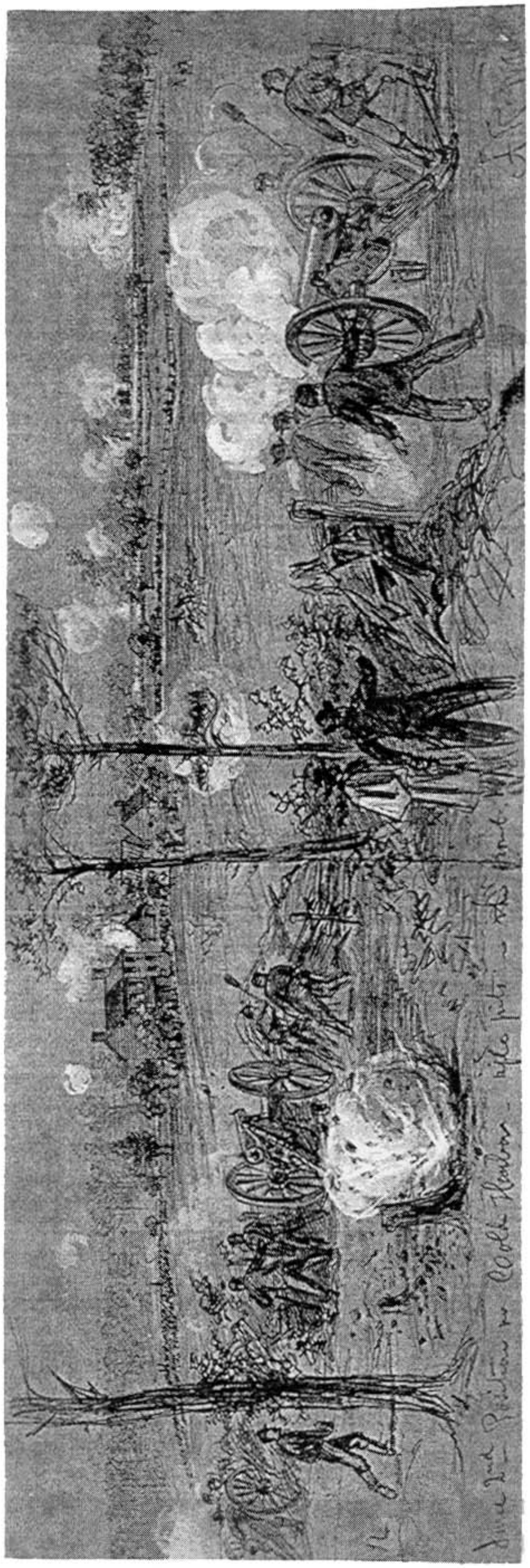

WATER RESOURCES MANAGEMENT PLAN

COLD HARBOR AND GAINES' MILL UNITS

RICHMOND NATIONAL BATTLEFIELD PARK

VIRGINIA

Water Resources Management Plan

Cold Harbor and Gaines' Mill Units
Richmond National Battlefield Park, Virginia

August 2000

Karen C. Rice
U.S. Geological Survey
Virginia District
Richmond, VA

in cooperation with:

David L. Vana-Miller

and

Mark D. Flora
Water Resources Division
National Park Service
Ft. Collins, CO

Approved by: Cynthia MacLeod 8/7/00

Superintendent
Richmond National Battlefield Park — Date

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EXECUTIVE SUMMARY

Richmond National Battlefield Park (Richmond NBP) consists of 764 acres in 11 geographically individual units that are located primarily east, northeast and southeast of the city of Richmond, Virginia. This Water Resources Management Plan addresses the Cold Harbor (including the Gathright House) and the Gaines' Mill units. These two units are located in the Atlantic Coastal Plain Physiographic Province between the James and York rivers. The small streams that drain each of the units are tributaries of the Chickahominy River and ultimately contribute to the Chesapeake Bay.

Little specific information is known about water quantity, water quality, wetland and riparian areas, and the water-dependent flora and fauna in the park units. Although it appears that the quality of water is good in the park units, encroaching suburban development threatens the future integrity of the water and aquatic biota on parklands.

Water-resources related issues discussed in this report include the following:

- Adequacy of current water-quality information for assessing potential water-quality degradation from nonpoint-source pollution related to changing land use -- Currently there are no baseline data to document the present water quality in the park units. Projection of future population growth in the lands surrounding the park units indicates that development likely will occur, along with associated nonpoint-source pollution, which will directly affect the quality of water in the park units.
- Wetland and riparian resource management -- There have been no inventories of riparian flora and fauna in the park units. Assessment of the existing riparian flora and fauna is important for identifying threatened and endangered species and for establishing a baseline of information against which future changes in quality and diversity can be made.
- Adequacy of inventory of water-dependent flora and fauna -- Likewise, there have been no inventories of water-dependent flora and fauna in the park units. This lack of documentation makes it impossible to detect changes in, or deterioration of, the resources, determine the presence/absence of state and federally listed species, and detect the presence and potential impacts of invasive exotic species.

Discussion of these issues is followed by proposed project statements designed to address the water-resources issues. The first project statement describes a biological monitoring activity that would establish a baseline of water-quality ratings in streams in the park units. The second project statement describes procedures to assess the proper functioning condition of riparian areas and associated flora and fauna in the park units. And the third project statement describes procedures to conduct a comprehensive inventory of water-dependent flora and fauna to determine the status of existing species, the presence of additional rare, threatened, or endangered species, and the presence of invasive exotic species.

INTRODUCTION

Richmond National Battlefield Park (Richmond NBP) is 110 miles south of Washington, D.C., in east-central Virginia, and comprises 764 acres adjacent to the city of Richmond (Figure 1). The park contains 11 geographically separated units, located primarily east, northeast and southeast of the city of Richmond. Ten of the units are associated with McClellan's 1862 Peninsula Campaign and/or Grant's 1864 Overland Campaign during the Civil War. The 11^{th} unit, which was the site of the Confederacy's Chimborazo Hospital, is the main park Visitor's Center, located within the city limits. Richmond NBP was established by federal legislation in 1936 to "protect the Civil War battlefield resources associated with the struggle for the capital of the Confederacy and to interpret these resources so as to foster an understanding of their larger significance" (National Park Service 1996).

Competing pressures on parkland, such as encroaching development, existing development outside of park boundaries, nonpoint-source pollutants, proximity to point-source pollutants, natural processes, and expected changes in land use are potential threats to the integrity of water quality and quantity in the park. Because of these pressures and potential degradation to the natural resources in the park, this Water Resources Management Plan (WRMP), with a focus on water-resource issues in the Cold Harbor and Gaines' Mill units, was written for Richmond NBP.

PARK SETTING

The Cold Harbor and Gaines' Mill units are between the James and York rivers, east of the transition zone (the Fall Line) between the Piedmont and Atlantic Coastal Plain physiographic provinces. Both units are on the U.S. Geological Survey (USGS) Seven Pines, Virginia, 1:24,000-scale topographic quadrangle. The units are northeast of the city of Richmond in proximity to one another in southeastern Hanover County, approximately 5 miles southeast of Mechanicsville (Figure 1). Cold Harbor, the northernmost of the two, consists of approximately 149 acres and is located along the north side of State Route 156. For this report, the Garthright House, which is a restored house that served as a Federal field hospital during the Battle of Cold Harbor, is included as part of the Cold Harbor unit. The Garthright House lies on a 2.1-acre parcel of land just to the east of the Cold Harbor unit and on the south side of State Route 156. The Gaines' Mill unit, approximately 0.75 mile to the southwest of the Cold Harbor unit, consists of approximately 60 acres and lies along State Route 718.

WATER RESOURCES MANAGEMENT PLAN

A water resources management plan supports the decision-making process of the National Park Service related to the protection, conservation, use and management of a park's water resources. The water resources management plan is a component of a park's overall resource management program and serves as a supplemental implementation plan appended to the park's Resource Management Plan (RMP). By compiling pertinent information about the park's water resources and water-related environments, and by

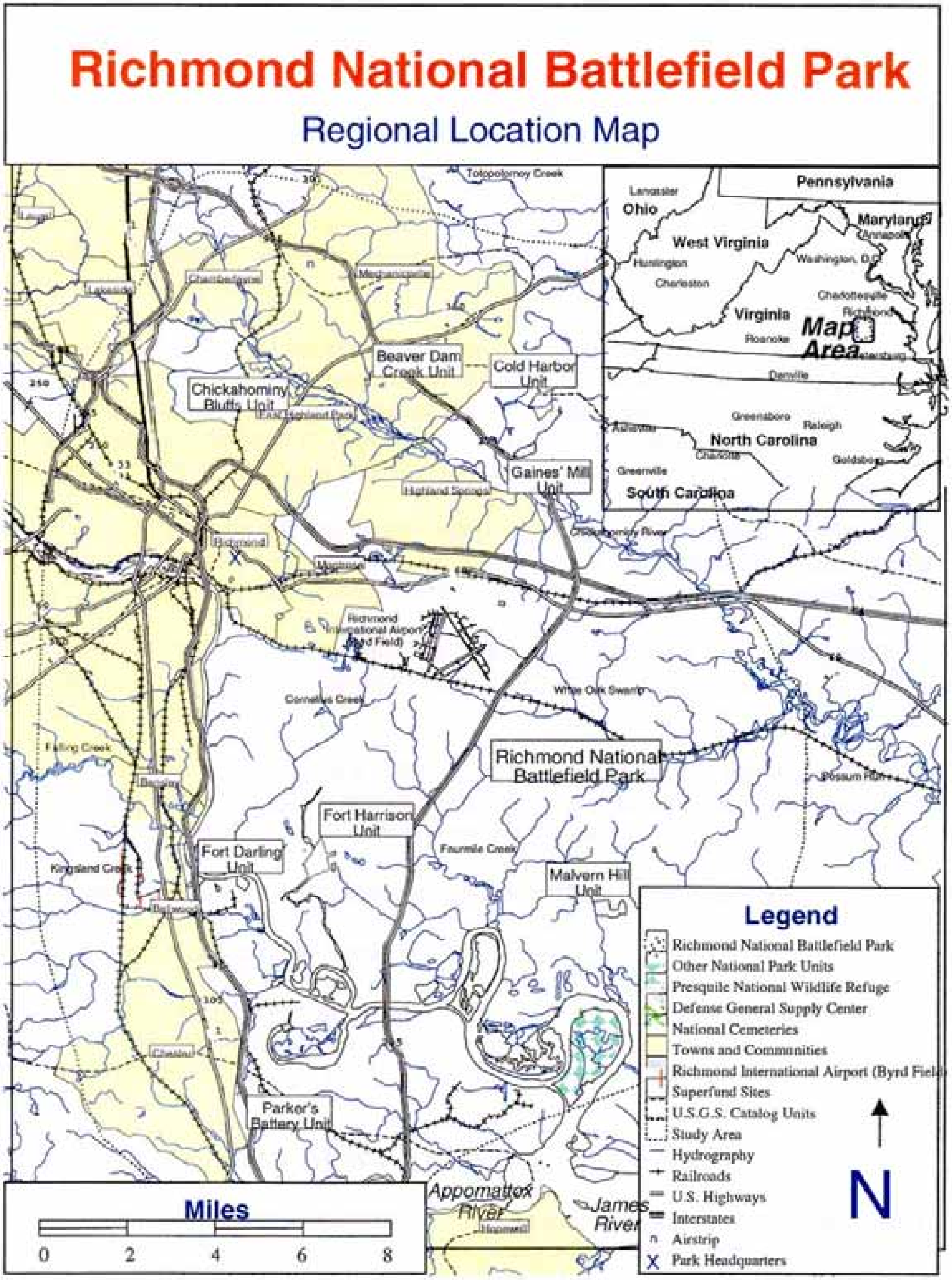

Figure 1. Map of location of Richmond National Battlefield Park.

identifying water-resources issues facing the park, the water resources management plan assists management in developing and evaluating alternative actions for addressing these issues and selecting a preferred course of action.

Actions recommended in the water resources management plan are incorporated into the RMP through the development of Project Statements. Project Statements are standard National Park Service programming documents that describe a problem or issue, discuss actions to deal with it, and identify additional staff and/or funds needed to carry out the proposed actions. Project Statements are planning tools used to identify problems and needed actions, and programming documents used to compete with other projects and park units for funds and staff.

Project Statements address water issues within the context of a suite of management objectives that are either formulated during the water-resources management planning process or during some previous planning process, such as the RMP or General Management Plan. Specific management objectives for Richmond NBP previously identified in the RMP (National Park Service 1994) are as follows:

1) To identify, evaluate, protect, restore and preserve park cultural resources important to the understanding of the military actions during the 1862 Peninsula Campaign and the 1864 and 1865 battle actions that resulted in the final struggle for Richmond;

2) To provide a historical context that will foster public understanding of battlefield actions, military strategies, and the role of the City of Richmond during the Civil War;

3) To promote the identification and conservation of important Richmond area Civil War battlefields and associated resources not currently in park ownership through cooperative Federal, State, County and private actions;

4) To make all of the units easily available and accessible to the visitor; and

5) To interpret each site in its overall historical context.

The common thread among Project Statements, issues and management objectives is the cornerstone of issue-driven planning. Three Project Statements designed to address water-resource issues specific to the Cold Harbor and Gaines' Mill units are included in this plan.

HISTORICAL CONTEXT OF WATER-RELATED RESOURCES

Waterways constitute significant features in the Coastal Plain of eastern Virginia. Major hydrologic features such as the Rappahannock, Pamunkey, North Anna, and Chickahominy rivers served as natural lines for the defense of Richmond throughout the Civil War. Federal commanders McClellan, Meade and Grant had to take these watery obstacles into account when planning any approach to Richmond from the north or northeast. On the other hand, rivers such as the Rappahannock, Pamunkey, and James also provided the vital supply routes for the Federal army during both the Peninsula (1862) and Overland (1864) campaigns (Inners et al. 1995). While the water-related terrain features at the battles of Gaines' Mill (1862) and Cold Harbor (1864) were more subtle, they may be considered as contributory factors in both tactics and troop movements that led to success or failure during those costly battles.

The battles of Gaines' Mill (June 27, 1862) and Cold Harbor (May 31 to June 12, 1864) took place on the upland Coastal Plain between Totopotomoy Creek and the Chickahominy River (Figure 2). Elevations ranged from about 125 feet in the ravines of tributary streams such as Bloody Run to about 185 feet on the ridges. The sand and gravel deposits that form the Coastal Plain afforded excellent opportunity for entrenching and the rapid construction of military rifle pits and earthworks (Inners et al. 1995).

The Battle of Gaines' Mill, which occurred on the 3'd day of the Seven Days' Battle, was the largest and costliest of the Peninsula Campaign (Sears 1992). The actual attacks occurred in a north-south orientation, centered on a plateau located southeast of Gaines' Mill. The plateau rose from 40 to 80 feet above the drainage of Boatswain Creek, a tributary of the Chickahominy River. Rising at the northeast corner of the plateau and curving around its northern and western sides, Boatswain Creek was selected as an easily definable terrain feature for establishing the first Federal line of defense. While not a formidable military obstacle, the banks and bottomlands were heavily overgrown with trees and underbrush, providing cover for the defending troops. Also, the ground to the north and west of the creek (over which the Confederate forces would mount their attack) was largely under cultivation, open, and gently sloping, providing good fields of fire. On the Federal side of the creek the bank rose sharply, which allowed the Federal commander, Fitz-John Porter, to arrange his main defensive line on the plateau above the creek facing north and west in the shape of an archer's bow approximately one and three quarters mile long (Sears 1992). As Porter did not consider his force strong enough to extend his line back to the Chickahominy, he took advantage of another water-related feature, anchoring his line on Elder Swamp, where he correctly assumed that the broken, swampy ground would be sufficient to discourage a flanking movement by the Confederate forces (Figure 2; Sears 1992). While the Confederate forces, due largely to superior coordination and tactics, were ultimately successful in routing the Federal V Corps, they did so only with high casualties.

The Battle of Cold Harbor (May 31 to June 12, 1864) was fought in an east-west orientation over a six-mile front extending from Totopotomoy Creek in the north to the Chickahominy River in the south. The gently sloping ground was not a promising place for an offensive, and consisted largely of a nondescript landscape of fields, forests and swampy ravines. Federal offensive tactics that resulted primarily in a number of poorly coordinated, frontal assaults against entrenched Confederate positions were largely ineffective, except for inducing disastrous levels of Federal casualties. Numerous participants from both the Union and Confederate sides were not exaggerating when they described the slaughter that occurred during the major Federal assault on June 3`d, 1864 as being more akin to "murder" than to "war" (Baltz 1994).

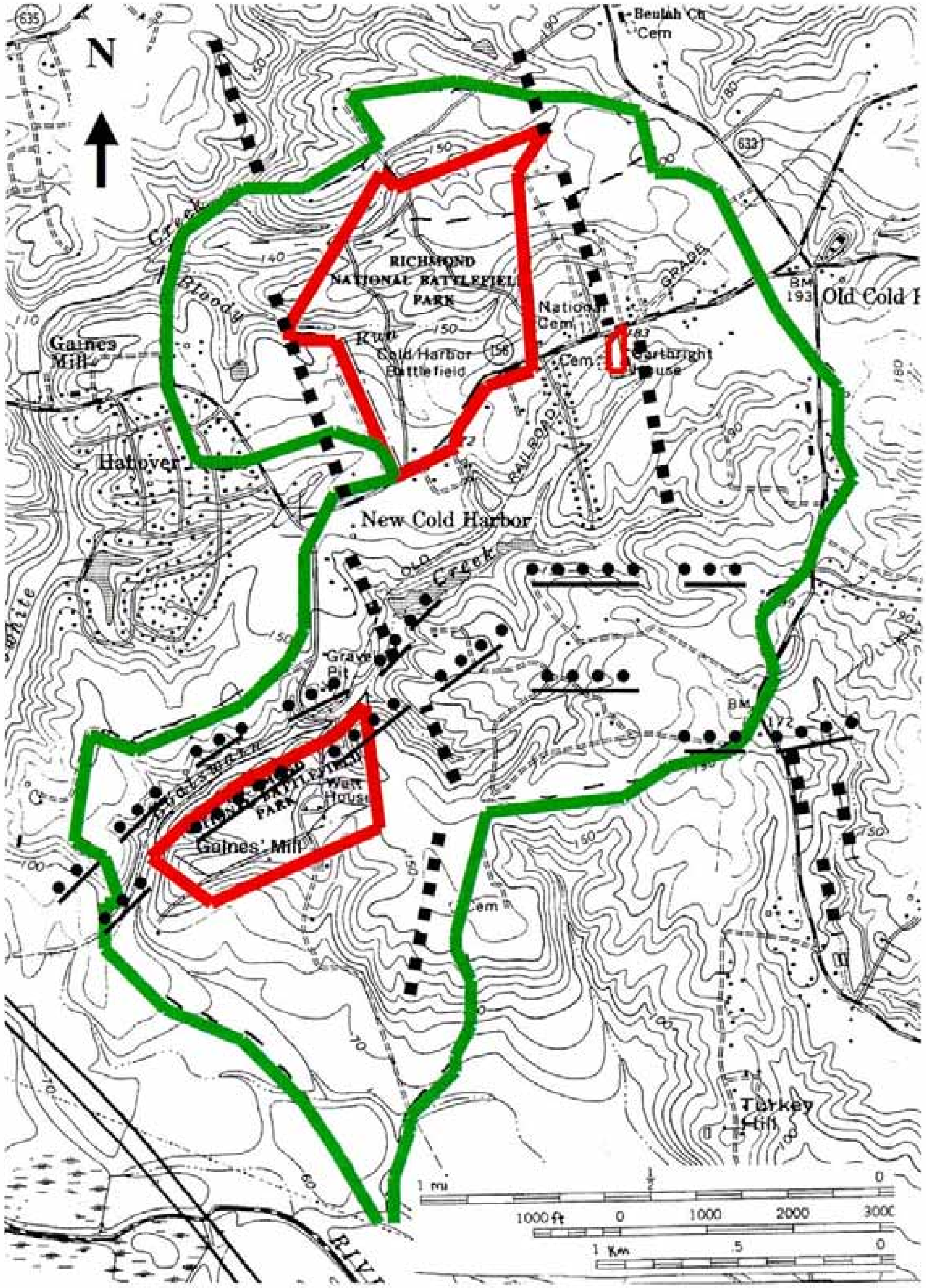

Figure 2. General location of Civil War Troops during the battles of 1862 (roughly east-west dotted lines) and 1864 (roughly north-south dotted lines) in relation to the watershed area of the tributaries (green) of the Cold Harbor and Gaines' Mill units (red) (based on Kennedy 1998).

Water-related features also were contributory factors to Federal successes on June 1st, 1864. At that time, the Federal VI Corps and XVIII Corps were positioned just west of Old Cold Harbor. North of the Cold Harbor Road, three swampy ravines, each of which intersected the Confederate lines, drain west into Gaines' Mill Pond (Figure 2). After a failed late afternoon frontal assault south of the Cold Harbor Road, elements of the Federal VI Corps mounted an early evening assault north of the Cold Harbor Road. Federal troops advancing west happened upon an undefended break in the Confederate lines within the southern-most ravine, and in the only coordinated Federal action of the evening, overpowered Confederate forces north and south of this ravine. As light faded, the Federal breakthrough resulted in confused, hand-to-hand fighting so fierce that this southern-most ravine became known as Bloody Run (Patrick Brady, pers. comm. 2000). Federal commanders, however, failed to take advantage of the resulting 'A-mile breakthrough in the Confederate lines, and the Federal advance was finally stopped short after several hours of fierce combat by Confederate artillery and reinforcements (Patrick Brady, pers. comm. 2000).

