USGS
science for a changing world

MDE

Prepared in cooperation with the
Maryland Department of the Environment
Maryland Department of Natural Resources
Maryland Department of Agriculture
Dorchester Soil Conservation District
U.S. Fish and Wildlife Service

Geology, Hydrology, and Water Quality of the Little Blackwater River Watershed, Dorchester County, Maryland, 2006–09

Scientific Investigations Report 2011–5054

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

Cover. Aerial view of Little Blackwater River looking north. The Key Wallace Drive bridge is in the foreground. Photograph by Jane Thomas, IAN Image Library (www.ian.umces.edu/imagelibrary/).

Geology, Hydrology, and Water Quality of the Little Blackwater River Watershed, Dorchester County, Maryland, 2006–09

By Brandon J. Fleming, Benjamin D. DeJong, and Daniel J. Phelan

Prepared in cooperation with the
Maryland Department of the Environment
Maryland Department of Natural Resources
Maryland Department of Agriculture
Dorchester Soil Conservation District
U.S. Fish and Wildlife Service

Scientific Investigations Report 2011–5054

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

U.S. Department of the Interior
KEN SALAZAR, Secretary

U.S. Geological Survey
Marcia K. McNutt, Director

U.S. Geological Survey, Reston, Virginia: 2011

For more information on the USGS—the Federal source for science about the Earth, its natural and living resources, natural hazards, and the environment, visit http://www.usgs.gov or call 1-888-ASK-USGS

For an overview of USGS information products, including maps, imagery, and publications, visit http://www.usgs.gov/pubprod

To order this and other USGS information products, visit http://store.usgs.gov

Suggested citation:
Fleming, B.J., DeJong, B.D., and Phelan, D.J., 2011, Geology, hydrology, and water quality of the Little Blackwater River watershed, Dorchester County, Maryland, 2006–09: U.S. Geological Survey Scientific Investigations Report 2011–5054, 82 p.

ISBN 978-1-4113-3123-5

Contents

Figures

Tables

Conversion Factors and Datums

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square foot (ft^2)	0.09290	square meter (m^2)
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
gallon (gal)	3.785	liter (L)
cubic foot (ft^3)	0.02832	cubic meter (m^3)
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
gallon per minute (gal/min)	0.06309	liter per second (L/s)
gallon per day (gal/d)	0.003785	cubic meter per day (m^3/d)

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

$$°F = (1.8 \times °C) + 32$$

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

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

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25 °C).

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

The term “water year” is defined as the 12-month period from October 1 of any given year through September 30 of the following year. The water year is designated by the calendar year in which it ends and which includes 9 of the 12 months. Thus, the year ending September 30, 2002, is called the “2002 water year.”

Geology, Hydrology, and Water Quality of the Little Blackwater River Watershed, Dorchester County, Maryland, 2006–09

By Brandon J. Fleming, Benjamin D. DeJong, and Daniel J. Phelan

Abstract

The Little Blackwater River watershed is a low-lying tidal watershed in Dorchester County, Maryland. The potential exists for increased residential development in a mostly agricultural watershed that drains into the Blackwater National Wildlife Refuge. Groundwater and surface-water levels were collected along with water-quality samples to document hydrologic and geochemical conditions within the watershed prior to potential land-use changes.

Lithologic logs were collected in the Little Blackwater River watershed and interpreted with existing geophysical logs to conceptualize the shallow groundwater-flow system. A shallow water table exists in much of the watershed as shown by sediment cores and surface geophysical surveys. Water-table wells have seasonal variations of 6 feet, with the lowest water levels occurring in September and October. Seasonally low water-table levels are lower than the stage of the Little Blackwater River, creating the potential for surface-water infiltration into the water table.

Two stream gages, each equipped with stage, velocity, specific conductance, and temperature sensors, were installed at the approximate mid-point of the watershed and near the mouth of the Little Blackwater River. The gages recorded data continuously and also were equipped with telemetry. Discharge calculated at the mouth of the Little Blackwater River showed a seasonal pattern, with net positive discharge in the winter and spring months and net negative discharge (flow into the watershed from Blackwater National Wildlife Refuge and Fishing Bay) in the summer and fall months. Continuous water-quality records showed an increase in specific conductance during the summer and fall months.

Discrete water-quality samples were collected during 2007–08 from 13 of 15 monitoring wells and during 2006–09 from 9 surface-water sites to characterize pre-development conditions and the seasonal variability of inorganic constituents and nutrients. The highest mean values of nitrogen are found in the deep groundwater system, with relatively low values in the water table. Surface-water-quality samples in the lower half of the basin show a significant increase in inorganic seawater constituents, especially in summer, corresponding with net negative discharge from the Little Blackwater River.

Samples also were collected from nine wells and four surface-water sites for pesticides in June 2008. The herbicides atrazine, metolachlor, and simazine, and the insecticide fipronil were detected at each of the four surface-water sites, with concentrations less than 2 micrograms per liter. Concentrations of pesticides found in groundwater were typically one to two orders of magnitude lower than pesticide concentrations found in surface water of the Little Blackwater River.

Seasonal hydraulic-gradient reversals between the shallow groundwater system and the Little Blackwater River, coincident with the inflow of brackish water from Fishing Bay and Blackwater National Wildlife Refuge, indicate a potential for saltwater intrusion into the water table. The likelihood of saltwater intrusion into the water table is further supported by high chloride concentrations observed in water-table wells near the Little Blackwater River.

Introduction

The U.S. Geological Survey (USGS), in cooperation with the Maryland Department of the Environment, the Maryland Department of Natural Resources, the Maryland Department of Agriculture, the Dorchester Soil Conservation District, and the U.S. Fish and Wildlife Service, began a study of the hydrology of the Little Blackwater River watershed in

Dorchester County, Maryland in September 2006. The study was designed to document the local geologic setting, measure seasonal groundwater and surface-water conditions, and analyze water quality in the drainage area of the Blackwater National Wildlife Refuge (BNWR) planned for municipal development.

The BNWR is located 12 mi (miles) south of Cambridge in Dorchester County, Maryland, and consists of over 25,000 acres of freshwater impoundments, brackish tidal wetlands, open fields, and mixed evergreen and deciduous forests (fig. 1). The refuge was established in 1933 primarily as a wildlife sanctuary for migratory birds but is the home of other threatened species such as the Delmarva fox squirrel and bald eagle. In the 20th century, wetland plants have disappeared from the wetlands for a variety of reasons including the presence of nutria (*Myocastor coypus*)—non-native semi-aquatic rodents that overgraze native wetland plants. Residential development is planned in the Little Blackwater River watershed between the refuge and the City of Cambridge (fig. 2). County, State, and Federal regulators and agencies as well as public civic groups are concerned that an increase in development could have detrimental effects on the BNWR by changing groundwater-flow patterns, increasing runoff from areas treated with fertilizers, and increasing discharges from on-site wastewater systems into the tidal Little Blackwater River that flows into the Blackwater River and the BNWR. In an effort to minimize the potential effects of development on the BNWR, the State of Maryland purchased part of the proposed development area that directly borders the Little Blackwater River, and no development will be allowed on the state-owned property (fig. 2).

Purpose and Scope

This report describes (1) the geology of the Little Blackwater River watershed based on the drilling results from concurrent regional geological investigations, (2) the groundwater-flow system in areas adjacent to proposed development, (3) streamflow characteristics, and (4) groundwater and surface-water quality in the Little Blackwater River watershed from 2006 through 2009. Data presented in this report will provide a baseline of preexisting conditions for comparison with future post-development conditions.

Description of Study Area

The Little Blackwater River watershed is in Dorchester County, Maryland, on the Eastern Shore of the Chesapeake Bay. The watershed extends from the south side of Cambridge to the Blackwater River in the BNWR (fig. 2). The Little Blackwater River watershed drains approximately 27,748 acres [43.3 mi^2 (square miles)] that are used primarily for agriculture. Land use in the watershed in 2005 included approximately 1,276 acres of residential, commercial, and light industrial land, and 26,472 acres of cropland, woodland, forested and marshy riparian areas, and tidal wetlands (James Newcomb, Dorchester Soil Conservation District, oral commun., 2007). The watershed is relatively flat, with an elevation of 30 ft (feet) near Cambridge, to sea level at the confluence with the Blackwater River. The Little Blackwater River is tidally affected for much of its reach, and flows generally southward to discharge to the Blackwater River (fig. 2).

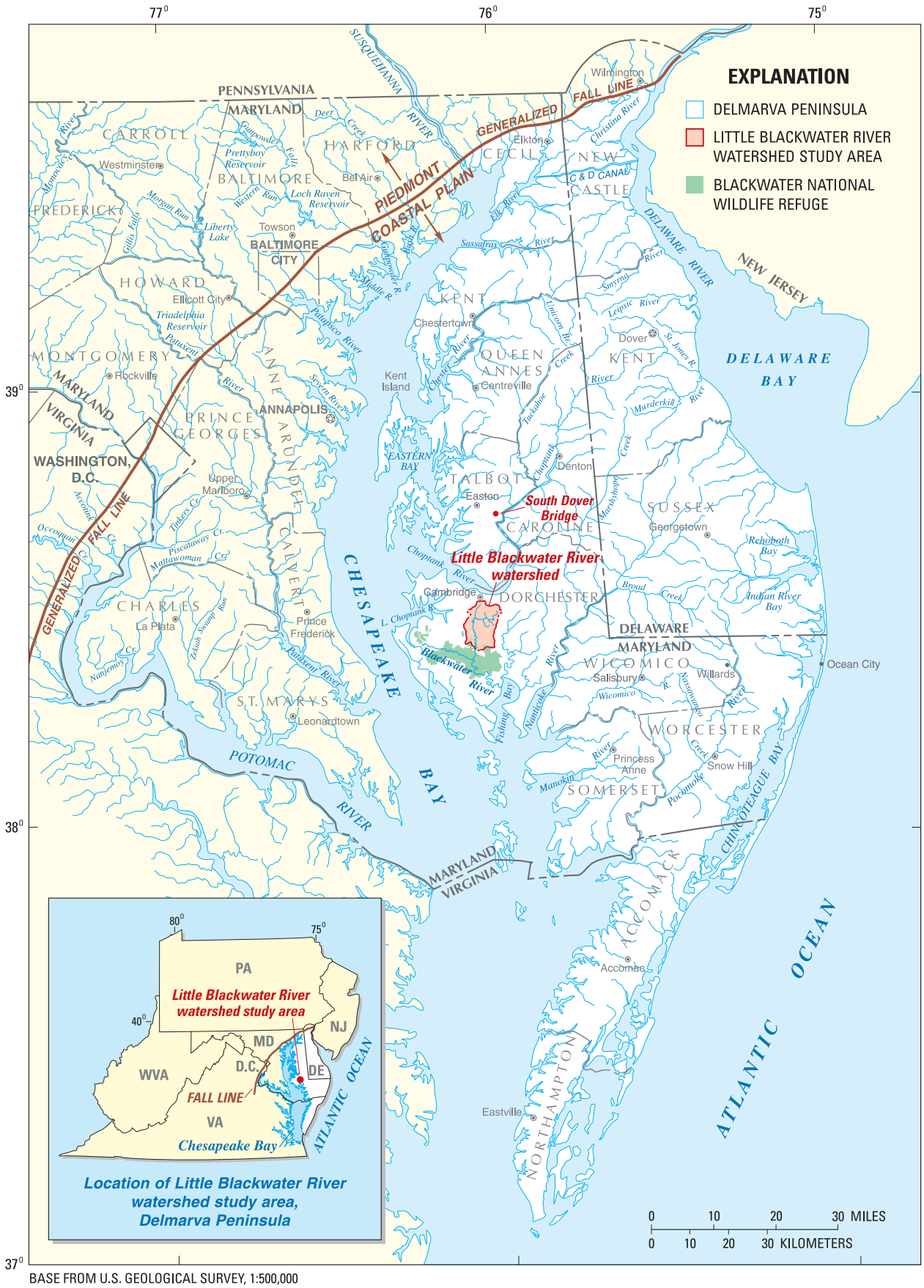
Methods

Groundwater and surface-water levels were measured over a multi-year period to describe the seasonal hydrologic variation within the Little Blackwater River watershed. Water-quality parameters including major ions, nutrients, and pesticides were collected from groundwater and surface-water sampling sites to characterize water quality prior to changes in land use.

Groundwater and Surface-Water Monitoring Methods

River conditions in the Little Blackwater River were monitored using two USGS gaging stations, station number 1490120 (Little Blackwater River near Cambridge, Md.), located at the approximate mid-point of the watershed with a drainage area of 15.3 mi^2, and station number 1490140 (Little Blackwater River at Seward, Md.), near the confluence of the Little Blackwater River and the Blackwater River at Key Wallace Drive, with a drainage area of 30.2 mi^2 (fig. 2) as calculated from a 30-m (meter) digital elevation model. These sites will hereafter be referred to as the Cambridge and the Key Wallace Drive gages. Both gages measured specific conductance, temperature, velocity, and river stage at 6-minute intervals. Discharge was calculated at Key Wallace Drive with an acoustic Doppler current profiler (ADCP), which measures both the velocity and the direction of flow.

The USGS installed a transect of three monitoring well nests (multiple wells screened at different depths at the location) consisting of eight wells, DO Cd 56-63, on the east side of Egypt Road in 2007, between the proposed development area and the Little Blackwater River (fig. 2). Another monitoring nest consisting of three wells, DO Cd 64-66, was installed about 0.4 mi farther south on the west side of Egypt Road in 2008. The USGS also installed a pair of monitoring wells (DO Dd 12 and DO Dd 13) in the Kentuck Swamp near the BNWR in 2007 as part of a more regional assessment of the hydrogeology of the basin (fig. 2). Two wells, DO Cd 67 and DO Cd 68, were installed prior to the start of the study and were only monitored for water levels. Continuous sediment core was recovered from the deep well at each nest site and was used in this study as the basis for the geologic interpretation. Once the wells were installed, water levels were measured monthly and selected wells were instrumented with continuous pressure transducers.



BASE FROM U.S. GEOLOGICAL SURVEY, 1:500,000

Figure 1. Location of Little Blackwater River watershed study area, Dorchester County, Maryland.

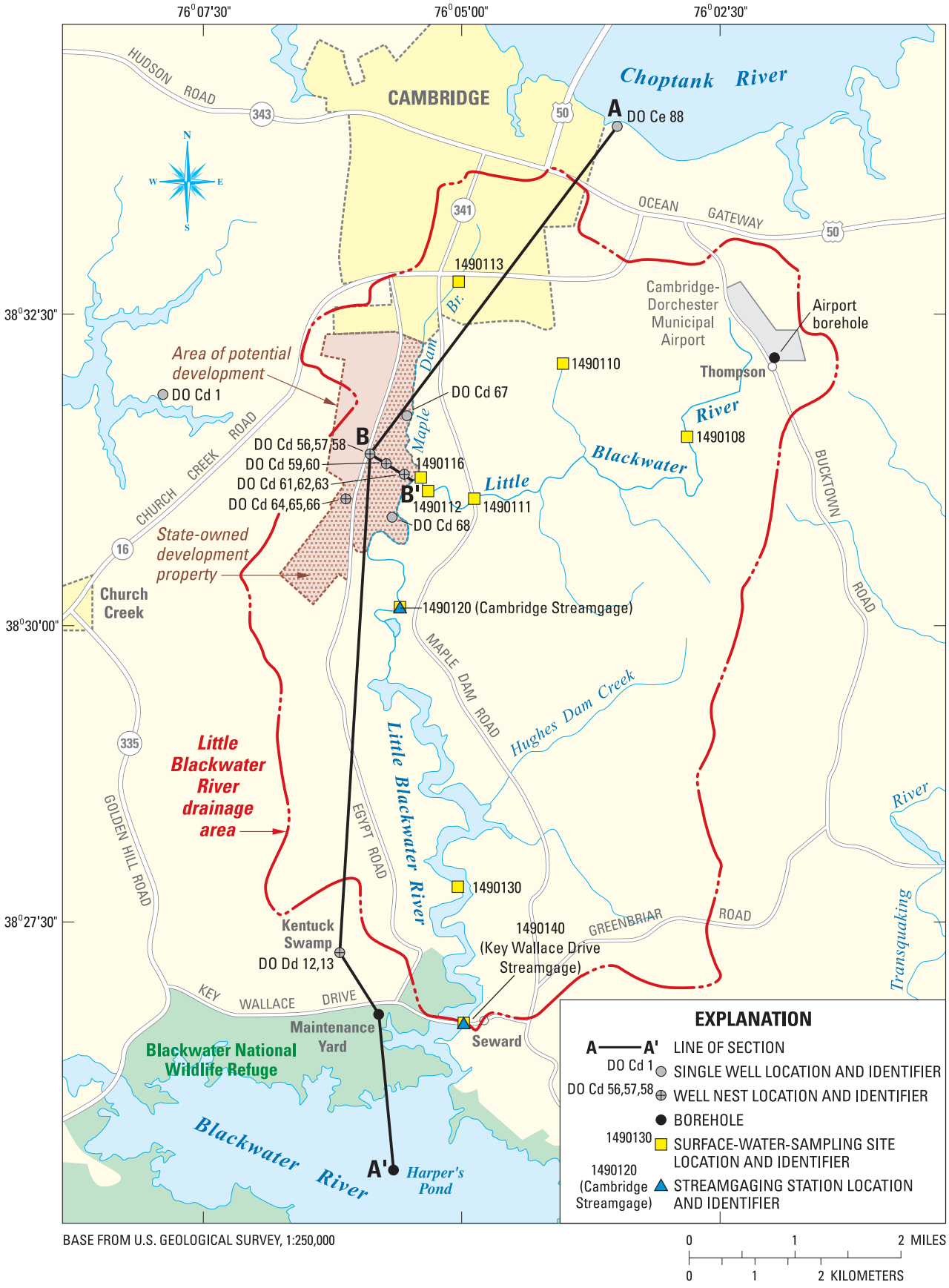


Figure 2. Location of the Little Blackwater River drainage area and monitoring sites.

Groundwater and Surface-Water Sampling Methods

Groundwater samples were generally collected using standard USGS sampling protocols (U.S. Geological Survey, variously dated) that were modified slightly because of the low permeability of the materials in which many of the wells were screened. Fultz groundwater sampling pumps were used and pumped at low-flow rates to minimize the drawdown in the wells so that well screens were not exposed to the atmosphere during the purging and sampling. For water-table wells, which had well screens that straddled the water table, the drawdown was minimized as much as possible, but some aquifer materials were exposed to the atmosphere. The intermediate-depth wells sampled in October 2007 along the transect (wells DO Cd 57, 60, and 62) had such low recovery rates that groundwater sampling pumps could not maintain flow rates high enough to recover sufficient volume for sampling. These wells were sampled with bailers during this sampling event, and were not sampled in June 2008.

The sampling procedure involved lowering the pump intake to the desired depth, and then pumping at a low-flow rate. Water-quality parameters were collected for pH, temperature, specific conductance, and dissolved oxygen during purging as the water was pumped through a flow-through cell. Parameter readings were taken every 5 minutes using YSI 6920 water-quality sondes until the change in parameter values between intervals reached stable values. Once stabilization was attained, defined as parameter values with less than a 5-percent change in six successive 5-minute intervals, sampling bottles for total (unfiltered) analyses were filled, then bottles for dissolved (filtered) analyses, followed by those requiring special sample-handling procedures, such as organic compounds. In-line filtration capsules were used to prevent atmospheric contact until the sample bottles were filled. All bottles were preserved, iced and processed, and shipped to the USGS National Water Quality Laboratory in Denver, Colorado within 48 hours.

Constituent group sampled for in study	Number of groundwater samples in study (including replicates and equipment blanks)	Number of surface-water samples in study (including replicates and equipment blanks)
Inorganic constituents including major ions, nutrients, and field parameters	20	71
Organic constituents including pesticides, fungicides, and insecticides	9	4

Surface-water-quality samples were collected using vertically integrated samplers at the approximate mid-stream location at each of the sampling points. Horizontal integration was not used due to the narrowness of the sampling locations. At two sampling locations (1490113 and 1490108) culverts were present under the roadways at each location. The culvert that had the most visual flow was sampled. Beginning on March 16, 2006, samples were collected from three surface-water sampling sites (1490112, 1490116, and 1490120) and analyzed for nutrients, major ions, and field parameters (fig. 2) in cooperation with the USGS Priority Ecosystems Science (PES) Program.

Two additional sampling locations (1490113 and 1490140) were added for the next quarterly sampling effort (June 22, 2006, fig. 2). Additional sampling locations (1490108, 1490110, and 1490130) were added and quarterly sampling was maintained until October 29, 2007. A final sampling was conducted June 10, 2008 at eight of the surface-water sites. Two storm-sampling events were also conducted on October 6, 2006 and April 16, 2007 to evaluate the impacts of major rain events when storm or wind surge was not bringing higher saline water from the Blackwater River or Fishing Bay into the Little Blackwater River watershed. The storm samples were collected following evaluations of the real-time discharge and specific conductance data in consultation with visual observations from staff from the BNWR. Groundwater and surface-water sampling sites, dates, and results of sampling are listed in Appendix 1 and 2. Also presented in Appendix 1 and 2 are the results of duplicate environmental samples and ion balances, with equipment blank results presented in Appendix 3 and described later in this report.

Geology

The Little Blackwater River watershed on the central Delmarva Peninsula is situated in the Atlantic Coastal Plain. The Coastal Plain is underlain by a wedge of Cenozoic and Mesozoic sediments that range in thickness from zero at the Fall Line west of the Chesapeake Bay in Virginia and Maryland to approximately 8,000 ft under the coast of Maryland at Ocean City (fig. 1), and is approximately 3,300 ft thick under the study area (Trapp and others, 1984). A study by Ator and others (2005) divides the surficial hydrogeology of the Mid-Atlantic Coastal Plain into seven sub-regions. The study area lies entirely within the coastal lowlands sub-region described by Ator and others (2005). The geological part of the current study is focused on both Pleistocene marine and non-marine deposits and Miocene substrates, which the Pleistocene deposits unconformably overlie. The subtle geomorphology of the area belies a complex stratigraphic sequence of laterally variable lithologies. The Delmarva Peninsula is highly sensitive to shifts in sea level because of its low relief and close proximity to the Atlantic. The complex sedimentology and stratigraphy of the region are evidence of

constantly alternating processes of erosion and deposition. Quaternary deposits lie unconformably on middle Miocene sediments, a relation that reflects both deep erosion during the Pleistocene and a potential long (approximately 10–12 million years) hiatus in deposition. The Miocene sediments are commonly shallow marine shelf facies with interbedded pro-delta deposits. The Miocene substrate is cut by numerous paleochannels of the Proto Chesapeake Bay and its tributaries. The channels are filled with the Pleistocene Kent Island Formation, an assemblage of cut-and-fill fluvial-to-marine, transgressive-regressive sequences locally overlain by a thin blanket of cold-climate modified sediments. This thin assemblage of surficial deposits is an artifact of a former landscape that was constructed, eroded, and modified by cold-climate processes during the late Pleistocene. When climate warmed at the beginning of the Holocene, the deeply incised drainages began to fill with fluvial-to-estuarine sediments as sea levels rebounded. Holocene sedimentation continues to fill the lower topography.

Miocene Stratigraphy

A core drilled to basement approximately 2 mi north of the study area placed the basal contact of the Miocene at 345 ft (Trapp and others, 1984; table 1). Miocene deposits in this area include the fossiliferous sand, silt, and clay beds of the Calvert and Choptank Formations. These units have low permeability, and have even been referred to as the "upper confining unit" of the Piney Point aquifer (see Klohe and Feehley, 2001).

The Calvert Formation is the oldest unit in the Chesapeake Group (table 1). The top of this unit was penetrated in several of the cores in the study area at elevations ranging from 48–87 ft bsl (below sea level) (table 2). In the study area, the Calvert Formation is generally composed of dark gray to olive gray very fine to medium sand with a variable abundance of fossils, including Chesapectinnefrens, barnacles, and small clams (fig. 3A). In a concurrent study, a sediment sample collected from this unit and analyzed for dinoflagellates in a core approximately 14 mi to the north of the study area (South Dover Bridge; SDB-1) (fig. 1), places this unit in the dinoflagellate cyst zone (DNZ) DN5 of deVerteuil and Norris (1996), and correlates this unit with Shattuck beds 14–16 (upper Calvert Formation; middle Miocene) of Gernant (1970) (Lucy Edwards, U.S. Geological Survey, oral commun., 2008).

The Choptank Formation unconformably overlies the Calvert Formation as an onlap in this area and has a variable thickness (2–53 ft) that is attributed to local scouring by Pleistocene channels. A distinctive local facies in the upper part of this unit ("red and green bed") ranges from gray fine sand to greenish, or reddish, gray silty clay or silty fine sand with local concentrations of whitish silty concretions and burrows; woody fragments and unoxidized iron sulfide growths also occur (fig. 3B). The lower part of this unit is generally a massive, dark gray clay with small (less than 1 inch) sand lenses. Two dinoflagellate samples collected from SDB-1 bracket this unit. These well-preserved samples contain an assemblage that fits in the DNZ DN6 of de Verteuil and Norris (1996), which in turn correlates with Shattuck beds 17–18 (Drumcliff and St. Leonard Members of the Choptank Formation; middle Miocene) of Gernant (1970) (Lucy Edwards, U.S. Geological Survey, oral/written commun., 2008).

The upper Miocene St. Mary's and Eastover Formations conformably overlie the Choptank Formation on the western side of the Bay (Gernant, 1970), but have not been observed in the study area east of the Bay. The absence of these overlying units indicates that they were stripped off the full extent of the Little Blackwater River watershed during repeated episodes of falling sea level in the Pleistocene.

Pleistocene-Holocene Stratigraphy

Climate variability during the Pleistocene was the dominant controlling factor on the stratigraphy and sedimentology in the Little Blackwater River watershed. The sea level was lowered as much as about 400 ft during glacial periods (Waelbroeck and others, 2002). These lower base levels greatly increased the erosive power of streams on the Delmarva Peninsula and caused deep incision of major rivers and their tributaries. Cold-climate processes and eolian sedimentation became extremely active while these cold, dry climatic conditions prevailed. During subsequent interglacial periods, climates warmed and sea level rose. River channels aggraded in response and filled the previously incised topography. The Pleistocene stratigraphy within the Little Blackwater River watershed is therefore largely defined by a variably thick package of transgressive-regressive sequences representing facies that range from cut-and-fill stream deposits to full estuarine fill, and have been capped with cold-climate-modified sediments.

Complete transgressive sequences from low stand (fluvial) to high stand (full estuarine) systems tracts can be seen in cores drilled near the center of paleochannels in the Little Blackwater River watershed (for example, DO Dd 12 core, 17–30 ft; Appendix 4). The fluvial facies are generally characterized by open-water, very fine to coarse sand with silt, pebbles, and sparse cobbles (fig. 4A). Bedforms range from coarse lag deposits and braided channel cross-beds to silty, laminated fining-upward sequences on tops of flood plains. Intermediate, or rising stage, facies are predominantly silt and clay with thin sand lenses throughout, and local burrows and organic materials (fig. 4B). The fully estuarine facies is commonly characterized by burrowed-to-massive silty clay with local concentrations of organic materials (fig. 4C). Although these full, orderly fining-upward transgressive sequences are present near the center of paleochannels in the Kent Island Formation, small lenses of sand, silt, and clay facies are often interfingered with one another on channel margins and are not laterally continuous (for example, Maintenance Yard core, 26–35 ft; Appendix 5).

Table 1. Geologic units described in previous investigations in the Coastal Plain of Delaware, Maryland, and Virginia.

[USGS, U.S. Geological Survey; shaded areas indicate geologic units not included in study.]

System	Series	Trapp and others (1984)	Cushing and others (1973) (Maryland names)		Mixon and others (1989) (West side of Chesapeake Bay)		Owens and Denny (1979) (Maryland and Delaware)	Aleman and others, USGS, written commun., 2010		This study	
Quaternary	Holocene						Tidal marsh deposits			Holocene sediments	
	Pleistocene	No name listed	Columbia Group				Parsonsburg Sand Kent Island Formation Sinepuxent Formation Ironshire Formation Omar Formation				
	Pliocene		?Brandywine Formation?		Bacons Castle and Yorktown Formations		Walston Silt Beaverdam Sand Yorktown Formation				
Tertiary	Miocene	Chesapeake Group (lower part)	Chesapeake Group	Yorktown Formation	Chesapeake Group	Eastover Formation	Pensauken Formation Chesapeake Group [St. Mary's Formation, Choptank Formation, Calvert Formation]	Chesapeake Group	Choptank Formation	Chesapeake Group	Choptank Formation
				St. Mary's Formation		St. Mary's Formation			Calvert Formation		Calvert Formation
				Choptank Formation							
				Calvert Formation		Calvert Formation					
	Oligocene				Old Church Formation		Not penetrated in this study	Drummonds Corner beds		Not penetrated in this study	
	Eocene	Piney Point Formation	Piney Point Formation		Piney Point Formation			Piney Point Formation			
		Nanjemoy Formation	Nanjemoy Formation		Nanjemoy Formation			Nanjemoy Formation			
					Marlboro Formation			Marlboro Formation			
	Paleocene	Aquia Formation	Aquia Formation		Aquia Formation			Aquia Formation			
		Brightseat Formation	Brightseat Formation								
Cretaceous	Upper Cretaceous	Severn and Matawan Formations, undifferentiated	Monmouth Formation					Not penetrated in this study			
			Magothy Formation								
		Magothy Formation	Raritan Formation								
	Lower Cretaceous	Potomac Group, undifferentiated	Potomac Group	Patapsco Formation	Potomac Group, undifferentiated						
				Arundel Formation							
				Patuxent Formation							

Table 2. Thickness and depth of geologic units in the Little Blackwater River watershed, Cambridge, Maryland (from Trapp and others, 1984).

System	Series	Group or Formation	Thickness (feet)	Depth (feet to base)
Quaternary	Pleistocene/Holocene		48	48
Tertiary	Miocene	Chesapeake Group (lower part)	297	345
	Eocene	Piney Point Formation	192	537
		Nanjemoy Formation	128	665
	Paleocene	Aquia Formation	124	789
		Brightseat Formation	30	819
Cretaceous	Upper Cretaceous	Severn and Matawan Formations, undifferentiated	46	865
		Magothy Formation	132	997
	Lower Cretaceous	Potomac Group, undifferentiated	2,302	3,299
Precambrian		Basement complex		

The lithologic contrast between two cores that were drilled less than 0.5 mi from one another (DO Cd 58 and DO Cd 66; Appendixes 6 and 7) clearly illustrates the high subsurface variability in this area. DO Cd 58 is located about one third of a mile from the Little Blackwater River and has an approximately 60-ft-thick section of Kent Island sediments, including a full transgressive sequence, a partial falling-stage sequence, and some minor wind-blown sands on the surface. These sediments rest unconformably over about 2 ft of the shallow, open-water facies of the middle Miocene Choptank Formation below. The Choptank Formation is conformable on the Calvert Formation at about 48 ft bsl. By contrast, DO Cd 66 is about 0.5 mi from the Little Blackwater River channel and only includes about 14 ft of Kent Island fill that includes a partial rising-stage sequence capped by minor wind-blown sands. This thin package rests unconformably on about 55 ft of the shallow, open-water facies of the middle Miocene Choptank Formation. The Choptank Formation at DO Cd 66 is conformable on the Calvert Formation at about 61 ft bsl. There are two possible explanations for the obvious lithologic contrast between these sediment records. The first explanation is that there could be a paleo-valley wall separating these two cores. In this scenario, the Kent Island sediments in DO Cd 58 filled a paleochannel that had previously eroded the missing Miocene record in this location, but not the one located at DO Cd 66. Alternatively, geologic structure may be interpreted from the shallow geology between the two cores; a fault could be offsetting these cores so that DO Cd 66 is on the headwall and DO Cd 58 is on the footwall. If this were the case, the thicker Kent Island package in DO Cd 58 indicates more accommodation space (fig. 5). However, the elevation of distinctive shell beds within the Calvert Formation in these cores indicates that if there were ever any structures offsetting these cores, it would be opposite from the one that was described above, as this datum is about 13.5 ft lower in DO Cd 66 than in DO Cd 58 (fig. 5).

As stated above, the uppermost Pleistocene sediments (the Parsonsburg Sand) were heavily impacted by cold-climate processes during glacial maxima. Cold, dense winds originating at the terminus of the Laurentide ice sheet (less than 150 mi to the north) froze large parts of the emergent topography and transformed the central Delmarva Peninsula into a periglacial landscape that has been well documented by French and others (2009). Thermal-contraction cracks filled with eolian material have been observed in gravel pits about 15 mi to the north of the study area in Easton, Maryland and about 25 mi to the southeast near Salisbury, Maryland, for example. These cracks are found in association with thermokarst structures such as deformed and involuted near-surface soil horizons that result from thermal subsidence of underlying frozen ground (French and others, 2009; Smoot and others, 2009). The surface materials in which these phenomena occur are generally composed of silty sand containing scattered small pebbles (figs. 6A and B), and have been interpreted as a cover-sand unit and considered an analog to the cover sands found in Europe. This suite of cold-climate-derived features is indicative of permafrost and (or) deep seasonal frost (French, 2007). Additionally, large, currently inactive dune fields have long been recognized across the central Delmarva and attributed to processes active during colder, drier climates (Denny and

Figure 3. Miocene formations observed in cores collected in the study area: *(A)* Calvert Formation (97.9–99-feet depth in Kentuck core), and *(B)* Choptank Formation (approximately 69–70.25-feet depth in Kentuck core). [Photographs by B.D. DeJong, USGS.]

others, 1979; Sirkin and others, 1977). Recent Light Detection and Ranging (LIDAR)-based investigations carried out in both the central Delmarva Peninsula and west of the Chesapeake Bay confirm these observations and highlight the regional impact of these climates during this period (Markewich and others, 2009; Newell and Clark, 2008).

Sea level has continued to rise since the Wisconsinan glaciation. As sea levels rose, the eroded Wisconsinan landscape filled with organic-rich silty peat, which is thickest in major river channels but also present in surficial wetlands.

Hydrology

The hydrology within the Little Blackwater River watershed is complex and variable, primarily due to lateral and vertical lithologic variability in the subsurface. Repeated climate oscillations during the Pleistocene caused both major stream incision into the existing Miocene land surface and subsequent backfilling of these channels with fluvial-to-estuarine sediments. Sediments that filled these stream channels represent a full range of sandy fluvial deposits to clayey estuarine-marine deposits that are interfingered throughout. The preferential flowpaths for shallow groundwater flow in this stratigraphy are extremely discontinuous. Although these sediments are young and non-indurated, they provide avenues for groundwater flow that are generally thin and lack significant lateral continuity (fig. 7). In many locations, erosion and deposition in the Pleistocene did not have an impact on the deeper strata. These locations have a thicker and more complete section of low permeability red and green beds of the upper Choptank Formation and are likely to create confining conditions in the Piney Point aquifer below.

Extensive ditching along agricultural fields can create artificial flowpaths that circumvent the typical topographically driven groundwater-flow system. The tidal nature of the Little Blackwater River affects groundwater fluxes, and because of the wide expanse of open water within the BNWR, southerly winds can increase river stage well into the headwater areas of the basin, creating temporary localized reversals in shallow groundwater-flow directions close to the river. Combined with the potential uptake of water during the growing season, all of these factors create a complex and dynamic hydrologic setting on the Delmarva Peninsula.

