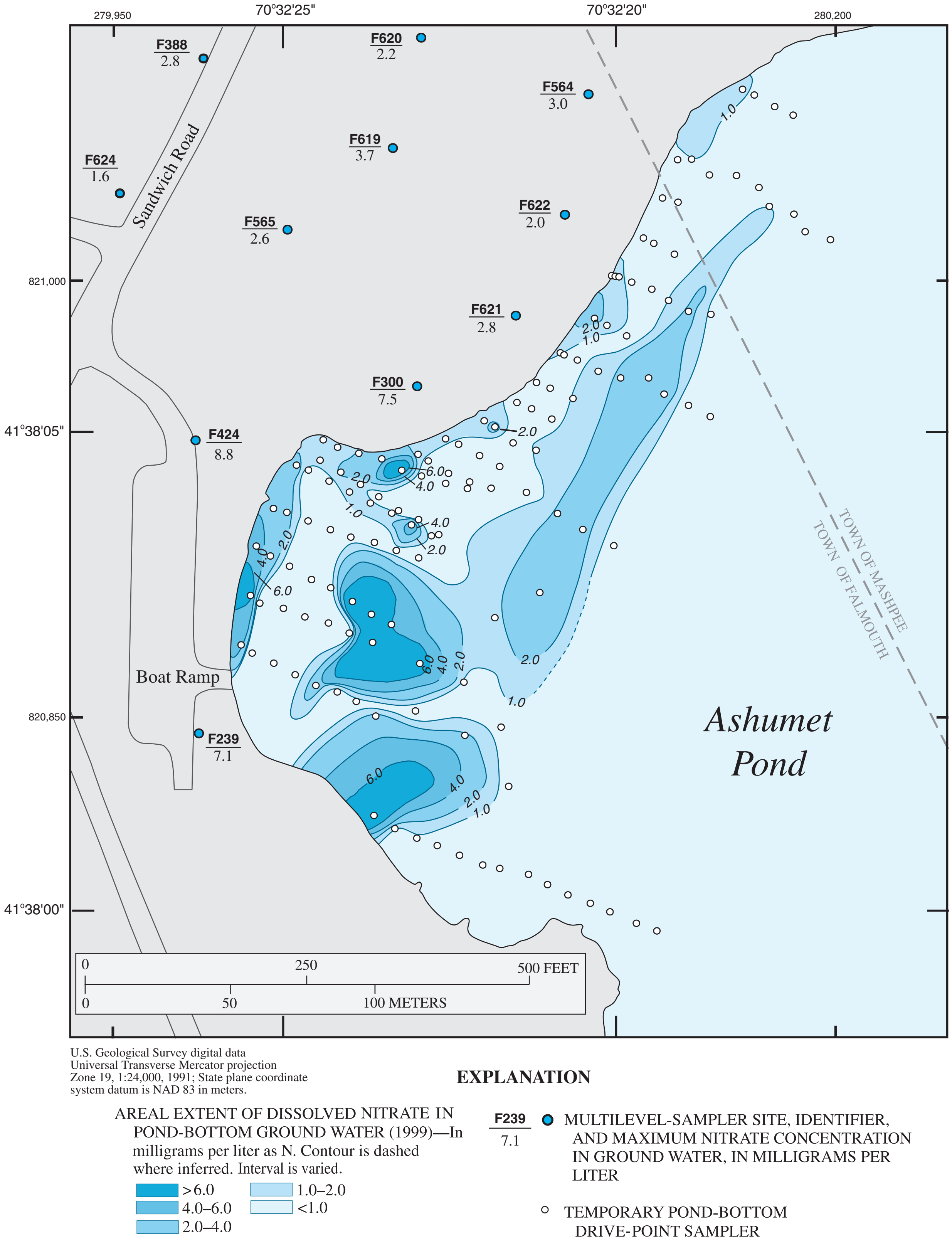
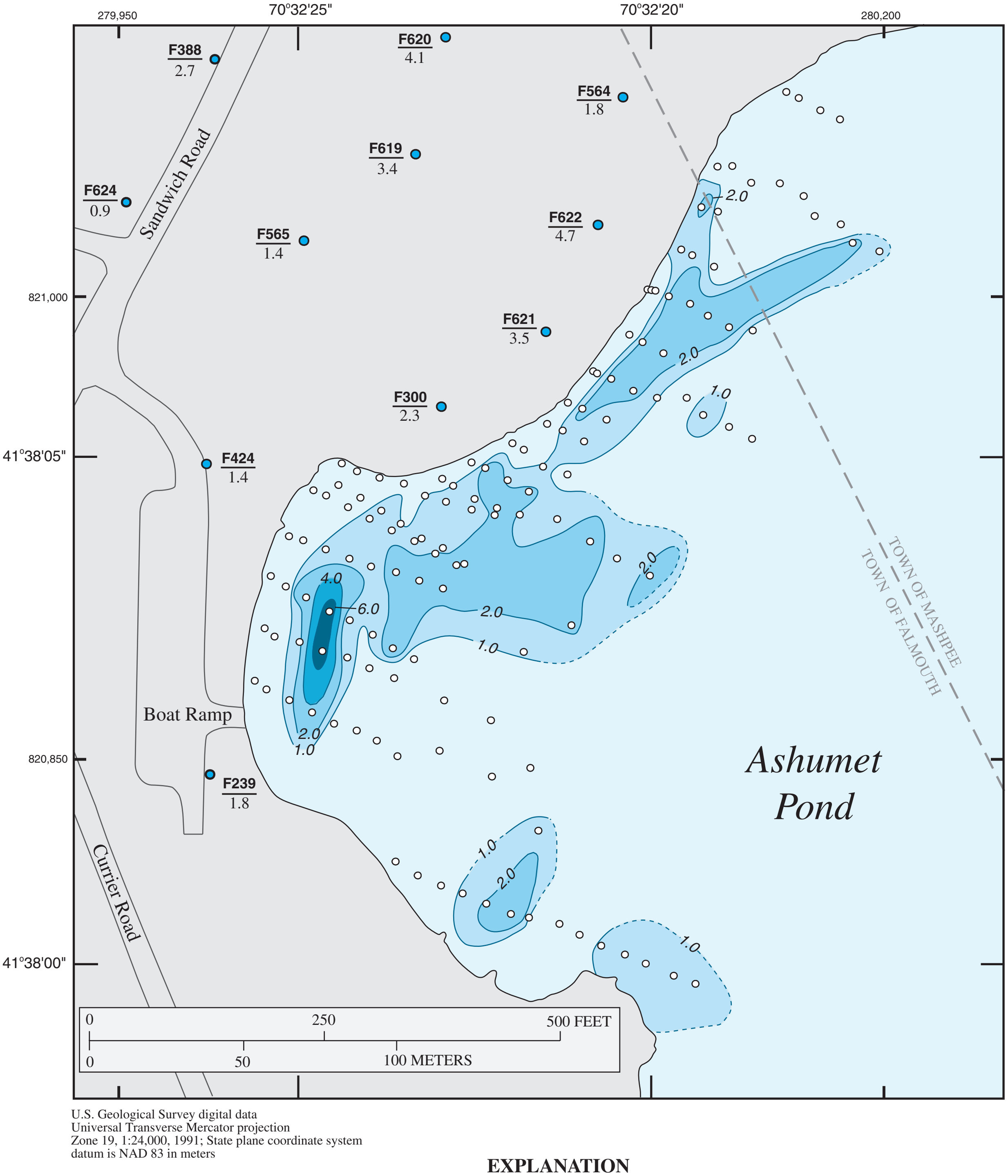


Figure 16. Areal distribution of dissolved nitrate in pond-bottom ground water in the contaminant-plume discharge area and maximum dissolved nitrate concentrations measured in ground water at upgradient multilevel-sampling sites, Ashumet Pond, Massachusetts, August–October 1999.



EXPLANATION

AREAL EXTENT OF DISSOLVED AMMONIUM IN POND-BOTTOM GROUND WATER (1999)—In milligrams per liter as N. Contour is dashed where inferred. Interval is varied.

- >6.0
- 4.0–6.0
- 2.0–4.0
- 1.0–2.0
- <1.0

F239 / 1.8 — MULTILEVEL-SAMPLER SITE, IDENTIFIER, AND MAXIMUM AMMONIUM CONCENTRATION IN GROUND WATER, IN MILLIGRAMS PER LITER AS N

○ TEMPORARY POND-BOTTOM DRIVE-POINT SAMPLER

Figure 17. Areal distribution of dissolved ammonium in pond-bottom ground water in the contaminant-plume discharge area and maximum dissolved ammonium concentrations measured in ground water at upgradient multilevel-sampling sites, Ashumet Pond, Massachusetts, August–October 1999.

Ammonium concentrations greater than 1 mg/L as N were measured along about 800 ft of shoreline over a large area 25 to 300 ft offshore (fig. 17). The greatest concentrations (about 7 mg/L as N) were in two samples from the inner portion of Fishermans Cove, approximately 75 ft from shore. Most of the detections of ammonium occurred at concentrations between 1 and 4 mg/L, and no values exceeded 4 mg/L within the zone of elevated phosphorus concentrations (figs. 9 and 17).

The nitrogen data from the samples of ground water beneath the pond bottom (figs. 16 and 17) indicate that dissolved nitrogen in ground water is presently (1999) discharging to Ashumet Pond throughout the region defined by elevated specific conductance (fig. 13). The spatial distribution of the nitrogen species in the pond-bottom samples appears to reflect the vertical distributions of ammonium and nitrate observed in samples from the upgradient wells and MLSs. As ground-water-flow lines bend upward and converge towards the pond, the vertical distributions of these species in the aquifer project horizontally on the pond bottom, so that areas of elevated nitrate surround areas of elevated ammonium. The general pattern of ammonium discharging between elevated zones of nitrate is observed even to the north, where only remnants of the nitrogen contamination exist.

FLUX OF PHOSPHORUS THROUGH THE AQUIFER TOWARDS THE POND

Walter and LeBlanc (1997) used a steady-state ground-water-flow model to calculate the flux of phosphorus in 1995 towards Ashumet Pond across a vertical section of model cells immediately upgradient of the pond (fig. 18). They used the model to determine the volumetric water flux across each model-cell face toward the pond at the location of interest. A phosphorus concentration was then assigned to each cell face by linearly interpolating between depth-weighted-average concentrations of the 1995 field-measured data values (Bussey and Walter, 1996). The phosphorus flux across each cell face was calculated by multiplying the phosphorus concentration and water-flux values. The sum of the cell-by-cell calculated phosphorus-flux values resulted in an estimated total mass flux of phosphorus across the vertical section of about 177 kg/yr towards the pond.

In 1999, two new MLS (sites F621 and F622) were installed about 75 ft upgradient of Ashumet Pond to better define the distribution of contaminants near the pond between two widely spaced adjacent sites sampled in 1995 (F300 and F564; fig. 18). Phosphorus concentrations at the new sites were greater than had been previously observed near the pond. Data from the more closely spaced samplers were used to recalculate the phosphorus flux. First, the location of the vertical section of model cells was adjusted slightly to include the new sites (fig. 18). A phosphorus concentration was then assigned to each cell vertically and horizontally along the section by linearly interpolating between the 1999 data values. The flow model used by Walter and LeBlanc (1997) was then used to determine the volumetric water flux across each cell face toward the pond. The total model-calculated water flux across the section was 37,800 ft^3/d. The phosphorus flux across each cell face was then calculated by multiplying the phosphorus concentration and water-flux values. The sum of the cell-by-cell calculated phosphorus-flux values for the 1999 data was 316 kg/yr towards the pond. The difference between the phosphorus fluxes determined from the 1995 and 1999 data (177 as compared to 316 kg/yr) can be attributed to the higher concentrations provided by the two new sites near the shoreline.

The vertical distribution of the calculated 1999 phosphorus flux along the cross section is shown in figure 19. Of the total flux, 72 percent (227 kg/yr) is contributed by model cells in the region between 385 and 715 ft north of the boat ramp. Of this amount, 92 percent flows through model layers 2 to 7 (altitude interval of 40 to –20 ft). Some of the water in the deeper layers of the cross section (layers 8 to 10), which extend to an altitude of about -20 ft, may flow under the pond, but the phosphorus flux associated with this water contributes less than 10 percent of the total flux. The distribution of the phosphorus flux across the section indicates that most of the 316-kg/yr flux of phosphorus could discharge to Ashumet Pond.

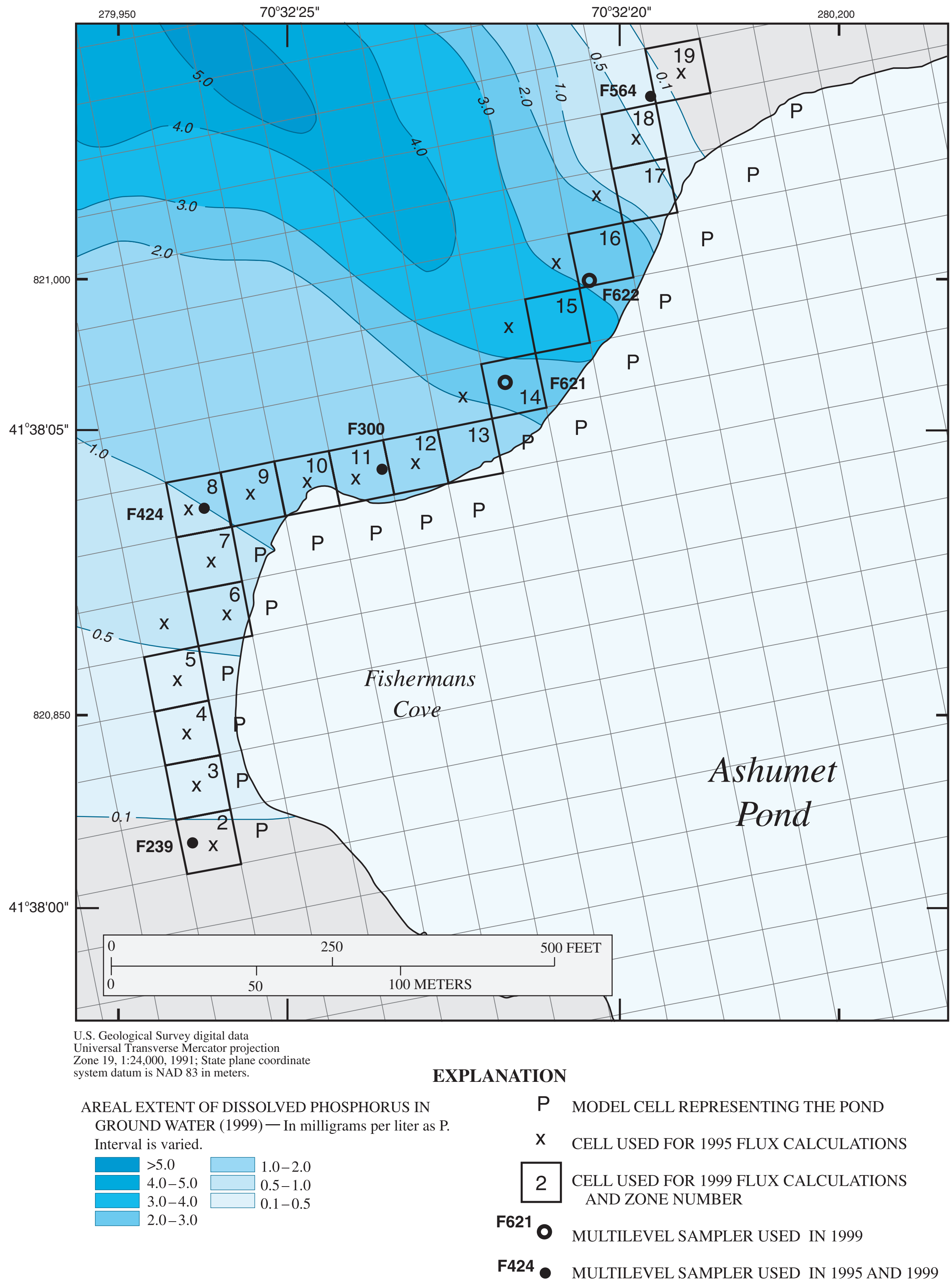


Figure 18. Location of ground-water-flow model cells and multilevel samplers used for calculating flux of phosphorus towards Ashumet Pond, Massachusetts.

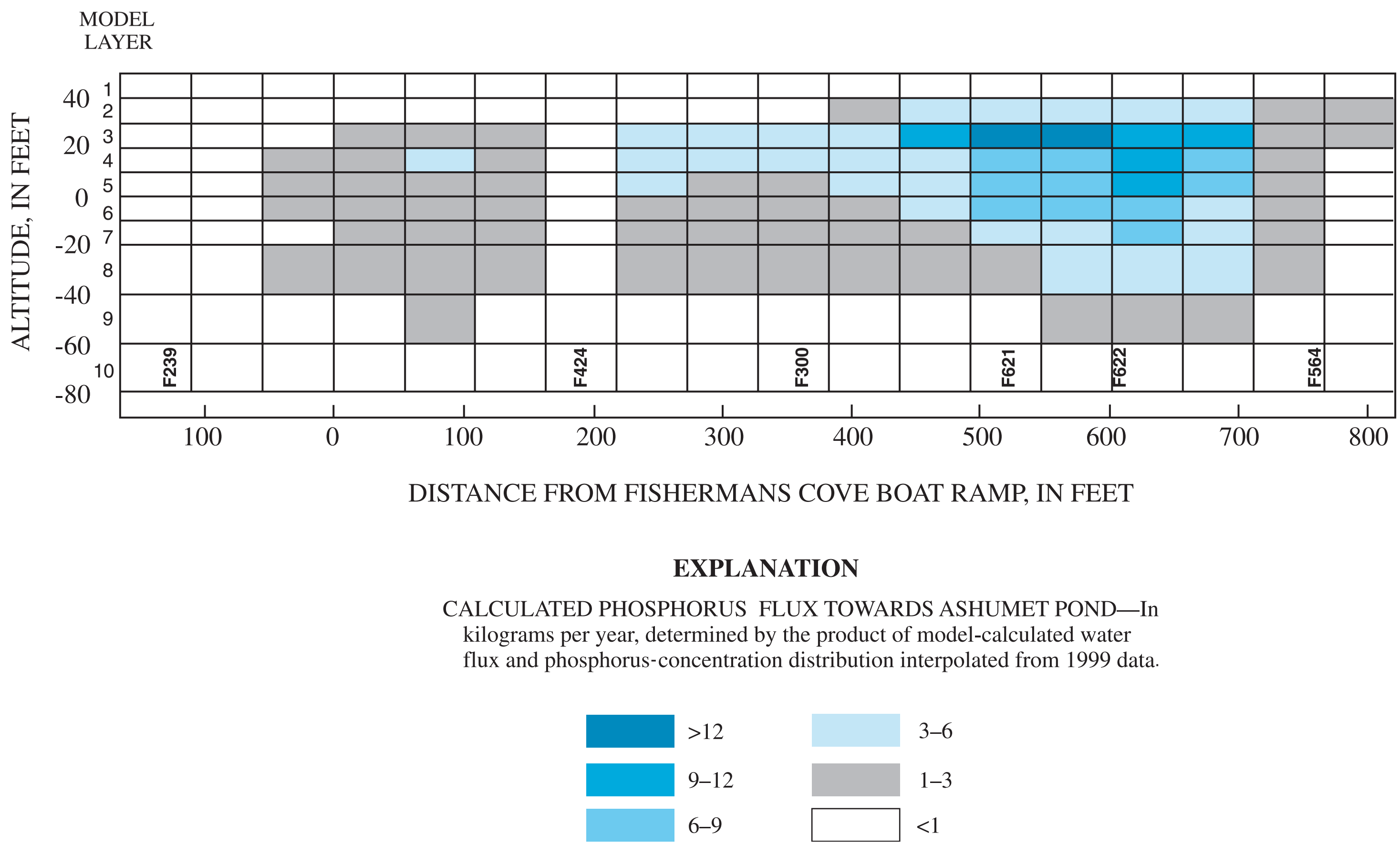


Figure 19. Dissolved phosphorus flux towards Ashumet Pond, Massachusetts, as determined by a steady-state ground-water-flow model and the distribution of phosphorus in ground water sampled in 1999.