Terrain and its associated water-related features also were contributory factors to the Federal failure on June 3rd. At 0430, elements of the Federal II, VI and XVIII Corps attacked well-entrenched Confederate positions both south and north of the Cold Harbor Road. The charge of nearly 50,000 Federal troops was shattered within one hour, with 6,006 Federal soldiers either killed or wounded in what is generally considered one of the most futile and costly frontal assaults of the war (Baltz 1994). Once again, a lack of knowledge of the terrain and poor coordination contributed to the failure. Swampy ground and ravines caused difficulties for both Hancock's II Corps and Smith's XVIII Corps. South of the Cold Harbor Road, elements of Barlow's division (II Corps) were able to slog through the swamps and temporarily gain some of the Confederate earthworks, although a delay in reinforcing them turned his penetration into a trap rather than an offensive wedge (Baltz 1994). Just to their north (but still to the south of the Cold Harbor Road), elements of Gibbon's division (II Corps) encountered swampy ground in the headwaters of Boatswain Creek, which caused the attacking units to be divided and to diverge during the assault, exposing them to withering flanking fire.

North of the Cold Harbor Road, swampy ground and ravines were also influencing the tactics and movements of Smith's XVIII Corps. The center of the three ravines that flow into Gaines' Mill Pond was used as an avenue of approach to the Confederate lines by Martindale's division (XVIII Corps). However, the ravine was narrow and the Federal troops became bogged down by marshy ground in front of the newly reinforced Confederate line, where Confederate musketry and artillery trapped them with cruel effect, virtually mowing them down (Baltz 1994).

Comparison of historical accounts with the present-day terrain appears to indicate that certain areas of the Gaines' Mill and Cold Harbor battlefields were wetter in the 1860s than they are today (Patrick Brady, pers. comm. 2000). While this has never been verified by data, research techniques are available that potentially could delineate those areas that may have been more swamp-like in character than they are today. This research would be difficult, and most of the areas discussed above are outside the current park boundary, but a project statement outlining the necessary research could be developed at the park's request.

PLANNING CONSIDERATIONS

The lands and waters of Richmond NBP are subject to myriad regulatory, planning, and management authorities, at least in part because of the geographic separation of the units. Many federal, state and local agencies have an interest, mandated or otherwise, in the water resources within the park. Protection of water resources requires an understanding of the various policy, regulatory, and management designations to facilitate coordination of all agency efforts and other landowners within the watershed. The following section of this report describes federal, state, and local legislation, regulatory designations and management oversight authorities that apply to Richmond NBP.

Federal Legislation, Policies, and Executive Orders

National Park Service Organic Act (1916)

In 1916 Congress created the National Park Service to:

> promote and regulate the use of the federal areas known as national parks, monuments, and reservations....by such means and measures as to conform to the fundamental purpose of said parks, monuments, and reservations, which purpose is to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such a manner and by such means as will leave them unimpaired for the enjoyment of future generations (National Park Service Organic Act, 16 USC 1).

The dual, and sometimes conflicting, mandates to preserve and protect resources while providing for their enjoyment by the public often complicates park management. Achieving a balance is at the heart of most decisions affecting the management of the park.

In recognition of the growing diversity of units and resources in the national park system, Congress reinforced the primary mandate in 1970 with legislation stating that all park lands are united by a common preservation purpose, regardless of title or designation. Hence, all water resources in the national park system, including Richmond NBP, whose purpose is cultural, are protected equally, and it is the fundamental duty of the National Park Service to protect those resources unless exceptions are specifically provided for by Congress.

Federal Water Pollution Control Act (Clean Water Act) (1972)

The Federal Water Pollution Control Act, more commonly know as the Clean Water Act, was first promulgated in 1972 and amended in 1977, 1987, and 1990. This law was designed to restore and maintain the integrity of the nation's waters. Goals set by the act were swimmable and fishable waters by 1983 and no further discharge of pollutants into the nation's waterways by 1985. The two strategies for achieving these goals were a major grant program to assist in the construction of municipal sewage treatment facilities and a program of "effluent limitations" designed to limit the amount of pollutants that could be discharged.

As part of the act, Congress recognized the primary role of the states in managing and regulating the nation's water quality within the general framework developed by Congress. All federal agencies must comply with the requirements of state law for water quality management, regardless of other jurisdictional status or land ownership. States implement the protection of water quality under the authority granted by the Clean Water Act through best management practices and through water-quality standards. Best management practices are defined by the U.S. Environmental Protection Agency as methods, measures or practices selected by an agency to meet its nonpoint control needs. These practices include but are not limited to structural and non-structural controls and operations and maintenance procedures. They can be applied before, during and after pollution-producing activities to reduce or eliminate the introduction of pollutants into receiving waters. Water-quality standards consist of the designated use or uses made of a water body or segment, water-quality criteria necessary to protect those uses and an anti-degradation provision that may protect the existing water quality.

Section 402 of the Clean Water Act requires that a National Pollutant Discharge Elimination System (NPDES) permit be obtained for the discharge of pollutants from any point source into the waters of the United States. "Point source", "waters of the United States" and "pollutants" are all broadly defined under the act, but generally all discharges and storm-water runoff from municipalities, major industrial and transportation activities, and certain construction activities must be covered under a NPDES program permit. The U.S. Environmental Protection Agency usually delegates NPDES permitting authority to a state. The state, through the permit process, establishes the effluent limitations and monitoring requirements for the types and quantities of pollutants that may be discharged into its waters. Under the antidegradation policy, the state must also insure that the approval of any NPDES permit will not eliminate or otherwise impair any designated uses of the receiving waters.

Section 404 of the Clean Water Act requires that a permit be issued for discharge of dredged or fill materials in waters of the United States including wetlands. The U.S. Army Corps of Engineers administers the Section 404 permit program with oversight veto powers held by the U.S. Environmental Protection Agency. The U.S. Environmental Protection Agency, the U.S. Fish and Wildlife Service and the National Marine Fisheries Service provide advice on the environmental impacts of proposed projects. National Park Service activities associated with wetlands are managed under Executive Order 11990, discussed later in this section.

Section 10 of the Rivers and Harbors Appropriations Act of 1899, as amended (33 USC 403)

This was the first general legislation giving the U.S. Army Corps of Engineers jurisdiction and authority over the protection of navigable waters. Navigable waters of the United States are those waters that are subject to the ebb and flow of the tide and/or are presently used, have been used in the past, or may be susceptible for use to transport interstate or foreign commerce. U.S. Army Corps of Engineers permits are required under Section 10 for structures and/or work in or affecting navigable waters of the United States.

The U.S. Army Corps of Engineers began regulation of wetlands under the Rivers and Harbors Act, and then received a much broader grant of jurisdictional authority under the Clean Water Act. Because of the broader geographic reach of "waters of the United States" jurisdiction under the Clean Water Act, Rivers and Harbors Act jurisdiction usually will not be of significance to wetlands regulation in current cases. There are, however, several situations in which Rivers and Harbors Act jurisdiction alone will be available: when an exemption from Section 404 coverage applies, and when activities, as opposed to waters, are covered by the Rivers and Harbors Act and not the Clean Water Act. For instance, the mooring of houseboats in a bay may require a permit under the Rivers and Harbors Act, but would not be under the jurisdiction of the Clean Water Act.

Floodplain Management (Executive Order 11988)

This executive order requires all federal agencies to "reduce the risk of flood loss, ...minimize the impacts of floods on human safety, health and welfare, and ... restore and preserve the natural and beneficial values weaved by floodplains" (Goldfarb 1988). Federal agencies are therefore required to implement floodplain planning and consider all feasible alternatives that minimize impacts prior to construction of facilities or structures. Construction of such facilities must be consistent with federal flood insurance and floodplain management programs. To the extent possible, park facilities should be located outside these areas. National Park Service guidance pertaining to Executive Order 11988 can be found in Floodplain Management Guidelines (National Park Service 1993).

Protection of Wetlands (Executive Order 11990)

This executive order requires all federal agencies to "minimize the destruction, loss or degradation of wetlands, and preserve and enhance the natural and beneficial values of wetlands" (Goldfarb 1988). Unless no practical alternatives exist, federal agencies must avoid activities in wetlands that have the potential to adversely affect the integrity of the ecosystem. National Park Service guidance for compliance with Executive Order 11990 can be found in Director's Order 77-1: Wetlands Protection, (National Park Service 1998a).

Water Quality Improvement Act (1970)

This act requires federally regulated activities to have state certification ensuring that water-quality standards are not violated.

Endangered Species Act (1973)

The Endangered Species Act requires the National Park Service to identify and promote the conservation of all federally listed endangered, threatened or candidate species within park boundaries. Specifically, Section 7 of the act requires all federal agencies to consult with the U.S. Fish and Wildlife Service to ensure that any action authorized, funded, or carried out by the agency does not jeopardize the continued existence of listed species or critical habitat. While not required by legislation, it is the National Park Service's policy to also identify state and locally listed species of concern, and to cooperate with appropriate state agencies to ensure protection of those species and their habitats within the park.

Safe Drinking Water Act (1974) and Amendments (1986)

The Safe Drinking Water Act is implemented by each state in order to ensure that public water supplies are safe. The National Park Service must comply with state regulations regarding the construction, operation, and monitoring of its public water-supply system. Important aspects of this act include the underground injection and well-head protection programs. Specific agency guidance is available in National Park Service Director's Order 83: Public Health (National Park Service 2000).

National Environmental Policy Act (1969)

The National Environmental Policy Act (NEPA) established a general federal policy for the responsibility of each generation as trustee of the environment for the succeeding generations. Specifically, NEPA requires that an environmental impact statement (EIS) be prepared as part of the review and approval process by federal agencies of major actions that significantly affect the quality of human life. The primary purposes of an EIS are to ensure that there is an evaluation of the impacts of proposed projects and to facilitate public review. An environmental assessment may be prepared prior to initiating an EIS in order to determine if the preparation of an EIS is required. Specific agency guidance is available in National Park Service Director's Order 12: Conservation Planning and Environmental Impact Analysis (National Park Service, in preparation).

Regulations implementing NEPA require the cooperation of federal agencies in the NEPA process. The regulations also encourage the reduction of duplication through cooperation of federal agencies with state and local agencies, including early efforts of joint planning, joint hearings and joint environmental assessments.

An environmental assessment is not included as part of this water resources management plan because this plan provides a general direction for the water resources program for the park. Where appropriate, compliance with NEPA will be undertaken for specific actions resulting from this plan, when it becomes apparent that individual actions, or groups of actions, will be implemented.

National Park Service Management Policies and Guidelines

The National Park Service Management Policies (National Park Service 1988) provide broad policy guidance for the management of units of the National Park System. Policy topics include park planning, land protection, natural and cultural resource management, wilderness preservation and management, interpretation and education, special uses of the parks, park facilities design, and concessions management.

Agreement of Federal Agencies on Ecosystem Management in the Chesapeake Bay

In 1994, the Secretary of the Interior and the Director of the National Park Service joined in signing the *Agreement of Federal Agencies on Ecosystem Management in the Chesapeake Bay*. This agreement committed the NPS to work together with the states, federal agencies and other Chesapeake Bay Program partners to manage the Chesapeake Bay watershed as a cohesive ecosystem. On the forefront of a growing national watershed protection trend, the Chesapeake Bay Executive Council's *Adoption Statement on Riparian Forest Buffers* sets ambitious goals for riparian buffer protection to further both nutrient-reduction and habitat-restoration goals. Goals of the Executive Council include the following:

1) To assure, to the extent feasible, that all streams and shorelines will be protected by a forested or other riparian buffer;

2) To conserve existing forests along all streams and shorelines; and

3) To increase the use of all riparian buffers and restore riparian forests on 2,010 miles of stream and shoreline in the watershed by 2010, targeting efforts where they will be of greatest value to water quality and living resources.

In response, the National Park Service developed a Chesapeake Bay *Riparian Buffer Protection Plan* (National Park Service 1998b) to provide appropriate guidance for riparian buffer planning. Through this plan, National Park Service units within the Chesapeake Bay watershed are required to assure, to the extent feasible, that a forested or other riparian buffer protects all streams and shorelines on the 1,128 miles of perennial and intermittent stream corridors that exist within the National Park Service units within the Chesapeake Bay watershed. In addition to conserving the existing buffers, the National Park Service will seek opportunities to restore or improve an additional 35 miles of riparian buffer within its units within the watershed (National Park Service 1998b).

Commonwealth of Virginia Statutes and Designations

The State Water Control Board promulgates Virginia's water regulations, including regulation of permits, permit fees, ground-water management, ground-water withdrawal and petroleum storage tanks. The Virginia Department of Environmental Quality administers the federal Clean Water Act and enforces state laws to improve the quality of Virginia's streams, rivers, bays and ground water for aquatic life, human health and other water uses. Permits are issued to businesses, industries, local governments and individuals that take into account physical, chemical and biological standards for water quality.

Virginia Pollutant Discharge Elimination System (VPDES) permits

The federal Clean Water Act enables the U.S. Environmental Protection Agency to authorize the states to implement certain U.S. Environmental Protection Agency responsibilities. One of these responsibilities is the authority to issue NPDES permits. The U.S. Environmental Protection Agency has authorized Virginia to issue NPDES permits. These permits, when issued by Virginia, are called Virginia Pollutant Discharge Elimination System (VPDES) permits. These permits carry the weight of both federal and state laws and regulations, and are enforceable under both state and federal authority. The Virginia Department of Environmental Quality requires VPDES permits for all point-source discharges (such as ditches or pipes) to surface waters by businesses, governments or individuals. The U.S. Environmental Protection Agency maintains authority to review applications and permits for "major" dischargers, a distinction based on discharge quantity and content.

The federal Water Quality Act of 1987 requires permits for certain industrial stormwater discharges and larger municipal stormwater systems. The Virginia Department of Environmental Quality regulates these stormwater discharges also through VPDES permits.

Stormwater Management Programs

The Virginia Department of Environmental Quality, the Virginia Department of Conservation and Recreation, and the Chesapeake Bay Local Assistance Department are coordinating three new and separate state programs that regulate the management of pollution carried by stormwater runoff. The programs were developed from separate. state and federal laws passed to address surface-water contamination from land-use activities.

The federal Clean Water Act requires cities and urbanized counties having populations of more than 100,000 to develop stormwater management plans and obtain discharge permits for stormwater outfalls. In Virginia, this program is handled by the Virginia Department of Environmental Quality, which issues VPDES permits to localities. Companies must submit applications to the Virginia Department of Environmental Quality to ensure that stormwater discharges that enter streams directly from industrial facilities also are permitted.

The Virginia Stormwater Management Act enables local governments to establish management plans and adopt ordinances that require control and treatment of stormwater runoff to prevent flooding and contamination of local waterways. Local programs must meet or exceed the minimum standards contained in regulations. Under the act, state agencies must employ management practices whether or not the locality in which a state facility is to be located has a program.

The Chesapeake Bay Preservation Act establishes requirements for stormwater management within Chesapeake Bay preservation areas in all Tidewater localities. Under this legislation, each local government enforces its own program, which has been patterned on a model developed by the Chesapeake Bay Local Assistance Board and Department (see section entitled "Local Legislation and Designations.")

<u>Ground Water Management</u>

Under the Ground Water Management Act of 1992, Virginia manages ground water through a program regulating the withdrawals in certain areas called ground-water management areas. Those wishing to withdraw 300,000 gallons per month or more must apply for and receive a ground-water withdrawal permit. Currently, there are two ground-water management areas in the state: the Eastern Shore and eastern Virginia.

<u>Petroleum Storage Tanks Regulation</u>

The Virginia Department of Environmental Quality regulates aboveground and underground petroleum storage tanks to ensure compliance with applicable regulations. The agency also manages all petroleum corrective action activities, including Corrective Action Plan permits for cleanup of underground storage tank leaks, and reimbursement of eligible costs to responsible parties.

<u>Surface Water Management</u>

The Surface Water Management Act of 1989 and associated regulations apply a principle similar to ground-water management to areas where surface-water resources have a history of low-flow conditions that threaten important instream and off-stream uses. The Commonwealth has the responsibility to ensure that adequate surface flow of water in streams is maintained at levels that allow for the variety of potential uses, including minimum flows during periods of drought, assimilation of treated wastewater, and support of aquatic and other water-dependent wildlife.

The Virginia Department of Environmental Quality 's surface-water withdrawal permit program became effective June 3, 1992. As needed, the Virginia Department of Environmental Quality designates surface-water management areas throughout the state. Each area is declared by a separate regulation that establishes a low water flow level for streams, below which permit limits for withdrawals from the streams become effective.

Water withdrawals of 300,000 or more gallons per month in a surface-water management area are required to have a surface-water withdrawal permit if new, or to have a surface-water withdrawal certificate to continue withdrawing surface water. Permits and certificates will include a conservation plan that is activated during low-flow conditions in the surface-water source.

Dredged Material

If a project requires a federal permit for discharges of dredged material into waterways or wetlands, or for other instream activities, the Virginia Department of Environmental Quality will review the project for issuance of a Virginia Water Protection permit, formerly called 401 certification.

Virginia Water-Quality Standards (Statutory Authority: § 62.1-44.15(3a) of the Code of Virginia)

The State Water Control Board mandates the protection of existing high-quality state waters and provides for the restoration of all other state waters so they will permit reasonable public uses and will support the growth of aquatic life. The adoption of water-quality standards under Section 62.1-44.15(3a) of the law is one of the Virginia Department of Environmental Quality 's methods of fulfilling the law's purpose.

Water-quality standards consist of statements that describe water-quality requirements. They also contain numeric limits for specific physical, chemical, biological or radiological characteristics of water. These statements and numeric limits describe the quality of water necessary to meet and maintain uses such as swimming and other water-based recreation, public-water supply, and the propagation and growth of aquatic life.

The standards are intended to protect all state waters for recreation, wildlife, the growth of a balanced population of aquatic life, and the production of edible and marketable fish and shellfish. Through the protection of these uses, other uses such as industrial water supply, irrigation and navigation also are usually protected. Should additional standards be needed to protect other uses as dictated by changing circumstances or improved knowledge, they will be adopted.

Selected Virginia Water-Quality Standards are attached in Appendix B, and the entire document can be found at < http://www.deq.state.va.us/water/wqstnd.html >.

Wetlands Protection Act

The Wetlands Protection Act decrees that it is unlawful to excavate in a wetland. Further, on or after October 1, 2001, except in compliance with an individual or general Virginia Water Protection Permit, it shall also be unlawful to conduct the following activities in a wetland: (i) new activities to cause draining that significantly alters or degrades existing wetland acreage or functions, *(ii)* filling or dumping, *(iii)* permanent flooding or impounding, or (iv) new activities that cause significant alteration or degradation of existing wetland acreage or functions.

Chesapeake Bay Preservation Act

In 1980, the legislatures of Virginia and Maryland established an organization that would coordinate the legislative planning efforts between the states in the restoration of the Chesapeake Bay. This organization was called the Chesapeake Bay Commission. In 1985, Pennsylvania joined the effort. Between 1983 and 1987, the Chesapeake Bay Commission, the U.S. Environmental Protection Agency, Washington D.C., and separate representatives from Virginia, Maryland and Pennsylvania worked together to form an agreement of goals and priorities for cleaning up the Chesapeake Bay. Finally, in 1987, the Chesapeake Bay Agreement was signed and became the basis for each state to create and implement programs to clean up the Chesapeake Bay.

The Virginia General Assembly responded to the Chesapeake Bay Agreement by enacting the Chesapeake Bay Preservation Act in 1988. The Bay Act established a cooperative program between state and local government aimed at reducing nonpointsource pollution. The Bay Act Program is designed to improve water quality in the Chesapeake Bay and its tributaries by requiring wise resource management practices in the use and development of environmentally sensitive land features. At the heart of the Bay Act is the idea that land can be used and developed in ways that minimize impact on water quality. The first sentence of the Bay Act serves as a theme for the entire statute: "Healthy state and local economies and a healthy Chesapeake Bay are integrally related; balanced economic development and water-quality protection are not mutually exclusive."

The Bay Act established the Chesapeake Bay Local Assistance Board and the Chesapeake Bay Local Assistance Department. The Chesapeake Bay Local Assistance Board developed regulations to provide guidance to localities creating their own Chesapeake Bay Preservation Programs. The Chesapeake Bay Local Assistance Department is the state agency that provides staff support to the Local Assistance Board in carrying out the requirements of the Bay Act. Major Department efforts in implementing the Bay Act include administering a competitive grants program for localities and planning districts, providing training for local government planners and engineers, and reviewing local comprehensive plans and ordinances for compliance. Once the Chesapeake Bay Local Assistance Board approved the regulations, each locality was given one year to establish its Chesapeake Bay Preservation Areas and enforcement mechanisms by incorporating development performance criteria through a separate ordinance or by revisions to existing zoning and subdivision ordinances.

As part of Virginia's efforts to help achieve the nutrient reduction goals for the Chesapeake Bay, nutrient reduction strategies are being developed for each of Virginia's Chesapeake Bay tributaries. The Virginia Department of Conservation and Recreation, working in cooperation with the Virginia Department of Environmental Quality and the Chesapeake Bay Local Assistance Department, is the lead agency for developing the nonpoint-source portion of Virginia's Tributary Strategies. The strategy for the Potomac and Shenandoah River basins has been written (the executive summary can be found at < http://www.state.va.us/– dcr/sw/ptexcsum.htm >. Activities are also underway to develop tributary strategies for the Rappahannock, York and James River basins. A key to achieving the nutrient reduction goals for each of these rivers will be the involvement of local governments, Soil and Water Conservation Districts, planning district commissions, and local businesses and interest groups.