Groundwater-Flow System

The USGS installed a transect of three monitoring well nests (multiple wells screened at different depths at the same location) consisting of eight wells, DO Cd 56-63 on the east side of Egypt Road in 2007, between the proposed development area and the Little Blackwater River (fig. 2). Another monitoring nest consisting of three wells, DO Cd 64-66 was installed about 0.4 mi farther south on the west side of Egypt Road in 2008 (table 3). The USGS installed a pair of monitoring wells (DO Dd 12 and 13) in the Kentuck Swamp near the BNWR in 2007 as part of a more regional assessment of the hydrogeology of the basin. The groundwater levels from September 2007 through September 2009 in wells DO Dd 12-13, and from May 2008 through September 2009 in wells DO Cd 64-66 have consistently shown downward vertical gradients, indicating the potential for movement of shallow groundwater towards the deeper flow system (figs. 8A and B). Monitoring well DO Cd 1, located just west of the basin (fig. 2) and screened at 320 ft bls (below land surface) in the Piney Point aquifer, has water levels that are typically 45–55 ft bsl (fig. 8C). These lower water levels, caused by

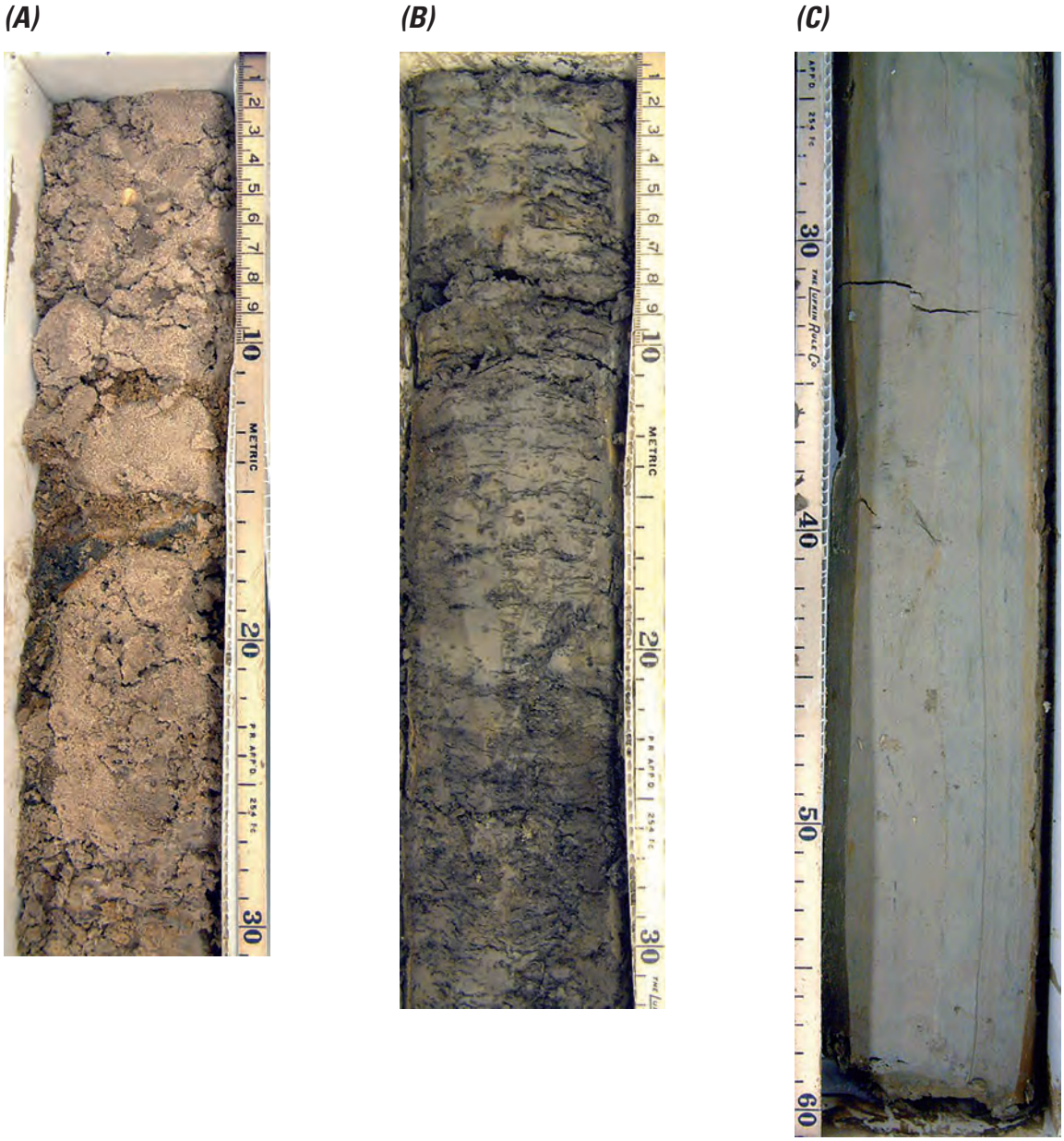


Figure 4. Examples of facies seen in Pleistocene sequences from the DO Dd 12 core: *(A)* fluvial (approximately 4–5.25-feet depth), *(B)* rising-stage (approximately 20–21.25-feet depth), and *(C)* estuarine-marine (41.75–43-feet depth). [Photographs by B.D. DeJong, USGS.]

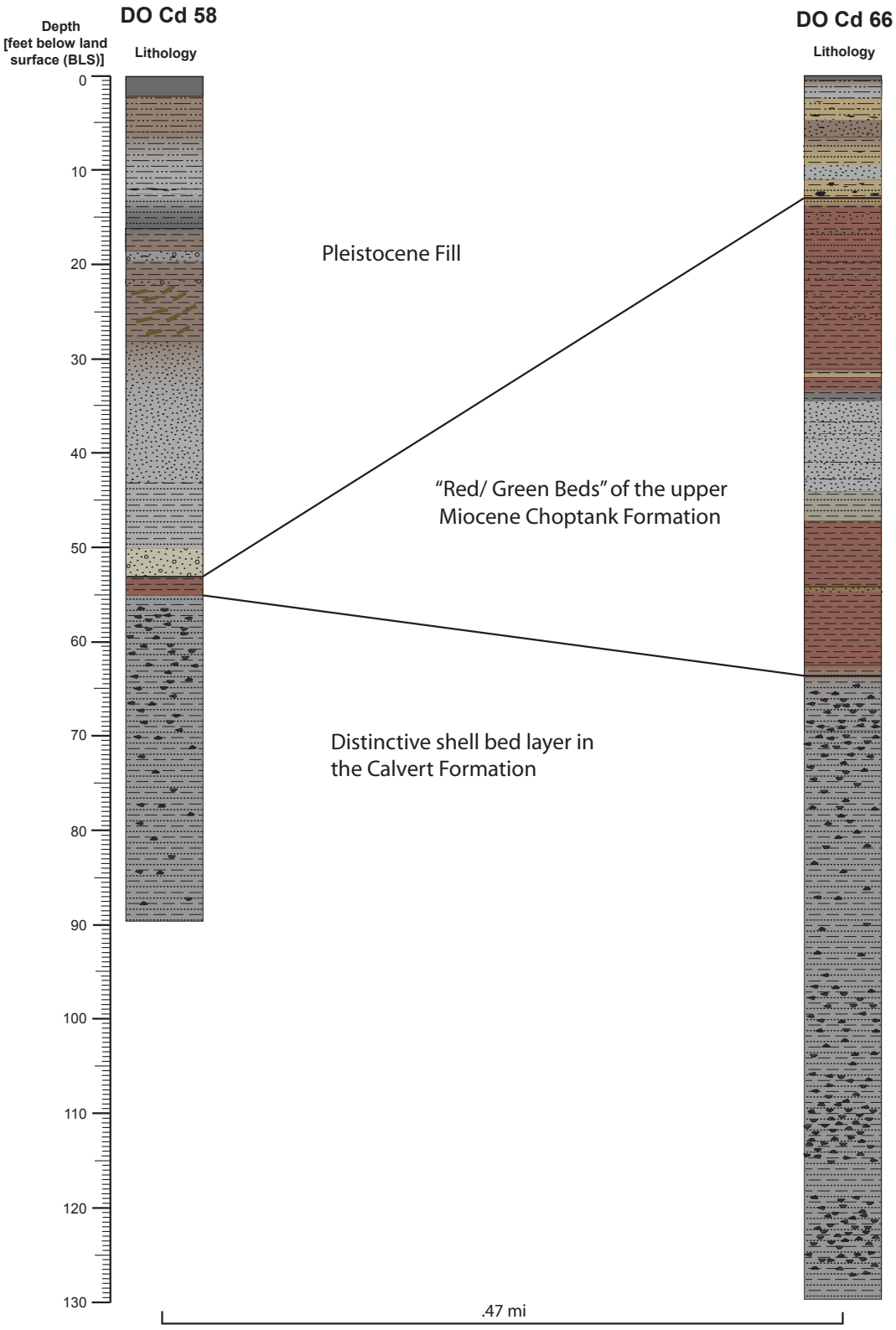


Figure 5. Stratigraphic contrast between DO Cd 58 (left) and DO Cd 66 (right).

Figure 6. The Parsonsburg Sand as expressed in *(A)* 2.25–4-feet depth in the DO Dd 12 core, and *(B)* 8.5–9.5-feet depth in the Maintenence Yard core. [Photographs by B.D. DeJong, USGS.]

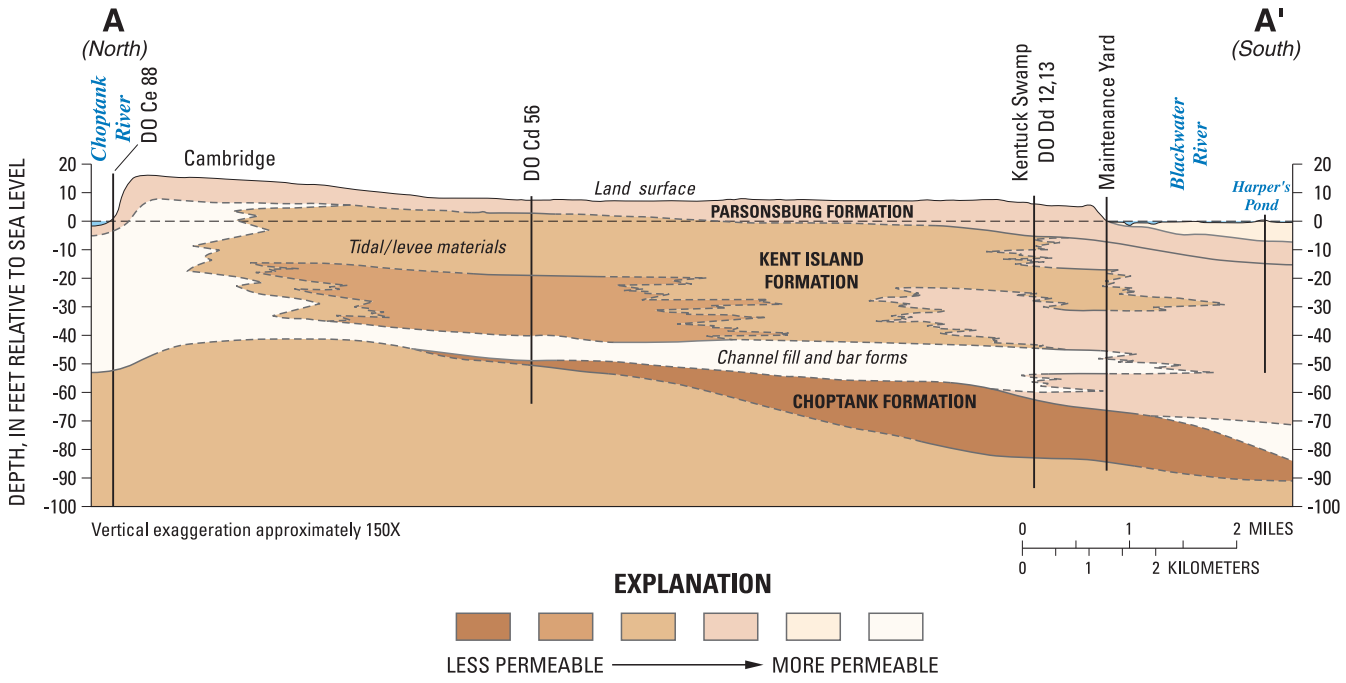


Figure 7. Generalized north-south hydrogeologic cross section through the Little Blackwater River watershed, Dorchester County, Maryland.

regionally extensive water withdrawals from the Piney Point aquifer, indicate a large downward gradient between the shallow and deeper groundwater systems.

The water-table wells, screened in the Parsonsburg Sand, generally have water levels slightly above sea level, with seasonal variations of several feet (fig. 9A). In winter and spring months, water-table well observations show groundwater gradients driven by the subtle topography, indicating potential flow towards the Little Blackwater River (fig. 9B). In summer and fall months, water-table well observations show groundwater levels that drop below the stage of the Little Blackwater River. These lower groundwater levels create gradient reversals with the potential for the Little Blackwater River to lose water into the water-table system (fig. 9C). This in turn creates the potential for infiltration of brackish river water into the shallow groundwater system close to the river, as evidenced by elevated chloride concentrations in monitoring wells DO Cd 61 and DO Cd 68 (see Appendix 1).

The deeper wells, screened in the Miocene sediments (at depths above the Piney Point aquifer, which is the primary groundwater supply in the area), generally have water levels that are several feet below sea level. Continuous water-level records from the deeper wells show a muted but instantaneous pressure response to tidal fluctuations observed at the Cambridge gage (fig. 10). Well DO Cd 58 is approximately 2,500 ft from the Little Blackwater River and screened at 89–94 ft bls, whereas well DO Cd 63 is 500 ft from the Little Blackwater River and screened at 47–52 ft bls.

The response of the deeper wells to changes in tides may be caused by pressure loading as the high tides press down on the system, forcing water levels to rise in confined-aquifer wells. The same type of responses are typical in coastal areas and are observed in monitoring wells along tidal areas under both non-pumping and pumping conditions, such as in the Ocean City and Manokin aquifers (about 250–400 ft bls) near Ocean City, Maryland (Phelan, 1987, fig. 26).

Geophysical (gamma) logs were collected in the deeper wells, and a 2-dimensional electrical resistivity survey was performed parallel to the well transect between Egypt Road and the Little Blackwater River. These logs (Appendixes 6 and 7) and results from the survey (Appendix 8), combined with geologic core descriptions, are the basis for the cross-sectional conceptual flow model of the water-table system for the Little Blackwater River (figs. 9B and C). In Appendix 8, red colors indicate higher electrical resistivity, typically sands saturated with fresh water. Blue colors indicate values of lower electrical resistivity, typically of silts and clays. This interpretation is consistent with the sediment cores collected from the drilling of the wells along this cross section, however, the sands are poorly sorted and contain some silts and clays. The interpretation using gamma logs, electrical resistivity surveys, and lithologic logs confirms the presence of thin sandy deposits (10–20 ft) of the Parsonsburg Sand, which has a relatively higher permeability than the underlying silts and clays in this part of the watershed.

Table 3. Locations and descriptions of wells installed and monitored during the Little Blackwater River study, Dorchester County, Maryland.

[USGS, U.S. Geological Survey; NAD83, North American Datum of 1983; NAVD88, North American Vertical Datum of 1988; PVC, polyvinylchloride; bls, below land surface]

USGS well name	USGS well number	Local well name	Latitude (decimal degrees, NAD83)	Longitude (decimal degrees, NAD83)	Casing diameter (inches)	Type of casing	Type of screen	Altitude of ground surface (feet above NAVD88)	Depth of borehole (feet bls)	Depth to top of screen interval (feet bls)	Depth to bottom of screen interval (feet bls)
DO Cd 56	383122076055701	ERN-1-A	38.522778	-76.099167	2	PVC	wire-wound	9.50	13.45	3.00	13.00
DO Cd 57	383122076055702	ERN-1-B	38.522778	-76.099167	2	PVC	wire-wound	9.85	21.98	16.00	21.00
DO Cd 58	383122076055703	ERN-1-C	38.522778	-76.099167	2	PVC	wire-wound	9.43	94	89.00	94.00
DO Cd 59	383118076054601	ERN-2-A	38.521667	-76.096111	2	PVC	wire-wound	7.28	13.11	3.00	13.00
DO Cd 60	383118076054602	ERN-2-B	38.521667	-76.096111	2	PVC	wire-wound	7.11	19.19	14.00	19.00
DO Cd 61	383112076053501	ERN-3-A	38.520000	-76.093056	2	PVC	wire-wound	3.68	13.20	3.00	13.00
DO Cd 62	383112076053502	ERN-3-B	38.520000	-76.093056	2	PVC	wire-wound	3.81	19.37	14.00	19.00
DO Cd 63	383112076053503	ERN-3-C	38.520000	-76.093056	2	PVC	wire-wound	3.12	53.2	47.00	52.00
DO Cd 64	383100076061101	ERN-4-A	38.516667	-76.103333	2	PVC	wire-wound	10.18	13.0	3.00	13.00
DO Cd 65	383100076061102	ERN-4-C	38.516667	-76.103333	2	PVC	wire-wound	10.00	75	70.00	75.00
DO Cd 66	383100076061103	ERN-4-D	38.516667	-76.103333	2	PVC	wire-wound	10.34	129.5	124.00	129.00
DO Cd 67	383139076053301	DW-1	38.527778	-76.092500	4	PVC	wire-wound	2	15	5.00	15.00
DO Cd 68	383051076054201	DW-2	38.514167	-76.095278	4	PVC	wire-wound	5	15	5.00	15.00
DO Dd 12	382718076062001	Kentuck-1	38.455000	-76.105556	2	PVC	wire-wound	5.26	100	95.00	100.00
DO Dd 13	382718076062002	Kentuck-2	38.455000	-76.105556	2	PVC	wire-wound	5.31	11.59	2.00	12.00

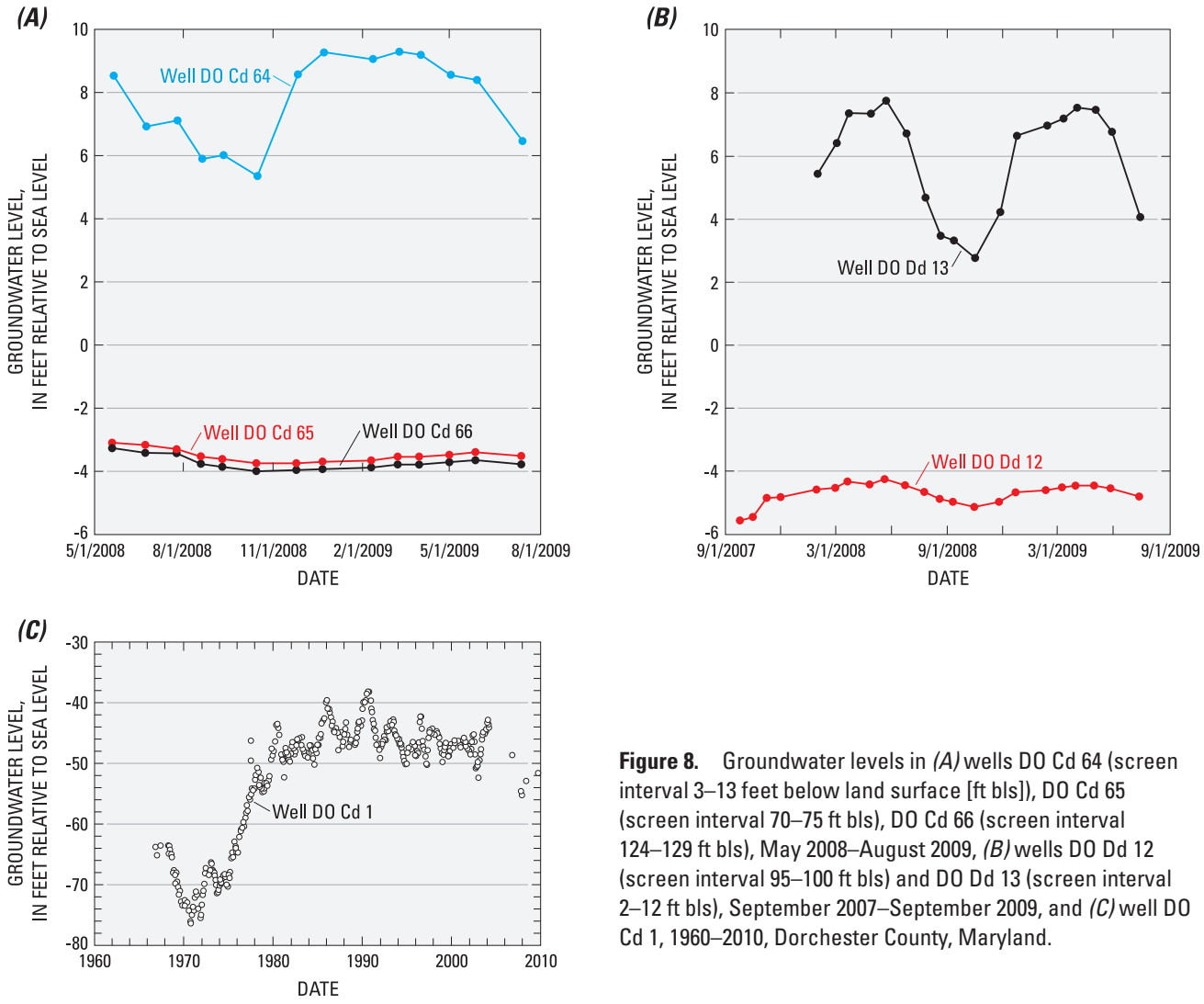


Figure 8. Groundwater levels in *(A)* wells DO Cd 64 (screen interval 3–13 feet below land surface [ft bls]), DO Cd 65 (screen interval 70–75 ft bls), DO Cd 66 (screen interval 124–129 ft bls), May 2008–August 2009, *(B)* wells DO Dd 12 (screen interval 95–100 ft bls) and DO Dd 13 (screen interval 2–12 ft bls), September 2007–September 2009, and *(C)* well DO Cd 1, 1960–2010, Dorchester County, Maryland.

Surface-Water System

Over the period of record, specific conductance varies seasonally at the Cambridge and Key Wallace Drive gages, with maximum values in late October, and minimum values in May (figs. 11A and B). Annual peaks in specific conductance are observed approximately 2 months after annual peaks in surface-water temperature. These specific conductance patterns reflect the same seasonal trends typically seen in the Chesapeake Bay as the saltwater front moves up the Bay in the summer and out of the Bay in the spring in response to seasonal changes in freshwater inflow to the Bay.

Specific conductance at the Key Wallace Drive and Cambridge gages ranged from 200 to 24,000 and 120 to 13,000 µS/cm (microsiemens per centimeter), respectively (fig. 11A). For comparison, the specific conductance of seawater is typically about 50,000 µS/cm (Hem, 1985), and the range of specific conductance values in the freshwater portion of the Choptank River on the Delmarva Peninsula in 685 samples between 1980 and 2009 ranged from 46 to 307 µS/cm, with a median of 133 µS/cm (U.S. Geological Survey, 2010).

Discharge calculated at Key Wallace Drive varies seasonally, with net negative discharge (more water flowing upstream than downstream) during the summer and fall seasons, and net positive discharge from the Little Blackwater River in the winter and spring (fig. 12). In water years 2008 and 2009 (October 1, 2007 through September 30, 2009), annual net discharge was negative, meaning more water flowed into the watershed from the Blackwater River than flowed out to the Blackwater River. The annual net discharge in water year 2007 was positive, however. Given the high percentage of agricultural land use and significant amounts of riparian wetland vegetation, evapotranspiration (ET) is likely a major cause of groundwater flux out of the watershed.

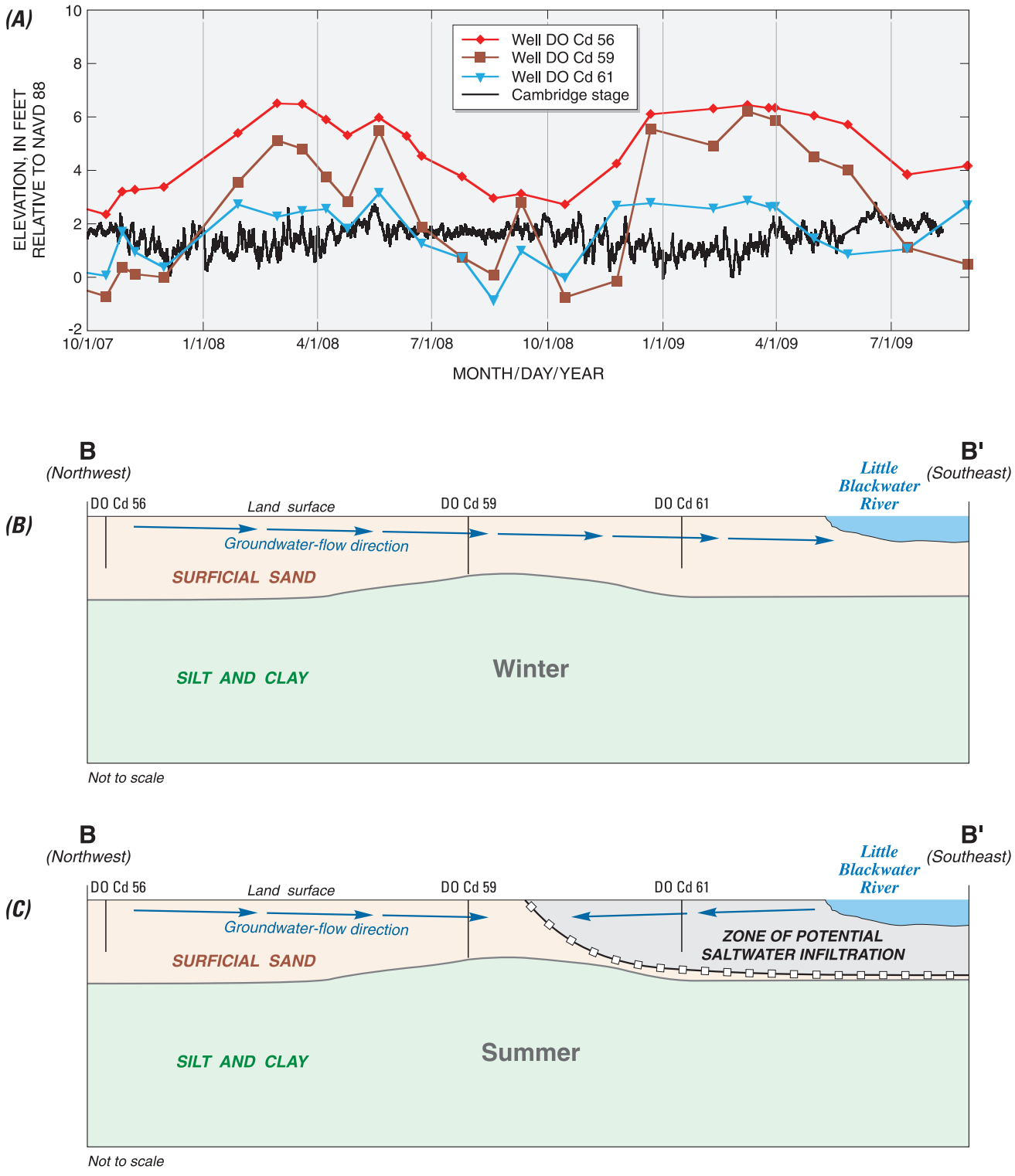


Figure 9. *(A)* Groundwater levels in water-table wells, and cross sections of *(B)* winter and *(C)* summer groundwater-flow directions, October 2007–July 2009, Little Blackwater River watershed, Dorchester County, Maryland.

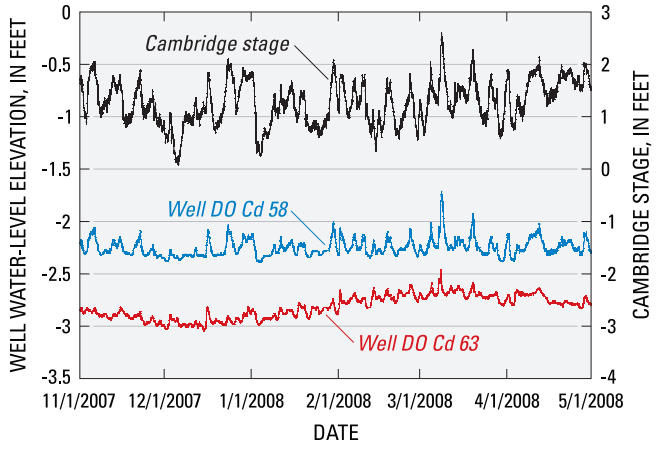


Figure 10. Groundwater levels in wells DO Cd 58 and DO Cd 63, and surface-water elevations at the gage on the Little Blackwater River at Cambridge, Maryland, November 2007–May 2008.

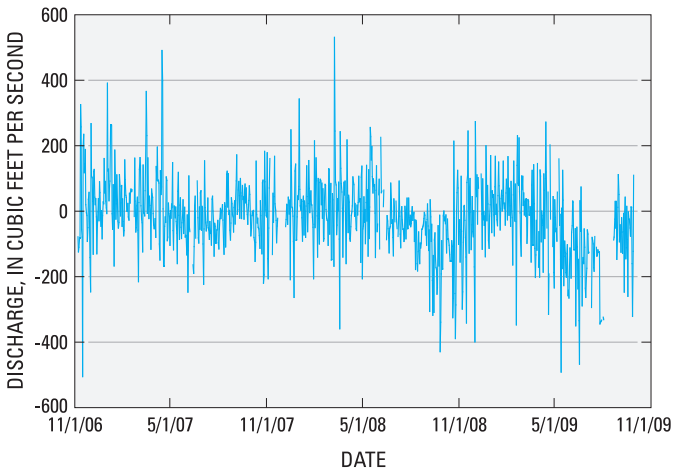


Figure 12. Discharge to and from the Little Blackwater River at Seward, Maryland on Key Wallace Drive, Dorchester County, Maryland, November 2006–September 2009.

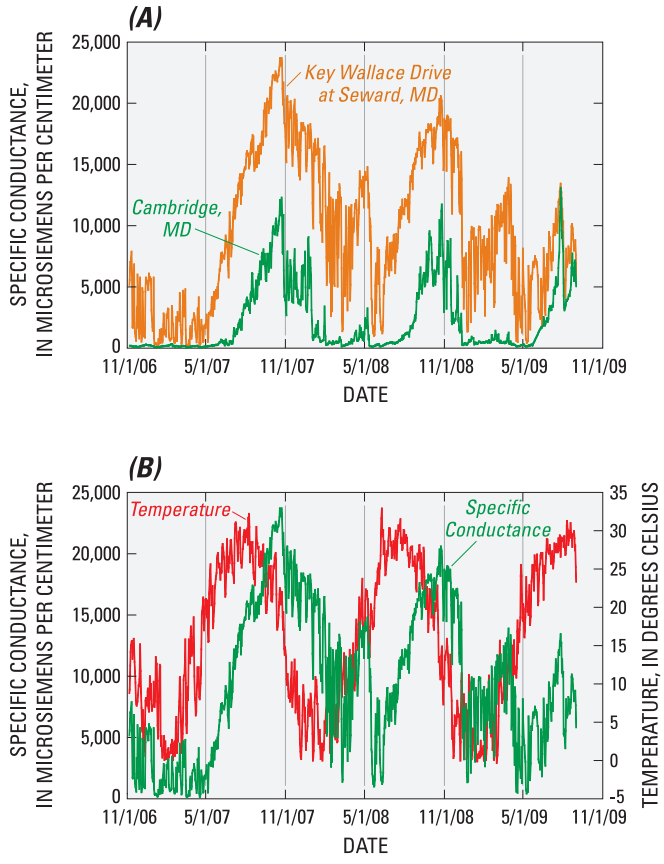


Figure 11. Comparison of *(A)* specific conductance at the Cambridge gage and Key Wallace Drive gage, Maryland, and *(B)* temperature and specific conductance at the Key Wallace Drive gage, Maryland, November 2006–November 2009.

Water Quality

Water-quality samples were collected during 2007–08 from 13 monitoring wells and during 2006–09 from 9 surface-water sites to characterize pre-development conditions and seasonal variability. Continuous water-quality monitors were installed at both gaging stations (Cambridge and Key Wallace Drive) to measure temperature and specific conductance and observe the seasonality of brackish-water conditions in the Little Blackwater River between 2006 and 2009.

Data Quality Assurance

Quality-assurance samples were collected during this study. Equipment blanks were collected to determine the potential for contamination of samples during the sampling, shipping, and laboratory handling procedures. Duplicate samples were collected to determine reproducibility, and ion balances were calculated to determine whether all appropriate major ions had been analyzed, and whether the analytical results were acceptable, and within generally accepted guidelines.

Blanks

Three field equipment blanks were collected during groundwater sampling, and one field equipment blank was collected during surface-water sampling to determine if there was a potential for contamination from the sampling equipment and filters, or if there was carryover contamination from previous samples (Appendix 3). One of the three blanks collected at the groundwater sites was analyzed for inorganic constituents

only, and the other two blanks were analyzed for both organic and inorganic constituents. The surface-water blank was analyzed for inorganic constituents only.

The inorganic blank groundwater samples had detectable concentrations of dissolved calcium that ranged from 0.02 to 0.1 mg/L (milligrams per liter) (Appendix 3) whereas the environmental calcium sample concentrations ranged from 1.1 to 95.5 mg/L. This indicates that up to about 10 percent of only the lowest calcium concentration may have been affected by sampling, handling, or laboratory procedures. Four other inorganic compounds were detected in concentrations near detection levels in at least one of the four blank samples for potassium, alkalinity, silica, and ammonia plus organic nitrogen. The potassium detection in the blank was less than 0.5 percent of the lowest environmental concentration. The acid-neutralizing capacity (ANC) in two blanks was detected at estimated concentrations (4 mg/L) below the minimum reporting level of 5 mg/L, but was about half of the concentration of the lowest environmental sample at 9 mg/L, indicating that very low ANC concentrations may be reported at almost twice the actual value.

Dissolved organic carbon (DOC) was detected in one surface-water blank at a concentration of 0.6 mg/L, whereas environmental concentrations in surface water ranged from 7.4 to 47 mg/L, indicating the potential to add greater uncertainty in samples with very low DOC concentrations. There were no detections of any organic compounds from the two groundwater equipment blanks. The lack of detections indicated that there was no contamination, but the unexpected analytical results of sulfometuron-methyl in a groundwater sample from DO Dd 12 may suggest otherwise.

Duplicates

Two duplicate groundwater sample pairs were collected to determine reproducibility of the inorganic analyses (Appendix 1). Both duplicate pairs were sampled within 15 minutes after the original sample. Most constituents were consistent between the duplicate samples, with the exception of well DO Cd 63, when sulfate concentrations nearly doubled (from 4.7 to 7.4 mg/L) between the first and second samples. Relative percent differences (RPDs) were calculated between duplicate pairs for each inorganic parameter that had measurable concentrations in both sample pairs to describe the reproducibility of the values. The formula for calculating RPD is:

$$\left| \frac{C_1 - C_2}{\frac{(C_1 - C_2)}{2}} \right| * 100 \qquad (1)$$

where C_1 is the concentration of the parameter in the original sample and C_2 is the concentration of the same parameter from the duplicate sample. With the exception of the one sulfate concentration mentioned above, RPDs from inorganic constituents ranged from 0 to 16.4 percent, with an average of 5.1 percent, indicating good reproducibility even after 15 minutes of pumping. These results show good reproducibility at the non-detect levels, but cannot address the reproducibility of the detected concentrations as found in other samples.

Ion Balances

The accuracy of major dissolved-constituent values in a reasonably complete chemical analysis of a water sample can be checked by calculating the cation-anion balance (Hem, 1985). If the analytical work has been performed accurately, and if all major ions were analyzed, the difference between the two sums will generally not exceed approximately plus or minus 5 percent. The cation-anion balances, given in percent differences between total cations and total anions when converted to milliequivalents per liter (meq/L), are presented for each groundwater and surface-water sample (inorganic constituents) from the Little Blackwater River watershed in Appendixes 1 and 2, respectively. Ion balances for 69 surface-water samples ranged from -15.4 to 10.9 percent, and averaged 1.7 percent. Nine surface-water samples had ion balances that exceeded 5 percent. Ion balances for 20 groundwater samples ranged from -6.9 to 3.8 percent, with an average of -2 percent. Five of the 20 samples had ion balances between 5 and 6.9 percent.

