

LEVEL I WATER-QUALITY INVENTORY AND MONITORING
RICHMOND NATIONAL BATTLEFIELD PARK, VIRGINIA



U.S. Geological Survey
1730 East Parham Road
Richmond, Virginia 23228

INTRODUCTION

The U.S. Geological Survey conducted a Level I Water-Quality Inventory and Monitoring (WAQIM) data-collection effort for Richmond National Battlefield Park (Richmond NBP) from August 2001 through April 2002. The primary objective of the WAQIM program was to provide the National Park Service (NPS) and Richmond NBP with at least a nominal inventory of its natural resources and to provide those data in a data-management system consistent with park management needs. Water-quality inventory data (physical, chemical, and biological) were collected from “key” water bodies within the boundaries of Richmond NBP. The key water bodies are those waters within park boundaries that are essential to the central cultural, historical or natural resources management themes of the parks or provide habitats to threatened or endangered plants and animals. Data were collected during the fall, winter, spring, and summer over a range of hydrologic conditions. Because of the drought conditions that persisted during the study period, variations in flow between seasons were less pronounced than during normal hydrologic conditions.

Established in 1936, Richmond NBP protects 1366 acres of historic ground. Between 1861 and 1865, Union armies repeatedly set out to capture Richmond, capital of the Confederacy, and end the Civil War. Three of those campaigns came within a few miles of the city. The park commemorates eleven different sites associated with those campaigns, including the battlefields at Gaines' Mill, Malvern Hill, and Cold Harbor. Richmond NBP has eleven units, of which seven units were sampled as part of the WAQIM.

Land uses adjacent to park boundaries range from forested to urbanized. Various forms of agricultural practices are in use around and within the park boundaries. Potential threats to water-quality in the park include: (1) encroaching development and (2) agricultural activities. Parameters most sensitive to these potential water-quality threats include nutrients and bacteria. The Drewrys Bluff unit has an old landfill where leachate drains into a small tributary of the James River. Data-collection sites and the parameters analyzed were selected on the basis of the spatial distribution of land-use activities inside and immediately outside of the park's boundaries and on the nature of the potential threats to park water quality.

DESCRIPTION OF INVENTORY PROCESS

Site Descriptions

The water-quality inventory for Richmond NBP included the periodic collection of physical, chemical, and microbiological data from fifteen sites within the seven units (Table 1). Data-collection activities were conducted in August 2001, October 2001, January 2002, and April 2002.

Table 1. Station descriptions for NBP.

| Station Name | Station ID | Station Type | Description | Quad | Map Scale | Latitude | Longitude | Method of Determining Lat/Long |
|---|------------|--------------|--|----------------|-----------|---------------|---------------|--------------------------------|
| Fort Harrison Unit | | | | | | | | |
| Coles Run trib to trib near Centralia, Va | 0203854250 | stream | Stream was typically 1 foot wide. Surrounding area is wooded. Site was upstream of Maintenance Way Road. | Drewry's Bluff | 1:24000 | 37 25' 44" | 77 22' 32" | Map |
| Coles Run trib pond near Centralia, Va | 0203854210 | pond | Pond was typically 15 feet wide. Surrounding area is wooded. Site was north of Battlefield Park Road. | Drewry's Bluff | 1:24000 | 37 25' 22.48" | 77 22' 37.01" | GPS, Unit 3 |
| Gaines Mill Unit | | | | | | | | |
| Boatswain Creek at Western boundary near Highland Springs, VA | 0204243830 | stream | Stream width was typically controled by beaver activity. Surrounding area is wooded and has heavy underbrush. Site was 75 feet west from a monument on the end of a trail at the western boundary. | Seven Pines | 1:24000 | 37 34' 21.93" | 77 17' 49.34" | GPS, Unit 3 |
| Boatswain Creek at Eastern boundary near Highland Springs, VA | 0204243790 | stream | Stream width was typically less than 3 feet wide. Surrounding area is wooded and has heavy underbrush. Site was 700 feet northeast of culvert at the unit's entrance on the eastern boundary. | Seven Pines | 1:24000 | 37 34' 38" | 77 17' 21" | Map |
| Malvern Hill and Glendale Unit | | | | | | | | |
| Crewes Channel at Route 156 near Elko, VA | 0203874785 | pond | Pond was typically 500 feet wide. Surrounding area is wooded, some farming on edges. Site was 5 feet upstream of Route 156. | Dutch Gap | 1:24000 | 37 24' 31.27" | 77 15' 21.41" | GPS, Unit 3 |
| Crewes Channel at Logging Road near Elko, VA | 0203874770 | ponded | Pond was typically 100 feet wide. Surrounding area is wooded. Site was about a mile from Carters Mill Road on an old logging road. | Dutch Gap | 1:24000 | 37 25' 16" | 77 15' 47" | Map |
| Western Run at Route 156 near Elko, VA | 0203874275 | stream | Stream was typically 12 feet wide. Surrounding area is wooded. Site was at bridge on Route 126. | Roxbury | 1:24000 | 37 25' 10" | 77 14' 43" | Map |
| McDowell Creek trib NPS North Boundary near Elko, VA | 0203874250 | stream | Stream was typically 3 feet wide. Surrounding area is wooded. Site was about a mile from Long Bridge Road on an old logging road. | Roxbury | 1:24000 | 37 26' 17" | 77 14' 38" | Map |

Table 1. Station descriptions for NBP.

| Station Name | Station ID | Station Type | Description | Quad | Map Scale | Latitude | Longitude | Method of Determing Lat/Long |
|--|------------|--------------|---|----------------|-----------|---------------|---------------|------------------------------|
| Beaver Dam Unit | | | | | | | | |
| Beaver Dam Creek at Mechanicsville, VA | 02042433 | stream | Stream width was typically 12 feet wide. Surrounding area is lightly wooded. Site was 2 feet downstream of footbridge at the unit's southern boundary. | Seven Pines | 1:24000 | 37 35' 42.93" | 77 21' 32.86" | GPS, Unit 3 |
| Chickahominy Bluff Unit | | | | | | | | |
| Chickahominy River Trib 12 at Boundary near Richmond, VA | 0204243350 | stream | Stream width was typically 3 feet wide. Surrounding area is lightly wooded. Site was 5 feet downstream of southern boundary. | Richmond | 1:24000 | 37 35' 01" | 77 23' 17" | Map |
| Cold Harbor Unit | | | | | | | | |
| Bloody Run at Eastern boundary near Highland Springs, VA | 0204243610 | stream | Stream width was typically less than a foot wide. Surrounding area is wooded and has heavy underbrush. Site was 75 feet upstream of tour road and at unit's eastern boundary. | Seven Pines | 1:24000 | 37 35' 30" | 77 16' 57" | Map |
| Bloody Run at Western boundary near Highland Springs, VA | 0204243650 | stream | Stream width was typically less than 3 feet wide. Surrounding area is wooded and has heavy underbrush. Site was 25 feet downstream of foot path and at unit's western boundary. | Seven Pines | 1:24000 | 37 35' 21.29" | 77 17' 31.25" | GPS, Unit 3 |
| Drewry's Bluff Unit | | | | | | | | |
| James River trib 5 at Western Boundary at Bellwood, VA | 0203853010 | stream | Stream was typically 1 foot wide. Surrounding area is wooded. Site was at the western boundary. | Drewry's Bluff | 1:24000 | 37 25' 20" | 77 25' 29" | Map |
| James River trib 5 below Landfill at Bellwood, VA | 0203853030 | stream | Stream was typically 1 foot wide. Surrounding area is wooded. Site was 150 feet upstream of first leachment pipe from old landfill. | Drewry's Bluff | 1:24000 | 37 25' 17" | 77 25' 26" | Map |
| James River trib 5 at Eastern Boundary at Bellwood, VA | 0203853050 | stream | Stream was typically 1 foot wide. Surrounding area is wooded. Site was 200 feet downstream of second leachment pipe from old landfill, at the southeastern boundary. | Drewry's Bluff | 1:24000 | 37 25' 13" | 77 25' 18" | Map |

The Beaver Dam Creek unit (Figure 1) is a 16-acre unit located approximately six miles northeast of downtown Richmond in Hanover County on Cold Harbor Road (State Route 156) near its intersection with I-295. It contains a short section of Beaver Dam Creek, a tributary of the Chickahominy River. Beaver Dam Creek at Mechanicsville (02042433) was sampled at a site 2 feet downstream of the footbridge at the unit's southern boundary. Stream width was typically 12 feet wide. Beaver dams downstream of the sampling site contributed to ponded water with minimal flow at the sampling site. The surrounding area is lightly wooded and is surrounded by housing developments.

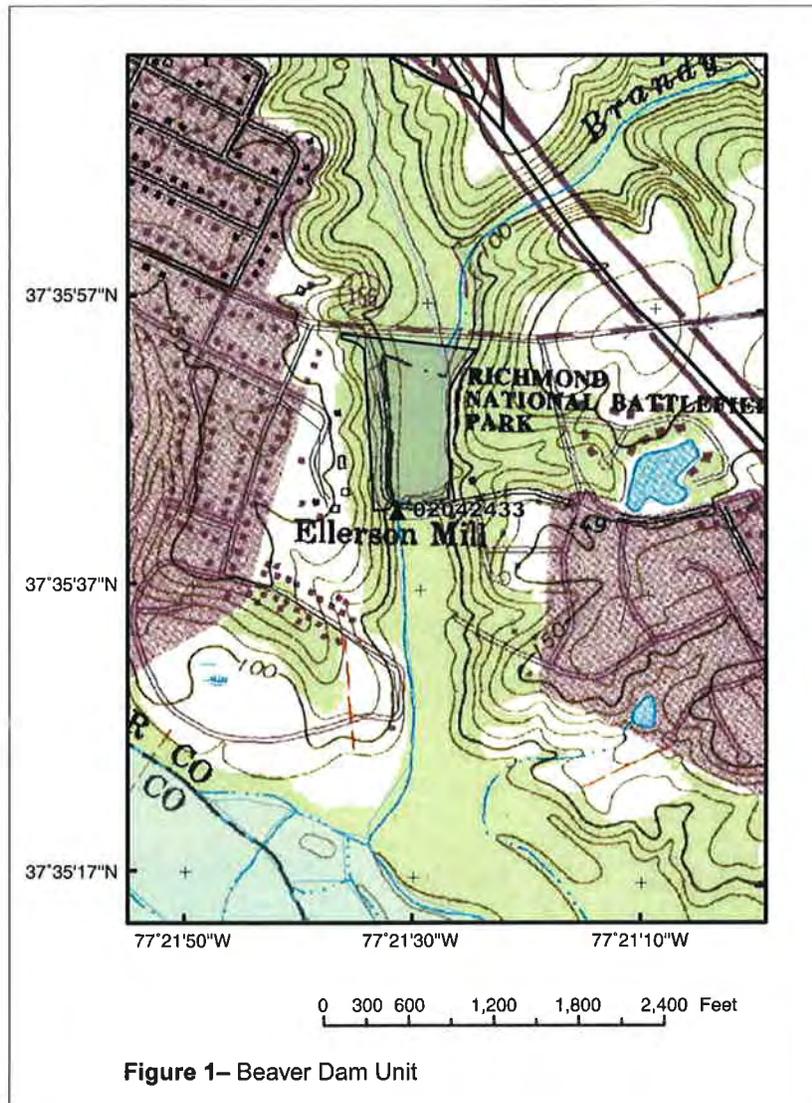


Figure 1– Beaver Dam Unit

The Chickahominy Bluff unit (Figure 2) is a 37-acre unit that lies five miles northeast of downtown Richmond on Mechanicsville Turnpike (State Route 360). The unit and a small parking area can be accessed by a short park road immediately east of Route 360. This site, Chickahominy River tributary 12 at boundary near Richmond (0204243350), was typically 3 feet wide. The site was 5 feet downstream of the southern boundary of the unit. The surrounding area is lightly wooded.