Local Legislation and Designations

Local governments have programs to control some of the potential problems for surface water created by land-use changes. These include floodplain ordinances, stormwater management, and erosion- and sediment-control programs. Local governments also implement the Chesapeake Bay Preservation Act, which requires setbacks from streams to protect water quality. Some of these programs receive assistance from the local Soil and Water Conservation District. The Hanover-Caroline Soil and Water Conservation District, Tappahannock Regional Office, serves the area in which the two park units are located. The Soil and Water Conservation District conducts programs to help farmers prevent pollution by reducing farm runoff that can carry excess sediment, fertilizers, and pesticides into waterways. Water-quality protection is also required for forestry activities to protect streams from excess sediment resulting from the construction of logging roads or from crossing streams to harvest trees. In addition, Soil and Water Conservation District staff administer nonpoint-source pollution control programs required by state law. These programs include erosion and sediment control, stormwater management, nutrient management, agricultural best management practices, shoreline erosion control, floodplain management, dam safety, and public beach conservation.

Local governments must amend their zoning ordinances, subdivision ordinances, and comprehensive plans to incorporate water-quality protection measures consistent with the Bay Act Regulations. The Bay Act Regulations use a "resource-based approach" that recognizes differences between various landforms and treats them differently. The Bay Act Regulations address nonpoint-source pollution by identifying and preserving certain lands called Chesapeake Bay Preservation Areas, Resource Protection Areas, and Resource Management Areas. By carefully managing land uses within these areas, local governments help reduce the water-quality impacts of nonpoint-source pollution and improve the health of the Chesapeake Bay. Local governments have flexibility to develop water-quality preservation programs that reflect unique local characteristics and embody other community goals.

The lands that make up Chesapeake Bay Preservation Areas are those that have the potential to impact water quality most directly. Chesapeake Bay Preservation Areas are lands "which, if improperly developed, may result in substantial damage to the water quality of the Chesapeake Bay and its tributaries." These lands include Resource Protection Areas and Resource Management Areas. Local governments are required to map the natural features that must be considered in designating Chesapeake Bay Preservation Areas. Development in all Chesapeake Bay Preservation Areas must meet general performance criteria that are designed to reduce nonpoint-source pollution and/or protect sensitive lands from disturbance. These criteria include the following:

- Preserve natural vegetation;
- Minimize disturbance of land;
- Minimize impervious cover such as paving;
- Strictly control soil erosion during land clearing and construction;
- Control stormwater runoff and its quality;
- Pump out septic tanks once every five years;
- Provide a reserve drainfield for septic tanks, which equals the waste treatment capacity of the primary drainfield;
- Subject all development to site plan review; and
- Control stormwater quality in agricultural and forested areas.

Resource Protection Areas are lands at or near the shoreline that have an intrinsic water-quality value due to the ecological and biological processes they perform. These lands may help to protect water quality or be easily damaged by the impacts of development. Local governments must include tidal wetlands, certain nontidal wetlands, tidal shores, and other lands that are especially important to water quality in the Resource Protection Areas. A Resource Protection Area must also include a buffer area, of 100 feet, measured from the landward side of these natural features.

Resource Management Areas are lands that protect the values of the Resource Protection Area. Improper development in these areas will have an adverse impact on water quality. Floodplains, highly erodible soils, steep slopes, highly permeable soils, other nontidal wetlands and other lands necessary to protect water quality are to be considered by local governments in delineating Resource Management Areas. A Resource Management Area must be designated landward of and contiguous to all Resource Protection Areas.

LAND USE/ZONING

Many park management and resource protection issues are a result of the complex pattern of land ownership and land use within the watershed surrounding the park unit.

Current land use in both units of the park is approximately 70% forested and 30% open in agricultural use. In the Gaines' Mill unit, the agricultural areas are planted in a variety of crops, which have included hay, wheat, soybeans, millet, and other low-growing crops, depending on the season (Land and Community Associates 1999). The surrounding area outside of park boundaries generally consists of open uplands in agricultural use and wooded stream corridors with swampy bottomlands.

In 1990, the population of Hanover County was 63,306; population is projected to rise to 142,200 by 2020 (a 124% growth rate) (National Park Service 1996). The current Land Use Plan for Hanover County (Lee Garman, County of Hanover, pers. comm. 2000), named Vision 2017, zones the area north of Route 156 for phased suburban development, which would commence in the 2002-2007 timeframe (Figure 3 a-b). The phased

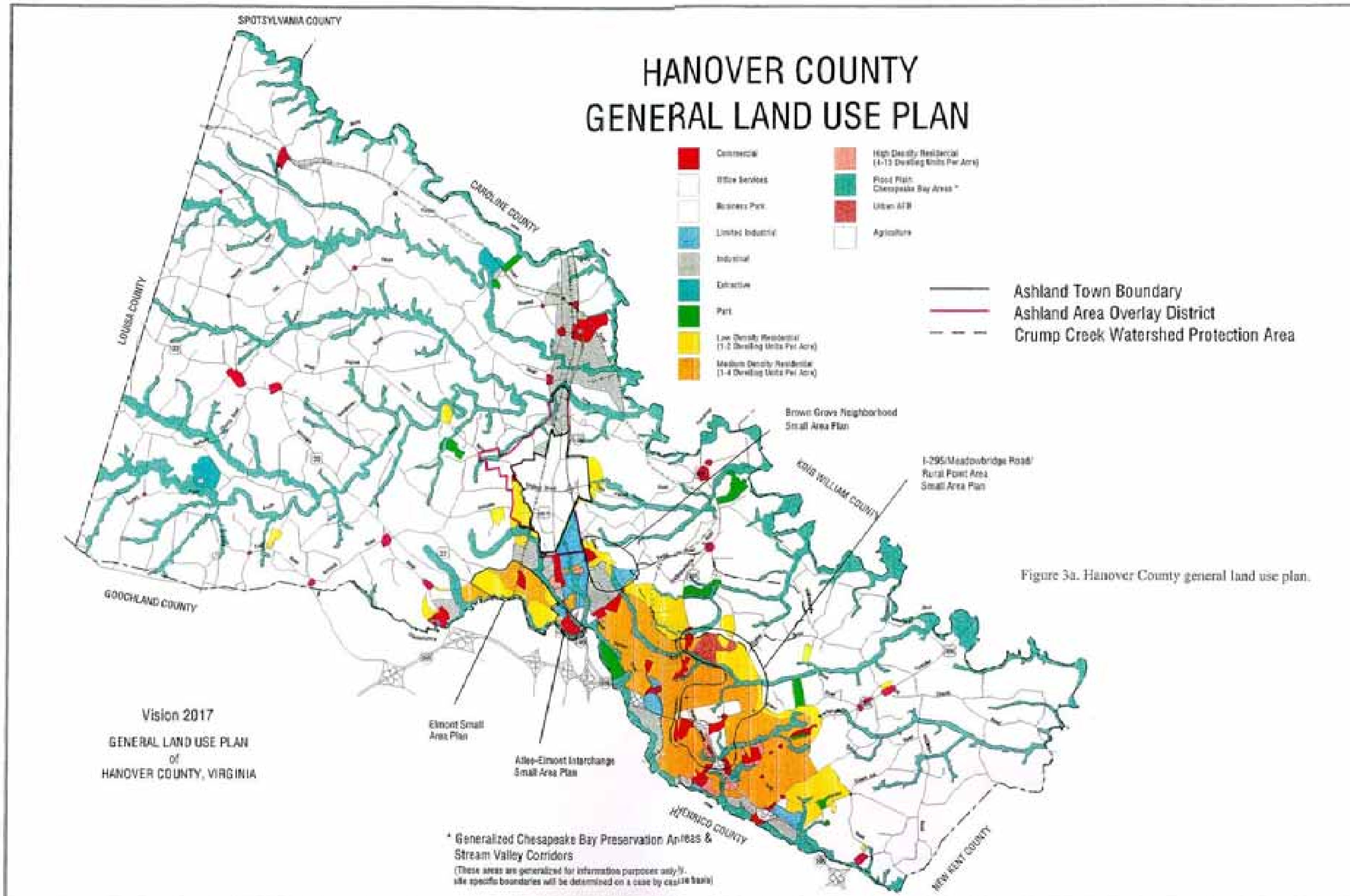

Figure 3a. Hanover County general land use plan.

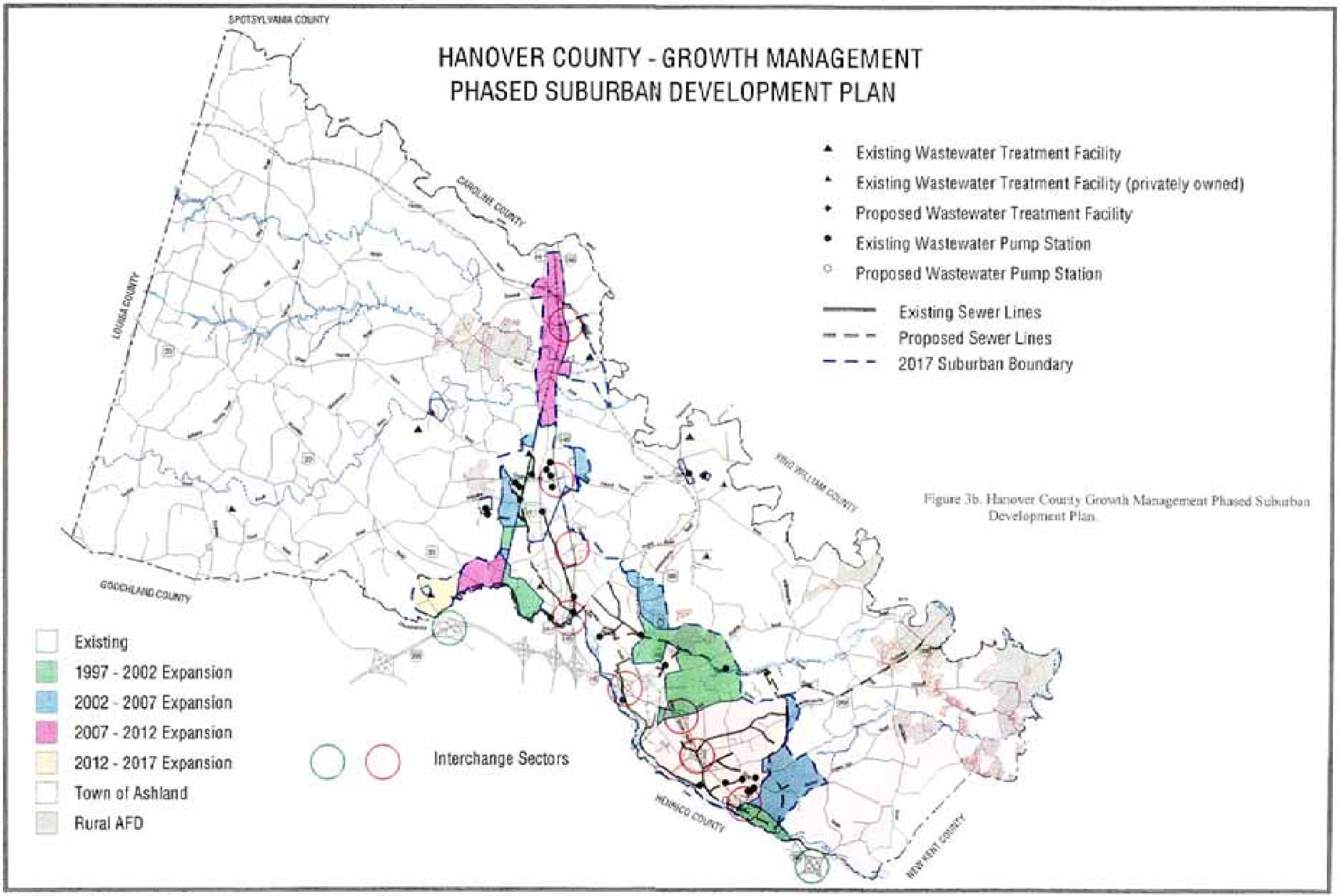

Figure 3b. Hanover County Growth Management Phased Suburban Development Plan.

suburban development in this area allows for low-density residential development (1-2 housing units per acre), once the water and sewer lines become available. Should this development occur to the full "build out" level allowed for by zoning, the Cold Harbor unit could be surrounded on the north, west, and east sides by low-density suburban development, which could have an impact on both water quantity and water quality. The 2.1-acre Garthright House portion of the park is surrounded on three sides by a 50.9-acre passive-use park being developed by Hanover County (National Park Service 1996).

Vision 2017 zones the land south of Route 156 as "Agricultural," which limits future residential development to a maximum of one housing unit per 10 acres (Figure 3a). The county in the future could approve rezoning to either "RC District" or "AR-6 District". Both of these categories would allow for development to a maximum density of 1 unit per 6.25 acres. The difference is that the AR-6 District zoning allows for the traditional subdivision layout (minimum lot size is 6.25 acres), whereas RC District zoning allows clustering of development. RC District has no prescribed minimum lot size as long as 70% of the land is deemed "open space" and a maximum density of 1 residence per 6.25 acres is maintained for the project. The present Agricultural zoning, or the rezoning to RC District or AR-6 District, would affect the land surrounding the Gaines' Mill unit and could potentially affect water quality. As an example of effects of development, Schueler (1994) used a biodiversity metric (index) to measure the effect of the percentage of impervious surfaces in watersheds in urban areas and found that at percentages above 15%, the biodiversity in the stream was degraded (Figure 4).

Hanover County also is in the early stages of developing a Historic Preservation Strategy, which could influence future zoning considerations in the county. This water resources management plan strongly encourages the park to take part in this effort, as the historical context of the lands ranged far beyond the present park boundary, and decisions made concerning surrounding land use will ultimately affect the water resources in the park.

A comprehensive effort is underway to document resource values of the Chickahominy basin and learn more about how the health of the Chickahominy wetlands and waterways are related to the surrounding land use. The U.S. Fish and Wildlife Service has teamed up with state and federal agencies and university researchers to study the effects of people and natural forces changing the landscape in the Chickahominy watershed. With existing information and new research, they hope to identify key areas to focus public and private conservation efforts.

EXISTING RESOURCE CONDITIONS

LOCATION AND HISTORICAL FEATURES

The Cold Harbor unit is on the north side of two-lane VA Route 156 between the Hanover Farms subdivision and the community of Old Cold Harbor and is accessed from Route 156 via an auto tour road. The Garthright House, portions of which date to the 1700's, served as a Union field hospital during the Battle of Cold Harbor and later served

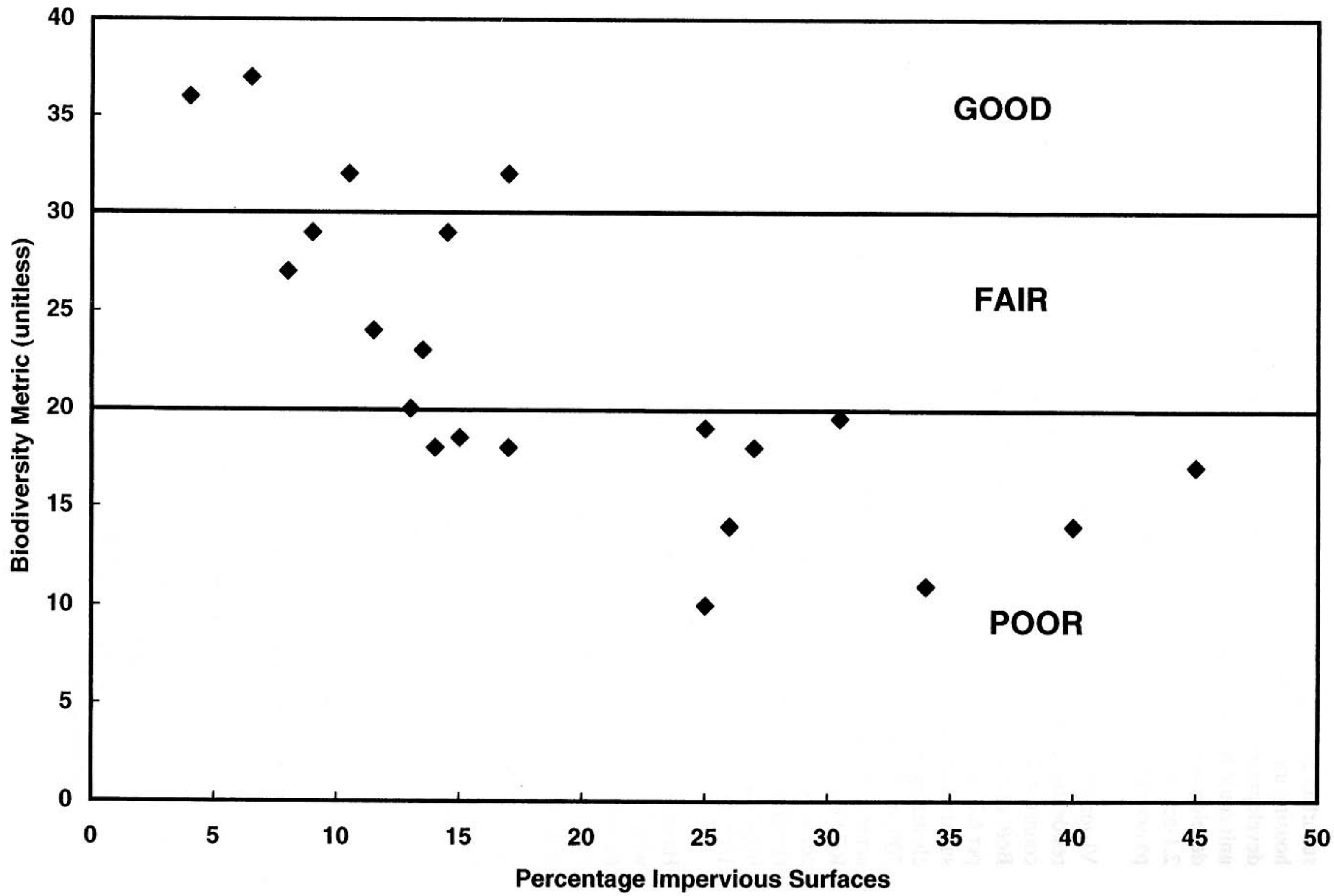

Figure 4. Relationship of a biodiversity metric to percentage of
Impervious surfaces in urban watersheds (after Schueler 1994).

as a Confederate hospital. It is used as an exterior exhibit only. The Garthright House is on the south side of VA Route 156 just east of the main Cold Harbor unit. Historical resources in the Cold Harbor unit include linear earthworks (8,812 yards), 655 associated holes and depressions, 9 artillery positions or emplacements and marked or volunteer trails (4,753 yards) (Michael Andrus, Richmond NBP, pers. comm. 2000). The potential for archeological resources exists throughout the entire site.

The Gaines' Mill unit lies southwest of the Cold Harbor unit on the southern bank of Boatswain Creek, approximately 0.5 mile south of Route 156 near the community of New Cold Harbor, and is accessed via Watt Farm Road. The Watt House, an 1830's structure, is situated within the boundaries of the Gaines' Mill unit and is used as an exterior exhibit only. Historical resources in the Gaines' Mill unit include rifle pits, potholes, a bridge and fill area, trenches and a trench complex, a breastworks area (linear ridge), and a mound; additionally, the area could contain battle-related deposits, defensive features, and graves and/or human remains (Land and Community Associates 1999).

CLIMATE

The climate of the Cold Harbor and Gaines' Mill units is typical for the east coast of the United States in general and the Virginia Piedmont and Coastal Plain in particular. The climate is characterized by warm, humid summers and generally mild winters, with little or no snowfall during some years (Land and Community Associates 1999). Average daytime summer temperatures reach 90° F, and winter daytime lows average 35° F. The annual average rainfall since 1962 is 43.5 inches, and the annual snowfall averages 14.2 inches between November and March (Land and Community Associates 1999).

GEOLOGY AND HYDROGEOLOGY

The Cold Harbor and Gaines' Mill units are situated in the Atlantic Coastal Plain Physiographic Province, immediately east of the transition zone (the Fall Line) between the Piedmont and Atlantic Coastal Plain physiographic provinces. The Fall Line, which separates the two physiographic provinces, trends roughly north-south. The Atlantic Coastal Plain consists of Cretaceous- through Quaternary-aged sediments that thicken eastward; at the Fall Line, the sediments are very thin, whereas at the Atlantic Ocean, the sediments are over 5,000 feet thick (Meng and Harsh 1988). In general, Atlantic Coastal Plain sediments consist of unconsolidated interbedded gravel, sands, silts, and clays (Meng and Harsh 1988).

Both park units are situated on a dissected upland plain that consists of early Pliocene-aged interbedded gravelly sand, sandy gravel, and fine-to-coarse-grained sand (Inners et al. 1995). Daniels and Onuschak (1974) describe the surficial sediments on the upland plain as fluvial clays, clayey silts, sands, and gravels. The surficial sediments at both sites are underlain by marine-deposited clayey silts, partly fossiliferous, with a firm, well-sorted basal sand (Daniels and Onuschak 1974). At both sites, the creek bottomlands consist of alluvium, which consists of organic and poorly sorted fluvial deposits that range in size from clay to gravel (Daniels and Onuschak 1974).