Groundwater Quality

Groundwater-quality samples were collected from nine monitoring wells in October 2007. Several wells were installed in the winter and spring of 2008, and nine wells, including the newest, were sampled during June 2008. The sets of parameters analyzed varied between the groundwater sampling rounds, but both included major ions and nutrients. The samples collected during June 2008 also were analyzed for concentrations of pesticides, pesticide degradates, and other organic compounds. Concentrations of inorganic constituents in the groundwater samples are shown in Appendix 1. Concentrations of organic compounds detected in groundwater and surface-water samples are shown in table 4. A list of organic compounds that were analyzed for, but not detected, is shown in table 5 along with detection levels.

Inorganic Constituents

Results from all major ion analyses from both groundwater and surface-water samples are shown in trilinear diagrams (fig. 13). Several patterns are apparent. Samples are grouped into four categories: shallow groundwater, deep groundwater, surface water in the upper basin and surface water in the lower basin. Deep groundwater samples (black squares) have higher values of bicarbonate, whereas shallow groundwater samples (red squares) have little to no bicarbonate. Boxplots

Table 4. Concentrations of organic compounds detected in surface-water and groundwater samples, Little Blackwater River watershed, Dorchester County, Maryland, June 2008.-

[USGS, U.S. Geological Survey; ft., feet; gal/min, gallons per minute; mi², square miles; mm, millimeters; Hg, mercury; µg/L, micrograms per liter; %, percent; --, data not available; dark shaded couplets indicate duplicate samples; Md., Maryland; <, less than; E, quantified above the long-term method detection limit (LT-MDL) but below the laboratory reporting level (LRL) with higher uncertainty]

Station name	USGS station number	Date	Time	Depth of well (feet below land surface)	Altitude of land surface (feet)	Water level, depth below measuring point (feet)	Flow rate (gal/min)	Pumping period prior to sampling (minutes)	Drainage area (mi²)	Sampling depth (feet)	Barometric pressure, (mm Hg)	2,4-D plus 2,4-D methyl ester, sum on a molar basis, (µg/L as 2,4-D)	2,4-D (µg/L)
Surface-water sites													
Christ's Rock	01490112	6/10/2008	1230	--	5	--	--	--	8.29	--	759	<0	<.02
Maple Dam Bridge	01490113	6/10/2008	0740	--	2.9	--	--	--	1.46	--	759	0.07	0.07
Tributary near Cambridge, Md.	01490116	6/10/2008	1245	--	6	--	--	--	4.19	--	759	<0	<.02
River near Cambridge, Md.	01490120	6/10/2008	1130	--	-1.25	--	--	--	15.3	--	759	0.08	0.08
Groundwater sites													
DO Cd 56	383122076055701	06/11/2008	0815	13.5	9.5	6.44	0.29	--	--	11.5	--	<0	<.02
DO Cd 59	383118076054601	6/10/2008	1520	13.1	7.28	--	0.73	--	--	13.1	--	<0	<.02
DO Cd 61	383112076053501	6/10/2008	1100	13.2	3.68	4.05	0.572	0.5	--	13.2	--	<0	<.02
DO Cd 63	383112076053503	6/10/2008	1030	53.2	3.12	--	0.83	50	--	51.5	--	<0	<.02
DO Cd 63	383112076053503	6/10/2008	1045	53.2	3.12								
DO Cd 64	383100076061101	06/11/2008	1555	13	10.18	--	--	--	--	15	766	<0	<.02
DO Cd 66	383100076061103	06/11/2008	1500	129.5	10.34	--	4.68	--	--	0	--	<0	<.02
DO Cd 68	383051076054201	06/11/2008	1050	15	5	5.52	--	--	--	0	--	<0	<.02
DO Dd 12	382718076062001	06/09/2008	1345	99.7	5.26	15.04	0.88	--	--	90	--	<0	<.02
DO Dd 13	382718076062002	06/09/2008	1610	12	5.31	--	1.09	--	--	9.5	--	<0	<.02

Table 4. Concentrations of organic compounds detected in surface-water and groundwater samples, Little Blackwater River watershed, Dorchester County, Maryland, June 2008.—Continued

[USGS, U.S. Geological Survey; ft., feet; gal/min, gallons per minute; mi², square miles; mm, millimeters; Hg, mercury; µg/L, micrograms per liter; %, percent; --, data not available; dark shaded couplets indicate duplicate samples; Md., Maryland; <, less than; E, quantified above the long-term method detection limit (LT-MDL) but below the laboratory reporting level (LRL) with higher uncertainty]

Station name	2-Chloro-4-isopropylamino-6-amino-*s*-triazine, (µg/L CIAT)	2-Chloro-6-ethyl-amino-4-amino-*s*-triazine (µg/L)	2-Hydroxy-4-isopro-pylamino-6-ethyl-amino-*s*-triazine (µg/L)	Aceto-chlor (µg/L)	Ala-chlor (µg/L)	Atrazine (µg/L)	Caffeine (µg/L)	Carbaryl[1], (µg/L)	Carbaryl[2], (µg/L)	Carbofu-ran (µg/L)	Chlorimur-on-ethyl (µg/L)	Desulfi-nylfipronil, µg/L
Surface-water sites												
Christ's Rock	E.167	E.030	0.88	<.0164	0.016	0.732	E.05	<.04	E.01	<.02	<.08	E.002
Maple Dam Bridge	E.023	<.08	<.04	<.006	<.006	0.044	<.06	E.01	E.01	<.02	<.08	E.007
Tributary near Cambridge, Md.	E.210	E.050	0.84	<.006	<.006	0.917	0.07	<.04	<.06	<.02	E.02	E.002
River near Cambridge, Md.	E.239	E.055	0.76	0.028	0.014	1.100	0.13	<.04	E.01	<.02	E.02	E.002
Groundwater sites												
DO Cd 56	<.014	<.08	<.04	<.006	<.006	<.007	<.06	<.04	<.06	<.02	<.08	<.012
DO Cd 59	<.014	<.08	<.04	<.006	<.006	<.007	<.06	<.04	<.06	<.02	<.08	<.012
DO Cd 61	<.014	<.08	<.04	<.006	<.006	0.009	<.06	<.04	<.06	<.0210	<.08	<.012
DO Cd 63	<.014	<.08	<.04	<.006	<.006	<.007	<.06	<.04	<.06	<.02	<.08	<.012
DO Cd 63	<.014	<.08	<.04	<.006	<.006	<.007	<.06	<.04	<.06	<.02	<.08	<.012
DO Cd 64	<.014	<.08	<.04	<.006	<.006	<.007	<.06	<.04	<.06	<.02	<.08	<.012
DO Cd 66	<.014	<.08	<.04	<.006	<.006	<.007	<.06	<.04	<.06	<.02	<.08	<.012
DO Cd 68	E.009	<.08	<.04	<.006	<.006	0.019	<.06	<.04	<.06	<.02	<.08	<.012
DO Dd 12	<.014	<.08	<.04	<.006	<.006	<.007	<.06	<.04	<.06	<.02	<.08	<.012
DO Dd 13	<.014	<.08	<.04	<.006	<.006	<.007	<.06	<.04	<.06	<.02	<.08	<.012

Table 4. Concentrations of organic compounds detected in surface-water and groundwater samples, Little Blackwater River watershed, Dorchester County, Maryland, June 2008.—Continued

[USGS, U.S. Geological Survey; ft., feet; gal/min, gallons per minute; mi², square miles; mm, millimeters; Hg, mercury; µg/L, micrograms per liter; %, percent; --, data not available; dark shaded couplets indicate duplicate samples; Md., Maryland; <, less than; E, quantified above the long-term method detection limit (LT-MDL) but below the laboratory reporting level (LRL) with higher uncertainty]

Station name	Disulfoton (µg/L)	Diuron (µg/L)	Desulfinyl fipronil amide (µg/L)	Fipronil sulfide (µg/L)	Fipronil sulfone (µg/L)	Fipronil (µg/L)	Metolachlor (µg/L)	Picloram (µg/L)	Prometon (µg/L)	Siduron (µg/L)	Simazine (µg/L)	Sulfometuron-methyl (µg/L)	Triclopyr (µg/L)
Surface-water sites													
Christ's Rock	<.04	E.0139	E.002	E.010	E.017	E.005	1.240	--	0.034	<.02	0.239	<.06	<.08
Maple Dam Bridge	<.04	<.04	E.005	E.008	E.019	E.027	0.058	--	0.064	0.04	0.015	<.06	E.0571
Tributary near Cambridge, Md.	<.04	E.0255	E.002	E.008	E.015	E.006	1.210	--	<.008	<.02	0.309	<.06	<.08
River near Cambridge, Md.	<.04	E.0217	E.002	E.007	E.011	E.006	1.260	--	<.008	<.02	0.391	<.06	<.08
Groundwater sites													
DO Cd 56	<.04	<.04	<.029	<.013	<.024	<.02	<.010	--	<.008	<.02	<.006	E.08	<.08
DO Cd 59	<.04	<.04	<.029	<.013	<.024	<.02	<.010	--	<.008	<.02	<.006	<.06	<.08
DO Cd 61	<.04	<.04	<.029	<.013	<.024	<.02	0.030	<.12	<.008	<.02	<.006	<.06	<.08
DO Cd 63	<.0863	<.04	<.029	<.013	<.024	<.02	<.010	<.12	<.008	<.02	<.006	<.06	<.08
DO Cd 63	<.0863	<.04	<.029	<.013	<.024	<.02	<.010	<.12	<.008	<.02	<.006	<.06	<.08
DO Cd 64	<.04	<.04	<.029	<.013	<.024	<.02	0.020	--	<.008	<.02	<.006	<.06	<.08
DO Cd 66	<.04	<.04	<.029	<.013	<.024	<.02	<.010	--	<.008	<.02	<.006	<.06	<.08
DO Cd 68	<.04	<.04	<.029	<.013	<.024	<.02	0.026	--	<.008	<.02	E.005	<.06	<.08
DO Dd 12	<.04	<.04	<.029	<.013	<.024	<.02	<.010	<.12	<.008	<.02	<.006	0.10	<.08
DO Dd 13	<.04	<.04	<.029	<.013	<.024	<.02	<.010	<.12	<.008	<.02	<.006	<.06	<.08

[1] Carbaryl concentration from high-performance liquid chromatography (HPLC).

[2] Carbaryl concentration from gas chromatography-mass spectrometry (GCMS).

Note: See table 5 for list of compounds that were not detected.

Table 5. Dissolved organic compounds analyzed for, but not detected, in surface-water and groundwater samples, Little Blackwater River watershed, Dorchester County, Maryland.

[<, less than; all concentrations in micrograms per liter, filtered through glass-fiber filter with 0.7-micron opening; see Appendixes 1 and 2 for detected concentrations]

Compound	Minimum reporting limit	Compound	Minimum reporting limit	Compound	Minimum reporting limit	Compound	Minimum reporting limit
2,4-D methyl ester	<.04	*cis*-Permethrin	<.01	Lindane	<.006	Parathion	<.010
2,4-DB	<.02	Cyanazine	<.02	Linuron[1]	<.04	Pebulate	<.004
2,6-Diethylaniline	<.002	Cycloate	<.02	Linuron[2]	<.06	Pendimethalin	<.012
3-Hydroxy carbofuran	<.04	Dacthal mono-acid	<.02	Malathion	<.016	Phorate	<.04
Acifluorfen	<.04	DCPA	<.003	MCPA	<.06	Propyzamide	<.004
Aldicarb sulfone	<.08	Diazinon	<.005	MCPB	<.06	Propachlor	<.006
Aldicarb sulfoxide	<.06	Dicamba	<.04	Metalaxyl	<.02	Propanil	<.006
Aldicarb	<.12	Dichlorprop	<.02	Methiocarb	<.04	Propargite	<.04
alpha-HCH	<.002	Dieldrin	<.009	Methomyl	<.12	Propham	<.04
Azinphos-methyl	<.12	Dinoseb	<.04	Methyl parathion	<.008	Propiconazole	<.04
Bendiocarb	<.04	Diphenamid	<.04	Metribuzin	<.012	Propoxur	<.04
Benfluralin	<.004	EPTC	<.002	Metsulfuron-methyl	<.14	Tebuthiuron	<.016
Benomyl	<.04	Ethalfluralin	<.009	Molinate	<.002	Terbacil[2]	<.018
Bensulfuron-methyl	<.06	Ethoprop	<.012	N-(4-Chlorophenyl)-N'-methyl-urea	<.12	Terbacil[1]	<.04
Bentazon	<.04	Fenuron	<.04	Napropamide	<.018	Terbufos	<.018
Bromacil	<.02	Flumetsulam	<.06	Neburon	<.02	Thiobencarb	<.010
Bromoxynil	<.12	Fluometuron	<.04	Nicosulfuron	<.1	Triallate	<.006
Butylate	<.002	Fonofos	<.01	Norflurazon	<.02	Trifluralin	<.006
Chloramben methyl ester	<.1	Imazaquin	<.04	Oryzalin	<.04		
Chlorpyralid	<.06	Imazethapyr	<.04	Oxamyl	<.12		
Chlorpyrifos	<.005	Imidacloprid	<.06	*p,p'*-DDE	<.003		

[1] Concentration from high-performance liquid chromatography (HPLC).

[2] Concentration from gas chromatography-mass spectrometry (GCMS).

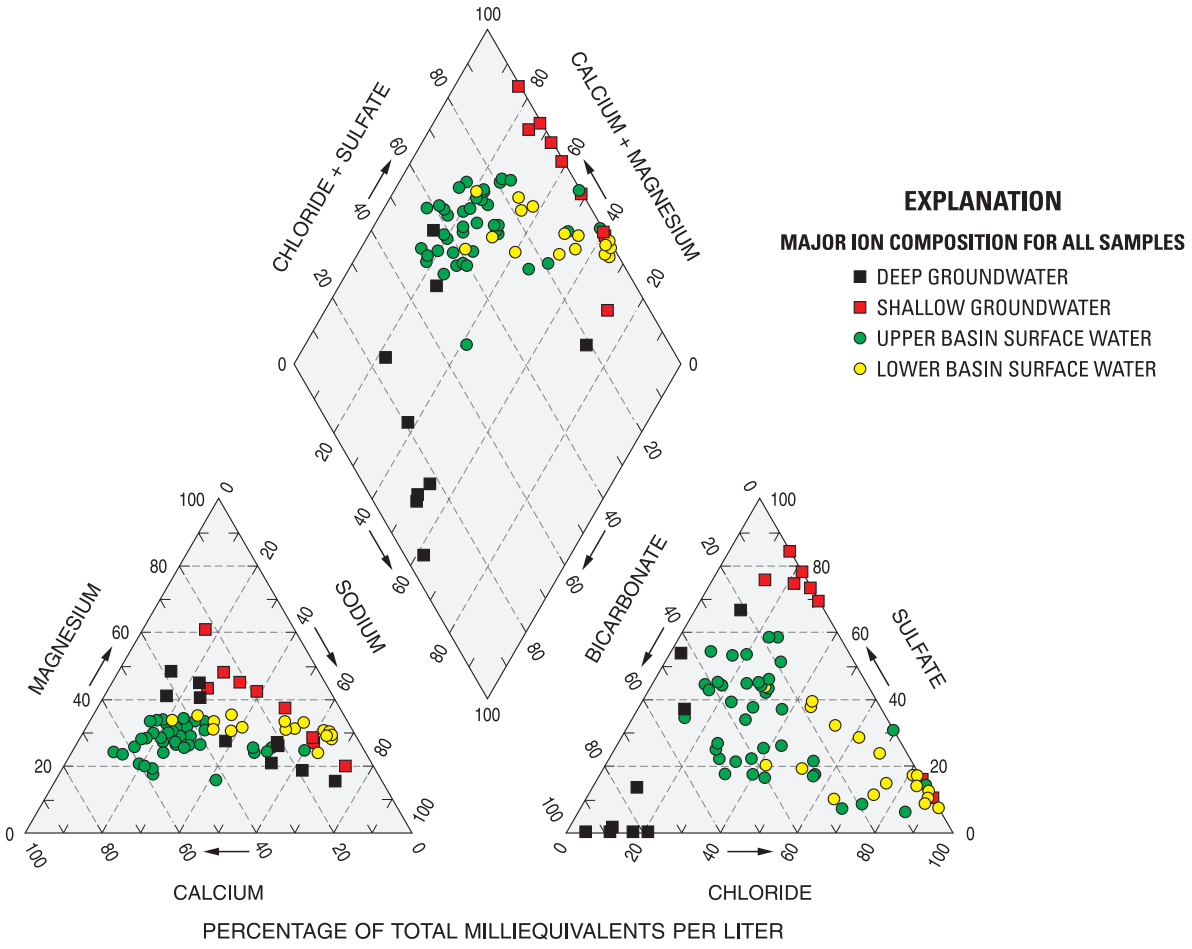


Figure 13. Trilinear diagrams showing chemical characteristics of inorganic constituents in surface water and groundwater, Little Blackwater River watershed, Dorchester County, Maryland.

of samples grouped into the same categories in figure 13 are shown in figure 14. Silica shows the highest mean and range in both groundwater groups, as would be expected. Manganese and iron are highest in shallow groundwater. Calcium has the highest mean in deep groundwater, which is consistent with the shell material found in the deep cores. Deep wells (greater than 15 ft bls) have higher nitrogen concentrations (2.32–6.89 mg/L) than shallow (less than 15 ft bls) wells (0.26–0.95 mg/L). The exception is well DO Cd 66, screened from 124–129 ft bls with a nitrogen concentration of 0.66 mg/L. The other inorganic constituents in figure 14 are relatively low compared to the lower basin surface-water samples.

The pH in shallow groundwater is relatively low—around 4—and increases with depth to over 7 at 130 ft deep (fig. 15). Several samples collected from water-table wells screened in more silty sediments have pH values around 5 (fig. 15). As noted in Ator and others (2005), shallow groundwater quality in Coastal Plain lowlands can be acidic in areas with weathered organic matter and higher quartz content in sediments. These characteristics, along with the low observed dissolved oxygen and reducing conditions contribute to the low values of nitrate in the shallow groundwater.

Chloride concentrations in the shallow groundwater increase with proximity to the Little Blackwater River. The wells closest to the river, DO Cd 61 and DO Cd 68, located 500 and 250 ft from the Little Blackwater River, respectively, have chloride concentrations over 381 mg/L and 219 mg/L. For reference, the U.S. Environmental Protection Agency Secondary Maximum Contaminant Level (SMCL) for chloride based on taste is 250 mg/L (U.S. Environmental Protection Agency, 2009). In observed monthly water-level measurements, there are seasonal gradient reversals between the water levels in wells DO Cd 61 and DO Cd 68 and the stage of the Little Blackwater River. These higher chloride concentrations are likely caused by infiltration of brackish river water into the shallow groundwater-flow system close to the river.

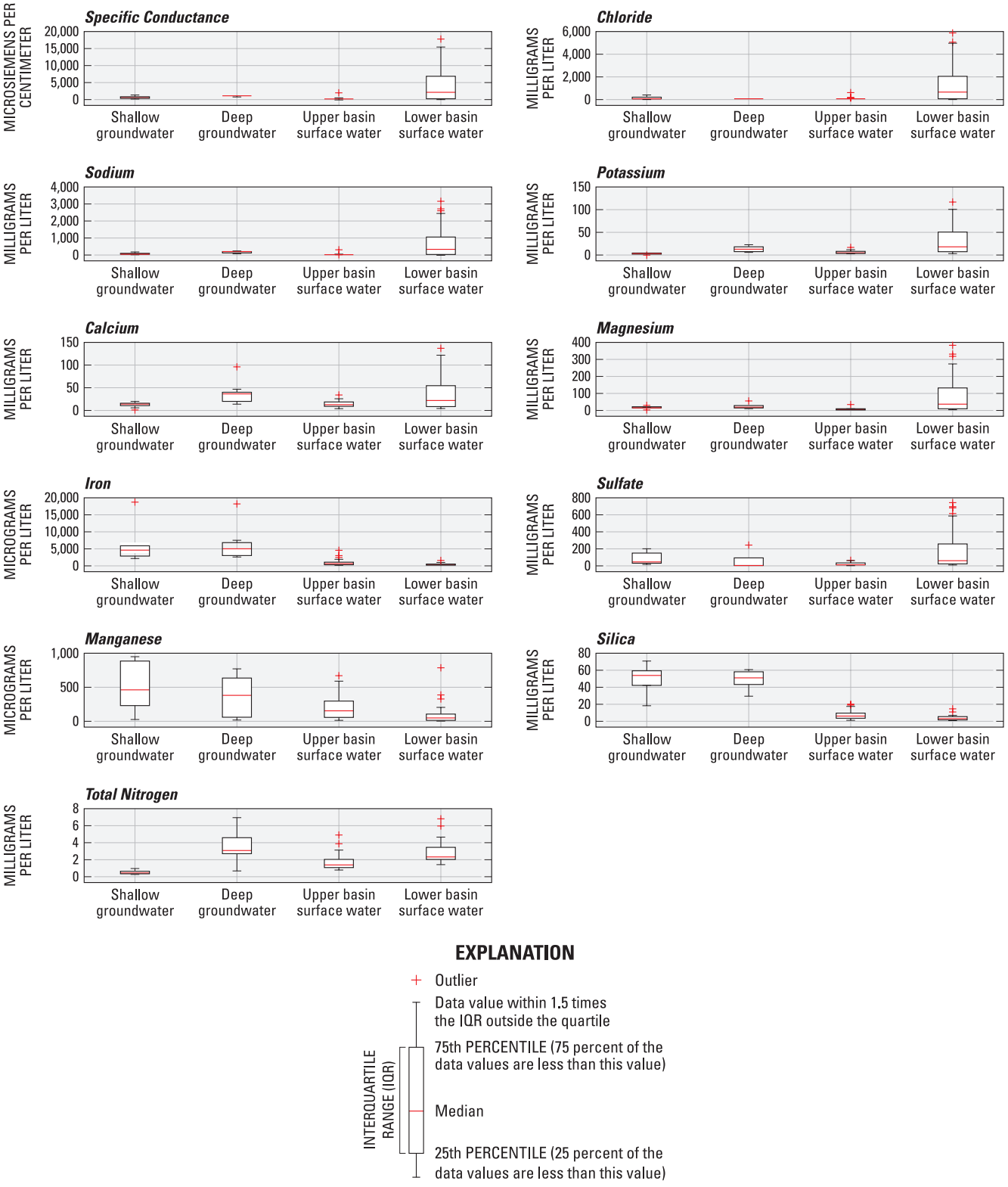


Figure 14. Boxplots showing inorganic constituents in surface water and groundwater, Little Blackwater River watershed, Dorchester County, Maryland.

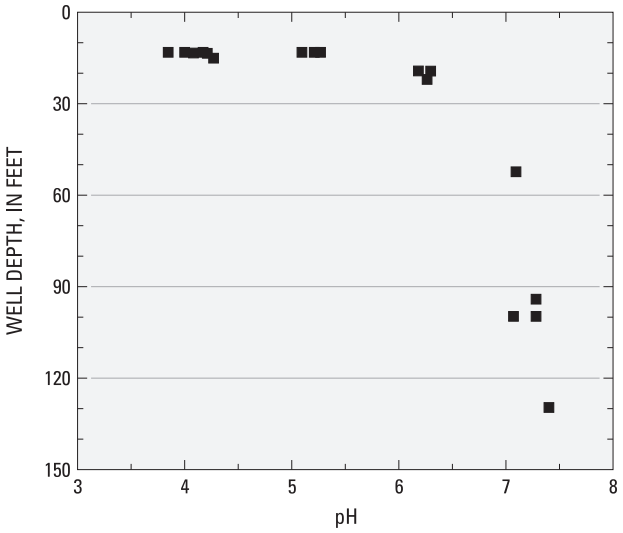


Figure 15. pH compared to well depth for all groundwater wells sampled, Little Blackwater River watershed, Dorchester County, Maryland.

Organic Constituents

Groundwater samples were collected and analyzed for pesticides from nine wells on June 9–11, 2008 (table 4). The commonly used herbicides atrazine, metolachlor, simazine, sulfometuron-methyl, and the atrazine degradate 2-chloro-4-isopropylamino-6-amino-*s*-triazine (CIAT) were detected at low concentrations (0.03 mg/L or less) in up to three of nine shallow wells that ranged in depth from 12 to 15 ft (table 4). One deeper well (DO Dd 12, 99.7 ft) had a single detection (0.10 mg/L) of the herbicide sulfometuron-methyl. The detection of sulfometuron-methyl in well DO Dd 12 may be due to contamination during sampling or laboratory analysis, and should be confirmed with subsequent sampling because sulfometuron-methyl is used far less than the other herbicides in Dorchester County (Maryland Department of Agriculture, 2002), and no other herbicides or insecticides were detected in that well. The detection was probably not caused by drilling because the shallow well at that location showed no concentrations of that compound.

Surface-Water Quality

Surface-water-quality samples were collected during storm events and also on a seasonal basis. Storm event sampling occurred on October 6, 2006 and again on April 16, 2007. Quarterly samples were taken from March 2006 through October 2007. A final sampling effort was conducted in June 2008.

Inorganic Constituents

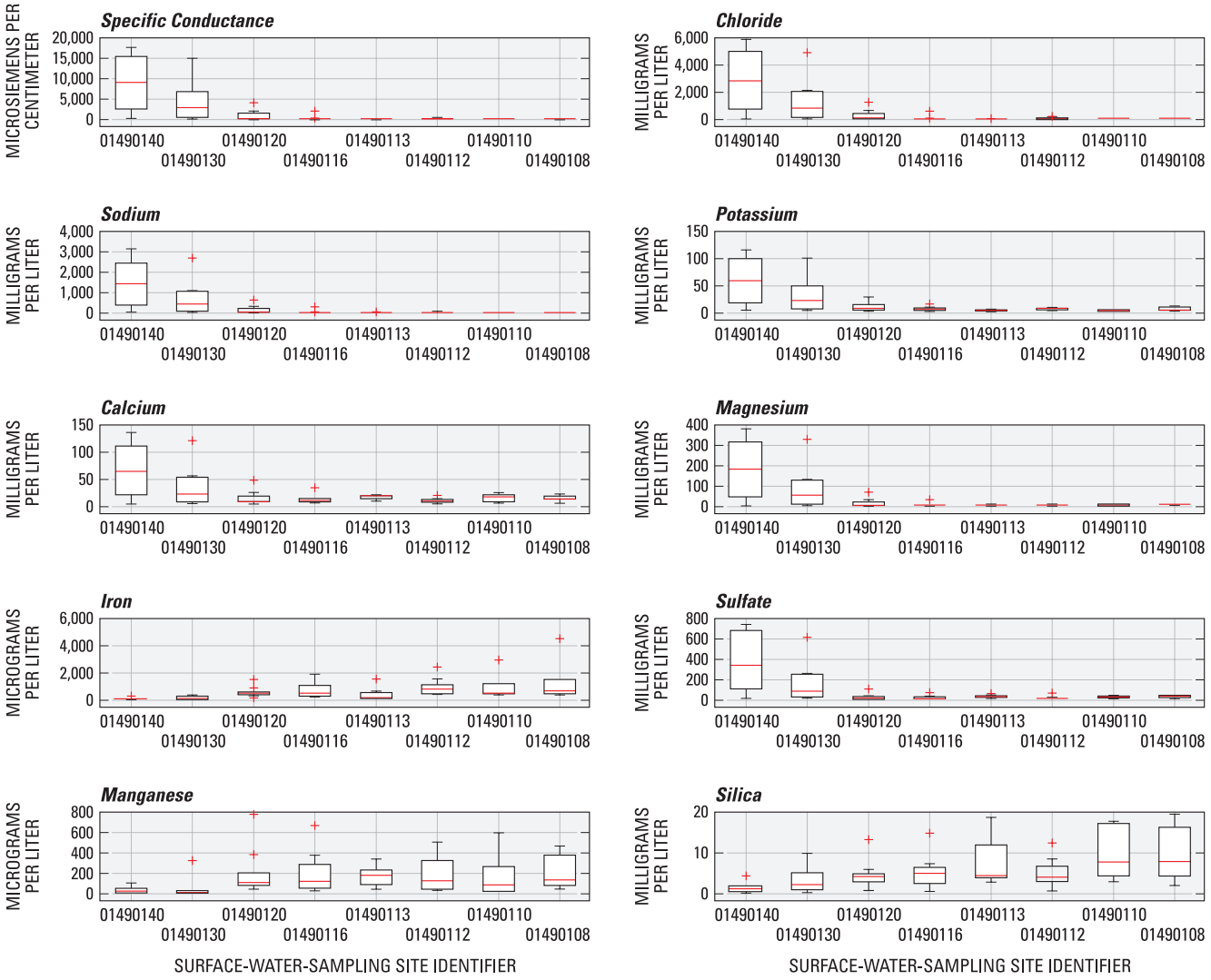
Major ions were sampled in surface water at several sites within the watershed (fig. 2). Results of surface-water and groundwater inorganic analyses are plotted on a trilinear diagram (fig. 13). The samples are separated into four groups: shallow groundwater, deep groundwater, surface water from the upper basin, and surface water from the lower basin. Surface-water samples from the lower half of the Little Blackwater River watershed have consistently higher chloride concentrations than the upper part of the watershed, with a maximum concentration of 5,870 mg/L at the southernmost site, 01490140. The lower (southern) part of the watershed is under a strong tidal influence, not only in stage but also in terms of brackish-water mixing. Daily and seasonal variations in specific conductance at the mouth of the river (site 1490140) and near the middle of the watershed (site 1490120) are shown in figure 11A. Both gage sites have strong seasonal variations in specific conductance, but the magnitude of the seasonal variation decreases further upstream in the watershed. Boxplots of selected inorganic constituents for surface-water sampling sites are shown in figure 16. Sites 1490140, 1490130, and 1490120, in the lower basin, show the greatest range of values for constituents associated with seawater. Ranges of silica, iron, and manganese are greatest at the surface-water sites in the upper basin where base flow from shallow groundwater contributes more significantly to overall streamflow.

Surface-water samples are further grouped into summer (June through November) and winter (December through May) samples in the upper and lower basin (fig. 17). During the winter months, when the water table is higher, the Little Blackwater River is discharging freshwater. As such, upper and lower basin inorganic constituents do not vary significantly. However, in summer months, the upper basin has higher mean values for iron, manganese, and silica, likely caused by a greater portion of total streamflow coming from groundwater.

There is a significant change in water chemistry in the lower basin from winter to summer. Constituents typically found in seawater are observed in much greater concentrations in the lower basin during summer (fig. 17). The source of seawater in the Little Blackwater River is from Fishing Bay, which flows through the BNWR.

Organic Constituents

Surface-water samples were collected and analyzed for pesticides only once at four surface-water sites on June 10, 2008 (table 4). This single sampling effort cannot address either variability or seasonality of the results, and is only representative of conditions at that time. The herbicides atrazine, metolachlor, and simazine, and the insecticide fipronil, were detected at each of the four surface-water sites. Atrazine, metolachlor, and simazine were 3 of 16 pesticides that were commonly found in surface waters of the Mid-Atlantic region



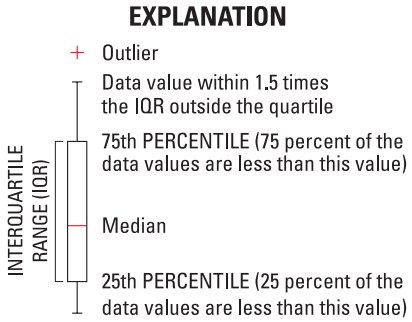


Figure 16. Boxplots showing inorganic constituents at surface-water sites, Little Blackwater River watershed, Dorchester County, Maryland.

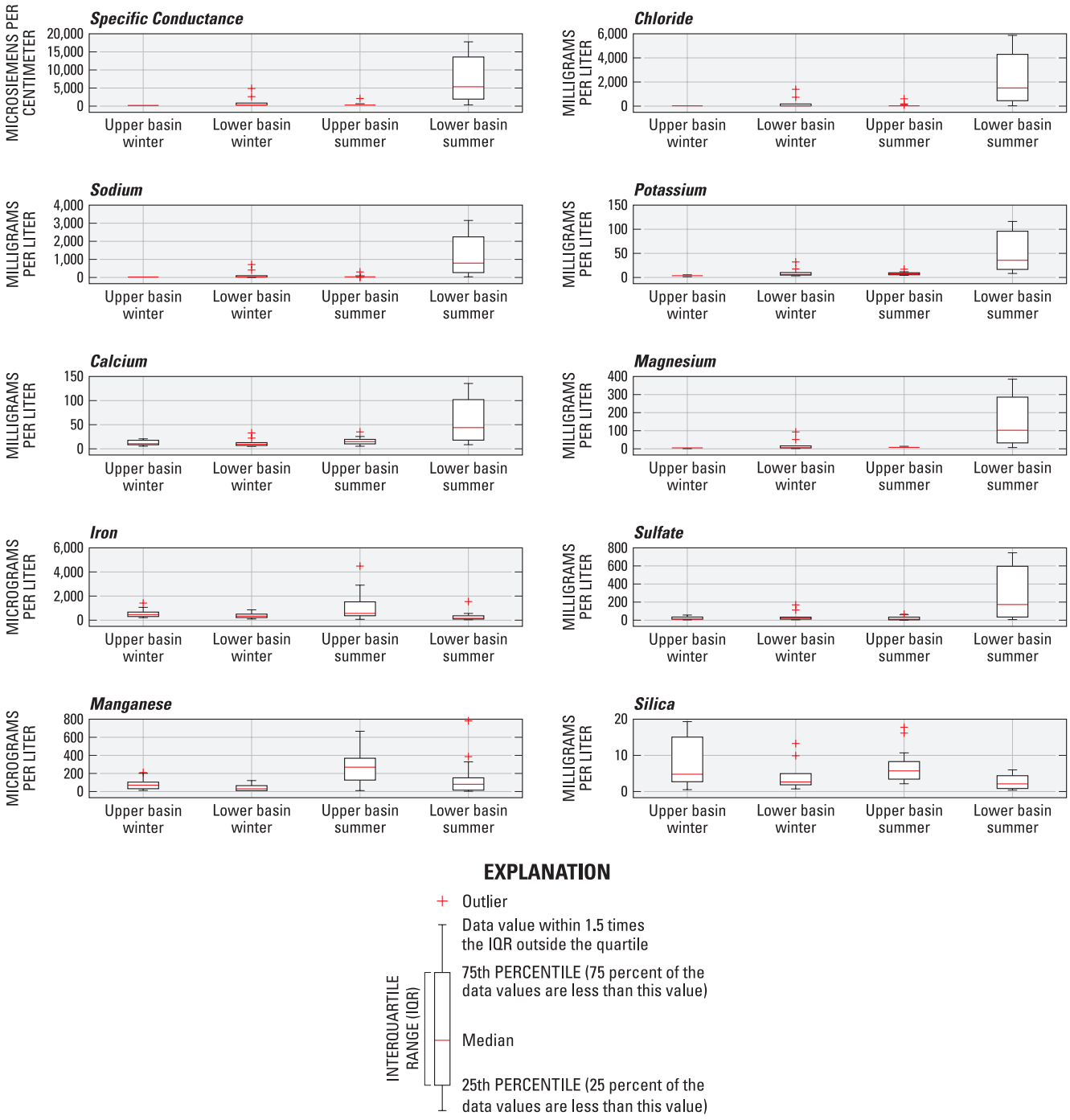


Figure 17. Boxplots showing summer (June through November) and winter (December through May) inorganic constituents in the upper and lower basin, Little Blackwater River watershed, Dorchester County, Maryland.

by Ferrari and others (1997), and were commonly used in Dorchester County in 2000, the latest date for which county pesticide usage data are available (Maryland Department of Agriculture, 2002).