An alternative method of determining phosphorus flux would be to calculate the product of the measured pond-bottom phosphorus concentrations and simulated flow rates across the model-cell faces that represent the pond bottom. This method is problematic, however, because most of the discharge to the pond occurs close to the shoreline. The strongly convergent upward flow may not be simulated accurately in the model because of the coarse model grid (55 ft x 55 ft). Also, the pond bottom must be approximated by a stair-step pattern of model cells, in which significant horizontal flow to the pond is simulated along the vertical faces of the pond-bottom model cells. Assigning a meaningful concentration to the horizontal water flux on the basis of the map view of the pond-bottom concentration distribution is not straightforward.

A study by AFCEE (2002b) calculated the phosphorus flux across the pond bottom by this alternative approach. They reported an estimated mass flux of phosphorus of 124 kg/yr for pond-bottom properties similar to those used by Walter and LeBlanc (1997). They used the pond-bottom concentrations reported in this report and the flux of water resulting from a different ground-water-flow model. Additional simulations and a sensitivity analysis would be needed to understand the cause of the differences between the mass-flux estimates obtained across the vertical section and across the pond bottom.

The estimate of phosphorus flux calculated from the ground-water-flow model and the 1999 concentration data (316 kg/yr) represents one condition in a temporally varying system. Geochemical transport simulations (Stollenwerk, 1996; Stollenwerk and Parkhurst, 1999) indicate that the flux of phosphorus to Ashumet Pond will continue for decades because of the large amount of phosphorus sorbed onto the aquifer sediments and the consequent retardation of phosphorus transport towards the pond.

SUMMARY AND CONCLUSIONS

Sixty years of disposal of treated sewage to infiltration beds at the Massachusetts Military Reservation created a zone of ground water contaminated with phosphorus, nitrogen, boron, and other common constituents of domestic wastewater. Elevated levels of dissolved phosphorus (greater than 0.1 mg/L) are migrating toward and discharging to Ashumet Pond located about 1,700 ft downgradient from the infiltration beds. Concern about excessive loading of nutrients, particularly dissolved phosphorus, by ground-water discharge to the pond, has led to consideration of remedial actions to minimize adverse effects to the ecological characteristics of the pond. To better define the location of the phosphorus contamination immediately upgradient of the pond, 349 ground-water samples were collected in 1999 from monitoring wells and multilevel samplers between the infiltration beds and the pond. Ground-water samples were also collected in 1999 from 135 temporary drive points driven 2 ft into the pond-bottom sediments. All samples were analyzed onsite for specific conductance, dissolved oxygen, and phosphate, and in the laboratory for inorganic solutes, including boron, manganese, phosphorus, and nitrogen species, including nitrate and ammonium, to delineate the discharge area of the contaminated ground water. A colorimetric method was used in the field to obtain preliminary phosphate concentrations to guide the sampling effort.

Data from the samples collected with temporary drive points indicate that phosphorus discharges to the pond along about 875 ft of shoreline. The discharge area of greatest phosphorus concentrations (greater than 2.0 mg/L) extends along 225 ft of shoreline in the northern portion of the discharge area. All phosphorus detections in ground water from beneath the pond-bottom were within 75 ft from shore, with the greatest concentrations within 30 ft from shore. The distribution of phosphorus in the pond-bottom samples is consistent with the distribution of phosphorus in ground water upgradient of the pond. The greatest concentrations of phosphorus were detected where specific conductance and boron are at low to moderate levels. This finding is consistent with the hypothesis that since the eastern infiltration beds were abandoned in 1984, phosphorus is desorbing from aquifer sediments as uncontaminated water enters the sewage-contaminated aquifer.

Elevated manganese concentrations (as high as about 10 mg/L) were detected along about 550 ft of shoreline and as far as 300 ft offshore. Dissolved manganese is in the ground water where suboxic to anoxic conditions exist. The black color of the sand and rocks along the pond shore where the contaminated ground water discharges to the pond is the result of manganese oxide precipitation as the suboxic to anoxic ground water encounters the oxic pond water.

Elevated concentrations of nitrate and ammonium (greater than 12 mg/L and 7 mg/L as N, respectively) were detected along about 1000 ft of shoreline. The greatest concentrations of each nitrogen species were detected in the center of Fishermans Cove. The horizontal distribution of the nitrogen species at the pond bottom reflects the upgradient vertical distributions in the aquifer, in which elevated ammonium concentrations in the center of the sewage-contaminated zone are surrounded by elevated nitrate concentrations.

Water flow simulated by a steady-state ground-water-flow model and phosphorus concentrations measured in wells and multilevel samplers near the shore were used to calculate the annual phosphorus flux across a vertical section of aquifer near Ashumet Pond. The estimated flux, 316 kg/yr of phosphorus, is greater than an earlier estimate of 177 kg/yr that resulted from chemical data obtained from a more widely spaced sampling network. Phosphorus-flux estimates made by the Air Force Center for Environmental Excellence from pond-bottom phosphorus concentrations and model-calculated water fluxes provided an estimated mass flux of phosphorus of 124 kg/yr. Additional model simulations in the area of the pond and a sensitivity analysis would be necessary to determine the cause of the differences between the estimates.

Geochemical transport simulations indicate that phosphorus will desorb slowly from the aquifer sediments and may discharge to Ashumet Pond for many decades. The persistence of elevated phosphorus levels north of Fishermans Cove, despite the decrease in other conservative species such as boron, supports this conclusion. Phosphorus, however, will likely continue to discharge in a narrow zone near the shore because of the strong upward flow to the pond.

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Tables 4 and 5

Table 4. Altitude data, field parameters, and selected laboratory analyses of ground-water samples collected from multilevel samplers near Ashumet Pond, Massachusetts, April–July 1999

[Source of phosphorus, boron, iron, and manganese data: Douglas B. Kent, U.S. Geological Survey, National Research Program. Source of nitrogen data: Richard L. Smith, U.S. Geological Survey, National Research Program. Location of sites shown in figure 2. **Altitude of midpoint of screen:** Is in feet relative to NGVD 29. ft, foot; mg/L, milligram per liter; µS/cm, microsiemen per centimeter at 25°C; --, no analysis; <, actual value is less than method detection limit]

Local site identifier		Altitude of mid-point of screen	Date	Specific conduc-tance (µS/cm)	pH (stan-dard units)	Oxygen, dis-solved (mg/L)	Phos-phorus, dis-solved (mg/L as P)	Boron, dis-solved (mg/L as B)	Iron, dis-solved (mg/L as Fe)	Manga-nese, dis-solved (mg/L as Mn)	Nitrogen, nitrate, dis-solved (mg/L as N)	Nitrogen, ammo-nium, dis-solved (mg/L as N)
FSW 239	M01-01	41.20	6-01-99	76	5.46	1.39	<0.10	0.012	<0.01	0.02	0.46	<0.03
	M01-02	36.20	6-01-99	69	5.33	.29	<.10	.008	<.01	.05	.08	<.03
	M01-03	31.20	6-01-99	54	5.48	8.18	<.10	.006	<.01	.01	.07	<.03
	M01-04	26.23	6-01-99	62	5.97	8.97	<.10	.006	<.01	<.01	.10	<.03
	M01-05	21.23	6-01-99	78	6.41	7.37	<.10	.026	<.01	<.01	.45	<.03
	M01-06	16.25	6-01-99	108	6.34	2.40	<.10	.058	.01	.33	1.91	<.03
	M01-07	11.25	6-01-99	155	6.33	.16	<.10	.116	<.01	1.22	3.84	<.03
	M01-08	6.28	6-01-99	214	6.50	.02	<.10	.162	<.01	.99	7.08	.32
	M01-09	1.28	6-01-99	251	6.77	.01	.15	.149	<.01	.62	6.11	.19
	M01-10	-8.70	6-01-99	221	6.55	.00	<.10	.133	.09	1.11	3.64	.49
	M01-11	-18.69	6-01-99	159	6.34	.03	.11	.099	<.01	2.07	.06	.83
	M01-12	-28.66	6-01-99	134	6.40	.00	<.10	.055	<.01	1.45	.06	.66
	M01-13	-38.65	6-01-99	123	6.14	.01	<.10	.036	<.01	2.31	<.03	.47
	M01-14	-48.63	6-01-99	96	6.29	.03	<.10	.017	<.01	1.92	2.11	.79
	M01-15	-58.62	6-01-99	117	6.32	.08	<.10	.014	<.01	1.12	2.94	1.75
FSW 300	M03-01	40.39	5-06-99	65	4.82	1.16	<.10	.006	.06	.98	<.03	<.03
	M03-02	37.39	5-06-99	55	5.53	.68	<.10	.010	<.01	.09	<.03	<.03
	M03-03	34.39	5-06-99	59	5.86	3.82	<.10	.014	<.01	<.01	<.03	<.03
	M03-04	31.37	5-06-99	79	6.11	5.81	<.10	.033	<.01	<.01	.34	.09
	M03-05	28.37	5-06-99	137	6.13	3.29	<.10	.103	<.01	.06	1.86	<.03
	M03-06	26.37	5-06-99	173	6.21	.18	.56	.133	<.01	1.80	2.82	<.03
	M03-07	24.37	5-06-99	235	6.28	.04	1.22	.174	<.01	3.61	4.40	<.03
	M03-08	22.36	5-06-99	257	6.27	.06	1.24	.206	<.01	4.63	3.04	<.03
	M03-09	20.36	5-06-99	270	6.28	.05	1.05	.219	<.01	5.61	3.99	<.03
	M03-10	18.36	5-06-99	312	6.25	.04	.99	.222	<.01	7.62	7.48	<.03
	M03-11	16.36	5-06-99	268	6.29	.06	1.30	.233	<.01	7.61	3.97	.55
	M03-12	14.36	5-06-99	233	6.38	.02	1.61	.195	<.01	4.98	.72	.67
	M03-13	12.36	5-06-99	246	6.43	.00	1.63	.188	<.01	4.05	.42	1.16
	M03-14	10.36	5-06-99	307	6.38	.24	1.32	.224	<.01	4.68	1.87	1.67
	M03-15	8.36	5-06-99	268	6.34	.17	1.15	.222	<.01	5.25	2.01	1.67

Table 4. Altitude data, field parameters, and selected laboratory analyses of ground-water samples collected from multilevel samplers in the vicinity of Ashumet Pond, Massachusetts, April–July 1999—*Continued*

Local site identifier		Altitude of mid-point of screen	Date	Specific conduc-tance (µS/cm)	pH (stan-dard units)	Oxygen, dis-solved (mg/L)	Phos-phorus, dis-solved (mg/L as P)	Boron, dis-solved (mg/L as B)	Iron, dis-solved (mg/L as Fe)	Manga-nese, dis-solved (mg/L as Mn)	Nitrogen, nitrate, dis-solved (mg/L as N)	Nitrogen, ammo-nium, dis-solved (mg/L as N)
FSW 300—*Continued*												
	M02-01	7.12	5-06-99	211	6.39	0.05	0.81	0.083	<0.01	5.40	1.05	1.47
	M02-02	5.12	5-06-99	146	6.44	.00	.85	.082	<.01	3.87	<.03	.85
	M02-03	2.12	5-06-99	135	6.45	.03	.80	.116	<.01	3.77	.06	.63
	M02-04	-.89	5-06-99	145	6.49	.01	.77	.118	<.01	3.99	<.03	.65
	M02-05	-3.89	5-06-99	160	6.48	.04	.78	.135	<.01	4.71	.28	.67
	M02-06	-6.89	5-06-99	174	6.43	.04	.74	.106	<.01	4.97	.92	1.05
	M02-07	-9.90	5-06-99	180	6.46	.04	.71	.083	<.01	4.81	1.24	1.17
	M02-08	-12.90	5-06-99	179	6.51	.04	.76	.078	<.01	5.13	1.49	1.79
	M02-09	-16.90	5-06-99	192	6.46	.03	.59	.078	<.01	6.05	1.79	2.26
	M02-10	-20.91	5-06-99	181	6.38	.01	.39	.065	<.01	4.51	1.55	1.67
	M02-11	-24.91	5-06-99	155	6.30	.02	.27	.047	<.01	2.42	1.74	.83
	M02-12	-28.91	5-06-99	133	6.29	.02	.23	.051	<.01	1.83	1.95	.66
	M02-13	-32.91	5-06-99	124	6.26	.02	.18	.040	<.01	1.06	2.06	.94
	M02-14	-43.00	5-06-99	87	6.21	.01	<.10	.029	<.01	.43	2.26	1.30
	M02-15	-52.91	5-06-99	90	6.04	.03	<.10	.012	<.01	.51	2.59	1.92
FSW 343	M03-01	45.29	6-08-99	53	5.16	3.67	<.10	.017	<.01	.02	<.03	.05
	M03-02	44.46	6-08-99	55	5.26	3.67	<.10	.017	<.01	<.01	.16	.11
	M03-03	43.63	6-08-99	68	5.54	2.07	<.10	.029	<.01	.01	1.09	.10
	M03-04	42.73	6-08-99	93	5.51	1.27	.46	.044	<.01	<.01	2.15	.09
	M03-05	41.89	6-08-99	115	5.58	.07	.77	.053	<.01	<.01	2.31	.09
	M03-06	41.06	6-08-99	123	5.62	.04	.87	.054	<.01	.02	2.45	.08
	M03-07	40.23	6-08-99	136	5.71	.04	1.09	.057	<.01	.09	2.00	.07
	M03-08	39.39	6-08-99	148	5.77	.04	1.29	.061	<.01	.12	1.61	.08
	M03-09	38.56	6-08-99	160	5.81	.13	1.55	.061	<.01	.13	.72	.14
	M03-10	37.73	6-08-99	166	5.89	.02	1.94	.061	<.01	.12	.29	.21
	M03-11	36.89	6-08-99	177	5.87	.07	2.07	.060	<.01	.12	<.03	.09
	M03-12	36.06	6-08-99	179	5.90	.03	2.19	.061	<.01	.13	<.03	.05
	M03-13	35.23	6-08-99	178	5.89	.04	2.12	.062	<.01	.13	<.03	.06
	M03-14	34.39	6-08-99	175	5.92	.03	2.18	.062	<.01	.16	.06	.13
	M03-15	33.56	6-08-99	179	5.91	.08	2.09	.062	<.01	.20	.07	.07
	M02-03	30.56	6-08-99	193	6.06	.03	2.06	.058	<.01	.22	.38	.09
	M02-04	27.56	6-08-99	263	6.03	.06	2.20	.045	<.01	.24	3.01	.10
	M02-05	24.56	6-08-99	214	6.30	.05	1.95	.040	<.01	.19	<.03	.56
	M02-06	21.56	6-08-99	155	6.41	.07	1.76	.046	<.01	.10	.05	.85
	M02-07	18.56	6-08-99	142	6.50	.08	<.10	.050	<.01	.10	<.03	.64

Table 4. Altitude data, field parameters, and selected laboratory analyses of ground-water samples collected from multilevel samplers in the vicinity of Ashumet Pond, Massachusetts, April–July 1999—*Continued*

Local site identifier		Altitude of mid-point of screen	Date	Specific conductance (µS/cm)	pH (standard units)	Oxygen, dissolved (mg/L)	Phosphorus, dissolved (mg/L as P)	Boron, dissolved (mg/L as B)	Iron, dissolved (mg/L as Fe)	Manganese, dissolved (mg/L as Mn)	Nitrogen, nitrate, dissolved (mg/L as N)	Nitrogen, ammonium, dissolved (mg/L as N)
FSW 343—*Continued*												
	M02-08	15.56	6-08-99	150	6.91	0.16	0.15	0.066	0.02	0.12	0.05	0.35
	M02-09	12.56	6-08-99	155	6.59	.47	.15	.052	.56	.09	<.03	.70
	M02-10	9.56	6-08-99	178	6.82	.00	1.12	.045	9.59	.14	<.03	.48
	M02-11	6.56	6-08-99	180	6.85	.00	2.47	.036	8.31	.13	<.03	1.30
	M02-12	3.56	6-08-99	162	6.91	.00	2.12	.027	6.99	.10	<.03	1.53
	M02-13	0.56	6-08-99	144	6.93	.01	1.60	.022	5.49	.07	<.03	1.32
	M02-14	-2.44	6-08-99	116	6.85	.00	1.46	.021	6.77	.09	<.03	.84
	M02-15	-5.44	6-08-99	110	6.82	.01	.28	.015	2.76	.09	<.03	.40
	M01-02	-10.47	6-08-99	101	6.34	.53	<.10	.020	<.01	.03	.24	.10
	M01-03	-15.47	6-08-99	84	6.03	3.99	<.10	.015	<.01	<.01	.84	.04
	M01-04	-20.47	6-08-99	87	5.92	4.02	<.10	.018	<.01	<.01	.83	.11
	M01-05	-25.47	6-08-99	118	5.72	7.66	<.10	.014	<.01	<.01	.63	.06
	M01-06	-30.47	6-08-99	91	5.89	8.60	<.10	.010	<.01	<.01	.66	.07
	M01-07	-35.47	6-08-99	69	5.78	8.25	<.10	.012	<.01	<.01	.62	.08
	M01-08	-40.47	6-08-99	77	5.72	8.67	<.10	.015	<.01	<.01	.50	.07
	M01-09	-43.47	6-08-99	81	5.72	8.59	<.10	.015	<.01	<.01	.48	.09
	M01-10	-46.47	6-08-99	71	5.75	8.68	.20	.013	<.01	<.01	.49	.08
FSW 347	M01-01	41.58	4-29-99	39	5.16	9.92	<.10	<.003	<.01	.05	<.03	.08
	M01-02	39.68	4-29-99	64	5.42	9.54	<.10	.034	<.01	.04	.37	<.03
	M01-03	37.78	4-29-99	78	5.78	9.15	.12	.172	<.01	.02	1.21	.03
	M01-04	35.88	4-29-99	96	5.81	8.54	.99	.287	<.01	.02	1.75	.04
	M01-05	33.93	4-29-99	116	5.95	3.74	2.43	.075	<.01	.22	1.48	.04
	M01-06	32.03	4-29-99	142	5.99	1.72	2.46	.068	<.01	.43	1.87	.06
	M01-07	30.13	4-29-99	156	6.03	.03	2.64	.052	<.01	.61	2.67	.14
	M01-08	28.23	4-29-99	162	6.12	.03	3.61	.077	<.01	.48	2.67	.04
	M01-09	26.33	4-29-99	190	6.10	.03	3.11	.091	.04	.83	3.40	.08
	M01-10	24.45	4-29-99	196	6.19	.04	4.12	.124	.13	.41	2.34	.09
	M01-11	22.55	4-29-99	220	6.12	.02	3.05	.117	<.01	.39	3.31	.13
	M01-12	20.65	4-29-99	233	6.16	.07	2.50	.136	<.01	.31	2.54	.09
	M01-13	18.75	4-29-99	255	6.16	.03	1.73	.137	<.01	.23	.99	.12
	M01-14	16.85	4-29-99	249	6.10	.05	1.16	.112	<.01	.23	.50	.29
	M01-15	14.95	4-29-99	236	6.07	.03	.85	.094	<.01	.23	.25	.31