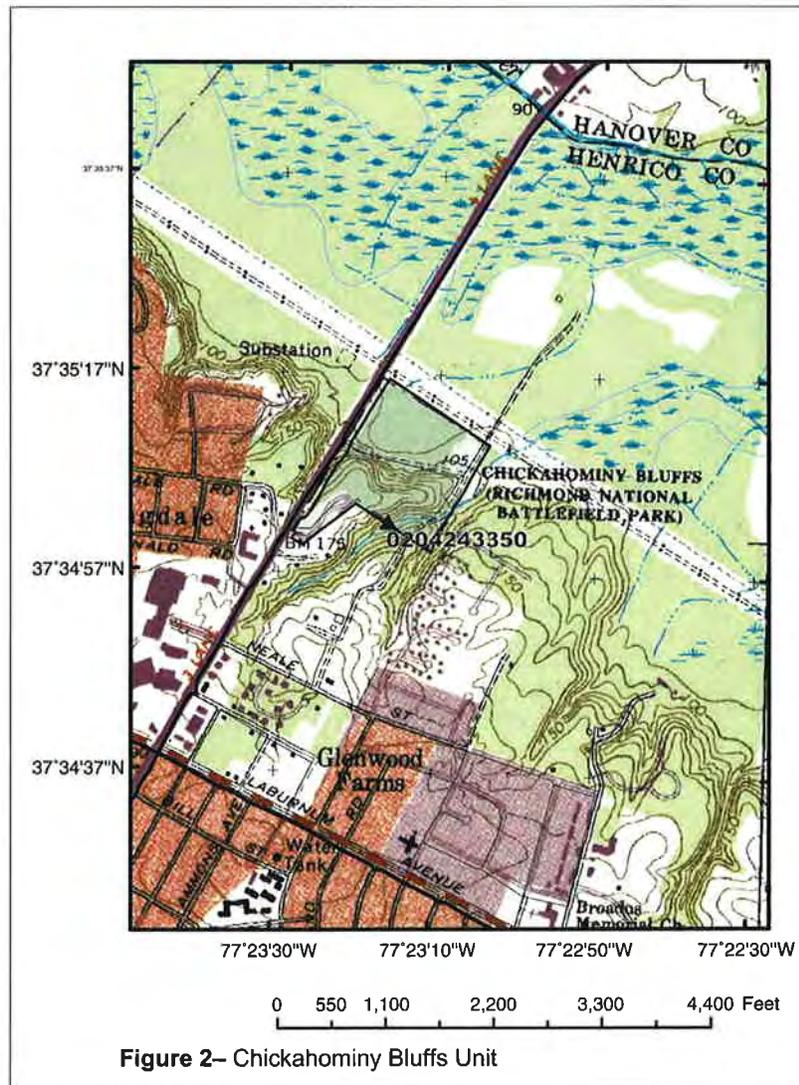
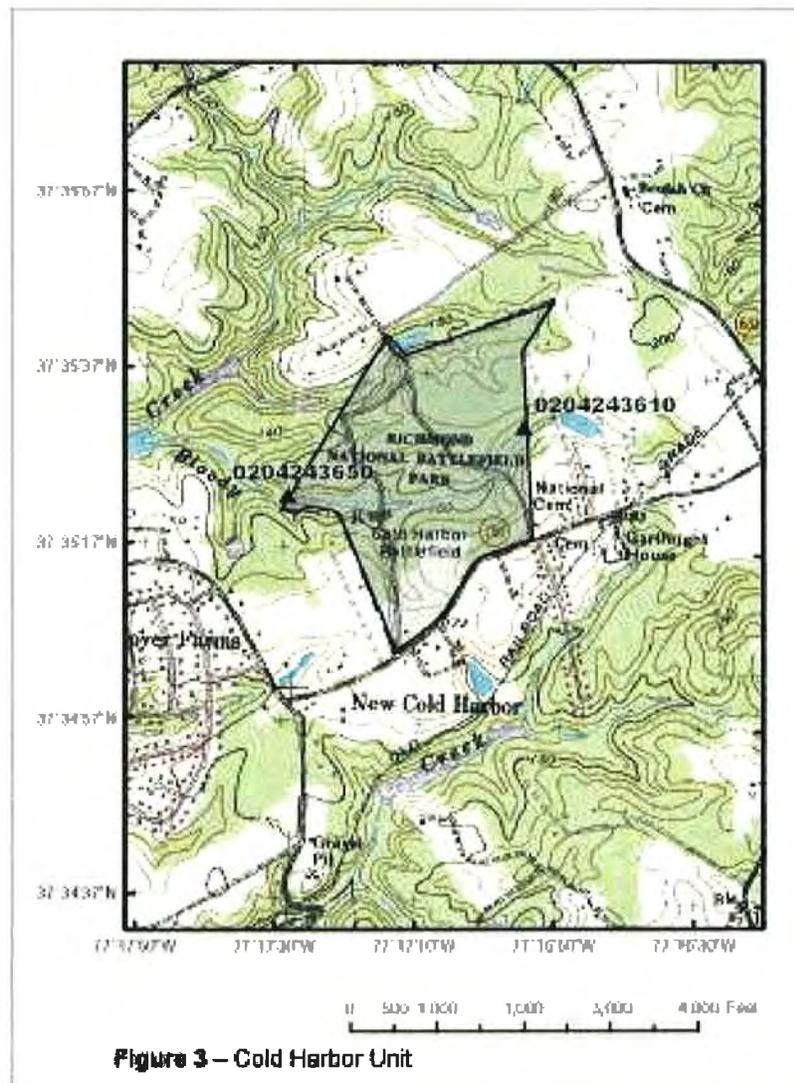


Figure 2- Chickahominy Bluffs Unit

The Cold Harbor unit (Figure 3) is a 151-acre unit on the north side of two-lane State Route 156 between the Hanover Farms subdivision and the community of Old Cold Harbor and is accessed from State Route 156 via an auto tour road. Bloody Run flows through the center of the unit. It was sampled at the eastern boundary (0204243610) and at the western boundary (0204243650) of the unit. Stream width was typically less than 3 feet wide. The surrounding area is wooded and has heavy underbrush.



The Drewry's Bluff unit (Figure 4) is a 39-acre unit approximately 8 miles south of downtown Richmond and overlooks the James River. It is accessed via Fort Darling Road off of Bellwood Road. A small tributary to the James River flows through the unit. The stream was sampled at the western boundary (0203853010), at a site 150 feet upstream of the first leachate pipe draining the landfill (0203853030), and at the eastern boundary (0203853050). The stream was typically 1 foot wide. The unit is wooded except for the landfill, which is grass covered.

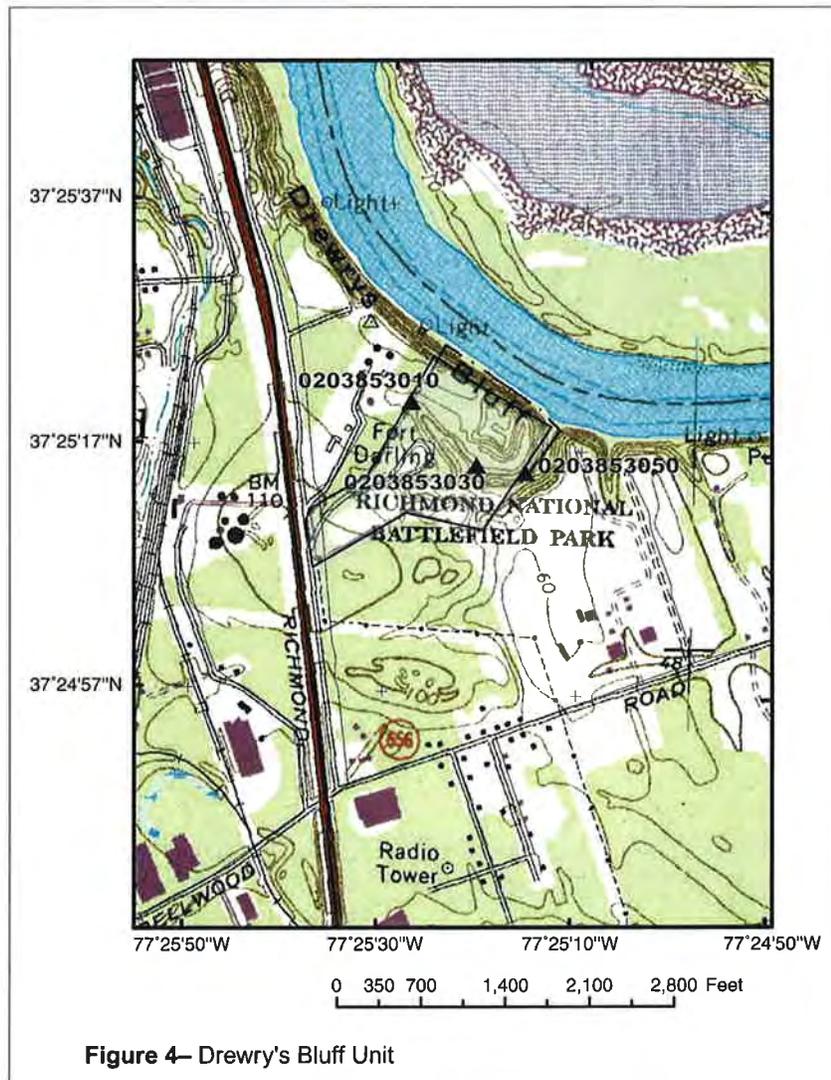
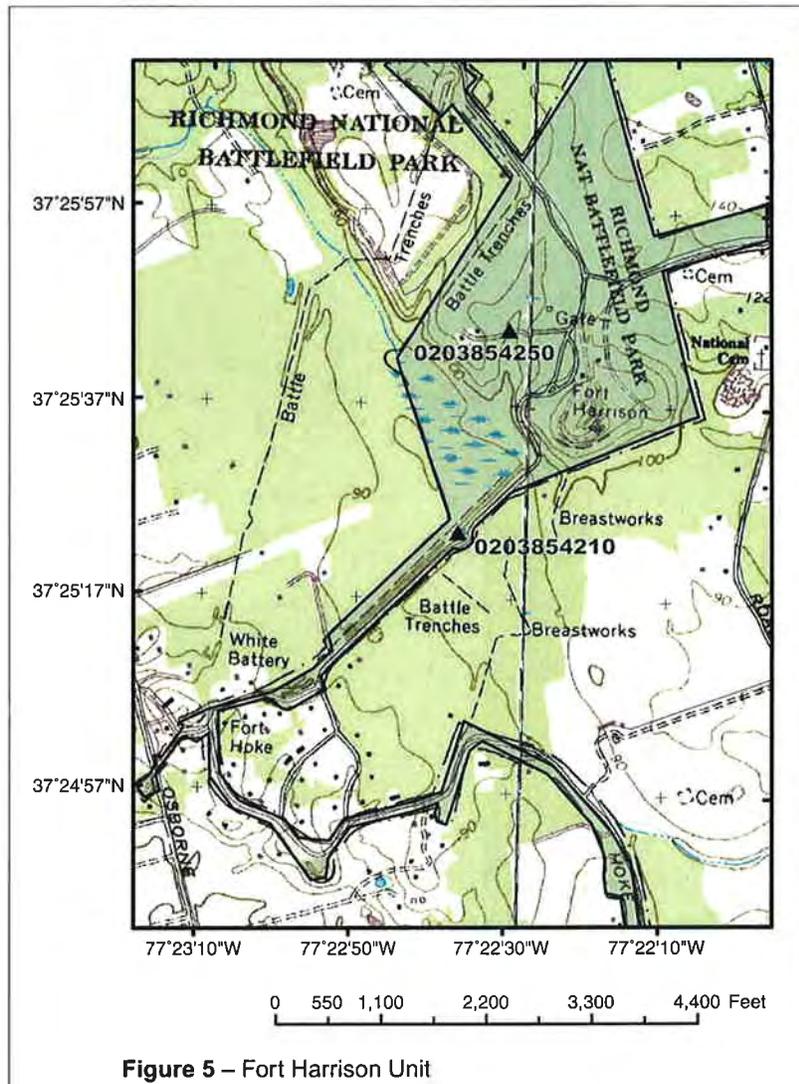