The regional hydrogeology of the Coastal Plain Physiographic Province is controlled by the configuration of the Coastal Plain sediments, i.e., the sediments are interbedded in a more or less regular sequence of layers of high permeability alternating with layers of low permeability. The layers of high permeability, which are generally composed of sand and sandy sediments, transmit ground water readily and are known as aquifers. An aquifer is defined as a water-bearing geologic unit. The layers of low permeability, which are generally composed of clay and clayey sediments, do not transmit ground water readily and are called confining units, or aquitards. Aquifers that are located between aquitards are termed confined aquifers.

The surficial aquifer is composed of permeable geologic materials and extends downward from elevations at or near land surface to the top of the uppermost aquitard. Because there is no upper confining unit, it is called an unconfined aquifer. It is this shallow ground water in the surficial aquifer that supplies most of the water to small streams and creates wetlands. The top of the water surface, called the water table, is free to rise in response to recharge (i.e. precipitation) and fall in response to discharge (i.e. from drawdown induced by pumping from wells that tap the surficial aquifer or by supplying water to streams). Water levels in confined aquifers are affected by pumping from wells that tap the aquifer to a relatively greater extent than are water levels in unconfined aquifers. In this report, water in a confined aquifer is referred to as deep ground water, and water in the surficial aquifer is referred to as shallow ground water.

On the basis of data in Meng and Harsh (1988), the sequence of aquifers and confining units underlying the two park units, with approximate depths below land surface, are as follows: from land surface to 210 feet, unconfined aquifer; 210 to 230 feet, Middle Potomac confining unit; 230 to 320 feet, Middle Potomac aquifer; 320 to 350 feet, Lower Potomac confining unit; 350 to 650 feet, Lower Potomac aquifer; and at 650 feet, basement rock.

TOPOGRAPHY AND SOILS

Topography in both units is gently rolling and locally incised by streams. In the Cold Harbor unit, land-surface elevations range from 125 feet in the Bloody Run stream channel to 185 feet in the uplands. In the Gaines' Mill unit, land-surface elevations range from 85 feet in the Boatswain Creek stream channel to 160 feet near the Watt House.

Soils in Hanover County, Virginia were mapped by Hodges et al. (1980). The soils in the two units are classified as Coastal Plain soils, which, in general, are deep, well drained and have a subsoil that is dominantly sandy, loamy, or clayey. Specifically, in the Cold Harbor unit, soil associations include the Caroline-Dogue complex, the Kempsville gravelly fine sandy loam, the Kenansville loamy sand, the Orangeburg fine sandy loam, the Suffolk loamy fine sand, and the Udults-Ochrepts complex. In the Gaines' Mill unit, soil associations include the Caroline-Dogue complex, the Kempsville-Bourne fine sandy loam, the Suffolk loamy fine sand, and the Udults-Ochrepts complex.

VEGETATION

In the Cold Harbor unit, woodland vegetation consists of second growth, typical eastern deciduous species of the oak-hickory association intermixed with conifers and understory. The woodlands contain maturing oaks, hickories, and the understory tree, chinquapin (National Park Service 1994). Several distinctive shrub and herbaceous species—including a rare sedge—are located along Bloody Run (National Park Service 1994). Portions of the Cold Harbor unit are open woodland parkland containing scattered oaks and loblolly pines (National Park Service 1994). The Garthright House is surrounded by lawn grasses and ornamental shrubs, along with exotic plant species (National Park Service 1994).

The Gaines' Mill unit has an open upland plateau as well as wooded slopes and creek bottomland. On the upland plateau near the Watt House, vegetation consists primarily of specimen trees and shrubs and relatively young fruit trees. Woodland vegetation consists of second growth, typical eastern deciduous species of the oak-hickory association intermixed with conifers, with considerable understory and ground cover plant material. The older woodland areas are dominated by white oak (some of the large individual trees likely were present during the Battle of Gaines' Mill in 1862), tulip tree, and American holly (National Park Service 1994). Areas that are transitional from fields to forest contain younger successional forest dominated by loblolly pine and the invasive exotic, Japanese honeysuckle (National Park Service 1994). Portions of the Gaines' Mill unit are under cultivation (see section entitled "Land Use/Zoning").

FLOODPLAINS, RIPARIAN AREAS AND WETLANDS

Floodplains, riparian areas, and wetlands occur at the interface between land and water. Collectively these areas represent only a small proportion of the landscape in the Cold Harbor and Gaines' Mill units, however, their hydrologic and ecological importance is significant (Naiman et al. 1993). Individually and collectively, these areas provide critical functions such as water supply, maintenance of water quality, flood attenuation, essential habitats for flora and fauna, and maintenance of the biodiversity.

Natural riparian areas are some of the most diverse, dynamic, and complex biophysical habitats in the terrestrial environment (Naiman et al. 1993). The riparian area encompasses that part of the stream channel between low and high water marks and that portion of the terrestrial landscape from the high water mark toward the uplands where vegetation may be influenced by elevated water tables or flooding and by the ability of the soils to hold water (Naiman and Decamps 1997). Thus, riparian areas may be considered ecotones between the aquatic habitat of a river and the surrounding terrestrial habitats. The riparian zone may be small in numerous headwater streams. In mid-sized streams, the riparian zone is larger, being represented by a distinct band of vegetation whose width is determined by long-term (>50 years) channel dynamics and the annual discharge regime. Riparian zones of large streams are characterized by well-developed but physically complex floodplains with long periods of seasonal flooding, lateral channel migration, oxbow lakes in old river channels, a diverse vegetative community, and moist soils (Malanson 1993). These attributes suggest that riparian zones are key systems for regulating aquatic-terrestrial linkages (Ward 1989), and that they may be early indicators of environmental change (Decamps 1993).

DESCRIPTION OF WATER RESOURCES

Both the Cold Harbor and Gaines' Mill units are within the 64,000 mi^2 Chesapeake Bay Watershed, the 10,102 mi^1 James River Watershed and the 470 mi^2 Chickahominy River Watershed. Small streams, which are tributary to the Chickahominy River, drain each of the units; the Chickahominy River drains to the James River, which drains to the Chesapeake Bay. The James River Watershed is the largest watershed in Virginia, drains one-fourth of the state's land area, and contains nearly one-third of Virginia's population. Industries in the James River Watershed include transportation, chemicals, furniture, textiles, shipping, shipbuilding, and tourism. Suburban areas characterize the Chickahominy River Watershed in the upper one-third and predominantly forested areas mixed with residential areas and farmland in the lower two-thirds of the watershed. Timber harvesting in the Chickahominy River Watershed is an important part of the local economy.

COLD HARBOR UNIT

Watershed Description

The main stream that flows through the Cold Harbor unit is Bloody Run, a tributary to Powhite Creek (Figure 2). An unnamed tributary to Powhite Creek forms part of the northern boundary of the Cold Harbor unit. Powhite Creek joins the Chickahominy River just upstream of where Boatswain Creek joins the Chickahominy River. No other perennial streams are shown within the unit on the USGS 1:24,000-scale topographic map, although the rolling topography suggests that ephemeral tributaries and wetlands exist during and shortly after storms. The Cretaceous-aged Patuxent Formation, which underlies the park units, holds "a significant amount of water" in the 100- to 300-foot thick aquifer (National Park Service 1996).

Surface-Water Resources

No stream-gaging stations exist within the Cold Harbor unit, so no direct information about surface-water quantity is available. A USGS stream-gaging station exists on the Chickahominy River, however, located approximately 17 miles downstream of the Cold Harbor unit (White et al. 2000). The gaging station (station 02042500) is in New Kent County near Providence Forge, Virginia and has a drainage area of 252 square miles (mi^2). Stream discharge data have been collected at this station continuously since January 1942, and for the period of record, the maximum and minimum, respectively, instantaneous discharges were 7,710 cubic feet per second (cfs) on August 15, 1955 and 0.06 cfs on September 12, 1997 (White et al. 2000). During the 1999 water year (October 1, 1998 through September 30, 1999), maximum instantaneous discharge was 5,370 cfs on September 17, 1999 and minimum instantaneous discharge was 0.51 cfs on August 17, 1999 (White et al. 2000). Daily mean discharge for this station for the 1999 water year is shown in Figure 5. Daily mean discharge of streams in the Cold Harbor unit should follow a pattern similar to that shown in Figure 5, although the magnitude of discharge would be substantially less because the drainage areas are so much smaller than that of station 02042500. Another USGS stream-gaging station (02042287) with a drainage area of 62.2 mi^{1} was located approximately 9 miles upstream of the Cold Harbor unit on the Chickahominy River near Atlee, Virginia, but the station was discontinued (White et al. 2000). Continuous stream discharge data were collected at this station from January 1990 through the end of September 1997 (White et al. 2000).

The National Park Service has developed a baseline survey of surface-water-quality data in and around Richmond NBP (National Park Service 1999). This Baseline Water-Quality Data Inventory and Analysis Report is a download of the U.S. Environmental Protection Agency's STORET surface-water-quality database. Users of STORET have been strongly advised that it is a "user-beware" database system, because there is no quality assurance of the data and the data are derived from and entered into the system by a wide variety of sources. No interpretation of the water-quality data in the Baseline report is provided.

The STORET data in the Baseline report were reviewed for water-quality monitoring stations in and near the Cold Harbor unit. No surface-water quality monitoring stations are located within the current boundaries of the unit. Four water-quality monitoring stations exist on the Chickahominy River, however, to the south of the unit. Two of the locations (RICH0132 and RICH0133) are approximately 2 miles upstream of the Cold Harbor unit, and the other two locations (RICH0130 and RICH0131) are approximately 2 miles downstream. Stations 0130 and 0131 are located at Rt. 156 near Seven Pines, Virginia; stations 0132 and 0133 are located at Rt. 615 near Highland Springs, Virginia. Stations RICH0130 and 0131 have identical latitude and longitude coordinates (37551948, 77271392), and stations RICH0132 (37576671, 77334171) and 0133 (37576948, 77334171) have very similar coordinates (National Park Service 1999). Results of selected water-quality parameters collected at these stations are shown in Table 1.

No dischargers, drinking intakes, water gages or impoundments are located within the current boundaries of the Cold Harbor unit (National Park Service 1999). Surface water draining the Cold Harbor unit is impounded downstream in Gaines' Mill Pond by an earthen dam (VA08506) that was completed in 1850 (National Park Service 1999).

Ground-Water Resources

A well owned by the National Park Service located at the Cold Harbor Visitor's Center is used for ground-water-level monitoring in a confined aquifer. The well was drilled in 1962 to a depth of 280 feet below land surface with a 6-inch diameter well casing to a depth of 10 feet, a 4-inch casing from 10 to 255 feet, a screened interval from 255 to 275 feet, and a 4-inch tailpipe from 275 to 276.4 feet (David Nelms, USGS, pers. comm. 2000). The well, referred to as well 52J 10 by USGS (and well 142-005 by Virginia

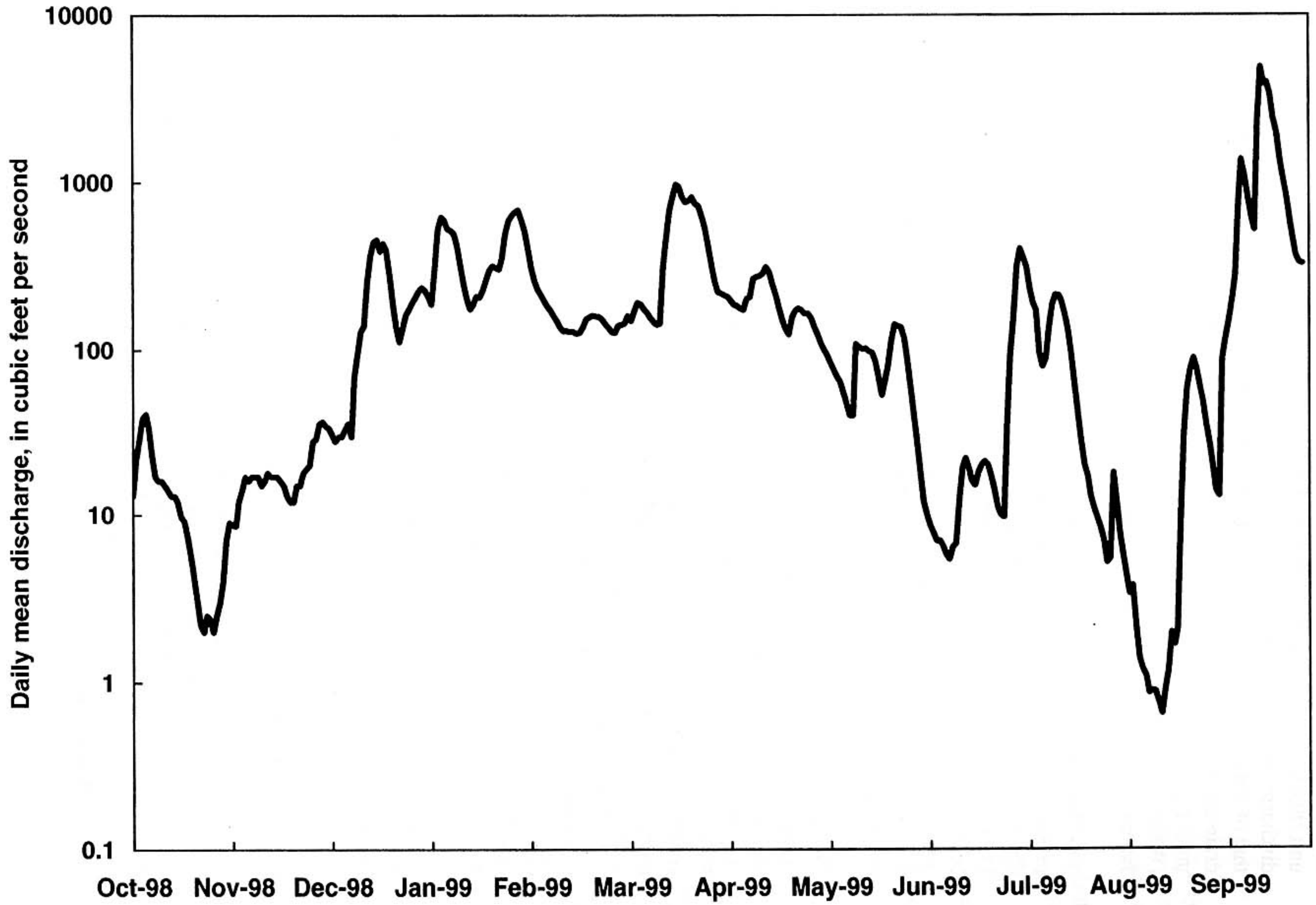

Figure 5. Daily mean discharge at the Chickahominy River near Providence Forge, Virginia stream-gaging station, October 1, 1998 through September 30, 1999.

Table 1. Results of water-quality sampling of surface water near the Cold Harbor unit.

Water-Quality Parameter, and Unit of Measurement	**Station 0130 (Sept. 1967 – Dec. 1998)**	**Station 0131 (Sept. 1984 – Sept. 1991)**	**Station 0132 (Sept. 1984 – Apr. 1990)**	**Station 0133 (July – Oct. 1994)**
Water temperature, °C	0-29	6.7-29.2	10-25.5	13.1-26.9
Specific conductance, pS/cm	69-227	48-188	87-200	--
pH, units	1.9-14.2	5.5-7.8	6-7.1	6.2-6.44
Oxygen, dissolved, mg/L	5.3-7.6	3.3-11.3	3.9-9.3	--
Nitrogen, (NO_2 + NO_3), mg/L	0.025-0.35	0.02-5.3	--	--
Phosphorus, mg/L	0.03-0.17	0.034-0.194	0.053-0.082	--
Chloride, mg/L	6-52	7-32	13-24	--
Sulfate, mg/L	2-52	2-57	4-37	--
Arsenic, pg/L	0.5-5	0.5-28	0.5-1	--
Cadmium, pg/L	1-10	0.5-8	0.5-9	--
Copper, pg/L	5-30	0.5-18	3-4	--
Iron, pg/L	600-1,839	910-4,100	1,300-2,400	--
Lead, pg/L	1.5-50	0.5-10	2-2.5	--
Manganese, pg/L	70-209.9	60-2,800	100-1,200	--
Zinc, pg/L	5-60	5-140	20-260	--
Fecal coliform, col/100mL	50-1,500	--	--	--

[All values given as the range in concentration for the sampling period shown, and all concentrations are total, unless otherwise noted; --, no data; °C, degrees Celsius; pS/cm, microsiemens per centimeter at 25 °C; mg/L, milligrams per liter; NO_2 + NO_3, nitrite plus nitrate; pg/L, micrograms per liter; col/100mL, colonies of fecal coliform per 100 milliliters of sample]

Department of Environmental Quality), yields water from a confined aquifer, the Middle Potomac aquifer of Cretaceous age (White and Powell 2000). USGS made a water-level measurement in the well in December 1972 when a water-quality sample was collected, and periodic measurements were made roughly every 3-4 months since October 1983. The next closest water-level monitoring well to the Cold Harbor unit with published records is in Henrico County at Highland Springs, approximately 3 miles to the southwest of the well located at the Visitor's Center (White and Powell 2000).

Water level in well 52J 10 at the Cold Harbor Visitor's Center is affected by regional drawdown in the confined aquifer. The highest water level measured was 165.75 feet below land-surface datum on December 1, 1972; the lowest water level measured was 209.44 feet below land-surface datum on September 9, 1999 (White and Powell 2000). The water level systematically declined from 1983 through August 1994, recovered from

September 1994 to March 1995, then declined at a faster rate from March 1995 to present (Figure 6). The recovery period from September 1994 to March 1995 coincides with a cessation of the use of the well for water supply at the Visitor's Center (T. Scott Bruce, Virginia Department of Environmental Quality, pers. comm. 2000 and confirmed by Jerry Helton, Richmond NBP, pers. comm. 2000). The decline in water level starting in March 1995 is likely due to increased pumping from another well that taps the same aquifer. A well located near the Garthright House, installed in 1988 and which taps the same aquifer, began to be used for public water supply for Hanover County starting in March 1995 (T. Scott Bruce, Virginia Department of Environmental Quality, pers. comm. 2000 and David Nelms, USGS, pers. comm. 2000).

Historians speculate that ground-water levels in the unconfined aquifer in this area were higher during the Civil War than they are in modem times. A letter written in 1987 by the late Mr. William F. Mallory of Richmond provides an account of the 1953 meeting between the Richmond and Chicago Civil War Roundtable. During that meeting, Dr. Douglas S. Freeman of Richmond stated that the water table in the 1860's was probably about 40% higher than it is now. Dr. Freeman speculated that swampy areas had been drained to "reclaim" the land, presumably for agricultural use. This speculation provides an oral history that is in agreement with soldiers' accounts of the difficult, swampy conditions encountered during the war. Dr. Freeman also suggested that an increase in population in the area, with the accompanying need for potable water, and the use of ground water for irrigation by truck farms caused the water table to be lower relative to its position during the Civil War. Although Dr. Freeman likely was referring to the unconfined aquifer, direct observations of more recent water levels in a confined aquifer in this area demonstrate that water levels have declined due to pumping of the aquifer (Figure 6).

Only one sample of deep ground-water quality is available for the Cold Harbor unit. According to USGS records, well 52J 10 was sampled on December 12, 1972 (Table 2).

Wetland and Riparian Resources

Wetland areas in the park provide vital functions, such as vegetation and wildlife habitat, drainageways for hydrologic systems, and improvement of water quality through physical and chemical processes. In general, wetland soils are associated with most of the waterways in the park. In addition, numerous areas of upland wetlands are situated between waterways where topography and internal drainage create locally moist conditions.

The U.S. Fish and Wildlife Service classifies wetlands for the National Wetlands Inventory (NWI) according to the document Classification of Wetlands and Deepwater Habitats of the United States (Cowardin et al. 1979). A 1:24,000-scale NWI map of the Seven Pines, Virginia USGS topographic quadrangle exists (U.S. Fish and Wildlife Service 1993) and was used in assessing wetlands in both the Cold Harbor and Gaines' Mill park units.

Table 2. Results of water-quality sampling of ground water in well 52J 10 on 12 December 1972 in the Cold Harbor unit.