Table 4. Altitude data, field parameters, and selected laboratory analyses of ground-water samples collected from multilevel samplers in the vicinity of Ashumet Pond, Massachusetts, April–July 1999—*Continued*

Local site identifier		Altitude of mid-point of screen	Date	Specific conduc-tance (µS/cm)	pH (stan-dard units)	Oxygen, dis-solved (mg/L)	Phos-phorus, dis-solved (mg/L as P)	Boron, dis-solved (mg/L as B)	Iron, dis-solved (mg/L as Fe)	Manga-nese, dis-solved (mg/L as Mn)	Nitrogen, nitrate, dis-solved (mg/L as N)	Nitrogen, ammo-nium, dis-solved (mg/L as N)
FSW 347—*Continued*												
	M06-01	19.93	4-29-99	246	6.20	0.04	2.05	0.144	<0.01	0.23	1.84	0.10
	M06-02	14.93	4-29-99	236	6.28	.00	.54	.129	.02	.26	.05	.16
	M06-03	9.93	4-29-99	230	6.36	.03	.19	.103	.12	.20	<.03	.12
	M06-05	-.06	4-29-99	221	6.53	.00	2.45	.098	12.26	.32	<.03	.68
	M06-06	-5.08	4-29-99	177	6.48	.00	2.58	.079	9.54	.39	<.03	.54
	M06-07	-10.08	4-29-99	190	6.55	.00	3.09	.051	14.38	.26	<.03	.19
	M06-08	-15.11	4-29-99	185	6.47	.00	3.27	.045	12.66	.25	<.03	.11
	M06-09	-20.11	4-29-99	227	6.32	.00	2.52	.057	14.20	.35	.22	.13
	M06-10	-25.15	4-29-99	194	6.15	.00	1.34	.053	10.97	.44	<.03	.07
	M06-11	-30.15	4-29-99	219	5.43	5.45	.13	.019	<.01	2.47	1.32	.12
	M06-12	-35.13	4-29-99	148	5.47	6.38	.13	.019	<.01	.34	1.33	.03
	M06-13	-40.13	4-29-99	150	5.52	6.42	.16	.022	<.01	.15	1.05	.03
	M06-14	-45.13	4-29-99	103	5.70	7.38	.17	.019	<.01	.02	--	--
	M06-15	-50.13	4-29-99	73	5.60	7.42	.19	.018	<.01	.42	.72	.06
FSW 378	M01-01	43.48	4-28-99	61	5.74	5.10	.14	.017	<.01	<.01	<.03	.06
	M01-02	35.49	4-28-99	195	5.99	.03	2.61	.055	<.01	.15	4.15	.05
	M01-03	27.50	4-28-99	130	6.17	.05	3.13	.042	<.01	.11	<.03	.15
	M01-04	19.50	4-28-99	112	6.12	.06	1.49	.030	<.01	.11	<.03	.08
	M01-05	11.50	4-28-99	119	6.21	.08	.15	.042	.04	.16	<.03	.09
	M01-06	3.48	4-28-99	115	6.21	.01	.20	.046	.85	.15	<.03	.05
	M01-07	-3.54	4-28-99	139	6.17	.05	.11	.054	<.01	.10	.68	.07
	M01-08	-10.57	4-28-99	178	5.96	2.45	<.10	.047	<.01	.11	1.67	.13
	M01-09	-17.57	4-28-99	159	5.87	5.19	.30	.030	<.01	.04	1.11	<.03
	M01-10	-24.60	4-28-99	120	6.00	6.39	<.10	.026	<.01	.02	.69	.08
	M01-11	-32.63	4-28-99	94	6.09	2.08	.69	.031	<.01	.44	.63	.04
	M01-12	-40.66	4-28-99	111	5.81	6.48	.25	.013	<.01	.53	.95	.05
	M01-13	-48.66	4-28-99	121	5.68	6.31	.23	.013	<.01	.52	.94	.07
	M01-14	-56.69	4-28-99	63	5.53	5.83	.28	.016	<.01	.13	1.19	.06
FSW 379	M01-01	45.77	4-29-99	45	5.86	9.01	<.10	.009	<.01	<.01	.06	.03
	M01-02	37.77	4-29-99	86	5.74	5.64	.63	.025	<.01	.03	1.01	.06
	M01-03	29.77	4-29-99	148	6.06	.16	3.09	.049	<.01	.23	.41	.12
	M01-04	21.77	4-29-99	64	6.12	3.26	.50	.014	<.01	.72	.66	.06
	M01-05	13.77	4-29-99	142	6.42	.26	2.26	.039	.17	.10	<.03	<.03

Table 4. Altitude data, field parameters, and selected laboratory analyses of ground-water samples collected from multilevel samplers in the vicinity of Ashumet Pond, Massachusetts, April–July 1999—*Continued*

Local site identifier		Altitude of mid-point of screen	Date	Specific conductance (µS/cm)	pH (standard units)	Oxygen, dissolved (mg/L)	Phosphorus, dissolved (mg/L as P)	Boron, dissolved (mg/L as B)	Iron, dissolved (mg/L as Fe)	Manganese, dissolved (mg/L as Mn)	Nitrogen, nitrate, dissolved (mg/L as N)	Nitrogen, ammonium, dissolved (mg/L as N)
FSW 379—*Continued*												
	M01-06	5.74	4-29-99	164	6.46	0.01	2.73	0.047	11.92	0.28	<0.03	0.58
	M01-07	-2.28	4-29-99	263	6.29	.00	2.31	.047	15.78	.53	<.03	1.19
	M01-08	-10.28	4-29-99	186	6.56	.30	2.98	.031	10.07	.30	.06	.89
	M01-09	-18.28	4-29-99	181	6.40	.12	2.64	.029	1.10	.38	<.03	.67
	M01-10	-26.29	4-29-99	153	6.60	.00	3.21	.022	4.35	.26	<.03	.56
	M01-11	-34.32	4-29-99	87	6.44	.08	2.69	.021	.02	.37	<.03	.32
	M01-12	-42.34	4-29-99	66	6.26	3.61	.65	.012	<.01	.56	.58	.03
	M01-13	-50.33	4-29-99	192	6.19	.03	2.96	.046	<.01	.32	.13	.05
	M01-14	-58.33	4-29-99	74	6.28	.38	.49	.018	<.01	.91	1.62	.66
	M01-15	-66.35	4-29-99	79	6.19	.51	.51	.015	<.01	.79	2.22	1.42
FSW 388	M01-01	43.16	5-04-99	37	4.98	9.20	<.10	.004	<.01	.04	<.03	.11
	M01-02	39.14	5-04-99	52	5.40	9.60	<.10	.009	<.01	.02	.15	.12
	M01-03	35.14	5-04-99	96	5.92	9.40	.97	.048	<.01	.03	.73	.10
	M01-04	31.14	5-04-99	177	5.98	.83	2.82	.097	<.01	.14	2.76	.12
	M01-05	27.14	5-04-99	187	6.16	.02	5.02	.151	<.01	.51	.36	.19
	M01-06	23.14	5-04-99	172	6.25	.00	5.48	.144	<.01	.63	<.03	.11
	M01-07	19.13	5-04-99	187	6.24	.02	5.15	.139	<.01	.84	.12	.09
	M01-08	15.13	5-04-99	289	6.16	.02	3.52	.129	<.01	1.32	1.14	.15
	M01-09	11.13	5-04-99	308	6.19	.05	2.33	.129	<.01	1.51	1.43	.11
	M01-10	7.09	5-04-99	132	6.37	.40	1.93	.199	<.01	.65	.06	.08
	M01-11	4.09	5-04-99	153	6.26	.40	2.70	.280	<.01	.85	.07	.35
	M01-12	1.09	5-04-99	136	6.33	.06	2.72	.170	<.01	.82	<.03	.78
	M01-14	-4.93	5-04-99	131	6.33	.07	1.88	.071	<.01	.96	<.03	.92
	M01-15	-7.93	5-04-99	132	6.30	.11	1.59	.057	<.01	1.20	<.03	.88
	M02-01	-10.80	5-04-99	111	6.64	.40	1.51	.041	<.01	1.06	<.03	.79
	M02-02	-13.80	5-04-99	109	6.64	.12	1.40	.031	<.01	.95	<.03	.63
	M02-03	-16.80	5-04-99	111	6.69	.27	1.48	.027	<.01	.81	<.03	.61
	M02-04	-20.84	5-04-99	79	6.77	.10	1.57	.024	<.01	.62	<.03	.77
	M02-05	-24.84	5-04-99	77	6.75	.08	1.10	.022	<.01	.96	.73	.90
	M02-06	-28.84	5-04-99	78	6.70	.11	.91	.018	<.01	1.41	1.39	.75
	M02-07	-32.88	5-04-99	74	6.69	.15	.64	.015	<.01	1.10	1.63	1.28
	M02-08	-36.88	5-04-99	74	6.68	.24	.63	.017	.01	.56	1.90	1.46
	M02-09	-40.88	5-04-99	75	6.66	.18	.67	.017	<.01	.45	2.03	1.72
	M02-10	-44.91	5-04-99	76	6.66	.17	.65	.019	<.01	.38	2.06	2.17

Table 4. Altitude data, field parameters, and selected laboratory analyses of ground-water samples collected from multilevel samplers in the vicinity of Ashumet Pond, Massachusetts, April–July 1999—*Continued*

Local site identifier		Altitude of mid-point of screen	Date	Specific conduc-tance (µS/cm)	pH (stan-dard units)	Oxygen, dis-solved (mg/L)	Phos-phorus, dis-solved (mg/L as P)	Boron, dis-solved (mg/L as B)	Iron, dis-solved (mg/L as Fe)	Manga-nese, dis-solved (mg/L as Mn)	Nitrogen, nitrate, dis-solved (mg/L as N)	Nitrogen, ammo-nium, dis-solved (mg/L as N)
FSW 388—*Continued*												
	M02-11	-48.91	5-04-99	75	6.51	0.18	<0.10	0.016	<0.01	0.23	2.65	1.83
	M02-12	-52.95	5-04-99	70	6.31	.13	<.10	.017	<.01	.13	2.29	1.53
	M02-13	-56.95	5-04-99	70	6.30	.23	<.10	.015	.01	.12	2.28	1.73
	M02-14	-60.96	5-04-99	67	6.37	.10	<.10	.015	.02	.11	2.24	1.77
	M02-15	-64.96	5-04-99	75	6.15	.07	<.10	.017	<.01	.06	2.62	2.71
FSW 424	M02-01	44.09	6-29-99	144	5.14	.89	<.10	.005	.02	<.01	<.03	<.03
	M02-02	41.59	6-29-99	96	5.31	2.09	<.10	.005	<.01	<.01	<.03	<.03
	M02-03	39.09	6-29-99	91	5.46	4.26	<.10	<.003	<.01	<.01	.07	<.03
	M02-04	36.57	6-29-99	70	5.72	2.35	<.10	.006	<.01	.07	.07	<.03
	M02-05	34.07	6-29-99	52	5.81	7.35	<.10	<.003	<.01	.01	.12	<.03
	M02-06	31.57	6-29-99	58	6.08	7.07	<.10	.017	<.01	<.01	.57	<.03
	M02-07	29.07	6-29-99	88	6.02	4.73	<.10	.058	<.01	<.01	2.48	<.03
	M02-08	26.55	6-29-99	119	6.01	2.94	.35	.087	<.01	<.01	5.05	<.03
	M02-09	24.05	6-29-99	175	6.05	.68	.58	.153	<.01	.21	8.40	<.03
	M02-10	21.55	6-29-99	229	6.13	.70	.77	.225	<.01	.73	8.84	<.03
	M02-11	19.05	6-29-99	250	6.26	.18	.96	.252	<.01	.96	5.99	<.03
	M02-12	16.53	6-29-99	260	6.34	.13	1.07	.285	<.01	1.20	1.54	<.03
	M02-13	14.03	6-29-99	287	6.36	.19	1.20	.304	<.01	1.17	.81	<.03
	M02-14	11.53	6-29-99	340	6.32	.16	1.12	.346	<.01	1.43	3.41	<.03
	M02-15	9.03	6-29-99	394	6.27	.20	.97	.370	<.01	2.04	6.57	<.03
	M01-01	5.86	6-29-99	381	6.29	.21	0.97	.371	<.01	2.49	4.71	<.03
	M01-02	.87	6-29-99	364	6.35	.19	1.04	.372	<.01	2.53	.17	.91
	M01-03	-4.13	6-29-99	361	6.46	.08	.97	.356	<.01	2.49	<.03	1.02
	M01-04	-9.12	6-29-99	298	6.51	.11	1.06	.340	<.01	1.83	<.03	.82
	M01-05	-14.12	6-29-99	290	6.43	.09	.88	.308	<.01	2.35	<.03	.74
	M01-06	-19.11	6-29-99	301	6.33	.01	.77	.301	<.01	2.93	<.03	1.24
	M01-07	-24.11	6-29-99	266	6.24	.22	.65	.261	<.01	3.00	<.03	1.06
	M01-08	-29.10	6-29-99	160	6.22	.12	.52	.171	<.01	1.92	.69	.83
	M01-09	-34.10	6-29-99	105	6.18	.27	.45	.107	<.01	1.24	.97	.31
	M01-10	-39.09	6-29-99	88	5.97	.17	.41	.058	<.01	1.35	1.42	.18
	M01-11	-44.09	6-29-99	73	5.88	4.09	.36	.033	<.01	.88	.84	.04
	M01-12	-49.07	6-29-99	74	5.75	5.88	.27	.021	<.01	.98	.70	<.03
	M01-13	-54.07	6-29-99	78	5.71	7.00	.27	.017	<.01	1.55	.74	<.03
	M01-14	-59.05	6-29-99	82	5.84	7.94	.14	.015	<.01	1.13	.67	<.03
	M01-15	-64.05	6-29-99	103	6.21	.12	.18	.011	<.01	.50	2.69	1.66

Table 4. Altitude data, field parameters, and selected laboratory analyses of ground-water samples collected from multilevel samplers in the vicinity of Ashumet Pond, Massachusetts, April–July 1999—*Continued*

Local site identifier		Altitude of mid-point of screen	Date	Specific conduc-tance (µS/cm)	pH (stan-dard units)	Oxygen, dis-solved (mg/L)	Phos-phorus, dis-solved (mg/L as P)	Boron, dis-solved (mg/L as B)	Iron, dis-solved (mg/L as Fe)	Manga-nese, dis-solved (mg/L as Mn)	Nitrogen, nitrate, dis-solved (mg/L as N)	Nitrogen, ammo-nium, dis-solved (mg/L as N)
FSW 432	M01-01	41.36	5-05-99	109	4.68	7.50	<0.10	0.016	<0.01	0.23	5.80	0.04
	M01-03	31.35	5-05-99	64	5.17	8.10	<.10	.012	<.01	.02	1.00	.05
	M01-05	21.36	5-05-99	104	5.81	8.10	<.10	.018	<.01	<.01	.44	.07
	M01-06	16.36	5-05-99	87	5.83	9.00	<.10	.032	<.01	<.01	.25	.09
	M01-07	11.36	5-05-99	86	5.83	8.10	<.10	.045	<.01	<.01	.37	.08
	M01-08	6.37	5-05-99	91	5.84	8.00	<.10	.041	<.01	<.01	.53	.08
	M01-09	1.37	5-05-99	97	5.78	8.80	<.10	.023	<.01	<.01	.61	.07
	M01-10	-8.61	5-05-99	153	5.68	8.40	<.10	.016	<.01	.01	.73	.06
	M01-13	-38.57	5-05-99	100	5.77	9.00	<.10	.012	<.01	<.01	.34	.04
	M01-15	-58.57	5-05-99	70	5.81	9.50	<.10	.015	<.01	<.01	.47	.11
FSW 510	M01-01	44.95	6-09-99	44	6.04	6.80	<.10	.029	<.01	.04	.04	<.03
	M01-03	40.78	6-09-99	53	5.73	9.65	.14	.014	<.01	.01	.12	.06
	M01-04	38.70	6-09-99	71	5.91	8.56	1.55	.032	<.01	.02	.64	.05
	M01-07	31.64	6-09-99	137	6.08	.05	1.98	.091	<.01	.14	1.35	<.03
	M01-08	29.14	6-09-99	138	6.19	.02	.82	.111	<.01	.11	.76	.10
	M01-09	26.64	6-09-99	142	6.22	.13	.45	.138	<.01	.11	.61	.08
	M01-10	24.11	6-09-99	153	6.16	.02	.37	.105	<.01	.13	.43	.04
	M01-12	19.11	6-09-99	171	6.11	.04	.15	.083	<.01	.15	.18	.04
	M01-13	16.61	6-09-99	163	6.11	.02	<.10	.106	<.01	.15	.04	.05
	M01-14	14.08	6-09-99	143	6.13	.03	.11	.164	<.01	.16	<.03	<.03
	M01-15	11.58	6-09-99	137	6.11	.04	.11	.132	<.01	.14	<.03	.04
	M02-01	36.81	6-09-99	108	5.99	5.71	2.98	.067	<.01	.05	2.87	.08
	M02-02	34.29	6-09-99	142	6.13	.05	3.33	.123	<.01	.15	3.39	.14
	M02-03	8.29	6-09-99	134	6.12	.06	.13	.114	.04	.17	<.03	.08
	M02-04	3.26	6-09-99	142	6.08	.04	.13	.111	.05	.23	<.03	.08
	M02-05	-1.79	6-09-99	142	6.08	.08	.13	.088	.04	.39	<.03	.10
	M02-06	-6.78	6-09-99	157	6.11	.02	<.10	.053	.03	.37	.04	.13
	M02-07	-11.78	6-09-99	155	6.15	.04	<.10	.068	.02	.27	<.03	.10
	M02-08	-16.82	6-09-99	137	6.17	.05	<.10	.063	<.01	.32	<.03	.08
	M02-09	-21.82	6-09-99	125	6.10	.05	<.10	.038	.04	.32	<.03	.09
	M02-10	-26.87	6-09-99	92	6.25	.03	.17	.030	<.01	.13	<.03	.09
	M02-11	-31.87	6-09-99	82	6.21	.08	.14	.022	.02	.16	.62	.08
	M02-12	-36.88	6-09-99	78	6.11	.08	.31	.023	<.01	.33	1.90	.12
	M02-13	-41.88	6-09-99	77	5.60	5.84	.20	.017	<.01	.35	1.01	.07
	M02-14	-46.95	6-09-99	81	5.55	8.51	.21	.025	<.01	.02	.64	.11
	M02-15	-51.95	6-09-99	81	5.59	8.12	.21	.017	<.01	.34	.65	.13

Table 4. Altitude data, field parameters, and selected laboratory analyses of ground-water samples collected from multilevel samplers in the vicinity of Ashumet Pond, Massachusetts, April–July 1999—*Continued*