Figure 4– Drewry's Bluff Unit

The Fort Harrison unit (Figure 5) is a 313-acre unit approximately 8 miles southeast of downtown Richmond and includes a 6-mile long section of Battlefield Park Drive and Hoke Brady Road. It can be accessed via New Market (State Route 5), Mill, Varina or Kingsland Roads, or Osborne Turnpike. One site was a seasonal tributary to Coles Run just upstream of Maintenance Way (0203854250), and the second site was the ponded water along Battlefield Park Road (0203854210), which was typically 15 feet wide. The unit is wooded and has houses along Battlefield Park Drive.



The Gaines' Mill unit (Figure 6) is a 60-acre unit that lies southwest of the Cold Harbor unit on the southern bank of Boatswain Creek, approximately 0.5 mile south of State Route 156 near the community of New Cold Harbor, and is accessed via Watt Farm Road. Boatswain Creek was sampled at the park's eastern boundary (0204243790) and at the western boundary (0204243830). The stream was typically 1-3 feet wide. The surrounding area is wooded and has heavy underbrush.

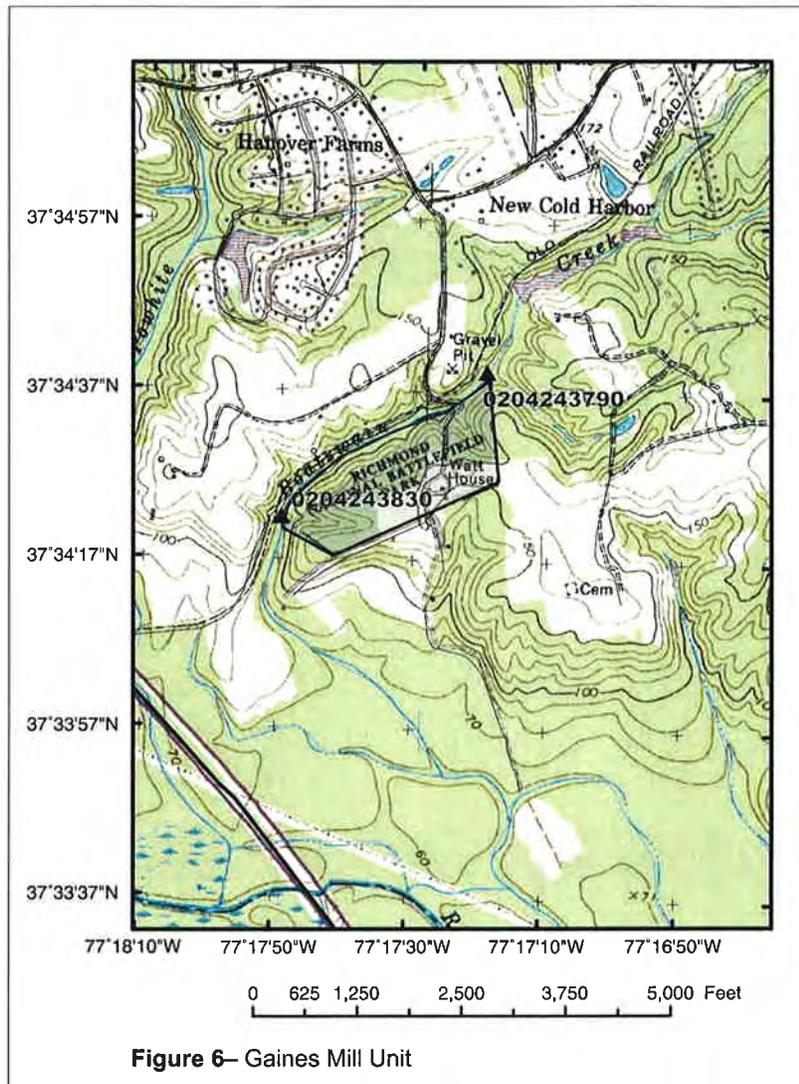


Figure 6– Gaines Mill Unit

The Malvern Hill and Glendale units (Figure 7) comprise 734 acres and are approximately 15 miles southeast of downtown Richmond on State Route 156 near its intersection with State Route 5. The units are accessible by either Carter's Mill Road or Willis Church Road. Four sites were sampled at this unit because of the unit's large area. Crewes Channel at a logging road on the northern boundary (0203874770) and at State Route 156 (0203874785) were both ponded by beaver dams. The other two sites were a tributary to McDowell Creek at the northern boundary (0203874250) of the unit and Western Run at State Route 156 bridge (0203874275). Both of these sites were flowing. The stream was typically 1-3 feet wide. The surrounding area is wooded and has heavy underbrush.

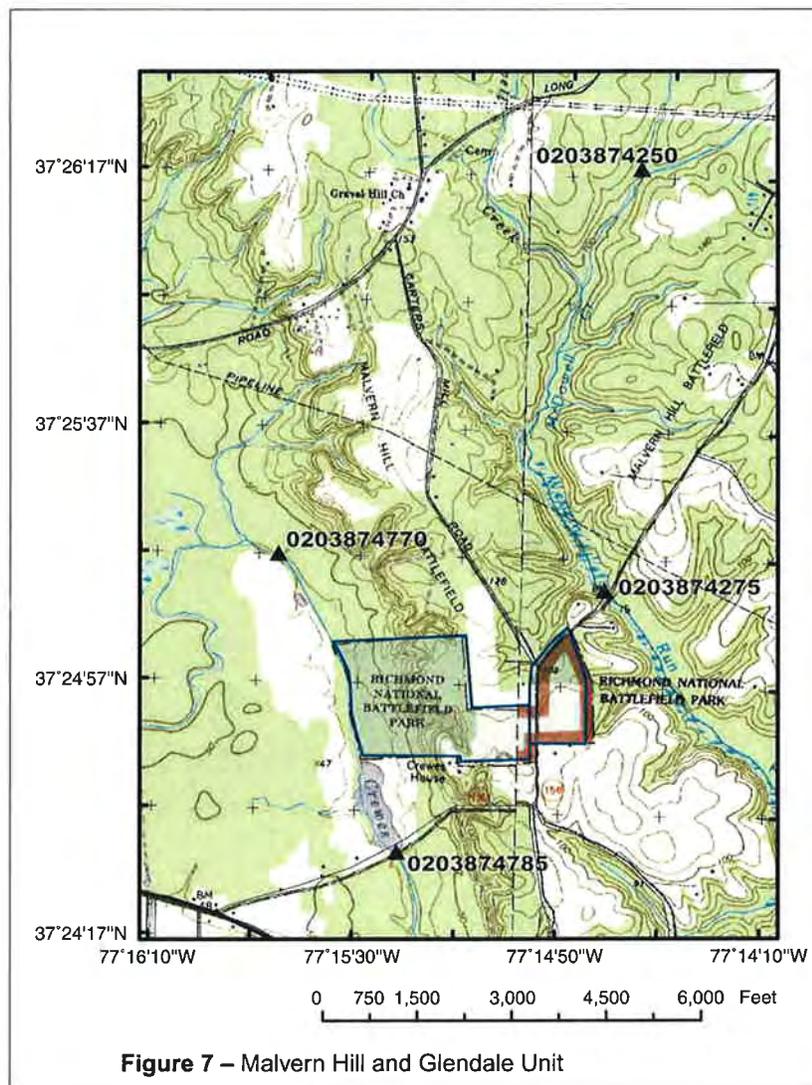


Figure 7 – Malvern Hill and Glendale Unit

Description of Data Collection

Data-collection activities were conducted in August 2001, October 2001, January 2002, and April 2002 (Table 2). Data-collection and analysis were conducted according to standard USGS protocols (U.S. Geological Survey, 1997, 1998, 1999; Rantz and others, 1982). Stream water-quality samples were collected as grab samples or cross-sectional depth-integrated samples, depending on streamflow conditions. Discharge, water temperature, pH, specific conductance, dissolved oxygen, and alkalinity were measured at every site on every visit. Water samples were collected and analyzed for nutrients and bacteria at every site on every visit. Samples collected during the October 2001 sampling trip were analyzed for major-ion and trace-element concentrations. One quality control (QC) sample was taken every sampling trip. One replicate sample and three field blanks were taken. Replicate samples are a group of samples collected in a manner such that the samples are thought to be essentially identical in composition. Field blanks can provide information on the efficacy of the equipment cleaning procedures used and on ambient atmospheric contamination.