Water-Quality Parameter, and Unit of Measurement	**Concentration or Measurement**
Water temperature, °C	--
Specific conductance, pS/cm	275
pH, units	7.9
Oxygen, mg/L	--
Bicarbonate, mg/L	140
Carbonate, mg/L	110
Nitrogen, (NO_2 + NO_3), mg/L	--
Total hardness, mg/L as $CaCO_3$	65
Calcium, mg/L	18
Magnesium, mg/L	4.9
Sodium, mg/L	25
Potassium, mg/L	13
Chloride, mg/L	1.9
Sulfate, mg/L	15
Fluoride, mg/L	0.4
Silica, mg/L	14

[--, no data; all concentrations are dissolved, unless otherwise noted; °C, degrees Celsius; p S/cm, microsiemens per centimeter at 25 °C; mg/L, milligrams per liter; NO_2 + NO_3, nitrite plus nitrate; $CaCO_3$, calcium carbonate; pg/L, micrograms per liter]

We evaluated the completed NWI map (Seven Pines) for the Cold Harbor unit by locating the park boundaries on the map, counting the total number of wetlands, and aggregating by wetland type based on criteria described by Cowardin et al. (1979). Three wetlands are delineated on the map for the Cold Harbor unit and one wetland is delineated near the Garthright House; all four are classified as Palustrine. The three wetland types in the Cold Harbor unit are described as broad-leaved deciduous Palustrine wetlands. In the Cold Harbor unit, one wetland is classified as temporarily flooded, one is classified as seasonally flooded, and the one mapped along Bloody Run is classified as seasonally flooded/saturated. At the Garthright House, the wetland is mapped as farmed Palustrine. As expected, Palustrine wetlands are the dominant type of wetland (100%) because of the forest cover in the Cold Harbor unit. Palustrine wetlands are all nontidal wetlands dominated by trees, shrubs, and persistent emergents. The Palustrine system was developed to group vegetated wetlands traditionally called by such names as marsh, swamp, bog, and fen (Cowardin et al. 1979). Broad-leaved deciduous refers to dominant trees such red maple, American elm *(Ulmus americana),* and ashes *(Fraxius* spp.), among others. Temporarily flooded refers to wetlands in which surface water is present for brief periods during the growing season, but where the water table usually lies well below the soil surface for most of the season. Seasonally flooded refers to wetlands in which

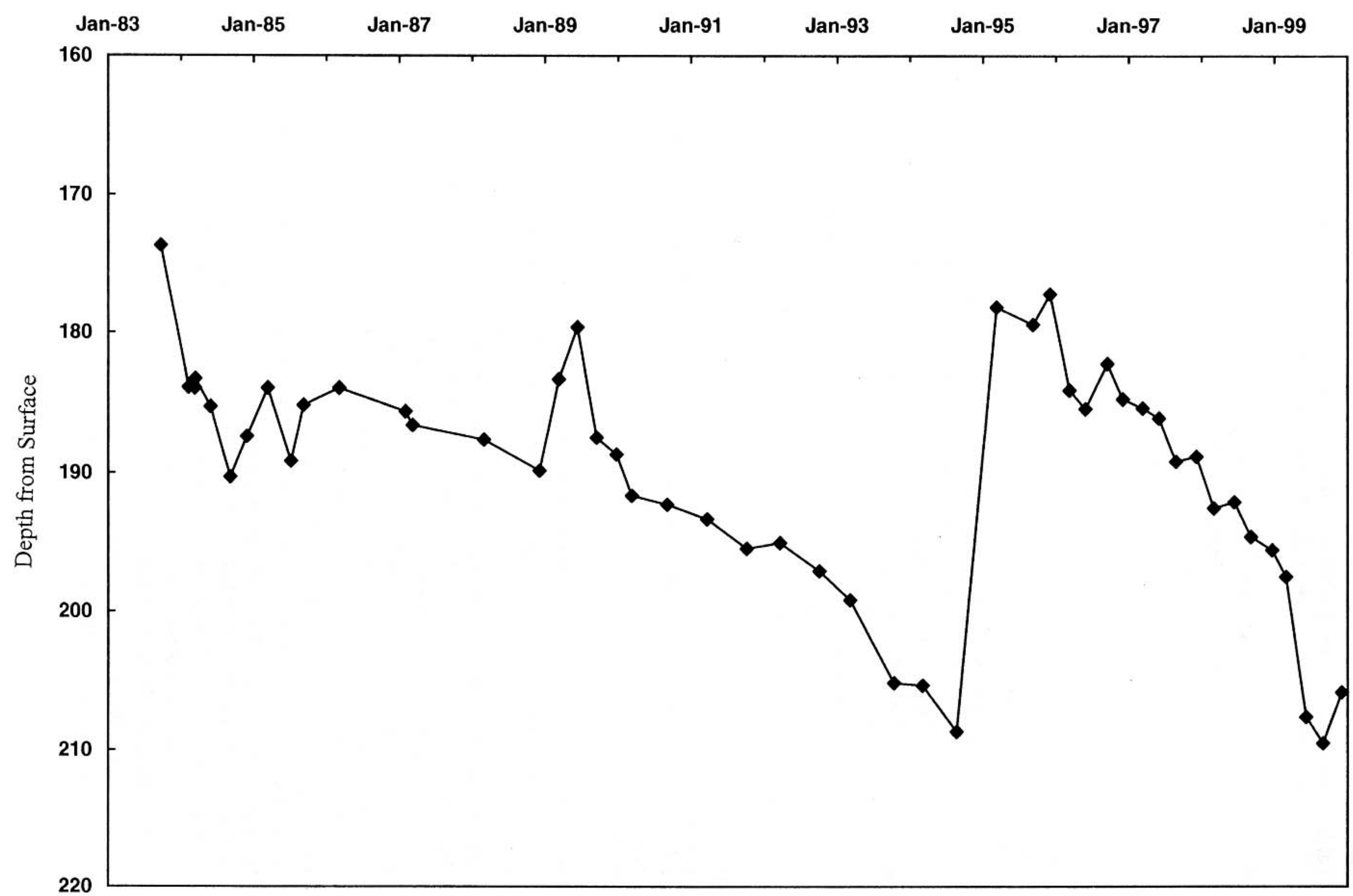

Figure 6. Water-level measurements in well at Cold Harbor visitor's Center, 1983 to 1999.

surface water is present for extended periods especially early in the growing season, but is absent by the end of the growing season in most years.

NWI maps are useful for a general understanding of the potential areal extent and types of wetlands that are present. These maps, however, are often many years old, not ground-truthed, and the scale (1:24,000) is not adequate to detect subtle changes that may be occurring with respect to habitat boundaries or species composition changes or to delineate small wetland sources, such as seeps or springs. Because of their limited accuracy and precision, NWI maps are only a first step in a wetland inventory for the park. A study on wetlands in Richmond NBP has been initiated by the USGS. The purpose of the wetlands study is to ground truth the NWI map, determine the accuracy of the map, and identify any wetland areas not mapped.

Aquatic Biological Resources

The James River fish fauna is fairly species rich for an Atlantic slope drainage, with 109 total taxa: 73 indigenous, 26 introduced, and 10 estuarine or diadromous taxa (Jenkins and Burkhead 1993). The high number of native species comes mainly from the southern Coastal Plain, from upland and montane species in the Roanoke drainage or Ohio basin, and from three endemic species.

There are no known studies of the fish fauna of the Powhite drainage nor of Bloody Run (nor of Boatswain Creek in the Gaines' Mill unit). In general, only a relatively few fish species in a drainage occupy a given stream site or reach. On the basis of Jenkins and Burkhead's (1993) efforts to capture most species present at most sites that were sampled, small creeks typically have 2 to 10 species. Given the presumed flow characteristics of Bloody Run and Boatswain Creek, if fish species are present, the number of species would probably tend to the low end of this range.

Additionally, there are no known studies of the aquatic flora and macroinvertebrates of these creeks.

To date, there has been no biological monitoring in or near any units of Richmond NBP by Virginia Department of Environmental Quality, and there are no plans to include sites in the park in the future (Richard Daub, Virginia Department of Environmental Quality, pers. comm., 2000). Some sites in Richmond NBP would be useful in the monitoring network as unimpaired or "reference" sites, however, no resources currently are available to expand the network (Richard Daub, Virginia Department of Environmental Quality, pers. comm., 2000).

Water Supply and Sewage Disposal

Prior to 1989, well 52J 10 was used for public water supply, as discussed in the Ground Water section, above. In 1988, a new well was installed at the Visitor's Center for public water supply, as the old well was declared "unusable" by the Virginia Department of Environmental Quality because of fecal coliform contamination (files at Richmond

NBP). The new well is approximately 16 feet to the southwest of the old well (site map on file at Richmond NBP). During 1994, Hanover County approached the park about connecting to the county public water supply, to which the park agreed (Jerry Helton, Richmond NBP, pers. comm. 2000). The transition from the well to the county for public water supply likely occurred during late 1994, as indicated by the recovery in ground-water level from September 1994 to March 1995 in adjacent well 52J 10 (Figure 6).

A fairly new, properly designed septic system with three fields is in use at the Cold Harbor Visitor's Center (David McKinny, Richmond NBP, pers. comm. 2000).

GAINES' MILL UNIT

Watershed Description

Boatswain Creek forms the northwestern boundary of the Gaines' Mill unit (Figure 2). The headwaters of Boatswain Creek originate near the Garthright House, approximately 1 mile upstream of the Gaines' Mill unit. Boatswain Creek joins the Chickahominy River approximately 0.8 mile southeast of the Gaines' Mill unit. No other perennial streams are shown within the unit on the USGS 1:24,000-scale topographic map, although the rolling topography suggests that ephemeral tributaries and wetlands exist during and shortly after storms. The Cretaceous-aged Patuxent Formation, which underlies the park units, holds "a significant amount of water" in the 100- to 300-foot thick aquifer (National Park Service 1996).

Surface-Water Resources

No stream-gaging stations exist within the Gaines' Mill unit, so no direct information about surface-water quantity is available. Surface-water quantity, however, is likely similar to that in the Cold Harbor unit, as described above. Like the Cold Harbor unit, no surface-water quality monitoring stations are located within the current boundaries of the unit. Surface-water quality, however, also is likely similar to that in the Cold Harbor unit, as described above and as shown in Table 1.

No dischargers, drinking intakes, water gages or impoundments are located within the current boundaries of the Gaines' Mill unit (National Park Service 1999).

Ground-Water Resources

A National Park Service employee inhabits the Watt House in the Gaines' Mill unit. A well is used for water supply at the Watt House and is referred to as well 142-072, according to the well-numbering system of the Virginia Department of Environmental Quality. The well was drilled in 1962 to a depth of 199 feet, with a 4-inch diameter well casing, and was screened from 180 to 190 feet below land surface (David Nelms, USGS, pers. comm. 2000). Ground-water level data are not available from well 142-072 located at the Watt House. Because of the proximity of the Gaines' Mill unit to the Cold Harbor unit and the similarity of the depths of the wells, however, water levels of deep ground water are likely similar in both units.

According to USGS records, a water-quality sample was collected from well 142-072 on 30 August 1984 (Table 3).

Table 3. Results of water-quality sampling of ground water in well 142-072 on 30 August 1984 in the Gaines' Mill unit.

Water-Quality Parameter, and Unit of Measurement	**Concentration or Measurement**
Water temperature, °C	20
Specific conductance, pS/cm	230
pH, units	7.4
Oxygen, mg/L	*0.7 (8%* saturation)
Carbonate, mg/L	102
Nitrogen, (NO_2 + NO_3), mg/L	0.17
Total hardness, mg/L as $CaCO_3$	63
Calcium, mg/L	17
Magnesium, mg/L	5.1
Sodium, mg/L	12
Potassium, mg/L	15
Chloride, mg/L	1.8
Sulfate, mg/L	7.3
Fluoride, mg/L	0.1
Silica, mg/L	13
Iron, pg/L	1,600
Manganese, p g/L	37
Zinc, pg/L	200
Aluminum, pg/L	200

[All concentrations are dissolved, unless otherwise noted; °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 °C; mg/L, milligrams per liter; NO_2 + NO_3, nitrite plus nitrate; $CaCO_3$, calcium carbonate; pg/L, micrograms per liter]

A spring located in eastern Henrico County approximately 6 miles south of the Gaines' Mill unit was sampled on October 28, 1998 by the USGS (White and Powell 2000). Springs in the Coastal Plain of Virginia typically are indicative of shallow ground water. For the purpose of comparison, results of the water-quality sampling of the wells at the Cold Harbor and Gaines' Mill units (representing deep ground water) and the spring (representing shallow ground water) are shown in Table 4. Comparison of these data demonstrates the differences in ground-water quality that are the result of differences in flow paths. In general, water emanating from a spring has followed relatively short and shallow flow paths and has short residence times below land surface, which cause the water to have relatively low dissolved solids. In contrast, deep ground water, such as that sampled in the wells, has followed longer, deeper flow paths and has longer residence

Table 4. Comparison of results of water-quality sampling of deep and shallow ground water in and near the Cold Harbor and Gaines' Mill units.

Water-Quality Parameter, and Unit of Measurement	**Cold Harbor well sampled 12/12/72**	**Gaines' Mill well sampled 8/30/84**	**Spring sampled 10/28/98**
Water temperature, °C	--	20	16
Specific conductance, pS/cm	275	230	66
pH, units	7.9	7.4	4.4
Oxygen, mg/L	--	*0.7 (8%* saturation)	3.9 (40% saturation)
Bicarbonate, mg/L	140	--	0.0
Carbonate, mg/L	110	102	0.0
Nitrogen, (NO_2 + NO_3), mg/L	--	0.17	2.9
Total hardness, mg/L as $CaCO_3$	65	63	--
Calcium, mg/L	18	17	--
Magnesium, mg/L	4.9	5.1	--
Sodium, mg/L	25	12	--
Potassium, mg/L	13	15	--
Chloride, mg/L	1.9	1.8	--
Sulfate, mg/L	15	7.3	--
Fluoride, mg/L	0.4	0.1	--
Silica, mg/L	14	13	--
Iron, pg/L	--	1,600	--
Manganese, pg/L	--	37	--
Zinc, pg/L	--	200	--
Aluminum, pg/L	--	200	--

[All concentrations are dissolved, unless otherwise noted; --, no data; °C, degrees Celsius; pS/cm, microsiemens per centimeter at 25 °C; mg/L, milligrams per liter; NO_2 + NO_3, nitrite plus nitrate; $CaCO_3$, calcium carbonate; pg/L, micrograms per liter]

times below land surface; this longer contact time with geologic materials increases the dissolved solids of the water. For example, the deep ground water in the wells had specific conductance measurements in excess of 200 pS/cm (indicating a longer contact time), in contrast to shallow water from the spring, which had a specific conductance of 66 pS/cm (indicating a shorter contact time) (Table 4). Also evident from the ground-water data (Table 4) is the similarity of the quality of the deep ground-water samples that were collected more than a decade apart. This indicates that the water sampled likely was from the same aquifer and that the water quality had changed little over time. Ground water with short, shallow flow paths tends to be more susceptible to contamination from the ground surface than deep ground water. For example, comparison of the nitrogen data between the Gaines' Mill well and the spring suggests that the shallow water might be influenced by nearby agricultural activities and fertilizer application. For this reason, potable water supplies typically are obtained from deep confined aquifers, such as the well used for water supply at the Cold Harbor Visitor's Center before the switch to county water. This comparison of deep and shallow ground-water quality demonstrates the difference between the two depths of ground water and emphasizes the importance of maintaining good shallow ground-water quality. The shallow ground water supplies most of the water to streams and wetlands and thus determines the quality of the aquatic habitat.

Wetland and Riparian Resources

As discussed for the Cold Harbor unit, wetland areas in the Gaines' Mill unit provide vital functions, such as vegetation and wildlife habitat, drainageways for hydrologic systems, and improvement of water quality through physical and chemical processes. In general, wetland soils are associated with most of the waterways in the park. In addition, numerous areas of upland wetlands are situated between waterways where topography and internal drainage create locally moist conditions.

As described for the Cold Harbor unit, we evaluated the completed NWI map (Seven Pines) for the Gaines' Mill unit. Only one wetland is delineated on the map for the Gaines' Mill unit, along Boatswain Creek. The mapped wetland is described as a seasonally flooded, broad-leaved deciduous Palustrine wetland. Palustrine wetlands are the dominant type of wetland (100%) because of the forest cover in the Gaines' Mill unit. Palustrine wetlands are all nontidal wetlands dominated by trees, shrubs, and persistent emergents. The Palustrine system was developed to group vegetated wetlands traditionally called by such names as marsh, swamp, bog, and fen (Cowardin et al. 1979). Broad-leaved deciduous refers to dominant trees such red maple, American elm *(Ulmus americana),* and ashes *(Fraxius* spp.), among others. Seasonally flooded refers to wetlands in which surface water is present for extended periods especially early in the growing season, but is absent by the end of the growing season in most years.

Aquatic Biological Resources

Similar to the situation at the Cold Harbor unit, there are no known studies of the aquatic flora and fauna of the Gaines' Mill unit.

To date, there has been no biological monitoring in or near any units of Richmond NBP by the Virginia Department of Environmental Quality, and there are no plans to include sites in the park in the future (Richard Daub, Virginia Department of Environmental Quality, pers. comm. 2000). Some sites in Richmond NBP would be useful in the monitoring network as unimpaired or "reference" sites, however, no resources currently are available to expand the network (Richard Daub, Virginia Department of Environmental Quality, pers. comm. 2000).

Water Supply and Sewage Disposal

Well 142-072, drilled in 1962, was used for private water supply to the Watt House. Because of a cracked casing, the well was abandoned in early 2000, and a new well was installed in February 2000 (Jerry Helton, Richmond NBP, pers. comm. 2000). The replacement well is 325 feet deep, has 4.5 inch-diameter casing, a screened interval from 295 to 325 feet, and a yield of 15 gallons per minute after 4 hours of pumping (David McKinny, Richmond NBP, pers. comm. 2000).

The septic system in use at the Watt House was installed in 1957 (drawings on file at Richmond NBP). Currently, the system appears to be functioning properly (David McKinney, Richmond NBP, pers. comm. 2000).

WATER-RESOURCES PLANNING ISSUES AND RECOMMENDATIONS

Representatives of the National Park Service-Water Resources Division (WRD) and National Park Service-Northeast Region Philadelphia Support Office traveled to Virginia in August 1999 to meet with representatives from Richmond NBP, the U.S. Geological Survey (USGS), and the National Park Service-Chesapeake Bay Program Coordinator. This meeting was designed to initiate dialogue on park water-resource features and concerns. Initial discussions indicated that there is a lack of baseline water-quality and quantity data for the park and that urbanization is encroaching on the boundaries of the park. Additional water-resources issues were identified at a scoping session with WRD, Richmond NBP, and USGS personnel on January 27, 2000 at Richmond NBP (Appendix C). As a result of these meetings, the following information deficiencies were identified:

1) Lack of adequate current water-quality information for assessing potential water-quality degradation from nonpoint-source pollution related to changing land use;

2) Lack of information on wetland and riparian resources; and

3) Lack of an adequate inventory for aquatic-dependent flora and fauna.

ADEQUACY OF CURRENT WATER-QUALITY INFORMATION FOR ASSESSING POTENTIAL WATER-QUALITY DEGRADATION FROM NONPOINT-SOURCE POLLUTION RELATED TO CHANGING LAND USE

While it appears that the quality of water is good within the headwater streams flowing through the two park units, nonpoint-source pollutants associated with increasing residential development could adversely affect existing water quality. Potential contamination could derive from such nonpoint sources as subdivision development, runoff associated with agriculture and developed areas, septic system leachate, and lawn and garden chemicals. Residential development often results in the reduction of infiltration areas by creating impervious surfaces, which can increase storm-water runoff and alter discharge and hydrologic patterns of streams. This, in turn, may lead to additional sediment loading and channel scour in the receiving stream. Improperly designed slope development or poor construction practices can also increase surface erosion and sediment load. Many of the residences surrounding the park units also contain expansive lawn areas, which undoubtedly receive applications of fertilizers and pesticides. Little information is currently available regarding the types and amounts of chemicals applied or the potential for runoff of these chemicals into adjacent streams. Point- and nonpoint-source pollutants in residential areas, however, generally are plentiful and easily transported over impervious surfaces, directly into watercourses and tributaries. Therefore, present and expected development in the watersheds draining the Cold Harbor and Gaines' Mill units has the potential to impair surface- and ground-water quality, reduce surface- and ground-water quantity, and negatively affect biological resources in the units.

The paucity of specific information on surface-water features (wetlands and riparian areas), surface- and ground-water quantity and quality, and aquatic biology compromises the direction of water-resources planning. Without better water-resource information and adequate baseline data, any impacts on water resources will remain undetected and changes will be difficult to document. However, a comprehensive water-qualitymonitoring program for surface and ground waters is not warranted given that the streams are small and drain headwater watersheds – impacts from adjacent land use are more immediate and there are no cumulative impacts from upstream land use. Additionally, at present, park financial and staff limitations would not sustain a long-term comprehensive monitoring program with adequate quality assurance and control. What is needed is a sustainable, scientifically credible, `canary-in-the-mine' monitoring program that is efficient and cost-effective. This type of monitoring program does not need to be conducted on a frequent basis because all that is desired is a warning of resource degradation. If the `canary' determines that a water-resource problem exists, then more intensive study is needed to determine the exact nature and cause of the problem.

The systematic, biological assessment of species assemblages using multimetric indexes to assess biological integrity is currently a very practical and cost-effective approach to determine if human actions are degrading water resources. The phrase "biological integrity" was first used in 1972 to establish the goal of the Clean Water Act: "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters." This mandate clearly established a legal foundation for protecting aquatic biota. The vision of biological integrity, however, was not reflected in the act's regulations for implementation. Those regulations were aimed at controlling or reducing release of chemical contaminants and thereby protecting human health; the integrity of biological communities was largely ignored (Karr 1991). The health of aquatic organisms and the quality of aquatic environments have declined in recent decades, possibly as a result of the biological communities being ignored. The assessment of water resources extends beyond degradation of water quality as a result of pollutants; in addition, we face loss of aquatic species and homogenized biological assemblages.

Biological integrity refers to the capacity to support and maintain a balanced, integrated, and adaptive biological system having the full range of elements (e.g. populations, species, assemblages) and processes (e.g. biotic interactions, energy dynamics, biogeochemical cycles) expected in a region's natural habitat (Karr et al. 1986). The biological integrity of water resources is jeopardized by altering one or more of five classes of environmental factors: physical habitat, seasonal flow of water, the food base of the system, interactions within the stream biota, and chemical contamination (Karr 1992). Urbanization, for example, compromises the biological integrity of streams by severing the connections among segments of a watershed and by altering hydrology, water quality, energy sources, habitat structure, and biotic interactions (e.g. Figure 4).