Local site identifier		Altitude of mid-point of screen	Date	Specific conduc-tance (µS/cm)	pH (stan-dard units)	Oxygen, dis-solved (mg/L)	Phos-phorus, dis-solved (mg/L as P)	Boron, dis-solved (mg/L as B)	Iron, dis-solved (mg/L as Fe)	Manga-nese, dis-solved (mg/L as Mn)	Nitrogen, nitrate, dis-solved (mg/L as N)	Nitrogen, ammo-nium, dis-solved (mg/L as N)
FSW 512	M01-01	45.00	6-03-99	74	5.58	4.38	<0.10	0.013	<0.01	<0.01	<0.03	0.06
	M01-02	42.91	6-03-99	60	5.56	6.56	<.10	.010	<.01	<.01	.06	.05
	M01-03	40.82	6-03-99	53	5.47	6.82	<.10	.010	<.01	<.01	.04	.05
	M01-04	38.73	6-03-99	51	5.59	6.07	<.10	.010	<.01	<.01	.04	.03
	M01-05	36.65	6-03-99	60	5.79	5.42	.10	.015	<.01	<.01	.06	.06
	M01-06	34.15	6-03-99	80	5.87	7.18	.31	.028	<.01	.07	.59	.05
	M01-07	31.65	6-03-99	102	5.92	4.43	.55	.047	<.01	.13	1.49	.06
	M01-08	29.15	6-03-99	113	6.03	2.14	.57	.056	<.01	.24	1.71	.07
	M01-09	26.65	6-03-99	106	6.17	.04	.51	.056	<.01	.24	1.05	.04
	M01-10	24.10	6-03-99	96	6.35	.06	.44	.055	<.01	.18	.55	.09
	M01-11	21.60	6-03-99	97	6.36	.06	.43	.052	<.01	.16	.29	<.03
	M01-12	19.10	6-03-99	96	6.40	.03	.31	.038	<.01	.11	.19	.09
	M01-13	16.60	6-03-99	105	6.32	.03	.26	.051	<.01	.17	.26	.06
	M01-14	14.07	6-03-99	113	6.20	.04	.18	.042	<.01	.19	.66	.07
	M01-15	11.57	6-03-99	121	6.08	.08	.14	.041	<.01	.20	1.41	.09
	M02-01	8.23	6-03-99	121	6.08	.06	<.10	.037	<.01	.31	1.92	.04
	M02-02	3.20	6-03-99	137	6.00	.05	<.10	.037	.11	.48	3.10	.06
	M02-03	-1.80	6-03-99	131	6.26	.00	.65	.035	13.19	.17	<.03	.11
	M02-04	-6.84	6-03-99	148	6.39	.00	1.41	.033	8.73	.50	<.03	.14
	M02-05	-11.84	6-03-99	155	6.51	.00	2.22	.031	12.63	.38	<.03	.33
	M02-06	-16.87	6-03-99	157	6.13	.00	2.13	.041	7.88	.70	<.03	.48
	M02-07	-21.87	6-03-99	118	6.12	.16	2.20	.034	.06	.57	<.03	.36
	M02-08	-26.89	6-03-99	74	6.18	.12	2.08	.023	.01	.30	<.03	.28
	M02-09	-31.89	6-03-99	59	6.12	.06	.72	.019	<.01	.27	.20	.09
	M02-10	-36.92	6-03-99	72	5.92	7.05	.30	.012	<.01	.58	.52	.06
	M02-11	-41.92	6-03-99	82	5.80	7.53	.24	.017	<.01	.97	.59	.03
	M02-12	-46.95	6-03-99	85	5.62	7.98	.24	.016	<.01	.63	.65	.07
	M02-13	-51.95	6-03-99	79	5.52	8.16	.16	.015	<.01	.23	.68	.05
	M02-14	-56.95	6-03-99	82	5.89	8.60	<.10	.015	<.01	<.01	.59	.05
	M02-15	-61.95	6-03-99	132	6.03	8.42	<.10	.017	<.01	<.01	.62	.06
FSW 564	M01-01	41.61	5-10-99	73	5.78	.14	<.10	.015	<.01	1.02	<.03	.05
	M01-02	36.65	5-10-99	61	5.55	7.74	<.10	.006	<.01	.01	.09	<.03
	M01-03	31.65	5-10-99	88	5.90	6.28	.61	.010	<.01	<.01	.51	<.03
	M01-04	26.66	5-10-99	110	5.99	4.28	.83	.014	<.01	.68	.37	<.03
	M01-05	21.66	5-10-99	95	5.97	3.40	.51	.024	<.01	.99	.33	<.03

Table 4. Altitude data, field parameters, and selected laboratory analyses of ground-water samples collected from multilevel samplers in the vicinity of Ashumet Pond, Massachusetts, April–July 1999—*Continued*

Local site identifier		Altitude of mid-point of screen	Date	Specific conduc-tance (µS/cm)	pH (stan-dard units)	Oxygen, dis-solved (mg/L)	Phos-phorus, dis-solved (mg/L as P)	Boron, dis-solved (mg/L as B)	Iron, dis-solved (mg/L as Fe)	Manga-nese, dis-solved (mg/L as Mn)	Nitrogen, nitrate, dis-solved (mg/L as N)	Nitrogen, ammo-nium, dis-solved (mg/L as N)
FSW 564—*Continued*												
	M01-06	16.67	5-10-99	95	6.03	4.14	0.29	0.022	<0.01	0.62	0.47	<0.03
	M01-07	11.67	5-10-99	109	6.08	1.98	.23	.024	<.01	1.25	.94	.03
	M01-08	6.64	5-10-99	151	6.13	.24	.24	.022	<.01	1.94	1.19	.51
	M01-09	1.64	5-10-99	150	5.90	.40	.16	.018	<.01	1.71	.85	<.03
	M01-10	-8.36	5-10-99	86	5.72	8.56	<.10	.011	<.01	.05	.44	.05
	M01-11	-18.36	5-10-99	66	5.80	9.03	.14	.009	<.01	.01	.38	<.03
	M01-12	-28.37	5-10-99	64	5.83	8.13	<.10	.010	<.01	<.01	.56	<.03
	M01-13	-38.38	5-10-99	102	6.23	.06	<.10	.014	<.01	.04	3.03	1.77
	M01-14	-48.38	5-10-99	67	6.28	9.74	<.10	<.003	<.01	<.01	.71	<.03
	M01-15	-58.36	5-10-99	67	6.39	9.86	<.10	.003	<.01	<.01	.70	.03
FSW 565	M01-01	35.68	5-10-99	104	5.96	3.30	<.10	.080	<.01	.01	2.17	.05
	M01-02	28.65	5-10-99	159	6.26	.04	1.35	.217	<.01	.32	.33	<.03
	M01-03	20.65	5-10-99	160	6.35	.05	1.61	.157	<.01	1.25	<.03	<.03
	M01-04	12.63	5-10-99	154	6.33	.02	1.61	.113	<.01	1.85	.06	.05
	M01-05	6.64	5-10-99	144	6.35	.06	1.57	.067	<.01	1.64	<.03	.87
	M01-06	.64	5-10-99	156	6.33	.03	1.09	.077	<.01	1.84	<.03	1.14
	M01-07	-5.39	5-10-99	157	6.36	.32	.92	.106	<.01	2.10	.06	.57
	M01-08	-11.39	5-10-99	143	6.40	.03	.86	.084	<.01	2.28	.66	.37
	M01-09	-19.39	5-10-99	119	6.39	.10	.80	.053	<.01	2.40	1.17	.21
	M01-10	-27.39	5-10-99	116	6.46	.02	.89	.040	<.01	2.63	--	--
	M01-11	-35.42	5-10-99	107	6.44	.06	.64	.043	<.01	2.46	1.91	0.74
	M01-12	-43.41	5-10-99	87	6.31	.01	.41	.028	<.01	1.24	2.11	.93
	M01-13	-51.44	5-10-99	83	6.24	.03	.34	.024	<.01	.41	2.49	1.40
	M01-14	-59.44	5-10-99	83	6.15	.03	<.10	.026	<.01	.47	2.63	1.08
	M01-15	-67.44	5-10-99	81	5.74	1.39	<.10	.014	<.01	.35	2.64	<.03
FSW 566	M02-01	41.05	6-10-99	31	5.21	3.05	<.10	.006	<.01	<.01	<.03	.04
	M02-02	38.97	6-10-99	46	5.34	2.12	<.10	.011	<.01	<.01	<.03	.08
	M02-03	36.89	6-10-99	84	5.83	1.43	<.10	.020	<.01	<.01	.27	.07
	M02-04	34.81	6-10-99	85	5.83	1.15	.16	.039	<.01	<.01	1.21	<.03
	M02-05	32.73	6-10-99	129	5.84	1.44	.46	.083	<.01	.02	3.47	.10
	M02-06	30.59	6-10-99	179	5.96	.05	.62	.124	<.01	.14	5.91	.05
	M02-07	28.51	6-10-99	222	6.06	.00	.79	.162	<.01	.35	7.74	.06
	M02-08	26.43	6-10-99	231	6.12	.03	.90	.176	<.01	.35	6.06	.11
	M02-09	24.35	6-10-99	202	6.15	.03	.86	.181	<.01	.29	2.18	.05
	M02-10	22.27	6-10-99	218	6.17	.09	.82	.173	<.01	.27	.89	.08

Table 4. Altitude data, field parameters, and selected laboratory analyses of ground-water samples collected from multilevel samplers in the vicinity of Ashumet Pond, Massachusetts, April–July 1999—*Continued*

Local site identifier		Altitude of mid-point of screen	Date	Specific conductance (µS/cm)	pH (standard units)	Oxygen, dissolved (mg/L)	Phosphorus, dissolved (mg/L as P)	Boron, dissolved (mg/L as B)	Iron, dissolved (mg/L as Fe)	Manganese, dissolved (mg/L as Mn)	Nitrogen, nitrate, dissolved (mg/L as N)	Nitrogen, ammonium, dissolved (mg/L as N)
FSW 566—*Continued*												
	M02-11	20.27	6-10-99	222	6.21	0.02	0.81	0.164	<0.01	0.26	0.22	0.04
	M02-12	18.19	6-10-99	260	6.17	.04	.69	.188	<.01	.24	.21	.05
	M02-13	16.11	6-10-99	249	6.19	.02	.76	.228	<.01	.25	.15	<.03
	M02-14	14.03	6-10-99	217	6.24	.03	.87	.232	<.01	.30	<.03	.03
	M02-15	11.95	6-10-99	223	6.29	.02	.96	.276	<.01	.42	.23	.05
	M01-01	7.01	6-10-99	206	6.26	.06	1.06	.343	.02	.29	<.03	.06
	M01-02	2.00	6-10-99	176	6.19	.08	1.33	.287	<.01	.27	<.03	.22
	M01-03	-3.00	6-10-99	183	6.63	.26	2.32	.193	<.01	.40	<.03	.98
	M01-04	-7.98	6-10-99	174	6.60	.01	2.81	.147	.02	.32	<.03	.77
	M01-05	-12.98	6-10-99	158	6.55	.03	2.15	.142	<.01	.34	<.03	1.00
	M01-06	-17.96	6-10-99	111	6.44	.02	1.45	.098	<.01	.23	<.03	.57
	M01-07	-22.96	6-10-99	94	6.21	.07	.88	.079	<.01	.18	.72	.11
	M01-08	-27.95	6-10-99	93	6.15	.00	.47	.064	<.01	.34	.94	<.03
	M01-09	-32.95	6-10-99	74	6.27	4.85	.51	.042	<.01	.31	.68	<.03
	M01-10	-37.96	6-10-99	75	5.91	7.04	.36	.020	<.01	.38	.59	.05
	M01-11	-42.96	6-10-99	79	5.70	7.40	.23	.024	.05	.03	.57	<.03
	M01-12	-47.94	6-10-99	78	5.46	8.07	.18	.016	<.01	.01	.62	.16
	M01-13	-52.94	6-10-99	77	5.61	7.06	.15	.012	<.01	.38	.88	.04
	M01-14	-57.93	6-10-99	84	5.72	6.76	<.10	.017	<.01	.11	1.05	.05
	M01-15	-62.93	6-10-99	102	5.70	2.35	<.10	.016	<.01	.15	2.44	.06
FSW 567	M01-01	41.86	5-05-99	42	5.60	9.40	<.10	.010	<.01	<.01	<.03	.16
	M01-02	37.86	5-05-99	59	5.74	8.40	<.10	.010	<.01	.04	.29	.28
	M01-03	33.86	5-05-99	88	5.85	5.40	.69	.027	<.01	.02	1.02	.13
	M01-04	29.88	5-05-99	110	6.04	.80	1.98	.039	<.01	.04	1.11	.13
	M01-05	25.88	5-05-99	124	6.10	.01	2.44	.043	<.01	.04	.88	.16
	M01-06	21.88	5-05-99	161	6.23	.00	3.29	.053	<.01	.47	<.03	.09
	M01-07	17.88	5-05-99	196	6.28	.26	2.87	.054	<.01	.53	<.03	.11
	M01-08	14.88	5-05-99	199	6.30	.12	2.58	.049	<.01	.44	<.03	.10
	M01-09	11.88	5-05-99	177	6.35	.13	2.22	.043	<.01	.28	<.03	.12
	M01-10	7.90	5-05-99	121	6.51	.08	.57	.045	<.01	.15	<.03	.09
	M01-11	4.90	5-05-99	123	6.46	.06	.69	.051	<.01	.19	<.03	.21
	M01-12	1.90	5-05-99	144	6.36	.11	1.79	.049	.01	.59	<.03	1.04
	M01-13	-1.10	5-05-99	176	6.38	.07	2.33	.049	.05	.82	<.03	.97
	M01-14	-4.10	5-05-99	184	6.33	.09	2.35	.048	<.01	.91	<.03	1.41
	M01-15	-7.10	5-05-99	197	6.20	.25	2.11	.039	<.01	.99	<.03	1.78

Table 4. Altitude data, field parameters, and selected laboratory analyses of ground-water samples collected from multilevel samplers in the vicinity of Ashumet Pond, Massachusetts, April–July 1999—*Continued*

Local site identifier		Altitude of mid-point of screen	Date	Specific conductance (µS/cm)	pH (standard units)	Oxygen, dissolved (mg/L)	Phosphorus, dissolved (mg/L as P)	Boron, dissolved (mg/L as B)	Iron, dissolved (mg/L as Fe)	Manganese, dissolved (mg/L as Mn)	Nitrogen, nitrate, dissolved (mg/L as N)	Nitrogen, ammonium, dissolved (mg/L as N)
FSW 567—*Continued*												
	M02-01	-8.79	5-05-99	175	6.62	0.61	2.09	0.039	0.01	0.79	2.54	1.45
	M02-02	-11.81	5-05-99	198	6.57	.33	1.86	.035	.02	1.03	<.03	1.60
	M02-03	-14.81	5-05-99	204	5.56	.18	2.30	.042	.01	1.09	.05	1.27
	M02-04	-17.81	5-05-99	200	6.64	.13	2.29	.038	.01	.95	<.03	1.11
	M02-05	-20.82	5-05-99	195	6.62	.33	2.20	.035	.01	.83	<.03	.97
	M02-06	-23.82	5-05-99	151	6.64	.13	2.64	.028	.01	.62	<.03	1.26
	M02-07	-26.82	5-05-99	156	6.57	.50	2.29	.026	<.01	.60	<.03	.78
	M02-08	-30.82	5-05-99	117	6.59	.11	2.65	.025	<.01	.45	<.03	.63
	M02-09	-33.82	5-05-99	113	6.55	.46	1.48	.021	.01	.60	<.03	.56
	M02-10	-36.82	5-05-99	82	6.59	.23	1.01	.015	<.01	.61	<.03	.57
	M02-11	-40.82	5-05-99	75	6.60	.58	.93	.012	<.01	.96	.07	.52
	M02-12	-44.82	5-05-99	78	6.53	.55	.59	.016	<.01	1.40	.63	.20
	M02-13	-48.82	5-05-99	70	6.25	3.50	.42	.012	<.01	1.26	1.41	.08
	M02-14	-52.84	5-05-99	90	6.55	.37	.70	.016	<.01	1.19	1.91	2.03
	M02-15	-57.84	5-05-99	87	6.52	.89	1.01	.020	<.01	.49	1.80	2.41
FSW 573	M01-01	42.55	5-04-99	54	5.31	8.30	<.10	.005	<.01	.02	.07	.12
	M01-02	34.52	5-04-99	127	5.85	3.10	1.57	.021	<.01	.02	3.28	.10
	M01-03	26.49	5-04-99	142	6.08	.08	2.14	.038	<.01	.53	.67	.10
	M01-04	19.46	5-04-99	135	6.35	.04	2.73	.026	<.01	.29	<.03	.42
	M01-05	12.46	5-04-99	109	6.45	.16	2.66	.021	<.01	.42	.06	.31
	M01-06	5.43	5-04-99	102	6.28	.09	2.86	.020	.03	.78	<.03	1.03
	M01-07	-1.58	5-04-99	121	6.34	.10	3.36	.030	<.01	1.13	<.03	.17
	M01-08	-8.58	5-04-99	139	6.33	.14	3.05	.034	<.01	.97	.06	1.39
	M01-09	-16.60	5-04-99	170	6.29	.12	2.28	.032	<.01	.83	<.03	1.02
	M01-10	-24.61	5-04-99	150	6.26	.14	1.93	.023	<.01	.74	<.03	.97
	M01-11	-32.60	5-04-99	114	6.32	0.67	.98	.016	.02	.68	.08	.86
	M01-12	-40.62	5-04-99	117	5.97	5.80	.34	.009	<.01	.84	.56	<.03
	M01-13	-48.62	5-04-99	92	6.43	.60	.43	.011	<.01	.27	2.04	.31
	M01-14	-56.64	5-04-99	84	6.22	.39	<.10	.012	<.01	.16	2.05	2.09
	M01-15	-64.63	5-04-99	90	6.21	.32	<.10	.012	<.01	.13	2.14	3.03
FSW 575	M02-01	41.16	6-07-99	38	5.64	9.05	<.10	.016	<.01	<.01	<.03	.08
	M02-02	39.08	6-07-99	60	5.74	6.75	<.10	.024	<.01	<.01	.65	.11
	M02-03	36.99	6-07-99	92	5.78	5.01	.49	.054	<.01	<.01	3.41	.06
	M02-04	34.91	6-07-99	115	5.90	.91	1.82	.074	<.01	<.01	3.82	.06
	M02-05	32.83	6-07-99	150	5.95	.05	2.23	.084	<.01	.18	--	.08

Table 4. Altitude data, field parameters, and selected laboratory analyses of ground-water samples collected from multilevel samplers in the vicinity of Ashumet Pond, Massachusetts, April–July 1999—*Continued*