Table 2. Data-collection schedule

| Parameter | Data collection period | | | |
|------------------|------------------------|--------------|--------------|------------|
| | August 2001 | October 2001 | January 2002 | April 2002 |
| Field parameters | X | X | X | X |
| Fecal bacteria | X | X | X | X |
| Nutrients | X | X | X | X |
| Major Ions | | X | | |
| Trace elements | | X | | |
| Replicate | | X | | |
| Field blanks | X | | X | X |

PRINCIPAL INVESTIGATORS

The principal investigators of the WAQIM program were Roger M. Moberg and Karen C. Rice of the U.S. Geological Survey (USGS), Water Resources Division district office in Richmond, Virginia. Roger M. Moberg, Hydrologic Technician, implemented all fieldwork. All water-quality samples collected as part of the inventory, with the exception of bacteriological samples, were submitted for analysis to the USGS National Water Quality Laboratory (NWQL) in Denver, Colorado. Bacteriological samples were processed by field personnel at each site and analyzed in the Richmond, Virginia office of the USGS.

WATER-QUALITY RESULTS

Tables 3-7 provide all physical, microbiological, and chemical data collected as part of the Richmond NBP WAQIM project. Included on these tables are the four QC samples. Data generated from QC samples were used to evaluate the quality of the sampling and processing techniques as well as the data from the samples themselves. All data from the three field blanks were below lab detection limits. The data for the replicate sample did not show significant variability in constituent concentration.

Four additional files of supporting documentation are included as attachments to this report:

- (1) "STATIONS.XLS";
- (2) "PARAMETER.DOC";
- (3) "WQDATA.XLS", and
- (4) "README.DOC"

"stations.xls" is a Microsoft Excel file that contains specific location information for each site where water-quality data were collected. "parameter.doc" is a Microsoft Word file that explicitly defines each water-quality parameter included in the tables of this report and also in the water-quality data spreadsheet. "wqdata.xls" is a Microsoft Excel spreadsheet that contains all water-quality data collected during this study. "Readme.doc" is a Microsoft Word file that contains basic information related to the project, such as contact information for those who conducted the work and analyzed the samples.

GENERAL CLIMATIC AND HYDROLOGIC CONDITIONS

The recent hydrologic drought conditions result from precipitation patterns over the past several years. The current statewide drought began in the summer of 1997. Precipitation was well below normal during the summer and fall of 1997, allowing streamflows to decline to levels below the normal range of flows. Precipitation was well above normal during the winter of 1998, increasing groundwater storage and streamflow to levels above the normal range of flows. During the summer and fall of 1998, precipitation again was well below normal, causing a significant agricultural drought; however streamflows never declined to below normal levels until late fall because of the unusually high ground-water storage. Ground-water storage was not replenished significantly during the winter of 1999, and new record minimums were recorded during the summer of that year. Hurricanes Dennis and Floyd brought significant precipitation during the fall of 1999, which increased ground-water storage in the eastern half of the State. During the winters of 2000 and 2001, precipitation did not replenish the ground-water storage to the extent normally expected, and water levels in wells have continued to decline. Precipitation patterns during the summers of 2000 and 2001 have allowed streamflows to maintain conditions near the normal range of flow. During the study period (August 2001-April 2002), precipitation at Richmond International Airport was in deficit 10.58 inches. One surface-water site (Chickahominy River near Providence Forge, Va 2042500) and one ground water well (372538077221501 at the Fort Harrison Unit) were used to evaluate hydrologic conditions. Analysis of streamflow records for the indicator gage (Figure 8) near the Richmond NBP study area indicates that mean daily discharges for the study period were below the median daily streamflow (based on 59 years of record) for the whole study period, except for August. The well at Fort Harrison did not show much recharge over the winter months (2001-2002) thus indicating the drought continues (Figure 9).

Figure 8. Indicator gage

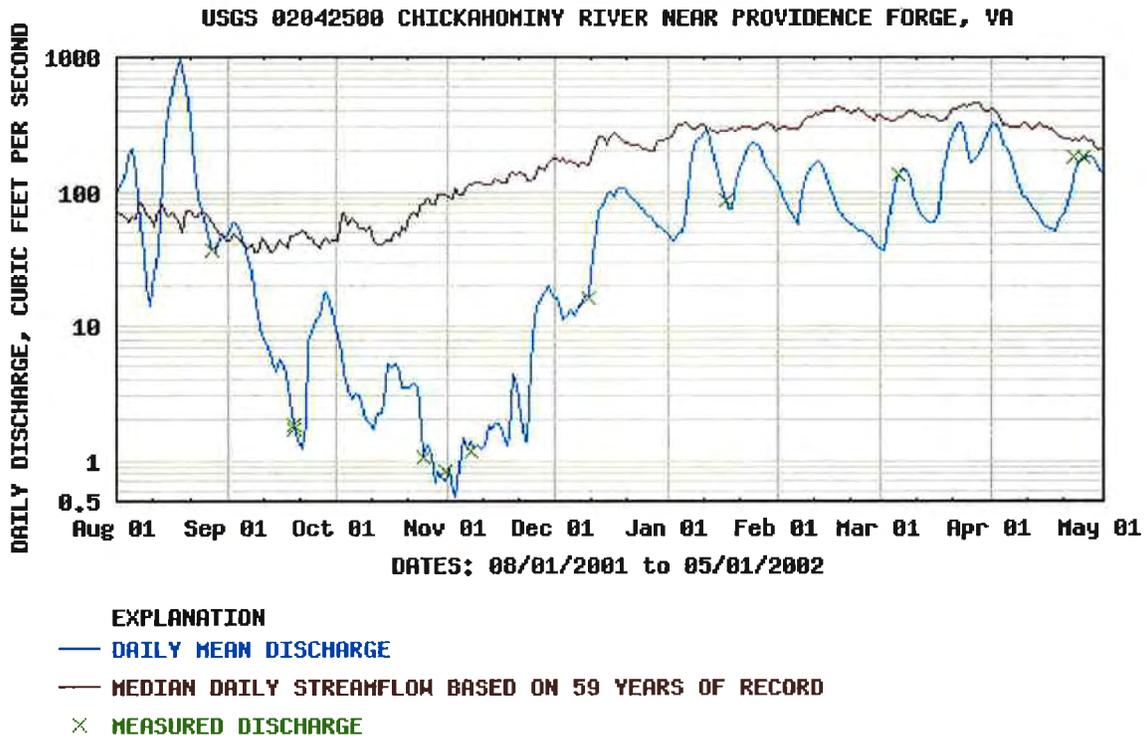
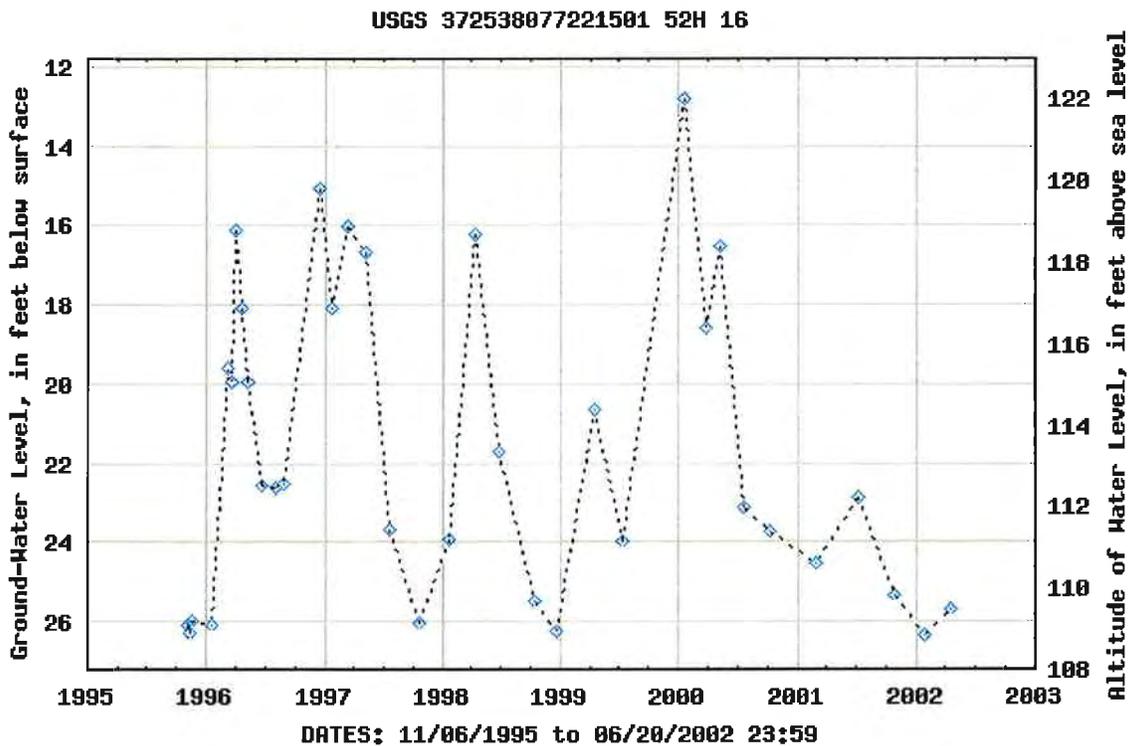


Figure 9. Well at Fort Harrison



EXCEEDENCES OF STATE WATER-QUALITY STANDARDS

In the Richmond NBP study area, all water-quality measurements were within the surface water standards established by the Virginia State Water Control Board (1997), except as noted below.

Fecal coliform: Of 58 measurements of fecal coliform bacteria made in the study area, 1 measurement exceeded the standard of 1,000 bacteria per 100 milliliters (mL). Bacteria counts of 1,200 per 100 ml were measured at station 0204243830 at the Gaines Mill unit (Boatswain Creek at western boundary near Highland Springs) on August 21, 2001.

Dissolved oxygen: There were several sites in the study with less than the minimum standard of 4.0 milligrams per liter (mg/L) for streamwater in the Piedmont zone. There were seven sites (0204243610, 0203853010, 0203853030, 0203854210, 0203874250, 0203874770, and 0203874785) with at least one incidence where the dissolved oxygen was below the standard. These sites were stagnant pools of water, with very little flow, if any.

pH: Most sites had pH values near or below the minimum standard of 6 pH units for streamwater in the Piedmont zone. These sites feed or drain swampy areas and may contain high concentrations of organic acids.