Water managers are increasingly being called upon to evaluate the biological effects of their management decisions. No other aspect of a river gives a more integrated perspective on its health than the condition of its biota. Widespread recognition of this and the continued degradation of our water resources have stimulated numerous efforts to improve our ability to track aquatic biological integrity (Davis and Simon 1995). Comprehensive, multimetric indexes (Barbour et al. 1995) were first developed in the Midwest for use with fishes (Karr 1981; Fausch et al. 1984; Karr et al. 1986), and modified for use in other regions of the U. S. (Miller et al. 1988) and with invertebrates (Ohio EPA 1988; Plafkin et al. 1989; Kerans and Karr 1994; Deshon 1995; Fore et al. 1996). The conceptual basis of the multimetric approach has now been applied to a variety of aquatic environments (Davis and Simon 1995), including large rivers, lakes, estuaries, wetlands, riparian corridors, and reservoirs, and in a variety of geographic locations (Lyons et al. 1995).

Comprehensive approaches have been developed and are being adopted by state and federal agencies. Forty-two states (including Virginia) now use multimetric biological assessments of biological condition and six states are developing biological assessment approaches; only three states used multimetric biological approaches in 1989 (U.S. Environmental Protection Agency 1996a). Only over the last few years have efforts been made to monitor the biological integrity of water resources, as mandated by the Clean Water Act 28 years ago (Karr 1991; Davis and Simon 1995; U.S. Environmental Protection Agency 1996a,b).

The set of metrics incorporated into a multimetric index integrates information from ecosystem, community, population, and individual levels (Karr 1991; Barbour et al. 1995). Multimetric indexes are generally dominated by metrics of taxa richness (number of taxa), because structural changes, such as shifts among taxa, generally occur at lower levels of stress than do changes in ecosystem processes (Karr et al. 1986; Schindler 1987; 1990). However, the most appropriate and integrative multimetric indexes embrace several concepts, including taxa richness, indicator taxa or guilds (e.g. tolerant and intolerant), health of individual organisms, and assessment of processes (e.g. as reflected by trophic structure) of the sampled assemblage.

Like the multimetric indexes used to track national economies, multimetric biological indexes measure many dimensions of complex ecological systems (Karr 1992). Multimetric economic indexes assess economic health against a standard fiscal period; indexes of biological integrity assess the biological well being of sites against a regional "baseline condition" reflecting the relative absence of human influence. The goal is to understand and isolate, through sampling design and analytical procedures, patterns that derive from natural variation in environments.

Biological assessments using multimetric indexes provide both numeric and narrative descriptions of resource condition, which can be compared among watersheds, across a single watershed, and over time (Karr 1991), and they do so at costs that are often less than the cost of complex chemical monitoring. Costs per evaluation are relatively low for ambient biological monitoring. Based on a decade of sampling and including equipment; supplies; and logistical, administrative, and data-analysis and interpretation activities, benthic invertebrates cost $824/sample and fish cost $740/sample (Yoder and Rankin 1995) in comparison with chemical and physical water quality ($1,653 per station) and bioassays ($3,573 to $18,318 per assay).

The Index of Biotic Integrity (MI; Karr 1981), the first of the multimetric indexes and centered on fish communities, was conceived to provide a broadly based and ecologically sound tool to evaluate biological conditions in Midwestern streams. The IBI and other, similar indexes are based on a series of assumptions and intuitions of how biotic assemblages change with increased environmental degradation. A single sample from a stream reach is evaluated using 12 metrics to determine the extent to which the resident biotic community diverges from that expected of an undisturbed site in the same geographic area and of the same stream size (Table 5). Unlike efforts to define chemical criteria that do not take variation by geographic region into account, this approach explicitly recognizes natural variation in water-resource conditions. Ratings are assigned, summed, and placed into integrity classes (excellent, good, fair, poor, and very poor) to provide an assessment of the biological integrity or health of a system.

Table 5. Typical effects of environmental degradation on biotic assemblages (from Fausch et al. 1990).

1. The number of native species, and those in specialized taxa or guilds declines
2. The percentage of exotic or introduced species or stocks increases
3. The number of generally intolerant or sensitive species declines
4. The percentage of the assemblage comprising tolerant or insensitive species increases
5. The percentage of trophic and habitat specialists declines
6. The percentage of trophic and habitat generalists increases
7. The abundance of the total number of individuals declines
8. The incidence of disease and anomalies increases
9. The percentage of large, mature, or old-growth individuals declines
10. Reproduction of generally sensitive species declines
11. The number of size- and age-classes declines
12. Spatial or temporal fluctuations are more pronounced

The 12 metrics represent differing sensitivities across the range of biotic integrity. Municipal effluents, for example, generally affect total abundance and trophic structure. Toxic effects are typically manifested as unusually low total abundance. On the other hand, some environments low in nutrients support a limited number of individuals, and an increase in abundance could indicate organic enrichment. Additionally, bottom-dwelling species that depend on benthic habitats are especially sensitive to siltation and benthic oxygen depletion and are good barometers of habitat degradation.

Regardless of whether fish, invertebrates, or other taxa are used, the search for a small set of metrics that reliably signals resource condition along gradients of human influence yields the same basic list of metrics (Miller et al. 1988; Karr 1991; Davis and Simon 1995). With usually only minor modification, the list can be adapted to specific regions (Miller et al. 1988).

In Virginia, the 1998 Biological Monitoring Program of the Department of Environmental Quality uses the study of bottom-dwelling macroinvertebrate communities to determine overall water quality. This monitoring program is composed of stations examined twice annually, during the spring and fall. The U.S. Environmental Protection Agency's Rapid Bioassessment Protocol II (Plafkin et al. 1989; Table 6) has been employed since the fall of 1990 as a standardized and repeatable methodology. The results of this protocol produce water-quality ratings of nonimpaired, moderately impaired, and severely impaired.

The procedure evaluates the macroinvertebrate community by comparing ambient monitoring network stations to "reference" sites. A reference site is one that has been judged to be representative of a natural, unimpaired waterbody. An additional product of this evaluation is a habitat assessment, which provides information on the comparability of each stream station to the reference site. Project Statement RICH-N-011.000 (Appendix A) proposes obtaining the services of the Virginia Department of Environmental Quality to conduct its Biological Monitoring Program on the streams in the two park units. However, because Program resources are currently limited, the project statement should be regarded as a template. For example, Dr. Greg Garman, Director of the Environmental Sciences Center of Virginia Commonwealth University, is a regional expert on the use of multimetric indexes to assess biological integrity in streams. If the services of the Virginia Department of Environmental Quality cannot be obtained within a reasonable time frame, the park is encouraged to seek the services of Dr. Garman or another consultant. Likewise, the Alliance for Chesapeake Bay (Diane Dunaway, Alliance for the Chesapeake Bay, pers. comm., 2000) has several appropriate outreach programs that could provide the labor force necessary to implement stream biological assessments through a partnership with the National Park Service. For example, the Alliance is beginning work to establish a Senior Environment Corps. The makeup of the Corps is commonly retired professionals (e.g. professors, federal/state agency employees). The Alliance would be good first step in any attempt to remedy the paucity of biological information at the park.

Table 6. Criteria[a] for the characterization of biological condition for Rapid Bioassessment Protocol II (after Plafkin et al. 1989).

<table>
<tr><th rowspan="2">Metric</th><th colspan="3">Biological Condition</th></tr>
<tr><th>Non-Impaired</th><th>Moderately Impaired</th><th>Severely Impaired</th></tr>
<tr><td>1. Taxa Richness</td><td rowspan="8">Comparable to the best situation to be expected within an ecoregion. Balanced trophic structure. Optimum community structure (composition and dominance) for stream size and habitat quality.</td><td rowspan="8">Fewer taxa due to loss of most intolerant forms. Reduction in EPT taxa.</td><td rowspan="8">Few taxa present. If high densities of organisms, then dominated by one or two taxa. Only tolerant organisms present.</td></tr>
<tr><td>2. Family Biotic Index (modified)</td></tr>
<tr><td>3. Ratio of Scrapers/ Filtering Collectors[b]</td></tr>
<tr><td>4. Ratio of EPT and Chironomid Abundances</td></tr>
<tr><td>5. % Contribution of Dominant Family</td></tr>
<tr><td>6. EPT[c] Index</td></tr>
<tr><td>7. Community Similarity Index[d]</td></tr>
<tr><td>8. Ratio of Shredders/ Total[b]</td></tr>
</table>

Scoring criteria are generally based on percent comparability to a reference station. ' Determination of Functional Feeding Group is independent of taxonomic grouping. Ephemeroptera (mayflies), Plecoptera (stoneflies), and Tricopteran (caddisflies). [d] Community Similarity Indices are used in comparison to a reference station.

WETLAND AND RIPARIAN RESOURCE MANAGEMENT

Riparian Resource Assessment

Physically, riparian areas help to control mass movements of materials and to determine channel morphology (Naiman and Decamps 1997). Material supplied to streams comes from erosion of stream banks, a process influenced by root strength and resilience, as well as from the uplands. Stream banks largely devoid of riparian vegetation are often highly unstable and subject to mass wasting, which can widen channels by several to tens of feet annually. Major bank erosion is 30 times more prevalent on nonvegetated banks exposed to currents as on vegetated banks (Beeson and Doyle 1995).

In addition, riparian areas provide woody debris to stream channels. Woody debris piles dissipate water energy, trap moving materials, and create habitat (Naiman and Decamps 1997). Depending upon size, position in the channel, and geometry, woody debris can resist and redirect water currents, causing a mosaic of erosional and depositional patches in the riparian corridor (Montgomery et al. 1995).

Riparian forests exert strong controls on the microclimate of streams (Naiman and Decamps 1997). Streamwater temperatures are highly correlated with riparian soil temperatures, and strong microclimatic gradients appear in air, soil, and surface temperatures, and in relative humidity.

Ecologically, riparian areas provide sources of nourishment -- allochthonous inputs to rivers and herbivory; control nonpoint sources of pollution, in particular, sediment and nutrients, in agricultural watersheds and in watersheds being developed; and, create, through variations in flood duration and frequency and concomitant changes in water-table depth and plant succession, a complex of shifting habitats at different spatio-temporal scales (Naiman and Decamps 1997).

Riparian habitats have evolved in a cycle of flood and drought, but they are systems in which there is a natural repeating cycle of events. All floodplain vegetation, including riparian vegetation, therefore, is adapted to natural flood regimes. Those species found on floodplains are present because they are better adapted to the conditions than nearby upland species. Five factors are critical in determining an individual plant's response to changes in water level: 1) the time of year during which flooding occurs; 2) flood duration; 3) water depth at time of flooding; 4) amount of siltation resulting from flood waters; and 5) flood frequency.

A delicate balance exists between the flora and fauna of riparian habitats and the annual flood regime. Unusually high summer flows may scour beds of aquatic vegetation, reducing cover for young-of-the-year fish, turtles, and invertebrates. Summer destruction of these plant beds also may affect waterfowl food supply and survival the following winter. Ill-timed high flows may destroy larvae of amphibians by flushing them from pools and backwaters. Ground-nesting birds in riparian habitats may also experience high mortality of nestlings.

The U.S. Bureau of Land Management has developed guidelines and procedures to rapidly assess whether a stream riparian area is functioning properly in terms of its hydrology, landform/soils, channel characteristics, and vegetation (Prichard et al. 1993, rev. 1995). This assessment, commonly called Proper Functioning Condition (PFC), is useful as a baseline analysis of stream condition and physical function, and it can also be useful in watershed analysis.

PFC is a methodology for assessing the physical functioning of a riparian-wetland area. It provides information critical to determining the health of a riparian ecosystem. PFC considers both abiotic and biotic components as they relate to the physical functioning of riparian areas, but it does not consider the biotic component as it relates to habitat requirements. For habitat analysis, other techniques must be employed.

PFC is a useful tool for watershed analysis. Although the assessment is conducted on a stream-reach basis, the ratings can be aggregated and analyzed at the watershed scale. PFC, along with other watershed and habitat condition information, provides a good picture of watershed health and causal factors affecting watershed health.
Identifying streams and drainages where riparian areas along streams are not in proper functioning condition, and those at risk of losing function, is an important first step in the ultimate goal of restoration. Physical conditions in riparian zones are excellent indicators of what is happening in a stream or drainage above.

With the results of PFC analysis, it is possible to begin to determine stream corridor and watershed restoration needs and priorities. PFC results may also be used to identify where gathering more detailed information is needed and where additional data are not needed.

PFC is not a quantitative field technique. An advantage of this approach is that it is less time consuming than other techniques because measurements are not required. The procedure is performed by an interdisciplinary team and involves completing a checklist evaluating 17 factors dealing with hydrology, vegetation, and erosional/depositional characteristics. Training in the technique is required, but the technique is not difficult to learn. While mainly developed in the arid West, it is considered to be applicable to riparian areas of the East (Joel Wagner, National Park Service, Water Resources Division, pers. comm. 1999). Project Statement RICH-N-012.000 (Appendix A) is designed to assess riparian functional condition in the two park units.

Enhanced Wetland Delineation

Richmond NBP has contracted with USGS to map the wetlands in the park. On the basis of an April, 2000 telephone conversation with Larry Handley (USGS), aerial photographs (orthophotoquads) at a scale of 1:12,000 are available for the park units located in Henrico County. These photos will be interpreted during the summer of 2000, and wetlands will be mapped based on the Cowardin classification. The mapping and interpretation will be followed up by field checking in October and November of 2000. For the three park units not located in Henrico County (i.e. including Cold Harbor and Gaines' Mill), however, aerial photographs are not yet available. These units of the park will be flown this winter (2000 to 2001) to obtain the aerial photographs; once the photographs are available, interpretation and field checking can proceed. Detailed mapping of wetlands in the Cold Harbor and Gaines' Mill units, then, cannot be expected to be completed until sometime during 2001.

ADEQUACY OF INVENTORY FOR AQUATIC-DEPENDENT FLORA AND FAUNA

To our knowledge, there have been no efforts to gather comprehensive data on any aspect of aquatic biology (e.g. fish, amphibians and reptiles, invertebrates, aquatic flora) in the Cold Harbor or Gaines' Mill units. This lack of documentation makes it impossible to detect changes or deterioration of the resources, determine the presence/absence of state and federally listed species, and detect the presence and potential impacts of exotic species. As succinctly stated in the Resource Management Plan of Richmond NBP, "The available biological information is incomplete and inadequate to meet the full needs of the park." (National Park Service 1994). Examples of and reasons for concern about, this lack knowledge for the Cold Harbor and Gaines' Mill units are detailed in the following paragraphs.

The Virginia Department of Conservation and Recreation's Natural Heritage Program lists plants and animals on state and federal lists of concern. We checked this list for both Hanover County and Henrico County because of the proximity of the units to Henrico County. These lists are available at < http://www.state.va.us/--dcr/hano.htm > and < http://www.state.va.us/—dcr/henr.htm >, respectively. The listed species for Hanover County include the amphibian *Ambystoma tigrinum* (tiger salamander; State of Virginia endangered); five mussels, including *Alasmidonta heterodon* (dwarf wedgemussel; both state and federally endangered) and State of Virginia species of special concern *Elliptio lanceolata* (yellow lance), *Lampsilis cariosa* (yellow lampmussel), *Lampsilis radiata* (eastern lampmussel), and *Lasmigona subviridis* (green floater). The listed species for Hanover County also include *Lasmigona subviridis* and another mussel, *Striatura milium* (fine-ribbed striate; State of Virginia species of special concern). In addition, two obligate wetland plants are listed: *Aeschyonomene virginica* (sensitive joint-vetch; federally listed as threatened) and *Juncus caesariensis* (New Jersey rush; state and federally listed as threatened).

Inventories of vascular plants in Richmond NBP were compiled from 1987 to 1992 by Virginia Commonwealth University and the Division of Natural Heritage of the Virginia Department of Conservation and Recreation (National Park Service 1994). A Virginia State rare plant, *Carex collinsii* (Collin's sedge) was identified in the Cold Harbor unit by the inventory (National Park Service 1994). National Park Service policy requires that state listed plants be treated the same as federally listed plants.

The park likely contains a number of reptile species, but they have not been surveyed. The box turtle *(Terrapene carolina carolina)* is known to exist in the park (Richmond NBP, pers. comm. 2000). The U.S. Fish and Wildlife Service considers this turtle to be one of the top ten most threatened species. Populations of the box turtle in Virginia have been declining.

The park likely also contains a number of amphibian species, but they too have not been surveyed. Amphibians are considered valuable indicators of environmental quality, and populations are in a state of worldwide decline. The worldwide decline in amphibian populations was initially brought to the attention of the international community in 1989 at the First World Congress of Herpetology held in England. In the decade that followed, the amphibian decline issue has come to be regarded as an ecological emergency in progress. Population declines involving a large percentage of the amphibian community continue to be documented. Ranges of many species have been dramatically reduced, and species extinctions have occurred rapidly even in some protected areas. Furthermore, amphibian populations of multiple species around the world are experiencing a surge in bizarre and perplexing abnormalities. Although questions still remain, several potential causes of decline and/or abnormalities have emerged: climate change; habitat loss and fragmentation; introduced (exotic) species; environmental contaminants; ultraviolet radiation; acid rain; disease; and unsustainable harvest and trade. Concern that amphibian declines are precursors of threats to human health has invoked the attention of the public, research biologists, and policy makers. The amphibian-decline crisis demands that the status of amphibian populations be assessed rapidly and that where declines and/or abnormalities are apparent, mechanisms of decline and/or abnormalities be identified, habitats managed, and recovery programs established.

The park likely also contains a number of fish and aquatic invertebrates, but they too have not been surveyed. The aquatic biological assessment described in Project Statement RICH-N-011.000 (Appendix A) would provide information on the aquatic invertebrates. The number of fish species probably is limited by the size of the streams draining the park units. An assessment of the fish species present in the park units could be accomplished at the same time as the aquatic biological assessment.

With a comprehensive inventory of water-dependent flora and fauna, the status of the above species, the presence of additional rare, threatened, or endangered species, and the presence of invasive exotic species could be determined. Project Statement RICH-N-013.000 (Appendix A) is designed to conduct such a comprehensive inventory in the two park units.

ADDITIONAL RECOMMENDATIONS

Most of the important land-use decisions made near a protected area involve elected local officials, citizen boards and commissions, and professional planning staffs at the city and county levels, with input from a large number of citizens and other agencies. National Park Service units, overall, have been slow to participate in these planning and decision-making activities despite the profound effects that external land-use changes are having on their ability to achieve both cultural- and natural-resource management objectives. With regard to streams and their watersheds, park units whose land base does not include the headwater areas are either the conduit or repository of water pollution from upstream sources.

There are a number of ways (listed below, after Wallace 1999) that park staff can legitimately participate in local land-use decisions in order to influence the location, extent, type, and spatial patterns of development near the Cold Harbor and Gaines' Mill units:

- Designate staff to be assigned to work with a wide variety of local government, landowners, homeowners' associations, and nonprofit organizations in order to address adjacent land-use issues.

- Conduct a GIS-based inventory of the park units with the following layers: 1) a base map showing current land use, infrastructure, ownership, and zoning; 2) a theme showing unique ecosystem components that extend beyond boundaries (e.g. streams and riparian habitats); and, 3) a theme depicting current and potential development activity as indicated by projects under review, ownership characteristics, available infrastructure, quantity of land for sale, and volume of land recently sold.

- A powerful exercise is to model what buildout (the subdivision and development of all adjacent land) on adjacent lands will look like. This can be accomplished by superimposing the infrastructure, development, and use patterns used by built-out developments with similar zoning on top of existing land uses that are not yet built out.

- Participate in the development or revision of the comprehensive (master) plans for the counties and cities adjacent to the park.

- Participate in the development or revision of the land-use code for the counties and cities adjacent to the park.

- Propose the creation of an overlay zone near the park.

- Participate in the review of development proposals that could affect management objectives.

- Collaborate with local open-space programs and efforts to protect agricultural lands.

- Develop a memorandum of understanding with counties and cities that codifies mutual concerns and describes how to initiate the actions listed above.

- Use these opportunities to be an advocate of land and community health.

A cultural landscape report exists for the Gaines' Mill unit (Land and Community Associates 1999), but a comparable report has not been published for the Cold Harbor unit. The cultural landscape report for the Gaines' Mill unit calls for "...clearing and thinning vegetation on the Boatswain Creek uplands to reestablish historic military sight lines and approaches." Terrain and vegetation maps of portions of both the Cold Harbor and Gaines' Mill units as they existed during the battles have been interpreted and drawn by C.R. Dickinson in 1988 and 1990, respectively. Data from the existing cultural landscape maps need to be entered into a GIS system for both units. Likewise, data from the current wetlands study need to be entered into a GIS system. Once in a GIS system, these data can be overlaid to determine whether any landscape alteration designed to emulate the landscape at the time of the battles may impact any wetlands or riparian buffers.

Currently there is no mowing or weed cutting in the vicinity of either Bloody Run in the Cold Harbor unit or Boatswain Creek in the Gaines' Mill unit (Jerry Helton, Richmond NBP, pers. comm. 2000). Any future changes in vegetation maintenance along streams and in riparian areas should be carefully evaluated to determine potential impacts. Any potential impacts need to be evaluated in light of the Agreement of Federal Agencies on Ecosystem Management in the Chesapeake Bay.