Local site identifier		Altitude of mid-point of screen	Date	Specific conduc-tance (µS/cm)	pH (stan-dard units)	Oxygen, dis-solved (mg/L)	Phos-phorus, dis-solved (mg/L as P)	Boron, dis-solved (mg/L as B)	Iron, dis-solved (mg/L as Fe)	Manga-nese, dis-solved (mg/L as Mn)	Nitrogen, nitrate, dis-solved (mg/L as N)	Nitrogen, ammo-nium, dis-solved (mg/L as N)
FSW 575—*Continued*												
	M02-06	30.72	6-07-99	202	6.02	0.03	1.91	0.108	<0.01	0.30	3.52	0.11
	M02-07	28.63	6-07-99	201	6.06	.06	1.77	.112	<.01	.31	3.49	.10
	M02-08	26.55	6-07-99	160	6.13	.01	.69	.110	<.01	.25	.91	.07
	M02-09	24.47	6-07-99	150	6.11	.21	.35	.102	<.01	.25	.60	.09
	M02-10	22.38	6-07-99	157	6.10	.08	.25	.099	<.01	.27	.44	.06
	M02-11	20.38	6-07-99	158	6.18	.18	.17	.091	<.01	.25	.33	.11
	M02-12	18.30	6-07-99	156	6.16	.20	.11	.084	<.01	.22	.06	.10
	M02-13	16.22	6-07-99	161	6.24	.07	.19	.119	<.01	.10	<.03	.05
	M02-14	14.13	6-07-99	186	6.35	.30	.22	.162	<.01	.05	<.03	.11
	M02-15	12.05	6-07-99	179	6.44	.18	.24	.129	.01	.04	<.03	<.03
	M01-01	8.19	6-07-99	180	6.44	.03	.23	.115	<.01	.07	<.03	.08
	M01-02	3.17	6-07-99	186	6.47	.02	.13	.138	.01	.08	<.03	.13
	M01-03	-1.83	6-07-99	176	6.29	.03	.14	.106	.39	.17	<.03	.06
	M01-04	-6.87	6-07-99	179	6.49	.00	1.41	.063	10.14	.20	<.03	.13
	M01-05	-11.87	6-07-99	174	6.58	.00	1.64	.056	10.51	.19	<.03	.13
	M01-06	-16.89	6-07-99	152	6.60	.00	1.39	.045	7.71	.15	.07	.12
	M01-07	-21.89	6-07-99	147	6.32	.00	1.08	.042	6.04	.14	<.03	.23
	M01-08	-26.92	6-07-99	115	6.07	.05	<.10	.037	<.01	.20	.26	.09
	M01-09	-31.92	6-07-99	119	5.92	2.73	<.10	.026	<.01	.41	.72	.06
	M01-10	-36.95	6-07-99	71	5.71	7.44	.32	.022	<.01	<.01	.66	.07
	M01-11	-41.95	6-07-99	78	5.81	8.97	.20	.019	<.01	<.01	.53	.06
	M01-12	-46.95	6-07-99	78	5.61	9.16	.16	.020	<.01	<.01	.53	.03
	M01-13	-51.95	6-07-99	77	5.57	9.06	.17	.017	<.01	<.01	.55	.06
	M01-14	-56.96	6-07-99	79	5.56	8.53	.14	.017	<.01	<.01	.75	.03
	M01-15	-61.96	6-07-99	85	5.65	8.74	.14	.019	<.01	.09	.75	.06
FSW 590	M01-01	41.43	4-28-99	35	5.63	8.63	<.10	.011	<.01	<.01	.10	.04
	M01-02	39.76	4-28-99	54	5.62	6.91	<.10	.015	<.01	<.01	.29	<.03
	M01-03	38.09	4-28-99	68	5.98	6.17	.41	.025	<.01	<.01	.61	<.03
	M01-04	36.42	4-28-99	76	5.98	5.77	.84	.033	.17	.02	1.31	<.03
	M01-05	34.75	4-28-99	103	6.16	.84	2.01	.085	.07	.03	2.38	<.03
	M01-06	33.08	4-28-99	125	6.28	.01	2.83	.109	<.01	.07	2.46	<.03
	M01-07	31.41	4-28-99	161	6.34	.08	3.00	.136	<.01	.16	1.75	<.03
	M01-09	28.07	4-28-99	204	6.30	.02	2.66	.136	<.01	.18	.20	<.03
	M01-10	26.40	4-28-99	236	6.27	.04	2.23	.130	<.01	.19	.56	<.03
	M01-11	24.73	4-28-99	251	6.32	.00	1.96	.150	<.01	.24	.50	<.03

Table 4. Altitude data, field parameters, and selected laboratory analyses of ground-water samples collected from multilevel samplers in the vicinity of Ashumet Pond, Massachusetts, April–July 1999—*Continued*

Local site identifier		Altitude of mid-point of screen	Date	Specific conductance (µS/cm)	pH (standard units)	Oxygen, dissolved (mg/L)	Phosphorus, dissolved (mg/L as P)	Boron, dissolved (mg/L as B)	Iron, dissolved (mg/L as Fe)	Manganese, dissolved (mg/L as Mn)	Nitrogen, nitrate, dissolved (mg/L as N)	Nitrogen, ammonium, dissolved (mg/L as N)
FSW 590—*Continued*												
	M01-12	23.06	4-28-99	263	6.22	0.00	1.43	0.143	<0.01	0.27	0.56	<0.03
	M01-13	21.39	4-28-99	274	6.12	.07	1.13	.131	.13	.30	.51	<.03
	M01-14	19.72	4-28-99	280	5.94	.04	1.14	.146	<.01	.32	.48	<.03
	M01-15	18.05	4-28-99	282	6.15	.02	.70	.139	<.01	.27	.26	.24
	M02-01	13.11	4-28-99	279	6.37	.03	.48	.186	.01	.18	.08	.61
	M02-02	8.21	4-28-99	235	6.41	.04	.85	.181	.02	.34	.06	.26
	M02-03	3.21	4-28-99	152	6.53	.14	2.41	.158	.06	.20	<.03	.42
	M02-04	-1.77	4-28-99	174	6.48	.00	2.42	.074	6.91	.35	<.03	.66
	M02-05	-6.77	4-28-99	181	6.47	.00	3.04	.070	9.88	.33	<.03	.60
	M02-06	-11.81	4-28-99	148	6.41	.00	2.94	.061	5.20	.37	<.03	.80
	M02-07	-16.81	4-28-99	99	6.46	.00	2.80	.043	2.90	.26	.06	.55
	M02-08	-21.83	4-28-99	83	6.32	.06	1.47	.041	.03	.70	<.03	.50
	M02-09	-26.83	4-28-99	104	6.09	.03	.78	.023	<.01	1.11	2.02	.32
	M02-10	-31.85	4-28-99	65	5.95	6.65	.49	.019	<.01	<.01	--	--
	M02-11	-36.85	4-28-99	72	5.69	6.71	.31	.017	<.01	<.01	.86	<.03
	M02-12	-41.90	4-28-99	72	5.52	7.42	.26	.016	<.01	<.01	.69	<.03
	M02-13	-46.90	4-28-99	80	5.39	7.98	.21	.018	<.01	<.01	.62	.04
	M02-14	-51.95	4-28-99	81	5.32	8.53	.22	.016	<.01	.05	.66	.07
	M02-15	-56.95	4-28-99	82	5.45	6.73	.23	.016	<.01	1.30	.85	.03
FSW 591	M01-01	41.80	5-03-99	60	5.63	9.62	<.10	.015	<.01	.02	.21	.04
	M01-02	37.85	5-03-99	116	5.96	.70	1.28	.062	.07	.05	2.15	.07
	M01-03	33.85	5-03-99	132	6.24	.15	3.27	.072	<.01	.20	.90	.07
	M01-04	29.84	5-03-99	147	6.43	.15	3.80	.076	<.01	.35	.12	.06
	M01-05	25.84	5-03-99	162	6.37	1.69	3.10	.056	<.01	.50	<.03	.07
	M01-06	21.84	5-03-99	132	6.41	.70	2.67	.043	<.01	.28	<.03	.60
	M01-07	17.85	5-03-99	125	6.45	.21	2.59	.048	<.01	.24	--	.20
	M01-08	14.85	5-03-99	127	6.46	.36	2.69	.056	<.01	.19	<.03	<.03
	M01-09	11.85	5-03-99	129	6.39	.17	2.75	.060	<.01	.19	<.03	.05
	M01-10	8.83	5-03-99	130	6.15	.07	2.16	.061	.24	.24	<.03	.10
	M01-11	5.83	5-03-99	138	6.11	.60	1.20	.058	.07	.34	<.03	.18
	M01-12	2.83	5-03-99	135	5.84	.44	.74	.055	.03	.64	<.03	.22
	M01-13	-.16	5-03-99	141	5.98	1.82	.66	.052	.25	.97	<.03	.05
	M01-14	-3.16	5-03-99	135	5.85	.90	.60	.046	<.01	.75	<.03	<.03
	M01-15	-6.16	5-03-99	131	6.13	.18	.47	.044	.09	.67	<.03	.03

Table 4. Altitude data, field parameters, and selected laboratory analyses of ground-water samples collected from multilevel samplers in the vicinity of Ashumet Pond, Massachusetts, April–July 1999—*Continued*

Local site identifier		Altitude of mid-point of screen	Date	Specific conductance (µS/cm)	pH (standard units)	Oxygen, dissolved (mg/L)	Phosphorus, dissolved (mg/L as P)	Boron, dissolved (mg/L as B)	Iron, dissolved (mg/L as Fe)	Manganese, dissolved (mg/L as Mn)	Nitrogen, nitrate, dissolved (mg/L as N)	Nitrogen, ammonium, dissolved (mg/L as N)
FSW 591—*Continued*												
	M02-01	-8.86	5-03-99	133	6.62	0.36	0.34	0.048	<0.01	0.65	<0.03	0.16
	M02-02	-11.79	5-03-99	138	6.60	.35	.26	.047	<.01	.44	.66	.12
	M02-03	-14.79	5-03-99	137	6.36	.10	.29	.043	<.01	.84	.99	.12
	M02-04	-17.79	5-03-99	112	6.33	.66	.51	.041	<.01	.86	.52	.13
	M02-05	-20.81	5-03-99	122	6.45	.12	.22	.036	<.01	.57	1.21	.14
	M02-06	-23.81	5-03-99	123	6.44	1.80	.24	.033	<.01	.55	1.16	.15
	M02-07	-26.81	5-03-99	130	6.34	.50	.17	.033	<.01	.31	1.28	.14
	M02-08	-30.82	5-03-99	130	6.14	.74	.13	.032	<.01	.71	.29	.12
	M02-09	-34.82	5-03-99	118	6.35	.83	.58	.031	.03	1.56	.62	.10
	M02-10	-38.82	5-03-99	140	6.06	.57	.41	.026	<.01	1.38	1.14	.22
	M02-11	-42.86	5-03-99	130	5.93	3.15	.37	.021	<.01	1.51	.98	.15
	M02-12	-46.86	5-03-99	109	6.02	6.31	.37	.020	<.01	1.40	.84	.09
	M02-13	-50.88	5-03-99	69	6.17	5.21	--	--	--	--	1.04	.10
	M02-14	-54.88	5-03-99	63	6.18	6.35	.45	.018	<.01	.55	1.11	.08
	M02-15	-58.88	5-03-99	63	6.18	7.32	.42	.017	<.01	.46	1.08	.06
FSW 618	M01-01	42.21	5-17-99	74	6.36	7.85	.28	.019	.02	.24	.18	.11
	M01-02	34.21	5-17-99	92	5.82	7.14	.25	.020	.02	.16	.36	.06
	M01-03	26.17	5-17-99	130	6.12	5.22	.32	.026	<.01	.28	.29	.06
	M01-04	18.99	5-17-99	108	6.30	5.35	<.10	.032	<.01	.21	.32	.15
	M01-05	11.99	5-17-99	111	6.33	6.14	<.10	.031	.02	.31	.53	.10
	M01-06	5.14	5-17-99	118	6.19	5.11	<.10	.023	.02	.74	.76	.14
	M01-07	-1.92	5-17-99	154	6.04	2.52	<.10	.014	<.01	.92	.68	.10
	M01-08	-8.92	5-17-99	131	6.16	6.07	<.10	.017	<.01	.60	.56	.12
	M01-09	-16.90	5-17-99	145	5.83	7.88	<.10	.016	<.01	.53	.55	.08
	M01-10	-24.92	5-17-99	141	6.31	7.99	<.10	.013	<.01	.63	.47	.13
	M01-11	-32.95	5-17-99	69	6.04	9.06	<.10	.010	<.01	.26	.31	.11
	M01-12	-41.03	5-17-99	72	6.19	8.26	<.10	.016	<.01	.24	.53	.24
	M01-13	-49.03	5-17-99	80	6.27	7.20	<.10	.015	<.01	.24	.72	.19
	M01-14	-56.99	5-17-99	75	6.00	7.50	<.10	.017	<.01	.10	.74	.12
	M01-15	-65.00	5-17-99	74	5.99	8.51	<.10	.017	<.01	.05	.76	.05
FSW 619	M01-01	39.50	7-20-99	62	5.81	7.29	<.10	.009	<.01	.30	<.03	<.03
	M01-03	23.50	7-20-99	224	6.12	.06	2.77	.180	<.01	.83	3.72	<.03
	M01-04	15.50	7-20-99	152	6.49	.15	4.56	.172	<.01	.90	<.03	<.03
	M01-05	9.50	7-20-99	146	6.58	.04	3.11	.178	<.01	.84	<.03	<.03
	M01-06	3.50	7-20-99	152	6.53	.09	1.31	.177	<.01	.87	.04	<.03

Table 4. Altitude data, field parameters, and selected laboratory analyses of ground-water samples collected from multilevel samplers in the vicinity of Ashumet Pond, Massachusetts, April–July 1999—*Continued*

Local site identifier		Altitude of mid-point of screen	Date	Specific conduc-tance (µS/cm)	pH (stan-dard units)	Oxygen, dis-solved (mg/L)	Phos-phorus, dis-solved (mg/L as P)	Boron, dis-solved (mg/L as B)	Iron, dis-solved (mg/L as Fe)	Manga-nese, dis-solved (mg/L as Mn)	Nitrogen, nitrate, dis-solved (mg/L as N)	Nitrogen, ammo-nium, dis-solved (mg/L as N)
FSW 619—*Continued*												
	M01-07	-2.50	7-20-99	196	6.53	0.08	3.26	0.097	<0.01	1.23	<0.03	0.92
	M01-08	-8.50	7-20-99	215	6.56	.05	2.26	.116	<.01	2.28	<.03	2.26
	M01-09	-16.50	7-20-99	194	6.61	.05	2.26	.084	<.01	1.87	<.03	1.83
	M01-10	-24.50	7-20-99	128	6.77	.07	2.45	.037	<.01	1.22	<.03	.83
	M01-11	-32.50	7-20-99	149	6.63	.05	1.41	.020	<.01	1.36	<.03	.97
	M01-12	-40.50	7-20-99	111	6.51	.12	.93	.014	<.01	1.62	1.24	1.56
	M01-13	-48.50	7-20-99	93	6.58	.09	.23	.021	<.01	.75	1.74	2.28
	M01-14	-56.50	7-20-99	93	6.58	.04	<.10	.022	<.01	.43	1.78	3.37
	M01-15	-64.50	7-20-99	89	6.38	.06	<.10	.018	<.01	.13	2.46	2.32
FSW 620	M01-01	39.81	7-21-99	160	5.51	9.38	<.10	.008	<.01	.15	.18	<.03
	M01-02	31.81	7-21-99	94	5.71	5.06	.10	.012	<.01	.11	2.03	<.03
	M01-03	23.81	7-21-99	144	6.18	.04	1.67	.030	<.01	.95	.28	<.03
	M01-04	15.81	7-21-99	135	6.44	.05	2.35	.025	<.01	1.27	<.03	.58
	M01-05	9.81	7-21-99	114	6.63	.09	3.12	.018	<.01	1.14	<.03	.94
	M01-06	3.81	7-21-99	111	6.69	.02	2.91	.016	<.01	1.75	.05	.99
	M01-07	-2.19	7-21-99	113	6.57	.06	2.94	.027	<.01	1.77	<.03	1.26
	M01-08	-8.19	7-21-99	134	6.56	.02	2.67	.025	<.01	2.04	<.03	2.40
	M01-09	-16.19	7-21-99	169	6.45	.00	1.49	.027	<.01	1.95	<.03	2.18
	M01-10	-24.19	7-21-99	191	6.41	.02	1.50	.020	<.01	1.50	<.03	1.02
	M01-11	-32.19	7-21-99	182	6.46	.04	1.49	.017	<.01	1.28	<.03	.66
	M01-12	-40.19	7-21-99	144	6.39	.00	1.09	.011	<.01	.91	.26	.46
	M01-13	-48.19	7-21-99	105	5.93	6.73	.31	.008	<.01	.94	.52	.06
	M01-14	-56.19	7-21-99	86	6.28	.03	<.10	.010	<.01	.46	2.16	1.37
	M01-15	-64.21	7-21-99	109	6.45	.17	<.10	.013	<.01	.43	2.15	4.05
FSW 621	M01-01	40.07	7-20-99	58	5.82	6.26	<.10	<.003	<.01	.10	.69	.30
	M01-02	32.07	7-20-99	170	6.16	.08	1.14	.140	<.01	.06	2.59	.16
	M01-03	24.07	7-20-99	179	6.51	.09	3.08	.242	<.01	1.81	.43	.15
	M01-04	16.07	7-20-99	238	6.51	.11	1.14	.179	<.01	3.90	1.57	.32
	M01-05	10.07	7-20-99	285	6.49	.07	1.89	.190	<.01	3.82	2.02	3.46
	M01-06	4.07	7-20-99	241	6.58	.14	1.66	.136	<.01	3.18	.44	2.46
	M01-07	-1.93	7-20-99	145	6.74	.10	1.84	.070	.06	1.60	.21	1.51
	M01-08	-7.93	7-20-99	142	6.70	.08	1.24	.034	<.01	2.17	.21	1.85
	M01-09	-15.93	7-20-99	93	6.75	.05	.92	.017	<.01	1.20	1.14	1.79
	M01-10	-23.93	7-20-99	90	6.68	.12	.48	.014	.08	.96	1.78	1.92

Table 4. Altitude data, field parameters, and selected laboratory analyses of ground-water samples collected from multilevel samplers in the vicinity of Ashumet Pond, Massachusetts, April–July 1999—*Continued*