Atrazine is a commonly detected herbicide in surface water and was detected at concentrations up to 1.1 mg/L. In addition, three compounds that are atrazine degradates (2-Chloro-4-isopropylamino-6-amino-*s*-triazine [CIAT], 2-Chloro-6-ethylamino-4-amino-*s*-triazine, and 2-Hydroxy-4-isopropylamino-6-ethylamino-*s*-triazine) also were detected at three of the four sites. For comparative purposes, the USEPA Maximum Contaminant Level (MCL) for atrazine in drinking water is 3 mg/L (U.S. Environmental Protection Agency, 2009). Commonly used pesticides in Dorchester County in 2000 that were also detected in surface water during this study were alachlor, atrazine, metolachlor, and simazine (Maryland Department of Agriculture, 2002). Metalachlor and simazine are pre-emergent herbicides and are commonly used in much of the Delmarva Peninsula (Ator and others, 2004; Maryland Department of Agriculture, 1999, 2002). Fipronil is an insecticide commonly used on termites and fleas, and was found at estimated concentrations below the minimum reporting level. Fipronil was not reported to have been used in the County in 2000, but was reported to have been used in adjacent counties (Maryland Department of Agriculture, 2002). Usage patterns may have changed between 2000, when the latest county-wide data on pesticide usage are available, and 2008, when samples were collected in the Little Blackwater River watershed.

Ator and others (2004) analyzed the seasonal variability of atrazine and metalachlor in two streams on the Delmarva Peninsula, and found that seasonal variability in pesticide concentrations in surface water is related to application patterns and that concentrations were generally highest in the growing season but were detectable throughout the year. Concentrations of pesticides found in the Little Blackwater River during this study were similar to concentrations found by Ator and others (2004) in the Pocomoke River between Wicomico and Worcester Counties, and in Chesterville Branch in Kent County, Maryland.

Summary and Conclusions

The goals of this study were to (1) document geochemical conditions in the shallow groundwater system and the Little Blackwater River prior to potential land-use changes, and (2) characterize the hydrology of the watershed, looking at both the tidal and seasonal variability of surface water and groundwater. The lithologic variability in the subsurface of the Little Blackwater watershed suggests an inherently complex hydrogeologic regime. Preferential pathways for groundwater flow in the shallow sediments are generally quite thin and lack significant lateral continuity. Areas where Pleistocene erosion and deposition did not have an impact on the deeper stratigraphy have a thicker and more complete section of the low-permeability beds of the upper Choptank Formation.

Much of the complexity within the shallow groundwater system is due to the heterogeneous nature of the surficial sediments. Extensive ditching along agricultural fields can create artificial flowpaths that circumvent the typical topographically driven groundwater-flow system. The tidal nature of the Little Blackwater River also affects groundwater fluxes, and because of the wide expanse of open water within the Blackwater National Wildlife Refuge, southerly winds can increase river stage well into the headwater areas of the basin, creating temporary, localized reversals in shallow groundwater-flow directions close to the river.

Water-table wells in the study area generally have water levels slightly above sea level, with seasonal variations of several feet. Horizontal hydraulic gradients are persistent throughout all seasons and indicate groundwater flow towards the Little Blackwater River. Lower seasonal groundwater levels in shallow wells close to the river during late summer and fall indicate a localized gradient reversal from the Little Blackwater River.

Discharge calculated at the lower gage varies seasonally, with net negative discharge (more water flowing upstream than downstream) from June through November and net positive discharge from the Little Blackwater River from December through May. Given the high percentage of agricultural land use and significant amounts of riparian wetland vegetation, evapotranspiration is likely the major flux of freshwater out of the watershed during the summer. In the summer months, brackish water encroaches up the Little Blackwater River from the Blackwater National Wildlife Refuge and Fishing Bay.

Water samples were collected during 2007–08 from 13 monitoring wells and during 2006–09 from 9 surface-water sites to characterize pre-development conditions and seasonal variability of inorganic constituents and nutrients. Pesticide samples were collected from nine wells and four surface-water sampling sites in June 2008. The herbicides atrazine, metolachlor, and simazine, and the insecticide fipronil, were detected at each of the four surface-water sampling sites. With the exception of sulfometuron-methyl, concentrations of pesticides found in the groundwater were typically one to two orders of magnitude lower than pesticide concentrations found in the Little Blackwater River during the same time period. Concentrations and the type of compounds found in the Little Blackwater River were similar to concentrations and compound types found in other investigations in the Pocomoke River between Wicomico and Worcester Counties, and in Chesterville Branch in Kent County, Maryland. Nitrogen concentrations were higher in deep groundwater than in shallow groundwater. Chloride concentrations in the water-table wells increase with proximity to the Little Blackwater River.

It is unclear what implications land-use change from agricultural to residential would have on the water quality in the Little Blackwater River watershed. Changes in land use

will likely affect the applications of pesticides, road salts, and nutrients within the watershed. These potential impacts are subjects for future studies.

Seasonal hydraulic-gradient reversals between the Little Blackwater River and the water table, coincident with a seasonal increase in specific conductance and chloride in the Little Blackwater River, along with elevated chloride in near-river water-table wells indicate saltwater intrusion into the shallow groundwater system during summer and fall months. Sea level rise could exacerbate the impacts to saltwater intrusion in the future. However, the mechanisms affecting saltwater intrusion into the shallow groundwater system are beyond the scope of this study and can be the subject of further investigations.

Acknowledgments

The authors would like to thank the Edgar family for allowing us to install and maintain a stream gage on their property, and USGS employees Jessica Teunis, Deborah Bringman, Michael Brownley, Anthony Tallman, and Douglas Yeskis for their sampling and data-collection efforts, and Wayne Newell for technical input for the geologic interpretation. The authors would also like to thank Michael Brayton and Gary Lauben of the USGS for assistance with geophysical surveys. The authors also thank the following personnel from other agencies and organizations who assisted in field logistical support and provided technical input during the completion of this project: Diane Cole and James Newcomb (Dorchester Soil Conservation District); Rebecca Fox and Thomas Fisher (University of Maryland, Horn Point Laboratory); William Giese, Dixie Birch, and Suzanne Baird (U.S. Fish and Wildlife Service, Chesapeake Marshlands Wildlife NWR Complex); and Gary Setzer (Maryland Department of the Environment).

Selected References

Ator, S.W., Denver, J.M., and Brayton, M.J., 2004, Hydrologic and geochemical controls on pesticide and nutrient transport to two streams on the Delmarva Peninsula: U.S. Geological Survey Scientific Investigations Report 2004–5051, 34 p., available online at *http://pubs.usgs.gov/sir/2004/5051/*.

Ator, S.W., Denver, J.M., Krantz, D.E., Newell, W.L., and Martucci, S.K., 2005, A surficial hydrogeologic framework for the Mid-Atlantic Coastal Plain: U.S. Geological Survey Professional Paper 1680, 44 p., available online at *http://pubs.usgs.gov/pp/2005/pp1680/*.

Cole, W.D., 2008, The Little Blackwater River watershed management plan: From city headwaters to National Wildlife Refuge: Cambridge, Maryland, Dorchester Soil Conservation District, 58 p., accessed October 27, 2009, at *http://www.ci.cambridge.md.us/uploads/images/Planning_Zoning/Draft_Little_Blackwater_Mgmt_Plan.pdf*.

Cushing, E.M., Kantrowitz, I.H., and Taylor, K.R., 1973, Water resources of the Delmarva Peninsula: U.S. Geological Survey Professional Paper 822, 58 p.

deVerteuil, L., and Norris, G., 1996, Miocene dinoflagellate stratigraphy and systematics of Maryland and Virginia: Micropaleontology, v. 42, supplement, p. 1–172.

Denny, C.S., and Owens, J.P., 1978, Sand dunes on the central Delmarva Peninsula, Maryland and Delaware: U.S. Geological Survey Professional Paper 1067–C, 15 p.

Denny, C.S., Owens, J.P., Sirken, L.A., and Rubin, M., 1979, The Parsonsburg Sand in the central Delmarva Peninsula, Maryland and Delaware: U.S. Geological Survey Professional Paper 1067–B, 16 p.

Ferrari, M.J., Ator, S.W., Blomquist, J.D., and Dysart, J.E., 1997, Pesticides in surface water of the Mid-Atlantic Region: U.S. Geological Survey Water-Resources Investigations Report 97–4280, 12 p.

French, H.M., 2007, The periglacial environment (3d ed.): Chichester, United Kingdom, John Wiley and Sons Ltd., 458 p.

French, Hugh, Demitroff, Mark, and Newell, W.L., 2009, Past permafrost on the Mid-Atlantic Coastal Plain, eastern United States: Permafrost and Periglacial Processes v. 20, no. 3, p. 285–294, DOI: 10.1002/ppp.659.

Gernant, R.E., 1970, Paleoecology of the Choptank Formation (Miocene) of Maryland and Virginia: Maryland Geological Survey Report of Investigations No. 12, 90 p.

Hem, 1985, Study and interpretation of the chemical characteristics of natural water: U.S. Geological Survey Water-Supply Paper 2254, 263 p.

Klohe, C.A., and Feehley, C.E., 2001, Hydrogeology and ground-water quality of the Piney Point-Nanjemoy and Aquia aquifers, Naval Air Station Patuxent River and Webster Outlying Field, St. Mary's County, Maryland: U.S. Geological Survey Water-Resources Investigations Report 01–4029, 51 p., available online at *http://pubs.usgs.gov/wri/wri01–4029/*.

Larsen, Curt, Clark, Inga, Guntenspergen, Glenn, Cahoon, Don, Caruso, Vincent, Hupp, Cliff, and Yanosky, Tom, 2004, The Blackwater NWR inundation model. Rising sea level on a low-lying coast: Land use planning for wetlands: U.S. Geological Survey Open-File Report 04–1302, online only, available at *http://pubs.usgs.gov/of/2004/1302/*.

Markewich, H.W., Litwin, R.J., Pavich, M.J., and Brook, G.A., 2009, Late Pleistocene eolian features in southeastern Maryland and Chesapeake Bay region indicate strong WNW–NW winds accompanied growth of the Laurentide Ice Sheet: Quaternary Research, v. 71, no. 3, p. 409–425, doi: 10.1016/j.yqres.2009.09.003.

Maryland Department of Agriculture, 1999, Maryland pesticide statistics for 1997: Maryland Department of Agriculture Report MDA–265–99, 56 p.

Maryland Department of Agriculture, 2002, Maryland pesticide statistics for 2000: Maryland Department of Agriculture Report MDA–265–02, 45 p.

Milheim, L.E., Jones, J.W., and Barlow, R.A., 2007, Development of an impervious-surface database for the Little Blackwater River watershed, Dorchester County, Maryland: U.S. Geological Survey Open-File Report 2007–1308, 6 p., available online at *http://pubs.usgs.gov/of/2007/1308/ofr2007-1308.pdf*.

Mixon, R.B., Berquist, C.R., Jr., Newell, W.L., Johnson, G.H., Powars, D.S., Schindler, J.S., and Rader, E.K., 1989, Geological map and generalized cross sections of the Coastal Plain and adjacent parts of the Piedmont, Virginia, IMAP: U.S. Geological Survey Numbered Series, 1 sheet.

Newell W.L., and Clark Inga, 2008, Geomorphic map of Worcester County, Maryland, interpreted from a LIDAR-based digital elevation model: U.S. Geological Survey Open-File Report 2008–1005, 34 p., 2 pls., available online at *http://pubs.usgs.gov/of/2008/1005/*.

Owens, J.P., and Denny, C.S., 1979, Upper Cenozoic deposits of the central Delmarva Peninsula, Maryland and Delaware: U.S. Geological Survey Professional Paper 1067–A, 28 p.

Owens, J.P., and Denny, C.S., 1986, Geologic map of Dorchester County, Maryland: Baltimore, Maryland, Maryland Geological Survey, 1 sheet, scale 1:62,500.

Phelan, D.J., 1987, Water levels, chloride concentrations, and pumpage in the coastal aquifers of Delaware and Maryland: U.S. Geological Survey Water-Resources Investigations Report 87–4229, 106 p.

Sirkin, L.A., Denny, C.S., and Rubin, M., 1977, Late Pleistocene environment of the central Delmarva Peninsula, Delaware-Maryland: Geological Society of America Bulletin, v. 88, no. 1, p. 139–142, doi: 10.1130/0016-7606(1977)88<139:LPEOTC>2.0.CO;2

Smoot, J.P., Newell, W.L., and DeJong, B.D., 2009, Investigation into the origin and character of surficial sedimentary deposits at the Midshore Regional Solid Waste Facility near Easton, Maryland: U.S. Geological Survey Open-File Report 2009–1052, 64 p., available online only at *http://pubs.usgs.gov/of/2009/1052/*.

Trapp, Henry, Jr., Knobel, L.L., Meisler, Harold, and Leahy, P.P., 1984, Test Well DO-Ce 88 at Cambridge, Dorchester County, Maryland: U.S. Geological Survey Water-Supply Paper 2229, 48 p.

U.S. Environmental Protection Agency, 2009, 2009 Edition of the drinking water standards and health advisories: U.S. Environmental Protection Agency, EPA 822-R-09-011, Office of Water, accessed February 02, 2011, at *http://water.epa.gov/action/advisories/drinking/drinking_index.cfm.*

U.S. Geological Survey, variously dated, National field manual for the collection of water-quality data: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chaps. A1–A9, available online at *http://pubs.water.usgs.gov/twri9A*.

U.S. Geological Survey, 2010, National Water Information System data available on the World Wide Web (Water Data for the Nation), accessed January 20, 2010, at *http://waterdata.usgs.gov/nwis/*.

Waelbroeck, C., Labeyrie, L., Michel, E., Duplessy, J.C., McManus, J.F., Lambeck, K., Balbon, E., and Labracherie, M., 2002, Sea-level and deep water temperature changes derived from benthic foraminifera isotopic records: Quaternary Science Reviews, v. 21, nos. 1–3, p. 295–305, doi: 10.1016/S0277-3791(01)00101-9.

Appendixes 1–8

Appendix 1. Concentrations of inorganic constituents in groundwater samples, Little Blackwater River watershed, Dorchester County, Maryland.

[ft, feet; gal/min, gallons per minute; FNU, formazin nephelometric units; mg/L, milligrams per liter, °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 °C; %, percent; µg/L, micrograms per liter; $CaCO_3$, calcium carbonate; SiO_2, silica; N, nitrogen; NH_4, ammonia; NO_2, nitrite; NO_3, nitrate; P, phosphorus; <, less than; E, estimated; M, present but not quantified; U, deleted value by lab; --, data not available; USGS, U.S. Geological Survey; shaded couplets indicate duplicate samples; NWQL, National Water Quality Laboratory]

USGS well number	USGS well name	Date	Time	Depth of well (feet below land surface)	Altitude of land surface (ft)	Water level, depth below measuring point (ft)	Pump flow rate (gal/min)	Pump period (minutes)	Sampling depth (ft)	Turbidity (FNU)	Carbon dioxide, dissolved (mg/L)	Dissolved oxygen (mg/L)	pH, field	pH, lab
383122076055701	DO Cd 56	10/30/2007	1135	13.5	9.50	8.48	--	--	--	--	--	1.2	4.2	3.8
383122076055701	DO Cd 56	06/11/2008	0815	13.5	9.50	6.44	0.3	--	11.5	--	--	0.9	4.1	3.9
383122076055702	DO Cd 57	10/31/2007	1240	22.0	9.85	8.4	--	--	--	--	--	2.8	6.3	6.5
383122076055703	DO Cd 58	10/30/2007	1515	94.0	9.43	14.9	0.3	--	--	--	--	--	7.3	7.2
383118076054601	DO Cd 59	10/30/2007	1445	13.1	7.28	8.53	0.1	--	--	--	--	0.1	5.1	3.7
383118076054601	DO Cd 59	06/10/2008	1520	13.1	7.28	--	0.7	--	13.1	--	--	0.4	4.2	4.1
383118076054602	DO Cd 60	10/31/2007	1158	19.2	7.11	7.75	--	--		7.8	--	0.9	6.2	6.2
383112076053501	DO Cd 61	10/31/2007	1110	13.2	3.68	--	0.2	--	--	--	--	--	4.0	3.9
383112076053501	DO Cd 61	10/31/2007	1115	13.2	3.68	--	--	--	--	--	--	--	--	3.9
383112076053501	DO Cd 61	06/10/2008	1100	13.2	3.68	4.05	0.6	0.5	13.2	--	--	2.3	3.8	4.0
383112076053502	DO Cd 62	10/31/2007	1029	19.4	3.81	4.61	--	--		9	--	--	6.3	6.5
383112076053503	DO Cd 63	10/31/2007	1225	53.2	3.12	8.01	1.1	--	46.18	6	--	--	7.1	7.5
383112076053503	DO Cd 63	06/10/2008	1030	53.2	3.12	--	0.8	50	51.5	--	95	0.2	7.1	7.3
383112076053503	DO Cd 63	06/10/2008	1045	53.2	3.12	--	0.1	65	51.5	--	--	0.0	7.1	7.3
383100076061101	DO Cd 64	06/11/2008	1555	13.0	10.18	--	--	--	--	--	124	0.7	5.3	5.8
383100076061103	DO Cd 66	06/11/2008	1500	129.5	10.34	--	4.7	--	--	--	46	0.1	7.4	7.5
383051076054201	DO Cd 68	06/11/2008	1050	15.0	5.00	5.52	--	--	--	--	--	0.3	4.3	3.9
382718076062001	DO Dd 12	10/31/2007	0915	99.7	5.26	16.01	0.4	--	5.47	--	--	--	7.3	7.4
382718076062001	DO Dd 12	06/09/2008	1345	99.7	5.26	15.04	0.9	--	90	--	64	0.3	7.1	7.3
382718076062002	DO Dd 13	06/09/2008	1610	11.6	5.31	--	1.1	--	9.5	--	97	0.4	5.2	5.6

Appendix 1. Concentrations of inorganic constituents in groundwater samples, Little Blackwater River watershed, Dorchester County, Maryland.—Continued

[ft, feet; gal/min, gallons per minute; FNU, formazin nephelometric units; mg/L, milligrams per liter, °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 °C; %, percent; µg/L, micrograms per liter; $CaCO_3$, calcium carbonate; SiO_2, silica; N, nitrogen; NH_4, ammonia; NO_2, nitrite; NO_3, nitrate; P, phosphorus; <, less than; E, estimated; M, present but not quantified; U, deleted value by lab; --, data not available; USGS, U.S. Geological Survey; shaded couplets indicate duplicate samples; NWQL, National Water Quality Laboratory]

USGS well name	Date	Time	Specific conductance, lab (µS/cm)	Specific conductance, field (µS/cm)	Temperature, water (°C)	Hardness (mg/L as $CaCO_3$)	Non-carbonate hardness, dissolved, field (mg/L as $CaCO_3$)	Non-carbonate hardness, dissolved, lab (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Potassium, dissolved (mg/L)	Sodium, adsorption ration	Sodium fraction of cations (% equivalent of major cations)
DO Cd 56	10/30/2007	1135	657	606	14.7	173	--	--	19.1	30.4	4.0	1.0	26.9
DO Cd 56	06/11/2008	0815	724	677	19.8	120	--	--	14.9	20.0	2.9	2.7	54.7
DO Cd 57	10/31/2007	1240	400	443	17.1	118	--	--	19.9	16.6	8.3	1.3	34.7
DO Cd 58	10/30/2007	1515	1,204	1,192	15.1	466	55.2	--	95.5	55.2	22.6	1.6	26.3
DO Cd 59	10/30/2007	1445	626	546	16.7	114	99.1	--	19.1	16.0	3.9	1.4	39.2
DO Cd 59	06/10/2008	1520	518	542	22.2	115	--	--	15.6	18.3	2.4	1.6	41.9
DO Cd 60	10/31/2007	1158	376	439	18.0	103	--	--	18.9	13.4	6.1	1.3	38.1
DO Cd 61	10/31/2007	1110	1,062	1,059	18.9	96	--	--	11.8	16.1	4.4	6.1	74.6
DO Cd 61	10/31/2007	1115	1,060	--	--	--	--	--	13.5	16.8	4.4	--	--
DO Cd 61	06/10/2008	1100	1,370	1,320	21.4	132	--	--	15.4	22.8	4.7	6.9	74.1
DO Cd 62	10/31/2007	1029	1,013	1,048	18.5	77	--	--	13.6	10.4	6.8	9.1	82.4
DO Cd 63	10/31/2007	1225	1,205	1,217	15.2	199	--	--	36.1	26.4	17.4	6.1	66.1
DO Cd 63	06/10/2008	1030	1,220	1,241	19.6	205	--	--	36.5	27.7	18.7	6.0	65.4
DO Cd 63	06/10/2008	1045	1,230	1,240	19.6	--	--	--	37.7	28.8	19.0	--	--
DO Cd 64	06/11/2008	1555	231	231	23.2	43	--	34.2	5.7	7.0	2.6	1.3	47.6
DO Cd 66	06/11/2008	1500	1,110	1,089	15.6	141	--	--	28.7	16.9	12.6	7.8	74.6
DO Cd 68	06/11/2008	1050	795	762	19.2	96	--	--	10.6	16.8	2.9	3.6	64.2
DO Dd 12	10/31/2007	0915	1,070	1,063	15.8	170	--	--	37.8	18.3	12.9	5.9	67.2
DO Dd 12	06/09/2008	1345	917	907	18.0	206	--	--	46.1	22.1	15.3	3.5	52.7
DO Dd 13	06/09/2008	1610	150	161	21.9	10	--	--	1.1	1.8	0.3	3.4	83.5

Appendix 1. Concentrations of inorganic constituents in groundwater samples, Little Blackwater River watershed, Dorchester County, Maryland.—Continued

[ft, feet; gal/min, gallons per minute; FNU, formazin nephelometric units; mg/L, milligrams per liter, °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 °C; %, percent; µg/L, micrograms per liter; $CaCO_3$, calcium carbonate; SiO_2, silica; N, nitrogen; NH_4, ammonia; NO_2, nitrite; NO_3, nitrate; P, phosphorus; <, less than; E, estimated; M, present but not quantified; U, deleted value by lab; --, data not available; USGS, U.S. Geological Survey; shaded couplets indicate duplicate samples; NWQL, National Water Quality Laboratory]

USGS well name	Date	Time	Sodium, dissolved (mg/L)	Acid-neutralizing capacity, lab, total (mg/L as $CaCO_3$)	Alkalinity, lab, dissolved (mg/L as $CaCO_3$)	Alkalinity, field, dissolved (mg/L as $CaCO_3$)	Bicarbonate, field, dissolved (mg/L)	Bromide, dissolved (mg/L)	Chloride, dissolved (mg/L)	Fluoride, dissolved (mg/L)	Silica, dissolved (mg/L as SiO_2)	Sulfate, dissolved (mg/L)	Residue, dissolved, sum of constituents (mg/L)
DO Cd 56	10/30/2007	1135	30.0	--	--	--	--	0.07	93.9	0.60	70.2	146	--
DO Cd 56	06/11/2008	0815	68.5	--	--	--	--	--	80.7	0.41	56.3	199	--
DO Cd 57	10/31/2007	1240	31.5	--	--	172	209	0.09	18.2	0.27	57.4	14.9	285
DO Cd 58	10/30/2007	1515	81.0	--	--	411.2	500.6	0.06	16.8	0.30	50.4	244	E822
DO Cd 59	10/30/2007	1445	35.1	--	--	14.3	17.6	0.08	58.1	0.15	58.1	138	357
DO Cd 59	06/10/2008	1520	39.0	--	--	--	--	--	47.1	0.19	59.0	174	--
DO Cd 60	10/31/2007	1158	31.2	--	--	129.3	157.7	0.11	21.4	0.16	50.1	44.9	286
DO Cd 61	10/31/2007	1110	137	--	--	--	--	1.02	285	0.71	51.4	37.4	--
DO Cd 61	10/31/2007	1115	138	--	--	--	--	1.05	297	0.77	49.7	39.0	--
DO Cd 61	06/10/2008	1100	181	--	--	--	--	--	381.1	0.92	49.7	49.8	--
DO Cd 62	10/31/2007	1029	184	--	--	159.5	194.4	0.31	61.0	0.27	47.6	238	668
DO Cd 63	10/31/2007	1225	198	--	--	585.6	712.6	<.02	51.0	0.32	56.4	1.2	E754
DO Cd 63	06/10/2008	1030	199	605	606	--	--	--	49.6	0.32	58.3	4.7	E777
DO Cd 63	06/10/2008	1045	200	621	614	--	--	--	49.0	0.32	57.6	7.4	--
DO Cd 64	06/11/2008	1555	19.4	11	9	--	--	--	25.6	0.19	41.8	48.4	E161
DO Cd 66	06/11/2008	1500	212	605	603	--	--	--	20.0	0.41	59.8	0.5	E716
DO Cd 68	06/11/2008	1050	82.0	--	--	--	--	--	219.6	0.22	17.8	17.8	--
DO Dd 12	10/31/2007	0915	176	--	--	474.4	577.1	E.016	68.5	0.29	29.0	1.1	E634
DO Dd 12	06/09/2008	1345	116	397	392	--	--	--	67.7	0.20	29.6	E.17	E541
DO Dd 13	06/09/2008	1610	24.5	8	13	--	--	--	9.7	0.15	66.4	37.3	155

Appendix 1. Concentrations of inorganic constituents in groundwater samples, Little Blackwater River watershed, Dorchester County, Maryland.—Continued

[ft, feet; gal/min, gallons per minute; FNU, formazin nephelometric units; mg/L, milligrams per liter, °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 °C; %, percent; µg/L, micrograms per liter; $CaCO_3$, calcium carbonate; SiO_2, silica; N, nitrogen; NH_4, ammonia; NO_2, nitrite; NO_3, nitrate; P, phosphorus; <, less than; E, estimated; M, present but not quantified; U, deleted value by lab; --, data not available; USGS, U.S. Geological Survey; shaded couplets indicate duplicate samples; NWQL, National Water Quality Laboratory]

USGS well name	Date	Time	Residue, dissolved (tons per acre-foot)	Residue on evaporation, dissolved (mg/L)	Ammonia plus organic nitrogen, total (mg/L as N)	Ammonia, dissolved (mg/L as NH_4)	Ammonia, dissolved (mg/L as N)	Nitrate plus nitrite, dissolved (mg/L as N)	Nitrate, dissolved (mg/L)	Nitrate, dissolved (mg/L as N)	Nitrite, dissolved (mg/L)	Nitrite, dissolved (mg/L as N)	Organic nitrogen, dissolved (mg/L)
DO Cd 56	10/30/2007	1135	--	412	--	0.61	0.47	0.12	0.52	0.12	0.01	0.00	0.15
DO Cd 56	06/11/2008	0815	--	--	0.39	0.28	0.22	0.13	0.57	0.13	0.01	0.00	0.20
DO Cd 57	10/31/2007	1240	0.39	287	--	3.55	2.75	<.04	--	--	0.01	0.00	--
DO Cd 58	10/30/2007	1515	1.16	853	--	4.57	3.55	<.04	--	--	E.006	E.00197	--
DO Cd 59	10/30/2007	1445	0.54	397	--	0.93	0.72	<.04	--	--	--	<.002	--
DO Cd 59	06/10/2008	1520	--	--	0.37	0.37	0.29	0.04	E.186	E.043	E.003	E.001	0.11
DO Cd 60	10/31/2007	1158	0.37	269	--	2.66	2.07	<.04	--	--	0.01	0.00	--
DO Cd 61	10/31/2007	1110	--	542	--	0.31	0.24	0.04	E.176	E.041	E.004	E.00122	0.13
DO Cd 61	10/31/2007	1115	--	575	--	--	0.28	E.03	--	--	--	E.002	--
DO Cd 61	06/10/2008	1100	--	--	0.43	0.41	0.32	<.04	--	--	--	<.002	--
DO Cd 62	10/31/2007	1029	0.92	679	--	3.07	2.38	<.04	--	--	0.01	0.00	--
DO Cd 63	10/31/2007	1225	1.04	764	--	7.99	6.20	<.04	--	--	E.004	E.00128	--
DO Cd 63	06/10/2008	1030	E1.1	--	6.85	8.08	6.27	<.04	--	--	E.005	E.002	--
DO Cd 63	06/10/2008	1045	--	--	6.90	--	6.36	<.04	--	--	--	E.002	--
DO Cd 64	06/11/2008	1555	E.22	--	0.30	0.19	0.15	<.04	--	--	E.006	E.002	--
DO Cd 66	06/11/2008	1500	E.97	--	0.65	0.62	0.48	<.04	--	--	E.003	E.001	--
DO Cd 68	06/11/2008	1050	--	--	0.21	0.16	0.12	0.11	E.488	E.112	E.006	E.002	0.10
DO Dd 12	10/31/2007	0915	0.92	678	--	3.20	2.48	<.04	--	--	E.005	E.00148	--
DO Dd 12	06/09/2008	1345	E.74	--	3.09	3.22	2.50	<.04	--	--	E.004	E.001	--
DO Dd 13	06/09/2008	1610	0.21	--	1.06	0.21	0.16	0.14	--	--	--	<.002	0.33

Appendix 1. Concentrations of inorganic constituents in groundwater samples, Little Blackwater River watershed, Dorchester County, Maryland.—Continued

[ft, feet; gal/min, gallons per minute; FNU, formazin nephelometric units; mg/L, milligrams per liter, °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 °C; %, percent; µg/L, micrograms per liter; $CaCO_3$, calcium carbonate; SiO_2, silica; N, nitrogen; NH_4, ammonia; NO_2, nitrite; NO_3, nitrate; P, phosphorus; <, less than; E, estimated; M, present but not quantified; U, deleted value by lab; --, data not available; USGS, U.S. Geological Survey; shaded couplets indicate duplicate samples; NWQL, National Water Quality Laboratory]

USGS well name	Date	Time	Organic nitrogen, total (mg/L)	Total nitrogen (NO_2+NO_3+NH_4+N), dissolved, analytically determined (mg/L)	Total nitrogen, total (mg/L)	Ortho-phosphate, dissolved (mg/L)	Ortho-phosphate, dissolved (mg/L as P)	Phospho-rus, total (mg/L as P)	Hydrogen ion, total, calculated (mg/L)	Organic carbon, total (mg/L)	Hydrogen sulfide, total (mg/L)	Iron, dissolved (µg/L)	Man-ganese, dissolved (µg/L)	Cation/ anion balance (% differ-ence)
DO Cd 56	10/30/2007	1135	--	0.75	--	0.03	0.01	--	0.06	--	--	2,496	404	-6.5
DO Cd 56	06/11/2008	0815	0.18	0.55	0.52	0.04	0.01	0.01	0.09	3.4	--	2,900	233	-6.7
DO Cd 57	10/31/2007	1240	--	3.18	--	2.95	0.96	--	0.00	--	--	7,477	729	-1.5
DO Cd 58	10/30/2007	1515	--	3.93	--	0.43	0.14	--	0	--	--	5,081	122	-0.7
DO Cd 59	10/30/2007	1445	--	0.95	--	0.04	0.01	--	0.01	--	--	18,690	954	-2
DO Cd 59	06/10/2008	1520	0.08	0.44	0.42	0.05	0.02	E.0071	0.07	2.0	U	5,100	569	-6.9
DO Cd 60	10/31/2007	1158	--	2.32	--	0.33	0.11	--	0.00	--	--	18,190	772	1.4
DO Cd 61	10/31/2007	1110	--	0.41	--	0.02	0.01	--	0.10	--	--	2,217	416	-3.9
DO Cd 61	10/31/2007	1115	--	0.47	--	--	0.01	--	--	--	--	2,550	454	-5.3
DO Cd 61	06/10/2008	1100	0.12	0.45	--	0.04	0.01	E.0057	0.15	2.3	U	4,870	511	-3.7
DO Cd 62	10/31/2007	1029	--	2.80	--	0.41	0.13	--	0.00	--	--	6,660	606	0.5
DO Cd 63	10/31/2007	1225	--	6.53	--	5.87	1.91	--	0	--	--	2,617	379	-0.2
DO Cd 63	06/10/2008	1030	0.57	6.89	--	5.72	1.87	1.98	0.00	8.3	M	4,990	546	-0.7
DO Cd 63	06/10/2008	1045	--	--	--	--	2.20	2.14	--	9.8	M	5,090	577	-0.7
DO Cd 64	06/11/2008	1555	0.15	0.26	--	0.03	0.01	0.02	0.01	2.5	--	4,240	223	-0.5
DO Cd 66	06/11/2008	1500	0.17	0.66	--	0.18	0.06	0.06	0.00	7.1	--	2,680	18.5	-0.8
DO Cd 68	06/11/2008	1050	0.09	0.34	0.32	0.02	0.01	<.008	0.06	1.1	--	5,860	890	-5.9
DO Dd 12	10/31/2007	0915	--	2.88	--	0.60	0.19	--	.000	--	--	3,160	49.6	-0.1
DO Dd 12	06/09/2008	1345	0.59	3.05	--	2.05	0.67	--	0.00	10.2	--	4,020	62.6	-0.3
DO Dd 13	06/09/2008	1610	0.90	0.64	1.20	0.14	0.05	0.31	0.01	14.4	M	4,290	27.7	3.8

Appendix 2. Concentrations of inorganic constituents in surface-water samples, Little Blackwater River watershed, Dorchester County, Maryland.