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APPENDICES

APPENDIX A

Proposed Water Resources-Related Project Statements

PROJECT STATEMENT NO. RICH-N-011.000
TITLE: MONITOR LAND-USE IMPACTS ON WATER QUALITY

FUNDING STATUS:	FUNDED: 0.0	UNFUNDED: 12.0

BACKGROUND

<u>The Park and Surrounding Land Use</u>

Richmond National Battlefield Park (Richmond NBP) is in and adjacent to the city of Richmond, Virginia. The park is spread out among 11 geographically separated units, which collectively cover 764 acres. The park units are primarily to the east, northeast and southeast of the city of Richmond; as such, the park is in an urban/suburban environment. Much land previously in rural or agricultural land use has been converted to suburban land use. Competing pressures on parkland, such as encroaching development, existing development within and outside of park boundaries, nonpoint-source pollutants, proximity to point-source pollutants, natural processes, and future changes in land use are potential threats to the integrity of water quality and quantity in the park. The small size of the individual portions of the park make each unit more susceptible to influences from surrounding land use than a large intact tract of park land; the larger a tract of land, the smaller the portion that will be affected by a given disturbance or pollutant.

Because of these pressures and potential degradation to the natural resources in the park, the impacts of land use on water quality in the park units need to be monitored. The initial collection of monitoring data (i.e. baseline), the first step in developing a plan to control nonpoint-source pollution from land use, will determine whether water quality is impaired. If impairment is noted, then the park can work with the appropriate political and regulatory entities in the application of best management practices (BMPs -- the primary means to protect water quality from nonpoint-source pollution). The effective application of BMPs requires regular monitoring to determine that the BMPs were applied as planned. This information must be fed back to managers in order for them to assess where the BMP planning and implementation process is working. This implementation monitoring feedback loop is a crucial link in helping to ensure that BMPs are properly integrated into ongoing management activities. Once BMPs are in place, continued water-quality monitoring is required to ensure that there is no degradation of water quality. These data must be evaluated on a continuing basis, and a degradation in water quality probably will force a change in the procedures being used to limit nonpointsource pollution or determine if additional control measures should be undertaken.

The Concept of Biological Integrity and its Assessment

The phrase "biological integrity" was first used in 1972 to establish the goal of the Clean Water Act: "to restore the chemical, physical, and biological integrity of the Nation's waters." This mandate clearly established a legal foundation for protecting aquatic biota. The vision of biological integrity, however, was not reflected in the act's regulations for implementation. Those regulations were aimed at controlling or reducing release of chemical contaminants and thereby protecting human health; the integrity of biological communities was largely ignored (Karr 1991).

Biological integrity refers to the capacity to support and maintain a balanced, integrated, and adaptive biological system having the full range of elements (e.g. populations, species, assemblages) and processes (e.g. biotic interactions, energy dynamics, biogeochemical cycles) expected in a region's natural habitat (Karr et al. 1986). The biological integrity of water resources is jeopardized by altering one or more of five classes of environmental factors: physical habitat, seasonal flow of water, the food base of the system, interactions within the stream biota, and chemical contamination (Karr 1991). Urbanization, for example, compromises the biological integrity of streams by severing the connections among segments of a watershed and by altering hydrology, water quality, energy sources, habitat structure, and biotic interactions.

Water managers are increasingly being called upon to evaluate the biological effects of their management decisions. No other aspect of a river gives a more integrated perspective on its health than the condition of its biota. Widespread recognition of this and the continued degradation of our water resources have stimulated numerous efforts to improve our ability to track aquatic biological integrity (Davis and Simon 1995). Comprehensive, multimetric indexes (Barbour et al. 1995) were first developed in the Midwest for use with fishes (Karr 1981; Fausch et al. 1984; Karr et al. 1986), and modified for use in other regions of the U.S. (Miller et al. 1988) and with invertebrates (Ohio EPA 1988; Plafkin et al. 1989; Kerans and Karr 1994; Deshon 1995; Fore et al. 1996). The conceptual basis of the multimetric approach has now been applied to a variety of aquatic environments (Davis and Simon 1995), including large rivers, lakes, estuaries, wetlands, riparian corridors, and reservoirs, and in a variety of geographic locations (Lyons et al. 1995). These indices incorporate many attributes of aquatic communities that cover the range of ecological levels from the individual through population, community and ecosystem. Biological community measures offer the advantage that they respond to a variety of stressors, they integrate impacts over time (thereby reducing the amount of sampling), and they directly assess the achievement of a primary objective of the Clean Water Act (Barbour et al. 1995). The original multimetric index, the Index of Biotic Integrity (Karr et al. 1986), summarized stream fish collection data into 12 ecological characters from three categories: species richness and composition, trophic composition, and fish abundance and condition. Each metric is scored as poor, good, or excellent relative to an 'expected community' from a natural undisturbed ecosystem of similar size and characteristics from the same ecoregion. The strength of these multimetric indices is that many factors that affect biotic integrity can be seen or measured. The goal is to understand and isolate, through sampling design and analytical procedures, patterns that derive from natural variation in environments.

Status of Stream Water Quality/Biological Integrity and Local Attempts at Biological Assessment

While it appears that the quality of water is good within the headwater streams flowing through the two park units, nonpoint-source pollutants associated with increasing residential development could adversely affect existing water quality. Potential contamination could derive from such nonpoint sources as subdivision development, runoff associated with agriculture and developed areas, septic system leachate, and lawn and garden chemicals. Residential development often results in the reduction of infiltration areas by the creation of impervious surfaces, which can increase storm-water runoff and alter discharge and hydrologic patterns of streams. This, in turn, may lead to additional sediment loading and channel scour in the receiving stream. Improperly designed slope development or poor construction practices can also increase surface erosion and sediment load. Many of the residences surrounding the park units also contain expansive lawn areas, which undoubtedly receive applications of fertilizers and pesticides. Little information is currently available regarding the types and amounts of chemicals applied or the potential for runoff of these chemicals into adjacent streams. Therefore, present and expected development in the watersheds draining the Cold Harbor and Gaines' Mill units has the potential to impair surface- and ground-water quality, reduce surface- and ground-water quantity, and negatively affect biological resources in the units.

The paucity of specific information on surface-water features (wetlands and riparian areas), surface- and ground-water quantity and quality, and aquatic biology compromises the direction of water-resources planning. Without better water-resource information and adequate baseline data, any impacts on water resources will remain undetected and changes will be difficult to document. However, a comprehensive water-qualitymonitoring program for surface and ground waters is not warranted given that the streams are small and drain headwater watersheds – impacts from adjacent land use are more immediate and there are no cumulative impacts from upstream land use. Additionally, at present, park financial and staff limitations would not sustain a long-term comprehensive monitoring program with adequate quality assurance and control. What is needed is a sustainable, scientifically credible, `canary-in-the-mine' monitoring program that is efficient and cost-effective. This type of monitoring program does not need to be conducted on a frequent basis because all that is desired is a warning of resource degradation. If the `canary' determines that a water-resource problem exists, then more intensive study is needed to determine the exact nature and cause of the problem.

In Virginia, the 1998 Biological Monitoring Program of the Department of Environmental Quality uses the study of bottom-dwelling macroinvertebrate communities to determine overall water quality. This monitoring program is composed of stations examined twice annually, during the spring and fall. The U.S. Environmental Protection Agency's Rapid Bioassessment Protocol II (Plafkin et al. 1989; Table 1) has been

employed since the fall of 1990 as a standardized and repeatable methodology. The results of this protocol produce water quality ratings of nonimpaired, moderately impaired, and severely impaired.

Table 1. Criteria[a] for the characterization of biological condition for Rapid Bioassessment Protocol II (after Plafkin et al. 1989).

Metric	Biological Condition: Non-Impaired	Biological Condition: Moderately Impaired	Biological Condition: Severely Impaired
9. Taxa Richness	Comparable to the best situation to be expected within an ecoregion. Balanced trophic structure. Optimum community structure (composition and dominance) for stream size and habitat quality.	Fewer taxa due to loss of most intolerant forms. Reduction in EPT taxa.	Few taxa present. If high densities of organisms, then dominated by one or two taxa. Only tolerant organisms present.
10. Family Biotic Index (modified)			
11. Ratio of Scrapers/ Filtering Collectors[b]			
12. Ratio of EPT and Chironomid Abundances			
13. % Contribution of Dominant Family			
14. EPT[c] Index			
15. Community Similarity Index[d]			
16. Ratio of Shredders/ Total[b]			

[a] Scoring criteria are generally based on percent comparability to a reference station.
[b] Determination of Functional Feeding Group is independent of taxonomic grouping.
[c] Ephemeropter (mayflies), Plecoptera (stoneflies), and Tricopteran (caddisflies).
[d] Community Similarity Indices are used in comparison to a reference station.

The procedure evaluates the macroinvertebrate community by comparing ambient monitoring network stations to "reference" sites. A reference site is one that has been judged to be representative of a natural, unimpaired waterbody. An additional product of this evaluation is a habitat assessment, which provides information on the comparability of each stream station to the reference site.

PROBLEM STATEMENT

Because of the lack of knowledge of stream aquatic biology and status of water quality; the development potential of tributary watersheds; and the need to establish a long-term, cost-effective assessment program for watersheds where none exists, the park will explore further the use of multimetric indices (or rapid bioassessment protocols) for use in its tributary systems. The systematic, biological assessment of species assemblages using multimetric indexes is currently a very practical and cost-effective approach to determine if human actions are degrading biological integrity (Davis and Simon 1995). Such monitoring provides both numeric and narrative descriptions of resource condition, which can be compared among watersheds, across a single watershed, and over time (Karr 1991), and it does so at costs that are often less than the cost of complex chemical monitoring. Furthermore, this monitoring can evaluate management actions and decisions, e.g., the effectiveness of BMPs such as riparian buffers. Costs per evaluation are relatively low for ambient biological monitoring. Based on a decade of sampling and including equipment; supplies; and logistical, administrative, and data-analysis and interpretation activities, benthic invertebrates cost $824/sample and fish cost $740/sample (Yoder and Rankin 1995) in comparison with chemical and physical water quality ($1,653 per station) and bioassays ($3,573 to $18,318 per assay).

The Index of Biotic Integrity (IBI; Karr 1981), the first of the multimetric indexes and centered on fish communities, was conceived to provide a broadly based and ecologically sound tool to evaluate biological conditions in Midwestern streams. The IBI and other, similar indexes are based on a series of assumptions and intuitions of how biotic assemblages change with increased environmental degradation. A single sample from a stream reach is evaluated using 12 metrics to determine the extent to which the resident biotic community diverges from that expected of an undisturbed site in the same geographic area and of the same stream size (Table 2). Unlike efforts to define chemical criteria that do not take variation by geographic region into account, this approach explicitly recognizes natural variation in water-resource conditions. Ratings are assigned, summed, and placed into integrity classes (excellent, good, fair, poor, and very poor) to provide an assessment of the biological integrity or health of a system.

DESCRIPTION OF RECOMMENDED PROJECT

Biological monitoring of tributary streams in Richmond NBP will be based on the premise that biological integrity can be measured in terms of the composition, structure, and function of resident biotic communities. Because fish and benthic macroinvertebrate communities are sensitive to and integrate diverse aspects of their environments, including human-induced alterations, they serve as continual monitors of biotic integrity. In an effort to foster partnering and to reduce any duplicative efforts, the park will contact the Virginia Department of Environmental Quality about the possibilities of a pilot study that would: 1) sample the habitat and benthic macroinvertebrate communities of the tributaries; and 2) use the benthic macroinvertebrate based multimetric index, Rapid Bioassessment Protocol II (Plafkin et al. 1989). Depending upon the level of state involvement, the park could conduct its own biological assessment program (with appropriate training and use of volunteers), conduct the sampling and contract to the state

Table 2. Typical effects of environmental degradation on biotic assemblages (from Fausch et al. 1990).

1. The number of native species, and those in specialized taxa or guilds declines
2. The percentage of exotic or introduced species or stocks increases
3. The number of generally intolerant or sensitive species declines
4. The percentage of the assemblage comprising tolerant or insensitive species increases
5. The percentage of trophic and habitat specialists declines
6. The percentage of trophic and habitat generalists increases
7. The abundance of the total number of individuals declines
8. The incidence of disease and anomalies increases
9. The percentage of large, mature, or old-growth individuals declines
10. Reproduction of generally sensitive species declines
11. The number of size- and age-classes declines
12. Spatial or temporal fluctuations are more pronounced

the identification and analysis phases, or just contract to the state all phases (sampling, identification, and analysis). The ultimate goal would be to establish two permanent (one for each park unit), park-based, stream sampling stations as part of the Virginia Department of Environmental Quality's monitoring and assessment program. To this end, the park would be able to assess tributary biological integrity on a regular basis with minimal personnel and monetary investments.

A biological-monitoring plan ($3K, first year only) will be developed that provides detailed technical guidance for completing the field studies, including the following information:

- Final study station locations;
- Reference station locations;
- Field protocols and sampling gear requirements for assessing habitat conditions and sampling benthic macroinvertebrate and fish communities;
- QA/QC protocols for sample handling, record keeping, and chain of custody;
- Field safety instructions; and,

• Schedule.

The monitoring plan will be peer-reviewed by personnel from the Water Resources Division of the National Park Service and the Virginia Department of Environmental Quality prior to implementation of the field studies.

Habitat and benthic macroinvertebrate assessments (combined cost is $3K/year) will be conducted at both monitoring stations once per year (time of year to be determined by Virginia Department of Environmental Quality) for the 3-year project. The 3-year project is intended to give enough time to implement and refine the monitoring plan, assess temporal variability, solidify the program, and prepare the park for continued, long-term monitoring. After the 3-year project, the park will absorb the costs of the monitoring program (i.e. approximately $3K/year plus staff time). However, sampling of the monitoring stations could be extended to once every two years. This is not the preferred approach, yet it is still viable, i.e. it would still provide an assessment of degradation of park resources. The possibility exists, however, that it would not be as timely an assessment as that on an annual basis.

Habitat assessments will be conducted at all monitoring stations following the procedures outlined in Plafkin et al. (1989). These procedures include an evaluation of the immediate watershed, substrates, stream width, and general water-quality conditions.

Benthic macroinvertebrates will be sampled at each monitoring station following the semi-quantitative techniques described in Plafkin et al. (1989). This multi-habitat method could be modified to maximize efficiency of fieldwork and analysis. This could involve compositing samples from the various habitats for analysis and data evaluation.

A numerical value will be calculated for each metric of Rapid Bioassessment Protocol II. Values will then be compared to values derived for the same metrics at corresponding reference stations. Each metric will be scored according to its percent comparability to the reference value. Scores for the individual metrics will then be totaled and compared to the total metric score for reference stations. The percent similarity between the total scores will correspond with one of four qualitative integrity ratings ranging from severely impaired to non-impaired. If the integrity rating drops from one year to the next, degradation of water resources may be occurring somewhere upstream of the monitoring station. The emphasis is on "may," because drought years or years of excessive rainfall can confuse the interpretation. If climatic conditions can be ruled out, then a detailed look at the trends in individual components of the index may provide additional clues to the cause of the rating drop. To explicitly determine the cause(s) of water-quality impacts, more intensive studies will need to be developed. On the other hand, if the integrity rating improves from one year to the next, some form of BMP may have been implemented, intentionally or otherwise. In this case, determining the cause of the beneficial impact is important in determining that it sustains itself in the long term.

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BUDGET AND FTEs

FUNDED

	Source	Act Type	Budget	FTEs

UNFUNDED

	Source	Act Type	Budget	1'1'Es
Year 1		RES	6,000	0.05
Year 2		RES	3,000	0.05
Year 3		RES	3,000	0.05
		Total	12,000	0.15

PROJECT STATEMENT NO. RICH-N-012.000
TITLE: ASSESS PROPER FUNCTIONING CONDITION OF RIPARIAN AREAS

Funding Status: Funded 0.00 Unfunded 20.00

PROBLEM STATEMENT

Natural riparian areas are some of the most diverse, dynamic, and complex biophysical habitats in the terrestrial environment (Naiman et al. 1993). The riparian area encompasses that part of the stream channel between low and high water marks and that portion of the terrestrial landscape from the high water mark toward the uplands where vegetation may be influenced by elevated water tables or flooding and by the ability of the soils to hold water (Naiman and Decamps 1997). Riparian zones are key systems for regulating aquatic-terrestrial linkages (Ward 1989), and they may be early indicators of environmental change (Decamps 1993).

Physically, riparian areas help to control mass movements of materials and to determine channel morphology (Naiman and Decamps 1997). Material supplied to streams comes from erosion of stream banks, a process influenced by root strength and resilience, as well as from the uplands. Stream banks largely devoid of riparian vegetation are often highly unstable and subject to mass wasting, which can widen channels by several to tens of feet annually. Major bank erosion is 30 times more prevalent on nonvegetated banks exposed to currents as on vegetated banks (Beeson and Doyle 1995).

Ecologically, riparian areas: 1) provide sources of nourishment -- allochthonous inputs to rivers and herbivory; 2) control nonpoint sources of pollution, in particular, sediment and nutrients, in agricultural watersheds and watersheds being developed; and 3) create, through variations in flood duration and frequency and concomitant changes in water-table depth and plant succession, a complex of shifting habitats at different spatio-temporal scales (Naiman and Decamps 1997).

Riparian habitats have evolved in a cycle of flood and drought, but they are systems in which there is a natural repeating cycle of events. All floodplain vegetation, including riparian vegetation, therefore, is adapted to natural flood regimes. Those species found on floodplains are present because they are better adapted to the conditions than nearby upland species.

A delicate balance exists between the flora and fauna of riparian habitats and the annual flood regime. Unusually high summer flows may scour beds of aquatic vegetation, reducing cover for young-of-the-year fish, turtles, and invertebrates. Summer destruction of these plant beds may affect waterfowl food supply and survival the following winter. Ill-timed high flows may destroy larvae of amphibians by flushing them from pools and backwaters. Ground-nesting birds in riparian habitats may also experience high mortality of nestlings.

Other than a cursory knowledge of the plant species present in the park, the riparian areas in the Cold Harbor and Gaines' Mill units are unstudied. The maintenance of healthy riparian systems is essential in obtaining and sustaining biologically diverse Coastal Plain ecosystems. Healthy riparian systems can be described as being geologically stable with stream flow and sediment discharges that are in dynamic equilibrium with their upland watersheds, and as having wetland and riparian vegetation that has appropriate structural, age, and species diversity. When these attributes are maintained, riparian systems provide forage and cover for wildlife or domestic livestock and improve water quality by filtering sediment and recycling nutrients. If, however, any of the essential attributes are missing or degraded, or if the system becomes geologically unstable, widespread erosion may occur that will degrade water quality and cause damage or loss of wetland and riparian habitats.

The U.S. Bureau of Land Management has developed guidelines and procedures to rapidly assess whether a stream riparian area is functioning properly in terms of its hydrology, landform/soils, channel characteristics, and vegetation (Prichard et al. 1993, rev. 1995). This assessment, commonly called Proper Functioning Condition, or PFC, is useful as a baseline analysis of stream condition and physical function. The basic goal of this project is to use the process for PFC to classify park riparian areas as either "proper functioning condition," "functional-at-risk," or "nonfunctional." This goal can be met by implementing a coordinated review of existing literature and tactical field investigations.

DESCRIPTION OF THE RECOMMENDED PROJECT

A riparian-wetland assessment tool called Assessing Proper Functioning Condition (Prichard et al. 1993, rev. 1995) will be used to evaluate riparian systems. This technique uses an interdisciplinary team to assess riparian area "functionality" according to 17 hydrological, vegetational, and stream geomorphological (e.g. erosion, deposition, channel geometry) factors. PFC is not a quantitative field technique. An advantage of this approach is that it is less time consuming than other techniques because measurements are not required. It provides an initial screening that can separate areas that are functioning well from those in need of more intensive evaluation or management actions. In this way, money and effort can be targeted toward the higher priority issues. Originally developed by the U.S. Bureau of Land Management for assessment of riparian areas managed by that agency, the method is now being applied throughout the western U.S. by the U.S. Forest Service and the Natural Resources Conservation Service. Use of this tool on eastern U.S. riparian areas is a logical extension.

PFC is a methodology for assessing the physical functioning of a riparian-wetland area. It provides information critical to determining the health of a riparian ecosystem. PFC considers both abiotic and biotic components as they relate to the physical functioning of riparian areas, but it does not consider the biotic component as it relates to habitat requirements. For habitat analysis, other techniques must be employed.

The "functioning condition" of a riparian area refers to the stability of the physical system, which in turn is dictated by the interaction of geology, soil, water, and vegetation. A healthy or stable stream/riparian area is in dynamic equilibrium with its stream flow forces and channel processes. In a healthy system, the channel adjusts in slope and form to handle larger runoff events with limited perturbation of the channel and associated riparian-wetland plant communities.

It is important to note that evaluation of functioning condition is not simply an assessment of the ecological status or seral stage of the vegetation community. Rather, evaluation is based upon the concept that in order to manage for natural vegetation communities, the basic elements of physical habitat must first be in place and functioning properly.

Identifying streams and drainages where riparian areas are not in proper functioning condition, and those at risk of losing function, is an important first step in the ultimate goal of restoration. Physical conditions in riparian zones are excellent indicators of what is happening in a stream or in the upstream watershed area. With the results of PFC analysis, it is possible to begin to determine stream corridor and watershed restoration needs and priorities. PFC results may also be used to identify where gathering more detailed information is needed and where additional data are not needed.

Riparian Functionality Assessment

In accordance with the BLM's protocols (Prichard et al. 1993, rev. 1995) for assessing riparian functionality, an interdisciplinary team with expertise in hydrology, soil science, geology, and riparian vegetation will evaluate the capability and potential of park streams in terms of riparian functionality by using existing literature and field examinations to perform the following tasks:

- identify and describe relict areas;
- review historical photos, survey notes, and other documents that indicate historical condition;
- review floral and faunal species lists;
- determine species habitat needs related to species that are/were present;
- examine soils and determine if they were saturated at one time and are now well drained;
- estimate frequency and duration of flooding on floodplains and terraces;
- identify vegetation that currently exists and determine if the same species occurred historically;
- determine the entire watershed's general condition and identify its major landforms; and
- identify limiting factors to functionality, both human-caused and natural, and determine if remedial actions are needed.