Organic ammonia: The two downstream sites at Drewrys' Bluff had elevated organic ammonia. Both sites had values that were higher than the chronic toxicity standard for freshwater, 2.13 mg/L. The two sites on Crewes Channel exceeded the chronic level for organic ammonia on one visit each.

SELECTED REFERENCES

- Rantz, S.E., and others, 1982, Measurement and computation of streamflow--v. 1, Measurement of stage and discharge, with a section on Discharge - Current-meter method: U.S. Geological Survey Water-Supply Paper 2175, p. 80-183.
- U.S. Geological Survey, 1997, 1998, 1999, National field manual for the collection of water-quality data: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9.
- Virginia State Water Control Board, 1997, Surface water standards with general, statewide application: Code of Virginia, 9 VAC 25-260-5 et seq. Water Quality Standards.
- White, R.K., Hayes, D.C., Guyer, J.R., and Herman, P.E., 2001, Water resources data, Virginia, water year 2001: U.S. Geological Survey Water-Data Report VA-01-1, 493p.

Table 3. Field parameter data

[ft³/s, cubic feet per second; mm of Hg, millimeters of mercury; °C, degrees Celsius; uS/cm, microsiemens per centimeter at 25 °C; mg/L, milligrams per liter; CaCO₃, calcium carbonate; --, no data]

| Station Number | DATE | TIME | Discharge (ft ³ /s) | Barometric pressure (mm of Hg) | Dissolved oxygen (mg/L) | pH (units) | Specific conductance (uS/cm) | Air Temperature (°C) | Water Temperature (°C) | Alkalinity (mg/L as CaCO ₃) |
|--------------------------------|----------|------|-----------------------------------|--------------------------------------|-------------------------------|---------------|------------------------------------|----------------------------|------------------------------|---|
| Beaver Dam Unit | | | | | | | | | | |
| 02042433 | 08/20/01 | 1040 | -- | -- | -- | -- | -- | -- | -- | -- |
| | 08/20/01 | 1045 | -- | 754 | 5.5 | 5.7 | 104 | 25.3 | 23.7 | 20 |
| | 10/16/01 | 1030 | -- | 756 | 6.6 | 5.8 | 101 | 14.9 | 14.3 | 17 |
| | 01/29/02 | 1020 | -- | 756 | 10.3 | 5.7 | 124 | 19.4 | 8 | 12 |
| | 04/26/02 | 1200 | -- | 760 | 8.8 | 6.8 | 114 | 16.7 | 14.2 | 16 |
| Chickahominy Bluff Unit | | | | | | | | | | |
| 0204243350 | 08/20/01 | 1210 | -- | 754 | 7.4 | 6.2 | 172 | 26 | 23.4 | 11 |
| | 10/17/01 | 0930 | 0.01 | 755 | 9.7 | 6.1 | 153 | 9.6 | 11.3 | 13 |
| | 01/25/02 | 1050 | 0.11 | 756 | 10.6 | 5.8 | 124 | 11.5 | 8.9 | 7 |
| | 04/22/02 | 1500 | 0.64 | 744 | 8.7 | 6.5 | 117 | 21.7 | 17.2 | 11 |
| Cold Harbor Unit | | | | | | | | | | |
| 0204243610 | 08/21/01 | 1200 | -- | 756 | 3.3 | 4.8 | 53 | 27.5 | 20.4 | 10 |
| | 10/23/01 | 1000 | -- | 751 | 0.8 | 5.2 | 73 | 16.7 | 15.2 | 22 |
| | 01/22/02 | 1410 | 0 | 761 | 5.3 | 5.6 | 44 | 10 | 8 | 5 |
| | 04/26/02 | 1115 | 0.01 | 760 | 3.5 | 5.8 | 53 | 17 | 12.6 | 13 |
| 0204243650 | 08/21/01 | 1100 | 0.19 | 756 | 5.6 | 4.7 | 67 | 25 | 19.8 | 3 |
| | 10/22/01 | 1050 | 0.12 | 755 | 6 | 4.8 | 70 | 18.4 | 14.9 | 4 |
| | 01/22/02 | 1020 | 0.13 | 761 | 10.3 | 5.1 | 64 | 3.9 | 5.4 | 2 |
| | 04/23/02 | 1130 | 0.59 | 757 | 7.9 | 5.6 | 61 | 15.3 | 13.8 | 3 |
| Drewry's Bluff Unit | | | | | | | | | | |
| 0203853010 | 08/23/01 | 1100 | -- | 758 | 7.9 | 5.7 | 142 | 25 | 21.2 | 19 |
| | 10/31/01 | 0905 | -- | 769 | 0.3 | 5.5 | 124 | 9.8 | 12.6 | 34 |
| | 10/31/01 | 0915 | -- | 769 | 0.3 | 5.5 | 124 | 9.8 | 12.6 | 34 |
| | 01/31/02 | 1050 | -- | 761 | 2.8 | 6.1 | 569 | 13.1 | 10.9 | 38 |
| | 04/24/02 | 1000 | 0.04 | 761 | 10.2 | 9 | 3900 | 12.7 | 11.7 | 68 |
| 0203853030 | 08/23/01 | 1315 | -- | 758 | 6.9 | 5.8 | 718 | 30.5 | 21.1 | 251 |
| | 11/01/01 | 1025 | -- | 766 | 0.3 | 6 | 830 | 14.2 | 13.9 | 292 |
| | 01/31/02 | 1145 | -- | 761 | 3.6 | 5.9 | 730 | 13.1 | 12.7 | 195 |
| | 04/24/02 | 1130 | 0.19 | 761 | 8.6 | 6.5 | 645 | 15.1 | 13.1 | 31 |
| 0203853050 | 08/23/01 | 1355 | -- | 758 | 7.2 | 6.3 | 434 | 32 | 20.9 | 84 |
| | 11/01/01 | 1345 | -- | 766 | 4 | 6 | 403 | 20.9 | 14.5 | 74 |
| | 01/31/02 | 1215 | -- | 761 | 6.9 | 6.1 | 459 | 13.3 | 12.3 | 70 |
| | 04/24/02 | 1250 | 0.23 | 761 | 7.9 | 6.6 | 476 | 18.1 | 13.8 | 79 |

Table 3. Field parameter data

[ft³/s, cubic feet per second; mm of Hg, millimeters of mercury; °C, degrees Celsius; uS/cm, microsiemens per centimeter at 25 °C; mg/L, milligrams per liter; CaCO₃, calcium carbonate; --, no data]

| Station Number | DATE | TIME | Discharge (ft ³ /s) | Barometric pressure (mm of Hg) | Dissolved oxygen (mg/L) | pH (units) | Specific conductance (uS/cm) | Air Temperature (°C) | Water Temperature (°C) | Alkalinity (mg/L as CaCO ₃) |
|---------------------------------------|----------|------|-----------------------------------|--------------------------------------|-------------------------------|---------------|------------------------------------|----------------------------|------------------------------|---|
| Fort Harrison Unit | | | | | | | | | | |
| 0203854210 | 08/22/01 | 1030 | 0 | 760 | 0.3 | 4.5 | 35 | 27.5 | 22.7 | 1 |
| | 11/02/01 | 1015 | 0 | 763 | 0.9 | 5 | 48 | 12.4 | 12.4 | 5 |
| | 01/24/02 | 1215 | -- | -- | -- | -- | -- | -- | -- | -- |
| | 01/24/02 | 1220 | 0 | 750 | 0.3 | 4.5 | 56 | 11.6 | 9.4 | 1 |
| | 04/22/02 | 1015 | 0 | 746 | 0.7 | 5.3 | 44 | 14.7 | 16.4 | 3 |
| 0203854250 | 04/22/02 | 0945 | 0.18 | 746 | 6.3 | 4.1 | 66 | 12.6 | 14.1 | 1 |
| Gaines Mill Unit | | | | | | | | | | |
| 0204243790 | 08/21/01 | 1000 | 0.12 | 756 | 7.6 | 5.9 | 54 | 23 | 23 | 6 |
| | 10/19/01 | 0910 | 0.07 | 759 | 10.5 | 6 | 52 | 4 | 9.2 | 5 |
| | 01/23/02 | 1400 | 0.38 | 758 | 11.6 | 5.4 | 54 | 7.1 | 5.7 | 3 |
| | 04/23/02 | 1015 | 0.5 | 757 | 8.4 | 6.5 | 59 | 16 | 11.3 | 9 |
| 0204243830 | 08/21/01 | 0915 | -- | 756 | 5.1 | 5.3 | 67 | 20 | 21.3 | 8 |
| | 10/18/01 | 1045 | -- | 763 | 4 | 5.7 | 61 | 8.5 | 9.8 | 8 |
| | 01/23/02 | 1020 | -- | 758 | 11.4 | 5.3 | 60 | 7 | 5.2 | 3 |
| | 04/23/02 | 0930 | -- | 757 | 6.2 | 6.2 | 57 | 11.1 | 14.6 | 9 |
| Malvern Hill and Glendale Unit | | | | | | | | | | |
| 0203874250 | 08/24/01 | 1300 | -- | 755 | 7.3 | 6.6 | 62 | 27 | 19.2 | 17 |
| | 10/30/01 | 1015 | -- | 764 | 3.6 | 5.3 | 58 | 12.1 | 9.6 | 15 |
| | 01/18/02 | 1150 | 0.08 | 755 | 9.3 | 6.1 | 63 | 11 | 8.8 | 17 |
| | 04/26/02 | 0945 | 0.14 | 760 | 7.4 | 6 | 96 | 16 | 12 | 12 |
| 0203874275 | 08/24/01 | 1400 | -- | 755 | 6.4 | 6.4 | 56 | 27 | 23.3 | 14 |
| | 10/29/01 | 1345 | -- | 766 | 7 | 5.8 | 70 | 9.8 | 10 | 17 |
| | 01/16/02 | 1045 | -- | 761 | 11.6 | 5.5 | 64 | 5.2 | 3.2 | 12 |
| | 04/25/02 | 1225 | -- | -- | -- | -- | -- | -- | -- | -- |
| | 04/25/02 | 1230 | 2.2 | 752 | 8 | 6.4 | 69 | 20.9 | 14.5 | 12 |
| 0203874770 | 08/24/01 | 1015 | -- | 756 | 2.2 | 5.1 | 52 | 27 | 22.1 | 11 |
| | 10/26/01 | 1025 | 0 | 751 | 7.2 | 5.2 | 74 | 12.9 | 11.8 | 14 |
| | 01/17/02 | 1400 | 0 | 755 | 10.5 | 5.7 | 80 | 11 | 6.2 | 3 |
| | 04/25/02 | 1015 | -- | 752 | 5.1 | 4.9 | 65 | 17.2 | 13.6 | 2 |
| 0203874785 | 08/24/01 | 0900 | -- | 758 | 5.5 | 5.6 | 94 | 26 | 25.8 | 27 |
| | 10/25/01 | 1130 | -- | 749 | 8.6 | 5.8 | 101 | 19.3 | 21.1 | 33 |