[ft, feet; ft^3/s, cubic feet per second; mg/L, milligrams per liter, °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 °C; %, percent; µg/L, micrograms per liter; mi^2, square miles; mm Hg, millimeters mercury; --, data not available; $CaCO_3$, calcium carbonate; SiO_2, silicate; N, nitrogen; NH_4, ammonia; NO_2, nitrite; NO_3, nitrate; P, phosphorus; <, less than; E, estimated; USGS, U.S. Geological Survey; dark shaded couplets indicate duplicate samples; H, high; L, low; R, rising; F, falling; ND, no data]

USGS station number	Date	Time	Tidal cycle	Altitude of land surface (ft)	Gage height (ft)	Discharge (ft^3/s)	Drainage area (mi^2)	Barometric pressure (mm Hg)	Carbon dioxide, dissolved (mg/L)	Dissolved oxygen (mg/L)	Dissolved oxygen (% saturation)	pH, field	pH, lab	Specific conductance, lab (µS/cm)	Specific conductance, field (µS/cm)
Little Blackwater River at Stone Boundary Rd. near Cambridge, Md.															
01490108	12/06/2006	1400	H	12	--	--	3.7	770	12.9	9.5	75	6.6	6.7	192	186
01490108	03/13/2007	0900	L	12	--	1.36	3.7	768	29.9	11	--	6.5	7.1	313	--
01490108	04/16/2007	0915	H	12	--	177	3.7	741	10.1	9.3	79	6.3	6.3	57	53
01490108	07/10/2007	1045	L	12	--	0.321	3.7	762	30.1	0.7	9	6.5	7.2	316	330
01490108	10/29/2007	1300	L	12	--	0.6	3.7	769	7.7	4.7	46	6.9	7.0	171	171
01490108	06/10/2008	0910	R	12	--	--	3.7	759	26.8	0.9	12	6.4	7.1	164	169
Little Blackwater tributary at Stone Boundary Rd. near Cambridge, Md.															
01490110	12/06/2006	1300	H	14	--	0.108	0.2	770	40.5	9.3	75	6.5	6.9	320	309
01490110	12/06/2006	1305	H	14	--	--	--	--	--	--	--	--	7.3	320	--
01490110	03/13/2007	1000	L	14	--	0.08	0.2	768	13.5	12.7	--	6.8	7.1	295	--
01490110	04/16/2007	1030	H	14	--	12.4	0.2	741	7.4	9.1	79	6.6	7.1	78	76
01490110	10/29/2007	1330	L	14	--	0.076	0.2	769	11.2	6.8	65	6.5	6.9	129	130
01490110	06/10/2008	0710	L	14	--		0.2	759	55.0	1.8	22	6.5	7.0	352	353
Little Blackwater River at Maple Dam Rd. near Cambridge, Md.															
01490111	06/10/2008	0815	L	7	--	--	--	--	45.6	0.3	--	6.1	7.0	124	128
Little Blackwater River near Christs Rock, Md.															
01490112	03/16/2006	1215	L	5	--	--	8.3	--	16.7	8.5	--	6.5	7.0	201	202
01490112	06/22/2006	1050	L	5	--	--	8.3	767	--	1.4	17	6.1	6.9	544	537
01490112	09/13/2006	1030	R	5	--	--	8.3	767	13.8	0.9	10	6.7	7.1	173	169
01490112	10/06/2006	1310	R	5	--	--	8.3	--	10.7	7.2	74	6.5	7.1	108	65
01490112	12/06/2006	1045	R	5	--	--	8.3	757	12.0	6.5	53	6.6	7.2	142	142
01490112	03/12/2007	1226	R	5	--	--	8.3	772	7.2	11.6	104	6.7	7.7	133	121
01490112	04/16/2007	1215	F	5	--	--	8.3	741	--	6.6	61	6.3	7.1	134	125
01490112	07/10/2007	0945	L	5	--	--	8.3	762	30.0	2.3	30	6.4	7.1	369	353
01490112	10/29/2007	1015	F	5	--	--	8.3	769	19.6	4.2	38	6.3	6.8	565	553
01490112	06/10/2008	1230	R	5	--	--	8.3	759	52.0	0.2	3	6.1	7.2	137	143

Appendix 2. Concentrations of inorganic constituents in surface-water samples, Little Blackwater River watershed, Dorchester County, Maryland.—Continued

[ft, feet; ft^3/s, cubic feet per second; mg/L, milligrams per liter, °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 °C; %, percent; µg/L, micrograms per liter; mi^2, square miles; mm Hg, millimeters mercury; --, data not available; $CaCO_3$, calcium carbonate; SiO_2, silicate; N, nitrogen; NH_4, ammonia; NO_2, nitrite; NO_3, nitrate; P, phosphorus; <, less than; E, estimated; USGS, U.S. Geological Survey; dark shaded couplets indicate duplicate samples; H, high; L, low; R, rising; F, falling; ND, no data]

USGS station number	Date	Time	Tidal cycle	Altitude of land surface (ft)	Gage height (ft)	Discharge (ft^3/s)	Drainage area (mi^2)	Barometric pressure (mm Hg)	Carbon dioxide, dissolved (mg/L)	Dissolved oxygen (mg/L)	Dissolved oxygen (% saturation)	pH, field	pH, lab	Specific conductance, lab (µS/cm)	Specific conductance, field (µS/cm)
Maple Dam Branch at Rt. 16 at Cambridge, Md.															
01490113	06/22/2006	1615	ND	2.9	--	--	1.5	767	--	2.3	28	6.4	7.7	246	248
01490113	09/13/2006	1300	H	2.9	--	--	1.5	767	10.4	0.98	10	7.0	7.2	218	220
01490113	10/06/2006	1430	R	2.9	--	--	1.5	--	5.0	8.2	83	7.0	7.1	110	100
01490113	12/06/2006	1210	R	2.9	--	--	1.5	770	13.6	8.8	68	6.8	7.2	262	254
01490113	03/13/2007	1030	R	2.9	--	1.26	1.5	768	5.1	--	--	7.1	7.8	319	309
01490113	04/16/2007	1100	H	2.9	--	11.2	1.5	741	7.6	9	78	6.7	7.5	90	91
01490113	07/10/2007	1135	R	2.9	--	0.475	1.5	762	19.6	5.6	72	7.0	7.4	319	335
01490113	10/29/2007	1400	L	2.9	--	--	1.5	769	10.4	6.7	64	6.9	7.3	187	188
01490113	06/10/2008	0740	L	2.9	--	--	1.5	759	26.4	0.6	8	6.6	7.1	203	209
Little Blackwater River tributary near Cambridge, Md.															
01490116	03/16/2006	1250	L	6	--	--	4.2	--	10.4	--	--	6.7	7.0	180	182
01490116	06/22/2006	1110	F	6	--	--	4.2	767	--	1.4	17	6.1	7.1	204	191
01490116	09/13/2006	1000	R	6	--	--	4.2	767	13.2	1.5	17	6.7	7.0	186	180
01490116	10/06/2006	1320	R	6	--	--	4.2	--	11.5	6.8	68	6.6	7.1	151	136
01490116	12/06/2006	1100	R	6	--	--	4.2	757	10.2	7.1	57	6.8	7.1	215	210
01490116	03/12/2007	1242	R	6	--	--	4.2	772	5.3	12.3	108	7.0	7.8	231	209
01490116	04/16/2007	1225	F	6	--	--	4.2	741	9.1	7.9	73	6.6	6.8	81	78
01490116	07/10/2007	0930	L	6	--	--	4.2	762	28.8	2.7	35	6.4	7.5	465	444
01490116	10/29/2007	1000	F	6	--	--	4.2	769	27.5	2.2	20	6.2	6.8	2,030	4,220
01490116	06/10/2008	1245	R	6	--	--	4.2	759	36.1	0.5	7	6.3	7.5	150	167
01490116	06/10/2008	1250	R	6	--	--	--	--	--	--	--	--	7.2	153	--

Appendix 2. Concentrations of inorganic constituents in surface-water samples, Little Blackwater River watershed, Dorchester County, Maryland.—Continued

[ft, feet; ft^3/s, cubic feet per second; mg/L, milligrams per liter, °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 °C; %, percent; µg/L, micrograms per liter; mi^2, square miles; mm Hg, millimeters mercury; --, data not available; $CaCO_3$, calcium carbonate; SiO_2, silicate; N, nitrogen; NH_4, ammonia; NO_2, nitrite; NO_3, nitrate; P, phosphorus; <, less than; E, estimated; USGS, U.S. Geological Survey; dark shaded couplets indicate duplicate samples; H, high; L, low; R, rising; F, falling; ND, no data]

USGS station number	Date	Time	Tidal cycle	Altitude of land surface (ft)	Gage height (ft)	Discharge (ft^3/s)	Drainage area (mi^2)	Barometric pressure (mm Hg)	Carbon dioxide, dissolved (mg/L)	Dissolved oxygen (mg/L)	Dissolved oxygen (% saturation)	pH, field	pH, lab	Specific conductance, lab (µS/cm)	Specific conductance, field (µS/cm)
Little Blackwater River near Cambridge, Md. gaging station															
01490120	03/16/2006	1130	L	-1.25	0.37	--	15.3	--	6.9	9	--	6.8	6.7	297	298
01490120	06/22/2006	1020	F	-1.25	--	--	15.3	767	--	5.7	73	5.8	7.3	2,140	2,160
01490120	09/13/2006	0915	R	-1.25	2.3	--	15.3	767	2.3	6.8	77	7.5	7.2	519	509
01490120	10/06/2006	1245	R	-1.25	--	--	15.3		5.9	8.5	88	7.0	7.1	225	219
01490120	12/06/2006	1000	R	-1.25	1.44	--	15.3	757	7.9	10.5	85	6.9	7.1	226	223
01490120	03/12/2007	1204	R	-1.25	0.71	-7.48	15.3	772	4.5	9.9	87	6.9	7.4	186	171
01490120	04/16/2007	1240	F	-1.25	2.06	--	15.3	741	8.7	8.9	79	6.3	6.7	73	69
01490120	07/10/2007	1230	R	-1.25	--	--	15.3	762	3.5	5.8	80	7.2	7.9	155	1,460
01490120	10/29/2007	1030	F	-1.25	--	--	15.3	769	15.3	6.4	62	6.6	6.9	4,140	4,110
01490120	06/10/2008	1130	R	-1.25	--	--	15.3	759	16.4	3	41	6.6	7.4	169	175
Little Blackwater River near Seward, Md.															
01490130	09/13/2006	0845	R	5	--	--	28.2	767	0.0	8.2	93	9.3	7.3	6,130	6,210
01490130	10/06/2006	1230	R	5	--	--	28.2		0.9	9.8	101	8.1	7.5	2,940	2,940
01490130	12/06/2006	0940	R	5	--	--	28.2	757	4.1	11.3	92	7.2	7.0	736	705
01490130	03/12/2007	1138	R	5	--	--	28.2	773	0.5	7.8	68	7.8	7.4	542	574
01490130	04/16/2007	1300	F	5	--	--	28.2	741	2.4	10	89	7.0	7.2	149	147
01490130	07/10/2007	1510	H	5	--	--	28.2	762	0.0	9.6	138	9.3	8.6	7,020	7,000
01490130	07/10/2007	1515	H	5	--	--	--	--	--	--	--	--	8.9	7,020	--
01490130	10/29/2007	1100	F	5	--	--	28.2	769	2.7	8.9	90	7.7	7.2	E14,900	14,910

Appendix 2. Concentrations of inorganic constituents in surface-water samples, Little Blackwater River watershed, Dorchester County, Maryland.—Continued

[ft, feet; ft^3/s, cubic feet per second; mg/L, milligrams per liter, °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 °C; %, percent; µg/L, micrograms per liter; mi^2, square miles; mm Hg, millimeters mercury; --, data not available; $CaCO_3$, calcium carbonate; SiO_2, silicate; N, nitrogen; NH_4, ammonia; NO_2, nitrite; NO_3, nitrate; P, phosphorus; <, less than; E, estimated; USGS, U.S. Geological Survey; dark shaded couplets indicate duplicate samples; H, high; L, low; R, rising; F, falling; ND, no data]

USGS station number	Date	Time	Tidal cycle	Altitude of land surface (ft)	Gage height (ft)	Discharge (ft^3/s)	Drainage area (mi^2)	Barometric pressure (mm Hg)	Carbon dioxide, dissolved (mg/L)	Dissolved oxygen (mg/L)	Dissolved oxygen (% saturation)	pH, field	pH, lab	Specific conductance, lab (µS/cm)	Specific conductance, field (µS/cm)
Little Blackwater River at Seward, Md. gaging station (at Key Wallace Drive)															
01490140	06/22/2006	0900	F	5	--	--	30.2	767	--	6.1	81	5.2	7.2	E15,300	15,470
01490140	06/22/2006	1520	ND	5	--	--	30.2	767	--	10	145	7.7	8.0	E15,300	15,660
01490140	09/13/2006	1200	R	5	--	--	30.2	767	0.3	8.5	99	8.6	7.3	E12,900	13,000
01490140	10/06/2006	1215	R	5	--	--	30.2	--	3.5	8.3	89	7.5	7.5	5,230	5,225
01490140	12/06/2006	0901	R	5	2.18	18	30.2	757	5.4	11.1	91	7.2	7.7	4,880	4,840
01490140	03/12/2007	1045	R	5	1.52	-195	30.2	772	1.5	11.4	98	7.5	7.3	2,603	2,450
01490140	04/16/2007	1340	F	5	2.68	450	30.2	741	1.9	9.9	88	7.1	7.4	287	215
01490140	07/10/2007	1730	F	5	2.44	356	30.2	762	2.3	6.5	93	7.6	7.8	E12,970	12,900
01490140	10/29/2007	1115	F	5	--	--	30.2	769	--	7.9	82	--	7.4	E17,540	17,500
01490140	06/10/2008	1050	R	5	--	-283	30.2	759	0.3	10	141	8.5	7.6	1,784	1,870

Appendix 2. Concentrations of inorganic constituents in surface-water samples, Little Blackwater River watershed, Dorchester County, Maryland.—Continued

[ft, feet; ft^3/s, cubic feet per second; mg/L, milligrams per liter, °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 °C; %, percent; µg/L, micrograms per liter; mi^2, square miles; mm Hg, millimeters mercury; --, data not available; $CaCO_3$, calcium carbonate; SiO_2, silicate; N, nitrogen; NH_4, ammonia; NO_2, nitrite; NO_3, nitrate; P, phosphorus; <, less than; E, estimated; USGS, U.S. Geological Survey; dark shaded couplets indicate duplicate samples; H, high; L, low; R, rising; F, falling; ND, no data]

USGS station number	Date	Temperature, air (°C)	Temperature, water (°C)	Hardness (mg/L as $CaCO_3$)	Noncarbonate hardness, dissolved, field (mg/L as $CaCO_3$)	Noncarbonate hardness, dissolved, lab (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Potassium, dissolved (mg/L)	Sodium, adsorption ratio	Sodium fraction of cations (% equivalent of major cations)	Sodium, dissolved (mg/L)
Little Blackwater River at Stone Boundary Rd. near Cambridge, Md.												
01490108	12/06/2006	9	5.5	51.5	26.0	25.5	12.5	4.9	3.6	0.83	34.6	13.6
01490108	03/13/2007	13.5	9	74.1	25.7	32.4	18.2	6.9	3.2	1.61	47.0	31.9
01490108	04/16/2007	10	7	16.6	--	6.6	4.4	1.4	2.4	0.34	25.7	3.1
01490108	07/10/2007	--	29	83.7	29.6	--	21.9	7.1	11.2	1.02	32.2	21.4
01490108	10/29/2007	--	15	47.8	16.6	--	12.8	3.9	9.7	0.53	23.2	8.3
01490108	06/10/2008	31.5	28.5	52.6	--	13.9	13.4	4.7	4.5	0.64	28.3	10.6
Little Blackwater tributary at Stone Boundary Rd. near Cambridge, Md.												
01490110	12/06/2006	10	6.5	76.6	14.2	10.3	19.3	6.9	4.5	1.43	43.2	28.7
01490110	12/06/2006	--	--	--	--	--	--	6.9	4.4	--	--	28.9
01490110	03/13/2007	9	7.5	69.5	26.0	23.4	17.0	6.6	3.0	1.54	46.7	29.6
01490110	04/16/2007	9.5	8	20.5	--	6.0	5.3	1.8	2.9	0.47	30.5	4.9
01490110	10/29/2007	14	14	32.3	18.4	--	8.3	2.8	3.9	0.78	37.4	10.2
01490110	06/10/2008	31	24	97.8	--	4.9	25.0	8.6	3.8	1.32	38.9	30.0
Little Blackwater River at Maple Dam Rd. near Cambridge, Md.												
01490111	06/10/2008	--	25.5	36.5	--	4.5	8.9	3.5	7.3	0.44	22.5	6.1
Little Blackwater River near Christs Rock, Md.												
01490112	03/16/2006	12	--	40.8	--	--	8.7	4.6	4.3	1.25	46.2	18.3
01490112	06/22/2006	--	26.5	70.0	--	--	13.5	8.8	9.2	3.43	63.7	66.0
01490112	09/13/2006	21	20	37.2	2.7	0.6	8.1	4.1	8.0	0.90	36.7	12.7
01490112	10/06/2006	--	14	19.6	--	2.4	4.4	2.1	7.1	0.79	37.8	8.0
01490112	12/06/2006	8.5	6	35.0	10.4	10.4	7.7	3.8	5.7	0.73	33.8	9.9
01490112	03/12/2007	--	11	33.2	16.0	15.0	7.6	3.4	3.7	0.80	37.6	10.5
01490112	04/16/2007	11	10.5	37.0	--	25.0	8.8	3.6	5.1	0.50	25.8	7.0
01490112	07/10/2007	--	30	55.3	15.1	--	11.7	6.3	8.5	2.54	58.8	43.4
01490112	10/29/2007	--	11	89.3	--	--	19.6	9.8	8.5	3.38	61.4	73.4
01490112	06/10/2008	--	27.5	37.7	--	2.3	8.9	3.8	7.7	0.56	26.5	7.9

Appendix 2. Concentrations of inorganic constituents in surface-water samples, Little Blackwater River watershed, Dorchester County, Maryland.—Continued

[ft, feet; ft^3/s, cubic feet per second; mg/L, milligrams per liter, °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 °C; %, percent; µg/L, micrograms per liter; mi^2, square miles; mm Hg, millimeters mercury; --, data not available; $CaCO_3$, calcium carbonate; SiO_2, silicate; N, nitrogen; NH_4, ammonia; NO_2, nitrite; NO_3, nitrate; P, phosphorus; <, less than; E, estimated; USGS, U.S. Geological Survey; dark shaded couplets indicate duplicate samples; H, high; L, low; R, rising; F, falling; ND, no data]

USGS station number	Date	Temperature, air (°C)	Temperature, water (°C)	Hardness, (mg/L as $CaCO_3$)	Noncarbonate hardness, dissolved, field (mg/L as $CaCO_3$)	Noncarbonate hardness, dissolved, lab (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Potassium, dissolved (mg/L)	Sodium, adsorption ratio	Sodium fraction of cations (% equivalent of major cations)	Sodium, dissolved (mg/L)
Maple Dam Branch at Rt. 16 at Cambridge, Md.												
01490113	06/22/2006	--	26	67.6	--	--	20.8	3.8	5.0	1.04	36.7	19.7
01490113	09/13/2006	21	18.5	60.2	8.5	5.2	18.1	3.7	4.7	0.81	32.0	14.4
01490113	10/06/2006	--	16	34.3	--	8.2	10.1	2.2	6.3	0.28	16.2	3.8
01490113	12/06/2006	8.5	5	70.9	29.9	27.5	19.5	5.4	3.3	1.03	36.6	20.0
01490113	03/13/2007	9	8.5	77.0	43.4	44.1	19.9	6.6	2.7	1.37	42.7	27.6
01490113	04/16/2007	10.5	8	31.1	--	12.0	9.1	2.0	2.2	0.35	22.3	4.5
01490113	07/10/2007	--	28	62.4	--	--	18.3	4.0	5.4	2.23	55.9	40.4
01490113	10/29/2007	14	14	49.8	8.8	--	15.0	3.0	5.1	0.84	34.4	13.6
01490113	06/10/2008	32	26.5	60.9	--	7.1	18.2	3.7	4.6	0.73	30.0	13.1
Little Blackwater River tributary near Cambridge, Md.												
01490116	03/16/2006	12		44.3	--	--	10.1	4.7	4.7	0.92	37.9	14.1
01490116	06/22/2006	--	24	46.1	--	--	11.0	4.5	6.3	1.06	40.0	16.6
01490116	09/13/2006	20	21	37.1	2.7	0.6	7.8	4.3	8.0	1.02	39.6	14.3
01490116	10/06/2006	--	15	33.6	--	10.2	7.9	3.3	9.1	0.69	30.5	9.1
01490116	12/06/2006	9	6	56.9	24.9	23.8	14.1	5.3	5.0	0.84	33.4	14.6
01490116	03/12/2007	--	10	58.7	34.1	31.8	14.4	5.5	3.7	1.05	38.9	18.5
01490116	04/16/2007	--	10.5	25.4	--	7.5	7.1	1.9	2.4	0.36	24.3	4.2
01490116	07/10/2007	--	29.5	61.5	22.1	--	12.6	7.3	8.0	3.14	63.2	56.7
01490116	10/29/2007	--	10	218.4	--	--	33.9	32.5	16.2	8.71	72.9	295.8
01490116	06/10/2008	--	30	39.5	--	2.1	9.3	3.9	7.8	0.63	28.5	9.0
01490116	06/10/2008	--	--	--	--	--	--	4.0	7.9	--	--	9.1

Appendix 2. Concentrations of inorganic constituents in surface-water samples, Little Blackwater River watershed, Dorchester County, Maryland.—Continued

[ft, feet; ft^3/s, cubic feet per second; mg/L, milligrams per liter, °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 °C; %, percent; µg/L, micrograms per liter; mi^2, square miles; mm Hg, millimeters mercury; --, data not available; $CaCO_3$, calcium carbonate; SiO_2, silicate; N, nitrogen; NH_4, ammonia; NO_2, nitrite; NO_3, nitrate; P, phosphorus; <, less than; E, estimated; USGS, U.S. Geological Survey; dark shaded couplets indicate duplicate samples; H, high; L, low; R, rising; F, falling; ND, no data]

USGS station number	Date	Temperature, air (°C)	Temperature, water (°C)	Hardness (mg/L as $CaCO_3$)	Noncarbonate hardness, dissolved, field (mg/L as $CaCO_3$)	Noncarbonate hardness, dissolved, lab (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L)	Magnesium, dissolved, mg/L	Potassium, dissolved (mg/L)	Sodium, adsorption ratio	Sodium fraction of cations (% equivalent of major cations)	Sodium, dissolved (mg/L)
Little Blackwater River near Cambridge, Md. gaging station												
01490120	03/16/2006	12	11.5	55.9	--	--	11.4	6.7	5.2	1.81	52.0	31.2
01490120	06/22/2006	--	28	204.1	--	--	25.8	33.9	16.6	9.71	75.5	319
01490120	09/13/2006	20	21.5	61.9	27.5	24.3	8.8	9.7	9.9	3.37	64.0	61.0
01490120	10/06/2006	--	17	36.7	--	5.9	7.0	4.7	9.1	1.63	50.4	22.6
01490120	12/06/2006	9	6	46.5	17.0	14.0	9.5	5.5	6.3	1.28	44.4	20.0
01490120	03/12/2007	--	10	39.7	24.1	21.4	8.6	4.4	4.0	1.22	46.2	17.7
01490120	04/16/2007	10.5	9	18.4	--	10.2	4.2	1.9	3.0	0.46	30.5	4.5
01490120	07/10/2007	--	32.5	135.6	115.9	--	18.7	21.6	14.8	8.12	75.4	217
01490120	10/29/2007	12	14	409.5	384.0	--	47.9	70.4	28.9	13.42	75.3	624
01490120	06/10/2008	34	31.5	39.4	--	6.0	8.2	4.6	7.9	0.92	36.7	13.2
Little Blackwater River near Seward, Md.												
01490130	09/13/2006	20	21	586.2	544.4	541.6	43.6	116	41.1	17.46	76.8	971
01490130	10/06/2006	--	17	289.9	--	237.8	23.1	56.4	22.5	10.93	74.5	428
01490130	12/06/2006	8.5	6	84.7	52.7	48.9	8.8	15.2	9.7	4.54	68.3	96.0
01490130	03/12/2007	9	10	67.3	48.4	49.5	8.7	11.1	6.3	3.82	67.5	72.0
01490130	04/16/2007	--	9	29.3	--	15.9	5.3	3.9	4.6	1.19	47.8	14.8
01490130	07/10/2007	--	33.5	689.1	658.7	--	56.8	133	52.3	18.02	75.8	1,087
01490130	07/10/2007	--	--	--	--	--		131	53.0			1,100
01490130	10/29/2007	13	14	1,654.4	1,599.5	--	121.3	328.2	99.6	28.82	76.7	2,694

Appendix 2. Concentrations of inorganic constituents in surface-water samples, Little Blackwater River watershed, Dorchester County, Maryland.—Continued

[ft, feet; ft^3/s, cubic feet per second; mg/L, milligrams per liter, °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 °C; %, percent; µg/L, micrograms per liter; mi^2, square miles; mm Hg, millimeters mercury; --, data not available; $CaCO_3$, calcium carbonate; SiO_2, silicate; N, nitrogen; NH_4, ammonia; NO_2, nitrite; NO_3, nitrate; P, phosphorus; <, less than; E, estimated; USGS, U.S. Geological Survey; dark shaded couplets indicate duplicate samples; H, high; L, low; R, rising; F, falling; ND, no data]

USGS station number	Date	Temperature, air (°C)	Temperature, water (°C)	Hardness (mg/L as $CaCO_3$)	Noncarbonate hardness, dissolved, field (mg/L as $CaCO_3$)	Noncarbonate hardness, dissolved, lab (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L)	Magnesium, dissolved, (mg/L)	Potassium, dissolved (mg/L)	Sodium, adsorption ratio	Sodium fraction of cations (% equivalent of major cations)	Sodium, dissolved (mg/L)
Little Blackwater River at Seward, Md. gaging station (at Key Wallace Drive)												
01490140	06/22/2006	--	28	1,579.5	--	--	111.9	315.7	94.2	26.88	75.9	2,455
01490140	06/22/2006	--	33	1,654.1	--	--	116.7	330.9	98.6	27.81	76.1	2,599
01490140	09/13/2006	21	21	1,321.8	1,269.3	1,264.8	90.7	266.0	82.4	25.04	76.1	2,092
01490140	10/06/2006	--	17	507.3	--	455.4	37.9	100.2	35.0	15.11	75.5	782
01490140	12/06/2006	8.5	5.8	459.9	418.1	416.0	32.1	92.2	32.0	14.69	75.9	724
01490140	03/12/2007	9.5	9	256.0	233.9	229.9	21.6	49.1	17.6	10.83	75.7	398
01490140	04/16/2007	--	9	37.8	--	23.0	5.0	6.2	5.3	2.47	63.0	34.9
01490140	07/10/2007	--	32	1,366.3	1,317.9	--	98.6	272.0	98.7	25.38	75.9	2,156
01490140	10/29/2007	13	14.5	1,905.5	1,842.3	--	135.9	380.3	115.1	31.39	77.0	3,149
01490140	06/10/2008	37	33	160.7	--	112.0	12.8	31.3	18.3	9.35	76.3	272

Appendix 2. Concentrations of inorganic constituents in surface-water samples, Little Blackwater River watershed, Dorchester County, Maryland.—Continued

[ft, feet; ft^3/s, cubic feet per second; mg/L, milligrams per liter, °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 °C; %, percent; µg/L, micrograms per liter; mi^2, square miles; mm Hg, millimeters mercury; --, data not available; $CaCO_3$, calcium carbonate; SiO_2, silicate; N, nitrogen; NH_4, ammonia; NO_2, nitrite; NO_3, nitrate; P, phosphorus; <, less than; E, estimated; USGS, U.S. Geological Survey; dark shaded couplets indicate duplicate samples; H, high; L, low; R, rising; F, falling; ND, no data]

USGS station number	Date	Acid-neutralizing capacity, lab, total (mg/L as $CaCO_3$)	Alkalinity, lab, dissolved (mg/L as $CaCO_3$)	Alkalinity, field, dissolved (mg/L as $CaCO_3$)	Bicarbonate, field, dissolved (mg/L)	Bromide, dissolved (mg/L)	Chloride, dissolved (mg/L)	Fluoride, dissolved (mg/L)	Silica, dissolved, (mg/L as SiO_2)	Sulfate, dissolved (mg/L)	Residue, dissolved, sum of constituents (mg/L)	Residue, total (mg/L)	Ammonia plus organic nitrogen, total (mg/L as N)
Little Blackwater River at Stone Boundary Rd. near Cambridge, Md.													
01490108	12/06/2006	26.5	26.0	25	31	--	21.3	0.18	19.46	22.8	116	<10	1.07
01490108	03/13/2007	48.8	41.7	49	59	--	38.1	0.18	7.70	35.9	172	38	0.84
01490108	04/16/2007	10.4	10.0	--	--	--	4.7	<.10	4.26	5.5	33.5	24	1.19
01490108	07/10/2007	49.1	--	54	66	--	30.1	0.32	2.04	37.8	E167	54	3.11
01490108	10/29/2007	31.5	--	31	38	<.02	11.8	E.110	8.07	26.1	E103	52	1.43
01490108	06/10/2008	34.7	38.6	--	--	--	15.9	0.16	16.2	10.4	E105	42	2.53
Little Blackwater tributary at Stone Boundary Rd. near Cambridge, Md.													
01490110	12/06/2006	66.2	66.2	63	76	--	35.3	0.21	17.0	27.7	179	12	0.93
01490110	12/06/2006	67.0	--	63	77	--	--	0.22	16.9	27.7	--	15	0.94
01490110	03/13/2007	44.1	46.1	43	53	--	35.6	0.15	7.71	34.5	161	32	E1.006
01490110	04/16/2007	15.2	14.5	--	--	--	8.0	E.065	2.95	6.9	E43.0	<20	1.35
01490110	10/29/2007	18.2	--	14	17	E.0149	12.5	E.076	4.79	21.6	E73.2	<20	0.75
01490110	06/10/2008	89.8	92.8	--	--	--	34.2	0.25	17.75	24.1	E204	24	1.77
Little Blackwater River at Maple Dam Rd. near Cambridge, Md.													
01490111	06/10/2008	31.8	32.0	--	--	--	11.2	0.12	8.31	6.0	74.3	26	2.16
Little Blackwater River near Christs Rock, Md.													
01490112	03/16/2006	27.2	--	--	--	--	34.5	0.15	1.16	7.3	96.7	--	--
01490112	06/22/2006	--	--	--	--	--	132	0.18	3.32	6.6	--	--	--
01490112	09/13/2006	35.7	36.6	34	42	--	22.4	0.12	6.67	6.8	92.8	<20	1.67
01490112	10/06/2006	17.5	17.2	--	--	--	15.9	E.084	2.92	3.4	E55.4	<16.7	0.80
01490112	12/06/2006	24.7	24.7	25	30	--	18.3	0.10	12.41	8.2	82.8	<20	1.02
01490112	03/12/2007	18.5	18.2	18	21	--	17.6	0.12	0.65	11.9	66.6	<10	0.99
01490112	04/16/2007	--	12.0	--	--	--	12.9	0.11	4.88	14.6	76.0	118	2.46
01490112	07/10/2007	38.9	--	40	49	--	76.6	0.19	3.16	5.7	E182	36	2.87
01490112	10/29/2007	20.2	--	--	--	0.598	195	E.101	6.58	59.2	E386	<10	0.93
01490112	06/10/2008	33.8	35.4	--	--	--	13.7	0.14	8.41	5.1	81.7	<20	2.09

Appendix 2. Concentrations of inorganic constituents in surface-water samples, Little Blackwater River watershed, Dorchester County, Maryland.—Continued

[ft, feet; ft^3/s, cubic feet per second; mg/L, milligrams per liter, °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 °C; %, percent; µg/L, micrograms per liter; mi^2, square miles; mm Hg, millimeters mercury; --, data not available; $CaCO_3$, calcium carbonate; SiO_2, silicate; N, nitrogen; NH_4, ammonia; NO_2, nitrite; NO_3, nitrate; P, phosphorus; <, less than; E, estimated; USGS, U.S. Geological Survey; dark shaded couplets indicate duplicate samples; H, high; L, low; R, rising; F, falling; ND, no data]

USGS station number	Date	Acid-neutralizing capacity, lab, total (mg/L as $CaCO_3$)	Alkalinity, lab, dissolved (mg/L as $CaCO_3$)	Alkalinity, field, dissolved (mg/L as $CaCO_3$)	Bicarbonate, field, dissolved (mg/L)	Bromide, dissolved (mg/L)	Chloride, dissolved (mg/L)	Fluoride, dissolved (mg/L)	Silica, dissolved (mg/L as SiO_2)	Sulfate, dissolved (mg/L)	Residue, dissolved, sum of constituents (mg/L)	Residue, total (mg/L)	Ammonia plus organic nitrogen, total (mg/L as N)
Maple Dam Branch at Rt. 16 at Cambridge, Md.													
01490113	06/22/2006	--	--	--	--	--	14.6	0.26	2.78	29.4	--	--	--
01490113	09/13/2006	53.5	55.0	52	63	--	13.4	0.16	10.06	26.0	122	30	0.76
01490113	10/06/2006	26.0	26.1	--	--	--	5.3	E.074	4.47	11.7	E62.2	46	1.26
01490113	12/06/2006	44.3	43.4	41	50	--	21.4	0.18	18.79	39.6	155	30	1.07
01490113	03/13/2007	33.4	32.9	34	41	--	37.0	0.19	15.72	58.7	191	12	0.64
01490113	04/16/2007	19.7	19.1	--	--	--	6.1	E.074	4.36	11.5	E52.7	66	0.94
01490113	07/10/2007	101.1	--	93	113	--	16.4	0.33	3.18	29.4	174	158	1.53
01490113	10/29/2007	42.8	--	41	50	0.029	8.3	0.16	4.06	30.1	106	32	0.99
01490113	06/10/2008	54.3	53.8	--	--	--	12.4	0.15	10.59	23.5	E121	46	1.80
Little Blackwater River tributary near Cambridge, Md.													
01490116	03/16/2006	27.0	--	--	--	--	25.9	0.15	0.53	10.9	88.7	--	--
01490116	06/22/2006	--	--	--	--	--	24.0	0.21	5.54	9.9	--	--	--
01490116	09/13/2006	34.1	36.5	34	42	--	25.9	0.12	6.45	6.8	97.1	20	1.85
01490116	10/06/2006	23.7	23.4	--	--	--	22.5	E.077	4.46	6.2	E78.5	<20	0.89
01490116	12/06/2006	33.2	33.1	32	39	--	23.3	0.12	14.91	24.4	E122	<10	0.87
01490116	03/12/2007	27.2	26.9	25	30	--	27.4	0.14	1.89	31.9	E119	<10	0.74
01490116	04/16/2007	18.7	17.9	--	--	--	5.6	E.073	3.55	9.4	E46.3	24	0.96
01490116	07/10/2007	37.3	--	40	48	--	105	0.22	2.39	8.6	E227	20	3.00
01490116	10/29/2007	22.5	--	--	--	1.828	576	0.13	5.83	66.1	E1,043	11	1.27
01490116	06/10/2008	37.2	37.5	--	--	--	15.5	0.17	7.41	6.8	87.2	20	2.05
01490116	06/10/2008	37.0	--	--	--	--	--	0.16	7.50	7.1	--	20	2.00

Appendix 2. Concentrations of inorganic constituents in surface-water samples, Little Blackwater River watershed, Dorchester County, Maryland.—Continued

[ft, feet; ft^3/s, cubic feet per second; mg/L, milligrams per liter, °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 °C; %, percent; µg/L, micrograms per liter; mi^2, square miles; mm Hg, millimeters mercury; --, data not available; $CaCO_3$, calcium carbonate; SiO_2, silicate; N, nitrogen; NH_4, ammonia; NO_2, nitrite; NO_3, nitrate; P, phosphorus; <, less than; E, estimated; USGS, U.S. Geological Survey; dark shaded couplets indicate duplicate samples; H, high; L, low; R, rising; F, falling; ND, no data]

USGS station number	Date	Acid-neutralizing capacity, lab, total (mg/L as $CaCO_3$)	Alkalinity, lab, dissolved (mg/L as $CaCO_3$)	Alkalinity, field, dissolved (mg/L as $CaCO_3$)	Bicarbonate, field, dissolved (mg/L)	Bromide, dissolved (mg/L)	Chloride, dissolved (mg/L)	Fluoride, dissolved (mg/L)	Silica, dissolved (mg/L as SiO_2)	Sulfate, dissolved (mg/L)	Residue, dissolved, sum of constituents (mg/L)	Residue, total (mg/L)	Ammonia plus organic nitrogen, total (mg/L as N)
Little Blackwater River near Cambridge, Md. gaging station													
01490120	03/16/2006	22.4	--	--	--	--	55.6	0.17	0.77	23.0	148	--	--
01490120	06/22/2006	--	--	--	--	--	629	0.21	2.64	36.0	--	--	--
01490120	09/13/2006	37.5	37.6	35	42	--	122	0.13	4.79	12.8	251	22	2.45
01490120	10/06/2006	30.4	30.8	--	--	--	41.1	0.12	4.50	4.4	113	<20	1.61
01490120	12/06/2006	32.6	32.5	30	36	--	36.4	0.13	13.27	9.3	E120	E23.3	1.41
01490120	03/12/2007	18.6	18.3	16	19	--	28.9	0.11	2.91	17.6	94.3	15	1.13
01490120	04/16/2007	9.0	8.2	--	--	--	7.5	E.063	4.86	7.6	E41.1	98	1.36
01490120	07/10/2007	28.4	--	20	24	--	431	0.23	4.05	30.1	E751	62	4.26
01490120	10/29/2007	31.4	--	26	31	4.076	1,256	0.14	3.26	103.4	E2,160	40	2.35
01490120	06/10/2008	33.7	33.4	--	--	--	22.2	0.15	5.92	7.4	E92.9	<20	1.75
Little Blackwater River near Seward, Md.													
01490130	09/13/2006	50.2	44.7	42	51	--	1,837	0.25	3.98	219.5	E3,260	32	3.64
01490130	10/06/2006	55.3	52.1	--	--	--	821	0.15	0.84	83.2	E1,470	82	2.90
01490130	12/06/2006	33.3	35.8	32	39	--	174	0.14	9.88	23.6	358	E36.7	2.65
01490130	03/12/2007	17.4	17.8	19	23	--	131	0.12	1.85	30.9	E273	45	1.47
01490130	04/16/2007	12.2	13.5	--	--	--	23.8	0.10	2.24	13.8	77.8	200	2.70
01490130	07/10/2007	41.5	--	30	37	--	2,101	0.31	5.49	261.5	E3,720	100	5.58
01490130	07/10/2007	42.0	--	--	--	--	--	0.30	5.60	261.0	--	92	2.40
01490130	10/29/2007	71.3	--	55	67	16.395	4,906	0.34	0.26	611.5	E8,810	24	2.74