Based on the evaluation of the above factors, the team will classify park riparian areas into one of the following three categories:

Proper Functioning Condition: Stream/riparian areas are functioning properly when adequate vegetation, landform, or large woody debris is present to:

- dissipate stream energy associated with high water flows, thereby reducing erosion and improving water quality;
- filter sediment, capture bedload, and aid floodplain development;

- improve floodwater retention and ground-water recharge;
- develop root masses that stabilize stream banks against cutting action;
- develop diverse ponding and channel characteristics to provide habitat and the water depths, durations, temperature regimes, and substrates necessary for fish production, waterfowl breeding, and other uses; and
- support greater biodiversity.

Functional-at-Risk: These stream/riparian areas are in functional condition, but an existing soil, water, vegetation, or related attribute makes them susceptible to degradation. For example, a stream reach may exhibit attributes of a properly functioning system, but it may be poised to suffer severe erosion during a large storm in the future due to likely headward erosion or increased runoff associated with a recent disturbance in the watershed.

Nonfunctional: These are stream/riparian areas that clearly are not providing adequate vegetation, landform, or large woody debris to dissipate stream energy associated with high flows, and thus are not reducing erosion, improving water quality, etc., as already described. The absence of certain physical attributes, such as a floodplain where one should exist, is an indication of nonfunctioning conditions.

The product of this project will be a report containing a compendium of the standard checklist for each riparian area evaluated by the team, and summary describing the team's conclusions regarding the overall condition of the park's riparian areas. The report will also provide recommendations for restoration of any Nonfunctional riparian areas, consistent with the park's management objectives and any cultural landscape studies that include these riparian areas. Any Functional-at-Risk riparian areas will be prioritized, highest risk for degradation to lowest, and recommendations will be provided for management and or restoration of these areas also subject to the same constraints as those for Nonfunctional riparian areas.

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BUDGET AND FTEs

FUNDED

	Source	Activity	Fund Type	Budget	FTEs
	Total:			0.00	0.00

UNFUNDED

	Source	Activity	Fund Type	Budget	FTEs
Year 1:		MON	One-time	20,000	0.05
	Total:			20,000	0.05

PROJECT STATEMENT No. RICH-N-013.000
TITLE: BASELINE ASSESSMENT OF INSTREAM AND RIPARIAN ZONE BIOLOGICAL RESOURCES

FUNDING STATUS: FUNDED: 0.0 UNFUNDED: 30.0

PROBLEM STATEMENT

<u>The Setting</u>

Richmond National Battlefield Park (Richmond NBP) is 110 miles south of Washington, D.C., in east-central Virginia, and comprises 764 acres adjacent to the city of Richmond. The park contains 11 geographically separated units, located primarily east, northeast and southeast of the city of Richmond. Ten of the units are associated with McClellan's 1862 Peninsula Campaign and/or Grant's 1864 Overland Campaign during the Civil War. The 11th unit, which was the site of the Confederacy's Chimborazo Hospital, is the main park Visitor's Center, located within the city limits. Richmond NBP was established by Federal legislation in 1936 to "protect the Civil War battlefield resources associated with the struggle for the capital of the Confederacy and to interpret these resources so as to foster an understanding of their larger significance" (National Park Service 1996).

The Cold Harbor and Gaines' Mill units are between the James and York rivers, east of the transition zone (the Fall Line) between the Piedmont and Atlantic Coastal Plain physiographic provinces. Both units are on the U.S. Geological Survey (USGS) Seven Pines, Virginia, 1:24,000-scale topographic quadrangle. The units are northeast of the city of Richmond in proximity to one another in southeastern Hanover County, approximately 5 miles southeast of Mechanicsville. Cold Harbor, the northernmost of the two, consists of approximately 149 acres and lies along the north side of State Route 156. The Gaines' Mill unit, approximately 0.75 mile to the southwest of the Cold Harbor unit, consists of approximately 60 acres and lies along State Route 718.

Both the Cold Harbor and Gaines' Mill units are within the 64,000 mi^{l} Chesapeake Bay Watershed, the 10,102 mi^{2} James River Watershed and the 470 mi^{l} Chickahominy River Watershed. Small streams, which are tributary to the Chickahominy River, drain each of the units; the Chickahominy River drains to the James River, which drains to the Chesapeake Bay. The James River Watershed is the largest watershed in Virginia, drains one-fourth of the state's land area, and contains nearly one-third of Virginia's population. Industries in the James River Watershed include transportation, chemicals, furniture, textiles, shipping, shipbuilding, and tourism. Suburban areas characterize the Chickahominy River Watershed in the upper one-third of the watershed and predominantly forested areas mixed with residential areas and farmland in the lower two-thirds of the watershed. Timber harvesting in the Chickahominy River Watershed is an important part of the local economy.

The main stream that flows through the Cold Harbor unit is Bloody Run, a tributary to Powhite Creek. An unnamed tributary to Powhite Creek forms part of the northern boundary of the Cold Harbor unit. Powhite Creek joins the Chickahominy River just upstream of where Boatswain Creek joins the Chickahominy River. No other perennial streams are shown within the unit on the USGS 1:24,000-scale topographic map, although the rolling topography suggests that ephemeral tributaries and wetlands exist during and shortly after storms. The Cretaceous-aged Patuxent Formation, which underlies the park units, holds "a significant amount of water" in the 100- to 300-foot thick aquifer (National Park Service 1996).

Boatswain Creek forms the northwestern boundary of the Gaines' Mill unit. The headwaters of Boatswain Creek originate near the Garthright House, approximately 1 mile upstream of the Gaines' Mill unit. Boatswain Creek joins the Chickahominy River approximately 0.8-mile southeast of the Gaines' Mill unit. No other perennial streams are shown within the unit on the USGS 1:24,000-scale topographic map, although the rolling topography suggests that ephemeral tributaries and wetlands exist during and shortly after storms. The Cretaceous-aged Patuxent Formation, which underlies the park units, holds "a significant amount of water" in the 100- to 300-foot thick aquifer (National Park Service 1996).

The Problem

Current land use in both units of the park is approximately 70% forested and 30% open in agricultural use. In the Gaines' Mill unit, the agricultural areas are planted in a variety of crops, which have included hay, wheat, soybeans, millet, and other low-growing crops, depending on the season (Land and Community Associates 1999). The surrounding area outside of park boundaries generally consists of open uplands in agricultural use and wooded stream corridors with swampy bottomlands.

In 1990, the population of Hanover County was 63,306; population is projected to rise to 142,200 by 2020 (a 124% growth rate) (National Park Service 1996). The current Land Use Plan for Hanover County (Lee Garman, County of Hanover, pers. comm. 2000), named Vision 2017, zones the area north of Route 156 for phased suburban development, which would commence in the 2002-2007 time frame. The phased suburban development in this area allows for low-density residential development (1-2 housing units per acre), once the water and sewer lines become available. Should this development occur to the full "build out" level allowed for by zoning, the Cold Harbor unit could be surrounded on the north, west, and east sides by low-density suburban development, which could have an impact on both water quantity and water quality. The 2.1-acre Garthright House portion of the park is surrounded on three sides by a 50.9-acre passive-use park being developed by Hanover County (National Park Service 1996), which greatly reduces the chances of its water resources being affected by outside development.

Vision 2017 zones the land south of Route 156 as "Agricultural," which limits future residential development to a maximum of one housing unit per 10 acres. Rezoning to either "RC District" or "AR-6 District" could be approved by the county in the future. Both of these categories would allow for development to a maximum density of 1 unit per 6.25 acres. The difference is that the AR-6 District zoning allows for the traditional subdivision layout, where the minimum lot size is 6.25 acres, whereas RC District zoning allows clustering of development without prescribed minimum lot size as long as 70% of the land is deemed "open space" and a maximum density of 1 residence per 6.25 acres is maintained for the project. The present Agricultural zoning, or the rezoning to RC District or AR-6 District, would affect the land surrounding the Gaines' Mill unit and potentially could affect water quality. As an example of effects of development, Schueler (1994) used a biodiversity metric (index) to measure the effect of the percentage of impervious surfaces in watersheds in urban areas and found that at percentages above 15%, the biodiversity in the stream was degraded (Figure 1).

There are no known studies of the aquatic and riparian flora and fauna of the Gaines' Mill and Cold Harbor units. This paucity of information needs to be rectified, especially if the above build-out scenario occurs. The park needs to document the current biodiversity of amphibians and reptiles, fishes, aquatic macroinvertebrates, aquatic algae and macrophytes, and riparian flora and fauna. For example, the worldwide decline in amphibian populations was initially brought to the attention of the international community in 1989. In the decade that followed, the amphibian decline issue has come to be regarded as an ecological emergency in progress. Population declines involving a large percentage of the amphibian community continue to be documented. Ranges of many species have been dramatically reduced, and species extinctions have occurred rapidly even in some protected areas. Furthermore, amphibian populations of multiple species are experiencing a surge in bizarre and perplexing abnormalities. Amphibians are considered valuable indicators of environmental quality, and concern that amphibian declines are precursors of threats to human health has invoked the attention of the public, research biologists, and policy makers.

DESCRIPTION OF RECOMMENDED PROJECT OR ACTIVITY

Objective

Provide the park with baseline data and supporting interpretations on the occurrence and distribution of instream and riparian zone biological resources of tributaries of the Chickahominy River within and adjacent to the Cold Harbor and Gaines' Mill units of Richmond NBP. This effort will provide park staff with important biological data upon which to base future management actions, such as: 1) consistent with the Endangered Species Act, identify, conserve, and where appropriate, attempt to recover all federally listed threatened and endangered species or species of special concern and their essential habitat; 2) identify and map the distributions of plant and animal species considered rare or unique to the park; 3) manage plant and animal populations where it is necessary to preserve and protect cultural resources and landscapes; and 4) exotic species management may be needed to stop disruption of the accurate presentation of a cultural landscape. Upon completion, the park will be positioned to influence future land-use decisions that affect water resources on adjacent lands or the management of adjacent lands, where appropriate.

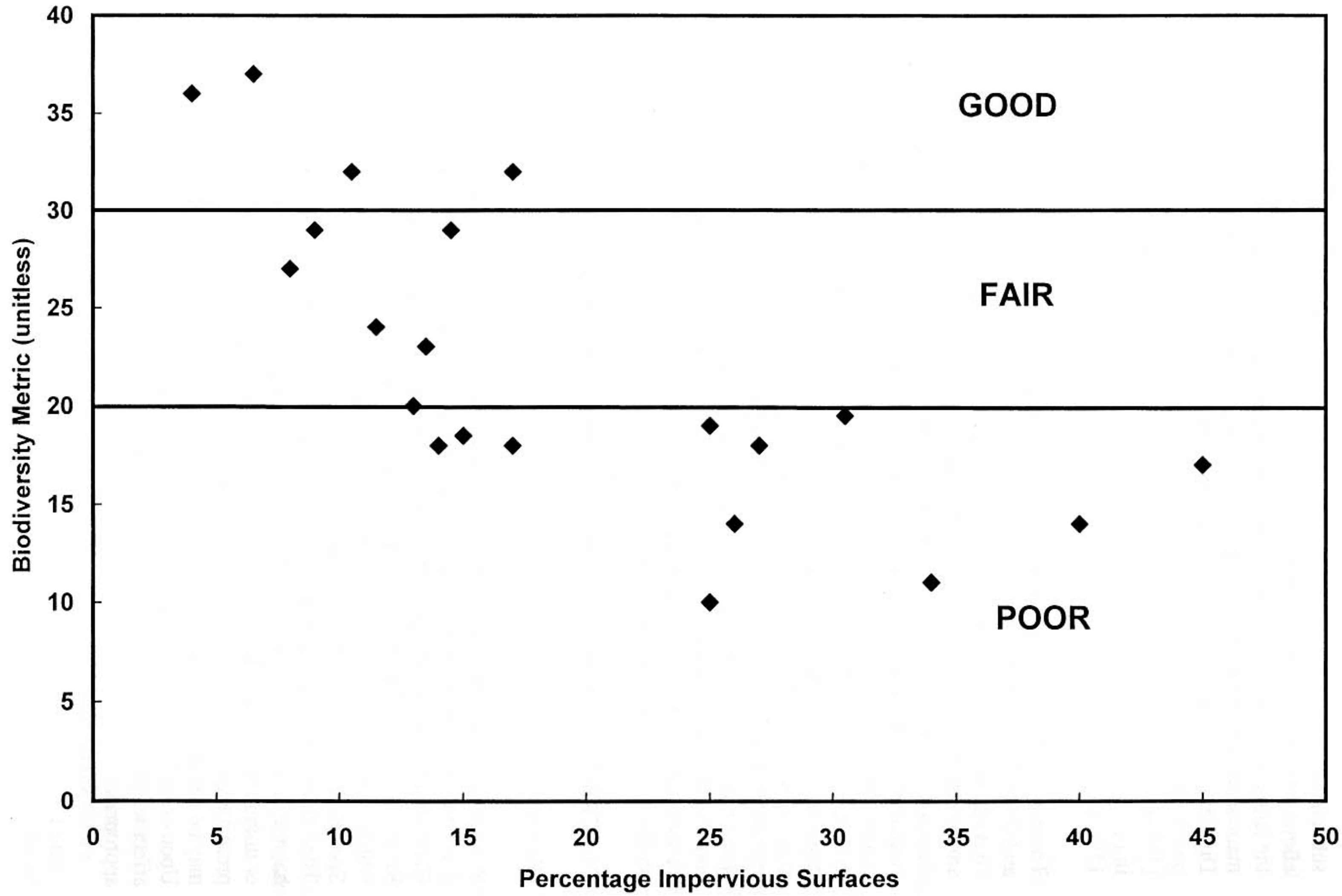

Figure 1. Relationship of a biodiversity metric to percentage of Impervious surfaces in urban watersheds (after Schueler 1994).

The Project

Acquire data on the occurrence, distribution, and abundance of fish, amphibians, aquatic invertebrates, aquatic plants and algae, and woody and herbaceous riparian vegetation of Chickahominy River tributaries of Cold Harbor and Gaines' Mill units of Richmond NBP.

Sampling Reach: Establish sampling reaches at up to two sites per unit based on geomorphic channel features (Meador et al. 1993a), generate a planimetric reach map, and characterize channel riparian zone habitat features including depth, velocities, bed and bank substrates, type, frequency and extent of geomorphic channel units (riffles, runs, and pools), and composition, dominance and density of riparian zone vegetation.

Amphibians and Reptiles: Sample amphibians and reptiles using pitfall traps and funnels (with drift fences and bait, as necessary), visual belt transects, direct capture methods, and vocalization recording. Pitfall traps and funnels are perhaps the most widely used, often producing more species per sampling effort than direct capture. These methods require multiple visits to a sampling area, first to set up and later to check traps. Sampling should occur during the mid-to-late growing season when maximum numbers of juveniles (e.g. tadpoles) are present. However, many species are easily found only after the first few days of rain following a drought, during late-summer thunderstorms, during the first spring thaw in northern areas, during mid-day basking hours, or at night.

Fish: Document species occurrence, distribution, and abundance (Meador, et al. 1993b) of fishes in the assessment reaches using electro fishing and seining techniques. Identify endangered, threatened, and at-risk species and associated locations, and establish sampling and identification protocols for future assessment.

Mollusks: Assess potential habitat to eliminate areas where mollusks could not occur; focus further efforts on sites where populations may still exist. Employ a variety of survey methods as appropriate, including random-area searches and timed or measured-area searches. Where mollusk populations are present and in appropriate densities, take quadrat samples or transect samples to document density. Note species present and population composition by location.

Aquatic Algae and Plants: Collect periphytic algae and vascular macrophytes (Porter et al. 1993) at each sampling station to document the composition, occurrence, and distribution of these groups. Subsample periphytic algae for analysis of chlorophyll and biomass as potential indicators of nutrient enrichment.

Select Water Quality/Quantity Parameters: Collect measurements of temperature, pH, dissolved oxygen, turbidity, conductivity and flow at each sampling station.

LITERATURE CITED

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BUDGET AND FTEs

FUNDED

	Source	Act Type	Budget	FTEs

UNFUNDED

FTEs 0.1

	Source	Act Type	Budget
Year 1		RES	30,000

APPENDIX B

Selected Virginia Water-Quality Standards

9 VAC 25-260-50. Numerical criteria for dissolved oxygen, pH, and maximum temperature.***

DESCRIPTION CLASS OF WATERS	DISSOLVED OXYGEN (mg/I)		pH	Maximum Temp. (°C)
	Min.	Daily Avg.		
I Open Ocean	5.0		6.0-9.0	
II Estuarine Waters (Tidal Water-Coastal Zone to Fall Line)	4.0	5.0	6.0-9.0	
III Nontidal Waters (Coastal and Piedmont Zones)	4.0	5.0	6.0-9.0	32
IV Mountainous Zones Waters	4.0	5.0	6.0-9.0	31
V Stockable Trout Waters	5.0	6.0	6.0-9.0	21
VI Natural Trout Waters	6.0	7.0	6.0-9.0	20
VII Wetlands	*	*	*	**

*This classification recognizes that the natural quality of these waters may fall outside of the ranges for D.O. and pH set forth above as water quality criteria; therefore, on a case-by-case basis, criteria for specific wetlands can be developed which reflect the natural quality of the waterbody.

**Maximum temperature will be the same as that for Classes I through VI waters as appropriate.

***The water quality criteria in 9 VAC 25-260-50 do not apply below the lowest flow averaged (arithmetic mean) over a period of seven consecutive days that can be statistically expected to occur once every 10 climatic years (a climatic year begins April 1 and ends March 31.

9 VAC 25-260-170. Fecal coliform bacteria; other waters.

A. General requirements. In all surface waters, except shellfish waters and certain waters addressed in subsection B of this section, the fecal coliform bacteria shall not exceed a geometric mean of 200 fecal coliform bacteria per 100 ml of water for two or more samples over a 30-day period, or a fecal coliform bacteria level of 1,000 per 100 ml at any time.

B. Disinfection policy. In waters that receive sewage discharges, all the designated uses in these waters shall be protected. The board's disinfection policy applies to these waters.

1. Sewage discharges in relation to water supply intakes. Discharges located within 15 miles upstream or one tidal cycle downstream of a water supply intake shall be disinfected in order to achieve a fecal coliform geometric mean value in the effluent equal to or less than 200 per 100 milliliters.

2. Sewage discharges into shellfish waters. When sewage discharges are permitted to or within five miles upstream of shellfish waters, they shall be disinfected in order to achieve a fecal coliform geometric mean value in the effluent equal to or less than 200 per 100 milliliters.

3. Sewage discharges into other waters. Sewage discharges into other waters shall be adequately treated and disinfected as necessary to protect all the designated uses in these waters. Generally, these discharges shall achieve a fecal coliform geometric mean value in the effluent equal to or less than 200 per 100 milliliters. However, the board, with the advice of the State Department of Health, may determine that reduced or no disinfection of a discharge is appropriate on a seasonal or year-round basis. In making such a determination, the board shall consider the designated uses of these waters and the seasonal nature of those uses. Such determinations will be made during the process of approving, issuing, or reissuing the discharge permit and shall be in conformance with a board approved site-specific use-attainability analysis performed by the permittee. When making a case-by-case determination concerning the appropriate level of disinfection for sewage discharges into these waters, the board shall provide a 45-day public notice period and opportunity for a public hearing.

9 VAC 25-260-190 General Requirements for Groundwater Standards

Except where otherwise specified, groundwater quality standards shall apply statewide and shall apply to all groundwater occurring at and below the uppermost seasonal limits of the water table. In order to prevent the entry of pollutants into groundwater occurring in any aquifer, a soil zone or alternate protective measure or device sufficient to preserve and protect present and anticipated uses of groundwater shall be maintained at all times. Zones for mixing wastes with groundwater may be allowed, upon request, but shall be determined on a case-by-case basis and shall be kept as small as possible. It is recognized that natural groundwater quality varies from area to area. Virginia is divided into four Physiographic Provinces, namely the Coastal Plain, Piedmont and Blue Ridge, Valley and Ridge, and Cumberland Plateau. Accordingly, the Board has established certain groundwater standards specific to each individual Physiographic Province.

APPENDIX C

Attendees of Scoping Session Held at Richmond National Battlefield Park, Richmond, Virginia, January 27, 2000

Name	Affiliation[1]	Phone Number	E-mail address
David Vana-Miller	NPS-WRD	303-969-2813	David_Vana-Miller@nps.gov
Michael Johnson	NPS-RNBP	540-654-5535	FRSP_Chief_Ranger@nps.gov
David McKinney	NPS-RNBP	804-795-1115	David_McKinney @nps.gov
Cynthia MacLeod	NPS-RNBP	804-226-1981	Cynthia_MacLeod@nps.gov
Mark Flora	NPS-WRD	303-969-2956	Mark_Flora@nps.gov
Vincent Clark	NPS-RNBP	804-795-2648	Vince_Clark@nps.gov
Karen Rice	USGS	804-297-0106	kcrice@usgs.gov
Michael Andrus	NPS-RNBP	804-226-1981	Mike_Andrus @nps.gov

[1] **Affiliations:**
NPS-WRD, National Park Service, Water Resources Division NPS-RNBP, National Park Service, Richmond National Battlefield Park USGS, U.S. Geological Survey

As the nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation The department assesses our energy and mineral resources and works to ensure that their development is in the best interior of all our people by encouraging stewardship and citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

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