Table 3. Field parameter data[ft³/s, cubic feet per second; mm of Hg, millimeters of mercury; °C, degrees Celsius; uS/cm, microsiemens per centimeter at 25 °C; mg/L, milligrams per liter; CaCO₃, calcium carbonate; --, no data]

| Station Number | DATE | TIME | Discharge (ft ³ /s) | Barometric pressure (mm of Hg) | Dissolved oxygen (mg/L) | pH (units) | Specific conductance (uS/cm) | Air Temperature (°C) | Water Temperature (°C) | Alkalinity (mg/L as CaCO ₃) |
|----------------|----------|------|-----------------------------------|--------------------------------------|-------------------------------|---------------|------------------------------------|----------------------------|------------------------------|---|
| | 01/17/02 | 0935 | -- | 755 | 8.6 | 5.8 | 163 | 10.1 | 5.7 | 33 |
| | 04/25/02 | 0930 | -- | 752 | 3.3 | 6.5 | 149 | 14.4 | 17.5 | 26 |

Table 4. Nutrient data

[mg/L as N, milligrams per liter as nitrogen; <, less than; E, estimated value; --, no data]

| Station Number | DATE | TIME | Nitrogen, | Nitrogen, | Nitrogen, | Nitrogen | Nitrogen, | Nitrogen, | Nitrogen, | Nitrogen, | Nitrogen, | Nitrogen, | |
|--------------------------------|----------|------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| | | | ammonia, | ammonia+ | ammonia+ | | nitrate, | nitrate+ | nitrite, | nitrite | | | organic, |
| | | | dissolved | dissolved | total | dissolved |
| | | | (mg/L as N) |
| Beaver Dam Unit | | | | | | | | | | | | | |
| 02042433 | 08/20/01 | 1040 | <.040 | <.10 | <.08 | -- | -- | <.050 | <.006 | -- | -- | -- | |
| | 08/20/01 | 1045 | 0.117 | 0.35 | 0.5 | 1.3 | 0.935 | 0.945 | 0.01 | 0.23 | 0.38 | 1.4 | |
| | 10/16/01 | 1030 | <.040 | 0.23 | 0.25 | 1.1 | -- | 0.864 | <.008 | -- | -- | 1.1 | |
| | 01/29/02 | 1020 | 0.056 | 0.22 | 0.35 | 1.7 | -- | 1.44 | <.008 | 0.16 | 0.29 | 1.8 | |
| | 04/26/02 | 1200 | 0.124 | 0.41 | 0.53 | 1 | 0.621 | 0.635 | 0.014 | 0.28 | 0.41 | 1.2 | |
| Chickahominy Bluff Unit | | | | | | | | | | | | | |
| 0204243350 | 08/20/01 | 1210 | E.033 | 0.11 | 0.18 | 0.89 | -- | 0.781 | <.006 | -- | -- | 0.96 | |
| | 10/17/01 | 0930 | <.040 | E.06 | 0.1 | -- | -- | 0.562 | <.008 | -- | -- | 0.67 | |
| | 01/25/02 | 1050 | 0.057 | 0.13 | 0.25 | 0.86 | -- | 0.735 | <.008 | 0.07 | 0.19 | 0.98 | |
| | 04/22/02 | 1500 | 0.114 | 0.28 | 0.28 | 0.72 | -- | 0.445 | E.006 | 0.16 | 0.17 | 0.73 | |
| Cold Harbor Unit | | | | | | | | | | | | | |
| 0204243610 | 08/21/01 | 1200 | 0.135 | 0.37 | 0.42 | 1.3 | -- | 0.905 | E.003 | 0.24 | 0.29 | 1.3 | |
| | 10/23/01 | 1000 | E.022 | 0.18 | 0.48 | 0.39 | 0.188 | 0.213 | 0.025 | -- | -- | 0.69 | |
| | 01/22/02 | 1410 | E.028 | 0.13 | 0.31 | 0.53 | -- | 0.397 | <.008 | -- | -- | 0.71 | |
| | 04/26/02 | 1115 | 0.105 | 0.35 | 0.56 | -- | -- | <.050 | E.005 | 0.24 | 0.45 | -- | |
| 0204243650 | 08/21/01 | 1100 | E.021 | 0.19 | 0.27 | 2.6 | -- | 2.43 | <.006 | -- | -- | 2.7 | |
| | 10/22/01 | 1050 | <.040 | 0.11 | 0.15 | 2.6 | -- | 2.47 | <.008 | -- | -- | 2.6 | |
| | 01/22/02 | 1020 | E.026 | 0.16 | 0.16 | 2.7 | -- | 2.5 | <.008 | -- | -- | 2.7 | |
| | 04/23/02 | 1130 | <.040 | 0.21 | 0.48 | 2.3 | -- | 2.06 | <.008 | -- | -- | 2.5 | |
| Drewry's Bluff Unit | | | | | | | | | | | | | |
| 0203853010 | 08/23/01 | 1100 | <.040 | 0.13 | 0.18 | 3.7 | 3.61 | 3.61 | 0.006 | -- | -- | 3.8 | |
| | 10/31/01 | 0905 | <.040 | 0.15 | 0.48 | 0.67 | 0.345 | 0.523 | 0.178 | -- | -- | 1 | |
| | 10/31/01 | 0915 | <.040 | 0.15 | 0.41 | 0.68 | 0.347 | 0.526 | 0.179 | -- | -- | 0.94 | |
| | 01/31/02 | 1050 | 0.071 | 0.57 | 0.71 | 0.66 | -- | 0.092 | E.004 | 0.5 | 0.64 | 0.8 | |
| | 04/24/02 | 1000 | 0.211 | 0.82 | 1.1 | 1.1 | 0.237 | 0.276 | 0.039 | 0.61 | 0.86 | 1.3 | |
| 0203853030 | 08/23/01 | 1315 | <.040 | 12 | 10 | -- | -- | E.026 | <.006 | -- | -- | -- | |
| | 11/01/01 | 1025 | 11.1 | 13 | 12 | -- | -- | <.050 | 0.042 | 2 | 0.72 | -- | |
| | 01/31/02 | 1145 | 7.84 | 8.6 | 8.1 | -- | -- | <.050 | 0.023 | 0.79 | 0.23 | -- | |
| | 04/24/02 | 1130 | 0.369 | 0.84 | 0.91 | 0.96 | 0.105 | 0.115 | 0.01 | 0.47 | 0.54 | 1 | |
| 0203853050 | 08/23/01 | 1355 | 3.99 | 4.4 | 4.4 | 4.5 | 0.095 | 0.115 | 0.02 | 0.41 | 0.39 | 4.5 | |
| | 11/01/01 | 1345 | 3.87 | 4.4 | 4.4 | -- | -- | <.050 | <.008 | 0.56 | 0.53 | -- | |
| | 01/31/02 | 1215 | 3.38 | 3.4 | 3.7 | 3.6 | 0.154 | 0.18 | 0.026 | 0.03 | 0.33 | 3.9 | |
| | 04/24/02 | 1250 | 2.65 | 3.2 | 3.1 | 3.3 | 0.163 | 0.18 | 0.017 | 0.5 | 0.5 | 3.3 | |

Table 4. Nutrient data

[mg/L as N, milligrams per liter as nitrogen; <, less than; E, estimated value; --, no data]

| Station Number | DATE | TIME | Nitrogen, | Nitrogen, | Nitrogen, | Nitrogen, | Nitrogen, | Nitrogen, | Nitrogen, | Nitrogen, | Nitrogen, | Nitrogen, |
|---------------------------------------|----------|------|--------------------------------------|--|--|--------------------------|--------------------------------------|--|-------------------------------------|--------------------------------------|----------------------------------|----------------------|
| | | | ammonia, dissolved (mg/L as N) | ammonia+ organic, dissolved (mg/L as N) | ammonia+ organic, total (mg/L as N) | dissolved (mg/L as N) | nitrate, dissolved (mg/L as N) | nitrate+ nitrite, dissolved (mg/L as N) | nitrite dissolved (mg/L as N) | organic, dissolved (mg/L as N) | organic, total (mg/L as N) | total (mg/L as N) |
| Fort Harrison Unit | | | | | | | | | | | | |
| 0203854210 | 08/22/01 | 1030 | 0.407 | 0.94 | 1.9 | -- | -- | E.028 | E.004 | 0.53 | 1.4 | -- |
| | 11/02/01 | 1015 | 0.643 | 1.2 | 7.4 | -- | -- | <.050 | E.005 | 0.54 | 6.8 | -- |
| | 01/24/02 | 1215 | <.040 | <.10 | <.10 | -- | -- | <.050 | <.008 | -- | -- | -- |
| | 01/24/02 | 1220 | 0.353 | 1.3 | 1.4 | -- | -- | <.050 | E.005 | 0.99 | 1 | -- |
| | 04/22/02 | 1015 | 0.277 | 1.2 | 1.8 | -- | -- | E.027 | 0.008 | 0.96 | 1.6 | -- |
| 0203854250 | 04/22/02 | 0945 | <.040 | 0.14 | 0.17 | -- | -- | <.050 | <.008 | -- | -- | -- |
| Gaines Mill Unit | | | | | | | | | | | | |
| 0204243790 | 08/21/01 | 1000 | 0.043 | 0.35 | 0.46 | -- | -- | E.025 | <.006 | 0.31 | 0.41 | -- |
| | 10/19/01 | 0910 | <.040 | 0.19 | 0.57 | 0.24 | -- | 0.049 | <.008 | -- | -- | 0.62 |
| | 01/23/02 | 1400 | E.037 | 0.21 | 0.28 | 0.73 | -- | 0.513 | <.008 | -- | -- | 0.79 |
| | 04/23/02 | 1015 | 0.136 | 0.55 | 0.65 | 0.63 | -- | 0.08 | E.004 | 0.42 | 0.51 | 0.73 |
| 0204243830 | 08/21/01 | 0915 | 0.065 | 0.38 | 0.47 | 1.2 | -- | 0.782 | <.006 | 0.32 | 0.41 | 1.3 |
| | 10/18/01 | 1045 | 0.05 | 0.33 | 0.45 | -- | -- | E.031 | <.008 | 0.28 | 0.4 | -- |
| | 01/23/02 | 1020 | 0.053 | 0.23 | 0.31 | 0.79 | -- | 0.559 | <.008 | 0.18 | 0.26 | 0.87 |
| | 04/23/02 | 0930 | 0.131 | 0.58 | 0.76 | 0.8 | -- | 0.225 | E.005 | 0.45 | 0.63 | 0.99 |
| Malvern Hill and Glendale Unit | | | | | | | | | | | | |
| 0203874250 | 08/24/01 | 1300 | <.040 | 0.77 | 0.34 | -- | -- | <.050 | <.006 | -- | -- | -- |
| | 10/30/01 | 1015 | <.040 | <.10 | E.05 | -- | -- | <.050 | <.008 | -- | -- | -- |
| | 01/18/02 | 1150 | E.026 | <.10 | 1 | -- | -- | E.040 | <.008 | -- | -- | -- |
| | 04/26/02 | 0945 | 0.428 | 0.84 | 0.95 | 1.8 | 0.907 | 0.925 | 0.018 | 0.42 | 0.52 | 1.9 |
| 0203874275 | 08/24/01 | 1400 | <.040 | 0.63 | 0.5 | -- | -- | <.050 | <.006 | -- | -- | -- |
| | 10/29/01 | 1345 | <.040 | 0.21 | 0.31 | -- | -- | <.050 | <.008 | -- | -- | -- |
| | 01/16/02 | 1045 | 0.083 | 0.27 | 0.36 | 0.41 | -- | 0.139 | <.008 | 0.19 | 0.28 | 0.5 |
| | 04/25/02 | 1225 | <.040 | E.05 | <.10 | -- | -- | <.050 | <.008 | -- | -- | -- |
| | 04/25/02 | 1230 | 0.112 | 0.49 | 0.72 | 0.55 | -- | 0.061 | <.008 | 0.38 | 0.61 | 0.78 |
| 0203874770 | 08/24/01 | 1015 | E.027 | 0.38 | 1.1 | -- | -- | E.037 | <.006 | -- | -- | -- |
| | 10/26/01 | 1025 | 0.9 | 2.2 | 8.8 | -- | -- | <.050 | <.008 | 1.3 | 7.9 | -- |
| | 01/17/02 | 1400 | 0.094 | 0.35 | 0.45 | 0.57 | -- | 0.22 | <.008 | 0.25 | 0.35 | 0.67 |
| | 04/25/02 | 1015 | <.040 | 0.75 | 0.91 | -- | -- | E.043 | <.008 | -- | -- | -- |
| 0203874785 | 08/24/01 | 0900 | <.040 | E.07 | 1.4 | -- | -- | 0.059 | <.006 | -- | -- | 1.5 |
| | 10/25/01 | 1130 | <.040 | 0.86 | 1.6 | -- | -- | <.050 | <.008 | -- | -- | -- |
| | 01/17/02 | 0935 | 1.75 | 3.1 | 6.3 | 3.3 | 0.222 | 0.237 | 0.015 | 1.3 | 4.5 | 6.5 |