Appendix 2. Concentrations of inorganic constituents in surface-water samples, Little Blackwater River watershed, Dorchester County, Maryland.—Continued

[ft, feet; ft^3/s, cubic feet per second; mg/L, milligrams per liter, °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 °C; %, percent; µg/L, micrograms per liter; mi^2, square miles; mm Hg, millimeters mercury; --, data not available; $CaCO_3$, calcium carbonate; SiO_2, silicate; N, nitrogen; NH_4, ammonia; NO_2, nitrite; NO_3, nitrate; P, phosphorus; <, less than; E, estimated; USGS, U.S. Geological Survey; dark shaded couplets indicate duplicate samples; H, high; L, low; R, rising; F, falling; ND, no data]

USGS station number	Date	Acid-neutralizing capacity, lab, total (mg/L as $CaCO_3$)	Alkalinity, lab, dissolved (mg/L as $CaCO_3$)	Alkalinity, field, dissolved (mg/L as $CaCO_3$)	Bicarbonate, field, dissolved (mg/L)	Bromide, dissolved (mg/L)	Chloride, dissolved (mg/L)	Fluoride, dissolved (mg/L)	Silica, dissolved (mg/L as SiO_2)	Sulfate, dissolved (mg/L)	Residue, dissolved, sum of constituents (mg/L)	Residue, total (mg/L)	Ammonia plus organic nitrogen, total (mg/L as N)
Little Blackwater River at Seward, Md. gaging station (at Key Wallace Drive)													
01490140	06/22/2006	--	--	--	--	--	4,974	0.37	0.52	680.6	--	--	--
01490140	06/22/2006	--	--	--	--	--	5,058	0.38	0.40	692.0	--	--	--
01490140	09/13/2006	58.5	56.9	53	64	--	4,099	0.35	2.01	514.0	E7,180	26	2.22
01490140	10/06/2006	56.7	51.9	--	--	--	1,522	0.19	1.38	167.5	E2,680	48	2.95
01490140	12/06/2006	44.4	43.9	42	51	--	1,411	0.21	4.35	165.4	E2,490	E46.0	1.93
01490140	03/12/2007	24.5	26.1	23	27	--	750	0.15	1.70	109.2	E1,360	13	1.98
01490140	04/16/2007	12.3	14.9	--	--	--	57.6	E.099	1.99	18.3	E140	330	3.27
01490140	07/10/2007	46.9	--	48.3	59	--	4,094	0.40	1.15	583.6	E7,330	48	2.41
01490140	10/29/2007	72.3	--	63	77	19.525	5,874	0.35	<.20	738.1	E10,500	32	1.87
01490140	06/10/2008	51.1	48.6	--	--		479	0.23	0.63	56.0	E901	62	3.08

Appendix 2. Concentrations of inorganic constituents in surface-water samples, Little Blackwater River watershed, Dorchester County, Maryland.—Continued

[ft, feet; ft^3/s, cubic feet per second; mg/L, milligrams per liter, °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 °C; %, percent; µg/L, micrograms per liter; mi^2, square miles; mm Hg, millimeters mercury; --, data not available; $CaCO_3$, calcium carbonate; SiO_2, silicate; N, nitrogen; NH_4, ammonia; NO_2, nitrite; NO_3, nitrate; P, phosphorus; <, less than; E, estimated; USGS, U.S. Geological Survey; dark shaded couplets indicate duplicate samples; H, high; L, low; R, rising; F, falling; ND, no data]

USGS station number	Date	Ammonia, dissolved (mg/L as NH_4)	Ammonia, dissolved (mg/L as N)	Nitrate plus nitrite, dissolved (mg/L as N)	Nitrate, dissolved (mg/L)	Nitrate, dissolved (mg/L as N)	Nitrite, dissolved (mg/L)	Nitrite, dissolved (mg/L as N)	Organic nitrogen, total (mg/L)	Total nitrogen (NO_2+NO_3+NH_4+N), dissolved, analytically determined (mg/L)	Total nitrogen, total (mg/L)
Little Blackwater River at Stone Boundary Rd. near Cambridge, Md.											
01490108	12/06/2006	0.11	0.083	0.208	0.897	0.203	0.018	0.005	1.053	1.34	1.274
01490108	03/13/2007	0.08	0.061	0.096	0.41	0.093	0.011	0.003	0.823	0.98	0.931
01490108	04/16/2007	0.06	0.048	0.17	0.732	0.165	0.016	0.005	1.057	1.28	1.362
01490108	07/10/2007	1.30	1.009	E.052	E.178	E.040	0.039	0.012	E2.82	3.83	E3.16
01490108	10/29/2007	0.13	0.102	0.361	1.508	0.341	0.067	0.020	1.325	1.79	1.79
01490108	06/10/2008	0.43	0.337	E.029	E.101	E.023	0.02	0.006	E2.06	2.40	E2.56
Little Blackwater tributary at Stone Boundary Rd. near Cambridge, Md.											
01490110	12/06/2006	0.13	0.103	0.281	1.218	0.275	0.019	0.006	0.867	1.25	1.21
01490110	12/06/2006		0.101	0.28		--	--	--	--	1.21	--
01490110	03/13/2007	0.08	0.064	0.089	0.379	0.086	0.011	0.003	0.901	1.05	E1.10
01490110	04/16/2007	0.32	0.247	0.175	0.746	0.168	0.022	0.007	1.112	1.53	1.53
01490110	10/29/2007	E.022	E.017	E.020	E.074	E.017	0.011	0.003	E.803	0.80	E.768
01490110	06/10/2008	0.39	0.301	E.031	E.109	E.025	0.021	0.006	E1.39	1.69	E1.80
Little Blackwater River at Maple Dam Rd. near Cambridge, Md.											
01490111	06/10/2008	0.44	0.338	<.04	--	--	0.011	0.003	1.819	2.08	--
Little Blackwater River near Christs Rock, Md.											
01490112	03/16/2006	--	<.04	<.060	--	--	--	<.008	--	1.40	--
01490112	06/22/2006	0.26	0.198	<.060	--	--	0.034	0.010	--	2.63	--
01490112	09/13/2006	0.21	0.163	<.060	--	--	0.009	0.003	1.505	1.70	--
01490112	10/06/2006	--	<.04	0.072	0.301	0.068	0.013	0.004	--	0.97	0.874
01490112	12/06/2006	0.09	0.069	<.060	--	--	0.014	0.004	0.947	0.96	--
01490112	03/12/2007	--	<.02	<.060	--	--	0.007	0.002	--	1.04	--
01490112	04/16/2007	0.52	0.403	2.371	10.214	2.307	0.209	0.064	2.07	4.84	4.83
01490112	07/10/2007	--	<.02	<.060		--	E.006	E.0018	--	3.06	--
01490112	10/29/2007	0.09	0.072	0.042	0.17	0.038	0.012	0.004	0.882	1.00	0.973
01490112	06/10/2008	0.47	0.365	<.04	--	--	0.015	0.005	1.73	1.98	--

Appendix 2. Concentrations of inorganic constituents in surface-water samples, Little Blackwater River watershed, Dorchester County, Maryland.—Continued

[ft, feet; ft^3/s, cubic feet per second; mg/L, milligrams per liter, °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 °C; %, percent; µg/L, micrograms per liter; mi^2, square miles; mm Hg, millimeters mercury; --, data not available; $CaCO_3$, calcium carbonate; SiO_2, silicate; N, nitrogen; NH_4, ammonia; NO_2, nitrite; NO_3, nitrate; P, phosphorus; <, less than; E, estimated; USGS, U.S. Geological Survey; dark shaded couplets indicate duplicate samples; H, high; L, low; R, rising; F, falling; ND, no data]

USGS station number	Date	Ammonia, dissolved (mg/L as NH_4)	Ammonia, dissolved (mg/L as N)	Nitrate plus nitrite, dissolved (mg/L as N)	Nitrate, dissolved (mg/L)	Nitrate, dissolved (mg/L as N)	Nitrite, dissolved (mg/L)	Nitrite, dissolved (mg/L as N)	Organic nitrogen, total (mg/L)	Total nitrogen (NO2+NO3+NH4+N), dissolved, analytically determined (mg/L)	Total nitrogen, total (mg/L)
Maple Dam Branch at Rt. 16 at Cambridge, Md.											
01490113	06/22/2006	0.05	0.039	<.060	--	--	0.012	0.004	--	3.07	--
01490113	09/13/2006	0.06	0.047	0.06	0.255	0.057	0.008	0.003	1.031	1.14	0.819
01490113	10/06/2006	--	<.04	0.335	1.449	0.327	0.025	0.008	--	1.48	1.59
01490113	12/06/2006	0.04	0.032	0.302	1.307	0.295	0.022	0.007	1.013	1.35	1.372
01490113	03/13/2007	0.03	0.021	0.29	1.265	0.286	0.014	0.004	0.558	0.87	0.933
01490113	04/16/2007	0.03	0.021	0.191	0.826	0.187	0.014	0.004	0.949	1.16	1.14
01490113	07/10/2007	0.10	0.073	<.060	--	--	0.007	0.002	1.454	1.70	--
01490113	10/29/2007	0.15	0.119	0.218	0.921	0.208	0.033	0.010	0.823	1.16	1.2
01490113	06/10/2008	0.46	0.354	E.034	--	--	--	<.006	E1.76	2.12	E1.83
Little Blackwater River tributary near Cambridge, Md.											
01490116	03/16/2006	--	<.04	<.060	--	--	--	<.008	--	1.33	--
01490116	06/22/2006	0.60	0.466	<.060	--	--	0.017	0.005	--	1.61	--
01490116	09/13/2006	0.23	0.178	<.060	--	--	0.009	0.003	1.667	2.02	--
01490116	10/06/2006	--	<.02	E.039	E.161	E.036	0.008	0.003	--	1.05	E.932
01490116	12/06/2006	0.19	0.146	E.040	E.154	E.035	0.017	0.005	E.663	0.81	E.907
01490116	03/12/2007	--	<.02	<.060	--	--	E.004	E.0013	--	0.74	--
01490116	04/16/2007	0.04	0.033	0.151	0.646	0.146	0.017	0.005	0.924	1.11	1.11
01490116	07/10/2007	--	<.02	<.060	--	--	E.006	E.0019	--	2.66	--
01490116	10/29/2007	0.10	0.076	E.035	E.141	E.032	0.01	0.003	E1.254	1.33	E1.30
01490116	06/10/2008	0.41	0.320	<.04	--	--	0.026	0.008	1.73	1.89	--
01490116	06/10/2008	--	0.349	<.04		--	--	0.008	--	2.07	--

Appendix 2. Concentrations of inorganic constituents in surface-water samples, Little Blackwater River watershed, Dorchester County, Maryland.—Continued

[ft, feet; ft^3/s, cubic feet per second; mg/L, milligrams per liter, °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 °C; %, percent; µg/L, micrograms per liter; mi^2, square miles; mm Hg, millimeters mercury; --, data not available; $CaCO_3$, calcium carbonate; SiO_2, silicate; N, nitrogen; NH_4, ammonia; NO_2, nitrite; NO_3, nitrate; P, phosphorus; <, less than; E, estimated; USGS, U.S. Geological Survey; dark shaded couplets indicate duplicate samples; H, high; L, low; R, rising; F, falling; ND, no data]

USGS station number	Date	Ammonia, dissolved (mg/L as NH_4)	Ammonia, dissolved (mg/L as N)	Nitrate plus nitrite, dissolved (mg/L as N)	Nitrate, dissolved (mg/L)	Nitrate, dissolved (mg/L as N)	Nitrite, dissolved (mg/L)	Nitrite, dissolved (mg/L as N)	Organic nitrogen, total (mg/L)	Total nitrogen (NO_2+NO_3+NH_4+N), dissolved, analytically determined mg/L)	Total nitrogen, total (mg/L)
Little Blackwater River near Cambridge, Md. gaging station											
01490120	03/16/2006	--	<.04	<.060	--	--	--	<.008	--	1.88	--
01490120	06/22/2006	0.01	0.010	<.060	--	--	E.005	E.0014	--	4.33	--
01490120	09/13/2006	0.02	0.012	<.060	--	--	0.007	0.002	2.439	2.28	--
01490120	10/06/2006	--	<.04	0.073	0.306	0.069	0.013	0.004	--	1.70	1.68
01490120	12/06/2006	0.34	0.261	E.043	E.161	E.036	0.022	0.007	E1.181	1.44	E1.45
01490120	03/12/2007	0.06	0.047	<.060	--	--	0.011	0.003	1.078	1.34	--
01490120	04/16/2007	0.09	0.068	0.379	1.615	0.365	0.046	0.014	1.574	2.02	1.74
01490120	07/10/2007	0.04	0.031	<.060	--	--	E.006	E.0017	4.228	4.56	--
01490120	10/29/2007	0.11	0.088	E.029	E.113	E.025	0.012	0.004	E2.419	2.51	E2.38
01490120	06/10/2008	E.02	E.013	<.04	--	--	0.01	0.003	E1.75	1.71	--
Little Blackwater River near Seward, Md.											
01490130	09/13/2006	0.03	0.024	<.060	--	--	--	<.002	3.615	3.56	--
01490130	10/06/2006	E.036	E.028	<.060	--	--	E.004	E.0013	E2.901	3.44	--
01490130	12/06/2006	0.70	0.543	0.087	0.321	0.073	0.047	0.014	1.695	2.33	2.74
01490130	03/12/2007	--	<.02	<.060	--	--	E.005	E.0016	--	2.00	--
01490130	04/16/2007	0.23	0.180	0.111	0.456	0.103	0.026	0.008	4.296	4.59	2.81
01490130	10/29/2007	1.00	0.774	E.032	E.106	E.024	0.026	0.008	E2.035	2.81	E2.77

Appendix 2. Concentrations of inorganic constituents in surface-water samples, Little Blackwater River watershed, Dorchester County, Maryland.—Continued

[ft, feet; ft^3/s, cubic feet per second; mg/L, milligrams per liter, °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 °C; %, percent; µg/L, micrograms per liter; mi^2, square miles; mm Hg, millimeters mercury; --, data not available; $CaCO_3$, calcium carbonate; SiO_2, silicate; N, nitrogen; NH_4, ammonia; NO_2, nitrite; NO_3, nitrate; P, phosphorus; <, less than; E, estimated; USGS, U.S. Geological Survey; dark shaded couplets indicate duplicate samples; H, high; L, low; R, rising; F, falling; ND, no data]

USGS station number	Date	Ammonia, dissolved (mg/L as NH_4)	Ammonia, dissolved (mg/L as N)	Nitrate plus nitrite, dissolved (mg/L as N)	Nitrate, dissolved (mg/L)	Nitrate, dissolved (mg/L as N)	Nitrite, dissolved (mg/L)	Nitrite, dissolved, (mg/L as N)	Organic nitrogen, total (mg/L)	Total nitrogen (NO_2+NO_3+NH_4+N), dissolved, analytically determined (mg/L)	Total nitrogen, total (mg/L)
Little Blackwater River at Seward, Md. gaging station (at Key Wallace Drive)											
01490140	06/22/2006	0.03	0.021	<.060	--	--	E.005	E.0014	--	2.06	--
01490140	06/22/2006	0.03	0.022	<.060	--	--	E.004	E.0013	--	2.07	--
01490140	09/13/2006	E.036	E.028	<.060	--	--	--	<.002	E2.217	1.89	--
01490140	10/06/2006	--	<.04	0.065	0.278	0.063	0.007	0.002	--	3.14	3.01
01490140	12/06/2006	0.30	0.231	E.053	E.204	E.046	0.023	0.007	E1.726	1.96	E1.98
01490140	03/12/2007	E.015	E.011	<.060	--	--	E.005	E.0015	E1.975	2.22	--
01490140	04/16/2007	0.32	0.248	0.241	1.011	0.228	0.041	0.013	6.218	6.71	3.51
01490140	07/10/2007	0.08	0.062	<.060	--	--	E.004	E.0014	2.349	2.36	--
01490140	10/29/2007	0.53	0.412	E.024	E.085	E.019	0.016	0.005	E1.726	2.14	E1.89
01490140	06/10/2008	E.020	E.015	<.04	--	--	0.009	0.003	E3.077	3.21	--

Appendix 2. Concentrations of inorganic constituents in surface-water samples, Little Blackwater River watershed, Dorchester County, Maryland.—Continued

[ft, feet; ft^3/s, cubic feet per second; mg/L, milligrams per liter, °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 °C; %, percent; µg/L, micrograms per liter; mi^2, square miles; mm Hg, millimeters mercury; --, data not available; $CaCO_3$, calcium carbonate; SiO_2, silicate; N, nitrogen; NH_4, ammonia; NO_2, nitrite; NO_3, nitrate; P, phosphorus; <, less than; E, estimated; USGS, U.S. Geological Survey; dark shaded couplets indicate duplicate samples; H, high; L, low; R, rising; F, falling; ND, no data]

USGS station number	Date	Orthophosphate, dissolved (mg/L)	Orthophosphate, dissolved (mg/L as P)	Phosphorus, total (mg/L as P)	Hydrogen ion, total, calculated (mg/L)	Organic carbon, dissolved, (mg/L)	Organic carbon, total, (mg/L)	Iron, dissolved (µg/L)	Manganese, dissolved (µg/L)	Cation/anion balance (% difference)
Little Blackwater River at Stone Boundary Rd. near Cambridge, Md.										
01490108	12/06/2006	0.206	0.067	0.274	0	21.3	26.4	1,411	92.3	5.0
01490108	03/13/2007	0.037	0.012	0.219	0	16.6	22.4	383	149.9	2.7
01490108	04/16/2007	0.31	0.101	0.232	0.001	22.0	22.7	543	37.8	8.7
01490108	07/10/2007	0.496	0.162	1.197	0	21.0	28.7	591	361.6	3.4
01490108	10/29/2007	1.13	0.368	0.647	0	12.5	15.4	292	69.5	1.7
01490108	06/10/2008	0.971	0.317	0.865	0	38.4	44.9	4,412	452.3	10.9
Little Blackwater tributary at Stone Boundary Rd. near Cambridge, Md.										
01490110	12/06/2006	0.066	0.021	0.298	0	12.0	16.3	405	77.2	0.8
01490110	12/06/2006	--	0.021	0.295	--	11.9	16.2	370	77.1	0.1
01490110	03/13/2007	0.057	0.019	0.226	0	13.3	17.2	514	145.2	3.4
01490110	04/16/2007	0.257	0.084	0.302	0	14.0	E14.8	312	14.6	2.4
01490110	10/29/2007	0.186	0.061	0.166	0	11.3	9.2	407	10.1	5.3
01490110	06/10/2008	0.705	0.230	0.587	0	22.0	23.7	2,860	586.9	2.1
Little Blackwater River at Maple Dam Rd. near Cambridge, Md.										
01490111	06/10/2008	1.09	0.355	0.972	0.001	28.7	30.3	1,815	374.4	7.5
Little Blackwater River near Christs Rock, Md.										
01490112	03/16/2006	0.478	0.156	0.362	0	--	--	785	80.4	2.2
01490112	06/22/2006	0.662	0.216	0.849	0.001	--	--	394	343.1	7.8
01490112	09/13/2006	1.48	0.482	0.762	0	17.1	22.2	1,474	154.9	3.2
01490112	10/06/2006	0.472	0.154	0.275	0	11.2	15.5	402	33.1	3.6
01490112	12/06/2006	0.571	0.186	0.304	0	22.1	25.0	1,069	26.3	5.0
01490112	03/12/2007	0.187	0.061	0.150	0	18.9	22.4	515	31.8	5.4
01490112	04/16/2007	0.41	0.134	0.599	0.001	17.3	21.4	343	43.9	4.6
01490112	07/10/2007	1.06	0.346	0.856	0	22.8	34.6	797	225.2	2.4
01490112	10/29/2007	0.235	0.077	0.221	0.001	13.9	19.3	713	317.3	-15.4
01490112	06/10/2008	1.62	0.530	0.999	0.00	27.3	34.8	2,340	500.0	7.2

Appendix 2. Concentrations of inorganic constituents in surface-water samples, Little Blackwater River watershed, Dorchester County, Maryland.—Continued

[ft, feet; ft^3/s, cubic feet per second; mg/L, milligrams per liter, °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 °C; %, percent; µg/L, micrograms per liter; mi^2, square miles; mm Hg, millimeters mercury; --, data not available; $CaCO_3$, calcium carbonate; SiO_2, silicate; N, nitrogen; NH_4, ammonia; NO_2, nitrite; NO_3, nitrate; P, phosphorus; <, less than; E, estimated; USGS, U.S. Geological Survey; dark shaded couplets indicate duplicate samples; H, high; L, low; R, rising; F, falling; ND, no data]

USGS station number	Date	Orthophosphate, dissolved (mg/L)	Orthophosphate, dissolved (mg/L as P)	Phosphorus, total (mg/L as P)	Hydrogen ion, total, calculated (mg/L)	Organic carbon, dissolved (mg/L)	Organic carbon, total, (mg/L)	Iron, dissolved (µg/L)	Manganese, dissolved (µg/L)	Cation/anion balance (% difference)
Maple Dam Branch at Rt. 16 at Cambridge, Md.										
01490113	06/22/2006	0.03	0.010	0.480	0	--	--	56	95.5	--
01490113	09/13/2006	0.028	0.009	0.235	0	6.4	8.2	121	259.1	-0.1
01490113	10/06/2006	1.16	0.378	0.544	0	8.9	12.8	97	37.3	3.9
01490113	12/06/2006	0.055	0.018	0.205	0	10.6	13.2	613	203.3	2.6
01490113	03/13/2007	0.03	0.010	0.108	0	7.5	8.8	468	212.3	-2.5
01490113	04/16/2007	0.197	0.064	0.252	0	15.3	E16.4	316	59.0	4.4
01490113	7/10/2007	0.094	0.031	0.465	0	13.3	13.9	64	174.7	3.3
01490113	10/29/2007	0.257	0.084	0.267	0	6.6	7.4	80	147.4	0.7
01490113	06/10/2008	0.33	0.107	0.407	0.00	13.2	15.2	1,480	334.0	1.2
Little Blackwater River tributary near Cambridge, Md.										
01490116	03/16/2006	0.537	0.175	0.362	0	--	--	956	71.4	4.7
01490116	06/22/2006	1.8	0.587	0.881	0.001	--	--	379	274.1	--
01490116	09/13/2006	1.36	0.444	0.830	0	18.1	25.2	1,049	162.8	1.6
01490116	10/06/2006	0.903	0.294	0.450	0	--	--	511	51.0	3.3
01490116	12/06/2006	0.165	0.054	0.224	0	12.1	E15.3	245	55.1	2.6
01490116	03/12/2007	0.094	0.031	0.123	0	12.3	14.0	238	73.9	3.4
01490116	04/16/2007	0.291	0.095	0.261	0	11.9	14.3	218	23.6	2.4
01490116	07/10/2007	1.03	0.336	0.749	0	21.8	32.0	1,070	285	-0.1
01490116	10/29/2007	0.134	0.044	0.354	0.001	13.0	15.3	420	663.0	-1.1
01490116	06/10/2008	2.05	0.668	0.930	0.00	22.8	30.7	1,870	371	4.5
01490116	06/10/2008	--	0.680	0.990	--	23.4	32.2	2,000	353	7.1

Appendix 2. Concentrations of inorganic constituents in surface-water samples, Little Blackwater River watershed, Dorchester County, Maryland.—Continued

[ft, feet; ft^3/s, cubic feet per second; mg/L, milligrams per liter, °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 °C; %, percent; µg/L, micrograms per liter; mi^2, square miles; mm Hg, millimeters mercury; --, data not available; $CaCO_3$, calcium carbonate; SiO_2, silicate; N, nitrogen; NH_4, ammonia; NO_2, nitrite; NO_3, nitrate; P, phosphorus; <, less than; E, estimated; USGS, U.S. Geological Survey; dark shaded couplets indicate duplicate samples; H, high; L, low; R, rising; F, falling; ND, no data]

USGS station number	Date	Orthophosphate, dissolved (mg/L)	Orthophosphate, dissolved (mg/L as P)	Phosphorus, total (mg/L as P)	Hydrogen ion, total, calculated (mg/L)	Organic carbon, dissolved (mg/L)	Organic carbon, total, (mg/L)	Iron, dissolved (µg/L)	Manganese, dissolved (µg/L)	Cation/anion balance (% difference)
Little Blackwater River near Cambridge, Md. gaging station										
01490120	03/16/2006	0.221	0.072	0.351	0	--	--	484	119	2.4
01490120	06/22/2006	0.149	0.049	0.591	0.002	--	--	119	382	-0.3
01490120	09/13/2006	1.14	0.372	0.650	0	15.6	25.0	439	95.3	-2.8
01490120	10/06/2006	0.599	0.195	0.410	0	14.3	25.4	498	79.8	2.5
01490120	12/06/2006	0.814	0.265	0.452	0	20.8	26.3	842	90.1	4.3
01490120	03/12/2007	0.129	0.042	0.185	0	16.1	18.0	455	64.0	5.4
01490120	04/16/2007	0.192	0.062	0.369	0.001	18.7	E25.6	549	43.5	7.8
01490120	07/10/2007	0.526	0.171	0.586	0	23.1	39.5	386	129	-2.5
01490120	10/29/2007	0.095	0.031	0.344	0	16.2	28.5	299	777	-2.7
01490120	06/10/2008	1.62	0.527	0.745	0.00	21.0	29.7	1,480	198	5.5
Little Blackwater River near Seward, Md.										
01490130	09/13/2006	0.028	0.009	0.307	0	16.0	28.1	E21.6	3.4	-2.0
01490130	10/06/2006	0.13	0.042	0.441	0	14.8	28.8	41	3.6	-1.9
01490130	12/06/2006	0.443	0.144	0.372	0	18.1	29.7	380	30.0	0.7
01490130	03/12/2007	0.034	0.011	0.231	0	15.3	21.6	203	27.3	-0.8
01490130	04/16/2007	0.278	0.091	0.717	0	16.8	47.2	271	6.2	4.5
01490130	07/10/2007	0.837	0.273	0.730	0	22.4	35.2	<30	10.9	-2.3
01490130	07/10/2007		0.295	0.720	--	24.4	35.7	<30	11.5	-2.3
01490130	10/29/2007	0.176	0.057	0.194	0	20.0	24.1	<120	322	0.2

Appendix 2. Concentrations of inorganic constituents in surface-water samples, Little Blackwater River watershed, Dorchester County, Maryland.—Continued

[ft, feet; ft^3/s, cubic feet per second; mg/L, milligrams per liter, °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 °C; %, percent; µg/L, micrograms per liter; mi^2, square miles; mm Hg, millimeters mercury; --, data not available; $CaCO_3$, calcium carbonate; SiO_2, silicate; N, nitrogen; NH_4, ammonia; NO_2, nitrite; NO_3, nitrate; P, phosphorus; <, less than; E, estimated; USGS, U.S. Geological Survey; dark shaded couplets indicate duplicate samples; H, high; L, low; R, rising; F, falling; ND, no data]

USGS station number	Date	Orthophosphate, dissolved (mg/L)	Orthophosphate, dissolved (mg/L as P)	Phosphorus, total (mg/L as P)	Hydrogen ion, total, calculated (mg/L)	Organic carbon, dissolved (mg/L)	Organic carbon, total, (mg/L)	Iron, dissolved (µg/L)	Manganese, dissolved (µg/L)	Cation/anion balance (% difference)
Little Blackwater River at Seward, Md. gaging station (at Key Wallace Drive)										
01490140	06/22/2006	E.013	E.004	0.156	0.006	--	--	<60	51.8	-4.7
01490140	06/22/2006	E.010	E.003	0.140	0	--	--	<60	38.8	-2.8
01490140	09/13/2006	E.015	E.005	0.094	0	13.9	21.6	<90	<9.0	-3.2
01490140	10/06/2006	E.012	E.004	0.316	0	13.7	23.9	21	6.8	-2.6
01490140	12/06/2006	0.027	0.009	0.184	0	14.3	E25.8	96	7.0	-3.0
01490140	03/12/2007	E.017	E.005	0.200	0	12.9	23.8	112	36.5	-2.2
01490140	04/16/2007	0.404	0.132	0.848	0	17.3	E66.6	289	9.5	2.0
01490140	07/10/2007	0.037	0.012	0.186	0	15.4	23.9	<60	75.4	-2.0
01490140	10/29/2007	0.038	0.012	0.128	--	14.8	17.7	<120	104	-1.2
01490140	06/10/2008	0.803	0.262	0.587	0	21.1	39.2	299	6.5	-0.4

Appendix 3. Concentrations of inorganic and organic constituents in equipment blanks, Little Blackwater River watershed, Dorchester County, Maryland, 2007–08.

[mg/L, milligrams per liter, °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25°C; %, percent; µg/L, micrograms per liter; <, less than; --, data not available; E, estimated]

Station number	Local identifier	Date	Sample start time	Specific conductance (µS/cm)	2,4,5-T (%)	a-HCH-d6 (%)	Barban (%)	Caffeine-13C (%)	Diazinon-d10 (%)	Residue (mg/L)	Residue, total (mg/L)	Calcium (mg/L)	Magnesium (mg/L)
1490140	Little Blackwater River at Seward, Md.	03/12/2007	1230	6	--	--	--	--	--	--	<10	E.02	<.014
382718076062001	DO Dd 12	06/09/2008	1234	<8	89.1	113	85.3	87.2	123	--	--	0.1	<.020
382718076062002	DO Dd 13	06/09/2008	1500	<8	77.7	105	94.2	81.8	116	--	--	0.08	<.020
383122076055703	DO Cd 58	10/30/2007	1023	4	--	--	--	--	--	<10	--	0.05	<.020

Date	Potassium (mg/L)	Sodium (mg/L)	$CaCO_3$ (mg/L)	Silica (mg/L)	Sulfate (mg/L)	NH_3+orgN (mg/L as N)	Ammonia (mg/L as N)	NO_3+NO_2 (mg/L as N)	Nitrite (mg/L as N)	Ortho-phosphate (mg/L as P)	Phosphorus (mg/L)	Total nitrogen (mg/L)	Total nitrogen (mg/L)
03/12/2007	<.04	<.20	<5	<.2	<.18	0.49	<.020	<.06	<.002	<.006	<.008	--	<.06
06/09/2008	<.02	<.12	E4	<.2	<.18	<.14	<.020	<.04	<.002	<.006	<.008	<.06	--
06/09/2008	E.01	<.12	E4	E.1	<.18	<.14	<.020	<.04	<.002	<.006	<.008	E.03	--
10/30/2007	<.02	<.12	--	<.02	<.18	--	<.020	<.04	<.002	<.006	--	<.06	--

Date	Iron (µg/L)	Manganese (µg/L)	2,4-D methyl ester (µg/L)	CIAT (µg/L)	CEAT (µg/L)	OIET (µg/L)	3-Hydroxy carbofuran (µg/L)	Acetochlor (µg/L)	Acifluorfen (µg/L)	Alachlor (µg/L)	Aldicarb sulfone (µg/L)	Aldicarb sulfoxide (µg/L)	Aldicarb (µg/L)
03/12/2007	<6	<.2	--	--	--	--	--	--	--	--	--	--	--
06/09/2008	<8	<.4	<.040	<.014	<.08	<.040	<.040	<.006	<.040	<.006	<.08	<.060	<.12
06/09/2008	<8	<.4	<.040	<.014	<.08	<.040	<.040	<.006	<.040	<.006	<.08	<.060	<.12
10/30/2007	<8	<.4	--	--	--	--	--	--	--	--	--	--	--

Appendix 3. Concentrations of inorganic and organic constituents in equipment blanks, Little Blackwater River watershed, Dorchester County, Maryland, 2007–08. —Continued

[mg/L, milligrams per liter, °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25°C; %, percent; µg/L, micrograms per liter; <, less than; --, data not available; E, estimated]

Date	alpha-HCH (µg/L)	Atrazine (µg/L)	Azinphos-methyl (µg/L)	Bensulfuron-methyl (µg/L)	Bentazon (µg/L)	Bromacil (µg/L)	Bromoxynil (µg/L)	Butylate (µg/L)	Carbaryl[1] (µg/L)	Carbaryl[2] (µg/L)	Carbofuran (µg/L)	Carbofuran (µg/L)	Chloramben ME (µg/L)
03/12/2007	--	--	--	--	--	--	--	--	--	--	--	--	--
06/09/2008	<.002	<.007	<.120	<.06	<.04	<.02	<.12	<.002	<.04	<.060	<.020	<.020	<.10
06/09/2008	<.002	<.007	<.120	<.06	<.04	<.02	<.12	<.002	<.04	<.060	<.020	<.020	<.10
10/30/2007	--	--	--	--	--	--	--	--	--	--	--	--	--

Date	Chlorimuron-ethyl (µg/L)	Chlorpyrifos (µg/L)	*cis*-Permethrin (µg/L)	Dacthal-monoacid (µg/L)	DCPA (µg/L)	Desulfinylfipronil amide (µg/L)	Desulfinylfipronil (µg/L)	Diazinon (µg/L)	Dicamba (µg/L)	Dichlorprop (µg/L)	Dieldrin (µg/L)	Dinoseb (µg/L)	Diphenamid (µg/L)
03/12/2007	--	--	--	--	--	--	--	--	--	--	--	--	--
06/09/2008	<.080	<.005	<.010	<.02	<.003	<.029	<.012	<.005	<.04	<.02	<.009	<.04	<.04
06/09/2008	<.080	<.005	<.010	<.02	<.003	<.029	<.012	<.005	<.04	<.02	<.009	<.04	<.04
10/30/2007	--	--	--	--	--	--	--	--	--	--	--	--	--

Date	Disulfoton (µg/L)	Diuron (µg/L)	EPTC (µg/L)	Fipronil sulfide (µg/L)	Fipronil sulfone (µg/L)	Fipronil (µg/L)	Flumetsulam (µg/L)	Fluometuron (µg/L)	Fonofos (µg/L)	Imazaquin (µg/L)	Imazethapyr (µg/L)	Imidacloprid (µg/L)	Lindane (µg/L)
03/12/2007	--	--	--	--	--	--	--	--	--	--	--	--	--
06/09/2008	<.04	<.04	<.002	<.013	<.024	<.020	<.06	<.04	<.010	<.04	<.04	<.060	<.006
06/09/2008	<.04	<.04	<.002	<.013	<.024	<.020	<.06	<.04	<.010	<.04	<.04	<.060	<.006
10/30/2007	--	--	--	--	--	--	--	--	--	--	--	--	--

Date	Linuron (µg/L)	Linuron (µg/L)	Malathion (µg/L)	Methiocarb (µg/L)	Methomyl (µg/L)	Methyl parathion (µg/L)	Metolachlor (µg/L)	Metribuzin (µg/L)	Metsulfuron-methyl (µg/L)	Molinate (µg/L)	N(4Chlorophenyl) N'methylurea (µg/L)	Napropamide (µg/L)	Neburon (µg/L)
03/12/2007	--	--	--	--	--	--	--	--	--	--	--	--	--
06/09/2008	<.02	<.060	<.016	<.040	<.120	<.008	<.010	<.012	<.14	<.002	<.12	<.018	<.02
06/09/2008	<.02	<.060	<.016	<.040	<.120	<.008	<.010	<.012	<.14	<.002	<.12	<.018	<.02
10/30/2007	--	--	--	--	--	--	--	--	--	--	--	--	--

Appendix 3. Concentrations of inorganic and organic constituents in equipment blanks, Little Blackwater River watershed, Dorchester County, Maryland, 2007–08. —Continued

[mg/L, milligrams per liter, °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25°C; %, percent; µg/L, micrograms per liter; <, less than; --, data not available; E, estimated]

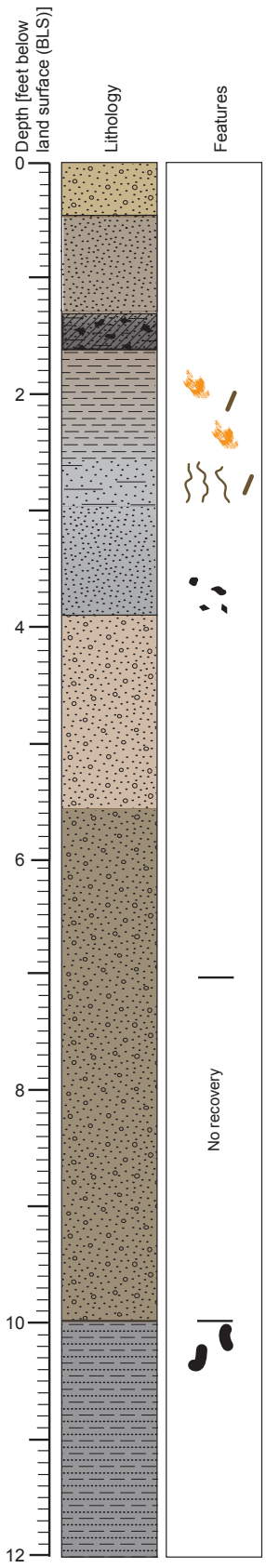
Date	Nicosulfuron (µg/L)	Norflurazon (µg/L)	Oryzalin (µg/L)	Pebulate (µg/L)	Pendimethalin (µg/L)	Phorate (µg/L)	Picloram (µg/L)	Prometon (µg/L)	Propachlor (µg/L)	Propanil (µg/L)	Propargite (µg/L)	Propham (µg/L)	Propiconazole (µg/L)
03/12/2007	--	--	--	--	--	--	--	--	--	--	--	--	--
06/09/2008	<.10	<.02	<.04	<.004	<.012	<.040	<.12	<.01	<.006	<.006	<.04	<.040	<.04
06/09/2008	<.10	<.02	<.04	<.004	<.012	<.040	<.12	<.01	<.006	<.006	<.04	<.040	<.04
10/30/2007	--	--	--	--	--	--	--	--	--	--	--	--	--

Date	Propoxur (µg/L)	Propyzamide (µg/L)	Siduron (µg/L)	Terbacil[1] (µg/L)	Terbacil[2] (µg/L)	Terbufos (µg/L)	Thiobencarb (µg/L)	Triallate (µg/L)	Triclopyr (µg/L)	Trifluralin (µg/L)	Sum 2,4-D + 2,4-D ME (µg/L)	Caffeine (µg/L)	Organic carbon (mg/L)
03/12/2007	--	--	--	--	--	--	--	--	--	--	--	--	0.6
06/09/2008	<.040	<.004	<.02	<.018	<.040	<.02	<.010	<.006	<.08	<.006	<.02	<.060	--
06/09/2008	<.040	<.004	<.02	<.018	<.040	<.02	<.010	<.006	<.08	<.006	<.02	<.060	--
10/30/2007	--	--	--	--	--	--	--	--	--	--	--	--	--

[1] Concentrations from high-performance liquid chromatography (HPLC).