Local site identifier		Altitude of mid-point of screen	Date	Specific conductance (µS/cm)	pH (standard units)	Oxygen, dissolved (mg/L)	Phosphorus, dissolved (mg/L as P)	Boron, dissolved (mg/L as B)	Iron, dissolved (mg/L as Fe)	Manganese, dissolved (mg/L as Mn)	Nitrogen, nitrate, dissolved (mg/L as N)	Nitrogen, ammonium, dissolved (mg/L as N)
FSW 621—*Continued*												
	M01-11	-31.93	7-20-99	84	6.51	0.03	<0.10	0.015	0.24	0.47	2.04	1.42
	M01-12	-39.93	7-20-99	87	6.43	.14	<.10	.015	.02	.32	2.33	2.86
	M01-13	-47.93	7-20-99	94	6.62	.07	<.10	.014	<.01	.07	2.28	1.12
	M01-14	-55.93	7-20-99	91	5.94	.08	<.10	.007	<.01	.03	2.56	.37
	M01-15	-63.94	7-20-99	99	6.33	.14	<.10	.010	<.01	.04	2.84	1.30
FSW 622	M01-01	38.47	7-20-99	54	5.51	8.35	<.10	.010	<.01	.07	.05	<.03
	M01-02	30.47	7-20-99	97	6.11	6.60	1.39	.027	.01	.11	.53	.06
	M01-03	22.47	7-20-99	149	6.43	.05	2.05	.043	<.01	2.18	<.03	.76
	M01-04	14.47	7-20-99	124	6.63	.02	1.88	.037	<.01	3.08	<.03	1.54
	M01-05	8.47	7-20-99	123	6.63	.06	2.38	.040	<.01	3.10	<.03	2.36
	M01-06	2.47	7-20-99	137	6.63	.02	2.30	.037	<.01	2.98	<.03	2.58
	M01-07	-3.53	7-20-99	153	6.57	.05	1.65	.036	<.01	2.73	<.03	2.20
	M01-08	-9.53	7-20-99	173	6.48	.03	1.61	.037	<.01	3.26	<.03	1.62
	M01-09	-17.53	7-20-99	193	6.51	.10	1.38	.031	<.01	3.26	<.03	2.40
	M01-10	-25.53	7-20-99	186	6.52	.00	1.15	.024	.12	2.11	.05	2.75
	M01-11	-33.53	7-20-99	159	6.60	.07	1.01	.020	.20	1.62	.06	2.12
	M01-12	-41.53	7-20-99	93	6.53	.15	.60	.013	.30	.95	.99	.63
	M01-13	-49.53	7-20-99	98	6.51	.05	1.00	.013	.10	.90	1.97	2.66
	M01-14	-57.53	7-20-99	105	6.53	.15	.24	.013	.17	.85	1.91	2.80
	M01-15	-65.50	7-20-99	131	6.53	.06	<.10	.025	<.01	.06	1.86	4.69
FSW 623	M01-01	40.71	7-19-99	60	5.40	8.97	<.10	.011	<.01	.03	.05	.05
	M01-02	32.71	7-19-99	120	5.52	4.18	.94	.020	<.01	.06	.54	.08
	M01-03	24.71	7-19-99	133	5.92	.22	1.18	.019	.03	.26	.67	.17
	M01-04	16.71	7-19-99	129	6.27	.27	.87	.028	.05	.21	1.67	.68
	M01-05	10.71	7-19-99	131	6.26	.10	1.24	.027	.09	.23	<.03	.94
	M01-06	4.71	7-19-99	159	6.31	.47	1.60	.025	.21	.72	.07	1.30
	M01-07	-1.29	7-19-99	159	6.38	.27	2.02	.026	.11	.62	<.03	1.24
	M01-08	-7.29	7-19-99	179	6.17	.17	1.16	.015	.05	.35	<.03	.51
	M01-09	-15.29	7-19-99	200	5.24	5.66	<.10	.015	<.01	.62	1.01	<.03
	M01-10	-23.29	7-19-99	96	5.94	7.15	<.10	.013	<.01	.65	.55	<.03
	M01-11	-31.29	7-19-99	81	5.91	6.56	<.10	.013	<.01	.55	.61	.05
	M01-13	-47.29	7-19-99	78	5.83	6.02	<.10	.020	<.01	.24	1.24	.03
	M01-14	-55.29	7-19-99	73	5.81	8.19	<.10	.018	<.01	.14	1.09	.13
	M01-15	-63.14	7-19-99	76	5.80	8.20	<.10	.017	<.01	.09	1.24	.06

Table 4. Altitude data, field parameters, and selected laboratory analyses of ground-water samples collected from multilevel samplers in the vicinity of Ashumet Pond, Massachusetts, April–July 1999—*Continued*

Local site identifier		Altitude of mid-point of screen	Date	Specific conduc-tance (µS/cm)	pH (stan-dard units)	Oxygen, dis-solved (mg/L)	Phos-phorus, dis-solved (mg/L as P)	Boron, dis-solved (mg/L as B)	Iron, dis-solved (mg/L as Fe)	Manga-nese, dis-solved (mg/L as Mn)	Nitrogen, nitrate, dis-solved (mg/L as N)	Nitrogen, ammo-nium, dis-solved (mg/L as N)
FSW 624	M01-01	41.28	7-21-99	51	5.61	6.24	<0.10	0.028	0.03	0.06	0.16	0.06
	M01-02	33.28	7-21-99	104	5.99	.22	.83	.085	.04	.12	1.61	<.03
	M01-03	25.28	7-21-99	275	6.31	.33	1.82	.153	.10	.97	1.11	<.03
	M01-04	17.28	7-21-99	206	6.46	.17	.93	.142	.11	.48	<.03	<.03
	M01-05	11.28	7-21-99	190	6.45	.14	1.39	.204	.07	.69	<.03	<.03
	M01-06	5.28	7-21-99	174	6.50	.08	1.80	.201	.03	.88	<.03	.47
	M01-07	-.72	7-21-99	177	6.59	.33	1.94	.118	.07	.61	<.03	.90
	M01-08	-6.72	7-21-99	192	6.49	.13	1.63	.104	.05	.82	<.03	.61
	M01-09	-14.72	7-21-99	144	6.52	.64	1.32	.071	.04	.75	<.03	.48
	M01-10	-22.72	7-21-99	107	6.47	.08	.69	.050	.13	.83	<.03	.14
	M01-11	-30.72	7-21-99	76	6.13	3.27	.31	.031	<.01	.91	.56	<.03
	M01-12	-38.72	7-21-99	67	6.04	6.64	.19	.022	<.01	.91	.74	.04
	M01-13	-46.72	7-21-99	70	5.98	6.59	.15	.019	<.01	1.21	.71	.08
	M01-14	-54.72	7-21-99	68	5.83	6.74	.12	.010	<.01	.55	.67	.05
SDW 317	M01-02	45.87	6-17-99	91	5.72	7.11	2.23	.058	<.01	.02	2.76	.15
	M01-03	43.87	6-17-99	103	6.03	4.39	3.39	.055	.03	.01	2.87	.18
	M01-04	41.87	6-17-99	90	6.01	2.50	1.99	.028	.02	.01	1.16	.10
	M01-05	39.94	6-17-99	92	5.96	1.96	1.51	.021	<.01	.02	.69	.07
	M01-06	37.94	6-17-99	104	5.86	3.04	1.28	.020	<.01	.02	.55	.07
	M01-07	35.94	6-17-99	115	5.85	3.40	1.17	.019	<.01	.03	.52	.11
	M01-08	33.94	6-17-99	135	5.88	7.60	1.24	.021	<.01	.03	.49	.15
	M01-09	31.94	6-17-99	149	5.88	3.89	1.22	.023	<.01	.03	.42	.10
	M01-10	29.94	6-17-99	139	5.86	3.96	1.15	.020	<.01	.02	.42	.13
	M01-11	28.01	6-17-99	120	5.93	3.84	1.23	.020	<.01	.02	.55	.10
	M01-12	26.01	6-17-99	113	6.01	2.52	1.55	.021	<.01	.02	.70	.14
	M01-13	24.01	6-17-99	101	5.96	2.71	1.42	.021	<.01	.02	.92	.25
	M01-14	22.01	6-17-99	104	5.89	3.26	1.25	.020	<.01	.03	1.18	.08
	M01-15	20.01	6-17-99	117	5.80	4.04	.92	.023	<.01	.04	1.34	.08
	M02-01	19.95	6-16-99	112	5.75	3.99	.93	.018	<.01	.04	1.25	.13
	M02-02	17.95	6-16-99	118	5.65	4.15	.74	.021	<.01	.05	1.34	.13
	M02-03	15.95	6-16-99	128	5.57	3.84	.62	.021	<.01	.04	1.47	.13
	M02-04	13.95	6-16-99	143	5.54	3.79	.57	.020	<.01	.05	1.32	.07
	M02-05	12.03	6-16-99	157	5.54	4.40	.53	.025	<.01	.07	1.06	.08
	M02-06	10.03	6-16-99	160	5.56	4.68	.53	.021	<.01	.06	.87	.07
	M02-07	8.03	6-16-99	162	5.57	5.30	.51	.022	<.01	.06	.70	.08
	M02-08	6.03	6-16-99	147	5.67	6.10	.57	.024	<.01	.05	.60	.10
	M02-09	4.03	6-16-99	143	5.66	6.20	.54	.022	<.01	.05	.60	.13
	M02-10	2.03	6-16-99	127	5.72	7.28	.55	.026	<.01	.05	.60	.11

Table 4. Altitude data, field parameters, and selected laboratory analyses of ground-water samples collected from multilevel samplers in the vicinity of Ashumet Pond, Massachusetts, April–July 1999—*Continued*

Local site identifier		Altitude of mid-point of screen	Date	Specific conduc-tance (µS/cm)	pH (stan-dard units)	Oxygen, dis-solved (mg/L)	Phos-phorus, dis-solved (mg/L as P)	Boron, dis-solved (mg/L as B)	Iron, dis-solved (mg/L as Fe)	Manga-nese, dis-solved (mg/L as Mn)	Nitrogen, nitrate, dis-solved (mg/L as N)	Nitrogen, ammo-nium, dis-solved (mg/L as N)
SDW 317—*Continued*												
	M02-11	.10	6-16-99	123	5.72	7.69	0.47	0.023	<0.01	0.02	0.67	0.10
	M02-12	-1.90	6-16-99	133	5.66	7.88	.38	.023	<.01	.01	.69	.11
	M02-13	-3.90	6-16-99	155	5.63	7.91	.29	.026	<.01	<.01	.67	.14
	M02-14	-5.90	6-16-99	176	5.58	7.70	.33	.023	<.01	.01	.69	.10
	M02-15	-7.90	6-16-99	192	5.50	7.39	.33	.021	<.01	.01	.71	.11
SDW 318	M01-01	46.86	6-29-99	115	6.07	9.05	3.32	.032	.02	<.01	2.19	.20
	M01-02	44.86	6-29-99	116	5.95	6.95	2.52	.045	.01	<.01	3.75	.27
	M01-03	42.86	6-29-99	104	5.76	4.55	2.28	.045	.01	.01	3.38	.07
	M01-04	40.86	6-29-99	93	5.90	2.95	2.48	.034	.02	.01	2.02	.08
	M01-05	38.86	6-29-99	90	5.89	1.25	1.74	.018	.01	.01	.95	.08
	M01-06	36.91	6-29-99	93	5.87	.81	1.58	.018	<.01	.01	.77	.03
	M01-07	34.91	6-29-99	100	5.85	1.59	1.54	.017	<.01	.02	.67	.07
	M01-08	32.91	6-29-99	110	5.84	1.55	1.56	.019	<.01	.02	.63	.11
	M01-09	30.91	6-29-99	135	5.81	3.10	1.25	.017	<.01	.03	.42	.11
	M01-10	28.91	6-29-99	125	5.85	3.37	1.23	.016	<.01	.02	.41	.08
	M01-11	26.96	6-29-99	110	5.91	3.04	1.44	.018	<.01	.01	.39	.13
	M01-12	24.96	6-29-99	109	5.94	6.17	1.50	.016	<.01	.02	.50	.08
	M01-13	22.96	6-29-99	101	5.89	2.02	1.50	.021	<.01	.02	.77	.07
	M01-14	20.96	6-29-99	99	5.84	3.01	1.40	.018	<.01	.02	.97	.11
	M01-15	18.96	6-29-99	102	5.72	3.46	1.09	.018	<.01	.03	1.26	.07
	M02-01	16.16	6-29-99	123	5.65	3.84	.69	.023	<.01	.05	1.33	.07
	M02-02	12.10	6-29-99	148	5.59	3.93	.67	.023	<.01	.06	1.06	.25
	M02-03	8.10	6-29-99	152	5.66	4.61	.67	.023	<.01	.04	.73	.08
	M02-04	4.10	6-29-99	129	5.73	6.19	.65	.023	<.01	.04	.57	.10
	M02-05	.05	6-29-99	120	5.77	6.94	.54	.023	<.01	.02	.60	.10
	M02-06	-3.95	6-29-99	139	5.71	7.15	.46	.023	<.01	.02	.59	.11
	M02-07	-7.97	6-29-99	191	5.56	6.91	.31	.025	<.01	.01	.69	.11
	M02-08	-11.97	6-29-99	155	5.43	7.56	.21	.019	<.01	.19	.85	.14
	M02-09	-15.97	6-29-99	118	5.51	7.58	.25	.015	<.01	.08	.81	.07
	M02-10	-19.99	6-29-99	118	5.60	8.11	.17	.010	<.01	.02	.69	.08
	M02-11	-24.99	6-29-99	88	5.70	8.38	.19	.013	<.01	<.01	.50	.10
	M02-12	-30.02	6-29-99	69	5.66	8.83	.00	.011	<.01	<.01	.46	.31
	M02-13	-35.02	6-29-99	62	5.73	8.34	.00	.010	<.01	<.01	.50	.13
	M02-14	-40.05	6-29-99	55	5.75	8.78	.00	.009	<.01	<.01	.45	.14
	M02-15	-45.05	6-29-99	72	5.63	8.02	.00	.012	<.01	<.01	.62	.10

Table 4. Altitude data, field parameters, and selected laboratory analyses of ground-water samples collected from multilevel samplers in the vicinity of Ashumet Pond, Massachusetts, April–July 1999—*Continued*

Local site identifier		Altitude of mid-point of screen	Date	Specific conduc-tance (µS/cm)	pH (stan-dard units)	Oxygen, dis-solved (mg/L)	Phos-phorus, dis-solved (mg/L as P)	Boron, dis-solved (mg/L as B)	Iron, dis-solved (mg/L as Fe)	Manga-nese, dis-solved (mg/L as Mn)	Nitrogen, nitrate, dis-solved (mg/L as N)	Nitrogen, ammo-nium, dis-solved (mg/L as N)
SDW 468	M01-01	46.25	6-01-99	72	5.32	2.86	2.22	0.033	0.01	0.02	2.20	0.13
	M01-02	43.25	6-01-99	236	5.68	1.83	.87	.040	<.01	.04	5.76	.10
	M01-03	40.25	6-01-99	284	5.90	.18	.99	.044	<.01	.08	5.31	.11
	M01-04	37.21	6-01-99	272	5.98	.19	1.13	.062	<.01	.15	6.37	.11
	M01-05	32.21	6-01-99	173	6.17	.11	1.19	.027	<.01	.08	1.46	.13
	M01-06	27.18	6-01-99	141	5.95	.12	.94	.019	<.01	.08	1.77	.11
	M01-07	20.18	6-01-99	125	5.61	.05	.52	.022	<.01	.10	1.84	.07
	M01-08	13.15	6-01-99	111	5.35	.09	.21	.034	<.01	.06	.77	.11
	M01-09	6.13	6-01-99	116	4.70	1.78	.00	.040	<.01	.04	.67	.10
	M01-10	-1.91	6-01-99	158	5.21	6.36	.25	.028	<.01	.04	.64	<.03
	M01-11	-9.91	6-01-99	151	5.51	7.65	.47	.021	<.01	.02	.50	.13
	M01-12	-18.94	6-01-99	102	5.65	8.69	.44	.010	<.01	.01	.38	.10
	M01-13	-27.96	6-01-99	60	5.80	9.03	.39	.007	<.01	.01	.56	.08
	M01-14	-36.99	6-01-99	55	5.75	9.59	.26	.006	<.01	<.01	.52	.10
	M01-15	-46.03	6-01-99	64	5.71	9.52	.25	.010	<.01	<.01	.43	.11
SDW 469	M01-01	46.24	7-01-99	119	5.93	7.84	3.17	.054	.04	<.01	5.24	.14
	M01-02	43.24	7-01-99	108	5.65	5.59	1.73	.034	.01	.02	4.78	.10
	M01-03	40.24	7-01-99	120	5.77	1.68	2.23	.026	.02	.02	2.31	.13
	M01-04	37.23	7-01-99	143	5.67	.23	1.58	.033	<.01	.03	1.75	.11
	M01-05	32.23	7-01-99	138	5.80	.13	1.71	.030	<.01	.02	.97	.15
	M01-06	27.21	7-01-99	131	5.85	.15	1.53	.023	.01	.02	.67	<.03
	M01-07	20.21	7-01-99	139	5.95	.11	1.78	.030	<.01	.03	<.03	<.03
	M01-08	13.18	7-01-99	116	5.77	.10	1.23	.026	.04	.12	<.03	.11
	M01-09	6.15	7-01-99	143	5.85	.35	1.90	.030	.25	.16	<.03	2.12
	M01-10	-1.87	7-01-99	160	5.92	.36	1.59	.039	.34	.12	.10	1.43
	M01-11	-9.87	7-01-99	154	5.87	.41	1.29	.034	.15	.10	.10	.50
	M01-12	-18.90	7-01-99	161	5.73	.49	.80	.024	.09	.04	.07	.45
	M01-13	-27.92	7-01-99	105	5.76	.30	.38	.016	<.01	.05	.08	.13
	M01-14	-36.94	7-01-99	76	5.67	8.30	.11	.014	<.01	.01	.76	.06
	M01-15	-45.95	7-01-99	84	5.92	7.77	.20	.020	<.01	<.01	.46	.07
SDW 470	M01-01	46.37	6-02-99	105	5.53	7.10	2.18	.043	<.01	.02	4.68	.17
	M01-02	43.37	6-02-99	115	5.51	2.90	2.76	.044	.01	.03	6.18	.21
	M01-03	40.37	6-02-99	116	5.65	.44	2.21	.029	<.01	.02	2.87	.13
	M01-04	37.34	6-02-99	136	5.45	3.00	.89	.027	<.01	.10	1.51	.11
	M01-05	32.34	6-02-99	157	5.21	.03	.85	.029	<.01	.03	2.42	.14

Table 4. Altitude data, field parameters, and selected laboratory analyses of ground-water samples collected from multilevel samplers in the vicinity of Ashumet Pond, Massachusetts, April–July 1999—*Continued*

Local site identifier		Altitude of mid-point of screen	Date	Specific conductance (µS/cm)	pH (standard units)	Oxygen, dissolved (mg/L)	Phosphorus, dissolved (mg/L as P)	Boron, dissolved (mg/L as B)	Iron, dissolved (mg/L as Fe)	Manganese, dissolved (mg/L as Mn)	Nitrogen, nitrate, dissolved (mg/L as N)	Nitrogen, ammonium, dissolved (mg/L as N)
SDW 470—*Continued*												
	M01-06	27.30	6-02-99	116	5.34	0.52	0.64	0.017	<0.01	0.02	1.25	0.13
	M01-07	20.30	6-02-99	117	5.54	.02	.85	.018	<.01	.02	1.47	.08
	M01-08	13.25	6-02-99	128	5.50	.05	1.09	.032	<.01	.04	4.15	.13
	M01-09	6.22	6-02-99	135	5.58	.04	.90	.033	<.01	.03	2.23	.18
	M01-10	-1.80	6-02-99	165	5.94	.06	.88	.035	<.01	.02	.78	1.26
	M01-11	-9.80	6-02-99	141	5.90	.09	.44	.026	<.01	.04	.53	.31
	M01-12	-18.84	6-02-99	95	5.58	6.00	.23	.012	<.01	.13	.46	.08
	M01-13	-27.88	6-02-99	77	5.55	8.20	.10	.006	<.01	<.01	.48	.10
	M01-14	-36.93	6-02-99	62	5.91	9.30	.21	.010	<.01	<.01	.66	.08
	M01-15	-45.95	6-02-99	79	5.92	9.80	.10	.010	<.01	<.01	.52	.10
SDW 471	M01-01	46.36	6-02-99	131	5.70	8.10	2.40	.067	<.01	.02	7.27	.10
	M01-02	43.36	6-02-99	71	5.56	5.90	1.06	.033	<.01	.03	2.05	.08
	M01-03	40.36	6-02-99	70	5.50	2.50	.67	.015	<.01	.13	1.08	.14
	M01-04	37.33	6-02-99	75	5.30	3.30	.44	.011	<.01	.11	.59	.15
	M01-05	32.33	6-02-99	63	5.32	4.40	.41	.009	<.01	.04	.36	.18
	M01-07	20.29	6-02-99	90	5.24	2.80	.37	.009	<.01	.03	1.39	.07
	M01-08	13.26	6-02-99	103	5.37	1.60	.00	.012	<.01	.07	1.72	.10
	M01-09	6.23	6-02-99	127	5.38	3.40	.00	.026	<.01	.16	1.08	.11
	M01-10	-1.80	6-02-99	166	5.34	5.40	.00	.034	<.01	.06	.73	.11
	M01-11	-9.80	6-02-99	173	5.33	8.00	.11	.016	<.01	.02	.53	.08
	M01-12	-18.84	6-02-99	147	5.45	8.40	.11	<.003	<.01	.02	.60	.10
	M01-13	-27.86	6-02-99	57	5.70	9.40	.13	.005	<.01	<.01	.41	.07
	M01-14	-36.93	6-02-99	80	5.42	9.50	--	--	--	--	.46	.08
	M01-15	-45.95	6-02-99	68	5.39	9.60	.00	.009	.02	.04	.36	.10
SDW 472	M01-01	46.30	6-24-99	110	5.61	5.45	1.14	.074	<.01	<.01	2.84	.11
	M01-02	43.30	6-24-99	81	5.69	2.39	1.37	.029	<.01	.02	1.96	.14
	M01-03	40.30	6-24-99	79	5.74	.01	1.23	.017	<.01	.02	.99	.11
	M01-04	37.27	6-24-99	79	5.78	.03	1.15	.015	<.01	.02	.70	.10
	M01-05	32.27	6-24-99	112	5.62	1.44	.81	.017	<.01	.02	.62	.10
	M01-06	27.24	6-24-99	135	5.51	1.50	.54	.015	<.01	.05	.50	.13
	M01-07	20.24	6-24-99	92	5.56	.02	.45	.019	<.01	.03	<.03	.08
	M01-08	13.21	6-24-99	105	5.54	.04	.23	.018	<.01	.02	.41	.08
	M01-09	6.19	6-24-99	107	5.60	2.83	.17	.021	<.01	.02	.70	.10
	M01-10	-1.84	6-24-99	118	5.61	7.13	.11	.036	<.01	<.01	.49	.08