Table 4. Nutrient data

[mg/L as N, milligrams per liter as nitrogen; <, less than; E, estimated value; --, no data]

| Station Number | DATE | TIME | Nitrogen, ammonia, dissolved (mg/L as N) | Nitrogen, ammonia+ organic, dissolved (mg/L as N) | Nitrogen, ammonia+ organic, total (mg/L as N) | Nitrogen dissolved (mg/L as N) | Nitrogen, nitrate, dissolved (mg/L as N) | Nitrogen, nitrate+ nitrite, dissolved (mg/L as N) | Nitrogen, nitrite dissolved (mg/L as N) | Nitrogen, organic, dissolved (mg/L as N) | Nitrogen, organic, total (mg/L as N) | Nitrogen, total (mg/L as N) |
|----------------|----------|------|---|---|---|--------------------------------------|---|---|--|---|---|-----------------------------------|
| | 04/25/02 | 0930 | 0.478 | 1.7 | 2 | -- | -- | E.036 | 0.01 | 1.2 | 1.6 | -- |

Table 4. Nutrient data--Continued

[mg/L as P, milligrams per liter as phosphorus; <, less than; E, estimated value]

| Station Number | DATE | TIME | Phosphorus | | |
|--------------------------------|----------|------|----------------------------------|------------------------------|------------------------------|
| | | | Phosphorus dissolved (mg/L as P) | ortho, dissolved (mg/L as P) | Phosphorus total (mg/L as P) |
| Beaver Dam Unit | | | | | |
| 02042433 | 08/20/01 | 1040 | <.006 | <.020 | <.004 |
| | 08/20/01 | 1045 | <.006 | <.020 | 0.05 |
| | 10/16/01 | 1030 | E.003 | <.020 | 0.023 |
| | 01/29/02 | 1020 | E.004 | <.020 | 0.025 |
| | 04/26/02 | 1200 | 0.016 | E.009 | 0.041 |
| Chickahominy Bluff Unit | | | | | |
| 0204243350 | 08/20/01 | 1210 | <.006 | <.020 | 0.009 |
| | 10/17/01 | 0930 | <.004 | <.020 | 0.006 |
| | 01/25/02 | 1050 | E.003 | <.020 | 0.021 |
| | 04/22/02 | 1500 | 0.006 | <.020 | 0.02 |
| Gold Harbor Unit | | | | | |
| 0204243610 | 08/21/01 | 1200 | E.004 | <.020 | 0.021 |
| | 10/23/01 | 1000 | E.003 | <.020 | 0.089 |
| | 01/22/02 | 1410 | E.003 | <.020 | 0.018 |
| | 04/26/02 | 1115 | 0.012 | <.020 | 0.03 |
| 0204243650 | 08/21/01 | 1100 | E.004 | <.020 | 0.01 |
| | 10/22/01 | 1050 | E.003 | <.020 | 0.009 |
| | 01/22/02 | 1020 | E.002 | <.020 | 0.007 |
| | 04/23/02 | 1130 | 0.009 | <.020 | 0.013 |
| Drewry's Bluff Unit | | | | | |
| 0203853010 | 08/23/01 | 1100 | 0.018 | E.010 | 0.027 |
| | 10/31/01 | 0905 | 0.013 | <.020 | 0.048 |
| | 10/31/01 | 0915 | 0.012 | <.020 | 0.051 |
| | 01/31/02 | 1050 | 0.079 | 0.057 | 0.094 |
| | 04/24/02 | 1000 | 0.682 | 0.653 | 0.755 |
| 0203853030 | 08/23/01 | 1315 | E.005 | <.020 | 0.059 |
| | 11/01/01 | 1025 | 0.007 | 0.044 | 0.068 |
| | 01/31/02 | 1145 | 0.008 | 0.124 | 0.049 |
| | 04/24/02 | 1130 | 0.037 | 0.022 | 0.094 |
| 0203853050 | 08/23/01 | 1355 | <.006 | <.020 | 0.008 |
| | 11/01/01 | 1345 | <.004 | <.020 | 0.015 |
| | 01/31/02 | 1215 | E.003 | 0.026 | 0.009 |
| | 04/24/02 | 1250 | 0.004 | <.020 | 0.034 |

Table 4. Nutrient data--Continued

[mg/L as P, milligrams per liter as phosphorus; <, less than; E, estimated value]

| Station Number | DATE | TIME | Phosphorus | | |
|---------------------------------------|----------|------|----------------------------------|------------------------------|------------------------------|
| | | | Phosphorus dissolved (mg/L as P) | ortho, dissolved (mg/L as P) | Phosphorus total (mg/L as P) |
| Fort Harrison Unit | | | | | |
| 0203854210 | 08/22/01 | 1030 | 0.048 | E.015 | 0.165 |
| | 11/02/01 | 1015 | 0.144 | 0.097 | 0.413 |
| | 01/24/02 | 1215 | E.003 | <.020 | <.004 |
| | 01/24/02 | 1220 | 0.167 | 0.087 | 0.169 |
| | 04/22/02 | 1015 | 0.161 | 0.1 | 0.288 |
| 0203854250 | 04/22/02 | 0945 | 0.006 | <.020 | 0.011 |
| Gaines Mill Unit | | | | | |
| 0204243790 | 08/21/01 | 1000 | E.005 | <.020 | 0.023 |
| | 10/19/01 | 0910 | E.003 | <.020 | 0.014 |
| | 01/23/02 | 1400 | E.004 | <.020 | 0.01 |
| | 04/23/02 | 1015 | 0.01 | <.020 | 0.042 |
| 0204243830 | 08/21/01 | 0915 | <.006 | <.020 | 0.024 |
| | 10/18/01 | 1045 | 0.004 | <.020 | 0.03 |
| | 01/23/02 | 1020 | 0.005 | <.020 | 0.013 |
| | 04/23/02 | 0930 | 0.013 | <.020 | 0.073 |
| Malvern Hill and Glendale Unit | | | | | |
| 0203874250 | 08/24/01 | 1300 | 0.019 | <.020 | 0.03 |
| | 10/30/01 | 1015 | 0.005 | <.020 | 0.013 |
| | 01/18/02 | 1150 | E.003 | E.009 | 0.006 |
| | 04/26/02 | 0945 | 0.027 | E.012 | 0.055 |
| 0203874275 | 08/24/01 | 1400 | 0.01 | <.020 | 0.035 |
| | 10/29/01 | 1345 | <.004 | <.020 | 0.023 |
| | 01/16/02 | 1045 | 0.006 | <.020 | 0.025 |
| | 04/25/02 | 1225 | <.004 | <.020 | <.004 |
| | 04/25/02 | 1230 | 0.011 | <.020 | 0.063 |
| 0203874770 | 08/24/01 | 1015 | 0.008 | <.020 | 0.107 |
| | 10/26/01 | 1025 | 0.061 | <.020 | 0.585 |
| | 01/17/02 | 1400 | 0.01 | <.020 | 0.025 |
| | 04/25/02 | 1015 | 0.026 | <.020 | 0.079 |
| 0203874785 | 08/24/01 | 0900 | 0.006 | <.020 | 0.209 |
| | 10/25/01 | 1130 | 0.028 | <.020 | 0.174 |
| | 01/17/02 | 0935 | 0.046 | E.015 | 0.454 |
| | 04/25/02 | 0930 | 0.104 | 0.053 | 0.347 |