[2] Concentrations from gas chromatography-mass spectrometry (GCMS).

Appendix 4. Lithologic log of DO Dd 12 core, Blackwater National Wildlife Refuge, Dorchester County, Maryland.



Comments

0-0.5 Yellowish brown (10YR 5/4) f-vc subangular-subrounded quartz sand (roadfill)

0.5-1.2 Very dark grayish brown (10YR 3/2) organic-rich silty clay. Small pods of dark gray (10YR 4/2) silt

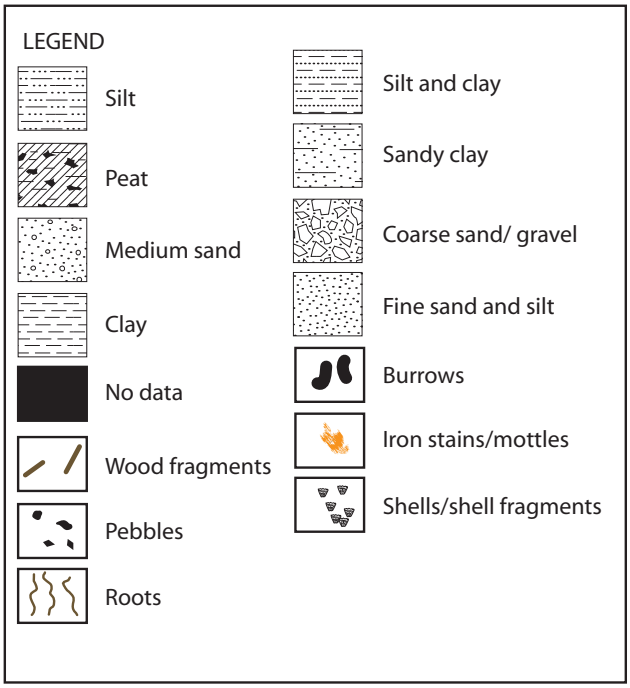
1.2-1.6 Gradual transition to black (10YR 4/2) peaty silt

1.6-2.5 Very dark grayish brown (10YR 4/2) to gray (10YR 5/1) organic-rich clay. Abundant oxidized zones; detrital limonite?

2.5-3.0 Gray (10YR 5/1) sandy (vf) clay. Abundant roots

3.0-3.9 Gray (10YR 5/1) to dark gray (10YR 4/1) silty vf-f sand. Granules common and less silt toward base

3.9-5.5 Light brownish gray (10YR 6/2) open-work f-m angular-subangular quartz sand

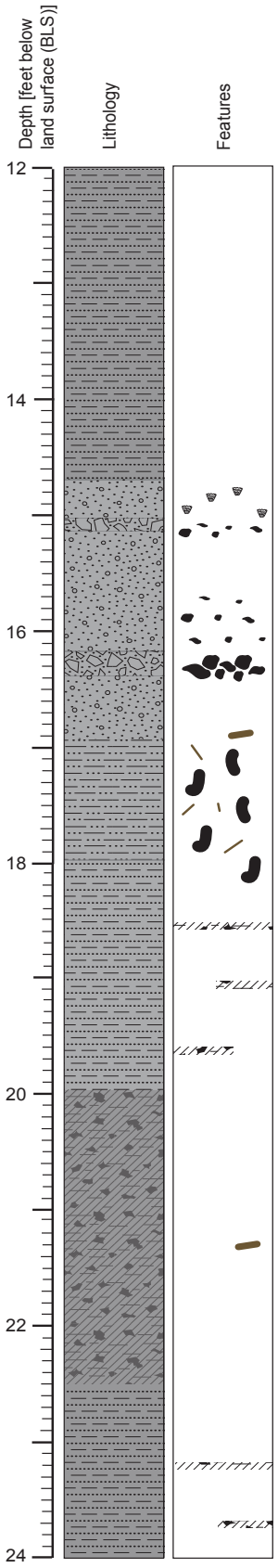


5.5-7.0 Color change to dark brown (10YR 3/3); appears stained by humate. Horizontally bedded and alternates between more brown and more gray colors

9.3-10.0 Pebble gravel in a matrix of dark gray m sand fining upwards to dominantly m sand

10.0-14.7 Very dark gray (10YR 3/1) clayey silt. Large sand-filled burrows in upper ~5 in.

Appendix 4. Lithologic log of DO Dd 12 core, Blackwater National Wildlife Refuge, Dorchester County, Maryland.—Continued



Comments

14.7-15.0 Dark gray (2.5 Y 4/0) clayey silt. Large sand-filled burrows in upper ~.4 in.

15.0-15.2 Small lag of c sand to pea gravel composed of rounded-well rounded quartz and chert with silt between clasts
15.2-16.2 Dark gray (2.5Y 4/0) silty m-vc subangular-well rounded quartz sand and ~7% black chert. Several pea gravel clasts in lower ~.5 in.

16.2-16.4 Gravel lag composed of well-rounded quartz clasts up to 4 cm in diameter
16.4-17.0 Dark gray (2.5Y 4/0) silty m-vc subangular-well rounded quartz sand and ~7% black chert

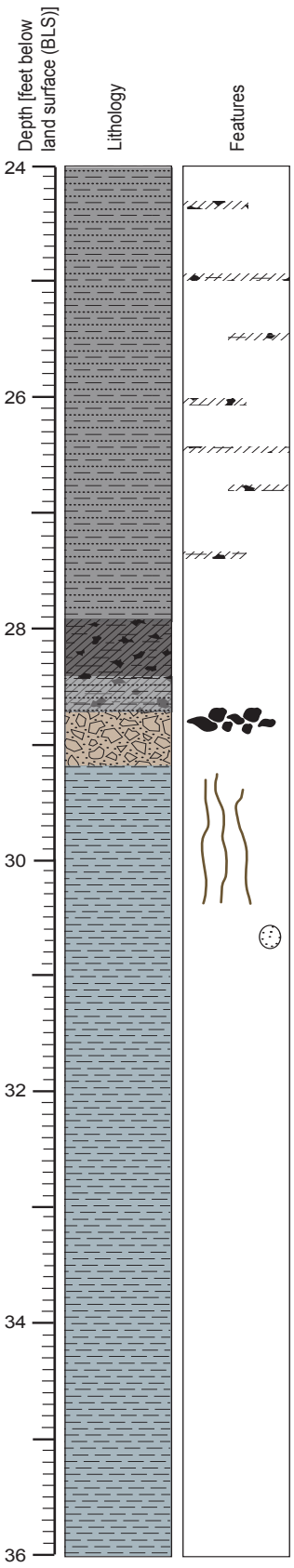
17.0-18.0 Dark gray (2.5Y 4/0) heavily burrowed silt. Burrows filled with sand from above; also abundant macro organic fragments

18.0-20.0 Dark gray (2.5Y 4/0) silty clay with several accumulations of peaty material

20.0-22.6 Very dark gray (10YR 3/1) peaty silty clay (~30% peat)

22.6-24.0 Very dark gray (10YR 3/1) silty clay with ~15% peat

Appendix 4. Lithologic log of DO Dd 12 core, Blackwater National Wildlife Refuge, Dorchester County, Maryland.—Continued



Comments

24.0-24.4 Very dark gray clay with few small shell fragments near base

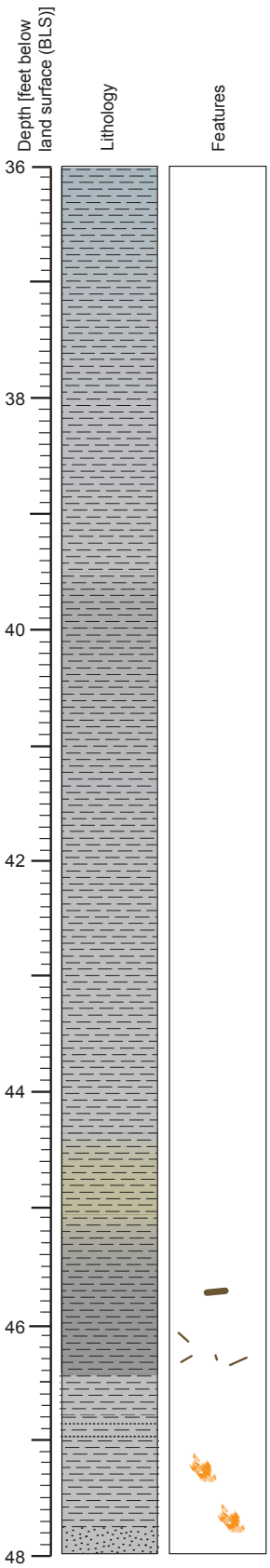
27.9-28.4 Black (10YR 2/1) peat

28.4-28.7 Dark gray (10YR 4/1) peaty silty clay

28.7-29.2 Gravel lag (to 28.9) composed of .4-1.2 in. well-rounded quartz and black chert with a matrix of grayish brown (2.5Y 5/2) silty f-vc subangular-well rounded quartz sand w/ few black chert fragments

29.2-44.3 Gray (5Y 4/1; more blue in upper ~7.0 ft) clay with abundant roots. ~2 in. concretion at 31 ft

Appendix 4. Lithologic log of DO Dd 12 core, Blackwater National Wildlife Refuge, Dorchester County, Maryland.—Continued



Comments

36.1 Color changes to gray (10YR 5/1)

36.1-44.0 Color varies to gray (10YR 5/1; 5Y 5/1) to dark gray (5Y 4/1)

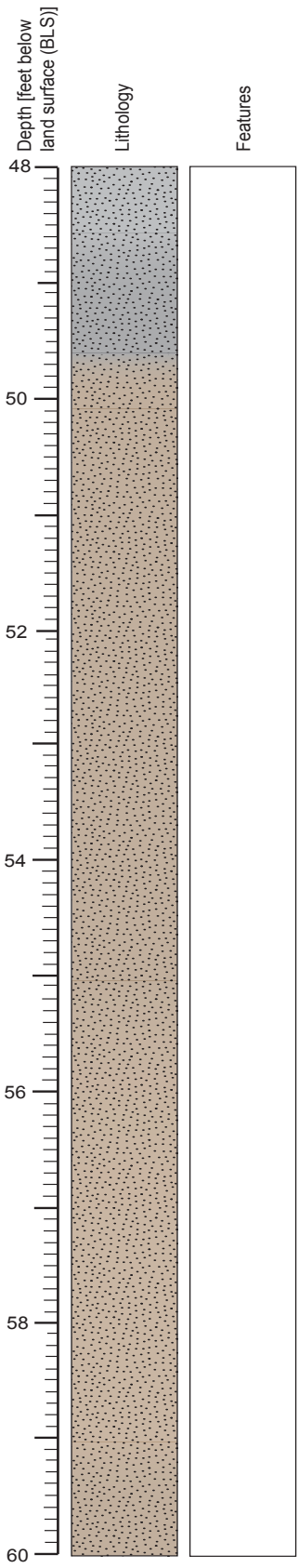
44.3-45.0 Olive gray (5Y 4/2) clay

45.0-46.5 Olive gray (5Y 4/2) clay with abundant organics

46.5-47.8 Gray (5Y 5/1) clay. Silty near the middle of unit, and oxidized in lower ~10 in., possibly in association with small limonite concretions

47.8-49.6 Gray (5Y 5/1) silty f angular-subangular quartz sand with few mica flakes. Color changes to dark gray (5Y 4/1) at 48.5 ft

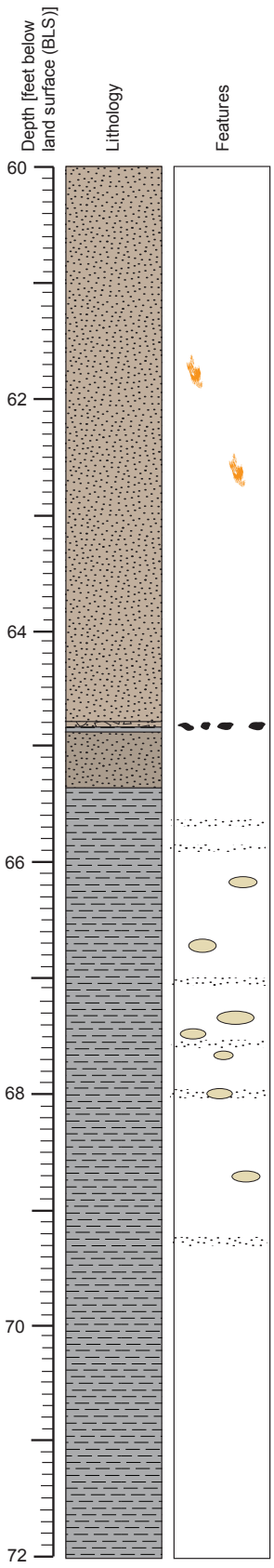
Appendix 4. Lithologic log of DO Dd 12 core, Blackwater National Wildlife Refuge, Dorchester County, Maryland.—Continued



Comments

49.6-64.8 Color changes to dark grayish brown (2.5Y 4/2) and silt disappears

Appendix 4. Lithologic log of DO Dd 12 core, Blackwater National Wildlife Refuge, Dorchester County, Maryland.—Continued

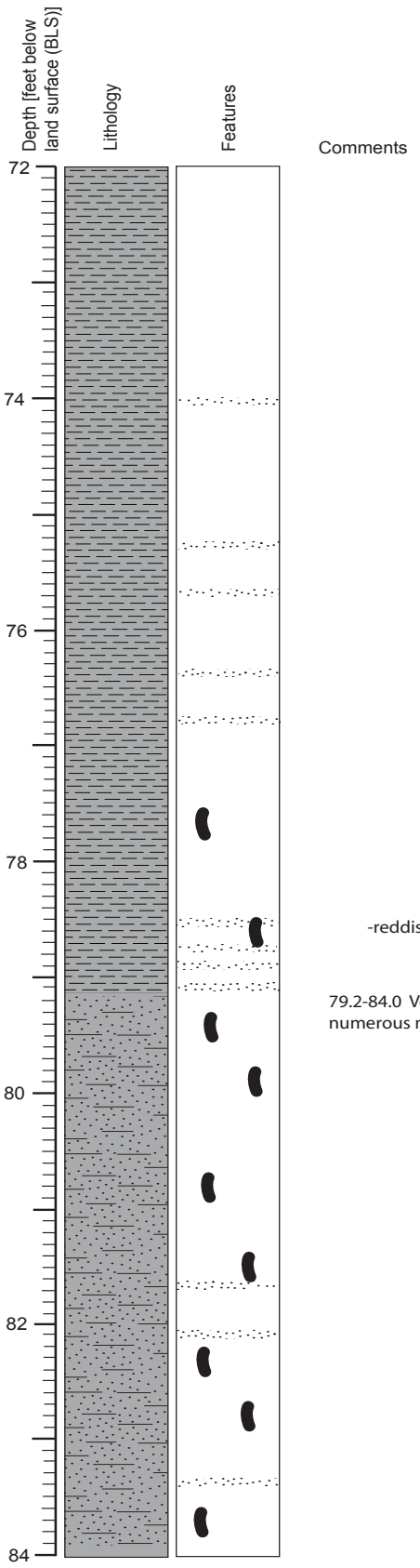


Comments

64.8-64.9 Gravel lag composed of rounded, but chipped, red-stained quartz pebbles, with a .8-in. clay lense directly underlying
64.9-65.4 Dark grayish brown (2.5Y 4/2) micaceous vf-f sand. No opaques

19.93-20.13 Dark gray (5Y 4/1 - 10YR 4/1) clay (alternates between more red and more green hues) with small vf sand lenses composed of above sand. Small light brownish gray (2.5Y 6/2) mud balls present from ~65.5 to 69.0 ft

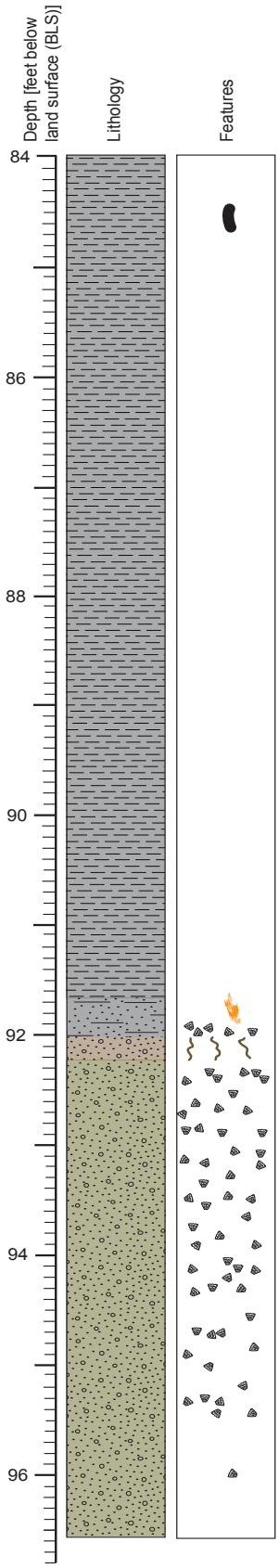
Appendix 4. Lithologic log of DO Dd 12 core, Blackwater National Wildlife Refuge, Dorchester County, Maryland.—Continued



-reddish color fades and disappears here

79.2-84.0 Very dark grayish brown (10YR 3/2) clay with several vf sand stringers and numerous mud balls ("little white balls")

Appendix 4. Lithologic log of DO Dd 12 core, Blackwater National Wildlife Refuge, Dorchester County, Maryland.—Continued



Comments

84.0-91.7 Dark gray (5Y 4/1) clay continues without sand, except that which fills burrows

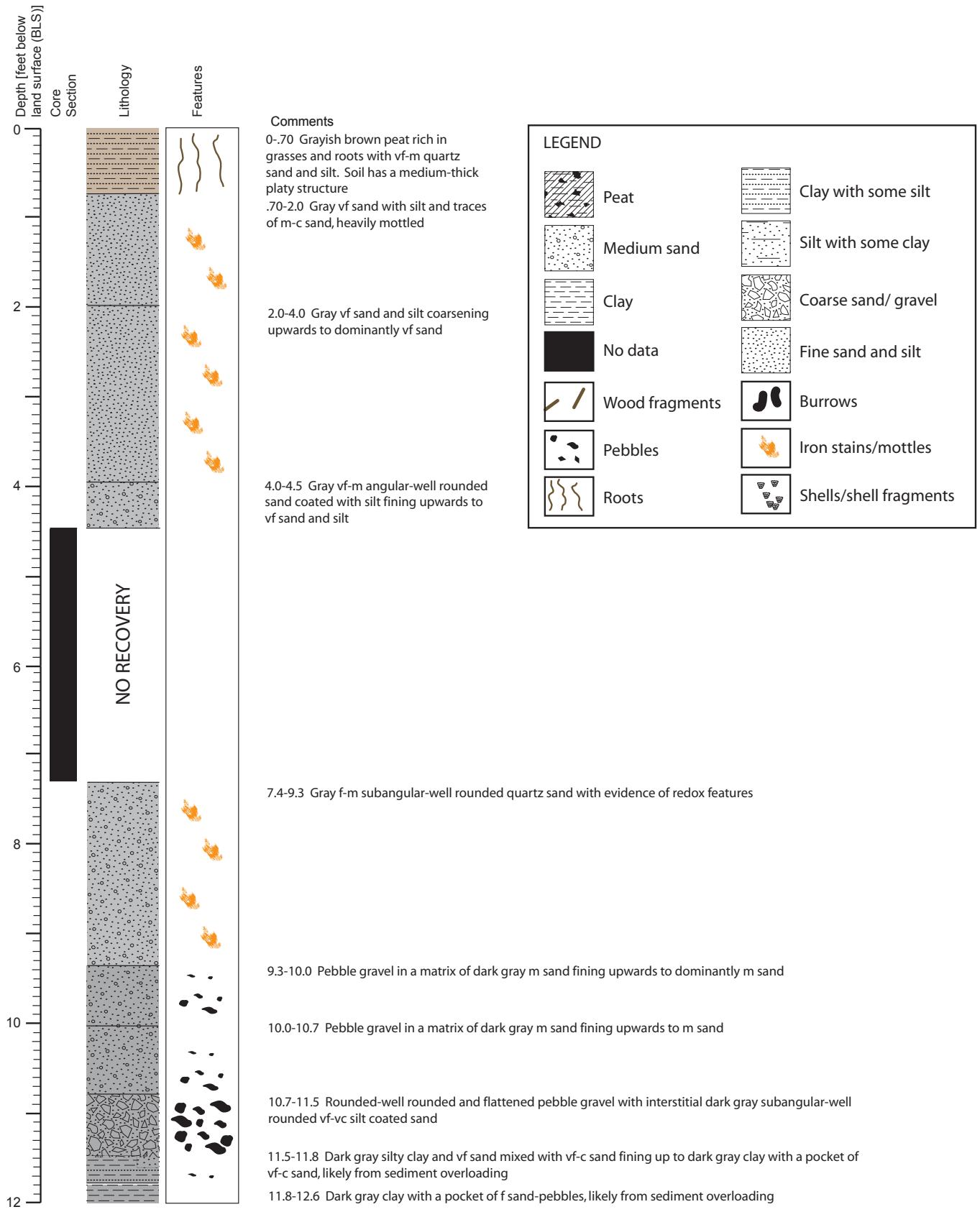
-alternations between red and green reappears

91.7-92.0 Dark gray (5Y 4/1) heavily oxidized sandy clay - clayey vf-f angular-subangular quartz sand with minimal mica; small fragments of pectin shells near base

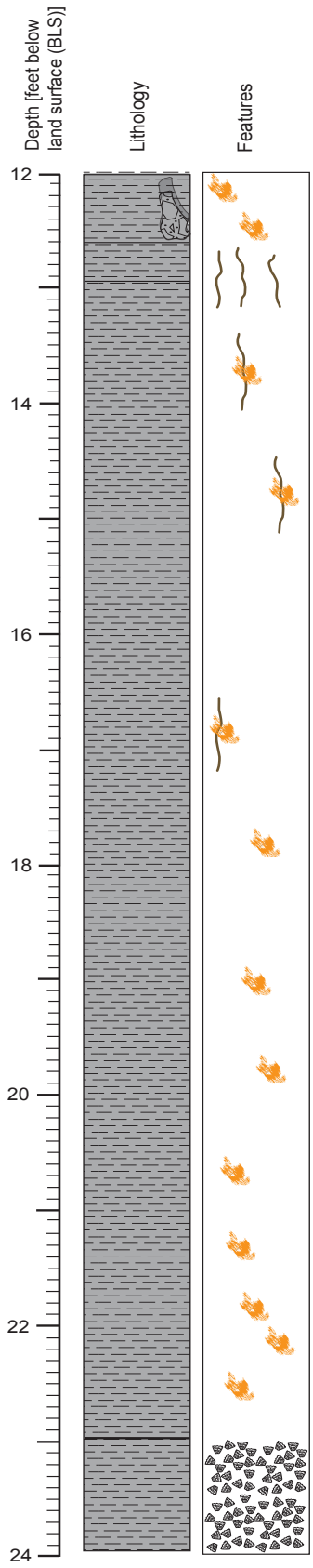
92.0-92.3 Dark grayish brown (2.5Y 4/2) vf-f angular-subangular quartz sand with minimal mica; micro and macro organics

92.3-96.0 Dark olive gray (2.5Y 3/2) vf-m angular-rounded quartz sand with minimal chert grains. Abundant pectin shell fragments down to 95.6 ft; potentially burrowed

Appendix 5. Lithologic log of Maintenence Yard core, Blackwater National Wildlife Refuge, Dorchester County, Maryland.



Appendix 5. Lithologic log of Maintenence Yard core, Blackwater National Wildlife Refuge, Dorchester County, Maryland.—Continued



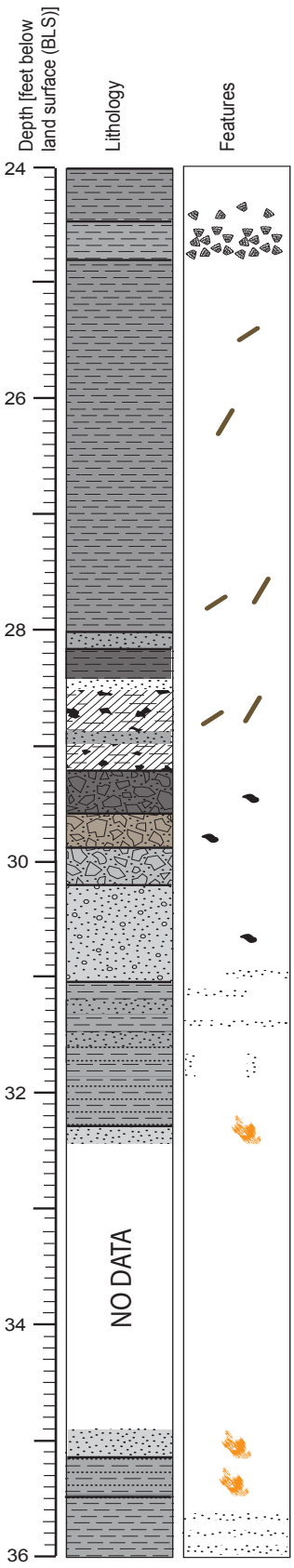
Comments

12.6-12.9 Dark gray clay rich in root fragments;. This layer dries out much more quickly than the underlying clay; sharp boundary between them

12.9-17.7 Dark gray clay with a small amount of organic material and associated redox features. small roots observed in core interior

22.9-23.9 Dark gray clay continues with abundant oyster shell fragments (>60%) with no apparent preferred orientation

Appendix 5. Lithologic log of Maintenence Yard core, Blackwater National Wildlife Refuge, Dorchester County, Maryland.—Continued



Comments

23.9-24.4 Very dark gray clay with few small shell fragments near base

24.4-24.8 Dark gray clay with abundant oyster shell fragments (>60%) with no apparent preferred orientation

24.8-28.1 Very dark gray clay with abundant organic material and charcoal

28.1-28.2 Lense of angular-subangular vf-c sand

28.2-28.4 Black clay coarsening up to sandy peat

28.4-29.2 Black peat with charcoal fragments interrupted by a 1 cm sand lense of dark gray vf-vc subangular-well rounded sand

29.2-30.2 Black vf-vc subangular-rounded sand rich in opaque minerals and likely stained by humate. Small charcoal fragments present. Fine silt binds grains together

* 29.5-29.9 Very dark grayish brown

*29.9-30.2 Light gray-dark gray; sharp basal contact

30.2-31.0 Light gray vf-m angular-subrounded sand with sharp basal contact

31.0-31.2 Dark gray - gray clay with small non-extensive sand laminae

31.2-31.3 Dark gray angular-subrounded vf-f sand
31.3-31.33 Dark gray clay bed with two thin sand lenses
31.33-31.6 Dark gray angular-subrounded vf-f sand
31.6-31.7 Dark gray clay and vf-f sand alternating every 1/2 cm
31.7-31.8 Dark gray clay with small vertical sand inclusions, possibly from burrow infilling
31.8-32.3 Dark gray clay and light gray finely laminated vf-f sand alternating every .2-.8 in.