Table 4. Altitude data, field parameters, and selected laboratory analyses of ground-water samples collected from multilevel samplers in the vicinity of Ashumet Pond, Massachusetts, April–July 1999—*Continued*

Local site identifier		Altitude of mid-point of screen	Date	Specific conduc-tance (µS/cm)	pH (stan-dard units)	Oxygen, dis-solved (mg/L)	Phos-phorus, dis-solved (mg/L as P)	Boron, dis-solved (mg/L as B)	Iron, dis-solved (mg/L as Fe)	Manga-nese, dis-solved (mg/L as Mn)	Nitrogen, nitrate, dis-solved (mg/L as N)	Nitrogen, ammo-nium, dis-solved (mg/L as N)
SDW 472—*Continued*												
	M01-11	-9.84	6-24-99	112	5.58	7.69	0.00	0.018	<0.01	<0.01	0.53	0.14
	M01-12	-18.85	6-24-99	79	5.55	7.94	.00	.009	<.01	<.01	.36	.08
	M01-13	-27.88	6-24-99	57	5.61	8.52	.00	.018	<.01	<.01	.45	.11
	M01-14	-36.92	6-24-99	75	5.43	8.86	.00	.013	<.01	.01	.36	.08
	M01-15	-45.95	6-24-99	81	5.36	8.90	.00	.015	<.01	.03	.42	.15
SDW 473	M01-01	46.58	6-28-99	80	4.69	8.79	.00	.019	<.01	.14	2.21	.06
	M01-02	43.58	6-28-99	96	4.92	6.60	.00	.020	<.01	.03	1.67	.06
	M01-03	40.58	6-28-99	139	5.88	7.23	.11	.016	<.01	.03	.78	.04
	M01-04	37.54	6-28-99	136	5.75	6.46	.15	.017	<.01	<.01	1.49	.06
	M01-05	32.54	6-28-99	122	5.46	3.33	.11	.015	<.01	.02	2.72	.06
	M01-06	27.52	6-28-99	113	5.40	.05	.10	.026	<.01	.55	2.14	.83
	M01-07	20.52	6-28-99	160	5.93	.08	.12	.039	<.01	4.02	<.03	1.64
	M01-08	13.49	6-28-99	110	6.04	.07	.10	.032	.03	2.32	<.03	.94
	M01-09	6.45	6-28-99	95	6.07	.11	.00	.024	.04	1.29	<.03	.49
	M01-10	-1.59	6-28-99	83	5.88	.01	.00	.019	<.01	.76	<.03	.28
	M01-11	-9.59	6-28-99	58	5.72	3.47	.00	.014	<.01	.89	.60	.06
	M01-12	-18.62	6-28-99	69	5.85	8.56	.00	.012	<.01	<.01	.39	<.03
	M01-13	-27.66	6-28-99	61	5.89	9.40	.00	.017	<.01	.01	.41	.04
	M01-14	-36.70	6-28-99	79	5.86	8.80	.00	.016	<.01	<.01	.43	.04
	M01-15	-45.74	6-28-99	87	5.84	9.10	.00	.020	<.01	<.01	.46	.06
SDW 474	M01-01	46.33	6-16-99	73	4.92	7.78	.00	.018	.03	.06	1.79	.07
	M01-02	43.33	6-16-99	57	5.34	7.36	.00	.009	<.01	<.01	.53	.07
	M01-03	40.33	6-16-99	97	5.18	8.23	.00	.008	<.01	.06	.53	.10
	M01-04	37.30	6-16-99	112	5.34	8.57	.00	.012	<.01	.03	.41	.07
	M01-05	32.30	6-16-99	84	5.39	8.21	.00	.012	<.01	.02	1.06	.07
	M01-06	27.27	6-16-99	101	5.32	3.91	.00	.016	<.01	.02	3.05	.07
	M01-07	20.27	6-16-99	134	5.42	6.70	.00	.027	<.01	.02	1.13	.07
	M01-08	13.25	6-16-99	187	5.43	8.20	.00	.036	<.01	.01	.55	.07
	M01-09	6.22	6-16-99	214	5.47	8.25	.00	.039	<.01	<.01	.46	.08
	M01-10	-1.82	6-16-99	146	5.58	9.16	.00	.036	<.01	<.01	.41	.10
	M01-11	-9.82	6-16-99	198	5.44	9.17	.00	.022	<.01	<.01	.56	.07
	M01-12	-18.85	6-16-99	87	5.44	9.58	.00	.010	<.01	<.01	.43	.07
	M01-13	-27.88	6-16-99	62	5.28	10.01	.00	.012	<.01	.01	.39	.07
	M01-14	-36.91	6-16-99	83	5.28	10.13	.00	.018	<.01	.02	.34	.07
	M01-15	-45.95	6-16-99	79	5.78	9.70	.00	.014	<.01	<.01	.43	.07

Table 5. Physical data and chemical analyses of ground-water samples collected from a temporary drive points driven 2 feet below the pond bottom, Ashumet Pond, Massachusetts, August–October 1999

[Source of phosphorus, boron, iron, and manganese data: Douglas B. Kent, U.S. Geological Survey, National Research Program. Source of nitrogen data: Richard L. Smith, U.S. Geological Survey, National Research Program. Location of sites shown in figure 5. State plane coordinates are from North Atlantic Datum 1983 (NAD83). **Latitude and longitude:** In degrees, minutes, and seconds. D, duplicate; ft, foot; m, meter; µS/cm, microsiemen per centimeter at 25°Celsius; <, actual value less than method detection limit; --, no data]

Local site identifier	Date sampled	Easting (m)	Northing (m)	Latitude ° ′ ″	Longitude ° ′ ″	Distance from shore (ft)	Water depth (ft)	Drive length (ft)	Specific conductance (µS/cm)
01-10	8-17-99	280115.1	821068.3	41 38 08	70 32 20	10	0.6	2.0	83
01-25	8-17-99	280119.0	821066.4	41 38 08	70 32 20	25	1.0	2.0	71
01-50	8-17-99	280125.7	821062.6	41 38 08	70 32 20	50	2.1	2.0	83
01-75	8-17-99	280131.8	821059.8	41 38 08	70 32 20	75	3.2	2.0	88
02-10	8-16-99	280093.8	821045.2	41 38 08	70 32 21	10	.9	2.0	102
02-25	8-16-99	280098.4	821045.4	41 38 08	70 32 21	25	3.3	2.0	148
02-50	8-16-99	280104.3	821040.2	41 38 08	70 32 21	50	3.6	2.0	72
02-75	8-16-99	280113.1	821040.0	41 38 08	70 32 21	75	4.3	2.3	67
02-100	8-16-99	280120.5	821036.1	41 38 07	70 32 20	100	5.2	2.0	141
02-125	8-16-99	280123.9	821029.9	41 38 07	70 32 20	125	6.6	2.0	156
02-150	8-16-99	280132.0	821027.3	41 38 07	70 32 20	150	8.2	2.0	135
02-175	8-16-99	280135.7	821021.5	41 38 07	70 32 20	175	10.5	2.8	104
02-200	8-16-99	280144.0	821019.0	41 38 07	70 32 19	200	13.6	2.0	106
02a-10	8-26-99	280088.9	821032.7	41 38 07	70 32 22	10	.8	2.0	124
02a-25	8-26-99	280093.9	821031.3	41 38 07	70 32 21	25	1.8	2.0	170
03-10	8-17-99	280082.6	821019.5	41 38 07	70 32 22	10	.9	2.0	152
03-25	8-17-99	280086.0	821017.7	41 38 07	70 32 22	25	1.8	2.0	137
03-50	8-17-99	280092.7	821014.2	41 38 07	70 32 21	50	3.2	2.0	143
03a-00	8-24-99	280072.1	821007.1	41 38 06	70 32 22	0	.0	2.0	70
03a-05	8-24-99	280073.3	821006.9	41 38 06	70 32 22	5	.4	2.0	390
03a-10	8-24-99	280074.6	821006.7	41 38 06	70 32 22	10	.9	2.0	194
03a-25	8-24-99	280078.7	821005.0	41 38 06	70 32 22	25	1.8	2.0	145
03a-50	8-24-99	280085.3	821002.7	41 38 06	70 32 22	50	3.5	2.0	162
03a-75	8-25-99	280090.8	820999.0	41 38 06	70 32 21	75	4.9	2.0	105
03a-100	8-25-99	280097.4	820995.4	41 38 06	70 32 21	100	7.4	2.0	115
03a-125	8-25-99	280104.7	820994.4	41 38 06	70 32 21	125	10.1	2.0	96
03a-00-ST1	8-24-99	280072.1	821007.1	41 38 06	70 32 22	0	.0	1.0	50
03a-00-ST2	8-24-99	280072.1	821007.1	41 38 06	70 32 22	0	.0	2.0	70
03a-00-ST3	8-24-99	280072.1	821007.1	41 38 06	70 32 22	0	.0	3.0	348
03a-00-ST4	8-24-99	280072.1	821007.1	41 38 06	70 32 22	0	.0	4.0	408
03a-00-ST5	8-24-99	280072.1	821007.1	41 38 06	70 32 22	0	.0	5.0	437
03a-00-ST6	8-24-99	280072.1	821007.1	41 38 06	70 32 22	0	.0	6.0	445
03a-00-ST7	8-24-99	280072.1	821007.1	41 38 06	70 32 22	0	.0	7.0	380
03a-00-ST8	8-24-99	280072.1	821007.1	41 38 06	70 32 22	0	.0	8.0	293
03a-00-ST9	8-24-99	280072.1	821007.1	41 38 06	70 32 22	0	.0	9.0	161
03a-00-ST10	8-24-99	280072.1	821007.1	41 38 06	70 32 22	0	.0	10.0	167
04-10	8-17-99	280066.5	820993.1	41 38 06	70 32 23	10	.9	2.1	251
04-25	8-17-99	280070.6	820990.8	41 38 06	70 32 22	25	1.7	2.0	261
04-50	8-17-99	280077.1	820987.4	41 38 06	70 32 22	50	3.7	2.0	85

Table 5. Physical data and chemical analyses of ground-water samples collected from a temporary drive points driven 2 feet below the pond bottom, Ashumet Pond, Massachusetts, August–October 1999

[Source of phosphorus, boron, iron, and manganese data: Douglas B. Kent, U.S. Geological Survey, National Research Program. Source of nitrogen data: Richard L. Smith, U.S. Geological Survey, National Research Program. Location of sites shown in figure 5. State plane coordinates are from North Atlantic Datum 1983 (NAD83). **Latitude and longitude:** In degrees, minutes, and seconds. D, duplicate; ft, foot; m, meter; µS/cm, microsiemen per centimeter at 25°Celsius; <, actual value less than method detection limit; --, no data]

Local site identifier	Oxygen, dissolved (mg/L)	Phosphorus, dissolved (mg/L as P)	Boron, dissolved (mg/L as B)	Iron, dissolved (mg/L as Fe)	Manganese, dissolved (mg/L as Mn)	Nitrogen, nitrate, dissolved (mg/L as N)	Nitrogen, ammonium, dissolved (mg/L as N)
01-10	4.00	<0.10	0.010	0.19	0.05	1.24	<0.03
01-25	8.20	<.10	.013	.11	.02	.31	<.03
01-50	.60	<.10	.019	.23	.06	<.03	<.03
01-75	1.55	<.10	.012	1.48	.09	.04	.31
02-10	7.10	<.10	.020	.04	.07	.53	<.03
02-25	7.00	<.10	.019	.10	.24	1.02	<.03
02-50	7.20	<.10	.008	.06	.03	.34	<.03
02-75	8.90	<.10	.010	.12	.06	.25	<.03
02-100	8.20	<.10	.012	.14	.05	.87	<.03
02-125	7.90	<.10	.016	.13	.04	.94	<.03
02-150	5.00	<.10	.019	.18	.04	.54	<.03
02-175	6.10	<.10	.057	.79	.06	.06	2.27
02-200	6.60	<.10	.015	1.12	.44	<.03	1.12
02a-10	.73	1.40	.017	.05	2.80	<.03	2.00
02a-25	.68	<.10	.017	.07	1.13	.04	.10
03-10	.89	2.21	.029	.16	4.97	<.03	1.22
03-25	.57	1.19	.030	.14	2.80	<.03	1.89
03-50	.47	.15	.013	.10	1.33	.07	.22
03a-00	7.90	.45	.004	.05	.18	.10	<.03
03a-05	7.30	1.07	.021	.08	2.66	.41	<.03
03a-10	.31	1.55	.065	.06	6.75	.27	.72
03a-25	.16	3.07	.093	.19	1.48	<.03	2.60
03a-50	.33	.66	.022	.08	2.65	.09	2.37
03a-75	.43	.26	.010	.09	.78	1.18	2.19
03a-100	.70	<.10	.017	.11	.15	2.27	2.40
03a-125	9.70	<.10	.010	.09	.06	.75	<.03
03a-00-ST1	3.90	.30	<.003	.05	.11	<.03	<.03
03a-00-ST2	7.90	.45	.004	.05	.18	.10	<.03
03a-00-ST3	8.50	.95	.016	.07	1.11	.39	<.03
03a-00-ST4	6.30	1.21	.028	.06	4.85	.56	<.03
03a-00-ST5	7.10	1.21	.033	.10	5.48	.78	--
03a-00-ST6	5.70	1.23	.030	.12	6.52	.68	<.03
03a-00-ST7	1.30	1.40	.043	.07	7.93	1.13	<.03
03a-00-ST8	.08	1.50	.060	.12	7.07	.76	.41
03a-00-ST9	.89	1.69	.072	.12	4.29	.20	.32
03a-00-ST10	.12	1.81	.085	.13	4.03	<.03	.47
04-10	.61	1.66	.207	.07	4.04	3.77	<.03
04-25	.57	1.88	.197	.11	3.50	1.41	2.73
04-50	.96	.68	.020	.07	1.47	.75	2.45

Table 5. Physical data and chemical analyses of ground-water samples collected from a temporary drive points driven 2 feet below the pond bottom, Ashumet Pond, Massachusetts, August–October 1999—*Continued*

Local site identifier	Date sampled	Easting (m)	Northing (m)	Latitude ° ′ ″	Longitude ° ′ ″	Distance from shore (ft)	Water depth (ft)	Drive length (ft)	Specific conductance (µS/cm)
04a-05	8-24-99	280055.3	820981.8	41 38 06	70 32 23	5	0.5	2.0	201
04a-10	8-24-99	280056.5	820981.1	41 38 06	70 32 23	10	.8	2.0	114
04a-25	8-24-99	280060.9	820979.4	41 38 06	70 32 23	25	1.8	2.0	289
04a-50	8-24-99	280067.8	820975.7	41 38 05	70 32 22	50	3.6	2.0	90
04a-75	8-26-99	280075.1	820973.5	41 38 05	70 32 22	75	5.9	2.0	95
04a-100	8-26-99	280084.3	820973.6	41 38 05	70 32 22	100	8.0	2.0	100
04a-125	8-26-99	280089.4	820968.2	41 38 05	70 32 22	125	10.9	2.0	98
04a-150	8-26-99	280097.4	820964.6	41 38 05	70 32 21	150	14.2	2.0	98
04a-150-D	8-26-99	280097.4	820964.6	41 38 05	70 32 21	150	14.2	2.0	--
04a-175	8-26-99	280104.5	820960.9	41 38 05	70 32 21	175	17.1	2.0	90
05-10	8-18-99	280047.5	820972.1	41 38 05	70 32 23	10	.9	2.0	162
05-25	8-18-99	280052.0	820970.2	41 38 05	70 32 23	25	1.8	2.0	145
05-50	8-18-99	280059.5	820966.8	41 38 05	70 32 23	50	3.6	2.0	102
05-50-D	8-18-99	280059.5	820966.8	41 38 05	70 32 23	50	3.6	2.0	--
05a-10	9-20-99	280041.1	820965.5	41 38 05	70 32 24	10	.6	2.0	153
05a-25	9-20-99	280045.9	820963.4	41 38 05	70 32 23	25	1.5	2.0	155
05a-50	9-20-99	280052.5	820960.1	41 38 05	70 32 23	50	3.0	2.0	153
05b-10	9-23-99	280030.3	820959.5	41 38 05	70 32 24	10	.8	2.5	84
05b-25	9-23-99	280033.8	820957.5	41 38 05	70 32 24	25	1.1	2.0	180
05b-50	9-23-99	280039.8	820952.3	41 38 05	70 32 24	50	2.5	2.0	145
05b-75	9-23-99	280047.3	820949.8	41 38 05	70 32 23	75	3.8	1.8	139
06-10	8-18-99	280017.6	820953.6	41 38 05	70 32 25	10	.7	2.8	220
06-25	8-18-99	280021.9	820951.8	41 38 05	70 32 24	25	1.3	3.2	179
06-50	8-18-99	280028.8	820948.0	41 38 05	70 32 24	50	2.4	4.8	159
06-75	8-18-99	280035.4	820944.5	41 38 04	70 32 24	75	3.5	2.0	168
06-125	10-05-99	280044.2	820936.0	41 38 04	70 32 24	125	5.3	2.0	172
06-150	10-05-99	280054.4	820929.1	41 38 04	70 32 23	150	7.2	2.0	103
06-175	10-05-99	280062.7	820923.8	41 38 04	70 32 23	175	6.7	2.0	119
06-225	10-05-99	280072.9	820918.5	41 38 04	70 32 22	225	10.5	2.0	119
06a-10	9-20-99	279977.5	820953.3	41 38 05	70 32 26	10	.3	2.0	79
06a-25	9-20-99	279982.2	820950.8	41 38 05	70 32 26	25	.3	2.5	77
06a-50	9-20-99	279989.2	820948.8	41 38 05	70 32 26	50	.3	2.0	138
06a-75	9-20-99	279996.7	820947.0	41 38 05	70 32 26	75	.5	2.0	197
06a-100	9-20-99	280003.2	820943.3	41 38 04	70 32 25	100	.9	2.0	295
06a-125	9-20-99	280009.8	820941.4	41 38 04	70 32 25	125	1.6	2.0	224
06a-150	9-20-99	280017.7	820939.0	41 38 04	70 32 25	150	2.4	2.6	193
06a-175	9-20-99	280024.8	820937.3	41 38 04	70 32 24	175	3.1	2.6	158
06a-310	10-05-99	280048.6	820903.1	41 38 03	70 32 23	310	7.2	2.0	175
06b-10	9-23-99	280008.6	820948.5	41 38 05	70 32 25	10	.5	2.0	205
06b-25	9-23-99	280012.0	820946.3	41 38 05	70 32 25	25	.9	2.0	197
06b-50	9-23-99	280018.6	820942.3	41 38 04	70 32 25	50	2.9	2.0	175
06b-75	9-23-99	280025.5	820939.4	41 38 04	70 32 24	75	3.0	2.0	159
06b-100	9-23-99	280032.6	820937.4	41 38 04	70 32 24	100	3.9	2.0	129