Table 5. Bacteria data

[col/100 mL, colonies per 100 milliliters; --, no data; k, non-ideal colony count, <, less than; E, estimated value]

| Station Number | DATE | TIME | Total coliform (col/100 mL) | Fecal coliform (col/100 mL) | Fecal streptococcus (col/100 mL) |
|--------------------------------|----------|------|-----------------------------|-----------------------------|----------------------------------|
| Beaver Dam Unit | | | | | |
| 02042433 | 08/20/01 | 1040 | -- | -- | -- |
| | 08/20/01 | 1045 | -- | 470 | 340 |
| | 10/16/01 | 1030 | 710 | 56k | 38k |
| | 01/29/02 | 1020 | 100 | 67 | E10k |
| | 04/26/02 | 1200 | 430 | 110 | 220 |
| Chickahominy Bluff Unit | | | | | |
| 0204243350 | 08/20/01 | 1210 | -- | 310 | 300 |
| | 10/17/01 | 0930 | 1300 | 310 | 72k |
| | 01/25/02 | 1050 | 420 | 67 | 1200 |
| | 04/22/02 | 1500 | 4200 | 680 | 580 |
| Cold Harbor Unit | | | | | |
| 0204243610 | 08/21/01 | 1200 | -- | E63 | 420 |
| | 10/23/01 | 1000 | 730 | 95k | 110k |
| | 01/22/02 | 1410 | 160 | E10 | 100 |
| | 04/26/02 | 1115 | 1400 | E14 | E52 |
| 0204243650 | 08/21/01 | 1100 | 1600 | 570 | 6800 |
| | 10/22/01 | 1050 | 1400 | 280 | 590 |
| | 01/22/02 | 1020 | 350 | 210 | 140 |
| | 04/23/02 | 1130 | 1300 | 87 | 200 |
| Drewry's Bluff Unit | | | | | |
| 0203853010 | 08/23/01 | 1100 | -- | 44k | 1000 |
| | 10/31/01 | 0905 | 5200 | 28k | <10 |
| | 10/31/01 | 0915 | 5200 | 28k | <10 |
| | 01/31/02 | 1050 | -- | 190 | 520k |
| | 04/24/02 | 1000 | E2500 | 950 | 2400 |
| 0203853030 | 08/23/01 | 1315 | 150k | 32k | 75k |
| | 11/01/01 | 1025 | 180 | <5 | <5 |
| | 01/31/02 | 1145 | 650 | <3 | E6 |
| | 04/24/02 | 1130 | -- | 330 | 1100 |
| 0203853050 | 08/23/01 | 1355 | 800 | 400 | 330k |
| | 11/01/01 | 1345 | 180k | <10 | 17k |
| | 01/31/02 | 1215 | 160 | <3 | E6 |
| | 04/24/02 | 1250 | -- | E58 | 110 |

Table 5. Bacteria data

[col/100 mL, colonies per 100 milliliters; --, no data; k, non-ideal colony count, <, less than; E, estimated value]

| Station Number | DATE | TIME | Total coliform (col/100 mL) | Fecal coliform (col/100 mL) | Fecal streptococcus (col/100 mL) |
|---------------------------------------|----------|------|--------------------------------|--------------------------------|-------------------------------------|
| Fort Harrison Unit | | | | | |
| 0203854210 | 08/22/01 | 1030 | 120k | <10 | <10 |
| | 11/02/01 | 1015 | 620 | <5 | <7 |
| | 01/24/02 | 1215 | -- | -- | -- |
| | 01/24/02 | 1220 | 130k | 50k | 10k |
| | 04/22/02 | 1015 | -- | 510 | 73 |
| 0203854250 | 04/22/02 | 0945 | 1000 | 220 | 370 |
| Gaines Mill Unit | | | | | |
| 0204243790 | 08/21/01 | 1000 | -- | 200 | 820 |
| | 10/19/01 | 0910 | 740 | 16k | 160 |
| | 01/23/02 | 1400 | 440 | E10 | E38 |
| | 04/23/02 | 1015 | 1400 | 93 | 180 |
| 0204243830 | 08/21/01 | 0915 | | 1200 | 2600 |
| | 10/18/01 | 1045 | 960 | 100 | 84k |
| | 01/23/02 | 1020 | 270 | 29k | 160 |
| | 04/23/02 | 0930 | 2600 | 290 | 330 |
| Malvern Hill and Glendale Unit | | | | | |
| 0203874250 | 08/24/01 | 1300 | 830 | 8k | 300k |
| | 10/30/01 | 1015 | 400 | 160 | 170 |
| | 01/18/02 | 1150 | 110 | E9 | 40 |
| | 04/26/02 | 0945 | 500 | E40 | 80 |
| 0203874275 | 08/24/01 | 1400 | 1200 | 410 | 480 |
| | 10/29/01 | 1345 | 720 | 340 | 190k |
| | 01/16/02 | 1045 | E63 | E20 | E47 |
| | 04/25/02 | 1225 | -- | -- | -- |
| | 04/25/02 | 1230 | 2000 | 740 | 920 |
| 0203874770 | 08/24/01 | 1015 | 2400 | 58k | 420 |
| | 10/26/01 | 1025 | -- | 29k | 1600 |
| | 01/17/02 | 1400 | 160 | E21 | 83 |
| | 04/25/02 | 1015 | -- | 700 | 320 |
| 0203874785 | 08/24/01 | 0900 | 140k | 100k | 230k |
| | 10/25/01 | 1130 | 700 | 190 | 82k |
| | 01/17/02 | 0935 | 170 | 120 | 110 |
| | 04/25/02 | 0930 | 560 | E39 | <5 |

Table 6. Major-element data

[mg/L, milligrams per liter; <, less than; E, estimated value; --, no data]

| Station Number | DATE | TIME | Calcium, dissolved (mg/L as Ca) | Magnesium, dissolved (mg/L as Mg) | Potassium, dissolved (mg/L as K) | Sodium, dissolved (mg/L as Na) | Acid Neutralizing capacity (mg/L as CaCO ₃) | Chloride, dissolved (mg/L as Cl) | Fluoride, dissolved (mg/L as F) | Silica, dissolved (mg/L as SiO ₂) | Sulfate, dissolved (mg/L as SO ₄) |
|--------------------------------|----------|------|---------------------------------------|---|--|--------------------------------------|---|--|---------------------------------------|---|---|
| Beaver Dam Unit | | | | | | | | | | | |
| 02042433 | 08/20/01 | 1040 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 08/20/01 | 1045 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 10/16/01 | 1030 | 4.15 | 2.8 | 2.75 | 8.5 | 20 | 13.3 | E.1 | 4.9 | 3.6 |
| | 01/29/02 | 1020 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 04/26/02 | 1200 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Chickahominy Bluff Unit | | | | | | | | | | | |
| 0204243350 | 08/20/01 | 1210 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 10/17/01 | 0930 | 7.82 | 2.43 | 2.66 | 14.2 | 15 | 25.5 | E.1 | 10.3 | 13.1 |
| | 01/25/02 | 1050 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 04/22/02 | 1500 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Cold Harbor Unit | | | | | | | | | | | |
| 0204243610 | 08/21/01 | 1200 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 10/23/01 | 1000 | 2.58 | 1.77 | 1.49 | 4 | 18 | 5.3 | <.1 | 8.8 | 0.7 |
| | 01/22/02 | 1410 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 04/26/02 | 1115 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 0204243650 | 08/21/01 | 1100 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 10/22/01 | 1050 | 1.11 | 2.81 | 1.36 | 5.9 | 5 | 9.6 | <.1 | 7.5 | 0.5 |
| | 01/22/02 | 1020 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 04/23/02 | 1130 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Drewry's Bluff Unit | | | | | | | | | | | |
| 0203853010 | 08/23/01 | 1100 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 10/31/01 | 0905 | 5.22 | 1.84 | 2.94 | 13.8 | 36 | 10.4 | <.1 | 15.9 | 5.7 |
| | 10/31/01 | 0915 | 5.22 | 1.84 | 2.94 | 13.8 | 36 | 10.4 | <.1 | 15.9 | 5.7 |
| | 01/31/02 | 1050 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 04/24/02 | 1000 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 0203853030 | 08/23/01 | 1315 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 11/01/01 | 1025 | 11.3 | 7.65 | 13.9 | 69.8 | 163 | 94.2 | <.1 | 6.8 | 2 |
| | 01/31/02 | 1145 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 04/24/02 | 1130 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 0203853050 | 08/23/01 | 1355 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 11/01/01 | 1345 | 14.6 | 8.66 | 11.3 | 32.5 | 74 | 70.2 | 0.1 | 14.1 | 5 |
| | 01/31/02 | 1215 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 04/24/02 | 1250 | -- | -- | -- | -- | -- | -- | -- | -- | -- |

Table 7. Trace-element data--Continued

[ug/L, micrograms per liter; <, less than; --, no data; E, estimated value; M, presence verified, not quantified]

| Station Number | DATE | TIME | Lead, total (ug/L as Pb) | Lithium, total (ug/L as Li) | Manganese, total (ug/L as Mn) | Mercury, total (ug/L as Hg) | Molybdenum, total (ug/L as Mo) | Nickel, total (ug/L as Ni) | Selenium, total (ug/L as Se) | Silver, total (ug/L as Ag) | Zinc, total (ug/L as Zn) |
|---------------------------------------|----------|------|--------------------------------|-----------------------------------|-------------------------------------|-----------------------------------|--------------------------------------|----------------------------------|------------------------------------|----------------------------------|--------------------------------|
| Fort Harrison Unit | | | | | | | | | | | |
| 0203854210 | 08/22/01 | 1030 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 11/02/01 | 1015 | 12 | <4.4 | 296 | <.01 | <1.8 | 8 | <4.0 | <.30 | 37 |
| | 01/24/02 | 1215 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 01/24/02 | 1220 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 04/22/02 | 1015 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 0203854250 | 04/22/02 | 0945 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Gaines Mill Unit | | | | | | | | | | | |
| 0204243790 | 08/21/01 | 1000 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 10/19/01 | 0910 | M | <4.4 | 15 | <.01 | <1.8 | <2 | <2.0 | <.30 | <25 |
| | 01/23/02 | 1400 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 04/23/02 | 1015 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 0204243830 | 08/21/01 | 0915 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 10/18/01 | 1045 | M | <4.4 | 56 | <.01 | <1.8 | <2 | <2.0 | <.30 | <25 |
| | 01/23/02 | 1020 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 04/23/02 | 0930 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Malvern Hill and Glendale Unit | | | | | | | | | | | |
| 0203874250 | 08/24/01 | 1300 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 10/30/01 | 1015 | <1 | <4.4 | 32 | <.01 | <1.8 | E1 | <2.0 | <.30 | <25 |
| | 01/18/02 | 1150 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 04/26/02 | 0945 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 0203874275 | 08/24/01 | 1400 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 10/29/01 | 1345 | <1 | <4.4 | 91 | <.01 | <1.8 | <2 | <2.0 | <.30 | <25 |
| | 01/16/02 | 1045 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 04/25/02 | 1225 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 04/25/02 | 1230 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 0203874770 | 08/24/01 | 1015 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 10/26/01 | 1025 | 8 | <4.4 | 1500 | 0.02 | <1.8 | 3 | <2.0 | <.30 | E20 |
| | 01/17/02 | 1400 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 04/25/02 | 1015 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 0203874785 | 08/24/01 | 0900 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 10/25/01 | 1130 | 5 | <4.4 | 1270 | <.01 | <1.8 | E1 | <2.0 | <.30 | <25 |