32.3-32.4 Light gray vf sand and silt; oxidized

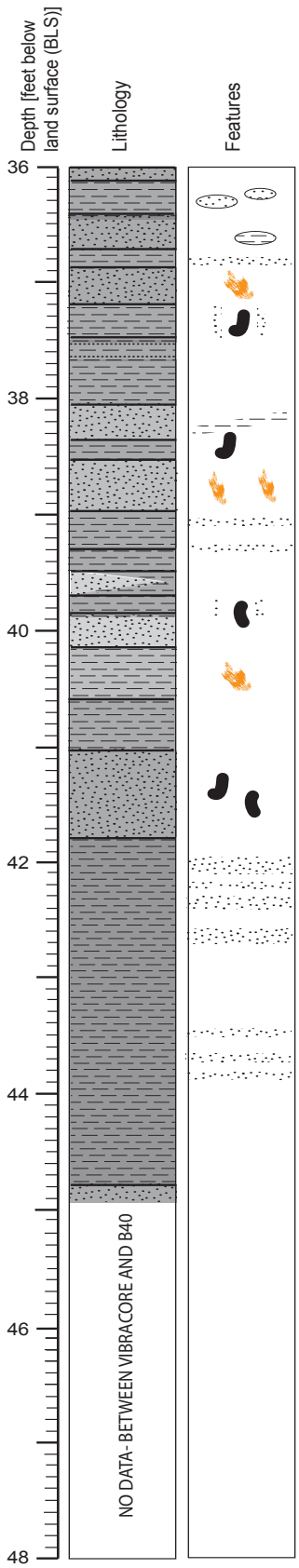
*32.4-34.9 Missing 2.5' of core according to labels on rods

34.9-35.1 Light gray vf sand and silt; oxidized

35.1-35.5 Dark gray clay with finely laminated beds of light gray sand; overall coarsening upward trend. Heavily oxidized disturbed laminae shows evidence of sediment loading

35.5-36.0 Dark gray with very thin (.25-.5 cm) fine sand & silt laminae

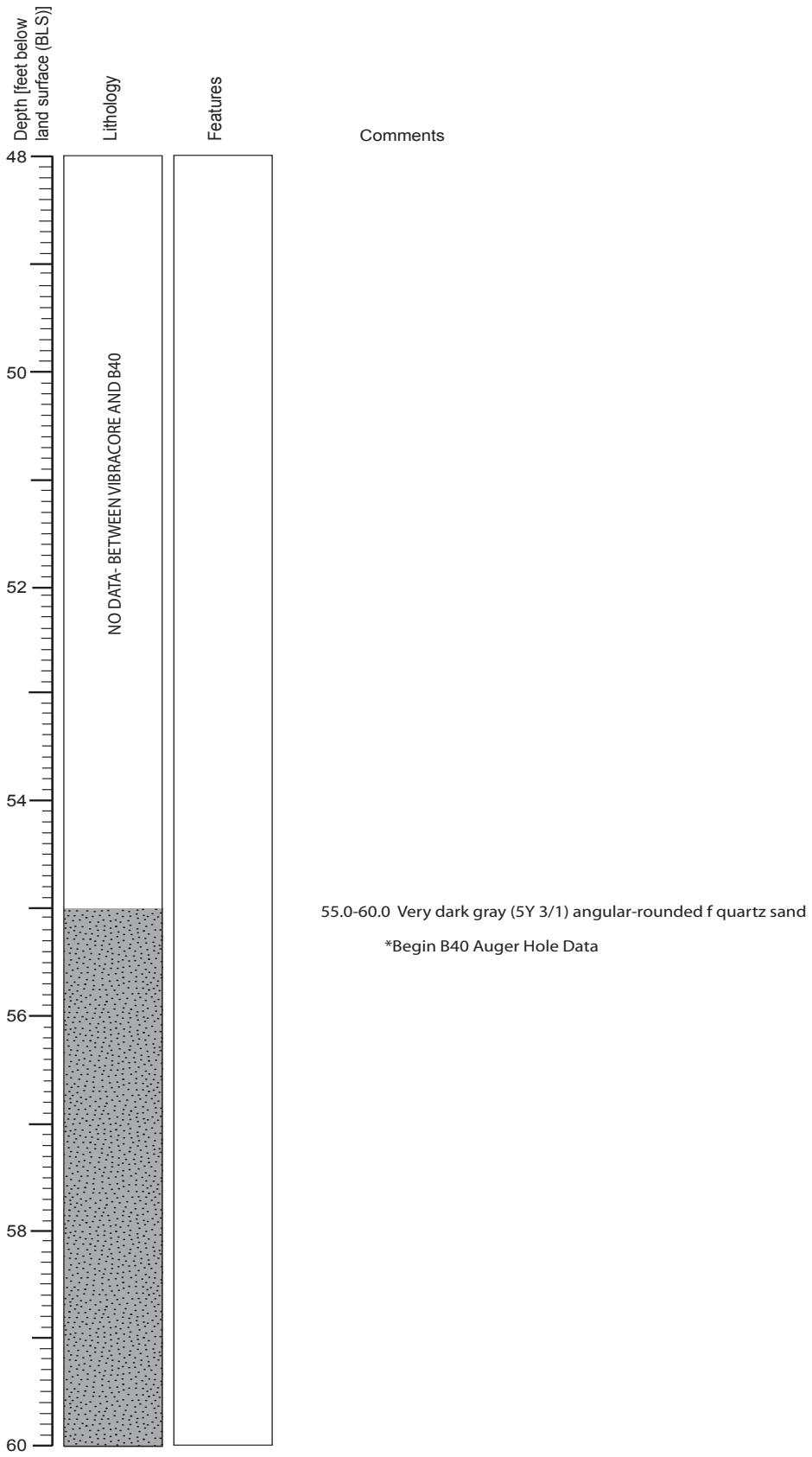
Appendix 5. Lithologic log of Maintenence Yard core, Blackwater National Wildlife Refuge, Dorchester County, Maryland.—Continued



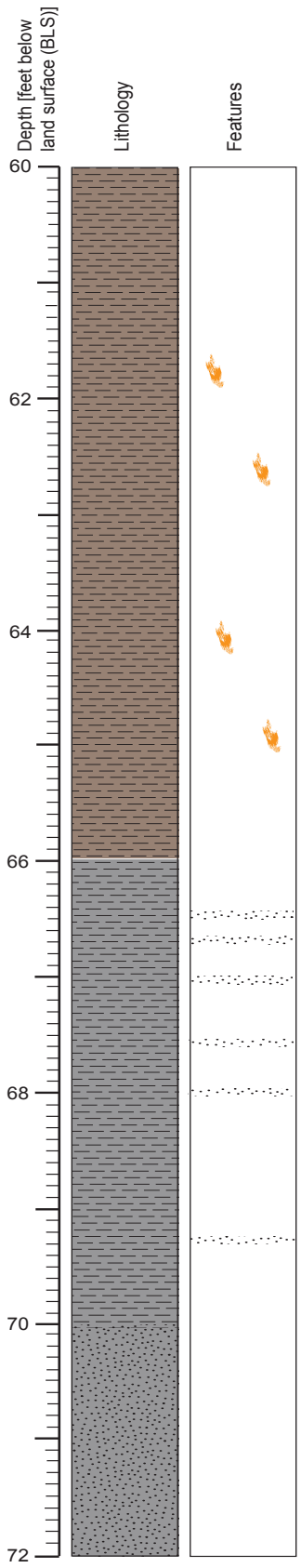
Comments

36.0-36.1 Dark gray fine sand/silt
36.1-36.5 Dark gray clay with non-continuous sand pockets ~.4-.6 in. in diameter. Sharp basal contact
36.5-36.7 Dark gray sand bed with small interstitial clay pockets
36.7-36.9 Dark gray clay with .1-in. thick vf sand beds spaced 1.5 cm apart
36.9-37.2 Dark gray sand bed with coarse mottling (~.4 in.)
37.2-37.5 Dark gray clay with small vertical sand inclusions; likely infilled burrows
37.5-38.0 Discrete packages of dark gray clay alternating with dark gray sand with sharp contacts
38.0-38.4 Gray vf-f sand bed with a 1.5-cm clay horizon diagonally bedded
38.4-38.6 Dark gray clay with small sand pockets; overall fines up. Possible bivalve traces
38.6-39.0 Gray vf-f sand bed with slight fining upward trend and bioturbated (vertical oxidized zones)
39.0-39.3 Dark gray clay interfingering with/coarsening upward to vf-f sand
39.3-39.5 Dark gray clay
39.5-39.7 Discontinuous light gray vf-f sand locally pinching to 0 thickness surrounded by dark gray clay
39.7-39.9 Dark gray clay with vertical sand intrusions (filled burrows?)
39.9-40.1 Light gray vf-f sand
40.1-40.6 Gray clay that oxidizes quickly upon exposure; possible bivalve trace
40.6-41.0 Dark gray clay; massive
41.0-41.8 Dark gray f sand with possible bioturbation (discolored) bound by abrupt contacts
41.8-44.8 Very dark gray clay with repeating flasers of vf-f very dark gray sand
44.8-44.9 Dark gray vf-f sand

Appendix 5. Lithologic log of Maintenence Yard core, Blackwater National Wildlife Refuge, Dorchester County, Maryland.—Continued



Appendix 5. Lithologic log of Maintenence Yard core, Blackwater National Wildlife Refuge, Dorchester County, Maryland.—Continued



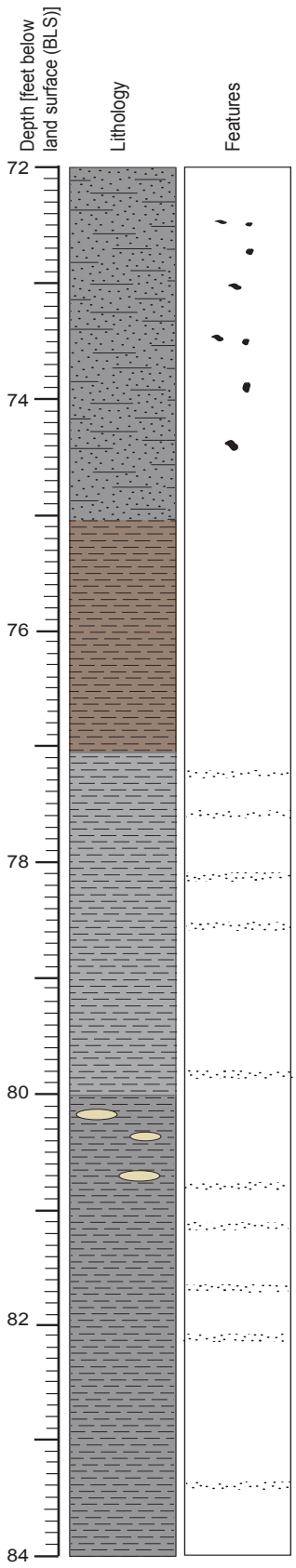
Comments

60.0-66.0 Very dark grayish brown (2.5Y 3/2) clay with vf-f quartz sand stringers (oxidized)

66.0-70.0 Very dark gray (5Y 3/1) clay with vf-f quartz sand stringers

70.0-72.0 Very dark gray (5Y 3/1) silty vf-f sand

Appendix 5. Lithologic log of Maintenence Yard core, Blackwater National Wildlife Refuge, Dorchester County, Maryland.—Continued



Comments

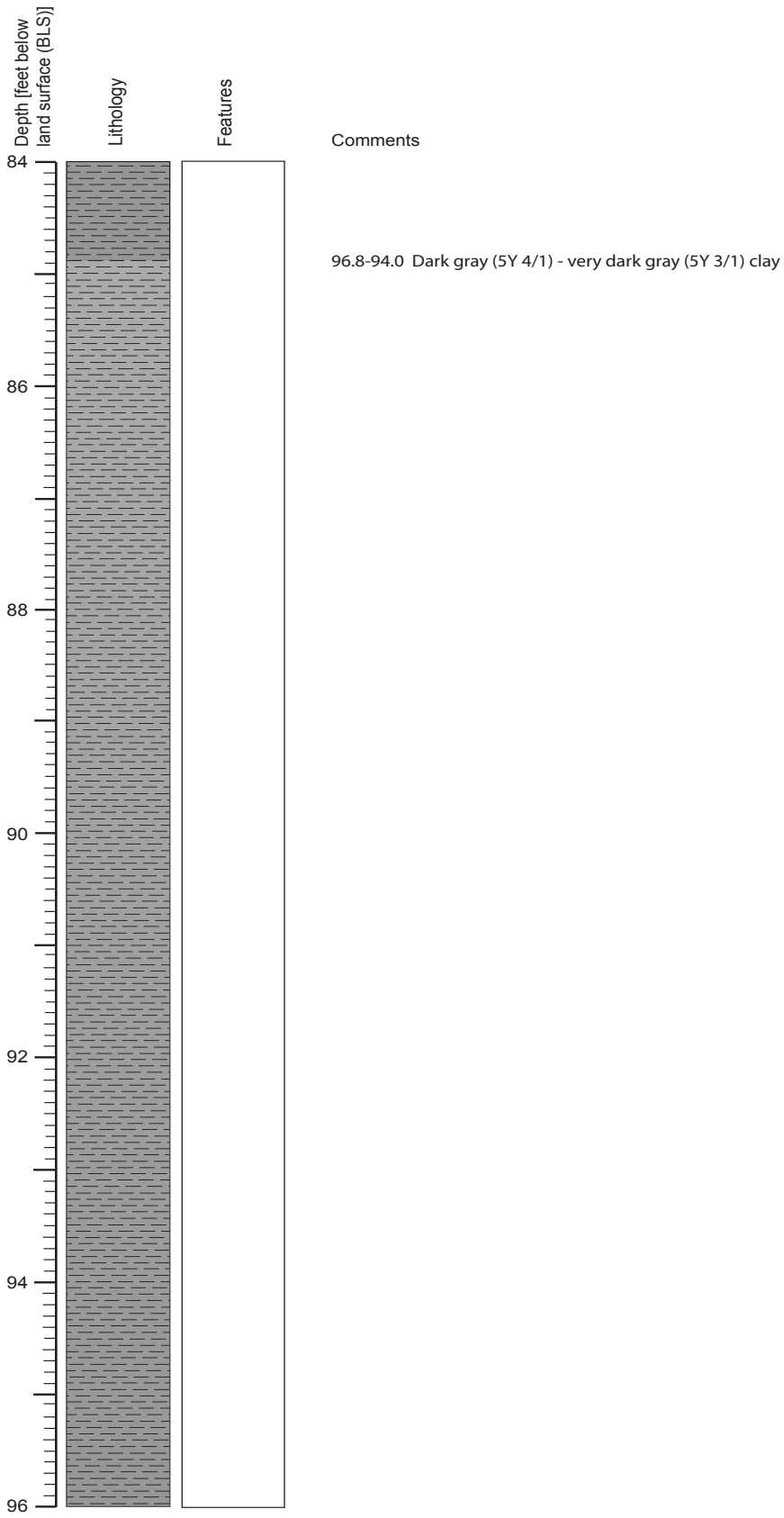
72.0-75.0 Very dark grayish brown (2.5Y 3/2) clay with abundant m-vc sand grains

75.0-77.0 Very dark grayish brown (2.5Y 3/2) clay

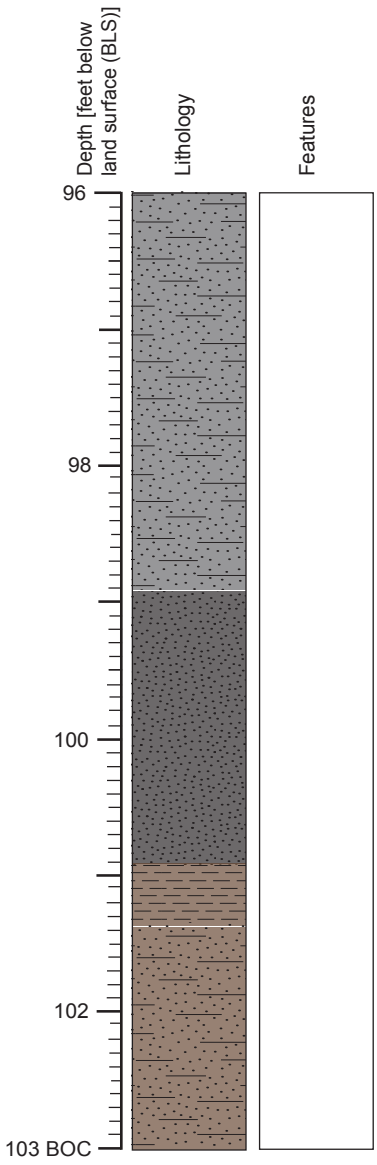
77.0-80.0 Dark gray (10YR 4/1) clay with small sand lenses/stringers

80.0-96.8 Very dark grayish brown (10YR 3/2) clay with several vf sand stringers and numerous mud concretions

Appendix 5. Lithologic log of Maintenence Yard core, Blackwater National Wildlife Refuge, Dorchester County, Maryland.—Continued



Appendix 5. Lithologic log of Maintenence Yard core, Blackwater National Wildlife Refuge, Dorchester County, Maryland.—Continued



Comments

94.0-99.0 Very dark gray (5Y 3/1) well-laminated silty vf sand

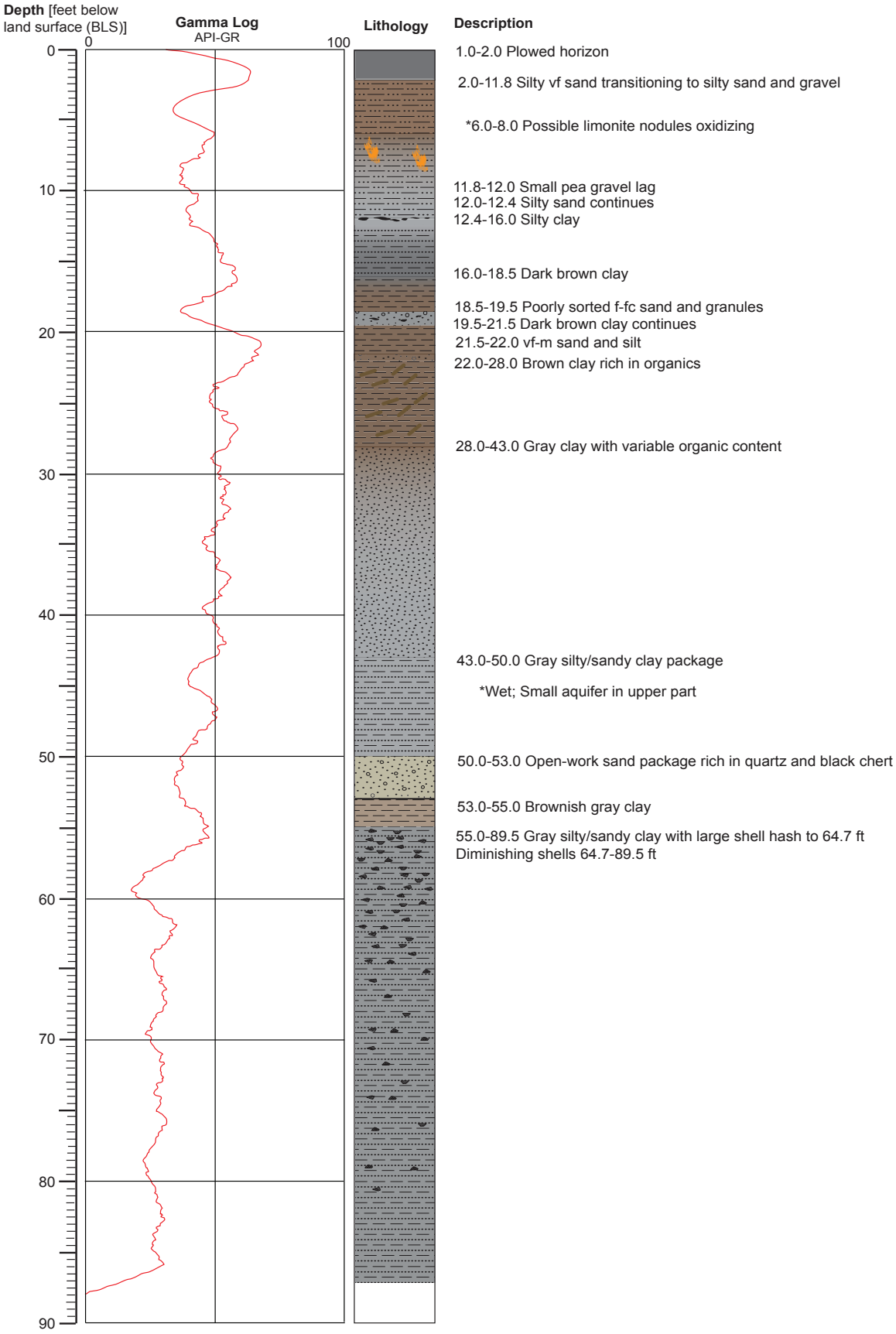
99.0-100.0 Black (5Y 2.5/2) vf sand

100.0-101.5 Very dark grayish brown (2.5Y 3/2) clay

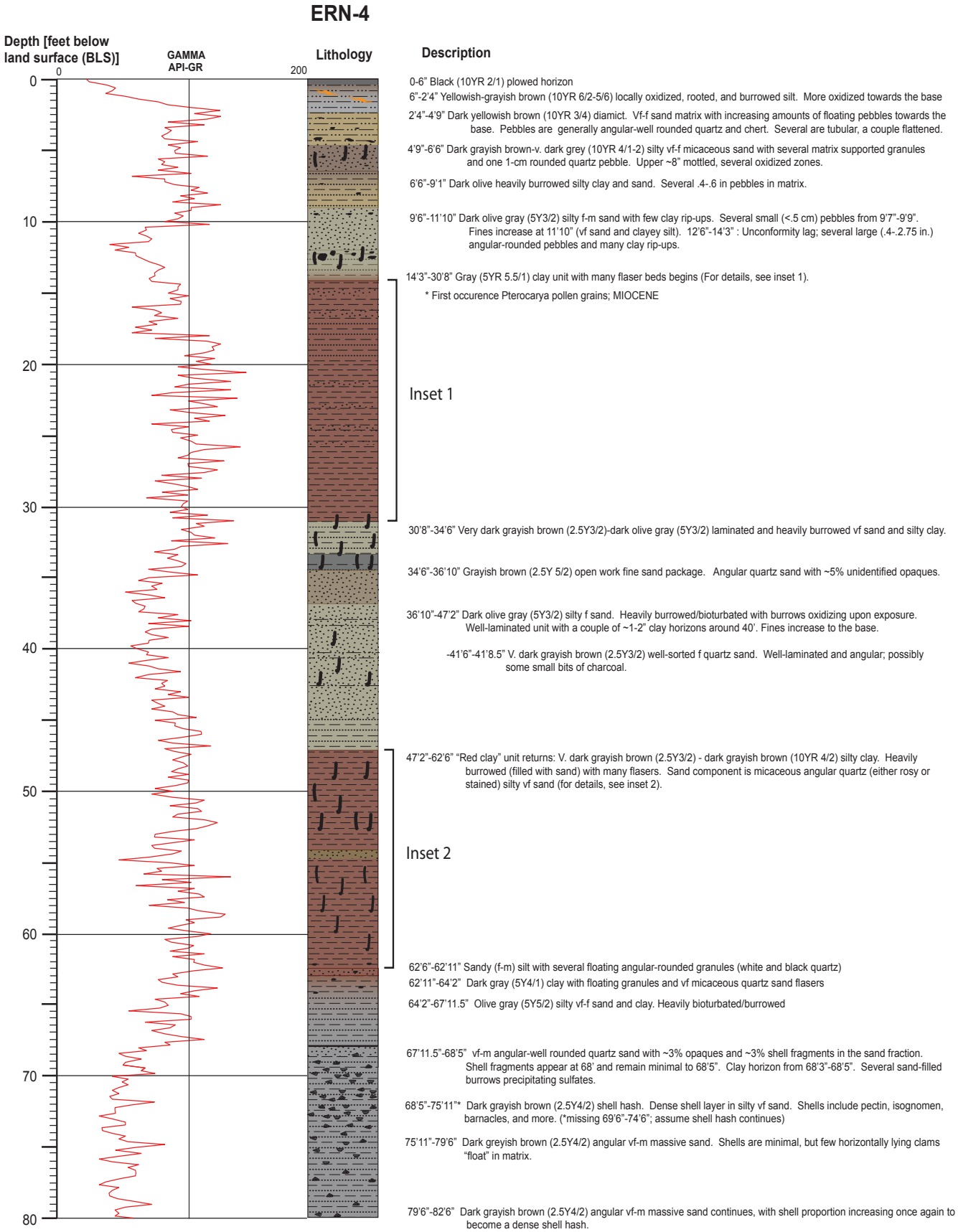
101.5-103.0 Very dark grayish brown (2.5Y 3/2) well-laminated sand

103.0 Very dark grayish brown (2.5Y 3/2) clay

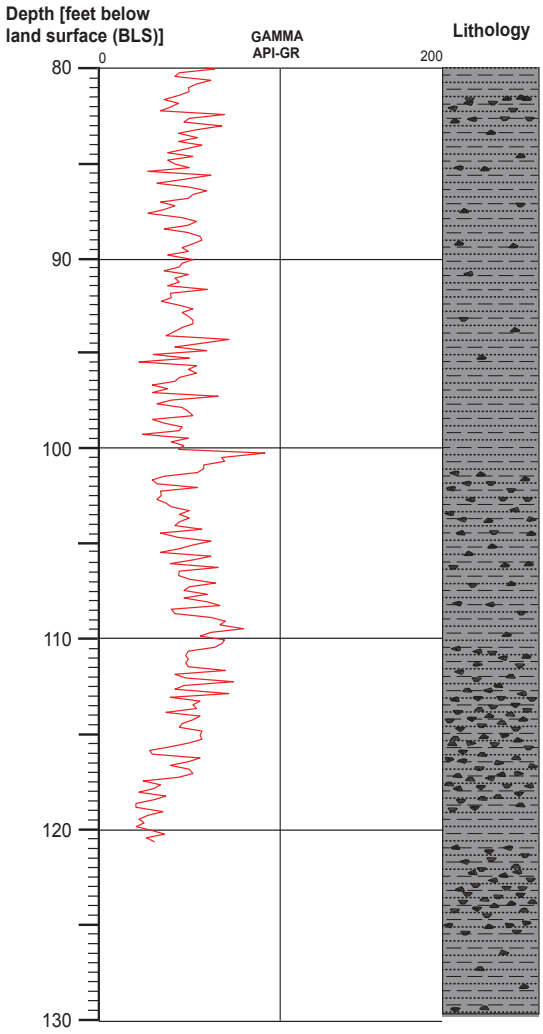
Appendix 6. Lithologic and geophysical logs of DO Cd 58 core, Little Blackwater River watershed, Dorchester County, Maryland.



Appendix 7. Lithologic and geophysical logs of DO Cd 66 core, Little Blackwater River watershed, Dorchester County, Maryland.



Appendix 7. Lithologic and geophysical logs of DO Cd 66 core, Little Blackwater River watershed, Dorchester County, Maryland. —Continued



Description

82'6"-89'6" Olive gray (5Y4/2) angular-subrounded m quartz sand with few clams and other bivalves in matrix suspension. Small clay films throughout.

89'6"-100'10"* Olive gray (5Y4/2) massive/bioturbated m quartz sand with minimal shells (*99'6"-100'10". missing).

100'10"-104'6"* Olive gray (5Y4/2) m quartz sand with high proportion of shells. Appears fragmented; storm surge? (*101'-104'6" missing)

104'6"-107' Olive gray (5Y4.5/2) silty vf-f quartz sand with high proportion of shells. The fine fraction appears to be made up largely of ground-up shell material that fizzes violently with HCL.
-Top ~3" indurated fossiliferous limestone clast (likely small portion of 101'-104'6" interval).

107'-108'9" Dark gray (5Y4/1) f-m silty quartz sand with several shell fragments in suspension; mostly pectin and isognomen.

108'9"-113'6"* Grayish brown (2.5Y5/2) vf-f quartz sand with fewer shells. Some organic material (roots?) (*113'6"-115'6" missing)

-110'4"-111'6" ~50% shells with long axes in horizontal position.

-111'6"-111'11" Open-work concentration of organics with oxidation stains and a couple of small pectin fragments.

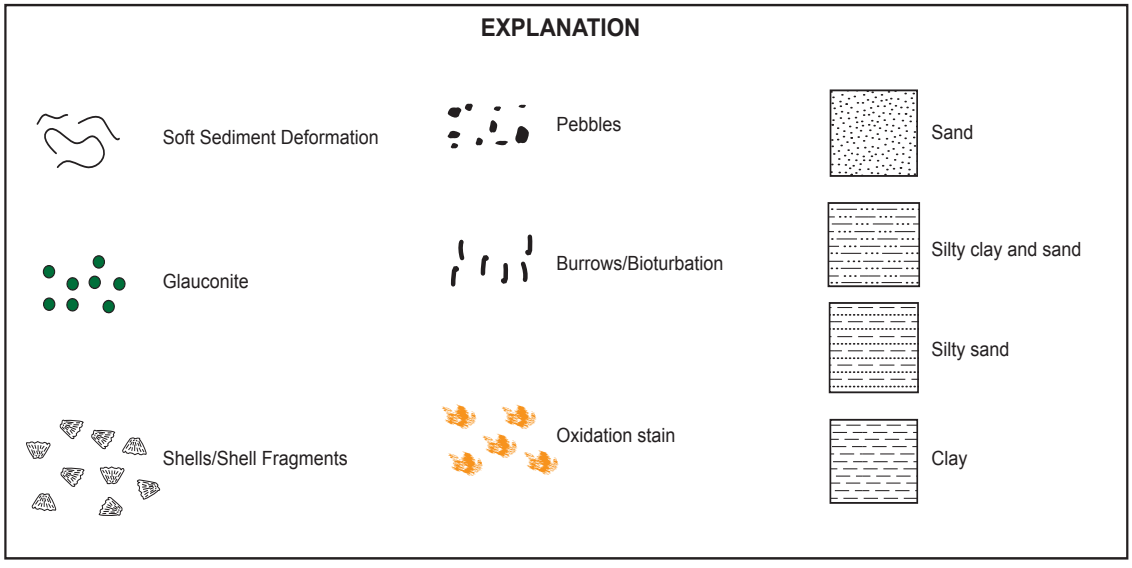
113'6"-116'1" Brown (10YR4/3) Indurated zone; disaggregated shells.

116'1"-119'6" Olive gray (5Y4/2) f angular quartz sand with many large clams both stacked and in suspension in horizontal orientation. Indurated from 117'-117'8"; shells minimal below 118'4"

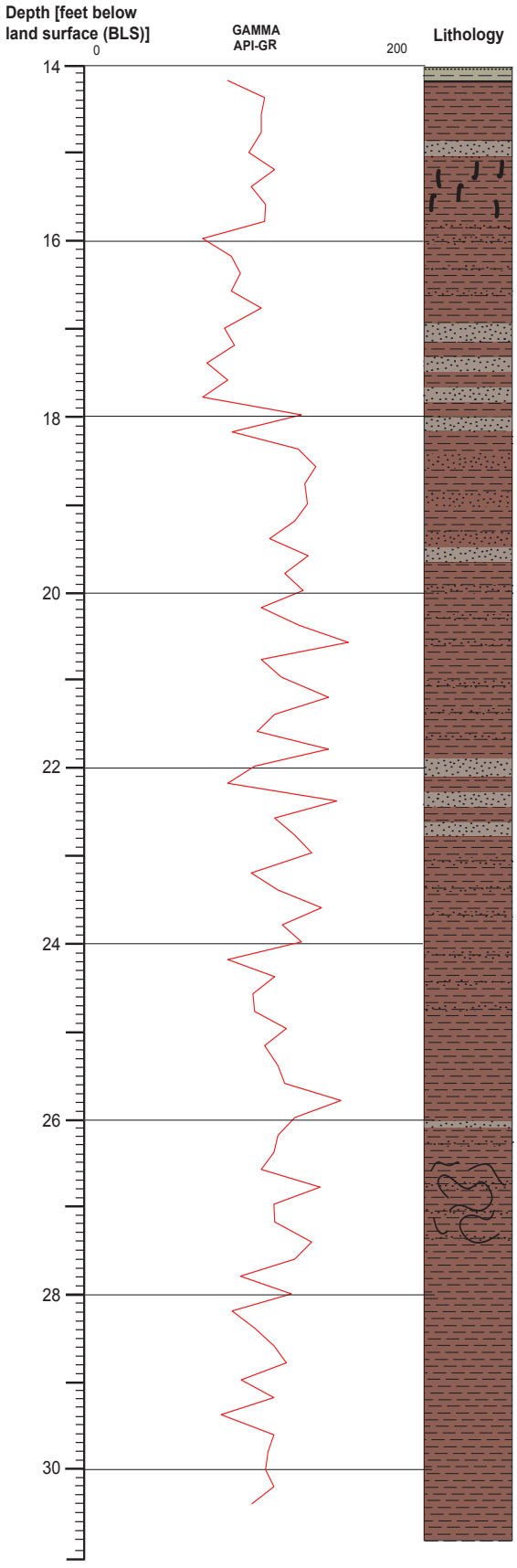
119'6"-123'8" Sand continues with increasing shell accumulation. Dense pectin and pearly isognomen.

123'8"-127'5" Dark greyish brown (2.5Y4/2) silty vf-f sand. Massive or structure destroyed by drilling. Shells minimal.

127'-129'6" Olive gray (5Y5/2) silty vf-f sand with variable induration. Generally well-laminated with bioturbation.



Appendix 7. Lithologic and geophysical logs of DO Cd 66 core, Little Blackwater River watershed, Dorchester County, Maryland. —Continued



Description

14'3"-14'11" Gray (5YR5.5/1) clay with several small flasers.

14'11"-15'3" Dark grayish brown (2.5Y4/2) vf sand
15'3"-15'6" Heavily burrowed gray (5YR5.5/1) clay. ~2 cm burrows and many flaser beds

15'6"-16'11" Gray (5YR5.5/1) clay. ~2 cm burrows and many flaser beds. Large burrows drop out.

16'11"-17'3" Light olive brown (2.5Y5/4) well-laminated, vf, angular quartz sand.
17'3"-18'2" Interbedded clay and sand; sand has very clear laminae.

18'2"-19'5" Dark gray (5YR4/1) clay cyclically interrupted by oxidized silty vf sand beds.

19'5"-19'11.5" Light olive brown (2.5Y5/4) vf well-laminated sand.
19'11.5"-21'10.5" Dark gray (5YR4/1) clay with sand flasers throughout.

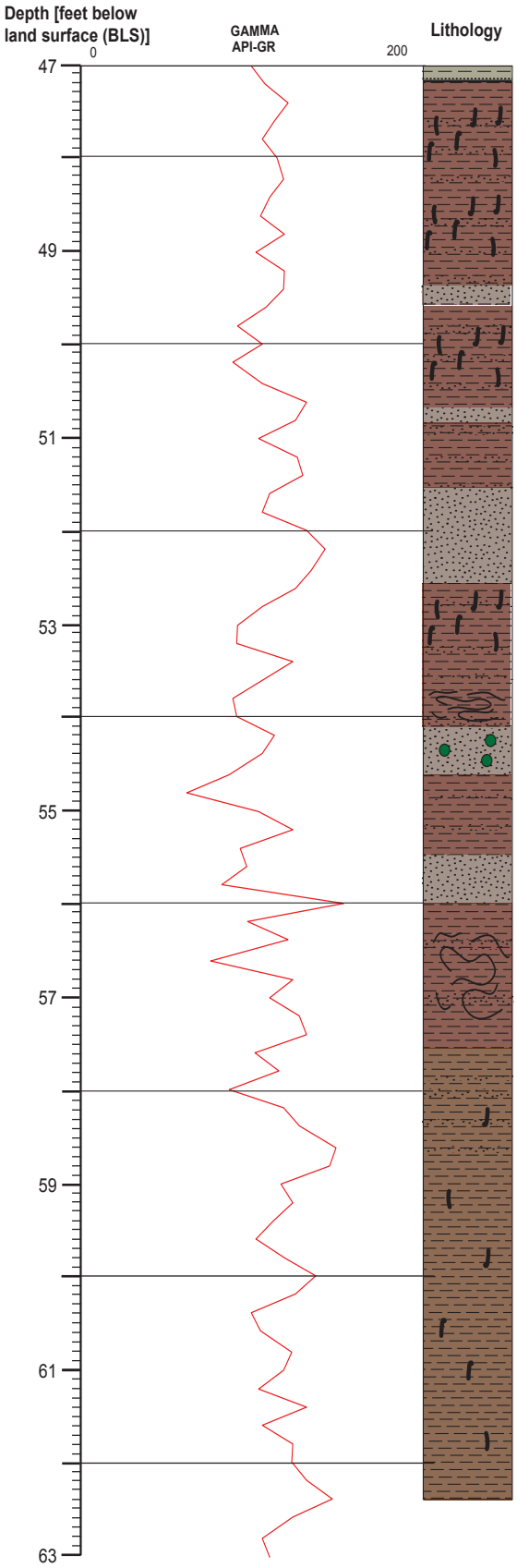
21'10.5"-22'9" Interbedded clay and sand on ~3' intervals. Some charcoal bits at the base. Sand part is well laminated.

22'9"-26' Dark gray (5YR4/1) clay with multiple vf sand flasers and ~1" sand beds.

26'-26'1" Dark olive gray (5Y3/2) angular-subrounded micaceous vf quartz sand.
26'1"-27'6" Clays and vf sands with soft-sediment deformation (due to drilling?)

27'6"-30'8" Dark gray (5YR4/1) clay. The most "pure" clay in the package; flasers throughout, but less common and smaller. Colors vary from above to grayish brown (2.5Y4/2).

Appendix 7. Lithologic and geophysical logs of DO Cd 66 core, Little Blackwater River watershed, Dorchester County, Maryland. —Continued



Description

47’2”-51’6” Very dark grayish brown (2.5Y3/2) silty clay. Heavily burrowed, multiple flasers, two sand excursions.

54’6”-52’8” Very dark grayish brown (2.5Y3/2) vf sand and silt.

52’8”-54’1” Very dark grayish brown (10YR3/2) heavily burrowed clay. Filling sands are micaceous angular quartz silty vf sand.

54’1”-54’8” Dark brown (10YR3/3) angular micaceous f sand excursion; possibly glauconitic.

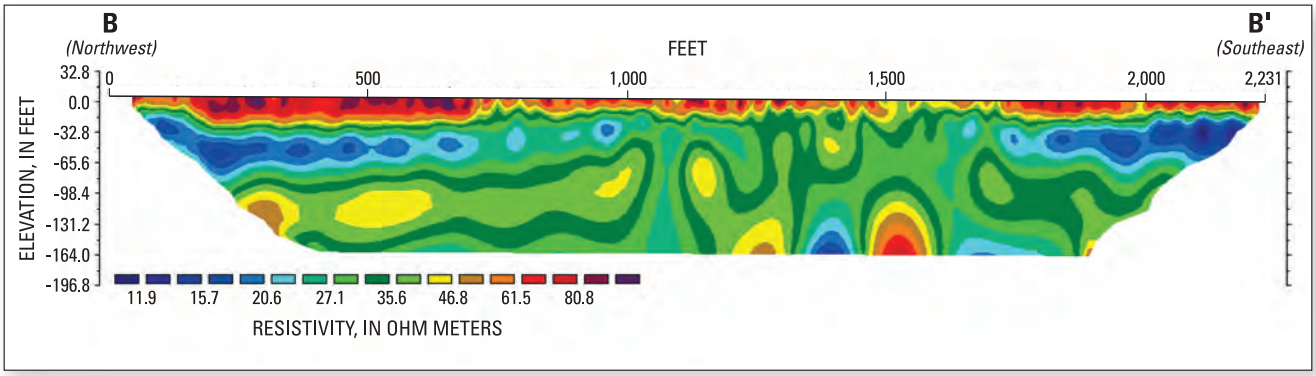
54’8”-55’6” Very dark grayish brown (10YR3/2) clay with 2 small well-laminated silty f sand beds.

55’6”-56’ Dark brown (10YR3/3) vf sand package. Micaceous quartz with possible charcoal in upper ~1”.

56’-57’6” Dominant clays and sands “swirled” together. Bioturbated? Soft sediment deformation? Disturbed by drilling?

57’6”-62’6” Brown (10YR4/3) clay with less sand/silt; also slightly less “red”. Few burrows.

Appendix 8. 2-D resistivity survey along the Egypt Road well transect B-B', Little Blackwater River watershed, Dorchester County, Maryland.



Prepared by USGS West Trenton Publishing Service Center.
Edited by Valerie M. Gaine.
Graphics and layout by Timothy W. Auer.

For additional information, contact:
Director, MD-DE-DC Water Science Center
U.S. Geological Survey
5522 Research Park Drive
Baltimore, MD 21228

or visit our Web site at:
http://md.water.usgs.gov

ISBN 978-1-4113-3123-5