Table 5. Physical data and chemical analyses of ground-water samples collected from a temporary drive points driven 2 feet below the pond bottom, Ashumet Pond, Massachusetts, August–October 1999—*Continued*

Local site identifier	Oxygen, dissolved (mg/L)	Phosphorus, dissolved (mg/L as P)	Boron, dissolved (mg/L as B)	Iron, dissolved (mg/L as Fe)	Manganese, dissolved (mg/L as Mn)	Nitrogen, nitrate, dissolved (mg/L as N)	Nitrogen, ammonium, dissolved (mg/L as N)
04a-05	0.09	2.79	0.231	0.09	4.22	1.32	<0.03
04a-10	3.20	1.39	.217	.06	2.11	.18	.52
04a-25	.05	1.09	.199	.08	5.70	.87	2.84
04a-50	.30	.24	.017	.07	.82	1.29	2.32
04a-75	.80	<.10	.018	.09	.15	2.34	.84
04a-100	.10	<.10	.019	.13	.06	2.18	.79
04a-125	.40	<.10	.020	.10	.16	2.74	1.57
04a-150	2.60	<.10	.044	.29	.08	.04	.25
04a-150-D	--	<.10	.039	.30	.14	.04	.27
04a-175	5.50	<.10	.016	.14	.07	<.03	<.03
05-10	.09	1.46	.153	.04	3.06	.10	.40
05-25	.09	.85	.061	.05	2.77	<.03	2.20
05-50	.08	.26	.025	.04	1.54	1.12	1.19
05-50-D	--	.34	.019	.05	1.66	1.00	1.22
05a-10	.41	1.37	.123	.08	3.05	<.03	.03
05a-25	.35	.62	.067	.08	3.52	<.03	1.70
05a-50	.20	.42	.037	.06	1.97	.46	1.87
05b-10	1.20	<.10	.031	.07	.18	1.43	<.03
05b-25	.10	.64	.202	.12	4.22	2.06	.10
05b-50	.12	.36	.115	.09	5.26	<.03	1.16
05b-75	.14	<.10	.052	.06	2.49	1.49	.69
06-10	.08	.83	.176	.03	5.03	1.93	<.03
06-25	.06	<.10	.185	.11	.47	<.03	2.77
06-50	.13	<.10	.072	.05	4.23	<.03	1.94
06-75	.24	<.10	.071	.08	5.47	<.03	2.07
06-125	.37	<.10	.085	.10	5.13	.14	1.60
06-150	.30	<.10	.022	.11	.78	2.30	2.81
06-175	.20	<.10	.021	.10	1.83	2.45	.80
06-225	.93	<.10	.017	.17	.87	--	2.66
06a-10	1.00	<.10	.057	.09	.20	.72	<.03
06a-25	1.70	<.10	.027	.10	.32	.73	<.03
06a-50	.57	.62	.104	.09	3.81	2.20	<.03
06a-75	.16	<.10	.106	.16	4.83	3.94	.40
06a-100	.16	<.10	.146	.13	6.79	7.95	1.02
06a-125	.41	.56	.053	.19	5.28	.14	1.74
06a-150	.51	.32	.074	.10	6.91	.08	1.52
06a-175	.51	<.10	.130	.11	3.57	<.03	2.36
06a-310	.40	<.10	.019	.18	1.75	4.17	2.09
06b-10	.07	.79	.089	.10	4.45	1.88	<.03
06b-25	.25	.79	.053	.14	4.93	.14	1.31
06b-50	.32	<.10	.054	.14	6.12	<.03	1.96
06b-75	.37	<.10	.074	.13	5.25	.07	2.34
06b-100	.24	<.10	.140	.07	3.82	.07	1.94

Table 5. Physical data and chemical analyses of ground-water samples collected from a temporary drive points driven 2 feet below the pond bottom, Ashumet Pond, Massachusetts, August–October 1999—*Continued*

Local site identifier	Date sampled	Easting (m)	Northing (m)	Latitude ° ′ ″	Longitude ° ′ ″	Distance from shore (ft)	Water depth (ft)	Drive length (ft)	Specific conductance (μS/cm)
06c-25	9-23-99	279976.4	820946.6	41 38 05	70 32 26	25	1.3	2.0	248
06c-50	9-23-99	279983.3	820942.6	41 38 04	70 32 26	50	1.6	2.0	237
06c-75	9-23-99	279989.7	820938.6	41 38 04	70 32 26	75	1.8	2.0	296
06c-100	9-23-99	279995.7	820934.5	41 38 04	70 32 26	100	2.0	2.0	277
06c-125	9-23-99	280002.2	820930.0	41 38 04	70 32 25	125	2.4	3.8	274
06c-150	9-23-99	280008.8	820927.1	41 38 04	70 32 25	150	3.0	2.0	341
06c-175	9-23-99	280015.4	820922.1	41 38 04	70 32 25	175	3.6	2.0	288
07-10	8-19-99	279968.7	820944.9	41 38 04	70 32 27	10	1.2	2.0	107
07-25	8-19-99	279972.6	820943.3	41 38 04	70 32 27	25	1.8	2.0	258
07-50	8-19-99	279979.4	820939.7	41 38 04	70 32 26	50	1.9	2.0	296
07-75	8-18-99	279986.1	820936.1	41 38 04	70 32 26	75	2.3	3.0	301
07-100	8-18-99	279992.9	820932.5	41 38 04	70 32 26	100	2.5	3.6	342
07-100-D	8-18-99	279992.9	820932.5	41 38 04	70 32 26	100	2.5	3.6	--
07-125	8-18-99	280000.0	820929.2	41 38 04	70 32 25	125	3.0	2.6	321
07-150	8-18-99	280006.4	820925.3	41 38 04	70 32 25	150	3.2	2.0	391
07-175	8-18-99	280013.0	820921.8	41 38 04	70 32 25	175	3.75	2.5	335
07-225	10-05-99	280032.9	820832.6	41 38 01	70 32 24	225	5.2	2.0	152
07a-10	9-21-99	279961.1	820930.7	41 38 04	70 32 27	10	.8	3.0	246
07a-25	9-21-99	279965.5	820929.4	41 38 04	70 32 27	25	1.6	2.0	302
07a-50	9-21-99	279972.5	820926.6	41 38 04	70 32 27	50	2.0	2.0	374
07a-75	9-21-99	279979.8	820923.8	41 38 04	70 32 26	75	2.2	2.0	383
07a-100	9-20-99	279986.5	820921.3	41 38 04	70 32 26	100	2.5	2.5	340
07a-125	9-20-99	279994.3	820919.5	41 38 04	70 32 26	125	2.8	2.0	364
07a-150	9-20-99	280001.5	820916.9	41 38 04	70 32 25	150	3.0	2.0	362
07a-175	9-20-99	280008.8	820914.5	41 38 03	70 32 25	175	3.5	2.5	352
08-10	8-23-99	279955.5	820918.4	41 38 04	70 32 27	10	.7	2.0	269
08-25	8-23-99	279960.1	820915.1	41 38 04	70 32 27	25	1.9	2.0	313
08-50	8-23-99	279966.4	820911.7	41 38 03	70 32 27	50	2.1	2.0	170
08-75	8-23-99	279973.6	820907.4	41 38 03	70 32 27	75	2.7	2.0	302
08-100	8-23-99	279979.9	820904.7	41 38 03	70 32 26	100	2.9	2.0	363
08-125	8-23-99	279987.1	820900.2	41 38 03	70 32 26	125	3.2	2.0	390
08-150	8-23-99	279993.3	820896.0	41 38 03	70 32 26	150	3.4	2.0	425
08-175	8-23-99	279999.9	820892.6	41 38 03	70 32 25	175	3.8	2.0	404
08-175-D	8-23-99	279999.9	820892.6	41 38 03	70 32 25	175	3.8	2.0	--
08-225	10-05-99	280004.6	820839.5	41 38 01	70 32 25	225	4.5	2.0	309
08-275	10-05-99	280023.7	820873.7	41 38 02	70 32 24	275	6.0	2.0	408
08-325	10-05-99	280035.9	820858.9	41 38 02	70 32 24	325	6.8	2.0	322
08a-10	9-21-99	279953.6	820902.2	41 38 03	70 32 27	10	.8	2.0	290
08a-25	9-21-99	279956.7	820899.6	41 38 03	70 32 27	25	1.6	2.0	265
08a-50	9-21-99	279964.4	820898.0	41 38 03	70 32 27	50	2.3	2.0	107
08a-75	9-21-99	279971.5	820895.1	41 38 03	70 32 27	75	2.5	2.1	294

Table 5. Physical data and chemical analyses of ground-water samples collected from a temporary drive points driven 2 feet below the pond bottom, Ashumet Pond, Massachusetts, August–October 1999—*Continued*

Local site identifier	Oxygen, dissolved (mg/L)	Phosphorus, dissolved (mg/L as P)	Boron, dissolved (mg/L as B)	Iron, dissolved (mg/L as Fe)	Manganese, dissolved (mg/L as Mn)	Nitrogen, nitrate, dissolved (mg/L as N)	Nitrogen, ammonium, dissolved (mg/L as N)
06c-25	0.37	0.85	0.242	0.18	2.77	1.41	<0.03
06c-50	.58	.45	.213	.17	3.73	2.14	.03
06c-75	.12	<.10	.220	.14	5.55	1.58	1.89
06c-100	.13	.43	.241	.23	6.07	<.03	.99
06c-125	.11	.43	.189	.10	5.49	<.03	1.59
06c-150	.14	<.10	.175	.13	8.54	.15	1.75
06c-175	.11	<.10	.063	.09	9.21	<.03	2.38
07-10	1.20	.60	.054	.06	1.11	2.61	<.03
07-25	.40	.70	.260	.10	2.89	.78	<.03
07-50	.47	.75	.295	.14	3.70	.91	.40
07-75	.31	.78	.294	.11	4.26	1.18	1.33
07-100	.11	.48	.280	.14	5.78	1.75	1.83
07-100-D	--	.55	.300	.16	6.23	1.73	1.81
07-125	.07	.43	.261	.05	5.77	1.30	1.72
07-150	.08	<.10	.228	.09	9.53	6.07	2.05
07-175	.11	<.10	.097	.12	10.34	.12	2.87
07-225	.80	<.10	.012	.15	1.98	.89	.84
07a-10	.37	.80	.241	.09	1.97	3.18	<.03
07a-25	.90	.69	.290	.18	3.35	2.57	<.03
07a-50	.59	.50	.340	.19	4.28	.21	1.56
07a-75	.27	.63	.337	.08	5.00	<.03	1.76
07a-100	.55	.36	.276	.18	5.78	.21	1.72
07a-125	.21	.31	.241	.15	6.98	<.03	2.31
07a-150	.18	<.10	.175	.25	8.58	<.03	2.14
07a-175	.31	<.10	.120	.22	8.85	<.03	2.62
08-10	.70	<.10	.277	.11	3.27	5.36	<.03
08-25	.57	<.10	.348	.17	.76	3.86	.52
08-50	.21	.11	.167	.32	.19	.08	2.54
08-75	.09	<.10	.255	.36	.17	<.03	7.37
08-100	.26	<.10	.323	.47	2.10	.31	.07
08-125	.09	<.10	.349	.11	6.15	10.50	1.46
08-150	.13	<.10	.315	.13	7.10	12.11	2.78
08-175	.45	<.10	.333	.10	7.17	5.86	.48
08-175-D	--	<.10	.343	.11	7.38	5.92	.45
08-225	.17	<.10	.282	.16	3.36	8.08	.32
08-275	.15	<.10	.351	.46	1.15	.67	.76
08-325	.50	<.10	.315	.34	4.01	.22	<.03
08a-10	.39	<.10	.292	.17	1.33	6.63	<.03
08a-25	.08	<.10	.154	.63	.08	.14	.18
08a-50	.41	.37	<.003	.92	.06	<.03	1.92
08a-75	.37	.11	.192	.59	.08	<.03	7.02

Table 5. Physical data and chemical analyses of ground-water samples collected from a temporary drive points driven 2 feet below the pond bottom, Ashumet Pond, Massachusetts, August–October 1999—*Continued*

Local site identifier	Date sampled	Easting (m)	Northing (m)	Latitude ° ′ ″	Longitude ° ′ ″	Distance from shore (ft)	Water depth (ft)	Drive length (ft)	Specific conductance (μS/cm)
08a-100	9-21-99	279979.2	820893.1	41 38 03	70 32 26	100	2.7	2.0	341
08a-125	9-21-99	279986.0	820889.8	41 38 03	70 32 26	125	3.0	3.1	309
08a-150	9-21-99	279993.7	820886.8	41 38 03	70 32 26	150	3.3	2.0	409
09-10	8-19-99	279950.5	820885.9	41 38 03	70 32 28	10	.8	2.0	179
09-25	8-19-99	279954.2	820883.2	41 38 03	70 32 27	25	2.0	2.0	244
09-50	8-19-99	279961.3	820879.9	41 38 02	70 32 27	50	2.0	2.0	99
09-50-D	8-19-99	279961.3	820879.9	41 38 02	70 32 27	50	2.0	2.0	--
09-75	8-19-99	279968.3	820876.1	41 38 02	70 32 27	75	2.6	2.0	145
09-100	8-19-99	279975.1	820872.6	41 38 02	70 32 27	100	3.0	2.8	292
09-125	8-19-99	279982.1	820870.5	41 38 02	70 32 26	125	3.0	2.0	227
09-150	8-19-99	279988.3	820867.4	41 38 02	70 32 26	150	3.5	2.0	258
09-175	8-19-99	279994.7	820862.6	41 38 02	70 32 26	175	3.8	2.0	191
09-225	10-5-99	280007.8	820864.2	41 38 02	70 32 25	225	4.5	2.0	217
09-275	10-5-99	280024.0	820856.3	41 38 02	70 32 24	275	5.6	2.0	248
09-325	10-5-99	280038.4	820839.5	41 38 01	70 32 24	325	6.0	2.0	312
10-25	8-25-99	279994.1	820829.9	41 38 01	70 32 26	25	.8	2.0	304
10-50	8-25-99	280001.0	820825.6	41 38 01	70 32 25	50	1.4	2.0	188
10-75	8-25-99	280008.2	820822.5	41 38 01	70 32 25	75	1.8	2.0	239
10-100	8-25-99	280014.9	820820.1	41 38 00	70 32 25	100	2.2	2.0	163
10-125	8-25-99	280022.2	820816.9	41 38 00	70 32 25	125	2.6	2.0	192
10-150	8-25-99	280029.8	820813.7	41 38 00	70 32 24	150	2.9	2.0	241
10-175	8-25-99	280044.9	820810.6	41 38 00	70 32 24	175	3.1	2.0	189
10-200	8-25-99	280035.4	820812.5	41 38 00	70 32 24	200	3.2	2.0	181
10-225	8-25-99	280051.1	820807.3	41 38 00	70 32 23	225	2.9	2.0	179
10-250	8-25-99	280057.8	820803.9	41 37 60	70 32 23	250	2.5	2.0	188
10-275	8-25-99	280065.1	820801.1	41 37 60	70 32 23	275	2.4	2.0	269
10-300	8-25-99	280071.6	820798.3	41 37 60	70 32 22	300	2.5	2.0	309
10-325	8-25-99	280080.3	820794.6	41 37 60	70 32 22	325	3.0	2.0	307
10-350	8-25-99	280087.0	820792.0	41 37 60	70 32 22	350	3.8	2.0	272

Table 5. Physical data and chemical analyses of ground-water samples collected from a temporary drive points driven 2 feet below the pond bottom, Ashumet Pond, Massachusetts, August–October 1999—*Continued*

Local site identifier	Oxygen, dissolved (mg/L)	Phosphorus, dissolved (mg/L as P)	Boron, dissolved (mg/L as B)	Iron, dissolved (mg/L as Fe)	Manganese, dissolved (mg/L as Mn)	Nitrogen, nitrate, dissolved (mg/L as N)	Nitrogen, ammonium, dissolved (mg/L as N)
08a-100	0.11	<0.10	0.271	0.48	0.16	<0.03	1.24
08a-125	.10	<.10	.251	.55	.68	.96	.23
08a-150	.60	<.10	.302	.14	6.69	13.14	.40
09-10	.95	<.10	.176	.12	1.03	4.28	<.03
09-25	.83	<.10	.198	.22	.14	<.03	.08
09-50	.06	.27	.011	.39	.11	.04	1.52
09-50-D	--	.22	<.003	.44	.08	<.03	1.63
09-75	.05	.23	.137	.28	.09	<.03	3.45
09-100	.11	<.10	.268	.08	.58	2.75	<.03
09-125	.70	<.10	.290	.23	.09	<.03	.04
09-150	.31	<.10	.310	.12	.17	.39	<.03
09-175	1.50	.12	.221	.15	.70	2.54	<.03
09-225	.31	<.10	.011	.73	1.83	<.03	1.43
09-275	.57	<.10	.255	.15	3.53	2.72	.64
09-325	.17	.12	.391	.62	.14	<.03	2.70
10-25	.31	<.10	.180	.11	4.09	9.78	.20
10-50	.77	<.10	.221	.28	2.81	.15	.77
10-75	.19	.12	.357	.72	.37	.15	.34
10-100	.65	<.10	.286	.33	.12	.08	2.76
10-125	.21	<.10	.200	.95	.09	<.03	3.11
10-150	.19	<.10	.248	.62	.07	<.03	4.12
10-175	.05	<.10	.198	.87	.08	<.03	1.23
10-200	.14	.10	.173	.73	.26	<.03	1.31
10-225	.06	<.10	.079	8.15	.53	<.03	.43
10-250	.52	<.10	.156	.41	.18	<.03	3.04
10-275	.72	<.10	.234	.65	.13	<.03	6.78
10-300	.00	<.10	.260	6.91	.28	<.03	7.06
10-325	.00	<.10	.225	10.93	.66	.16	4.90
10-350	.00	<.10	.207	11.99	.65	.15	5.24